Time Domain SVSWR for Compliance Site Validation Measurements Based on ANSI C63.25.1-2018

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C63.25

- C63.25.1 is the first one of a series of standards in C63 for site validation requirements
- C63.25.1 (1 – 18 GHz): its main contribution is the Time Domain Site VSWR (TD SVSWR) method as an alternative to CISPR 16 SVSWR method.
- C63.25.2 (30 – 1000 MHz) for site validation requirements currently is currently going through final reviews/vote at C63 main committee. If successful, the next step is to form a ballot group @ IEEE.
- C63.25.3 (18 GHz -) working group has been formed, and working on a first draft

What is new?

- C63.25.1-2018 is an active standard, which can be obtained from IEEE Xplore
- FCC has tentatively proposed rulemaking to adopt C63.25.1 on Jan. 6, 2022.

C63.25.1-2018 - American National Standard Validation Methods for Radiated Emission Test Sites, 1 GHz to 18 GHz

Status: Active - Approved

Abstract | Keywords | Versions

Abstract:
This standard specifies methods for the validation of test sites used for radiated emission measurements in the frequency range of 1 GHz to 18 GHz.

Purpose:
The purpose of this standard is to describe validation methods of test sites used for radiated emissions measurements in the 1 GHz to 18 GHz frequency range as required by ASC C63® standards. The site validation requirements described in this document are applicable to fully anechoic rooms (FAR) and open area test sites (OATS) as well as semi-anechoic chambers (SAC) that are configured with absorber on the ground plane. NOTE--Site validation methods for frequencies above 18 GHz are outside the scope of this standard. Concerning site validation for 18 GHz to 40 GHz, the following text from 5.5.1 of ANSI C63.4-2014 [B4]2 gives an example provision from other ASC C63® standards: "There are no test site validation requirements applicable to the frequency range of 18 GHz to 40 GHz. A test site that satisfies the requirements stated in this subclause from 1 GHz to 18 GHz is deemed to be suitable for use over the frequency range of 18 GHz to 40 GHz."

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Persistent Link: https://ieeexplore.ieee.org/servlet/opac?punumber=8675709
More »

Publisher: IEEE

C63.25.1 – why another VSWR method?

- TD SVSWR Method provides equivalent results as the CISPR SVSWR. C63.25.1 has provisions to use either method.
- The TD SVSWR method has several advantages:
  - Much more repeatable/reproduceable
  - Requiring much reduced time to perform the validation above 1 GHz
  - Debugging - giving an indication of where the site may be deficient and thus allowing the use of corrective measures to bring the site into compliance

Background

- SVSWR is required to qualify an anechoic EMC chamber for >1 GHz
- It is specified in international standard CISPR 16-1-4
- The concept is based on moving an omnidirectional antenna along a line to sample the standing wave in a chamber
- The antenna in the QZ must be an omni-directional antenna to illuminate the chamber

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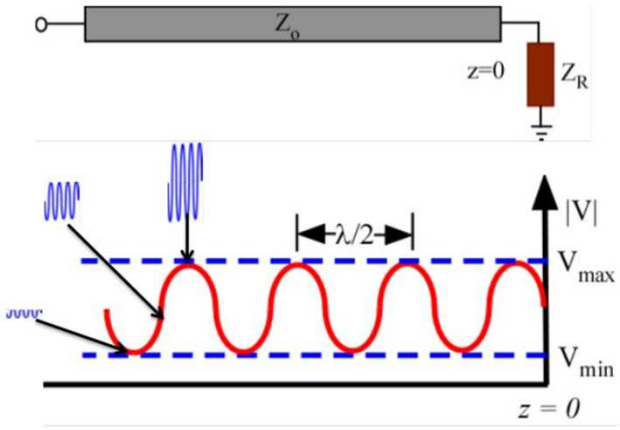
Similar to Standing Wave on a Transmission Line



*picture from U of Illinois online course ECE451
http://slideplayer.com/slide/6379625/

