L'électromagnétisme pour raison d'être

Webinar

Radiated Immunity test in reverberation chamber

Presenter: Maxime BLIN Support BAT-EMC

Rules

- Presentation/questions
- Webcam & micro switched off
- Use Chat for questions during presentation
- My colleagues can answer or ask me to answer

Webinar Agenda

- 40 Min Webinar presentation
- 15 Min for questions

Overview

1. NEXIO presentation
2. Introduction on reverberation chamber
3. Standard introduction
4. Calibrations
    1. Empty
    2. Loaded
    3. On EUT
5. Immunity Test
    1. Automatic
    2. Manual
    3. Export and Report

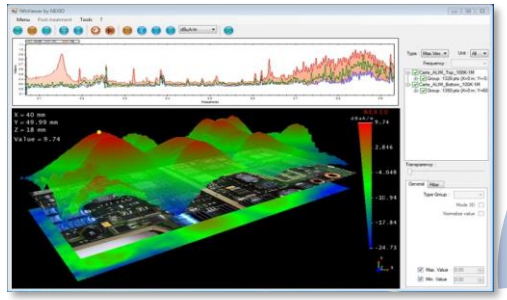
1. Since 2003: Electromagnetism is our thing

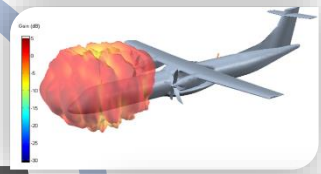
NEXIO
L'électromagnétisme pour raison d'être

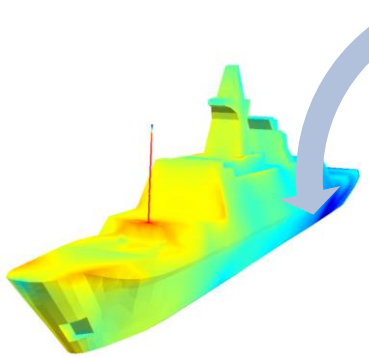
Toulouse – Paris – Grenoble – Austin – Munich

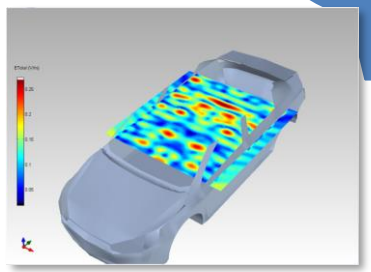
INTERFERENCES
EMC
Lightning
ESD

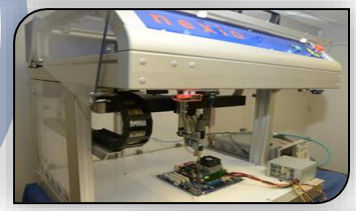
PROPAGATION
Antenna
Radio Frequency
Stealth (RCS)











Tests & Measurement Software and System

Simulation Software

Engineering Subcontracting Services Design Simulation

Employees: 90 – Turnover: 7M€
250 Customers - 25 countries

15 R&D Projects since 2008

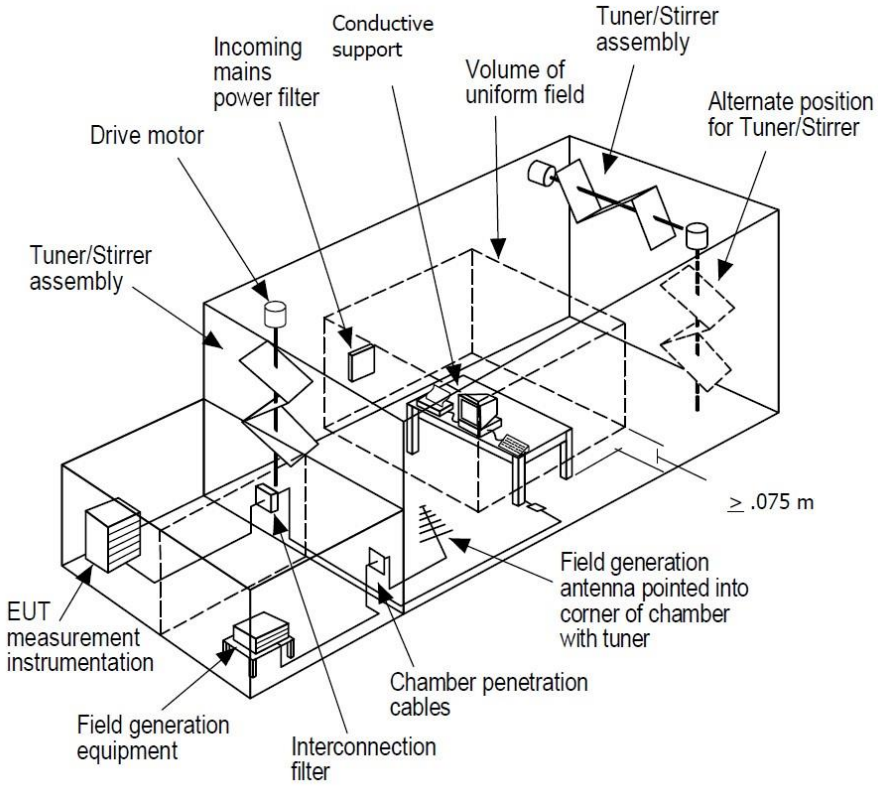
2. Reverberation chamber

The reverberation chamber has been used in Electromagnetic Compatibility test for more than 20 years.

The reverb chamber is a an electrically large highly conductive cavity with a mechanism for altering its modes.

When the chamber is excited with RF energy, the resulting multi-mode electromagnetic environment can be “stirred” by the mechanical tuner/stirrer. The resulting field is statistically uniform, statistically isotropic (i.e., the energy having arrived from all aspect angles) and statistically randomly polarized (i.e., with all possible directions of polarization) when averaged over enough positions of the tuner/stirrer.

Warning a reverb chamber has a minimum frequency usage.



2. Reverberation Advantages and disadvantages

Advantages

EUT in the uniform field zone:
- Immunity on EUT on all direction and on cables.
- Test closer to reality

No absorbent :
- Lower installation cost.
- Possibility to generate higher E field.

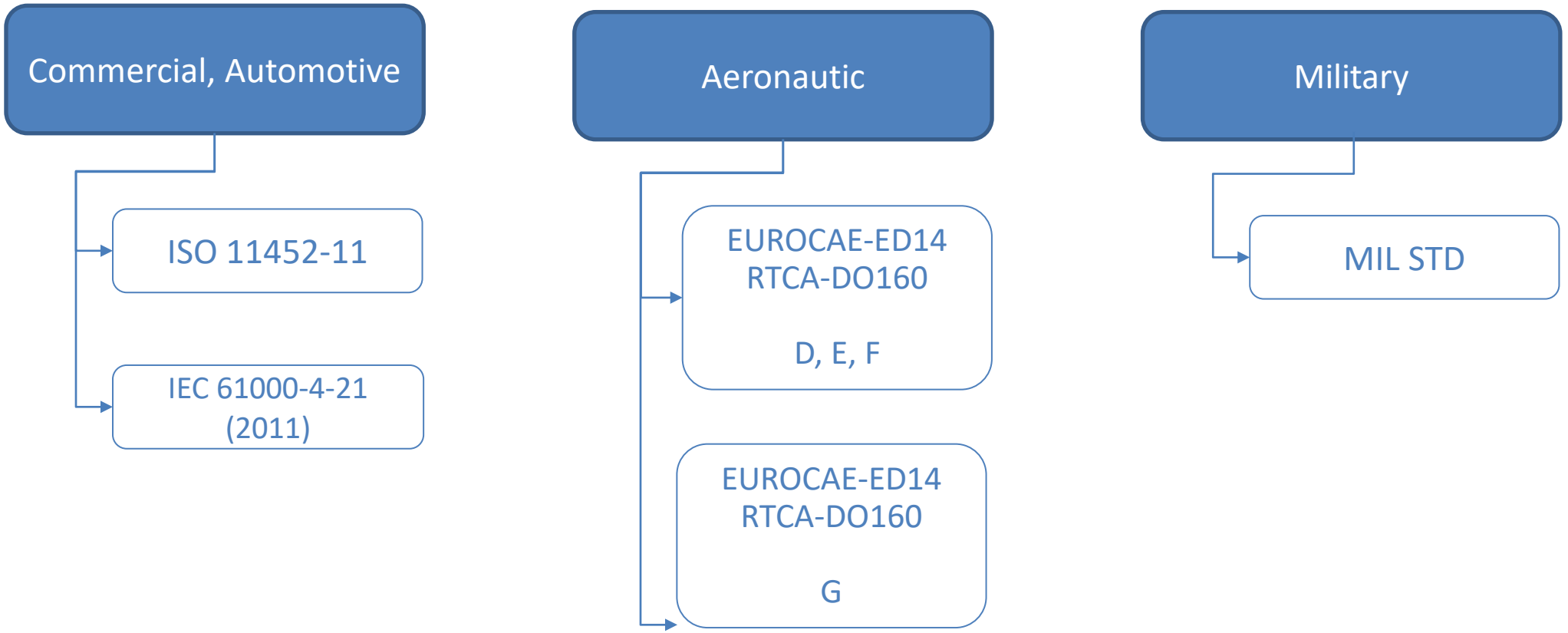
Very good ration Field /Power:
- Amplifiers less expensive or higher field than in anechoide chamber

Disadvantages

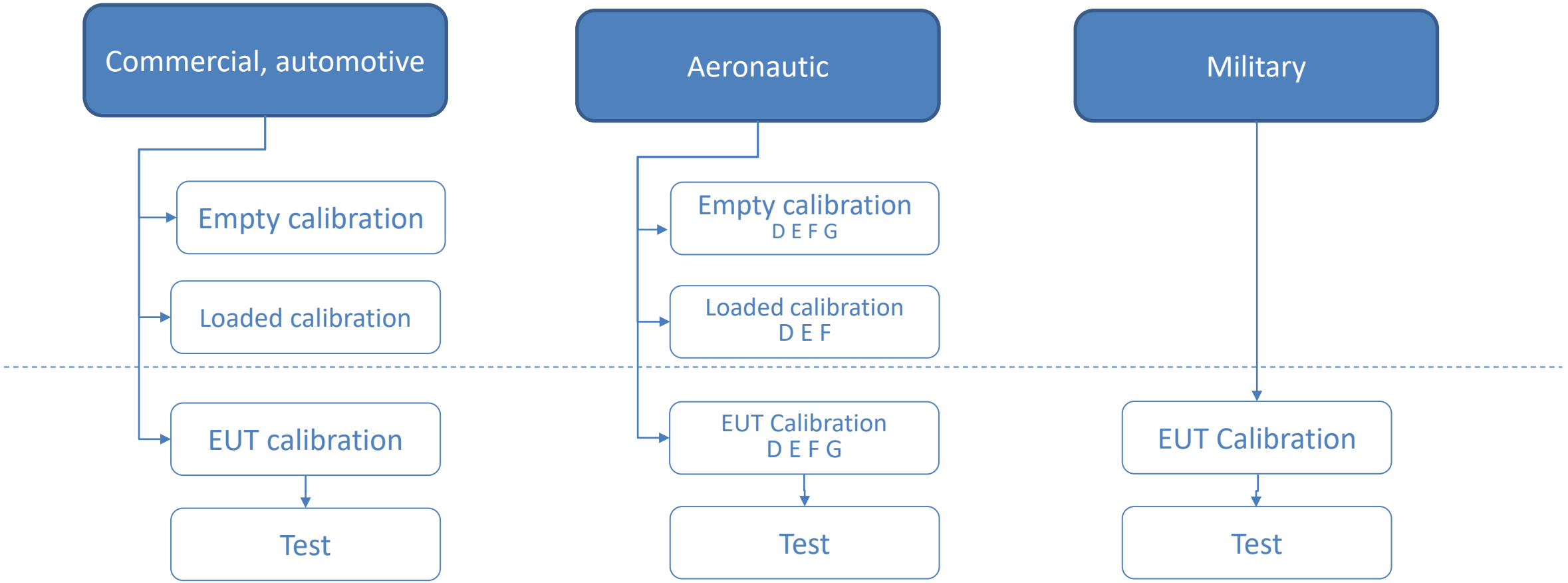
EUT in the uniform field zone:
- Size of the chamber vs start frequency
- Bigger amplifier with a bigger chamber

