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DCT-REES overview developed Notes – electrical engineering education
About the project: https://www.dut.ac.za/dct-rees/
For an explanation of the Notes concept: https://www.dut.ac.za/dct-rees/educational-output/

Nr	1a
Title	MPP Tracking Overview - (DC-)Mains-Integration of PV systems
Abstract	This note describes the basic principles of the PV power conversion using a maximum power point (MPP) tracker. It provides the information why such a system has to be installed and the basic functionality. PV characteristic and the change of input impedance will be discussed. Basic topologies for MPP trackers in the PV system are presented. Also the comparison between an MPP Tracker in DC and AC grids is conducted.
Author	Prof.dr.dipl.ing Christian Dick
Institution	Technische Hochschüle Köln / Cologne University of Applied Sciences
Key Words	MPPT, Power Point Tracking, Solar, PV

Nr	1b
Title	PV capacitive leakage currents
Abstract	This note describes the problems and solutions that come with photovoltaic modules and their capacitance against protective earth (PE). Capacitive leakage currents have to be minimized and therefore solutions for low frequency and high frequency currents are presented.
Author	Prof.dr.dipl.ing Christian Dick
Institution	Technische Hochschüle Köln / Cologne University of Applied Sciences
Key Words	Power Quality, Earth Leakage

Nr	2
Title	MPP Tracking Hardware
Abstract	This note describes the basic strategies on building an MPP tracker using a standard 2 quadrant chopper topology. A MATLAB tool is included to see how the impedance conversion works using this topology. Basic strategies to calculate the inductance and capacitors and for choosing the switches depending on voltage and power level of the PV-system and the grid are presented. The reader can adept basic principles if he wants to build up a converter himself.
Author	Prof.dr.dipl.ing Christian Dick
Institution	Technische Hochschüle Köln / Cologne University of Applied Sciences
Key Words	MPPT, Solar, PV Hardware, Power Point Tracking

Nr	3
Title	MPPT Tracking Software
Abstract	This note describes the basic strategies to build up a software for MPP tracking. The basic algorithms are presented and discussed and there will be a manual how to implement the algorithms using standard controllers and programming languages. Furthermore the needs for measurement are presented
Author	Prof.dr.dipl.ing Christian Dick
Institution	Technische Hochschüle Köln / Cologne University of Applied Sciences
Key Words	MPPT, Solar, PV software, Power Point Tracking

Nr	4
Title	MPP Tracking Showcase
Abstract	This note provides all design files, software code and parts-list for building up an MPP tracker. The tracker is build using an FPGA board. The PCB converts the energy from the PV generator and powers a small lamp, which indicates how much power is transferred (if the MPP is found or not). The students can do the MPP tracking on their own by clicking + and – buttons or switch to automatic mode and see the result of the programmed controller.
Author	Prof.dr.dipl.ing Christian Dick
Institution	Technische Hochschüle Köln / Cologne University of Applied Sciences
Key Words	MPPT, Solar, PV, Power Point Tracking, MPPT demonstrator

Nr	5
Title	Off-grid Solar Home Systems
Abstract	This note describes the basic steps behind the mathematical modeling of Solar Home Systems (off-grid PV systems). The note will cover the basics of locational issues, PV module temperature estimation, DC yield calculation while also explaining the basic method followed to dimension an off-grid system.
Author	Dr.ir. Nishant Narayan, Prof dr.ir. Pavol Bauer
Institution	Delft University of Technology, the Netherlands
Key Words	Picogrids, Solar Home, Rural Electrification modelling, off grid PV

Nr	6
Title	How to build a PV trailer as PV and DC demonstrator
Abstract	This note describes how a PV trailer can be built. The aim of the PV trailer is to show the use and possibilities of PV systems, DC and AC nanogrids. The note briefly describes all the components of the electrical design. Basic design choices are discussed and explained. Mechanical drawings, component lists and electrical wiring diagram are provided within the scope of this note.
Author	ir Jan Elsen, MSc Thomas Vanhove
Institution	University College Leuven Limburg - UCLL
Key Words	Off grid PV, PV trailer, DC nanogrid

Nr	7
Title	PV trailer electrical components
Abstract	This note describes the choice and dimensioning of all the electrical components of a PV trailer. This includes PV panel characteristics, MPPT trackers, Battery protection, Batteries, cabling, DC-DC converters, AC inverter, protection and safety components. The note includes a short lab tutorial on how to use component-specific software to dimension an off-grid PV system and e-learning modules.
Author	ir Jan Elsen, MSc Thomas Vanhove
Institution	University College Leuven Limburg - UCLL
Key Words	Off grid PV, PV trailer, DC nanogrid components

Nr	8
Title	How to obtain measurement data from the PV trailer
Abstract	Most of the components on the PV trailer have communication possibilities to retain measurement data. This note describes how to setup and configure communication between these components and how to capture measurements both local and in a cloud-based environment. The different communication bus systems onboard are described.
Author	ir Jan Elsen, MSc Thomas Vanhove
Institution	University College Leuven Limburg - UCLL
Key Words	Off grid PV, PV trailer, DC nanogrid, nanogrid measurements

