MEASUREMENT HEAD WMW-9 FOR BASIS-WEIGHT

Measurement of Basis Weight

META-Automation is specialized in Micro-waves using them in a quite broad Assortment of Applications (Moisture, Mass Flow, Thickness, Distance etc.).
Basis Weight or Mass per Area of Materials is a Key Parameter in many industrial- or experimental Applications. The META- WMW-9 has been developed on the Base of Microwaves and offers a non-radioactive, contactless Gauge to measure on-line the Basis Weight ([gr/m2], [gsm]).
Along with a Moisture Measurement using either Microwave- or Infrared Radiation the Oven-dry (Bone-dry) -Weight can be delivered with high Precision.
The Head can be deployed to measure Materials such as :

- Paper and carton
- Glas
- Wood
- Non Woven
- Food
- Gum
- Textiles
- Plastics
- Construction materials
- Agricultural

etc.

Micro-Waves are high Frequency electromagnetic Waves with Wavelengths of 1 [mm] to 10 [cm] i.e. 3 GHz to 300 GHz.
Due to that Ranges the Rules of Optic are applied, so their propagation in Materials obeys

$$c = \frac{1}{\sqrt{\varepsilon_0\, \varepsilon_r\, \mu_0\, \mu_r}} = c_0 / n, \text{ with}$$

c_o the velocity in air, $\varepsilon = \varepsilon_0\, \varepsilon_r$, the Material-Permitivity, $\mu = \mu_0\, \mu_r$, the Material-Permeability and n, the Refraction-Index.

Microwaves can significantly penetrate materials, whereby they behave at Boundaries or Fringes like Light. By their Interaction with Materials the relative Permittivity of these Substances can be exploited in order to determine unambiguously the Mass (Weight) of the Materials.

The relative Permittivity is generally described as complex Form :

$$\varepsilon r = \varepsilon' (\omega) - j\, \varepsilon'' (\omega) \text{ , with}$$

the real Part ε´ or dielectric Constant, the imaginary Part ε” or dielectri Loss and $j = \sqrt{-1}$

ε” depends on the electrical (σ_{electr})- and ionic (σ_{ionic})- Conductivity and can be described as

$$\varepsilon'' = \varepsilon''_{Dielcrtic} + (\sigma_{electr} + \sigma_{ionic}) / \varepsilon_0\, \omega,$$

Advantages by using Microwaves

The Advantages of implementing Microwave Gauges are manifold.

Without to claim Fullness some of them comprise :

- Microwaves work nondestructively, need no Contact to Material and leave the measured Material unaffected.
- Their Penetration into Materials is significant and depends on the selected Frequency. They can intrude deeply into any Material with Excemption Metals. Therefore any even so small Change in Material Properties can be easily detected.
- For the Measurements “Low-Power” Microwaves are used and they are safe for Humans and don’t need governmental Regulations and Allowances for their Applications.
- The Nature of Microwaves makes possible and easy to choose for each Application the suitable Configuration (Angle of Incident, measuring Gap, Transmission- or Backscattering -Methods can be freely applied, Non-problematic Mountings).

Therefore their Flexibility in Configuration makes Customization easy, non time consuming and inexpensiv.

- Microwaves are robust against changing enviromental conditions and get not disturbed in measuring places which are problematic for other Measurements e.g. Presence of Dust, Vapor or Vibrations coming from the Production Line.

- Due to the wide Range of available Frequencies, the Measurement can be easily get customized to adapt to the particular Material.

