Measuring method of permeability and permittivity of noise suppression sheets at the frequency from 6 GHz to 30 GHz

-- Report on for IEC/TC51/WG10※ activities--

IEC/TC51/WG10 Convenor
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※ **IEC**：**International Electrotechnical Commission**
TC51：**Technical Committees 51 MAGNETIC COMPONENTS AND FERRITE MATERIALS**
WG10: Magnetic materials and components for EMC applications

Mr. Matthew Wilkowski invite me to present in Technical Demonstration portion of the 2025 Power Magnetics at High Frequency Workshop. We are currently working on the second revision of TR63307 in IEC/TC51/WG10. We would like to thank him for giving us the opportunity to present this activities.
The agenda for today's presentation is as follows:

Agenda

1. Background

1.1 Noise Suppression Sheet (NSS)

1.2 History of IEC 62333 Standard (Evaluation of the noise reduction effect by NSS)

1.3 IEC 62333-2

1.4 TR63307 (Measuring method of permeability and permittivity of NSS from 1 MHz to 6 GHz)

1.5 High frequency of information equipment (5G)

2. This new work Item (start at 2021/11 Japan)

Measuring method of permeability and permittivity of noise suppression sheets at the frequency from 6 GHz to 30 GHz

2.1 Round robin test

2.2 Measuring method

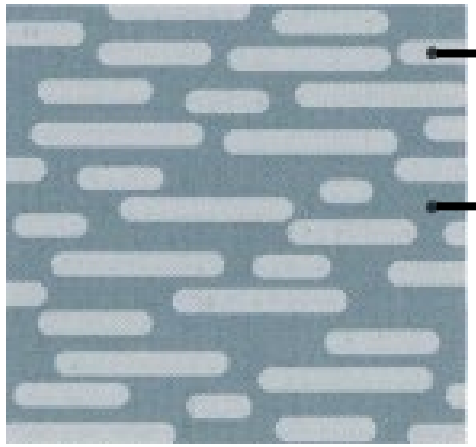
2.3 Results of Round robin test

2.4 Progress report Progress chart

2.4 Summary

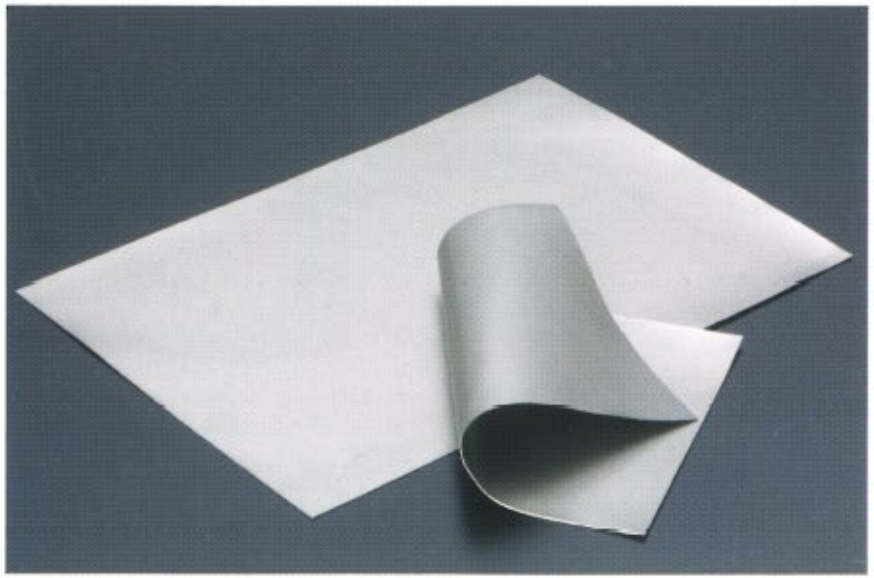
1. Background

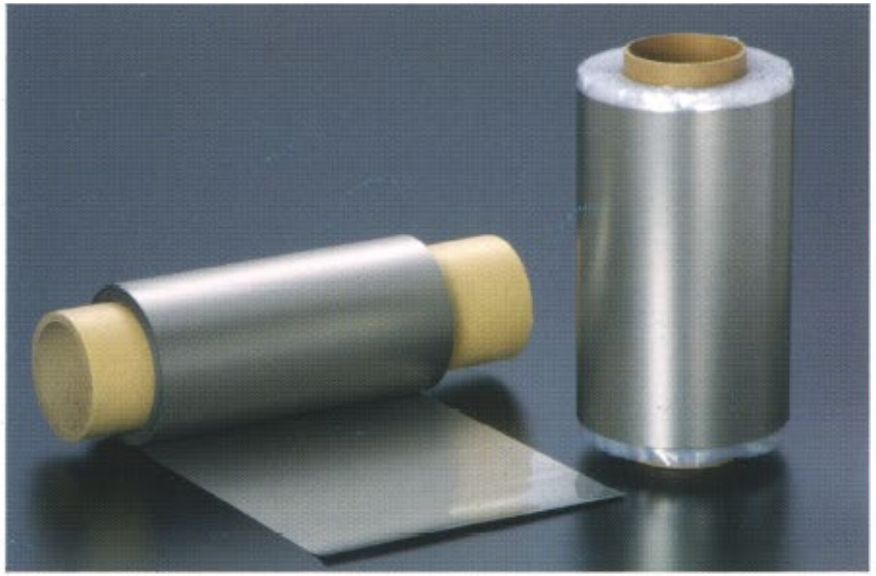
1.1 Noise Suppression Sheet (NSS)



Soft magnetic metal powders

Composite rubber

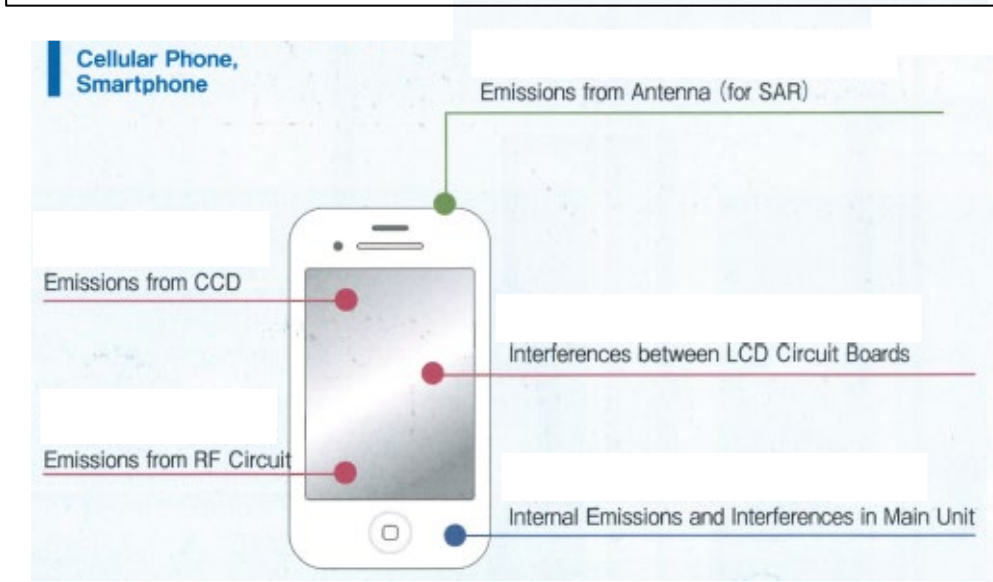


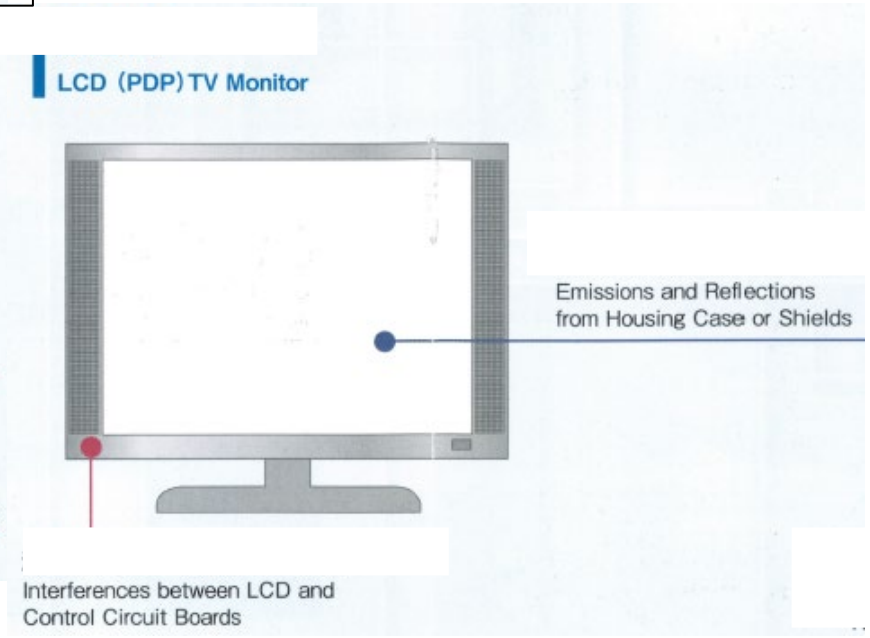


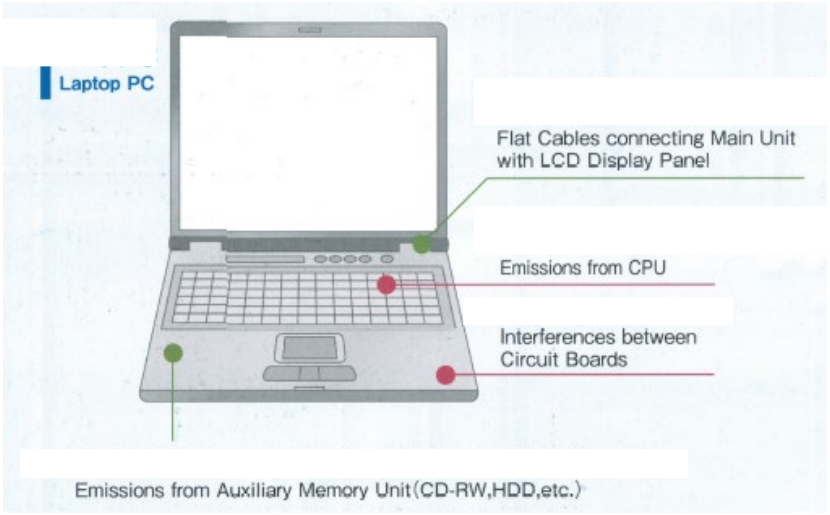
1. Background

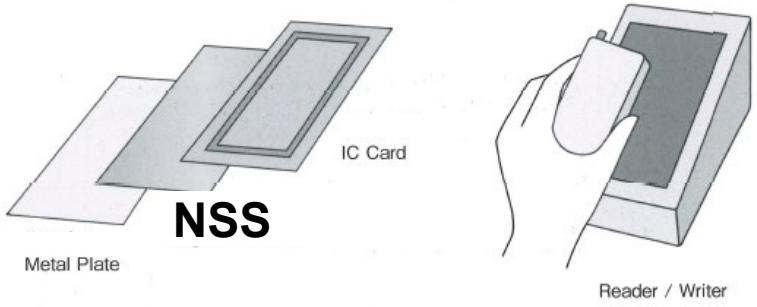
1.1 Noise Suppression Sheet (NSS)

