How to Increase the quality of Wireless Charging Tx and Rx by testing more

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Introduction
Trend very favourable

Units shipped with Wireless charging feature (TX+RX)

Total Wireless Charging Units (m)
CAGR 80%
Trend very favourable

Wireless charging is on an incredibly positive trend.

Implementation in :
- High end mobile phones: not an accessory market anymore
- Cars
- Public transportation (metro, airport, ..)
- Merchants (coffee shops, ..)

Big announcement coming up?
- Rumors buzzing about an additional leading smartphone designer embedding Wireless Charging in their products?

Wireless charging is now mainstream:
- Gets attention from the consumer
- It HAS to work
What does « it HAS to work » mean?

Wireless charging needs to be:

- Safe
- Cost effective
- Environment friendly
- Interoperable

Now is the time to give consumers a flawless Wireless Charging experience.
Testing more to achieve more?
Typical Wireless Charging product life cycle
Validation, Verification, Qualification

V&V testing aims at making sure of the core functionality of a product, and assessing its performance. Tests may go beyond the boundaries of conformance testing.

Typically, V&V is made using general purpose instrumentation

- Oscilloscopes
- VNA
- Signal generators

Instruments well known, easy to find in development laboratory

- This kind of instrument is not specialised in Wireless Charging: no protocol management for example
  - Not optimum to accelerate time to market
Validation, Verification, Qualification
What is the value of increasing tests?

Case study 1: checking the foreign object detection of a Tx

Typically, I would use the WPC defined foreign objects.

**Pros:**
- This is cheap
- This is close from the conformance testing

**Cons:**
- This does not tell me about the margin my design has, compared to the spec requirement

**Alternative:**
- A programmable Rx simulator would enable me to simulate different values of received power, and allow me to simulate different cases linked to foreign object detection

**What do I gain?**

By achieving a perfect characterization of my FOD mechanism, I make sure of the safety of my customers.
Validation, Verification, Qualification

What is the value of increasing tests?

Case study 2: checking the demodulation performance / reaction time of my sample

Communication in Qi Power Class 0 15W introduced bi-directionnal communication. It may be interesting to understand how long it takes for my device to be ready to accept a frame.
Validation, Verification, Qualification
What is the value of increasing tests?

Case study 2: checking the demodulation performance / reaction time of my sample

Communication in Qi Power Class 0 15W introduced bi-directionnal communication. It may be interesting to understand how long it takes for my device to be ready to accept a frame.

I would use golden duts, that I have qualified to make sure of the communication.

**Pros:**
- This is cheap

**Cons:**
- This does not give me any flexibility in the timings definition

**Alternative:**
- A programmable simulator would enable me to simulate different response time, and make it possible to enhance the overall performance of my device.

What do I gain?

I increase the level of interoperability of my device.

I propose to my customers an optimised device.
What is the value of increasing tests?

Case study 3: qualifying the protocol handling of my device

Communication in Qi Power Class 0 15W introduced bi-directionnal communication. It becomes interesting to be able to qualify the behaviour of my device to unexpected events.

Golden duts is one way, but it is not possible to gather in one room all types of samples, and therefore all known potential issues.

Pros:
- This is cheap

Cons:
- It is not a flexible solution. It does not allow me to program meaningless packets, play with timings, …

Alternative:
- A programmable simulator would enable me to simulate different types of packets, different timing behaviours, and make my own script library to deploy each time I do a hw or fw release.

What do I gain?

I increase the level of interoperability of my device

I protect my device against hacks

I protect my customers
Conformance testing

Conformance testing allows to make sure that a device is compliant with the regulations defined by an authority. Ultimately, the goal of conformance testing is to allow a device to enter the market, use a logo, …

Conformance testing is done according to well established test specifications, defining:

► Test methods
► Tolerances
► Pass/fail criteria

Test specifications are written in order to implement the requirement from the system spec.

Trivial example

System specification
Test specification Vpp must be between 1.0 and 2.0V

Take an oscilloscope probe, and measure Vpp at those measurement plots. You should measure between 1.0 and 2.0V
Conformance testing is generally performed by an Authorised Test Laboratory (ATL). ATLs generally have to use tools that are certified by the regulatory authority.

Pre-conformance testing is the action of preparing official certification session outside of ATL premises. Typically, the designer’s own R&D center.

ATLs perform conformance tests, and deliver a test report to the regulatory authority.

The regulatory authority then decide with the certification of a product.
Pre-conformance testing
What is the value of increasing tests?

Case study 4: preparing the certification session of my device

One way to do this, is to confront my DUT to a multitude of certified devices.

Pros:
► This is cheap

Cons:
► It is not really a preparation to conformance testing, as the test cases that will be played at the ATL is not played.
► It is impossible to conclude on the compliance of a device with a standard this way

Alternative:
► Using a dedicated tool, that implements the test cases defined by the test specification. In order to be efficient, and to avoid operator mishandling, this tool ought to be automated.

What do I gain?
I save money and time, by doing debug sessions in my own laboratory
I reduce my time to market, by testing more in my own laboratory
Normative tests include power management/measurement features, this increases the overall system safety
Manufacturing tests

Once a device has obtained official certification, it is now time to mass produce it.

