Portable Smart Grids power distribution and management training system.

Bijlage 2:
Concept requirements

HAN/Kenmerk HAN/INK/2018/PS/MSGTD

Version: 1
Executed: purchase department Hogeschool van Arnhem en Nijmegen, the Netherlands.

Date: 20 February 2018

1 Introduction

1.1 General:

This is the description of the requirements of a portable Smart Grids device. This requirements are set up on the basis of a test setup of New Age Learning for an innovation day at the HAN.

1.2 The function of the demonstration, investigation and exercise Smart Grids board:

Het Applied Research Laboratory Engineering (ARLE), a department of HAN Engineering, intends to purchase a portable hardware and software Smart Grids simulation device for laboratory demonstrations, research and exercises for students and employees of companies.

Smart Grids are important in electricity networks to absorb the increasing form of variability. This plays at European level as well as nationally and at regional level. By linking various forms of energy (fossil / nuclear, wind, solar, bio, water, etc.) and intelligently embedding the supply and demand of energy, major steps can be taken.

The panels that must be set up for both education and research must be flexibly and adjustable. Voltage levels and amounts of energy and also in which direction the energy flows must be adjustable and readable. The teacher and researcher must be able to bring in various configurations and link them to his or her own learning environment. The results that come up from the panels must be able to be integrated into the teaching material again.

The panels must consist of five different parts namely four forms of generation of electrical energy: fossil energy, wind energy, solar energy and hydropower energy and one management system including the possibility to realize the storage of electrical energy in a battery (physical device that can also be a car that is charged and discharged at smart times).

The panels must be able to be used as an integrated whole and as (mobile) separate units in teaching and research. (The mobile units must be able to use separately in physically different places.)

The device must have the possibility to create a full European 50Hz electrical grid (like the interchange of hydro power with Norway and HV-interconnections with Germany, Belgium and UK) up to Smart Grids as a local system on city level. The flexibility is very important for users and should be done in minutes for different class situations.
The whole system is in English.

Version: 1
Executed: purchase department Hogeschool van Arnhem en Nijmegen, the Netherlands.

Date: 20 February 2018

1.3 Further technical details:

General specification

Interactive Courses:

- All the experiment setups are delivered with interactive courses including animation, exercise, questions in English language.
- The software can be installed on multiple PC's (no limitation in number of working places) and the contents are compatible with scorm (technical standard for e-learning software).
- A copy of all the courses in English must be delivered with the submission on CD/DVD or USB.

Scada Software:

- All the measurement values can be displayed on the Scada software and can be memorized in a time diagram.
- Export of values is possible as an image or as a table of values.
- The Scada viewing software can be installed on multiple PC's (no limitation in number of working places),
- Open software with room for integrating/programing own models/applications
- A copy of the Scada viewing software must be delivered with the submission of the tender.

Flexible assembling of all the items

=>All the items contain different panels with DIN A4 height, which allows to combine them easily without special tools

=>All the items are delivered on mobile benches

Security and certificates

=>The supplier must have a copy of his CE certificate

<u>Smart Grid Electric Power Distribution device</u>:

Minimal Training contents:

Three-phase double busbar system

- Basic circuits of a three-pole, double busbar system
- Three-phase, double busbar system with load
- Busbar changeover without interruption of the branch
- Preparation of algorithms for various switching operations/Busbar Coupling
  Investigations on Three-phase Transmission Lines
- Voltage increases on open-circuit lines / Voltage drop as a function of line length
- Voltage drop as a function of cos-phi / Phase shift on a line
- Capacitive and inductive power losses on a line as a function of U and I
  Overcurrent time protection for lines
- Designing and parameterizing overcurrent time protection
- Determining the reset ratio in the case of single-, double- and triple-pole short circuit
- Determining a relay‘s shortest release time
- Checking a circuit breaker‘s release behavior in the event of a failure

Minimal training modules with the following minimal characteristics:

4x Double busbar unit, three-phase, incoming/ outgoing feeder

- 2x disconnectors, with remote switching mechanism and auxiliary contact
- 1x heavy-duty switches 10A, with remote switching mechanism and auxiliary contact
- Ethernet Scada control with 2 integrated Ethernet ports
- 3x integrated three phase measurements: voltage 500V, current 5A
- Integrated monitors for over-current, over-voltage, phase angle, voltage differential
- Integrated protection for secured switching manually or remote with Scada

1x Double busbar unit, three-phase, coupler panel

- 2x Isolators, with remote switching mechanism and auxiliary contact
- 1x Circuit breaker 5A, with remote switching mechanism and auxiliary contact
- Ethernet Scada control with 2 integrated Ethernet ports
- 3x integrated three phase measurements: voltage 500V, current 5A

Version: 1
Executed: purchase department Hogeschool van Arnhem en Nijmegen, the Netherlands.

Date: 20 February 2018

- Integrated monitors for over-current, over-voltage, phase angle, voltage differential
- Integrated protection for secured switching manually or remote with Scada

1x Transmission line Model 150 km / 300 km

- Resistance per phase: 3,6Ohm 7,2Ohm / Inductance per phase: 115mH 230mH
- Capacity per phase: Line-to-line: 2 x 150nF 300nF / Line-to-ground: 2 x 0,55µF 1,1µF
- Changing of the simulated line length with overlay and photo-electric detection
- Voltage 3x400V, Current 2A, power min. 900W

1x Time Overcurrent Relay

- Power consumption in the circuit path: 0.1 VA at IN =1A
- Thermal load capacity of current circuit:
  Surge current (half-wave) 250x IN / for 1s 100x IN / for 10s 30x IN / continuous 4x IN
- Output relay: Switch-on current: 20A / Nominal current: 5A
  Max. contact rating: 1250 VA/DC; 120W/DC, Ohmic / 500VA/AC; 75W/DC, inductive
- The integrated interface RS 485 is suitable for setting the relay parameters. It is also possible to store and transmit measured relay values to and from the PC. Optical signal transmission guarantees galvanic isolation.