locations and purposes of NSS







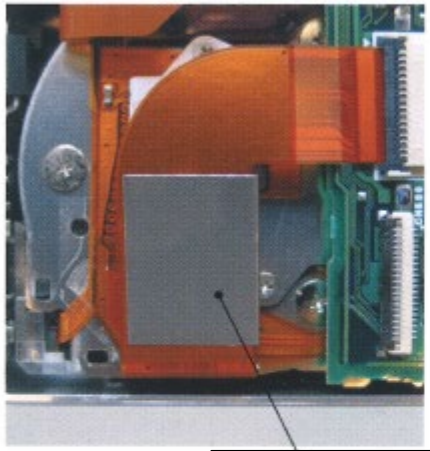


1. Background

1.1 Noise Suppression Sheet (NSS)

Performance of NSS

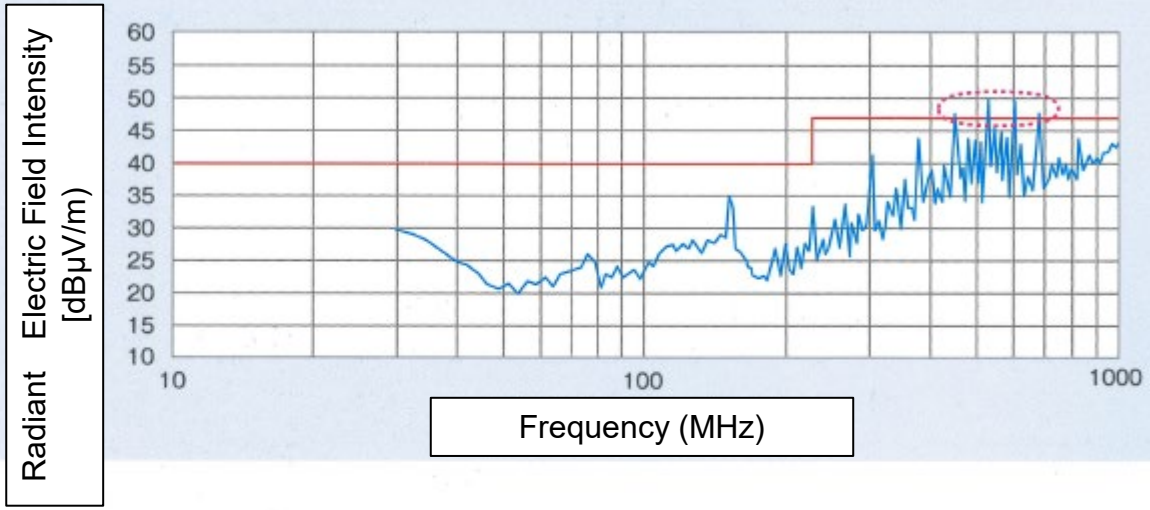
Attaching Position of NSS



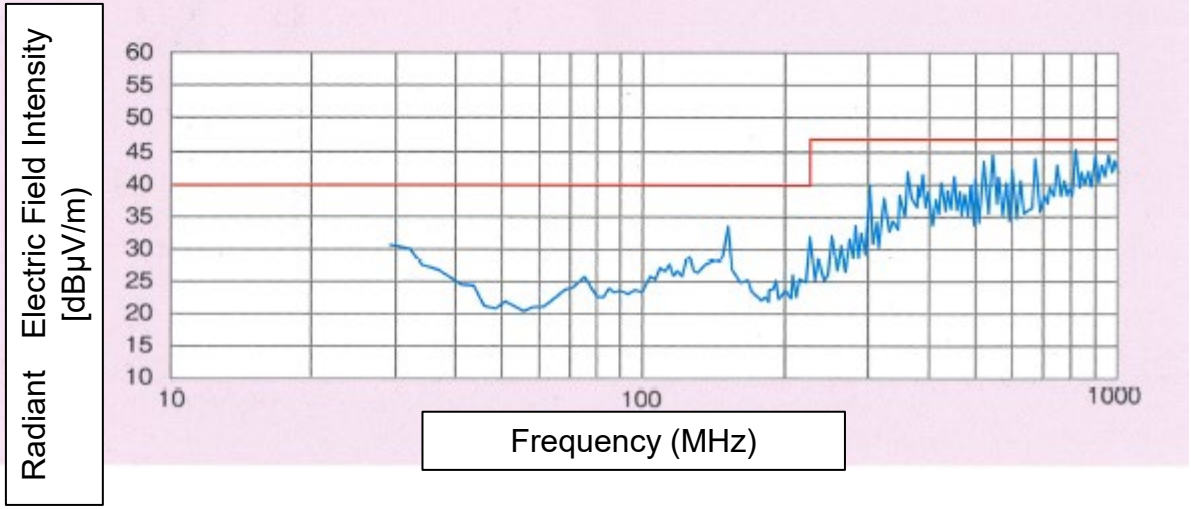
NSS

To suppress incidental noises occurring from FPC connecting the LCD and the driving circuit , NSS is attached to the FPC.

Test Result (Without NSS):VCCI Regulation Figures Not Cleared.



Test Result (With NSS):VCCI Regulation Figures Cleared.

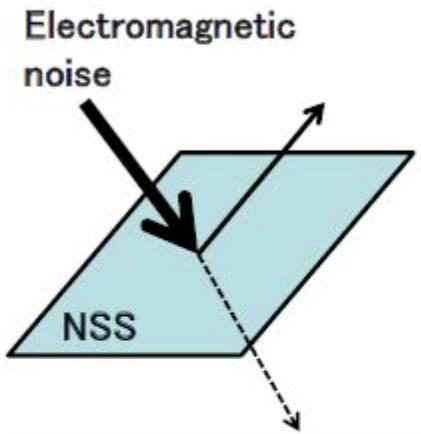


1. Background

1.1 Noise Suppression Sheet (NSS)

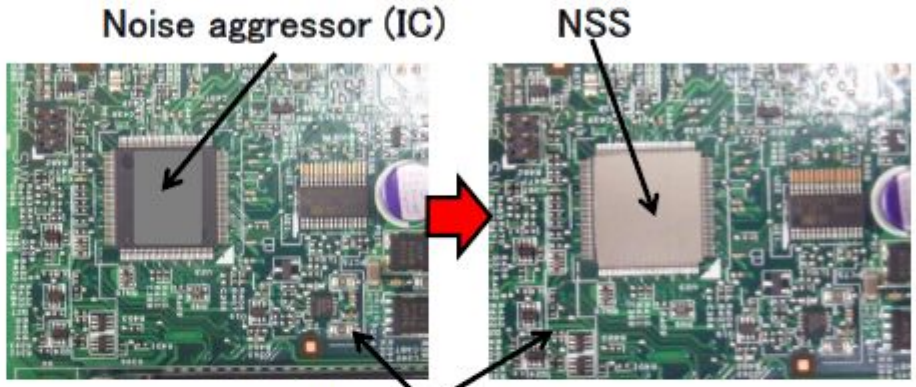
IEC standard for Noise Suppression Sheet

NSS feature



Electromagnetic noise are reduced by NSS.

NSS application



NSS is attached to noise aggressor to reduce noise of electric product.

IEC 62333-2 standard

We have proposed the measurement methods to evaluate the noise reduction effect considering the noise path of electric product.

1. Background

1.2 History of IEC 62333 Standard

(Evaluation of the noise reduction effect by NSS)

IEC 62333 Standard

IEC 62333: Noise suppression sheet (NSS) for digital devices and equipment
Project leader: S. Yoshida

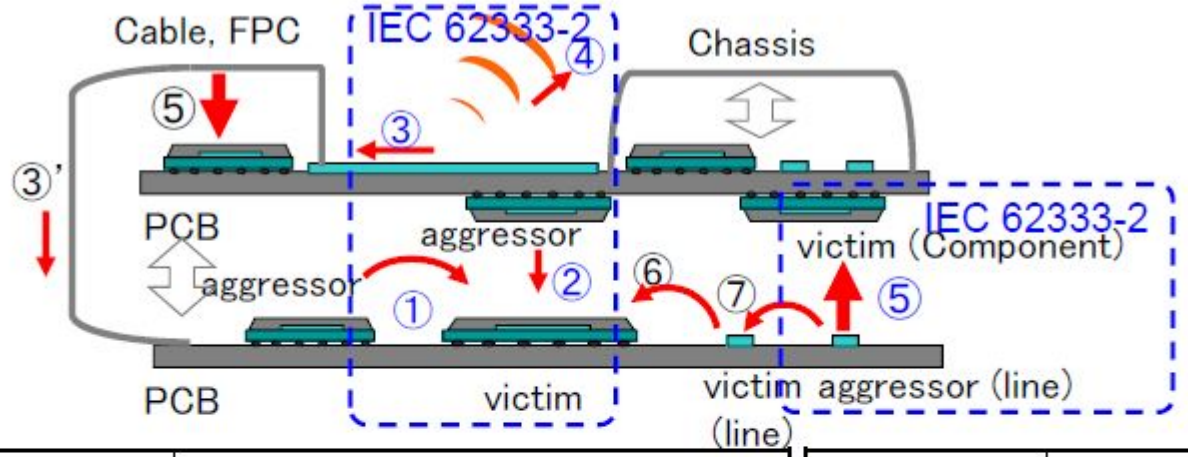
IEC 62333-1: Definitions and general properties (Published 2006)
IEC 62333-2: Measuring method (Published 2006)

IEC 62333-3: Characterization of parameters of noise suppression sheet (Published 2010)

IEC 62333-2: Amendment
New measurement method is added as an amendment (Published 2015)

1. Background
1.3 IEC 62333-2

Noise Path and Noise Suppression Effect



Victim / Aggressor	Near field coupling		
	Component		Line
	same side	opposite side	line in vicinity
Component	① Intra-decoupling	② Inter-decoupling	⑤ Line decoupling
Line	⑥	⑤ Line decoupling	⑦

Conduction	Radiation
Line Plane	Far field
③ Transmission Attenuation	④ Radiation suppression

IEC 62333-2

The measurement methods for noise suppression effect (① to ⑤) was published as IEC standards.

