Technical description

System for shadow monitoring and species conservation

Revision 1.00

NORTHTEC
automation technology

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1 Changes

Revision	Date	Description	Author	Reviewed by
1.00	1.06.2017	1st Edition	MMA	MHA

2 Introduction

This description outlines the components deployed in the system for shadow monitoring and species conservation as well as their functions. We will also demonstrate how such a system can be set up within a wind park.

3 Components

By deploying various additional components, it is possible to customise the system for shadow monitoring and species conservation in accordance with the existing systems of the wind park and with regard to applicable permit conditions.

3.1 Master unit

During operation, the master unit will calculate the shadow impact periods, communicate with connected sensors, retrieve the current operational data from the WTGs, send stop and start commands to the WTGs and log all relevant events. The logged data are saved to two USB flash drives (for redundancy) and can be retrieved with Shadow Manager 4.

The master unit can be installed in the wind park in different versions as required. The master unit can be installed in an existing switch cabinet or in an additional one. When incorporated into an existing cabinet, the master unit requires a buffered 24 V DC voltage supply and a DC OK signal in order to be able to shut down in a controlled manner if there is no external power supply.

The master unit may be fitted with various interfaces designed to retrieve the operational data from the monitored WTGs. Many of those interfaces communicate directly with the control systems of the WTGs or with a central server through the Ethernet interface. Where this is not possible, slave units can be installed in the WTGs to be monitored.

Based on correct operational data, the master unit can calculate the exact shadow impact in such a way that unnecessary WTG downtimes are avoided. If the master unit does not have any operational data from the WTG, it will base its calculations on a worst case scenario (e.g. nacelle position 90° to the sun). Based on the rotor speed of the WTG, the master unit can determine whether a transmitted stop command is executed by the WTG. If it is not executed, the master unit will log an error.
The wind speed and the outside temperature measured by the WTGs can be used to check whether the current conditions require shut-downs aimed at species conservation.

Through the web interface of the master unit, the user can get a quick overview of the master unit, the status of the sensors connected to it, the WTGs monitored and the places of immission.

Master unit specifications

	Integrated master unit	**Separate switch cabinet**
Power supply	24 V DC (UPS, min. 11 s)	110–230 V AC
Frequency	N/A	50–60 Hz
Power consumption	max. 2 A	max. 2.3 A
Dimensions (WxHxD)	205x165x85 mm	500x540x320 mm
Weight	1 kg	25 kg
Protection	IP20	IP65
Temperature range	-25 °C…60 °C	-40 °C…60 °C

3.2 Slave units

If the master unit cannot communicate with the control systems of the WTGs or a central server directly over the wind park network, slave units can be deployed as an interface between the master unit and the WTGs to be monitored.

The slave units will transfer the stop or start command sent from the master unit over a relay output to a digital input of the WTG control system. The digital input of the WTG control system must be configured in such a way that the WTG will shut down as soon as the respective signal is present. Depending on the type of slave unit used, the slave unit may be able to communicate the status of the system for shadow impact monitoring and species conservation to the WTG control system (in addition to the stop command) over another relay output than the one used for the stop command.

The most simple version of a slave unit is connected to the master unit by fibre optics using media converters. If a WTG has to be shut down by the master unit, the master unit will send a digital signal to the respective input of the media converter. The media converter within the master unit will send the status of its digital inputs to the receivers in the slave units via fibre optics. As soon as the respective slave receives the signal via fibre optics, it switches the output relay and stops the respective WTG. With this type of WTG monitoring, the master unit does not receive feedback as to whether or not the stop command has reached the slave unit without errors.

Another type of slave unit, the Shadow Interface Unit (SIU), can communicate with the master unit directly via TCP/IP. This type of slave unit has four relay outputs: one for the

error message, one for shut-downs due to shadow impact, one for shutdown due to species conservation and one spare output. Optionally, the slave unit can receive and process four analogue signals. The values have to be available as 0(4)…20 mA or as 0…10 V signals. Typical parameters are nacelle position, rotor speed, generated power and wind speed. The connection between the master unit and the slave units can be established either using an existing wind park network or using a network with media converters (Ethernet -> fibre optics or Wireless -> Ethernet) set up separately.

