IEEE STD 1128-1998: IEEE Recommended Practice for RF Absorber Evaluation in the Range of 30 MHz to 5 GHz

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What is IEEE STD 1128

- Recommended Practice for absorber evaluation
- Current Structure:
  - Instrumentations: Spectrum analyzers, Network analyzers, vector voltage meter, and EMC antennas
  - Material bulk-parameter evaluation: measuring permittivity and permeability
  - Absorber reflectivity: Arch, TEM horn TD method, waveguide, coaxial reflectometer

The need for the absorber standard

- Typically users are interested in the final chamber performance. Why should they care about individual absorber RF performances?
  - Chamber performance shows macro level absorber performance. It is important for chamber designers to understand absorber material and performance to design the best chambers
  - MIL-STD 461 chambers defines absorber reflectivity specs, with no chamber level testing
  - It is important to have industry-wide common practice for absorber evaluations

Why update?

- Keeping up with industry's demand for higher frequency ranges.
- New test methods
- New instrumentations
- Need guidance on applications of absorber in high power applications

Background

- Initial ad hoc meeting was held in conjunction with IEEE EMC Symposium
  - 8-20-2015 Dresden, Germany
  - Meets have been held at AMTA and IEEE EMC symposium every year.
- Current working group has approximately 20 members
  - Anyone interested in absorber testing can join!

Current document

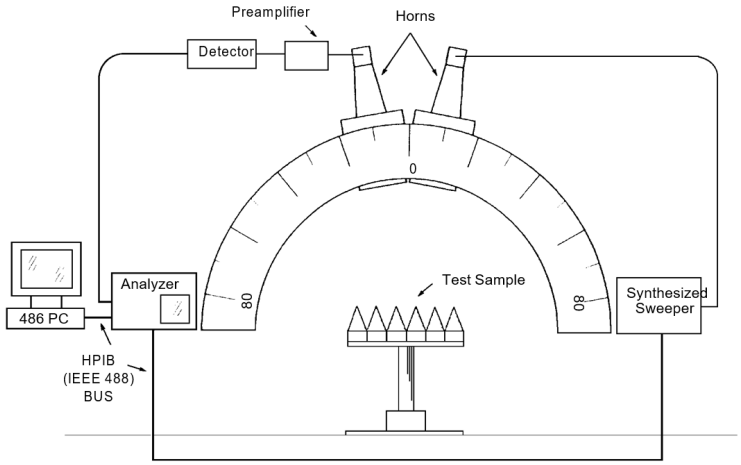
- **Description:** Realistic and repeatable criteria, as well as recommended test methods, for characterizing the absorption properties of typical anechoic chamber linings applied to a metallic surface are described. Parameters and test procedures are described for the evaluation of RF absorbers to be used for radiated emissions and radiated susceptibility testing of electronic products, in the absorber manufacturer and/or absorber user environment, over the frequency range of 30 MHz to 5 GHz.

Areas of interest for update

- Frequency range 30 MHz – 5 GHz
  - 40 GHz
  - >40 GHz considerations
- Terms
- Instrumentations
- Structure of the document. Absorber reflectivity measurements in Chapter 7. Move contents to annexes?
- Measurement uncertainties

- Material property measurements (chapter 6)
- Absorber measurement (chapter 7)
- Chamber qualification (chapter 8)
- Power handling of absorbers
- Fire properties and standards compliance