1. Background

1.4 TR63307 (Published 2020)

(Measuring method of permeability and permittivity of NSS from 1 MHz to 6 GHz)

Measurement of complex relative permeability μ_r
and complex relative permittivity ε_r of NSS from 1 MHz to 6 GHz .

EMC designer recently uses Simulation,
so, this simulation method needs permeability μ_r and permittivity ε_r of NSS.
We proposed this project. (IEC 2017 Vladivostok)

Finally, TR63307 showed measuring method of permeability μ_r
and permittivity ε_r of NSS from 1 MHz to 6 GHz. (Published 2020)

PROJECT NUMBER:
IEC TR 63307 ED1
CLOSING DATE FOR VOTING:
2020-09-18
SUPERSEDES DOCUMENTS:
51/1338/CD, 51/1346/CC

1. Background

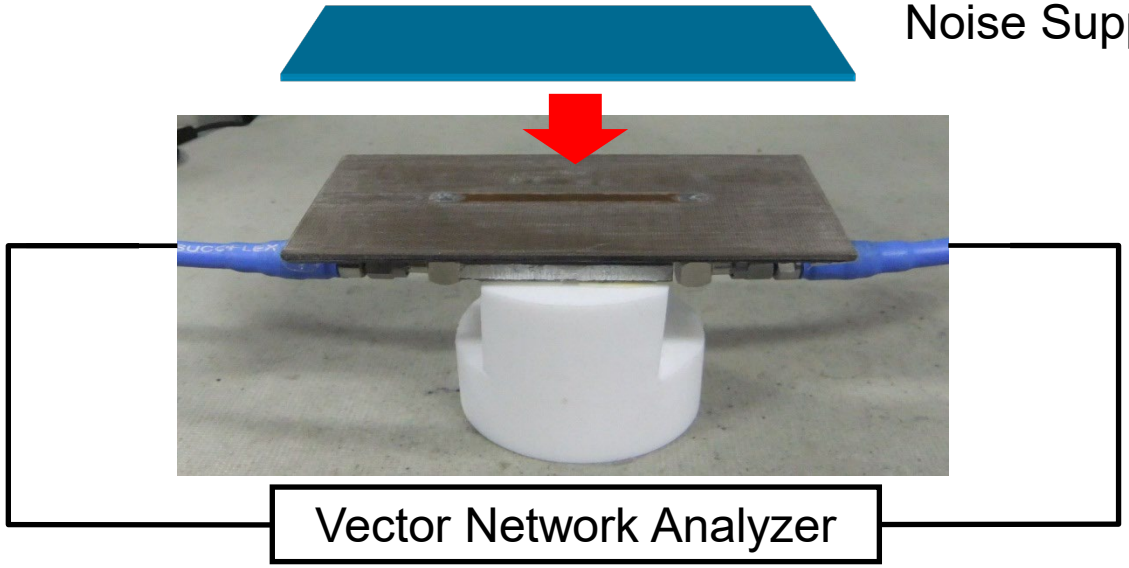
1.4 TR63307 (Published 2020)

(Measuring method of permeability and permittivity of NSS from 1 MHz to 6 GHz)

For example: IEC 62333-2 ③Transmission Attenuation

Experiment

$$R_{tp} = -10\log\{(10^{S_{21M}/10})/(1-10^{S_{11M}/10})\}[dB]$$



Measurement : S-parameters

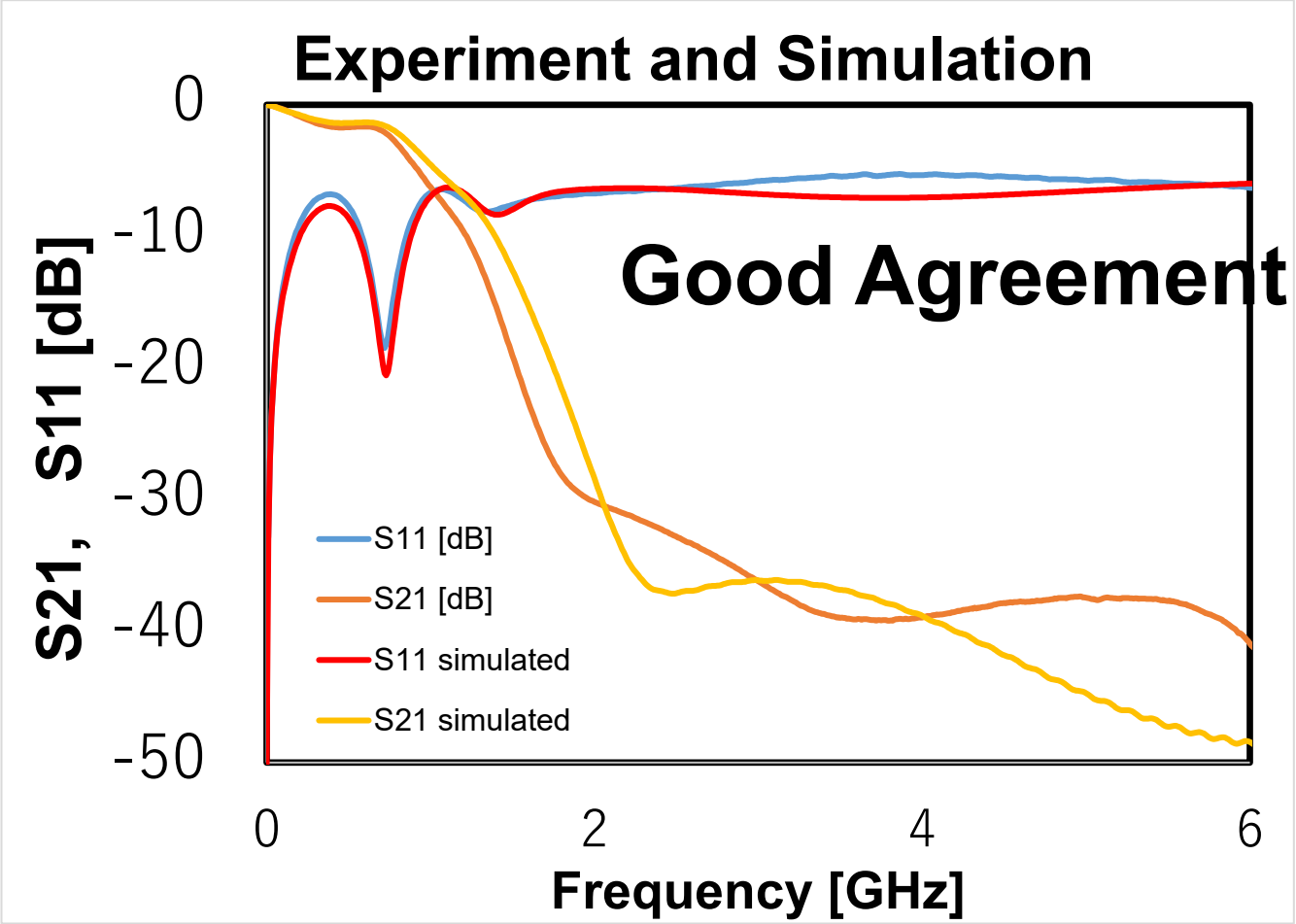
1. Background

1.4 TR63307　(Published 2020)

(Measuring method of permeability and permittivity of NSS from 1 MHz to 6 GHz)

For example: IEC 62333-2 ③Transmission Attenuation

We calculated S-parameters by using μ_r and ε_r of NSS



（HS05-R050）

1. Background

1.4 TR63307 (Published 2020)

(Measuring method of permeability and permittivity of NSS from 1 MHz to 6 GHz)

- Contents of Technical Report

FOREWORD
INTRODUCTION
1. Scope
2. Normative references
3. Terms and definitions
4. General
5. Summary of measuring methods of Noise Suppression Sheets(NSS)
   - 5.1 Inductance Method
   - 5.2 Nicolson Ross Weir Method
   - 5.3 Shielded Loop Coil Method
   - 5.4 Short- & Open- Circuited Coaxial Line Method
   - 5.5 Short-circuited Micro strip Line Method
   - 5.6 Harmonic Resonator Perturbation Method

Bibliography

1. Background

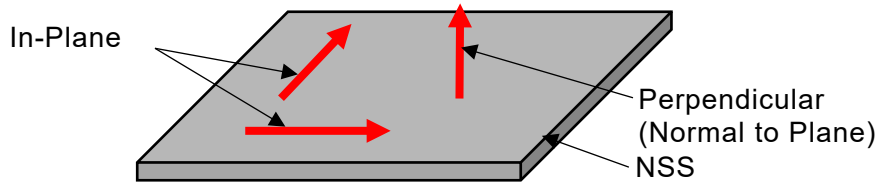
1.4 TR63307 (Published 2020)

(Measuring method of permeability and permittivity of NSS from 1 MHz to 6 GHz)

◆ Method and Frequency

Method Name	μ_r and ε_r				Frequency
	In-Plane		Perpendicular		
	μ_r	ε_r	μ_r	ε_r	1 MHz to 10 MHz / 100 MHz / 1 GHz / 10 GHz / 100 GHz
5.1 Inductance	○				1 MHz to 1 GHz
5.2 Nicolson Ross Weir	○	○			500 MHz to 18 GHz
5.3 Short-circuited micro strip line	○				10 MHz to 10 GHz
5.4 Short- circuited coaxial line	○	○			1 MHz to 18 GHz
5.5 Shielded loop coil	○				1 MHz to 10 GHz
5.6 Harmonic resonance cavity perturbation	○		○		250 MHz to 18 GHz
		○		○	1,8 GHz to 8 GHz