1x Ohmic load 3x 560 Ohm

2x Power switch module three phase 16A, control voltage 24V,
2 push-buttons

2x Three Phase Power Quality Meter with display and long-term memory

- Three-phase measurement of current and voltage 3x400V/5A
- Measurement of phase voltages, line-to-line voltages and currents
- Determination of the apparent, active and reactive power and work
- Determination of the frequency and distortion factors for current and voltage
- Detection of mains harmonic oscillations and neutral conductor current
- Pulse measurement / Peak and mean value detection
- Large-scale, contrast-rich graphic display with background illumination
- Display in tables, diagrams and vector diagrams
- Digital input and output for free configuration including functions

Minimal other equipment with the following minimal characteristics:

1x Mobile adjustable 3-phase power supply, 0-400V/2A

- 1 Voltmeter 0...450V (moving iron instrument) / 1 Ammeter 0...3A (moving iron instrument)
- 3 Phase control lights
- 1 Measuring point selector switch L1-N, L2-N, L3-N, L1-L2, L1-L3, L2-L3
- 1 Measuring point selector switch I1, I2, I3
- Protection: 3 thermo-magnetic device circuit breakers, Motor protection switch adjustable from 1.6...2.5A, Undervoltage trip

1x Visualization Scada Smart Grid software for creating own models, modifying pre-defined models

- Visualization and remote control ; PLC programming possibility PLC integrated
- Symbolic equipment arrangement of all equipment on the screen
- Standardized electronic circuit symbols for the circuit visualization
- Freely configurable circuit setup
- Individually configurable tabular list of as many measurement values as desired
- Real-time display of measured values and operating states
- Recording and plotting of measured values in diagrams
- Processing, analyzing and export of diagrams
- Creating own control panels
- Implementation and analysis of intelligent grids (Smart Grid)

1x Interactive multimedia course in English

- Interactive experiment setups with animation
- Measured values and diagrams can be stored in the experiment instructions per drag and drop
- Direct link to instruments/measurement and test software from the experiment instructions
- Includes questions with feedback and evaluation logic for progress monitoring
- Documents can be printed out for hardcopy of experiment instructions including solutions

Version: 1
Executed: purchase department Hogeschool van Arnhem en Nijmegen, the Netherlands.

Date: 20 February 2018

1x Mobile aluminum experiment stand, 3 levels

- 30-mm table top made of highly compressed, multi-layer fine chipboard conforming to DIN EN 438-1
- Resistant to heat and many chemicals and reagents including dilute acids and alkalis
- Power strip with 5-outlet sockets and power switch mounted to the table
- 8 equally sized grooves in extruded aluminum profiles
- Protected power distribution 2x CEE sockets 400V 16A, 1x 230V socket, three phase 16A circuit breaker
- Cable holder for 48 safety measuring cables
- Adjustable size PC holder, monitor holder and keyboard holder

Minimum of accessories to provide to guarantee the full functioning:

1x Set of safety measurement cables 4mm and safety connecting plugs 4mm
1x 5 Port Ethernet Switch with Patch cable Cat5E and USB Network adapter
1x USB to RS485 converter for integration of RS485 protection relays to the Scada

<u>Smart Grid Energy Management – Complex Loads:</u>

Minimal Training contents:

Complex loads, power consumption measurement and peak load monitoring

- Three-phase consumers with star and delta connections (R, L, C, RL, RC and RLC loads)
- Measurement with active and reactive energy meters:

- for symmetric and asymmetric RL loads / - in the event of a phase failure
- in the event of over-compensation (RC load) / - for active loads
- in the event of energy-flow reversal

- Determination of the first and second power maxima
- Determination of the power maximum in the event of an asymmetric load
- Recording of load profiles

Dynamic loads

- Dynamic, three-phase load (asynchronous motor)
- Power measurement in the case of energy-flow reversal

Manual and automatic compensation of reactive power

- Operating an asynchronous machine and recording its characteristic parameters
- Calculating parameters for compensation capacitors
- Compensation using various capacitors / Determining stage power
- Manual compensation of reactive power
- Automatic identification of a reactive power controller‘s connections
- Automatic compensation of reactive power

Minimal electrical machines with the following minimal characteristic:

- Industrial machines mounted to a platform with anti-vibration system
  Simple coupling of the machine to the servo-machine without tools
  Colored print of winding scheme on front panel (approx. 170 x 140 mm)
  4mm safety connection sockets pointed out to the front
  Temperature sensor against overheating of the machine integrated in every machine

1x Three-phase asynchronous motor, squirrel-cage, 1kW

Minimal training modules with the following minimal characteristics:

1x Lamp board 230V with 3 lamps Halogen, compact, LED
1x Inductive load, three-phase, 1kW
1x Capacitive load, three-phase, 1kW
1x Ohmic load, three-phase, 1kW
1x Star-Delta switch
1x Power supply for DC, AC, three-phase and synchronous machines.

- Three-phase: L1, L2, L3, N with 4-mm safety sockets
- DC: 0...240VDC variable, controlled with electronic overload and short-circuit protection
  210VDC fixed voltage supplying 6A current
- Output current at least 3...10A (adjustable current limiting)
- Motor protection switch adjustable between 6,3...16A
- Undervoltage cut-out / Safety cut-off

1x Motor protection switch, 3 pole, 1.8-2.5A
1x Power switch module three phase 16A, control voltage 24V,
2 push-buttons

1x Braking System with servo machine test bench for experimenting with electrical machines

- Regulation of the brake possible with and without PC
- Automatic and secured regulation of speed, torque and synchronization mode

Version: 1
Executed: purchase department Hogeschool van Arnhem en Nijmegen, the Netherlands.

