

# The Influence of Distributed Power Substation on Automatic Bus Transfer

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**Abstract:** In order to make the backup power supply device can work properly, we study the influence of distributed power substation on automatic bus transfer. Based on the systematic analysis of distributed generation technology, different types of DG are discussed and analyzed, and the corresponding results are obtained. At the same time, the corresponding solution is given. The results show that the anti-islanding device can be installed in the inverter grid DG. In addition, the original line protection can be changed into full-speed fiber longitudinal differential protection. The monitoring device can also be mounted at the switch to detect the voltage, current, and power direction. Finally, a substation backup power supply based on DG access was developed.

## 1. Introduction

Electricity occupies a pivotal position in modern society and is closely linked with the development of the entire national economy (Mishra and Modi, 2016). Distributed Generation (DG) is a new, highly efficient, green independent power supply. Distributed generation system is usually based on a certain capacity of the scattered arrangement near the power load, and has good economic and environmental benefits. Such as micro-gas turbine, biomass units, energy generating devices (Saharia and Manas, 2017). However, the impact of DG access on the standby power switching control is mainly due to the major changes in the structure of the power supply system in the area (Mohapatra et al, 2016). In other words, the original single-supply radial power supply network is changed to multi-side power supply network for small and medium-sized power. Automatic bus transfer device start criterion is to verify the voltage and current in the grid, however, the access of DG may prolong the operating time (Moran and Pongvuthitham, 2016). The content of this article is not only an important complement to the current research work, but also it can lay a solid foundation for future research. It is an important basis for carrying out the follow-up work of the entire subject, so it has a deep theoretical and practical value for its research (Saravanakumar and Jena, 2016).

## 2. Backup power configuration

automatic bus transfer device is mainly used in 110kV following medium and low voltage distribution system. Therefore, the design of its main wiring scheme is based on the power station, power plant and low voltage substation wiring scheme (Cheng and Tseng, 2016). There are three main functional modes, switch-in, switch-on and low-voltage bus. And each mode has a variety of ways of working (Yang et al, 2016).

### 2.1 Mode 1: incoming line and non-segment automatic bus transfer

Mode 1 is a microcomputer automatic bus transfer device based on the non-segmented mode, its wiring diagram shown in Figure 1. This model is usually used for rural power distribution system, miniaturization substation or in-plant power system (Hou and Chang, 2016). If only one of lines L1 and L2 is the main power supply and the other is the backup power supply (Damouche et al, 2016). Bus is separate, then the program shown in Figure 2 has two ways of working. Mode 1: when L1 as the main power, the line L1 is opened, QF1 is turned off. Lines L2, QF2 are on standby. When QF1 jumps open for some reason, bus loss of power, then QF2 closed. L2 becomes a power supply device (Kudtongngam et al, 2016).

Mode 2: When L2 is the main power supply, incoming line L2 is opened and QF2 is closed. Line L1, QF 1 open, in a standby state. When QF2 jump for some reason, the bus power loss, then QF 1 closed. L1 becomes a power supply device.