Specifications of slave units

	Shadow Interface Unit		Fibre optics converter
	with analogue inputs	without analogue inputs	
Power supply	110–230 V AC	110–230 V AC	110–230 V AC
Frequency	50–60 Hz	50–60 Hz	50–60 Hz
Max. power consumption	250 mA	250 mA	250 mA
Dimensions (WxHxD)	380x435x225 mm	300x355x225 mm	300x355x225 mm
Weight	12.5 kg	8 kg	8 kg
Protection	IP65	IP65	IP65
Temperature range	-20 °C…50° C	-20 °C…60° C	-20 °C…60° C

3.3 Sensors

In order to take into account various environment-related parameters, you can integrate several sensors into the system for shadow impact monitoring and species conservation. In addition to the light sensor (at least one is required), it is possible to integrate precipitation monitors (optionally with temperature sensor) and hygro-thermo transmitters into the system.

To enable the master unit to determine whether or not shadow impact effects are possible at all at a given point in time, the light sensor measures the sunlight's direct intensity of illumination. Furthermore, the light sensor uses a GPS receiver to provide the master unit with time and location data. Based on the location data, the system determines the exact sunrise and sunset times for the location. For big wind parks or if there are long distances between the WTGs and the sensor location (>1,000 m), deployment of further light sensors may be required in order to ensure that varying light conditions are reliably detected even if the sky is partly cloudy. If it cannot be ruled out that the light sensor of a location might be shadowed, it is possible to install a second light sensor in order to ensure that the light conditions are always assessed correctly. Up to 40 light sensors can be integrated into one

system for shadow impact monitoring and species conservation. The light sensor is mounted on top of the WTG nacelle using a mounting bracket type that fits the respective WTG type.

The precipitation monitor measures the current precipitation and transfers the reading in mm/h. Optionally, it can be fitted with a temperature sensor whose readings will be processed by the precipitation monitor. The results will then be transferred in addition to the precipitation reading.

The hygro-thermo transmitter measures the relative humidity and temperature.

One system can process the readings of 5 precipitation sensors and 5 hygro-thermo transmitters.

All sensors will be supplied with 24 V and communicate via RS485. In order to reduce material and labour costs, sensors may be operated in parallel. Example: a light sensor has to be installed on top of a WTG; a precipitation sensor can be installed in the same place and connected to the same hardware.

To prevent damage to the sensors or the processing electronics, the supply lines to the sensors in the nacelle are protected against overvoltage.
The sensors can be connected to the RS485 interface of the master unit directly using a cable, or, if the master unit is connected to the wind park network, over an RS485 Ethernet interface converter integrated into the wind park network. If the master unit is not connected to the wind park network and if sensors have to be installed on more than one WTG, then another converter will be needed in order to convert the RS485 signal from the sensor and establish the connection to the master unit via fibre optics.

Sensor specifications

	Light sensor (type 01/ type 03)	**Precipitation monitor**	**Hygro-thermo transmitter**
Power supply	24 V DC	24 V DC	24 V DC
Power consumption	500 mA / 900 mA	750 mA	5 mA
Dimensions (WxHxD)	100x81x100 mm	540x170x270 mm	180x275x120 mm
Weight	1.5 kg	4.8 kg	0.45 kg
Protection	IP66	IP65	IP65
Temperature range	-20 °C/-30 °C…50 °C	-40 °C…70 °C	-45 °C…85 °C

Specifications of the RS485 converter

	Separate switch cabinet	Integrated converter
Power supply	110–230 V AC	24 V DC
Power consumption	max. 450 mA	max. 100 mA (w/o sensor)
Dimensions (WxHxD)	300x355x225 mm	150x150x150 mm
Weight	8.3 kg	1 kg
Protection	IP65	IP20
Temperature range	-20 °C…60° C	-20 °C…60° C

4 Software

For proper operation of the system for shadow impact monitoring and species conservation, its master unit needs various data, i.e. data on the places of immission, the WTGs, the sensor system as well as on the shut-down conditions for species conservation. Shadow Manager 4 can transfer this information to the master unit and retrieve information from there through the Ethernet interface (encrypted data transfer).

The data logged by the master unit can be retrieved and displayed using Shadow Manager 4. The retrieved log entries can be reduced to the entries required using customisable filters. Thus, they can be shown and/or printed in a user-friendly manner.

