Advanced EV testing Solutions

By

Chroma

Value Added Solutions in Testing

Focus:

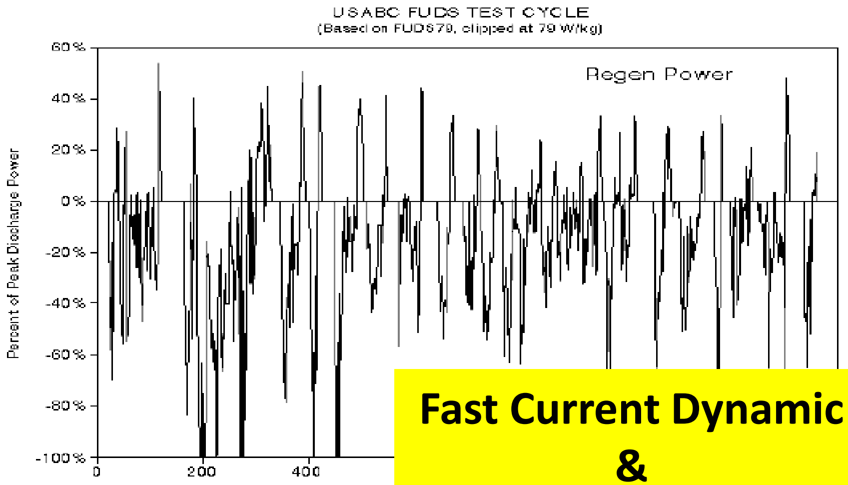
- **Automotive Battery Testing (functional and safety)**
- **Electric Vehicles Powertrain Components Testing ;**
- **Inverter for Energy Storage Systems Testing ;**

Worldwide Presence

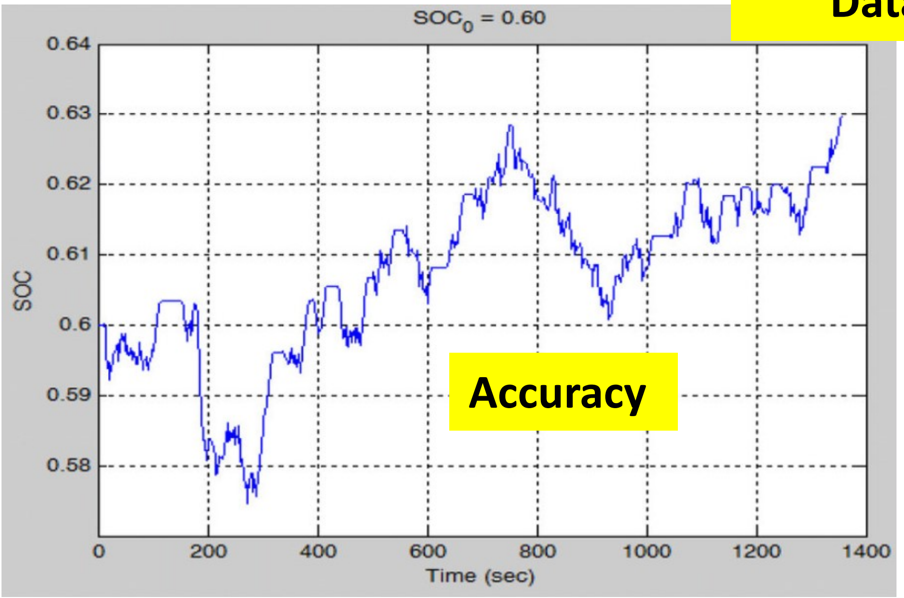
Battery Life Cycle Prediction Challenge

Drive Cycles Simulations or Real Drive Cycles Test have shown to be a more accurate and more reliable method for **life cycle prediction** than Standard Constant Current (CC) Constant Power (CP) cycling Tests.

It is fundamental for Carmakers or Cells Manufacturers to have the Capability to repeat In the Laboratory **the real stress conditions** of a Battery Pack with **Drive Cycle Simulation** .



Fast Current Dynamic & Data Sampling



Accuracy

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Accurate Measurement of Coulombic Efficiency

The accurate measurement of Li CE is a critical factor to predict the cycle life of Li metal batteries.

Measurement of CE is affected by various factors . one of them is the accuracy of the Measurement I Battery Testers .

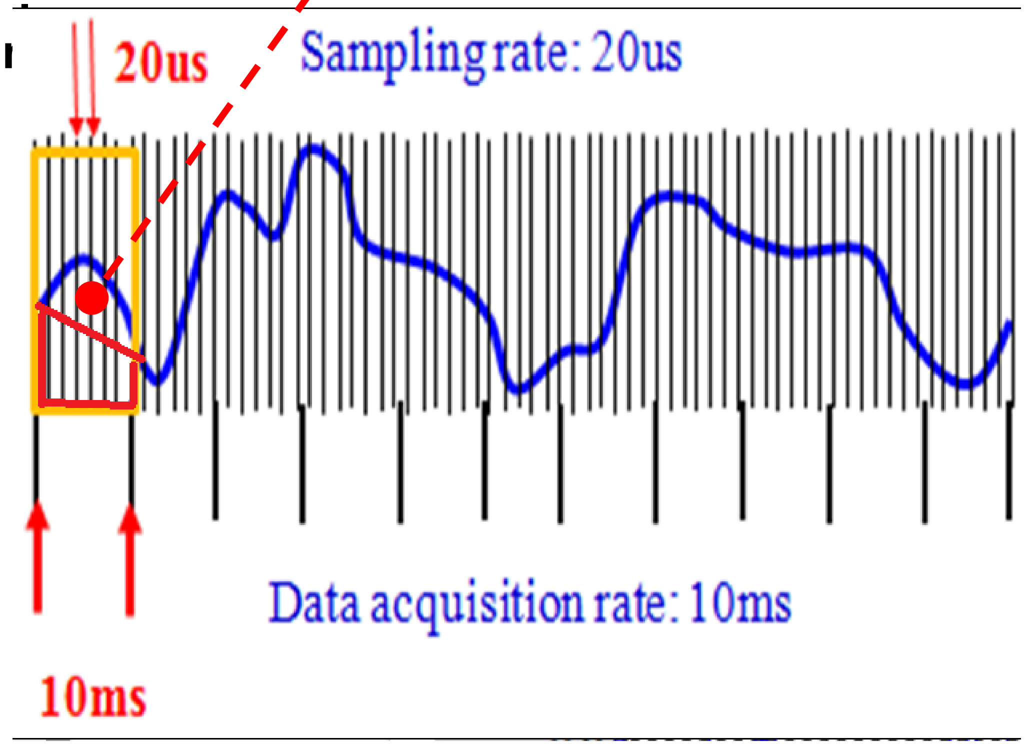
$$SOC_c(t) = SOC_c(0) - \frac{1}{Q}\int_0^t I(t)dt,$$

High V & I measurement accuracy :

Voltage: 0.02%+0.02%F.S.

Current: 0.05%+0.05%F.S.

The Area on the Top Side Is my error in the Capacity Calculation (repeated for all the Cycles)



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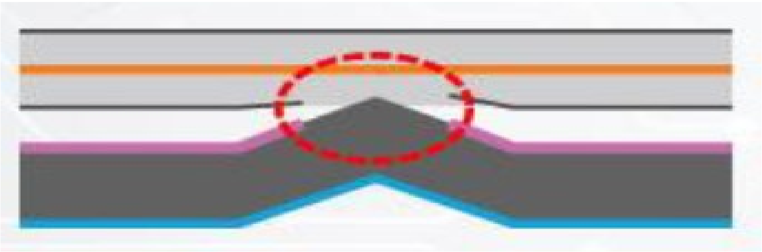
Electrical Safety for ESS

The topic of Safety has a Top Priority in ESS system where Batteries Are used either for stationary (Energy Storage Systems in Your home) as well as for Mobile applications (or Your car)

Why Lithium Cells fail or explode after passing the Insulation Test ?

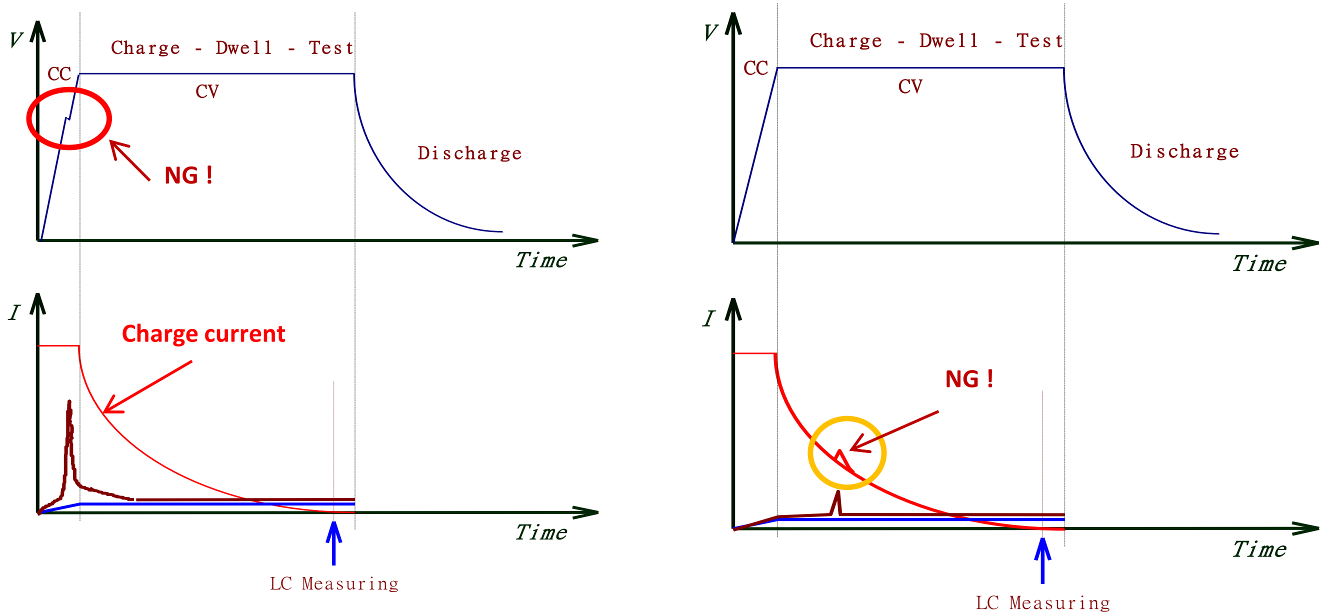
- cells catch fire or explode during charging processes in production line, but the insulation test can not detect the defects in the insulator ;
- There are still cases that the cells explode during normal operation after the LIB are shipped to the customers ;

Internal Short Circuit between ANODE and CATODE material is the major cause of fire and explosion ;
Anode Material keeps Inflating during CHG/DCHG Process and the rise in temp will cause fire ;



