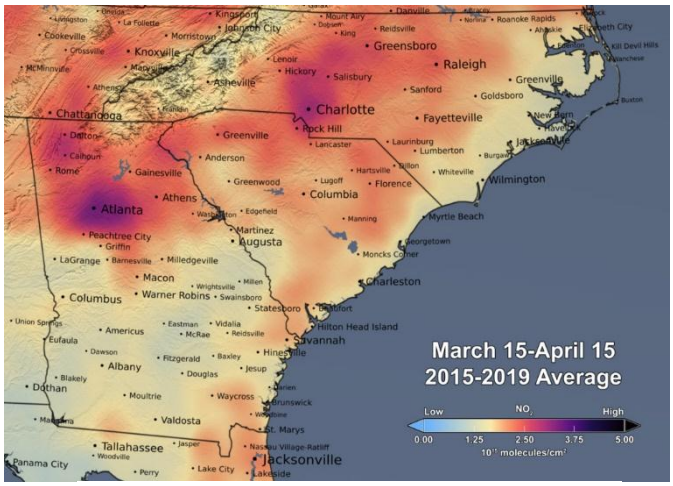
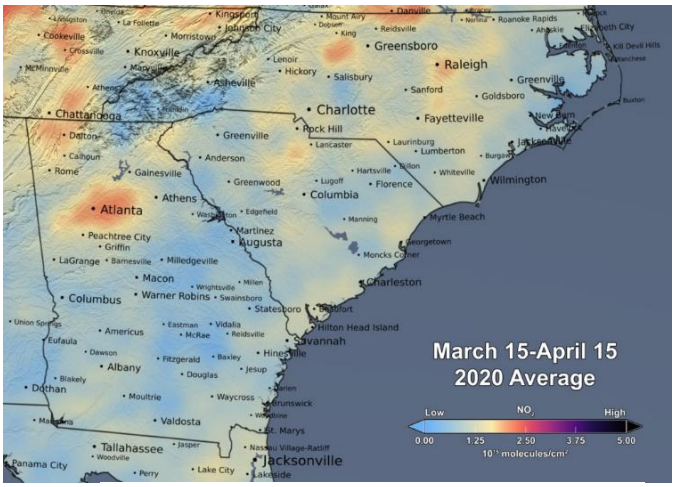
Innovative testing solutions to make EV battery / EVSE work more efficiently

E-mobility leads the future transportation

In the year of 2020, due to the outbreak of COVID-19, people started to quarantine and seldom travel by automobiles, ships, airplanes, etc. It in turn has significantly reduced air pollution emissions. This can be clearly seen from the satellite pictures taken before and after the COVID-19 outbreak.



March 15-April 15 2015-2019 Average



March 15-April 15 2020 Average

Tropospheric NO2 Column, southeast USA, with cities

(Source: NASA scientific visualization studio)

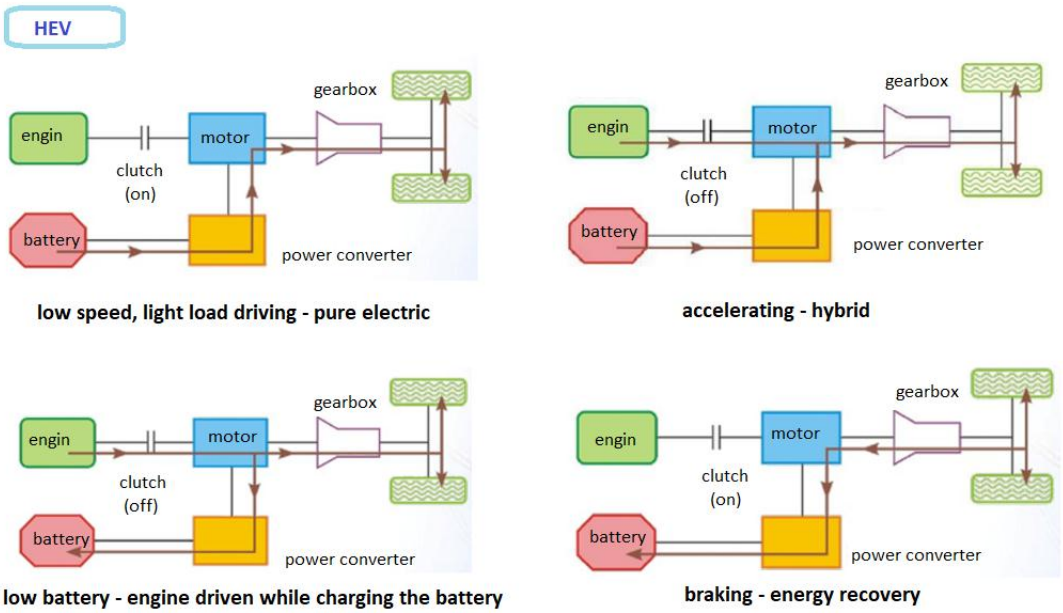
However, people's activities will surely become active again as the pandemic dissipates. At that time, transportation and related infrastructure will also recover. But do we have to face the

