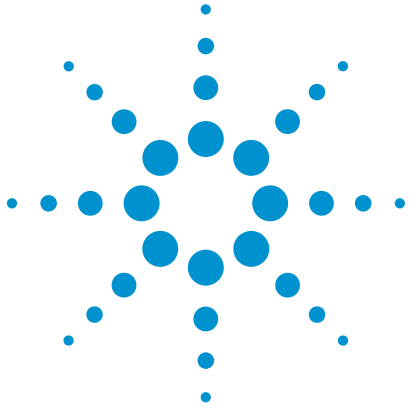




Base Station Subassemblies: Addressing DC Power Test Challenges

Application Note

Overview

Electronic subassemblies for base stations derive individual circuit voltages from a main DC bus voltage through a series of DC/DC regulators. Due to the complexity of their distributed power architecture, base station providers are faced with a number of challenges during development and production test of subassemblies.

They include:

- Assuring operation under a specified sequence of many bias voltages and tolerance to change in timing and sequence.
- Validating peak and steady state power demands under worst case operating conditions for power budgeting purposes
- Make certain turn-on inrush current is within acceptable limits
- Measure current demand and verify tolerance under abnormal voltage conditions

Performing this testing requires precise control of several DC sources in close coordination with corresponding voltage and current measurements. While this task can be accomplished with effort and a lot of test equipment, it can be greatly simplified using the Agilent N6705A DC Power Analyzer. The N6705A is tailored for this testing, combining the function of several pieces of test equipment into an intuitive, easy-to-use solution for DC power-related testing. In addition, the Agilent N6700 Modular Power System provides a complementary solution for production test.



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Base Station Organization and its DC Power Architecture

Current generation base stations utilize a modular mainframe approach for easier configuring, scaling and upgrading. The base station subassemblies are plug-in modules. As one example the capacity is expanded with additional channel and RF cards. An example base station organization is depicted in Figure 1. As shown they are generally powered by a loosely regulated, battery backed-up DC bus of typically 24 to 60 volts.

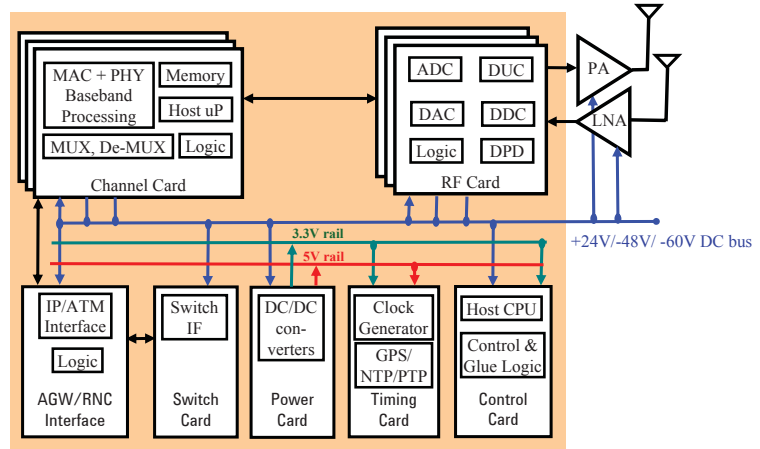


Figure 1. Representative Base Station Organization

Base station subassemblies have their own DC power conversion and distribution systems to provide individual DC bias voltages to all the circuits as required. A typical subassembly DC power system is depicted in Figure 2. Often a main, isolated DC to DC converter provides isolation from the main DC bus while stepping the voltage down closer to circuit levels. Non-isolated DC to DC converters and regulators in turn provide individual circuit voltages. In addition, within the base station mainframe, a power card converts the main DC bus voltage to common DC voltages that are available to all the subassemblies via the backplane.

The power these regulators need to provide covers a broad range. Most analog signal and digital processing circuits are 10 watts or less. The RF power amplifier (PA) in contrast is very high power. With a typical Power Added Efficiency (PAE) of 20%, 50 watts of RF transmit power needs

250 watts of DC input power. The amount of RF power scales with the number of channels the base station accommodates, accomplished with higher power amplifiers and combining multiple amplifiers into a larger RF PA subassembly.

