Hoe grid-, en batterijemulatie kan bijdragen aan een stabiel energienet

René Bos

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Test & Measurement is our Knowledge,
Supporting customers our Business

Onderwerpen

Inleiding

Power conversie

Emulatie

Batterij/Fuel Cell emulatie

Bi-directionele DC power supplies

AC (DC) Grid emulatie

Anti Island Test Procedure

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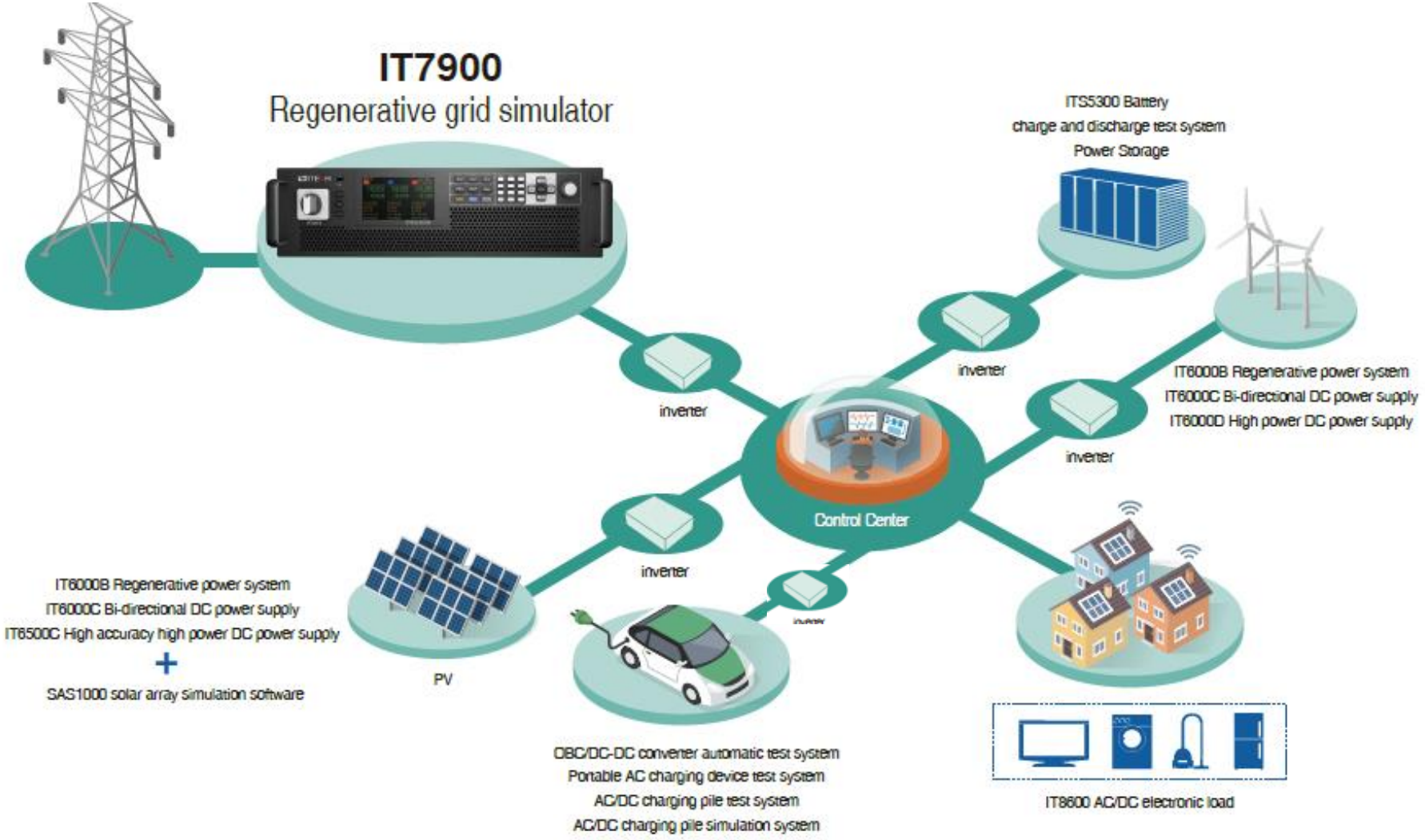
Power Conversie



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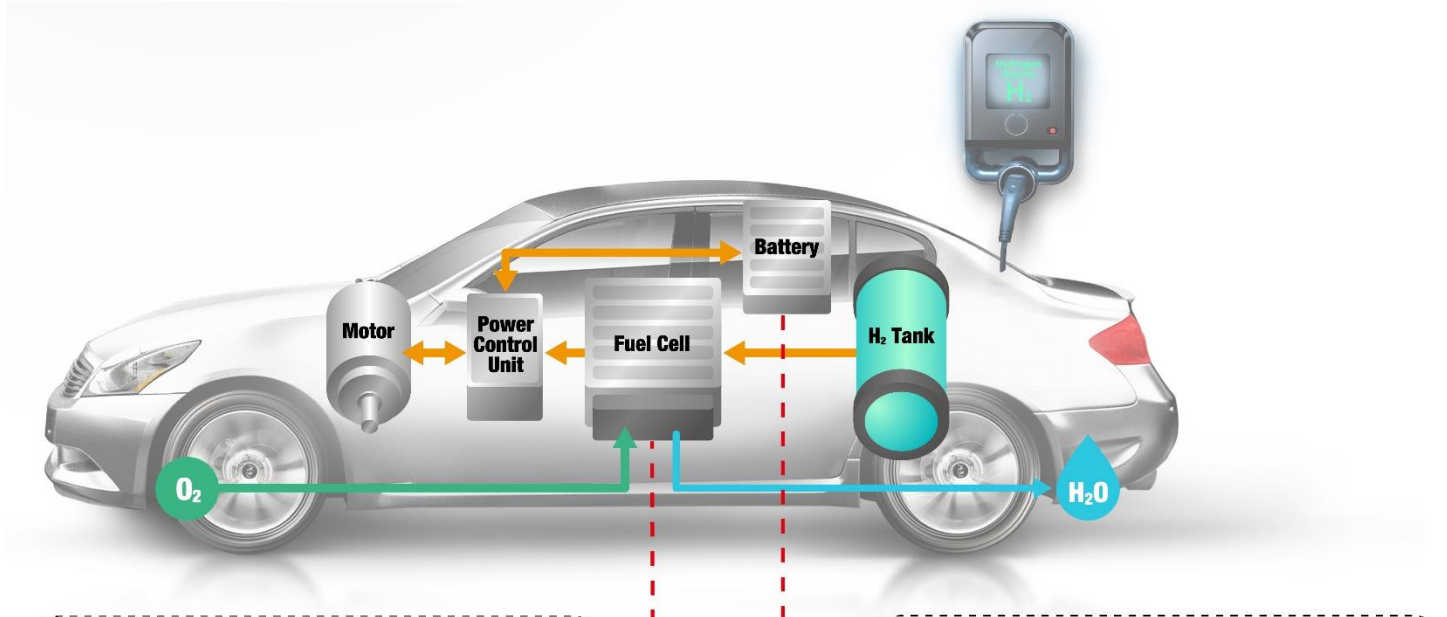
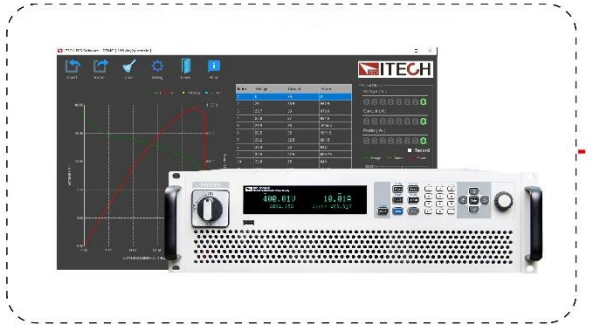
Power Electronics & Energy Storage event
POWER ELECTRONICS 2022
ENERGY STORAGE EVENT 2022
14 juni 2022 | 1931 Congrescentrum 's-Hertogenbosch

Power Conversie





燃料电池模拟器

电池模拟器（锂电/铅酸...）

Fuel Cell Simulator

Battery Simulator

Waarom Emulatie?