Date: 20 February 2018

- Numeric display of speed and torque
- USB interface for command and measurement of mechanic and electric characteristics
- Simulation of 10 different active loads (Pump, compressor, lifting drive, flywheel,…)
- Saving and analyzing data
- Coupling sleeve and Coupling guard

1x Reactive Power controller

- Control contacts: 6 floating relay contacts
- Load rating of the control contacts:
  Switch voltage according to VDE 0110 group B, 400V/AC;
  according to VDE 0110 group C, 250V/AC
- Switching current: 5A, maximum
- Rating: 1800VA, maximum

1x Switchable Capacitor Battery

- Capacitance values:
  State 1: 3 x 2µF, 450 V, 50 Hz / State 2: 3 x 4µF, 450 V, 50 Hz
  State 3: 3 x 8µF, 400 V, 50 Hz / State 4: 3 x 16µF, 400 V, 50 Hz
- Compensating reactive power: max. 1546VAR

1x Three Phase Power Quality Meter with display and long-term memory

- Three-phase measurement of current and voltage 3x400V/5A
- Measurement of phase voltages, line-to-line voltages and currents
- Determination of the apparent, active and reactive power and work
- Determination of the frequency and distortion factors for current and voltage
- Detection of mains harmonic oscillations and neutral conductor current
- Pulse measurement / Peak and mean value detection
- Large-scale, contrast-rich graphic display with background illumination
- Display in tables, diagrams and vector diagrams
- Digital input and output for free configuration including functions

Minimal other equipment with the following minimal characteristics:

1x Interactive multimedia course in English

- Interactive experiment setups with animation
- Measured values and diagrams can be stored in the experiment instructions per drag and drop
- Direct link to instruments/measurement and test software from the experiment instructions

Version: 1
Executed: purchase department Hogeschool van Arnhem en Nijmegen, the Netherlands.

Date: 20 February 2018

- Includes questions with feedback and evaluation logic for progress monitoring
- Documents can be printed out for hardcopy of experiment instructions including solutions

1x Visualization Scada Smart Grid software for pre-defined models

- Visualization and remote control ; PLC programming possibility PLC integrated
- License with unlimited number of PC at the same time

1x Mobile aluminum experiment stand, 3 levels

- 30-mm table top made of highly compressed, multi-layer fine chipboard conforming to DIN EN 438-1
- Resistant to heat and many chemicals and reagents including dilute acids and alkalis
- Power strip with 5-outlet sockets and power switch mounted to the table
- 8 equally sized grooves in extruded aluminum profiles
- Protected power distribution 2x CEE sockets 400V 16A, 1x 230V socket, three phase 16A circuit breaker
- Cable holder for 48 safety measuring cables
- Adjustable size PC holder, monitor holder and keyboard holder

Minimum of accessories to provide to guarantee the full functioning:
1x Set of safety measurement cables 4mm and safety connecting plugs 4mm
1x 5 Port Ethernet Switch with Patch cable Cat5E and USB Network adapter
1x USB to RS485 converter for integration of RS485 protection relays to the Scada

Smart Grid Advanced Photovoltaics:

Minimal Training contents :

- Testing the optimum alignment of solar modules
- Recording the characteristics of solar modules
- Investigating the module's response to shadow formation and how bypass diodes operate
- Learning about various types of wiring and connection configurations for solar modules
- Installation of PV systems
- Design and testing of a standalone PV systems in direct operation and storage operation
- Design and testing of a standalone PV system for the generation of 230 V AC voltage

- Design and testing of PV systems with mains feed / Measure generated power of a PV system
- Determine efficiency of the grid-connected inverter
- Investigate response of a PV system to mains failure

Minimal training modules with the following minimal characteristics:

1x Load unit for solar module 1kOhm

1x Solar panel emulator, 1,5kW / 500V / 10A
- Realistic simulation of solar panels with software control
- Software control including daily sun level and shadow effect
- The system is protected against short circuits

1x 3-phase industrial photovoltaic inverter 3kW
- Photovoltaic inverter consisting of an actual inverter, a monitoring unit and a DC circuit breaker
- Feed management conforming to EEG2012 via separate communications interface
- Power reduction adjustable from 0 to 100% in 1% steps
- Adjustable power factor from 0.8 capacitive to 0.8 inductive
- USB port for remote operation for Scada control and integrated web server
- With Scada software possible reprogramming of complete power synch curve
- Overload voltage protection for photovoltaic and bus terminals
- DC input voltage range: 250-1000V; Output voltage: 3x400 V/50 Hz
- 1x Ohmic load, three-phase, 1kW , 3x750 Ohm

1x Isolating transformer Three-phase, 1kW , 3x400V
- Output voltage 1: 3 x 400V, 2 A
- Output voltage 2: 3 x 30V, 0.2A
- Power rating: 1000 VA, for a short time: 2000VA

1x Three-phase variable transformer with motor drive
- Primary: 3 x 400 V windings / Secondary: 3 x 450 V, 1.25 A windings / Nominal power: 1000 VA
- Protection: 1 automatic circuit breaker, 1.1...1.6 A (adjustable)

1x Power supply for DC, AC, three-phase and synchronous machines.
- Three-phase: L1, L2, L3, N with 4-mm safety sockets
- DC: 0...240VDC variable, controlled with electronic overload and short-circuit protection
  210VDC fixed voltage supplying 6A current

Version: 1
Executed: purchase department Hogeschool van Arnhem en Nijmegen, the Netherlands.

Date: 20 February 2018

- Output current at least 3...10A (adjustable current limiting)
- Motor protection switch adjustable between 6,3...16A
- Undervoltage cut-out / Safety cut-off

1x Instrument system TRMS with USB interface

- Electrically indestructible up to 20A/600V
- Large, high-contrast backlit graphic display (5.7"), display of up to four values (analog or numeric)
- TRMS multimeter / Wattmeter / Power factor meter
- USB interface with numerous virtual instruments like oscilloscope, power consumption meter, display of voltage/current/power

1x Three Phase Power Quality Meter with display and long-term memory

- Three-phase measurement of current and voltage 3x400V/5A
- Measurement of phase voltages, line-to-line voltages and currents
- Determination of the apparent, active and reactive power and work
- Determination of the frequency and distortion factors for current and voltage
- Detection of mains harmonic oscillations and neutral conductor current
- Pulse measurement / Peak and mean value detection
- Large-scale, contrast-rich graphic display with background illumination
- Display in tables, diagrams and vector diagrams
- Digital input and output for free configuration including functions

