Technical Report

Functional testing of SOC based RF devices

Abbreviations

SOC	-	System on Chip
ISM	-	Industrial, Scientific and Medical Band
UUT	-	Unit Under Test
PLL	-	Phase locked Loop
LNA	-	Low noise amplifier
WIFI	-	Wireless Network
RF	-	Radio Frequency

1 Introduction

The market for RF enabled devices is increasing rapidly, and they are finding their way into a diverse range of products and market segments ranging from to very low volume to very high volume. This increase is driven by the popularity of WIFI, Bluetooth and ZigBee communication standards, among others, which now can be implemented very cost effectively with either SOC or module based solutions.

Functional testing of these RF devices is often thought to be an extremely complex and expensive task. RF enabled devices are often either inadequately or excessively tested due to a lack of understanding of what actually needs to be tested, and how it can be tested.

This document will briefly highlight some of the considerations and solutions available to test engineers to help them achieve the best test solution, in terms of cost and complexity, when dealing with RF enabled devices.

2 Test Considerations

A test engineer's job is to work out the best test solution to give maximum test coverage whilst keeping the complete test solution small and, more importantly, as low cost as possible. To best achieve this the engineer needs to understand the system and what failures can occur and what effect this may have on the performance of the UUT. If the test engineer does not fully understand this, they are in danger of either under or over testing the UUT at the cost of time and money.

In a very high percentage of modern RF enabled devices the testable RF section commonly only consists of device communications, RF power output, RF receive signal input path and a reference signal oscillator.

So what has happened to the complex testing of the PLL, modulation/demodulation, 1st/2nd stage mixers, filters, LNA and power amplifier circuits that are needed to construct a RF transceiver? Well quite simply these have been integrated into a SOC, transceiver IC or RF module as shown in the below block diagram:

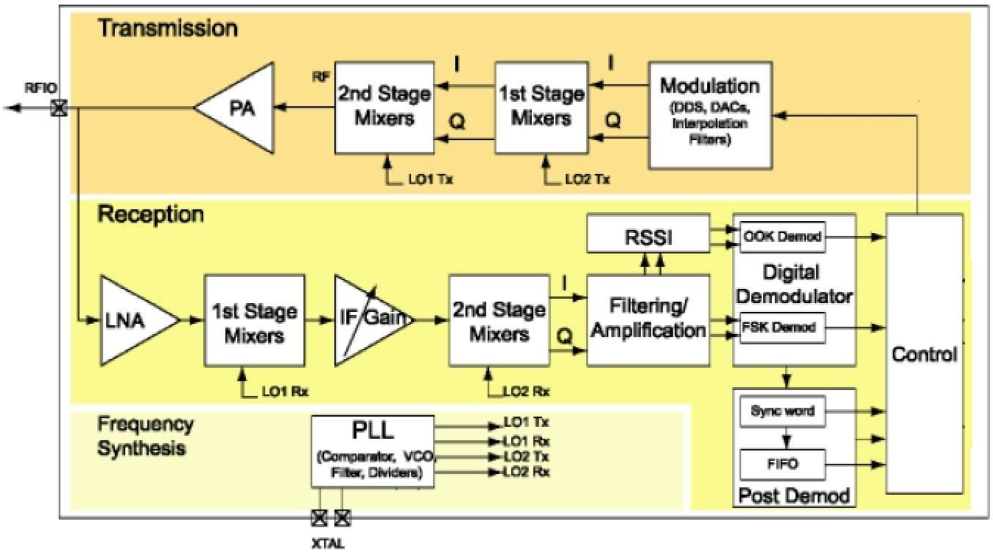


Figure 1 - Typical Modern RF SOC Device

This means that all these complex to test functions are all tested by the silicon and/or module manufactures, thus meaning testing them all over again would be duplication and is completely unnecessary.

Looking at the below typical block diagrams of modern RF enabled devices, the required three test areas become clear.