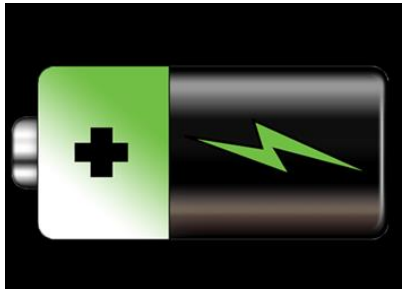
Emulatie is de combinatie van hardware en software om de werkomstandigheden van een ander systeem te herscheppen

Batterij, brandstofcel, zonnepaneel, AC Grid

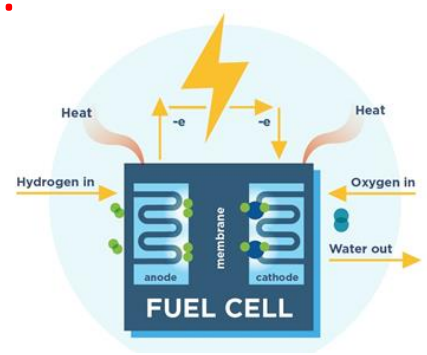
HARDWARE + SOFTWARE

Het gebruik van een emulator helpt om input en output condities van een UUT vast te stellen

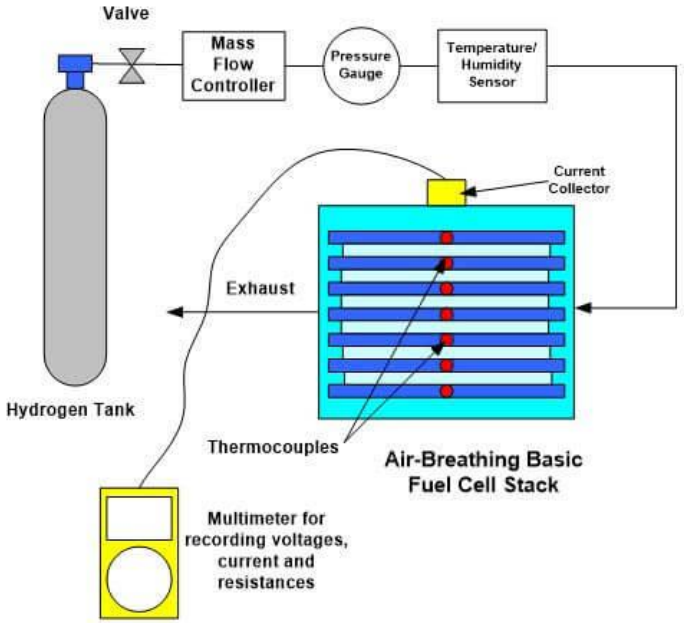
Waarom Emulatie?



- Flexibiliteit en snelheid.
- Geen geschikte batterij voorhanden
- De wens om meerder typen batterij te kunnen vergelijken
- Snel het gewenste S.O.C niveau bereiken
- Bepalen van de benodigde capaciteit
- U wilt het piekvermogen van uw ontwerp bepalen
- Kunt u de veiligheid waarborgen?
- ……



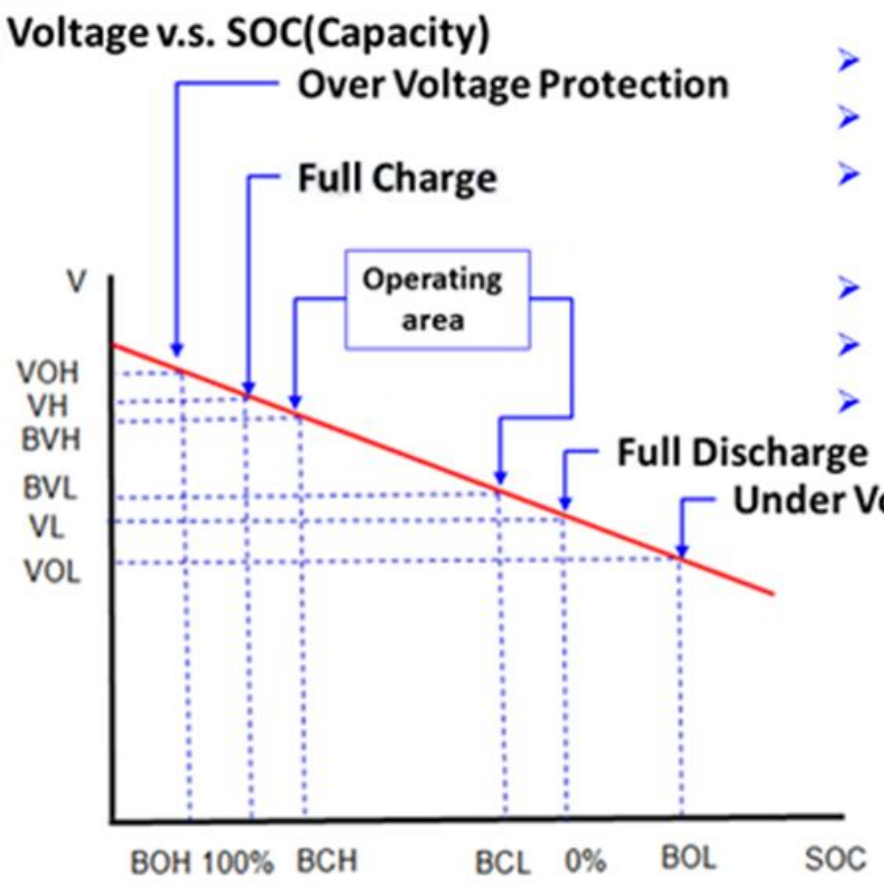
Waarom Emulatie?