Flashover Detection During Hi-Pot

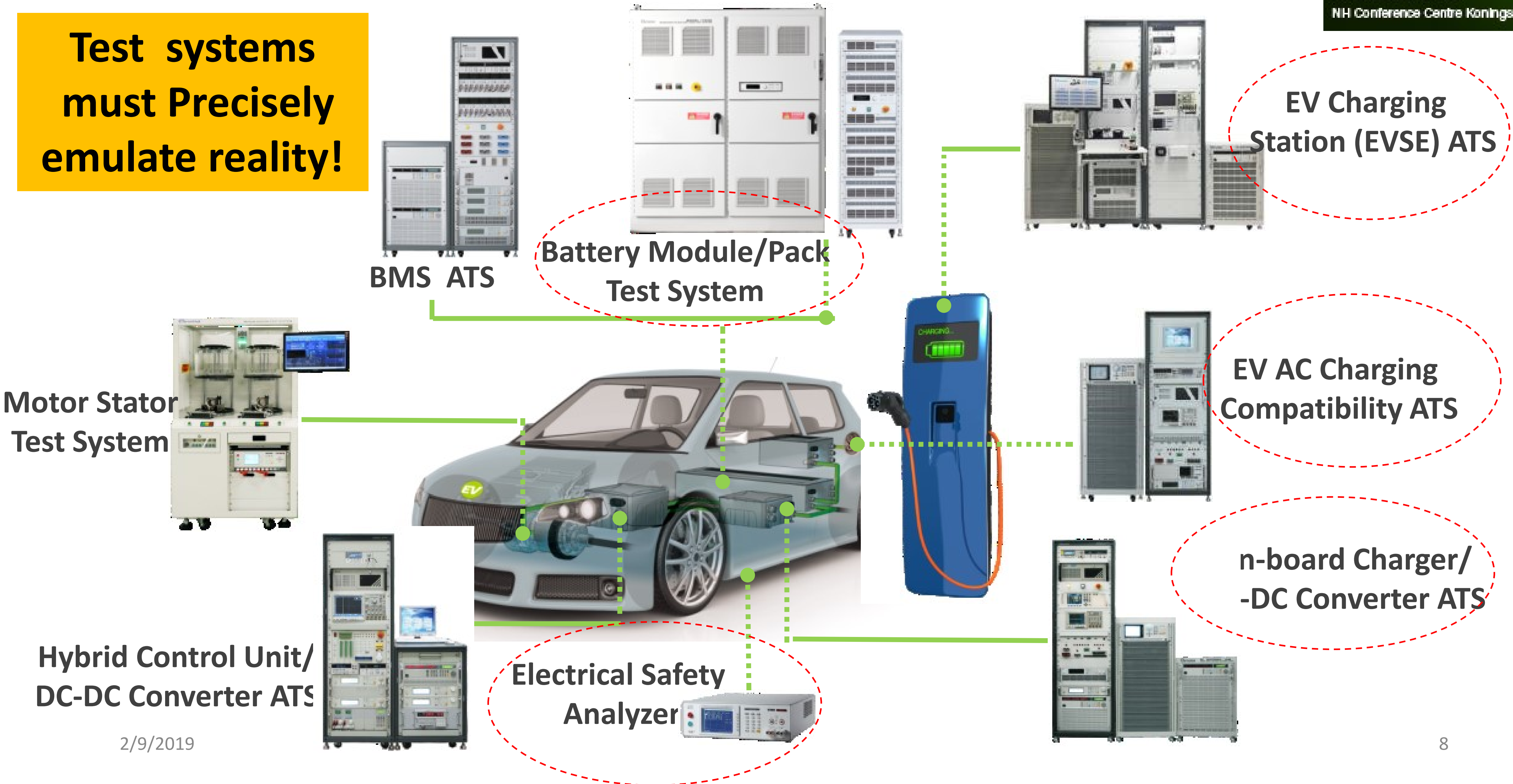
It is not enough to just measure the leakage current in the test. Flashover detection is a must for this issue, for the entire testing duration is closely monitored for flashover detection.



Flashover detection is a must for the entire testing duration

EV Powertrain Environment Complexity

Test systems must Precisely emulate reality!

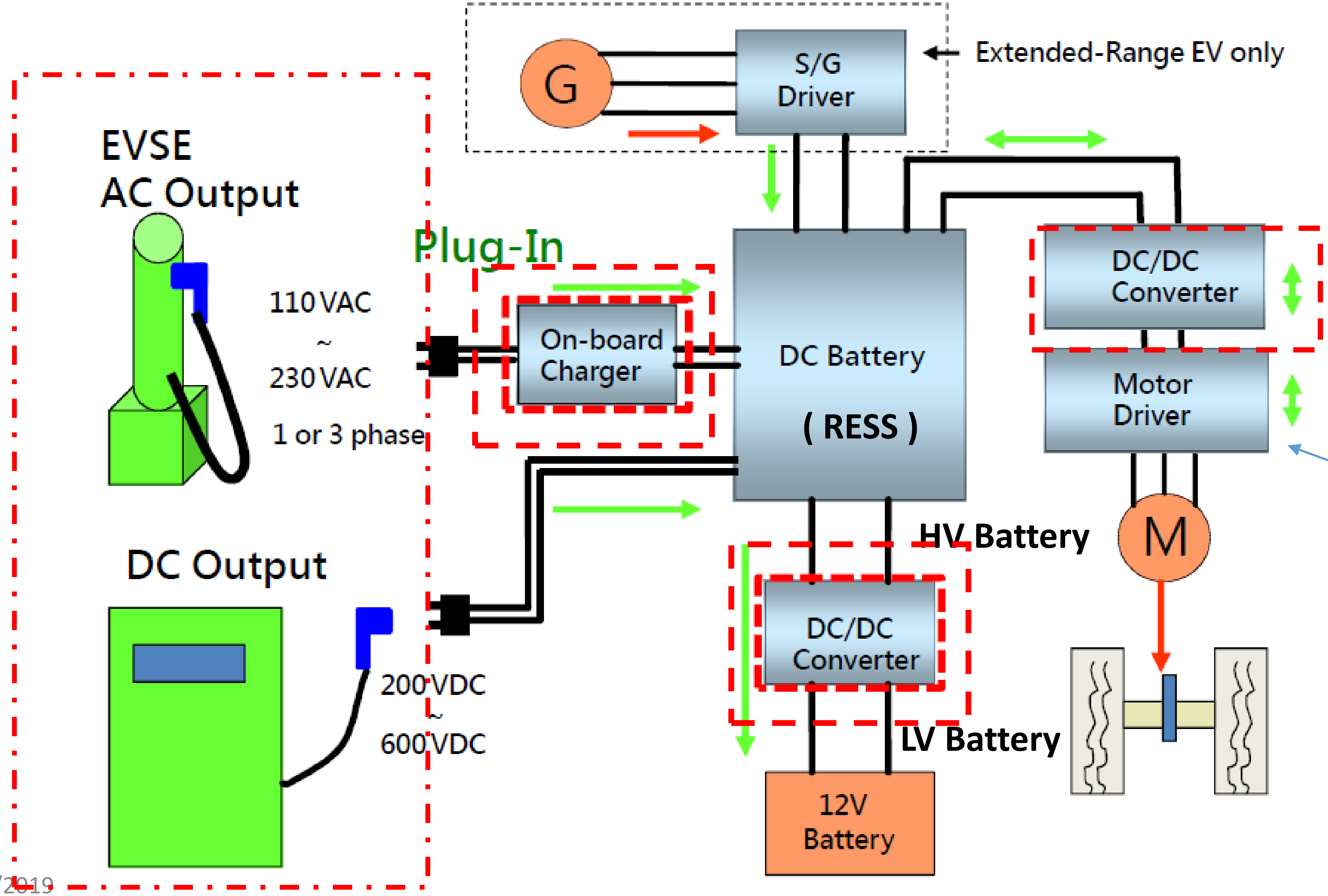


EV Testing can support Electrification

Challenges and the Goal is to achieve Zero-Emission Mobility
To reach a zero-emission mobility goal , the electrification of vehicle powertrains is necessary. This fact leads to new challenges for car makers and suppliers:

- **To make powertrain components more efficient** to extend the range & reduce the charging time;
- **To introduce compact and lightweight high-power** electronics without compromising passenger safety ;
- To fit **new technologies** (New Semiconductors GaN) for e-Drive applications to extend functionality and maximize the performance;
- **To ensure safe operation** in every environmental conditions for each component of the EV Powertrain ;

OBC in the EV Powertrain



This element is not Always present

Bi-Directional For Regen Breaking

OBC and DC-DC Converters High Power Density

On board Charger - OBC

Power Rating: 3.3kW~6.6kW up to 21kW

- Change AC power to DC power to recharge the EV's battery pack.




DC/DC Converter - LDC

Power Rating: 1.6kW ~ 3.8kW

- That converts voltage from high-voltage batteries to low-voltage batteries (12V typical), recharging the batteries and supplying power to electric components as lights, audio, wipers, power windows and ECUs.





THQZ1000-14

Testing Challenges

- **Higher Power Density;**
- **Higher Switching Frequency**
- **Hardware Safety Protection**

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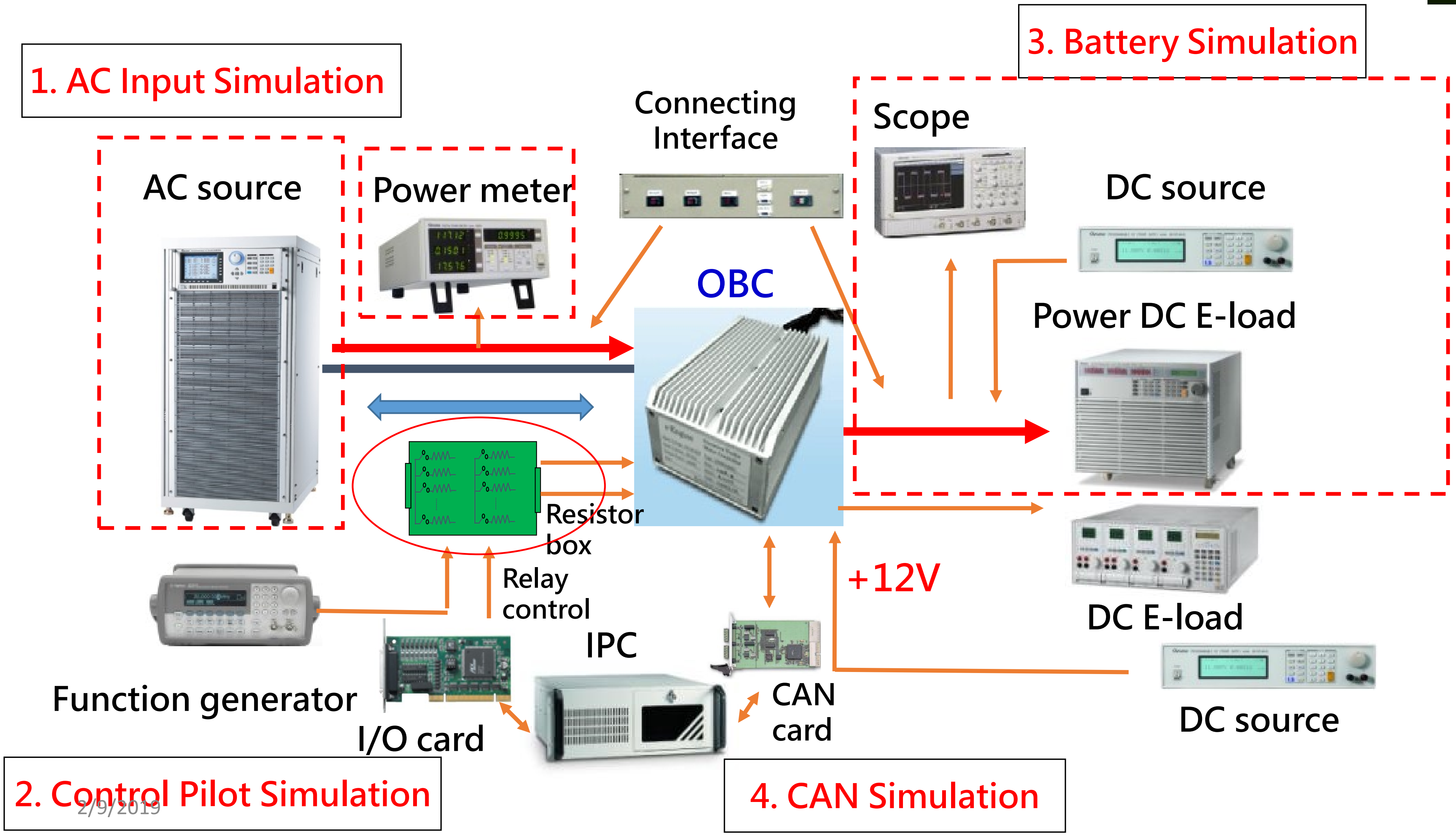
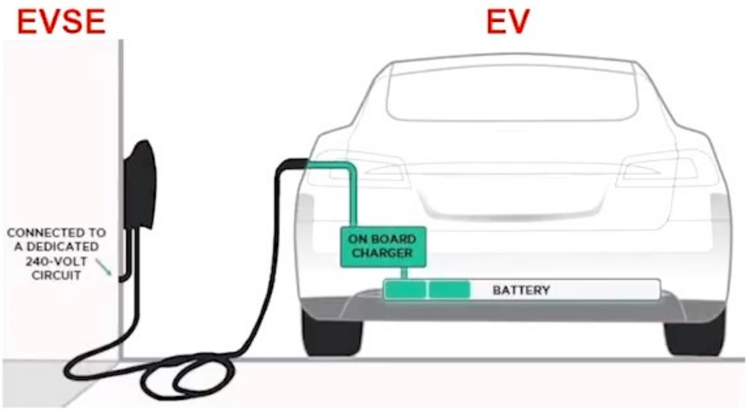
On-Board Charger ATS Test Bench

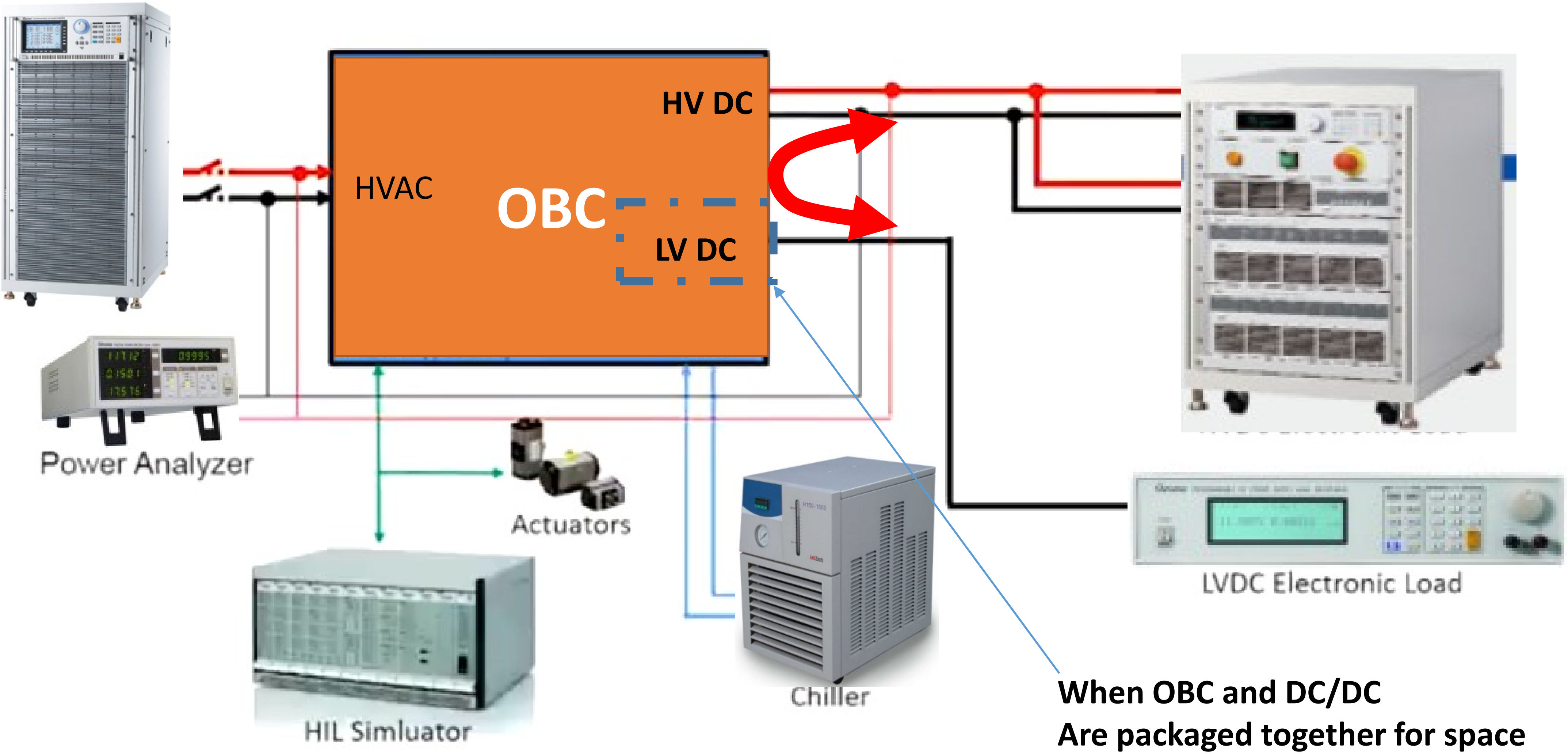


Key areas to be tested :

- AC/DC Power Conversion -> Power Module ;
- Communication with EVSE (PLC or CAN) -> Control Pilot Signal and CAN emulation ;
- Vehicle Plug Control (Proxy, Lock , Pilot Signal) -> Proximity Sensors;
- Communication within the ECU (CAN , LIN , Ethernet) -> Communication ;
- Charging Interface Management (LEDs, Pumps , Relays) -> I/O ;
- AC and DC Charge Management -> Software/Firmware ;
- Water Cooling System -> Temperature Sensors / Power Derating ;



HIL OBC Test Bench Configuration



**When OBC and DC/DC
Are packaged together for space
And costs reasons**

HIL OBC Test Advantages

- **Deterministic Execution** :
  we will always have the same output from the same starting conditions;

- **Automation of the Process** :
  Using Scripts numerous tests can be easily developed .This Process can be fully automated using recursive methodology ;

- **Test Execution without Human Presence** :
  Test can run 24hrs without human presence ,improving ECU software quality and saving time ;

- **Perform Regulation , safety and Failure Tests without risk** :
  With HIL simulation , all tests can be performed without risk for the UUT or for the People during all stages of the Design ;

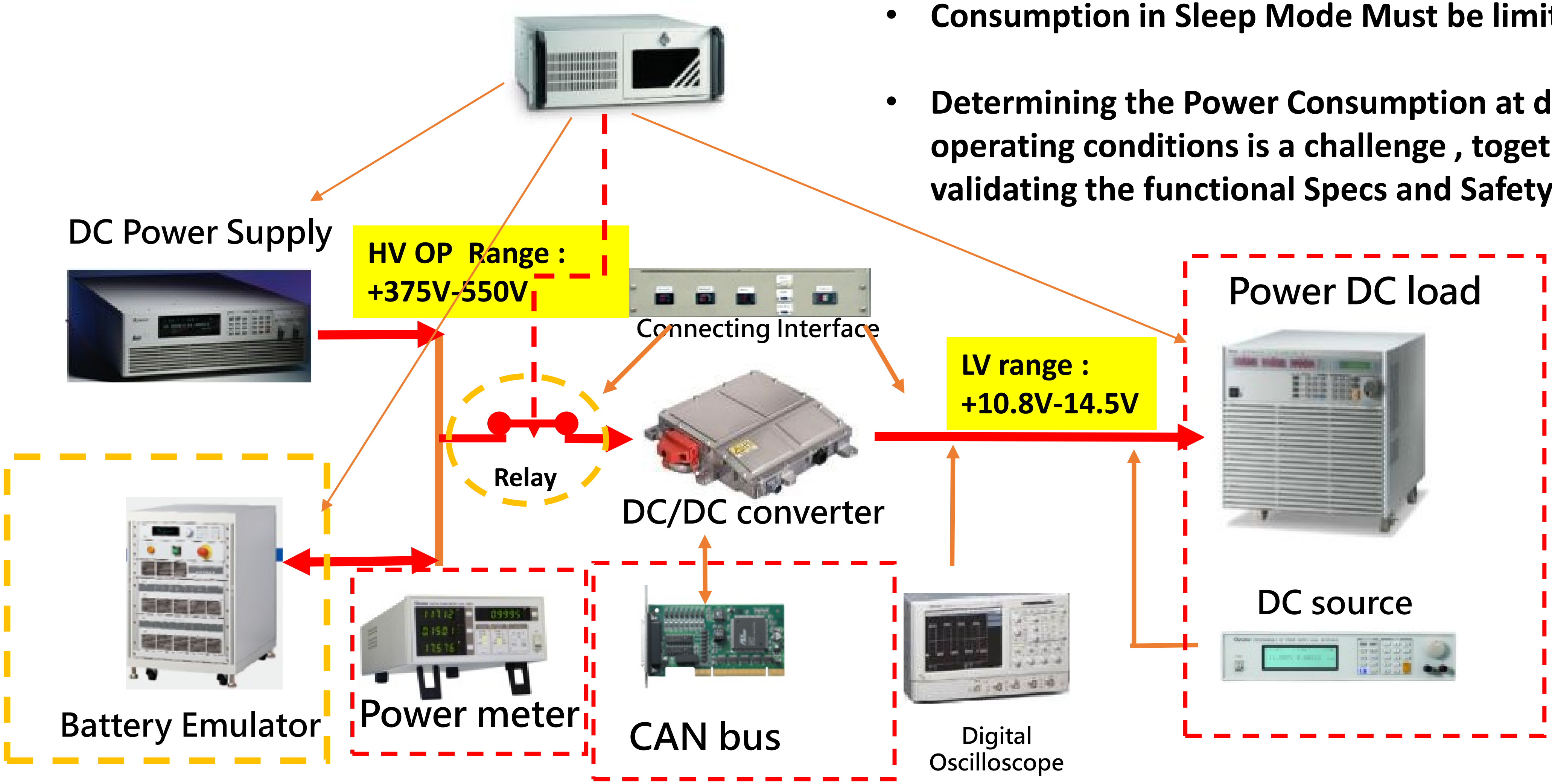
- **Reduce the Time To Market for Our customers** :
  With HIL Simulation errors can be found at early stage of the development and corrected ; HIL is therefore an effective technique to reduce commissioning :

- **Reduce Working Time for Testing** :
  HIL simulation usually requires more time at the beginning , but at the End can reduce your total time for testing ;

DC-DC ATS architecture

Mono & Bi-Directional DC/DC Converter (12V-14V) Test : 1.6kW – 3.8kW.

- **Consumption in Sleep Mode Must be limited to 100uA ;**
- **Determining the Power Consumption at different operating conditions is a challenge , together with validating the functional Specs and Safety Requirements**



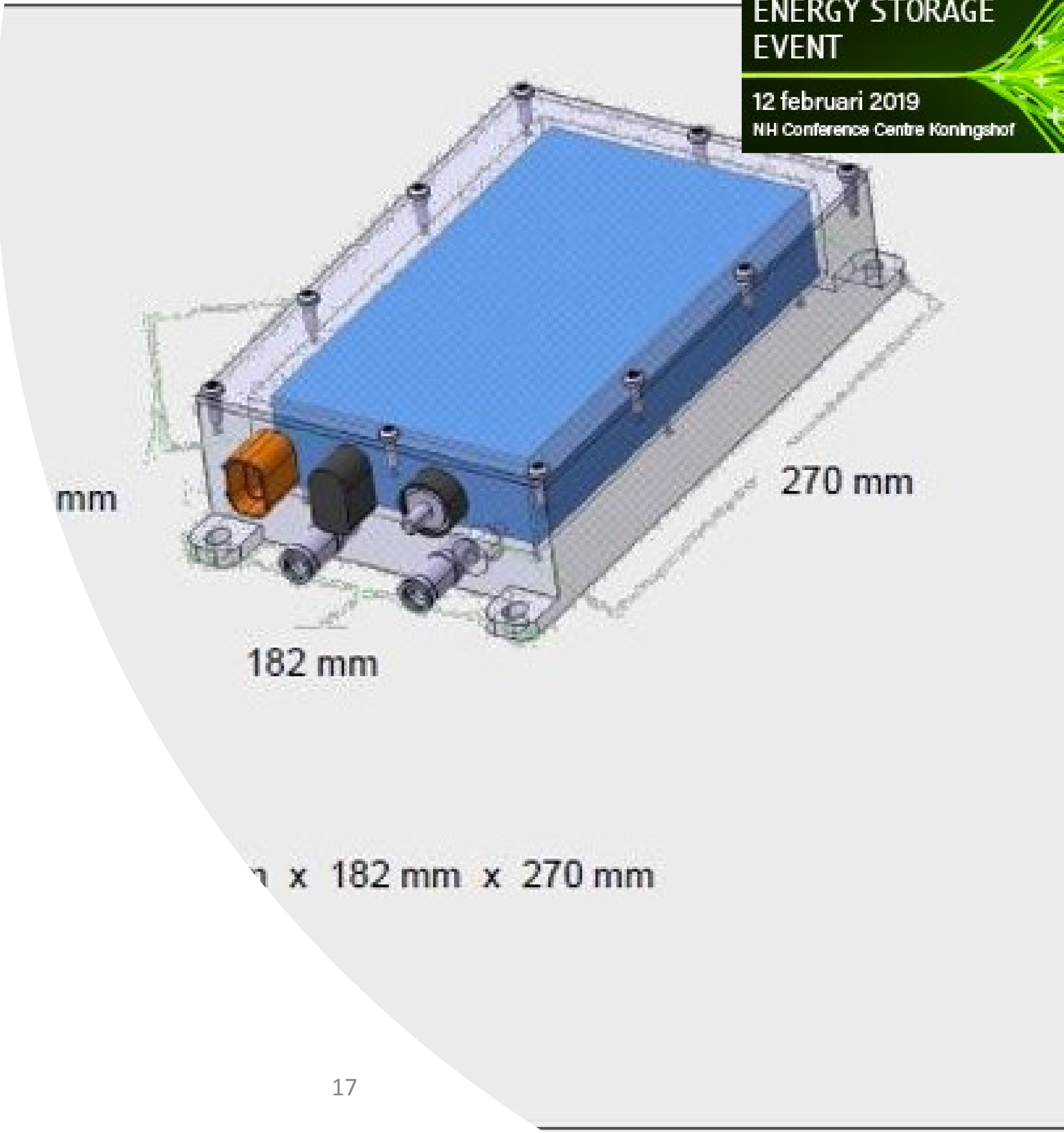
Pre-charge Ramp Requirements : 2mF in 200mesc ;

DC/DC Converter Real Dimensions

- gallium nitride (GaN), offer better thermal conductivity, higher switching Frequency and physically smaller devices than silicon ;

- Carmakers have been more demanding in testing to validate their new designs ;

- Physical Dimensions : 70 mm x 182 mm x 270 mm (3 Liter)



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Battery Charger Functional and Safety Requirements

No	Name	Regulations
1	CAN Bus Read/Write_ Charger	QC/T 895 6.1.6 ; Industrial requirement
2	CHARGER LINE REGULATION TEST	QC/T 895 6.3.1, 6.3.2
3	CHARGER STATIC TEST	QC/T 895 6.4.1
4	**CHARGER OVER LOAD PROTECTION TEST**	QC/T 895 6.4.2.2
5	**CHARGE OUTPUT UVP / OVP (CV MODE) TEST**	QC/T 895 6.4.3.1, 6.4.3.2
6	**CHARGE INPUT UVP / OVP TEST**	QC/T 895 6.4.3.1, 6.4.3.2
7	**CHARGER SHORT CIRCUIT PROTECTION TEST**	QC/T 895 6.4.3.3
8	CHARGE START UP & INRUSH CURRENT TEST	QC/T 895 6.5.1
9	CHARGE OUTPUT VOLTAGE ACCURACY TEST	QC/T 895 6.5.2
10	CHARGE OUTPUT CURRENT ACCURACY TEST	QC/T 895 6.5.3
11	CHARGER RIPPLE & NOISE TEST	QC/T 895 6.5.4
12	CHARGER INPUT OUTPUT TEST	QC/T 895 6.5.5
13	CHARGER CURSOR MEASURE TIME	QC/T 895 6.5.6
14	CHARGE CURRENT HARMONICS TEST	QC/T 895 6.7.3
15	CHARGER HOLD ON ADJUST TEST	Industrial requirement
16	CHARGER PEAK CURRENT TEST	Industrial requirement
17	CHARGER WAVEFORM MEASURE TEST	Industrial requirement

With HIL testing , these Tests could be performed In HIL environment without High Voltage instruments

Electric Vehicles Supply Equipment

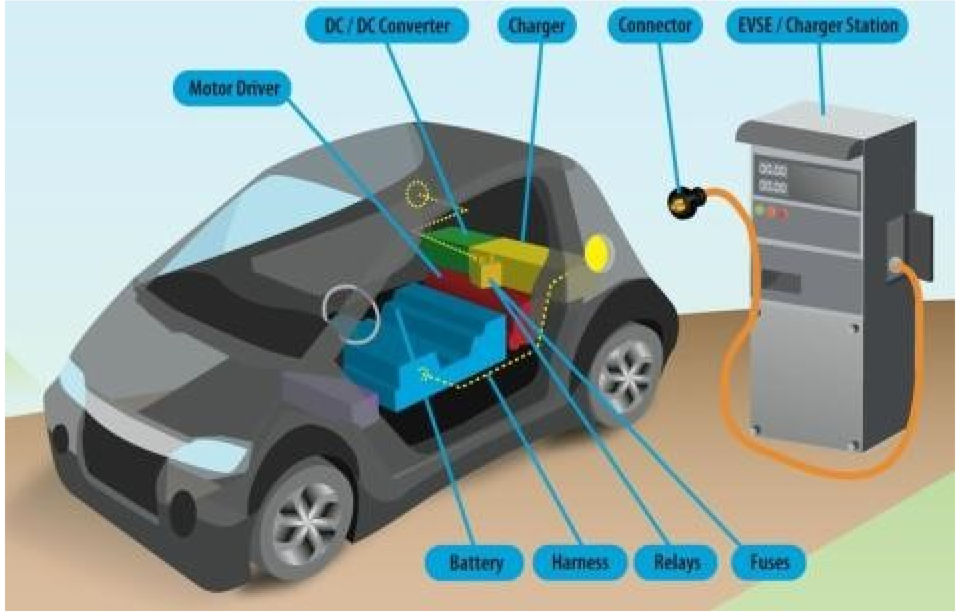
- AC & DC EVSE Functional testing
- AC & DC EV Charging For Interoperability Validation

SAE J1772 Has three Level of Interoperability Testing

Tier 1
- Mechanical Interoperability
- Charge Functionality
- Safety Feature Functionality

Tier 2
- Indefinite Grid Events
- Dynamic Grid Events

Tier 3 (Not all EVSE are capable)
- Ampacity Control
- Scheduled Charge
- Staggered Scheduled Charge
- Charge Interrupt/Resume

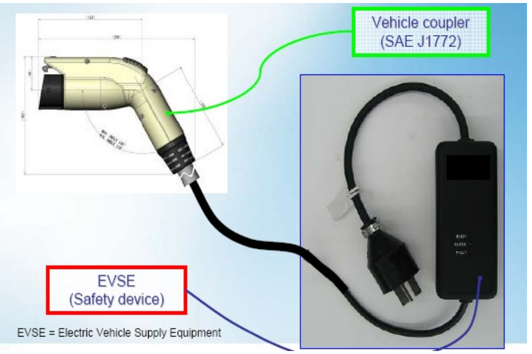


EVSE Different Charging Methods

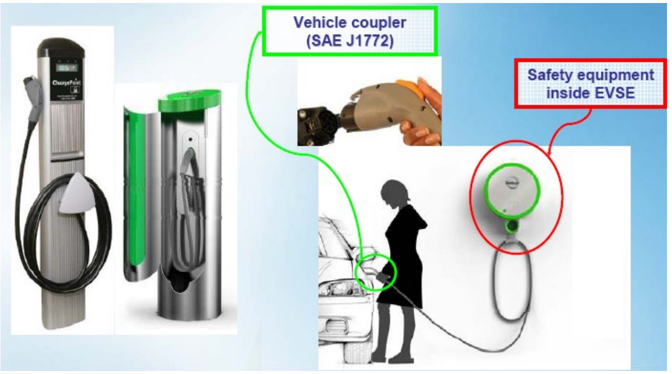
EVSE : Electric Vehicle Supply Equipment (SAE J1772)

Charge Methods	Nominal Supply Voltage	Max Cont. current	Duration Of Charge	Locations Of EVSE
AC Level 1	120V AC , 1-phase	16A	8Hrs	Home , Wall Charger
AC Level 2	208 to 240V AC , 1-phase	<80A	4Hrs	Public Places
DC Level 3	480V AC , 3-phase	>200A	30mins	Transit Corridors

SAE J1772 AC Level 1
= IEC 61851-1 Mode 2

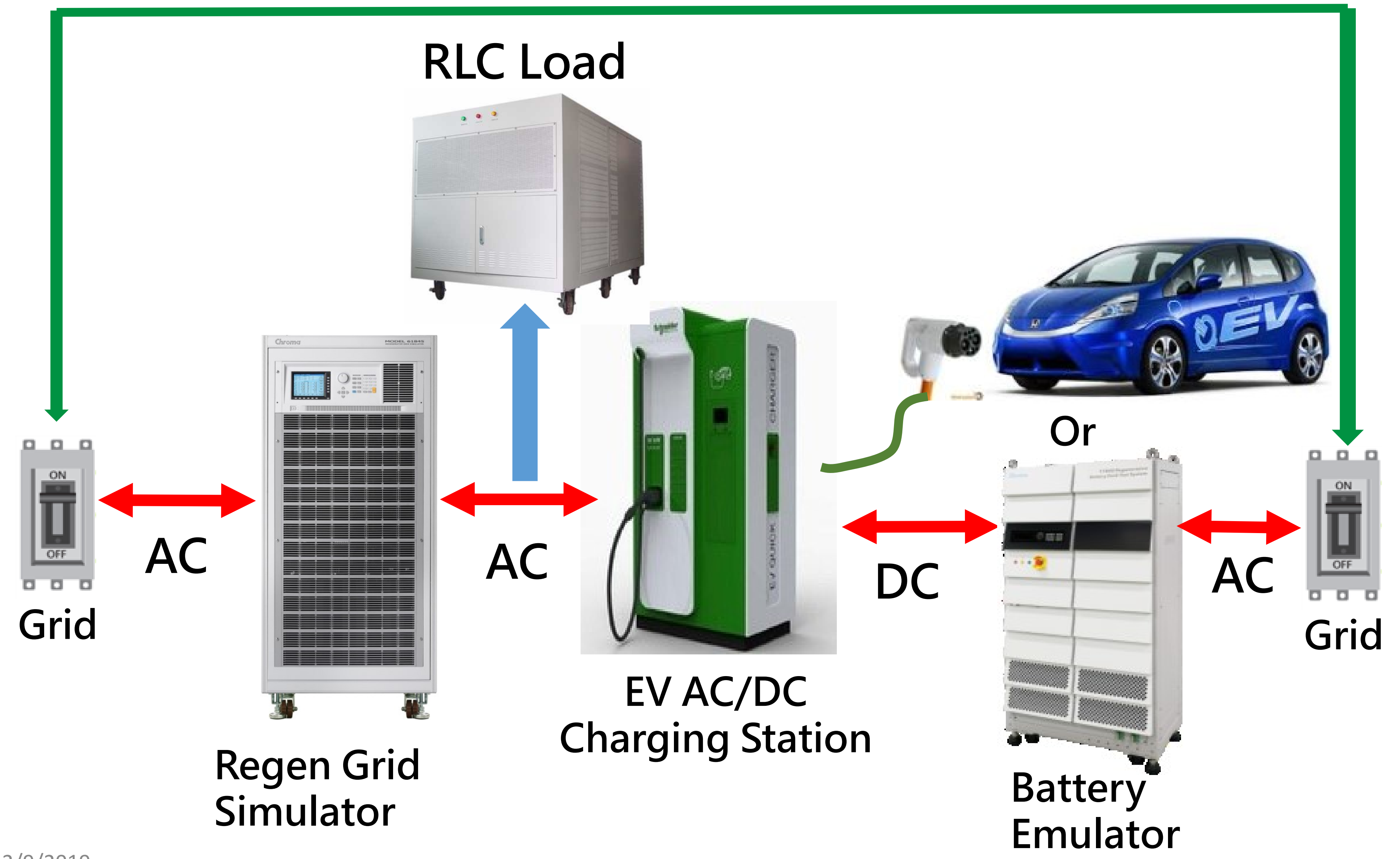


SAE J1772 AC Level 2
= IEC 61851-1 Mode 3= IEC62196 Type 1

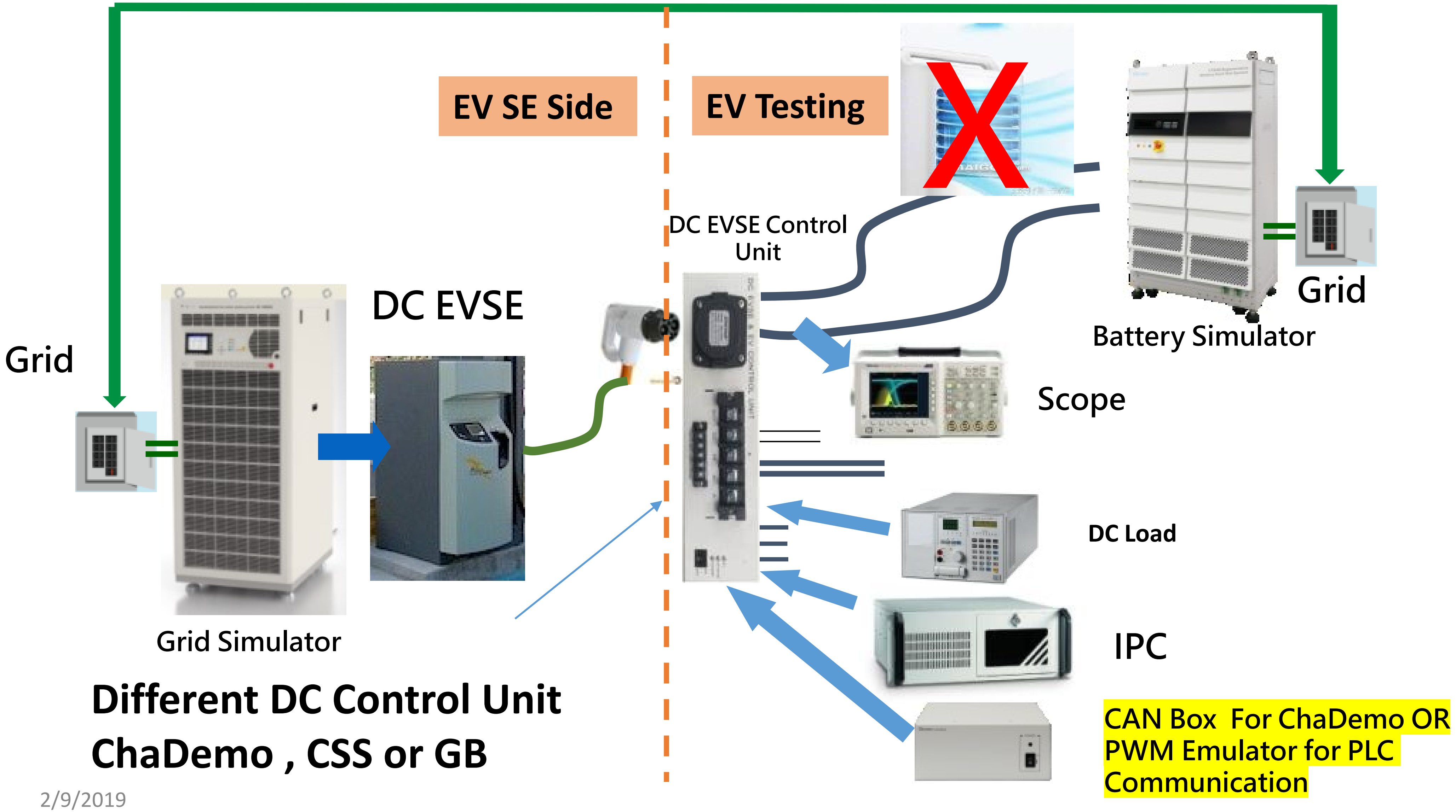


For Level 3 Charging in DC , also Called Fast Charging , there is no standardized protocol yet .
1-Combined Charging System (CCS) ,
2- CHAdeMO System ;
3- Tesla SuperCharger ;

EVSE Testing Architecture



DC EVSE with Control Unit

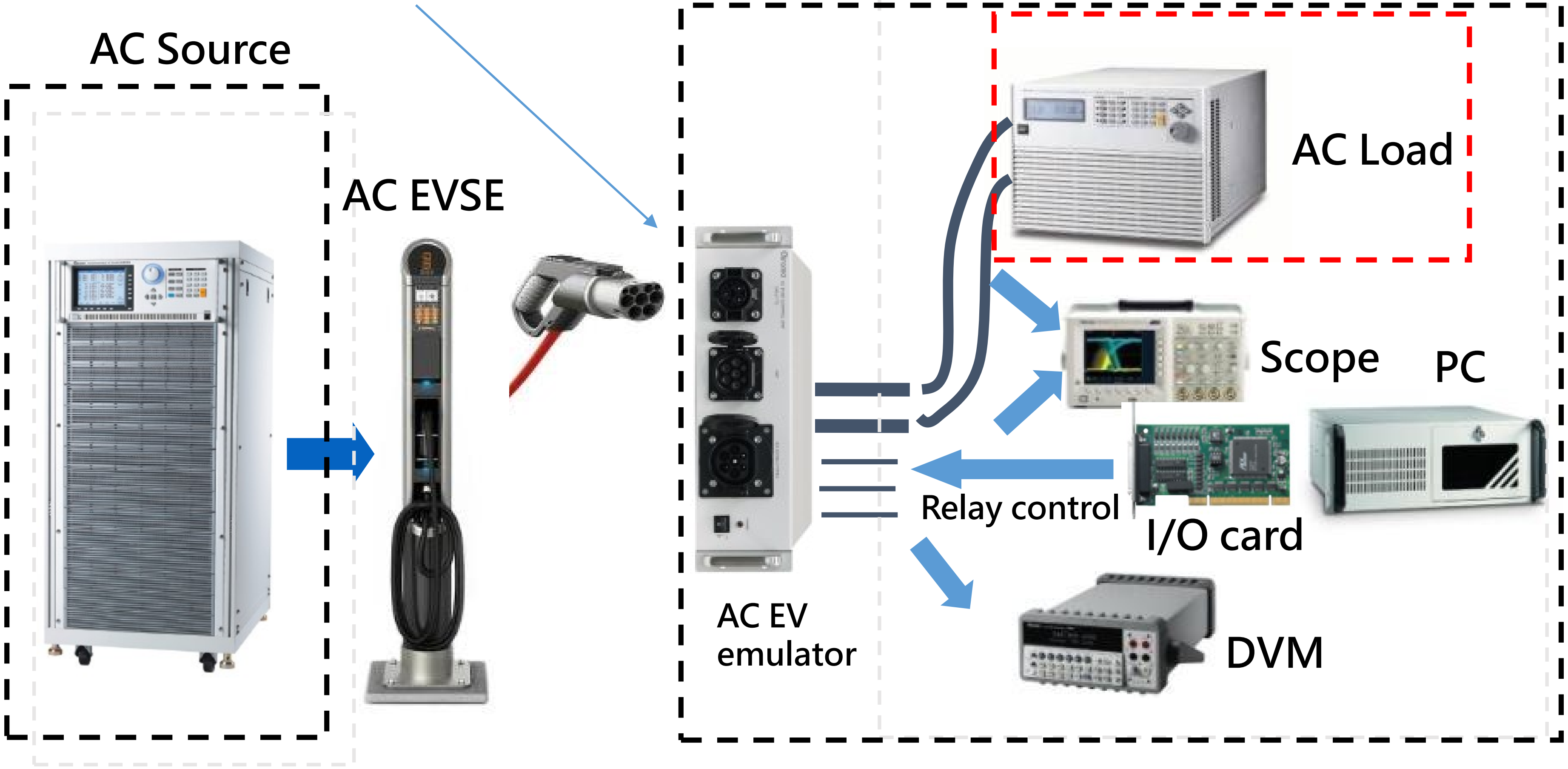


Different DC Control Unit

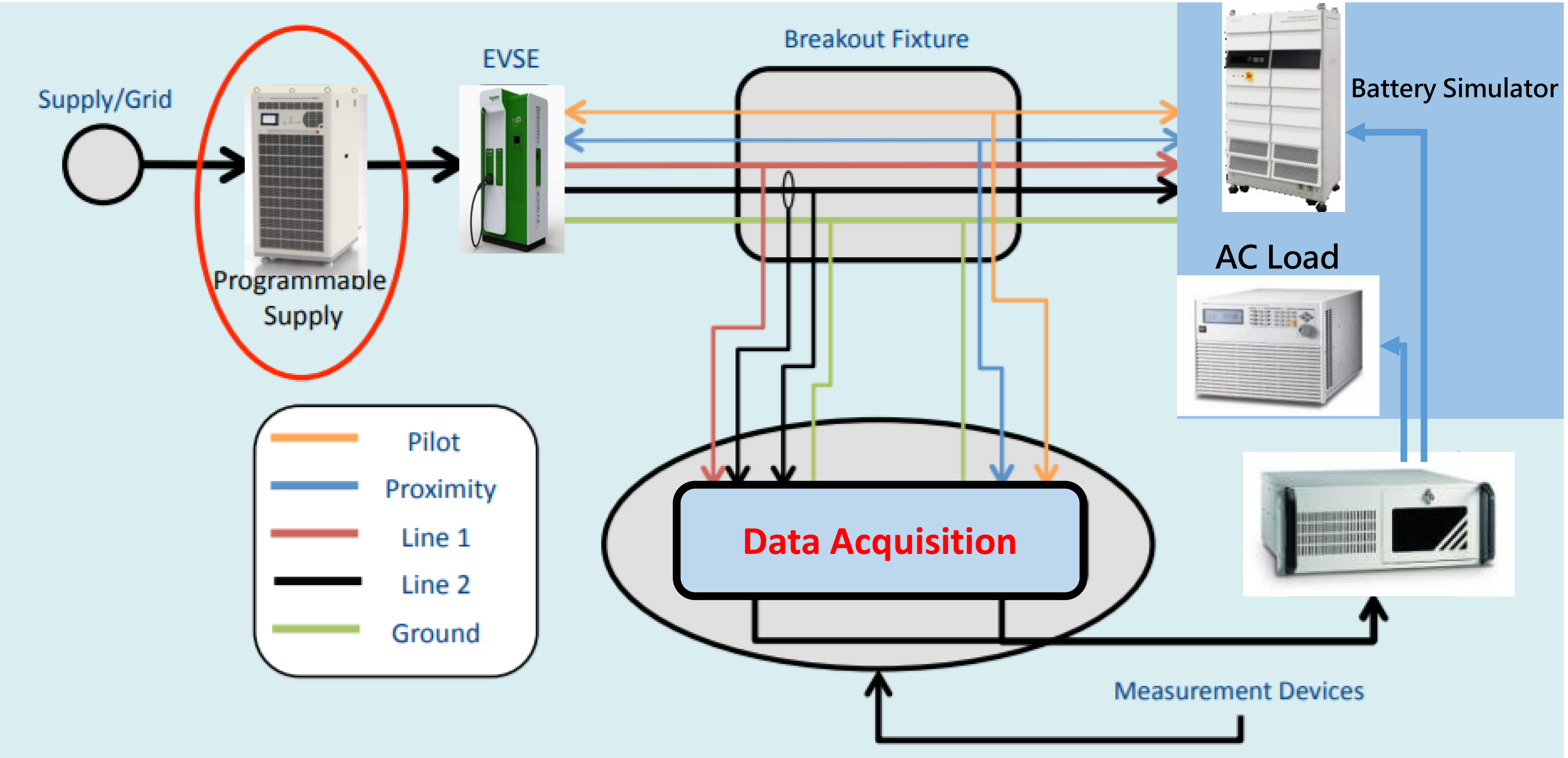
ChaDemo , CSS or GB

AC EVSE with AC Emulator

Designed to Emulate the PWM Control Signal
And mechanical Interface for Different AC EV SE

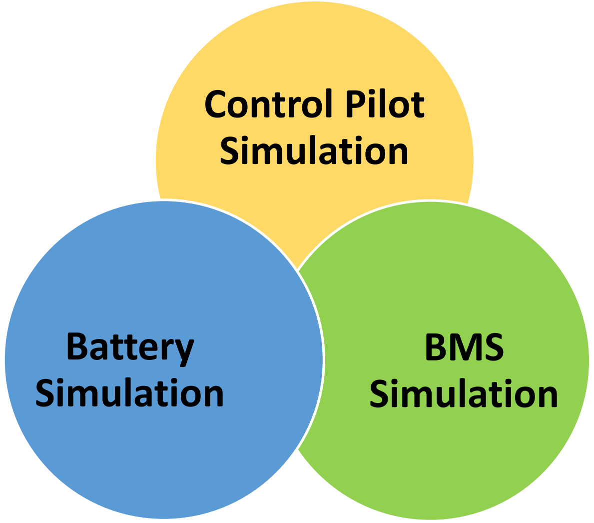


Breakout Fixture for EVSE



Purpose of the Control Box

17040 Battery Simulator



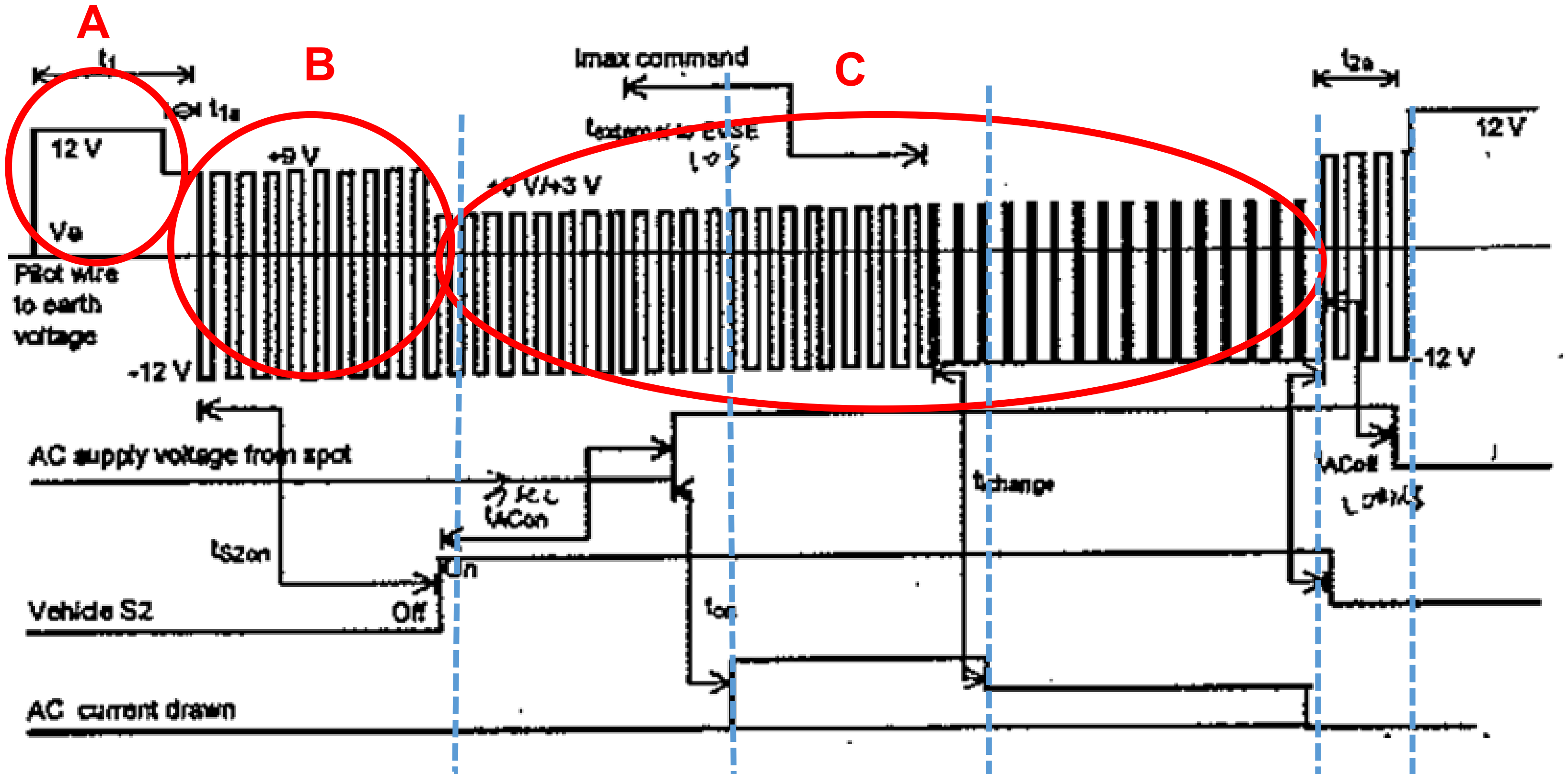
SOFTWARE

+

CAN Box

63200A DC Load

Typical Charging Cycle : Signal Pilot .



Status A :
Not Connected

Status B :
Connected and Ready

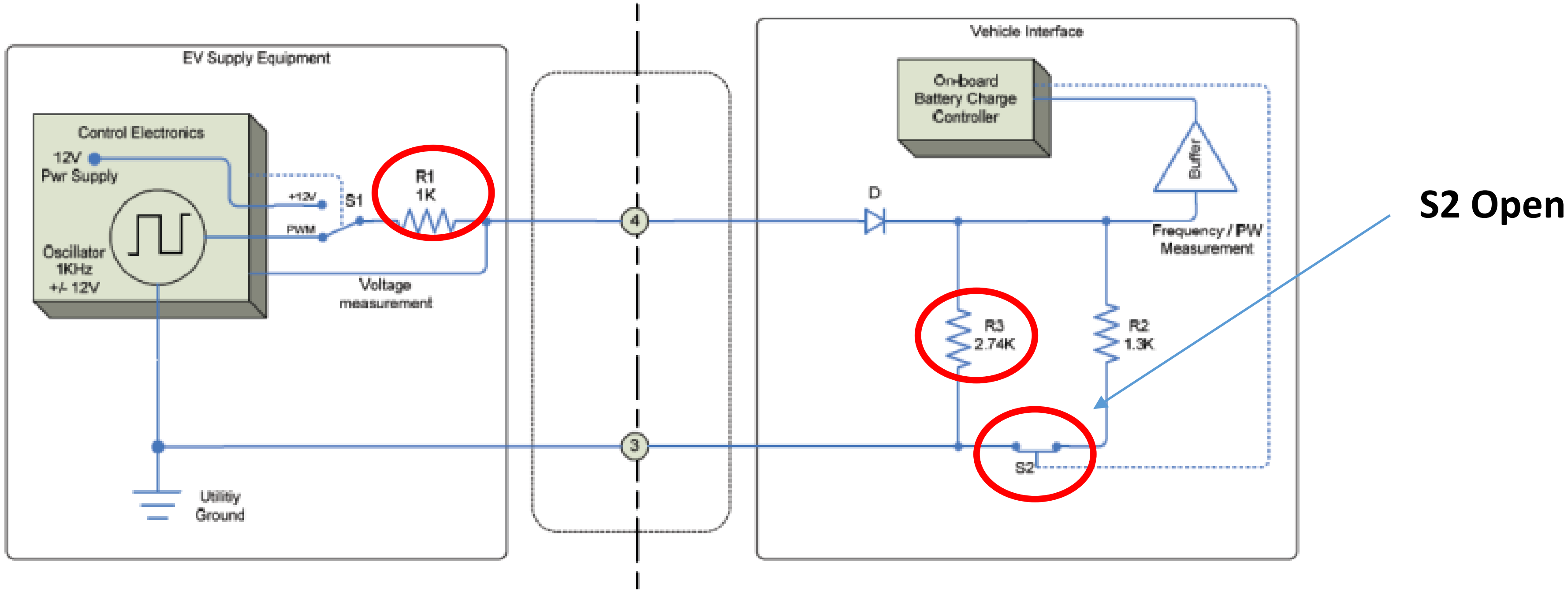
Energy Transfer
(There is a delay from where We start the PWM and start Drawing current)

Modulate the PWM To Control Current

Standard Items : SAE & GB

Control Pilot Signal Test	Change the Pilot Signal to different states
Control Pilot Abnormal Test	Change the Pilot Signal and Check the EVSE response
Current Capacity Test	The EVSE communicates the **maximum available continuous** current capacity to the EV/PHEV by modulating the pilot duty cycle
Coupler Disconnection Test	Using scope to measure the delay time from disconnect until the contactor opens and terminates AC energy transfer.
AC Energy Transfer Test	Using scope to measure the delay time until contactor closes/open and initiates AC energy transfer in response to S2 closed/opened
Harmonic Distortion Immunity Test	Introducing Harmonic Distortion at EVSE Input and Analyzing the AC output Harmonics ;
Voltage Interruption & Variation Test	Introducing AC Input Voltage Surge and Sags and Variations and see the AC Output voltage quality
EVSE Invalid Test	measure the delay time from EVSE setting invalid pilot (simulate utility power not available) until termination AC energy transfer
Protection Tests	Short Circuit Test , Overload Conditions Tests

Control Pilot Signal Test : State B



2. State B= S2 is open, R1 series R3 = 1kohm series 2.74kohm
+12V -> +9V*, -12V, 1khz PWM
-> Vehicle connected / NOT ready to accept energy
Spec. : Min. 8.36V / Max. 9.56V

* 12V-(11.3V/(1000+2740ohm)*1000ohm)
= 12V-3V = 9V

Control Pilot Signal Test

TABLE 5—EV CONTROL PILOT CIRCUIT PARAMETERS (SEE FIGURE 7)

Parameter[(1)]	Symbol	Units	Nominal value	Maximum value	Minimum value
Equivalent load resistance – State B	R2B	Ohms	2740	2822[(2)]	2658[(2)]
Equivalent load resistance – State C[(3)]	R2C	Ohms	882	908[(2)]	856[(2)]
Equivalent load resistance – State D[(4)]	R2D	Ohms	246	253[(2)]	239[(2)]
Total equivalent capacitance	C2	picofarads	n.a.	2400	n.a.
Equivalent diode voltage drop[(5)]	Vd	Volts	0.70	0.85	0.55

TABLE 3 - DEFINITION OF VEHICLE STATES

Vehicle State Designation	Voltage (vdc Nominal)	Description of Vehicle State
State A	12.0[(1)]	Vehicle not connected
State B	9.0[(2)(3)]	Vehicle connected / not ready to accept energy
State C	6.0[(2)]	Vehicle connected / ready to accept energy / indoor charging area ventilation not required
State D	3.0[(2)]	Vehicle connected / ready to accept energy / indoor charging area ventilation required
State E	0	EVSE disconnected, utility power not available, or other EVSE problem
State F	–12.0[(1)]	EVSE not available, or other EVSE problem

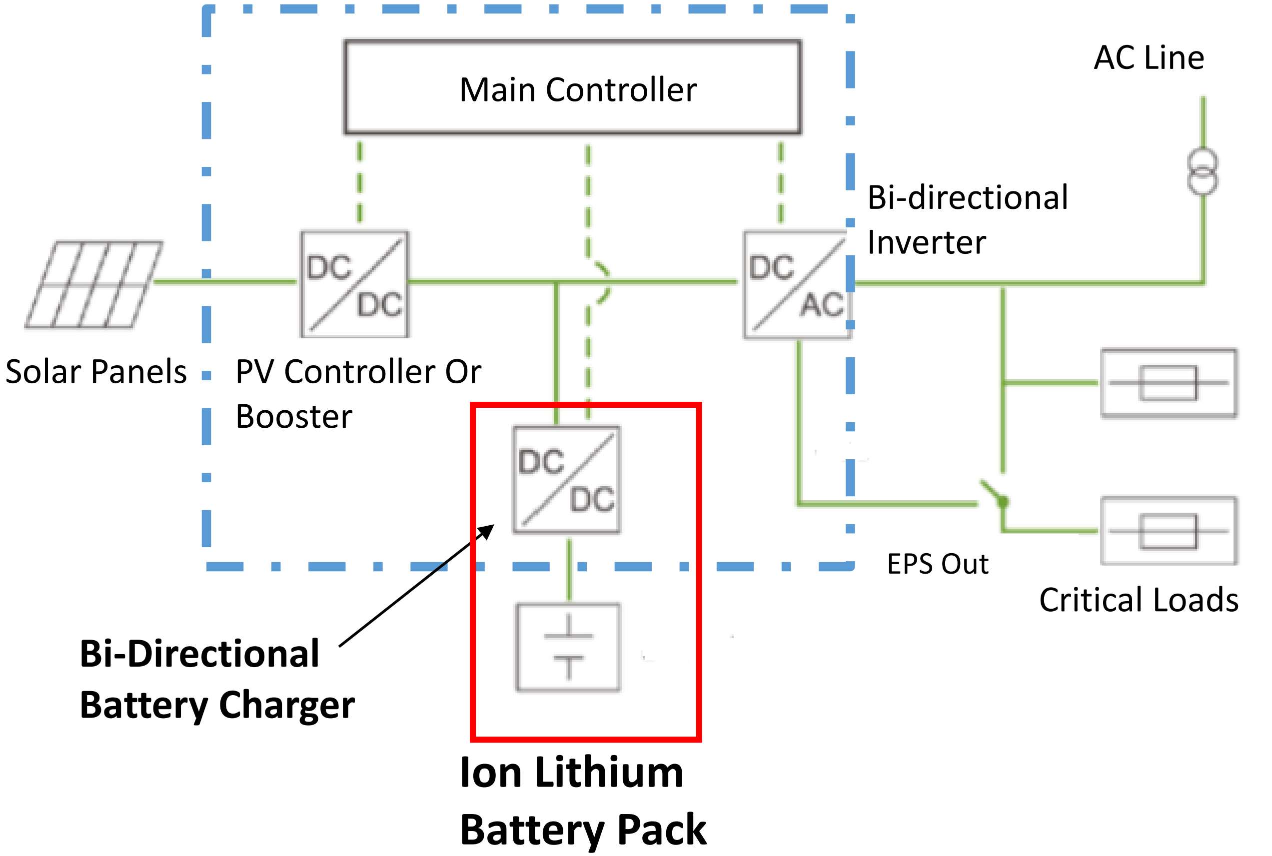
1. Static voltage.
2. Positive portion of 1 KHz square wave, measured after transition has fully settled.
3. From a transition from State A to State B begins as a static DC voltage which transitions to PWM upon the EVSE detection of vehicle connected / not ready to accept energy.

State B=12V-(11.3V/(1000+2740ohm)*1000ohm)
= 12V-3V = **9V -> Vehicle Connected , Ready To accept Energy ;**

State C=12V-(11.3V/(1000+882ohm)*1000ohm)
= 12V-6V =6V -> **Vehicle Connected , Ready to Accept Energy , No Ventilation Required ;**

State D=12V-(11.3V/(1000+246ohm)*1000ohm)
= 12V-9V =3V -> **Vehicle Connected , Ready to Accept Energy , Ventilation Required**

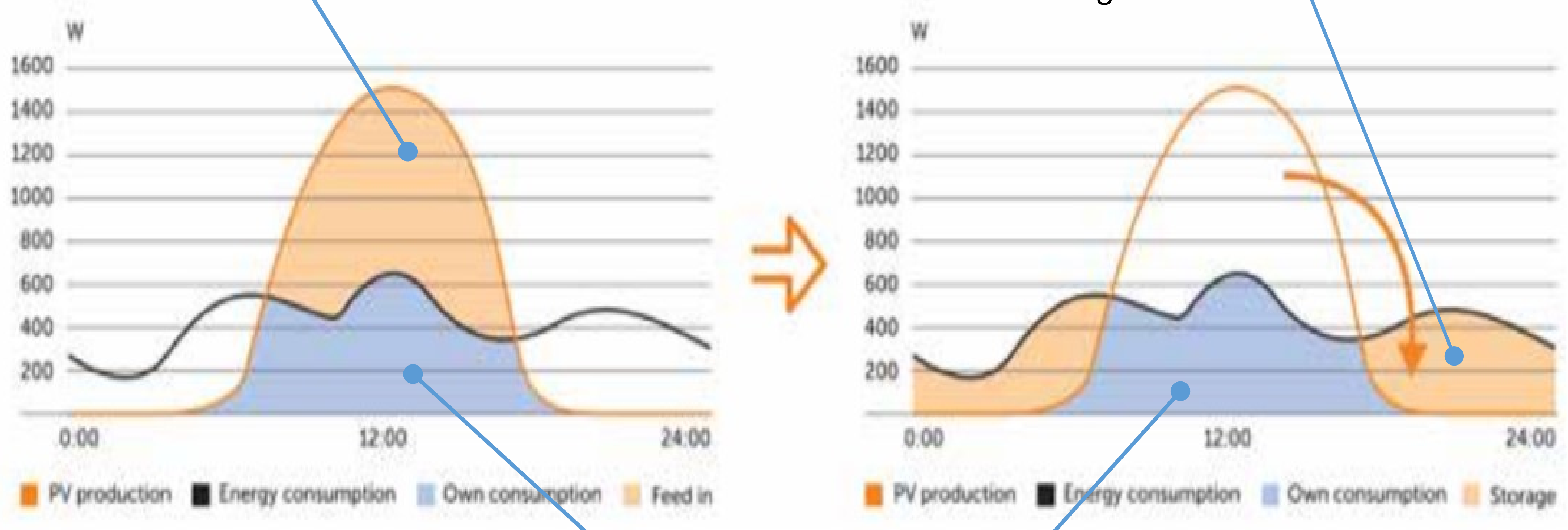
Energy Storage Hybrid Inverter Architecture



