

Schnelle und effektive Tests in der Fertigung von drahtlosen Modulen und Geräten

LitePoint entwickelt drahtlose Testlösungen und Dienstleistungen für die weltweit innovativsten Hersteller von drahtlosen Geräten. Durch enge Zusammenarbeit mit den Chip-Herstellern kann LitePoint äußerst effektiv und schnell in der Serien-Produktion testen. Die beiden Tester IQxstream und IQxel-M sind für zukünftige Messaufgaben bestens ausgestattet und weisen ein hohes Maß an Funktionalität auf. Im folgenden Text stellen wir die Methoden vor, wie drahtlose Geräte und Systeme gemäß aktueller Normen und Standards effektiv und komfortabel damit getestet werden können.



IQxstream and IQxel-M are manufacturing oriented, physical layer wireless test systems that represent a fundamentally new value proposition when discussing production test as compared to the more familiar lab test environment. To fully leverage these capabilities it is important to understand how they differ from the lab testers available and why production test is very different from lab testing. This technical note will describe the differences between a lab test environment and production test. It will also describe some of the unique advantages that a physical layer tester such as IQxstream or IQxel-M bring to the production floor.

When implementing a production test solution, there will always be a conflict between test coverage and manufacturing throughput. The production floor manager wants to move as many pieces per hour through test as he can. The quality manager wants to ensure that all defects are detected and the CFO wants to support both but within the smallest capital budget possible.

Among the factors that need to be taken into account when designing a test system are:

- Type of tester – physical layer vs. signaling

- Tester speed – number of DUTs supported, measurement speed, configuration speed
- Failure mechanisms in the DUT associated with manufacturing
- Types and number of tests required

At the top of the list is the type of tester. It's a very familiar path to take what the development engineers used for device design and then replicate it in large numbers for production test. Too often, this results in a less than optimal solution from both a cost and throughput perspective.

Lab Testers

are fundamentally designed to support the design and system integration processes associated with the development of a phone, tablet or laptop module. In this role they may perform physical layer, signaling and system testing. Beyond basic design and troubleshooting, their measurements may be used for conformance, regulatory and regression purposes.

In a lab environment they may be integrated into a complex environment including channel emulators and infrastructure simulators. They may operate under manual control of a

design/system engineer or they may be under computer control executing complex test scripts, from physical layer tests, through signaling performance to complex interference, fading and handoff scenarios, exploring every nuance of a standard.

In these circumstances, ease of use, flexibility and top to bottom test capability of lab testers take precedence. Test speed, instrument cost and the ease of integration into a production environment are far down the list of priorities. To a certain extent, lab testers are the multi-tools of testing. They are fun to pull out of your pocket and can impress your friends but they cost a lot more than a dedicated tool and really aren't the most convenient when you have a focused task to perform.

Production Test

is completely different from lab testing. The emphasis in production is to accurately determine if a mobile is working in the absolute minimum time. With the emphasis on quality in today's production lines, excessive or unnecessary testing is an unjustifiable expense to find what few defects may exist.

In production the basic assumption has to be that the design handed off from engineering meets all the requirements of the customer and when assembled correctly will do so consistently. Without this assurance, with today's extremely complex devices, the dimension of tests is simply too large to examine all the possibilities that might have escaped the design engineering process. The production floor is not the place to be verifying millions of lines of firmware nor the hardware functionality associated with a multi-million gate DSP/ASIC design.

The emphasis in production test is on finding manufacturing defects and the variability typi-

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cally associated with the analog components of the design. Is there a solder joint bad? Is a decoupling capacitor missing? Is the Power Amplifier yield high enough? The digital functionality of a production unit is locked down in firmware and the ASIC/processor design. This digital implementation drives all of the signaling and most of the signal generation and detection and does not change due to production variances. It also should be noted that digital ICs are extensively tested as part of their manufacturing process and while circuits that support the digital functionality may be damaged during module production, they usually will be fundamentally so, easy to detect, often by the power up tests conducted by the device itself.

The optimal production test focuses on physical layer measurements, the area that exhibits the greatest degree of variability associated with the manufacturing process. Transmit power, the quality of the TX waveform, the accuracy of the TX frequency are all key to the cell site or access point's ability to receive a mobile's signal. On the RX side, the ability of the mobile to successfully decode the received signal at the lowest and highest signal levels defines its successful operation in the network. These are all measurements that are made by a physical layer tester.

So what role does signaling play in production test, given that it is fully proven out in the lab? The correct answer is very little. The following section explores this in detail.

Signaling Driven Testing vs. the Terminal Interface

When conducting production test, it is necessary to put the DUT into a configuration in which a desired measurement or series of measurements can be made. From a traditional air interface standard perspective, the logical way to do this is by emulating a base station or

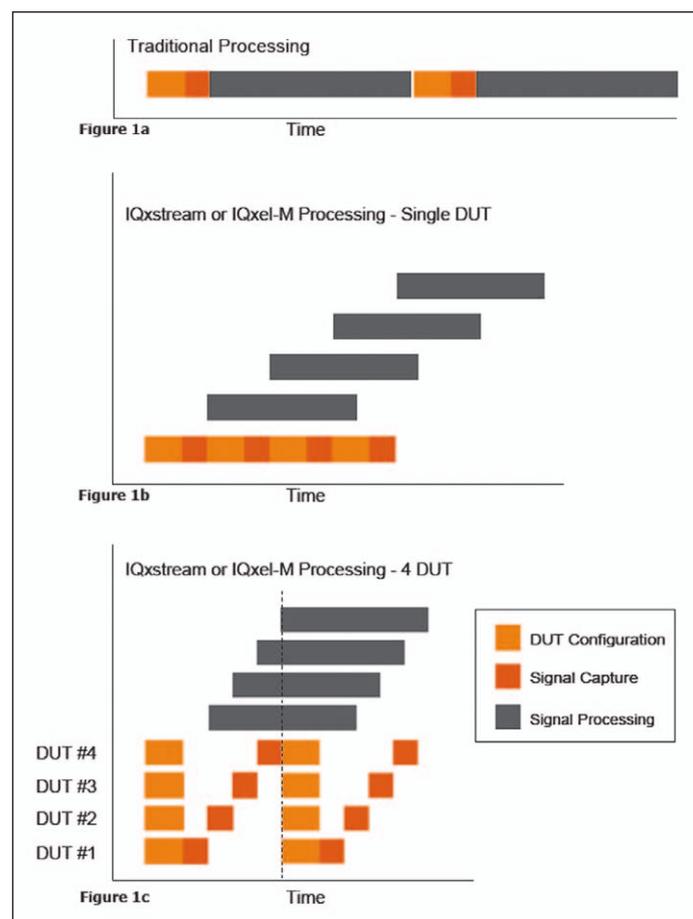


Figure 1 – Decoupling Measurement from Analysis

access point and sending signaling messages to the DUT.

This will involve the standard sequence of power up, system acquisition and then being ordered onto a channel in a particular mode by the test equipment. In many cases getting to a given test state may involve stepping through a series of intermediate states that conform to normal operation of the air interface. Each of these transitions will have their own signaling latencies none of which add any value to the test case of interest. Unfortunately all of this is painfully slow and simply not viable in a production environment.

To speed things up, the faster way to get a DUT into a given state is to leverage its baseband data port. Virtually all mobile devices built today have some means of connecting to their host processor typically via a USB Port, UART, or JTAG interface. Using this connection, the DUT

can be placed into a special test mode and commanded directly into the desired state. This is much faster than the back and forth of over-the-air messages and is supported by virtually all major IC manufacturers today.

This reliance on the terminal interface as opposed to signaling, in addition to being much faster, also makes for a simpler, more reliable tester as it no longer has to conform to the upper layer signaling protocols and the potential variances of different device manufacturers.