- Brandgevaar, explosie gevaar, lekkage
- Hoge temperaturen
- Zwaar en onhandelbaar
- Te specialistisch en kostbaar (opstelling brandstofcellen)
- Oplopende kosten (als gevolg van aankoop, opslag)

Batterij Emulatie

Initial SoC setting function



- VOH/BOH = SOC >100% (OVP)
- VH/100% = SOC 100%
- BVH/BCH = SOC 80% (Operating area high)
- BVL/BCL = SOC 20% (Operating area Low)
- VL/0% = SOC 0%
- VOH/BOH = SOC < 0% (UVP)

Batterij Emulatie

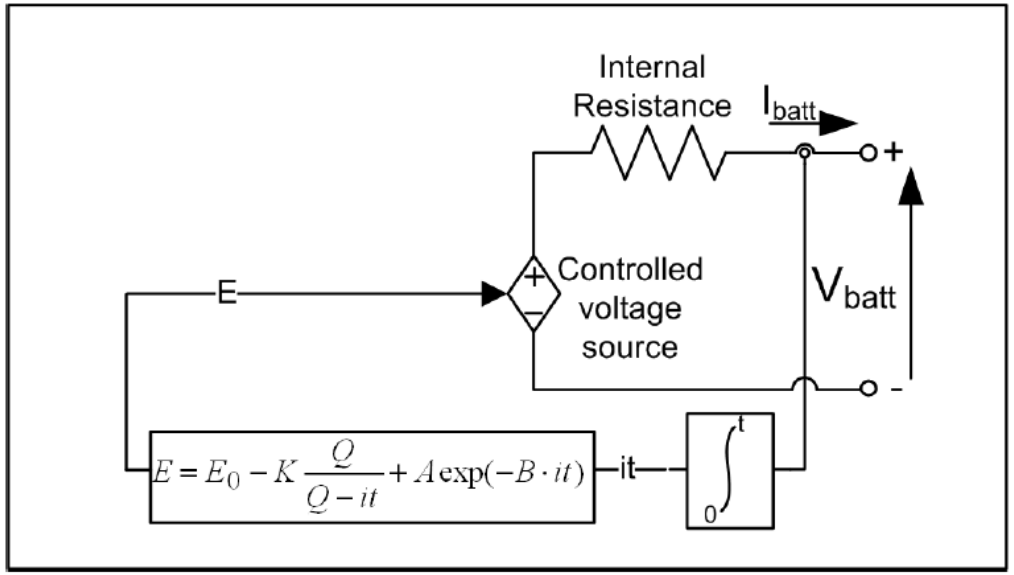


Fig. 1. Non-Linear battery model

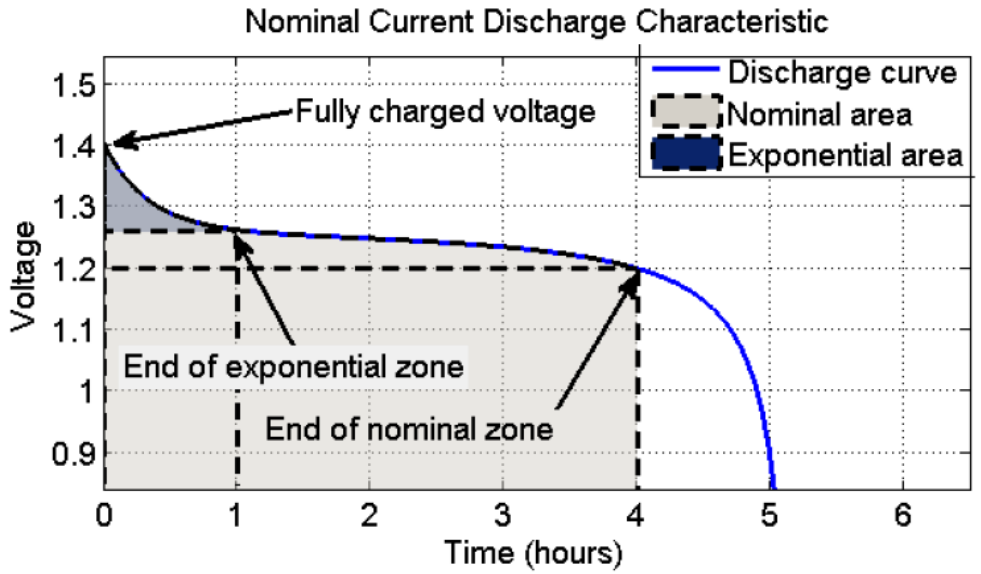


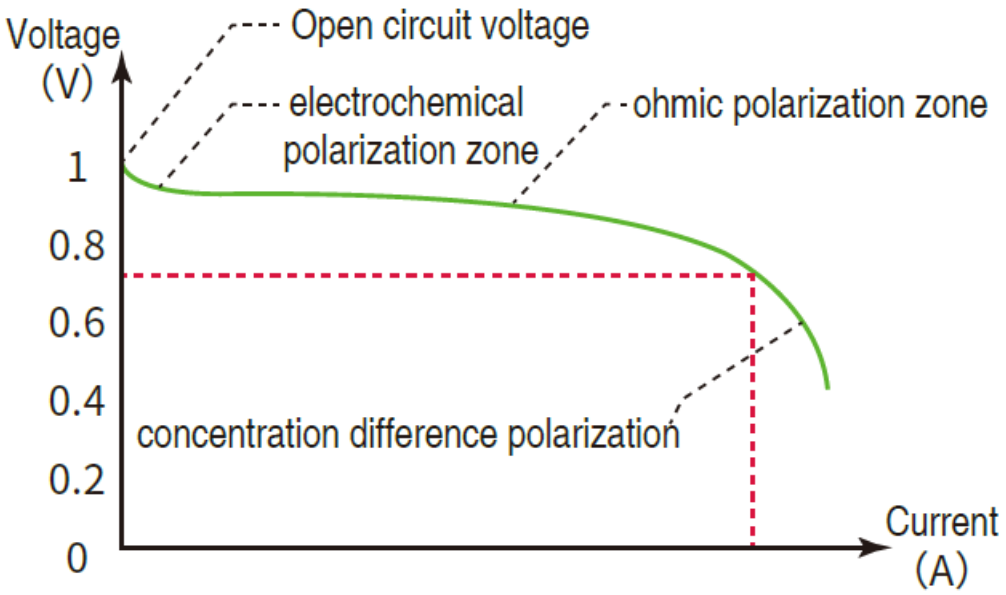
Fig. 2. Typical discharge curve

Model and picture above are from: O. Tremblay, L.-A. Dessaint, A.-I. Dekkiche, "A Generic Battery Model for the Dynamic Simulation of Hybrid Electric Vehicles", 2007 IEEE® Vehicle Power and Propulsion Conference, September 9-13, 2007, Arlington/Texas, USA

$$V_{Bat} = V_{const} - K_{pol} \cdot \frac{Q_{cap}}{Q_{cap} - Ah} + A_{exp} \cdot e^{(-B_{exp} \cdot Ah)}$$

Emulatie

Fuel cell output polarization curve

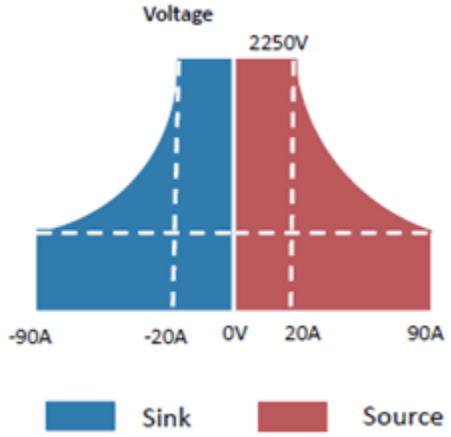


Een enkele brandstofcel levert in theorie een spanning van ongeveer 1,20 volt

Bij belasting ligt die spanning veel lager; tussen de 0,5 en 0,8 volt

Een typische curve van een Fuel Cell / stack;
Drietal polarisatie zones (electrochemical, ohmic, concentration difference polarization)