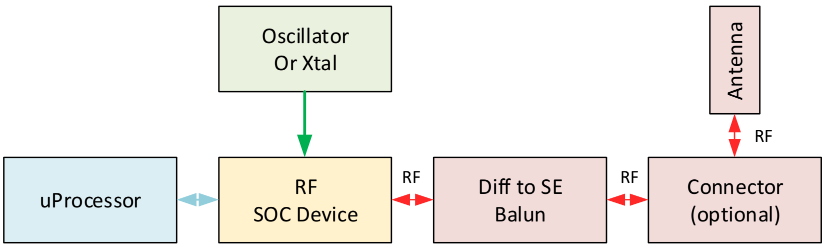


Figure 2 - Microprocessor, RF SOC and Balun Driven RF Power Path

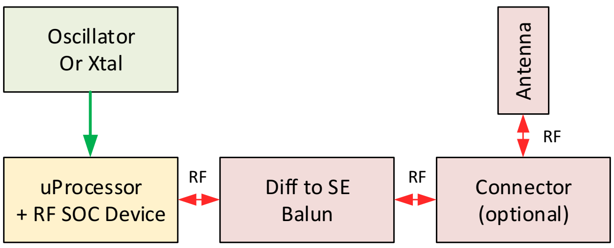


Figure 3 - RF SOC, with built in microprocessor, and Balun driven RF Power Path

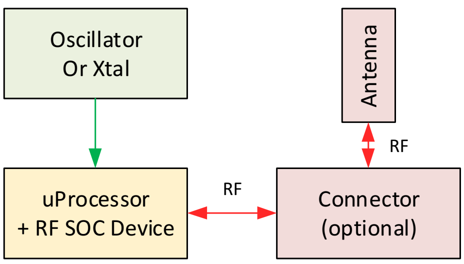


Figure 4 - RF SOC, with built in microprocessor, and direct driven RF Power Path

These test areas are shown below with highlighted potential failure modes and effect

RF Signal Path

- Bad/broken solder joint or short
  - Reduced/no RF signal power/sensitivity
- Value issue / broken balun transformer
  - Reduced/no RF signal power/sensitivity
  - Effect on frequency
- Antenna connector solder joint (if not using a PCB antenna)
  - Reduced/no RF signal power/sensitivity
- PCB antenna value / damage
  - Reduced/no RF signal power/sensitivity
  - Effect on frequency
- Damaged tracking
  - No RF signal power/sensitivity

Micro-controller to Transceiver communications

- Bad/broken solder joint or short
  - No communications

References oscillator

- Bad/broken solder joint or short
  - No frequency reference oscillation
  - Effect on the tuned circuit or RF frequency output
- Incorrect value
  - Wrong RF frequency output
- Incorrect loading capacitor (oscillators using crystal input)
  - Marginally incorrect RF frequency output (slightly detuned)
  - Wrong/no RF frequency output (greatly detuned)

3 Testing

In the last section we considered and identified the tests required to be executed to give adequate test coverage to the RF section of a modern RF enabled devices.

In this section we will detail the measurements required and how they can be implemented to fully test the RF enabled UUT accurately and efficiently.

3.1 RF Signal Path

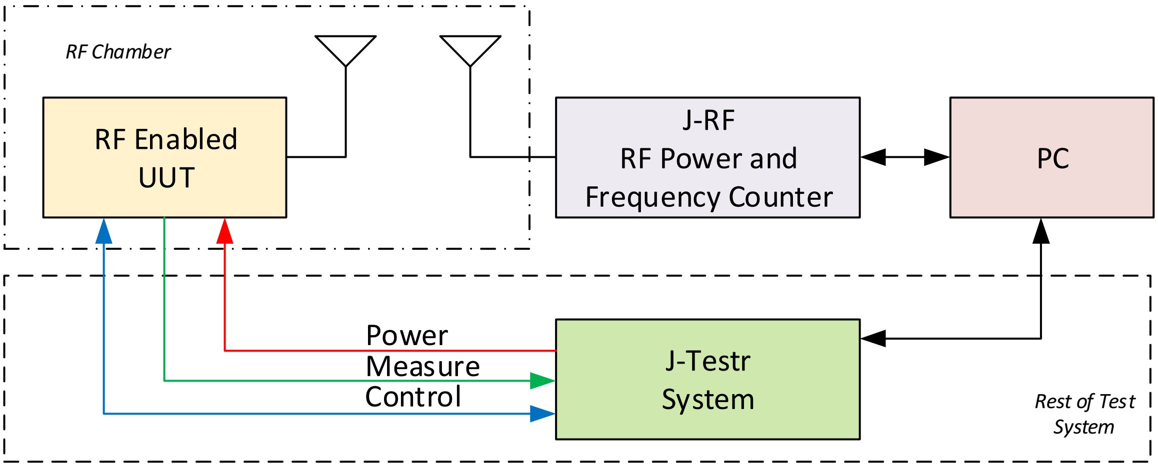
A fault on the RF signal path was seen to have two possible effects. Firstly a reduced RF output power, which in turn, as it is normally always a shared TX and RX signal path, means a reduced receiving sensitivity. Secondly, although much less likely, is an effect on the turned circuit which ultimately affects the output frequency.

To fully test for such issues a functional test system must be able to measure the RF power output and the RF output frequency.

Testing of the RF output power can be done as a relative measurement against a known ‘Golden’ UUT to avoid the complication involved in calculating attenuations between the transmitting and receiving nodes. A relative measurement requires the UUT and power meter to be a constant distance apart and have similar physical construction between multiple testers, where applicable, which is further explained in section 4.1 Chamber Reflections.

The testing of the output frequency is best achieved using an RF frequency counter, which is not only more accurate than a spectrum analyser but also considerably cheaper and more compact.

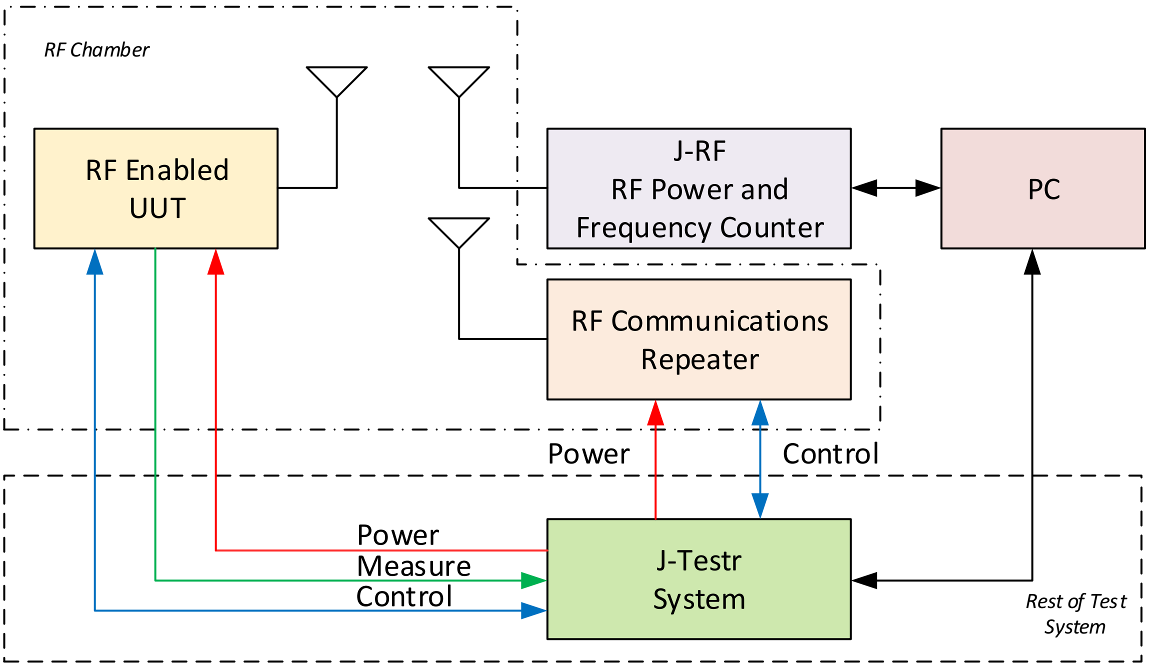
Devices, such as the Eiger Design J-RF, can measure both the RF power and frequency all in one device measuring no more than 180mm x 60mm x 35mm including RF connections and is easily integrated into automated functional testers.



3.2 Microcontroller to transceiver communications

Testing of the microcontroller to transceiver communications can be achieved in many ways depending on the device. Sometimes if the RF SOC or module has a simple communications bus, like UART or SPI, which enables reading and writing to internal registers, this would be adequate to test the communications between the two devices.

However if a more robust test is required, a 'repeater communication test' could be implemented such that the UUT talks to a special 'repeater' device that simply replays any transmitted data back to the UUT as show in the below block diagram.



It is important that if such a 'repeater test' is implemented that the repeater device remains 'off' during the UUTs RF power and frequency measurement so it does not affect these sensitive measurements.

Some people may argue that this repeater device test also tests the UUTs frequency output, however given the normal frequency band spans this would not be a very accurate test. Such a test would certainly be unable to detect slightly detuned oscillators caused by incorrect loading capacitors.

3.3 References oscillator

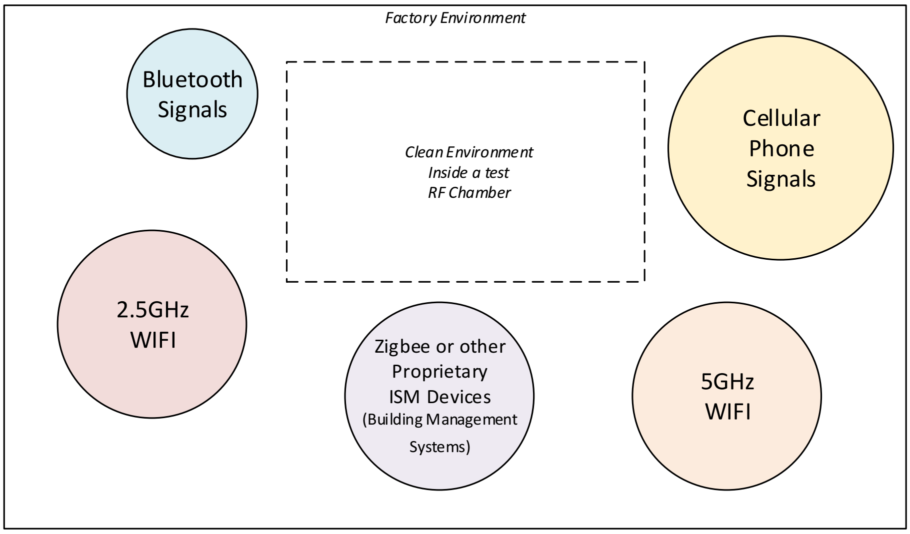
The effect of a fault on the reference oscillator has the obvious effect of causing the output (TX)/input (RX) RF frequency to also be incorrect.

As with the RF signal path the testing the output frequency is best achieved using an RF frequency counter hence this test covers two potential fault areas.

4 RF Isolation

Measuring any kind of RF signals within a standard factory environment is fraught with issues, especially when dealing with common ISM frequency bands. Factory and office airways are full of other signals from local WIFI networks, Bluetooth devices, wire-less building management systems and, of course, mobile phones.

These unwanted RF signals can interfere with the accuracy of the real RF measurement of interest, hence for the most reliable and consistent results it is best that the RF enabled UUT is situated inside an RF isolated chamber or within and RF isolated room.

