SIC BASED INNOVATIVE 3-PHASE GRID-TIED CURRENT-SOURCE PHOTOVOLTAIC INVERTER

Sustainable Places 2018 | BIER Anthony

CONTEXT OF THE PV PLANTS AND INVERTERS

http://www.pvresources.com

Large-Scale PV Power Plants - Top50

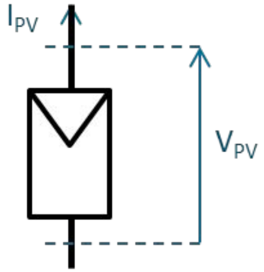
Power	Location	Description	On Grid
1000 MW	India *Gadivemula, Orvakal,* Andhra Pradesh	Kurnool Solar	2017
1000 MW	China *Yanchi,* Qinghai Province	Yanchi Solar PV Station	2016
1000 MW	India *Gadivemula* Andhra Pradesh	Kurnool Solar Park	2017
850 MW	China *Longyangxia Dam,* Qinghai Province	Longyangxia Hydro-Solar PV Station	2013-2017
648 MW	India *Kamuthi,* Tamil Nadu	Kamuthi Solar	2017
600 MW	India *Karnataka*		2017
575 MW	USA *Rosamond, CA*	Solar Star Projects	2015
550 MW	USA *Riverside County, CA*	Desert Sunlight Solar Farm	2015
550 MW	USA *San Luis Obispo County, CA*	Topaz Solar Farm	2011-2014
350 MW	USA *Boulder City, NV*	Copper Mountain III Solar Facility	2015
345 MW	India *Charanka,* Patan District	Charanka Park PV power plant	2012-2015
300 MW	France *Cestas, Bordeaux* Gironde	Centrale solaire de Cestas	2015

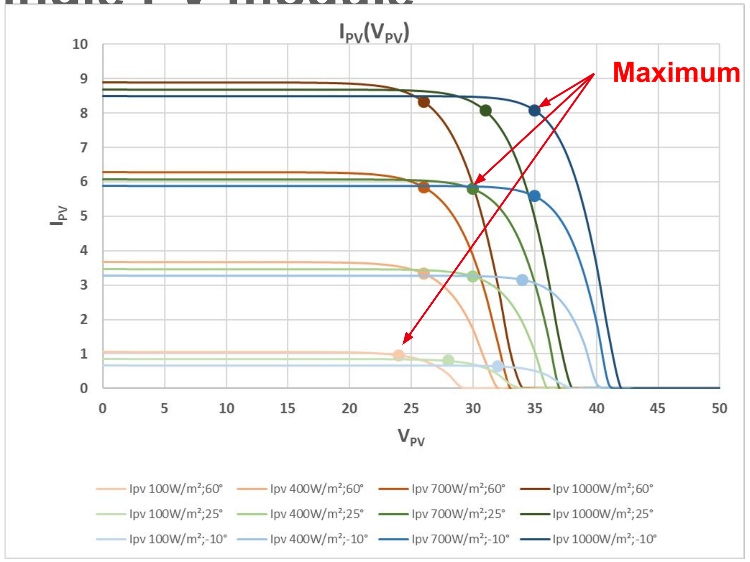
Some Examples of Large Photovoltaic Roofs

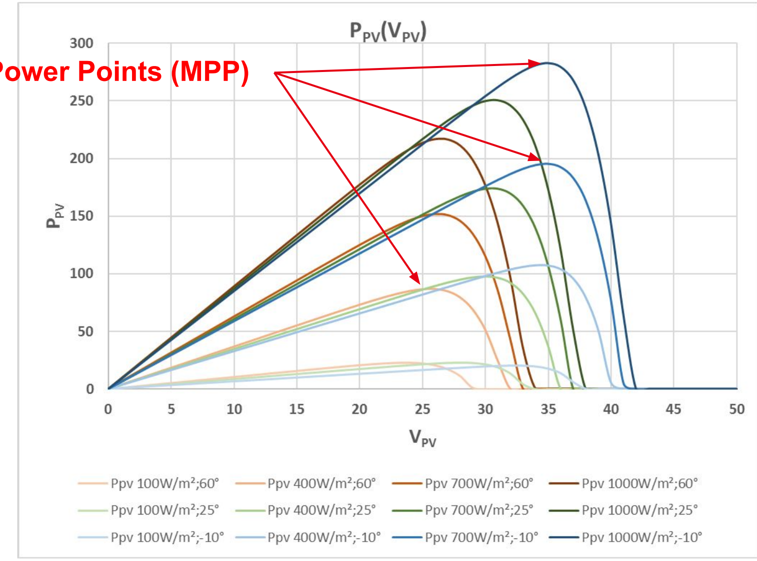
Power	Location	Description	On Grid
20 MW	South Korea, *Busan*	Renault, Samsung facility	2012
13 MW	Belgium, *Kallo*	Loghidden City, Katoen Natie	2010
12.5 MW	Italy, *Padova*	Interporto Padova	2010-2011
12 MW	India, *Amritsar*	RSSB-EES PV Roof System	2015
11.9 MW	France, *Maubeuge*	Renault Solar Project	2012
11.9 MW	France, *Batilly*	Renault Solar Project	2012
11.8 MW	Spain, *Figueruelas*	GM facility	2008
11 MW	Spain, *Martorell*	Seat al Sol, SEAT facility	2010-2013
10.6 MW	France, *Flins*	Renault Solar Project	2012
10.5 MW	France, *Sandouville*	Renault Solar Project	2012
10.4 MW	France, *Douai*	Renault Solar Project	2012
9.2 MW	Germany, *Rüsselsheim*	OPEL facility	2011
9.2 MW	France, *Quincieux*	Quincieux Car Port	2010
9.1 MW	France, *Perpignan*	Saint-Charles International	2010
8.6 MW	USA, *Rialto, CA*	Prologis facility	2011

ELECTRICAL CHARACTERISTICS OF PV GENERATOR

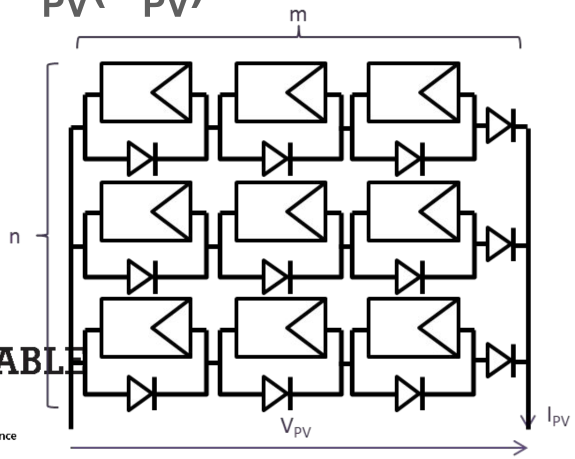
- $I_{PV}(V_{PV})$ and $P_{PV}(V_{PV})$ curves of a single PV module

