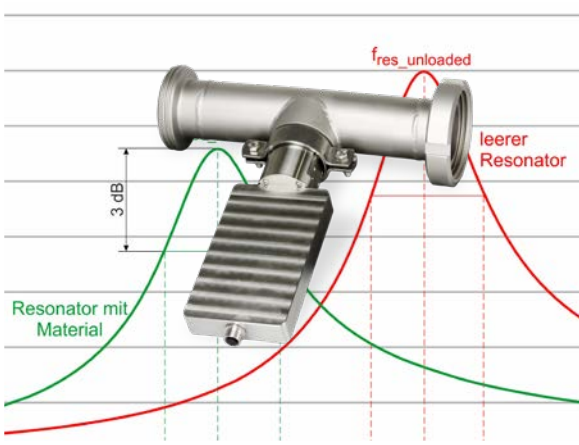
WORK MICROWAVE

we are the wave –
excellence in high frequency

# Microwave Resonator-Based Sensors for Measuring Mass and Moisture




With over thirty years of experience in microwave technology, WORK Microwave is a leading provider of high-precision sensor solutions for the food, paper, pharmaceutical, textile and construction industries.

# Sensor with stray field resonator

This type of sensor uses a microwave resonator that is open on one side. The resonator field can thus penetrate outwards within a given area. If a material, for instance a textile web, is placed within this stray field range, it affects the field of the microwave resonator and the change can be determined very precisely by measuring the resonant frequency. The size of the measurement area can be adjusted by varying the frequency used. Smaller measurement areas call for a resonator with higher frequency. Resonators ranging from approximately 0.5 GHz to 5 GHz are available for practical application.

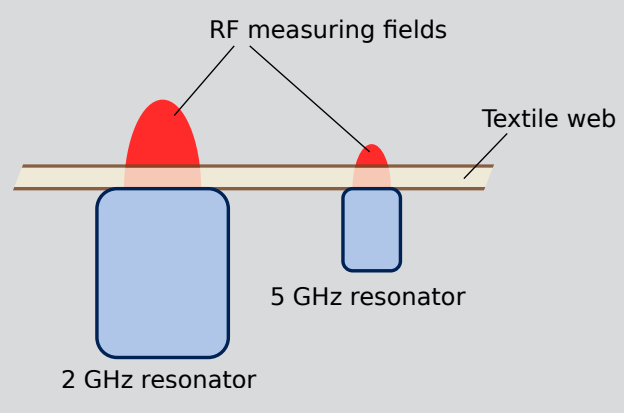



**Figure 1: Sensors with stray field resonator**

Resonators in the 2.4 GHz range have proved to be a universal solution suited to a wide variety of applications. In practical terms, the sensor surface is circular with a diameter of 20 mm.