terrible air pollution again? To balance the world economy and good environment, the development of electric transportation is perhaps one of the most worthwhile shots.

Nowadays, countries all over the world are increasing investment to study how to transform mobility to e-mobility, such as the development of electric vehicles, electric planes, electric ships, and electric trains. The most important part is the research and development of key components of the electric transportation, such as the new technologies of lithium-ion batteries, fuel cells, electric devices and so on. Until today, there are still many challenges in the entire transportation electrification ecosystem. Let us take electric vehicles as an example to find the difficulties in its R&D and manufacturing process and the possible solutions.

E-mobility revolution --- from fossil fuel vehicle to electric vehicle

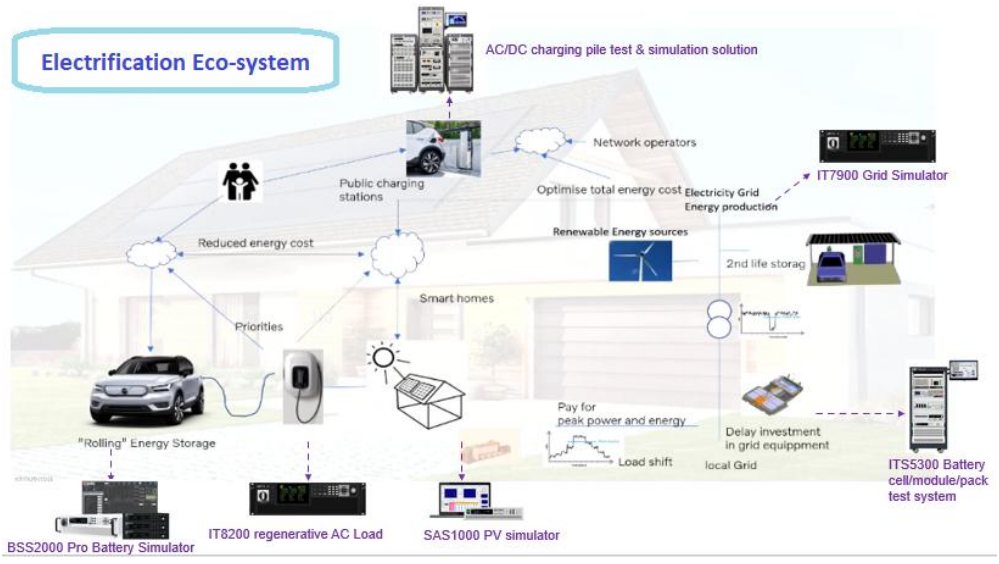
According to data from the World Economic Forum, "By 2023, the number of passenger EVs will reach 215 million." At present, most passenger EVs are BEVs and HEVs. The power transmission systems of parallel hybrid EV and BEV (without engine) are driven by a high-voltage bus provided by a large-capacity battery pack. The voltage of a typical power battery (passenger vehicles) is about 350V. And there are even higher voltages, like Porsche's Taycan, it has an 800V system. The higher voltage power battery can shorten the charging time, on the other hand, it will face bigger challenge in the aspect of insulation and electromagnetic compatibility .