Nr	9
Title	PV trailer measurements
Abstract	This Lab tutorial contains several lab experiments to obtain and analyze measurements from the PV trailer. - PV panel characteristics and MPP tracking - Batteries and principles of battery management - The use of DC-DC converters and AC inverters - How to share and compare measurements on PV (trailer) systems based at the DCT-REES partner campuses
Author	ir Jan Elsen, MSc Thomas Vanhove
Institution	University College Leuven Limburg - UCLL
Key Words	Off grid PV, PV trailer, DC nanogrid, nanogrid measurements

Nr	11
Title	Lab setup for power electronics
Abstract	In this note a power electronics converter is described that is developed for educational purposes, considering topologies and power transfer for general applications. The considered topology is first evaluated by students via simulation. Secondly, using an experimental setup and regulation via a low cost embedded digital control, the students can experiment with various applications such as solar, battery charging, DCDC conversion and PWM motor control.
Author	Dr.ir. Peter van Duijsen
Institution	The Hague University of Applied Sciences / De Haagse Hogeschool
Key Words	Engineering education, laboratory setup, power electronics, converters, learning by doing

Nr	12
Title	BMS for Batteries
Abstract	The cost of Lithion-ion batteries is decreasing and becomes a valuable alternative for providing backup and improved reliability for smart nanogrids. (Building or home with DC-grid). But these technologies need some precautions when they are used and implemented in homes for unskilled people. The Knoledge Note will discuss the most important battery parameters like SOC, SOH, DOD, C-rate and Cycle life without diving into the battery technologies. Insight in these parameters will be the base for the discussion of the Battery-Monitoring-System (BMS). The main functions of the BMS will be discussed and the importance of the functions will be explained for the integration of the battery within a small Nano-grid.
Author	ir Geert VandenSande
Institution	KU Leuven
Key Words	BMS, Battery management, Battery monitoring, State of charge (SOC)

Nr	14
Title	Transmission means for MVDC compared to MVAC
Abstract	In current transport, the AC voltage ranges have been in demand so far. With growing development in electrical engineering, the transmission paths with the DC range are becoming more interesting. The fundamentals of medium voltage transmission are explained as well as the possible transmission paths. These include the types of lines and their necessary specifications. Differences between AC- and DC-transmission are explained.
Author	Vincent Schmitz MSc. / Prof. dr. Michael Bragard
Institution	FH Aachen / Aachen University of Applied Sciences
Key Words	MVDC, Transmission grids

Nr	15
Title	Components used for MVDC
Abstract	Power electronics is a key for the application of medium voltage DC transmission. For example, protective devices are required to disconnect the mains in the event of a fault. Converters and rectifiers are required to integrate MVDC into existing AC networks. The article describes the power semiconductors are used in this article in accordance with their current state of development.
Author	Vincent Schmitz MSc. / Prof. dr. Michael Bragard
Institution	FH Aachen / Aachen University of Applied Sciences
Key Words	MVDC, MVDC-components, high voltage converters, high voltage rectifiers

Nr	16
Title	Areas of application for MVDC
Abstract	Different areas of application for MVDC are presented in this paper. It explains how they are used and when it makes sense to choose one of these DC solutions. Furthermore, the function of a Microgrid network is explained, its advantages and disadvantages are listed and compared, and an example is given of how to use a Microgrid. Limitations and different voltage levels are addressed and explained, how they are possible in a Microgrid in the medium voltage direct current range. The difference between a Microgrid and a Macrogrid is also explained
Author	Vincent Schmitz MSc. / Prof. dr. Michael Bragard
Institution	FH Aachen / Aachen University of Applied Sciences
Key Words	DC Microgrids, MVDC Grids, MVDC

Nr	17
Title	Power electronics for regenerative systems
Abstract	This Note (power point presentation) provides technical knowledge on selected current topics in power electronics and power engineering. The technical challenges and opportunities closely related to the energy system transformation are explained. You get an understanding of the technology factors and cost parameters that are crucial for development. In this course the general boundary conditions are explained. Building on this, the possibilities of power electronics (components, topologies,) are presented. The basics for photovoltaic systems and wind power are described.
Author	Vincent Schmitz MSc. / Prof. dr. Michael Bragard
Institution	FH Aachen / Aachen University of Applied Sciences
Key Words	Power Electronics, PE, Renewable Energy technology

Nr	18
Title	High Voltage DC-DC converters
Abstract	High-power dc-dc converters are key enabling components in MVDC grids as dc transformers, where galvanic isolation is usually required due to the high voltage-ratio and fault isolation requirement. Depending on different applications, unidirectional topologies e.g. series resonant converter (SRC) or bidirectional topologies e.g. dual-active bridge (DAB) converter are the most promising candidates among others, mainly attributed to the soft-switching operation. This note aims to give an introduction of selected dc-dc topologies, the operation principle, and the corresponding control.
Author	dr Jingxin Hu / Prof. dr. ir. dr. h. c. Rik W. De Doncker
Institution	RWTH Aachen University
Key Words	High Voltage DC, DC-DC converter topologies, MVDC technology, Power Electronics