Calibration:
- Depending on standard, empty and loaded calibration could takes time.
- Calibration on EUT is highly recommended before starting the test

3. Introduction to reverb standard



3. Introduction on reverb standard



4.1 Empty calibration

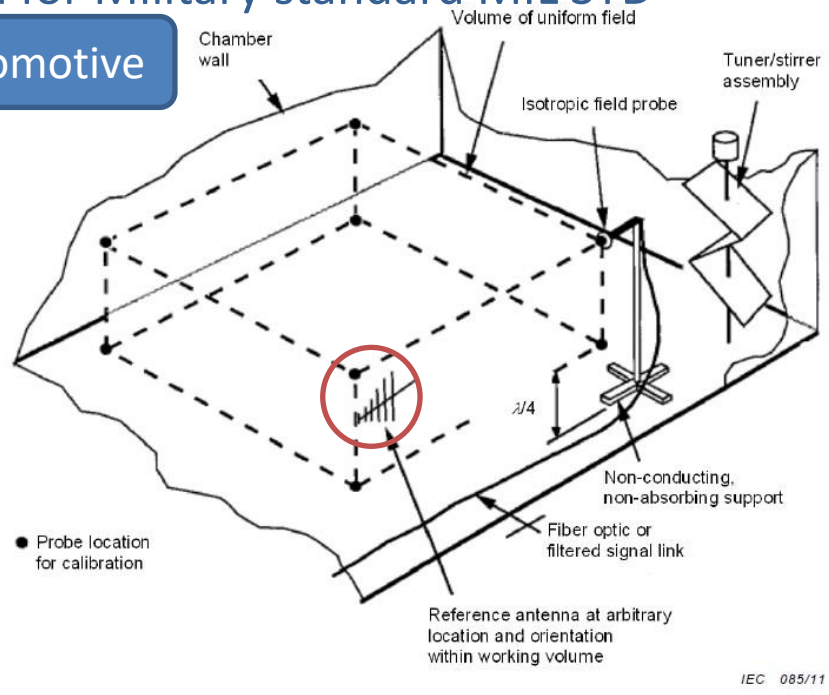
2 goals reach by 2 measurement type:

1. E Field Measurement : Check the Volume of the uniform field area and the first frequency usage of the chamber
2. Power received on the received antenna: Measurement of the ratio Field/Power empty chamber

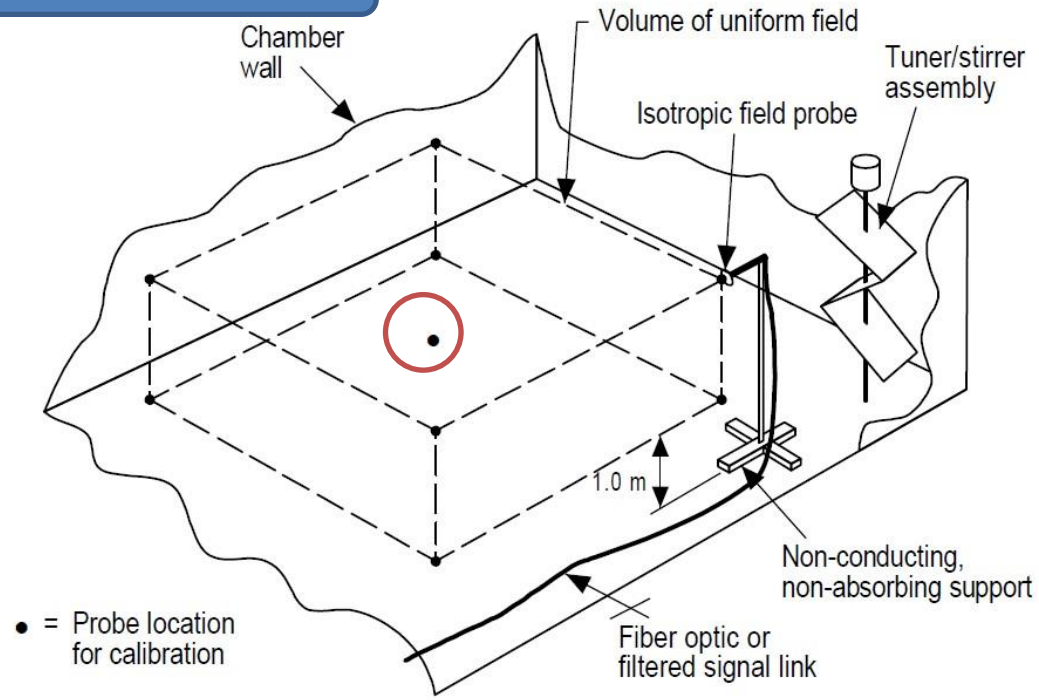
A 3rd measurement is performed the Forward Power (and optional Reverse, to have P_{Net})

Not needed for Military standard MIL STD

Commercial, Automotive



Aéronautic



4.1 Empty calibration, Measurement types :

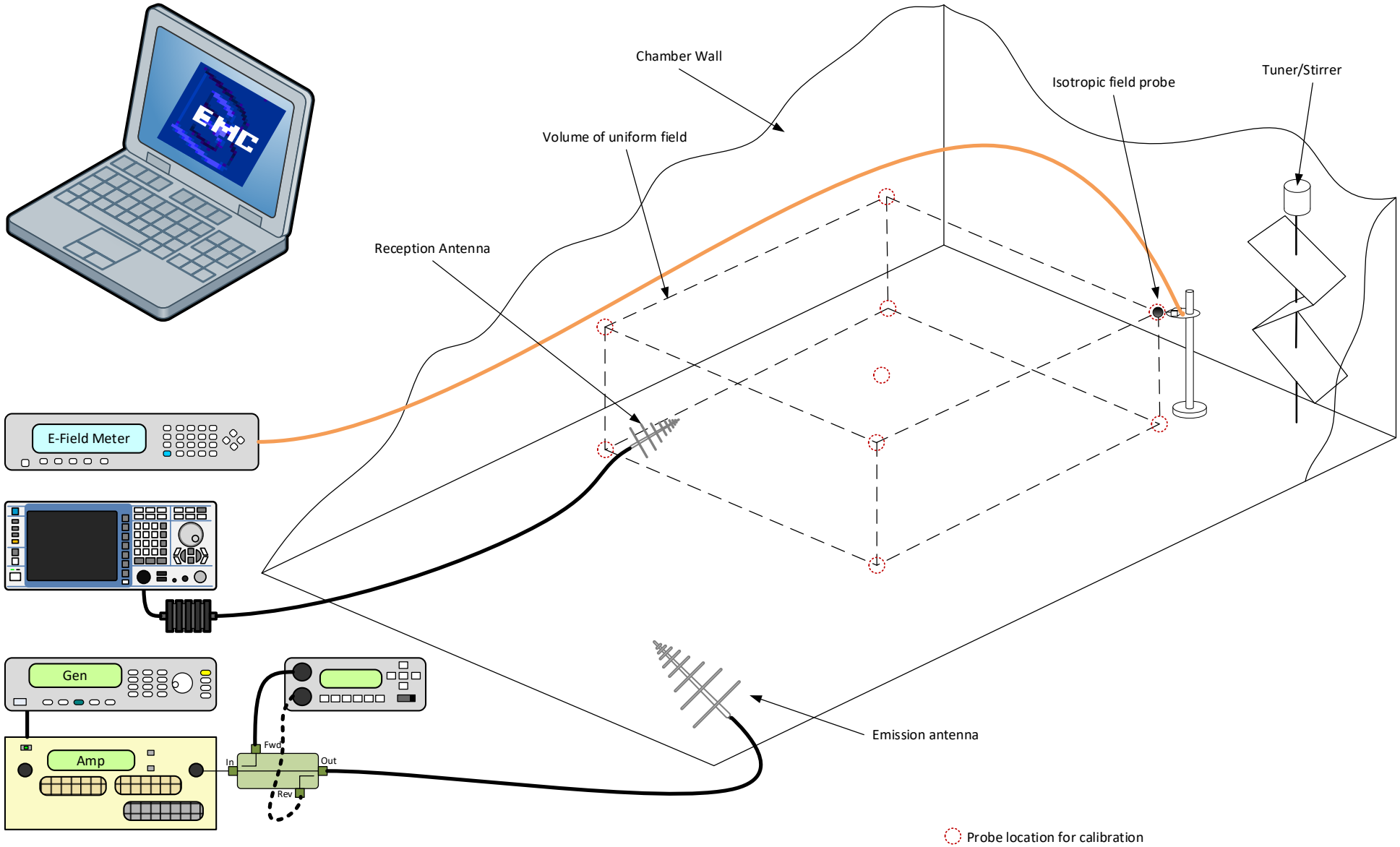
Value to measure:

- E field:
  - Ex
  - Ey
  - Ez
- Received power in the chamber from the received antenna
- Forward power and Reverse power (optional)

These values should be measure :

- For each frequency
- For each angular step (stirrer step)
- For each position of the field probe/antenna (location on the perimeter of the chamber working volume)

4.1 Empty calibration, working schema :



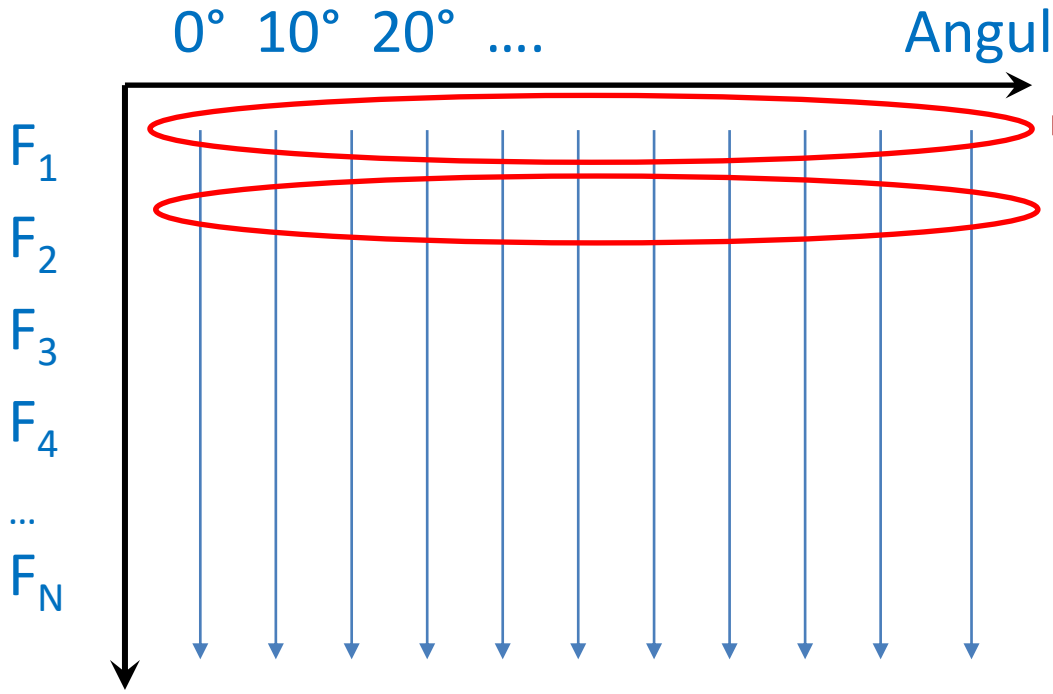
4.1 Needed mathematic tools

3 mathematic tools are needed:

- Function maximum
- Function average
- Function Standard Deviation:
  - The standard deviation will describe the variation around the average
  - For example :
    - Average (9 ; 11) = average (0 ; 20) = 10
    - σ(9,11) is low
    - σ(0,20) is high

