Keysight Technologies
Increasing Reliability and Efficiency in Next Generation Power Converter Designs (Part 4)
Design Validation and Certification

Application Note

Power Device and Component Evaluation
Electronic Design Automation
Hardware Design and Debug
Design Validation/Certification
The need to reduce energy consumption as well as CO2 emissions is driving the growth of power electronics and power converters. These needs are driven by growth in the vehicle electrification and home energy management systems where renewable energy usage is becoming more prevalent. Two of the main power converter design drivers are increased conversion efficiency and better reliability. In green energy applications such as solar power, Levelized Cost of Energy (LCOE) is the main decider for what solar inverter a customer chooses for their solar installation. Both efficiency and reliability are two of the main variables in the LCOE algorithm that determines whether your inverter company gets the sale or not. In hybrid electric (HEV) and electric vehicles (EV) reliability is tied to an automotive manufacturer’s reputation and is also linked to safety and the preservation of human life. Hence comprehensive EV test for the various vehicle electrical subsystems at the design and test stages is vital.

The ceiling or limits of these design drivers was getting close for many power converter applications that used power devices based on silicon. The emergence of wide band gap (WBG) power devices based on silicon carbide (SiC) and gallium nitride (GaN) hold promises of raising the ceiling of these design drivers. With the ability to switch faster, handle higher voltages, and larger temperature ranges WBG devices can increase efficiency and reliability as well as reduce form factor in next generation power converter designs. But before power converter designs based on WBG power devices can become main stream there are design and test challenges that must be understood and overcome to utilize them to their full potential.

This is part four in a four part series that takes a look at each stage of the power converter design cycle. At each stage we will look at design and test challenges of next generation power converters and discuss hardware and software tools to help you overcome them. We will put an emphasis on improving the design drivers previously mentioned: increasing efficiency, improving reliability, and reducing form factor. We also consider the design and test challenges that WBG devices introduce into the power converter design cycle. Each of the four parts of this series will cover one of the following design cycles:

1. Power device and component evaluation
2. Design software simulation
3. Hardware design and debugging
4. Design validation and certification
Design Validation and Certification

At this point in the design cycle you have your power converter prototypes working well. It is now time to verify the full functionality of the design through various operating conditions and environments. You also need to establish your specifications, which includes the often critical efficiency specification. Finally you have to conform to various standard and certification tests that may vary depending on the part of the world you want to sell your device. These tests may be done by a testing house or you may have to have an independent certified third party verify your tests methods. The bottom line is in this stage of the design cycle there is a lot of time consuming testing that needs to be done before you can go to market.

Keysight provides a large portfolio of differentiated hardware and software products applicable to this stage of the design cycle. Products with proven measurement science to ensure accurate and repeatable results as well as products with capabilities geared towards ease of use and reducing test complexity to help reduce test times. Keysight also stands behind its products with excellent post sales services and support to help you avoid unnecessary long interruptions in test, including:

- Standard three year warranty on all products
- Worldwide technical support
- Worldwide repair capabilities with loaner equipment options
- Worldwide calibration capabilities with onsite calibration options

Keysight’s post sales services and support cannot be matched by anybody else in the test and measurement industry. In the following sections let’s look at some of the test challenges you face during this stage of the design cycle and how Keysight Technologies, Inc. can help you address them.

Getting better insight into your power measurements

Measuring power quality and efficiency of your design is critical to meet regional test standards and to be competitive in the market. Since measurements require the ability to capture input and output voltage, current, and power at high accuracy and resolution, a power analyzer is typically the instrument of choice for these applications. Today there are numerous power analyzers on the market. At Keysight we noticed most of the power analyzers on the market are hard to use. Additionally, they do not provide very much insight in the signals you are measuring to assist you in identifying issues or problems in the design quickly. With this in mind, Keysight launched the PA2200 IntegraVision series of power analyzers consisting of the:

- PA2201A IntegraVision Power Analyzer, 2-channels, 1 Phase
- PA2203A IntegraVision Power Analyzer, 4-channels, 3 Phase

Figure 1. PA2201A IntegraVision Power Analyzer with large display for analysis
Keysight’s IntegraVision series of power analyzers provides an intuitive user interface that leverages touch-screen technology to ensure ease of use, reducing unneeded complexity. Think back to power analyzers you have used in the past. Often configuring the power analyzer for a simple efficiency measurement required a lot of front panel instrument interaction, references to the user manual, and sometimes a call into the support line. With the IntegraVision power analyzers that type of user interface complexity is a thing of the past.

Once again think back to power analyzers you have used in the past. What did you do if a power quality measurement you were making was ‘way off’ the expected value? At best, the power analyzer may provide a small display of the power waveform with limited analysis capability. At worse the power analyzer just gives you the textual measurement reading, forcing you to get another instrument to get better insight into the power signal. The IntegraVision series offers a 12.1” touch display and various analysis tools that you commonly find on an Oscilloscope, see Figure 1.

This familiar oscilloscope interface allows you to quickly develop insight into your power signal and diagnosis your toughest design problems. For instance, it includes analysis tools such as:

- 29 pre-defined cursor measurements on waveforms including peak-to-peak, rise time, frequency, and area under waveform.
- Simultaneously view signal data in the time domain and frequency domain as well as view harmonic data in a bar plot or in an exportable list, see figure 2 below. Perform IEC 61000-3-2 precompliance standard measurements on current harmonics.
- Use math functions to operate on captured waveforms to create new user-defined measurements, such as $i^2T$ to calculate thermal energy to properly size a fuse.
- Capture one-time events (like start-up) or transient events (like cycle drop-out) to visualize and perform analysis right on your power analyzer, see Figure 3.

