

Refrigeration System Technology

Practical Training for a Safer Future

The easy way to understanding the fundamentals of refrigeration process control and refrigeration circuitry



Contents

Training systems manufactured by Lucas-Nülle for the topic of refrigeration technology are based on a syllabus used in training programmes for "Mechatronics technicians for refrigeration technology". For each of the training systems in this catalogue, you can see which topic the system is designed for by reading the page headers:

Training topic:

Investigation and functional testing of electrical system components in refrigeration and air conditioning systems 10-13

Students are to measure voltage, current and resistance in electric circuits and make an evaluation of the results. They should determine the power consumption and evaluate them in the light of ecological and economic aspects. They will assemble electric circuits, put them into operation and test how they work. They will analyse faults, describe them and suggest solutions to them.

Training topic:

Planning and carrying out installation of a single phase AC network 14, 22-23

Students are to plan typical steps in the work of installing and/or connecting electrical components. They should also determine the procedure for fulfilling a job order, obtaining materials and liaising with others working on the building. They should select equipment appropriate to the relevant standards and coordinate their working procedures. As they install the components they should also take into account prevention of accidents, operational safety and cost efficiency. They are to carry out measures to protect people and equipment. They will then test for functionality and also look for faults and rectify them.

Training topic:

Connection and testing of single-phase AC motor drives for refrigeration and air conditioning systems 15-16, 24-25

Students are to make plans concerning the use of single-phase AC motor drives in refrigeration and air conditioning systems, taking into account protection of people, components and other equipment as well as operational safety. They should select appropriate components for the fans or compressors to be powered and document the work by sketching the circuits in equivalent circuit diagrams. Students will carry out measurements on the single-phase motor drives and identify faults. They should select appropriate methods to test for winding damage, faulty capacitors and defective safety components. The results are to be logged and the sources of any faults should be backed up with relevant measurements. They will connect up the single-phase AC motor drives, measure their electrical operating parameters and compare them with the figures provided by the manufacturers. They are also asked to draw circuit diagrams for refrigeration systems using single-phase AC motor drives.

Training topic:

Installation and testing of electromechanical and electronic control systems 17, 26-27

Students are to assemble control systems for refrigeration and air conditioning systems and practice instructing end users in how to operate them. They should analyse controls systems for refrigeration and air conditioning, draw up circuit diagrams in accordance with relevant standards with a variety of functions used in refrigeration systems. They are to check all the components in operation personally and in teams. They should also make use of equipment for the protection of people, wiring, refrigeration components and equipment.

Training topic:

Commissioning refrigeration and air conditioning systems 28-29

Students are to work in teams to devise a procedure for commissioning a whole system, taking into account environmental aspects, operational safety and functionality. They will check to see that the system is air and watertight and will document the entire procedure in a handover report. They should then commission the actual system, check that it is working and compile reports on the commissioning procedure.

Training topic:

Selection of electrical components and their connection to a three-phase mains grid 18, 30-36

Students are to select motors, taking into account their start-up properties and speed control attributes. These will then be connected to a mains system along with heating filaments and other equipment, taking into account permitted line-to-line voltage and power. Students should take into account the type of mains system being used, whereby they should make measurements of operating parameters and set up systems for protecting motors and wiring in accordance with the specified objectives. They should also select the size of capacitors needed for reactive power compensation. Testing procedures are to be used to identify faults and electrical problems. These are to be rectified and measurements and results documented.

Training topic:

Installation set-up and testing of open and closed-loop electrical control systems 19, 37

Students are to install electronic components for the optimisation and monitoring of refrigeration and air conditioning systems. They will select methods for limiting starting current taking into account load reduction for the start-up of refrigeration systems. They should also select methods for controlling speed bearing in mind the suitability of the motor and the effects of the heat-cycle and air conditioning, then install the components they have chosen. The students should then install refrigeration controllers and set them up as appropriate. They should test that sensors are working properly and document their results. Also, they are to evaluate the use of programmable logic controls and employ of such a system. In addition, they should assess systems for information transfer in building wiring installations, particularly those related to monitoring, cost efficiency, user friendliness and flexibility, then put such systems to use where appropriate. The functionality of components and sub-systems is to be matched to the conditions under which they will be used.

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Animated Presentation of Complex Training Contents

Project-oriented Mixture of Media Content – Adaptable to any Training System

Manuals

Manuals provide not only a detailed description of the experiments to be performed on the respective training systems but also include countless exercises, examples and projects.

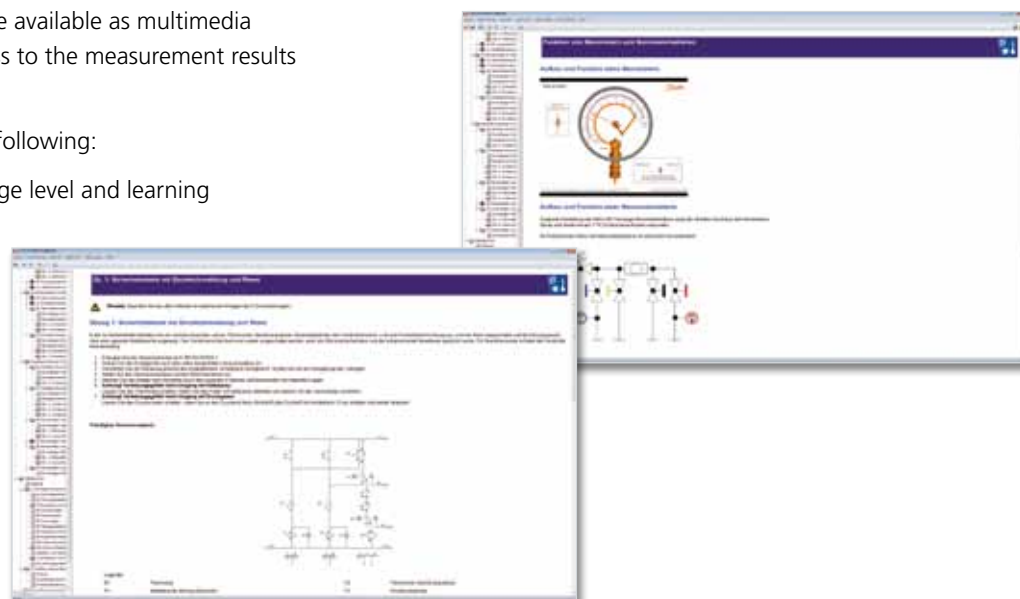


Multimedia courses

Many experiment instructions are available as multimedia courses. These allow direct access to the measurement results from various equipment.

