Internal Transformer System

[3.XM/50Hz]

Product Description

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SENVION
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Disclaimer [European Market]

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List of relevant documents

The documents referred to in the table below are included for information only. Reference to them in this product description does not make them part of the contract.

Title	Document no.
Product description Senvion 3.4M104 [3.4M/104/50 Hz]	PD-3.1-WT.WT.01-A-*
Product description Senvion 3.2M114 [3.2M/114/50 Hz]	PD-3.2-WT.WT.01-A-*
Product description Senvion 3.2M114VG [3.2MVG/114/50 Hz]	PD-3.2-WT.WT.01-B-*
Product description Senvion 3.0M122 [3.0M/122/50 Hz]	PD-3.5-WT.WT.01-A-*
Standard conditions of use Senvion 3.4M104 [DiBt/3.4M/104/50 Hz]	SD-3.1-WT.SC.00-A-*-DE
Standard conditions of use Senvion 3.2M114 [DiBt/3.2M/114/50 Hz]	SD-3.2-WT.SC.00-A-*-DE
Standard conditions of use Senvion 3.2M114VG [DiBt/3.2MVG/114/50 Hz]	SD-3.2-WT.SC.00-B-*
Standard conditions of use Senvion 3.0M122 [DiBt/3.0M/122/50 Hz]	SD-3.5-WT.SC.00-A-*-DE
Installation instructions: wind farm medium voltage cables to the WTG switchgear	M-2.1-EL.SA.01-A-*

* The individual documents appear as contractual annexes in their respectively valid revisions as warranted by the project-specific selection of Senvion products by the customer.

List of abbreviations and units

Abbreviation/unit	Explanation
AF	Air forced (forced air cooling)
AN	Air natural (natural air cooling)
BoB	Base box
FEU	Feeder end unit
IEC	International Electrotechnical Commission
ITS	Internal transformer system
GSP	Generator stator panel
LV	Low voltage
MS	Medium voltage
ONAN	Oil natural air natural
RMU	Ring main unit
TDC	Tower distribution cabinet
U_N	Nominal voltage
UPS	Uninterruptible power supply
WT	Wind turbine

1 Introduction

This document describes the Senvion product Internal Transformer System. The Internal Transformer System is part of the Senvion product group “Internal Transformer System, External Transformer Station & Transfer Stations”.

The Internal Transformer System is required for the grid connection and parallel operation of the WEC. Besides the transformer itself, the transformer system contains the MV-switchgear and a suitable number of cable-fields to establish the grid connection.

For the WEC type Senvion 3.XM [50Hz], described in this document, only Internal Transformer Systems are used. The transformer is located in the foundation section, at the bottom of the WEC. The switchgear is placed on the platform above, see chapter 3 Component Overview.

2 Standards and Regulations

2.1 General

The installation and operation of the electrical equipment meets the applicable parts of the following standards, technical rules and regulations.

- IEC 60364
- IEC/EN 60038
- IEC/EN 61936
- EN 50110
- IEC/EN 60204
- IEC/EN 60947
- IEC/EN 61439

2.2 Transformer

The transformer meets the applicable parts of the following standards, technical rules and regulations:

- IEC/EN 60076
- 2009/125/EG with no. 548/2014

2.3 Switchgear

The switchgear meets the applicable parts of the following standards, technical rules and regulations.

- IEC/EN 62271

Note: The applicable parts of the above mentioned standards refer to the edition, valid at the time of release of this product description.

3 Component Overview

The transformer enclosure is mounted directly on the foundation. The position within the tower foundation is defined by Senvion. Furthermore, the placement of the additional components depends on the tower design. In the images below the arrangement of all parts in a steel tower and a hybrid tower is shown.