Bi-directionele DC Power Supplies



Power : 60Watt tot 1 MW+

Voltage : 20V - 2.250V

Current : ±3A – ±2.040A

CV, CC, CP mode

Regenerative sinking

Master – Slave

USB, LAN, RS232

Analog Remote control

Laboratory and Industrial

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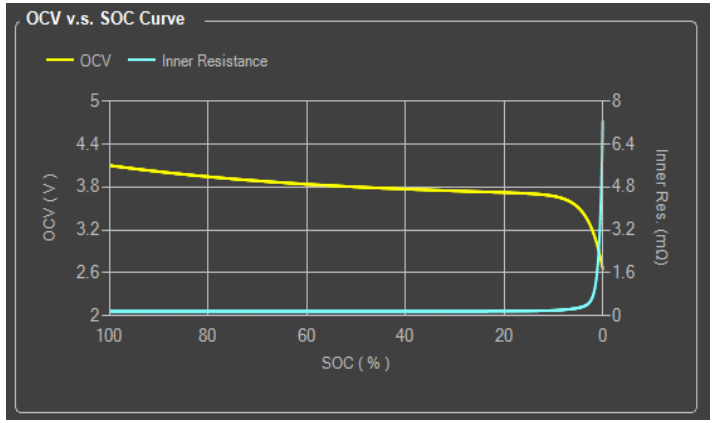
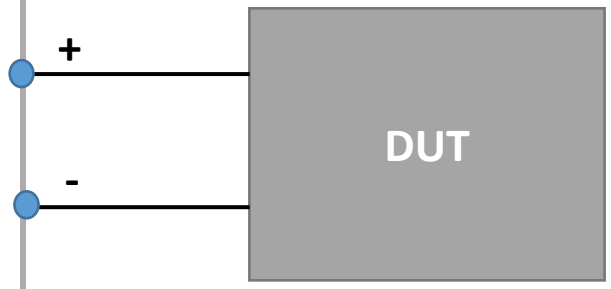
Bi-directionele DC Power Supplies

Battery simulator

Voltage output



Simulation of lithium battery discharge characteristic curve (VOC-SOC)



De capaciteit en spanning is veranderlijk tijdens het laad- en ontlaadproces

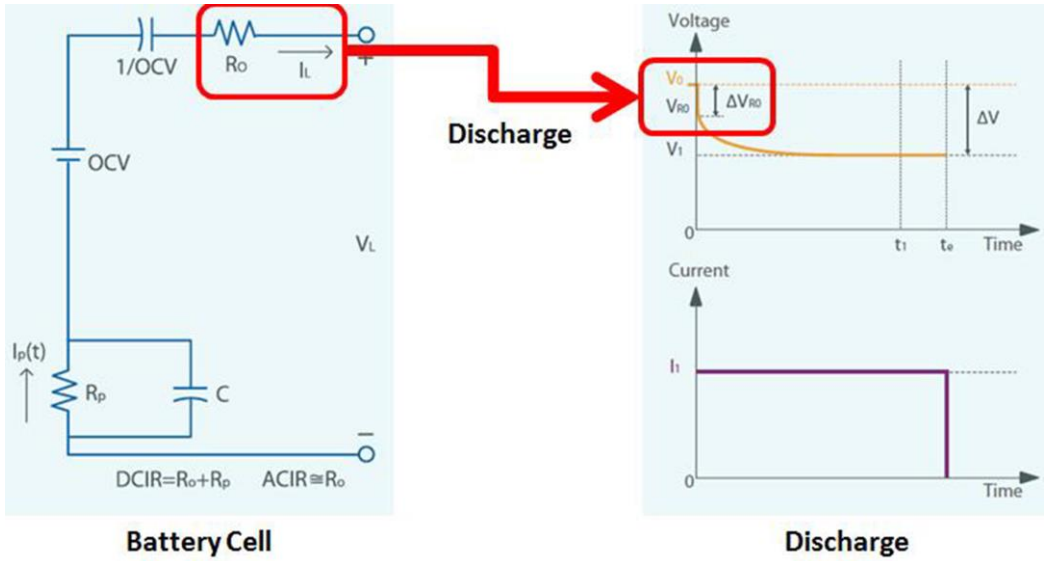
De laad- en ontlaadkarakteristieken zijn niet lineair

Behoefte aan een praktisch model

Bi-directionele DC Power Supplies

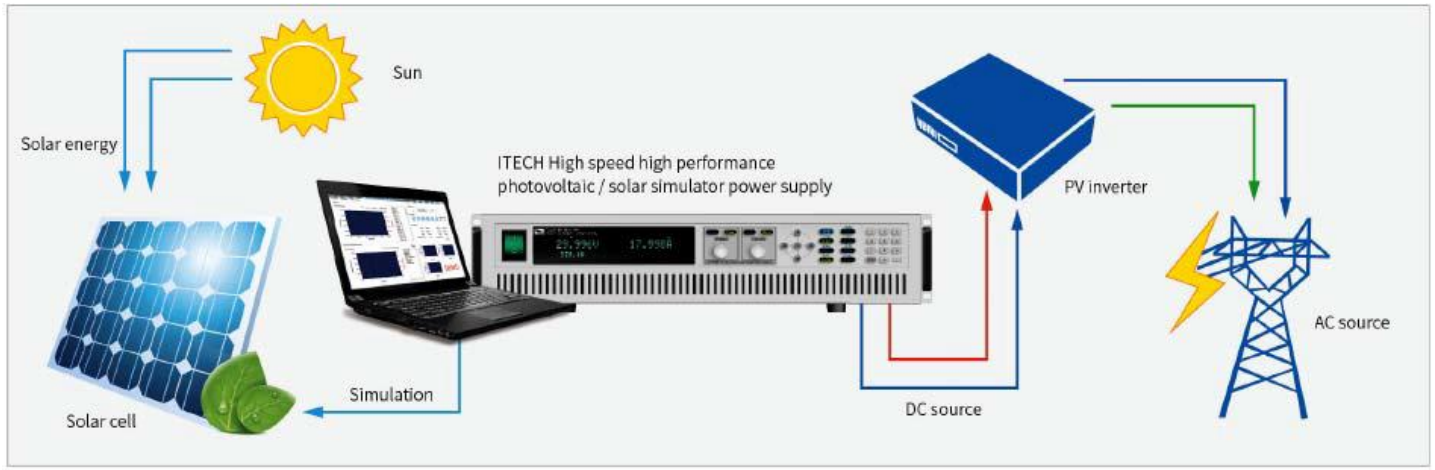
Parameter setting (emulatie software)

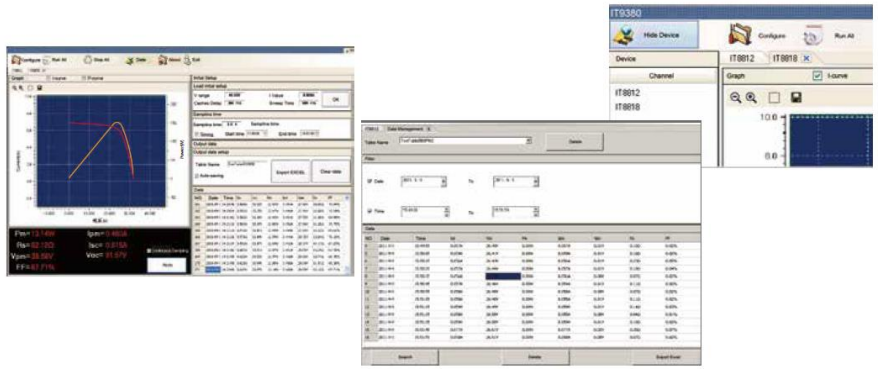
Parameters: full voltage, empty voltage, number of series and parallel sections, internal resistance, rated capacity