Multimedia courses contain the following:

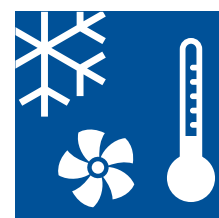
- Questions to monitor knowledge level and learning
- Interactive experiment set-ups
- Navigation bars
- Animated sections devoted to theory





UniTrain-I in refrigeration technology

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UniTrain-I

Our goal: To meet all demands.

The UniTrain-I multimedia experimentation and training system guides students through experiments by means of clearly structured course software with the help of text, graphics, animations and knowledge tests. In addition to the educational software, each course includes an experiment card for conducting practical exercises. Courses on installation technology impart the knowledge and skills needed to become a professional electronics engineer for energy technology and building management systems, and for other careers such as in the areas of plumbing, heating and air-conditioning.



Your benefits

- Theory and practice at the same time and location
- High student motivation through a use of computers and new media
- Rapid success through structured courses
- Rapid understanding through animated theory
- Practical competence through independent experimentation
- Continuous feedback by means of quizzes and knowledge tests
- Guided trouble-shooting with an integrated fault simulator
- Safe thanks to a use of protective extra low voltages
- Vast selection of courses
- Sample solutions for teachers



UniTrain-I system

- Comprehensive portable laboratory
- Multimedia courses
- High-tech measurement and control interface
- Theory and practice in conjunction



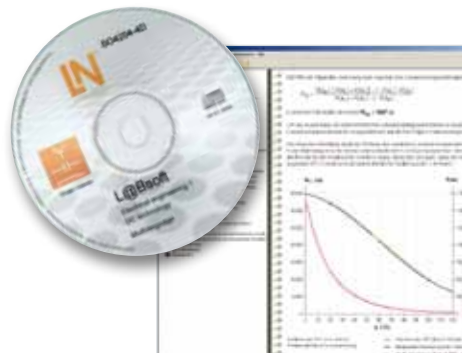
UniTrain-I interface with USB interface

- Oscilloscope with 2 analogue differential inputs
- Sampling rate 40 Msamples/s
- 9 measuring ranges 100 mV - 50 V
- 22 time ranges 1 μ s - 10 s
- 16 digital inputs/outputs
- Function generator for frequencies up to 1 MHz
- 8 relays for fault simulation



UniTrain-I experimenter

- Accommodates experiment cards
- Experiment voltage supply ± 15 V, 400 mA
- Experiment voltage supply 5 V, 1 A
- Variable DC or three-phase source 0 ... 20 V, 1 A
- IrDa interface for multimeters
- Additional serial interface for cards



LabSoft training and experiment software

- Huge selection of courses
- Comprehensive theory
- Animations
- Interactive experiments with instructions
- Flexible navigation
- Documentation of experiment results
- Tests



Integrated measuring equipment and power supplies

- Multimeters, ammeters, voltmeters
- Dual-channel storage oscilloscope
- Function generator and waveform generator
- Three-way AC/DC power supply
- Three-phase power supply
- ... and many other instruments

DC Technology

Current – Voltage – Resistance

Acquire a practical knowledge of voltage, current and resistance – the fundamentals of electrical engineering. The course clearly explains the basic laws of electrical engineering by means of numerous experiments that are easy to understand and are illustrated by animations and text.



Article no.: SO4204-4D, consisting of

- 1 x CD with "DC technology" courses
- 1 x Experiment card "Resistor circuits"
- 1 x Experiment card "Voltage dividers"
- 1 x Experiment card "Variable resistors"