While Shadow Manager 4 is connected to a master unit, a lot of information on the system for shadow impact monitoring and species conservation can be displayed and edited in real-time.

Shadow Manager 4 can only be used if a USB dongle is connected to the computer. Thanks to the use of an USB dongle, it is also possible to trace changes made to the configuration of the master unit, i.e. trace who is responsible for a certain change.

The entire host of functions available in Shadow Manager 4 is described in detail in the accompanying manual.

5 Description of system examples

In the following, we will show various ways in which the system for shadow impact monitoring and species conservation can be set up. Under certain conditions, it may be possible to combine different variations in order to monitor different types of WTGs with just one system for shadow impact monitoring and species conservation.

5.1 Explanation for figure 1

In figure 1, the master unit of the system for shadow impact monitoring and species conservation fully monitors the wind park over the wind park's network.

The master unit receives the operational data of the WTGs from the respective WTG control system and directly sends the status and stop or start signals (as applicable) to the control system. The master unit communicates with the WTG control system via the modbus interface (other protocols possible).

The installed sensors are integrated into the wind park network in the nacelle of the respective WTG using interface converters; thus the master unit can retrieve the values directly.

Using the optional remote maintenance access, it is possible to comfortably control the master unit and change its configuration (if necessary) from a remote location. The installed sensors can also be checked remotely (remote maintenance access).

5.2 Explanation for figure 2

In figure 2, the master unit of the system for shadow impact monitoring and species conservation fully monitors the wind park over the wind park's network.

The master unit receives the operational data of the WTGs via the central server and sends its status as well as stop or start signals (as applicable) to the central server. The master unit is capable of communicating with different server variants. A common type is an OPC server which provides the master unit with the operational data of the WTGs, accepts the stop and start signals and forwards them to the respective WTG.

The installed sensors are integrated into the wind park network in the nacelle of the respective WTG using interface converters; thus the master unit can retrieve the values directly.

Using the optional remote maintenance access, it is possible to comfortably control the master unit and change its configuration (if necessary) from a remote location. The installed sensors can also be checked remotely (remote maintenance access).

5.3 Explanation for figure 3

Figure 3 shows an example of the system for shadow impact monitoring and species conservation in which the master unit monitors the WTGs over the wind park network using slave units.

The operational data of the WTGs can be transmitted to the master unit either over the WTG control system or over the optional analogue inputs of the slave units. The stop and start commands are transmitted to the respective slave unit over the wind park network or handed over by master unit to the WTG control system directly via relay outputs. The slave units hand over the received stop signals through a relay output to a digital input of the WTG control system. The status of the system for shadow impact monitoring and species conservation is output by the master unit and each slave unit through a relay output and can also be processed by the WTG control systems. The status relay is activated (energised) during normal operation. A deactivated relay indicates a defect or a complete failure.

The installed sensors are integrated into the wind park network in the nacelle of the respective WTG using interface converters; thus the master unit can retrieve the values directly.

Using the optional remote maintenance access, it is possible to comfortably control the master unit and change its configuration (if necessary) from a remote location. The installed sensors can also be checked remotely (remote maintenance access).

5.4 Explanation for figure 4

Figure 4 shows an example of the system for shadow impact monitoring and species conservation in which the master unit monitors the WTGs over a separate network with Ethernet -> fibre optics converters using slave units.

The operational data of the WTGs are retrieved by the master unit through its own analogue inputs and through the analogue inputs whose signals are processed by the slave units. The stop and start commands are transmitted to the respective slave unit over the separate network or handed over by master unit to the WTG control system directly through relay outputs. The slave units hand over the received stop signals through a relay output to a digital input of the WTG control system. The status of the system for shadow impact

monitoring and species conservation is output by the master unit and each slave unit through a relay output and can also be processed by the WTG control systems. The status relay is activated (energised) during normal operation. A deactivated relay indicates a defect or a complete failure.

In this example, the master unit is to be installed in a WTG in which also a light sensor will be installed.

The sensor system of the WTG is protected against overvoltage and directly connected to the RS485 interface of the master unit with a cable. If other sensors have to be installed in the wind park, they will also be protected against overvoltage and integrated into the separate network with a cable connection to a RS485-Ethernet converter in the slave unit. Realising a remote maintenance access with this configuration would require further hardware.

