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Calibration kit coefficients - the saga continues

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Jürg Rüfenacht

Swiss Federal Office of Metrology and Accreditation
metas

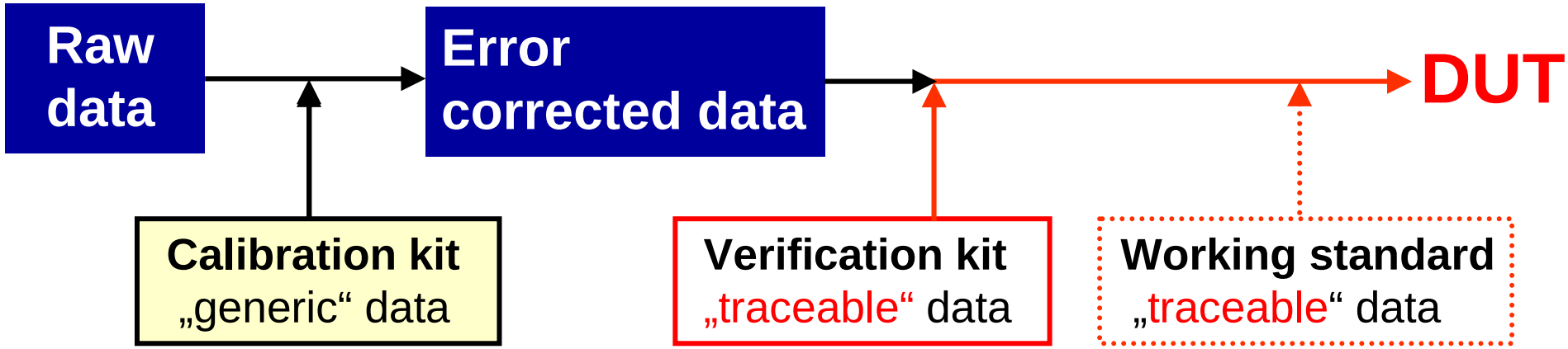
Lindenweg 50, CH-3003 Bern-Wabern, Switzerland
Phone: +41 31 32 33 493
Mail: juerg.ruefenacht@metas.ch

Topics :

- **Using “traceable” calibration kits**
- **Characterisation of a new Type-N calibration kit**
- **Some background information:**
  -> the “world” of the calibration coefficients
- **Which are the correct cal kit coefficients?**
- **Recent answer from Agilent USA** (Rohnert Park)
- **Discussion: What is your experience and opinion ?**

Traceability

Traditional VNA calibration approach:



Direct “traceable” VNA calibration approach:

Characterisation of two new 85032F calibration kits:

The Agilent 85032F calibration kit contains precision 50 ohm Type-N standards. Standards include fixed terminations, offset open circuits, and offset short circuits in both sexes (with slotted female contacts). This kit is specified from dc to 9 GHz.

Goal of the calibration kit characterisation:

- **Verification of the manufacturers specifications :**
  - Calculation of nominal reflection coefficients (VRC)
  - Difference between nominal data and measurement data

- **”Calibration” of each calibration standards :**
  - Measurement of the actual VRC for each cal standard
  - Evaluation and verification for the use up to 18 GHz
  - Using this “traceable” VRC information with „VNA Tools”

Calculation of the nominal VRC for each standard:

Table A-7 Standard Definitions for the 8510

System Z_0[a] = 50 Ω
Disk File Name: CK_NTYPF1
Calibration Kit Label: Type N F.1

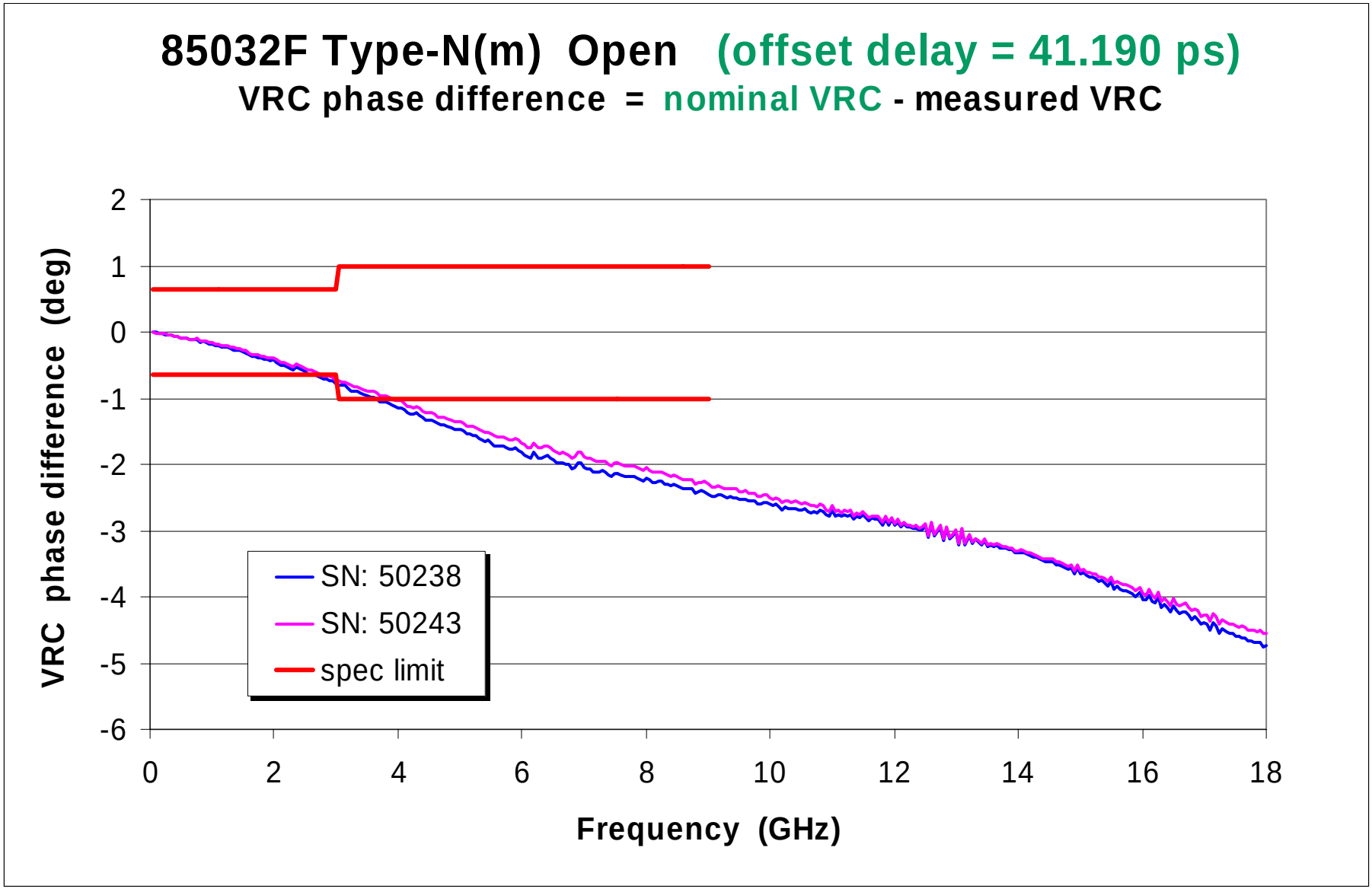
Standard[b]		C0 $\times 10^{-15}$ F	C1 $\times 10^{-27}$ F/Hz	C2 $\times 10^{-36}$ F/Hz^2	C3 $\times 10^{-45}$ F/Hz^3	Fixed or Sliding[c]	Offset			Frequency in GHz[d]		Coax or Waveguide	Standard Label
Number	Type	L0 $\times 10^{-12}$ H	L1 $\times 10^{-24}$ H/Hz	L2 $\times 10^{-33}$ H/Hz^2	L3 $\times 10^{-42}$ H/Hz^3		Delay in ps	Z_0 Ω	Loss in GΩ/s	Min	Max		
1	Short[e]	3.3998	−496.4808	34.8314	−.7847		45.955	49.99	1.087	0	999	Coax	Short
2	Open[e]	89.939	2536.80	−264.990	13.400		41.19	50	0.93	0	999	Coax	Open

- **Calculation reference for the Agilent calibration kits:**
  -> Appendix C of the 8510-5B product note
- **Calculation done wit the free metrology software „VNA Tools"**
  -> calculate the complex VRC from the given cal coefficients

Reference measurement system:

- **8510C VNA :**
  - **“traceable” 85054B Type-N calibration kit (Open / Short / Load / Sliding-Load).**
  - **Slotless test port and cal standard connectors.**

- **Traceability of the used 85054B calibration kit :**
  - **TRL calibration method**
  - **“Cross-ratio” calibration** (air line based 1 port approach)