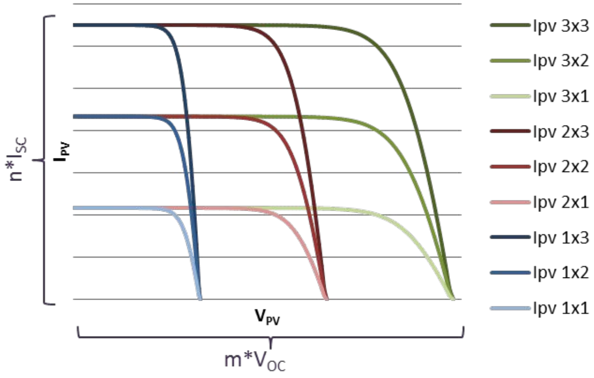


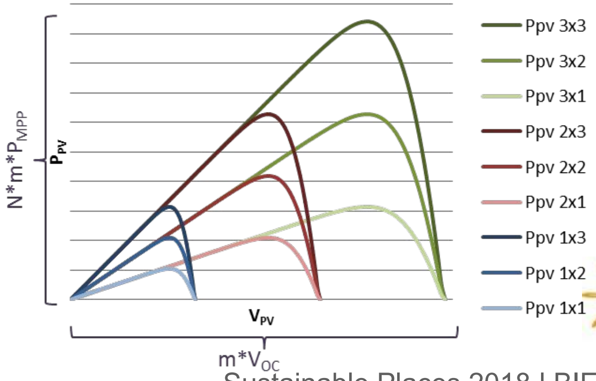




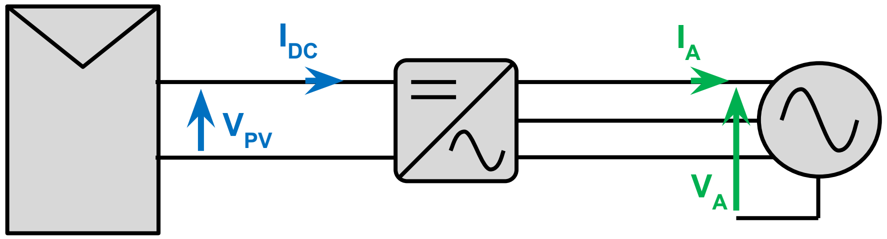
- $I_{PV}(V_{PV})$ and $P_{PV}(V_{PV})$ curves of a PV array