1x Double busbar unit, three-phase, incoming / outgoing feeder

- 2x disconnectors, with remote switching mechanism and auxiliary contact
- 1x heavy-duty switches 10A, with remote switching mechanism and auxiliary contact
- Ethernet Scada control with 2 integrated Ethernet ports
- 3x integrated three phase measurements: voltage 500V, current 5A
- Integrated monitors for over-current, over-voltage, phase angle, voltage differential
- Integrated protection for secured switching manually or remote with Scada

Minimal other equipment with the following minimal characteristics:

1x Solar module with solar altitude emulator

- Various rooftop angles can be emulated using the tilt adjustment of the solar module

- Peak power: 10 Wp / No-load voltage: 21 V

1x Visualization Scada Smart Grid software for pre-defined models

1. Visualization and remote control ; PLC programming possibility PLC integrated
2. License with unlimited number of PC at the same time

1x Interactive multimedia course in English

- Interactive experiment setups with animation
- Measured values and diagrams can be stored in the experiment instructions per drag and drop
- Direct link to instruments/measurement and test software from the experiment instructions
- Includes questions with feedback and evaluation logic for progress monitoring
- Documents can be printed out for hardcopy of experiment instructions including solutions

1x Mobile aluminum experiment stand, 3 levels

- 30-mm table top made of highly compressed, multi-layer fine chipboard conforming to DIN EN 438-1
- Resistant to heat and many chemicals and reagents including dilute acids and alkalis
- Power strip with 5-outlet sockets and power switch mounted to the table
- 8 equally sized grooves in extruded aluminum profiles
- Protected power distribution 2x CEE sockets 400V 16A, 1x 230V socket, three phase 16A circuit breaker
- Cable holder for 48 safety measuring cables
- Adjustable size PC holder, monitor holder and keyboard holder

Minimum of accessories to provide to guarantee the full functioning:

1x Set of safety measurement cables 4mm and safety connecting plugs 4mm
1x 5 Port Ethernet Switch with Patch cable Cat5E and USB Network adapter

Smart Grid Battery storage:

Minimal Training contents :

- Design and installation of the battery storage unit
- Putting the storage unit into operation

Version: 1
Executed: purchase department Hogeschool van Arnhem en Nijmegen, the Netherlands.

Date: 20 February 2018

- Remote control of energy storage units using SCADA software
- Optimizing operating response through smart consumers (loads)
- Storage unit integration into a smart grid

Specific characteristic of the equipment :

1x Energy storage system

- 3 phase grid inverter with lithium-iron-phosphate battery storage
- Battery capacity min. 1.8 kWh / Nominal power of the inverter 1.4 kW
- Long life battery for 20 years and > 10.000 charge cycles
- Multi-touch display for power information and integrated web server
- Reactive power control over the Scada software
- 3 phase B6A automatic circuit breaker

Minimal other equipment with the following minimal characteristics:

1x Interactive multimedia course in English

- Interactive experiment setups with animation
- Measured values and diagrams can be stored in the experiment instructions per drag and drop
- Direct link to instruments/measurement and test software from the experiment instructions
- Includes questions with feedback and evaluation logic for progress monitoring
- Documents can be printed out for hardcopy of experiment instructions including solutions

1x Mobile aluminum experiment stand, 3 levels

- 30-mm table top made of highly compressed, multi-layer fine chipboard conforming to DIN EN 438-1
- Resistant to heat and many chemicals and reagents including dilute acids and alkalis
- Power strip with 5-outlet sockets and power switch mounted to the table
- 8 equally sized grooves in extruded aluminum profiles

<u>Smart Grid Hydro Power and electrical power stations:</u>

Minimal Training contents :

- How water plants and pumped storage power plants operate
- Start and synchronization of synchronous machines
- Manual power regulation: both in generator and motor modes

- Semi-automatic active and reactive power control
- Smart grid integration of pumped storage power plants
- Fully-automatic compensation for externally measured active and reactive power
- SCADA open and closed-loop system control
- Additional power plants models minimum lignite, coal-fired, gas turbine, biogas combined heat and power (cogeneration), nuclear power plants

Minimal electrical machines with the following minimal characteristic:

- Industrial machines mounted to a platform with anti-vibration system
  Simple coupling of the machine to the servo-machine without tools
  Colored print of winding scheme on front panel (approx. 170 x 140 mm)
  4mm safety connection sockets pointed out to the front
  Temperature sensor against overheating of the machine integrated in every machine

1x Three-phase synchronous machine with smooth core rotor, 800W

- 1500rpm nominal speed, exiting current approx. 1,5A, exiting voltage approx. 220V
- Integrated starting button with starting resistance

Minimal training modules with the following minimal characteristics:

1x HMI (Human Machine Interface) for generators

- Three-phase measurement of current and voltage 3x400V/5A
- Measurement of phase voltages, line-to-line voltages and currents
- Determination of the apparent, active and reactive power / apparent work
- Determination of the frequency and distortion factors for current and voltage
- Detection of harmonic oscillations and neutral conductor current in the electricity supply
- Pulse measurement / Peak and mean value detection / Event logging, Real-time clock
- Large-scale, contrast-rich graphic display with background illumination
- Display in tables, diagrams and vector diagrams
- 2 digital inputs / 6 digital outputs / Ethernet interface

1x Synchronization Unit three phase

- synchronizer display (comprising 3 lamps) is used to display voltage and phase angles between generator and power supply circuit (light-dark indication)
- zero voltmeter / double frequency meter / double voltmeter / digital Synchronoscope
- Operating voltage: 400V

1x Multi-function relay, power controller, cos-phi controller, synchronizing unit

- Measuring voltage: 180...440 V/AC / Measuring frequency: 40....85 Hz
- Measuring current: 2.5 A
- Outputs: Relay manager with 3 floating relays
  Synchronizing output LS-on / Ls-off
- Inputs: Circuit-breaker (LS) acknowledgment signaling
- Displays: 2 LED – Alarm, Stop / red lamp – Circuit-breaker (LS) on
  128×64 dot graphical interactive LC display with soft keys
- Interfaces: 2 x USB / Motor protection switch, 1 - 1.6A

1x Power switch module three phase 16A, control voltage 24V, 2 push-buttons

1x Ohmic load, three-phase, 1kW
1x Inductive load, three-phase, 1kW
1x Braking System with servo machine test bench for experimenting with electrical machines

- Regulation of the brake possible with and without PC
- Automatic and secured regulation of speed, torque and synchronization mode
- Numeric display of speed and torque
- USB interface for command and measurement of mechanic and electric characteristics
- Simulation of 10 different active loads (Pump, compressor, lifting drive, flywheel,…)
- Saving and analyzing data
- Coupling sleeve and Coupling guard

1x Power supply for DC, AC, three-phase and synchronous machines.