4.1 E Field measurement

For each position of the field probe



$$E_{Maxx,y,z}$$

$$\vec{E}_{x,y,z} = \frac{E_{Maxx,y,z}}{\sqrt{P_{Input-empty}}}$$

$$\vec{E}_{Total} = \frac{E_{MaxTotal}}{\sqrt{P_{Input-empty}}}$$

For each position of the probe

$$\langle \vec{E}_x \rangle_9 = \left(\sum \vec{E}_x\right)/9$$

$$\langle \vec{E}_y \rangle_9 = \left(\sum \vec{E}_y\right)/9$$

$$\langle \vec{E}_z \rangle_9 = \left(\sum \vec{E}_z\right)/9$$

$$\langle \vec{E} \rangle_{27} = \left(\sum \vec{E}_{x,y,z}\right)/27$$

4.1 Standard deviation

Standard deviation from each probe axis

$$\sigma_x = 1.06 * \sqrt{\frac{\sum (\vec{E}_{ix} - \langle \vec{E}_x \rangle_9)^2}{9-1}}$$

Standard deviation for all probe axis

$$\sigma_{27} = \sqrt{\frac{\sum (\vec{E}_{ix,y,z} - \langle \vec{E} \rangle_{27})^2}{27-1}}$$

Standard deviation in dB

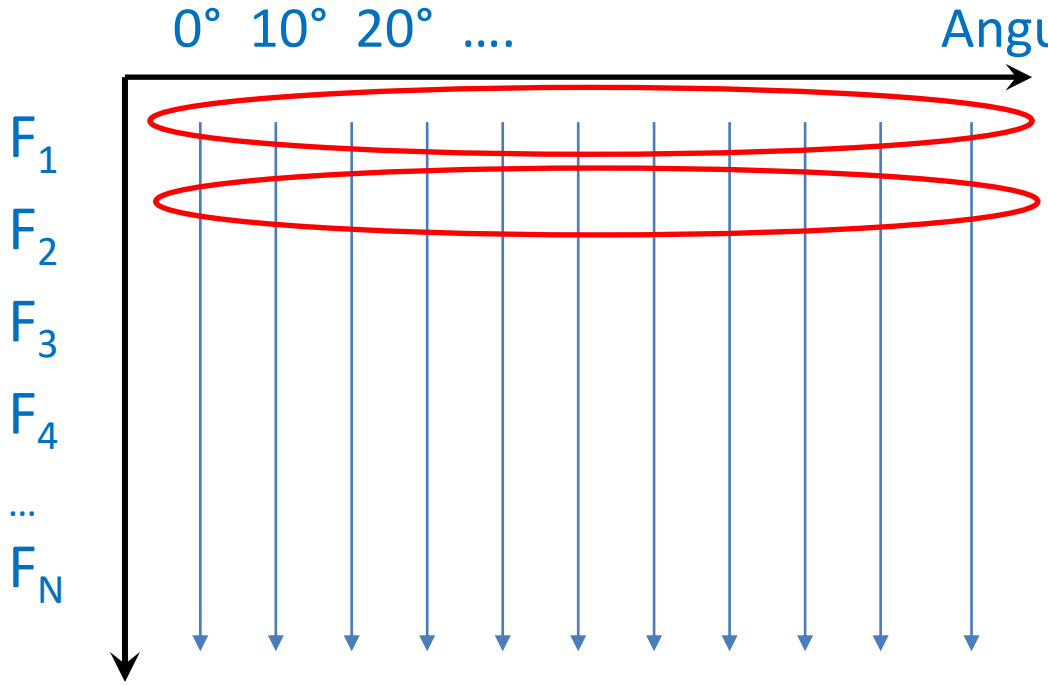
$$\sigma(dB) = 20 * \log\left(\frac{\sigma + \langle \vec{E} \rangle}{\langle \vec{E} \rangle}\right)$$

the standard deviation of the individual field components (e.g. σx,y,z) should not exceed the standard deviation limit.

The standard deviation symbolize the possible deviation of the E Field, Maximum on one complete rotation, with the different positions of the probe, for the different position.

4.1 Measurement of Power received in the chamber

For each position of the antenna



P_{AveRec}

Average of received Power

$$\left\langle \frac{P_{AveRec}}{P_{AveInput}} \right\rangle$$

This average value will be used to calculate:

- Quality factor
- Time constant for the chamber
- The power to generate for the test (depending on standard)

4.1 Measurement of Power received in the chamber

Average of the received power

$$\left\langle \frac{P_{AveRec}}{P_{AveInput}} \right\rangle$$

Warning the same calculation is named differently according to standard and revision:

- 61000-4-21 : AVF (Antenna Validation Factor)
- DO 160 F : ACF_{empty} (Antenna Calibration Factor)
- DO 160 G : CCF (Chamber Calibration Factor)
- MIL STD 461 : different method (next slide)

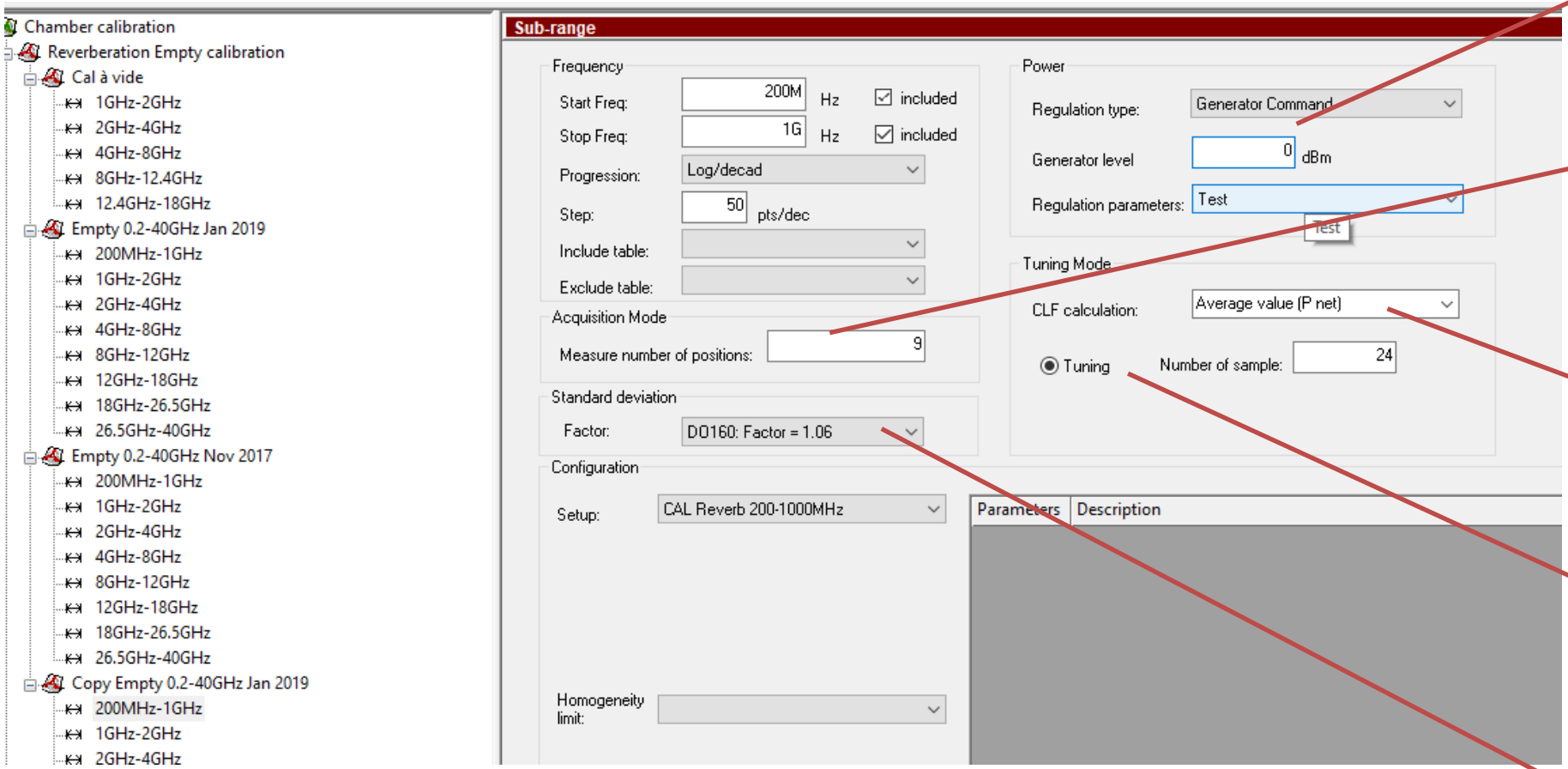
Warning in the DO 160 G, the CCF is the average power for the empty calibration (as written above), But in version F the CCF is the average power for the calibration on EUT

4.1 Reverberant Resources in BAT-EMC

BAT-EMC allows you to defined the information from the standard:

- Chambre volume
- The antenna efficiency factors for the transmit and receive antenna (used for Quality factor and time constant)
- The homogeneity limit

4.1 Empty Calibration– Configuration in BAT-EMC



Generator in constant power or Regulation on a target

Number of measured position (8 or 9)

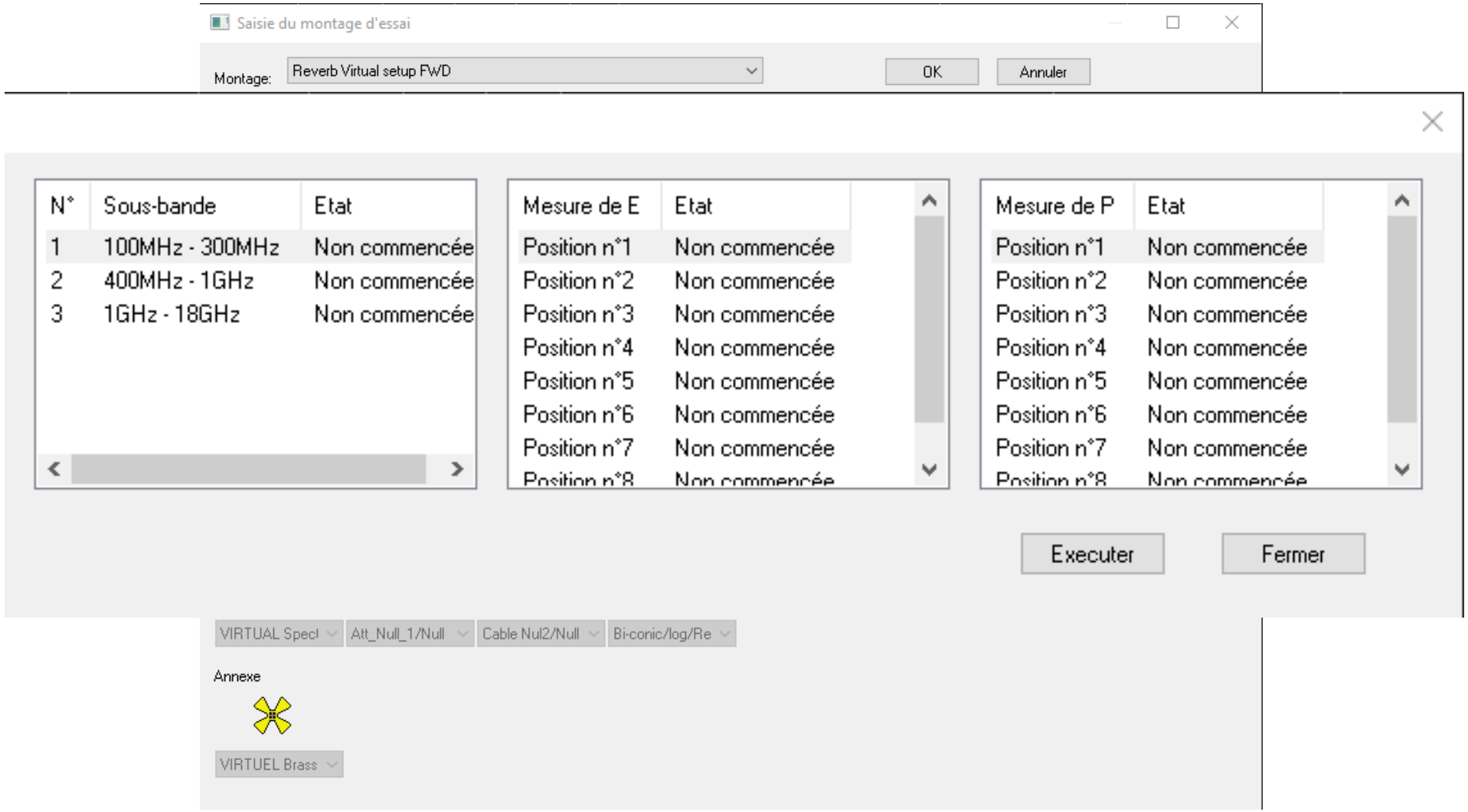
Calculation method based on the average or maximum of the power received.

And normalization on P Incident or Net

Number of steps for the stirer

Coefficient of 1.06 or 1 for the DO 160 or IEC standard

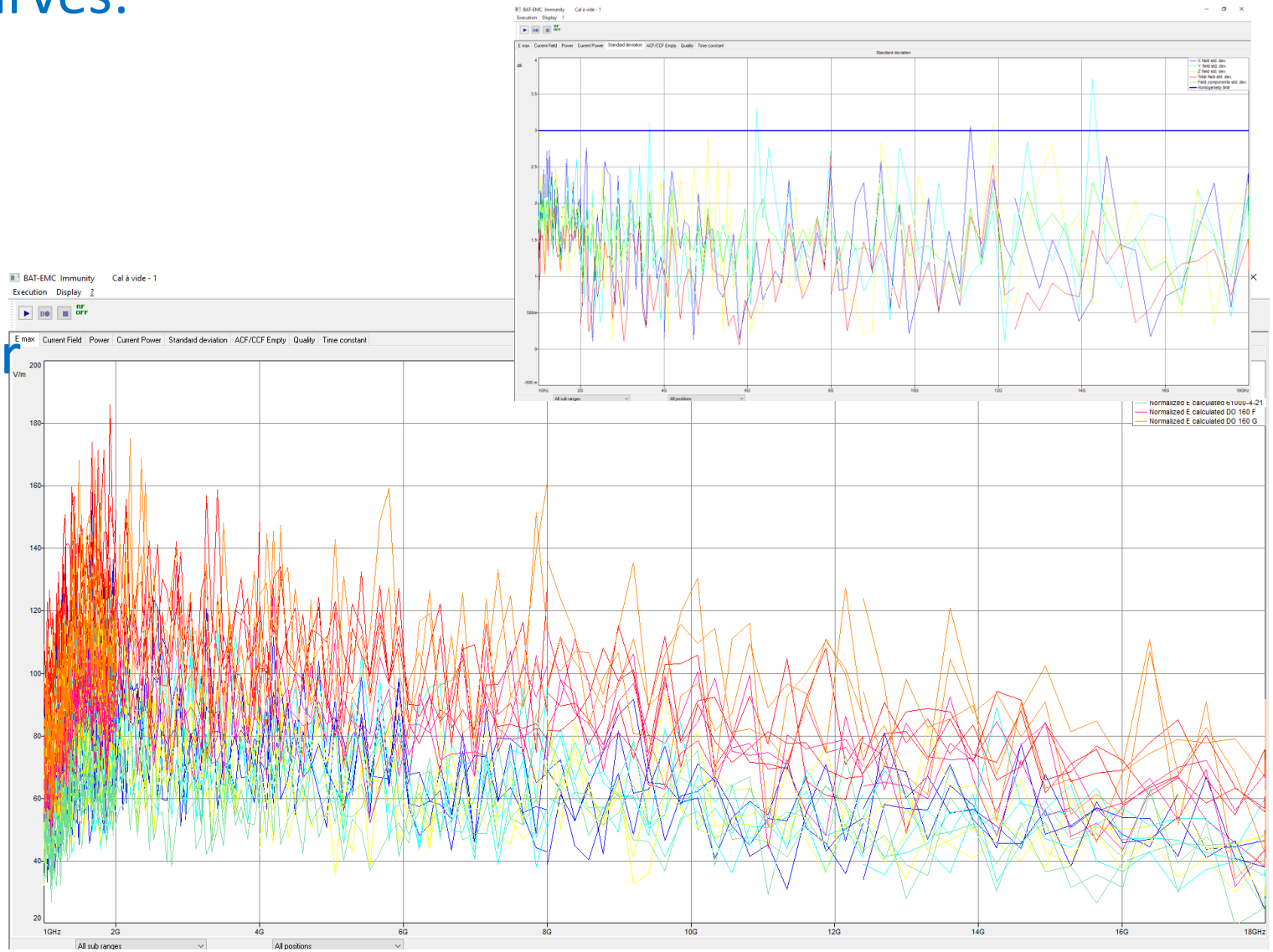
4.1 Empty Calibration – Before the measurement



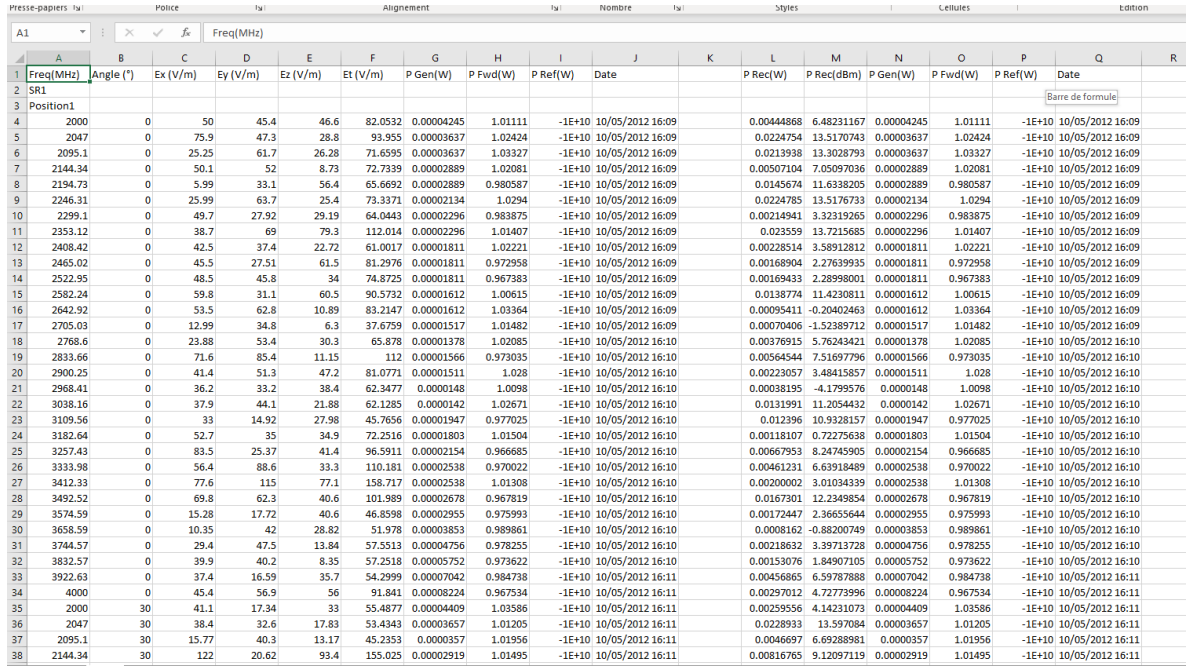
4.1 Empty Calibration

At runtime we display the curves:

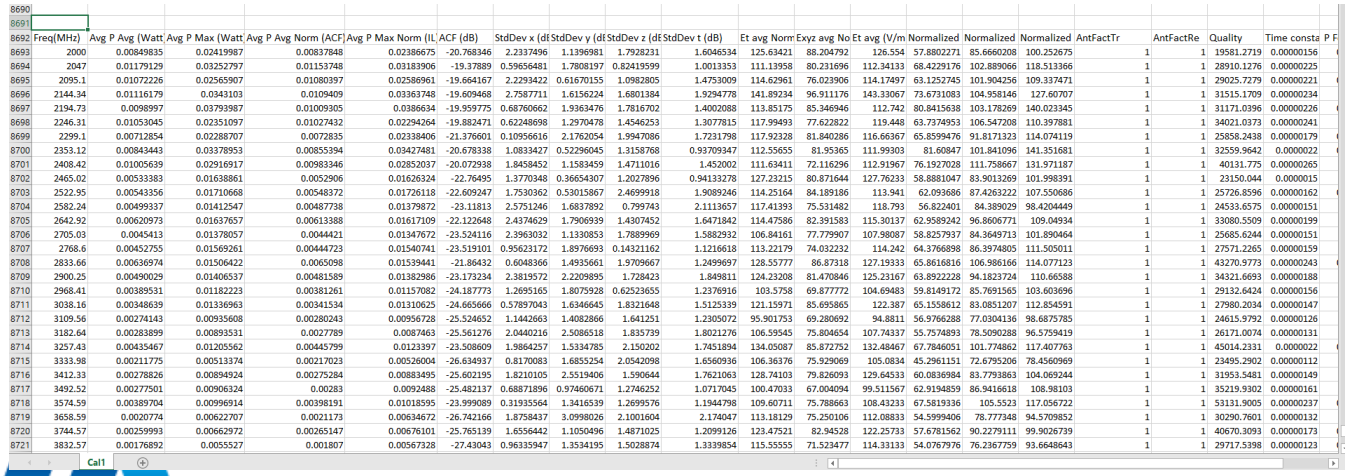
- field
- power
- standard deviation
- Normalized average power
- Quality coefficient
- Response time



