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| C:\Users\a03551\Desktop\01.png | **MySE series Wind Turbine Generator System** | **Date** |
| **FEB. 5, 2021** |
| **Technical Specifications of**  **Grid Connection performance**  **(Italy)**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Preparer**  **汪奎** | **Checked**  **唐彬伟** | **Standardized**  **黎婉兰** | **Approval**  **罗荣锋** | **Released**  **郭涛** | |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | | **Document No.** | M0000018199 | **Revision** | **C** | | **Classification** | | **Number of pages** | **21** | | **□ Strictly Confidential ■ Confidential □ Secret □ Internal□ Published** | | | | | | |

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# 1. Purpose and Scope of Application

This document specifies the grid connection characteristics of MySE series wind turbine generator system (WTGS).

This document applies to the description of grid connection characteristics of MySE series WTGS.

# 2. Normative References

Clauses in the following standards are incorporated into this standard through reference and shall be observed. For the undated standards, the latest version shall prevail.

The following standards:

Access to the National Transmission Grid - Section 1A - Connections to the NTG.

Access to the National Transmission Grid - Section 1B - Technical regulations for connection.

Network Code on requirements for grid connection of generators- RfG.

Annex.A17 Technical Specifications: WIND FARMS General Conditions for Connection to HV networks Control, Set-Up, and Protection Systems

IEC 61400-21:2005 Measurement of power quality characteristics

IEC 61000-2-2:2002 (Edition 2.0 2002-03) Electromagnetic compatibility (EMC) Part 2-2: Environment – Compatibility levels for Low-frequency conducted disturbances and signaling in public low-voltage power supply system – Basic EMC publication.

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IEC 61000-4-7:2008 (Edition 2.0 2008-06) Electromagnetic compatibility (EMC) Part 4-7: Testing and measurement techniques – General guide on harmonics and inter-harmonics measurements and instrumentation, for power supply systems and equipment connected thereto.

IEEE 519 Standard, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

# 3. WTGS Overview

MySE series WTG is a super-compact wind turbine generator system which featured with semi-direct drive, the gearbox and generator are integrated into a compact single body. Due to the medium-speed gearbox, the high failure rate of the traditional doubly-fed system with a high-speed gearbox is been overcame. Compared with the low-speed permanent magnet direct-drive generator at the same power capacity, the medium-speed permanent magnet synchronous generator (PMSG) has a smaller size and lighter weight. In addition, the excellent LVRT (grid support) capability and grid adaptability of the PMSG are retained. Below Figure 1 show block diagram of the main circuit.

Figure 1 Block Diagram of Main Circuit of MySE WTGS

With the rotor rotating, the gear speed will increase, driving the generator to output the six-phase variable-voltage and variable-frequency AC power. The AC power will be transmitted to the DC bus through the motor-side converter, and then converted by the grid-side converter into the constant-frequency (synchronized with the grid frequency) and constant-voltage AC power. Finally, the AC power will be transmitted to the grid through the grid-connected switch and grid-connected transformer. The filter that used for inhibiting voltage distortion and current harmonics is mounted between the grid-side converter and grid. As the total output power of the PMSG is regulated by the electrical and electronic devices before transmitted into the grid, a full-power efficient and compact converter system is the guarantee of output capacity and power quality. In this WTGS, the advanced power converter (with the IGBT switching device) is applied to ensure high efficiency within the whole wind speed range or rotor speed range.

# 4. Grid-side parameters

Grid-side Rated Output Parameters of WTGS、Maximum Short-circuit Current、Protection Setting and Parameters of Grid-side Step-up Substation see Figure 1、Figure 2、Figure 3 and Figure 4.

Table 1 Grid-side Rated Output Parameters of WTGS

| Parameter Name | | Values | | Remarks |
| --- | --- | --- | --- | --- |
| Number of phases | | 3 | | - |
| Rated phase voltage (rms) Urated | | 690/1.732 | | V |
| Rated active power Prated | 3.0MW | 3000 | | kW |
| Rated apparent power Srated | 3.0MW | | 3334 (power factor = 0.9) | kVA |
| Rated frequency frated | | 50 | | Hz |
| Power factor (rated conditions i.e. rated regulation range under rated active power, rated voltage, rated ambient condition etc.) | | 1.0 (default)  regulation range: -0.9(lag) to +0.9(advance) | | - |
| Reactive power regulation range (rated conditions) | 3.0MW | -1455 (inductive) to +1455(capacitive) | | kVar |

