Evaluation of heavy wire bond tools with ceramic tip technology

PHYSIKTECHNIK

Introduction

F&K Physiktechnik GmbH, Potsdam – Germany, develops and offers test and measurement equipment to characterize the ultrasonic components of wire and flip chip die bonders for microelectronic production.

There are measurement systems now available to evaluate the complete ultrasonic system of a bonder. The transducer test system **TTS-030** is used to measure all the electrical characteristics of the ultrasonic system. The optical displacement measurement systems **ODS 10** & **ODS 20** are used to measure directly the excursion of the ultrasonic at the tip of the bond tools.

All systems can be used independently from each other, but using the TTS and an ODS together gets the maximum information out of the ultrasonic system.

The *"ultrasonic system"* is not only the ultrasonic transducer. The *"ultrasonic system"* is made up of the transducer the generator and the bond tool.

1) The transducer is clamped in a bond head. The kind of clamping, as well as the clamping forces has an impact on the behavior of the transducer.
2) The material of the bond tool (wedge, capillary or die collets), and the clamping of the bond tool determines the behavior of the system.
3) The behavior of the ultrasonic generator and how it cooperates with the transducer is important.

Objective

1) A company provided two bonding tools of the same type from the same manufacturer. This company observed through bond quality measurements that one of the tools was "good" and one was potentially "bad". However, the company had no way to determine if the "bad" tool was really "bad" except to replace it.

2) These evaluated tools had a ceramic tip and are 2" long.

3) Standard 2" tools without ceramic tips are used as a baseline for comparison.

Measurement conditions

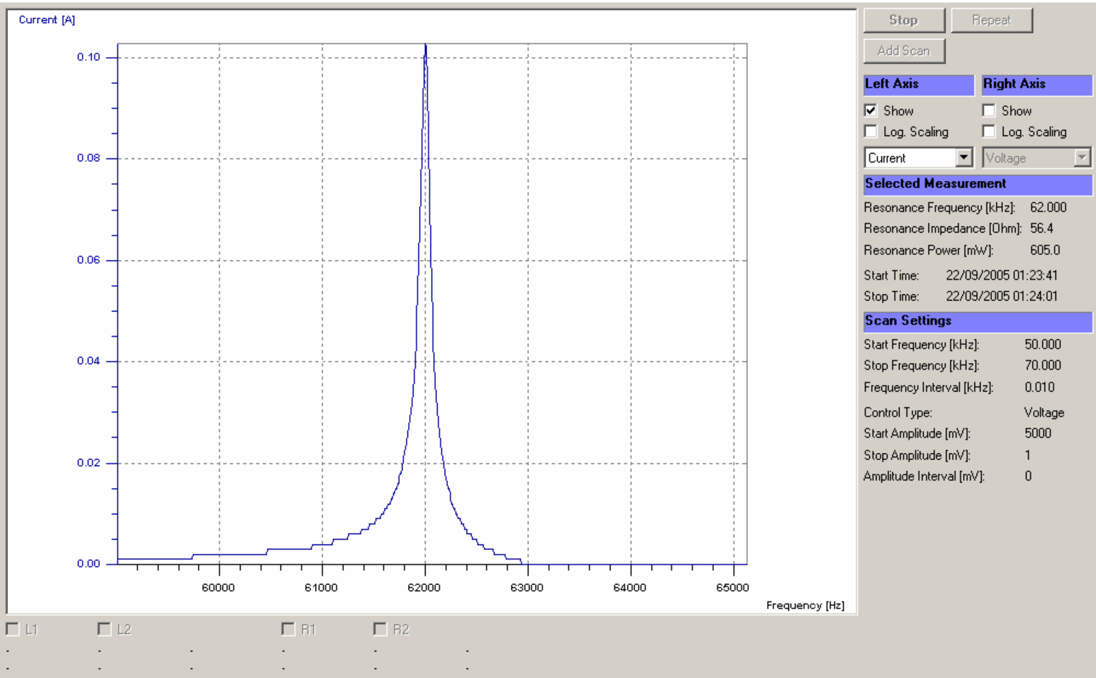
The following equipment was used:

- 60 kHz transducer (heavy wire)
    - clamped according to the specification from the manufacturer
- Standard 2" wedge tool for reference
- Transducer Test System TTS-030

Test without tool

1) Clamped the transducer correctly using a torques screw driver.
2) Scanned the transducer without tool to determine the behavior using the TTS-030, please see Picture 1.

