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# A NEW TECHNIQUE FORTHE DFIG's RSC AND GSC CONVERTERSTO REJECT DC LINK VOLTAGE RIPPLE

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**Abstract**

*This paper presents a new control strategy to reduce the fluctuation of DC bus voltage for a back-to-back PWM converter in a DFIG wind turbine systems. DC-link voltage Feed-forward compensation control strategy for DFIG's RSC and GSC converter is proposed to limit the fluctuation range of the dc-link voltage. The dynamic performances of the DFIG are compared with the traditional control method. Furthermore, the capabilities of keeping the dc-link voltage stable are also compared in the ride-through control of DFIG during a three-phase grid fault, by using a developed 2 MW DFIG wind power system model. The simulation results have shown that the proposed control strategy is more effective, and the fluctuation of the dc-link voltage may be successfully limited in a grid fault .*

***Keywords:*** *Doubly fed induction generator (DFIG), Rotor side converter (RSC), Grid side converter (GSC), improved control, DC - link voltage ripple.*

## 1. Introduction

The wind turbines operating in variable speeds have been used for many reasons. The DFIG system has as main advantage the reduced size and low cost of the power electronics converter, and other advantages: high efficiency, high power density, andability of reactive power control. The speed range of DFIG systems is limited to ±30% about the base speed of the machine[1].

Several control methods have been proposed to control the rotor-side converter in order to realize the DFIG ride-through [2,3]. In [4], an improved control strategy has been proposed to control the rotor current to counteract the effect of the transient components in the stator flux, and make the DFIG ride through a grid fault. Whatever the control strategy of the rotor-side converter is used, the grid-side converter should be properly controlled and the dc-link voltage should be kept stable to realize thefault ride-through control of a DFIG. In this paper, an improved control strategy for DFIG is presented:DC-link voltage Feed-forward compensation control strategy for DFIG's RSC and GSC converter is proposed to limit the fluctuation range of the dc-link voltage. Then the dynamic performances of the DFIG are compared with the traditional control method. Also, the capabilities of keeping the dc-link voltage stable are also compared in the ride-through control of DFIG during a three-phase grid fault.

## 2. Modeling and control

### 2.1. Establish new model of the relationship between the control signal $V_{g}^{*}{}_{q}$ and the actual signal $V_{gq}$ of the RSC and GSC.

To establish control loops of the DFIG, in the traditional vector control scheme, we assume that: $V_{dc} \; V_{dc} \; const$ , the RSC and GSC is ideal and using the state averaging method[5], the RSC and GSC converter may be represented by a gain :

$$G \quad \frac{V_{dc}}{2.V_P}$$ With:

$V_P$ : the amplitude of the triangular carrier of the generation of the PWM.

$V_{dc}$ : voltage of the DC link capacitor.

$V_{dc}^{*}$ : DC steady state voltage

$V_{gq}^{*}$ : control signal of the RSC and GSC

$V_{gq}$ : actual signal of the RSC and GSC

$G^{*}$ : Steady state gain

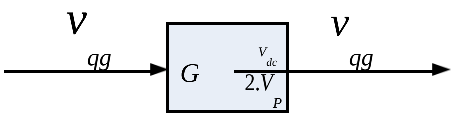


Figure 1. *The relationship between $V_g{}^{*}{}_q$ and $V_{gq}$ via idealized converter gain coefficient*

The amplitude of the triangular carrier of the generation of the PWM ($V_P$) must be secured to $V_{dc} / 2$, implying a gain $G^{*} = 1$ (the grid voltages and rotor voltages are equal to their references $V_{pg} V_{pg}, V_{qg} V_{qg}$).