Full Voltage (V)	12.00	
Empty Voltage (V)	8.00	
Inner Resistance (mΩ)	1.000	
Capacity (Ah)	10.000	
Parallel	1	
Series	1	
I+ (A)	1.00	
I- (A)	-1.00	
Initial SOC (%)	50.00	
Count of Loop	1	
Cut-off Condition		
	H	L
SOC (%)	105.00	-5.00
	H	L
Cap (Ah)	10.000	1.000

Emulatie





Simulate I-V curve under different temperature and irradiation
Simulate I-V curve for solar panel under shadow
Static & dynamic MPPT efficiency test
Built-in EN50530 / Sandia / NB/T32004 / CGC/GF004 /
CGC/GF035 test program

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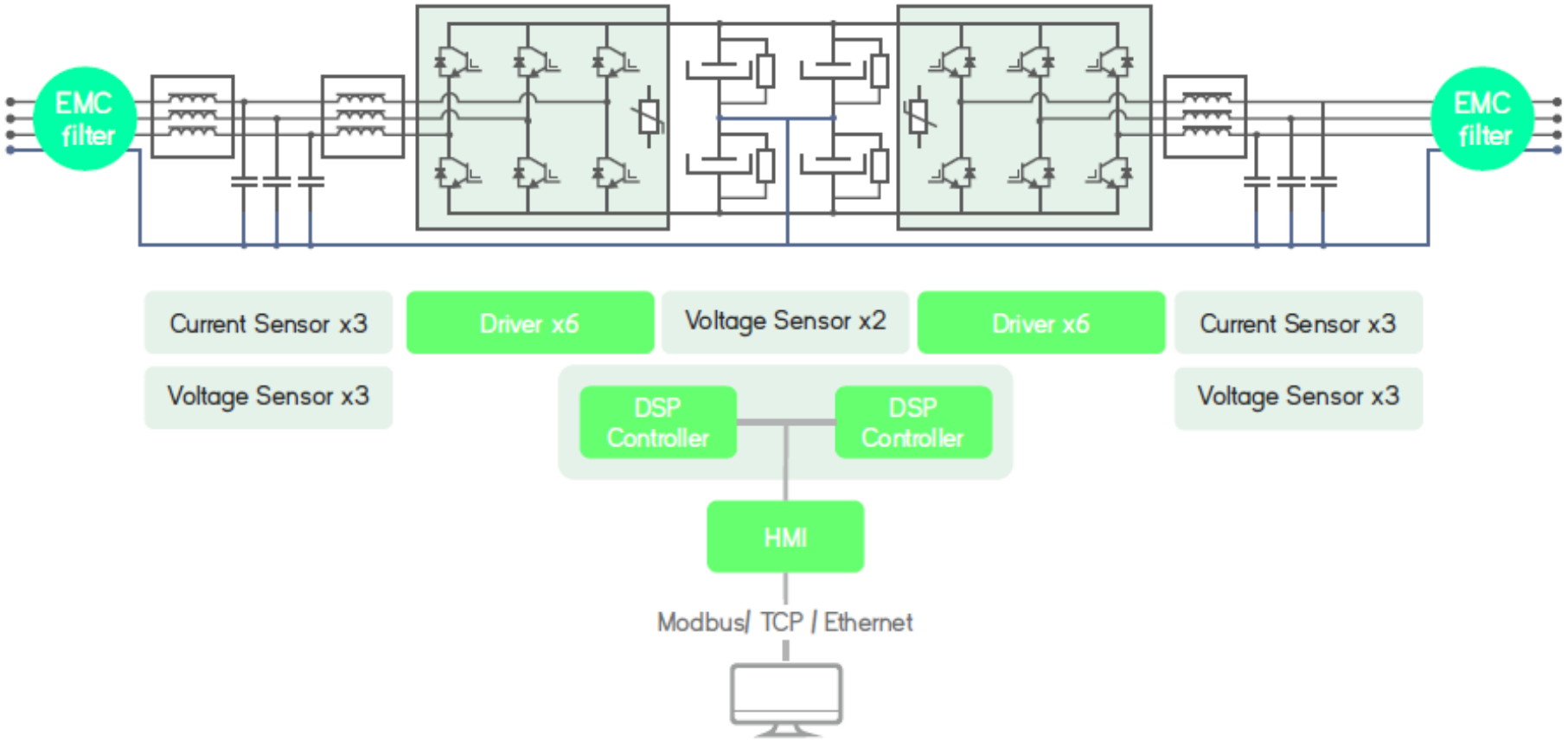
AC (DC) Grid Emulatie



AC (DC) Grid Emulatie

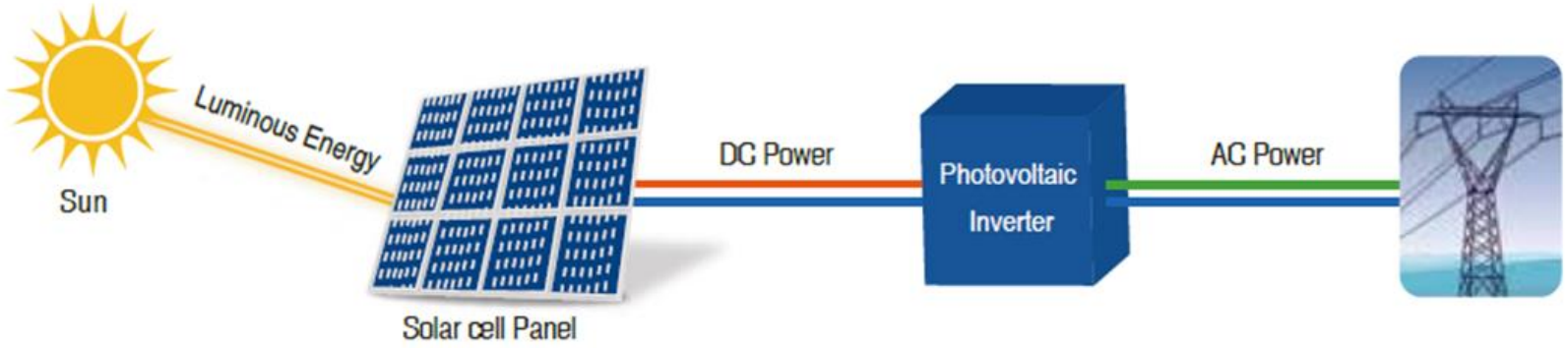
Key features
Bidirectional and Regenerative
Clean grid current: THDi < 3% and PF > 0.98
Same power in DC and AC

Generation of Worldwide electrical grids:
3-phase/ 1-phase/ split phase/ Multichannel