85032F Type-N(m) Open (offset delay = 41.190 ps)
VRC phase difference = nominal VRC - measured VRC
VRC phase difference (deg)
2
1
0
-1
-2
-3
-4
-5
-6
0
2
4
6
8
10
12
14
16
18
Frequency (GHz)
SN: 50238
SN: 50243
spec limit

Summary of the 85032F cal kit deviations:

- **Type-N(male) Open :**
  - **Phase deviation from nominal value at 9 GHz = 2.3 deg**
  - **Specification at 9 GHz: max. phase deviation = 1.0 deg**
- **Type-N(female) Open :**
  - **Similar as for the Type-N(male) Open**
- **Type-N adapters (Option 100, 200, 300) :**
  - **female to female : offset delay = 169.4 ps**
  - **male to male : offset delay = 169.7 ps**
  - **male to female : offset delay = 169.6 ps**

-> 85032F manual: offset delay coefficient = 339 ps

Request to Agilent USA (Rohnert Park, California)

why do we have these deviations ?

which are the correct coefficients ?

Short introduction to the “world” of the cal coefficients

To improve VNA measurements:

- **Quality management documents**
  - selection of methods
  - detailed cal process instructions

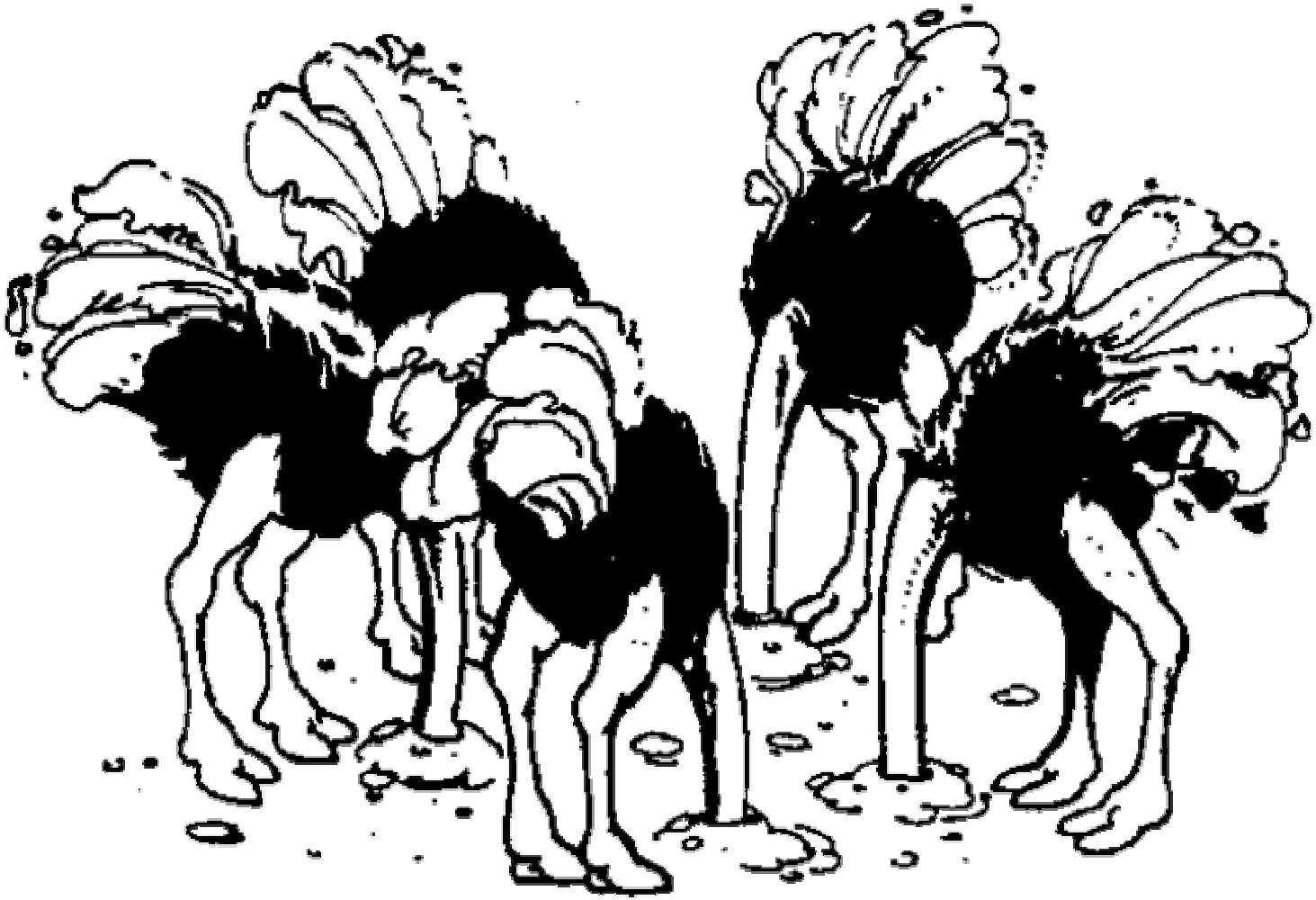
- **High performance VNA equipment**
  - Expensive VNA
  - Precision test port cables and connectors
  - Calibration Kits
  - “calibrated” verification kits