In actual $V_{dc}$ are always changing, so modulation indexes $G \; 1$. The author of the paper proposes that need for additional modulation indexes $G \; V_{dc} / 2.V_P$ to model of the RSC and GSC:

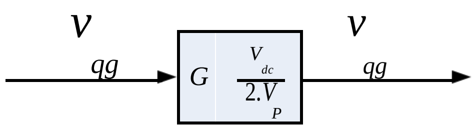


Figure 2. *The relationship between $V_g{}^{*}{}_q$ and $V_{gq}$ via actual converter gain coefficient*

From figure 2:

$$V_{qg} \quad \frac{V_{dc}}{2.V_P}.V_{qg} \tag{1}$$

Based on Figure 2 can improve the figure 3. Assumed that the equivalent diagram of Figure 2 as follows:

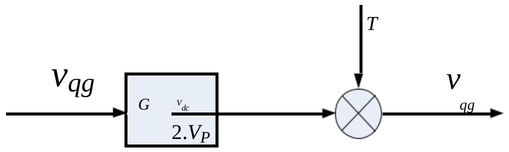


Figure 3. *The equivalent diagram of relationship between the $V_g{}^{*}{}_q$ and $V_{gq}$*

From figure 3, we obtain equation (2) *:*

$$V_{qg} \quad \frac{V}{2.V_P}.V_{qg} \quad T \tag{2}$$

From equation (1) and equation (2) we obtain equation (3)

$$\frac{V}{2.V_P}.V_{qg} \quad \frac{V}{2.V_P}.V_{qg} \quad T$$

$$T \quad \frac{V}{2.V_P}.V_{qg} \quad \frac{V}{2.V_P}.V_{qg}$$

$$\frac{V_{qg}}{2.V_P}(V_{dc} \quad V_{dc}) \quad \frac{V_{qg}}{2.V_P}.V_{dc} \tag{3}$$

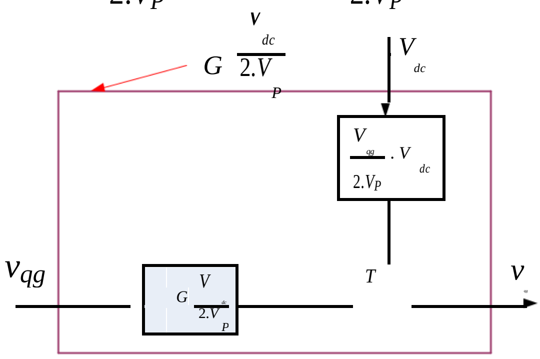


Figure 4. *The improved model of relationship between $V_g{}^{*}{}_q$ and $V_{gq}$*

## 2.2. Improved control model for the RSC and GSC

In the traditional model of the DFIG, it is assumed that: $V_{dc} \; V_{dc} \; const$, RSC and GSCconverter is idealized by a gain

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$G\ V_{dc} / 2.V_P$ . In actually the DC bus voltage can *be* changed, so converter gain coefficient ( $G\ V_{dc} / 2.V_P$ ) also changes. If value of the G increases, the control signal also increases, endangering the safety of the RSC and GSCconverter. To ensure stable of the converter gain coefficient G under changing conditions of the DC bus voltage, Control strategy for DFIG's RSC and GSC converter must change as follows:

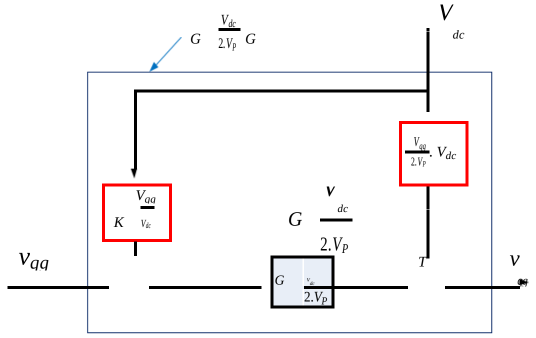

**Figure 5.** *The improved block diagram of relationship between* $V^*_{gq}$ *and* $V_{gq}$

We showed that: the improved block diagram in figure 5 have equivalent gain coefficient is constant $G\ G\ const$ , it no longer be dependent on the change of $V_{dc}$.

DC link Voltage Feed-forward Compensation Control strategy for DFIG's RSC and GSC converter [6] is shown in the diagram 6.

### 3. Results and analysis

In order to verify the proposed modified DFIG models and associated control strategies, the simulations for 2MW DFIG generation were carried out using MatlabSimulink.

#### 3.1. The traditional control strategy for the RSC and GSCwhen three-phase ground fault

A three-phase fault to ground at the wind turbine output terminals was simulated in this case study. It was considered to happen at the low voltage side (690 V) of the transmission line at time 0.1 s, and cleared at 0.2 s. Also, a constant wind speed of 11 m/s was used as input for the wind turbine.