Nr	19
Title	Lab Note for High-Power DC-DC Converters
Abstract	This Note aims to give a lab practice course of dc-dc topologies for MVDC applications. Single active bridge (SAB) and series resonant converter (SRC) with down-scaled power and voltage ratings are designed and compared in this lab tutorial. Printed circuit boards (PCBs) and components are prepared for students. The series capacitor of the SRC converter can be bypassed to be configured as an SAB converter. The switching frequency can be tuned by a potential meter for different operation conditions.
Author	dr Jingxin Hu / Prof. dr. ir. dr. h. c. Rik W. De Doncker
Institution	RWTH Aachen University
Key Words	High Voltage DC, DC-DC converter topologies, MVDC technology, Power Electronics

Nr	20
Title	High Power Multilevel Converters
Abstract	Using power electronics conversion units for applications with power levels in the order of several MW up to GW places certain demand on the converter technology. Special measures have to be taken to cope with voltages in the kV range and currents of several kA. Therefore, this note is dedicated to converter topologies and their corresponding modulation strategies for medium-voltage applications. As power electronics converters with very high voltage and power ratings are increasingly used for transmission and distribution of electrical energy, high-voltage direct current (HVDC) transmission systems are covered as well.
Author	dr Jingxin Hu / Prof. dr. ir. dr. h. c. Rik W. De Doncker
Institution	RWTH Aachen University
Key Words	High voltage converter topologies, MVDC, HVDC, power electronics

Nr	21
Title	(MV)DC Circuit Breakers
Abstract	Protection of dc grids is more challenging than ac grids, since dc fault currents do not have natural zero crossing and they are developed much faster. To interrupt dc fault currents, dc circuit breakers with fast fault clearing capability are required. Solid-state circuit breakers exhibit the highest fault current clearing speed, but they are costly and present high conduction losses in the normal operation. Hybrid circuit breakers compromise between the low conduction loss of mechanical switches and the high switching speed of semiconductor devices. This note aims to give an overview of different dc circuit breaker technologies especially for medium-voltage (MV) applications.
Author	dr Jingxin Hu / Prof. dr. ir. dr. h. c. Rik W. De Doncker
Institution	RWTH Aachen University
Key Words	MVDC, Power Electronics, electronic protection

Nr	22
Title	Cybersecurity for energy automation products
Abstract	Cyber attacks on power networks' critical components and infra-structure is a reality, and it is quite regularly reported. Two reasons for this are the increased networking of systems and standardization of systems and protocols, which allows hackers the opportunity to exploit loop-holes and vulnerabilities in the systems. Networking simplifies processes and streamlines operations, but this comes at a risk of cyber attacks. Therefore one has to take care of security and develop protocols to ensure safe-guarding of the networks. Note that the proven security controls from the field of Information Technology (IT) do not necessarily fit exactly one by one to the field operational technology, including automation technology, because of the different conditions in the two fields.
Author	Prof. dr. Jaco Jordaan
Institution	TUT – Tshwane University of Technology
Key Words	Cyber Security Smart Grids, Smart Grid protection, cybersecurity electricity grids

Nr	25
Title	Low Income Area Electrification
Abstract	Low income areas may struggle to pay sufficient to cover the costs of standard electrification systems. The electrification may be implemented as an investment for future returns, but a more affordable system may be better to implement, providing it can be readily upgraded as needed. Two major groups of residents have been identified, which include those familiar and not familiar with electricity. Those not familiar will need much more education to explain what the system to be implemented can do, and what it cannot do. Much training is required about how to look after the system. The difficulty and expense of electrical grid expansion in remote areas, coupled with low financial return expectations, often curtails the grid expansion. In such areas, off grid systems are often installed. However, if these systems are not adequate, there will be no expansion of wealth and little possibility of expansion in the future. Technically, the options to consider are ac systems and dc systems. Presently there are very few appliances for voltages other than 230V 50Hz, or 12V dc. If electrical safety is a major issue (as in some urban areas), then using extra low voltage (below 50V) is preferable. However, there still needs to be a conversion stage to 230V 50Hz, or to 12Vdc for currently available appliances to be used.
Author	Prof.dr. Peter Freere
Institution	NMU – Nelson Mandele University / Port Elizabeth
Key Words	Low Income Area electrification, Energy Poverty Area

Nr	26
Title	Basic Concepts of IGBT Gate Driving Methods
Abstract	A brief history of power semiconductors is given, followed by a description of typical electrical waveforms that can be expected. Equivalent circuits of an IGFBT is given, followed by a discussion of various gate driving topologies. A variety of means to protect the IGBTs is explored.
Author	Prof.dr. Peter Freere, MEngTech Edwin Ribisi, in close collaboration with dr. Francesco Iannuzzi of Aalborg University, Danmark
Institution	NMU – Nelson Mandele University / Port Elizabeth
Key Words	Power Electronics high frequency switching, switch mode power supplies, IGBT, Gate Driving