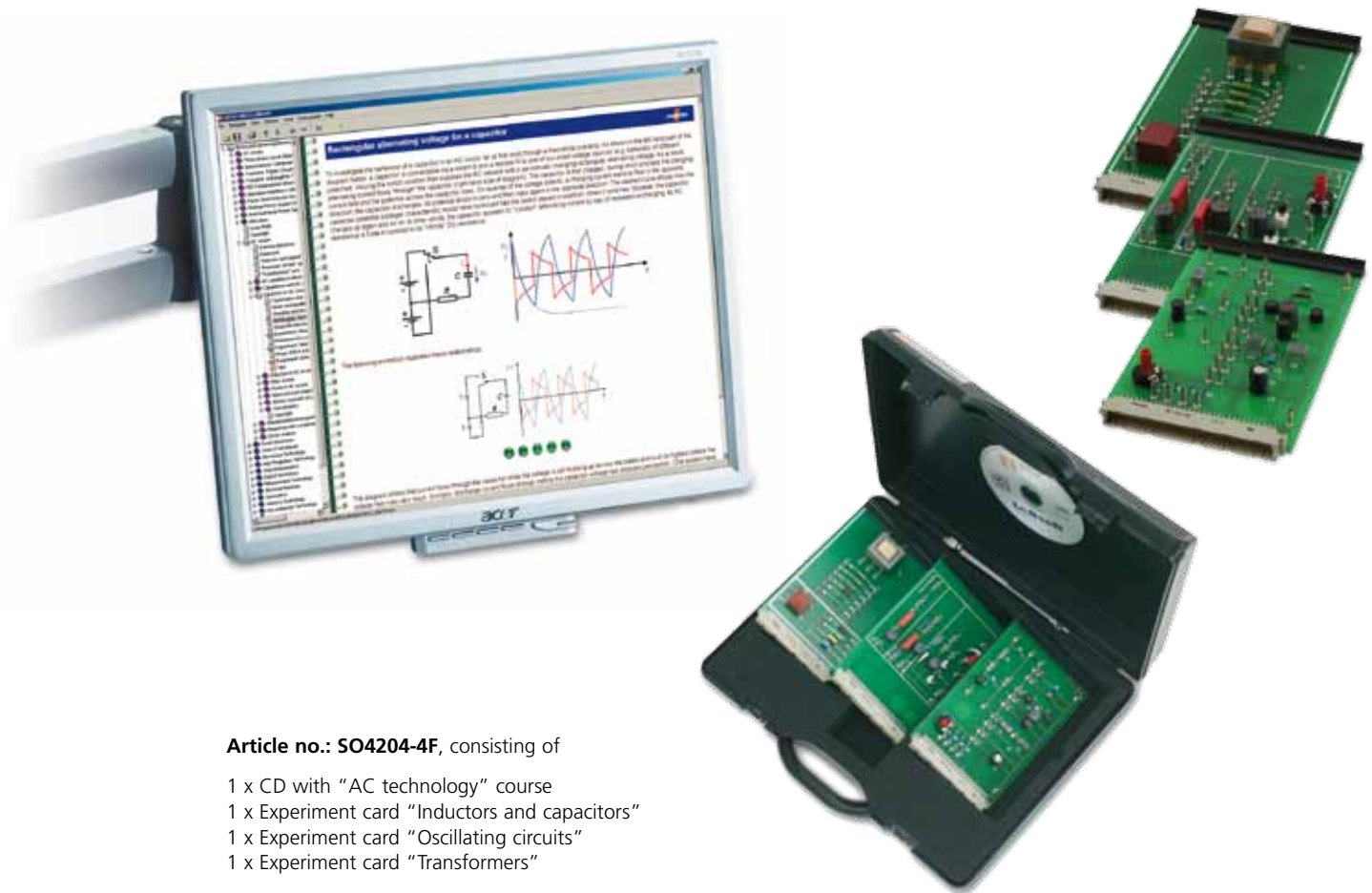
Training content

- Basic terminology: electric charge, electric field, current, voltage, resistance and power
- Using power supplies and measuring instruments
- Experimental demonstration of Ohm's law and Kirchhoff's laws
- Measurements involving series and parallel resistor circuits and voltage dividers
- Recording of characteristics for variable resistors (LDR, NTC, PTC, VDR)
- Investigation of coils and capacitors in DC circuits
- Fault simulation

AC Technology

Inductance – Capacitance – Oscillating Circuits/Transformers

How do coils and capacitors respond to alternating current? What is an oscillating circuit and how does a transformer work?



Article no.: SO4204-4F, consisting of

- 1 x CD with "AC technology" course
- 1 x Experiment card "Inductors and capacitors"
- 1 x Experiment card "Oscillating circuits"
- 1 x Experiment card "Transformers"

Training contents

- Characteristics for periodic or sine-wave signals
- Use of vector diagrams
- Experimental determination of reactance for coils and capacitors
- Explanation of active, reactive and apparent power
- Frequency response of simple filter circuits
- Electrical resonant circuits: resonance, quality, band width and cut-off frequencies
- Measurement of frequency response for series and parallel resonant circuits
- Measurements with and without load or with short circuit
- Frequency response of transformers and repeaters
- Fault simulation

Three-phase Technology

Star and Delta Circuits – Three-phase Current Generators

Three-phase current plays a vital role in energy and drive technology, more specifically in the generation and transmission of electrical energy, and operation of powerful industrial machines.



Article no.: SO4204-4H, consisting of

- 1 x CD with "Three-phase technology" course
- 1 x Experiment card "Three-phase circuits"
- 1 x Experiment card "Three-channel oscilloscope"

Training contents

- Measurement of phase-to-phase and line-to-line properties
- Experimental determination of laws relating to phase-to-phase and line-to-line properties
- Resistive and capacitive loads in star (Y) and delta circuits
- Phase shift between phase-to-phase and line-to-line properties
- Measurement of equalising current in neutral conductors
- Effect of breaks in a neutral conductor
- Current and voltage measurement under balanced and unbalanced loads
- Power measurement for a three-phase load

Conducting Measurements with a Multimeter

Current Measurement – Voltage Measurement – Measurements on Resistors and Diodes

This course teaches proper and safe measurement using conventional multimeters by means of numerous measurement exercises and animated illustrations.



Article no.: SO4204-4B, consisting of
 1 x CD with "Conducting measurements with a multimeter" course
 1 x Experiment card "Test components"
 1 x Multimeter "Multi 13S"

Training contents

- Introduction to multimeter controls
- Hazards when measuring electrical circuitry
- Measurement of DC and AC voltage using a multimeter
- Measurement of DC and AC current using a multimeter
- Measurements on resistors and diodes
- Zero calibration and continuity testing
- Setting measuring ranges
- Possible sources of measurement errors
- Identification of unknown components in a circuit by means of voltage and current measurement

Energy technology

Protective measures and network systems

This teaching system imparts an understanding of the safe handling of current and voltage, a topic of special relevance not only to electrical engineers but other professions too. Trainees independently learn how to ensure safe handling, which protective measures to take, and how to test facilities.



Article no.: SO4204-4M, consisting of
 1 x CD with „Protective measures and network systems“ course
 1 x Experiment card „Protective measures and network systems“

Training content

- Design of various network systems (TN, TT, IT)
- Protection against direct and indirect contact
- Protection through isolation measures
- Protection by extra-low low voltages
- Overcurrent protection mechanisms
- Fault-current protection mechanisms
- Measuring and testing protective mechanisms
- Protective conductor resistance measurement
- Insulation resistance measurement
- RCD test with and without trigger
- Earthing device measurement
- Loop resistance measurement

Magnetism/Electromagnetism

Magnetic Fields – Induction – Circuit Components

Magnetism and electricity are closely interlinked, many electrical components making use of the effects of electromagnetism.