“...but how about the knowledge and traceability of the used calibration standard coefficients? ”

The calibration kit coefficients:

- **The VNA itself is a “stupid” instrument** (just: 1 source and 4 receivers)
- **The quality and the knowledge of the used calibration standards and the calibration methods / approaches make the real difference.**
- **The manufacturers provide the best possible sets of cal coefficients**
  but which are the correct ones?

- **those advertised in the cal kit manual ?**
- **those found in the floppy disk delivered with the cal kit ?**
- **those found in the firmware of the VNA model “abcd” ?**
- **those found in the firmware of the VNA model “xyz” ?**
- **those which come with a new similar cal kit (manual / disk)?**
- **those published on the manufacturers website ?**



... a very fast answer from Agilent USA !

....after some research and measurements...

They sent us new 85032F coefficients derived from TRL measurements / calibrations. It turns out that the male and female open do not have quite the same set of constants as advertised in the manual, due to the slotted contacts.

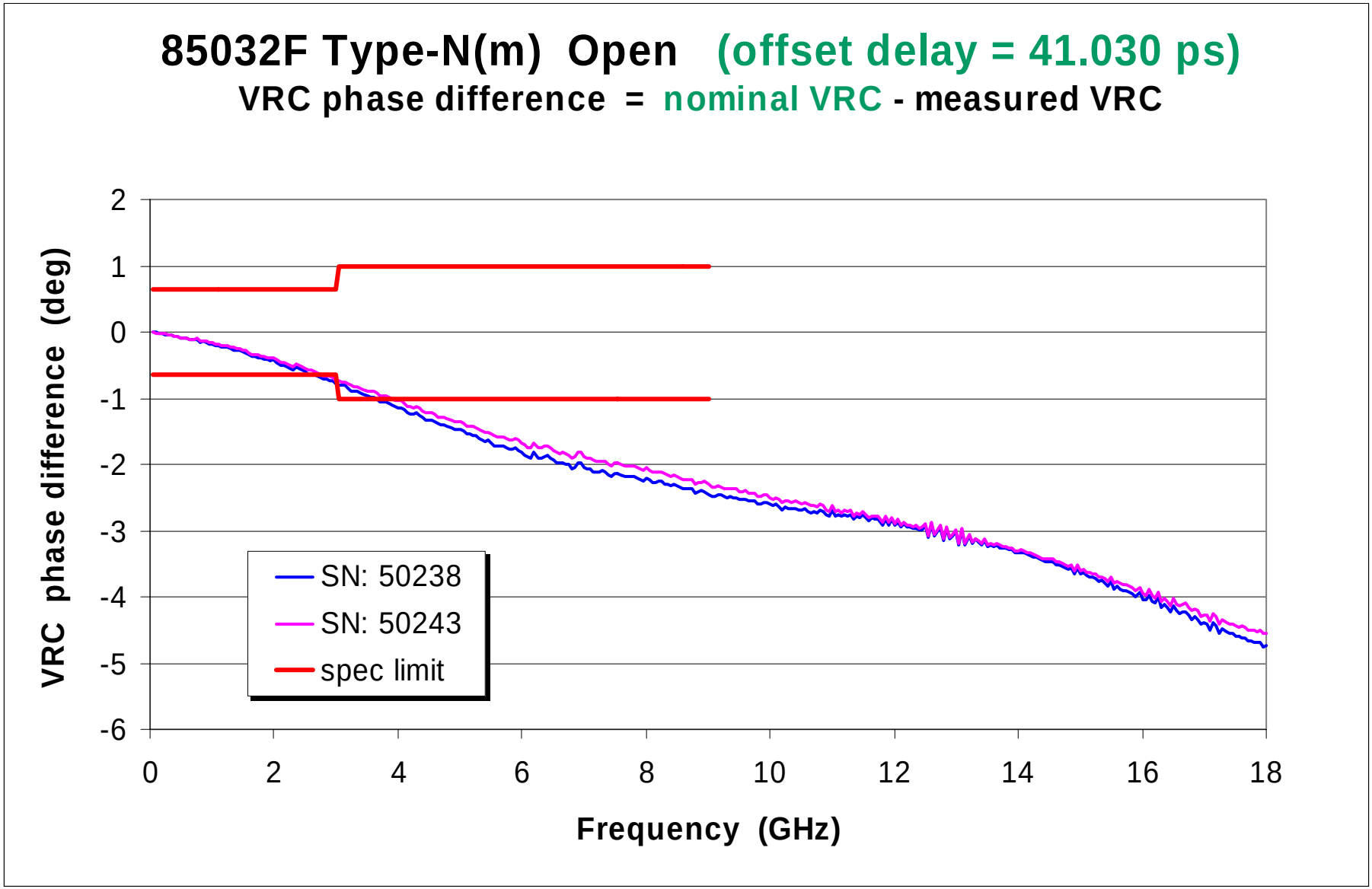
The offset delay for the adapters is not correct and should be: 169.5 ps