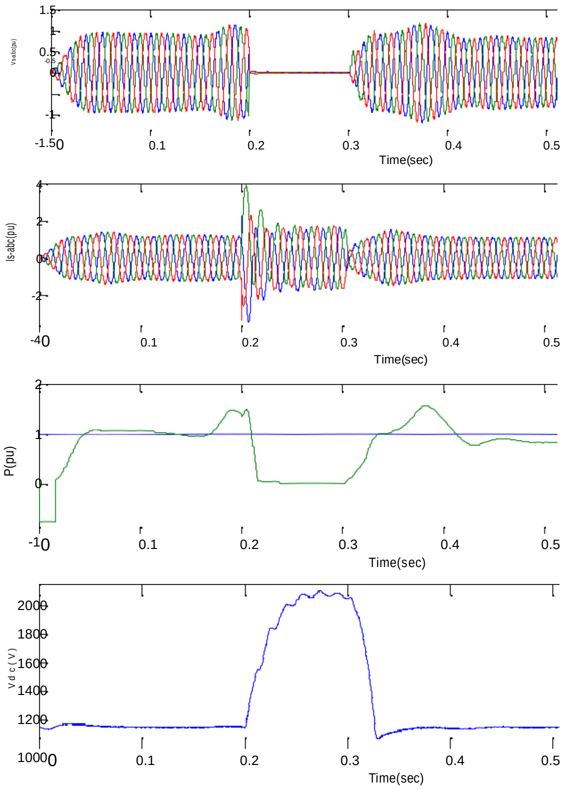


Figure 7. $V_s$, $I_s$, $P_s$, $V_{dc}$ *with the traditional vector control strategy for the RSC & GSC* Figure 7 showed that the waveforms of $V_s$, $I_s$, $P_s$, $V_{dc}$ with the traditional vector control strategy for the RSC and GSC, when the three-phase to ground fault. It shows that: The proposed fault causes a sudden drop on the generator voltage ($V_s$= 0), and subsequently on the active power generation of the wind turbine as ($P_s$= 0). In the period of grid fault appears (0.1-0.2 s), the Stator current is instability, while the DC-link voltage increases ($V_{dc}$> 2000 V).

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### 3.2. The proposed control strategy for the RSC and GSCwhen three-phase ground fault

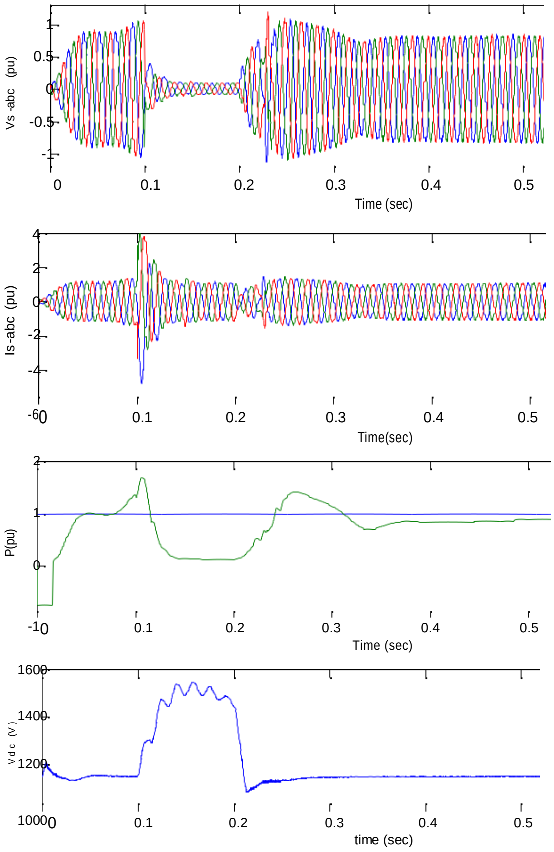


Figure 8. *$V_s$, Is, Ps, $V_{dc}$with the proposedcontrol strategy for the RSC and GSC when the three-phase to ground fault*

Figure 8 showed that the waveforms of Vs, Is, Ps, Vdc with the proposed vector control strategy for the RSC and GSC, when the three-phase to ground fault. In the proposed control scheme, control voltage for the RSC and GSC is additional the DC link Voltage Feed-forward Compensation component to keep the dc-link voltage stable. In the period of grid fault appears (0.1-0.2 s), it shows that the generator voltage of the wind turbine still exists with small amplitude. The Stator current and the DC-link voltage is much more stable.