- Three-phase: L1, L2, L3, N with 4-mm safety sockets
- DC: 0...240VDC variable, controlled with electronic overload and short-circuit protection
  210VDC fixed voltage supplying 6A current
- Output current at least 3...10A (adjustable current limiting)

- Motor protection switch adjustable between 6,3...16A
- Undervoltage cut-out / Safety cut-off

1x Exciter voltage controller with de-excitation
- Output: DC 200V / 2A
- 2 inputs for voltage boosting and decreasing
- 1 input for de-excitation using a relay
- 2 pushbuttons for switching the DC voltage on and off
- Incremental rotary encoder for setting the voltage

1x Motor protection switch, 3 pole, 1.8-2.5A
1x Three Phase Power Quality Meter with display and long-term memory
- Three-phase measurement of current and voltage 3x400V/5A
- Measurement of phase voltages, line-to-line voltages and currents
- Determination of the apparent, active and reactive power and work
- Determination of the frequency and distortion factors for current and voltage
- Detection of mains harmonic oscillations and neutral conductor current
- Pulse measurement / Peak and mean value detection
- Large-scale, contrast-rich graphic display with background illumination
- Display in tables, diagrams and vector diagrams
- Digital input and output for free configuration including functions
-

1x Double busbar unit, three-phase, incoming / outgoing feeder
- 2x disconnectors, with remote switching mechanism and auxiliary contact
- 1x heavy-duty switches 10A, with remote switching mechanism and auxiliary contact
- Ethernet Scada control with 2 integrated Ethernet ports
- 3x integrated three phase measurement: voltage 500V, current 5A
- Integrated monitors for over-current, over-voltage, phase angle, voltage differential
- Integrated protection for secured switching manually or remote with Scada

Minimal other equipment with the following minimal characteristics:

1x Visualization Scada Smart Grid software for pre-defined models
3. Visualization and remote control ; PLC programming possibility PLC integrated
4. License with unlimited number of PC at the same time

1x Interactive multimedia course in English
- Interactive experiment setups with animation

Version: 1
Executed: purchase department Hogeschool van Arnhem en Nijmegen, the Netherlands.

Date: 20 February 2018

- Measured values and diagrams can be stored in the experiment instructions per drag and drop
- Direct link to instruments/measurement and test software from the experiment instructions
- Includes questions with feedback and evaluation logic for progress monitoring
- Documents can be printed out for hardcopy of experiment instructions including solutions

1x Mobile aluminum experiment stand, 3 levels

- 30-mm table top made of highly compressed, multi-layer fine chipboard conforming to DIN EN 438-1
- Resistant to heat and many chemicals and reagents including dilute acids and alkalis
- Power strip with 5-outlet sockets and power switch mounted to the table
- 8 equally sized grooves in extruded aluminum profiles
- Protected power distribution 2x CEE sockets 400V 16A, 1x 230V socket, three phase 16A circuit breaker
- Cable holder for 48 safety measuring cables
- Adjustable size PC holder, monitor holder and keyboard holder

Minimum of accessories to provide to guarantee the full functioning:
1x Set of safety measurement cables 4mm and safety connecting plugs 4mm
1x 5 Port Ethernet Switch with Patch cable Cat5E and USB Network adapter

Smart Grid Wind power plants with DFIG and three phase synchronization:

Minimal Training contents :

- Explore the physical fundamentals from wind to wave
- Learn about different wind power concepts
- Set up and commission a double-feed asynchronous wind generator
- Operate the generator with varying wind force levels and regulate the output voltage and frequency

- Determine optimum operating points under changing wind conditions
- Detailed emulation of a modern wind power station
- Measurement, calculation and graphic representation of all mechanical and electrical operating parameters (SCADA)
- Automatic or manual operation
- Selection of set point values for active and reactive power
- Definition and emulation of wind power and wind profiles
- Operating with various wind forces including pitch control
- Step-by-step initial setup and commissioning to demonstrate functional operation

Minimal electrical machines with the following minimal characteristic:

- Industrial machines mounted to a platform with anti-vibration system
  Simple coupling of the machine to the servo-machine without tools
  Colored print of winding scheme on front panel (20pprox.. 170 x 140 mm)
  4mm safety connection sockets pointed out to the front
  Temperature sensor against overheating of the machine integrated in every machine

1x Three-phase asynchronous motor with slip-rings (also used as synchronous machine), 800W

Minimal training modules with the following minimal characteristics:

1x Control unit for wind turbine double-fed asynchronous generator incl. software

- Control unit with two controlled three-phase inverters
- Operation of the double-feed asynchronous generator in under-synchronous and over-synchronous operating mode
- Integrated power switch for switching the generator on line
- Autonomous control of reactive and active power, frequency, voltage
- Manual and automatic mains synchronization
- USB interface / Input for incremental shaft-encoder
- Integrated brake chopper permits Fault Ride Through experiments
- 1x 3-phase isolation transformer, 1kW for wind power plants
- Primary voltage: 3 x 400 V / Secondary: 3 x 300 V / Rated power: 1000 VA
- 1x Braking System with servo machine test bench for experimenting with electrical machines
- Regulation of the brake possible with and without PC
- Automatic and secured regulation of speed, torque and synchronization mode

- Numeric display of speed and torque
- USB interface for command and measurement of mechanic and electric characteristics
- Simulation of 10 different active loads (Pump, compressor, lifting drive, flywheel,…)
- Saving and analyzing data
- Coupling sleeve and Coupling guard

1x Power supply for DC, AC, three-phase and synchronous machines.

