Moderation of Power Quality Problems Utilizing an Improved Interline Dynamic Voltage Restoring Device with Pv System

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Abstract: Presently a day in the distribution system the sustainable power sources significance has been expanded. In this paper an interline dynamic voltage restorer (IDVR) has proposed for the distribution systems to relieve voltage hang/swell issues and enhance control quality. All in all for the typical voltage levels, the DVRs ought to be skirted, however as opposed to bypassing the DVRs, this paper proposes new working plan for the DVRs, if necessary, to improve the relocation factor in any of the included feeders. Generally, an interline dynamic voltage restorer includes a couple of dynamic voltage restorers (DVRs) with a sharing dc interface.IDVR is associated with the free feeders to secure the electric energy to the basic burdens. One of the DVRs adjusts for the neighborhood voltage hang in its feeder, and alternate DVRs recharge the normal dc-connect voltage is provided by utilizing sun powered energy (PV). DF change can be accomplished through dynamic and receptive power trade (PQ sharing) between various feeders. To approve the proposed system, Simulation comes about have been introduced utilizing MATLAB/SIMULINK software.

Keywords: PQ Sharing Mode, Displacement Factor Improvement, PV System, IVDFC, IDVR.

1. INTRADUCTION

Systems are for the most part inductive at the crucial frequency due to the idea of the predominant associated loads (e.g., enlistment engines).This, in turn, reduces the displacement factor (DF) and places an additional burden on the electrical supply. Low DF operation is not recommended due to several negative effects on the power system including:

- Higher current for a given active power and a corresponding increase in total copper loss (i.e., system efficiency decrease);
- lower utilization of power system components;

- Voltage regulation issues and rising power delivery costs.

A few viable procedures are generally used to enhance DF. DF change utilizing capacitor saves money with size and area improvement has been presented in. The ideal area and size of the capacitor bank to be put in spiral dispersion feeders to enhance their voltage profile and to lessen the aggregate vitality misfortune are exhibited in. Distinctive strategies are utilized in to limit the power misfortune in appropriation systems. In, the feeder reconfiguration concept in distribution systems is introduced to reduce system loss. In a joined framework for symphonious concealment and reactive power remuneration is proposed to enhance the DF as well as the power factor. A Statcom can be utilized as a suitable option for DF change. Appropriate change of the stage and greatness of the STATCOM yield voltages empower viable control of dynamic and reactive power trades between the STATCOM and the dispersion framework. Such an arrangement enables the gadget to retain or produce controllable dynamic and reactive powers. A STATCOM has different highlights, including quick reaction, low-space necessity, and great soundness edges. As of late, it is quickly supplanting the regular normally commutated reactive power controllers and static VAR compensators. The reactive power provided by the STATCOM for DF change is capacitive in nature. Instinctively, the higher the STATCOM's reactive power, the higher the dc-interface voltage of the STATCOM (the higher the voltage prerequisites of the semiconductor devices).The DVR is a standout amongst the most well-known and compelling answers for securing basic burdens against voltage sag.The DVR is a power electronic device used to inject three-phase voltages in series and in synchronism with the distribution feeder voltages in order to compensate for voltage sags. Moreover, it can be effectively used to enhance the fault ride through capability in wind applications. Detection time is an important factor in the voltage restoration process. In distribution frameworks, stack voltage rebuilding can be accomplished by infusing active or potentially reactive power into the distribution feeder. Active power ability of the DVR is administered by the limit of the vitality stockpiling component and the utilized remuneration system. A few control systems have been proposed for voltage sag remuneration, for example, pre-sag, in-stage, and negligible vitality control approaches. On the off chance that the required power for voltage reclamation is acquired from the neighboring feeder(s), the repaying gadget is actually called an interline dynamic voltage restorer (IDVR). The fundamental idea driving the IDVR is gotten from the interline control stream controller (IPFC) proposed by Gyugyi in 1999 to trade control between parallel transmission lines. The two converters of the IPFC shown in Fig. 1 are used to control the transmitted power in each line (P1 and P2) and active power transfer between lines (P12). With respect to the line current, the injected voltage has two components. The quadrature segment gives reactive power pay to the line, while the in-stage part retains or creates the required active power. The fundamental contrasts between an IPFC, IDVR, and the proposed framework are abridged in Table I. In this table, the IPFC, which is utilized as a part of transmission applications, is contrasted and an IDVR and IVDFC, which are considered for distribution frameworks. It ought to be noticed that the IPFC was the motivation for proposing the IDVR for distribution systems. The IDVR can be utilized to moderate voltage sag, or swell, at basic loads in distribution frameworks. It comprises of a few consecutive voltage source converters with regular dc interface associating autonomous feeders as appeared in Fig. 2. Every converter can be worked in either control (PC) or voltage control (VC) modes. On the off chance that one of the feeders is subjected to voltage sag, its converter will work in VC mode and the required power for voltage rebuilding will be ingested from the dc interface. In this express, alternate converters associated with the sound feeders ought to be changed to PC mode to recharge the dc-connect voltage; a power-sharing plan to decide the reference energy of each solid feeder is displayed in. The infused voltage in a sound feeder amid PC mode ought to have two segments. The main segment is in-stage with line current, which assimilates active power from the supply and gives it to the dc connect to help its voltage. The second segment is in quadrature with the line current and is utilized to maintain a strategic distance from stack voltage size bothers after voltage infusion as appeared in Fig. 1. In past work, the infused voltage in a solid feeder is copied by utilizing the virtual impedance.

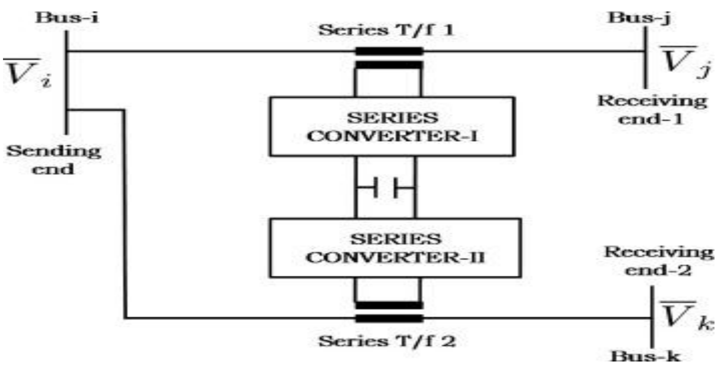

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Fig.1. Single line diagram of an IPFC in transmission system.

During normal operating conditions (i.e., all feeders are healthy), the DVRs are typically bypassed via bypass switches, or they can be alternatively used for load sharing purposes as presented in [26]. Instead of bypassing the IDVR in normal operation, this paper proposes a new operational mode, namely PQ sharing mode, to improve the DF of one of the involved feeders by sharing active and reactive power among different system feeders through the buffering stage (the common dc link). To apply this concept, several constraints are observed throughout the paper. The proposed interline dynamic voltage restoring and DF controlling device (IVDFC) is supported using simulation results.

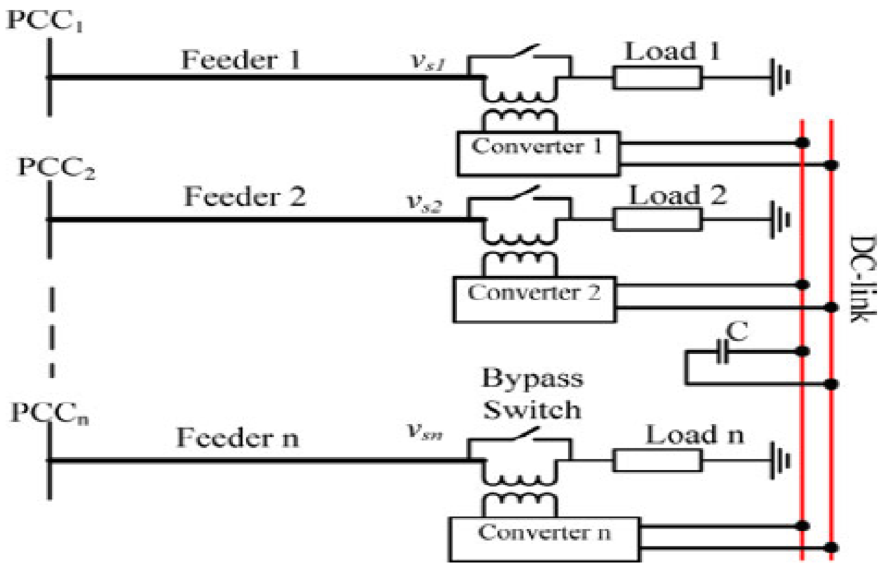

Fig.2. Single line diagram of multiline IDVR in the Distribution system.