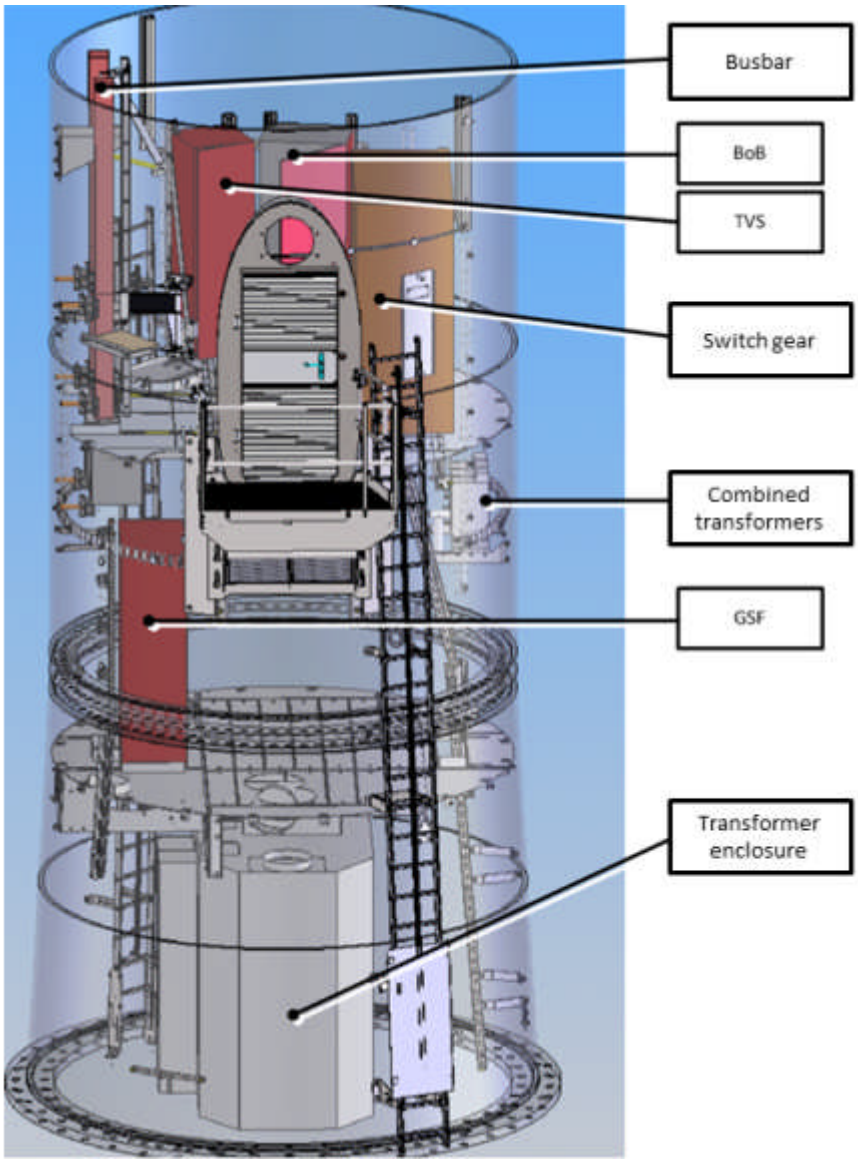


Fig. 3 - 1: Arrangement of components in steel tower

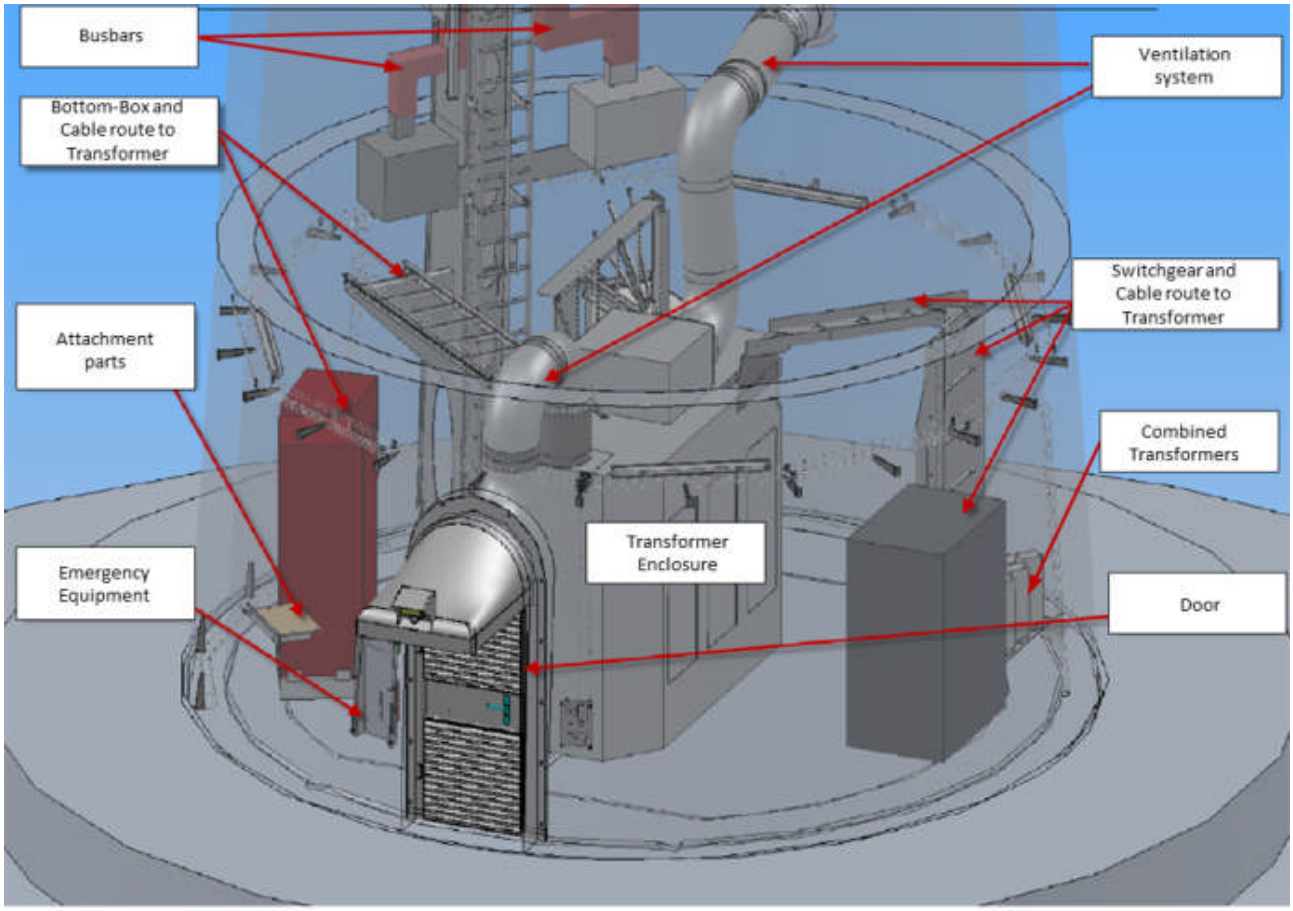


Fig. 3 - 2: Arrangement of components in hybrid tower

4 Transformer

4.1 General Information

The transformer enclosure contains following main systems:

- Cast resin 3 winding transformer including Transformer box (LV fuses, control contacts, transformer for auxiliary devices)
- Transformer housing with forced air cooling system

In case of a damaged transformer, the active part can be replaced in one piece by dismantling the transformer cabinet.

Fig. 4.1 - 1: Exemplary arrangement of a dry type cast resin 3-phase transformer

4.2 Technical Data Transformer

Transformer technical data

Property	Value				
Rated power (MV side)	Forced air cooling: 3800 kVA ON: 3300 kVA				
Rated frequency	50 Hz				
Rated voltage (MV side)	10 kV	15 kV	20 kV	30 kV	33 kV
Tapping range (MV side)	± 2x2.5% of nominal voltage				
Rated voltage (LV side) LS1: stator LS2: converter	0.95 kV 0.66 kV				
Inrush current (r.m.s. value) [I_{Inrush} / I_{Rated}]	5.2	5.2	5.2	6.3	6.3