Examples of Absorber Testing Methods

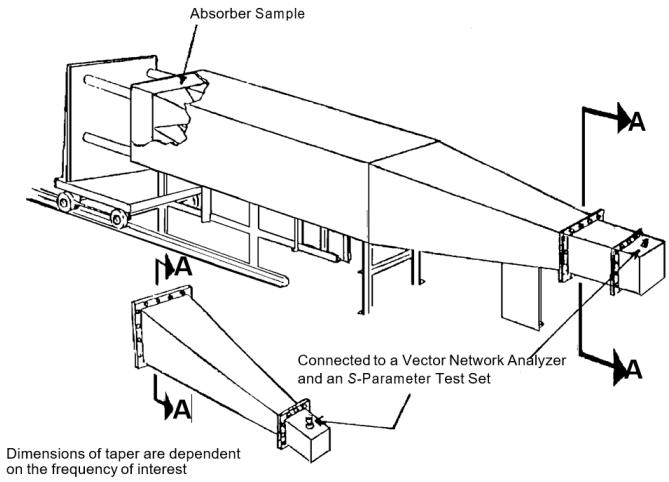


NRL Arch Test Setup

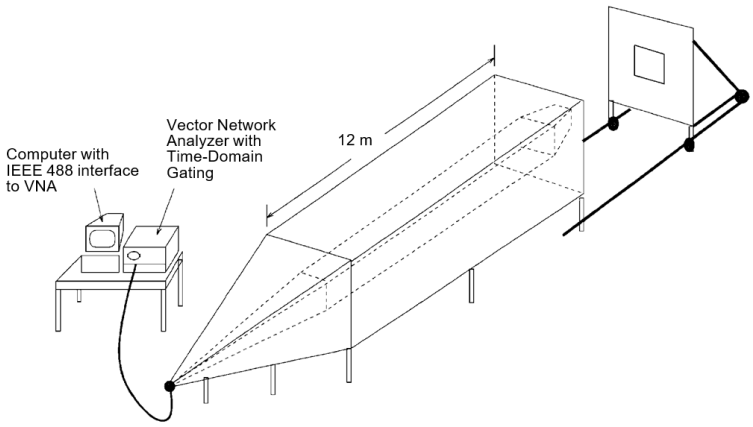
NRL arch Method

- The predominant method to evaluate absorber > 1 GHz
- Limited by the test distance, arch can get exceedingly large, e.g., 30’ in radius
  - $R = \frac{2D^2}{\lambda}$
- Sample absorber sizes: up to 30 (2’x2’) samples are needed to perform reflectivity tests of absorbers
- IEEE 1128: “sample sizes of less than 20 should not be considered if one wishes to measure 50 dB reflection coefficients”

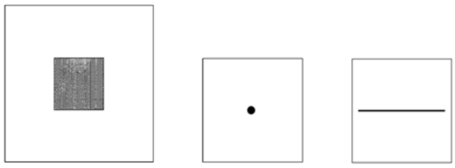
Flared Waveguide Method



Coaxial Reflectometer



Cross-section of coaxial line



- Design 1 is the most recommended because characteristic impedance is close to 50 ohm, and higher order mode start at higher frequencies.
- Time domain gating is used to isolate reflections
- Long coax lines are needed for gating (e.g., 25')
- Challenges: low frequency edge effects from gating

PAR 1128

- a PAR was officially approved by IEEE on March 3, 2017. It was amended in September 2017 to include APS as a co-sponsor to the IEEE EMC Society
- There are significant interests expressed by EMC and antenna measurement society members
- Working group members consist of over 20 people and a diverse group from absorber manufacturers, antenna measurement equipment providers, end users, and general interests.

7 Task Groups

1. Power Handling of Absorbers
2. Measurement Techniques
   1. Coaxial/waveguide reflectometer
   2. NRL Arch Method
3. Measurement Uncertainties
4. Instrumentation
5. Material properties measurements
6. Applications of absorbers in chamber, including Free-space VSWR, NSA, Site VSWR etc.
7. Editorial group

Summary

- Not only important for absorber manufactures, but all users of absorbers.
- Working group has been formed to update the recommended practice for absorber evaluation from 1998 edition.
- 7 task groups are formed to update the areas including testing method, material properties, instrumentation, measurement uncertainties. Adding high power applications as a new section.
- Work is just starting. If you are interested, IEEE 1128 is an open group!

ANSI C63.25.1 Validation Methods for Radiated Emission Test Sites

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Two documents to cover site validations

- C63.25.1 (> 1000 MHz). The main contribution is Time Domain Site VSWR method as an alternative to CISPR 16 SVSWR method
- C63.25.2 (30 – 1000 MHz) to include a stand-alone NSA. Moving any site validation requirements in C63.4/C63.4a and C63.5 to this document

Background

- The CISPR technique for site validation above 1 GHz (CISPR 16-1-4:2012-07), called the Site-VSWR (SVSWR) approach, is referenced C63.25.1
- The alternative approach to test site validation is the time domain method detailed in C63.25.1. The user will now have the ability to select the option of choosing among the two techniques.
- Because the time domain approach is relatively new and as yet to be adopted universally, detailed specifics of how to perform the measurement will be provided in C63.25.1
- Scope in C63.25.1:
- *This standard provides methods of measurement requirements for the validation of radiated emission test sites in the frequency range of 1 GHz to 18 GHz. These requirements are applicable to fully anechoic rooms (FAR) and when spectrally treated on the floor open-area test sites (OATS), fully- and partially-covered OATS, semi-anechoic chambers (SAC).*