Article no.: SO4204-4A, consisting of

- 1 x CD with "Magnetism" course
- 1 x Experiment card "Magnetism and electromagnetism"

Training contents

- Magnetism: magnetic poles, magnetic field, field lines and field strength
- Hard and soft magnetic materials, hysteresis
- Investigation of magnetic field around a current carrying conductor
- Investigation of magnetic field around a coil (containing air, or a ferrite core)
- Electromagnetic induction and the Lorentz force
- Design and function of a transformer
- Investigation of a transformer under various loads
- Design and function of electromagnetic components: relays, reed switches, Hall switches
- Investigation of applied circuits

Shunt-wound Machines – Series-wound Machines – Compound-wound Machines – Universal Machines

Although DC machines are becoming less and less popular in industrial practice, they still represent an introduction to the topic of electrical machines.



Article no.: SO4204-7S, consisting of

- 1 x CD with "DC machines" course
- 1 x Experiment card "DC machines"
- 1 x Rotor
- 1 x LED stroboscope

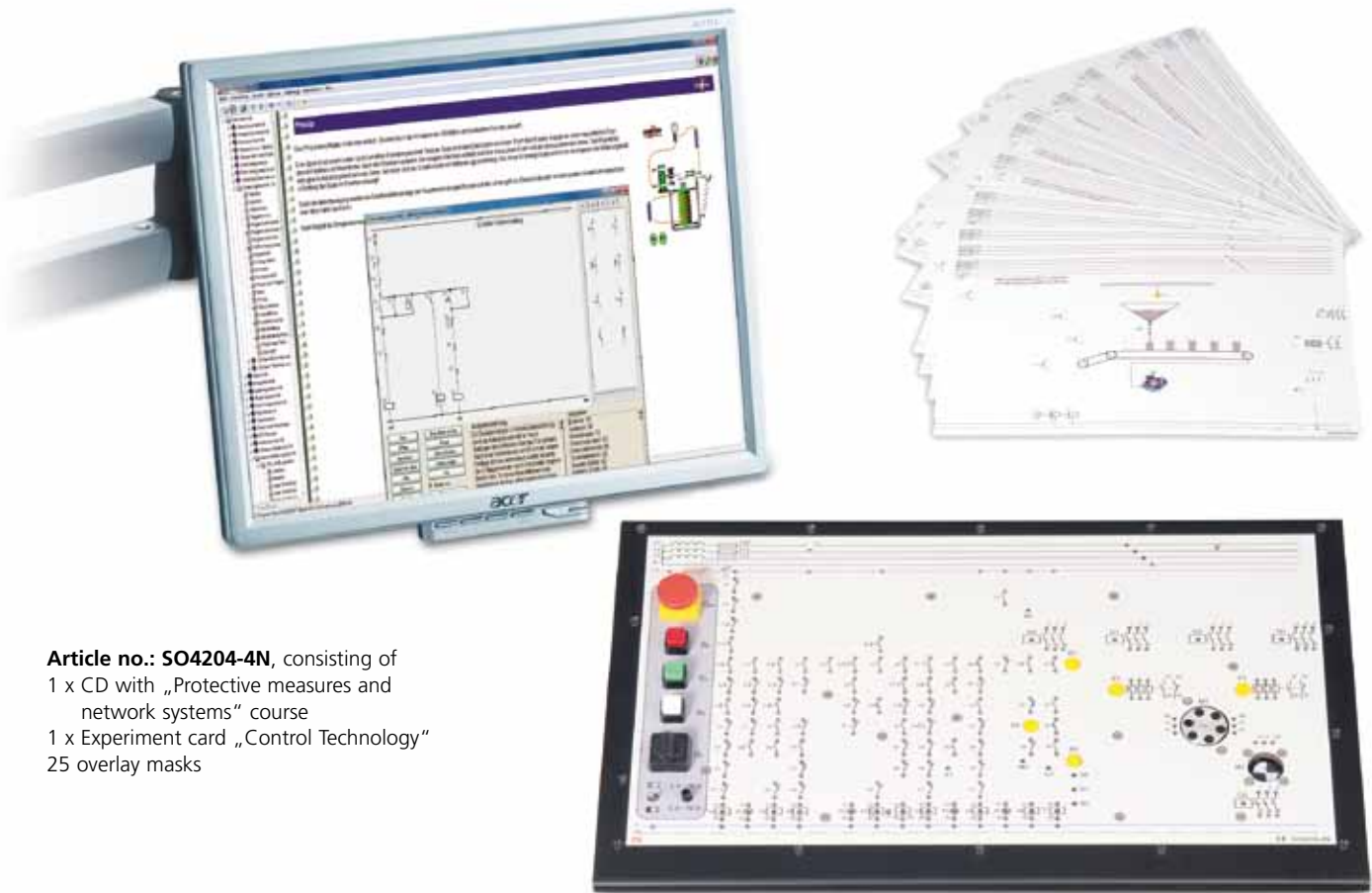
Training content

- Connection of a DC machine
- Start-up experiments
- Setting neutral zone
- Investigation of field-weakening response
- Introduction to methods of open-loop speed control
- Experiments on generator and braking operation

Control technology

Contactor circuits

Through simple control exercises, trainees learn how to work in a systematic, structured manner. A use of low voltages allows the trainees to experiment independently. All control tasks are performed using practical examples.



Article no.: SO4204-4N, consisting of
 1 x CD with „Protective measures and
 network systems“ course
 1 x Experiment card „Control Technology“
 25 overlay masks

Training content

- Introduction to components forming part of control technology
- Planning control projects
- Monitoring functions with a circuit simulator
- Function tests and trouble-shooting as part of control projects
- Self-locking and interlocking circuits
- Circuits for speed control and direction reversal
- Various types of star-delta circuit
- Time-dependent control
- Complex sequences and sequence control

Asynchronous Machines

Squirrel-cage Rotors – Permanent Magnet Motors – Capacitor Motors – Short-circuit Rotors – Variable Transformers

Due to their enormous popularity, asynchronous machines are extremely important, and this is certainly the case when training electrical engineers.