Table 2 Grid-side Maximum Short-circuit Current of WTGS

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter Name | | Values | Unit |
| Maximum short-circuit current | 3.0MW | 4,000 | A |

Table 3: Grid-side Protection Setting of WTGS

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Protection Name | | Protection Setting | Unit | Delay | Remarks |
| High voltage protection | | U≥1.3 p.u.. | p.u. | 0.2s | According to the Annex A17  7.1.2  Wind turbine  protecton |
| 1.20p.u.≤u＜1.3p.u. | p.u. | 1.1s |
| 1.10p.u.＜u＜1.2p.u. | p.u. | 60s |
| The continuous operable voltage | | 0.9p.u.≤u≤1.10 p.u. | p.u. | Continuous  Operable |
| Low voltage protection | | 0.80p.u.＜u＜0.9p.u. | p.u. | 60s |
| 0.80p.u. | p.u. | 2.9s |
| 0.00p.u. | p.u. | 0.2s |
| High frequency protection | | f≥52.5 | Hz | 0.2s |
| 51.5＜f＜52.5 | Hz | 1s |
| The continuous operable frequency | | 47.5≤f≤51.5 | Hz | Continuous operable |
| Low frequency protection | | 46.5＜f＜47.5 | Hz | 4s |
| f≤46.5 | Hz | 0.2s |
| Over-current protection | 3.0MW | 3200 | A | 0s | - |
| Overload protection | 3.0MW | 3250 | kW | 0s | - |
| Three-phase voltage unbalance protection | | 8 | % | 3s | - |
| Three-phase current unbalance protection | | 15 | % | 3s | - |
| Notes: 1. Rated voltage: U*rated* = 690V;  2. Considering the inherent errors of the measuring device and calculation method, the allowable error of protection response is 5%.  3. The unbalance and over-current protection is shielded in the LVRT period, in order to meet the LVRT requirements.  4. The protection will stop the wind turbine Generator with Grid-side switch opening. | | | | | |

Figure 2 for the FRT curve.

 Figure 2: FRT Curve

Parameters for Figure 2 for fault-ride-through capability.

Table 4 Parameters of Grid-side Step-up Substation

| Parameter Name | | Range | Unit | Remarks |
| --- | --- | --- | --- | --- |
| Rated capacity | 3.0MW | 3340 | kVA | - |
| Rated voltage of primary side | | 33 or Client defined | kV | - |
| Rated voltage of secondary side | | 0.69 | kV | - |
| Short-circuit impedance | | 8% | - | - |
| Connection group | | Dyn11 | - |  |
| Number of phases/windings | | Three-phase/double-winding | - | - |
| Neutral grounding | | Grounded | - | The neutral point of the low-voltage side is grounded. |

Table 4: Parameters of Grid-side Step-up Substation (continue)

| Parameter Name | Range | Unit | Remarks |
| --- | --- | --- | --- |
| Voltage regulation | Manual regulation within the following tapping range: ±2×2.5% | - |  |
| Note: It is recommended to install one step-up transformer in one WTGS. | | | |

# 5. Grid Adaptability

5.1 Operating Voltage Range

Normal operating range of voltage:85%Vn≤V≤115%Vn at unlimited time, Vn=690V

5.2 Operating Frequency Range

In order to meet the frequency requirements of national standards and various countries, the master control frequency protection is set as shown in Figure 3. The operating frequency is 47.5Hz ≤f≤51.5Hz , unlimited time. MINGYANG have no commitment to the operating capacity under the frequency below 47.5Hz or above 51.5Hz.



Figure 3 Operable frequency

5.3 Operating Harmonic Range

When the harmonic voltage of the grid is≤5%, the WTGS can be connected to the grid. When the background harmonic voltage (THDu) of the grid is 5% or less, the grid-connected harmonic current shall meet the standard IEC 61800-3、IEEE 519.

5.4 Voltage Fluctuation and Flicker

The voltage fluctuation and flicker at the grid-connected point of the wind farm shall meet the standard IEC 61000-3-7. See Table 5 and 6.