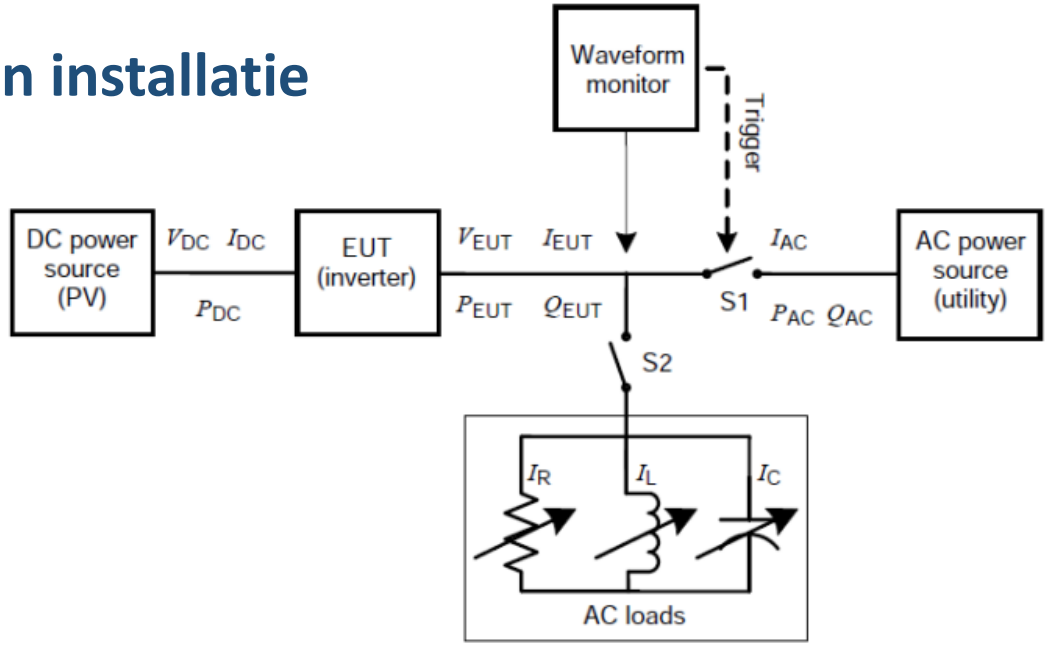
Independent phase configuration of:
voltage rms, phase angle, frequency and harmonics

Generation of disturbances:
harmonics, interharmonics, subharmonics, voltage dips
frequency variaton, flicker

Anti-Island Testing Procedure



- **Veiligheid**
- **Voorkomen defecten aan installatie**



Anti-Island Test Procedure

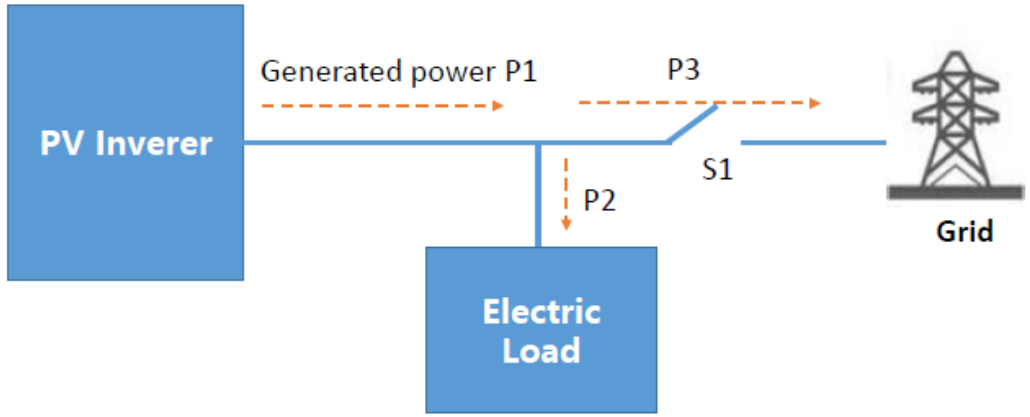
Islanding detection method: (e.g. voltage, frequency or phase).

condition1：P1=P2+P3 or P2=P1+P3

In het geval het AC grid wegvalt zal de balans worden verbroken. Gevolg, een Spanning, frequency, phase shift.

Condition2：P1=P2

Bij wegvallen AC grid (S1 = open)
Geen verandering in de load impedantie.
Voor de invertor is de island mode moeilijker te detecteren.



Anti-Island Test Procedure

IEC

IEC 62116

Edition 2.0 2014-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures

Test standard： IEC 62116

6.2 Pass/fail criteria

An EUT is considered to comply with the requirements for islanding protection when each case of recorded run-on time is less than 2 s or meets the requirements of local codes.

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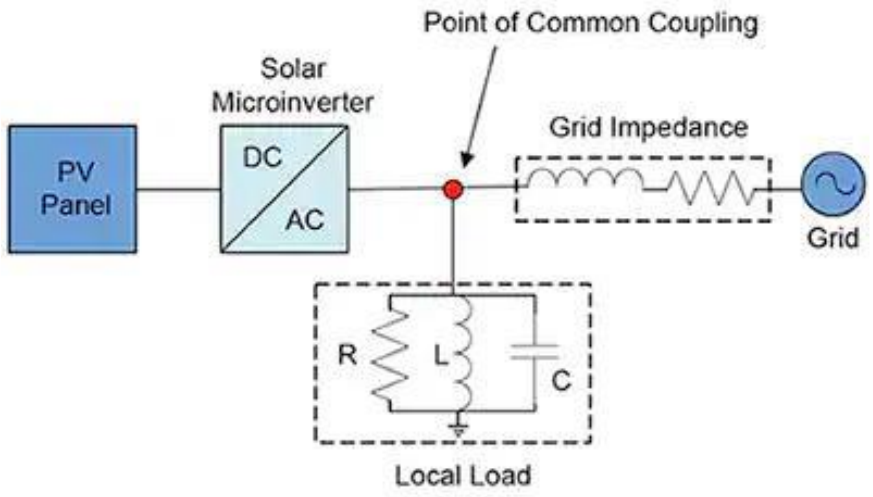
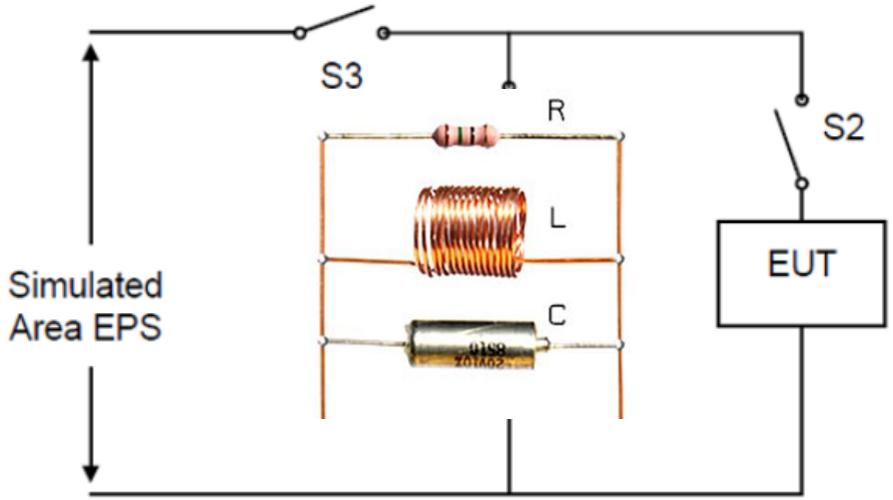
Anti-Island Testing Procedure





Voor de specifieke anti-island test is een RLC belasting van belang. RLC-parameters zijn te variëren om actief vermogen en blindvermogen te configureren. Dit om bijvoorbeeld een zuivere weerstand of niet-lineaire belasting te realiseren.