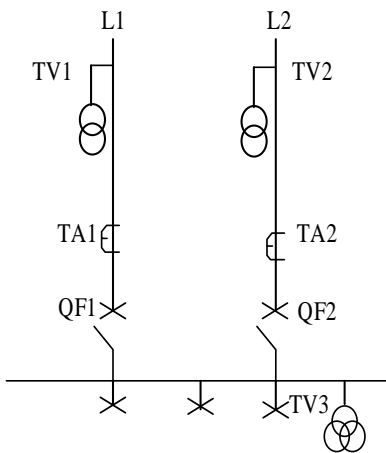


Figure 1: Mode 1 wiring diagram

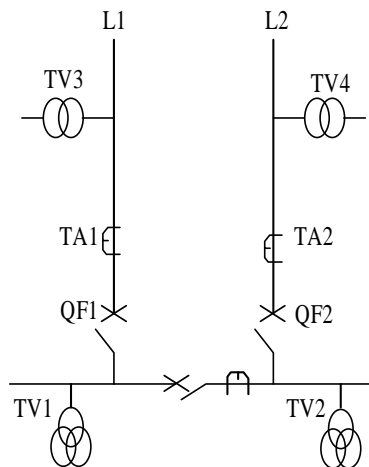


Figure 2: Mode 2 wiring diagram

## 2.2 Mode 2: incoming line and segment automatic bus transfer

Figure 2 shows the wiring diagram of single busbar or bridge self-feeding mode. L1 and L2 are the working power supply. When the system is operating normally, the single busbar is run in sections. Line L1 is opened, QF1 is closed and the power bus 1 (Yan et al, 2016). Line L2 is opened, QF2 is closed, the power bus 2. QF3 is turned on, then two busbars are alternate (Nair and Nithiyananthan, 2016). When bus 1 or 2 is de-energized, QF1 or QF2 is turned on and QF3 is turned off. In this case, the user's power supply can be quickly restored (Laakkonen, 2016). Therefore, bus 1, 2 is not only a working power supply, but also a backup power supply. This method is called dark standby mode. It has the following four ways of working:

Method 1: Bus 1 and 2 are separated and operated, respectively supplying power to L1 and L2 lines. If bus 1 lose power, then QF2 will be tripped and QF3 will be closed automatically (Sarwito et al, 2016). Bus 2 will be powered by L1.

Method 2: Bus 1 and 2 are separated and operated, respectively supplying power to L1 and L2 lines. If bus 1 lose power, QF1 jumps open automatically, QF3 closes automatically, bus 1 is powered by L2.

Method 3: QF3 closing. Bus 1, 2 tied to a bus, powered by L2, QF 1 off. If bus 1 and bus 2 lose power, after QF2 is tripped, QF 1 will close automatically. Bus 1 and 2 will be powered by L1.

Method 4: QF3 closing. Bus 1, 2 side by side as a bus, powered by L1, QF2 disconnect. If the bus 1, 2 power, then jump QF1, QF2 automatically closed, the bus 1,2 powered by L2.

Mode 1 and mode 2 is dark standby mode, mode 3 and mode 4 is light standby mode (Robinette, et al, 2016).

### 3. Impact of DG Access on Substation Automatic Bus Transfer Control

#### 3.1 Impact of DG access on automatic bus transfer mode 1

##### (1) Impact of DG access on 110kV bus terminal

The normal mode of operation is: line L1 is running, line L2 is backed up, QF1, QF3 in the merged state, QF2 in the separate state. This section uses DG on substation 110kV bus access terminal substation as an example to analyze the impact of DG access on automatic bus transfer mode 1. Therefore, the schematic is shown in Figure 3.

When the power line L1 fails, the F1 point will occur short-circuit ground fault. In this case, the switch QF1 contralateral protection is activated and the contralateral switch is opened. Therefore, 110kV power supply will be cut off. At the same time, the backup power supply is activated quickly so that the user's power supply is restored. However, due to the large capacity and margin of the DG, the system has a certain ability to adjust after the power suddenly disappears, so that the system has enough capacity to maintain the islanding effect. Therefore, DG and 110kV busbar and local load may form local short-term island. Due to the presence of DG, there is still voltage on the 110kV bus, and the voltage value is higher than the check value of no-pressure detection. At the same time, DG can provide a certain short-circuit current. Automatic bus transfer cannot be put into use because there is no load starting condition. After the local load demand gradually loses its stability, the substation's stability control device is used. Therefore, the access of DG prolongs the startup time of automatic bus transfer.