Table 5 Flicker Limit

|  |  |  |  |
| --- | --- | --- | --- |
| Flicker Coefficient | Low-voltage System | Medium-voltage System | High-voltage System |
| Pst | 1.0 | 0.9 | 0.8 |
| Plt | 0.8 | 0.7 | 0.6 |

Table 6 Voltage Fluctuation Limits

| r /(times/h) | d (%) | |
| --- | --- | --- |
| LV and MV | HV |
| r≤1 | 4 | 3 |
| 1≤r≤10 | 3 | 2.5 |
| 10≤r≤100 | 2 | 1.5 |
| 100≤r≤1000 | 1.25 | 1 |
| Note: d(%) represents the voltage fluctuation, i.e. the difference between two adjacent limits on the voltage (RMS) curve, expressed as a percentage of the nominal voltage. r represents the frequency of voltage fluctuation, i.e. the times of voltage fluctuation per unit time (voltage rise or drop will be regarded as one fluctuation). If the intervals of fluctuations in different directions are less than 30 microseconds, the voltage will be regarded fluctuating once. | | |

5.5 Unbalanced Operating Range

If the voltage unbalance of the grid is ≤5%, the WTGS can be connected to the grid.

5.6 Impulse current during grid-connecting

For full capacity convertor, the impulse current will not over the peak value of grid-side rated value of the convertor.

# 6. Grid Connection Performance of WTGS

6.1 Active Power Control

The maximum output active power and the variation ratio of active power of the MySE WTGS can be controlled in a manner of variable-speed and variable-pitch. If the wind speed is less than the rated wind speed, the generator speed can be controlled to track the wind speed, in order to achieve the Max-optimized Cp. If the wind speed is higher than the rated wind speed, the blade pitch angle can be adjusted to stabilize the output power at the maximum power, thus preventing the generator and converter system from overload. The WTGS can also be controlled centrally via the wind farm EMS (Energy Management System) of MINGYANG.

According to the requirements of the grid dispatching regulation, the wind farm should be involved in the function of frequency regulation, peaking and standby operation of the grid system. The grid dispatching system can be connected to the grid via MINGYANG’s EMS, to achieve the automatic generation control (AGC) of the wind farm. The control performance shall meet the Technical regulations for connection for Connecting Wind Farm into Power Grid. Specific control functions are descripting as follows:

1) If the active power of the wind farm exceeds the total rated capacity by more than 20%, the active power of all WTGs in service on the wind farm shall be regulated continuously and smoothly, and involved in the active power control.

2) In the process of active power control, the active power output of the wind farm shall be evaluated dynamically via the EMS.

3) The wind farm shall be able to receive and automatically execute the commands from the power system dispatching organization for control of the active power and its variation. In addition, the value of active power and its variation shall be as same as the values given by the power system dispatching organization.

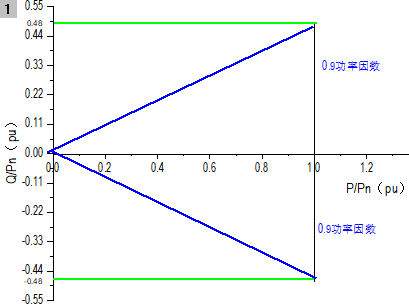
4) Uploading of the operation data of the wind farm and WTGS:

The WTGS may be suddenly disconnected from the grid as a result of the failure or mis-operation of the grid (excluding the zero-voltage ride-through status within the specified range). In these two statuses, the “emergency stop” shall be automatically executed to prevent damage to the WTGS.

6.2 Reactive Power Control

The MySE WTGs has the function of reactive power control and ability to receive and automatically execute the reactive power control signal remotely sent by the power dispatching department or MINGYANG’s EMS.

The blue and green solid lines in Figure 4 below are for the long-term reactive power regulation under the rated conditions. In the default control mode, the grid-side power factor is 1. If no necessary, the WTGS shall not absorb or generate reactive power.



Power factor: -0.9

Power factor: 0.9

Figure 4 Reactive Power Regulation Range of WTGS

V/Q Capability curve of wind turbine



Figure 5 V/Q Capability curve of wind turbine

The capability curve V/Q at the maximum required power Pnd (without optional capacitive compensation elements) is shown in Fig. 5 with red edge.

6.3 Fault Ride-through

6.3.1 Fault Ride-through (FRT)

MySE series WTG has the functions of Fault Ride-through (FRT) in the case of grid failure occurred (including symmetrical and asymmetrical failure), as shown in Figure 6.



Figure 6 Operating Voltage Range of WTGS

The red line in the Figure 5 represents the FRT Characteristic of Mingyang WTGS.

For the WTGs that were not disconnected during voltage drop, once the fault is eliminated, the active power shall be quickly recovered to the output level of nominal wind speed condition at the rate of at least 10%Pn/s. the entry into service of the Wind Power Plant with power input is conditioned to a grid frequency not exceeding 50.2 Hz.