- Three-phase: L1, L2, L3, N with 4-mm safety sockets
- DC: 0…240VDC variable, controlled with electronic overload and short-circuit protection
  210VDC fixed voltage supplying 6A current
- Output current at least 3…10A (adjustable current limiting)
- Motor protection switch adjustable between 6,3…16A
- Undervoltage cut-out / Safety cut-off

1x Instrument system TRMS with USB interface

- Electrically indestructible up to 20A/600V
- Large, high-contrast backlit graphic display (5.7”), display of up to four values (analog or numeric)
- TRMS multimeter / Wattmeter / Power factor meter
- USB interface with numerous virtual instruments like oscilloscope, power consumption meter, display of voltage/current/power

1x Three Phase Power Quality Meter with display and long-term memory

- Three-phase measurement of current and voltage 3x400V/5A
- Measurement of phase voltages, line-to-line voltages and currents
- Determination of the apparent, active and reactive power and work
- Determination of the frequency and distortion factors for current and voltage
- Detection of mains harmonic oscillations and neutral conductor current
- Pulse measurement / Peak and mean value detection
- Large-scale, contrast-rich graphic display with background illumination
- Display in tables, diagrams and vector diagrams
- Digital input and output for free configuration including functions

1x Double busbar unit, three-phase, incoming / outgoing feeder

- 2x disconnectors, with remote switching mechanism and auxiliary contact
- 1x heavy-duty switches 10A, with remote switching mechanism and auxiliary contact
- Ethernet Scada control with 2 integrated Ethernet ports

Version: 1
Executed: purchase department Hogeschool van Arnhem en Nijmegen, the Netherlands.

Date: 20 February 2018

- 3x integrated three phase measurement: voltage 500V, current 5A
- Integrated monitors for over-current, over-voltage, phase angle, voltage differential
- Integrated protection for secured switching manually or remote with Scada

Minimal other equipment with the following minimal characteristics:

1x Incremental position encoder 1024 pulses

1x Interactive multimedia course in English

- Interactive experiment setups with animation
- Measured values and diagrams can be stored in the experiment instructions per drag and drop
- Direct link to instruments/measurement and test software from the experiment instructions
- Includes questions with feedback and evaluation logic for progress monitoring
- Documents can be printed out for hardcopy of experiment instructions including solutions

1x Visualization Scada Smart Grid software for pre-defined models

5. Visualization and remote control ; PLC programming possibility PLC integrated
6. License with unlimited number of PC at the same time

1x Mobile aluminum experiment stand, 3 levels

- 30-mm table top made of highly compressed, multi-layer fine chipboard conforming to DIN EN 438-1
- Resistant to heat and many chemicals and reagents including dilute acids and alkalis
- Power strip with 5-outlet sockets and power switch mounted to the table
- 8 equally sized grooves in extruded aluminum profiles
- Protected power distribution 2x CEE sockets 400V 16A, 1x 230V socket, three phase 16A circuit breaker
- Cable holder for 48 safety measuring cables
- Adjustable size PC holder, monitor holder and keyboard holder

Minimum of accessories to provide to guarantee the full functioning:

1x Set of safety measurement cables 4mm and safety connecting plugs 4mm

<u>Smart grid High voltage transformers (extension for previous items)</u>:

Minimal Training contents:

- Transformer equivalent circuit diagram
- Multiphase transformer operating at no-load and short-circuit
- Multiphase transformer with Ohmic, inductive and capacitive load
- Parallel operation of multiphase transformers
- Current distribution for different vector groups
- Determining zero impedance / Investigating the transformation ratio

Specific characteristic of the equipment:

1x Double busbar unit, three-phase, incoming / outgoing feeder

- 2x disconnectors, with remote switching mechanism and auxiliary contact
- 1x heavy-duty switches 10A, with remote switching mechanism and auxiliary contact
- Ethernet Scada control with 2 integrated Ethernet ports
- 3x integrated three phase measurement: voltage 500V, current 5A
- Integrated monitors for over-current, over-voltage, phase angle, voltage differential
- Integrated protection for secured switching manually or remote with Scada

Minimal other equipment with the following minimal characteristics:

1x Interactive multimedia course in English

- Interactive experiment setups with animation
- Measured values and diagrams can be stored in the experiment instructions per drag and drop
- Direct link to instruments/measurement and test software from the experiment instructions
- Includes questions with feedback and evaluation logic for progress monitoring
- Documents can be printed out for hardcopy of experiment instructions including solutions

Version: 1
Executed: purchase department Hogeschool van Arnhem en Nijmegen, the Netherlands.

Date: 20 February 2018

Smart grid High voltage transmission line Three phase and line protection

Minimal Training contents:

Investigations on Three-phase Transmission Lines

- Voltage increases on open-circuit lines / Voltage drop as a function of line length
- Voltage drop as a function of cos-phi
- Capacitive and inductive power losses on a line as a function of U and I
- Phase shift on a line

Transmission Line with Earth-fault Compensation

- Earth fault on a line with an isolated star point
- Response to earth faults / Earth-fault compensation

Parallel and series connection of transmission lines

- Distribution of power and current among parallel/series-connected lines of equal/unequal length
- Load distribution, power flow
- Voltage distribution
- Quantitative and qualitative evaluations of operational relationships

Overvoltage and undervoltage protection

- Determining rise/ fall times, the reset ratio, the inherent time
- Setting and testing various characteristics

Minimal training equipment:

1x Transmission line Model 150 km / 300 km

- Resistance per phase: 3,6Ohm 7,2 Ohm / Inductance per phase: 115mH 230mH
- Capacity per phase: Line-to-line: 2 x 150nF 300nF / Line-to-ground: 2 x 0,55µF 1,1µF
- Changing of the simulated line length with overlay and photo-electric detection
- Voltage 3x400V, Current 2A, power min. 900W

1x Earth fault compensation unit

- Compensation between the neutral line and the earth

Version: 1
Executed: purchase department Hogeschool van Arnhem en Nijmegen, the Netherlands.