Wireless chargers are relatively cheap devices (a few dozens of US$)

- They generate power
- They need to detect FOD, so they are the warrant for overall system safety
- Some have particular life span constraints (automotive, transportation, …) and need a deep quality control
- It is therefore important to test transmitters

Wireless charging is embedded in flagship mobile phones (Samsung, LG, HTC, …)

- A mobile phone is not dangerous by itself
- It is pricey, and having to exchange defective mobile phones is pricey, in terms of public image, and in handling fees.
- It is therefore important to test receivers
Pre-conformance testing
What is the value of increasing tests?

Case study 5 : doing test in manufacturing of mobile phones (Rx mode)

Generally golden DUTs are used

Pros :
► This is cheap
► This is quick

Cons :
► No statistics are consolidated, it is impossible to monitor any parameter
► Impossible to detect defective coils, bad soldering

Alternative :
► A specialised tool, which is able to act as a high end power Tx could help to test the DUT in different configurations, and make sure the quality is good and consistent.
► Examples : measure load modulation amplitude, or the internal power meter

What do I gain?

I save money and time, because I decrease the amount of customer complaints

Getting statistics may help me to optimize my manufacturing processes

I make sure all my phones are consistent between each other

I am independant from any golden DUT (availability issue, consistence issues)
Pre-conformance testing
What is the value of increasing tests?

- Dedicated test tool
  - Tool emits 10W
  - Phone measures 10W

- Dedicated test tool
  - Tool emits 10W
  - Phone measures 5W
How do I test all of this?
Introduction

SOFTWARE
Powerful viewer: For comprehensive debug sessions
- See all the packets exchanges synchronized with the physical measurements (Vr/Ir)
- Perform efficiency measurement for Rx & Tx or coil only
- Zoom on the trace to get accurate information
- Add some triggers for timing measurement
- Look for specific packets, and get a detailed packet information
- Show all the errors

HARDWARE
One single test tool for Rx and Tx testing:
- In Low and Medium Power
- Provided with a single antenna for Rx testing
- Single antenna for Tx testing
- One Foreign object
- Own calibration function for accurate power & efficiency measurement
Conformance Platforms

Hardware: receiver (RX) tests

Test system:
- PC
- MP500 TCL3
- TPT Connection unit
- TPT antennas
  - TPT#1
  - TPT#2
  - TPT#MP1
Conformance Platforms

Hardware: transmitter (TX) tests

Test system:
- PC
- MP500 TCL3
- TPR Connection unit
- TPR antennas:
  - TPR#1A/3/4
  - TPR#1B
  - TPR#1C
  - TPR#1D
  - TPR#1E
  - TPR#MP1A
  - TPR#MP1B
  - TPR#MP1C
  - TPR#5/6-MP3/4
Script Editor

Write your own scripts with a predefined commands list

Emulate a Tx or Rx
Script Editor

Change all parameters that matter

Comprehensive parameters list for each command
Script Editor

Add some comments.
Once finished, launch the script and get the script log, as well as detailed information in the viewer.
Conformance platform : Interface software

- Integrated viewer: Graphical display of all measurements and protocol information
- Gives a clear verdict: why a test case passes, or fails
- Possibility to generate reports (PDF, word...)
Conformance platform: Interface software

- Fully automated test suites following 100% of the Qi test spec
- Possibility to run all test cases at the same time, or one by one
- Gives a clear understanding of the test result
Conformance platform: Interface software

Generate comprehensive reports with all test results, graphs and detailed logs in Word, PDF or Excell formats.
Viewer

Allow to see the protocol information (packets, modulation, characters) synchronized with the analog measurements ($V_r$ and $I_r$)
Place some triggers to perform timing measurements easily, or \( V_r / I_r \) measurement at a specific time.
Look for a specific packet or error, and get all the detailed packet information.
Tools for mass production of Rx & Tx

MP500 PT1-NFC + Qi HW add-on

- Performs protocol and physical tests in manufacturing lines
- Subset of Qi defined test cases to ensure a high level of quality
- Accessible through APIs or LabVIEW
- Turnkey solution: no need for additional measurement devices
Tools for mass production of Rx & Tx

MP500 PT1-NFC + Qi HW add-on

Example of test plan (Rx testing case):
DUT modulation checking
- Modulation depth
- Internal modulation clock
- Checking of the packets

DUT internal voltmeter checking
- Rectified voltage measurement during digital ping

Charging procedure simulation
- Usage of the real life battery, or
- Definition of a test accessory, for a finer test accuracy

FSK handling checking (Extended Power Profile)
- Negotiation phase completion with several FSK depths

Power measurement, light load/connected load switching (EPP)
- Calibration phase, power measurement
Conclusion
We illustrated in this presentation that testing more has many positive impacts:

**Verification & validation:**
- Allows a better understanding of the design (its limits, its performance)
- Increase the safety
- Improves interoperability level

**Conformance:**
- Reduces the time to market
- Improves interoperability level

**Manufacturing:**
- Ensure to monitor a consistency in the manufacturing lines
- Increases the customer satisfaction, by making his experience flawless
- Protect the brand image
By testing more, we achieve more?
By testing more, we win more!