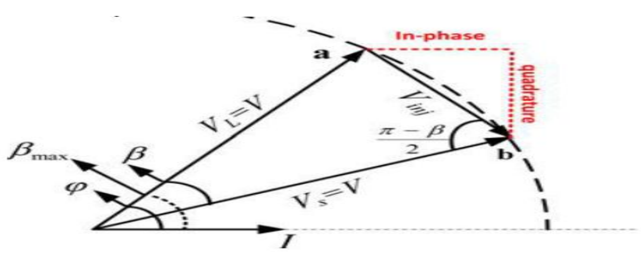

Fig. 3 PC mode.

	IPFC	IDVR	IDVR (DF improvement)
Function	It is used in transmission systems to control the power flow of parallel	It is used in distribution system for voltage sag/swell restoration.	It is used in distribution systems for voltage sag/swell restoration and improvement of displacement power factor during normal conditions.
Operation	Employed is normal operation	Employed in abnormal conditions	It can be employed in normal as well as abnormal conditions
In-phase Voltage injection	Active power control	When the feeder is switched to power control mode, the in-phase voltage component represents the active power to be pumped/ absorbed by that feeder to/from the DC-link (Active power control	When the feeder is switched to power control mode or DF improvement mode, the in-phase voltage component represents the active power to be pumped/ absorbed by the feeder to/from the DC-link(Active power control)
Quadrature voltage injection	Line reactive impedance control	When the feeder is switched to power control mode, the quadrature voltage component is used to keep the load voltage magnitude of that feeder constant (Load voltage control)	When the feeder is switched to power control mode or DF improvement mode, the quadrature voltage component is used to keep the load voltage magnitude of that feeder constant (Load voltage control)

Table-1 Salient Features of the IPFC, normal IDVR and IDVR with Displacement Factor improvement.

2. PROPOSED TOPOLOGY

Fig2 shows the proposed controller for a two-line IVDFC (two feeders are involved, namely, feeder x and feeder y), which is able to manage the power transfer through the dc-link in normal as well as abnormal operating conditions. As a general controller, voltage sag/swell and DF improvement problems are merged into one control circuit. Referring to Fig. 2, each converter may be switched to one of four possible modes (off mode, VC mode, PC mode, or PQ mode). The PCC voltages are continuously monitored by a logic unit that is responsible for choosing the appropriate mode of operation for each converter based on the voltage levels.

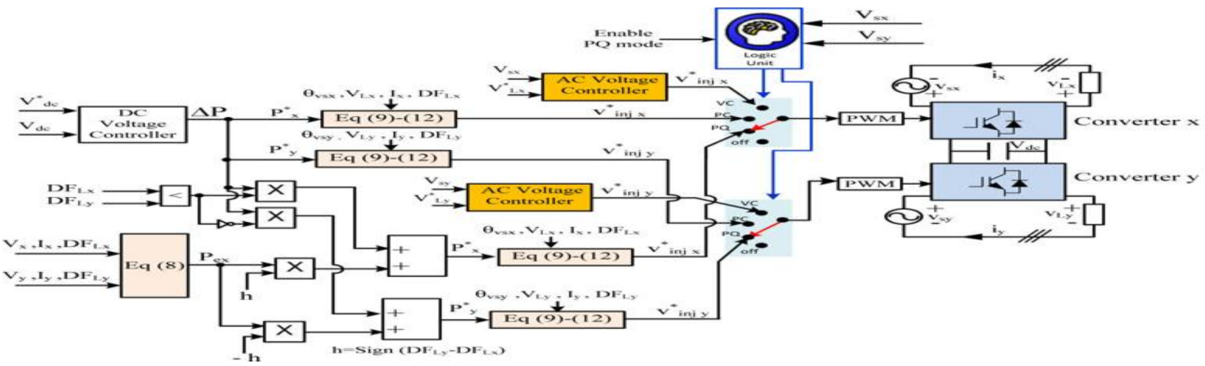

Fig. 2. Proposed controller.

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The following section will show how different modes of operation are handled individually in the proposed controller. A set of scenarios can be envisioned for the system. The main cases are summarized in Table 2 and in the following subsections (where the hyphenated condition describes the state of one of the feeders to the left of the hyphen and the other feeder to the right of the hyphen). For all other cases, the converters will be switched to the off position.