Vector group	Dyn5yn5 or Dyn11yn11				
No-load loss (75°C, rated voltage and frequency, tolerance 15%)	≤ 5.2 kW*	≤ 5.2 kW*	≤ 5.2 kW*	≤ 6.05 kW*	≤ 6.05 kW*

Property	Value				
Short-circuit losses at rated active power (75°C, rated voltage and frequency, tolerance 15%)	≤ 29.5 kW*	≤ 29.5 kW*	≤ 29.5 kW*	≤ 25.3 kW*	≤ 25.3 kW*
U_k (short circuit voltage) (at 75°C and nominal position) U_{K12} (MV – LV1)	(tolerance acc. to IEC/VDE) Approx. 7.50%				
MV/LV1/LV2 winding	Aluminum or copper				
Insulation system class MV/ LV1/LV2	F / F / F (acc. to DIN EN 60076, part 11)				
Operating temperature range	[as specified in the “Standard conditions of use” document for Senvion WTs; see list of documents]				
Transformer cooling method	AF				
Condensation and humidity class (environmental class)	E2				
Climate class	C2				
Fire class	F1				
Max. height	[as specified in the “Standard conditions of use” document for Senvion WTs; see list of documents]				
Degree of protection of transformer housing Degree of protection of transformer	IP44 IP00				

* : Available for installations from 01.07.2015 onwards.

