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WoS Researcher ID: AAD-7530-2020

j.szymanski@uthrad.pl

HEAT not LOST

23 -24 luty 2022 Targi Kielce oraz on-line

VI Konferencja Naukowo - Techniczna

Przemysłowy scenariusz rozwoju elektromobilności

Industrial scenario of electromobility development

Prof. UTH, Dr hab. inż.
Jerzy Ryszard Szymański
Uniwersytet Technologiczono-Humanistyczny
w Radomiu

CHAPTER 6

High-Power Charging Strategies of EV Batteries and Energy Storage (Pages: 159-174)

Marta Zurek-Mortka, Jerzy R. Szymanski

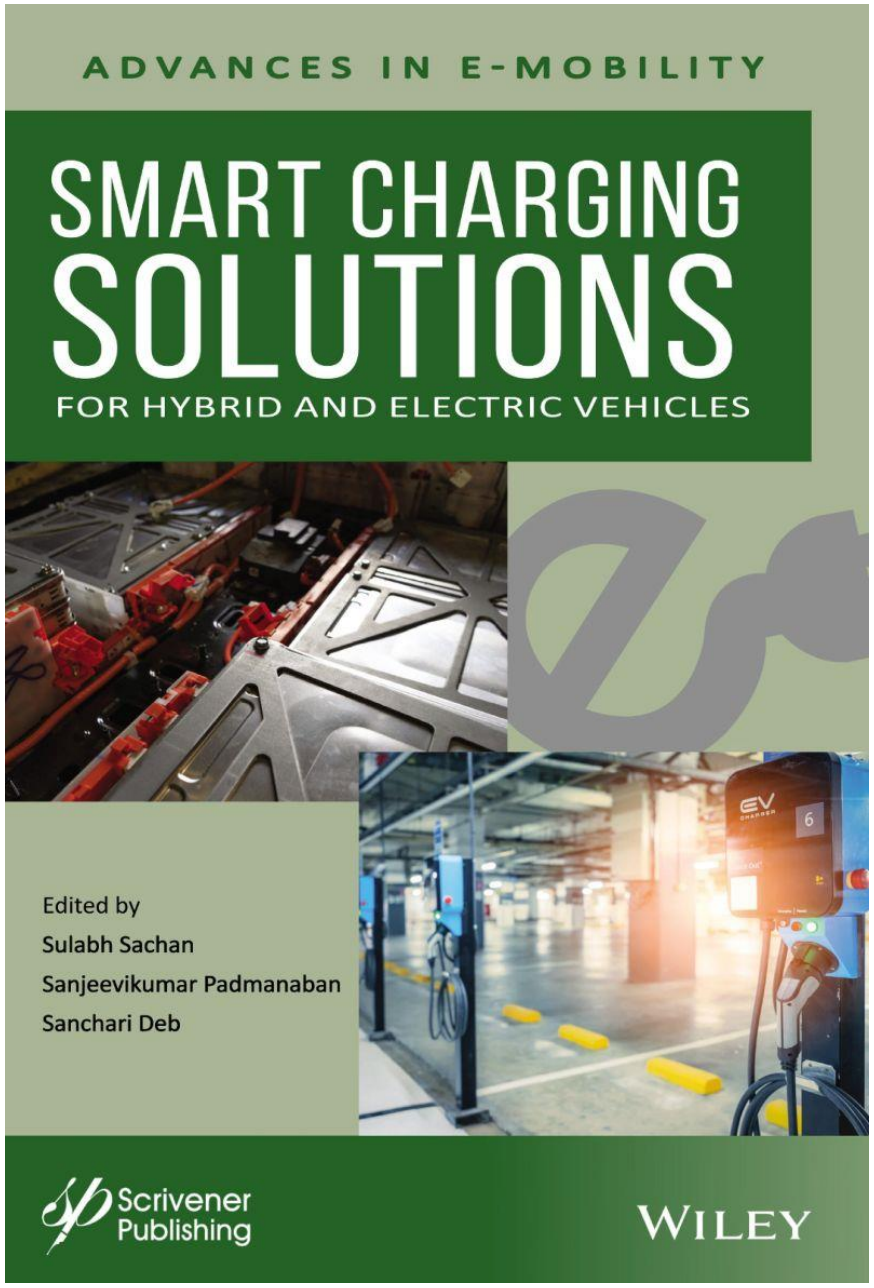
Summary | PDF | References | Request permissions

CHAPTER 7

Integration of Fast Charging Stations for Electric Vehicles with the Industrial Power System (Pages: 175-194)

Marta Zurek-Mortka, Jerzy R. Szymanski

Summary | PDF | References | Request permissions



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Industrial Scenario of Electro Mobility Development

Agenda:

1. Drive frequency converters as common use converter in industry
2. Local industry 600V DC microgrid with green energy
3. Drive frequency converter as a fast battery charging system

The main documents changing the production and use of electricity

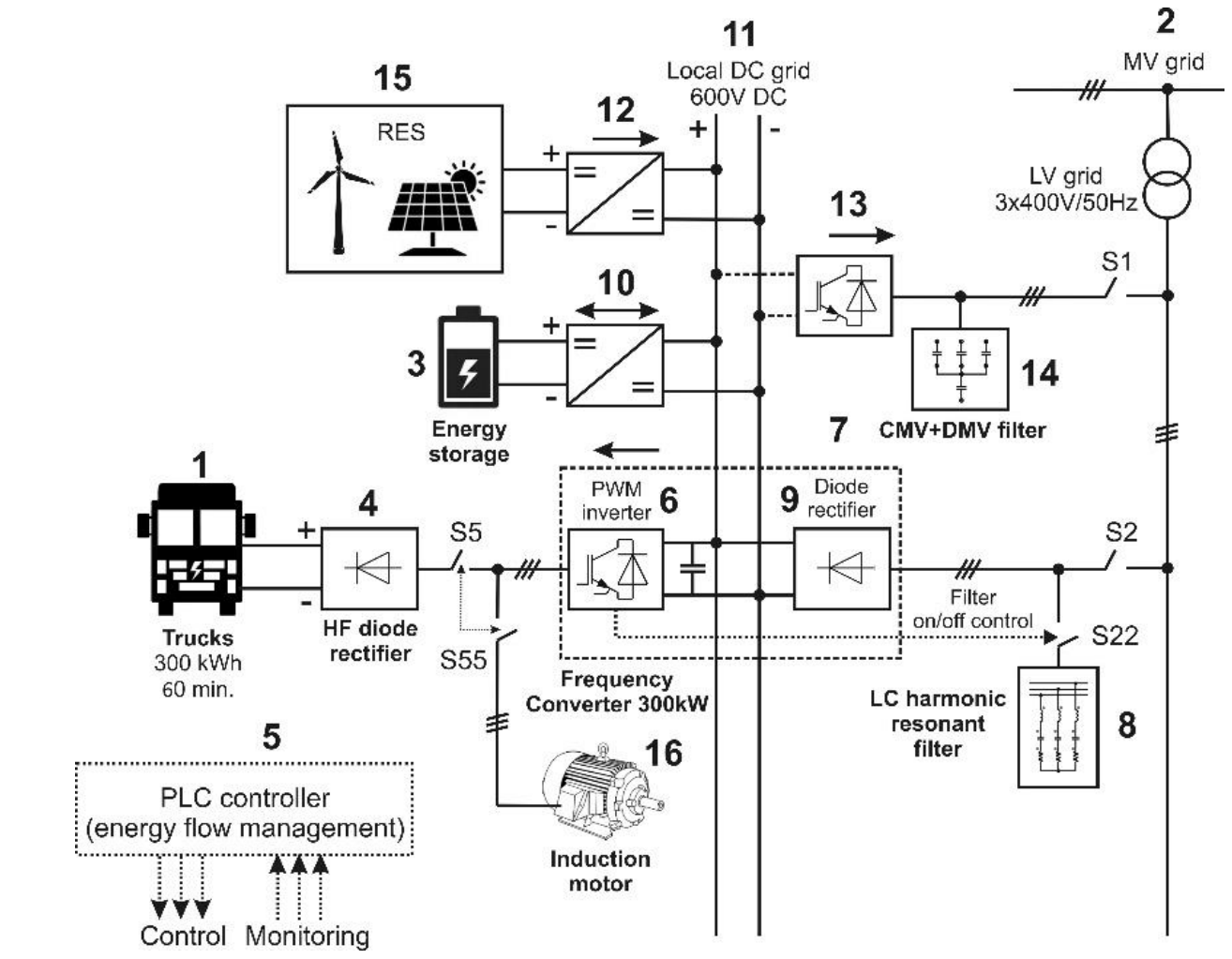
- Key importance for current policies and activities is the so-called the Paris Agreement concluded in December **2015** at the 21st Conference of the United Nations **Convention on Climate Change (COP21).**

- In **2019**, the European Commission published a communication on the **European Green Deal**, i.e. a strategy whose ambitious goal is to achieve climate neutrality by the EU by 2050 - as a world leader in this field.

- In **2020** was establish document "**Energy policy of Poland until 2040**"

Prediction of development of industrial EV mobile vehicles and work machines

Future industrial power network

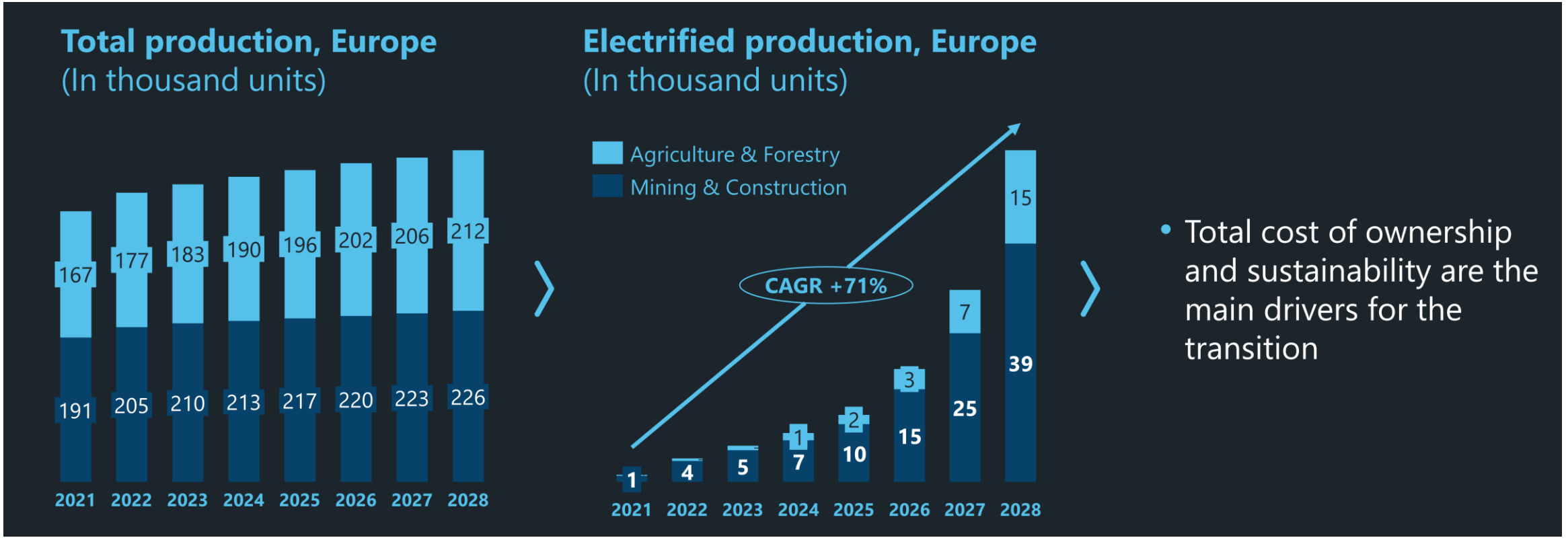


Heavy EV road and of road vehicles

Truck & Bus

Off-Highway

Off-highway – market size and growth



Electrification behind automotive by approximately 5 years - market develops slow but steadily with an expected acceleration from 2025

Better solution: long-term rental of heavy loaded EV (off-highway) in place of sale!

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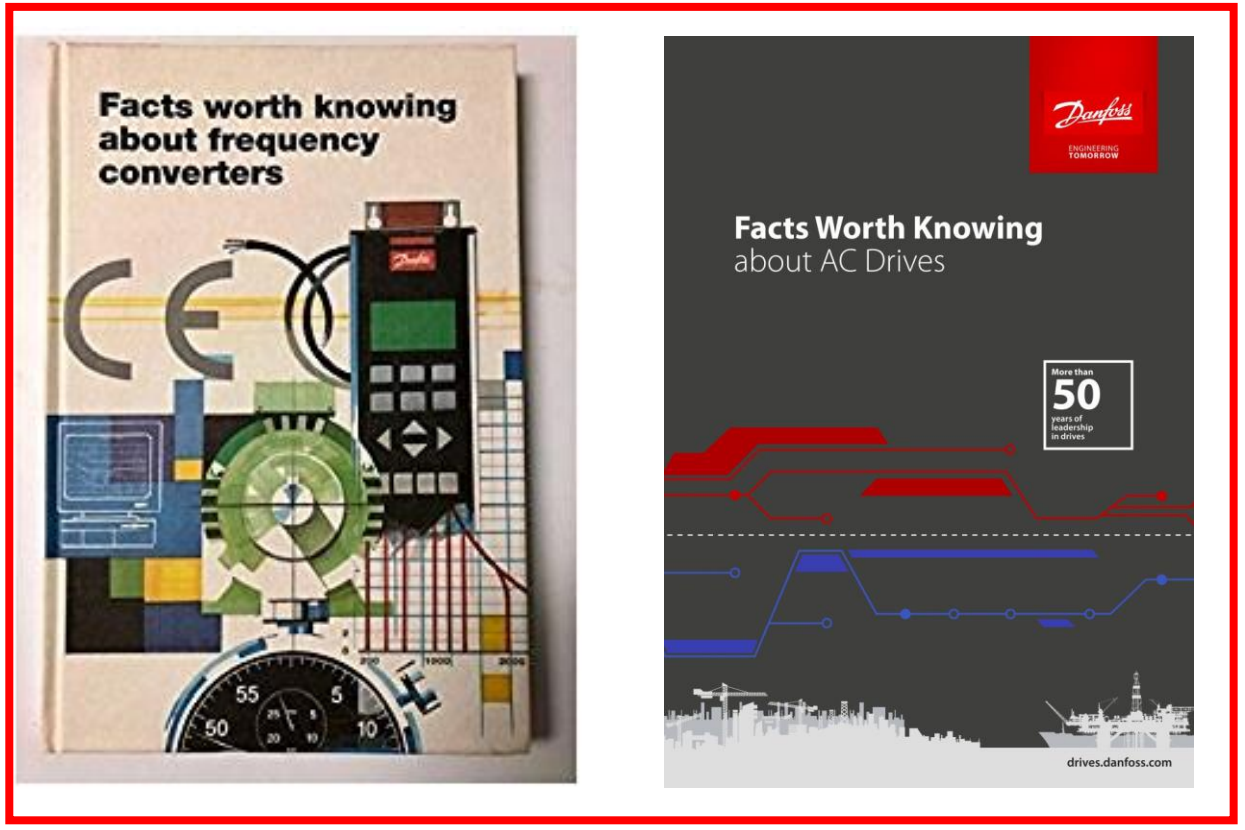
Topology of industrial frequency drives – components easy to use to other kinds of applications, ex. fast EV chargers



1968 1998 2018

Over 50 years of production of drive frequency converters

https://1drv.ms/u/s!Avw6RtlpJhda5FIncxcmyXE0aK1f?e=GcYZIO

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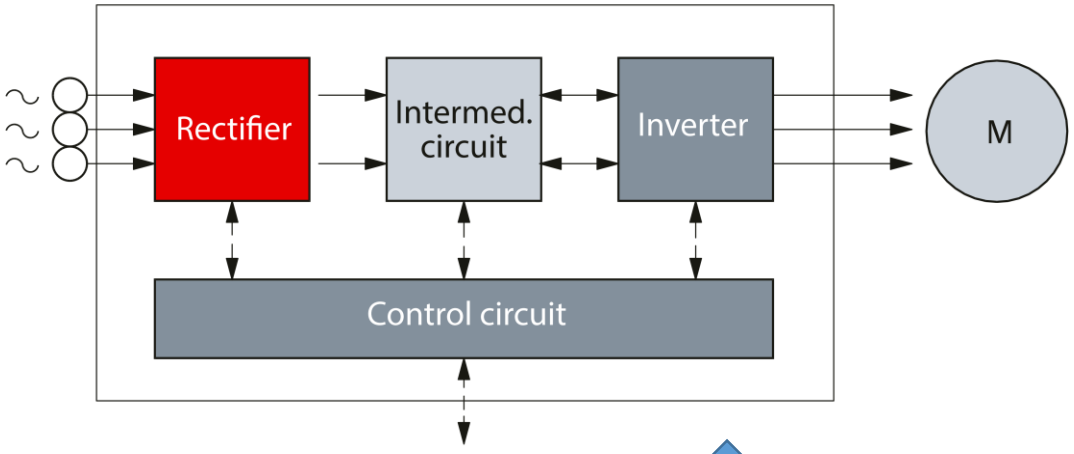
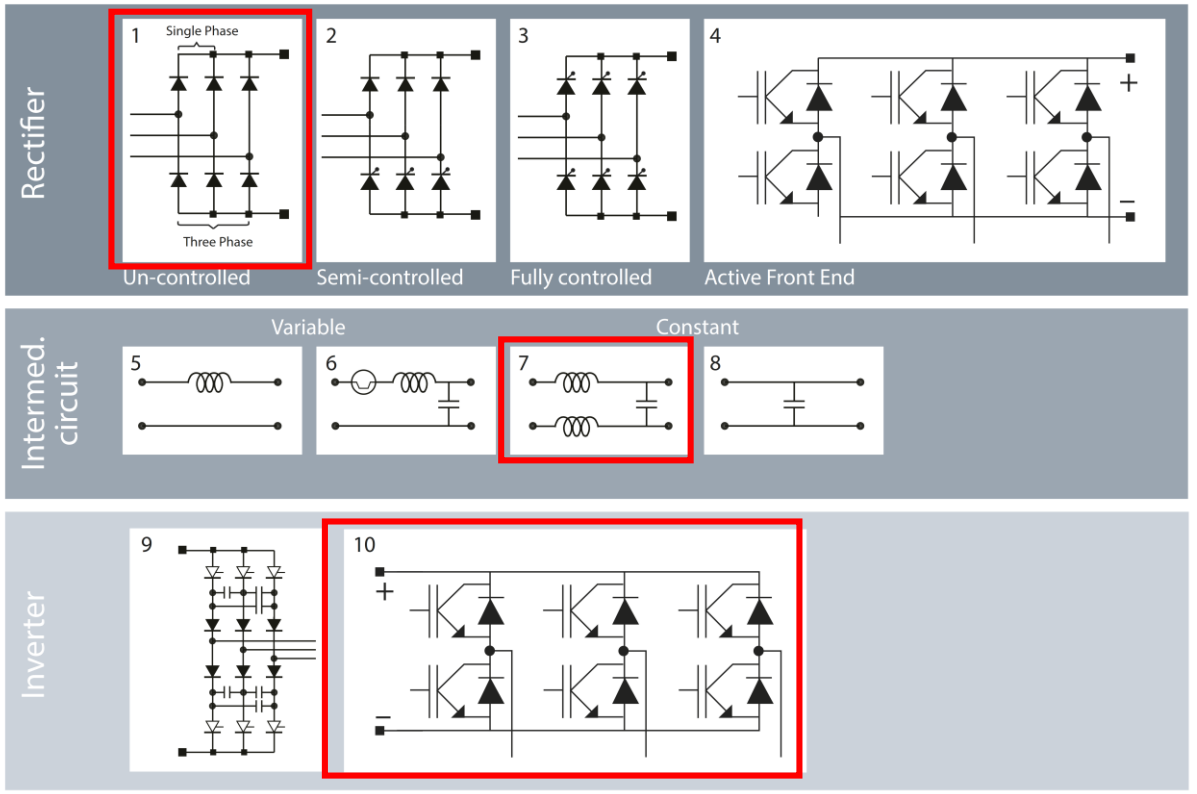
Main components of voltage drive converters (Variable Speed Drive)