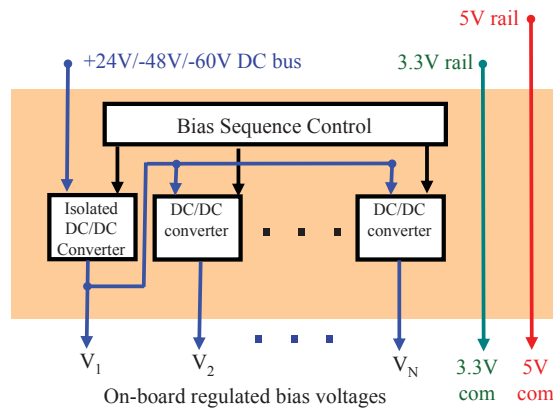


Figure 2. Typical DC Power System of a Base Station Subassembly

DC Power Test Needs and Traditional Approaches

Bias Voltage Sequencing

Bias voltages must be brought up and back down in specific sequences and within certain timing windows, in order to avoid hung up digital operation, possible IC latch up, or even damage to the sub-assemblies. Proper sequencing is needed both during development and for production test. Validating robustness against timing limits and faulty sequencing is needed for validation testing.

A traditional approach to sequencing bias voltages have been to use several DC sources having hardware output enable/disable inputs connected to a digital output I/O card under control of a PC, providing the appropriate sequence and timing. Alternately building up the base station's actual DC power system with a means to adjust sequencing and timing of the outputs is sometimes employed.

Measuring Inrush Currents

When first powered on base station equipment draws significant inrush current from the DC bus, the peak often exceeding the average up to 50-fold. Telecommunications standards including ETSI EN 300-132-2 and others specify the allowable peak to average ratio versus time that equipment must meet in order to not momentarily overload the DC bus. Inrush current must be characterized in development and design verification, often down to individual bias voltages on subassemblies, in order to meet the equipment's overall inrush current limit.

Inrush current measurements traditionally require a DC source, a power switch, a shunt or current probe, all having high peak capacity, and an oscilloscope, to capture the inrush current waveform.

Determining Power Demands

Maximum power draw of the overall base station, subassemblies, and circuits powered from each of the individual bias voltages on the subassemblies must be assessed during development. This is needed for correctly sizing the DC to DC converters and voltage regulators as well as establishing overall power requirements for the base station and its subassemblies.

Modeling provides a first pass estimate for power followed by testing for all of the operating conditions over an extended time period. Worst case current drains for individual circuits, subassemblies, and the overall base station do not necessarily coincide all under the same condition.

A traditional approach to determining power demand is to set up a system of current shunts for each point, monitored with a multi-channel scanning data logger set up. The base station is then put through its series of operating conditions while continually logging current drain. To keep channel count reasonable one subassembly may be fully monitored at a time, repeating the test suite for each subassembly.

Validating Power Demand after Abnormal Operating Voltage Conditions

The DC bus is loosely regulated, varying by +/- 20% under normal conditions and up to +25%/-100% under abnormal conditions. Telecommunications standards including ETSI EN 300-132-2 and others specify the maximum temporary current drain equipment can draw after being subjected to an abnormal operating voltage, after voltage returns to within acceptable conditions.

A traditional approach is to have a programmable DC power source create voltage steps and drop outs simulating abnormal operating conditions. At the same time current drain is captured using a current shunt or probe and oscilloscope for at least several seconds duration, to determine the power demand after recovering from an abnormal voltage condition.

The Agilent N6705A DC Power Analyzer Addresses Test Challenges

The Agilent N6705A DC Power Analyzer, depicted in Figure 3, combines the functions of several pieces of test equipment together into one user-friendly instrument tailored for performing a variety of tests requiring complex DC power stimuli and measurements.

Challenges with Traditional DC Power Test Approaches

The traditional test approaches just described all require a complex set up consisting of several pieces of test equipment, extensive development work and programming. Often considerable debugging is needed to get everything working properly and to have a high level of confidence in results being returned. As performing just one of these tests is significant, performing all of them becomes huge effort requiring a considerable expenditure of capital, people resources, and time allocated in the project schedule.