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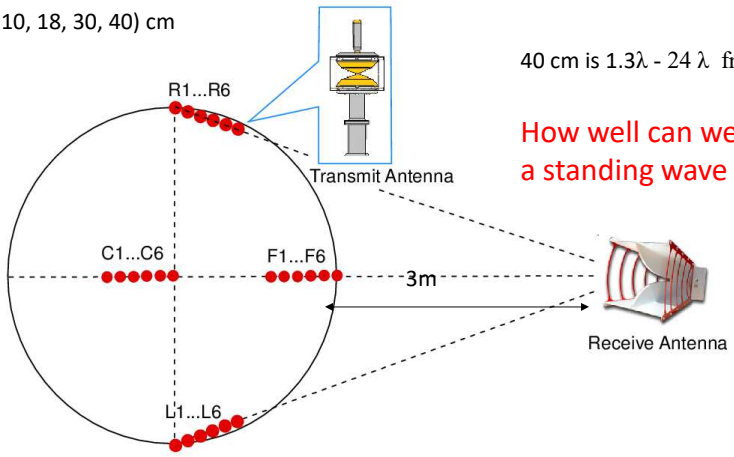
CISPR SVSWR Test Setup

(0, 2, 10, 18, 30, 40) cm



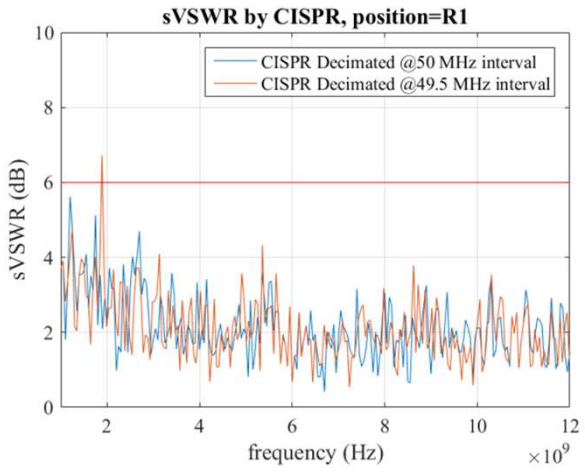
40 cm is 1.3λ - 24 λ from 1 – 18 GHz

How well can we sample a standing wave with 6 points?

Compromises in the CISPR SVSWR

- In order to reduce test complexity and time, several (over) simplifications are made
  - The travel length is limited to 40 cm
  - 6 (irregularly positioned in order to break harmonic relations) measurement points along the line are sampled
  - Minimum frequency step is 50 MHz
- These compromises made SVSWR less accurate, and repeatability is a major concern

Example of Repeatability



- Even changing frequency steps can have a major impact on SVSWR results
- Positioning accuracy – A change in mm can change the peak!

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C63.25.1 TD SVSWR

- Measurement setup is largely the same as CISPR, with one notable difference:
  - No need to move the receive antenna to 6 spots to try to catch max or min.
  - Data is acquired at only **ONE** of the six points.
- Vector frequency response is obtained. Time domain results are obtained from inverse Fourier Transform. Gating is used to measure the VSWR of the chamber
- A close correlation between the TD SVSWR and CISPR method SVSWR is maintained
- C63.25.1 TD method adopts a “sophisticated” post process to maintain “severity” to the existing standards

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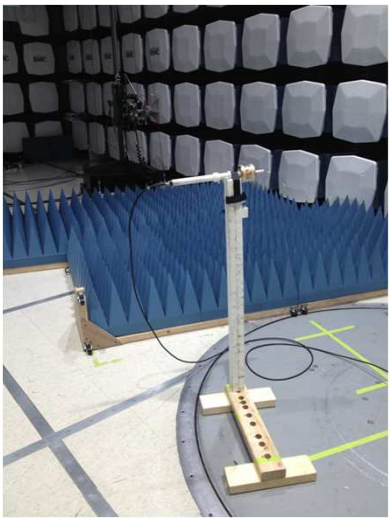
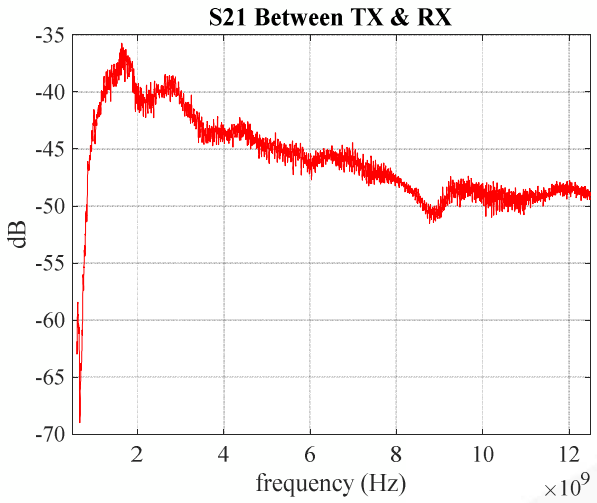
Illustration of the Test Method