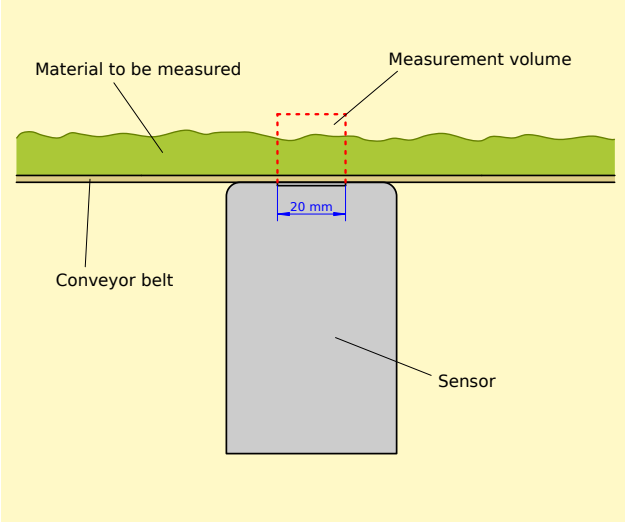



**Figure 2: Sensor for measuring mass**

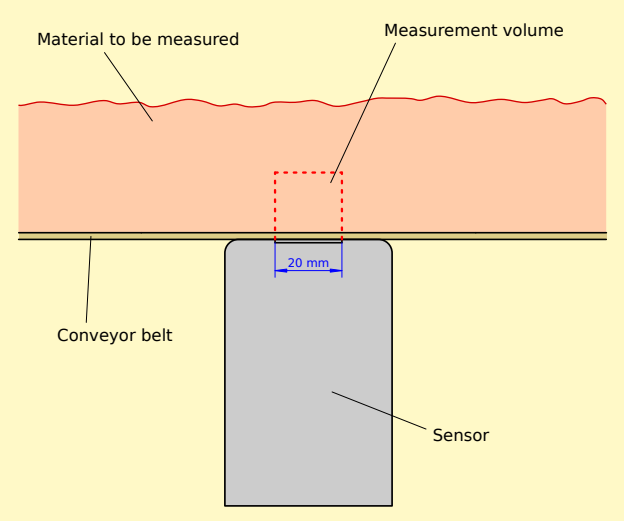



**Figure 3: Sensor for measuring moisture**

In figure 2, the material to be measured only partially fills the measurement volume. The full extent of the material falls within the active range of the resonator field. The value of a substance parameter – such as mass – can thus be determined from the change in measuring signal. The material to be measured must have a homogeneous structure.

In figure 3, the material to be measured completely fills the measurement volume. The resonator field dissipates completely within the material. Moisture and/or density values can thus be determined from the change in the measuring signal.

Figure 4 shows a typical case in practice. While the material to be measured does fill the measurement volume completely, it is not evenly distributed – shown here by the air pockets. If the appropriate sensor measurement volume is now selected, there are places where accurate readings can still be taken. A moisture value, for example, could then be determined by appropriately processing the recorded measurements. Since the raw signal will always deliver higher readings at the points with air pockets, a search could be performed to determine the minimum value over a specified time frame in this case.