Article no.: SO4204-7T, consisting of

- 1 x CD with "Asynchronous machines" course
- 1 x Experiment card "Asynchronous machines"
- 3 x Rotors

Training content

- Generation of static and rotating magnetic fields
- Voltage and current measurements on a stator
- Connection of a stator in star and delta configuration
- Differences between various rotor types
- Response during start up and field weakening
- Fault simulation

Frequency Converter Drives

Intermediate Circuit – Inverters – Speed Adjustment

Frequency converters permit low-loss and continuous adjustment of the speed of asynchronous three-phase motors. Besides serving to control and protect motors, these devices also perform process automation functions nowadays.



Article no.: SO4204-7P and -7M, consisting of

- 1 x CD with "Frequency converter drives" course
- 1 x Experiment card "Intermediate circuit for frequency converters"
- 1 x Experiment card „Self-commutated power converters“
- 1 x Experiment card „Frequency converter drives“

The following courses are required in addition:
UniTrain-I course „Asynchronous machines“ SO4204-7T (p. 18)

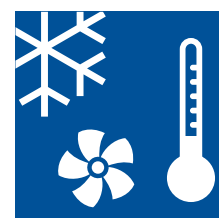
Lerninhalte

- Classification of frequency converters
- Design of modern frequency converters
- Generation of intermediate circuit voltage
- Recording V/f characteristics and boost
- Need for speed ramps
- Operation of three-phase motors in conjunction with frequency converters
- Design and function of brake choppers
- Optimisation of speed-controlled drives
- Introduction to so-called "87-Hz technology"
- Recording and analysis of currents, voltages and power levels



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Protection in Accordance with VDE/EN Standards

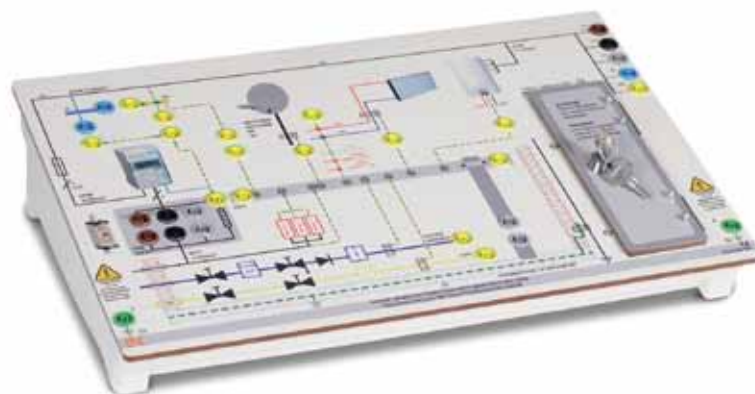
Mains Systems and Protective Measures

The topic of "Protection against coming into contact with high voltages (protective measures conforming to VDE 0100)" is important for all those whose career involves the manufacture, operation or repair of electrical equipment, especially for trainees in the electrical professions.

The training system provides ideal assistance in both theoretical and practical lessons teaching how protective measures conforming to VDE 0100 standards are implemented for the existing types of mains circuit. The direct link with authentic practice is one of the key aspects for LN training systems. Measurements in the various exercises are made using genuine, commonly used equipment.



Particularly suitable for "Jobs Carried Out by Electricians or Correspondingly Trained Specialists".



Training contents

- Various mains systems used in customer installations (TT, TN, TN-C, TN-S or TN-C-S systems)
- Choice of various protective components and how they work in different mains systems
- Various protective systems and how to test them with the appropriate measuring equipment
- Carrying out initial and subsequent tests in accordance with DIN VDE 0100-600
- Testing RCDs
- Measurement of loop impedance, local insulation impedance and insulation resistance
- Dangers of electric current
- Advice and instruction to people regarding hazards of electrical systems
- Evaluation of measurements and targeted fault finding
- Preparing documentation and test reports
- Continuity of equipotential binding conductors

IT systems

An IT mains system is a special kind of system, which is mainly used where there is a self-contained power supply provided locally, such as in mining, provision of field power in military operations or power generators for hospitals. This kind of system also makes specific demands of trainees. The board is equipped with an isolating transformer and isolation monitoring. An additional fault simulator and various application simulations make it possible to carry out initial and in-service checks conforming to DIN VDE 0100 under a variety of conditions. In conjunction with other components, it is possible to set up quite extensive project exercises.



Contents

- Power feed via CEE plug, 400V/50Hz
- Main switch, 3-pole
- 3 Fuses (or circuit breakers)
- 3 Phase indicator lights
- Isolation monitor 1...110 k Ω
- Test/reset button
- Optical signalling via indicator light
- Fault simulation

AC Machines

Single-phase motor with bifilar starter winding

The single-phase motor with bifilar starter winding is one of the asynchronous machines. In addition to the main winding, there is a starter winding which has a high internal resistance which is partially bifilar and thus magnetically ineffective. This is disconnected after starting is achieved. The motors do not contain any parts which would be subject to wear and tear like a collector or slip-rings, and operate at a fixed, virtually synchronous speed. The power range reaches up to approx. 2 kW.



Experiment example: "Single phase motor with bifilar starter winding EEM 3.3"

Training content

- Connecting, wiring and putting into operation
- Reversal of rotation direction
- Recording the speed and torque response
- Operation with different load machines, like ventilators

Transformer Trainer

Single-phase and three-phase transformers

Transformers are made to convert currents and voltages. These so-called passive electrical machines are designed to adapt designated equipment to the different voltage levels made available by the power industry. The power levels range beyond 1,000 MVA. Small transformers can be found everywhere in industry and in the consumer goods sector. The power classes can range from the smallest version up to the large-scale transformers that supply entire production plants.



