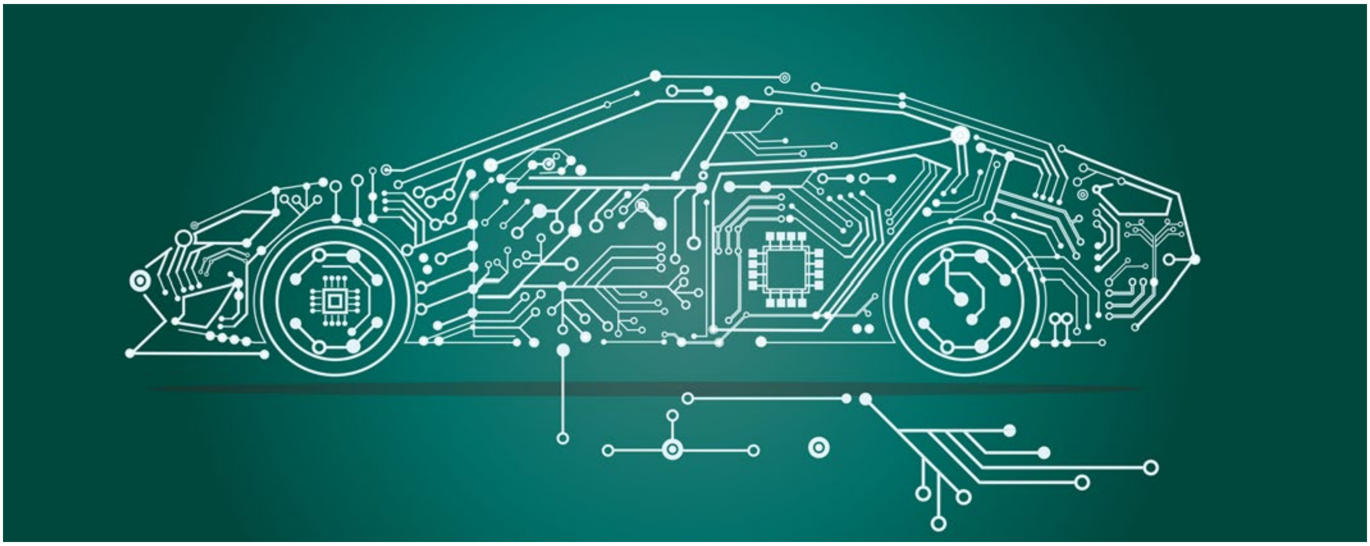

Process Survivability, Reliability and Robustness Testing for EVs

Feature Article by Bob Neves
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Electric vehicles encompass more than just automobiles. Trains, subways, ships, motorcycles, scooters, skateboards, and even aircraft are now going electric. Electric vehicles have unique power needs that directly affect the manufacturing and reliability of the printed circuit boards (PCBs) used in them. Drive train and environmental control systems require PCBs with the ability to process significant power to interact with and control them. Adding to the power needs of electric vehicles are the dozens of support, monitoring, entertainment, and safety systems that have become a part of the vehicle experience we expect.

In combustion engines, power generated from fuel was used for all mechanical and electrical needs with a surplus of energy remaining. The elimination of the combustion engine has forced power to now be carefully managed and conserved as it all needs to be stored locally and there is not much extra that can be wasted.

The power used by an electrical system is equal to the current flowing through the system multiplied by the voltage drop across the system. This means that in order to obtain significant power for your electrical system, you can increase current, voltage, or some combination of both. In addition, the energy storage systems on the vehicle must balance increases in voltage and current to maximize power distribution. These increases in current and voltage create unique issues for the PCBs used in these high-power systems. Increased current requires thicker copper conductors while increased voltage requires more spacing between conductors to prevent electrical leakage. Increased power going through the PCB also generates heat, causing expansion which increases stress to the PCBs' via structures and can contribute to long-term degradation to its insulation systems.

The desire for high reliability in our vehicle electrical systems has driven us to try to better understand the factors that affect the long-term interconnection and isolation reliability of the electrical circuits that comprise a PCB.

As the via structures that interconnect components and layers in a PCB are typically the weak point in a conductive circuit, testing requirements have rapidly evolved, attempting to assess the process survivability, robustness, and reliability of via structures.

Process survivability, reliability testing, and robustness testing are terms that tend to be confused with each other and lumped into "reliability testing." Let's clarify these terms and show how they fit together into the PCB world so that it is clearly understood what it means when each is used.

Process Survivability

Process survivability testing is the simulation of the environmental stresses experienced by the PCB during the component attachment process including any repair or rework that might be allowed prior to the product going into use in the field. This means that a representative test sample must be subjected to multiple exposures of the test temperatures utilized for component attachment and rework/repair processes. As this represents what could happen to a PCB during component attachment, process survivability simulation should be performed prior to any reliability or robustness testing. The IPC recently published IPC-TM-650 2.6.27B that defines assembly reflow process survivability testing for via structures. This test method defines the testing of via resistance during the simulation of a convection reflow oven environment. The results of this testing will allow understanding of whether the vias can survive the multiple reflow/rework/repair processes that are allowed during component attachment. An extension of this test is also sometimes used as a robustness test where reflow simulation cycles are repeated until via structure failure.