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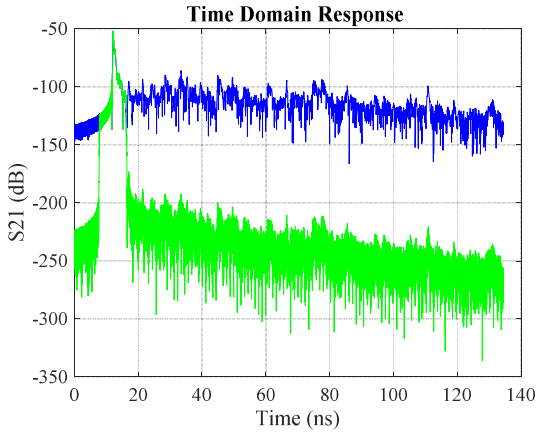
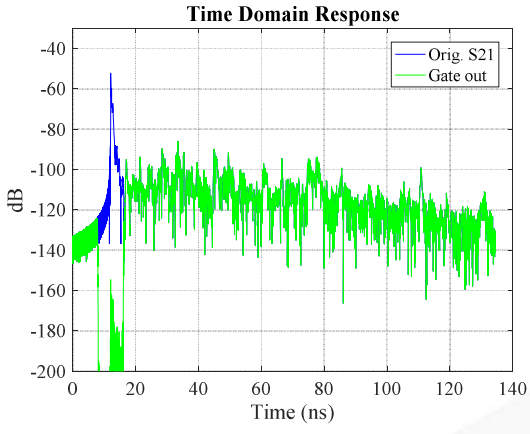
Frequency ->Time Domain (Inverse Fourier Transform)



Gate In – Keeping main response only



Gate out – Nulling out main response

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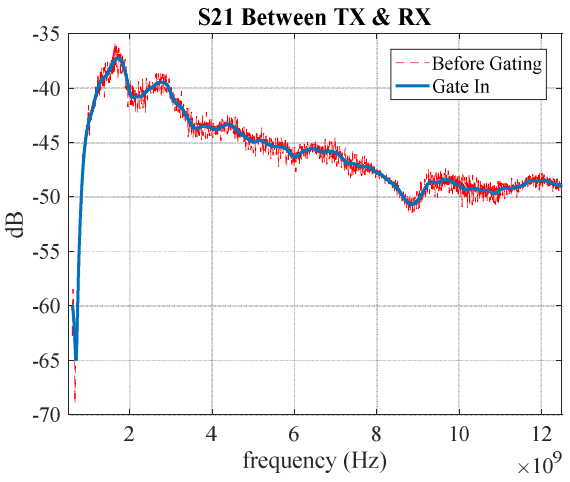
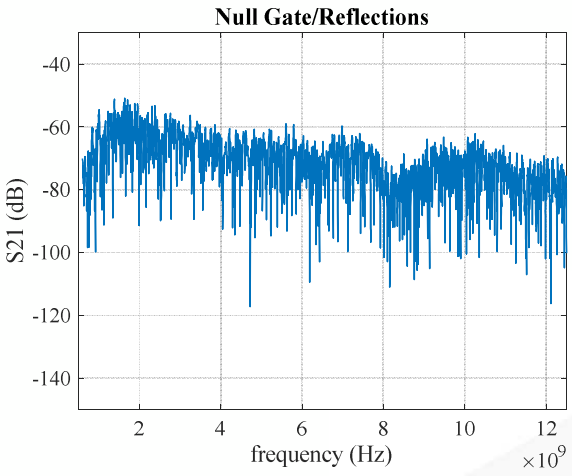
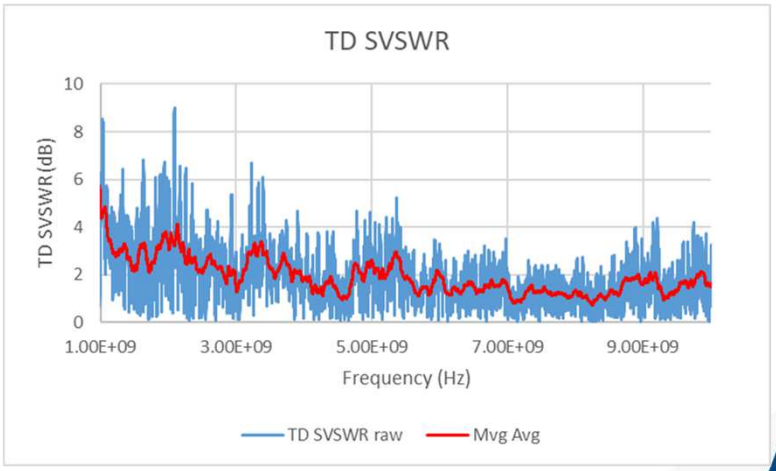
Back to Frequency Domain