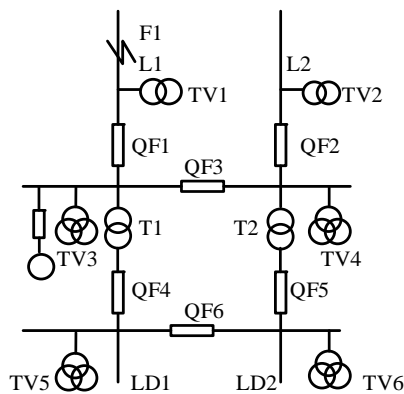


Figure 3: DG access on 110kV bus terminal

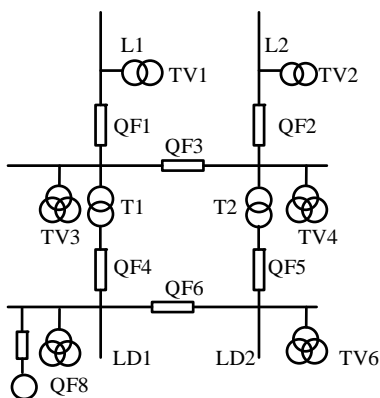


Figure 4: DG access on 10kV bus terminal

##### (2) Impact of DG access on 10kV bus terminal

Figure 4 is DG access on 10kV bus terminal. When DG acts on a 10kV female access terminal substation, if line L1 fails, the opposite protection of switch QF1 will be activated rapidly. In this case, the opposite switch is activated, causing the 110kV bus to lose operating power. This phenomenon occurs in small photovoltaic power plants, small wind power generation and fuel cell power generation. At the same time, DG's capacity is small and its regulation is poor. However, the substation has a heavy load. As a result, the unit will quickly

lose stability and be removed by the Steering Control. The condition of the line will be quickly met. In this case, the power supply of the substation is quickly restored. Sensitivity and reliability are basically meet the system requirements. However, if DG has a larger access capacity, the period of system failure will be prolonged, causing automatic bus transfer for a longer period of time. This is detrimental to the start-up, so certain measures need to be taken to improve this problem.

### 3.2 Impact of DG access on automatic bus transfer mode 2

#### (1) Impact of DG access on 110kV bus terminal

When DG acts on the 110kV access terminal in the substation, power failure of the system or circuit causes the 110kV bus to lose power. Due to the larger capacity DG access, the bus voltage is maintained at a high level. In this case, a certain short-circuit current is supplied. This prompted the automatic bus transfer cannot meet the current and voltage conditions. Therefore, the system cannot be started, thus seriously reducing the reliability of power supply.

#### (2) Impact of DG access on 10kV bus terminal

When DG acts on a 10kV bus terminal substation, system power or failure can cause a 10kV bus to lose its power. Considering the DG capacity, regulatory capacity and anti-disturbance capacity constraints, the unit will quickly lose stability. In this case, the control device is cut off. At the same time, the conditions of the automatic bus transfer bus are met quickly so that the power to the substation can be restored after the system is started up quickly. This shows that the sensitivity and reliability are basically meet the system requirements. However, if the DG has a larger access capacity, then the DG fault period is extended, resulting in a long delay from standby. This is detrimental to the priming operation, so certain measures need to be taken to improve this shortcoming.

## 4. Measures of different types of DG access on automatic bus transfer

### 4.1 DG of inverter grid

Distributed generation system must have anti-islanding function, Table 1 shows the grid inverter time requirements.

Table 1: Island detection time limit

States	Voltage amplitude	Power network frequency	Maximum detection time
A	$V < 0.5V_{nom}$	$f_{nom}$	6 cycles
B	$0.5V_{nom} < V < 0.88V_{nom}$	$f_{nom}$	2 seconds
C	$0.88V_{nom} < V < 1.10V_{nom}$	$f_{nom}$	-
D	$1.10V_{nom} < V < 1.37V_{nom}$	$f_{nom}$	2 seconds
E	$1.37V_{nom} < V$	$f_{nom}$	2 cycles
F	$V_{nom}$	$f < f_{nom} - 0.7$	6 cycles
G	$V_{nom}$	$f > f_{nom} + 0.5$	6 cycles

Inverter-based anti-islanding protection devices usually take the initiative to detect programs. In this scenario, the disturbance signal is deliberately introduced and the corresponding changes in voltage, frequency, and impedance in the system are monitored to determine the presence of the grid. Such as impedance measurement scheme, sliding mode shift scheme, active frequency shift / frequency shift scheme, Sandia shift scheme and so on. The IEEE states that DG must detect island effects within a specified time (<2s) and stop operating immediately. Current island detection devices can meet this requirement, the action time limit ranging from hundreds of milliseconds to 2 seconds.

Therefore, we can install anti-islanding protection device in distributed generator set. The specific implementation of the program can be based on DG type, economy, rapidity and other requirements. Its action course is as follows: When the power grid breaks down, the anti-islanding protection device detects the island effect rapidly, jumps the DG access switch rapidly. In this case, the voltage rapidly decayed to the non-

pressure threshold value, the power supply of the substation is restored, and the reliability of the power supply system is improved.

#### 4.2 DG of rotating electrical grid

In order to reliably and quickly remove the DG, the following two solutions can be used.

Method 1: The original line protection was transformed into full-speed fiber longitudinal differential protection. Once the line fails, the switch on both sides of the line will be activated, thus connecting the DG access switch. Automatic bus transfer is activated, thereby speeding up the startup speed of the device. This solution is easy to implement, it has strong interference ability and high reliability. But the disadvantage is the higher transformation costs.

Method 2: The monitoring device is installed at the switch QF 1, and the monitoring device can detect the voltage, current and power direction at the switch QF 1. When the system is operating normally, the power flow of switch QF 1 is the line directed to the bus. When the power line fails, QF 1 power direction is bus-to-line.

#### 4.3 DG access system based on automatic bus transfer device

The device system uses dual CPU architecture. 32-bit fixed-point DSP2812 + MAX125 chip is used. It not only can control multi-channel A / D conversion, but also can control a variety of relay output switch. In this case, the protection function of the device is realized and a high-performance real-time algorithm is realized. At the same time, P89C668 chip was chosen to achieve network communications, human-machine interface and LCD display and other functions. It can improve the reliability and overall performance of the entire installation. Figure 5 is a hardware diagram of the device. According to the realization of different functions, automatic bus transfer device can be divided into the following major modules: the main CPU module, analog acquisition module, digital input and output modules, communication interface module, human interface module and power module.

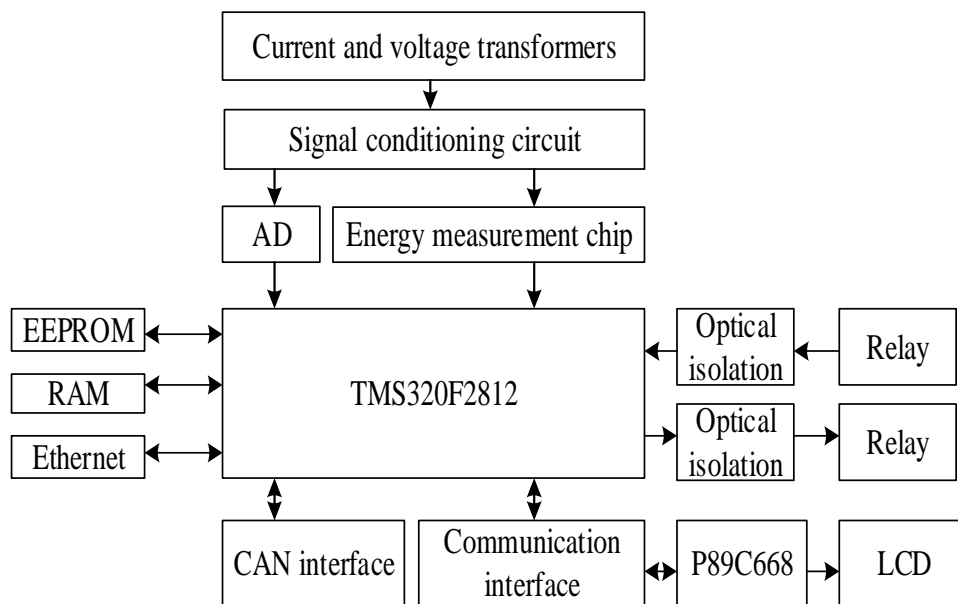


Figure 5: Device hardware structure diagram

## 5. Conclusions

The use of renewable energy can effectively ease the situation of energy consumption, it can also improve the power system reliability, safety and flexibility. However, the large number of DG's access will have an impact on power system operation, protection and control. Therefore, in order to effectively solve the problem that the automatic bus transfer device cannot work normally when the DG is connected, this paper takes DG substation with single-side power supply as an example to analyze the impact of DG. The results show that the access of DG prolongs the startup time of automatic bus transfer. At the same time, the corresponding solutions are put forward for DG with larger capacity of rotating electric machine and grid connection.

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