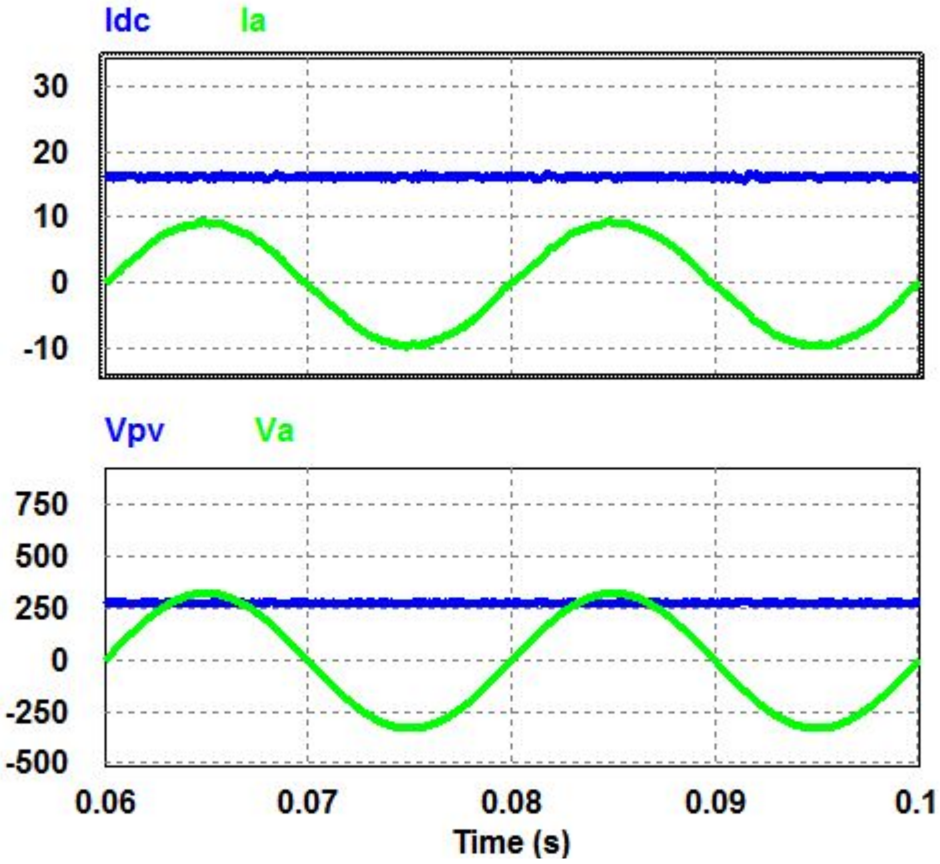






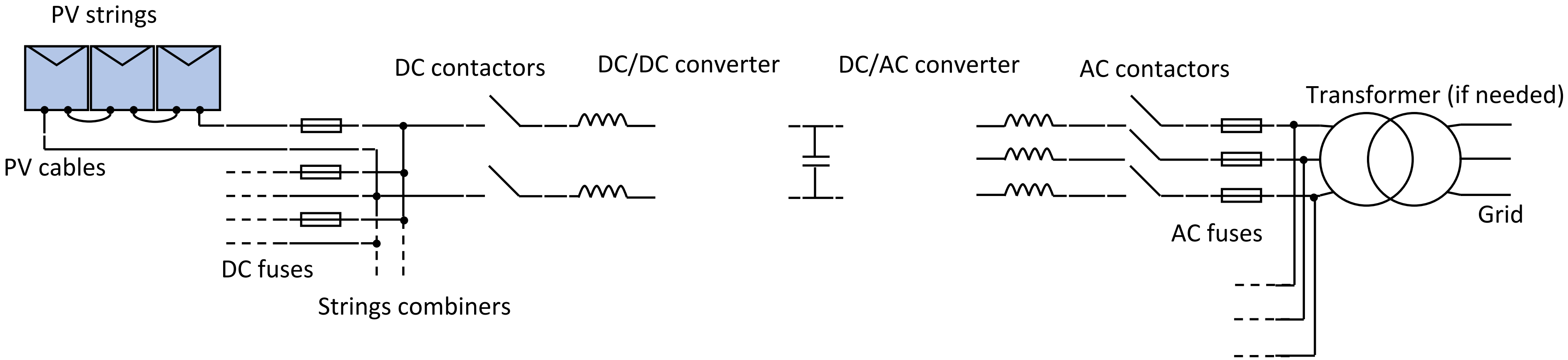
FUNCTIONALITY OF THE PV INVERTER





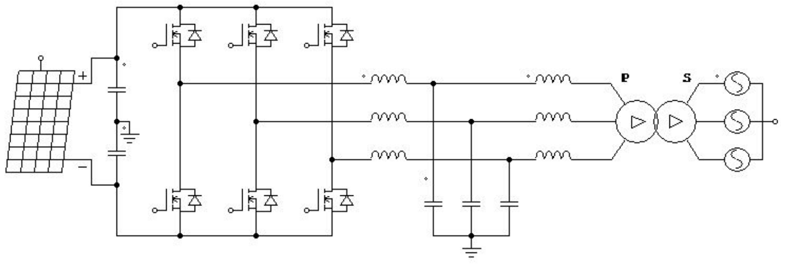
TYPICAL PV PLANT ARCHITECTURE

- **Components of a typical PV plant**

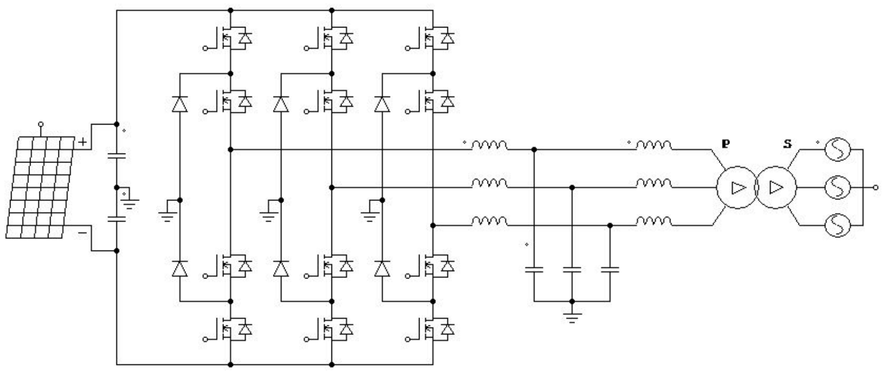


USUAL PV INVERTER TOPOLOGIES

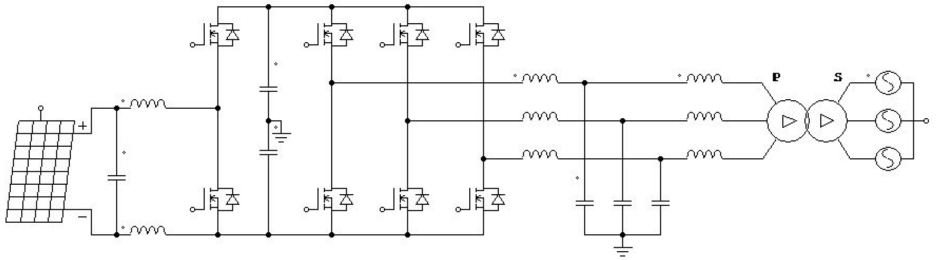
2 levels
voltage-source
inverter



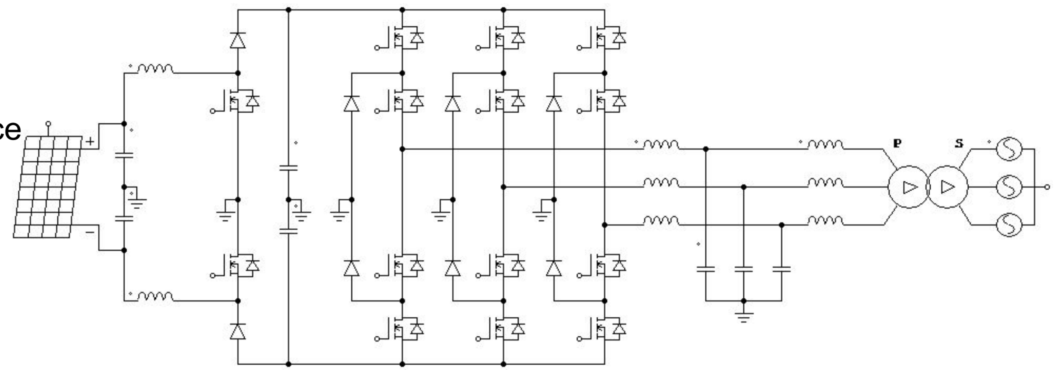
3 levels NPC
voltage-source
inverter



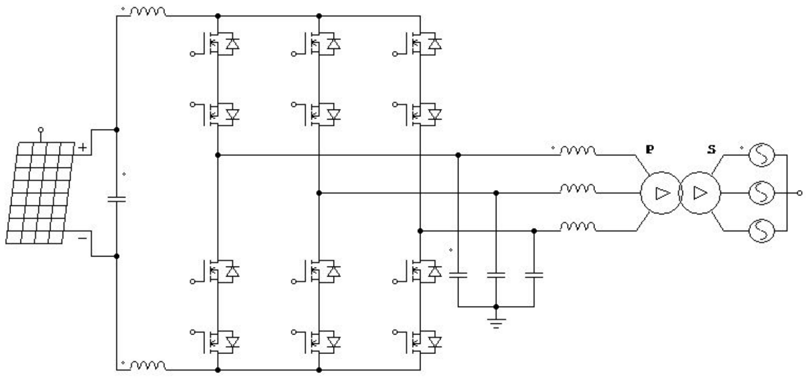
2 levels
voltage-source
inverter
+ boost DC/DC



3 levels NPC
voltage-source
inverter +
symmetrical
boost DC/DC

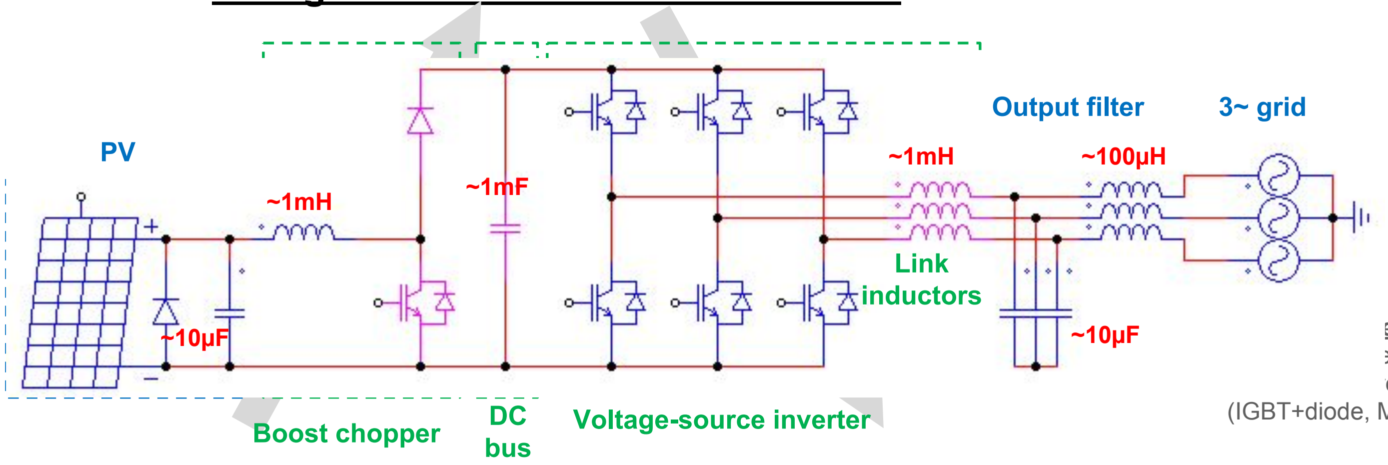


Current-source inverter



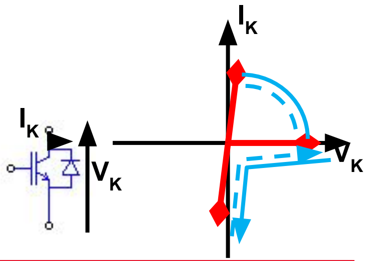
COMPARISON OF THE VSI + BOOST VERSUS THE CSI

