

Datasheet

Free-Space Permittivity Measurement



EM labs, inc.

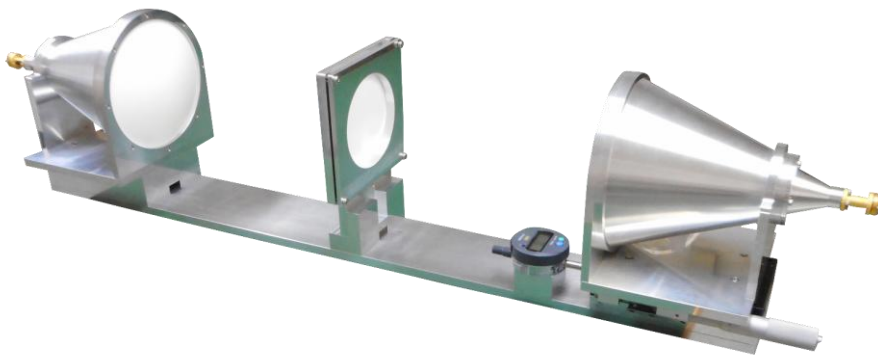
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General:

EM labs' Free-Space system, combined with a Keysight Technologies network analyzer, enables the measurement of the complex relative permittivity of dielectric materials and the complex relative permeability of magnetic materials. Using Keysight's N1500A-001 software, you can efficiently and accurately obtain permittivity and permeability with ease.

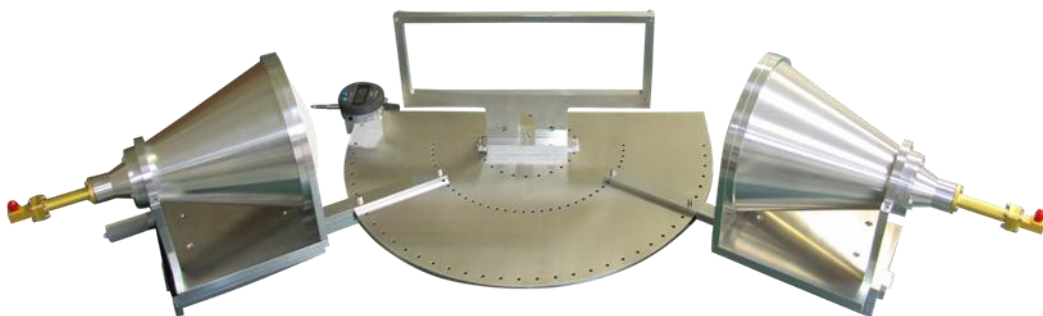
Standard model (straight transmission and reflection):

EM labs' Free-Space system covers a frequency range from 18GHz to 330GHz. It consists of a main body and band adaptors corresponding to the measurement frequency bands. For frequency below 110GHz, both waveguide connection and coaxial connectors are available, while for frequencies above 110GHz, only waveguide connections can be used.



Oblique reflection measurement option:

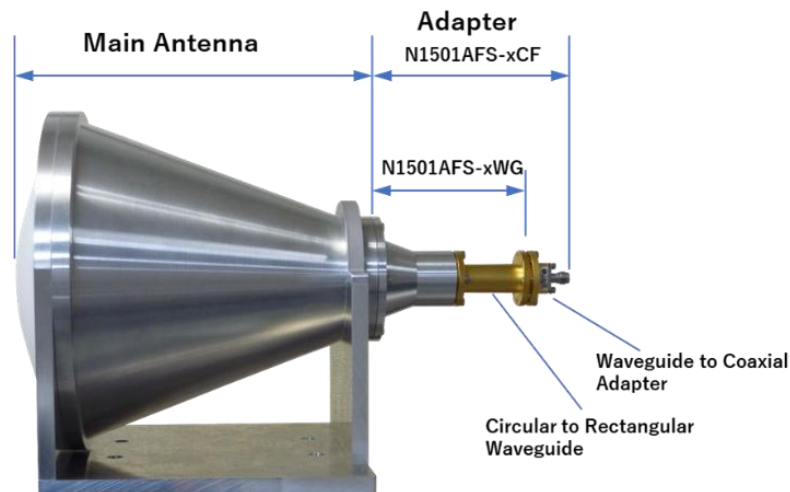
In addition to straight transmission and reflection measurements, an oblique reflection measurement option is also available. The measurable reflection angles range from 60degree to 120degree with 10degree resolution.