All with Keysight’s proven measurement science to ensure you get accurate and reliable power measurement results you trust. Power measurements include: efficiency, real power, apparent power, reactive power, phase, power factor, and much more. To experience the difference yourself, contact your local Keysight sales representative to try an IntegraVision power analyzer firsthand.
Verifying the reliability of your design:

Reliability is a critical design aspect in power converter applications. Take a look at solar inverters as an example. Purchase decisions for solar inverters are most often tied to an algorithm called the levelized cost of energy (LCOE). Reliability or the warranted life of a solar inverter is a major variable in this algorithm. This means if a company cannot provide a good enough warranted life on their product the result of the LCOE algorithm will not come out in their favor and they will not survive in the market place. A similar argument can be made for power converters in hybrid electric and electric vehicles. Often the reliability rating of a vehicle or the reliability reputation of a manufacturer is the customer's main criteria for them making a purchase decision. Hence, the need for reliable EV test for power conversion.

Verifying reliability often involves running a design through its various operating conditions over a long period of time in an environment where it can be tested through its rated temperature ranges. During this type of testing it is typically necessary to make and log various temperature, voltage, current, and power measurements to ensure device performs within its specified limits. Often you have various instruments around the lab that can make the needed measurements, but the issue is finding or creating software that ties them all together to log, plot, and record the measurement data for an hour, 24 hours, or even longer. Keysight enables this capability with its BenchVue software. BenchVue allows you to easily connect, control, and log data from your benchtop instruments. With BenchVue you can setup a data log of various instruments with no programming needed. For instance you can log measurements from a scope, a DMM, and multi-channel temperature DAQ like the 34970A/72A all at the same time. BenchVue will plot the data for you, save a record of all logged data, and export it to an Excel or CSV file. Best of all BenchVue can log for as short or as long as you want and it gives you the ability to set your sample interval. Below is a screen shot from BenchVue showing a setup of four instruments logging or reporting trace data. The four instruments are a DMM, Spectrum Analyzer, power supply, and oscilloscope.

![Figure 4. BenchVue interface connected to four instruments](image)

Since a lot of time and man hours can be tied into one of these long running tests, the software engineers that designed BenchVue put a lot of design effort into ensuring the software is stable over long logging intervals. With the 3.0 release of BenchVue a new capability allows for custom creation of test sequences. This capability will be offered through the BenchVue Test Flow App. With the Test Flow App you can easily drag and drop instrument controls and measurements within BenchVue to rapidly prototype simple automated tests.
BenchVue supports most Keysight Benchtop instruments such as DMMs, power supplies, oscilloscopes, DAQ instruments. Coming soon in 2016 it will support the PA2200A Power Analyzer series. For a complete list of support instruments go to www.keysight.com/find/BenchVueInstruments. Besides just logging capabilities BenchVue allows you to easily get screenshots from instruments, create tests reports, capture trace data, and easily access documentation on an instrument. BenchVue is free to download and start using with your Keysight benchtop instruments. To data log for a limited period of time is also free of charge. For unlimited data logging with an instrument or use of the Test Flow app with live instruments, purchasing a license for a small fee is required. To download BenchVue today go to: www.keysight.com/find/BenchVue.

EMC compliance testing

In EMC compliance testing, your success depends on moving products through the test queue quickly and efficiently. Conduct full standards-compliant testing in accordance with CISPR and MIL-STD with the upgradeable N9038A MXE EMI receiver. For a complete EMI test solution, Keysight Solutions Partners provide a single point of contact for you to combine the MXE with chambers, antennas, software, value-added integration, probes, and more.

Ensuring measurement confidence and equipment up time

For this stage of the design cycle you need to have confidence in the measurements your instruments are making. And this underscores the need for periodic calibrations to ensure you’re getting accurate and repeatable results. Incorrect measurements can lead to incorrect conclusions, which will impact your development cycle, time-to-market, and budget. For example, test equipment used to verify EMC compliance must receive calibrations that are accredited to ISO 17025. Not only does Keysight fully test all performance parameters and product options for all of our products, but we also provide calibrations that comply with ISO 17025 and ANSI Z540, including accredited calibrations for the N9038A MXE EMI receiver.

Here are some other ways that Keysight services and support can help you and your design cycle:

- Technical support
  - Start-up assistance will help you quickly and effectively begin using your new instruments.
  - Additional product training or measurement consulting can improve personal productivity or test system development.

- On-going maintenance
  - Automated calibration and adjustment procedures, plus factory diagnostics, parts, and firmware, ensure your Keysight products continue to meet all of their performance specifications.
  - Calibration and repair services are available from a worldwide network of over 50 local service centers. And on-site calibration, which reduces your turnaround time from days to hours, is also available in many countries.

- Procurement
  - Keysight Premium Used equipment gives you the same high-performance, and the same 3-year standard warranty and support, as a new unit.
  - By trading in your existing Keysight (or non-Keysight) equipment, our Trade-In program can offer you significant credits toward the latest Keysight technology.
Summary

In this stage of the design cycle we discussed the importance of reducing test complexity to speed up time to market, ensuring the reliability of your design, and measurement integrity when establishing specifications such as efficiency. We discussed how Keysight’s test and measurement hardware and software can help you achieve all these goals. Whether it’s reducing test and ensuring strong measurement integrity with the IntegraVision power analyzers or easily setting up reliability tests with BenchVue software. Beyond just products, Keysight can reduce test downtime with its standard three year warranty on all products, its worldwide calibration and repair services, and worldwide technical support.