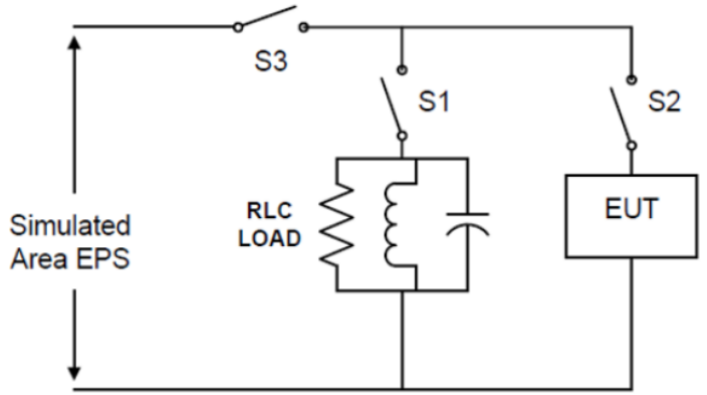
Anti-Island Test Procedure

Anti-islanding protection test;
Simulatie van de situatie waarbij P1=P2,

Het volledige vermogen moet worden geconsumeerd door de RLC Load
(in deze balans situatie zal de invertor de Island mode moeten detecteren)

RLC Load dient zich als als Resonant circuit te gedragen.

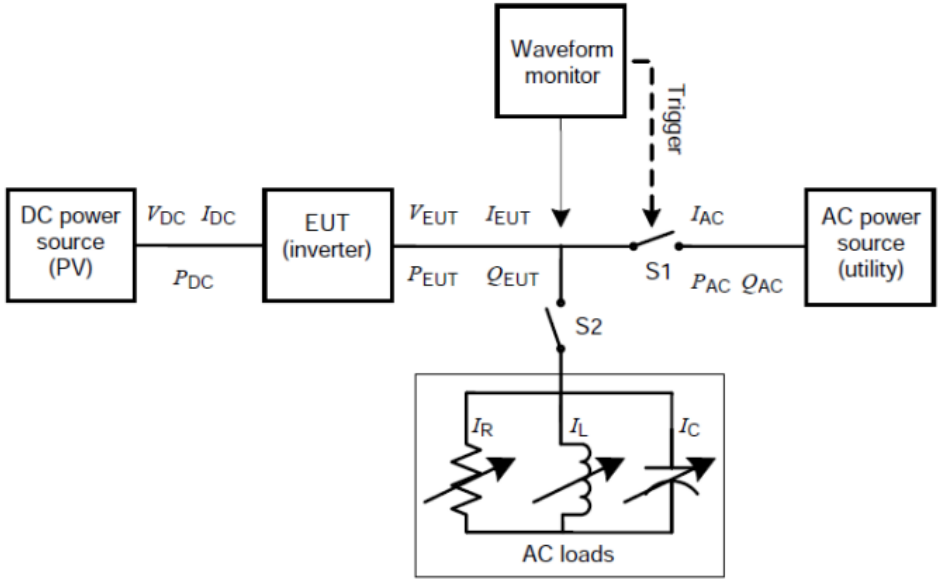
De essentie van resonantie is dat de reactive power Qc in de condensator en de reactive power QL in de spoel, elkaar opheffen.



Anti-Island Test Procedure

Benodigde testopstelling:

- **Grid simulator**: De grid simulator wordt gebruikt voor het simuleren van frequency variaties, voltage fluctuaties, 3 fase onbalans, en het genereren van harmonischen
- **RLC Load**: De RLC Load wordt ingezet voor de noodzakelijke belasting
- AC/DC Power source
- Oscilloscope: Wordt gebruikt voor het vaststellen van de afschakeltijd

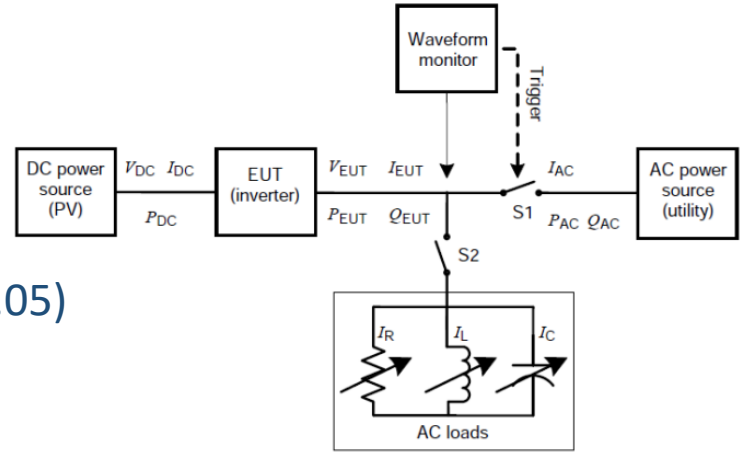


Anti-Island Test Procedure

Test procedure:

a) Determine the EUT test output power, P_{EUT}, to be used from Table 5. Test conditions A, B, and C may be performed in any order convenient to testing.

Condition	EUT output power, P_{EUT}	EUT input voltage [c]	EUT trip settings [d]
A	Maximum [a]	> 75 % of rated input voltage range	Voltage and frequency trip settings according to National standards and/or local code
B	50 % to 66 % of maximum	50 % of rated input voltage range, ±10 %	Voltage and frequency trip settings according to National standards and/or local code
C	25 % to 33 % [b] of maximum	< 20 % of rated input voltage range	Voltage and frequency trip settings according to National standards and/or local code



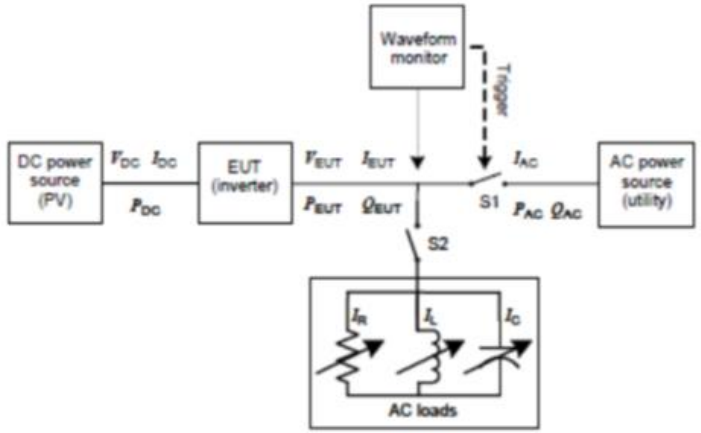
The island load is adjusted to ensure a power quality factor (Q) of 1.0 (+/- 0.05) and the “central” balanced load condition.

The anti-islanding test is repeated for 3 output power levels: 33%, 66%, and 100% of the rated output power of the unit under test.

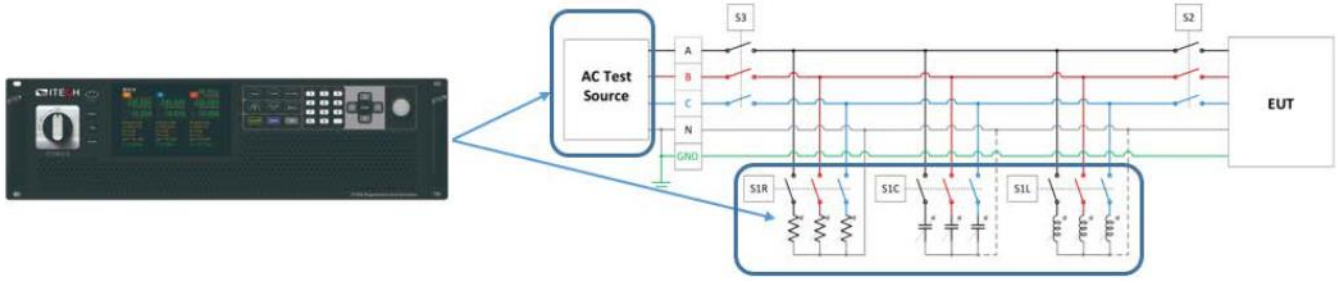
Set imbalance load
(+5,+5) as example, the power flow from the inverter to the grid is achieved by reducing the load amount of R and C by 5% for reducing the power at the load side.