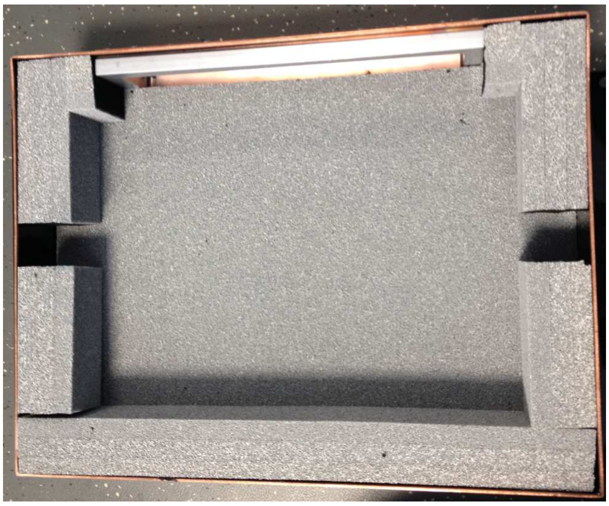


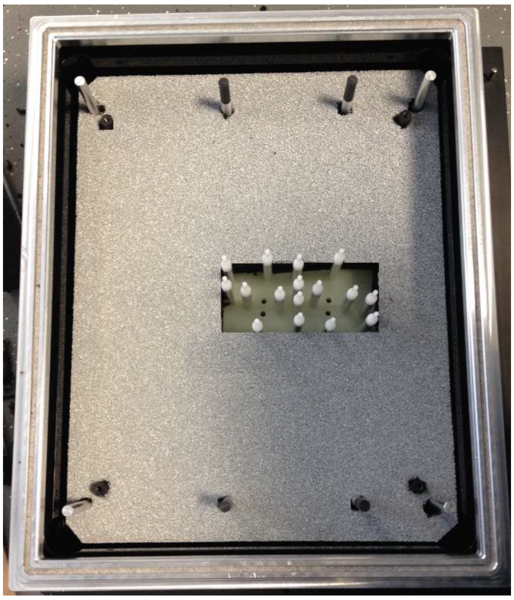
Although this can seem like an expensive exercise there are many dedicated RF test fixtures on the market that provide cost effective solutions with costs as little as 2000USD extra over traditional fixtures. If the UUT test volumes do not justify a test fixture a simple metal enclosure can often suffice with costs under 1000USD.

4.1 Chamber Reflections

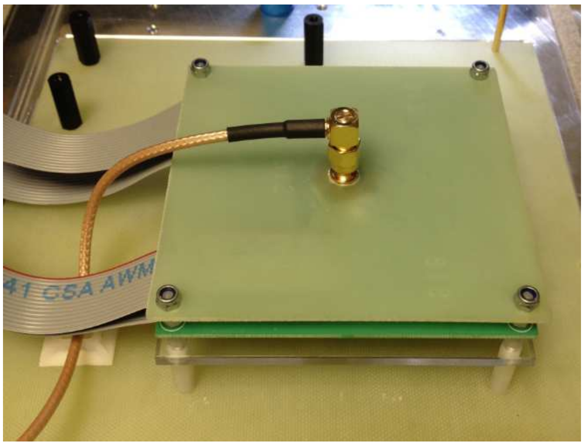
One question that always causes much debate is the effect of reflections within a RF chamber, especially as this effect is more prominent in small sized chambers. When a UUT transmits, the RF signal travels through the air until it hits the RF chamber metal wall, effectively shorting out the signal and hence reflecting 100% of the signal with its polarity inverted. Depending on the RF chamber geometry this reflected signal can have the effect of reducing or increasing the measured signal strength (due to forward and reflected wave cancellation or addition)

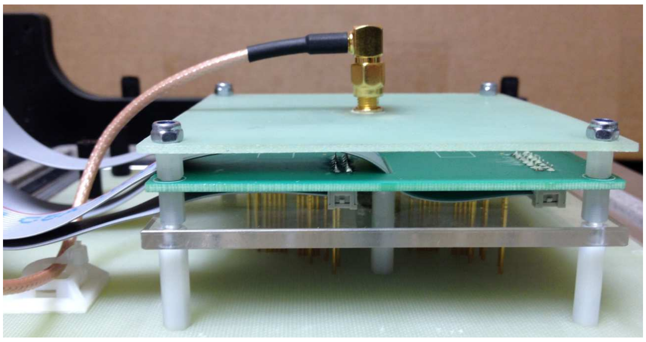
This RF theory is extremely complex and involves complex subjects and equations, however, as we are only interested in a relative measurement, compared to a golden UUT, we can ignore these effects. Sometimes it is good practice, although not necessarily required, to line the RF chamber with an RF absorbing material such as Laird ECCOSORB® AN series, which can reduce reflections up to -25dbm and can often help increase the measured signal strength





If production volumes require multiple test stations then it is extremely important that each test rig is a similar as possible within the RF chamber such that any reflected signal effects inside the chamber are consistent between different test stations. This is easily achieved with a good mechanical layout, the use of wireless receptacles (in test fixtures) and fixed sized ribbon cabling instead of individual wire wrap wires such as that shown below:





5 Conclusion

This document highlights that if given some careful consideration, the testing of RF enabled devices need not be as complex and expensive as often though. Complex measurement equipment, such a vector spectrum analysers and protocol analysers, is rarely required to adequately functionally test a RF device based on a RF SOC or RF module.

At Eiger Design GmbH we are able to supply everything required to test RF enabled devices within an extremely compact function test system using our ‘J-Testr’ test platform, ‘J-RF’ compact RF power/frequency module and JT12 RF chamber fixture.

For more information please contact your Eiger Design Distributor.

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