A. Normal–Normal (PQ Sharing Mode is disabled)

In this case, the logic unit selects the off positions (see Fig. 2) for both converters.

B. Normal–Normal (PQ Sharing Mode is enabled)

In this case, the logic unit selects the PQ positions (see Fig. 2) for both converters after verifying all constraints that accompany this mode. Based on the DFs of the loads connected to the involved feeders (DFLx and DFLy), the direction of active power flow will be defined. The feeder with a lower load DF will be the sourcing feeder with a positive active power reference, and the other feeder will be the receiving feeder with a negative active power reference. In Fig. 2, the sign of the variable h, which represents the difference between the two DFs, is used to determine the sign of the different reference powers. To maintain a constant dc-link voltage during the PQ sharing mode, the output of the dc link voltage controller,

ΔP (which represents the active power needed to regulate the dc link) is added to the reference active power of the sourcing feeder. To achieve that, the two DFs (DFLx, and DFLy) are compared to decide the sourcing and receiving feeders. The comparator output is used to add ΔP to the reference active power of the sourcing feeder only as shown in Fig. 2. For example, if DFLx is less than DFLy, the comparator output will be high; therefore,ΔP will be added to Pex (i.e., P*x = Pex+ΔP and P*y = − Pex). The voltage reference of each converter is then determined based on the corresponding active power references (P*x and P*y) as given by (9)–(12), where i = x or y

$$\varphi_i = \cos^{-1}\left(\mathrm{DF}_{Li}\right) \tag{9}$$

$$\beta_i = \left(\varphi_i - \cos^{-1}\left(\frac{3I_iV_i\mathrm{DF}_{Li} + P_i^*}{3I_iV_i}\right)\right) \times \mathrm{sign}\left(P_i^*\right) \tag{10}$$

$$\left|v_{\mathrm{inji}}^*\right| = 2V_i \sin\left(\frac{\beta_i}{2}\right) \tag{11}$$

$$\llcorner\, v_{\mathrm{inji}}^* = \theta_{vsi} - \left(\mathrm{sign}\left(P_i^*\right)\left(\frac{\pi - \beta_i}{2}\right)\right). \tag{12}$$

C. Normal–Voltage Sag

If one feeder exhibits voltage sag, the logic unit has to switch its series converter to VC position (see Fig. 2) to regulate the load voltage, and the required power for restoration will be absorbed from the dc link. The converter of the healthy feeder will

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be switched to its PC position (see Fig. 2) to replenish the dc-link voltage. The needed power to restore the dc link voltage will be the output of the dc voltage controller. This power is used to estimate the corresponding converter reference voltage.

D. Normal–Voltage Swell

If one feeder exhibits voltage swell, the logic unit switches its series converter to the VC position (see Fig. 2) to regulate the load voltage. Additional power is then fed to the dc link. The converter of the healthy feeder will be switched to its PC position (see Fig. 2), to avoid increasing the dc-link voltage. The amount of power, which should be absorbed by the healthy feeder, will be the output of the dc voltage controller. In this paper the proposed system with PV can control the voltage unbalances like voltage sags, swells etc. The displacement factor will be improved by active and reactive power sharing between the feeders by a DC link, which is controlled by PV system. This system creates the importance of renewable systems at distribution sector.

Logic unit decision / Cases	Converter x				Converter y			
	VC	PC	PQ	off	VC	PC	PQ	off
v_{sx} is normal and sag/swell at v_{sy}	0	1	0	0	1	0	0	0
v_{sy} is normal and sag/swell at v_{sx}	1	0	0	0	0	1	0	0
Normal condition, PQ is enabled	0	0	1	0	0	0	1	0
Normal condition, PQ is disabled	0	0	0	1	0	0	0	1

TABLE 2: Proposed Controller Combinations

3. SIMULATION RESULTS

Fig.3 shows simulink diagram of proposed IVDFC with PV system. Fig. 3 shows DC voltage of PV system.