5.5 Explanation for figure 5

In this example, the WTG is controlled over the digital outputs of the master unit.

The master unit transmits the status and the stop signal to the digital inputs of the WTGs over its relay outputs. The status relay of the master unit is activated (energised) during normal operation. A deactivated relay indicates a defect or a complete failure.

The other WTGs are controlled via slave units. If a WTG has to be shut down, the master unit will send a digital signal to the input of a media converter; the media converter will then send the digital signal to the slave units via fibre optics. As soon as the respective slave unit receives the signal, it will send the stop command to the input of the WTG control system through a relay output.

The installed sensors are integrated into the wind park network in the nacelle of the respective WTG using interface converters; thus the master unit can retrieve the values directly.

Using the optional remote maintenance access, it is possible to comfortably control the master unit and change its configuration (if necessary) from a remote location. The installed sensors can also be checked remotely (remote maintenance access).

Figure 1: Communication with the WTG control system

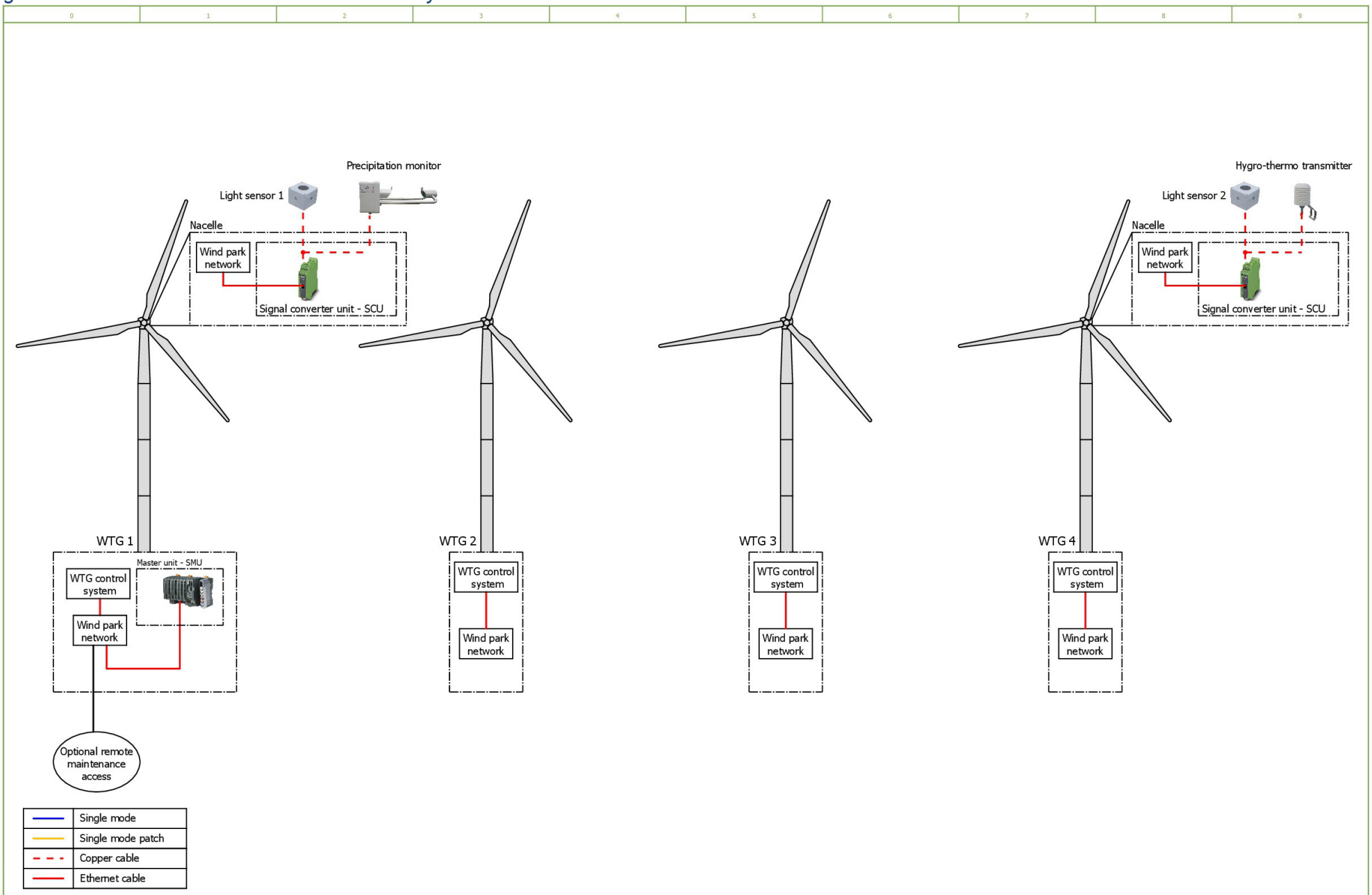

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Figure 2: Communication with the central server

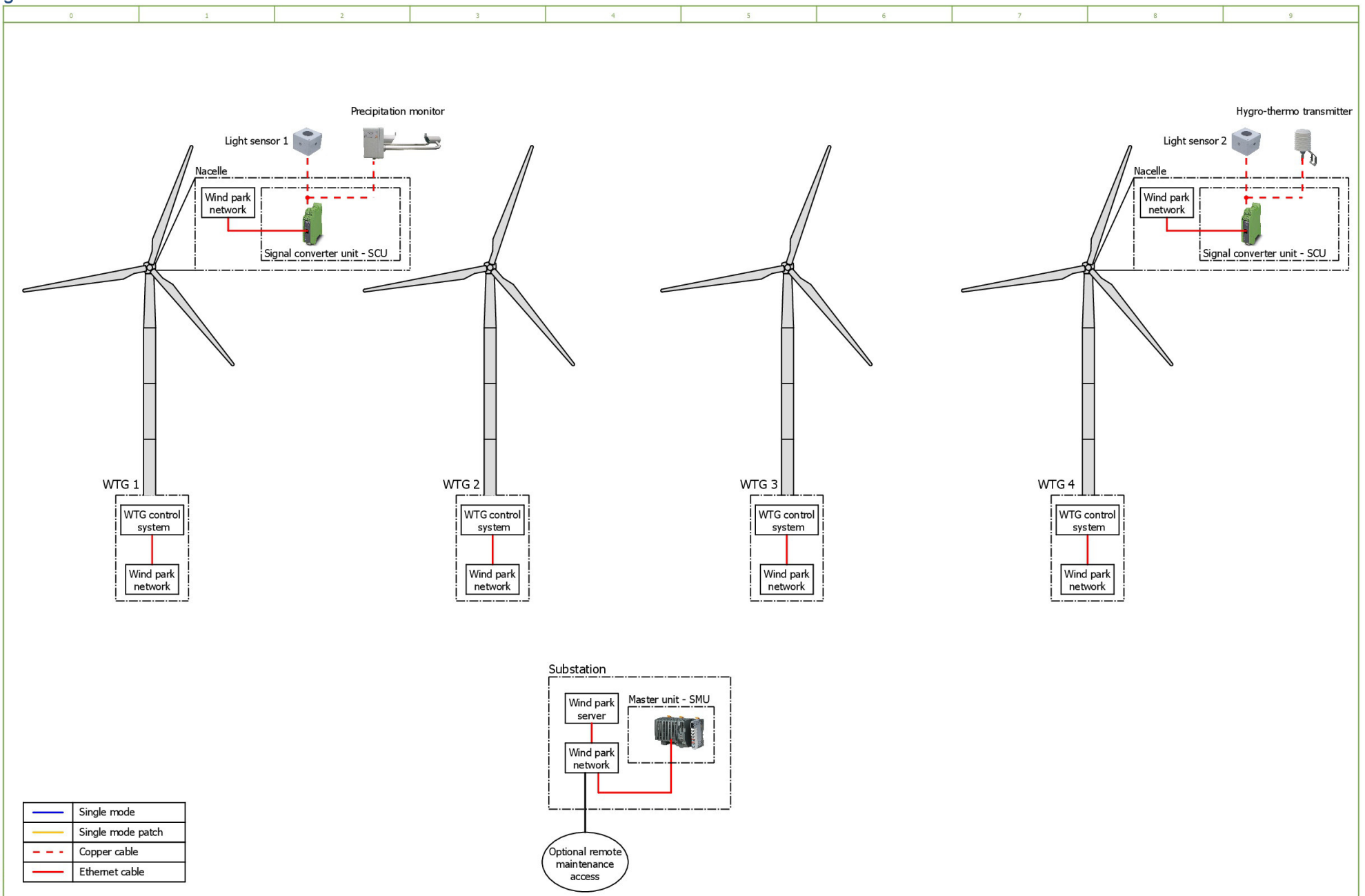

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Figure 3: Slave communication over the wind park network