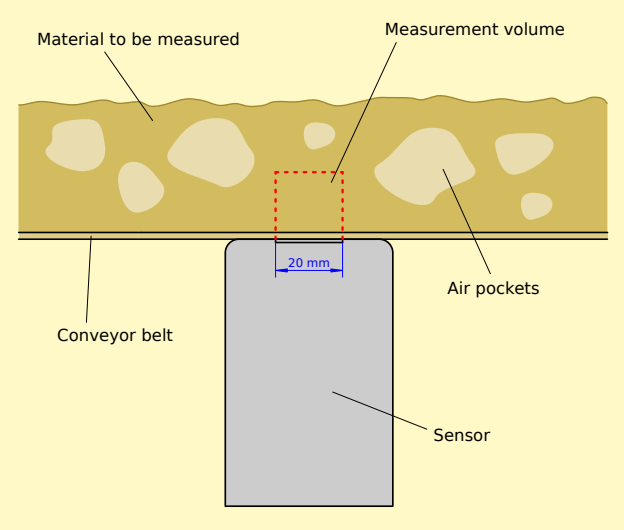



**Figure 4: Correct sensor selection for measuring moisture**

## Basic sensor structure with stray field resonator

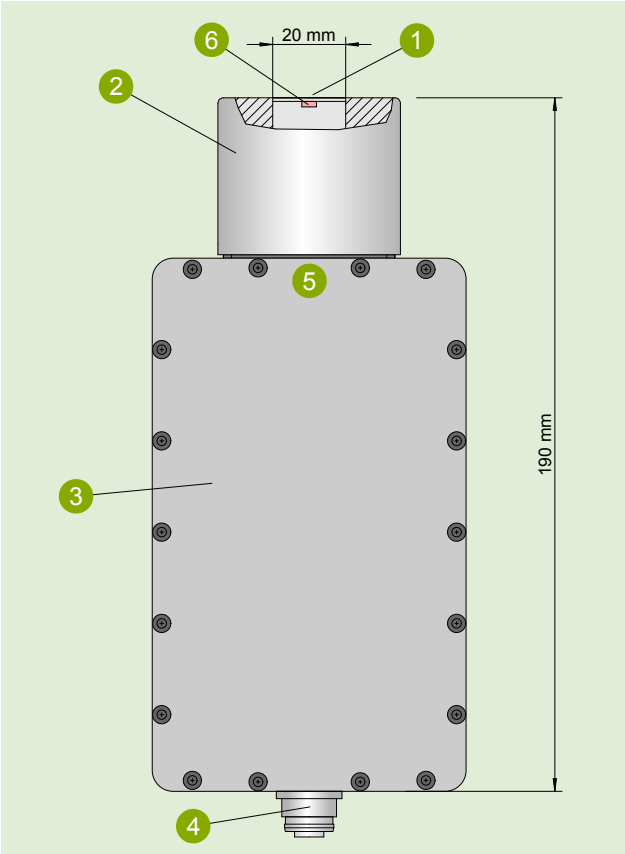



**Figure 5: Sensor for measuring moisture**

Figure 5 shows a sensor with a resonator in the 2 GHz range.

The sensor surface (1) has a diameter of 20 mm and is sealed with an abrasion-resistant ceramic plate. The sensor is mounted via a flange (2) so that it sits flush. The electronics are enclosed in the housing (3) and the electrical connection is via a socket (4). The overall height without the connector socket is 190 mm. The maximum permissible temperature at position (5) must not exceed 80°C. Temperatures of up to 120°C are permissible on the sensor surface (1).

The temperature sensor (6) is calibrated at the factory and supplies the temperature readings directly. The temperature sensor is adjusted for a measuring range of 0 to 100°C as standard, with 0 to 120°C also possible. The temperature sensor is located in the resonator head directly beneath the white ceramic plate.

# Sensor Design Options with Stray Field Resonator

**Sensor 87150.020 with straight resonator head**

| | |
|---|---|
| Sensing area: | d=20 mm |
| Measurement area: | up to 20 mm |
| Moisture range: | 0 ... 50 % (depending on material) |
| Operating range: | 0 ... +100 °C (optionally 0 ... +120 °C) |

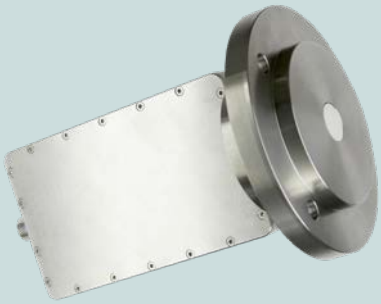
**Sensor 87150.022 with angled resonator head**

Customized sensor with resonator head at 90° angle.

The outer gray ring is made of high-strength ceramic. It is designed as a wear part for applications with high abrasion and can be easily replaced.

**Sensor 87150.030 with resonator head for extended sensing area**

| | |
|---|---|
| Sensing area: | d=40 mm |
| Measurement area: | up to 40 mm |
| Moisture range: | 0 ... 100 % |
| Operating range: | 0 ... +100 °C (optionally 0 ... +140 °C) |



**Sensor 87150.024 with customized flange**

The resonator head is optionally available with customer-specific flanges.

Flange diameter: 128 mm

**Sensor mounted with T-piece adapter**

For measuring high humidity up to 100% moisture content.

Tube diameter: 50 mm

Operating range: 0 ... 100 °C

Additional temperature sensor

Other tube diameters also available

# Sensor with Cavity Resonator

The flow channel of the microwave resonator in the example below has a diameter of 10 mm. In principle, this design can be scaled to larger dimensions as required.

The measurement area is a cylindrical zone slightly larger in height than the resonator. All material within this area affects the field of the microwave resonator and can thus be measured by the shift in resonant frequency.

A limiting factor here is the fact that the material to be measured must be evenly distributed throughout the measurement area – i.e. the measurement volume must always be filled completely to ensure accurate readings.

Measuring a second electrical parameter such as the quality factor of the resonator enables two values – for instance, humidity and density – to be determined simultaneously.