Connected to the power battery is the electric drive system, which includes a motor, a reducer and a motor controller. The performance of the electric drive system affects the vehicle's dynamic performance in terms of uphill speed and acceleration. Generally speaking, the power of electric drives and motors/generators are in the range of 50kW to 180kW, or even more. Till today, many EV manufacturers still adopt the separate design of the three components: motor, inverter and reducer. The components are connected by wire harnesses, and the layout is very complicated in large space. However, we also see that some advanced EV manufacturers adopted an "all-in-one" solution, which integrated the three components into an electric drive axle. It not only makes it smaller, but also improves the energy conversion efficiency at the same time.

Develop electric vehicle with renewable energy--- Electrification eco-system

As the change of automobile drive power, production and consumption modes, the EV industry is gradually evolving from the "supply chain" between parts, vehicle R&D/production and sales to a "net-like ecology" involving multiple roles: automobile, renewable energy, transportation, and communications. In details, it includes charging stations, energy management systems, smart microgrids, energy storage systems, etc. Take the energy storage system for example, it is used to store power energy and provide it to electrical equipment during peak periods to help maintain the stability of the grid. Moreover, building an automotive electrification ecosystem is also very important to the new technology development of IoV and autonomous driving.



The development of electric vehicles has generated many power test requirements. Engineers pay more attention to test safety and begin to build a professional test platform which can be used to test and verify every process from EV development to mass production. Surely, there are also difficulties and challenges happening during this period.

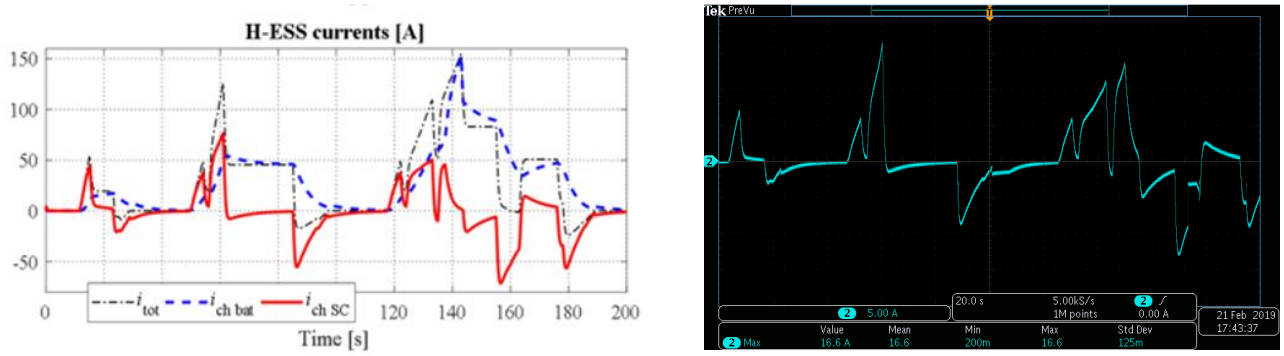
How to drive far？ EV battery is the key.

In order to solve the problem of the short mileage of EVs, major manufacturers focus on the research and development of power batteries. When the Tesla Model S was launched in 2012, the largest battery pack capacity was 85kWh, and the EPA rated mileage was 265 miles. In 2016, Tesla created an 100kWh battery pack that can reach 315 miles. The latest Model S Long Range Plus has an officially announced mileage of 402 miles. This year, Tesla released a new customized battery 4680. It is said that its energy density is increased by 5 times and the output power is increased by 6 times. The mileage of EV equipped with this battery can be increased by 16%. According to industry analysts, if the model 3 were replaced with a 4680 battery, the NEDC mileage is estimated to be more than 497 miles, far exceeding the current 415 miles.

