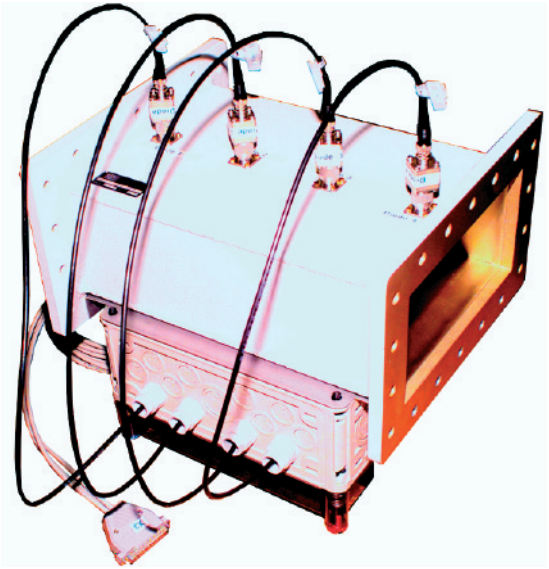
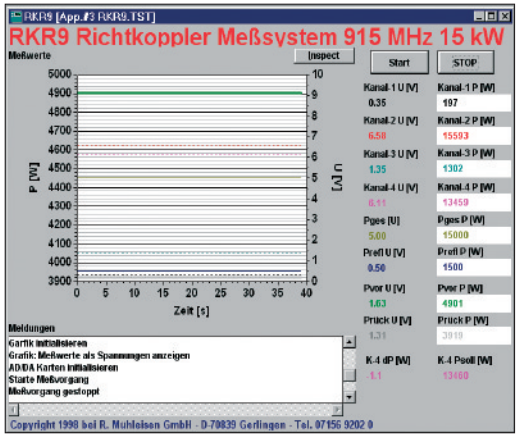
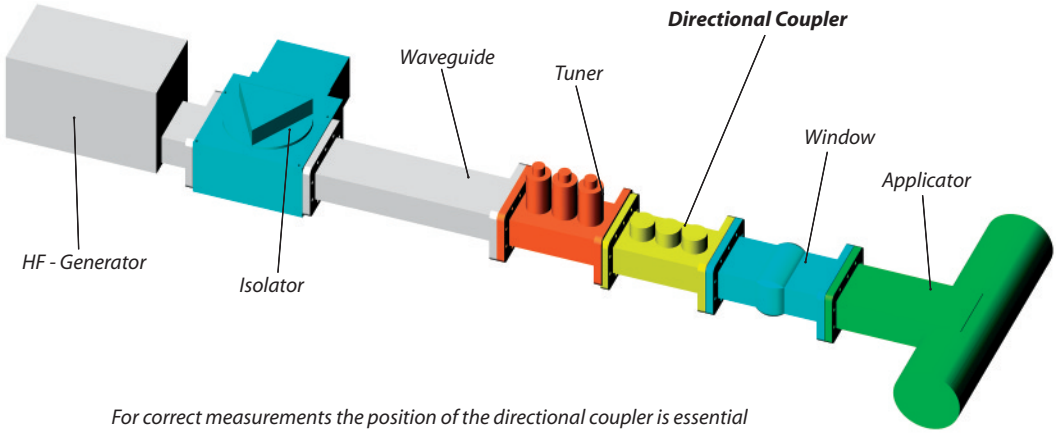
Directional Coupler Measurement System





The RKR9 Directional Coupler Measurement System consists out of a measurement waveguide (top left), the measurement PC (top right) and the measurement software with graphical user interface (bottom right)



For correct measurements the position of the directional coupler is essential

A directional coupler serves as a useful diagnostic tool to measure the amount of forward and backward propagating power in a monomode waveguide. It provides the operator of a microwave installation with helpful insight into his system and enables him to better understand the process he is performing. He also can detect trapped resonances and hence a possible too high VSWR that if not observed carefully may jeopardize his installation.

In microwave processing installations generally consisting of a

- high power voltage supply
- microwave generator
- isolator
- tuner
- applicator

The directional coupler is often installed either

- between the generator and the tuner or
- between the tuner and the applicator (which is shown in the left graphic)

In the first case it is used to measure the amount of backward reflected power which helps the operator to find the optimum position of the stubs when tuning the system. However after tuning of the system the directional coupler can not give any information about the behaviour of the applicator.

Additionally there are isolators available that have diode detectors at different ports allowing an independent measurement of the forward and backward propagating power at this position.

More useful is a location of the directional coupler between the tuner and the applicator. The tuning can be performed by evaluating of the signal of the mentioned diode detectors either at the isolator or

by observing both the forward and backward signal of the directional coupler. The better the system is tuned the higher is the signal from the directional coupler. This however leads to a rough tuning only.

The most useful application of the directional coupler starts as soon as the system finally is tuned. This is because for a tuned system the applicator and the feed waveguide section between applicator and tuner can be considered as a coupled resonator.

The lower the absorption of the sample in the applicator is the higher is the quality factor of this resonator and the higher is the field strength detected by the directional coupler.

Hence any change of absorption behaviour of the sample during the process can be observed.

Principle of Operation

The axial dependence of the field amplitude of the superposition of the forward and backward propagating power can be written as:

$$E = E_0 e^{i\omega t}\left(e^{ik_z z} + a e^{-ik_z z + i\phi_0}\right)$$

which means we have three unknowns

- the amplitude E_0 of the forward propagating signal
- the amplitude a E_0 of the backward propagating signal
- the relative phase between these signals

For that reason at least three simultaneous measurements have to be made at three different positions. These measurements are performed by means of coaxial antennas and diodes.

However there are imperfections of the measurement due to

- the diode characteristic
- noise
- power of the magnetron generated in higher harmonics that are detected as well and that perturb the measurements.

For that reason the power is measured at four different locations. By means of an in-house developed algorithm not only the power propagating on both directions is determined but also the precision of the measurement can be detected.

Description of the Setup

As can be seen in the figures on the front side, four antennas are located along the waveguide at a distance of a quarter of the waveguide wavelength.

The diodes attached to the antennas convert the measured signal into a voltage signal that is amplified with the electronic devices integrated into a shielded box. The amplified signal is evaluated by means of a Pentium PC that is equipped with a A/D card.

The total system is shown in figure on the front side. The system provides either digital information, analog signals or a utility for process control. The screenshot shows the graphical user interface of the RKR9 measurement software.

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