Voltage-source inverter + boost DC/DC

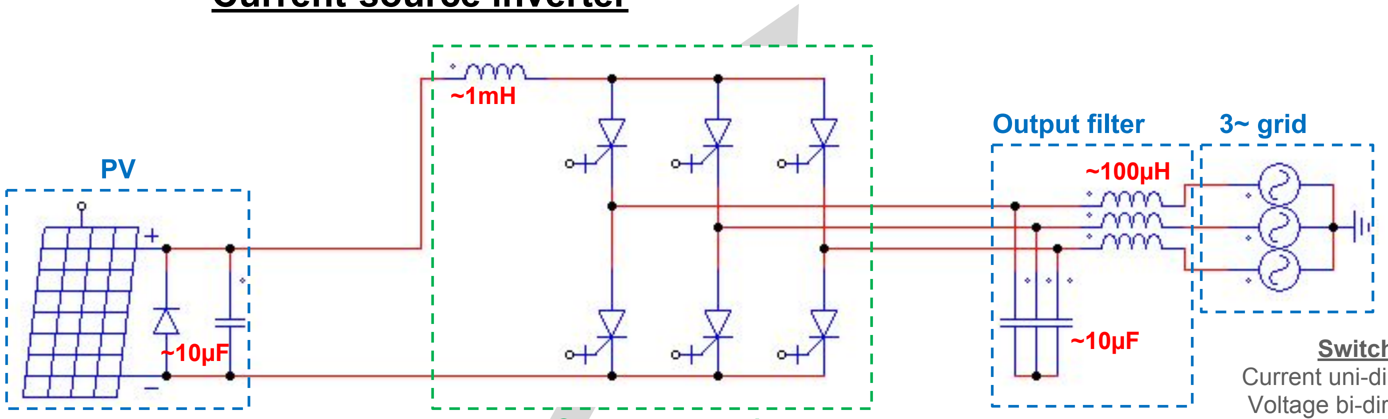


Grid voltage	Switches blocking voltage
400 V_{RMS}	1200V / 1700 V
690 V_{RMS}	2400 V

es
ectionnal
ectionnal
(IGBT+diode, MOSFET)

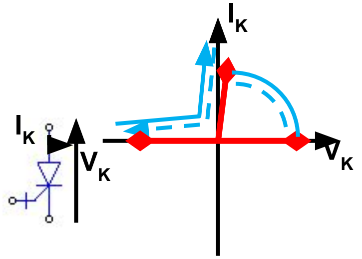


Current-source inverter



Grid voltage	Switches blocking voltage
400 V_{RMS}	900V / 1200 V
690 V_{RMS}	1700V

Switches
Current uni-directionnal,
Voltage bi-directionnal,
(GTO)



CSI pros :

- Directly elevating topology
- Suppression of the boost chopper, the DC bus and the link inductors
- Reduced switches blocking voltage

LABORATORY DEVELOPED INVERTER IN THE FRAME OF EU-PVSITES PROJECT

- **Demo-sites and inverter specifications**

	#1 demo site PV module (C-Si)	#2 demo site PV module (CIGS)
I_{SC}	**5,7 A**	**1,91 A**
I_{MPP}	**5,4 A**	**1,66 A**
V_{OC}	**41,6 V**	**48 V**
V_{MPP}	**34,88 V**	**36 V**
P	**191,5 W**	**60 W**
Module number	**96**	**336**
Total power	**18,4 kW**	**20,2 kW**

PVSITES SiC based current-source inverter specification	
DC maximum power	5 kW
DC maximum voltage	416 V
MPP voltage range at rated power	250 V to 416 V
Minimum starting voltage	140 V
DC maximum current	20 A
Number of MPP inputs	1

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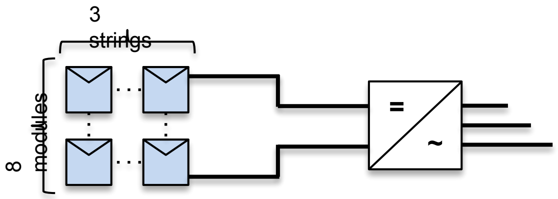
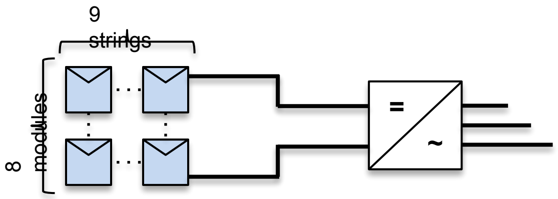
- **DC cabling and electrical characteristic for the 2 demo-sites**

Site #1

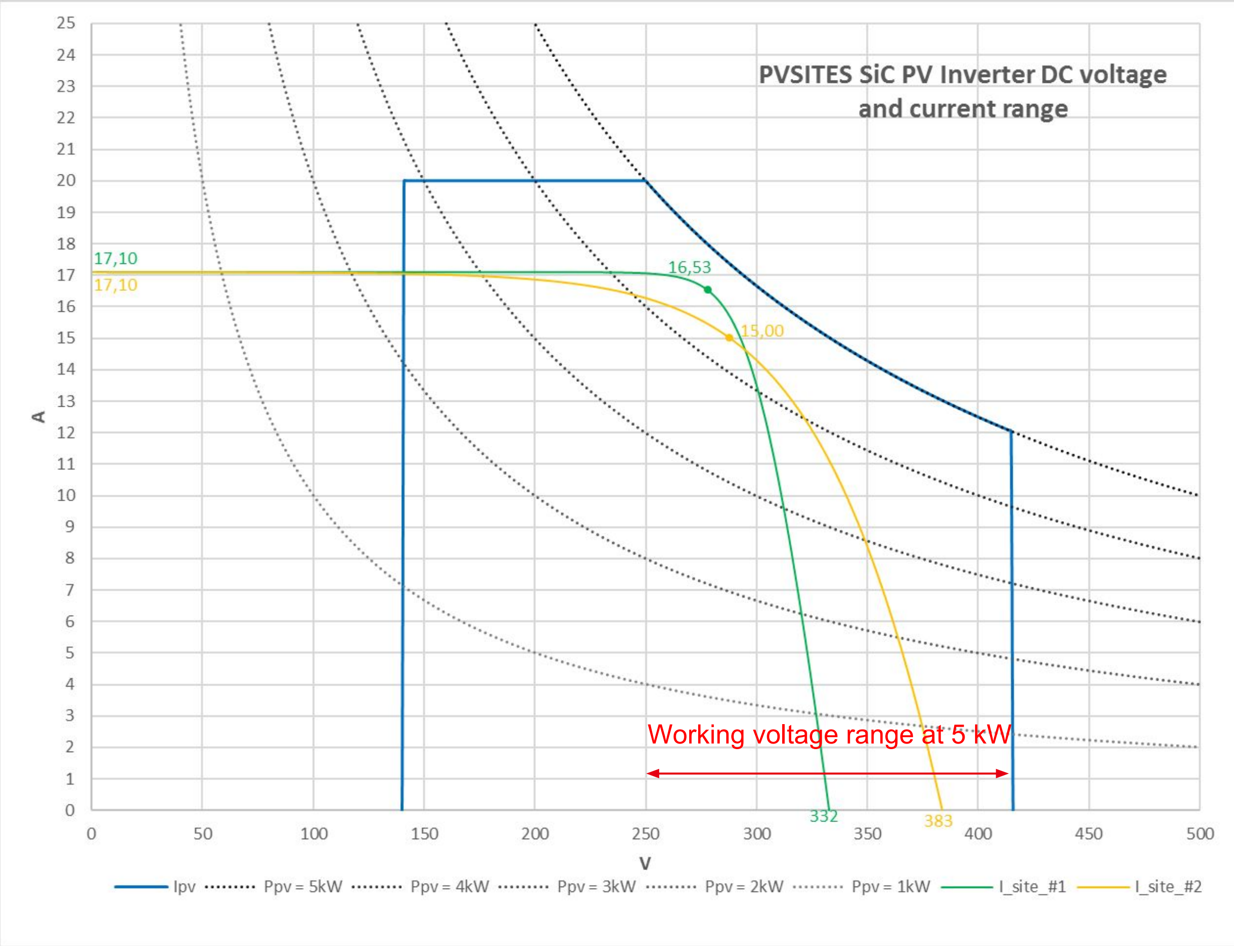


Electrical DC characteristic for 1 inverter, site #1	
	PVSITES CSI
PV modules in series	8
PV modules in parallel	3
Number of PV modules	24
DC maximum power	4,6 kW
DC maximum voltage	333 V
DC maximum current	17,1 A

Site #2



Electrical DC characteristic for 1 inverter, site #2	
	PVSITES CSI
PV modules in series	8
PV modules in parallel	9
Number of PV modules	72
DC maximum power	4,32 kW
DC maximum voltage	384 V
DC maximum current	17,19 A



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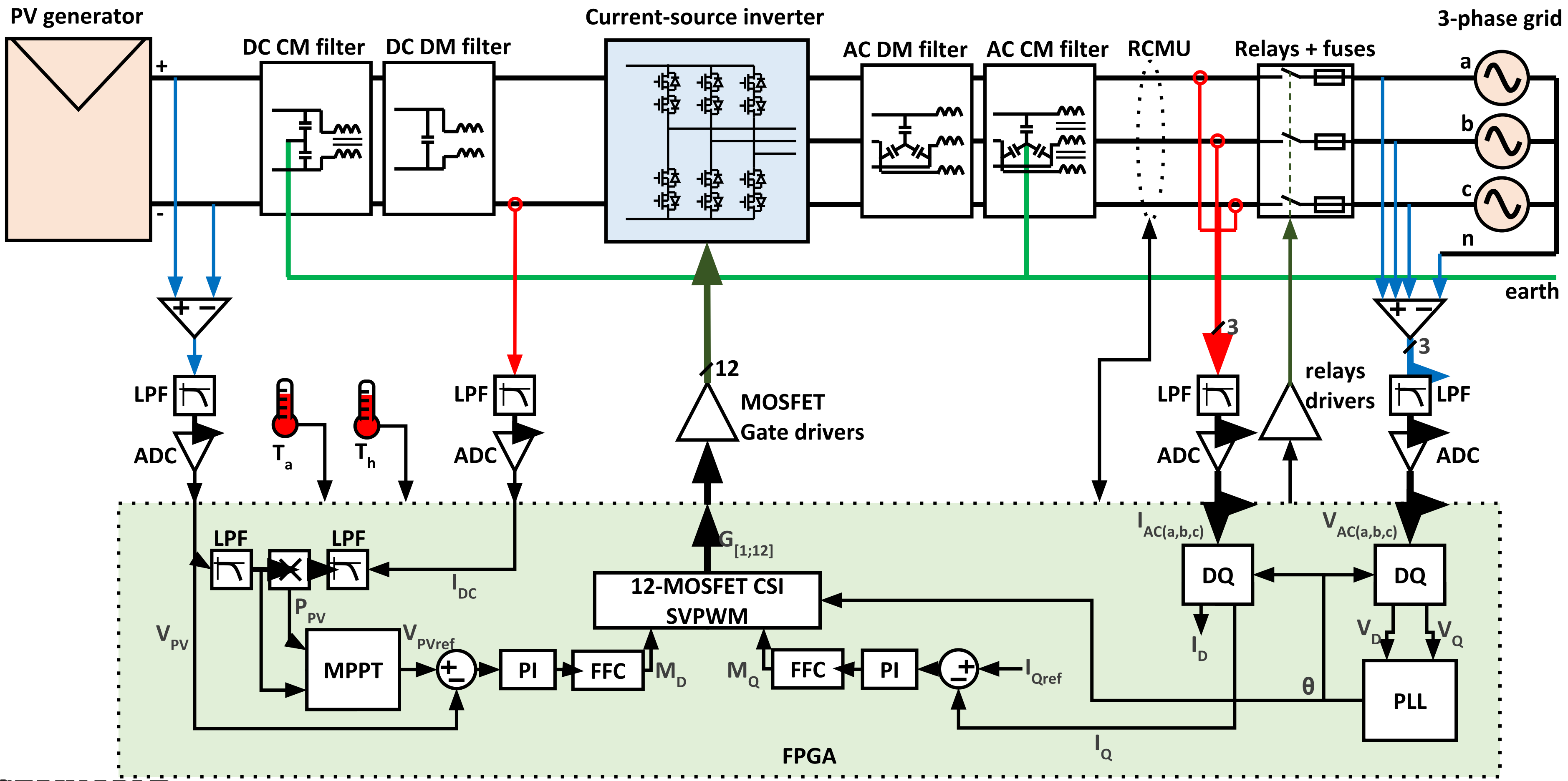
- Power and control schematic



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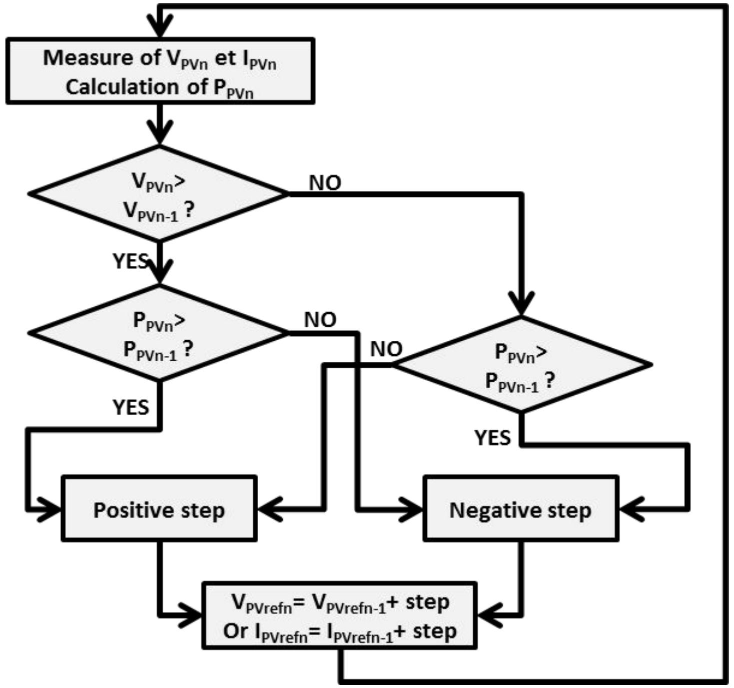
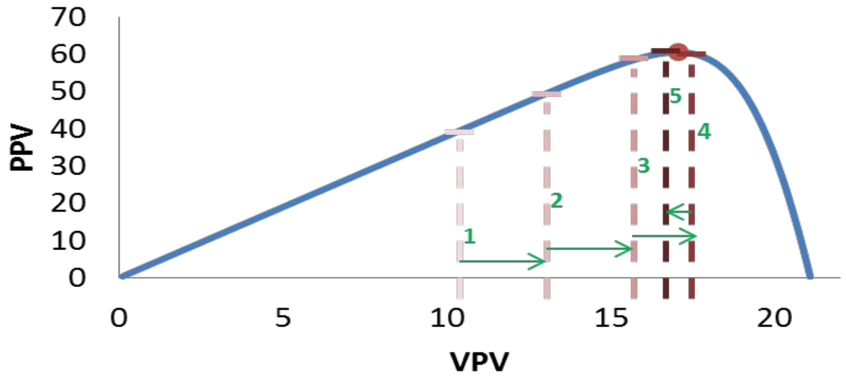
- **Focus on the Maximum Power Point Tracking**