Block diagram of an AC drive with an intermediate circuit



AC drive configuration examples

Configuration example	Abbreviation	Configuration: Reference to components in Fig. 3.3
Pulse amplitude modulated converter	PAM	1 or 2 or 3 and 6 and 9 or 10
Pulse width modulated converter	PWM	1 or 2 or 3 or 4 and 7 or 8 and 9 or 10
Current-source converter	CSI	3, 5, and 9

Main component topologies

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High-Power Electronic Devices

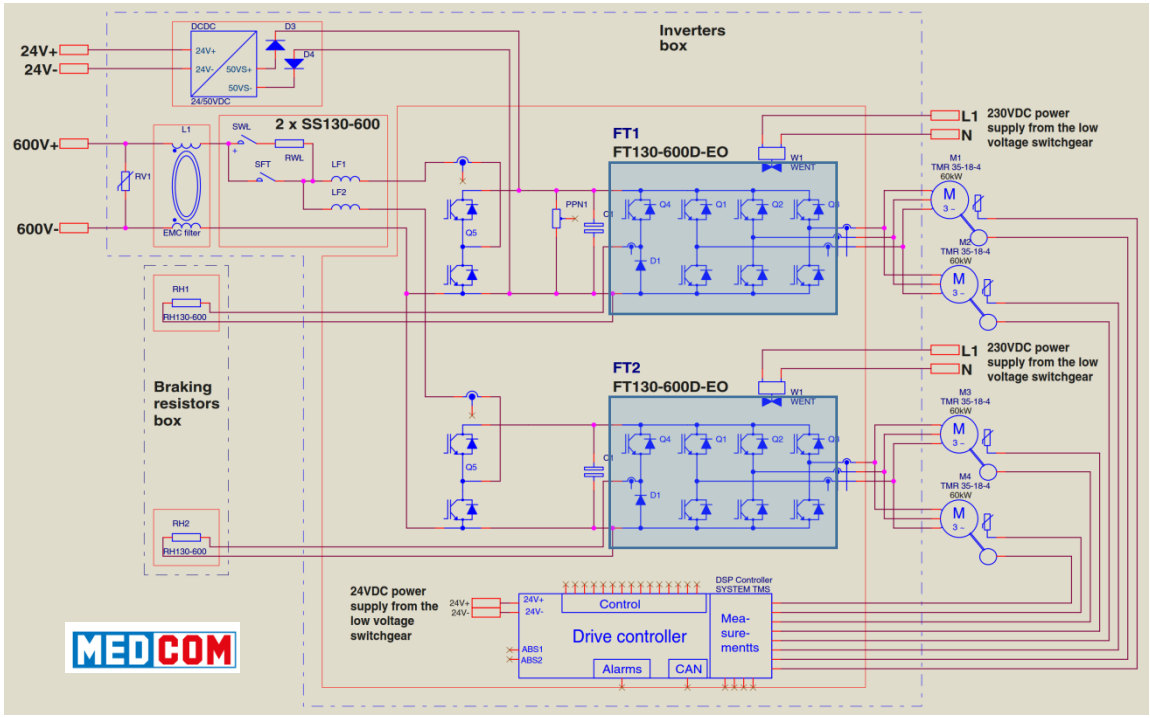
FT-130-600D-EO

Traction Inverter for Asynchronous Drives

Specification

Input rated voltage	600 VDC +30 % ÷ –33 %
Auxiliary voltage	24V DC +25 % ÷ –30 %
Rated current	300 A
Peak current	600 A
Rated power	2x130 kW
Frequency	0 ÷ 160 Hz
PWM frequency	1000 – 2500 Hz
Insulation strength	4 kV 50 Hz 1 min
Cooling	forced, air
Weight (with/without DCDC)	352 kg / 332 kg
Dimensions	450×1280×1300 mm

The application of two level inverters for powering the tram drives.



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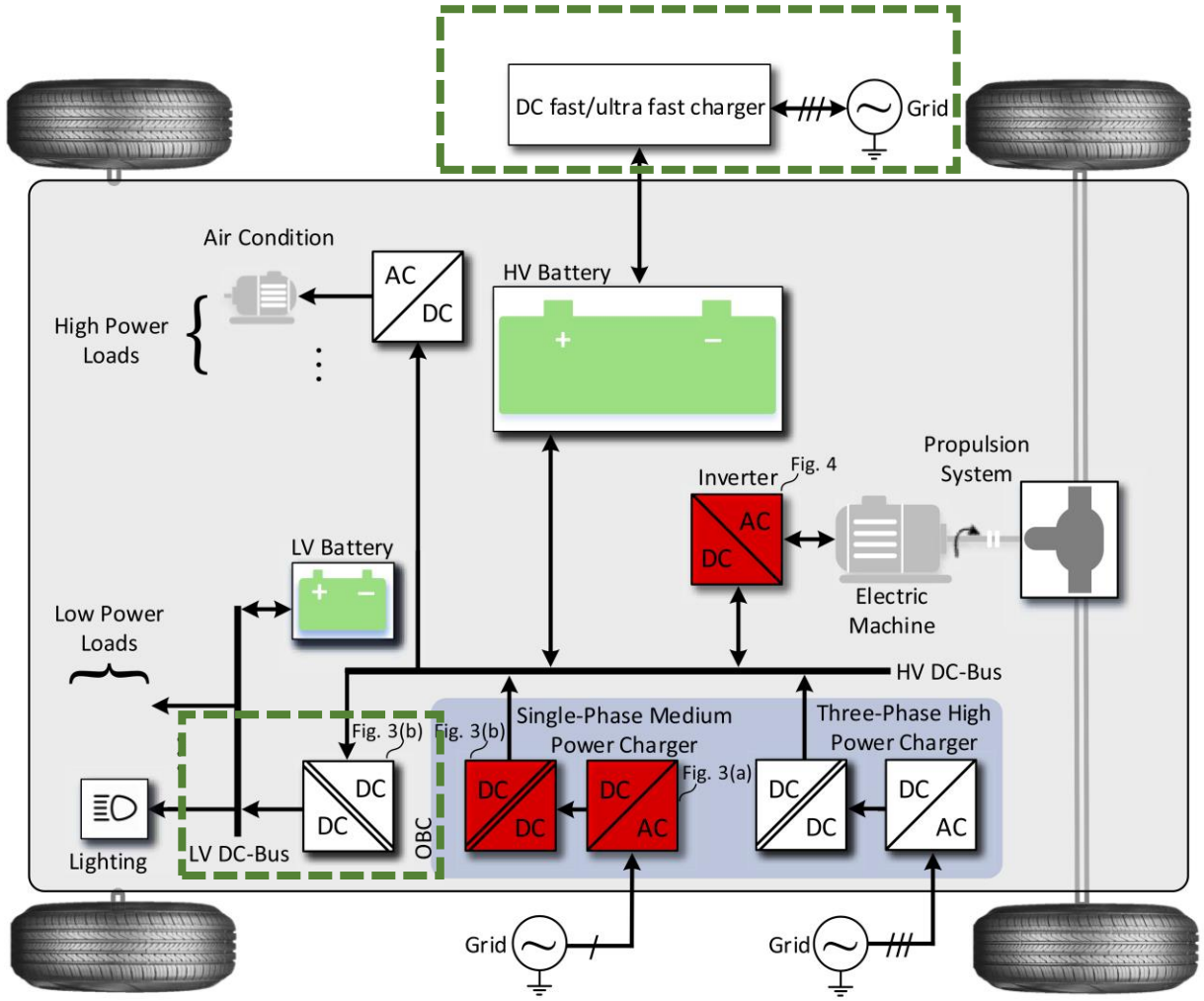
Overview of the electrical power system in EV



The onboard charger (OBC) is an essential part of the EV.
OBC has two main roles:

- *first* - charging the battery through the main power grid;

- *second* - power factor correction (PFC) to provide high power factor (≈0.99) and low harmonic distortion following the standard power network.

Source - DOI: 10.1109/JPROC.2020.3031041

My research projects: VFC in electric drives of lignite (brown) coal machines

Polish Scientific Research Committee purposeful projects:

[1] **Modernization of lignite coal excavators' electrical drive type SRs 1200**

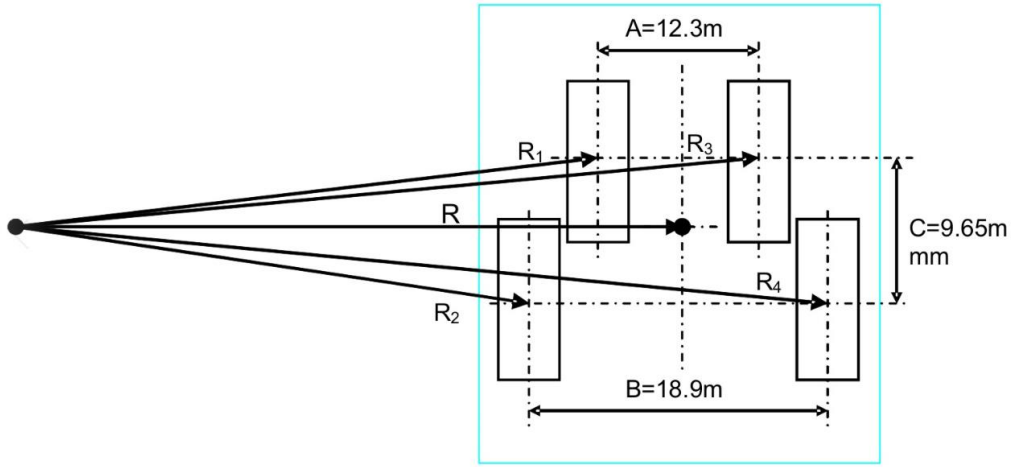
–

[2] **Study and realization of electrical drives in conveyor belts system with automatic control of belt's speed**

excavators' electrical drive type SRs 1200

Conveyor with control of belt's speed

Drive of open coast caterpillar machines



$$R_1 = \sqrt{\frac{1}{4}C^2 + \left(R - \frac{1}{2}A\right)^2}$$

$$R_2 = \sqrt{\frac{1}{4}C^2 + \left(R - \frac{1}{2}B\right)^2}$$

$$R_3 = \sqrt{\frac{1}{4}C^2 + \left(R + \frac{1}{2}A\right)^2}$$

$$R_4 = \sqrt{\frac{1}{4}C^2 + \left(R + \frac{1}{2}B\right)^2}$$

The turn radii of the center of individual caterpillar for right turn are calculated from equations like above
(According to Pythagoras theorem)

The frequencies for individual frequency converter

$$F_n = F_S \cdot \frac{R_n}{R}$$

SRs1200 caterpillar excavator

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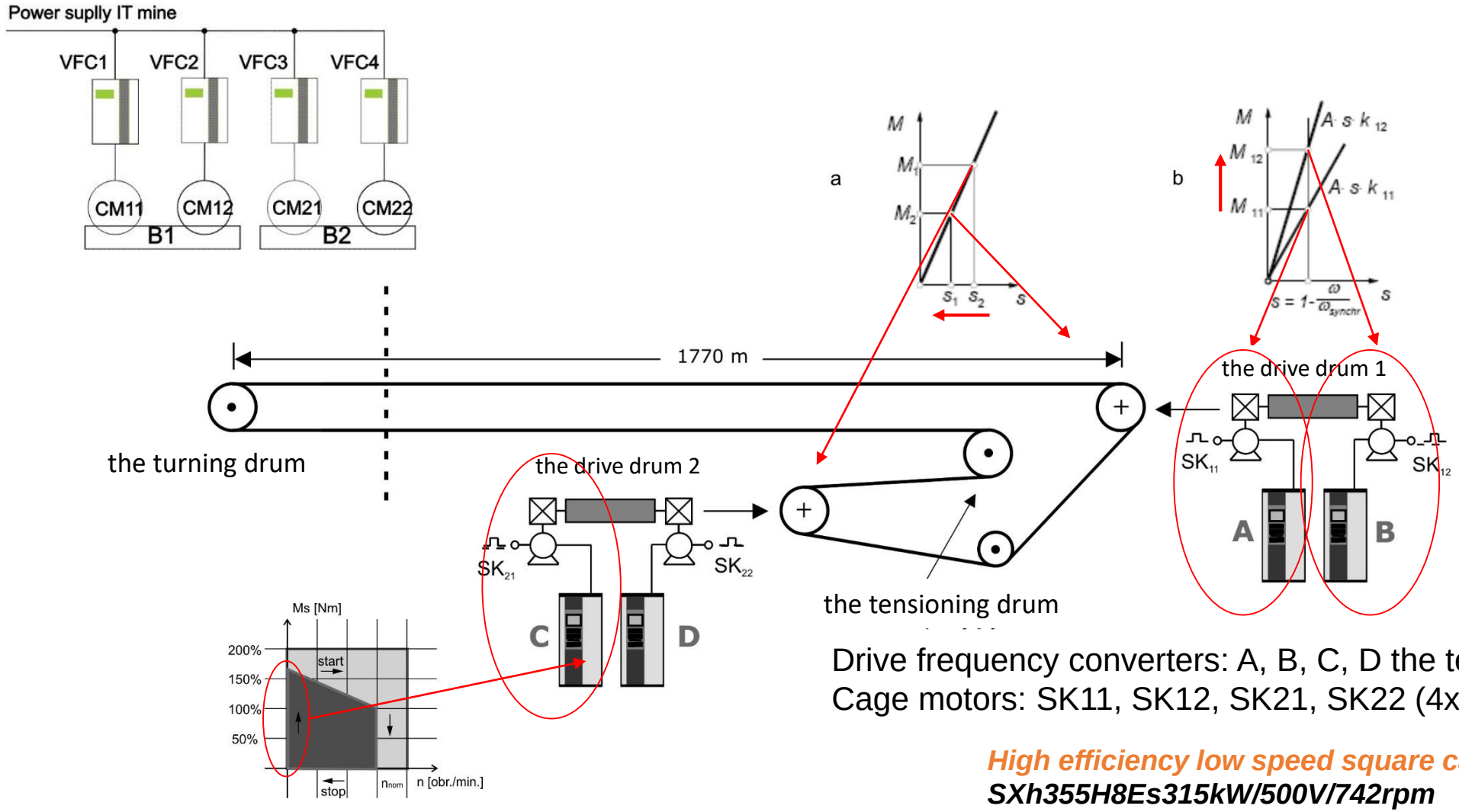
University of Technology and Humanities in Radom, Poland

Control of the conveyor drive with adjustable belt speed



Drive frequency converters: A, B, C, D the tensioning
Cage motors: SK11, SK12, SK21, SK22 (4x315kW/500V/742rpm)

High efficiency low speed square cage motors:
SXh355H8Es315kW/500V/742rpm
Voltage frequency converters:
Type FOC 400kW/160%T_{nom}, then T_{rush}= 2.2$T_{m\ nom}$

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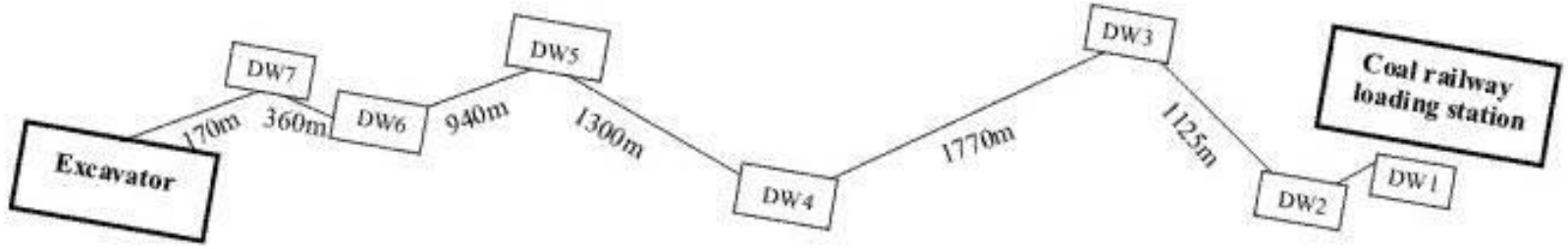
Drive of the conveyor with regulated belt speed



Conveyor name	Drive system	Motors power (kW)	Force in belt in stop state (10 N) max.	Force in belt in stop state (10 N) min.	Force in belt in motion state(10 N) max.	Force in belt in motion state(10 N) min.	Force in belt in motion state(10 N) real
DW-1		2 x 55					
DW-2		3 x 315	14	6	12	5	9
DW-3		4 x 315	16	7	14	6	10
DW-4		2 x 315	11	6	10	5	8
DW-5		2 x 315	11	6	10	5	8
DW-6		2 x 315	12	6	11	5	8
DW-7		1 x 315	8	5	7	4	5
DW-8		2 x 315	12	6	11	5	8

Total length of technological set of 7 conveyors with regulated belt's speed is about 6 km

The power of the motors and drive sets of the coal conveyor belts system of the new opencast "Drzewce" in „Konin" brown coal mine.

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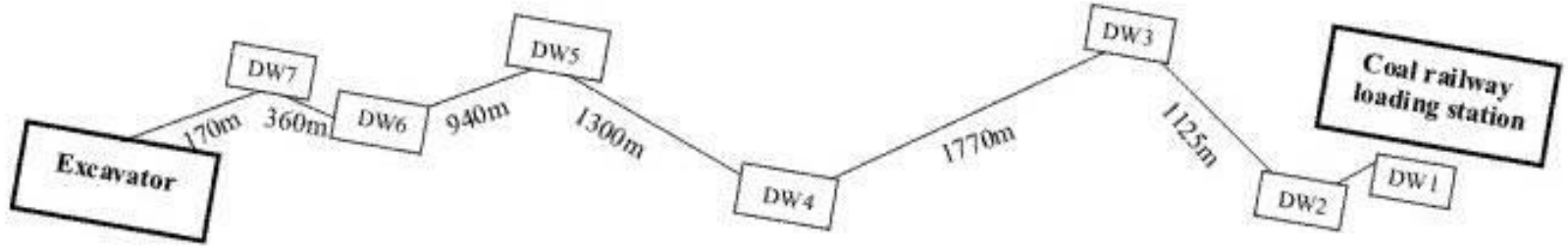
University of Technology and Humanities in Radom, Poland

Drive of the conveyors set with regulated belt speed (lignite mine “KWB Konin“)



Energy consumption of coal lines in the "Konin" Mine in 11 months (May-2006 to March-2007)

Coal pit	Speed of the conveyors line	Length line	Energy consumption	Coal mining	Energy intensity index
	m/s	km	kWh	t	kWh/tkm
Kazimierz	5,24	3,897	5902431	3486294	**0,434**
Jóźwin	5,24	9,326	9352128	1612415	**0,622**
Drzewce	3.0 for 8 months, May 2006-Dec 2006 2.5 for 3 months, Jan 2006-Mar 2006	5,867	3328782	2323101	**0,244**

The total coast of new drive station with LV ASD & CM is cheaper about 20% then traditional solution with 6kV SRM

energy consumption lower by over 50%

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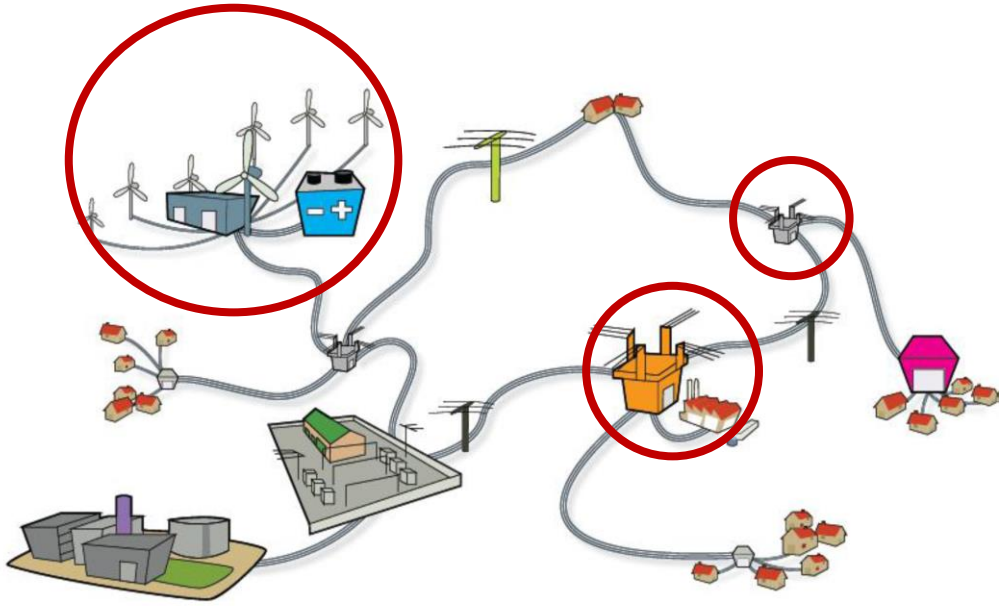
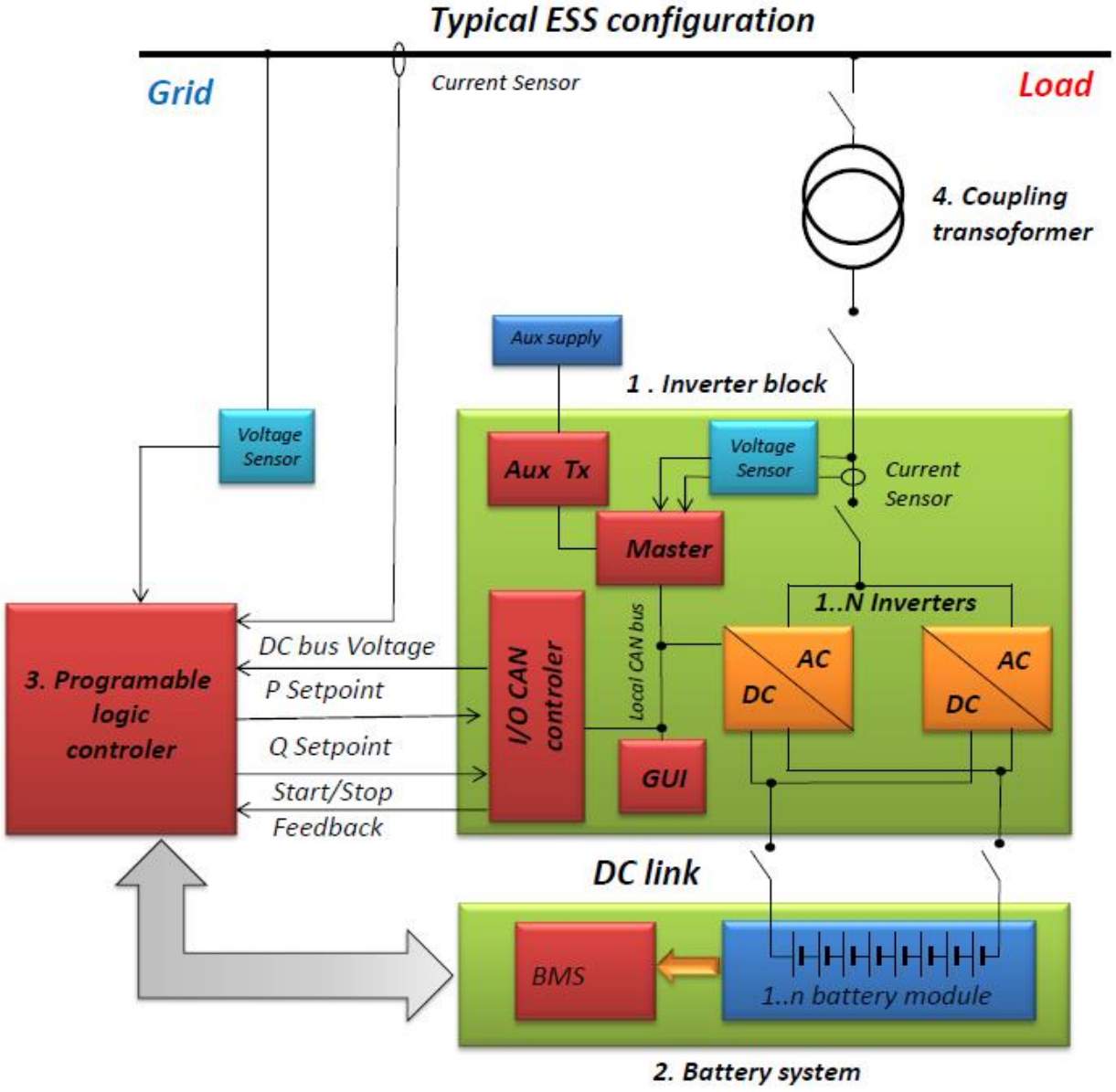
Electricity Storage in AC power electricity grid



Energy Management System EMS

Battery Management System BMS



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Power and energy management

German manufacturer of power backup systems

QINOUS ESS MEDIUM

Power:	up to 500 kVA
Capacity:	up to 828 kWh
Dimensions (LxWxH):	6.1 x 2.5 x 2.9
Weight:	6.0 to 12.0 tons

QINOUS ESS LARGE

Power:	up to 1,500 kVA
Capacity:	up to 2,318 kWh
Dimensions (LxWxH):	12.2 x 2.5 x 2.9
Weight:	12.0 to 25.0 tons

Hybrid Diesel-PV-Battery System - Australia

Energy storage 800 kW / 1,982 kWh (Lithium-ion)

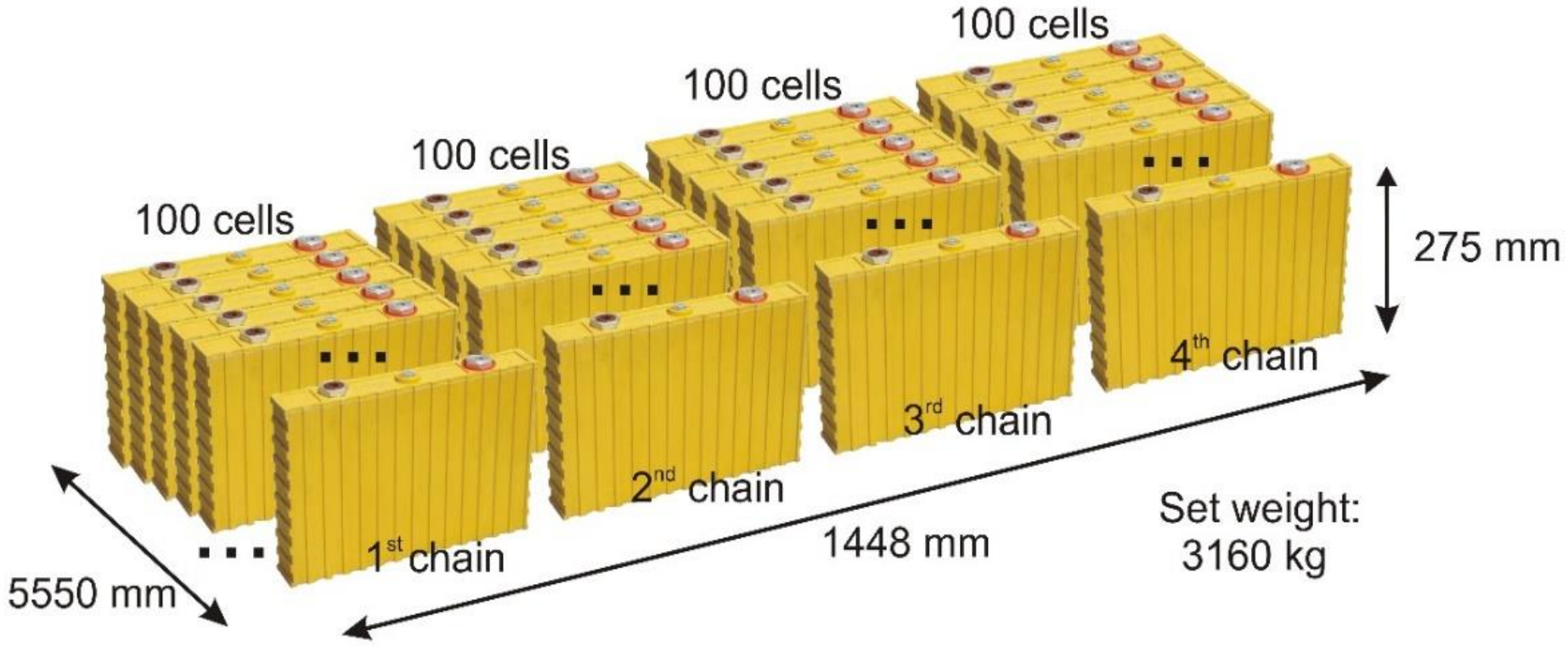
1,000 kWp photovoltaic system

Diesel generators

http://qinous.de/references/community-electrification-australia/

Li-ion battery set or energy storage

Single Li-ion cell: Q_n=200Ah/U_n=3.2V
Set with 100 cells in series connection and 4 paralel branchs creates:
The set: 3.2Vx100 and 200Ax4 – 320V/800A/256kWh



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Li-ion battery set or energy storage - producers

WINSTON 48V, 33.6KWh LiFeYPO4 Set With 700Ah Cells, BMS Mobile Monitoring

Manufacturer: ThunderSky Winston
Art.#: WB-48V700AH-SET

Price without VAT: **14,774.40$**

Stock status : 2 pcs
Next delivery:
July 2022 (free for orders)

Quantity: 1

add to Cart

Individual pricing for large scale projects and wholesale demands is available.
Contact us:
phone: +420 277 007 550
email: export@gwl.eu

Contact form

Delivery by country

Shipping weight: 369.60 kg

https://shop.gwl.eu/Winston-12V-sets/48V-33-6kWh-LiFeYPO4-set-with-700Ah-cells-BMS-mobile-monitoring.html#tab1

Magazyn energii BYD 10.2 kWh Kostal 10 kW 3F

Magazyn energii BYD 10,2 kWh + Kostal 10 kW, trójfazowy

Ceny

Ilość	Cena Netto	Cena Brutto
Od 1 szt.	53475.00 zł	65774.25 zł

1 Dodaj do koszyka Dodaj do oferty

BYD Battery-Box Premium LVS 16.0 & SMA Sunny Island 4.4M solar battery inverter Storage Package