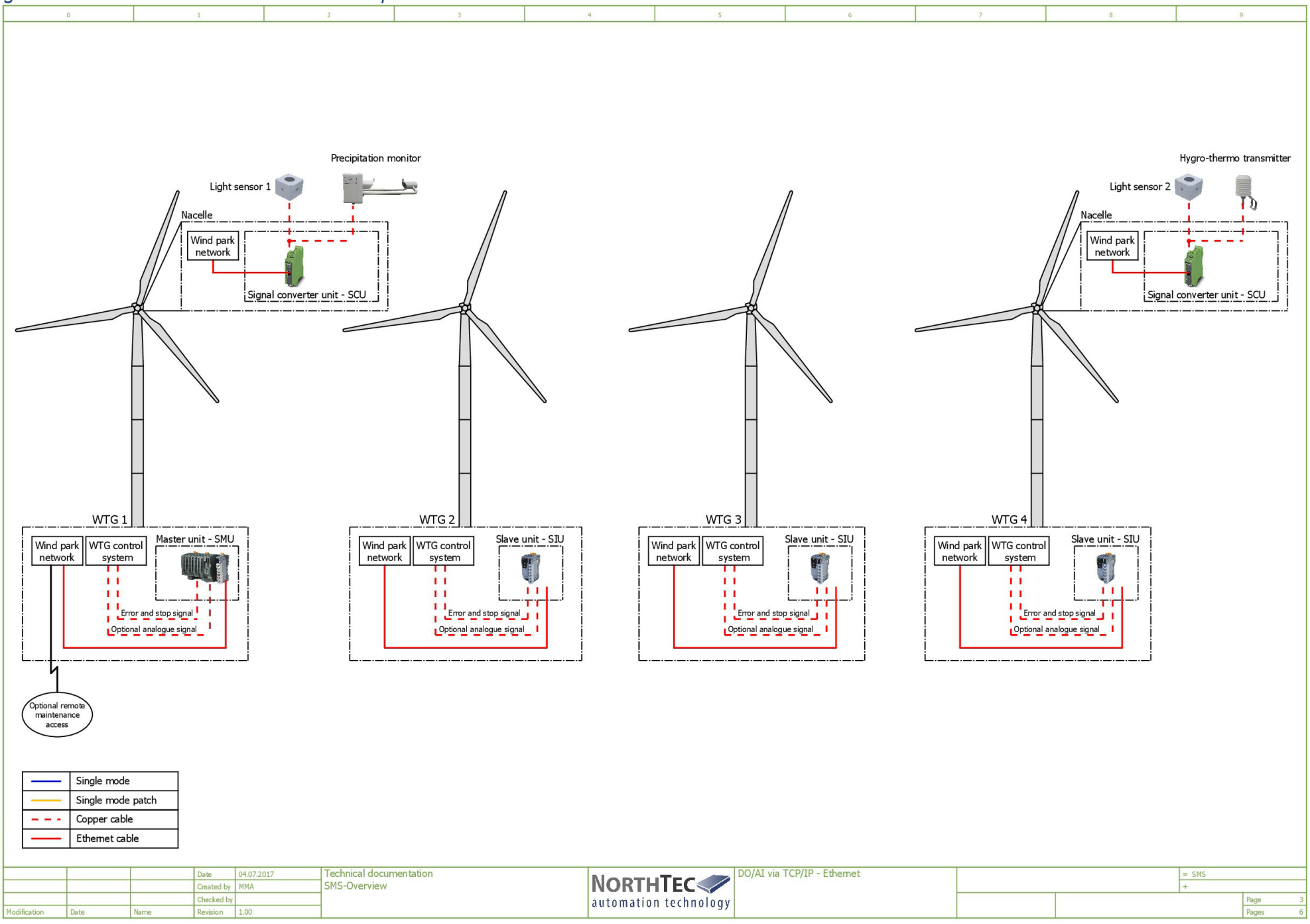

Figure 4: Ethernet over the fibre optics network