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White Paper

RF Couplers for mobile phone testing

Keeping production costs low is a major factor during the development of mobile phones. All components are subject to strict variability analysis, the result being that only the minority of mobile phones are equipped with an RF socket for an external antenna. This means for testing mobile phone functions, a radio frequency coupler is imperative for connecting the measuring device to the tester.

RF coupling also tests the antenna

If an existing RF connection is used to test the functions then the mobile phone's antenna is not tested. A switch is located inside the mobile phone to direct the wireless signal to the RF connection or to the integrated antenna. If the test is performed with the RF connection, the path from the switch to the antenna element remains untested. Some mobile phones having an integrated flat antenna are susceptible to contact problems at the base of the antenna and therefore emit only a fraction of the energy. These types of errors are best detected using a coupling element, ideally with an antenna coupler.

A final test using a coupler tests all RF components, as well as the function of the mobile phone's antenna. Such coupling devices can be constructed in three different forms: inductive, capacitive or antenna couplings.

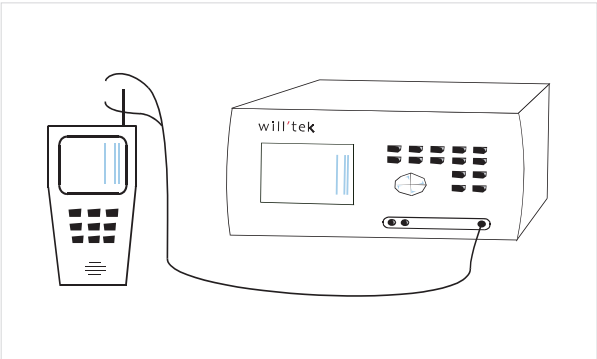
Inductive coupling

In the case of an inductive coupler, the coupling element is a coil. Generally, the mobile phone's antenna is located at the centre of this coil. The RF field emitted from the device to be tested unites in the coil and is transferred by means of an RF cable to the measuring device.

Inductive coupling devices ensure good coupling. Optimal dimensions ensure that a major portion of the energy is transferred to the measuring device. The disadvantages lie with the mechanical design and the RF retroactivity. In order for a coil to enclose the mobile's antenna, an external stick antenna on the mobile is preferable.

With the flat antennae found in many modern mobile phones, use of inductive coupling is only minimal, if at all. The reason being that flat antenna are integrated into the case and are therefore inaccessible from the exterior.

From a measuring aspect, the mobile phone may be influenced by the coupling element. Results can differ due to the small space between the coupling coil and the mobile phone antenna. The antenna base impedance is altered, meaning that the connecting point of the antenna has a different electronic characteristic.
The detuning of the mobile phone antenna causes an effect on the power amplifier or its controller.
The measurement set-up alters the behaviour of the mobile phone and different power levels will be measured, than would be in normal use. Incorrectly aligned phones could be dispatched from the radio workshop, possibly causing interference in the radio network.



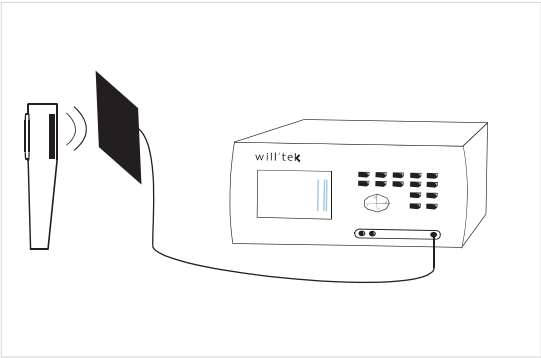
Inductive coupling

Capacitive coupling

With the capacitive coupler, the area of the mobile phone is placed opposite another area. The two areas combine to create a type of capacitor, which couples the high frequency energy of the mobile phone in the tester. For optimal coupling, the two areas should be of approximately the same size.

Capacitive coupling elements are distinguishable by a broad frequency area. However, their coupling values are strongly influenced by distance. For optimal coupling values, the coupling area and the mobile antenna should be located adjacently. Even minimal fluctuations in distances have a direct effect on the coupling factor, which varies reciprocally to the distance. A further disturbing effect occurs as a result of the closeness. The small space affects the mobile antenna causing a charge in antenna base impendance, as previously discussed with inductive coupling.