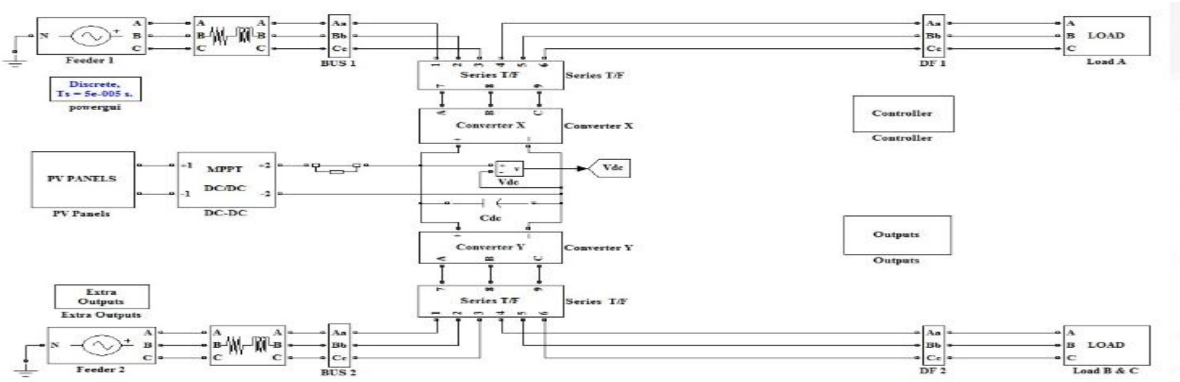

Fig.3. simulink diagram of proposed IVDFC with PV system.

Parameter	Value
Bus 1 and Bus 2 Voltage	220∟0 V (rms)
Load (A) impedance	• *Normal conditions* **Case1:** 40 Ω, 0.8 DF lag **Case 2:** 40 Ω, 0.5 DF lag • *Voltage sag condition* 40 Ω, 0.8 DF lag
Load (B) impedance (critical load)	40 Ω, 0.99 DF lag
Load (C) impedance	13.33 Ω,0.99 DF lag
DF_d for bus 1	0.95 Lag
DF_a	0.95 lag

TABLE 3: Simulation Data

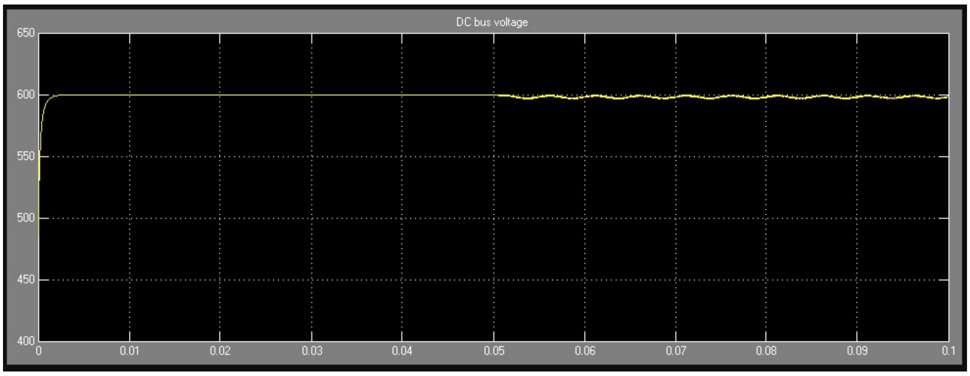

Fig. 4 DC voltage of PV system.

A. Normal Operating Conditions (PQ Sharing Mode)

Case 1: During normal operating conditions, feeder 2 is feeding an impedance of 10 Ω (40 Ω // 13.33 Ω) with a 0.99 lagging DF (receiving feeder), while feeder 1 is feeding an impedance of 40 Ω with a 0.8 lagging DF (sourcing feeder). If it is desired to improve the DF of bus1 to 0.95 (DFa), the proposed PQ sharing mode is employed. The exchanged active power command (Pex) is calculated based on (8). For the data given in Table 3, the amount of active power needed to increase the DF of the sourcing feeder (feeder 1) from 0.8 lagging to 0.95 lagging is ≈544.5 W (3 (220 V ×(220/40)A × (0.95 − 0.8))). On the other hand, the amount of active power needed to decrease the DF of the receiving feeder (feeder 2) from 0.99 lagging to 0.95 lagging is ≈580.8 W (3 (220 V × (220/10)A × (0.99 − 0.95))), i.e., Pex should be the minimum of these two values (544.5, 580.8). Hence, the controller sets Pex to 544.5 W. This value is applied to the controller at t = 0.05 s. The injected, supply voltage and supply current of buses 1 and 2 are in Fig. 5(a) and (b), respectively. When the PQ sharing mode is applied, the phase difference between the supply voltage and current of bus 1 is decreased, i.e., DF of bus 1 is improved. On the other hand, the phase difference between the supply voltage and current of bus 2 is slightly increased, i.e., its DF is decreased. The DF of each bus before and after applying the PQ sharing mode is shown in Fig. 5(c). The simulation results in this case are summarized in Table IV. Generally, it shows slight variation in DF of bus 2 while the DF of bus1 is improved from 0.8 to 0.95 lagging successfully.