4.1 Empty Calibration : export of the results



Freq(MHz)	Angle (°)	Ex (V/m)	Ey (V/m)	Ez (V/m)	Et (V/m)	P Gen(W)	P Fwd(W)	P Ref(W)	Date	P Rec(W)	P Rec(dBm)	P Gen(W)	P Fwd(W)	P Ref(W)	Date
SR1															
Position1															
2000	0	50	45.4	46.6	82.0532	0.00004245	1.01111	-1E+10	10/05/2012 16:09	0.00444868	6.48231167	0.00004245	1.01111	-1E+10	10/05/2012 16:09
2047	0	75.9	47.3	28.8	93.955	0.00003637	1.02424	-1E+10	10/05/2012 16:09	0.0224754	13.5170743	0.00003637	1.02424	-1E+10	10/05/2012 16:09
2095.1	0	25.25	61.7	26.28	71.6595	0.00003637	1.03327	-1E+10	10/05/2012 16:09	0.0213938	13.3028793	0.00003637	1.03327	-1E+10	10/05/2012 16:09
2144.34	0	50.1	52	8.73	72.7339	0.00002889	1.02081	-1E+10	10/05/2012 16:09	0.00507104	7.05097036	0.00002889	1.02081	-1E+10	10/05/2012 16:09
2194.73	0	5.99	33.1	56.4	65.6692	0.00002889	0.980587	-1E+10	10/05/2012 16:09	0.0145674	11.6338205	0.00002889	0.980587	-1E+10	10/05/2012 16:09
2246.31	0	25.99	63.7	25.4	73.3371	0.00002134	1.0294	-1E+10	10/05/2012 16:09	0.0224785	13.5176733	0.00002134	1.0294	-1E+10	10/05/2012 16:09
2299.1	0	49.7	27.92	29.19	64.0443	0.00002296	0.983875	-1E+10	10/05/2012 16:09	0.00214941	3.32319265	0.00002296	0.983875	-1E+10	10/05/2012 16:09
2353.12	0	38.7	69	79.3	112.014	0.00002296	1.01407	-1E+10	10/05/2012 16:09	0.023559	13.7215685	0.00002296	1.01407	-1E+10	10/05/2012 16:09
2408.42	0	42.5	37.4	22.72	61.0017	0.00001811	1.02221	-1E+10	10/05/2012 16:09	0.00228514	3.58912812	0.00001811	1.02221	-1E+10	10/05/2012 16:09
2465.02	0	45.5	27.51	61.5	81.2976	0.00001811	0.972958	-1E+10	10/05/2012 16:09	0.00168904	2.27639935	0.00001811	0.972958	-1E+10	10/05/2012 16:09
2522.95	0	48.5	45.8	34	74.8725	0.00001811	0.967383	-1E+10	10/05/2012 16:09	0.00169433	2.28998001	0.00001811	0.967383	-1E+10	10/05/2012 16:09
2582.24	0	59.8	31.1	60.5	90.5732	0.00001612	1.00615	-1E+10	10/05/2012 16:09	0.0138774	11.4230811	0.00001612	1.00615	-1E+10	10/05/2012 16:09
2642.92	0	53.5	62.8	10.89	83.2147	0.00001612	1.03364	-1E+10	10/05/2012 16:09	0.00095411	-0.20402463	0.00001612	1.03364	-1E+10	10/05/2012 16:09
2705.03	0	12.99	34.8	6.3	37.6759	0.00001517	1.01482	-1E+10	10/05/2012 16:09	0.00070406	-1.52389712	0.00001517	1.01482	-1E+10	10/05/2012 16:09
2768.6	0	23.88	53.4	30.3	65.878	0.00001378	1.02085	-1E+10	10/05/2012 16:10	0.00376915	5.76243421	0.00001378	1.02085	-1E+10	10/05/2012 16:10
2833.66	0	71.6	85.4	11.15	112	0.00001566	0.973035	-1E+10	10/05/2012 16:10	0.00564544	7.51697796	0.00001566	0.973035	-1E+10	10/05/2012 16:10
2900.25	0	41.4	51.3	47.2	81.0771	0.00001511	1.028	-1E+10	10/05/2012 16:10	0.00223057	3.48415857	0.00001511	1.028	-1E+10	10/05/2012 16:10
2968.41	0	36.2	33.2	38.4	62.3477	0.0000148	1.0098	-1E+10	10/05/2012 16:10	0.00038195	-4.1799576	0.0000148	1.0098	-1E+10	10/05/2012 16:10
3038.16	0	37.9	44.1	21.88	62.1285	0.0000142	1.02671	-1E+10	10/05/2012 16:10	0.0131991	11.2054432	0.0000142	1.02671	-1E+10	10/05/2012 16:10
3109.56	0	33	14.92	27.98	45.7656	0.00001947	0.977025	-1E+10	10/05/2012 16:10	0.012396	10.9328157	0.00001947	0.977025	-1E+10	10/05/2012 16:10
3182.64	0	52.7	35	34.9	72.2516	0.00001803	1.01504	-1E+10	10/05/2012 16:10	0.00118107	0.72275638	0.00001803	1.01504	-1E+10	10/05/2012 16:10
3257.43	0	83.5	25.37	41.4	96.5911	0.00002154	0.966685	-1E+10	10/05/2012 16:10	0.00667953	8.24745905	0.00002154	0.966685	-1E+10	10/05/2012 16:10
3333.98	0	56.4	88.6	33.3	110.181	0.00002538	0.970022	-1E+10	10/05/2012 16:10	0.00461231	6.63918489	0.00002538	0.970022	-1E+10	10/05/2012 16:10
3412.33	0	77.6	115	77.1	158.717	0.00002538	1.01308	-1E+10	10/05/2012 16:10	0.00200002	3.01034339	0.00002538	1.01308	-1E+10	10/05/2012 16:10
3492.52	0	69.8	62.3	40.6	101.989	0.00002678	0.967819	-1E+10	10/05/2012 16:10	0.0167301	12.2349854	0.00002678	0.967819	-1E+10	10/05/2012 16:10
3574.59	0	15.28	17.72	40.6	46.8598	0.00002955	0.975993	-1E+10	10/05/2012 16:10	0.00172447	2.36655644	0.00002955	0.975993	-1E+10	10/05/2012 16:10
3658.59	0	10.35	42	28.82	51.978	0.00003853	0.989861	-1E+10	10/05/2012 16:10	0.0008162	-0.88200749	0.00003853	0.989861	-1E+10	10/05/2012 16:10
3744.57	0	29.4	47.5	13.84	57.5513	0.00004756	0.978255	-1E+10	10/05/2012 16:10	0.00218632	3.39713728	0.00004756	0.978255	-1E+10	10/05/2012 16:10
3832.57	0	39.9	40.2	8.35	57.2518	0.00005752	0.973622	-1E+10	10/05/2012 16:10	0.00153076	1.84907105	0.00005752	0.973622	-1E+10	10/05/2012 16:10
3922.63	0	37.4	16.59	35.7	54.2999	0.00007042	0.984738	-1E+10	10/05/2012 16:11	0.00456865	6.59787888	0.00007042	0.984738	-1E+10	10/05/2012 16:11
4000	0	45.4	56.9	56	91.841	0.00008224	0.967534	-1E+10	10/05/2012 16:11	0.00297012	4.72773996	0.00008224	0.967534	-1E+10	10/05/2012 16:11
2000	30	41.1	17.34	33	55.4877	0.00004409	1.03586	-1E+10	10/05/2012 16:11	0.00259556	4.14231073	0.00004409	1.03586	-1E+10	10/05/2012 16:11
2047	30	38.4	32.6	17.83	53.4343	0.00003657	1.01205	-1E+10	10/05/2012 16:11	0.0228933	13.597084	0.00003657	1.01205	-1E+10	10/05/2012 16:11
2095.1	30	15.77	40.3	13.17	45.2353	0.0000357	1.01956	-1E+10	10/05/2012 16:11	0.0046697	6.69288981	0.0000357	1.01956	-1E+10	10/05/2012 16:11
2144.34	30	122	20.62	93.4	155.025	0.00002919	1.01495	-1E+10	10/05/2012 16:11	0.00816765	9.12097119	0.00002919	1.01495	-1E+10	10/05/2012 16:11



Freq(MHz)	Avg P Avg (Watt	Avg P Max (Watt	Avg P Avg Norm (ACF	Avg P Max Norm (IL	ACF (dB)	StdDev x (dB	StdDev y (dB	StdDev z (dB	StdDev t (dB)	Et avg Norm	Exyz avg No	Et avg (V/m	Normalized	Normalized	Normalized	AntFactTr	AntFactRe	Quality	Time consta	P F
2000	0.00849835	0.02419987	0.00837848	0.02386675	-20.768346	2.2337496	1.1396981	1.7928231	1.6046534	125.63421	88.204792	126.554	57.8802271	85.6660208	100.252675	1	1	19581.2719	0.00000156	
2047	0.01179129	0.03252797	0.01153748	0.03183906	-19.37889	0.59656481	1.7808197	0.82419599	1.0013353	111.13958	80.231696	112.34133	68.4229176	102.889066	118.513366	1	1	28910.1276	0.00000225	
2095.1	0.01072226	0.02565907	0.01080397	0.02586961	-19.664167	2.2293422	0.61670155	1.0982805	1.4753009	114.62961	76.023906	114.17497	63.1252745	101.904256	109.337471	1	1	29025.7279	0.00000221	
2144.34	0.01116179	0.0343103	0.0109409	0.03363748	-19.609468	2.7587711	1.6156224	1.6801384	1.9294778	141.89234	96.911176	143.33067	73.6731083	104.958146	127.60707	1	1	31515.1709	0.00000234	
2194.73	0.0098997	0.03793987	0.01009305	0.0386634	-19.959775	0.68760662	1.9363476	1.7816702	1.4002088	113.85175	85.346946	112.742	80.8415638	103.178269	140.023345	1	1	31171.0396	0.00000226	
2246.31	0.01053045	0.02351097	0.01027432	0.02294264	-19.882471	0.62248698	1.2970478	1.4546253	1.3077815	117.99493	77.622822	119.448	63.7374953	106.547208	110.397881	1	1	34021.0373	0.00000241	
2299.1	0.00712854	0.02288707	0.0072835	0.02338406	-21.376601	0.10956616	2.1762054	1.9947086	1.7231798	117.92328	81.840286	116.66367	65.8599476	91.8171323	114.074119	1	1	25858.2438	0.00000179	
2353.12	0.00843443	0.03378953	0.00855394	0.03427481	-20.678338	1.0833427	0.52296045	1.3158768	0.93709347	112.55655	81.95365	111.99303	81.60847	101.841096	141.351681	1	1	32559.9642	0.0000022	
2408.42	0.01005639	0.02916917	0.00983346	0.02852037	-20.072938	1.8458452	1.1583459	1.4711016	1.452002	111.63411	72.116296	112.91967	76.1927028	111.758667	131.971187	1	1	40131.775	0.00000265	
2465.02	0.00533383	0.01638861	0.0052906	0.01626324	-22.76495	1.3770348	0.36654307	1.2027896	0.94133278	127.23215	80.871644	127.76233	58.8881047	83.9013269	101.998391	1	1	23150.044	0.0000015	
2522.95	0.00543356	0.01710668	0.00548372	0.01726118	-22.609247	1.7530362	0.53015867	2.4699918	1.9089246	114.25164	84.189186	113.941	62.093686	87.4263222	107.550686	1	1	25726.8596	0.00000162	
2582.24	0.00499337	0.01412547	0.00487738	0.01379872	-23.11813	2.5751246	1.6837892	0.799743	2.1113657	117.41393	75.531482	118.793	56.822401	84.389029	98.4204449	1	1	24533.6575	0.00000151	
2642.92	0.00620973	0.01637657	0.00613388	0.01617109	-22.122648	2.4374629	1.7906939	1.4307452	1.6471842	114.47586	82.391583	115.30137	62.9589242	96.8606771	109.04934	1	1	33080.5509	0.00000199	
2705.03	0.0045413	0.01378057	0.0044421	0.01347672	-23.524116	2.3963032	1.1330853	1.7889969	1.5882932	106.84161	77.779907	107.98087	58.8257937	84.3649713	101.890464	1	1	25685.6244	0.00000151	
2768.6	0.00452755	0.01569261	0.00444723	0.01540741	-23.519101	0.95623172	1.8976693	0.14321162	1.1216618	113.22179	74.032232	114.242	64.3766898	86.3974805	111.505011	1	1	27571.2265	0.00000159	
2833.66	0.00636974	0.01506422	0.0065098	0.01539441	-21.86432	0.6048366	1.4935661	1.9709667	1.2499697	128.55777	86.87318	127.19333	65.8616816	106.986166	114.077123	1	1	43270.9773	0.00000243	
2900.25	0.00490029	0.01406537	0.00481589	0.01382986	-23.173234	2.3819572	2.2209895	1.728423	1.849811	124.23208	81.470846	125.23167	63.8922228	94.1823724	110.66588	1	1	34321.6693	0.00000188	
2968.41	0.00389531	0.01182223	0.00381261	0.01157082	-24.187773	1.2695165	1.8075928	0.62523655	1.2376916	103.5758	69.877772	104.69483	59.8149172	85.7691565	103.603696	1	1	29132.6424	0.00000156	
3038.16	0.00348639	0.01336963	0.00341534	0.01310625	-24.665666	0.57897043	1.6346645	1.8321648	1.5125339	121.15971	85.695865	122.387	65.1558612	83.0851207	112.854591	1	1	27980.2034	0.00000147	
3109.56	0.00274143	0.00935608	0.00280243	0.00956728	-25.524652	1.1442663	1.4082866	1.641251	1.2305072	95.901753	69.280692	94.8811	56.9766288	77.0304136	98.6875785	1	1	24615.9792	0.00000126	
3182.64	0.00283899	0.00893531	0.0027789	0.0087463	-25.561276	2.0440216	2.5086518	1.835739	1.8021276	106.59545	75.804654	107.74337	55.7574893	78.5090288	96.5759419	1	1	26171.0074	0.00000131	
3257.43	0.00435467	0.01205562	0.00445799	0.0123397	-23.508609	1.9864257	1.5334785	2.150202	1.7451894	134.05087	85.872752	132.48467	67.7846051	101.774862	117.407763	1	1	45014.2331	0.0000022	
3333.98	0.00211775	0.00513374	0.00217023	0.00526004	-26.634937	0.8170083	1.6855254	2.0542098	1.6560936	106.36376	75.929069	105.0834	45.2961151	72.6795206	78.4560969	1	1	23495.2902	0.00000112	
3412.33	0.00278826	0.00894924	0.00275284	0.00883495	-25.602195	1.8210105	2.5519406	1.590644	1.7621063	128.74103	79.826093	129.64533	60.0836984	83.7793863	104.069244	1	1	31953.5481	0.00000149	
3492.52	0.00277501	0.00906324	0.00283	0.0092488	-25.482137	0.68871896	0.97460671	1.2746252	1.0717045	100.47033	67.004094	99.511567	62.9194859	86.9416618	108.98103	1	1	35219.9302	0.00000161	
3574.59	0.00389704	0.00996914	0.00398191	0.01018595	-23.999089	0.31935564	1.3416539	1.2699576	1.1944798	109.60711	75.788663	108.43233	67.5819336	105.5523	117.056722	1	1	53131.9005	0.00000237	
3658.59	0.0020774	0.00622707	0.0021173	0.00634672	-26.742166	1.8758437	3.0998026	2.1001604	2.174047	113.18129	75.250106	112.08833	54.5999406	78.777348	94.5709852	1	1	30290.7601	0.00000132	
3744.57	0.00259993	0.00662972	0.00265147	0.00676101	-25.765139	1.6556442	1.1050496	1.4871025	1.2099126	123.47521	82.94528	122.25733	57.6781562	90.2279111	99.9026739	1	1	40670.3093	0.00000173	
3832.57	0.00176892	0.0055527	0.001807	0.00567328	-27.43043	0.96335947	1.3534195	1.5028874	1.3339854	115.55555	71.523477	114.33133	54.0767976	76.2367759	93.6648643	1	1	29717.5398	0.00000123	

In the results export file, you can find:

- All your measurement :E field, Powers, and P_{Fwd} P_{Rev}
- For all frequencies and all angular steps and all positions

- A statistical calculation table is also available with all the calculated values

4.2 Loaded Calibration

The loaded calibration makes it possible to know whether the isotropy and homogeneity properties are still respected when the chamber is artificially loaded around 12dB.
Loaded calibration is **required** in **IEC 61000** and **DO 160F** and earlier standards. Calibration under load is not necessary for the DO160 G and MIL-STD.