Anti-Island Testing Procedure

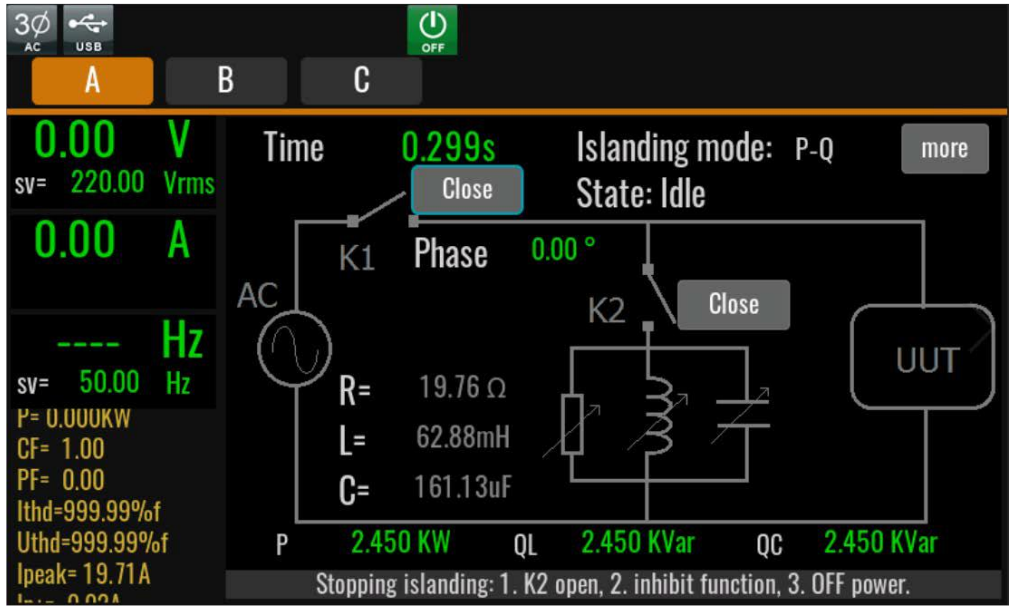
Grid simulator met islanding test function;

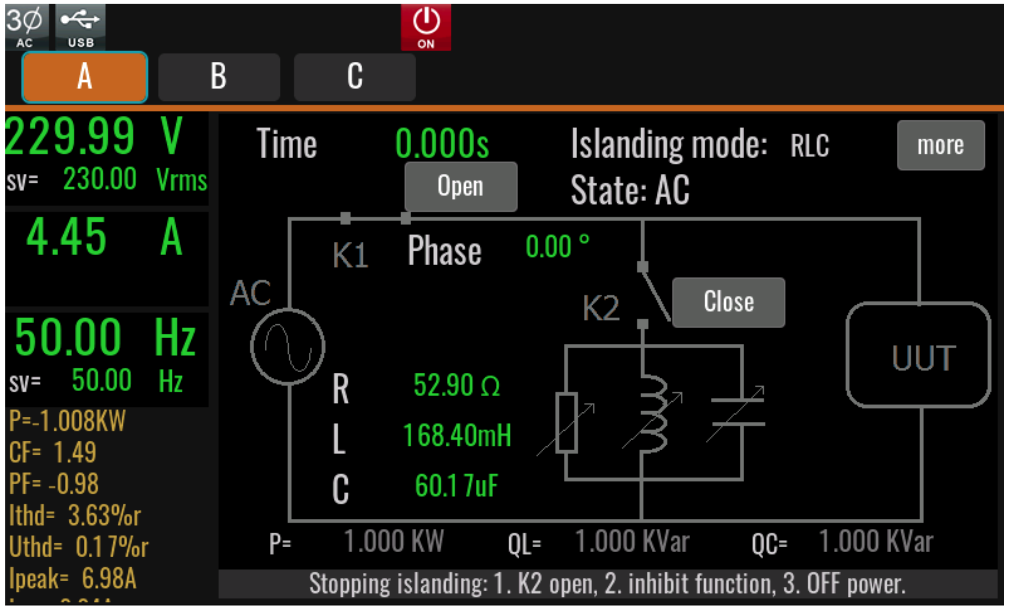


- Geen additionele RLC load equipment meer nodig
- Veel eenvoudiger aansluiten (no additional wiring)
- Directe programmering van RLC parameters en active/reactive power parameters
- Vaststellen van de “islanding protection response time” snel vast te stellen.
- Geschikt voor zowel 1/3 phase load resonantie.



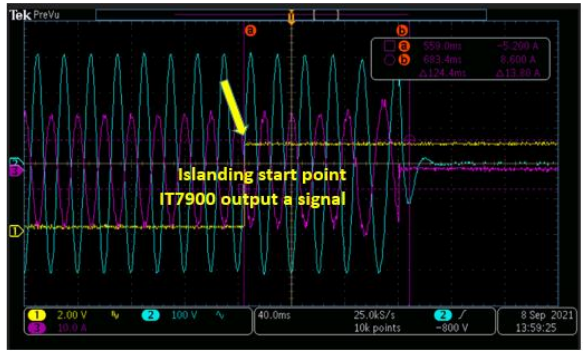
Anti-Island Testing Procedure





Zr = Zl = Zc ➔ 2.450kW, 2.450KVar, 2.450KVar

R = 19,76 ohm (R = 220^2/2.450)
L = 62,88 mH (Zl=2*Pi*f*L ➔ L=19.76/2/Pi/50)
C = 161,13 uF (Zc =1/2*Pi*f*C ➔ C=1/(19.76*2*Pi*50)



Anti-Island Testing Procedure

Introduction of dummy RLC LOAD in IEC 62116 standard

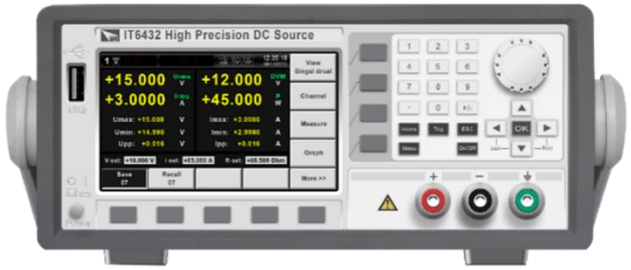
5.4 AC Loads

On the AC side of the EUT, variable resistance, capacitance, and inductance shall be connected in parallel as loads between the EUT and de AC power source.

Other sources of load, such as electronic loads, may be used if it can be shown that the source does not cause results that are different than would be obtained with passive resistors, inductors and capacitors.

IT7900 Island test function ondersteunt RLC and PQ settings, waarbij de Island protective tijd direct kan worden gemeten.

Praktische oplossingen



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Tot slot

Samenvattend

- Emulatie draagt significant bij aan het inkorten van ontwikkel- en testtijd.
- In Power conversie & energy storage oplossingen.
- Zoals bij Wetenschappelijk onderzoek, R&D en tijdens benodigde productie / kwaliteit testen…etc.

- Flexibiliteit, veiligheid, financieel!

- Een emulator op basis van;
- BIDIRECTIONEEL power supply / 4Q AC voeding is veel breder inzetbaar!

Dank voor uw aandacht!

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