The “best” calibration kit coefficients:
(based on the recent answer from Agilent)

1) The coefficients advertised in the manual are typical values only, values on disk are more actual and may be different.

2) The coefficients stored in the firmware represent the typical values known at the release date of the firmware revision.

3) Use the latest update if one exists for the revision that applies to your kit. “If we update the design of a standard, the revision of the kit will change too.”


85032F Type-N(m) Open (offset delay = 41.030 ps)
VRC phase difference = nominal VRC - measured VRC
VRC phase difference (deg)
2
1
0
-1
-2
-3
-4
-5
-6
0
2
4
6
8
10
12
14
16
18
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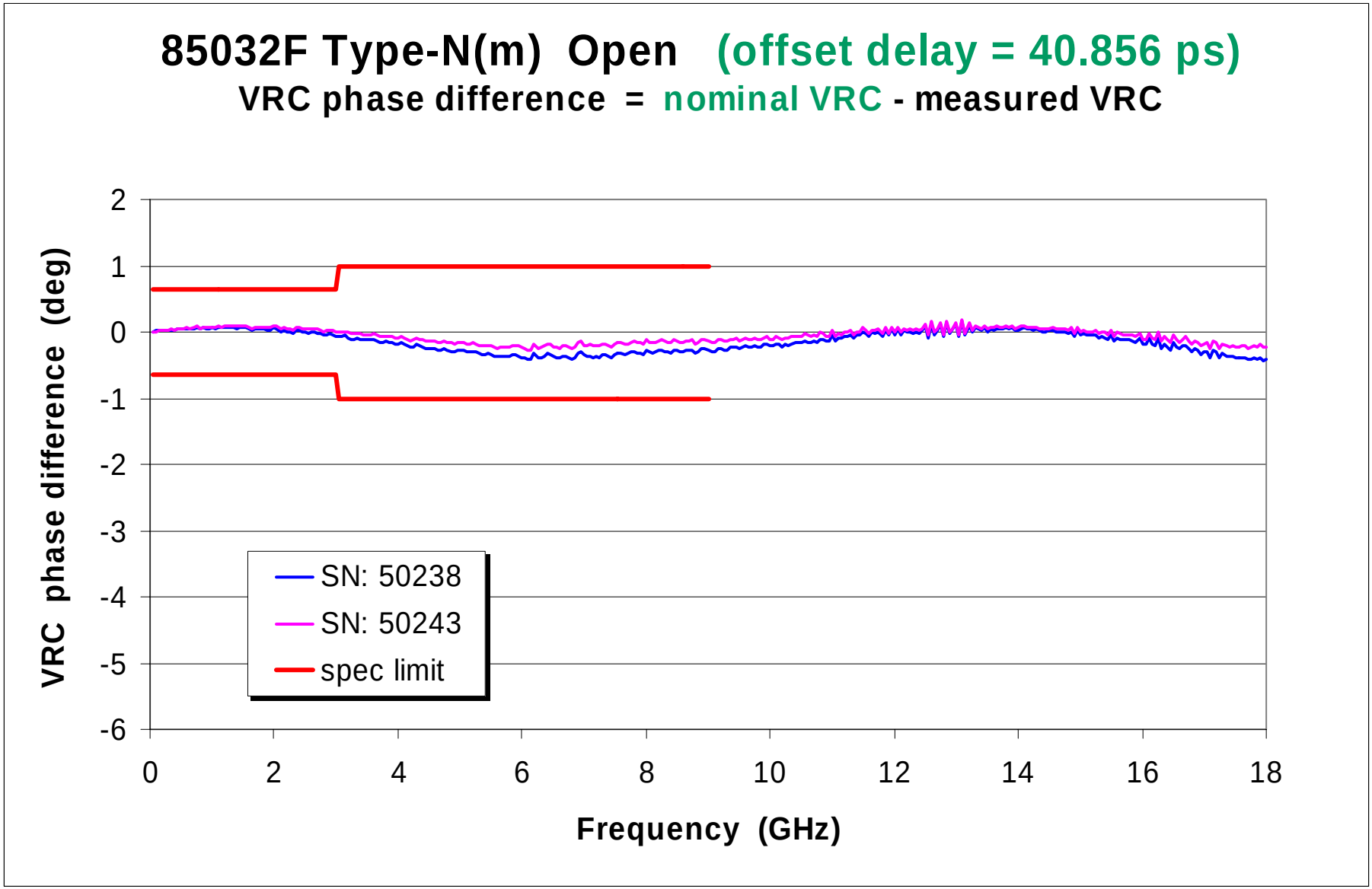
85032F Type-N(m) Open (offset delay = 40.856 ps)
VRC phase difference = nominal VRC - measured VRC
VRC phase difference (deg)
2
1
0
-1
-2
-3
-4
-5
-6
0
2
4
6
8
10
12
14
16
18
Frequency (GHz)
SN: 50238
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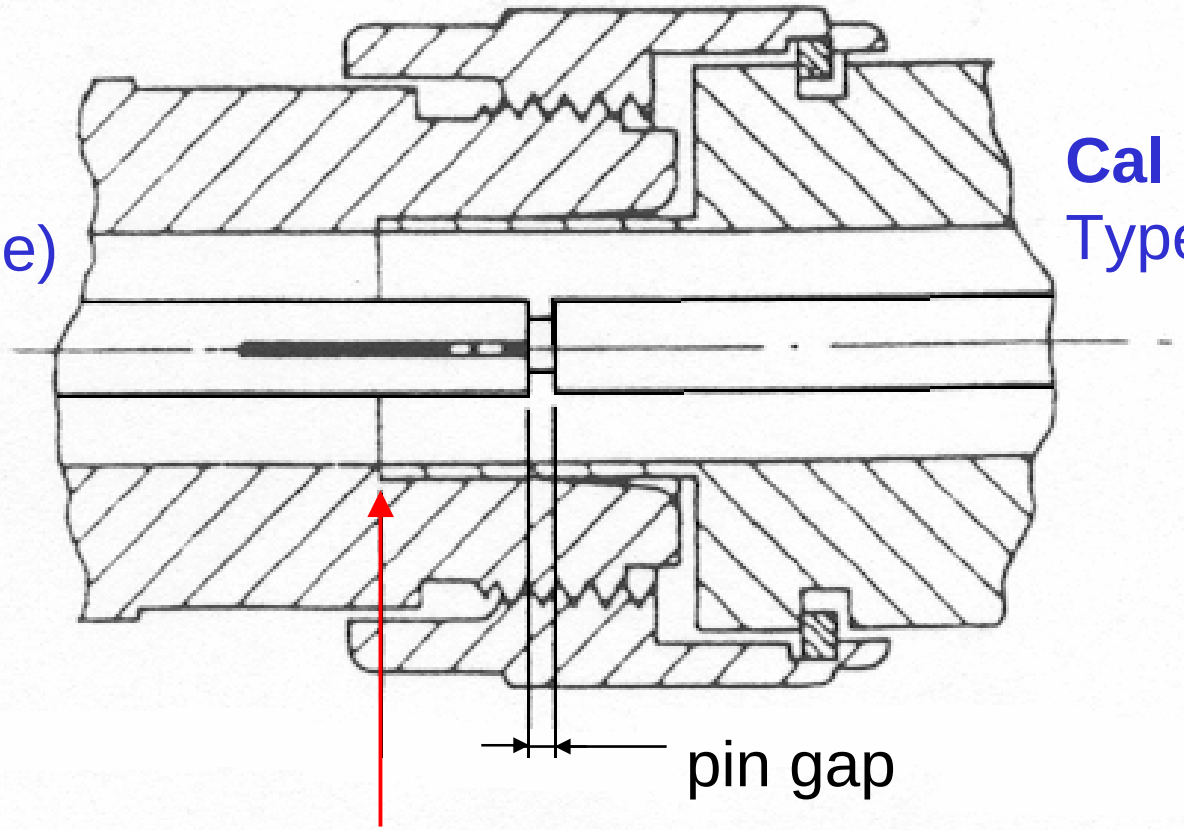
spec limit