Experiment example: "Transformer trainer ENT 5"

Training content

- Isolation and autotransformers
- Equivalent circuit diagrams
- Transformation ratios
- No-load and short-circuit experiments
- Vector groups in three-phase transformers
- Design and operation of transformers
- Single-phase transformer
- Three-phase transformer

Process Control Technology in Refrigeration Systems



This equipment set was designed for teaching the basics of process control in the area of refrigeration and air-conditioning technology. Trainees, apprentices or technical staff in companies involved in refrigeration and air-conditioning systems with a similar technical background are introduced step-by-step into open-loop and closed-loop process controls as they pertain to cooling and air-conditioning. As such they obtain a first-class foundation for future work in this area. The combination of theory and practice is a guarantee for solid training.

Training content

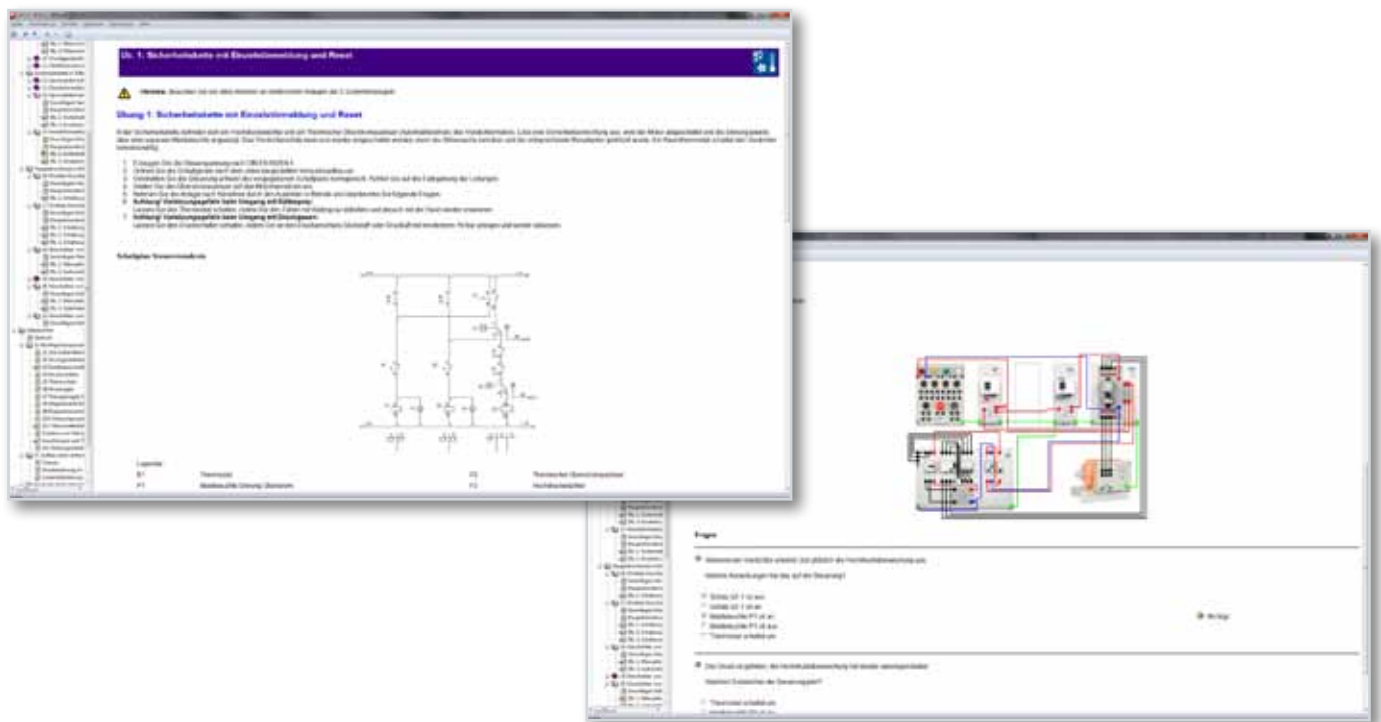
- Relationship between pressure and temperature
- Methods of generating cooling and refrigeration
- Main components of the refrigeration system
- Industry approved/ environmentally friendly handling of refrigerants
- Fundamentals of process control technology
- Safety equipment
- Compressor control, speed control
- Supplementing basic know-how in the areas of thermodynamics, methods of generating cooling and refrigeration as well as refrigeration system components
- Design, function and operation of refrigeration controllers

Experimenting, Learning, Testing and Understanding

Control of machines and motor drives is a key aspect of refrigeration, air conditioning and ventilation systems. The training program covers the safety and functionality of controllers and optimisation of control circuitry in a wide variety of applications. Specific attention is paid to the energy efficiency of the control systems and motor drives.

The training contents are focused on various motor drives, including three-phase asynchronous motors, Dahlander motors and even partially wound motors controlled by means of a variety of sensors, controllers and contactors.

Training is supported by an extensive multimedia course, designed to enhance the self-directed learning skills of trainees and students.



Overview of training topics:

- Circuit symbols, labelling, documentation
- Generating a control voltage conforming to EN60204-1
- Circuits with primary and auxiliary contactors with manual or automatic operation
- Time-dependent control circuits
- Control systems using thermostats or pressure switches
- Signalling and acknowledgement controls
- Safety chain, differential oil pressure monitoring

Refrigeration Circuits under Different Operating Conditions



The focus of this training module is the investigation of the refrigeration circuit. Various compressors, valves and other components of this cooling circuit are examined using a real cold storage cell operating under varying conditions. The content primarily covers the effects of refrigerant quantities, external temperature or even faulty components on the refrigeration circuit. Training is also carried out on how to handle refrigerants during evacuating and charging of the system in an environmentally friendly manner fashion is carried out.