A further influence can occur through reflection at the coupling areas. The reflected energy can confuse the adjustment in some types of mobile phones. The output power may start oscillating. The reflected signal couples directly with the adjustment loop. This then measures an incorrect value, which is then corrected. The reflection is altered by this correction, resulting in the original instantaneous value, which is then recorrected. In this way, the adjustment changes continuously between various levels. This type of influence clearly renders it impossible to extract accurate measurements.



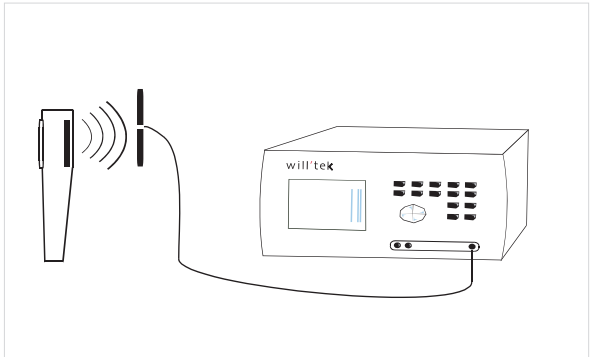
Capacitive coupling

Antenna coupling

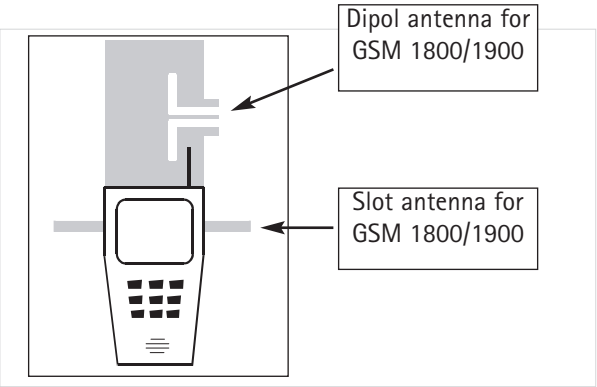
In this type of coupling, a further antenna is arranged opposite the mobile phone antenna to act as a coupling element. Tuned antennae are neither capacitive nor inductive. They only influence each other minimally and thereby permit a close realistic measurement. Back coupling can almost be excluded by the suitable choice of distance to the antenna. With a space of about 4 cm, a change in distance of 5 mm causes a drop in level of about 0.5 dB only. With capacitive coupling and an obligatory spacing of 0.5 cm, the same change in distance would result in the level dropping by 3 dB. However, advantages bring disadvantages. Antennae are tuned elements. They only work in a narrow frequency band, which is considerably larger than each of the bands assigned for wireless communications. One design example uses two antennae, one for the GSM 850/900 band and the other for GSM 1800/1900 and UMTS. The antennae are adjacently located or, if they are in a circle, inside each other. The latest antenna designs can now comprise several octaves, whereby one antenna can encompass all frequency bands.

The antenna coupler achieves repeatable accuracy in tenths of a dB. This accuracy is reliant on an identical measuring system. Consideration has not been given to the deviations between couplers.

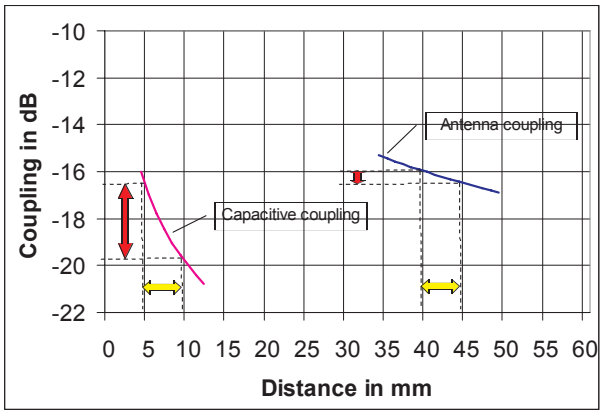
The antenna coupler offers the most accurate measurement results of all the various coupling methods for mobile phone testing, as there is little change the coupling factor despite changing the position of the mobile phone. Additionally, antenna couplers achieve good coupling values. Despite the smaller frequency range of this coupling principle, its use is not generally restricted, as mobile phones are only operated in specific frequency bands. A functional test with an antenna coupler is very application-oriented, as it only influences the tester minimally and provides accurate measurement results.



Antenna coupling



Antenna coupler example



Effect of distance deviation for capacitive and antenna coupling

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