Range of frequency (1 MHz to 6 GHz)



1. Background

1.4 TR63307 (Published 2020)

(Measuring method of permeability and permittivity of NSS from 1 MHz to 6 GHz)

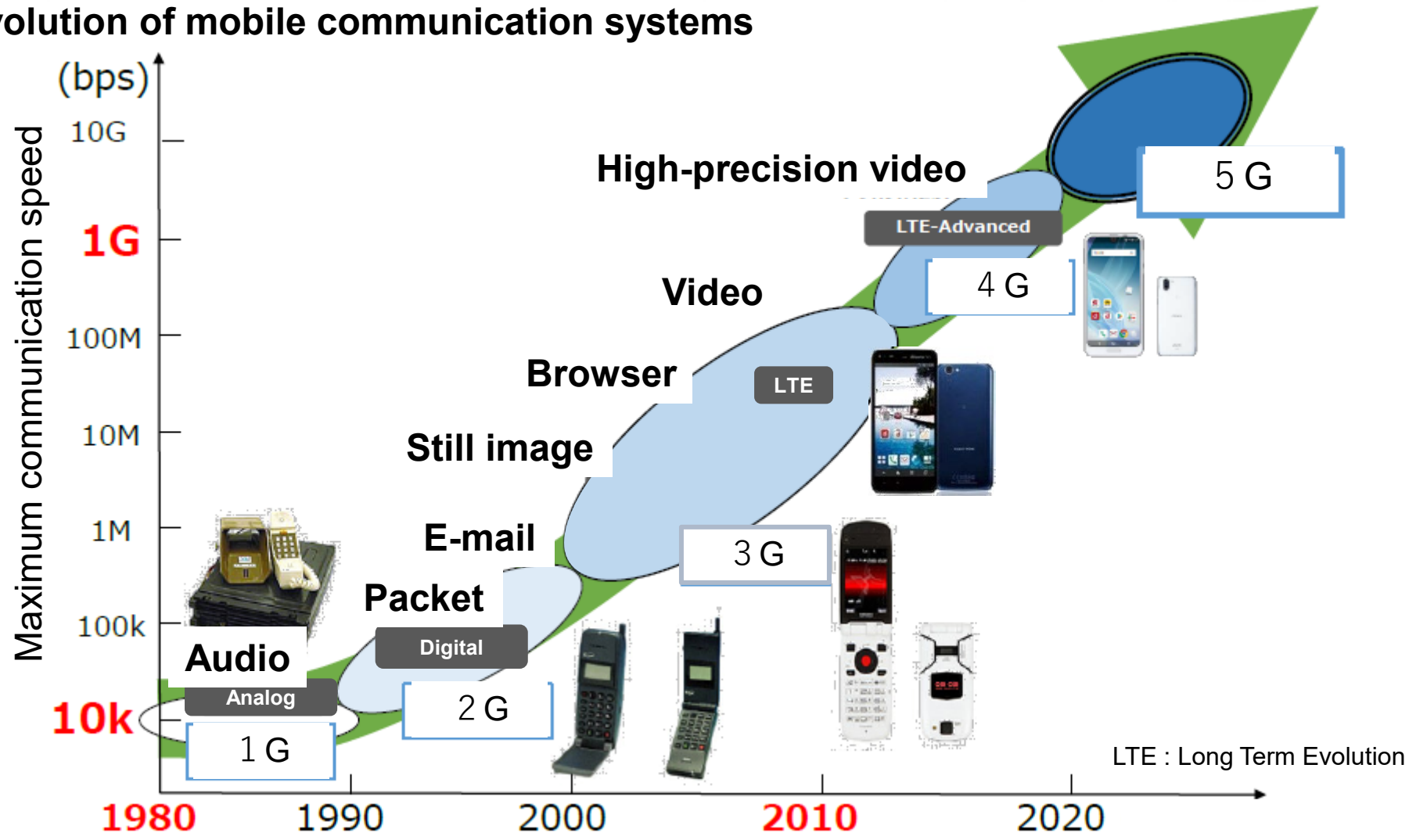
TR63307 showed that complex relative permeability and permittivity of NSS can were measured by the 6 methods at frequencies range from 1MHz to 6GHz.
The round robin test results showed that there was almost no difference between 6 measuring methods of permeability.
On the other hand, there was a slight difference between 6 measuring methods of permittivity in plane.

In the domestic WG10 committee, we discussed the different results of permittivity in plane and we thought that this issue was academic problem.

In our conclusion,
we made TR63307 that showed the 6 measuring methods of the permeability and permittivity of NSS at frequencies range from 1MHz to 6GHz.

1. Background

1.5 High frequency of information equipment (5G)

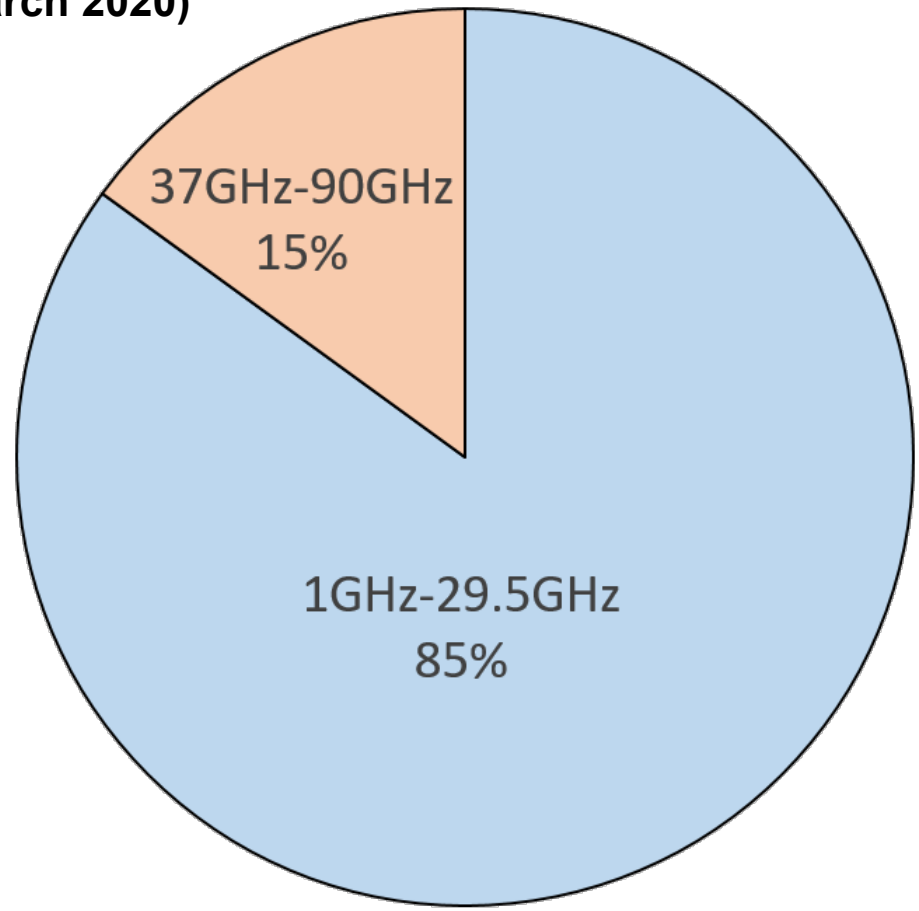


Source: https://www.soumu.go.jp/main_content/000633132.pdf

1. Background
1.5 High frequency of information equipment (5G)

Commercial situation of Mobile 5G service on Major countries and regions (March 2020)

Major countries and regions	Frequency band							
Japan			3.7GHz	4.5GHz			28GHz	
America	600MHz	2.5GHz			24GHz		28GHz	39GHz
Europe	700MHz		3.6GHz			26GHz		
China		2.6GHz	3.5GHz	4.9GHz				
Korea			3.5GHz				28GHz	
Australia			3.6GHz					



Demonstration experiment(July 2018)

Source: https://www.soumu.go.jp/johotsusintokei/whitepaper/ja/r02/pdf/n1300000.pdf

1. Background

1.5 High frequency of information equipment (5G)

Commercial situation of Mobile 5G service on Major countries and regions (March 2020)

Major countries and regions	Frequency band							
Japan			3.7GHz	4.5GHz			28GHz	
America	600MHz	2.5GHz			24GHz		28GHz	39GHz
Europe	700MHz		3.6GHz			26GHz		
China		2.6GHz	3.5GHz	4.9GHz				
Korea			3.5GHz				28GHz	
Australia			3.6GHz					

IEC TR 63307(1MHz-6GHz)
(September 2020)

This possible new work
6GHz-30GHz

Beyond5G/6G
7.125G～8.4GHz ／ 14.8G～15.35GHz ／ 92G～300GHz

Source: https://www.soumu.go.jp/johotsusintokei/whitepaper/ja/r02/pdf/n1300000.pdf

2. This new work Item (start at 2021/11 Japan)

Measuring method of permeability and permittivity of noise suppression sheets at the frequency from 6 GHz to 30 GHz

2.1 Round robin test

- ✓ **We, the WG10 Japan Committee, selected several commercially available NSSs for this round robin test.**
- ✓ **Our committee got NSS samples on December,2022.**

Samples: EFS(02)-240×240,EFS(05)-240×240,
IFL10M-100NN300×200,IFL10M-200NN300×200,

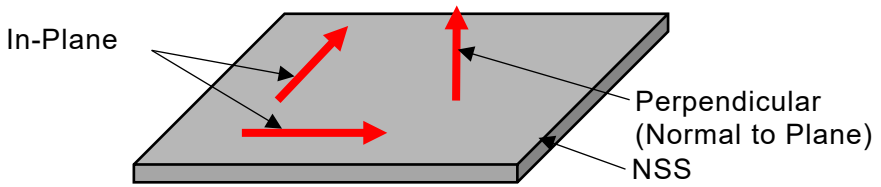
- ✓ **We investigated the quantity of NSS required for these seven measuring methods and ordered on September,2022.**
- ✓ **We finished the Round robin test on 2023.**

2.2 Measuring method

Method Name	Round robin	μ_r and ε_r				Frequency
		In-Plane		Perpendicular		10 MHz / 100 MHz / 1 GHz / 10 GHz / 100 GHz
		μ_r	ε_r	μ_r	ε_r	
1 Nicolson Ross Weir	◆	○	○			500 MHz to 18 GHz (Coaxial)
2 Nicolson Ross Weir	◆	○	○			18 GHz to 40 GHz (Waveguide)
3 Short-Circuited Micro Strip Line	◆	○				100 MHz to 18 GHz
4 Short- Circuited Coaxial Line	◆	○				10 MHz to 10 GHz
5 Shielded Loop Coil	◆	○				1 MHz to 10 GHz
6 Microstrip line type probe	◆	○				1 GHz to 40 GHz
7 Harmonic Resonator resonance cavity perturbation	◆	○				250 MHz to 35 GHz

Range of frequency (6 GHz to 30 GHz)

New joined methods (after TR63307)
The method was described by Mr. Yabukami in the WG 10 remote meeting on 2022-10-19



2.2 Measuring method

◆1 Nicolson Ross Weir (Coaxial)

500 MHz to 18 GHz

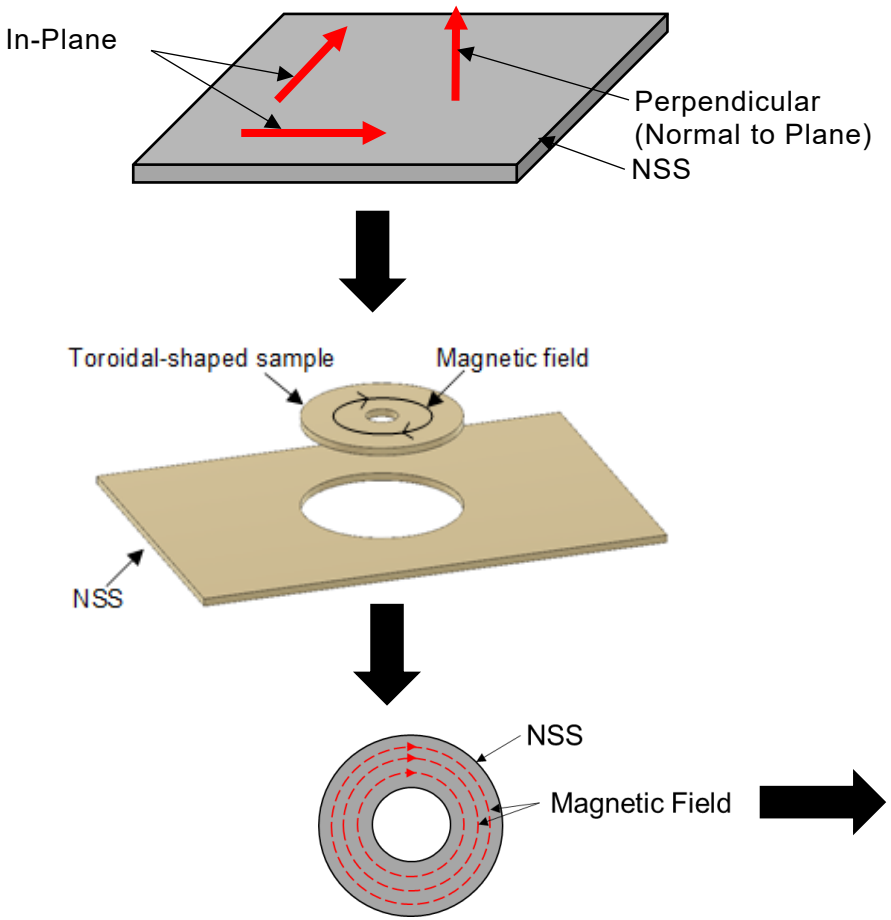


Figure – Cross section of coaxial line with NSS

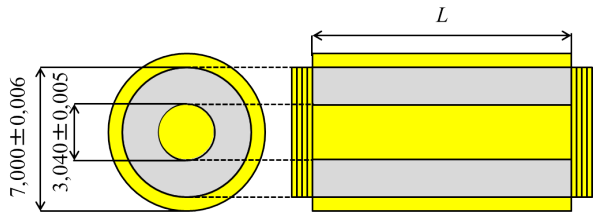


Figure – Specification for test fixture of a 7-mm coaxial transmission line

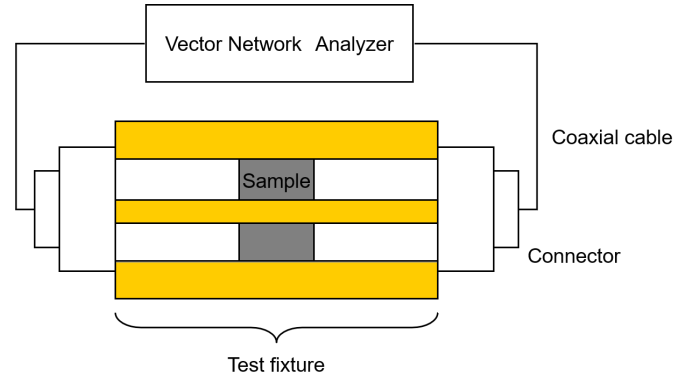


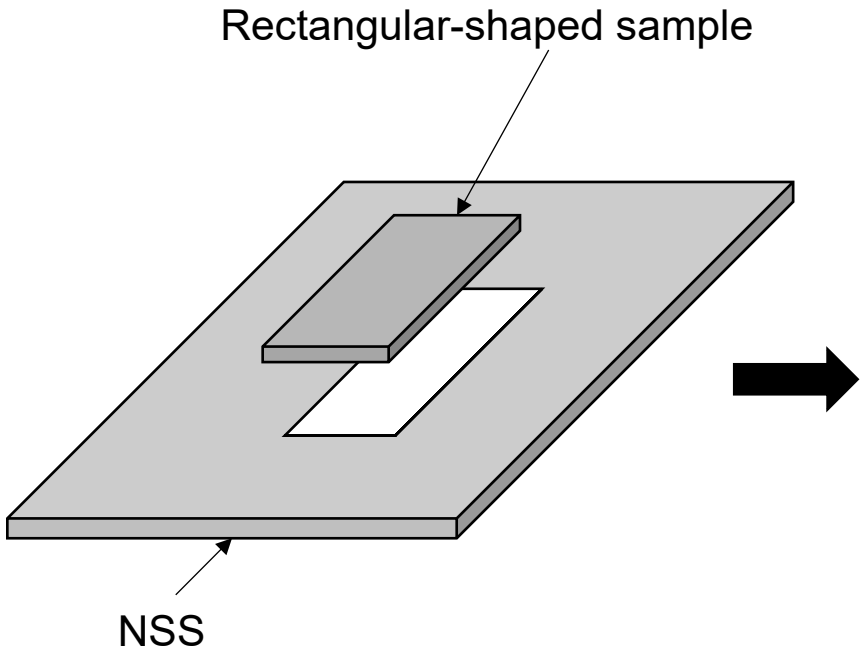
Figure – Schematic diagram of measurement system

2.2 Measuring method

◆ 2 Nicolson Ross Weir (Waveguide)

18 GHz to 40 GHz

	Range of frequency [GHz]	a [mm]	b[mm]
R220	17.6～26.7	10.668± 0.021	4.318± 0.021
R320	26.4～40.0	7.112 ±0.020	3.556 ±0.020