4.2 Loaded Calibration measurement method

The loaded calibration is performed in the same way as the empty calibration:

- Field measurement identical to the empty calibration to verify uniformity (same measurement and same calculation)
- Power measurement identical to empty calibration

4.2 Loaded Calibration

- An additional result: the ratio of powers received for empty chamber vs loaded chamber

IEC

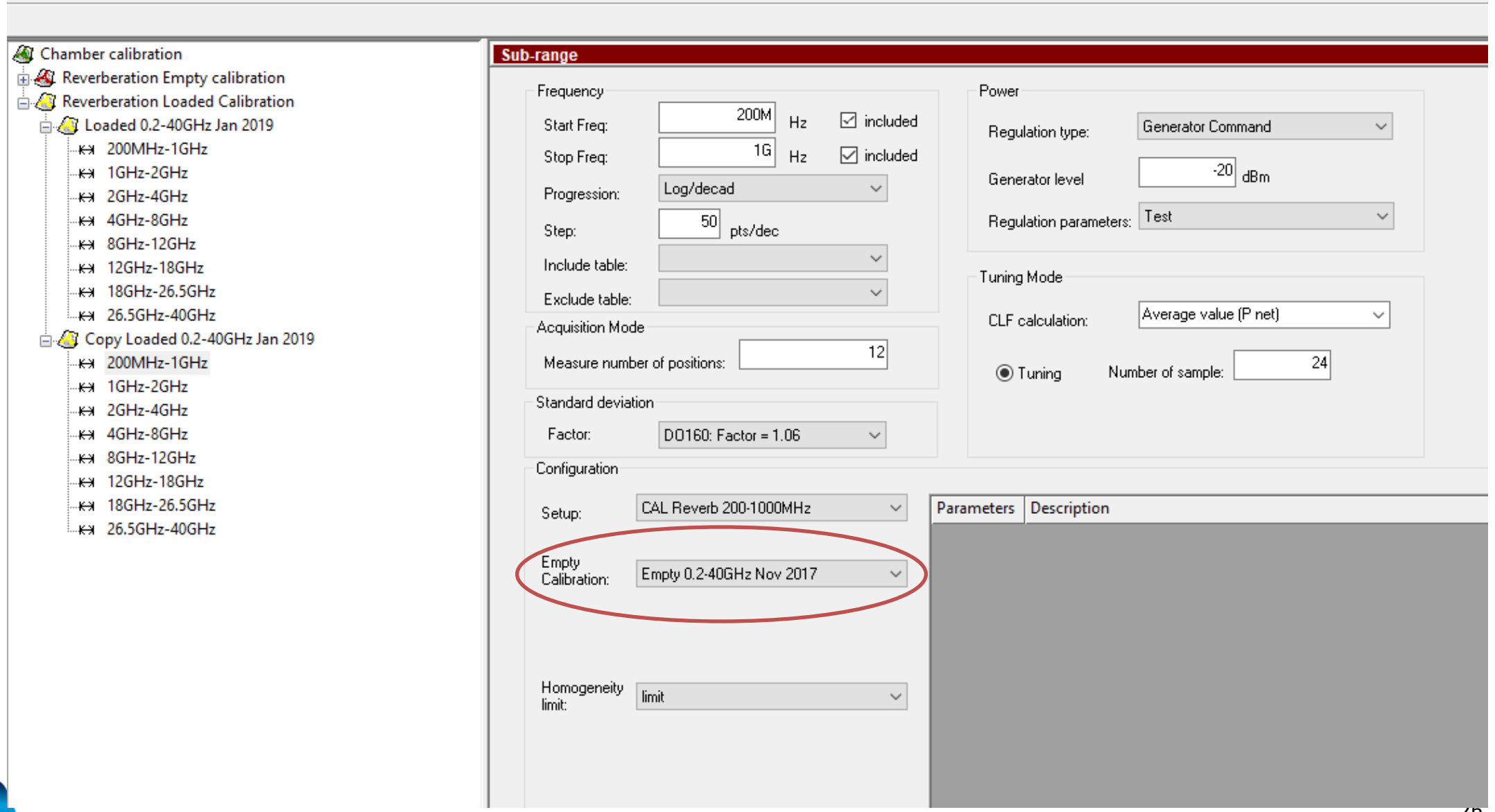
$$Loading = \frac{AVF_{\text{Empty Chamber}}}{AVF_{\text{Loaded Chamber}}}$$

DO 160 F

$$Loading = \frac{ACF_{Empty\ Chamber}}{ACF_{Loaded\ Chamber}}$$

- This load factor represents the maximum load of the chamber while maintaining the uniformity of the volume.
- The load of the EUT must be less than this maximum load.

4.2 Loaded Calibration - BAT-EMC configuration



4.3 Calibration of the Equipment Under Test

Calibration with equipment measures the power ratio or field ratio with the EUT in the chamber.

These measurements will allow to calculate the power required for the test.

4.3 EUT Calibration according to IEC or DO160 F

For IEC and DO 160 F:

- No field measurement
- Measurement of the received power (same calculation method as empty and loaded calibrations)

$$CVF = \left\langle \frac{P_{AveRec}}{P_{Input}} \right\rangle_{n}$$

$$CCF = \left\langle \frac{P_{AveRec}}{P_{Input}} \right\rangle_{n,f}$$

$$CLF = \frac{CCF}{ACF}$$

4.3 EUT Calibration according to DO160 G

For DO 160 G:

- Continuous or step-by-step rotation method
- Calculation of the E_{Max} from the maximum power received over a complete rotation

$$E_{\max} = \sqrt{\frac{377 * 8 * \pi * (P_{rcv\max})}{\lambda^2}}$$

- P_{Fwd} measurement: Max forward power over a complete rotation

4.3 EUT Calibration according to MIL STD

For MIL-STD 461:

- Step by step rotation
- 2 calculation methods:
  - In Field

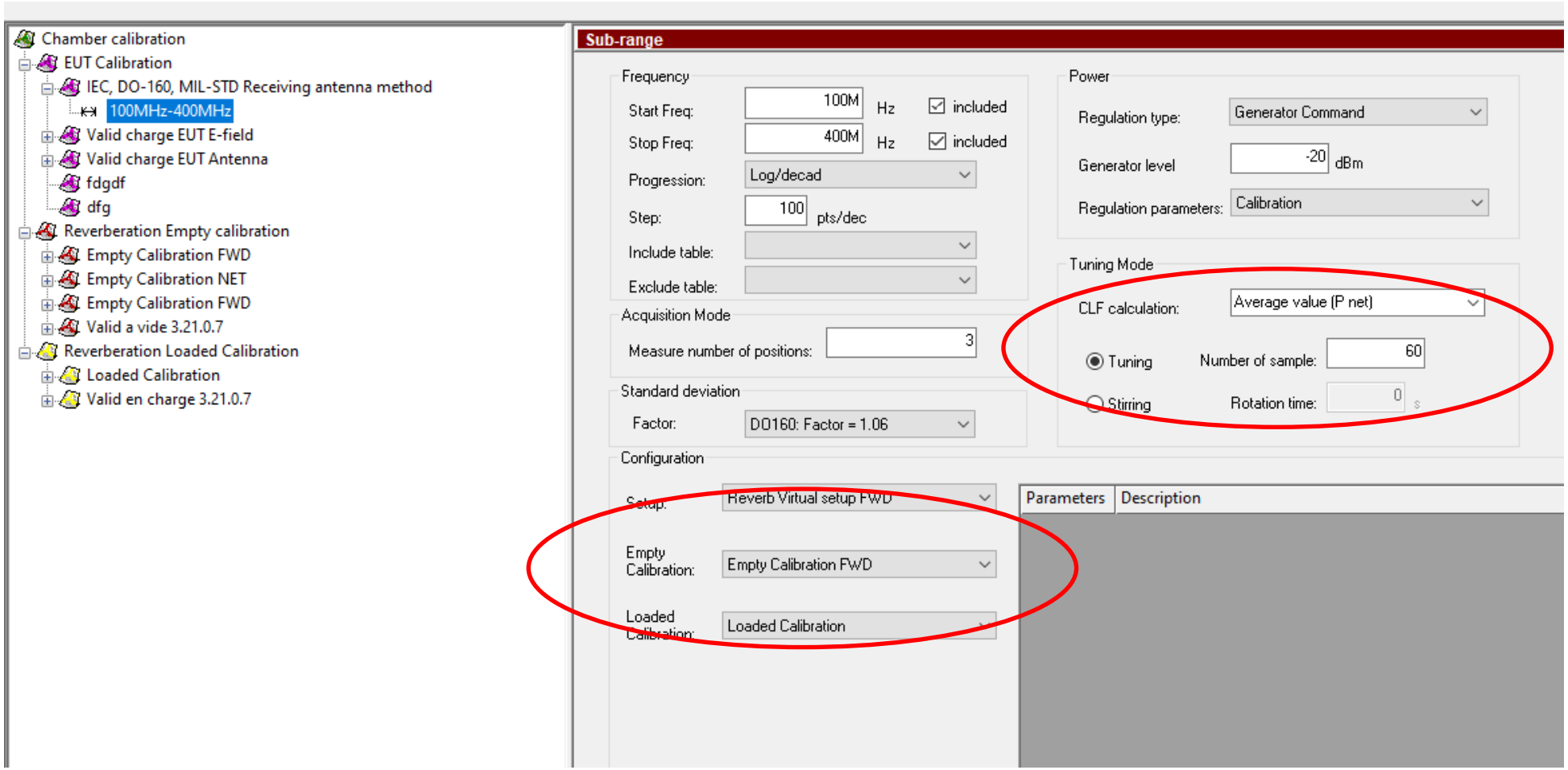
$$\text{Calibration factor} = \sqrt{\left(\frac{E_{x-\max} + E_{y-\max} + E_{z-\max}}{3}\right)^2 \Big/ P_{forward}}$$

  - In power

$$\text{Calibration factor} = \frac{8\pi}{\lambda}\sqrt{5\left(\frac{P_{r-\max}}{P_{forward}}\right)}$$