Reliability Testing

Reliability testing is the process of creating an environment for test samples that significantly accelerates the factors influencing a PCB's performance during its expected life. The results from testing in this environmental acceleration can be evaluated using mathematical models (Weibull, etc.) in order to predict the expected life of the product in the field. Reliability testing attempts to maximize acceleration factors actually seen by the product during its life and eliminate acceleration factors that cannot be directly correlated to real life use.

In order to assess the long-term reliability of via structures, thermal shock/cycling is performed on test samples in accordance with IPC-TM-650 method 2.6.7.2 between -55°C to (T_g - 10)°C. Keeping the upper temperature to which the samples are exposed to 10°C below the T_g ensures that the expansion rate of the material is consistent with what is expected during the life of the PCB. The resistance of single vias or daisy-chains of vias is monitored during thermal shock/cycling and resistance increases over time are indicative of cracking or separation in the via structure(s).

When assessing the long-term reliability of a PCB's insulation system, testing for conductive anodic filaments (CAF) in accordance with IPC-TM-650 method 2.6.25 is normally performed. This testing exposes parallel via structures to 85°C and 85% RH environment while placing a 100 VDC potential across them. Electric vehicle electronic systems often run at voltages well above 100 V and variations of CAF testing up to 4000 VDC have been done at my lab, Microtek Laboratories China (www.TheTestLab.cn). There is no standard for CAF testing at voltages above 100 VDC and custom fixtures, cabling and safety systems must be deployed to properly perform high-voltage CAF testing.

Robustness Testing

Robustness testing is essentially reliability and/or survivability testing plus. The plus includes environmental or electrical acceleration factors that cannot be directly correlated to the factors that influence a PCB's long-term performance during its expected life. This creates stresses that accelerate failures faster than possible with reliability testing. Robustness testing is used in situations where obtaining faster results is more important than directly understanding life expectancy in the field. These types of tests typically expose PCB test samples to temperatures above the material's glass transition temperature (T_g) or pressures higher than 1 atmosphere. These conditions create stresses and acceleration factors that are not seen during a product's normal life. These types of tests are useful when comparing materials, processes, or products to each other. After exposure to the extraordinary test conditions of robustness testing, observations point to the "better" one, but that may or may not mean that the better one will outperform "worse" ones in a product's real-life use environment.

For via structures, robustness testing usually means thermal shock/cycling between 25°C and 190-260°C, well above the T_g of the PCB's material. Z-axis expansion rates of the PCB's substrate material above T_g are 4–10 times what is experienced below T_g and causes extreme stress to the via structures that does not occur during the product's life. These additional acceleration factors speed the via structure's time to demise but creates difficulty when trying to correlate the results to real world operating conditions.

All the process survivability, reliability testing, and robustness testing of via structures can be performed using a HATS^{2}™ tester. The HATS^{2}™ tester can test a wide variety of PCB test coupons at temperatures from -55°C to 260°C. Please visit www.HATS-Tester.com for more information. **PCB007**

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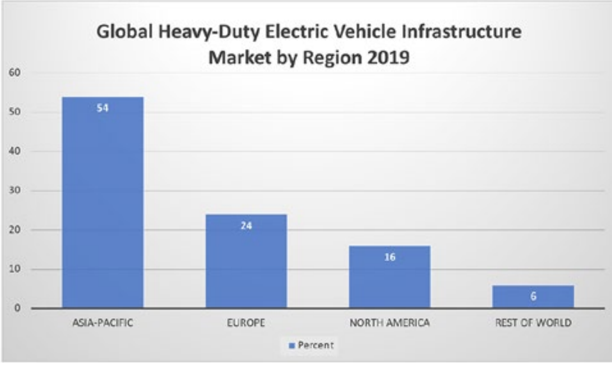
Heavy-Duty EV Charging Infrastructure Market Set for Strong Growth

The heavy-duty electric vehicle charging infrastructure market is anticipated to grow at a healthy 35.07% CAGR over the period of 2018–2030, reveals the current Market Research Future (MRFR) report. The heavy-duty electric vehicle charging infrastructure, put simply, is a complete assembly for transferring electricity from the electric grid and distributing electricity to charge electric vehicles like trucks and e-buses.

According to the report, there are numerous factors propelling the heavy-duty electric vehicle charging infrastructure market growth. Some of these include the increasing adoption of electric cars, people in Germany, the UK, Norway, and China increasingly switching to electric cars, favorable government subsidies and policies, and demand for electric cars as they reduce carbon footprints on the environment and also produce fewer emissions which are responsible for smog and climate change.



The additional factors adding market growth include the growing need for energy-efficient commuting and support from the government for electric cars and their charging infrastructure through tax rebates, subsidies, and preferential policies.

On the contrary, the high price involved in initial investments for fast charging, the need for better batteries, the charging time of electric cars being higher than fossil fuel cars, especially in level 2 and level 1 charging, the compatibility of charging not being uniform, and the current trend of pricing and grid capacity of electric cars being higher than that of their fossil counterparts may limit the global heavy-duty electric vehicle charging infrastructure market growth over the forecast period.

(Source: Market Research Future)