Date: 20 February 2018

- Current min 0,4A; Coil 1.0 to 2.0H, 9 variable stages

1x Cable Model 12,5 km / 37,5 km (7.8 miles / 23.3 miles)

- Resistance per phase: 0,25Ohm 0,75 Ohm
- Inductance per phase: 6,25mH 18,75mH
- Capacity per phase: 2 x 2µF 6µF
- Max power consumption: 400W
- Voltage: 3x 110V; 50/60Hz
- Current: 1A

1x Conversion station 380V/110V

- Primary: 3 x 380-V windings
- Secondary: 3 x 110-V windings
- Nominal power: 400VA
- Vector group: YNyn0
- Protection: 1 automatic circuit breaker, 0.7...1 A (adjustable)

1x Time Over / Undervoltage Relay; 100V / 110V / 230V / 400V; 3,5VA

- Thermal stability: 1.3x UN (constant)
- Resert ratio: Adjustable, via the hysteresis
- Release time: 300ms
- Output relay: Switch-on current: 20A / Nominal current: 5A
  Max. contact rating: 250 VA/DC; 120W/DC, Ohmic / 500VA/AC; 75W/DC, inductive
- Potentiometer controls:
  for U</UN 70%...110% / for U>/UN 90%...130% / for t = 0s...10s / for differential 2%...10%
- The integrated interface RS 485 is suitable for setting the relay parameters. It is also possible to store and transmit measured relay values to and from the PC. Optical signal transmission guarantees galvanic isolation.

1x Three Phase Power Quality Meter with display and long-term memory

- Three-phase measurement of current and voltage 3x400V/5A
- Measurement of phase voltages, line-to-line voltages and currents
- Determination of the apparent, active and reactive power and work
- Determination of the frequency and distortion factors for current and voltage
- Detection of mains harmonic oscillations and neutral conductor current
- Pulse measurement / Peak and mean value detection
- Large-scale, contrast-rich graphic display with background illumination
- Display in tables, diagrams and vector diagrams
- Digital input and output for free configuration including functions

Version: 1
Executed: purchase department Hogeschool van Arnhem en Nijmegen, the Netherlands.

Date: 20 February 2018

1x Double busbar unit, three-phase, incoming / outgoing feeder

- 2x disconnectors, with remote switching mechanism and auxiliary contact
- 1x heavy-duty switches 10A, with remote switching mechanism and auxiliary contact
- Ethernet Scada control with 2 integrated Ethernet ports
- 3x integrated three phase measurement: voltage 500V, current 5A
- Integrated monitors for over-current, over-voltage, phase angle, voltage differential
- Integrated protection for secured switching manually or remote with Scada

Minimal other equipment with the following minimal characteristics:

1x Interactive multimedia course in English

- Interactive experiment setups with animation
- Measured values and diagrams can be stored in the experiment instructions per drag and drop
- Direct link to instruments/measurement and test software from the experiment instructions
- Includes questions with feedback and evaluation logic for progress monitoring
- Documents can be printed out for hardcopy of experiment instructions including solutions

1x Mobile aluminum experiment stand, 3 levels

- 30-mm table top made of highly compressed, multi-layer fine chipboard conforming to DIN EN 438-1
- Resistant to heat and many chemicals and reagents including dilute acids and alkalis
- Power strip with 5-outlet sockets and power switch mounted to the table
- 8 equally sized grooves in extruded aluminum profiles
- Protected power distribution 2x CEE sockets 400V 16A, 1x 230V socket, three phase 16A circuit breaker
- Cable holder for 48 safety measuring cables
- Adjustable size PC holder, monitor holder and keyboard holder

Minimum of accessories to provide to guarantee the full functioning:

1x Set of safety measurement cables 4mm and safety connecting plugs 4mm

1x 5 Port Ethernet Switch with Patch cable Cat5E and USB Network adapter
1x USB to RS485 converter for integration of RS485 protection relays to the Scada

Smart grid High voltage transmission line Three phase and line protection:

Minimal Training contents :

Investigations on Three-phase Transmission Lines

- Voltage increases on open-circuit lines / Voltage drop as a function of line length
- Voltage drop as a function of cos-phi
- Capacitive and inductive power losses on a line as a function of U and I
- Phase shift on a line

Transmission Line with Earth-fault Compensation

- Earth fault on a line with an isolated star point
- Response to earth faults / Earth-fault compensation

Parallel and series connection of transmission lines

- Distribution of power and current among parallel/series-connected lines of equal/unequal length
- Load distribution, power flow
- Voltage distribution
- Quantitative and qualitative evaluations of operational relationships

Overvoltage and undervoltage protection

- Determining rise/ fall times, the reset ratio, the inherent time
- Setting and testing various characteristics

Minimal training equipment:

1x Transmission line Model 150 km / 300 km

- Resistance per phase: 3,6Ohm 7,2 Ohm / Inductance per phase: 115mH 230mH
- Capacity per phase: Line-to-line: 2 x 150nF 300nF / Line-to-ground: 2 x 0,55µF 1,1µF
- Changing of the simulated line length with overlay and photo-electric detection
- Voltage 3x400V, Current 2A, power min. 900W

1x Earth fault compensation unit

- Compensation between the neutral line and the earth
- Current min 0,4A; Coil 1.0 to 2.0H, 9 variable stages

1x Cable Model 12,5 km / 37,5 km (7.8 miles / 23.3 miles)

- Resistance per phase: 0,25Ohm 0,75 Ohm
- Inductance per phase: 6,25mH 18,75mH
- Capacity per phase: 2 x 2µF 6µF
- Max power consumption: 400W
- Voltage: 3x 110V; 50/60Hz
- Current: 1A