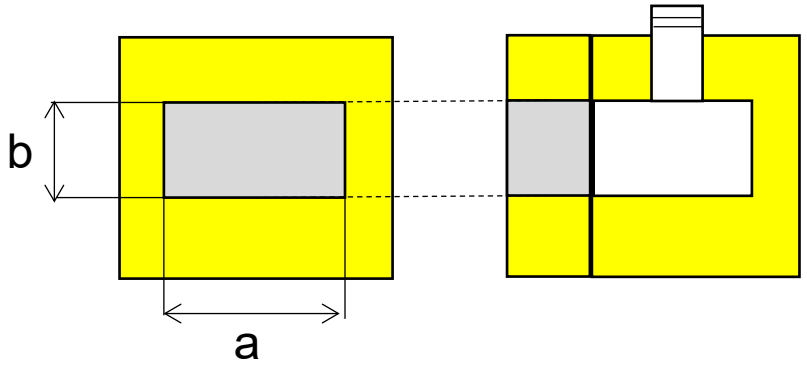


Figure – Specification for test fixture

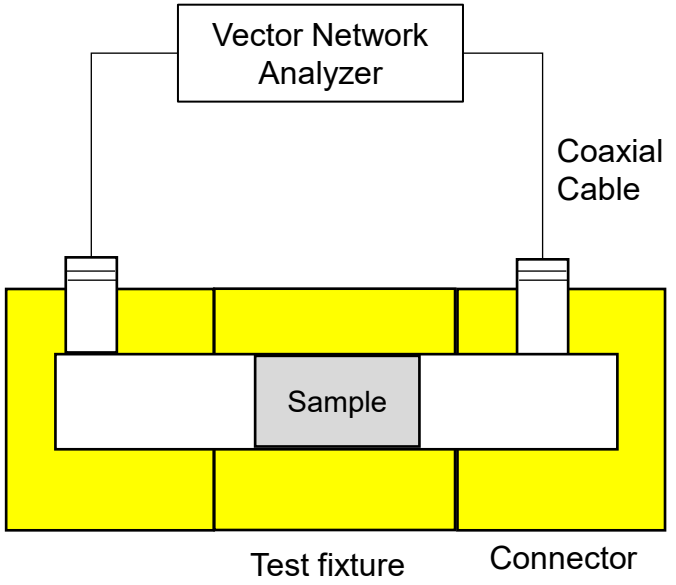


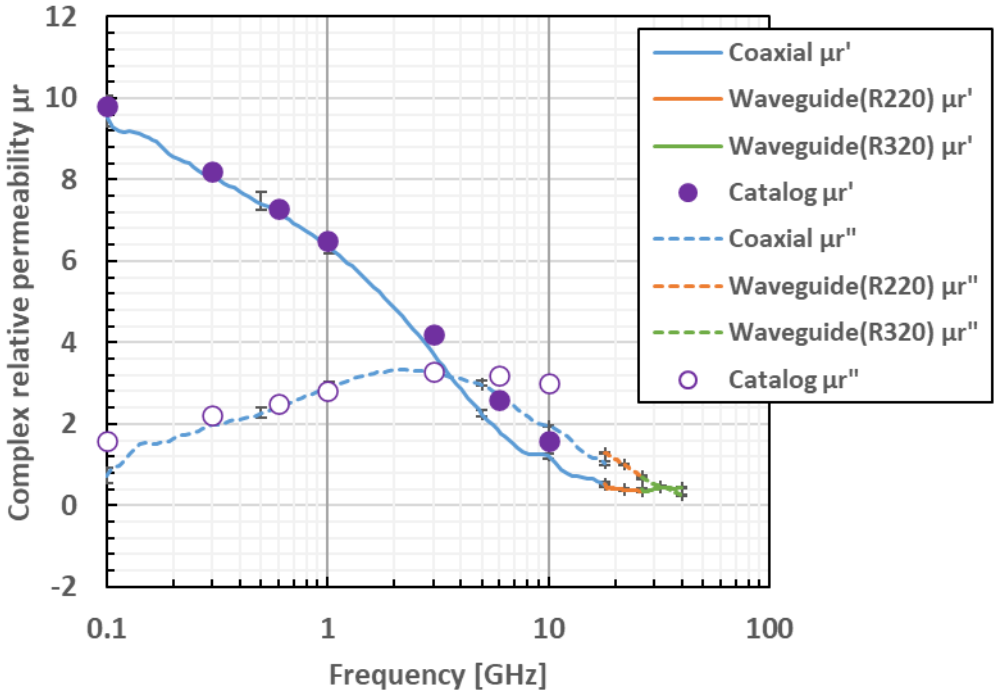
Figure – Schematic diagram of measurement system

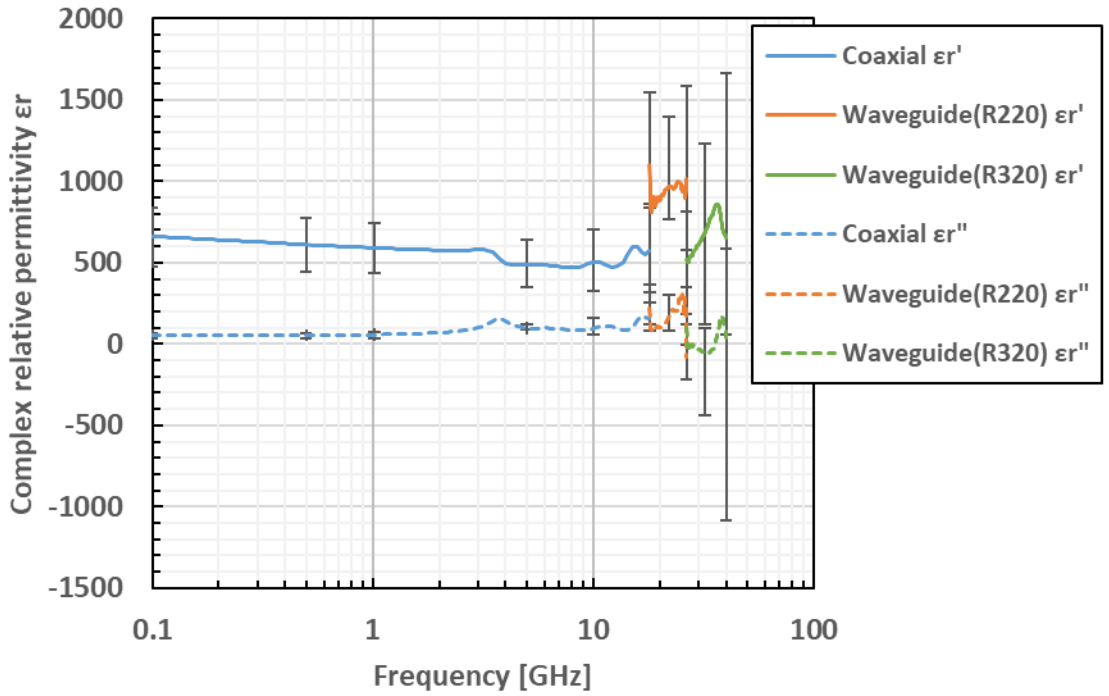
2.4 Results of Round robin test

- 1 and 2 Nicolson Ross Weir (Coaxial and Waveguide)

Sample: IFL10M (thickness: 0.2 mm)

【Results and Comparison with catalog data】





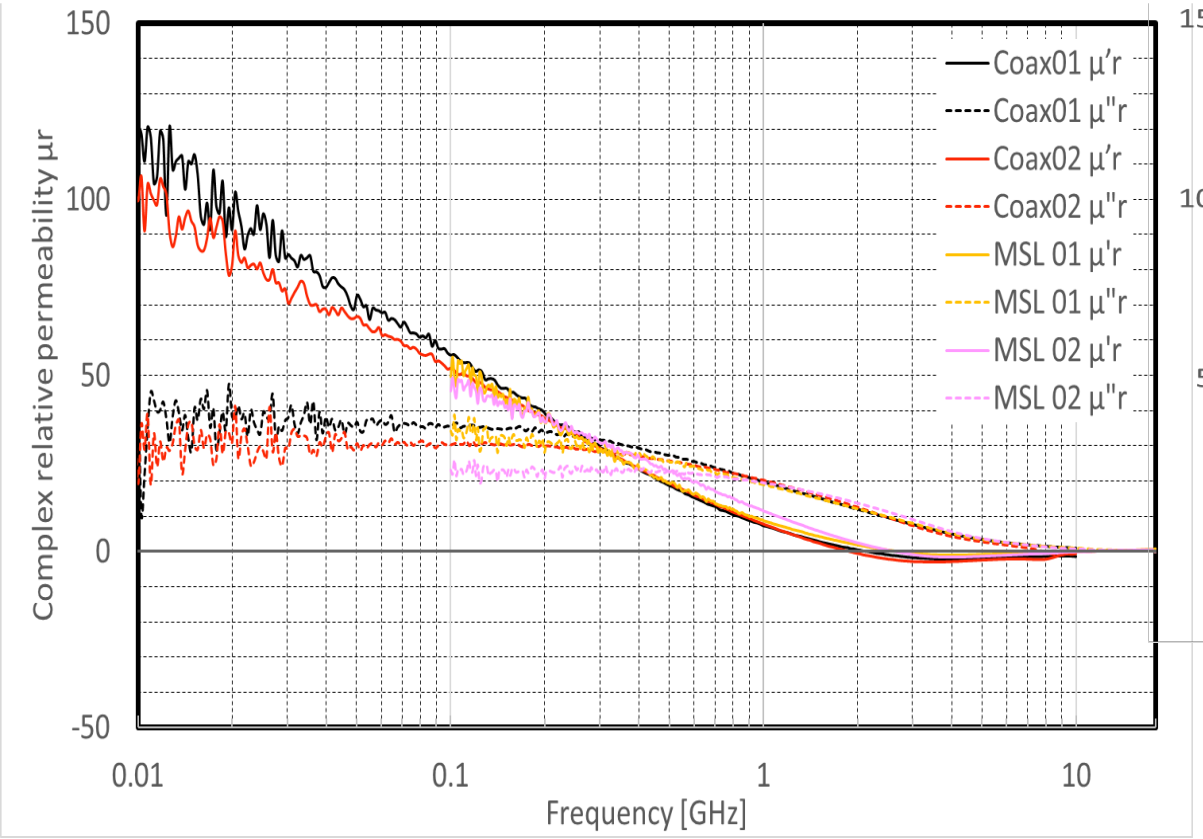
Number of sample=5, Line=average, Bar=maximum/minimum

2.4 Results of Round robin test

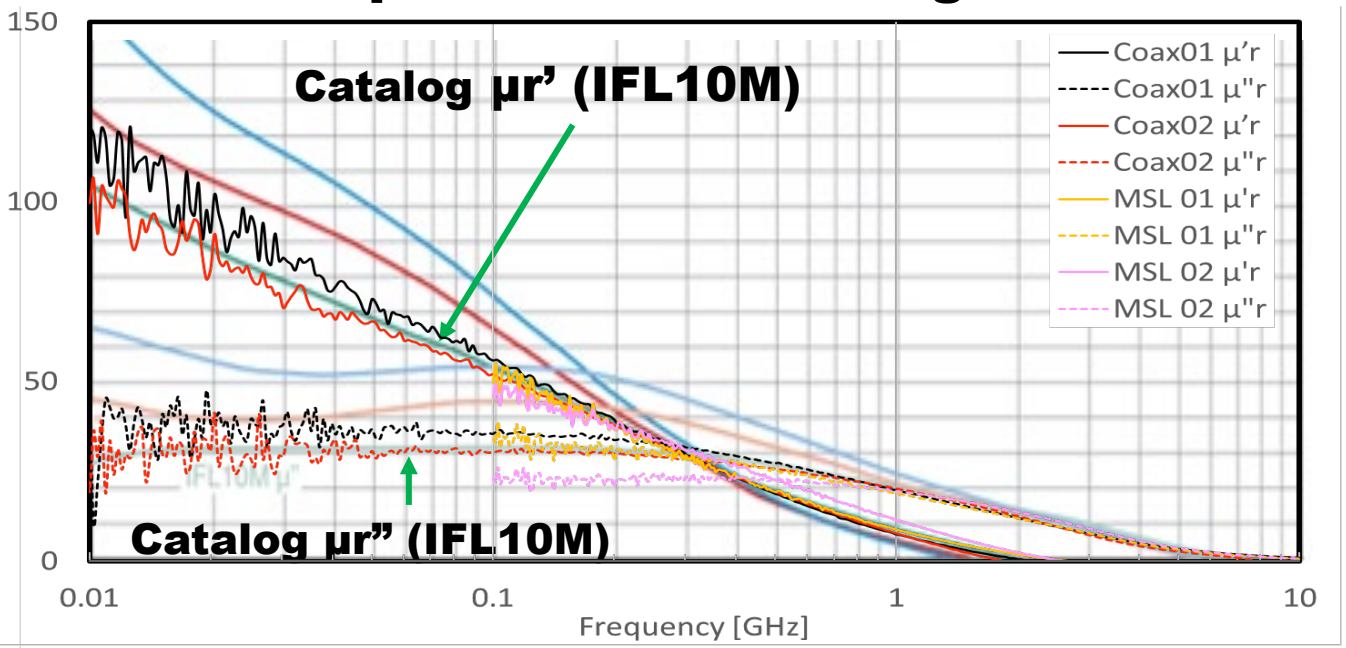
◆ **3 Short-Circuited Micro Strip Line and 4 Short- Circuited Coaxial Line**