How The System Works

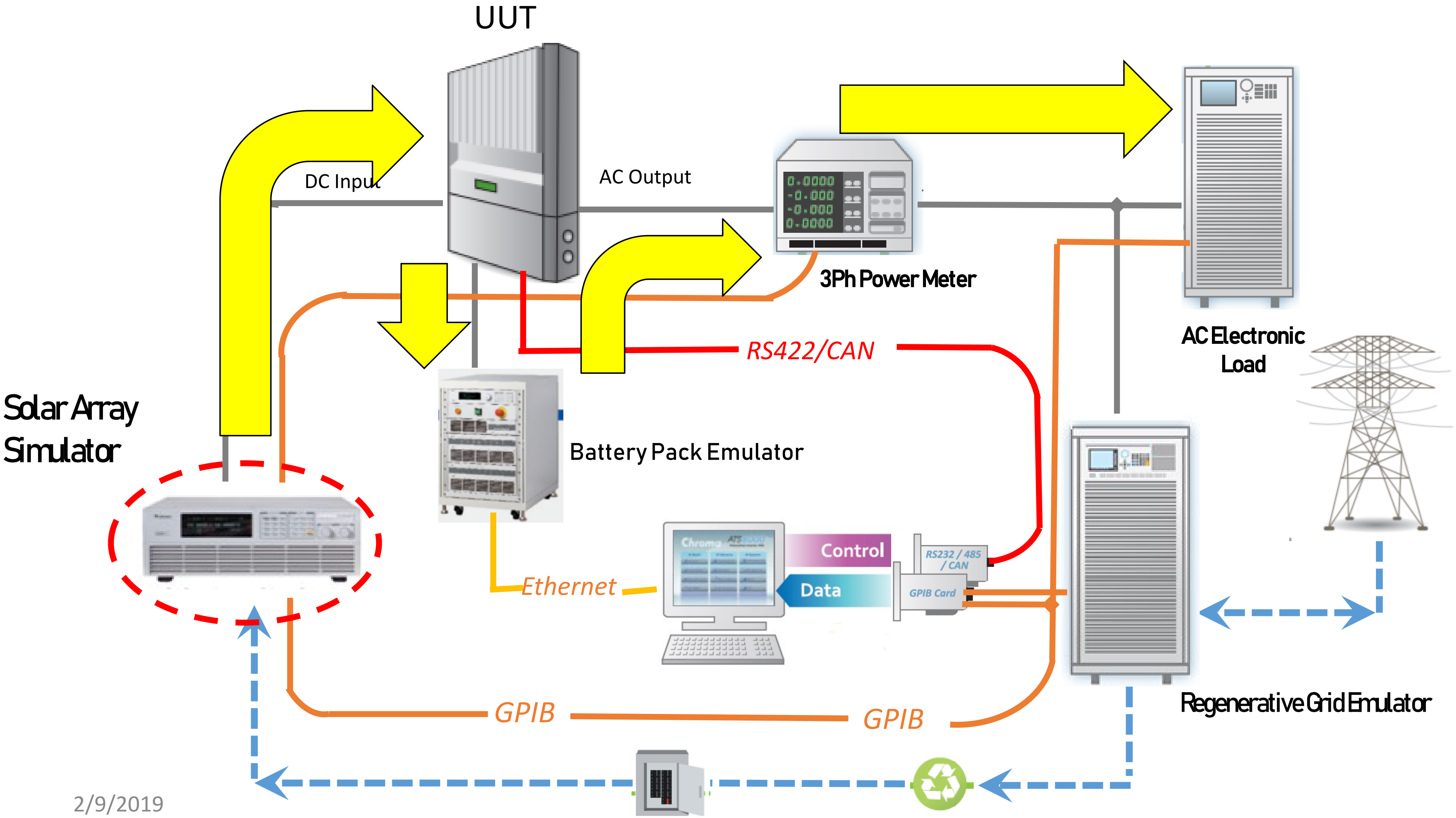
Energy in excess Provided by PV and Not Used

Energy Storage in Batteries For Future Usage

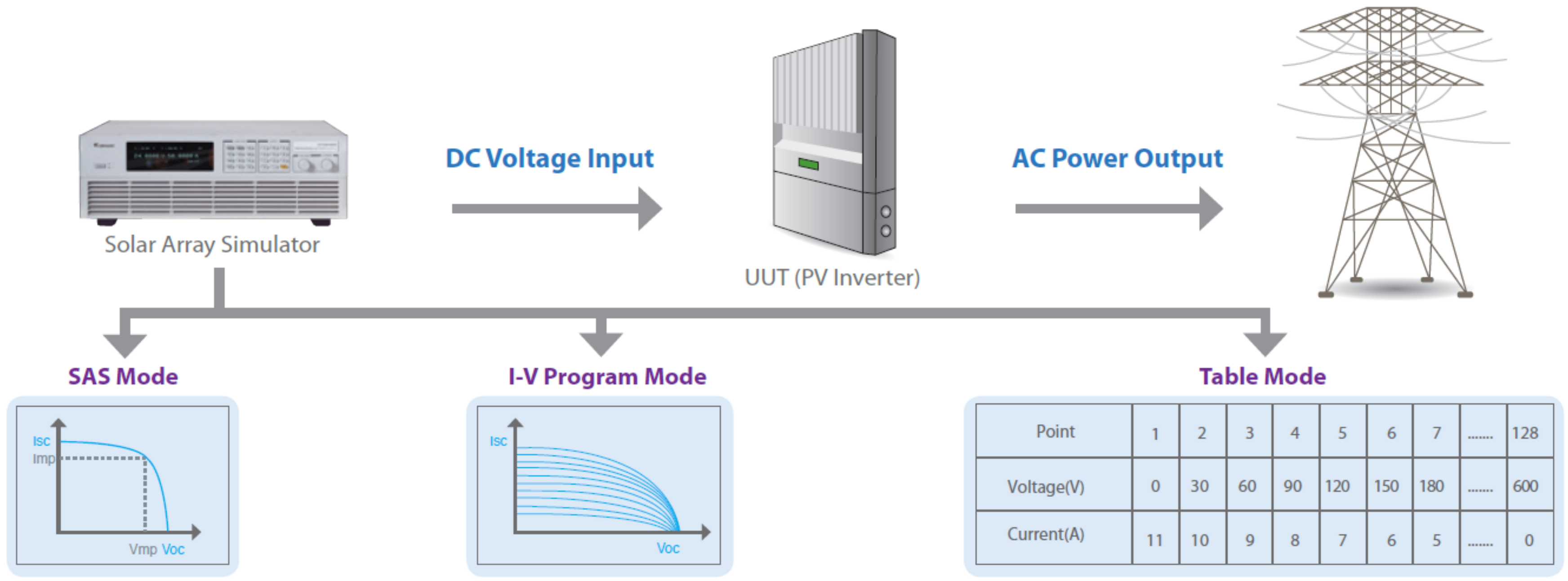


Home Owner Consumption

ESS Testing Architecture



Simulate Different Solar Cell V-I Characteristics



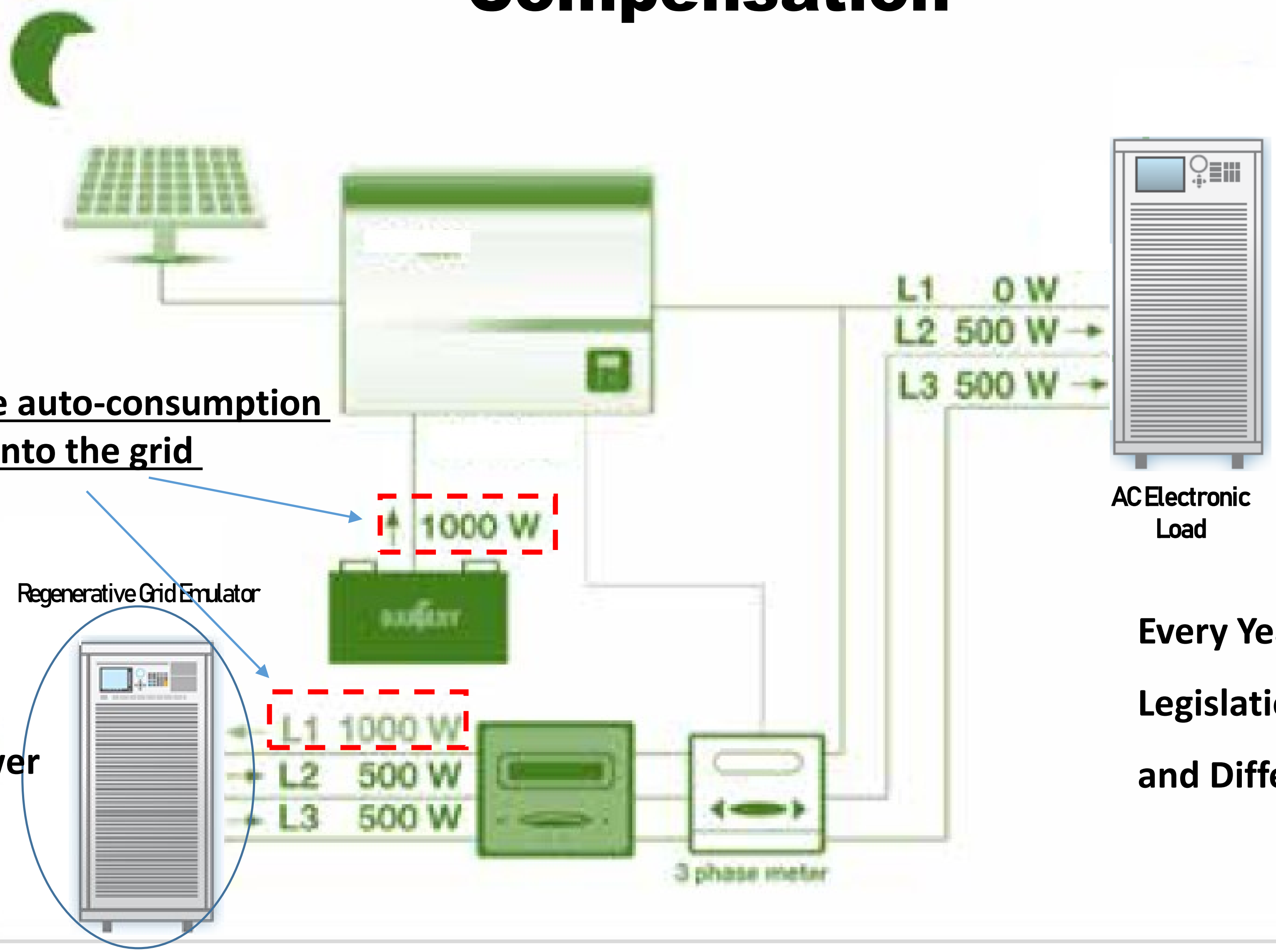
Point	1	2	3	4	5	6	7	....	128
Voltage(V)	0	30	60	90	120	150	180	....	600
Current(A)	11	10	9	8	7	6	5	....	0

- **Built-In Mode** with SANDIA's SAS Model to simulate different Solar Cells V-I;
- **I-V Program Mode**: up to 100 I-V curves and dwells Intervals ;
- **Table Mode** : up to 4096 points array with user programmed Voltages and Currents ;

PV side Inverter Testing

- Design and verify the maximum power tracking circuit and algorithm ;
- Verify the high/low limit of operating input voltage allowed (for Different Countries) ;
- Verify the static maximum power point tracking efficiency of the PV inverter.
- Measure and verify the overall efficiency & conversion efficiency ;

Unbalanced Loads and Reactive Power Compensation



Unbalance Load per Phase

<u>To maximize auto-consumption</u>
<u>Inject 1kW into the grid</u>

Reactive Power

Every Year Different Rules and

Legislation entails Different Software

and Different testing Requirements

Chroma

Thanks for your kind attention

Contact Chroma or your local dealer for more information.

sales@chromaeu.com