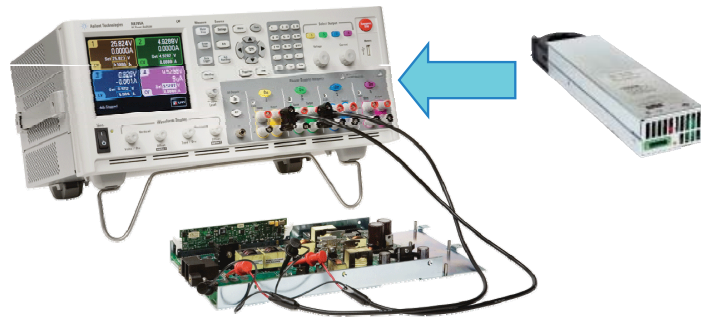


Figure 3. Agilent N6705A DC Power Analyzer and DC Power Modules

The N6705A DC Power Analyzer is mainframe of 600W total DC output power that can accommodate up to four single-width DC power modules, ranging from 50 to 300W DC output each and having a wide range of performance capabilities. The mainframe combines these modules together through a front panel control and display, operating system, and additional control hardware, all for performing DC power stimuli and measurements, providing insights on DC power characteristics in minutes instead of hours or days.

Table 1. Agilent N6705A DC Power Analyzer Functions

Sourcing Functions	Measurement Functions
Up to 4 advanced DC power outputs	Digital voltmeter and ammeter
Arbitrary waveform generator	Multi-channel oscilloscope
Output sequence controller	Multi-channel data logger

Sequencing Bias Voltages

As shown in Figure 4, set up screens in the N6705A let the user quickly configure turn-on and turn-off sequence timing and slew rates for all of the outputs. Multiple mainframes can be linked and synchronized when more than four outputs are needed. Correspondingly, the N6705A's oscilloscope mode readily validates correct sequencing and slew rates of the outputs.

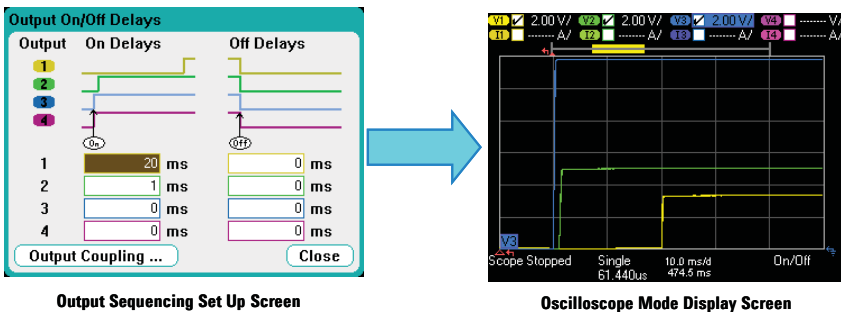


Figure 4. Agilent N6705A Output Sequencing

Measuring Inrush Currents

The N6705A greatly simplifies making inrush current measurements. Capturing the resulting current waveform in oscilloscope mode while applying and triggering on the output voltage turn-on step is all that is needed, as shown in Figure 5.

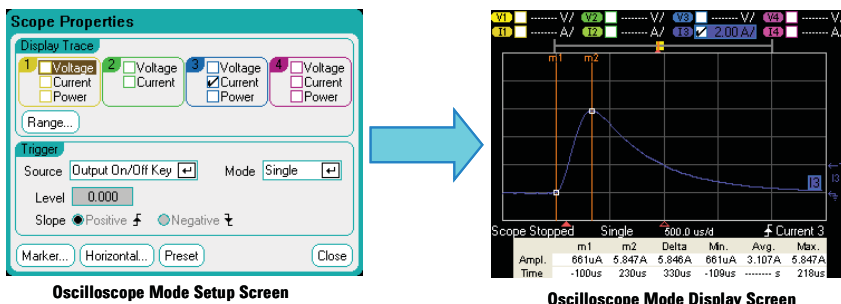


Figure 5. Inrush Current Measurement with the Agilent N6705A

Determining Power Demands

The N6705A can be quickly configured to continuously log all of its DC power module output currents and voltages for minutes, hours, even days at a time while the device being powered is being put through its paces, to determine its worst case power consumption. Results can be monitored in real time as well as saved, recalled, and analyzed afterward, from the data log mode screen, shown in Figure 6. Data can also be conveniently exported as a .csv file for further analysis with other software applications.