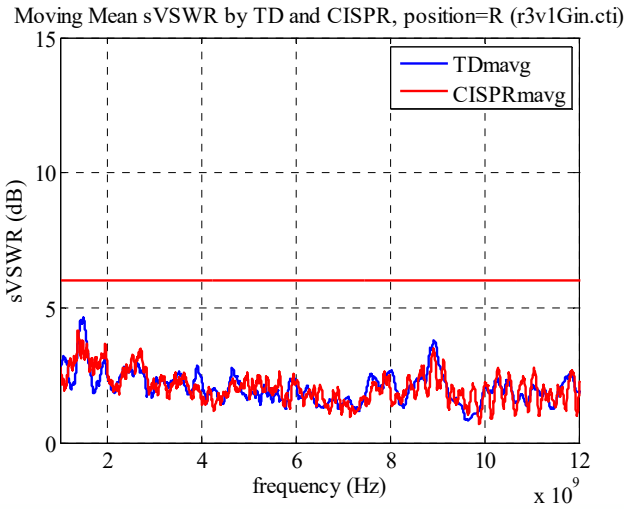


Calculate SVSWR

- In frequency domain, reflection coefficient
- $\rho = \frac{\text{Gate Out}}{\text{Gate In}}$
- $\text{SVSWR} = \frac{1+|\rho|}{1-|\rho|}$



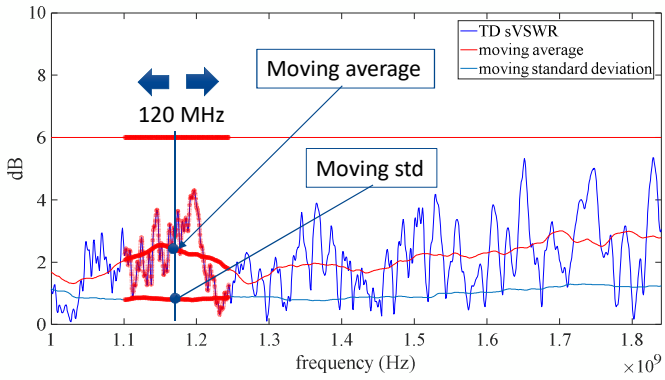
On average: TD SVSWR correlates to CISPR SVSWR



Processing the data – Equiv. “Severity”

- The TD SVSWR data looks rather “erratic”
- Experienced user will notice the TD SVSWR can be more “pessimistic” than the traditional site VSWR data
- The reason is because of the undersampling in the traditional SVSWR method
- A post processing of TD SVSWR is needed to correlate to the traditional VSWR