Variations		Next step sign
V_{PV} or I_{PV}	P_{PV}	
+	+	+
-	-	+
+	-	-
-	+	-



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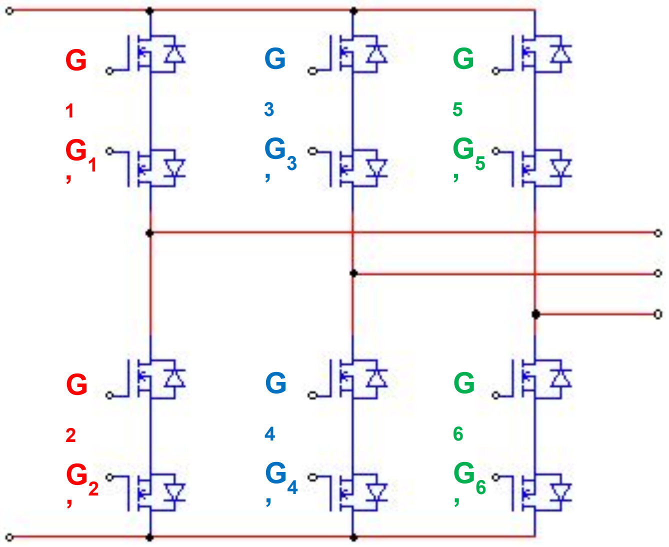
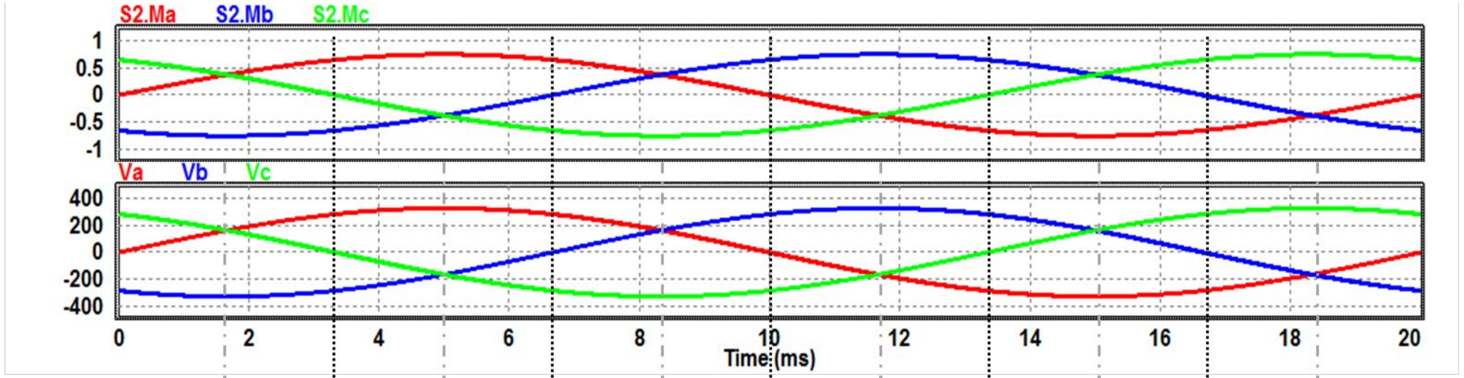
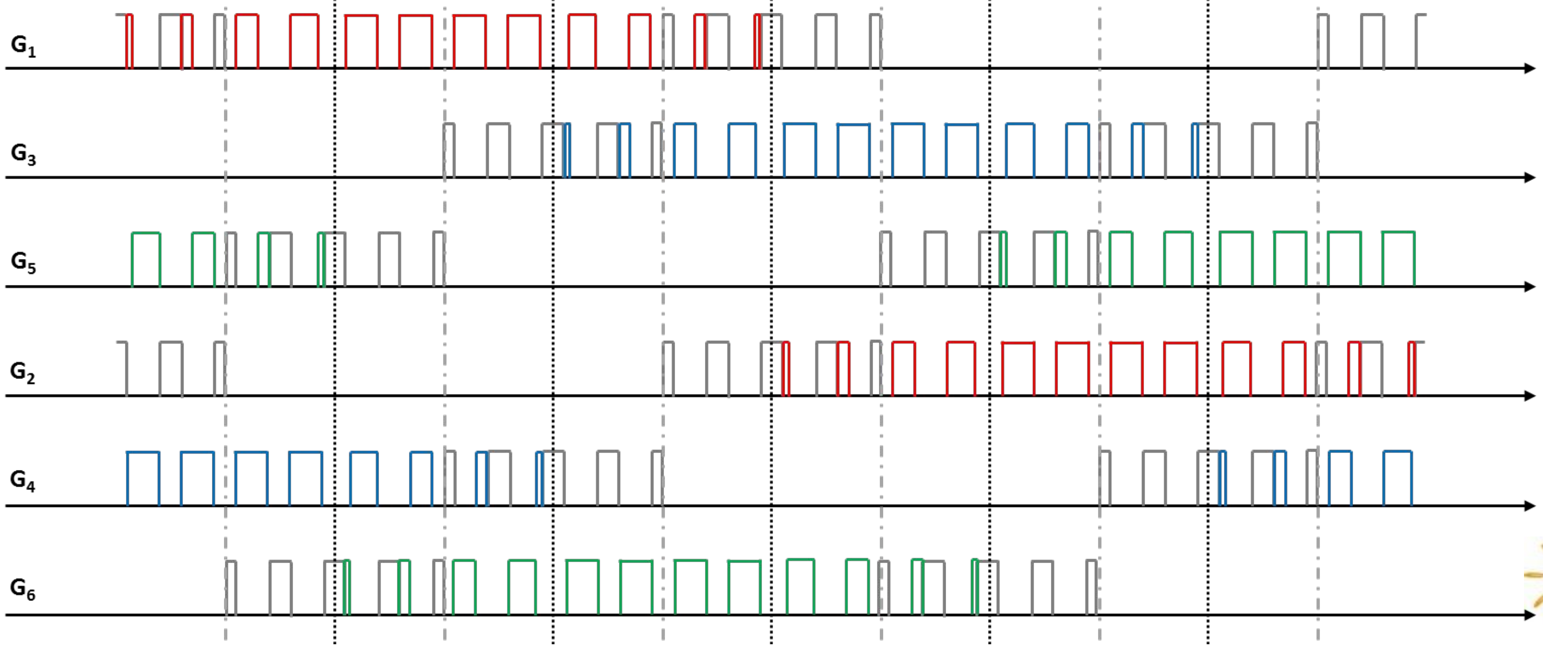
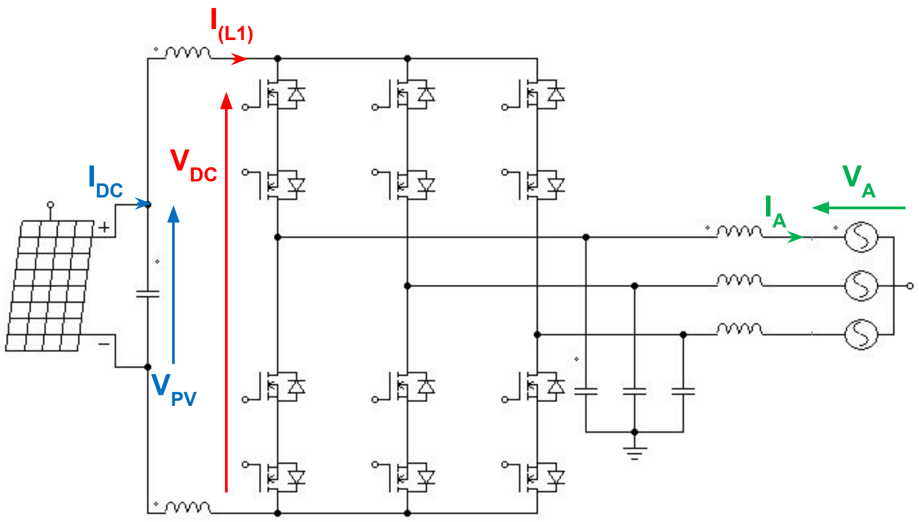
- **MOSFET's gate controls waveforms**

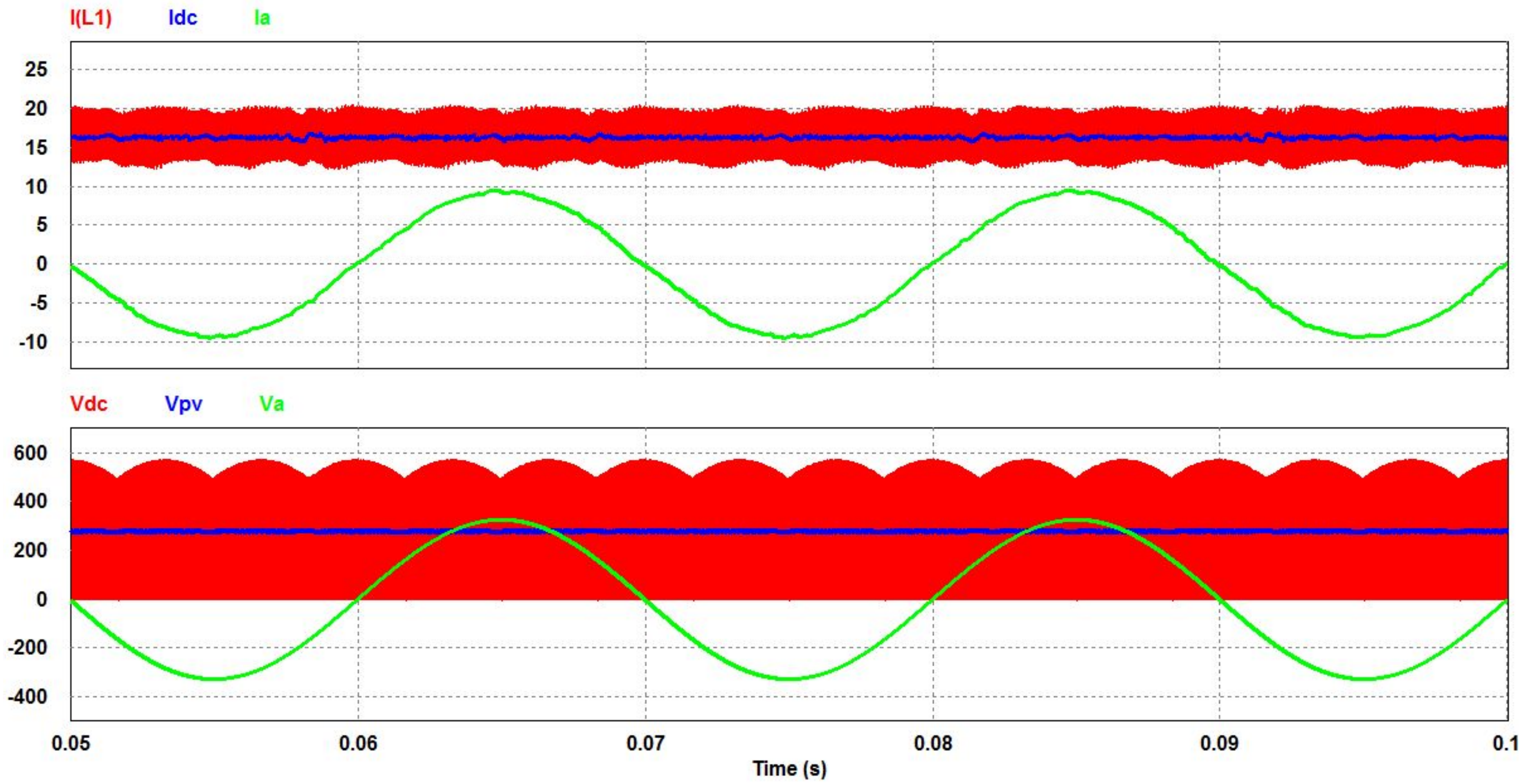






- Simulation results





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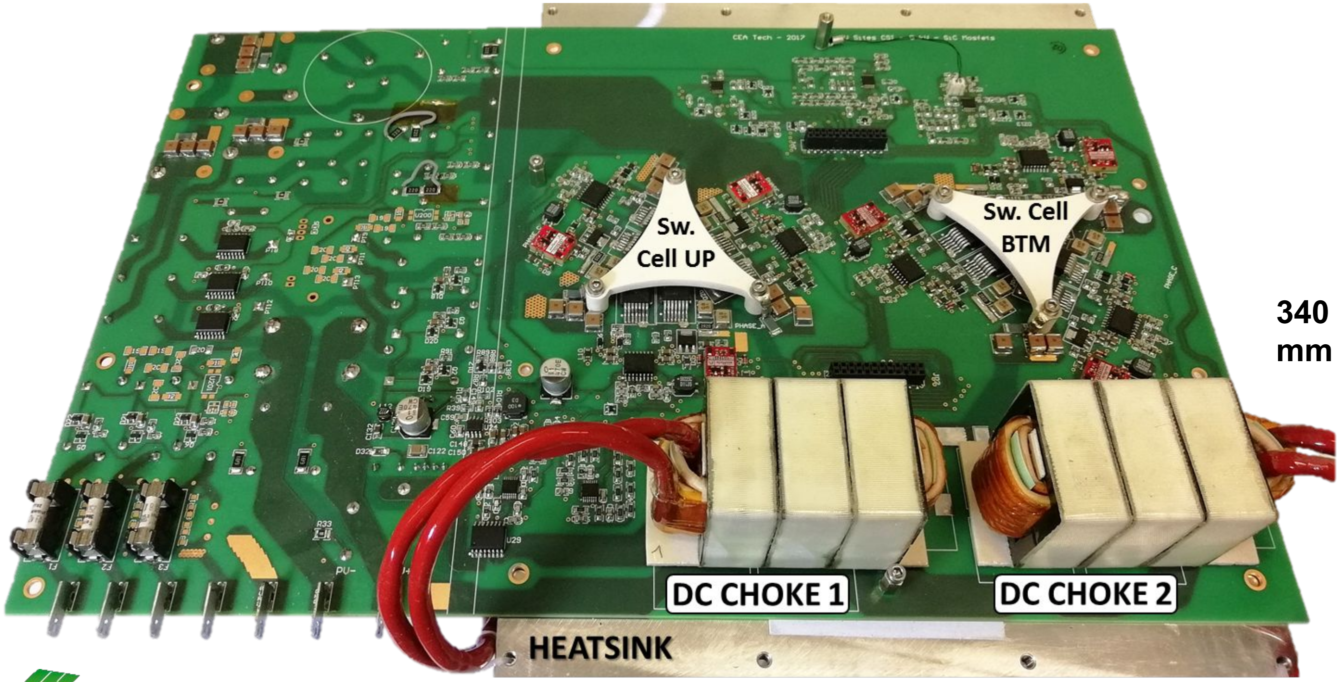
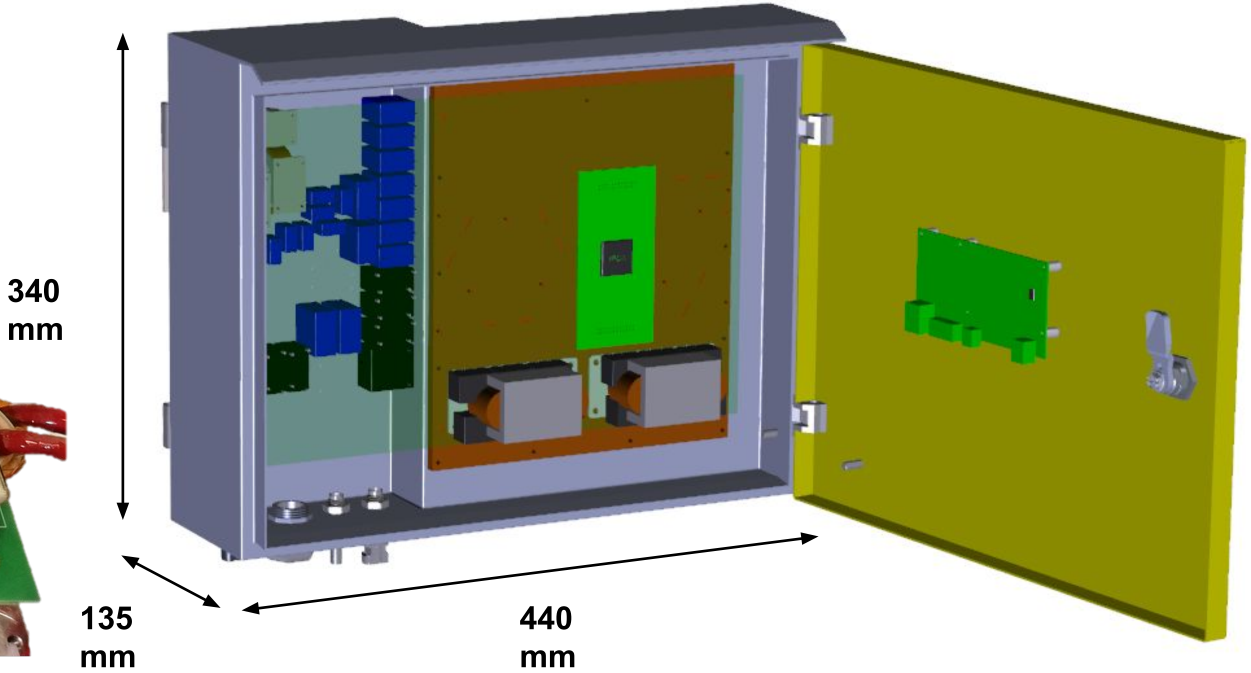
- **Printed Circuit Board and packaging of the inverter**