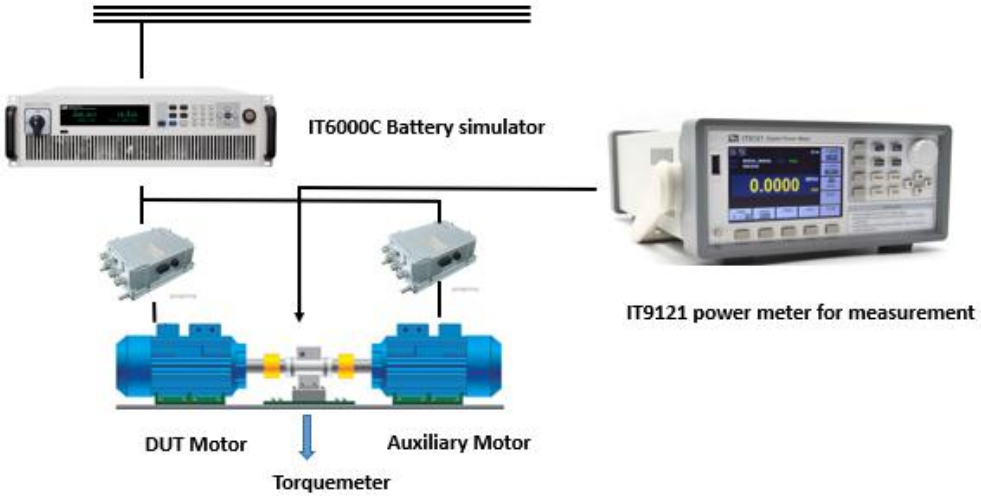
In the design stage of power batteries, EV manufacturer and its battery provider always need to verify the performance of the battery system, especially to evaluate the impact of road conditions on the overall performance of the battery in advance. During the running of the vehicle, the operating voltage and current of the battery system will fluctuate with EV acceleration, deceleration, braking, idling and so on. At this time, the power battery will instantly has a large current and it suddenly switches between charging and discharging. In any case, the output power of the battery pack must meet the power requirement under the actual roading conditions. High-speed charge/discharge switching is the biggest challenge in roading condition simulation during power battery test. The previous solution is using 1 power supply and 1 electronic load to realize the charging test and discharging test of the battery respectively. When the charging is

switched to discharging, it needs to turn off the power supply and then turn on the electronic load. Even operating with the software, the minimum switching time is no less than 100ms. It is far from test requirement of EV power battery under real road conditions.

To solve the problem, ITECH provides a revolutionary solution-a high-speed bidirectional DC power supply (IT6000C/IT6000B), which integrates power supply and electronic load into one device. Based on the high-speed DSP algorithm and internal bidirectional inverter technology, IT6000C can not only complete seamless charge and discharge switching, but also invert the absorbed energy into AC and feed it back to the grid, largely saving electricity costs for battery manufacturers. During the test, it is easy to import the driving condition curve of the EV in .csv file, and the data is up to 10 million points. It can realize the simulation of the NEDC or WLTP curve. Further more, IT6000C can also be equipped with ITECH's professional battery charging and discharging software to make an automated test system. It can complete a comprehensive test of battery cycle life, temperature, overcharge charge, over discharge and HPPC performance.



Roading condition simulation curve



ITECH IT6000C bidirectional power supply (3U@18kW)

(link: https://www.itechate.com/en/product/dc-power-supply/IT6000C.html)

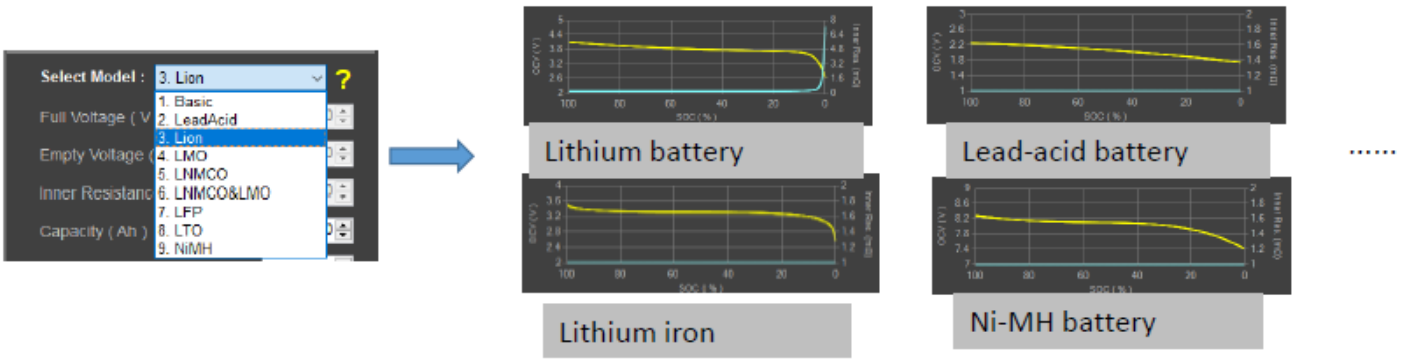
New challenges in EV power performance research

One of the advantages of EV over fossil fuel vehicles is its faster start-up acceleration. This is because the electric motor can output with the maximum torque at low speed, which the fuel engine cannot. The power performance of electric vehicles is generally evaluated by indicators such as the maximum speed, acceleration time, maximum uphill capability and so on.