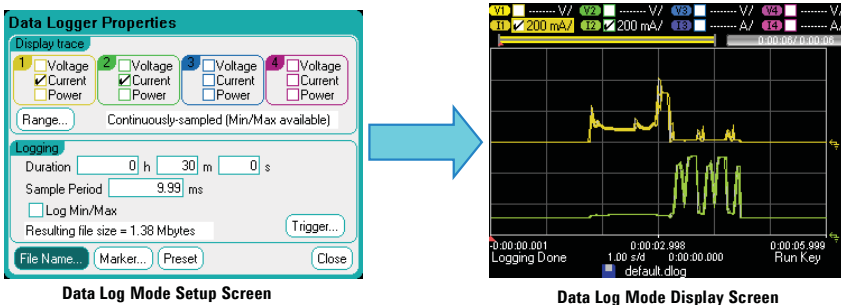


Figure 6. Logging Multiple Currents with the Agilent N6705A

Validating Power Demand after Abnormal Operating Voltage Conditions

Validating impact on the power demand of a device after experiencing an abnormal operating voltage condition, such as an over or under voltage, becomes a simple matter to perform on the N6705A. Dynamic DC stimulus can be synchronized with measurements in either oscilloscope mode or data logging mode, as shown in Figure 7.

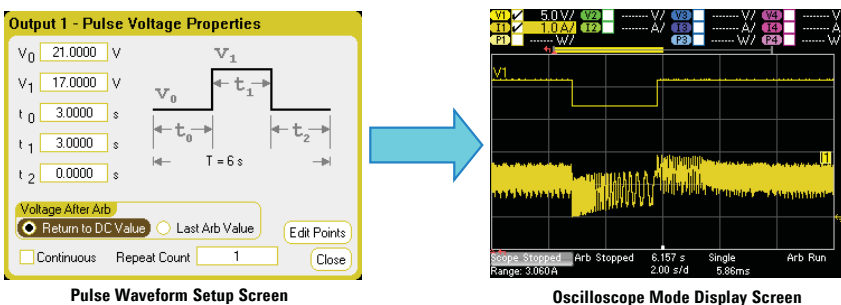


Figure 7. Brown-out Test using the Agilent N6705A

Production Test Considerations

Production test needs are a subset of design and validation tests. The Agilent N6700B Modular Power System is the ideal companion to the Agilent N6705A DC Power Analyzer for production test due to the following:

- Shares the same DC power modules with the N6705A for comparable power and measurement results
- Holds up to 4 outputs per mainframe
- Outputs can be sequenced on and off
- Mainframes can be coupled for a greater number of synchronized outputs
- Low profile 1 EIA rack unit tall provides high output channel count density
- Three power levels of 400W (N6700B), 600W (N6701A), and 1,200W (N6702A) available provide flexibility and high power density
- LXI compliant, with LAN, USB, and GP-IB interfaces, and handy Web-based graphical interface as standard, provide flexibility for the test application
- High speed command processing, command list execution, and much more to provide excellent test throughput



Figure 8. Agilent N6700B series Modular Power System

Summary

Base station providers are faced with numerous DC power-related challenges during development and production test of their subassemblies, including:

- Assuring operation under a specified sequence of many bias voltages and tolerance to change in timing and sequence.
- Validating peak and steady state power demands under worst case operating conditions for power budgeting purposes
- Make certain turn-on inrush current is within acceptable limits
- Measure current demand and verify tolerance under abnormal voltage conditions

Performing these DC power tests are difficult and time consuming, requiring integrating several pieces of general purpose equipment and developing software to accomplish.

The Agilent N6705A DC Power Analyzer is a solution tailored specifically for performing DC power tests during development, returning results in minutes instead of taking hours or days to do.

After the base station subassemblies are developed, the Agilent N6700 series Modular Power System is an ideal solution for powering and making necessary measurements while providing high throughput during automated testing in production. In addition, a high level of commonality with the Agilent N6705A DC Power Analyzer assures excellent correlation of test results between development and production.

Related Products

Agilent N6705A DC Power Analyzer: www.agilent.com/find/N6705A

Agilent N6700 series Modular Power System: www.agilent.com/find/N6700

Additional Information

“Properly Powering On and Off Multiple Power Inputs in Embedded Designs”
application note: www.agilent.com/find/5990-4043EN

“Dynamic Current Profiling”
application note: www.agilent.com/find/5990-4399EN

“Bench-top Test & Debug of Power Transient Issues for Automotive & Aerospace/ defense Applications”
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