Training content

- Design and operation of refrigeration circuits
- Connection of system components using hoses, without manifold to closed refrigeration circuit loop
- Connection of the 4-way manifold gauges
- Nitrogen pressure test for initial leakage test
- Leak detection
- Evacuation and drying
- Handling of refrigerant bottles
- Design, function and adjustment as well as testing safety facilities (HD; ND)
- Testing and adjusting for correct overheating
- Comparison and evaluation of measured variables for varying system conditions
- Change in overheating, change in TX (thermal expansion valve) nozzle diameter

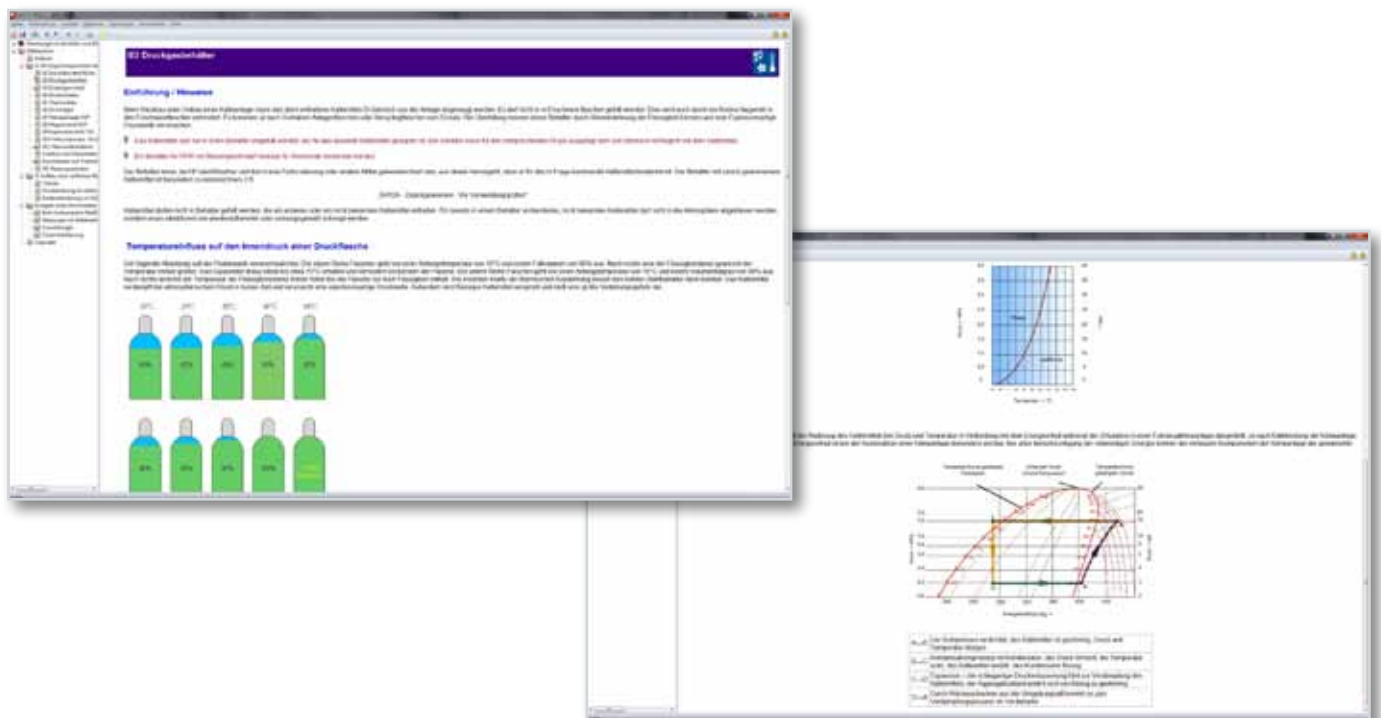
Training practical skills and abilities

Handling coolants (R134a, R404 and others) or test gases such as nitrogen requires a high degree of special know-how.

In this topic, students are trained in filling, flushing and maintaining refrigeration systems by means of simple experiments.

A simple refrigeration heat cycle and the physical processes involved are demonstrated by means of educationally designed multimedia software. All measurements can immediately be documented by means of interfaces with the digital measuring and testing instruments.

The refrigeration circuit is to be optimised by means of various open-loop controllers and other components. This allows trainees and students to become familiar with designs of refrigeration systems for a variety of applications.



Overview of training topics:

- Components in refrigeration systems
- Design of simple refrigerators
- Recording logarithmic pressure-enthalpy (log(p)-H) diagrams for various coolants
- Commissioning, finding leaks and testing air and watertightness
- Calibrating thermostatic expansion valves
- Function of high- and low-pressure switches
- Use of evaporation pressure regulators
- Use of hot-gas by-pass regulators
- Investigation of soiled filter dryers
- Operational response of refrigeration circuits under various loading

Asynchronous Machines

Three-phase motors with squirrel-cage rotor

Three-phase motors with squirrel-cage rotors are the most frequently used motors in industry. These motors are not only both robust as well as maintenance-free but are also inexpensive to produce. The motors can be found in low-power versions in the watt ranges up to and including power levels of several megawatts. Thanks to the use of modern frequency converters, these motors can operate virtually loss-free at varied speeds enabling ever-more application areas to be found for them.



Experiment example: "Three-phase motor with squirrel-cage rotor EEM 4.1"

Training content

- Connecting, wiring and putting into operation
- Operation in star and delta connection configuration
- Deployment of a star-delta switch
- Recording speed and torque characteristics
- Operation with various load machines such as ventilators, hoisting machinery

Three-phase, pole-switchable motor according to Dahlander

Due to the special winding, the three-phase motor with a Dahlander circuit enables the three-phase motor to be operated at two different speeds. The ratio of the speeds for this circuit is 2:1. With this type of motor simple drives can be assembled that are capable of two speeds, for example, a two-staged ventilator drive.



Experiment example: "Three-phase, pole-switchable motor according to Dahlander EEM 4.2"

Training content

- Connecting, wiring and putting into operation
- Operation with high- and low-speed stages
- Using a pole-reversing switch
- Recording speed and torque characteristics
- Operation with different load machines such as ventilators, hoisting equipment

Asynchronous Machines

With
Part-Winding
Machine

Three-phase pole-changing motor – two separate windings

The system consists of two three-phase motors in a single housing with separate windings. Since both windings operate separately from each other, different integer ratios can be produced between the speeds. These motors are always used for simple applications wherever the speed ratio between slower and faster speed is greater than two, for example, in crane applications where you have inching mode and higher speed.