TABLE 4: Effect of Applying PQ Mode in Simulation

		1^{st} Case (rms values)		2^{nd} Case (rms values)	
		t< 0.05s	t>0.05s	t< 0.05s	t>0.05s
Sourcing Feeder	V_{s1} (V)	220∟0°	220∟0°	220∟0°	220∟0°
	I_1 (A)	5.5∟-36.8°	5.5∟-18.2°	5.5∟-60°	5.5∟-48.8°
	DF_1	0.8 lag	0.95 lag	0.5 lag	0.66 lag
Receiving Feeder	Vs_2 (V)	220∟0°	220∟0°	220∟0°	220∟0°
	I_2 (A)	22∟-8.1 °	22∟-17.8°	22∟-8.1 °	22∟-18.2°
	DF_2	0.99 lag	0.952 lag	0.99 lag	0.95 lag

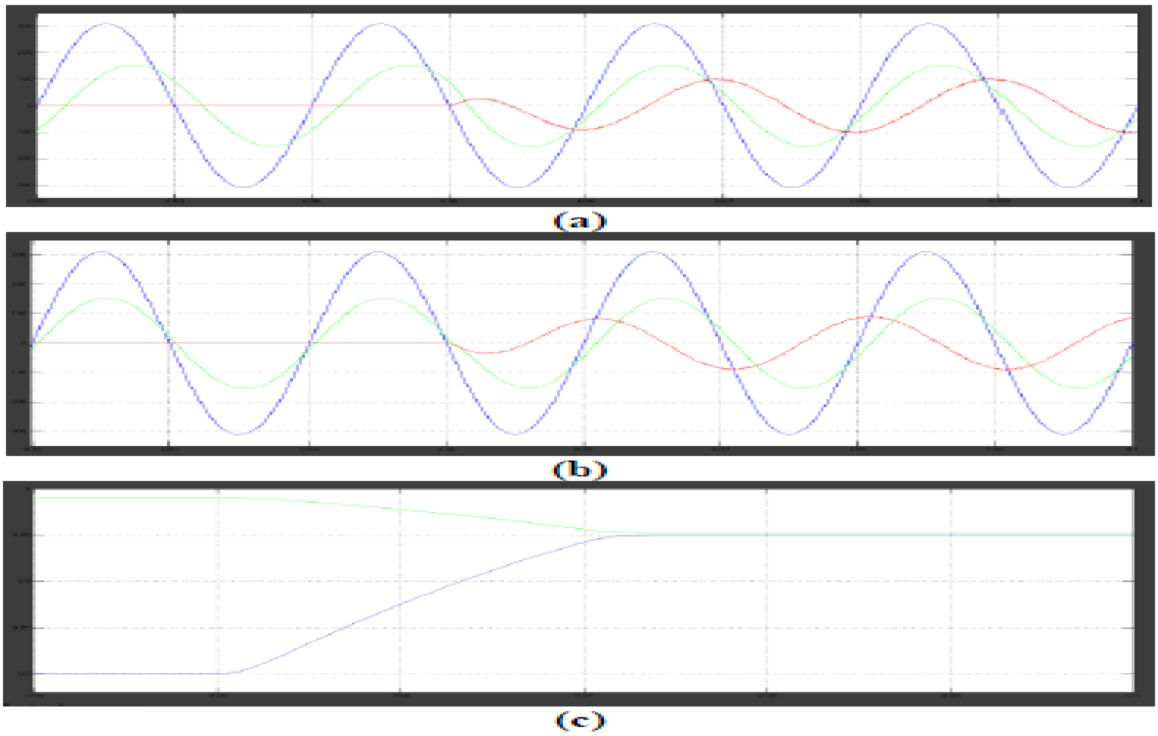

Fig.5. Per-phase PQ sharing mode simulation results: (a)–(c) for first case.

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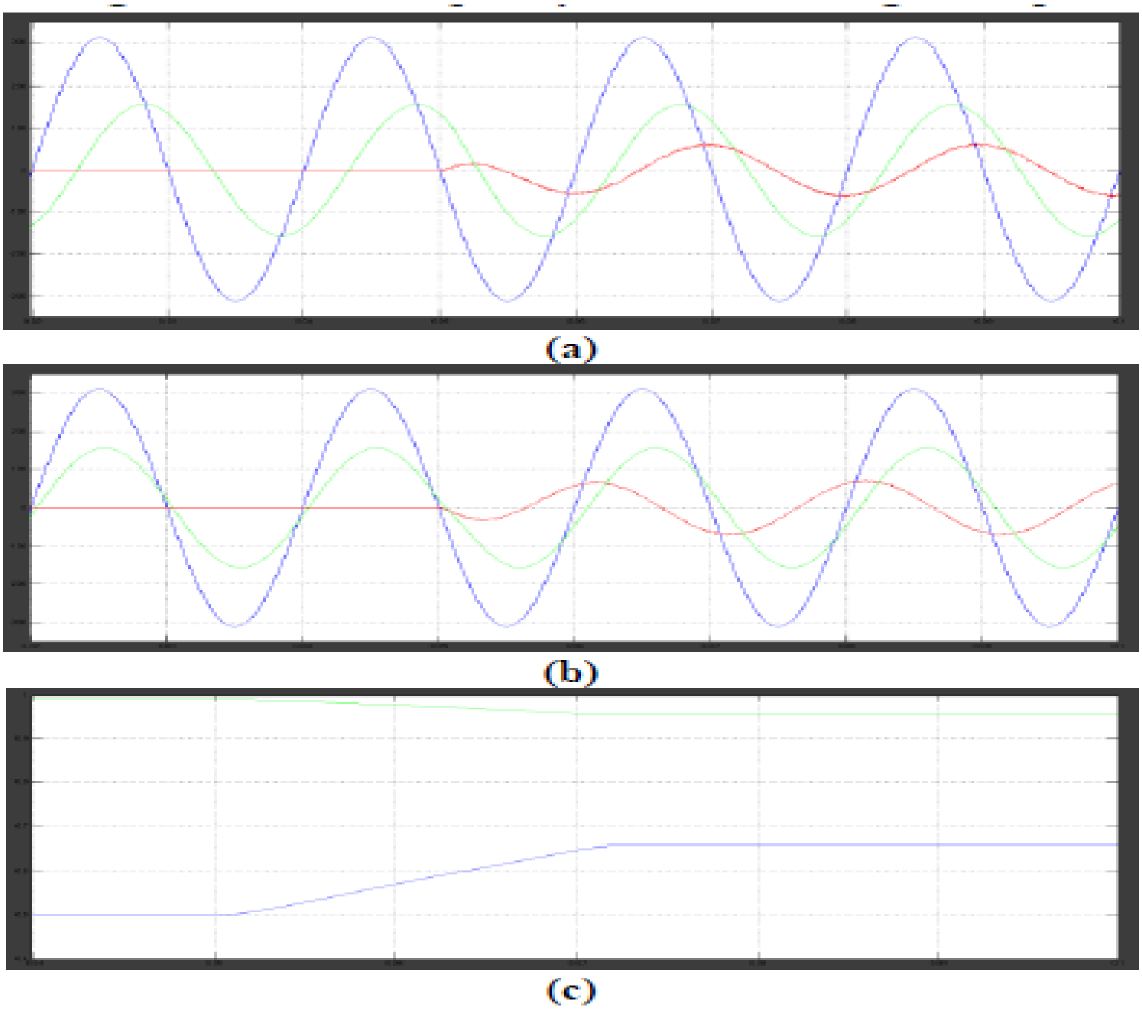

Fig. 6 Per-phase PQ sharing mode simulation results: (d)–(f) for the second case.