TD SVSWR in C63.25.1

- TD SVSWR Method is equivalent to measure SVSWR. This is used as an alternative to CISPR SVSWR.
- The TD SVSWR method has several useful features:
  - such as requiring less time to perform the validation above 1 GHz
  - giving an indication of where the site may be deficient and thus allowing the use of corrective measures to bring the site into compliance

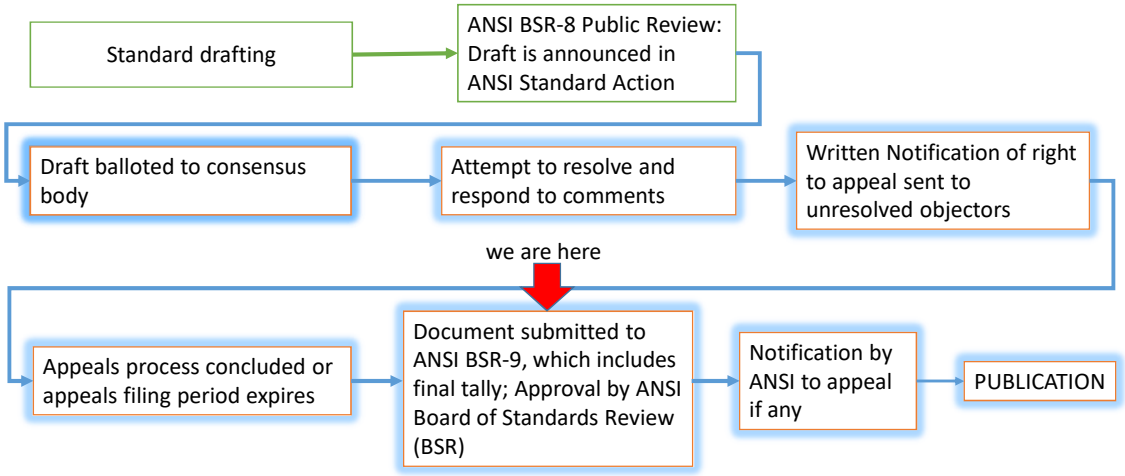
Current Status for publication

- Draft Standard has been circulated in the ANSI ASC C63 main committee, and all technical comments have been addressed.
- The C63.25-1 (Site > 1 GHz) has passed the public comment period, and is current in the process of being published (BSR-9)

Timeline

- A ballot group was called and formed in April 2018.
- The document went into balloting in May 2018, which is a 30 day Voting Period
- Comments received. C63.25.1 WG updated to resolve comments
- C63.25 has gone through MEC
- ANSI posted the standard for public comments (BSR-8), and none received
- BSR-9: Prepare for publication

ANSI Procedures



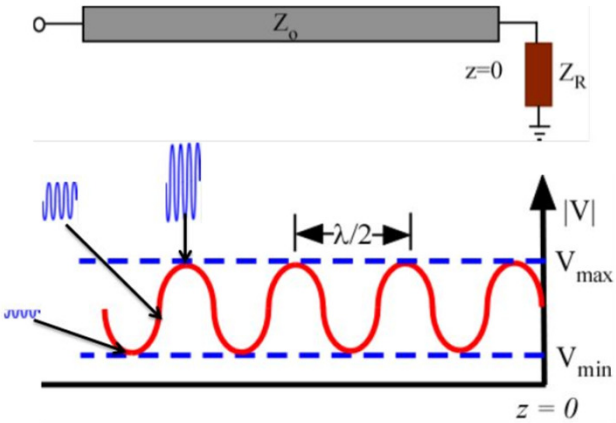
Voting Process

- Only votes that count towards approval of the document are those of the eligible members of the balloting group
- Consensus - According to ANSI rules, consensus is defined as a > 50% return of ballots from the balloting group, and a 66.7% approval rate from that 50% return group.
- Any negative comments must be responded to. Once consensus is achieved, the document can go to publication
- It is difficult to estimate the publication date, not knowing the vote or comments we might receive.
- Publication of C63.25.1 is hopeful in < 6 months (as of May 2018)