Note: If deviations of the rated voltage (MV) apply after signature date of the respective turbine sales contract, the customer has to inform Senvion at least 25 weeks before planned delivery of transformer at site.

4.3 Ventilation System

The transformer enclosure is designed for a better cooling of the transformer. The figure below shows the directed air flow inside the enclosure. To reduce the losses, the exhaust fan will operate in different modes, depending on e.g. measured temperatures.

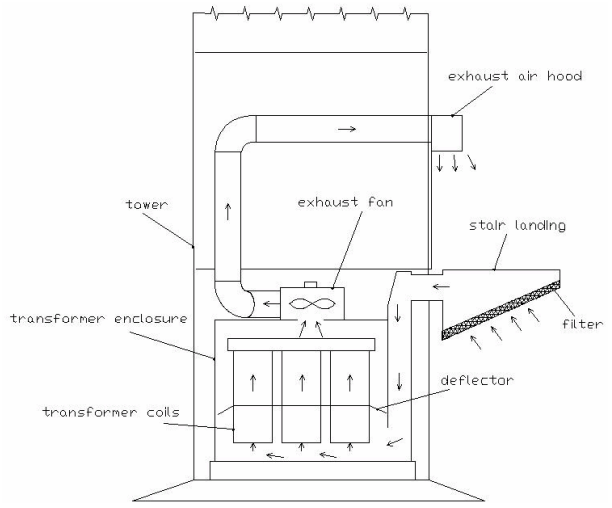


Fig. 4.3 - 1: Exemplary arrangement ventilation system

4.4 Complete transformer protection

The temperature of the transformer core and the windings as well as the exhaust air is monitored by the operating control of the wind turbine. Therefor, several temperature sensors are installed. Two temperature limits are set for warning and tripping. If the warning temperature level is reached, the WEC enters operation with limited output power. If the temperature rises above the tripping limit, the WEC is shut down. In this way a soft shutdown is realized, when overtemperature occurs.

5 Switchgear

5.1 Protective Concept

The protective concept of each WEC contains several means, that are descibed in this chapter. The figure below shows the setup of this concept in a single line diagram.

The transformer feeder is equipped with a circuit breaker and an associated over current relay for protection of the transformer and back up protection of the WT. The transformer feeder has also a grounding possibility executed via a ground switch. The MV circuit breaker can be tripped via the temperature monitoring of the transformer. In addition the WT controller and the backup protection of the converter of the WT are able to trip the MV circuit breaker. The cable feeder is equipped with a load breaker and a ground switch.