Sample: IFL10M (thickness: 0.1mm and 0.2mm)

【Results】



【Comparison with catalog data】

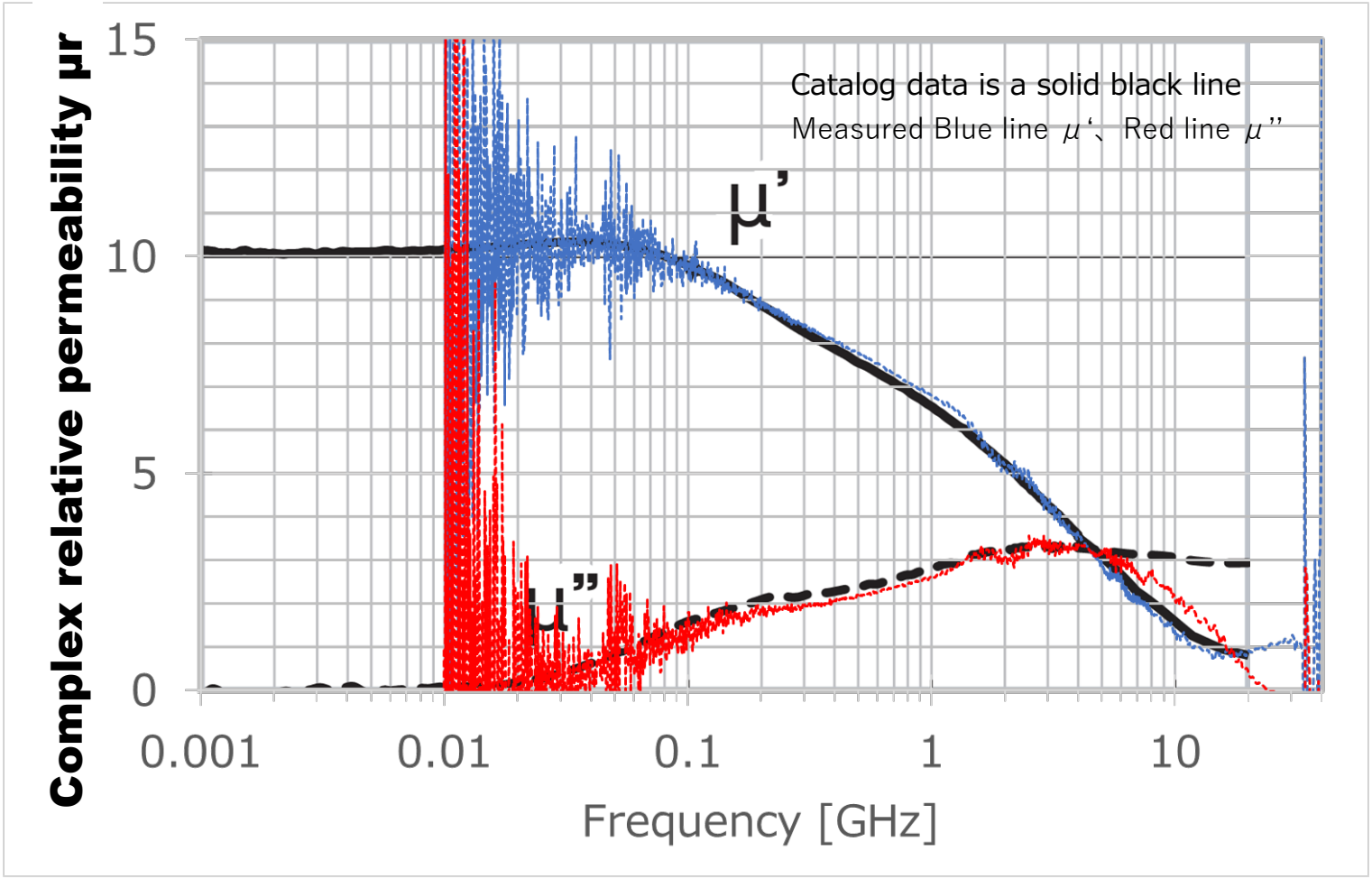


2.4 Results of Round robin test

◆ 5 Shielded Loop Coil

Sample EFS(02)

【Results and Comparison with catalog data】

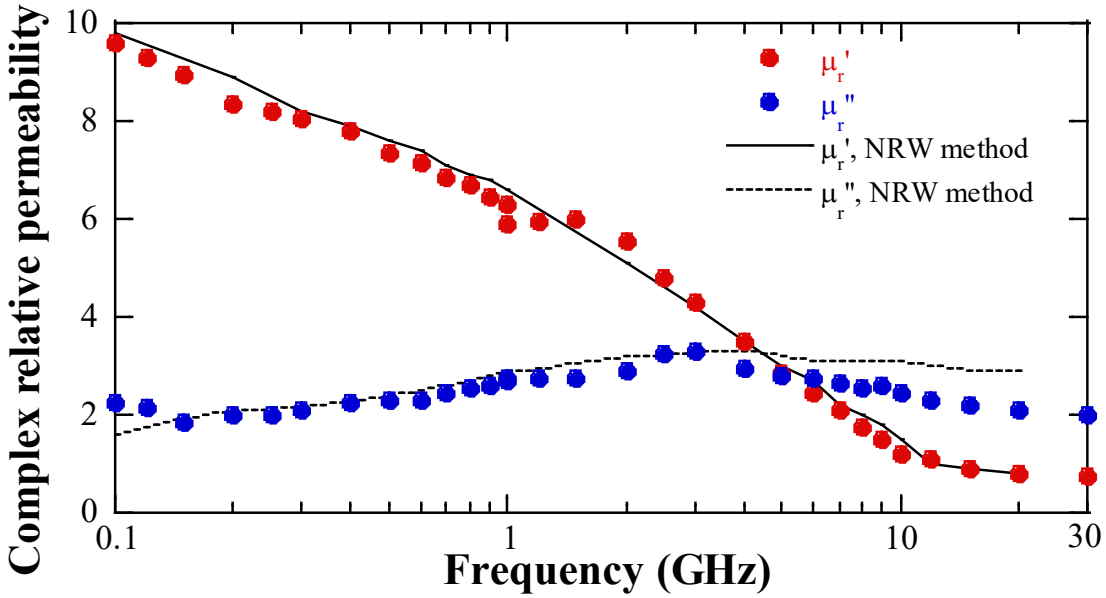


(Sample Size, Width : 0.9243 mm、Length : 20.24 mm、Thickness : 206.0 μm)