In traditional testing solution of electric drive system, real batteries are generally used as energy storage media. To test and evaluate the performance of the system under different working conditions, a lot of money is needed for battery pack purchasing. And you need to change battery packs frequently to fulfill various test requirements under different working conditions. The inflexible test solution often leads to longer test time and higher cost. Therefore, a "battery simulator" that has almost all the characteristics of real batteries can effectively improve development efficiency. This has also become an inevitable trend in the development of EV drive system and the test of powertrain.

Now there are not many researches on battery simulators, the most difficult part is fast switching between positive and negative current. The real batteries can quickly switch when the EV is

accelerating and braking, but it's hard for battery simulators to do the same. Besides, in order to evaluate the impact of the battery on the performance of the vehicle in different seasons, different internal resistances and different SOC, engineers need to study it and then do the simulation accordingly. It's not an easy job. The current solution usually requires the curve parameters of the real battery under specific conditions in advance, so the test efficiency is low. To improve it, ITECH created a better test solution, a battery simulator with modular design. Integrating software and hardware, it can simulate a lot of battery characteristics. The hardware is a high-speed bidirectional DC power supply (IT6000C/IT6000B) which can simulate the "charging" and "discharging" of the battery with fast current switching (not more than 2ms from -90% to +90%). The professional software is BSS2000 Pro which is based on the mathematical model of the power battery and turns complex curve of characteristic simulation into visible parameter settings (no voltage, full voltage, rated capacity, etc.). Further more, engineers can even recall the built-in battery characteristic curves for different type of batteries, such as the LiFePO4 ,Li4Ti5O12,LiMn204 battery and so on. In addition, BSS2000 Pro battery simulation software can directly import the battery model simulated with Matlab in a .mat file. This provides more efficient solution in studying the characteristic curve of a new type battery and battery working under different conditions.

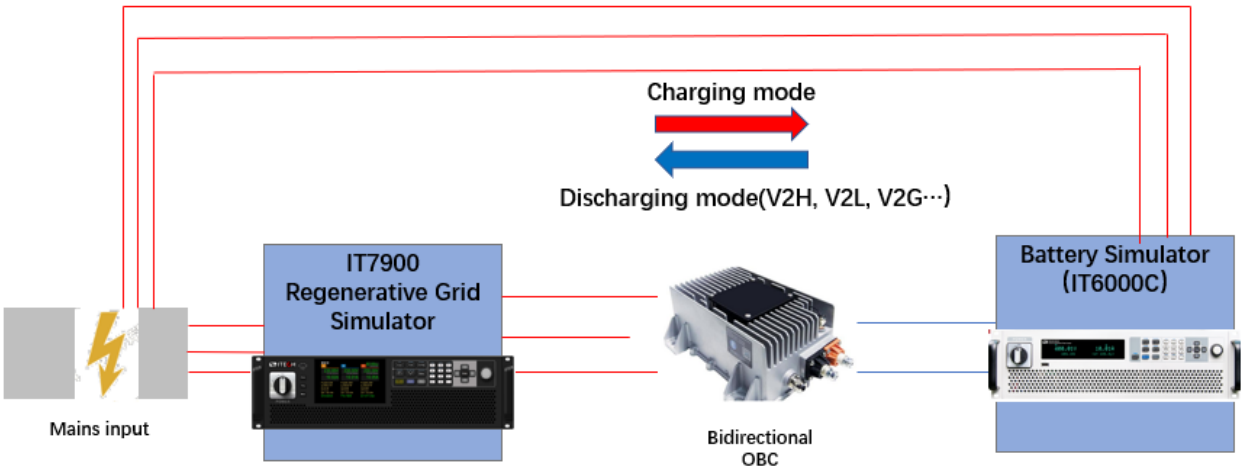


Bidirectional power conversion - new trend in EV design

It is said that Tesla is adding new function of bidirectional charging to Model 3 and Model Y. It

allows users to use their cars to power their house (V2H) during a power cut or to charge another car (V2V). However, the bigger value of this function actually lies in grid services (V2G), especially when electric vehicles reach a certain scale. With the permission of the car owner, Tesla can provide the grid company with electricity collected from Tesla vehicles on their power network. This can help to fill the gap of power demand during peak hours. The concept of "cut peaks and fill valleys" will surely improve grid efficiency.