Mated Type-N connector pair (with slotted female part)

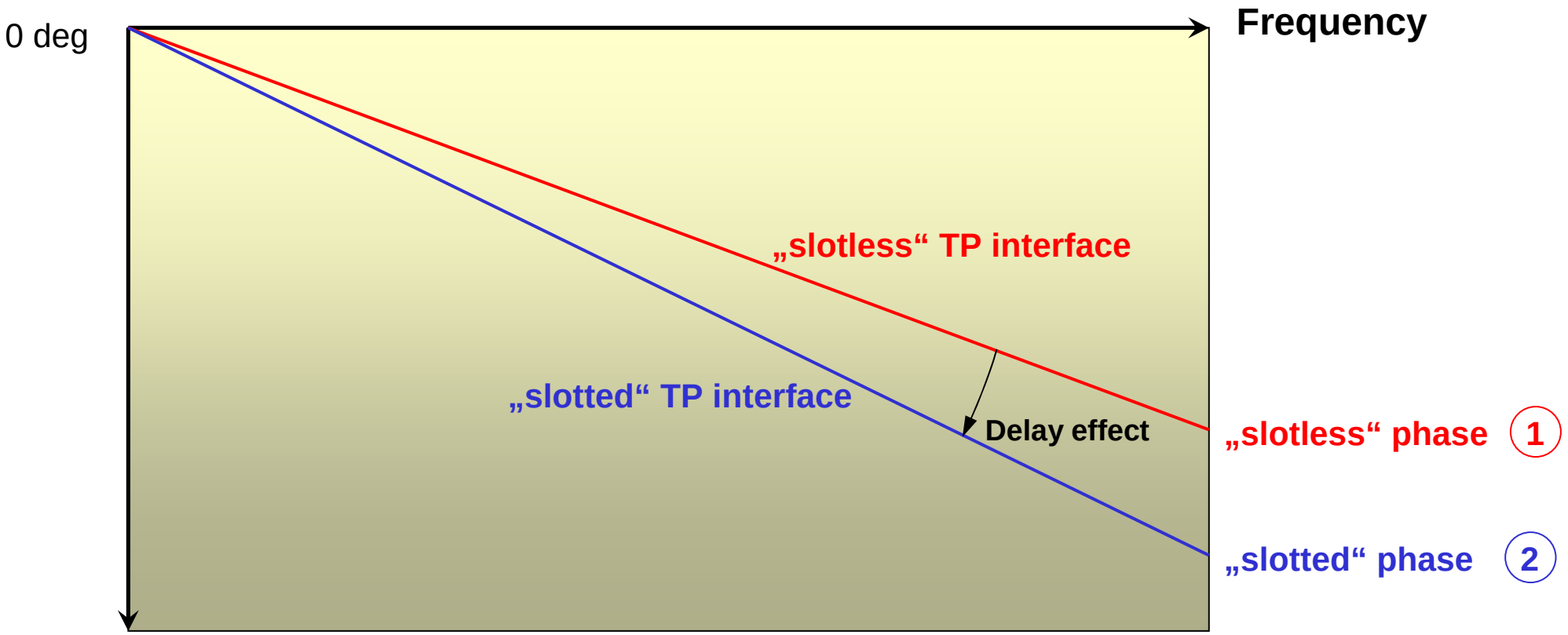
Test port:
Type-N(female)



Cal standard:
Type-N(male)

Example: Type-N(male) OPEN calibration standard (“offset” Open)