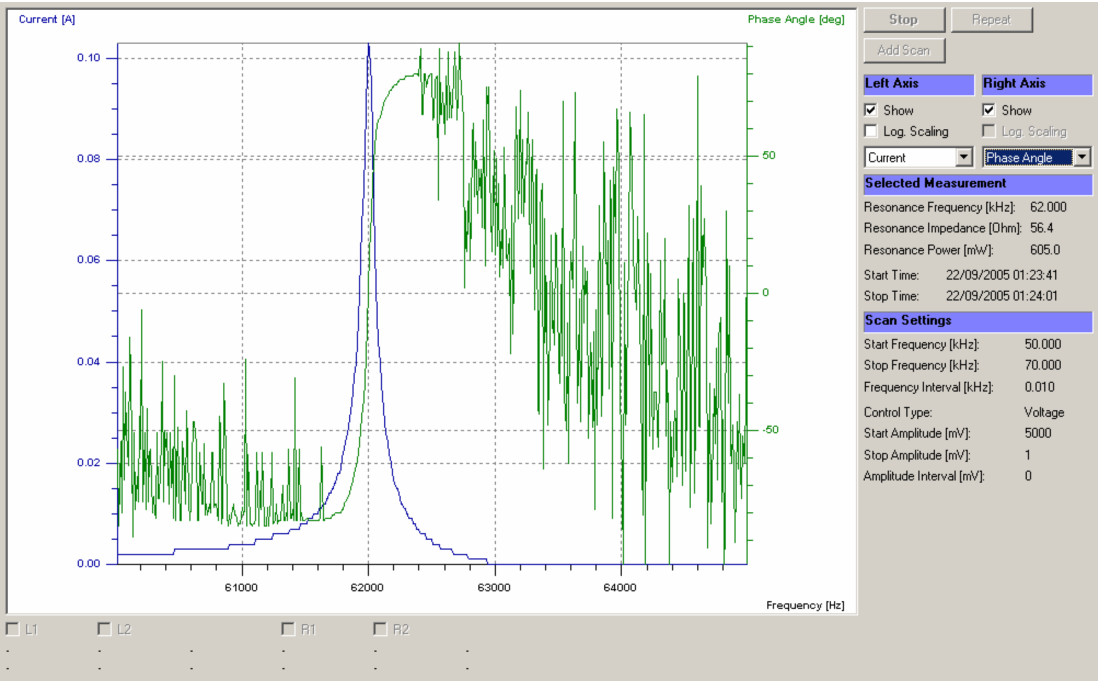
Scans are done by driving the transducer at a fixed voltage at different frequencies around the expected resonant / working frequency. The TTS-030 measures transducer voltage, transducer current and the phase between voltage and current and can display and store this data for further investigations.



Picture 1: transducer without tool – current versus frequency

The transducer without a tool shows the typical behavior with 1 maxim peak for the current through the resonance point. There are no distortions in current response within the measured frequency range. The resonant frequency of the transducer was found to be of 62 kHz and the impedance was approximately 56.4 Ohms. This is typical for the chosen type of the 60 kHz heavy wire transducer.