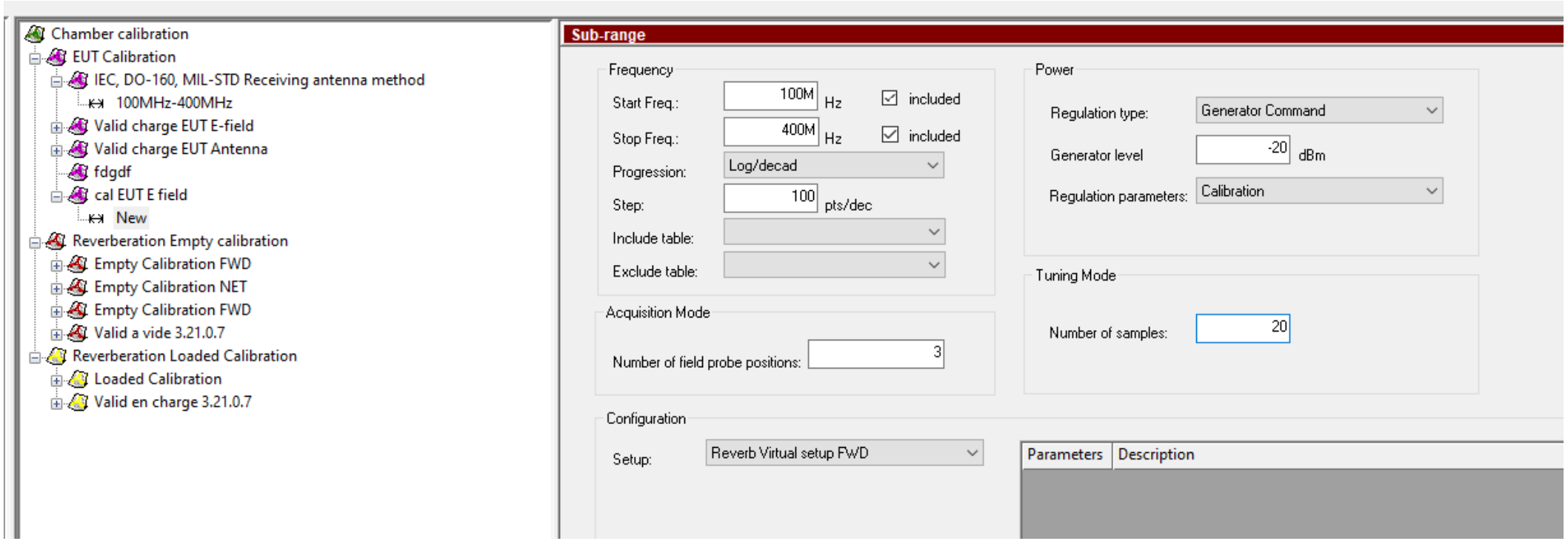
4.3 EUT Calibration - BAT-EMC configuration

Configuration in BAT-EMC for IEC, DO 160 F, DO160G and MIL STD “power method” calibration



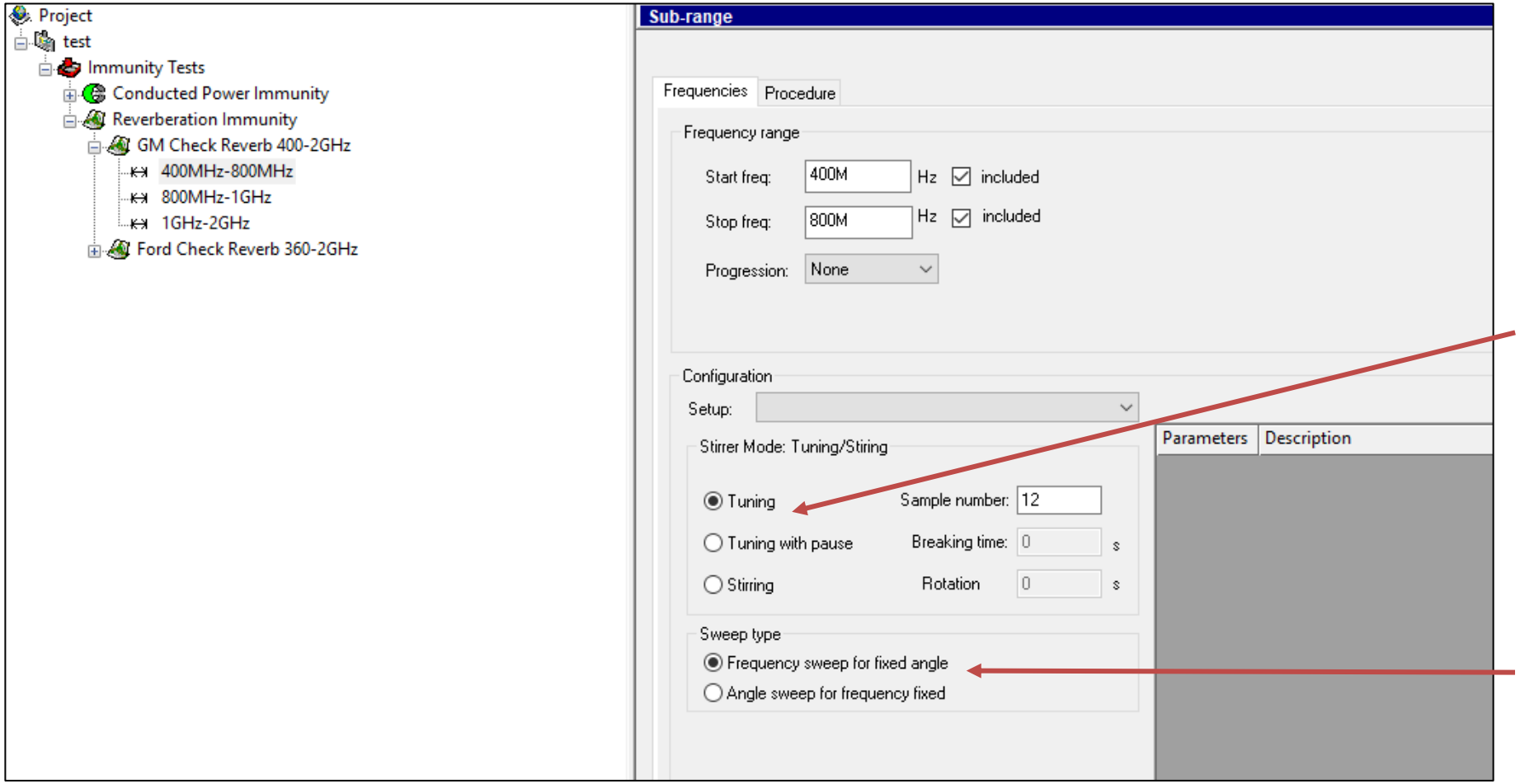
4.3 EUT Calibration - BAT-EMC configuration

Configuration in BAT-EMC for MIL STD “field method” calibration



5. EUT test

Configuration in BAT-EMC



Stirrer : Step by step or Continuous

2 types of sweep: frequency or angular

5. EUT test

The power (Fwd or Net) for a required field is calculated according to the formulas of the different standards:

DO 160 F

$$P_{Input} = \left[\frac{E_{Test}}{\left\langle \vec{E}_{Total} \right\rangle_n * \sqrt{CLF}} \right]^2$$

IEC

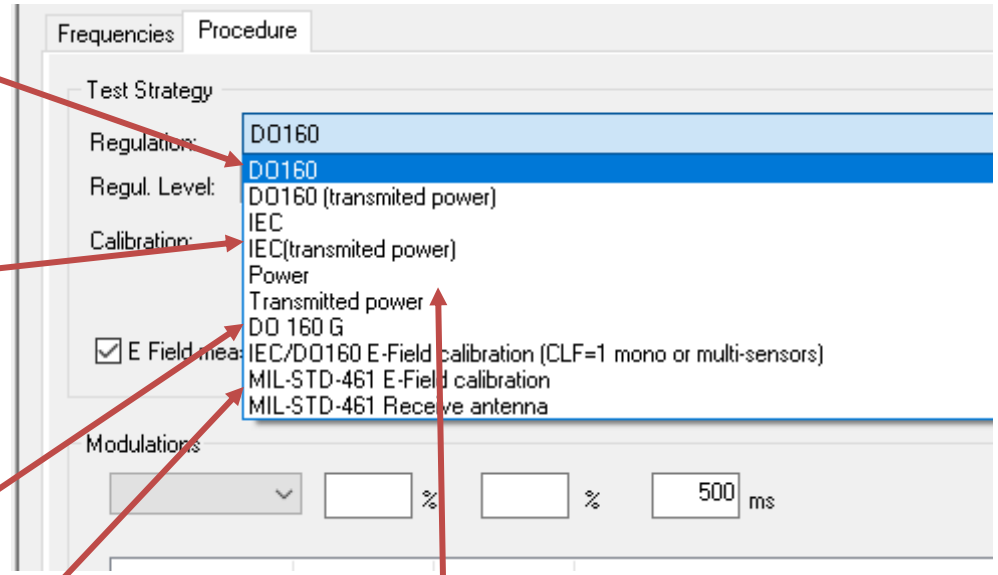
$$P_{Input} = \left[\frac{E_{test}}{\left\langle \vec{E} \right\rangle_{24 \text{ or } 9} \times \sqrt{CLF(f)}} \right]^2$$