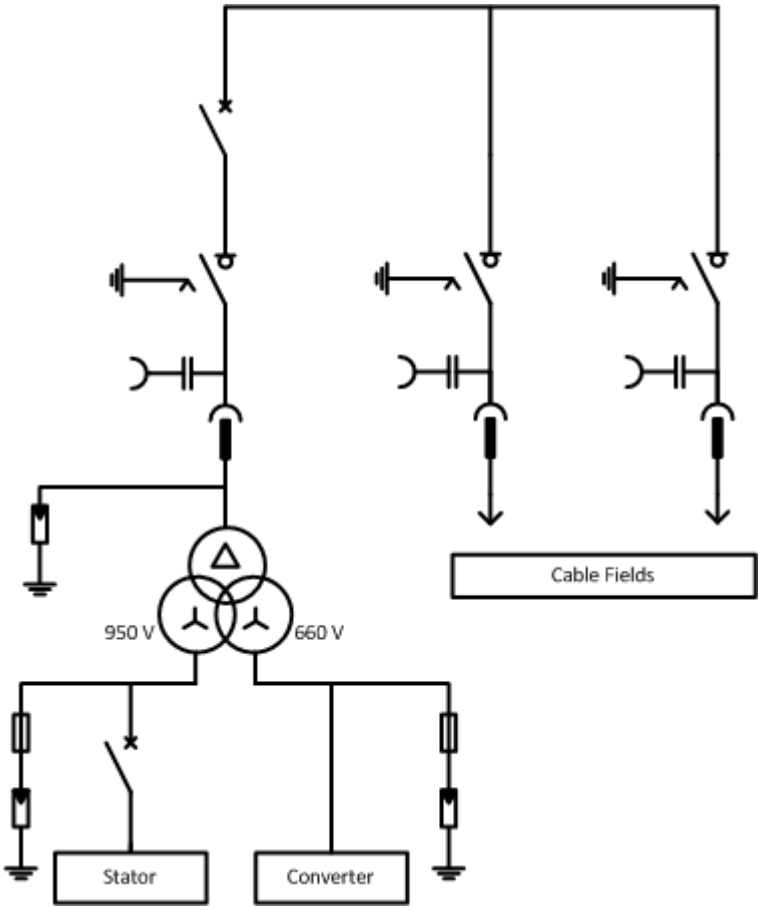


Fig. 5.1 - 1: Example of a single line diagram

5.2 MV Switchgear

5.2.1 MV Switchgear Configuration

The switchgear for each wind turbine depends on the project specific wind farm layout. The figure below shows typical wind farm feeders, with branch possibilities as an example.

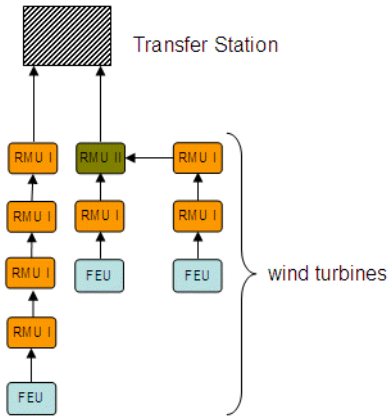
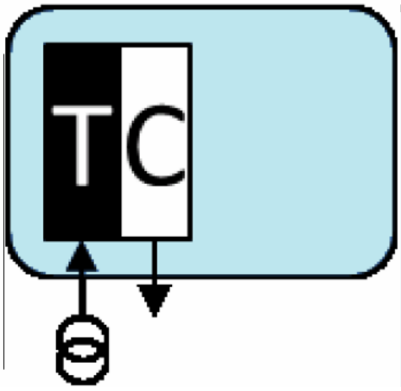
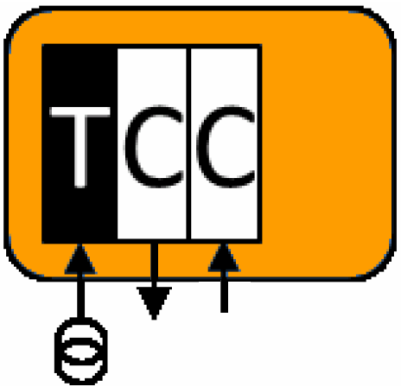
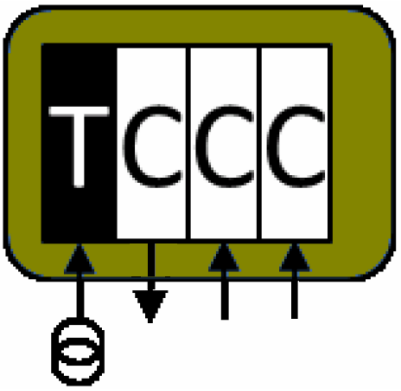


Fig. 5.2.1 - 1: Example layout of a wind farm

Depending on the position of the respective wind turbine, one of the following configurations of MV switchgear can be selected.

Definition of panels in a wind farm

Symbol	Description	Configuration
	Feeder end unit [FEU]	Panel 1: WT transformer Panel 2: grid supply
	Ring main unit I [RMU I]	Panel 1: WT transformer Panel 2: grid supply 1 Panel 3: cable outlet 1
	Ring main unit II [RMU II]	Panel 1: WT transformer Panel 2: grid supply 1 Panel 3: cable outlet 1 Panel 4: cable outlet 2

Note on the availability of medium voltage switchgear: The availability of switchgear may be restricted depending on the tower and hub height. During the planning of the project, the availability of the desired hub height/rated voltage level/number of feeders combination must be requested from Senvion.

Note: The symbols in the table above do not show the actual arrangement of the cable- and transformerfields within the switchgear. See figure 5.2.2 - 1, where the transformer-field is located in the center between two cable feeder fields. The naming of the different switchgear fields (T for transformer feeder and C for cable feeder) is exemplary only. The naming is not consistent within Senvion's suppliers and thus may vary.