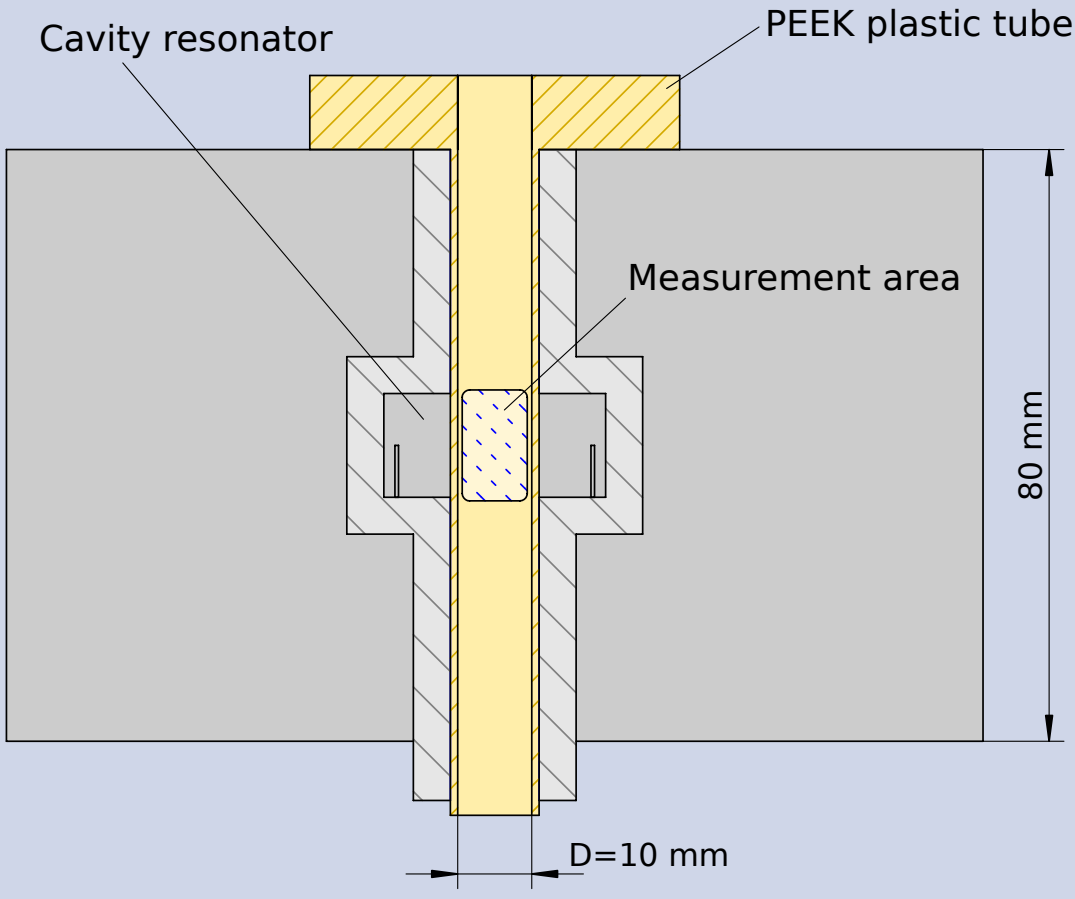



**Figure 6: Sensor with cavity resonator**

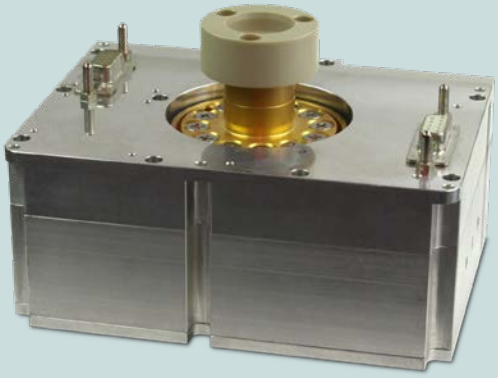
# Sensor Design Options with Cavity Resonator