DO 160 G

$$P_{Target} = 20 * \log\left(\frac{E_{desire}}{E_{max}}\right) + P_{Fwd}$$

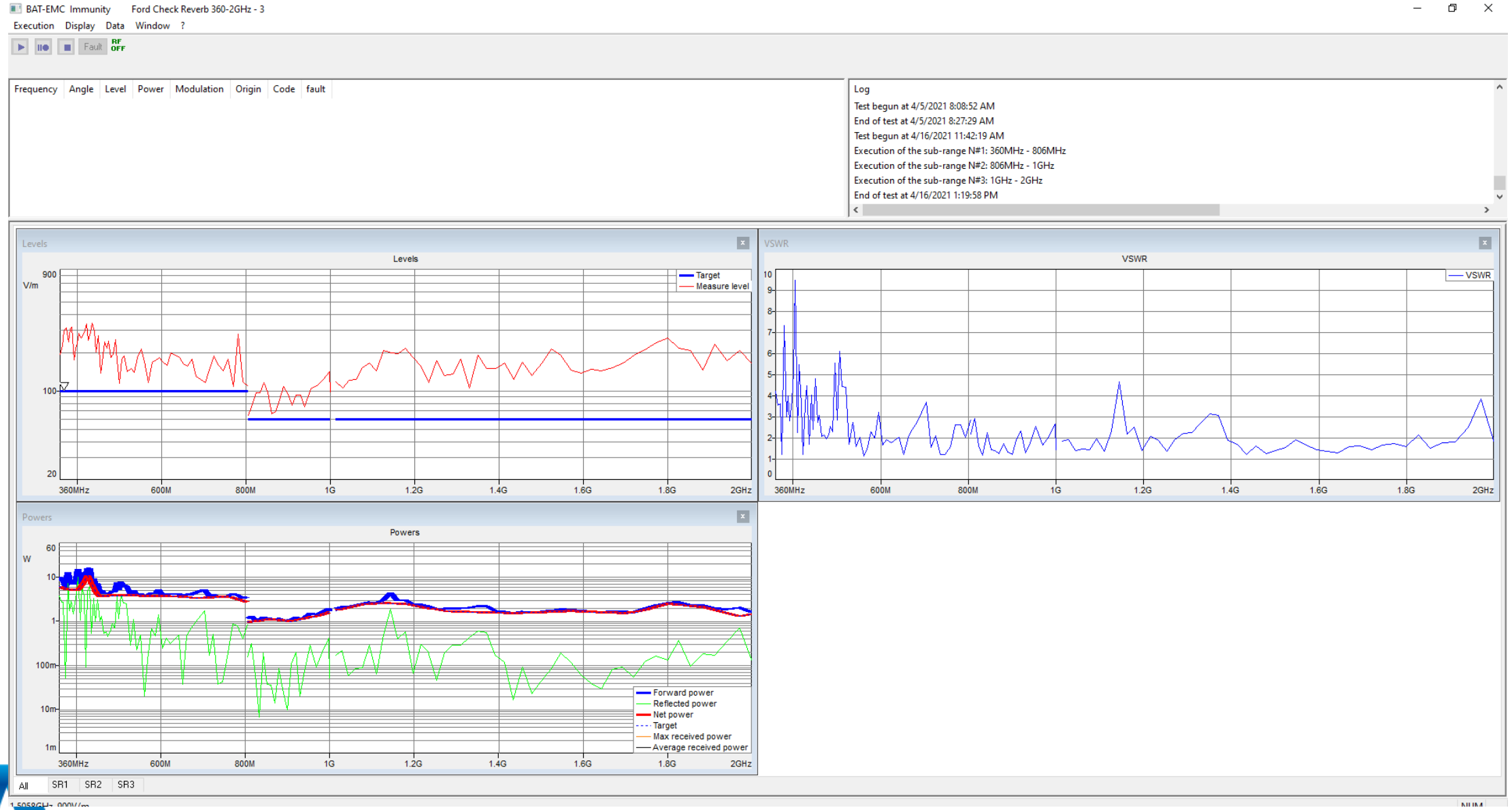
MIL STD

$P_{Fwd} = E_{Field}$ / calibration factor

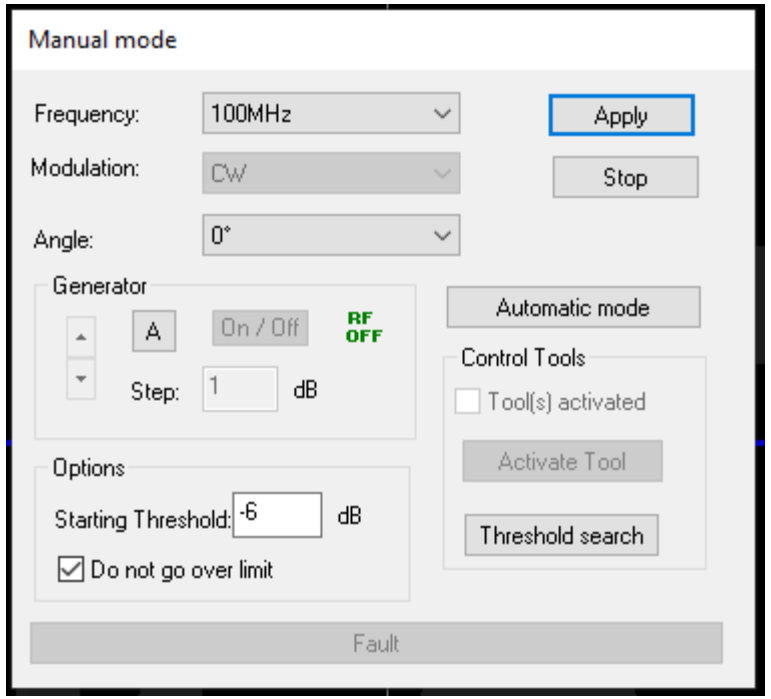


A Power field to allow you to apply your formula

5.1 Automatic execution



5.2 Manual Mode



In manual mode, the operator can modify parameters such as:

- frequency,
- modulation,
- the angle,
- generator level

It is possible to use control tools to monitor the EUT.

5.3 Report and export of results

As for all tests in BAT-EMC,

Ability to export results to Excel and generate a highly configurable test report

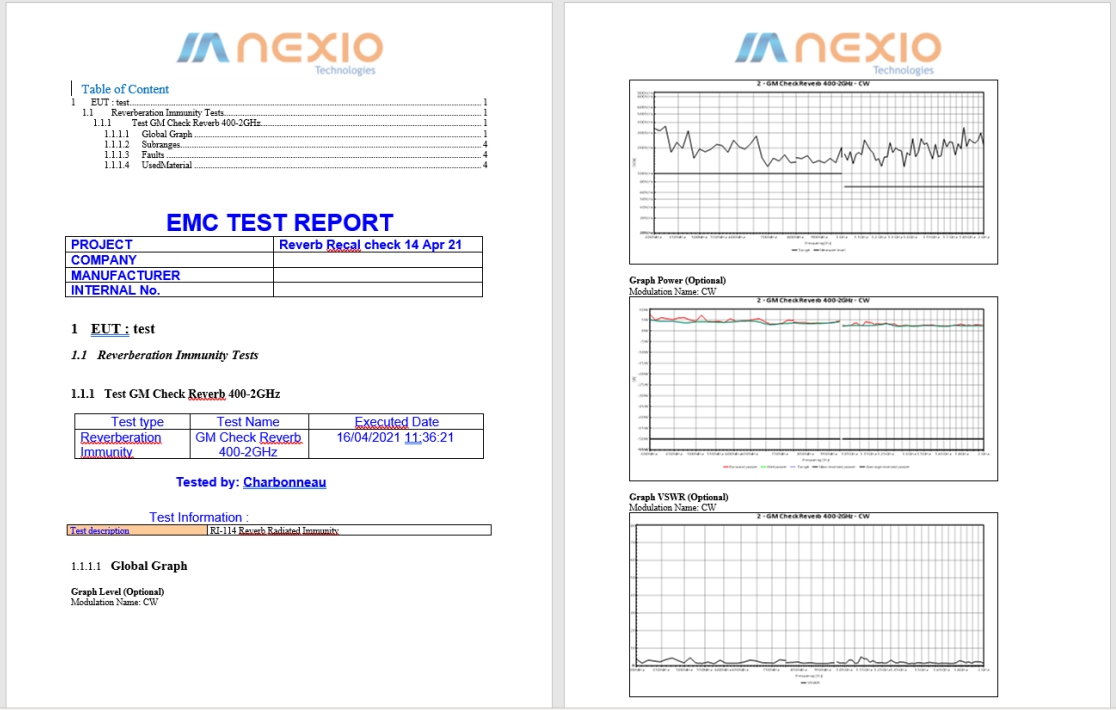


Table of Content

1 EUT : test 1
1.1 Reverberation Immunity Tests 1
1.1.1 Test GM Check Reverb 400-2GHz 1
1.1.1.1 Global Graph 1
1.1.1.2 Subranges 4
1.1.1.3 Faults 4
1.1.1.4 UsedMaterial 4

EMC TEST REPORT

PROJECT	Reverb Recal check 14 Apr 21
COMPANY	
MANUFACTURER	
INTERNAL No.	

1 EUT : test

1.1 Reverberation Immunity Tests

1.1.1 Test GM Check Reverb 400-2GHz

Test type	Test Name	Executed Date
Reverberation Immunity	GM Check Reverb 400-2GHz	16/04/2021 11:36:21

Tested by: Charbonneau

Test Information :

Test description	RI-114 Reverb Radiated Immunity

1.1.1.1 Global Graph

Graph Level (Optional)
Modulation Name: CW

Graph Power (Optional)
Modulation Name: CW

Graph VSWR (Optional)
Modulation Name: CW

STEP	Frequency (f	Angle (~)															
Target1CW	400	0															
Target1CW	400	30															
Target1CW	400	60															
Target1CW	400	90															
Target1CW	400	120															
Target1CW	400	150	100	0	156.3	-1.798e+308	100.7	0.06132	5.036	13.56	8.453	-14.6	8.5	0	0	0	0	0	0 4/16/2021 10:21
Target1CW	400	180	100	0	148.3	-1.798e+308	100.8	0.07135	5.036	8.945	3.826	-15.8	4.78	0	0	0	0	0	0 4/16/2021 10:23
Target1CW	400	210	100	0	166.6	-1.798e+308	102.3	0.1981	5.036	8.814	3.543	-15.7	4.47	0	0	0	0	0	0 4/16/2021 10:25
Target1CW	400	240	100	0	85.2	-1.798e+308	100.2	0.01635	5.036	8.791	3.736	-15.7	4.75	0	0	0	0	0	0 4/16/2021 10:27
Target1CW	400	270	100	0	338.5	-1.798e+308	100.1	0.01028	5.036	6.427	1.38	-15.6	2.73	0	0	0	0	0	0 4/16/2021 10:29
Target1CW	400	300	100	0	243.6	-1.798e+308	100	0.004047	5.036	7.638	2.597	-15.7	3.8	0	0	0	0	0	0 4/16/2021 10:31
Target1CW	400	330	100	0	337.1	-1.798e+308	101.7	0.1483	5.036	5.707	0.496	-16.7	1.84	0	0	0	0	0	0 4/16/2021 10:33
Target1CW	411.246	0	100	0	171.8	-1.798e+308	100.6	0.05148	4.664	5.448	0.7286	-18.23	2.15	0	0	0	0	0	0 4/16/2021 10:11
Target1CW	411.246	30	100	0	111	-1.798e+308	101.4	0.1183	4.664	5.993	1.2	-17.23	2.62	0	0	0	0	0	0 4/16/2021 10:12
Target1CW	411.246	60	100	0	211.3	-1.798e+308	101.2	0.1051	4.664	4.988	0.2096	-17.53	1.52	0	0	0	0	0	0 4/16/2021 10:14
Target1CW	411.246	90	100	0	102.6	-1.798e+308	100.6	0.05445	4.664	4.765	0.04166	-17.53	1.21	0	0	0	0	0	0 4/16/2021 10:17
Target1CW	411.246	120	100	0	91.28	-1.798e+308	101.2	0.106	4.664	11	6.225	-14.33	7.07	0	0	0	0	0	0 4/16/2021 10:19
Target1CW	411.246	150	100	0	298.9	-1.798e+308	100.8	0.06589	4.664	7.142	2.406	-16.33		0	0	0	0	0	0 4/16/2021 10:21
Target1CW	411.246	180	100	0	150.9	-1.798e+308	101.9	0.1601	4.664	5.943	1.104	-16.33		0	0	0	0	0	0 4/16/2021 10:23
Target1CW	411.246	210	100	0	144.8	-1.798e+308	102.1	0.1796	4.664	7.07	2.209	-15.83		0	0	0	0	0	0 4/16/2021 10:25
Target1CW	411.246	240	100	0	201.5	-1.798e+308	102	0.1694	4.664	10.35	5.496	-14.83		0	0	0	0	0	0 4/16/2021 10:27
Target1CW	411.246	270	100	0	317.8	-1.798e+308	101.8	0.1564	4.664	10.32	5.482	-14.43		0	0	0	0	0	0 4/16/2021 10:29
Target1CW	411.246	300	100	0	155.7	-1.798e+308	102.1	0.1835	4.664	7.637	2.771	-15.83		0	0	0	0	0	0 4/16/2021 10:31
Target1CW	411.246	330	100	0	104.3	-1.798e+308	100.1	0.01248	4.664	4.849	0.1718	-17.03		0	0	0	0	0	0 4/16/2021 10:33
Target1CW	422.807	0	100	0	142.8	-1.798e+308	100.8	0.0672	4.324	6.109	1.718	-17.58		0	0	0	0	0	0 4/16/2021 10:11
Target1CW	422.807	30	100	0	183.9	-1.798e+308	100.9	0.07657	4.324	5.038	0.6378	-17.58		0	0	0	0	0	0 4/16/2021 10:12
Target1CW	422.807	60	100	0	190.5	-1.798e+308	101.2	0.1045	4.324	5.192	0.7633	-17.18		0	0	0	0	0	0 4/16/2021 10:14
Target1CW	422.807	90	100	0	96.91	-1.798e+308	100.9	0.07732	4.324	7.4	2.998	-15.68		0	0	0	0	0	0 4/16/2021 10:17
Target1CW	422.807	120	100	0	215.8	-1.798e+308	105.4	0.4566	4.324	7.218	2.415	-15.68		0	0	0	0	0	0 4/16/2021 10:19
Target1CW	422.807	150	100	0	360.4	-1.798e+308	101.8	0.1592	4.324	6.444	1.959	-15.98		0	0	0	0	0	0 4/16/2021 10:21
Target1CW	422.807	180	100	0	139.7	-1.798e+308	101.7	0.1476	4.324	8.623	4.15	-14.88		0	0	0	0	0	0 4/16/2021 10:23
Target1CW	422.807	210	100	0	154.8	-1.798e+308	101.7	0.1457	4.324	5.894	1.423	-16.08		0	0	0	0	0	0 4/16/2021 10:25
Target1CW	422.807	240	100	0	111.1	-1.798e+308	101.6	0.1365	4.324	8.069	3.608	-14.98		0	0	0	0	0	0 4/16/2021 10:27
Target1CW	422.807	270	100	0	169	-1.798e+308	101.5	0.1329	4.324	5.85	1.392	-16.08		0	0	0	0	0	0 4/16/2021 10:29
Target1CW	422.807	300	100	0	173.4	-1.798e+308	101.5	0.1335	4.324	6.088	1.629	-15.88	3.14	0	0	0	0	0	0 4/16/2021 10:31
Target1CW	422.807	330	100	0	136.6	-1.798e+308	101.5	0.1309	4.324	4.917	0.4616	-16.58	1.88	0	0	0	0	0	0 4/16/2021 10:33
Target1CW	434.694	0	100	0	156.7	-1.798e+308	100.8	0.07297	4.339	8.572	4.159	-17.05	5.59	0	0	0	0	0	0 4/16/2021 10:11

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