1x Conversion station 380V/110V

- Primary: 3 x 380-V windings
- Secondary: 3 x 110-V windings
- Nominal power: 400VA
- Vector group: YNyn0
- Protection: 1 automatic circuit breaker, 0.7...1 A (adjustable)

1x Time Over / Undervoltage Relay; 100V / 110V / 230V / 400V ; 3,5VA

- Thermal stability: 1.3x UN (constant)
- Resert ratio: Adjustable, via the hysteresis
- Release time: 300ms
- Output relay: Switch-on current: 20A / Nominal current: 5A
  Max. contact rating: 250 VA/DC; 120W/DC, Ohmic / 500VA/AC; 75W/DC, inductive
- Potentiometer controls:
  for U</UN 70%...110% / for U>/UN 90%...130% / for t = 0s...10s / for differential 2%...10%
- The integrated interface RS 485 is suitable for setting the relay parameters. It is also possible to store and transmit measured relay values to and from the PC. Optical signal transmission guarantees galvanic isolation.

1x Three Phase Power Quality Meter with display and long-term memory

- Three-phase measurement of current and voltage 3x400V/5A
- Measurement of phase voltages, line-to-line voltages and currents
- Determination of the apparent, active and reactive power and work
- Determination of the frequency and distortion factors for current and voltage
- Detection of mains harmonic oscillations and neutral conductor current
- Pulse measurement / Peak and mean value detection
- Large-scale, contrast-rich graphic display with background illumination
- Display in tables, diagrams and vector diagrams

Version: 1
Executed: purchase department Hogeschool van Arnhem en Nijmegen, the Netherlands.

Date: 20 February 2018

- Digital input and output for free configuration including functions

1x Double busbar unit, three-phase, incoming / outgoing feeder
- 2x disconnectors, with remote switching mechanism and auxiliary contact
- 1x heavy-duty switches 10A, with remote switching mechanism and auxiliary contact
- Ethernet Scada control with 2 integrated Ethernet ports
- 3x integrated three phase measurement: voltage 500V, current 5A
- Integrated monitors for over-current, over-voltage, phase angle, voltage differential
- Integrated protection for secured switching manually or remote with Scada

Minimal other equipment with the following minimal characteristics:

1x Interactive multimedia course in English
- Interactive experiment setups with animation
- Measured values and diagrams can be stored in the experiment instructions per drag and drop
- Direct link to instruments/measurement and test software from the experiment instructions
- Includes questions with feedback and evaluation logic for progress monitoring
- Documents can be printed out for hardcopy of experiment instructions including solutions

1x Mobile aluminum experiment stand, 3 levels
- 30-mm table top made of highly compressed, multi-layer fine chipboard conforming to DIN EN 438-1
- Resistant to heat and many chemicals and reagents including dilute acids and alkalis
- Power strip with 5-outlet sockets and power switch mounted to the table
- 8 equally sized grooves in extruded aluminum profiles
- Protected power distribution 2x CEE sockets 400V 16A, 1x 230V socket, three phase 16A circuit breaker
- Cable holder for 48 safety measuring cables
- Adjustable size PC holder, monitor holder and keyboard holder

<u>Smart grid Cyber Security</u>:

Minimal Training contents:

- Code of practice for use of systems
- Physical measures

Version: 1
Executed: purchase department Hogeschool van Arnhem en Nijmegen, the Netherlands.

Date: 20 February 2018

- Configuration of a secure LAN router
  - Configuration via command line interface (CLI) and via web interface
  - DHCP server
  - Firewall
  - Open VPN
  - Sinema RC
  - Administration of X.509 certificates
  - (Error) analysis via log files
- Open VPN
  - Open source software
  - Setting up X.509 certificates
  - Setting up an encrypted VPN connection
- Analysis of network protocols
  - Open source network protocol analyzer
  - Secure Shell (SSH)
  - Telnet
  - HTTP(S)
  - Open VPN
- Remote maintenance using Sinema RC
  - User administration
  - Access control
  - Encryption using Open VPN
- Integration of equipment into a security structure
  - Configuration of device-specific security mechanisms
    - Encryption
    - Access restrictions
  - Automation
    - PLC
    - ERP
  - Energy management
    - SCADA
- Analysis of access rights
  - Open source utility for network discovery and security auditing

Minimal training equipment:

1x Security LAN Router

- Use of state full inspection firewall
- Product function for VPN connection: IPsec, Open VPN (client for SINEMA RC)
- Types of encoding algorithms (VPN connection): AES-256, AES-192, AES-128, 3DES-168, DES-56

- Types of authentication procedures (VPN connection): pre-shared key (PSK), X.509v3 certificates
- Types of hashing algorithm (VPN connection): MD5, SHA-1
- Number of allowable connections (VPN connection): 20
- Password protection
- Addressing: NAT/NAPT
- Connection to SINEMA RC
- 1x Digital output/1x Digital input
- Removable media: C-PLUG

Minimal other equipment with the following minimal characteristics:

1x Interactive multimedia course in English
- Interactive experiment setups with animation
- Measured values and diagrams can be stored in the experiment instructions per drag and drop
- Direct link to instruments/measurement and test software from the experiment instructions
- Includes questions with feedback and evaluation logic for progress monitoring
- Documents can be printed out for hardcopy of experiment instructions including solutions

1x USB to RS485 converter for integration of RS485 protection relays to the Scada

Installation and Training

1x Installation on place (3 days)
- Mounting of the delivered material on place

1x Training (3 days)
- Training on the delivered material
- For min 6 participants

Administration software for training systems (license with 1 dongle):

- Compatible with all the courses of the different items
- Administration program: Administration of students and courses
- Reporting program: Student reports and statistics
- Editing program: Creation and editing of courses of previous items
- Question editing program: Creation of electronically evaluable questions, measuring exercises and sets of questions for courses and tests

- Exam creation program: Automatic generation of tests based on a library of questions

Version: 1
Executed: purchase department Hogeschool van Arnhem en Nijmegen, the Netherlands.

Date: 20 February 2018