### 3.3. The proposed control strategy for the RSC and GSC when the unsymmetrical ground fault appears

At the time (0.1 to 0.2 sec), phase A and phase B ground fault has appeared:

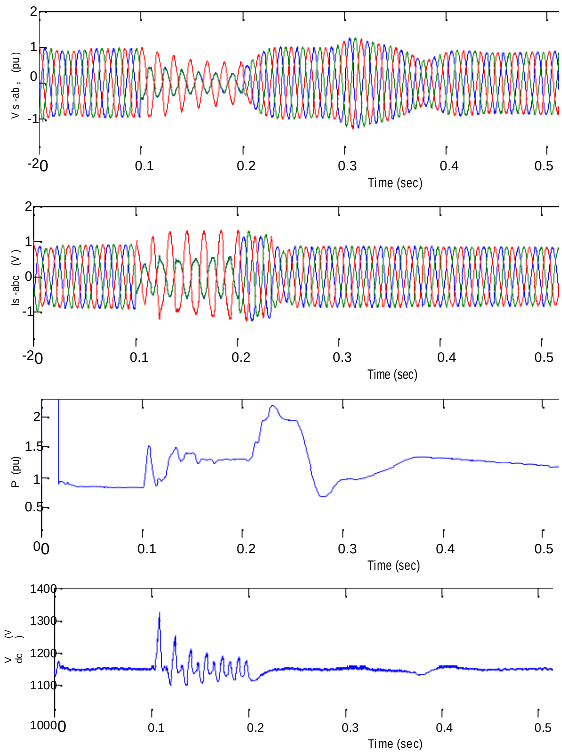


Figure 9. *$V_s$, $I_s$, $P_s$, $V_{dc}$with the proposed control strategy for the RSC and GSC when the phase A and phase B to ground fault*

Figure 9 showed that the waveforms of $V_s$, $I_s$, $P_s$, $V_{dc}$ with the proposed vector control strategy for the RSC and GSC, the unsymmetrical ground fault appears. In the proposed control scheme, control voltage for the RSC and GSC is additional the DC link Voltage Feed-forward Compensation component, so in the period of grid fault appears (0.1-0.2 s), it shows that the generator voltage of the wind turbine, the Stator current and the DC-link voltage is much more stable.

### 4. Conclusion

Wind power system under the normal control, when the wind speed changes, the DC bus voltage fluctuates greatly and the control system responds slowly, which is unfavourable to system safe and stable operation. Therefore, In order to strengthen the feed forward control to offset the disturbance, it is necessary to join the compensation in the feed forward control channel to further improve the feed forward control affect. The comparison of simulation verifies the correctness and effectiveness of the control strategy.

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## MỘT KỸ THUẬT MỚI CHO BỘ CHUYỂN ĐỔI PHÍA RSC VÀ GSC ĐỂ KHỬ ĐỘT BIẾN ĐIỆN ÁP KÊNH DC CỦA MÁY PHÁT ĐIỆN GIÓ DFIG

**Tóm tắt**

*Bài báo trình bày một chiến lược điều khiển mới cho bộ chuyển đổi PWM back-to-back để giảm sự đột biến của điện áp DC - bus trong hệ thống tuabin gió DFIG. Chiến lược điều khiển bù tiền quy điện áp DC-link cho bộ chuyển đổi RSC và GSC của DFIG được đề xuất, để hạn chế biên độ dao động của điện áp DC-link. Hiệu quả làm việc của DFIG được so sánh với các phương pháp điều khiển truyền thống. Mặt khác, công suất duy trì ổn định điện áp DC-link cũng được so sánh với trường hợp điều khiển DFIG vượt qua một lỗi lưới ba pha, bằng cách sử dụng mô hình hệ thống năng lượng gió DFIG 2 MW. Các kết quả mô phỏng chỉ ra rằng chiến lược điều khiển đề xuất có hiệu quả hơn, và có thể hạn chế được những đột biến điện áp DC-link trong một lỗi lưới.*