Experiment example: "Three-phase pole-switchable motor with two separate windings EEM 4.3"

Training content

- Connecting, wiring and putting into operation
- Operation at higher and lower rotation speeds
- Using a pole-reversing switch
- Recording speed and torque characteristics
- Operation with different load machines such as ventilators, hoisting equipment

Three-phase motor with slip-rings

In contrast to motors with squirrel-cages, slip-ring motors are equipped with a rotor outfitted with wound coils. These rotors can be connected to resistors or static converters. This makes speed adjustment possible.



Experiment example: "Three-phase motor with slip-rings EEM 4.4"

Training content

- Connecting, wiring and putting into operation
- Adjusting the speed by altering resistance across the rotor
- Recording speed and torque characteristics
- Operation with various load machines such as ventilators, hoisting equipment

Asynchronous Machines

Fault simulation on electrical machines

Simply plug the fault simulator into a three-phase asynchronous motor. The widest range of realistic faults can be activated using lockable fault switches. These faults can be detected and analysed using industrial-type measuring instruments. Repair measures can be worked out on the basis of the measuring results. All measurements are performed with the power switched off.



Experiment example: "Fault simulation on electrical machines EEM 4.5"



Open fault simulator

Training content

- Winding breaks in coils
- Winding-to-winding insulation faults
- Winding-to-housing insulation faults
- Combination of various faults
- Fault assessment and practical repair measures
- How to handle insulation meters

Protection for electrical machines

Squirrel-cage motors were designed to operate with constant loads. Load changes as well as high start-up currents lead to excessive overheating of the motor. Sensors are used to monitor the temperature and the motor's current consumption. These activate protective devices such as motor circuit-breakers, protective relays or thermistor relays.



Experiment example: "Protection for electrical machines EEM 4.6"

Training content

- Selection, installation and adjustment of various motor protection systems
- Motor circuit-breaker
- Motor protection relay
- Thermistor protection
- Influence of various operating modes on the heat build-up of the motor
- Tripping characteristics of the protective systems
- Protection against impermissible loads

Smooth starting Three-phase Machines

Cutting high switch-on currents

Smooth starters use phase-angle control to reduce the motor's voltage during switch-on. The starting current drops proportionally to the terminal voltage. The power section of a smooth starter normally consists of two thyristors switched anti-parallel per phase. In order to be able to keep the power losses and the associated heat build-up as low as possible, the power semiconductors are shunted by a power circuit-breaker subsequent to the starting phase.



Experiment example: "Smooth starting three-phase machines EDT 17"

Training content

- Putting the circuit into operation
- Setting the parameters for run-up, run-down and starting voltage
- Examining the current and voltage levels during starting
- Starting under different load scenarios
- Comparing star and delta start-up

Frequency Converter Drives

The variable speed drive

Modern frequency converters transform any given three-phase standard motor into a drive with variable speed. The robust nature and popularity of three-phase standard motors have made a significant contribution to the huge success that electronic drive technology with frequency converters enjoys. The higher demands placed on drives due to developments in process automation means that more and more motors are being controlled by frequency converters. Thanks to customised open-loop speed control, today pumps and air-conditioning units are able to save a substantial amount of energy.



300-W and 1-kW
power classes available

Experiment example: "Frequency converter drives EDT 25"

Training content

- Computer-assisted set-up and operation
- Parameterization of setpoint variables, rotation direction, starting operation, operating frequency, limiting values, nominal voltage, nominal current, rated frequency, power factor etc.
- Investigating the operating response under working machine loads
- Recording the speed and torque characteristics across all four quadrants
- Drive optimization
- Operation with a brake chopper
- Operation with vector control

Key product benefits

... keep customers happy



Manfred Seikel, director and head of the Kälte Klima technical college in Maintal:

"The Kälte Klima (refrigeration and air conditioning) technical college in Maintal offers various courses to open up the most flexible possible range of career opportunities for its trainees and students. So when we were seeking training equipment for our practical workshop, we wanted to find a modular and adaptable solution, which could handle the wide variety of key topics in our educational programs.

Lucas-Nülle training systems are excellent for this capability. That is why we knew from the start that we should work together with the company from Kerpen, who are leaders in the field of technical training equipment.

"Our students have been using the latest systems from Lucas-Nülle for several years and are highly appreciative of their user friendliness and their proximity to authentic practice. The accompanying teaching software helps them to understand the topic material better and to cement their own systematic knowledge.

"We use the 'Control systems for refrigeration' training system" to introduce our students to the fundamentals of control technology.

"Conversion of non-electrical properties into usable electrical signals and the control of machines and motor drives are also key topics, in the training of mechatronics engineers for refrigeration systems, for example.

"One other important educational topic is the heat cycle or refrigeration circuit itself. We teach such material with the help of a training panel system which demonstrates a refrigeration circuit operating under various conditions. Trainees learn how pressure and temperature depend on one another, how the cold zone is created and what components are involved in a refrigeration system. We also introduce environmental protection measures, testing for air and watertightness and setting up safety equipment in our lesson programme. Whether it's compressors, valves or any other components, our trainees learn all about refrigeration circuits and how to identify and rectify possible faults that might occur in them."

The Whole is Greater than the Sum of its Parts

Individual Consultation with Lucas-Nülle

Do you require detailed advice or a specific quotation?

You can contact us as follows:

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Fax: +49 2273 567-39

Lucas-Nülle stands for tailor-made training systems for vocational training and education in the following areas:



Installation Engineering



Electropneumatics, Hydraulics



Electrical Power Engineering



Instrumentation



Renewable Energies



Refrigeration and
Air-conditioning Technology



Power Electronics, Electrical Machines,
Drive Technology



Microcontrollers



Electrical and Electronic Circuits



Automation Technology



Communications Technology



Automotive Technology



Process Control



Lab Systems

Ask for detailed information via any of the contact methods mentioned above.

Our employees will be happy to advise you.

Further information on our products can also be found at:

www.lucas-nuelle.com

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