5.2.2 MV Feeder Technical Data

A compact SF6 switchgear with type/PEHLA approval is being used.

Fig. 5.2.2 - 1: Exemplary arrangement MV switchgear (RMU I configuration)

It contains the following switchgear properties:

- Indication of SF6-tank pressure (pressure gauge) with alarm contacts, in case a SF6 isolated Switchgear is used
- Clear control panel and mimic diagram panel
- Interlock and lockability of the switch drives (padlock, locking system)
- Interlocking and locking of operating mechanism of switches for each function
- Possibility of testing voltage and phase sequence (capacitive voltage measure according VDE 0105)

Technical data MV-feeder

Property	Value	
Rated voltage U_m	24 kV	36 kV
Basic impulse level	125 kV	170 kV
Power frequency withstand voltage	50 kV	70 kV
Rated current busbar	630 A	630 A
Insulation	SF6 or solid insulated	SF6 insulated
Rated frequency	50 Hz	

5.2.3 Transformer Feeder

Technical data transformer feeder

Property	Value	
Rated voltage U_m	24 kV	36 kV
Corresponding voltage level	10 - 20 kV	30 - 33 kV
Transformer feeder rated current	≥ 200 A	≥ 200 A
Transformer feeder rated short-time current	20 kA (1 s)	20 kA (1 s)
Rated current busbar	630 A	630 A
Switch types	• Vacuum circuit breaker (on/off) • Three-position switch (on/off/ground) • Grounding switch (on/off)	
Cable compartment cover	Arc-resistant	
Trip circuit breaker via protective device or relay (MV side)	• Trip via temperature monitoring and hermetic protection • WTG spare protection • Overcurrent protective circuit without time delay t - I > - I >> (ANSI 50 & 51)	
Nominal voltage of shunt release (solenoid)	230 V AC	

5.2.4 Cable feeder panel

Technical data cable feeder

Property	Value	
Rated voltage U_m	24 kV	36 kV
Cable feeder rated current	630 A	630 A
Cable feeder rated short-time current	20 kA (1 s)	20 kA (1 s)
Switch type	• Load break switch (on/off) • Earth switch (on/off)	
Cable compartment cover:	Arc-resistant	
Three outer cone cable bushings	630 A	

6 Description of Subsystems

6.1 LV- and MV-Cables

The Internal Transformer System includes the delivery, installation and mounting of following cables/connectors:

- MV cabling between transformer and MV switchgear
- LV cabling between converter cabinet and transformer
- Control cables
- Cabling for earth connection

LV-Power cables and equipment will be connected with compression type cable lugs.

6.2 Combined Current and Voltage Transformer

The combined current and voltage transformer (in the following referred to as combi transformer) is installed on the MV-side between transformer and the transformer field of the MV-switchgear. It is necessary to measure the voltage and current on MV-side. These data are needed for control and operation of the Senvion WEC type 3.XM. Combi transformers are used instead of measuring fields because of spatial restrictions inside the tower. Optionally, the combi transformer can be equipped with calibrated measurement windings for confirmatory measurements.

The combi transformer is constructed as a metal case, with the enclosure being connected to protective earth. There are alway three combi transformers installed per WEC, one for each phase. The location of the combi transformers depends on the hub heigth of the respective WEC.

6.3 Standard Interlocking

It is necessary to ensure that access to the transformer itself is only possible if the transformer feeder is switched off and earthed. The basement of the WT can be entered without switching off the transformer because it is placed in a touch safe enclosure.

To get access to the transformer enclosure, the following procedure is implemented:

1. Switch off transformer feeder
2. Earth transformer feeder
3. The key for the transformer enclosure is released
4. The transfomer enclosure can be unlocked and dismantled

7 System Options

The following optional products are not part of the product scope of the Internal Transformer System. Project specific system options have to be defined in the respective turbine sales contract.

Deviations of the scope of System Options are only possible within a limited time frame, after contractual agreement is done. Deviations have to be approved and agreed by Senvion.

7.1 Automatic Cut Off - Cut In

If the voltage drops too low, the wind turbine transformer system will be automatically disconnected at the transformer feeder. This is done by the motorized switching device powered via UPS. To reduce the impact on the grid voltage, caused by the inrush current of the transformers, the single transformers will cut in successively following a timing schedule that can be specified project specifically. The Automatic Cut Off – Cut In option comprises following additional hardware:

- Motorized circuit breaker at transformer feeder
- Programmable controller
- 24 VDC power supply [UPS]
- Wiring

Note: Depending on different parameters (temperature, ageing, network outage duration) the UPS power will be available for max. 48 h. At full load conditions of the UPS approx. 20 switching sequences are possible.