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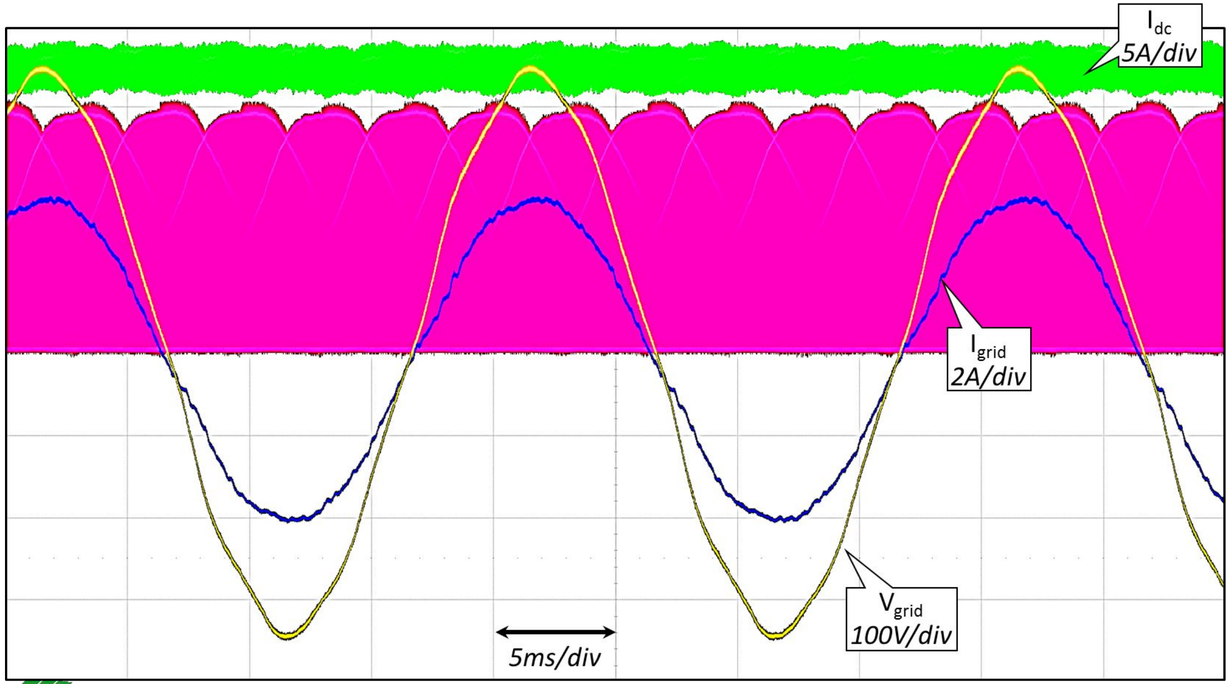
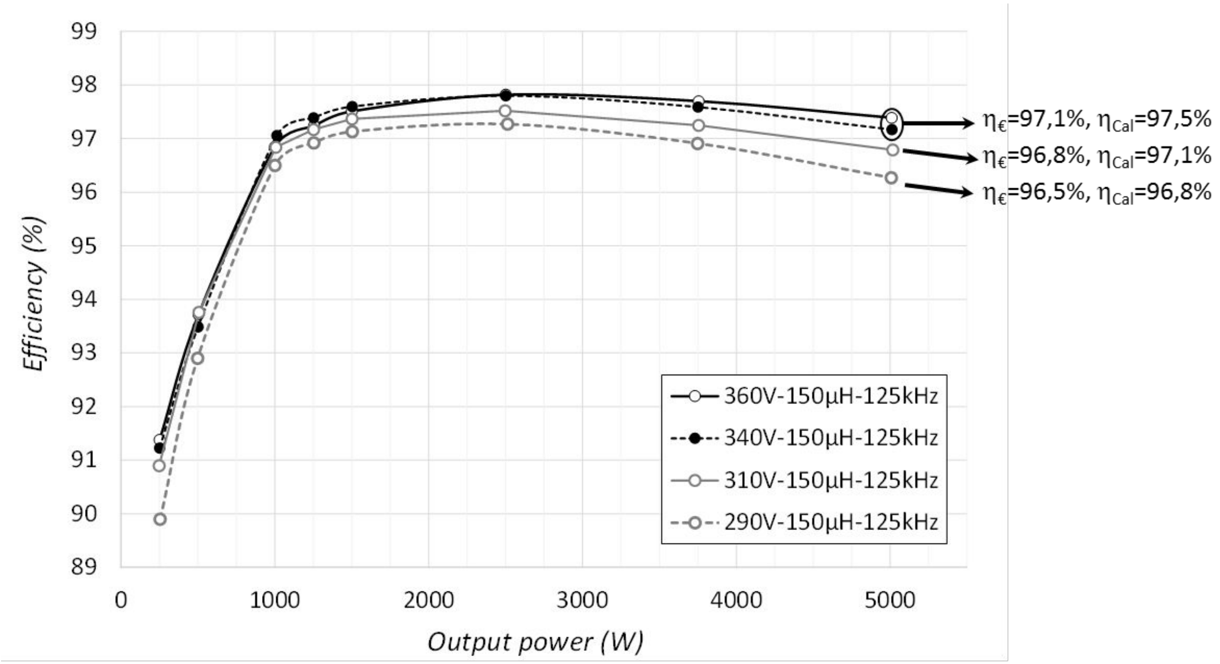
- **Experimental results**





MERCI POUR VOTRE ATTENTION

THANKS FOR YOUR ATTENTION

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