Case 2: In this case, load (A) has a lower DF compared to the aforementioned case (0.5 lagging instead of 0.8 lagging).The amount of active power needed to increase the DF of the sourcing feeder from 0.5 lagging to 0.95 lagging is 1633.5 W (3 (220 V × (220/40)A × (0.95 − 0.5))). On the other hand, the amount of active power needed to decrease the DF of the receiving feeder is not changed (580.8 W), i.e., Pex should be the minimum of these two values (1633.5, 580.8). Hence, the controller sets Pex to 580.8 W. This value is applied to the controller at t = 0.05 s. The injected, supply voltage and supply current of buses 1 and 2 are in Fig. 6(a) and (b), respectively. The DF of each bus before and after applying the PQ sharing mode is shown in Fig. 6(c). The simulation results for this case are also summarized in Table- 4. Generally, it shows that the DF of bus 1 is improved from 0.5 to 0.66 lagging; hence, reaching the desired value was not possible since the DF of the receiving feeder reached its minimum accepted level (DFa) as shown in Fig.6(a) and (b).

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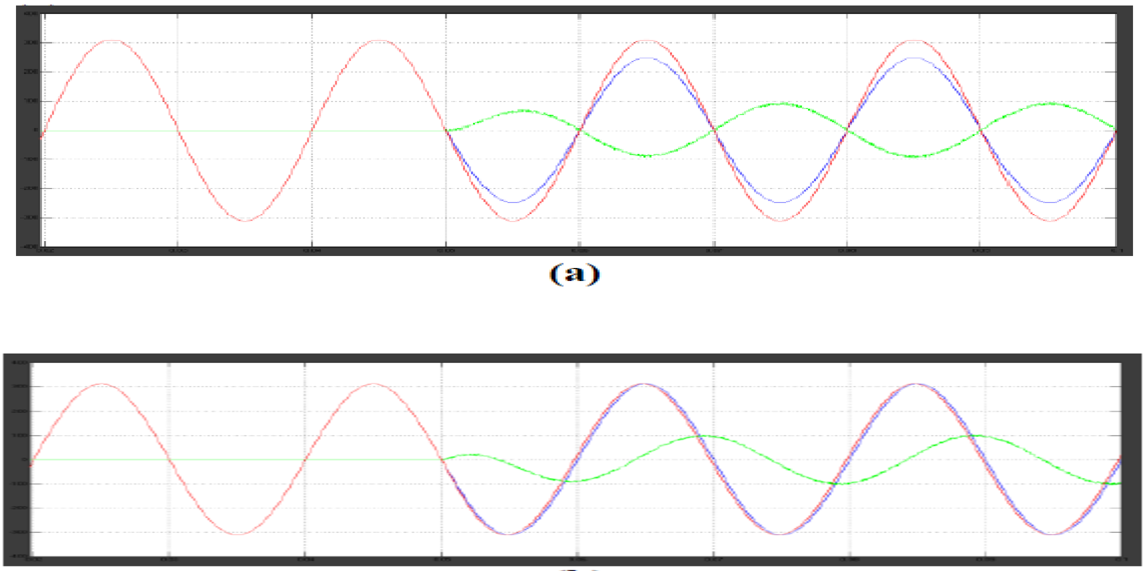

(a)

(b)

Fig. 7. Per-phase simulation results for voltage sag case: (a) at feeder 1 and (b) at feeder 2.

4. CONCLUSION

This paper proposes a new operational mode for the IDVR to improve the DF of different feeders under normal operation. In this mode, the DF of one of the feeders is improved via active and reactive power exchange (PQ sharing) between feeders through the common dc link is supplied by using solar energy (PV). The same system can also be used under abnormal conditions for voltage sag/swell mitigation. Under PQ sharing mode, the injected voltage in any feeder does not affect its load voltage/current magnitude, however, it affects the DFs of both sourcing and receiving feeders. From the results it can observed that the PQ sharing will be done between the feeders using PV system via common DC link capacitor. In the unbalanced conditions like sags/swells the PV system maintained the system balanced and by maintaing constant DC voltage at the common DC link capacitor. The proposed mode is highly beneficial if the active power rating of the receiving feeder is higher than the sourcing feeder. The DF of the sourcing feeder increases while the DF of the receiving feeder decreases. When applying the proposed concept, some constraints should be satisfied to maintain the DF of both sourcing and receiving feeders within acceptable limits imposed by the utility companies. These operational constraints have been identified and considered. In this case, the DF of the sourcing feeder will have a notable improvement with only a slight variation in DF of the receiving feeder.

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