7.2 Advanced Interlocking

To avoid not permitted earthing of live components, which would result in short circuit to ground, the following procedure will be implemented additionally to the standard interlocking (see section 6.3):

1. Switch off and earth the MV cable feeder A1 of switchgear 1.
2. Key 1 is released.
3. Key 1 is locked into the top lock of the following feeder A2 of switchgear 2, so switchgear 2 can be disconnected and earthed too.
4. Switch off and earth feeder B1 of switchgear 2, Key 2 is released.
5. Switch off and earth the MV cable feeder B2 of the following switchgear 3

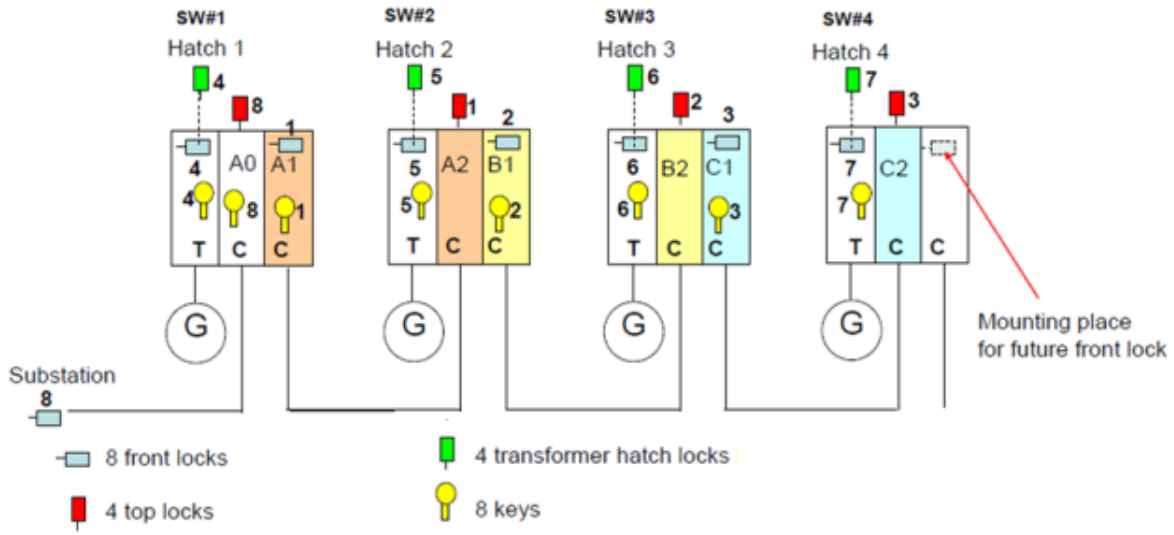


Fig. 7.2 - 1: Principle procedure “Advanced interlocking”

All locks are unique within the wind farm.

8 Scope of Supply

8.1 Hardware

This document describes different configuration options of the Internal Transformer System. Therefore it does not reflect the project specific scope of supply. The respective project specific Senvion scope of supply has to be defined contractually.

8.2 Installation and Commissioning

Senvion or the subcontractor in behalf of Senvion will be responsible for the installation and commissioning of components described within this product description. Furthermore, Senvion will be responsible for the placement of the MV switchgear within the WEC. The installation of the equipment will start before the installation of the related WEC, the mechanical completion and the commissioning are done after installation of the respective WEC.

The customer or the supplier on behalf of the customer is responsible for the design, installation, testing and connection of the medium voltage wind farm cables to the switchgear. The technical data described within this document have to be considered. The test has to be done after the installation of the cables and must be presented to and approved by the Senvion project manager.

To protect the MV cables against water ingress during possible handover periods, the MV-cables must be temporarily sealed with protection caps.

The MV-cables have to be placed with a specific overlength to be measured from the foundation into the wind turbine, for the mounting of cable connectors and the connection of the cables to the switchgear. The exact overlengths are listed in the table below.

Overlength of MV cables depending on tower heigth

Tower	Overlength
steel tower: < 100 m	6 m
steel tower: = 100 m	8.5 m
hybrid tower: > 100 m	10 m