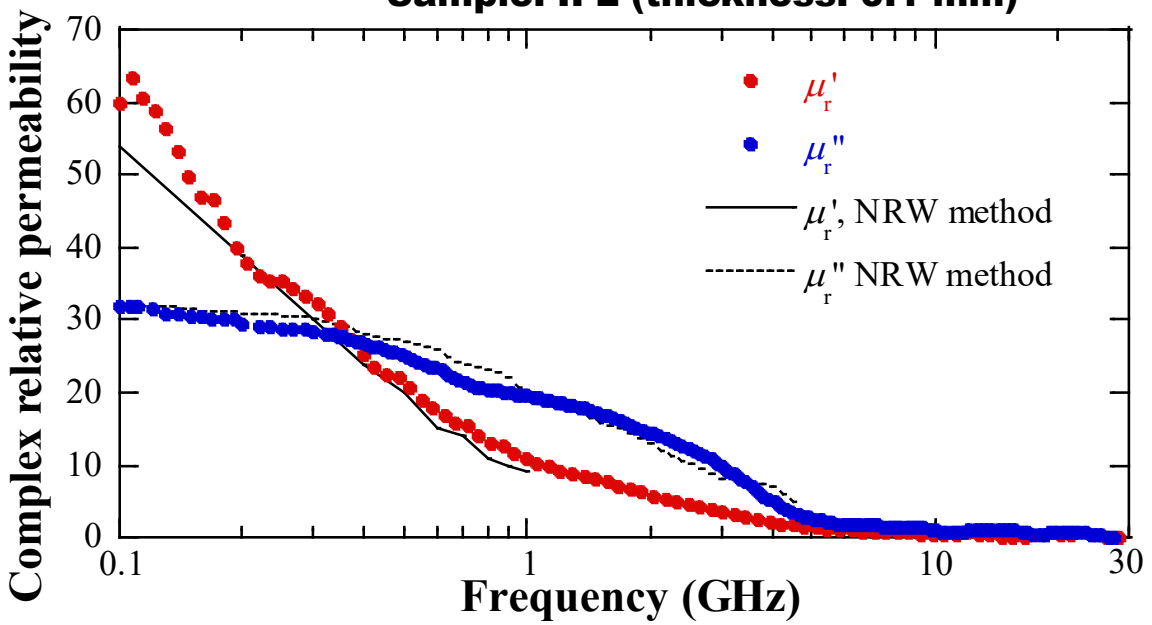
2.4 Results of Round robin test

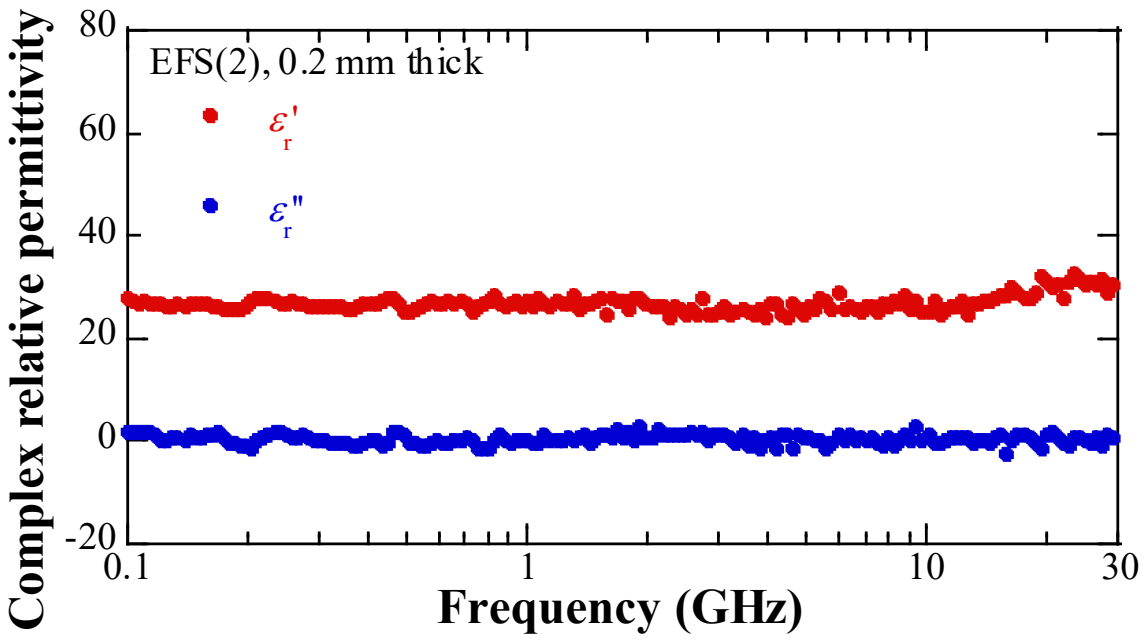
◆ 6 Microstrip line type probe

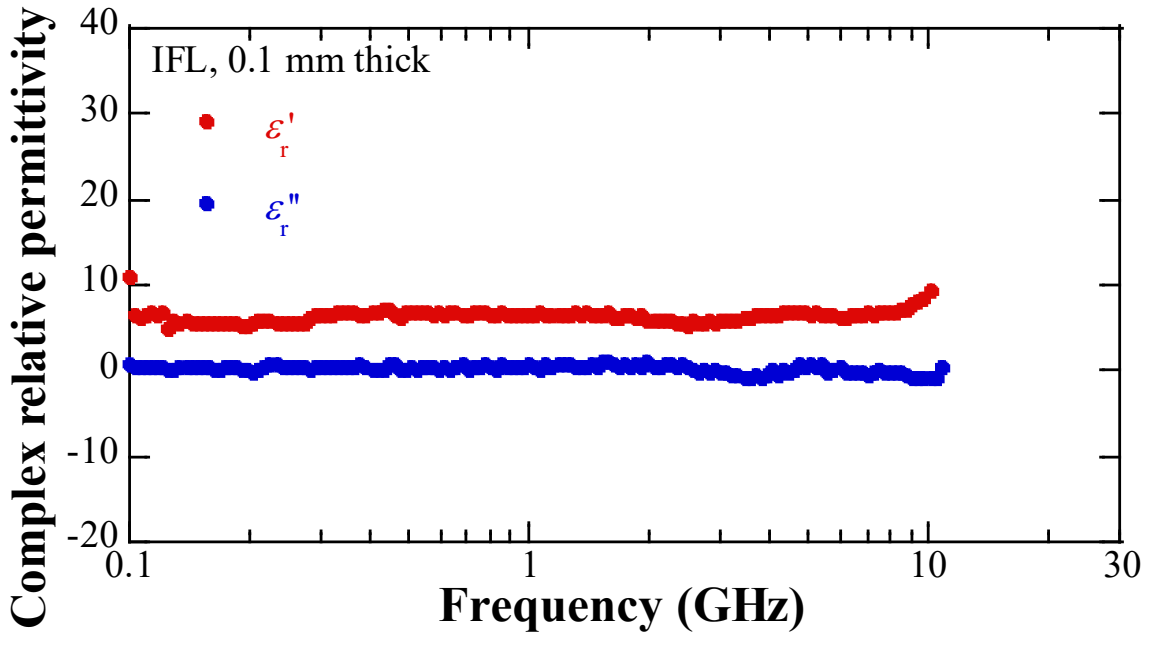
Sample: EPS02 (thickness: 0.2 mm)



Sample: IFL (thickness: 0.1 mm)





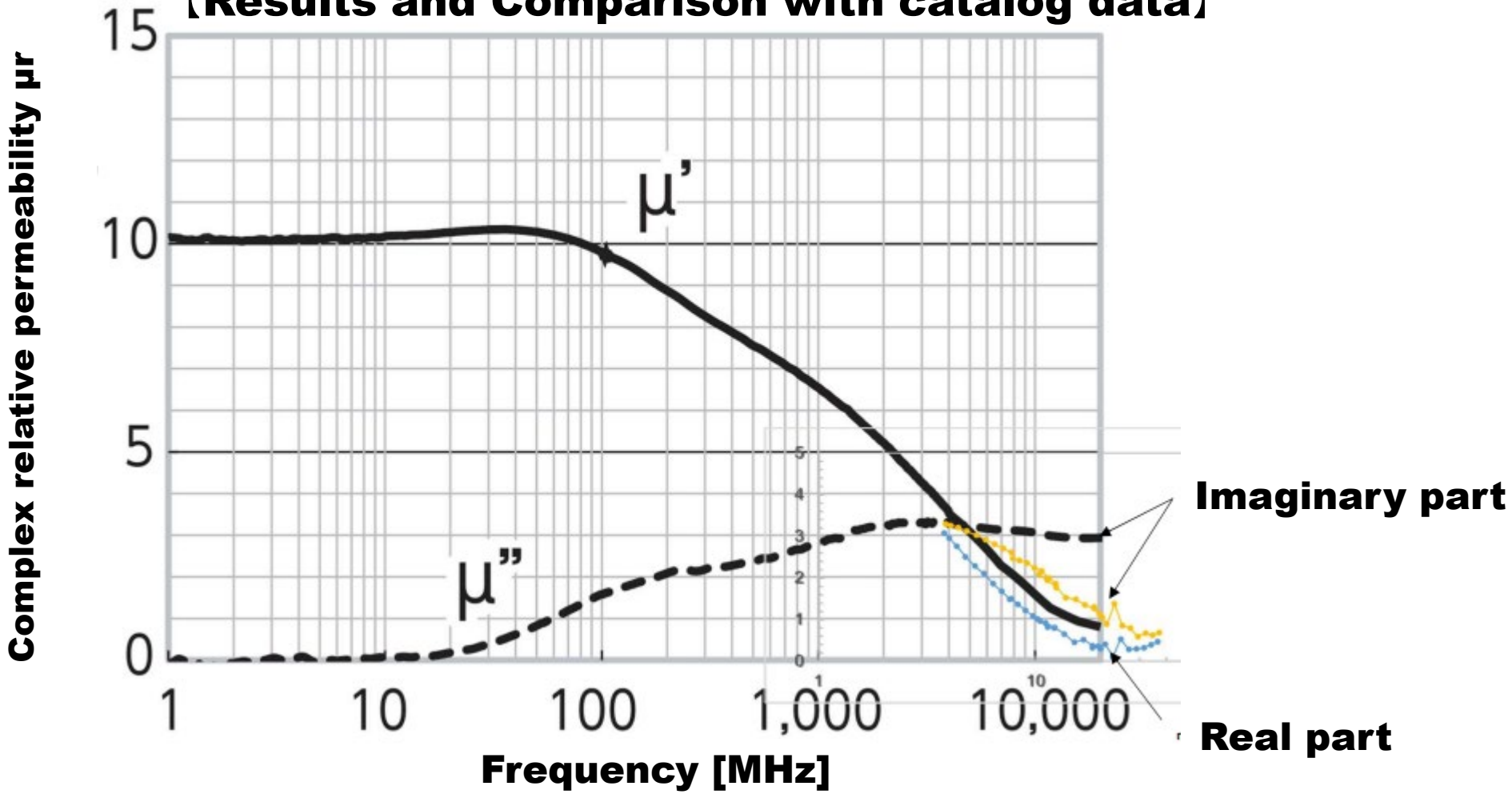


2.4 Results of Round robin test

◆ 7 Harmonic Resonator resonance cavity perturbation

Sample: EFS (thickness: 0.5 mm)

【Results and Comparison with catalog data】



2.4 Progress report Progress chart

Method Name and Frequency	1 Principle	2 Measurement frequency and accuracy	3 Measurement parameters	4 Test sample	5 Measurement environment	6 Measurement uncertainly	7 Measurement system	8 Test fixture	9 Measurement procedure	10 Example of Measurement results	11 Remarks
1 Nicolson Ross Weir **500 MHz to 18 GHz (Coaxial)**	○レ	■レ	○レ	■レ	○レ	○レ	○レ	○レ	○レ	■レ	■レ
2 Nicolson Ross Weir **18 GHz to 67 GHz (Waveguide)**	○レ	■レ	○レ	■レ	○レ	○レ	○レ	○レ	○レ	■レ	■レ
3 Short-Circuited Micro Strip Line **100 MHz to 18 GHz**	○レ	■レ	○レ	■レ	○レ	○レ	○レ	○レ	○レ	■レ	■レ
4 Short- Circuited Coaxial Line **10 MHz to 10 GHz**	○レ	■レ	○レ	■レ	○レ	○レ	○レ	○レ	○レ	■レ	■レ
5 Shielded Loop Coil **1 MHz to 10 GHz**	○レ	■レ	○レ	■レ	○レ	○レ	○レ	○レ	○レ	■レ	■レ
6 Microstrip line type probe **1 GHz to 40 GHz**	■レ	■レ	■レ	■レ	■レ	■レ	■レ	■レ	■レ	■レ	■レ
7 Harmonic Resonator resonance cavity perturbation **1,8 GHz to 36 GHz**	○	○	○	○	○	○	○	○	○	○	○

○：Availability of TR63307 :2020 ED1 sentences
■：Need to compose new sentences
レ：Checked at the WG10 Japan Committee meeting on February 7, 2025

2.5 Summary

- ✓ **We, the WG10 Japan Committee, got NSS samples on December,2022.**

  Samples: EFS(02)-240×240,EFS(05)-240×240
  (thickness: 0.2mm and 0.5mm)
  IFL10M-100NN300×200,IFL10M-200NN300×200
  (thickness: 0.1mm and 0.2mm)

- ✓ **We started the round robin test with seven measurements in December,2022.**

- ✓ **We obtained the measurement results of seven measurement methods.**

- ✓ **We start compiling the TR(Technical Report).**

Thank you for your attention.

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