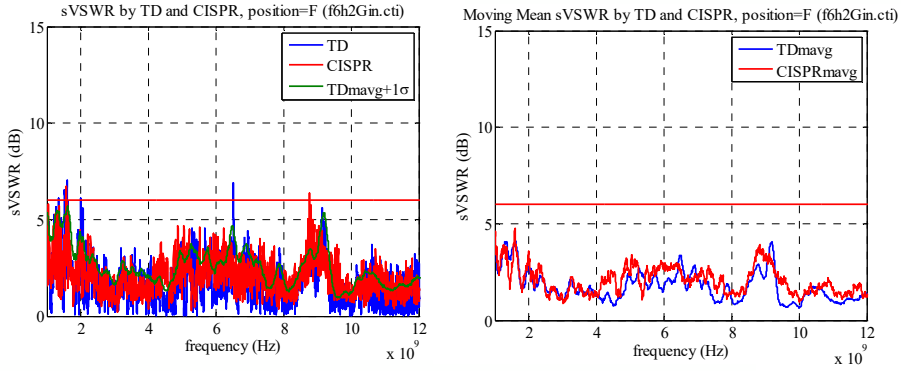
Sliding Window



The final reported TD SVSWR

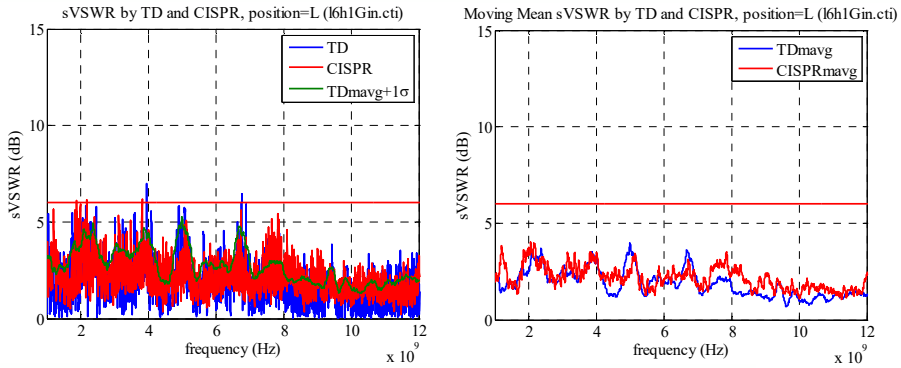
- $Final\ TD\ SVSWR = moving\ average + 0.676\ \sigma$
- Moving average is determined from 120 MHz moving window
- σ is the standard deviation of the (TD-moving average) in the same 120MHz window
- Essentially the post processing includes 75% of the SVSWR. This is needed so the severity of TD method matches the severity of the CISPR SVSWR.

Example Data: Front 2mH



the two methods show close correlation

Chamber : Left 1mH



The process can be automated

- Scripts are available to download
  - http://standards.ieee.org/downloads/C63/
- Scripts/functions from Rohde & Schwarz, Keysight and other manufacturers (e.g., CMT) which can automate the process. Results is shown in real time with a single button push
- Excel examples can be downloaded for manual processing

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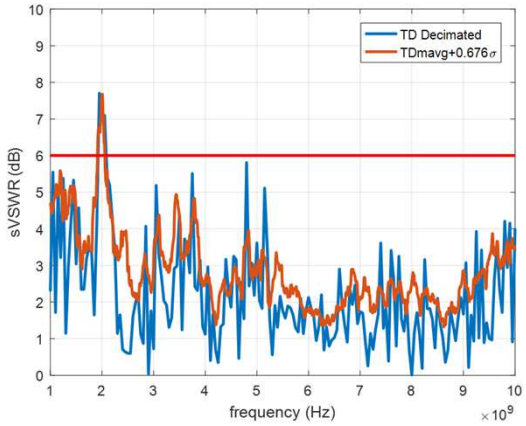
Bonus feature: Debugging a Chamber



YouTube

ETS-Lindgren Time Domain Demonstration
https://www.youtube.com/watch?v=x1o22_JW28U&t=2484s