Decoupling Measurement from Analysis

Once you have made the decision to use physical layer testing to evaluate a DUT in production, a number of other test performance benefits are enabled. Conventional testing consists of a configure-capture-analyze sequence as shown in figure 1a. Ironically

the most expensive component of a tester – the capture hardware – is the least used in this model of measurement.

Most measurement in physical layer testing can be considered static. This is not to say there is no time component to the measurement but there is generally little or no back and forth RF dialogue between the tester and the DUT. At best the tester (or the DUT) generates a signal and the DUT does something in response. There is no subsequent 'response to the response' so to speak. Without the requirement to support an ongoing dialogue, there is no need for real-time decoding of the signal in the tester.

This permits the tester to decouple the signal capture from the analysis as shown in figure 1b. In this model, measurement becomes a configure-capture model with analysis on a separate plane from the capture activity. With analysis no longer part of the critical path, the expensive capture hardware is more fully utilized and at the same time, you are able to parallelize the analysis component across general purpose multi-core processors. The result is a much faster tester at incremental cost. This change alone on a single DUT tester can lead to a 2x speed up in processing.

The next step in this evolution is shown in figure 1c and is where IQxstream and IQxel-M begins. By providing support for four DUTs, DUT configuration can be parallelized and since capture is independent of analysis, DUT reconfiguration can begin immediately following the last capture. Again, you get a significant gain in performance with only an incremental increase in cost.

The reader may make the comment that the test designer does not need to wait for completion of the capture for DUT #4 before beginning the reconfiguration for DUT #1. This is certainly true however it is good practice in such an event to make sure the PA is powered down during the

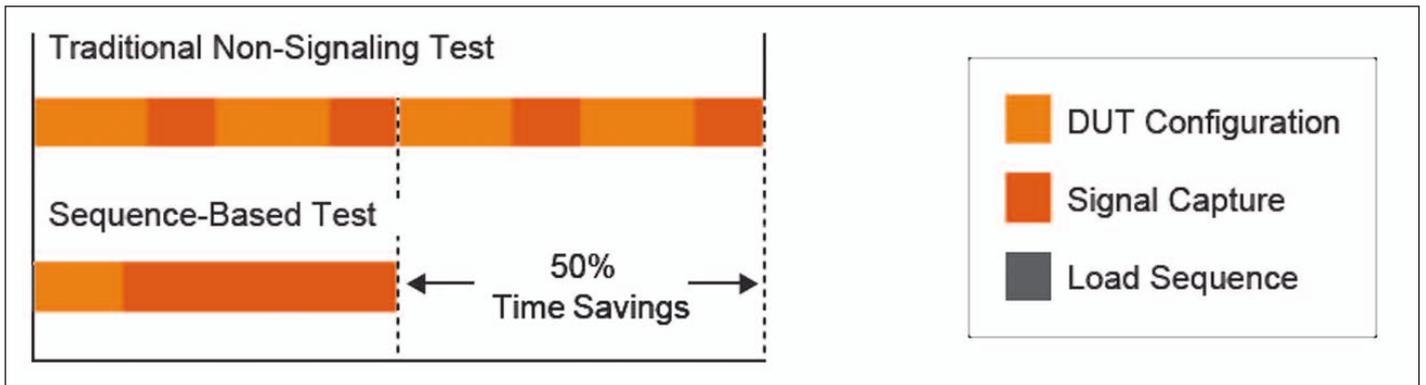


Figure 2 – IQxstream and IQxel-M Sequence-Based Testing Enables Significant Time Saving over Traditional Testing

reconfiguration process. The PAs for all the DUTs should only be turned back on once all previous captures are complete. This is to insure that the DUTs do not interfere with each other during tests. For example, you will not want to have a DUT transmitting at full power while trying to make measurements on another DUT at minimum power.