In any case, it is required that the limitation of the active power delivered is related to the depth of the voltage hole/peak and with limited involvement of the phases not affected by voltage lowering/raising. In any case, the techniques for managing the active power delivered during voltage drops must be specified and the related adjustments must be agreed with the Grid Operator.

6.4 Frequency-Dependent Active Power Adjustment

Wind turbines shall be designed to provide primary frequency control in a manner similar to conventional rotary units around the nominal frequency.

This adjustment mode must be implemented in a settable range [fB1;fB2]

On request, two BFSMu and BFSMo adjustment ranges must be reserved, respectively in under-frequency and over-frequency, between 1.5% and 10% of the value of the available rated power (Pnd), avoiding the detachment of the wind turbines in compliance with the declared technical operating limits.

For Pe power values lower than 15% Pnd, limitations in the delivery of this regulation are accepted.

The intervention of this mode has priority over the set-points and limitations set.

A maximum insensitivity of 10 mHz is required.

It is required to carry out the adjustment according to a droop straight line sFSM with a dead band ΔfDB adjustable in the range [0;500 mHz] according to the indications provided by the Operator.

The time of complete supply (t2) of this reserve must be less than 2 seconds.

The activation of the response must take place without intentional delays.

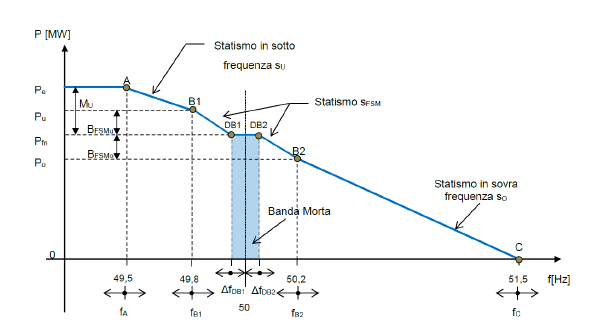


Figure 7 P/f curve for a Wind Power

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Characteristic Point | Frequency Values[Hz] | | | |
| Calibration Range | | Adjustment Step | Default Value |
| A | fA | 47.5-50 | 0.1 | 49.5 |
| B1 | fB1 | 49.5-50 | 0.1 | 49.8 |
| B2 | fB2 | 50-50.5 | 0.1 | 50.2 |
| DB1-DB2 | ΔfDB1-ΔfDB2 | 0-±0.5 | 0.05 | 0 |
| C | fC | 50.2-51.5 | 0.1 | 51.5 |

Rated Power of the Wind Power Plant (Pn).

Available Rated Power of the Wind Power Plant (Pnd).

Potential Output Power of the Wind Power Plant (Pe).

Potential Output Power of the Wind Turbine Generator (Pe-ag).

6.4.1 Limited frequency sensitive mode — overfrequency (LFSM-O)

Wind farms must provide support for over-frequency transients by reducing the power fed into the grid according to the frequency error amount. This mode, called Limited Frequency Sensitive Mode Over-Frequency (LFSM-O), is active for frequencies between fB2 and fC according to an so droop that cancels the power fed in for a frequency of 51.5 Hz.

If FSM mode is not enabled, and the input power is equal to the output power Pe, with activation at fB2=50.2 Hz, the resulting droop value, calculated as a function of Pe, is so=2.6%

The activation of the response must take place in the shortest possible time without intentional delays and the time of supply of all the contribution of this reserve must be less than 10 seconds.

In the case of step frequency variations that require power variations of more than 50% Pnd, the supply may take place in longer times, but in any case less than 30 seconds.

For reasons of mechanical instability, in the case of power reductions below 10% Pnd, in the individual wind turbines can be progressively disconnected to approximate the droop line shown in Fig. 7.

1) The power-generating module shall be capable of activating the provision of active power frequency response according to figure 8 at a frequency threshold.



Figure 8 Active power frequency response capability of power-generating modules in LFSM-O

Pref is the reference active power to which ΔΡ is related and may be specified differently for synchronous power- generating modules and power park modules. ΔΡ is the change in active power output from the power-generating module. fn is the nominal frequency (50 Hz) in the network and Δf is the frequency deviation in the network. At overfrequencies where Δf is above Δf1, the power-generating module has to provide a negative active power output change according to the droop δ.