Technical Background

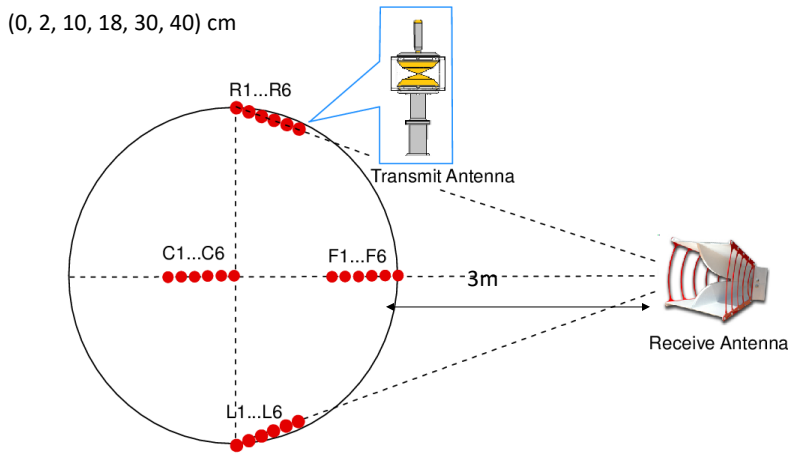
- SVSWR is required to qualify an anechoic EMC chamber for >1 GHz
- It is specified in international standard CISPR 16-1-5
- The concept is based on moving an omnidirectional antenna along a line to sample the standing wave in a chamber
- The antenna in the QZ must be an omni-directional antenna to illuminate the chamber

Similar to Standing Wave on a Transmission Line



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

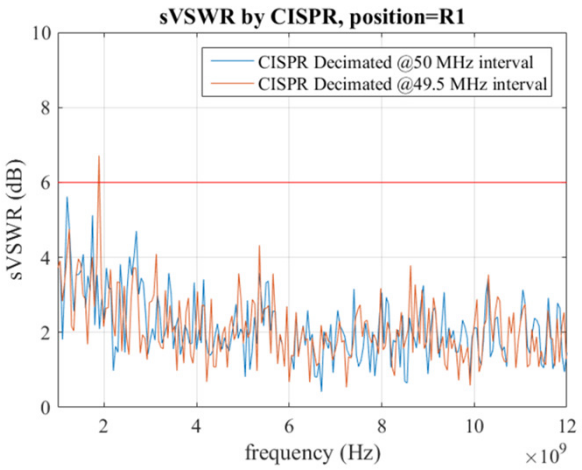
SVSWR Test Setup



Compromises in the CISPR SVSWR

- In order to reduce test complexity and time, several simplifications are made
  - The travel length is limited to 40 cm
  - Only 6 (irregularly positioned in order to break harmonic relations) measurement points along the line are sampled
  - VSWR measurements is typically done at every 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!