**Sample cavity resonator**

For powders or small particles of up to 2 mm

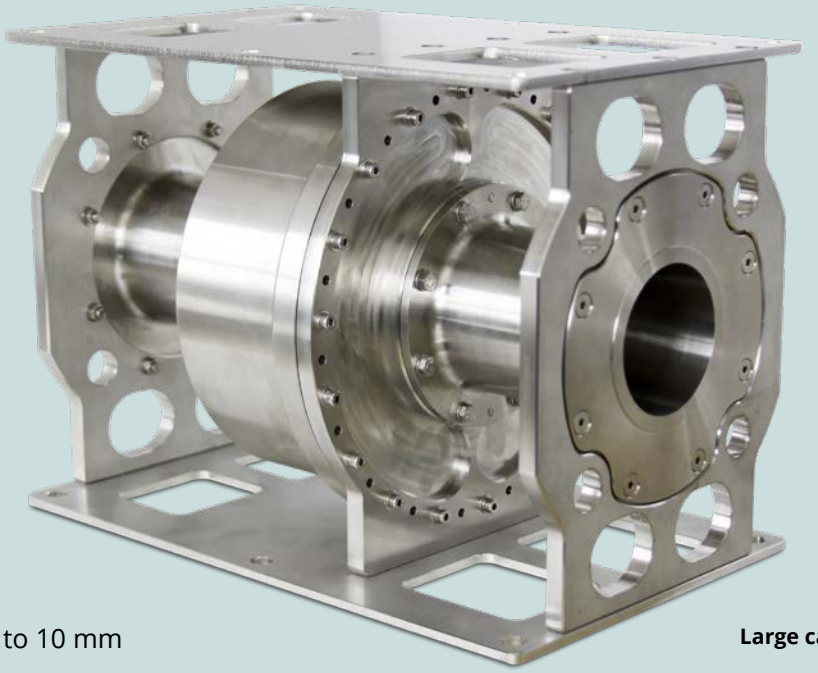
Measurement channel: d=10 mm

Measurement of low humidity up to 20 % depending on density



**Sensor with cavity resonator**

This image shows an implemented sensor design featuring a cavity resonator for moisture and density detection with a flow channel diameter of 10 mm.



**Large cavity resonator**

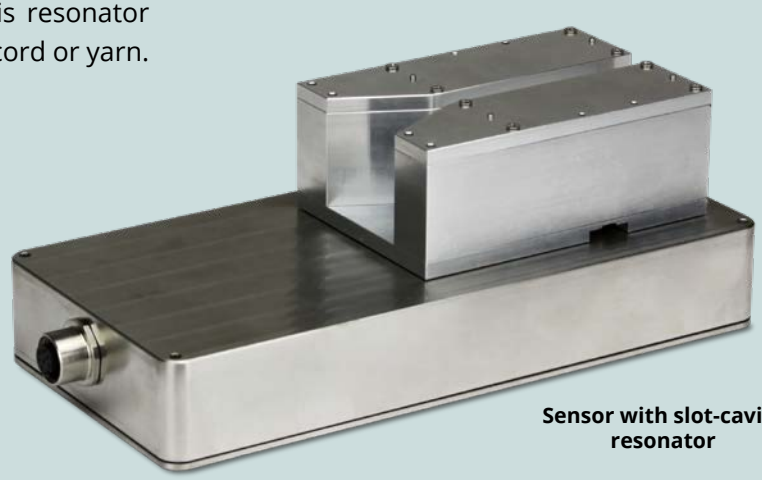
For particle sizes up to 10 mm

| | |
|---|---|
| Resonator length: | 120 mm |
| Total length: | 326 mm |
| Measurement channel: | d=50 mm |
| Operating range: | 0 ... +100 °C |

Other tube diameters also available

## Slot Resonator

Designed to be open at one side, this resonator version is ideally suited to measuring cord or yarn.