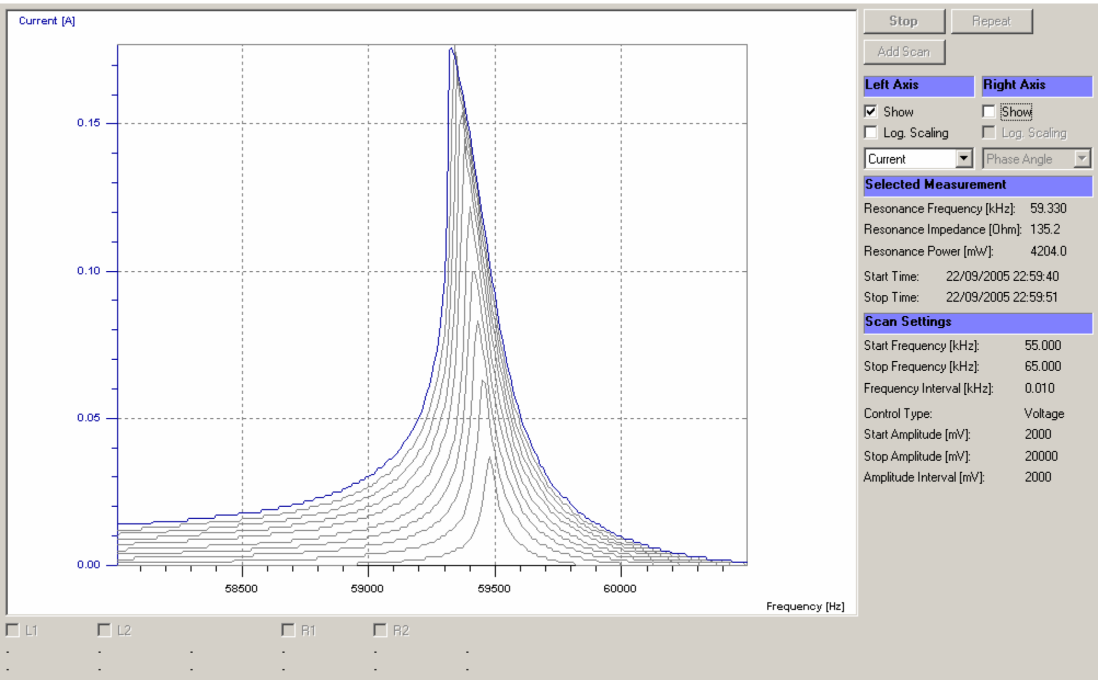
Picture 2 shows the phase response of the transducer together with the measured current. One should find only one transient through a phase of Zero degree in the resonance peak. This is important since the PLL (phase lock loop) of the ultrasonic generator should only lock in at the same position each time. If there are multiple peaks then the PLL may choose the incorrect peak.



Picture 2: transducer without tool – current and phase versus frequency

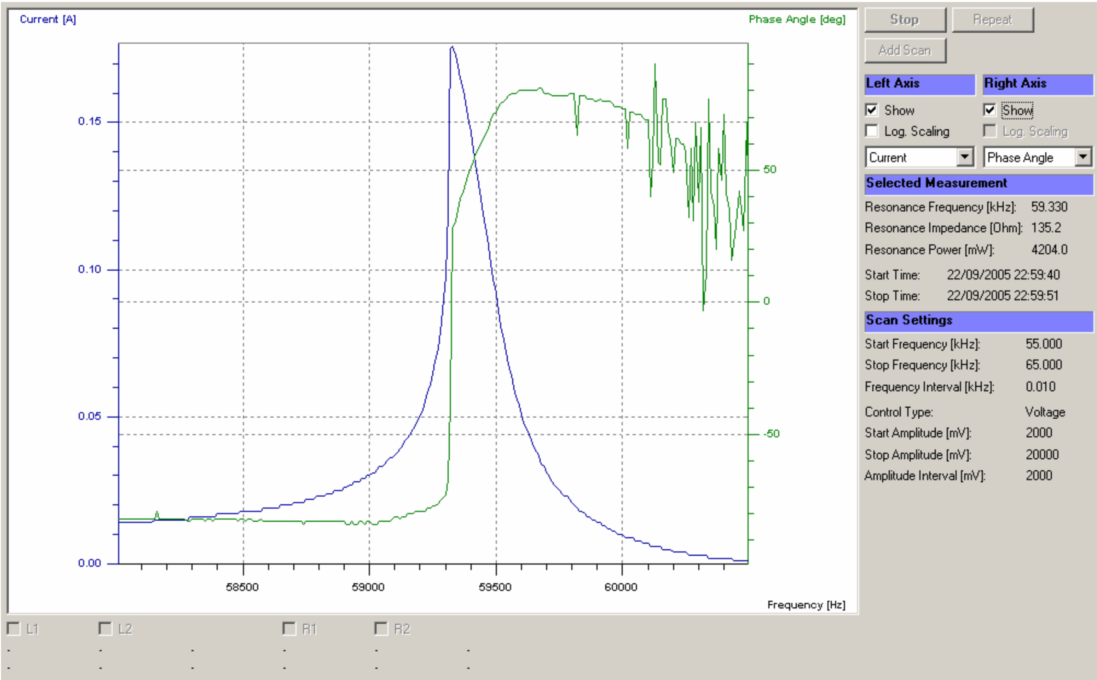
Test with standard tool

Picture 3 shows the measured current at increasing power levels for the “Standard Tool” of 2 inch length.



Picture 3: transducer with standard tool – current and versus frequency

Figure 3 shows smooth curves with no distortions. The resonance frequency is a little bit lower than without tool, but this is normal behavior. In addition, with increasing voltage the resonant frequency drops down slightly. This is expected behavior for all transducers.



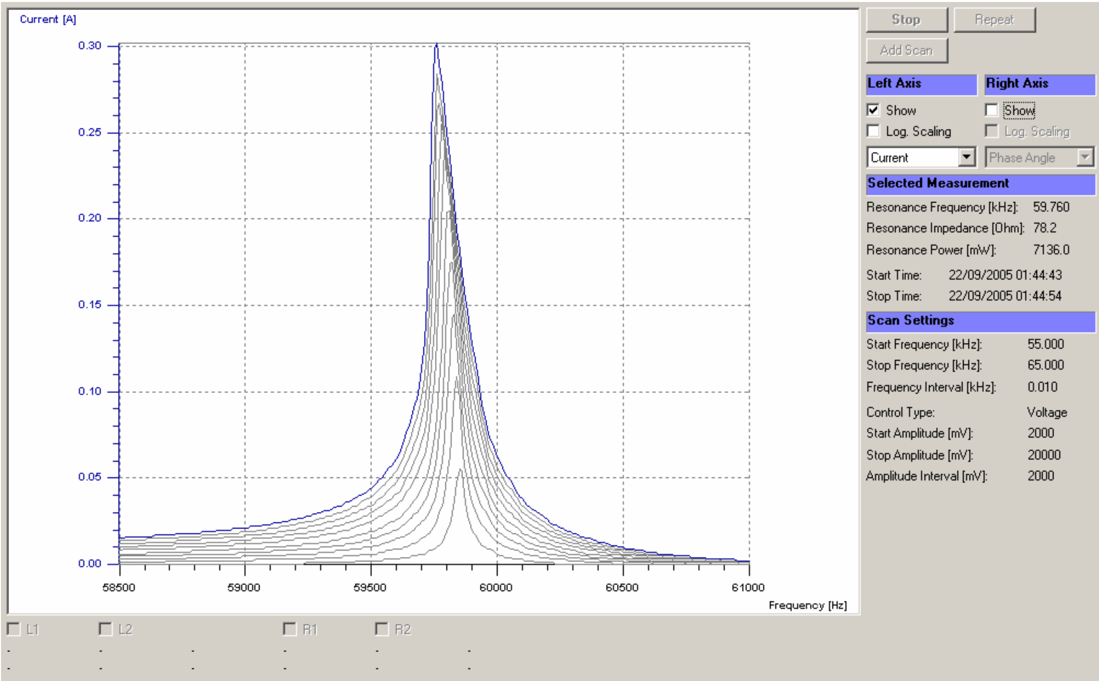
Picture 4: transducer with standard tool – current and phase versus frequency, maximum voltage

Picture 4 shows the phase measured versus the frequency for the Standard Tool of 2” length. This is acceptable since there is only one transition through Zero degree phase.

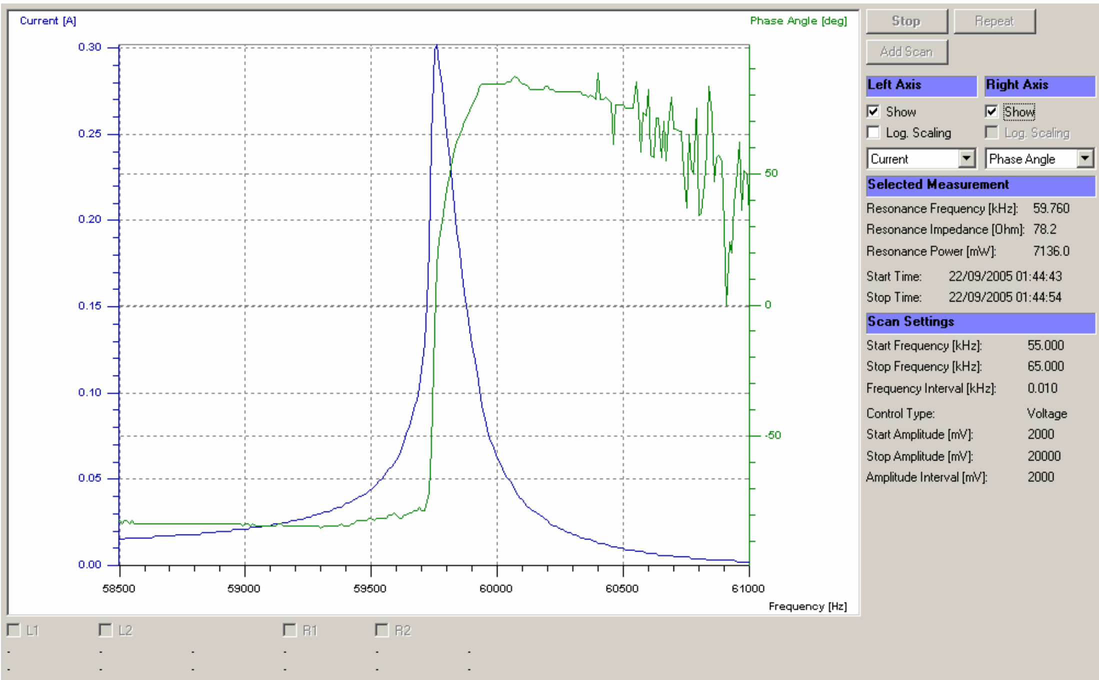
Test with tools with ceramic tip

The first ceramic tip tool, 2” was measured and the results can bee seen in Pictures 5 and 6, using the same measurement conditions as the Standard Tool.

Bond tool No 1 (picture 6) shows the same behavior as the standard tool without ceramic tip. Therefore, it should act like the standard tool during the wire bond process. No problems should be expected using this bond tool for production.

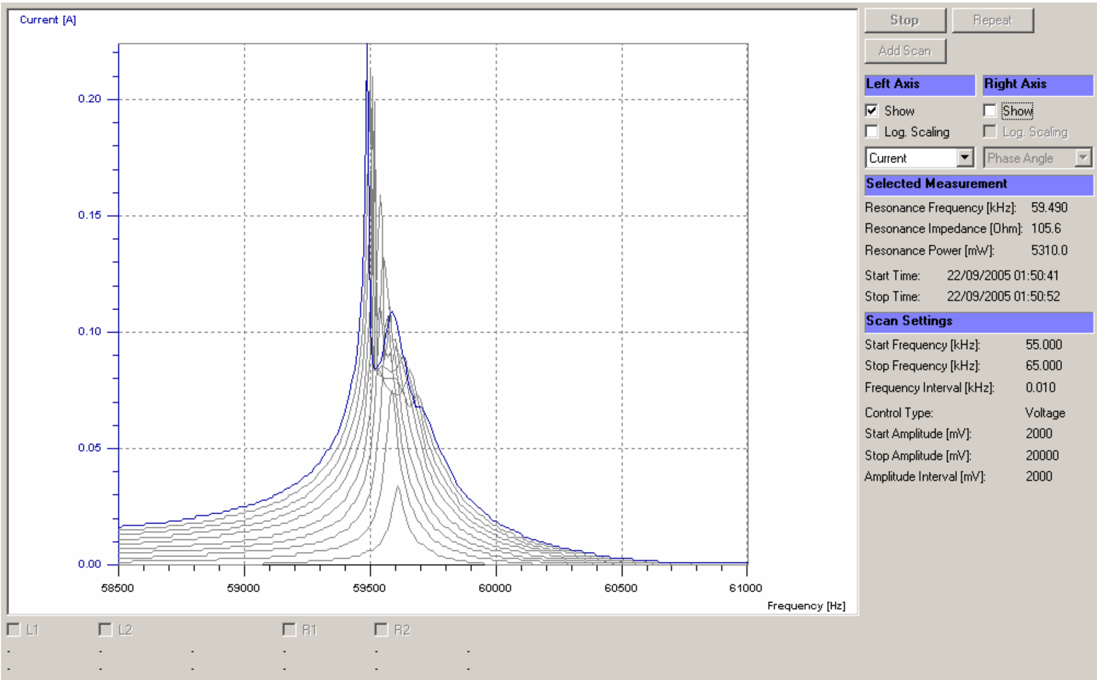


Picture 5: transducer with ceramic tip Tool No 1 – current versus frequency



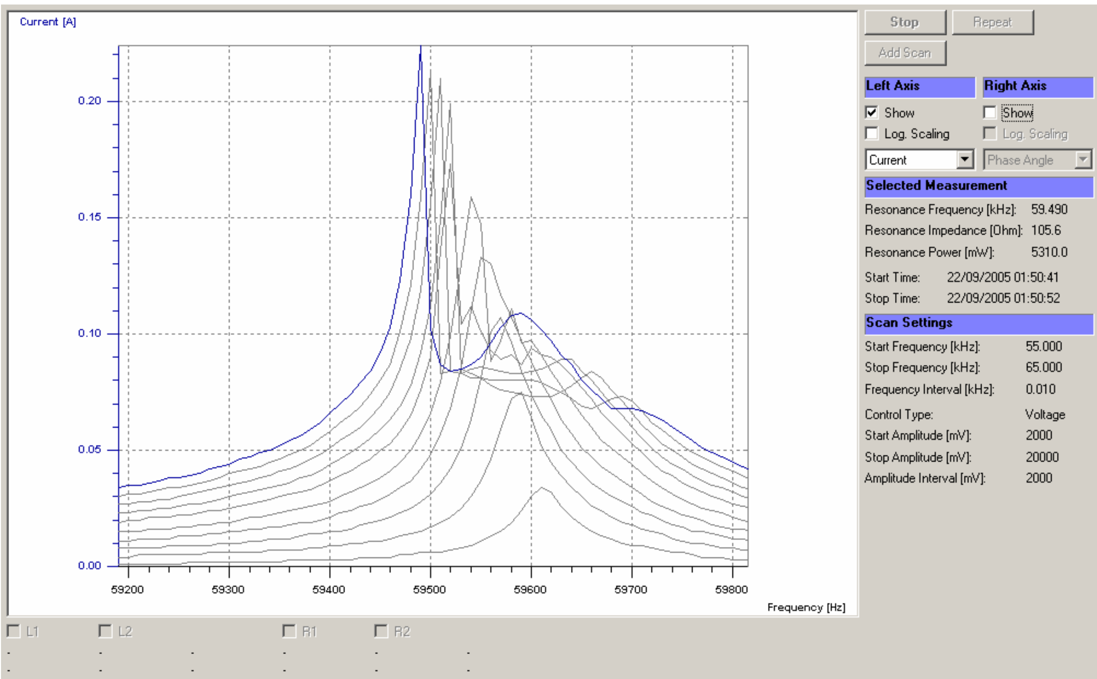
Picture 6: transducer with ceramic tip tool No 1 – current and phase versus frequency, maximum voltage

The next step was to measure bond tool No 2 (2 inch bond tool with ceramic tip). Picture 7 shows distortions for bond tool No 2.