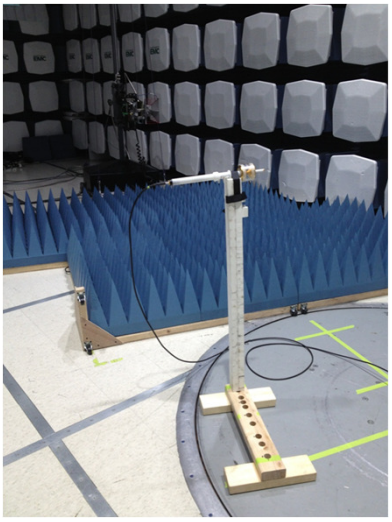
C63.25.1 TD SVSWR

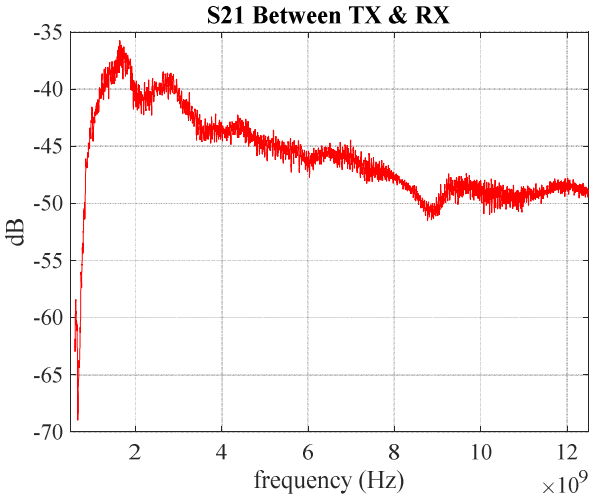
- Instead of moving the receive antenna to plot the standing wave pattern. A vector response is measured between two antennas.
- Time domain transformation is used on the frequency domain data
- Gating is used to measure the VSWR of the chamber
- It emulates the test setup in the CISPR 16 sVSWR method, and uses the same antennas, so a close correlation between the TD sVSWR and CISPR sVSWR is maintained

TD sVSWR ⇔ CISPR sVSWR

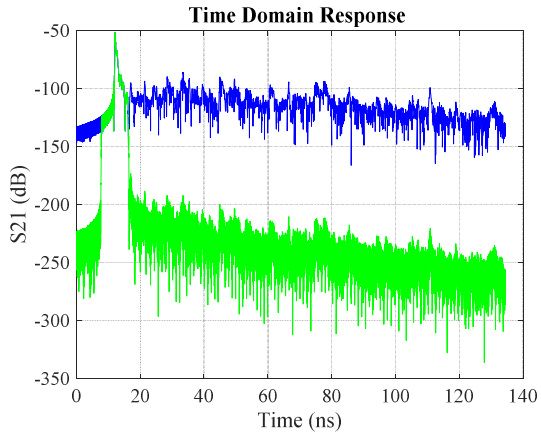
- TD sVSWR is developed so
  - It can be closely correlated to the CISPR sVSWR results
  - It overcomes the repeatability and under-sampling difficulties of the CISPR sVSWR
- Additional benefits of the TD sVSWR method:
  - Real-time/Fast results
  - More accurate in detecting defects
  - Results with defined uncertainties and sound mathematical principles

Illustration of the Test Method

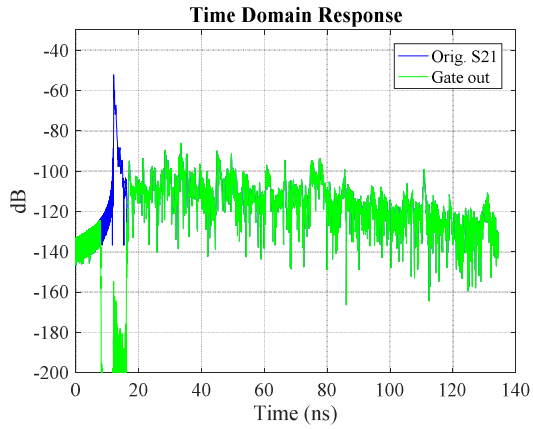




Frequency ->Time Domain (Inverse Fourier Transform)