**Sensor with slot-cavity resonator**

Cord diameters up to 3 ... 5 mm

Moisture detection up to 40 %

Resonator open at one side for simple threading

## Split Resonator

This resonator is split into two halves, with the material for measuring running between them. This type of resonator configuration allows for separation distances of up to approximately 2 cm. This resonator is suitable for detecting moisture in thin textile or paper webs.

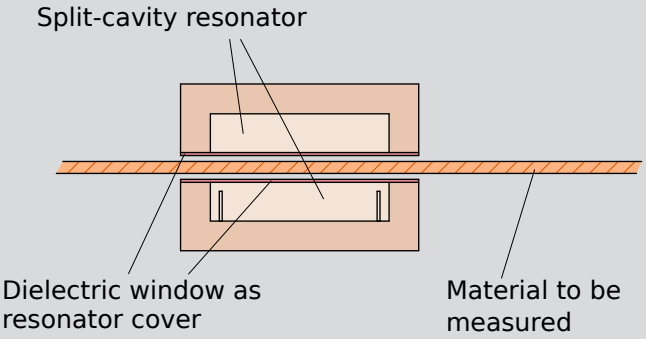
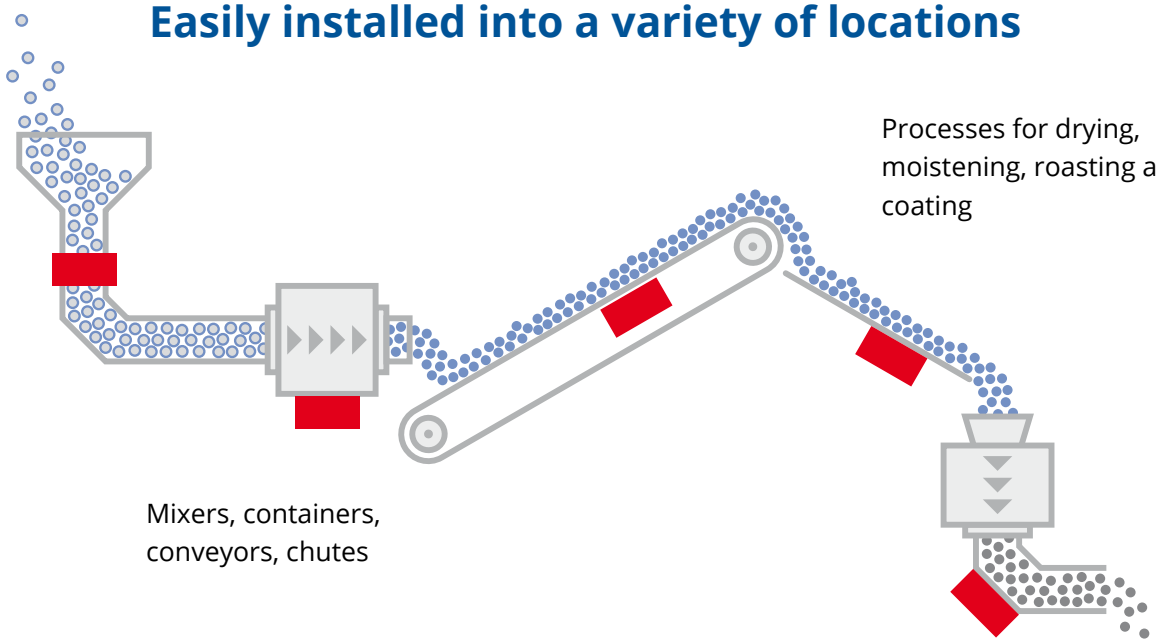



**Figure 7: Split resonator principle**

## Easily installed into a variety of locations




## Key features

- Suitable for solid, granular and powdered materials
- High measuring speeds from 100 to 100,000 measurements per second
- Rapid in-line weight determination for tablets, tabs and other individual elements
- Moisture detection up to 100 %
- Measurement of sample sizes from 1 mm³
- Robust housing for harsh operating conditions

## Typical applications


Medicines / chemicals


Foodstuffs / animal feed


Wood-based materials / textiles


Bulk solids


Household cleaning products

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