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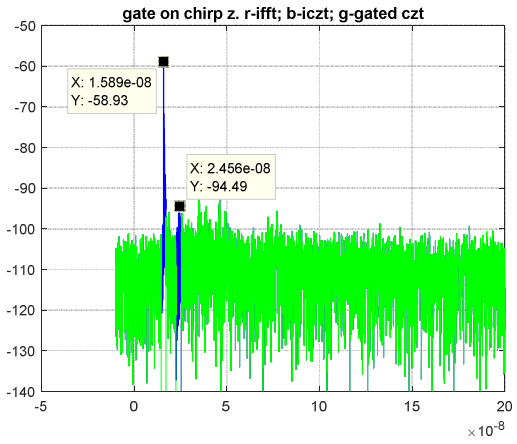
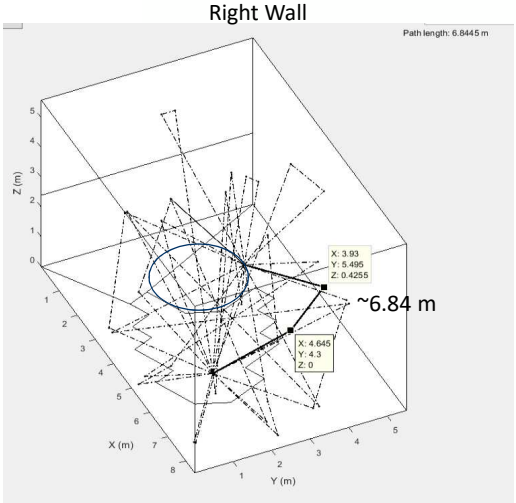
Getting the corresponding reflection distance

Difference = 24.56ns – 15.89ns
= 8.67 ns
~ 8.67 ft
= 2.643 m
Total reflection path length,
T = 4.1 + 2.643 = **6.743** m

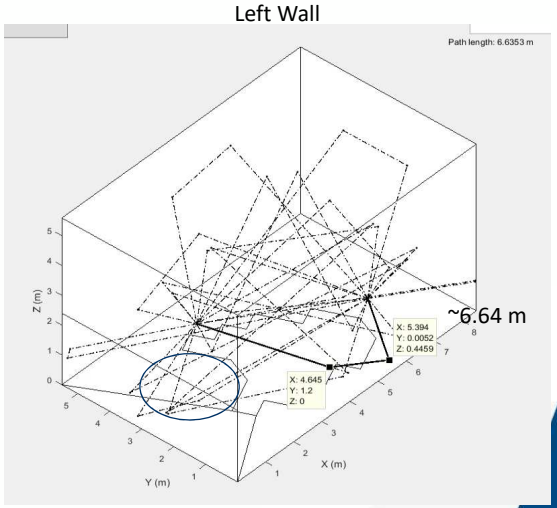


Finding the right reflection

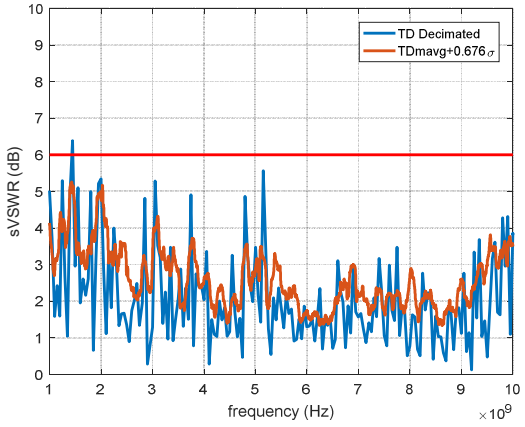
Right Wall



Left Wall



TD SVSWR after Adding Absorbers @ Right wall



Summary

- C63.25.1 TD SVSWR and CISPR SVSWR produce equivalent results
- C63.25.1 method is less erratic.
- **Catch the peak in sVSWR feels like finding a needle in a haystack**. The nature of the data makes it more suitable to judge the results using statistical metrics. Otherwise, the resulting sVSWR could be sensitive to small antenna displacement, or a slight frequency step change (for example using a 49.9 MHz step vs. a 50 MHz step).

Why would one consider using the TD SVSWR?

- FCC has officially proposed to incorporate C63.25.1. Official NPRM is to be published soon, which will trigger a 30 day comment period.
- TD method produces equivalent SVSWR results – not identical!
- Better repeatability. Results are much more immune to small variations in antenna positioning or frequency shift.
- Much faster – instantaneous results
- Bounded and predictable measurement uncertainties, and more mathematically rigorous.
- Less uncertainties without the need to move antenna, or to upset the cable positions between measurements
- Provide clues to debug a failed chamber

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