-> effect of the female test port (TP) interface



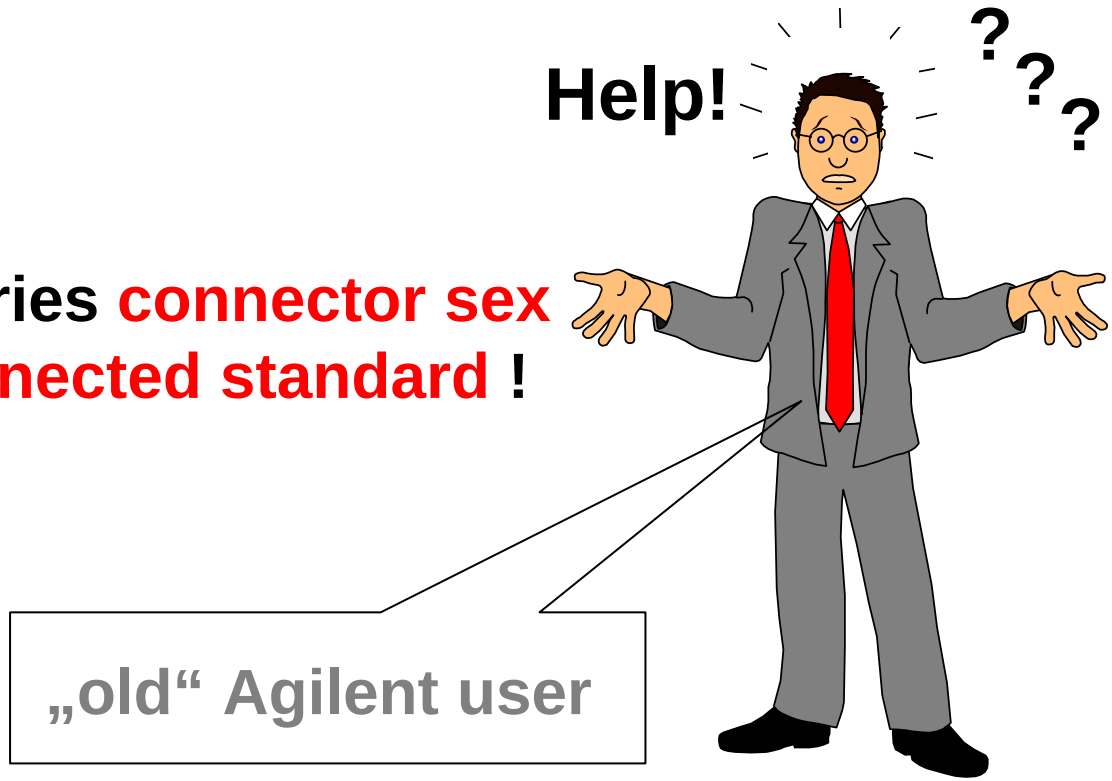
1 = “true” phase behaviour in a “slotless” environment

2 = “true” phase behaviour in a “slotted” environment

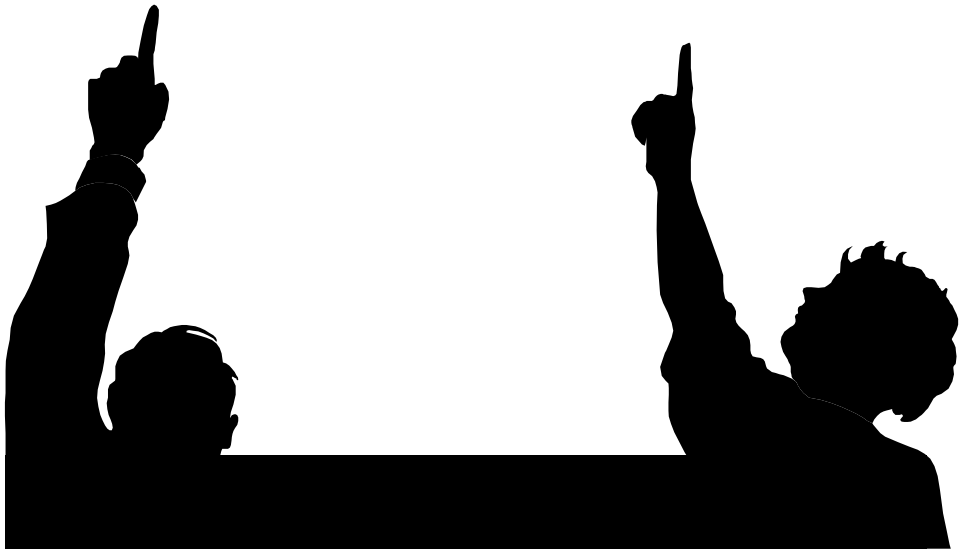
just to keep the cal kit saga going on:

With the „legacy" cal kits from Agilent the connector sex always refers to the test port sex, not the sex of the connected standard (during the calibration process).

With the new PNA series connector sex now refers to the connected standard !



Thank you very much for your attention !



Discussion on the effect of slotted or slotless connectors