2) The frequency threshold shall be between 50,2 Hz and 50,5 Hz inclusive;

3) The droop settings shall be between 2 % and 12 %;

6.4.2 Limited frequency sensitive mode — underfrequency (LFSM-U).

This mode, called Limited Frequency Sensitive Mode Under-Frequency (LFSM-U), will be provided by the Wind Power Plant whenever the power fed into the grid is lower than the maximum deliverable power as shown in Fig.7.

The intervention of this mode has priority over the set-points and limitations set.

If this setting is activated, the system must provide a response according to an under-frequencydroop depending on the frequency thresholds fB1 and fA specified.

The activation of the response must take place in the shortest possible time without intentional delays and the time of supply of this reserve must be less than 10 seconds. In the case of step frequency variations that require power variations of more than 50% Pnd, the supply may take place in longer times, but in any case less than 30 seconds.

Mu=Pe-Pfn,BFSMU, and BFSMO may be included, in case of intentional limitations of Pfn, in the calibration ranges shown in the following table:

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Possible Calibration Range | Adjustment Step | Default Value |
| Mu | 0-80%Pn | 0.1%Pn | 0 |
| BFSMu, BFSMO | 0-20%Pn | 0.1%Pn | 0 |

The power-generating module shall be capable of activating the provision of active power frequency response at a frequency threshold and with a droop specified ,the same synchronous area as follows:

1. The frequency threshold specified shall be between 49,8 Hz and 49,5 Hz inclusive;
2. The droop settings specified shall be in the range 2-12 %. This is represented graphically in Figure 9.



Figure 9 Active power frequency response capability of power-generating modules in LFSM-U

Pref is the reference active power to which ΔΡ is related and may be specified differently for synchronous power- generating modules and power park modules. ΔΡ is the change in active power output from the power- generating module. fn is the nominal frequency (50 Hz) in the network and Δf is the frequency deviation in the network. At underfrequencies where Δf is below Δf1 the power-generating module has to provide a positive active power output change according to the droop δ.

6.4.3 Maximum power capability reduction with falling frequency

Admissible active power reduction from maximum output with falling frequency in its control area as a rate of reduction falling within the boundaries, illustrated by the full lines in Figure 10:

(a) below 49 Hz falling by a reduction rate of 2% of the maximum capacity at 50Hz per 1Hz frequency drop;

(b) below 49,5 Hz falling by a reduction rate of 10% of the maximum capacity at 50Hz per 1Hz frequency drop.



Figure 10 Maximum power capability reduction with falling frequency

6.5 Local Adjustment of Reactive Power

The following parameters must be adjustable and calibrated according to Terna's instructions:

1. Dead band adjustable from 0 (zero) up to 1% of Vn in steps not exceeding 0.1% Vn
2. Controller insensitivity range adjustable from 0 (zero) up to 1% Vn in steps not exceeding 0.1% Vn

Following a mains voltage variation ΔV, the system must be able to deliver 90% of the required reactive power variation within 2 seconds and 100% within 5 seconds with an accuracy of ≤ 5% of the value of the maximum reactive power that can be delivered or ≤ 0.2 MVAr.

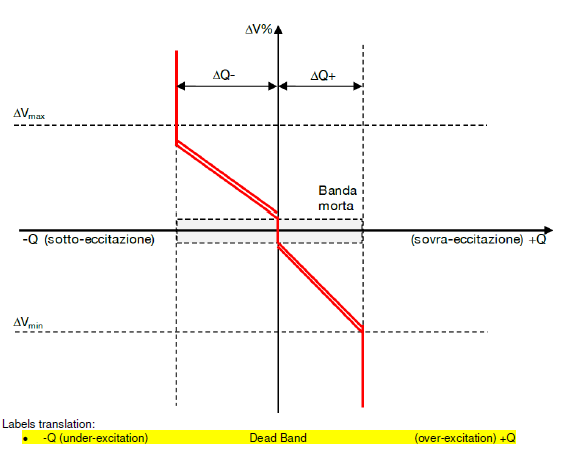


Fig. 11 – Characteristic curve Q=f(ΔV)

6.6 Inertia

MingYang Wind turbines will be prepared in order to be able to provide an active inertial response function to the Operator's request in the event of under-frequency transients. The control system of the wind turbines must provide a control loop that allows, depending on the frequency deviation, the delivery of an inertial response by changing the adjustment logic. For a predefined time, higher power values must be supplied at the expense of a lower rotation speed (operating zone for power lower than Pn) or by varying the pitch angle (zone with constant P).