***Từ khoá:*** *Bộ chuyển đổi phía rotor (RSC), Bộ chuyển đổi phía lưới (GSC), điều khiển cải tiến, khử điện áp DC - link.*

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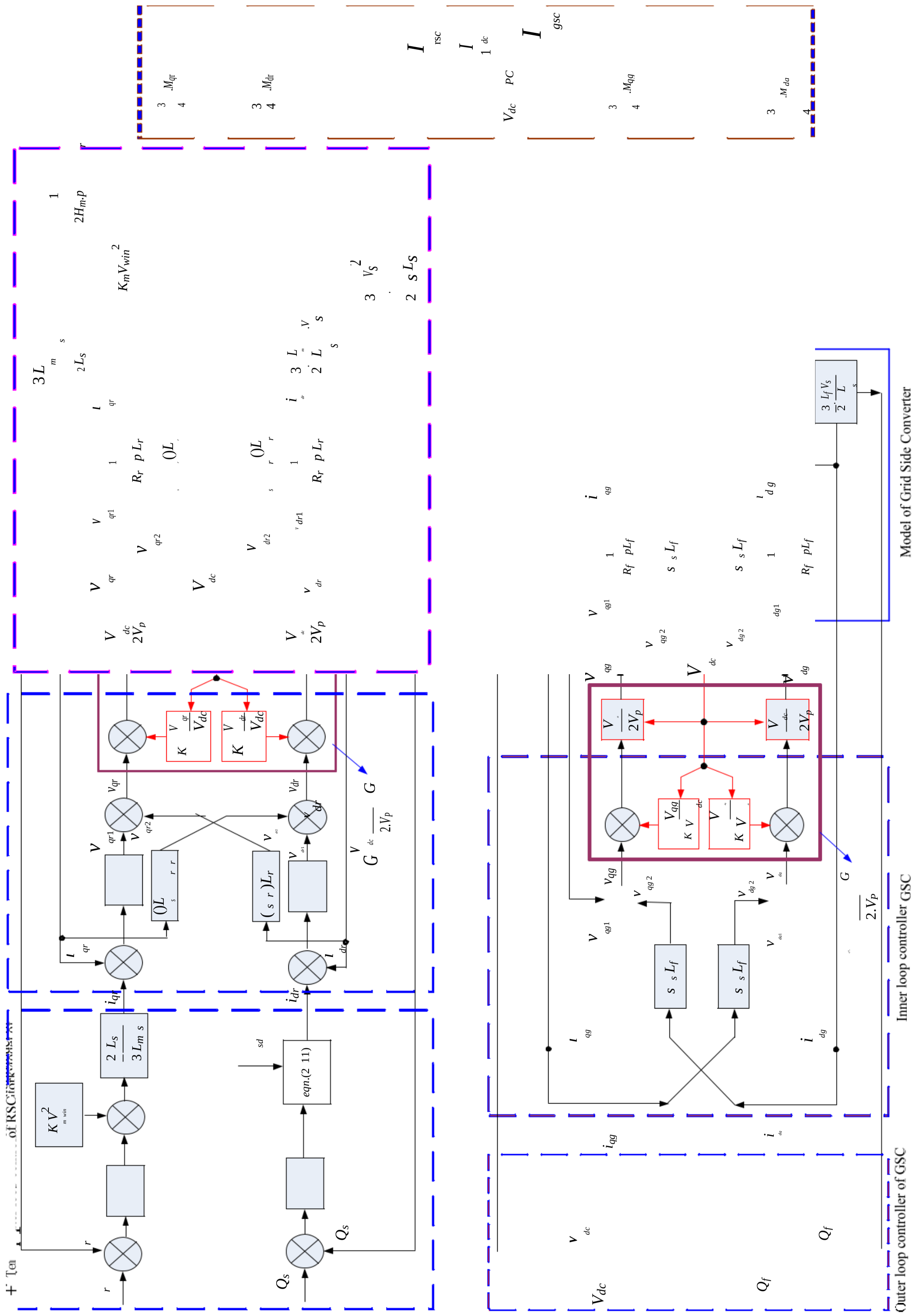
## APPENDIX




.6Figure C D FeedVoltagelink forward- strategyControlCompensation