The combination of electric vehicles and smart grids (V2G) is one of the important tasks of building an electrified ecosystem. It means that the electrical topology design of vehicles needs to support bidirectional power flow ---bidirectional BOBC and bidirectional charging piles. Engineers need not only consider the conversion efficiency in the bidirectional mode, but also the verification of grid-connected characteristics to ensure that EV can be reliably connected to the grid without causing any interference.

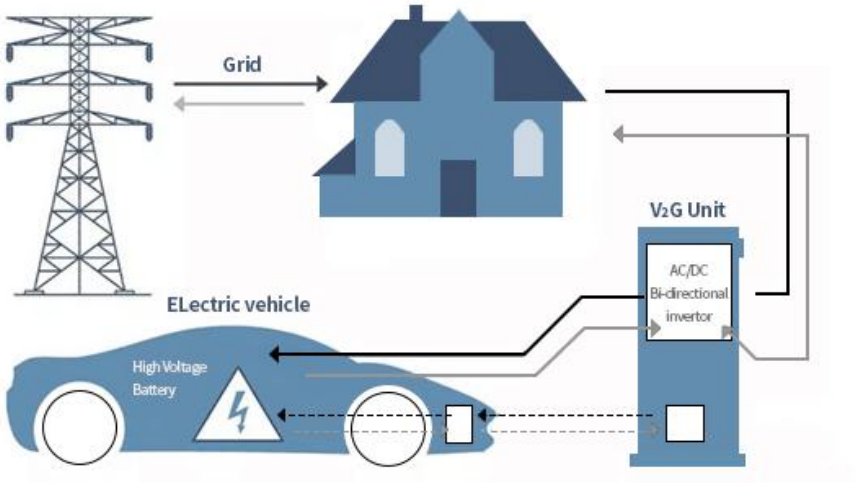


Let us check the BOBC (V2G) test. It includes two major items: AC-DC and DC-AC. In the DC-AC test, the DC end needs a DC power supply to simulate battery discharging. The AC end needs an AC source and an AC electronic load. The AC source is to simulate the grid voltage. This is a general test solution. But any risk with it ? Sure. When the energy fed back by the BOBC exceeds the maximum energy that can be absorbed by the AC load, it will inevitably flow back to the AC source. The AC source generally can not absorb energy, which will eventually

lead to reverse breakdown. And even worse, in case of miss operation on the sequence between turn-on and turn-off the AC load and AC source, it will result in test failure or even instrument damage.

Better solution for bidirectional BOBC and charging piles (V2G) is to test with a power grid simulator (like ITECH IT7900). The power grid simulator is a four-quadrant source with the ability of seamlessly switching between source and sink. Besides the basic functions, ITECH IT7900 power grid simulator also has the feature of power amplifier, which can well match the power HIL test.

Now more and more bidirectional power conversion technologies is going to speed up and definitely better serve for the EV electrification ecosystem.



As the transformation of the energy market and the accelerating development of the electric transportation market, the core technologies of the electrification ecosystem have been updated, bringing various applications and new challenges at the same time. It’s easy to find that one test solution can not cope with verification challenges for all new designs. And good test solutions are required to have the advantages of high level automation, good performance and low cost. This is also what millions of automotive design engineers expect.

ITECH, as a leading power test solution provider, is always committed to providing variety of test

and measurement solutions for the innovation and development of the global transportation electrification ecosystem (EV, E-ship, E-plane...).

For more information, pls. visit www.itechate.com

Abstract

In the new era of e-mobility, electrification eco-system has been established gradually. Engineers meet the challenges every day in the research of various new technologies and verification of different electric devices. How to make the design more feasible, reliable and safer ? ITECH provide you with innovative test and measurement solutions to make it easier and faster for the EV R&D and manufacturing.

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