It is required that this system starts to operate by decreasing the frequency below an adjustable reference value in the range [49.5 Hz; 50 Hz] with a step of 0.05 Hz and a default value of 49.8 Hz.

This mode has priority over the set-points and limitations and other frequency adjustments.

The function must be activated in the shortest possible time without intentional delays.

Due to possible mechanical and electrical constraints, this function can be activated if the power supplied at the start of the transient is higher than a limit value specified by the manufacturer of the Wind Turbine Generator and in any case not higher than 30% of the rated power available Pnd.o during Fault Ride Through phases.

A surplus of power equal to a value adjustable between [0;10%Pnd] with a default value equal to 6% Pnd is required.

Following the delivery of the surplus power, in case of operation in the area with a power lower than Pn, it is necessary to restore the optimum conditions by re-accelerating the rotor of the wind turbine. This process (recovery) must take place gradually when one of the following conditions occurs:

a) Return of the frequency above the activation value

b) Upon exceeding an adjustable limit time from the start of the transient (recovery time). This time must be adjustable between the values [0s;30s]; default value 10 seconds.

In case of operation of the wind turbines in the constant power zone, recovery is not necessary. The greater production must therefore be supported as much as possible by the electrical and thermal sizing of the wind turbines, but in any case for a period of at least 10 seconds.

The availability of this inertial response on subsequent under-frequency transients is possible if the power recovery phase has already ended or at least 60 seconds have elapsed since the end of the last additional power delivery.

To implement this function, a suitable frequency filtering system is required.

6.7 Power Quality

The power quality of the MySE series WTGS will meets the following standards:

Access to the National Transmission Grid - Section 1B - Technical regulations for connection.

Network Code on requirements for grid connection of generators- RfG.

IEC 61400-21:2005 Measurement of power quality characteristics

IEC 61000-2-2:2002 (Edition 2.0 2002-03) Electromagnetic compatibility (EMC) Part 2-2: Environment – Compatibility levels for Low-frequency conducted disturbances and signaling in public low-voltage power supply system – Basic EMC publication.

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6.8 WTGS Model

The electrical simulation model of the WTGS is available, its structure show in Figure 12.



Figure 12 Structural Diagram of WTGS Model

For the MySE series WTGS:

1) The generator converter system module shall include the models of generator and converter.

2) The control system module shall include the central control system model of WTGS.

3) The electrical equipment module shall include the grid-connected breaker.

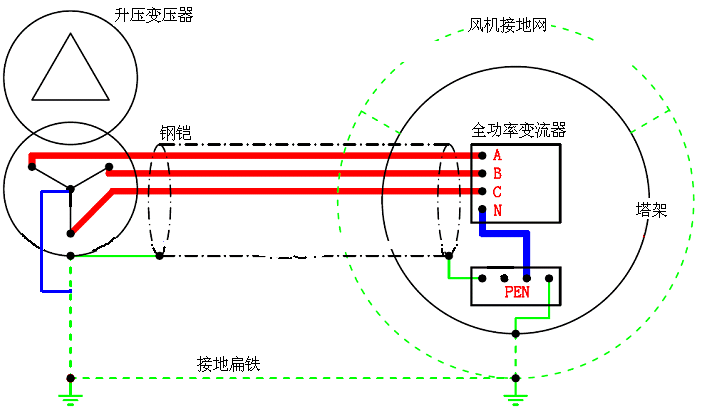
4) If the some WTG need additional equipment to achieve the LVRT function, the additional attachment simulation model shall be established.

5) If the WTG is equipped with the LVRT protection circuit (such as the DC chopper circuit) in a full capacity convertor, the generator-side converter, generator, drive chain, aerodynamic module and pitch system may be simplified. The simplified model shall accurately reflect the impact of the generator, drive chain, aerodynamic module and pitch system on the converter operation and grid-connected characteristics in the transient LVRT process. The generator-side converter can be simplified in an equivalent way, but the simplified model shall reflect the transient voltage and current response characteristics of the generator-side converter and its DC bus in the LVRT process.

6.8 Anti-interference Performance of WTGS

The grid is a huge dynamic system. When the grid frequency, grid voltage, grid voltage unbalance and grid power quality of the grid-connected point fluctuate frequently within their normal ranges or meet the related standards, the WTGS shall work normally, with good anti-interference performance.

# 7. Grid-side Grounding System of the WTGS



Step-up transformer

Grounding grid of WTGS

Tower

Grounding flat iron

Full-power converter

Steel armor

Figure 13 Grid-side Grounding of WTGS