Sequence-based Physical Layer Testing - next step

DUT testing typically takes place by commanding a DUT into a specific fixed configuration, and then a snapshot is captured from its output. This process is repeated for each required configuration of the DUT, e.g., power settings, modulation type, etc. This configure/measure sequence is shown in the upper part of Figure 2. While far superior to signaling-based DUT configuration, there is still room for improvement.

In sequence-based testing, the DUT is preconfigured at setup with a given sequence of configurations and exactly how much time to spend on each configuration. IQxstream and IQxel-M then synchronize their configurations and measurements to the changing configuration of the DUT without any dialogue between the tester and the DUT.

While sequence-based testing depends upon the capabilities of the DUT, many IC manufacturers today support such testing. This methodology can reduce test times by as much as

50% as shown by comparing the upper and lower portions of Figure 2. This is another example of how a production-focused tester can exploit innovative test techniques.

IQxstream and IQxel-M’s unique architecture changes testing from being test-equipment limited, to DUT-speed limited – determined by how fast the DUT can be directed to change to a new configuration. Reducing test times, while maximizing expensive data-capture hardware utilization makes for the most cost-effective solution in the industry.

Physical Layer Testing

So far we have discussed why a signaling approach to production testing is less than desirable but just what do we mean by physical layer testing?

Physical layer testing focuses on the lowest layer of the air interface. It seeks to determine conformance with the key parameters essential to the successful transmission of a signal over the air. Transmit power, the quality of the TX waveform, the accuracy of the TX frequency, are all key to a mobile station’s performance. On the receive side, the ability of the mobile to successfully decode the received signal at the lowest and highest signal levels defines its successful operation in the network. Each air interface in cellular, WiFi, and Bluetooth has its nuances however many tests will be the same or have analogous measurements. Often you will find the

names of a test will vary between the test specs of the various air interfaces but the following can be considered a representative sample of physical layer measurements.

Conclusion

In production test, the primary goal is to exercise the mobile as much as possible to identify manufacturing defects while minimizing test time. The digital ICs have already gone through extensive testing during their production. The software and digital designs have been proven during engineering and conformance testing. Digital failures, when they occur, will typically be catastrophic resulting in the phone not powering up, not producing an output or not being able to receive a signal. Those that are more subtle will typically show up in physical layer measurements. Therefore the optimal production tests focus on physical layer measurements, the area that exhibits the largest degree of variability associated with the manufacturing process. Physical layer measurements, allow decoupling of the data

capture process from the analysis process making for optimized use of tester resources. Leveraging the ‘capture once, measure many’ ability of IQxstream and IQxel-M has great benefits both in terms of test speed but also overall test coverage. Sequence based testing and Multi-DUT support extend the performance gap even more vs. lab based testers. See Figure 3.

All these capabilities merged together yields a greater than 10x improvement in test throughput. This increased capability can be used to both reduce test cost and to expand test coverage as compared to traditional signaling, single DUT testers. IQxstream and IQxel-M represent a fundamentally new value proposition when discussing production test as compared to the more familiar lab test environment. With multi-DUT and ‘capture once, measure many’ capability, combined with an architecture that separates data capture from analysis, the IQxstream and IQxel-M provide throughputs and flexibility never thought possible in a manufacturing environment. ◀

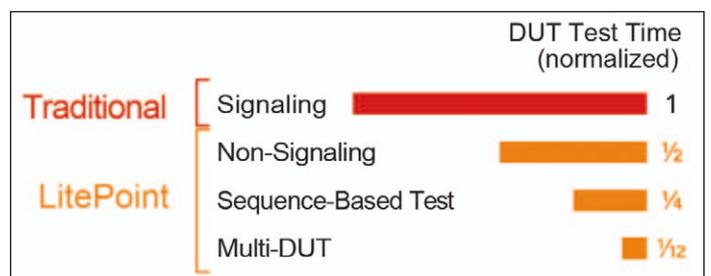


Figure 3 – Traditional vs. LitePoint