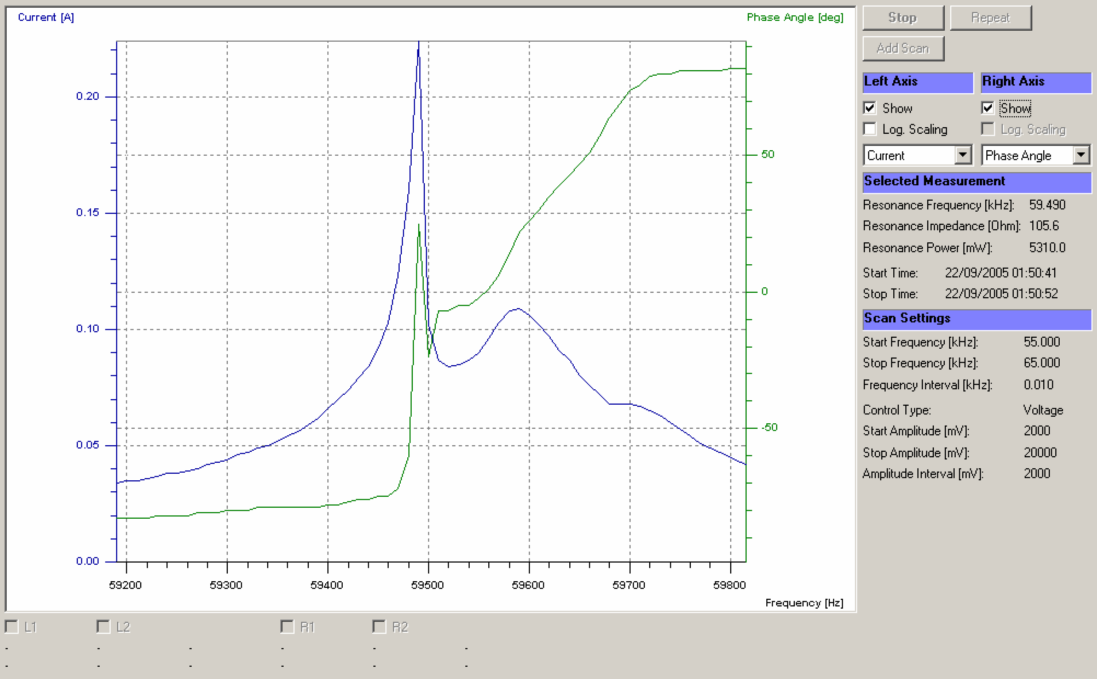
Picture 7: transducer with ceramic tip tool No 2 – current versus frequency

These distortions are displayed in more details in Picture 8.



Picture 8: transducer with ceramic tip tool No 2 – current versus frequency multiple scans- details

The phase is displayed for the scan at maximum voltage for bond tool 2 (picture 9).



Picture 9: transducer with ceramic tip tool No 2 – current and phase versus frequency – One scan. details

There are 3 transitions through Zero degree phase in a range of only a few dozen Hertz. This is a not acceptable behavior, since the PLL of the ultrasonic generator can not distinguish between these three points. Depending which point the PLL locks onto, any of the three different ultrasonic power levels could be acquired and they could randomly change.

Interpretation / conclusions

- The TTS-030 distinguished successfully between the “good” ceramic tip bond tool and the “bad” ceramic tip bond tool.
- It is possible that the “bad” bond tool (No 2) is the result of defective coupling at the interface between the ceramic and the rest of the bond tool. Why the bond tool is “bad” can not be concluded from these tests. However, these tests did conclude that the bond tool was defective.
- Effective test procedure can be established to check all bond tools before they are used for wire bonding.

The graphs and data in the body of this document are related to tests performed with the **TTS-030** system. Additional tests were performed using an **ODS 10** system to measure the excursion of the tip of the tool. Excursion results were within an acceptable range.