Method of Operation

The Measurement Method used to determine the Basis Weight exploits the distinct Changes of the dielectric Constant ε' and the Loss-Factor ε" due to Changes of the Basis Weight.
The Dependence of that variables from Moisture can be precisely compensated by using a Moisture Sensor to determine the Moisture.
Hereby the Relations of Attenuation and Phase Shift, when Microwaves interact with Material are taken into Consideration :

I) Microwave Attenuation

$$\Delta A = 10 \log (P_{in} / P_{out}) = f\,(\,8.686\,\pi\, d\, \varepsilon'' / (\,\lambda_0 \sqrt{\varepsilon''}\,)\,) \qquad [dB]$$

II) Microwave Phase Shift

$$\Delta\Phi = f\,(\,360\, d\, (\sqrt{(\varepsilon' - 1)}\,)/\lambda 0\,)$$

The total Basis-Weigt obeys then the Function

$$M_{tot} = f\,(\,k_1\, \varepsilon' - k_2\, \varepsilon''\,)$$

k_1 ,k_2 : Calibration Constants ,

M_{tot} =M_{dry} + M_{H2O} , total Weight = Oven-dry Weight plus Weight of H2O.

This Function is depicted in Fig.1

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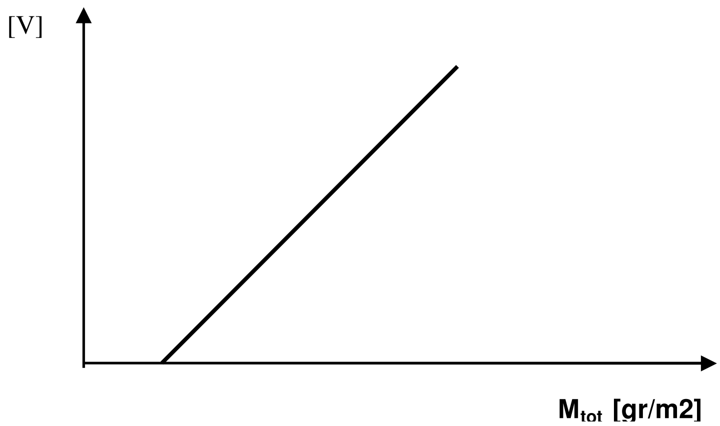

Fig.1 : Calibrated Output for Basis Weight

As aforementioned the Flexibility in Placement of the Gauge-Parts, i.e. Measurement Configuration is nearby unrestricted. But basically there are two distinct Methods always applied : The Transmission- and the Backscattering Method, showed in Fig. 2 as Scheme :

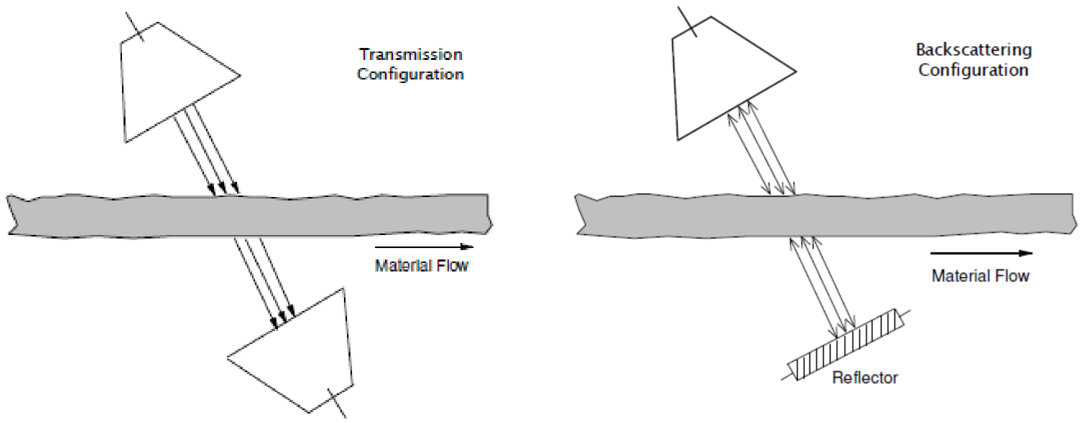

Fig.2 : Measuring Head Configurations.
Transmission and Backscattering with Reflector

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Technical specifications of MMR-9

Accuracy of Measurement : +/-0.2%

Basis Weight Range : 20 – 5000 [gr/m2] (MMW-2 : up to 35 [kg/m2]).

Microwave Power : ≤ 10 [mW]

Frequencies : 485 [MHz] – 125 [GHz]

Scanners – Frame Assembly

Scanners are used to continuously move the Gauges over the Material to be measured in order to get a two-dimensional Profile of the Measurement. As the Measurement Process demands that Accuracy and Repeatability should lie in the order of better than 1 [µm] (micron), the Scanner Stability and Robustness become a crucial Part for the Measurement.
Due to the Fact that the Variety of the Measurement-Materials is nearby indefinite and for the various Production Procedures and Machines the Installation Conditions differ significantly, not a Standard Form of Frame can be used and the META-Standard Scanner- Drawings are only an indicative Sorting for the Task.
Here is important to refer to a Standard Assembly/Construction-Set a it is used by META.
In that manner for each new Task a special Assembly is projected on the Base of our Standard and proven Modules i.e. Linear Motion Unit, Motor and Installation/Mounting Technique.
Fig.3, 4 and 5 depict the META Standard Assembly-Set in Use.

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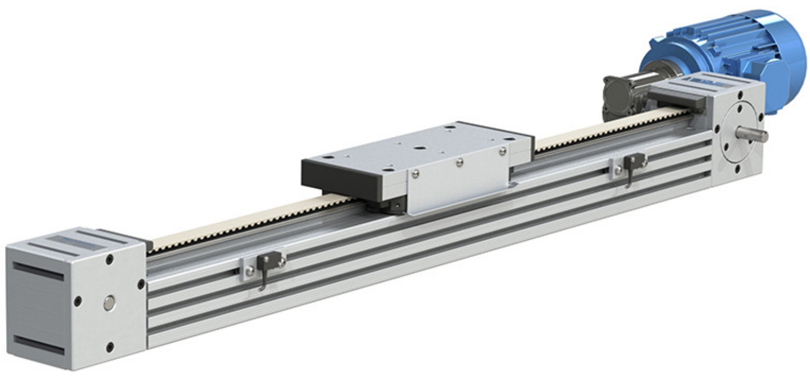

Fig.3 : Linear Units of META-Scanners

Mechanical Properties of Scanner-Units

- Modules in any length to 6m as standard, and even longer on application.
- Hardened and Precision Ground linear Slide.
- Double row Cap sealed Bearings for long System Life and low Maintenance.
- Polyurethane Steel-reinforced Belt for Minimum Stretch and high Speed capability.
- Quiet, Trouble free Operation from proven V Guide Bearing Technology.
- T-nut Slots on Beam and End Boxes allow simple Attachment of Clamps and Switches.
- Removable Carriage for secondary Machining.
- AC Motor and controller for simple positioning to suit most Applications (Servomotor Solutions on Demand).
- Planetary Gearbox directly coupled for compact Assembly.
- Corrosion resistant Version on available