9,000EUR

SKU: BYD Battery-Box Premium LVS 16.0 & SMA Sunny Island 4.4M

https://www.europe-solarstore.com/storage-and-system-solutions/solar-battery-packages/byd-sma/byd-battery-box-premium-lvs-16-0-sma-sunny-island-4-4m-solar-battery-inverter-storage-package.html

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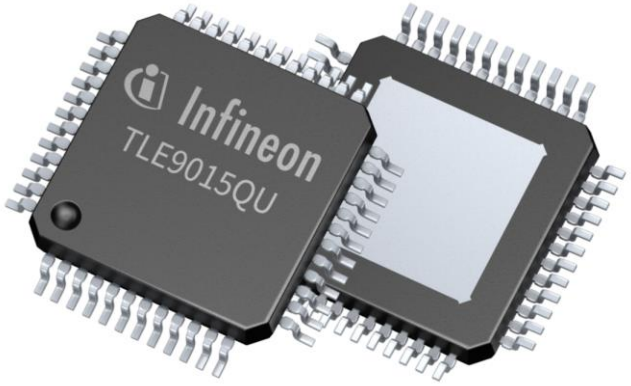
Battery management system (BMS) in EV vehicles

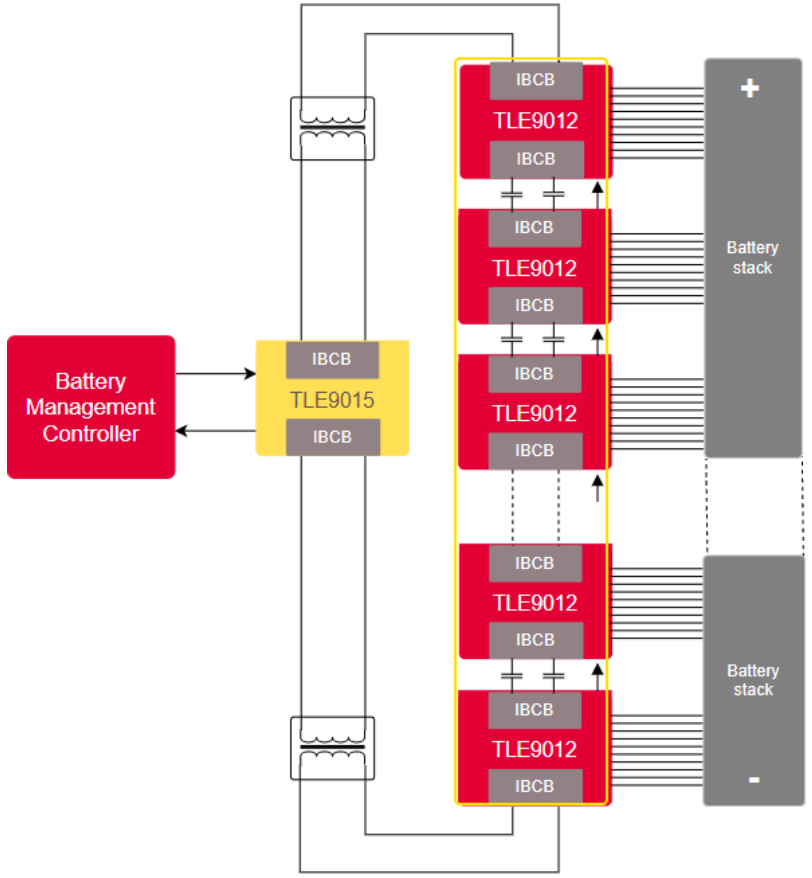
Cell monitoring and balancing (CMC)



CMC Isolated Transceiver

https://www.infineon.com/cms/en/applications/solutions/battery-management-system/battery-balancing/

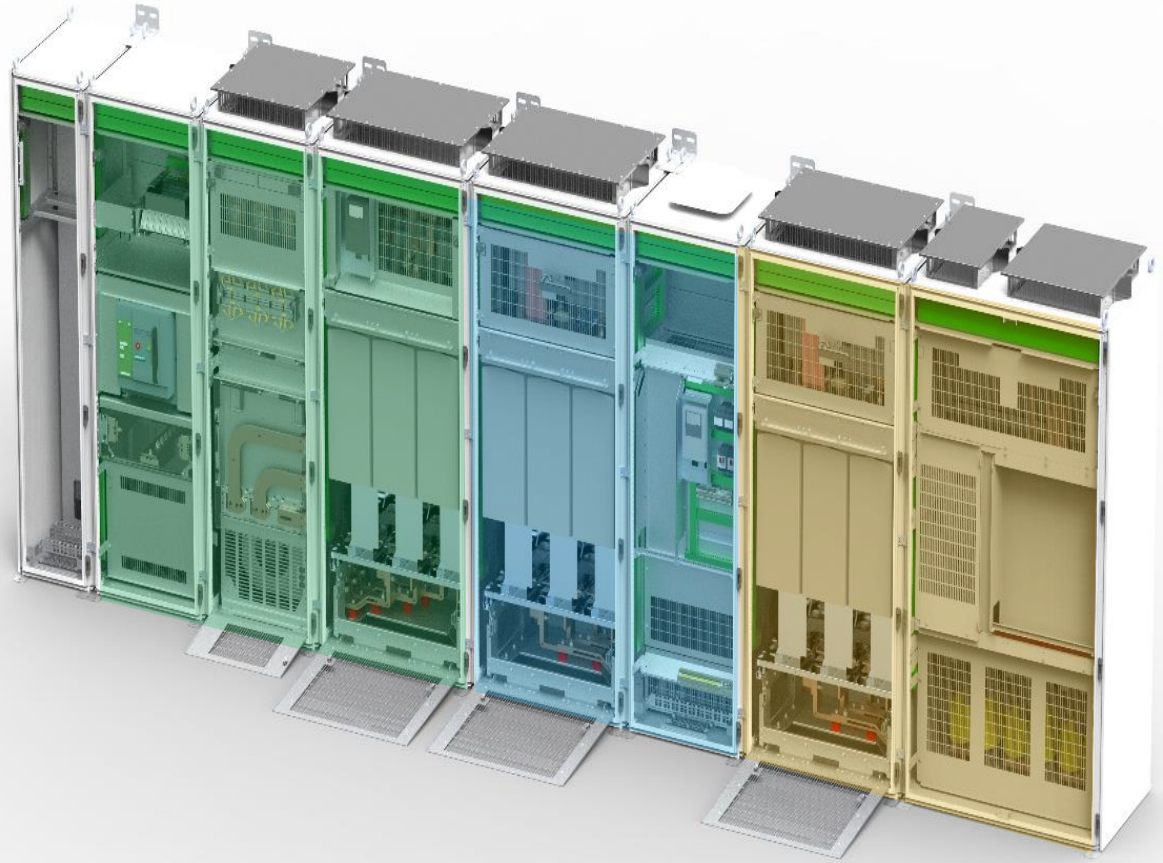
Normal "Master-on-Top (MOT)" Connectivity

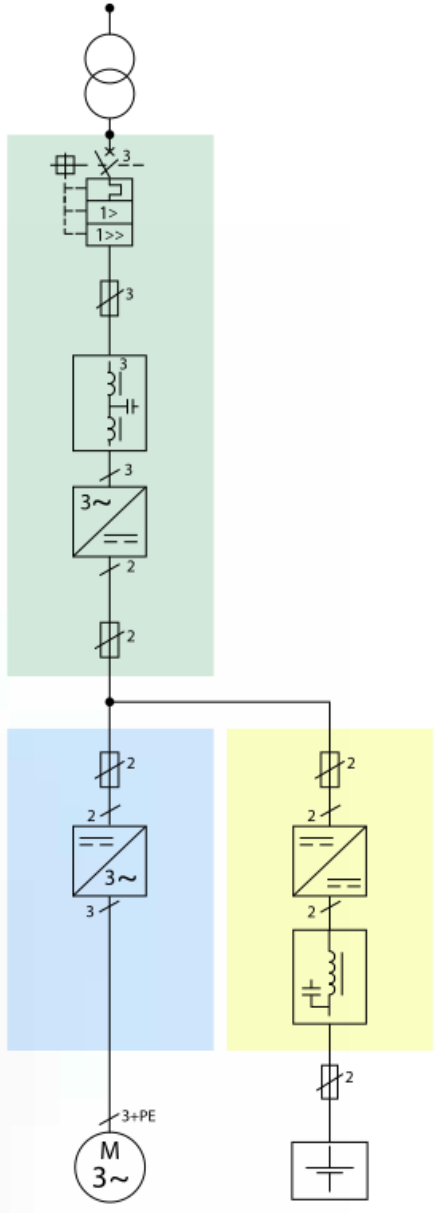


Optional "Redundant Ring" Connectivity(e.g. broken wire protection)

DC/DC converter connected between the DC link and the energy storage

- This brings the load power close to the consumption.
- Provides different voltage BES and technology adaptations.
- It increases expandability and enables the battery stack to be replaced as needed.