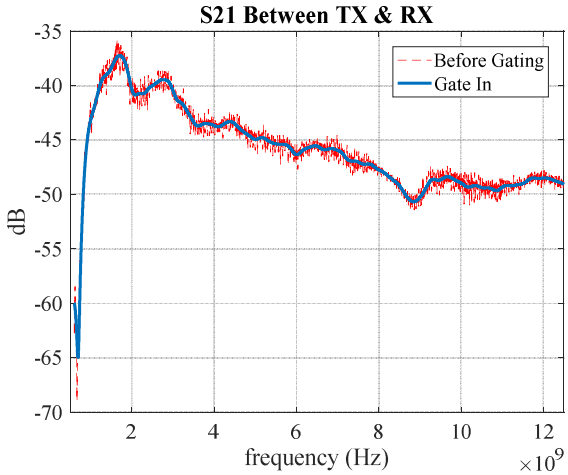


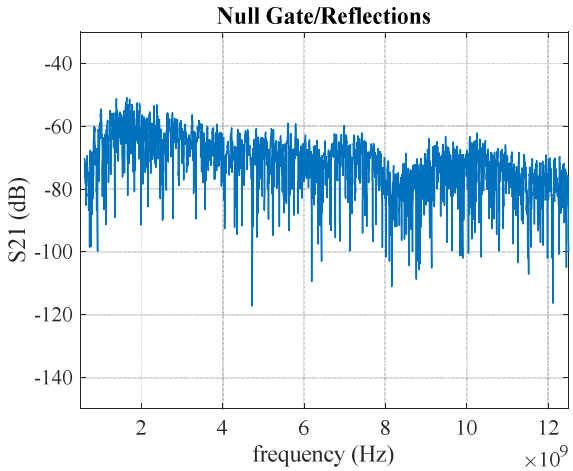
Gate In – Keeping main response only



Gate out – Nulling out main response

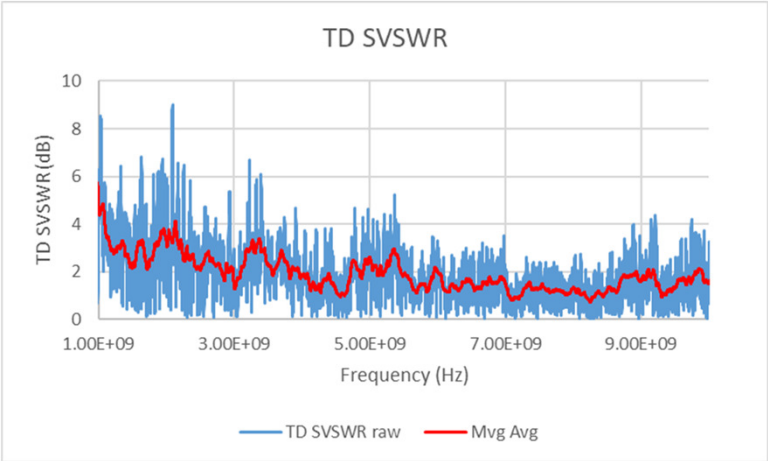
Back to Frequency Domain



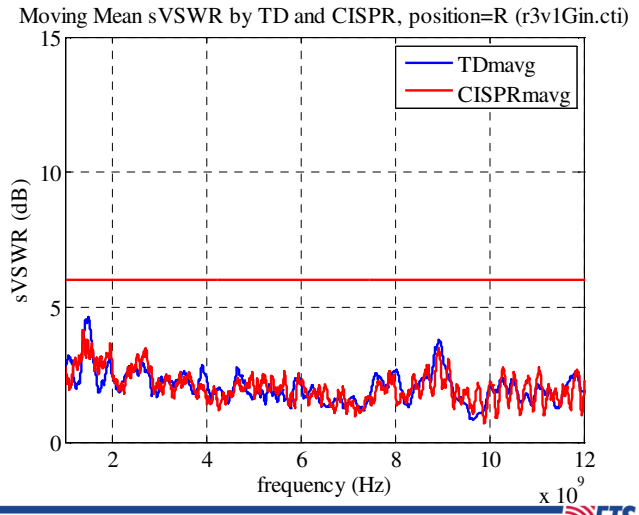


Calculate SVSWR

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



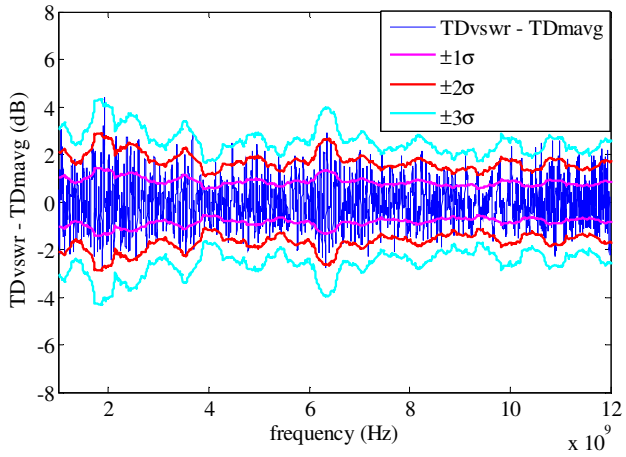
TD SVSWR correlates to CISPR SVSWR

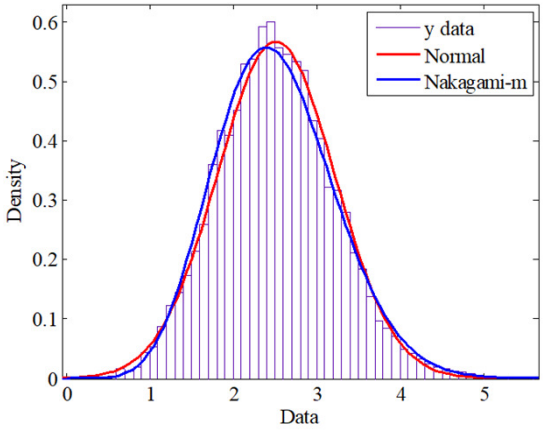


Processing the data

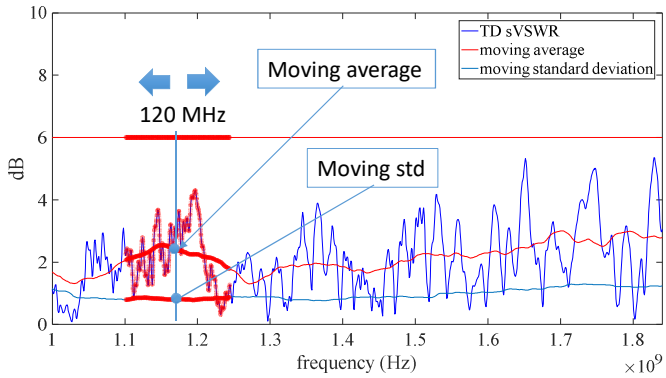
- The TD SVSWR data looks rather “erratic”
- Experienced user will notice the TD SVSWR maybe more “pessimistic” than the CISPR VSWR data
- The reason is because of the undersampling in the CISPR SVSWR method
- A post processing of TD SVSWR is needed to correlate to the CISPR VSWR

TD SVSWR has a “random” normal distribution





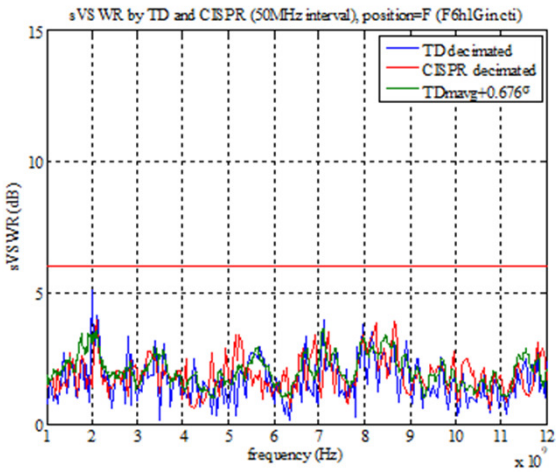
Sliding Window



The final reported TD SVSWR

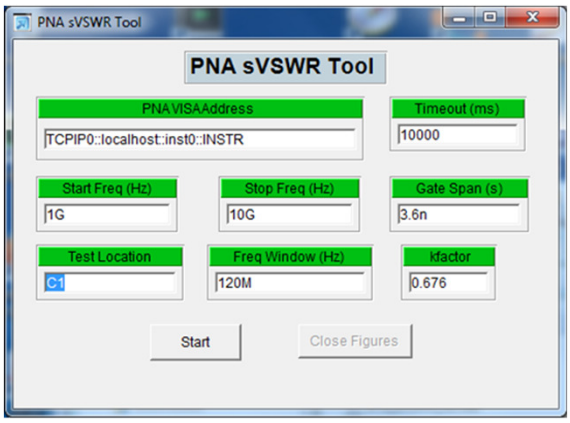
- $Final\ TD\ SVSWR = moving\ average + 0.676\ \sigma$
- Moving average is determined from 120 MHz moving window
- σ is the standard deviation of the (TD-moving average) in the same 120MHz window
- Essentially the post processing includes 75% of the SVSWR. This is needed so the severity of TD method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

Final TD SVSWR compared to CISPR SVSWR



The process can be automated

- Scripts are available from URL links in the standard to download
- Scripts written for Keysight and Rhode & Schwarz automates the process. Results is shown in real time with a single button push
- Excel examples can be downloaded for manual processing



Summary: C63.25.1 TD SVSWR

- Vastly improved repeatability
- Proposed as an alternative method to measure site VSWR
- Fast and instantaneous SVSWR result (1/6th of measurement points)
- Smaller uncertainties without the need to measure distances
- TD SVSWR method provides information to debug a chamber
- Current document has passed public review, and is being prepared for publication.