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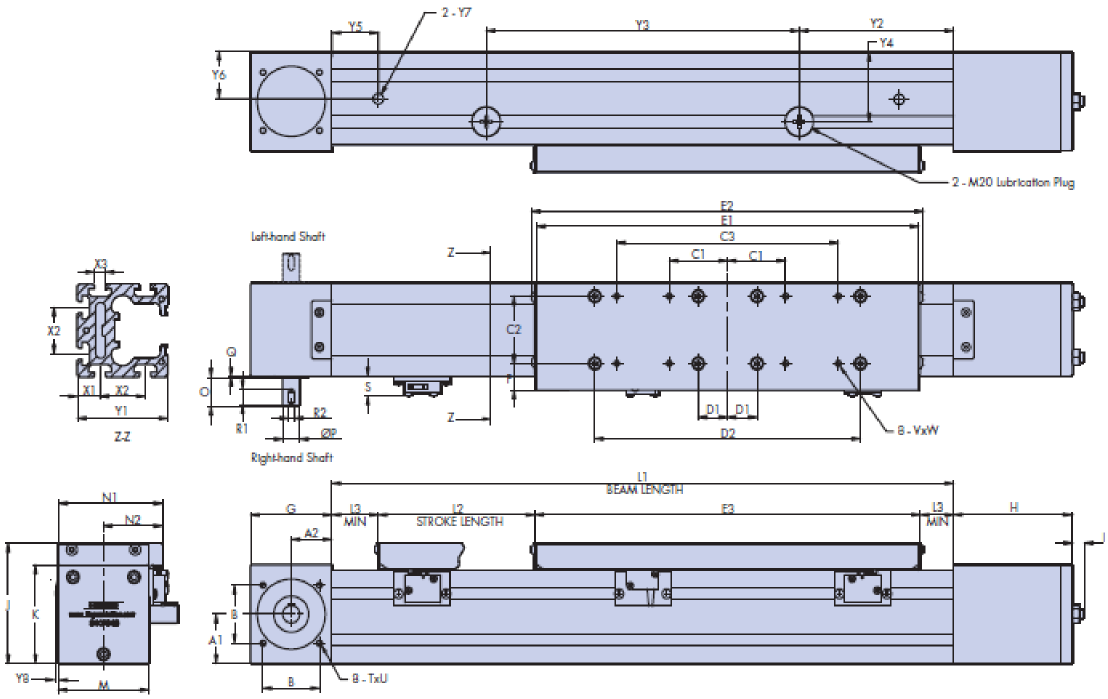
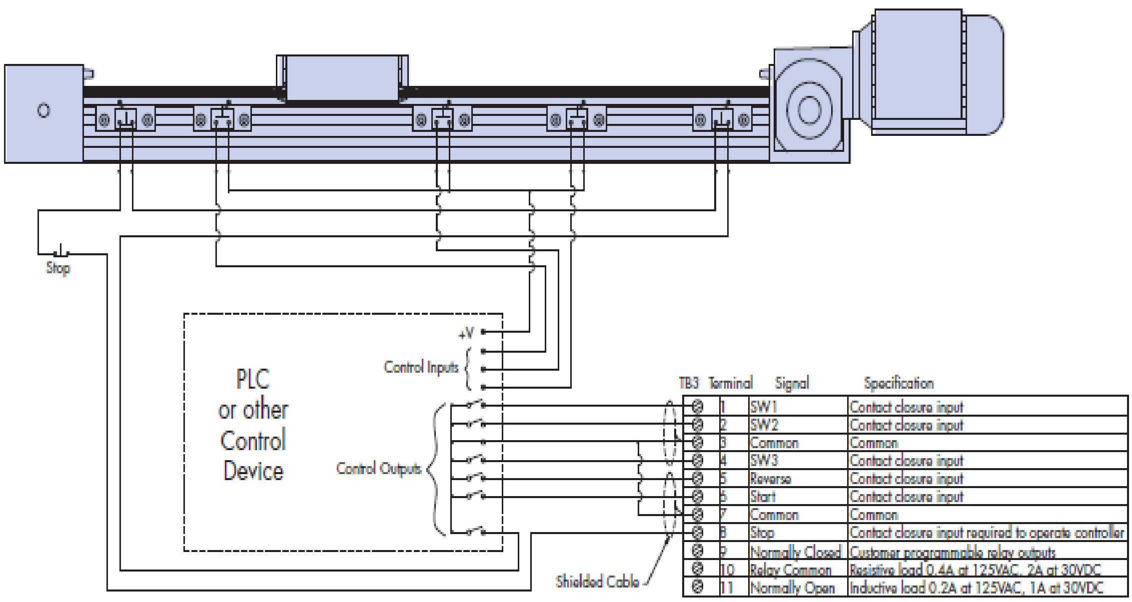


Fig.4 : Linear Unit Dimensioning



TB3	Terminal	Signal	Specification
	1	SW1	Contact closure input
	2	SW2	Contact closure input
	3	Common	Common
	4	SW3	Contact closure input
	5	Reverse	Contact closure input
	6	Start	Contact closure input
	7	Common	Common
	8	Stop	Contact closure input required to operate controller
	9	Normally Closed	Customer programmable relay outputs
	10	Relay Common	Resistive load 0.4A at 125VAC, 2A at 30VDC
	11	Normally Open	Inductive load 0.2A at 125VAC, 1A at 30VDC

Fig.5 : Typical Motion Control of Scanners