of the wind park

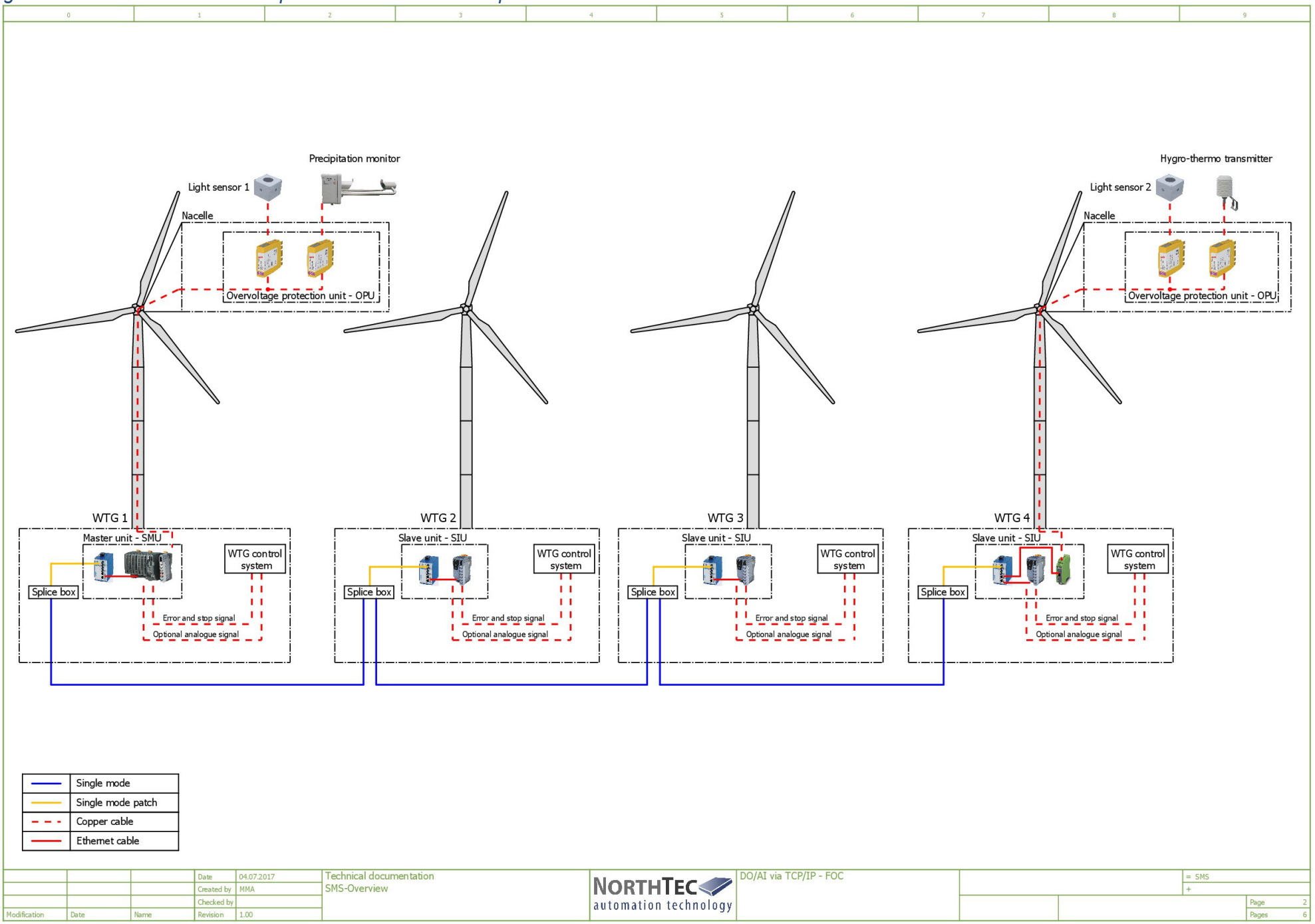

Figure 5: DO over fibre optics