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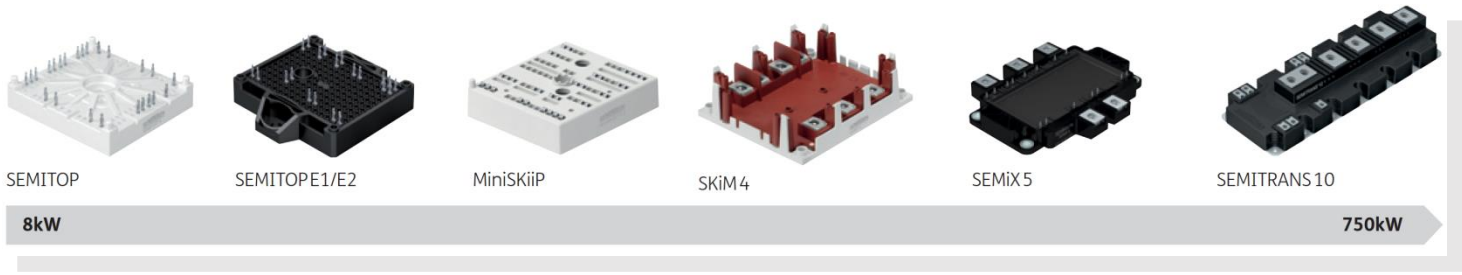
PV power electronics and control systems steer the EU towards green energy

Road

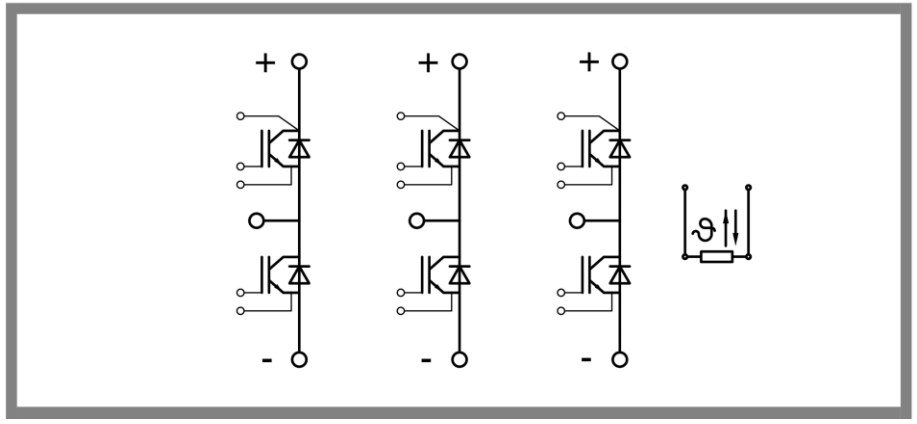
Bridges

Railway

SEMIKRON
innovation+service

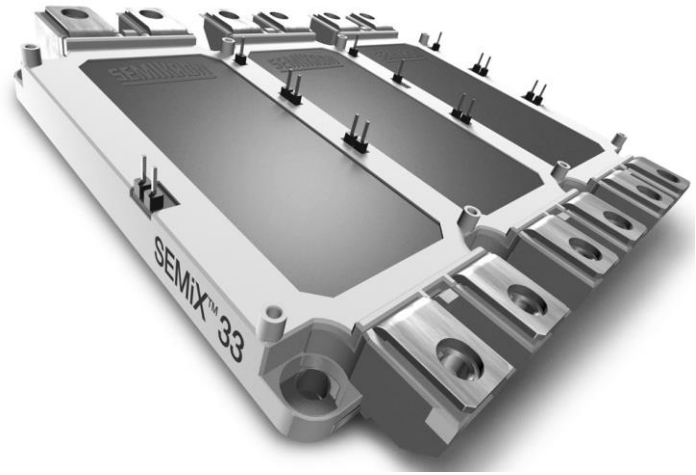


IGBT power electronic chip



Absolute Maximum Ratings		T_{case} = 25°C, unless otherwise specified	
Symbol	**Conditions**	**Values**	**Units**
IGBT			
V_{CES}		1200	V
I_C	T_c = 25 (80) °C	700 (490)	A
I_{CRM}	T_c = 25 (80) °C, t_p = 1 ms	1400 (980)	A
V_{GES}		± 20	V
T_{vj}, (T_{stg})	$T_{OPERATION} \leq T_{stg}$	- 40 ... + 150 (125)	°C
V_{isol}	AC, 1 min.	4000	V
Inverse diode			
$I_F = - I_C$	T_c = 25 (80) °C	560 (380)	A
I_{FRM}	T_c = 25 (80) °C, t_p = 1 ms	1400 (980)	A
I_{FSM}	t_p = 10 ms; sin.; T_j = 25 °C		A

SEMiX 703GD126HDc



Dimensions [mm] LxWxH162x150x20

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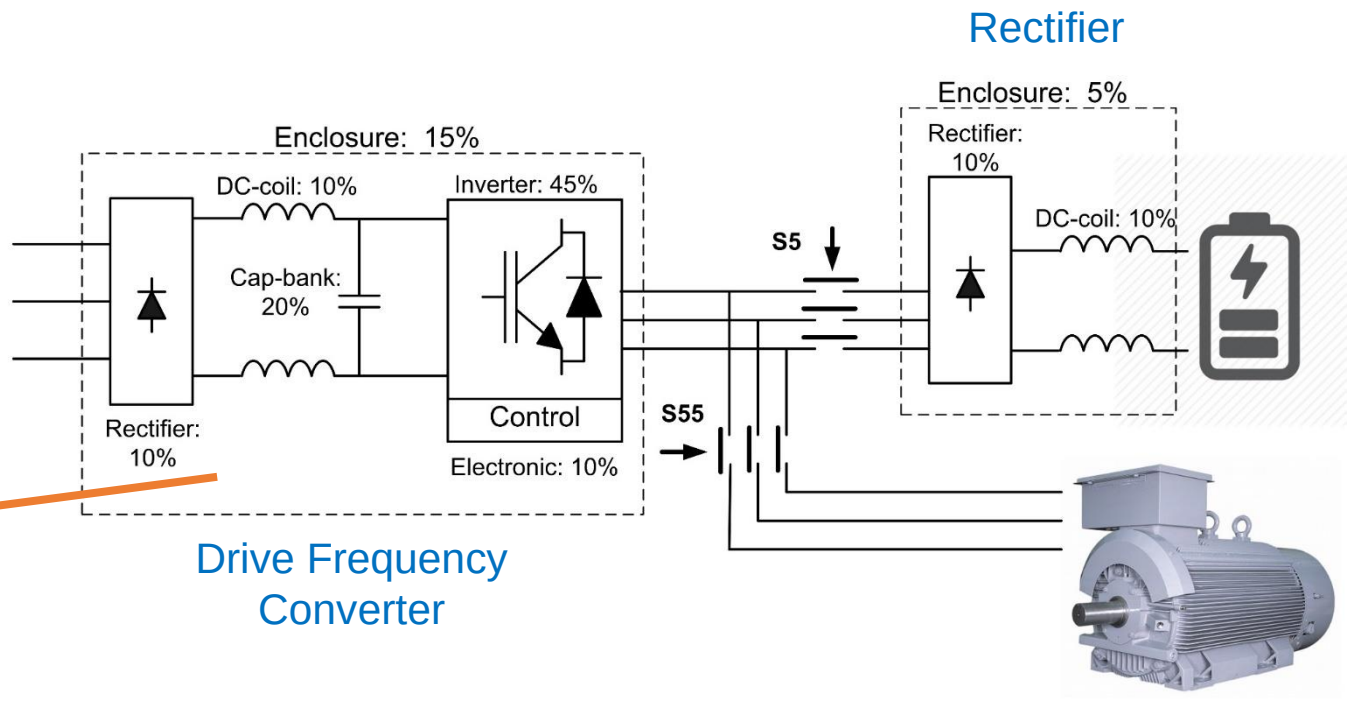
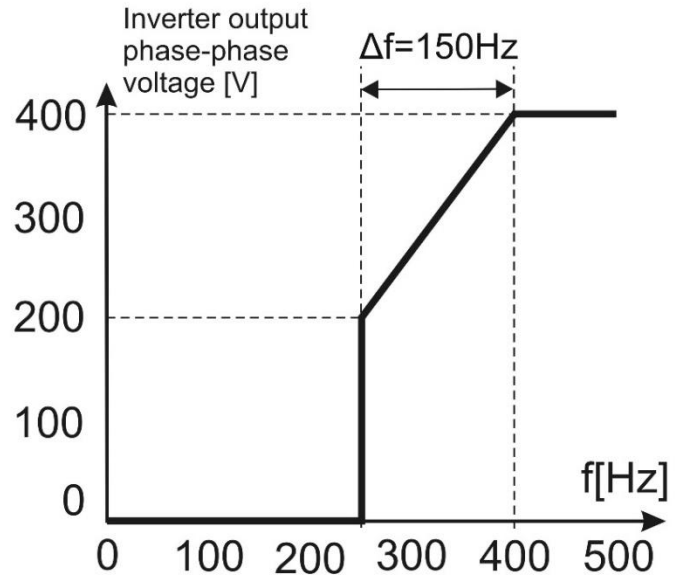
Drive Frequency Converter as a DC/AC/DC Converter for EV Fast Battery Charging



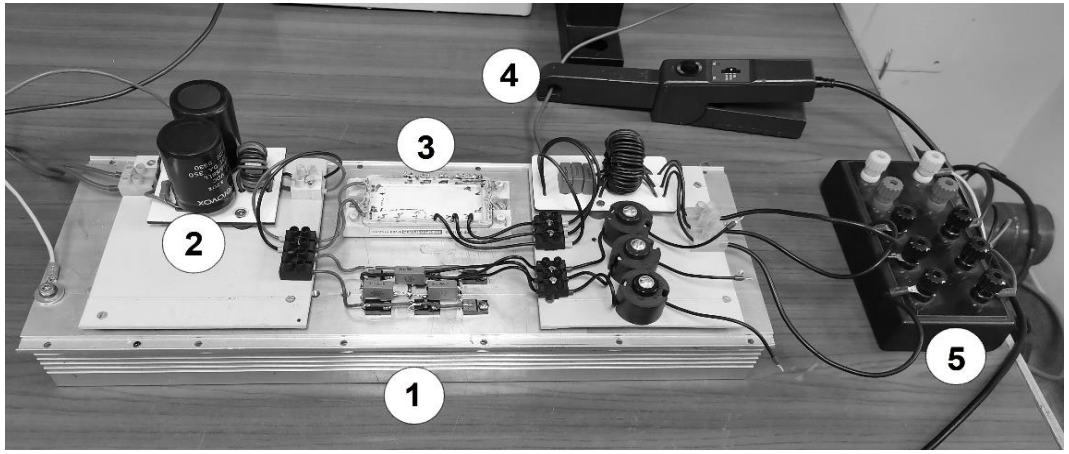


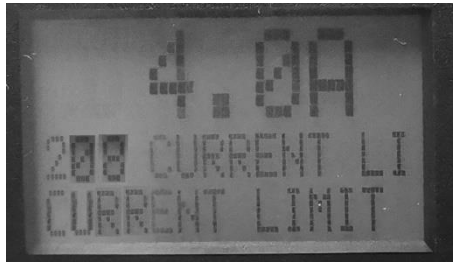
u/f special characteristic for EV battery charging

Components of the FC drive powered from the DC 600V microgrid has two functions:

1. motor power supplying (S55 contactor is on)
2. fast EV battery charging

5b. Experimental Tests of the DC/AC/DC Converter

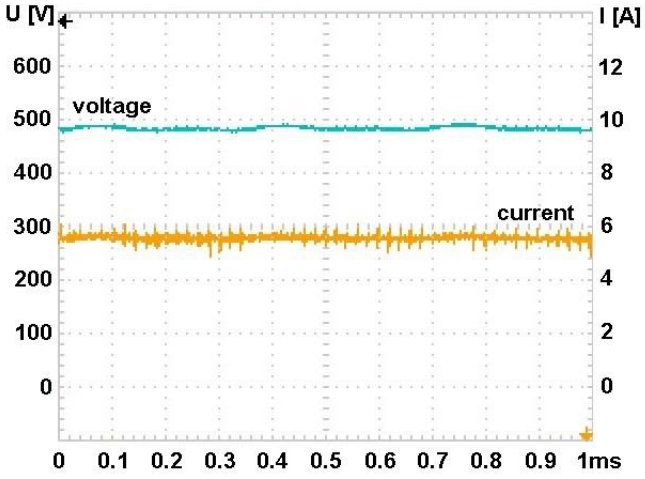




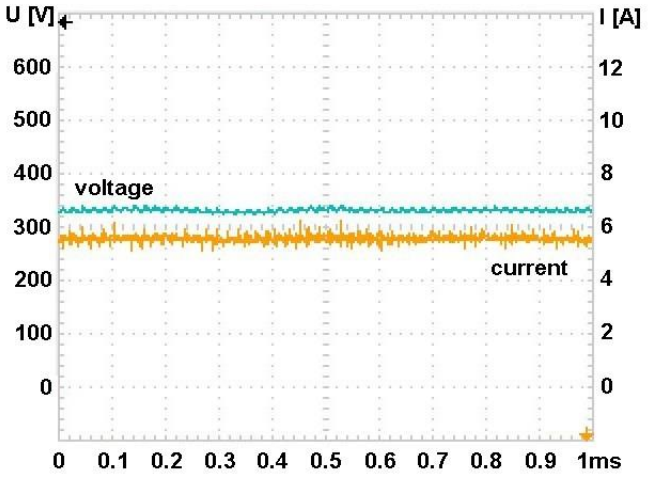
Drive FC as DC/AC/DC converter for charging EV batteries with programmed DC output current value (4.0A)

1. Fast 6-diode rectifier
2. Constant voltage side
3. DC chokes
4. Current probe
5. Drive frequency converter outputs

a)



b)



Voltage and current of the DC/AC/DC converter rectification load for various load resistances:

a) maximum rectifier output voltage 500V at stabilized current at I_{DC} = 5.5A, R_{load} = 91Ω,

b) reduced rectified voltage to 320V with reduced load resistance to 58Ω, I_{DC} = 5.5A.

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Low cost FAST CHARGER with VFC's components

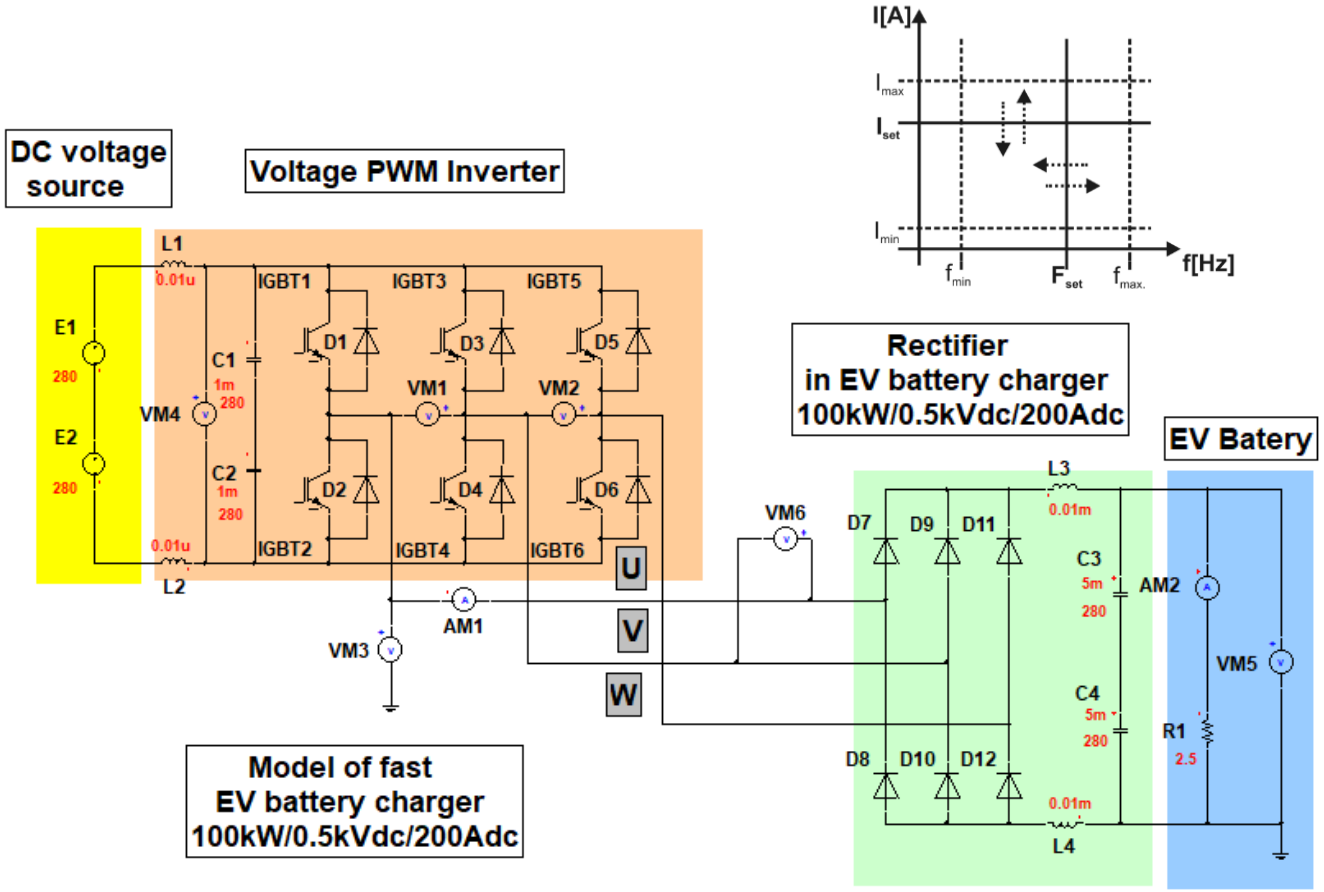
FAST POINT CHARGER

Two DC plug-ins + AC plug-in can be used at the same time.
200 - 810V DC

150 kW DC + 43 kW AC

207 kVA

DC plug-in Combo	DC plug-in	AC plug-in
CCS type 2 Mode 4* cooled with liquid	CHAdeMO*	type 2 Mode 3
150 kW	-	43 kW
100 kW	50 kW	43 kW
max. 400 A	max. 125 A	max. 63 A



Model of fast charger with VFC's components

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University of Technology and Humanities in Radom, Poland

Conclusions

- Existing drive frequency converter can be adapted for battery charging.
- After using a rectifier attached to the drive inverter, a DC voltage source with adjustable value was obtained in such a way that a constant current of battery charging was ensured.
- The software functions of drive FCs are used here to shape the inverter voltage characteristics and thus the value and quality of the rectified voltage.
- The use of rectification and inverter implemented in one power integrated circuit decreases the negative side effects of the inverter CM voltage.

More about it you can find here:

Springer Link

Review Paper | Open Access | Published: 18 September 2020

Unidirectional voltage converter for battery electric vehicle ultrafast charger

Jerzy Ryszard Szymanski, Marta Zurek-Mortka & Dulal Acharjee

Microsystem Technologies (2020) | Cite this article

228 Accesses | Metrics

https://link.springer.com/article/10.1007/s00542-020-05038-7

energies

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Unidirectional DC/DC Converter with Voltage Inverter for Fast Charging of Electric Vehicle Batteries

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Low cost FAST CHARGER with VFC's components

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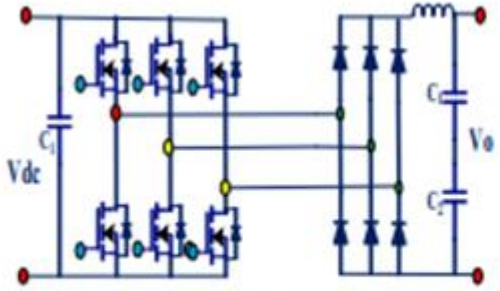
Review

Electric Vehicles Charging Stations' Architectures, Criteria, Power Converters, and Control Strategies in Microgrids

Dominic Savio Abraham [1], Rajesh Verma [2], Lakshmikhandan Kanagaraj [3], Sundar Rajan Giri Thulasi Raman [4], Narayanamoorthi Rajamanickam [1], Bharatiraja Chokkalingam [1,*], Kamalesh Marimuthu Sekar [5] and Lucian Mihet-Popa [6]

[153]	 DC/AC/DC Converter	PWM modulation factor value and thereby controls	• The extension of drive FCs to the additional battery charging functionality of EVs and mobile electric work machines allows the distribution of battery charging stations. • Existing converter electric drives can be adapted for battery charging.

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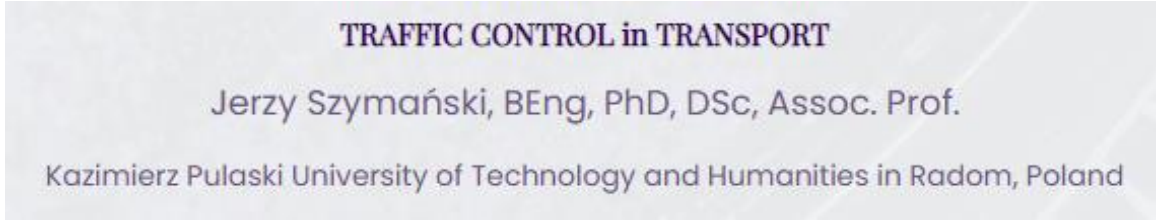
Thank you very much for participating in my seminar



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