Models:

Moders number	Description	Connector
N1501AFS-330	Main Body	
N1501AFS-ORM	Oblique Reflection	
N1501AFS-KWG	K-band waveguide (18-26.5GHz)	WR-42
N1501AFS-KCF	K-band coaxial (18-26.5GHz)	2.4mm(f)
N1501AFS-RWG	R-band waveguide (26.5-40GHz)	WR28
N1501AFS-RCF	R-band coaxial (26.5-40GHz)	2.4mm(f)
N1501AFS-QWG	Q-band waveguide (33-50GHz)	WR22
N1501AFS-QCF	Q-band coaxial (33-50GHz)	2.4mm(f)
N1501AFS-UWG	U-band waveguide (40-60GHz)	WR19
N1501AFS-UCF	U-band coaxial (40-60GHz)	1.85mm(f)
N1501AFS-VWG	V-band waveguide (50-75GHz)	WR15
N1501AFS-VCF	V-band coaxial (50-75GHz)	1mm(f)
N1501AFS-EWG	E-band waveguide (60-90GHz)	WR12
N1501AFS-ECF	E-band coaxial (60-90GHz)	1mm(f)
N1501AFS-WWG	W-band waveguide (75-110GHz)	WR10
N1501AFS-WCF	W-band coaxial (75-110GHz)	1mm(f)
N1501AFS-DWG	D-band waveguide (110-170GHz)	WR6
N1501AFS-GWG	G-band waveguide (140-220GHz)	WR5
N1501AFS-JWG	J-band waveguide (220-330GHz)	WR3

Multiple bands can be measured by swapping the adapters.



Sample holders:

Two types of sample holders and two pairs of sandwich plates are provided with the Free-Space system. An additional sample holder is included for the oblique reflection measurement



option,

Standard sample holder (with two pairs of sandwich plates) (left picture):

A sample with the dimensions of 118mm x 118mm and a thickness between 0.5mm and 3mm can be set in the standard sample holder, ensuring best ease of use. The diameter of the opening for sample exposure is 100mm.

A smaller sample that does not easily fit in the standard sample holder, or a thin and soft sample that cannot be securely placed in the holder, can be set using a pair of sandwich plates. The sample is held between the plates, which are then inserted together into the standard sample holder.

Two pairs of plates are provided. One with a measurement area with a diameter of 50mm and the other with 30mm. Appropriate plates need to be used to assure the measurement accuracy.

Sampler holder with an open flat plane (center picture):

A large sample that does not fit the standard sample holder, or a sample with a unique shape, can be set using the sample holder with an open flat plane. The sample must be fixed to the holder with clips to ensure that the measurement plane is parallel to the plane of the holder. The diameter of the opening for sample exposure is 100mm.

Sample holder for oblique reflection (right picture):

Oblique reflection measurements require a horizontally longer sample. The holder can accept a maximum of 280mm for horizontal direction. A sample with a height larger than 100mm can be held.

Sample size:

The recommended sample size is 118mm x 118mm square, which provides the best ease of use. However, accurate measurements can still be performed with samples larger than the sizes listed in the following table.

Measurement parameters	Recommended minimum size
Permittivity and Permeability	9 WL in diameter
Permittivity	9 WL in diameter
S-parameters	6 WL in diameter
Oblique reflection	100mm x 6 WL/cos(angle)

Note: WL = wavelength

Note: For example, the wavelength at 75GHz is 4mm, so 9 wavelengths correspond to 36mm and 6 wavelengths to 24mm.

Note: Samples smaller than the recommended sizes can still be measured, but with reduced accuracy. Please consult your Keysight representative for further guidance.

Sample thickness:

The recommended thickness is between 0.5mm and 3 mm, which offers the best ease of use. However, accurate measurements can still be performed with samples within the thickness range listed in the following table.

Measurement parameters	Recommended thickness
Permittivity and Permeability	$WL/4 < t < WL/2$
Permittivity	$100\mu\text{m} < t < 10\text{mm}$
S-parameters	$10\mu\text{m} < t < 20\text{mm}$
Oblique reflection	$100\mu\text{m} < t < 2\text{mm}$

Note: WL = wavelength

Note: For example, the wavelength at 75GHz is 4mm, so WL/4 corresponds to 1mm and WL/2 to 2mm.

Note: Samples outside the recommended ranges can still be measured, but with reduced accuracy. Please consult your Keysight representative for further guidance.

Reference sample:

A reference Polycarbonate plate (118mm x 118mm x 2.0mm) with pre-measured permittivity is provided for verification and maintenance purposes.

Reference Polycarbonate has Dk of approximately 2.8 and Df of approximately 0.08.

Measurement accuracy:

- Dk error < 0.05 (~2%)
- Df error < 0.01

Measurement accuracy is defined only as the deviation from the premeasured values of the reference Polycarbonate.

Note1: Premeasured values are not always valid because permittivity of Polycarbonate is sensitive to temperature and humidity.

Note2: Absolute accuracy cannot be specified due to the absence of an absolute standard.

Repeatability:

- Dk standard deviation < 1%
- Df standard deviation < 0.002

Repeatability is defined as the standard deviation of ten measurements of the reference Polycarbonate sheet, with the sheet being removed, flipped, and reinserted into the resonator before each measurement.

Dielectric lens antennas:

Focal length ~ 280 mm

Beam size < 3 WL (3 dB power)

Side lobe < -30dBs

Operating temperature:

- 10 to 40°C (no condensation)

Weight: 14kg

Size: Refer to the following drawing:

