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# PWA MI preamplifiers

## Flight Model calibrations vs temperature and Models

M. Hamelin & M. Chabassière, May 2011

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*Foreword: the PWA instrument was designed and built by four institutes: RSSD-ESTEC, Noordwijk; IAA, Granada; IWF, Graz; and LPCE, Orléans. The preamplifiers were built in Orléans, but all institutes were involved in test and calibration procedures. The reader should be aware of the HASI-PWA documents in the ESA-NASA HUYGENS archive.*

### 1. Introduction

The PWA-MI preamplifiers are linked without connectors to the receiving electrodes (RX). During the descent in the atmosphere of Titan, the preamplifiers, located in the Huygens Probe are close to the usual terrestrial ‘room temperature’ whereas the part of the cables outside Huygens and the coupling circuits (capacitive link to the electrodes) are close to the outside Titan atmosphere temperature.

The calibrations of the flight model (FM) have been performed in two ways:

- Calibration of PWA-MI receiving part (PWA-AC for passive measurements, preamplifiers + filters) from electrode to ADC point, at room temperature in the laboratory.
- Special calibrations of the preamplifiers connected to the electrodes: preamplifiers at room temperature, but with two conditions for the booms: either at room temperature or at LN2 temperature in a cooling chamber. This last setup corresponds roughly to the case of the descent in the atmosphere of Titan.

Then the FM laboratory calibrations should be slightly modified depending on the accuracy needed. Generally the impact of temperature is low for passive measurements of the electric field but can be important for Mutual Impedance measurements.

Two cases will be considered here for Titan as well as for laboratory calibrations:

- Warm = room temperature of laboratory testing or temperature inside Huygens
- Cold = Booms, with part of the cables and coupling circuits in the cryogenic chamber or in the atmosphere of Titan (but electronics Warm).

There will be two approaches;

- To calculate numerically a temperature correction for the preamplifiers transfer function amplitude, from the laboratory thermal tests. This can be used to modify the AC transfer functions (amplitude only) that were measured at room temperature.
- To model the preamplifier and electrodes circuits. Then by fitting with the calibration data (complex transfer functions), to obtain a physical analog model. This provides better understanding and ability to treat impulsive signals but maybe less accuracy at given frequencies as in the case of MI measurements.

## 2. Calibration at cryogenic temperature and transfer function corrections.

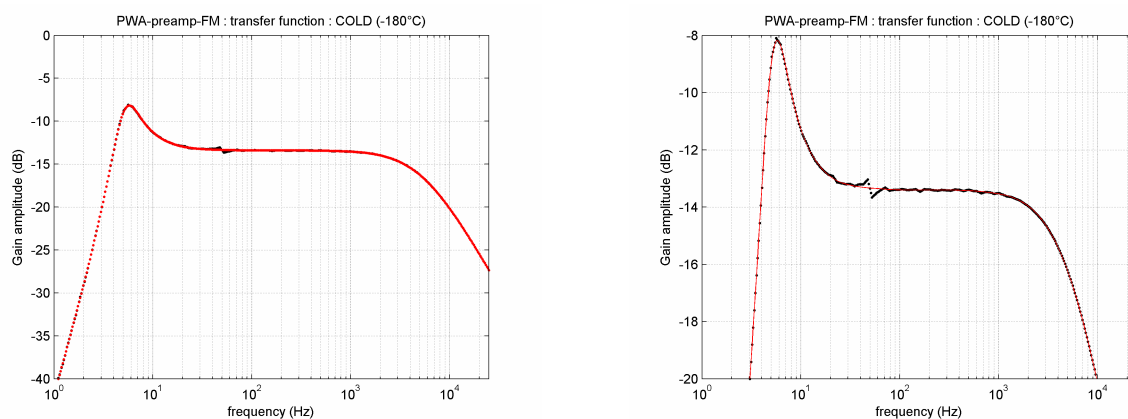
The booms were installed inside the cryogenic chamber and the preamplifiers outside. Parts of the cables were at room temperature and part of them at LN2 temperature, simulating the case of Huygens in the atmosphere of Titan.

Three measurements of the complex transfer function were performed in sequence (files in annex B1-B7, raw data):

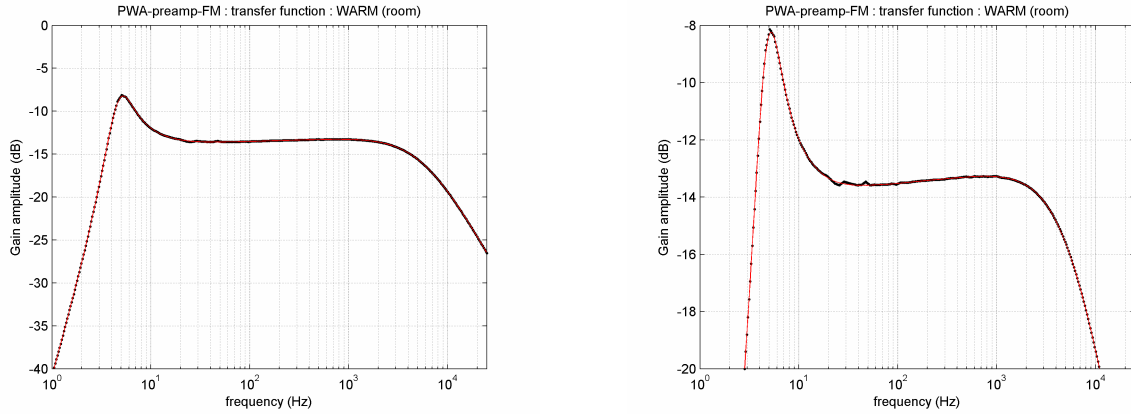
- B1: frequency list (1 Hz to 25800 Hz)
- B2: Gain, real part at room temperature, before cold test
- B3: Gain, imaginary part at room temperature, before cold test
- B4: Gain, real part at LN2 temperature
- B5: Gain, imaginary part at LN2 temperature
- B6: Gain, real part at room temperature, after cold test
- B7: Gain, imaginary part at room temperature, after cold test

The cryogenic facility introduced some perturbations in the measurement range: at 50 Hz but also at some frequencies around. For the Warm data, the average of the two room temperature tests has been used. The figures 1-3 show the data: raw data and empirical 'cleaned' data. The 'cleaned' amplitudes are shown in Annex Data Files):

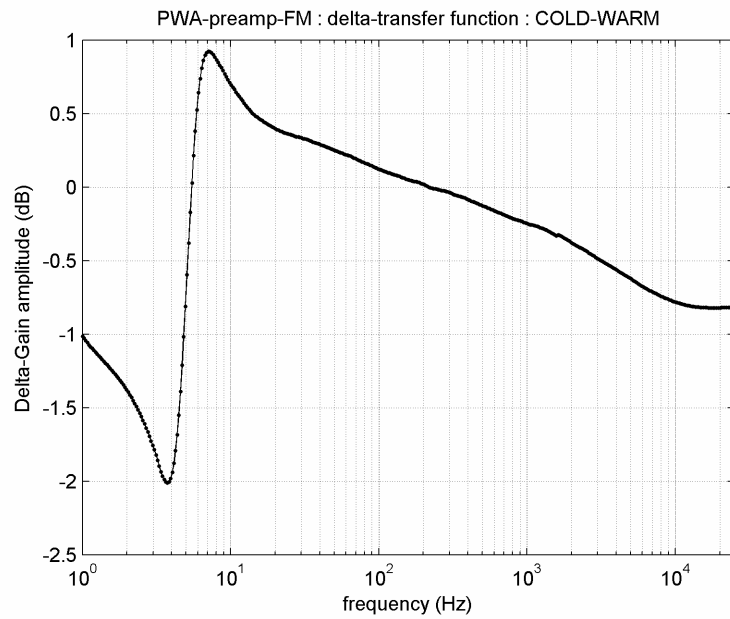
- B8: File PWA\_MI\_preamp\_HP\_COLD\_dB.txt Cold gain (dB)
- B9: File PWA\_MI\_preamp\_HP\_WARM\_dB.txt Warm gain (dB)
- B10: File PWA\_MI\_preamp\_HP\_CmW\_dB.txt Difference Cold - Warm



**Figure 1.** Preamplifier transfer function. Cold case (boom at -180°C). [raw data: black; cleaned data: red]



**Figure 2.** Preamplifier transfer function. Warm case. [raw data: black; cleaned data: red]



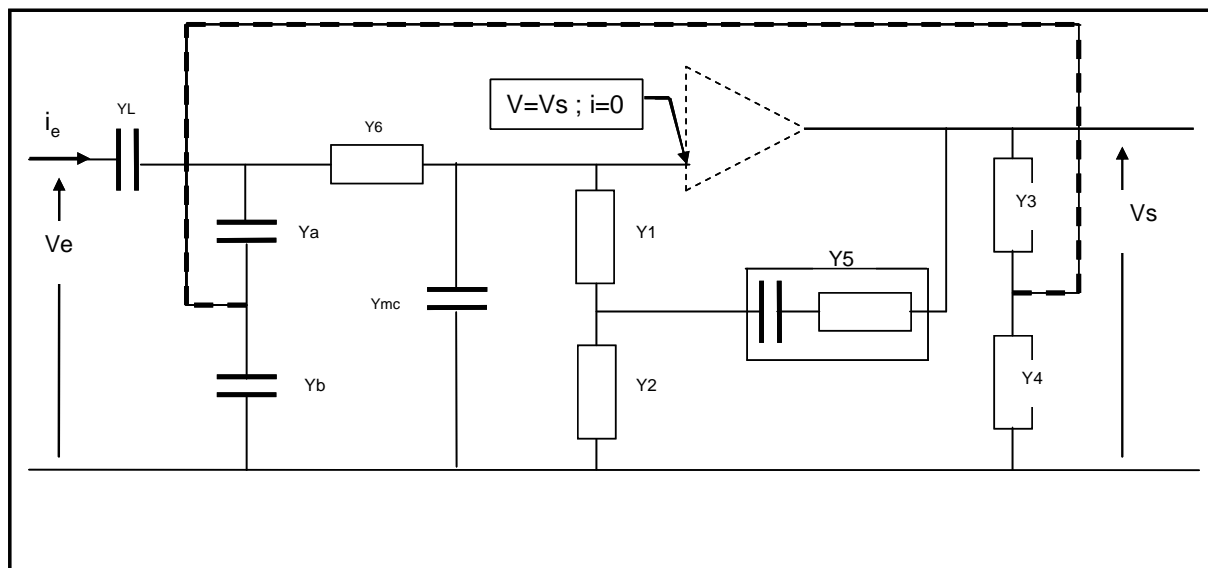
**Figure 3.** Preamplifier transfer function. Difference Cold case - Warm case. The large amplitude variation near 7 Hz is due to a slight frequency shift of the resonance.

The curve of fig. 3 (file PWA\_MI\_preamp\_HP\_CmW\_dB.txt ) will be used for correcting the PWA-AC calibrations that were performed at room temperature.

### 3. Analog Model of PWA-MI preamplifiers at room and at LN2 temperatures.

#### 3.1 Schematic and mathematical model

The schematic is shown in Fig. 4. The electrode is connected to the circuit through a very small capacitor to provide high input impedance. The serial RC element (admittance  $Y_5$ ) is the main feedback element; it produces an overshoot at low frequency. The cables are triaxial, with the intermediate conductor and a guard around the coupling capacitor connected to  $\sim 99.9\%$  of the OA output. This reduces the high impedance input losses in the cables up to some high frequency limit. For details, see Cadène, 1995.



**Figure 4.** MI preamplifier model.  $Y_L$  is the coupling capacitor admittance (close to the Rx electrode).  $Y_a$  and  $Y_b$  are the admittances of the triaxial cable (respectively inner to intermediate and intermediate to outer).

#### Formulas for gain and input impedance

Solving the circuit equations provides the main characteristics of the circuit: the input impedance  $V_e / I_e$  and the transfer function (complex gain):  $V_s / V_e$ . All electronic components are well known (within the nominal accuracy), but not the following ones:

- The coupling capacitor  $C_L$ , embedded in a guard and too small to be measured accurately.
- The common mode admittance  $Y_{mc}$  that we consider as capacitive, 0.8 pF from the data sheet, but which depends on the wiring details.
- The triaxial cables capacitances  $C_a$  and  $C_b$  (including the guard around the coupling capacitor); those are not accessible in final tests.

For these reasons the mathematical solutions for the gain and the input impedance are given as a function of the not accurately known parameters in Annex 1 as a Matlab<sup>®</sup> procedure (easy to translate in mathematical formulas or other language).

### Gain as a filter and rational function formula

The complex transfer function is given in the classical form of a rational function of  $s = 2\pi i f$ :

$G = GN / GD$ , with:

$$GN = a_1 s + a_2 s^2 + a_3 s^3$$

$$GD = b_0 + b_1 s + b_2 s^2 + b_3 s^3 + b_4 s^4$$

The formulas are given as a Matlab<sup>®</sup> procedure in Annex 2

*[Warning: as Matlab<sup>®</sup> does not allow zero and negative indexes, there is a shift by 1 of indexes; see comments in Annex A2]*

This form can be helpful to compute the analog output of some impulsive signals through Laplace transforms.

### 3.2 Evaluation of parameters CL, CO and LO by best fit with calibration data

The common mode input OA capacitor, that is in Warm conditions in the laboratory as well as inside Huygens, would have about the same value for Warm and Cold cases. The CL capacitor, made with PCB tracks close to the electrodes is *a priori* sensitive to temperature. The cable capacitors are divided into two parts: inside Huygens at Warm temperature and outside at Cold temperature (the continuation of the cable guard around the coupling capacitor is treated as part of the cable). The cable capacitances  $C_a$  and  $C_b$  of the cables is proportional to  $\epsilon l$  where  $\epsilon$  is the dielectric constant of the insulator and  $l$  the length of the cable (if we assume a 3D isotropic dilatation, there is no radial influence). Then, LO, an 'equivalent length' that represents both geometrical and  $\epsilon$  variation effects is used in the model.

We search for a best fit for the amplitude of the gain, between the mathematical value and the measured value (corrected from ~50 Hz perturbations).

#### 3.2.1 COLD case

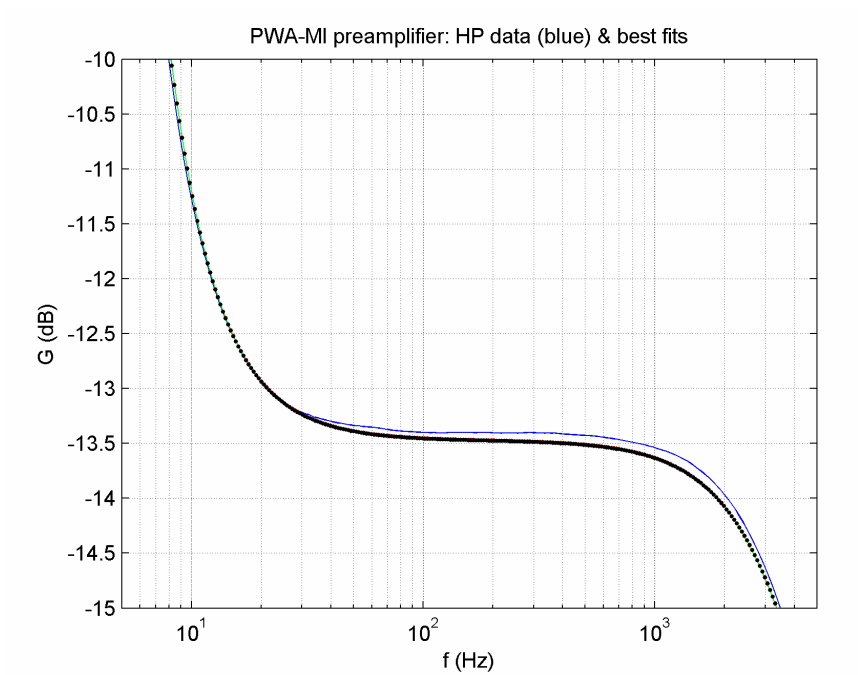
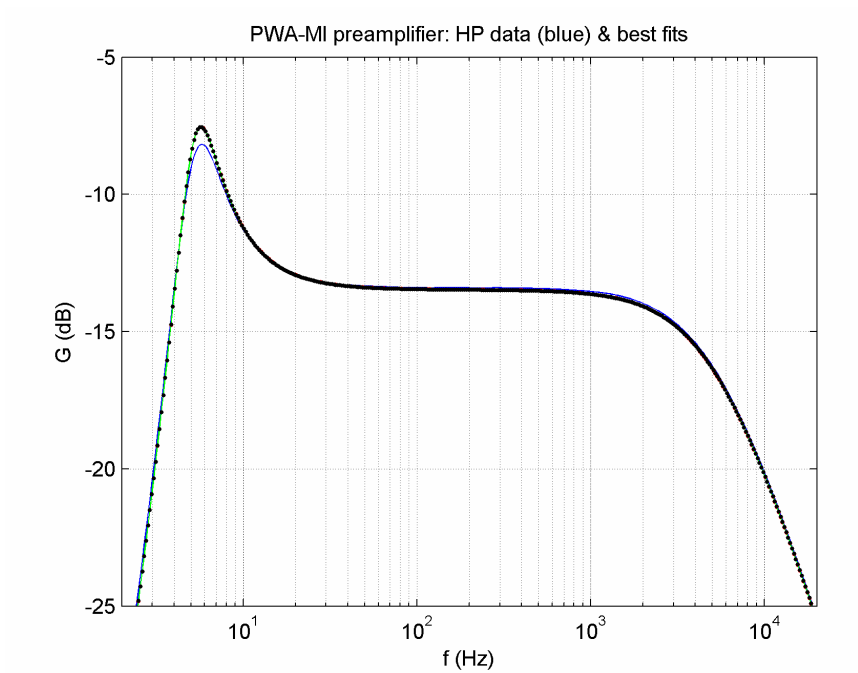
The best agreement is found for:

$$CL = 0.3653 \text{ pF}$$

$$CO = 1.2420 \text{ pF}$$

$$LO = 1.395 \text{ m}$$

The model fits very well with the calibration data and the curve is flat in a large domain where a rough value for the gain amplitude is  $CL / (CO + CL)$ .



**Figure 5.** MI preamplifier: best fit on CL, CO and LO, COLD case. [data: blue; model: black]

### 3.2.2 WARM case

The overall analog calibration has been performed at room temperature. For comparison with measurements a Warm model is useful.

It is difficult to find a good fit of the parameters for the whole frequency range. We focused the agreement either on the ‘plateau’ or for higher frequencies (in particular in view of the 1440 and 5760 Hz of the surface MI mode). The value of CO is kept as for the cold case.

The best agreement for the plateau (~200-2000 Hz) is found for:

CL = 0.4050 pF

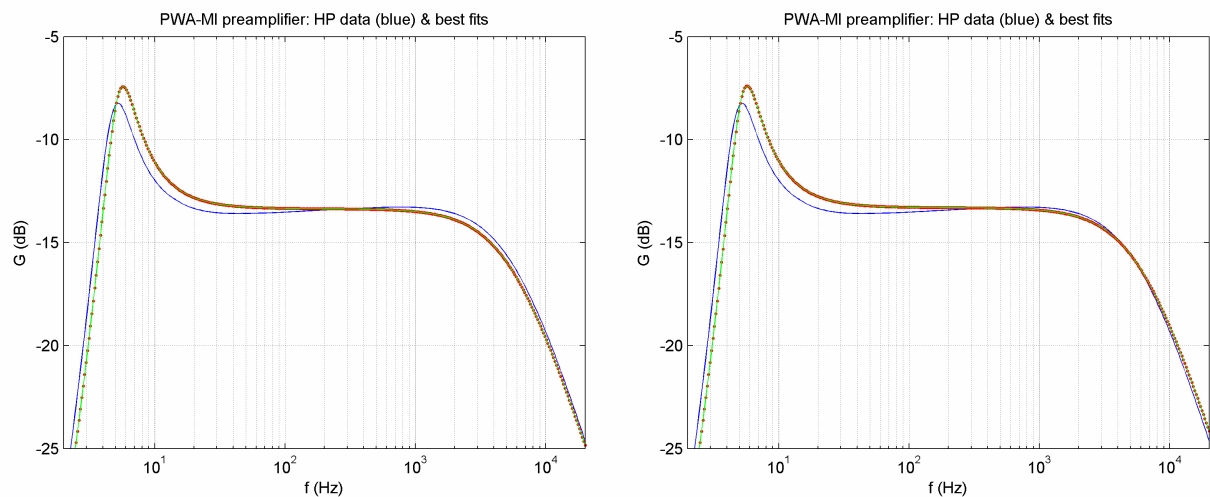
LO = 1.25 m

But for the higher frequencies (~800-8000 Hz):

CL = 0.3715 pF

LO = 1.30 m

The experimental curve (blue) has a smooth secondary maximum around 800 Hz, which cannot be represented by the mathematical model. An element would be missing in the model, probably some resistive leakage in the cold area. At cryogenic temperatures this resistive leak would decrease to practically zero. Fortunately the secondary maximum is absent for the COLD case which is close to reality.



**Figure 6.** MI preamplifier: best fit on CL, CO and LO, WARM case. Two fits: left: adjusted for the range 200-2000 Hz; right: adjusted for the range 800-8000 Hz. [data: blue; model: red]

Remarks:

- The ‘equivalent length’ LO is smaller at WARM temperature, but it includes the variation of the dielectric constant of the cable insulator material (to be investigated).
- The coupling capacitor CL seems to be larger at WARM temperature (without good accuracy).



### 3.2.3 Gain rational function coefficients

The coefficients are calculated with the procedure `pwapreamp_scoef` (Annex 2). For the COLD case they are shown in Table 1.

(n): coef. of $s^n$	gn	gd
0	0	$5.91188 \cdot 10^{-22}$
1	$4.34878 \cdot 10^{-27}$	$9.29836 \cdot 10^{-24}$
2	$1.13136 \cdot 10^{-25}$	$5.37666 \cdot 10^{-25}$
3	$3.06194 \cdot 10^{-33}$	$1.67446 \cdot 10^{-29}$
4	0	$3.30990 \cdot 10^{-37}$

Table 1. PWA preamplifier Gain rational function for the COLD case.

### 3.3 Conclusions for COLD case

The preamplifier transfer function from raw HP data and from the model are shown in Fig. 7. The agreement is very good in the overall frequency range. However, at 5760 Hz (the higher MI frequency in the surface mode) there is an argument difference of  $\sim 2^\circ$ , which could be not negligible. Then for the MI surface mode analysis, particular care is needed, for instance the use of the model at 45 and 90 Hz because of perturbations in calibration data, but the use of raw calibration data at higher frequencies.

The choice for selecting the values of CL, CO and LO was the best fit for the whole frequency range. The rough value of the gain for the plateau,  $CL / (CL+CO)$  is close but not exactly at the plateau level. It is clear that one can find better agreement for the plateau, but then it would be worse for other frequencies.

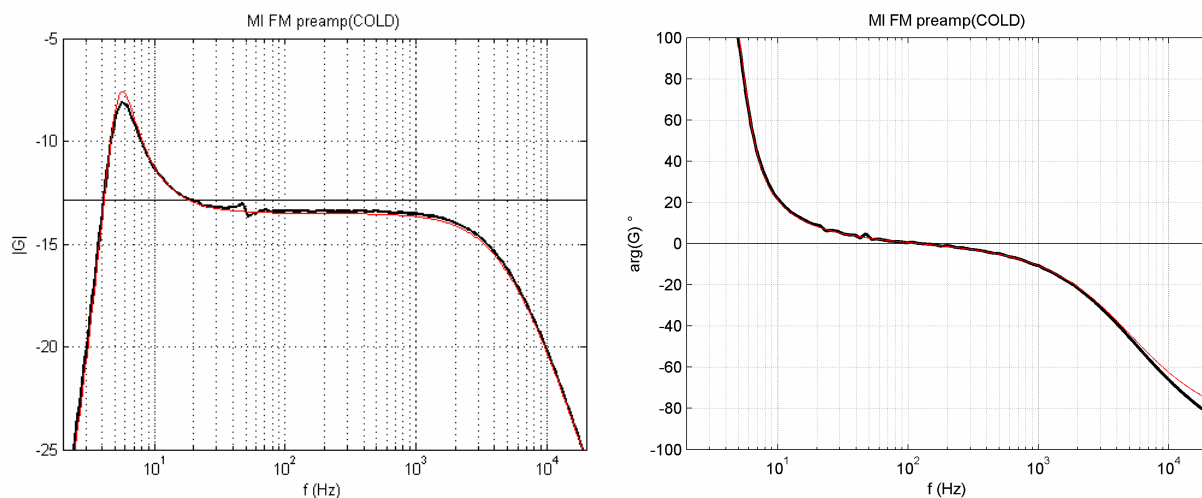


Figure 7. Preamplifier transfer function (COLD). The horizontal line in the left panel represents the ratio  $CL / (CL+CO)$ . Raw HP data: black; model: red.

## References:

F. Cadène, “*Méthodologie de mesure de conductivité d’atmosphères planétaires*”, *Doctorate Thesis*, Paris 6 University, 1995

P. Falkner, “*Permittivitäts Wellen und Altimeter Analysator für das ESA/NASA Projekt CASSINI-HUYGENS*“, *Doctorate Thesis*, Graz University, 2004.

[ftp://psa.esac.esa.int/pub/mirror/CASSINI-HUYGENS/HASI/HP-SSA-HASI-2-3-4-MISSION-V1.1/CALIB/PWA/HASI\\_PWA\\_CALIBRATION\\_REPORT.PDF](ftp://psa.esac.esa.int/pub/mirror/CASSINI-HUYGENS/HASI/HP-SSA-HASI-2-3-4-MISSION-V1.1/CALIB/PWA/HASI_PWA_CALIBRATION_REPORT.PDF)

## ANNEX 1 – PWA – MI – Preamplifier Gain and Input Impedance

```

% compute gain & input impedance of preamp PWA-MI
function[G,Zi] = pwapreampGZi(f,CL,CO,LO)
% input
% f = frequency (Hz)
% CL = coupling capacitor (pF)
% CO = Cmc = common mode input capa AD549 + wiring leak
% LO = equivalent length of cable
% output
% G = complex gain
% Zi = complex input impedance (Ohms)
% resistors
R6 = 0.332e6 ;
R1 = 1e7;
R2 = 1e7;
R5 = 3010;
R3 = 51;
R4 = 5.1e4;
% triax capacitors
l_capa = LO; % length of triax
cpm_a = 88e-12; % inner capa per meter
cpm_b = 289e-12; % outer capa per meter
Ca = l_capa * cpm_a;
Cb = l_capa * cpm_b;
% other capacitoers
Cmc = CO; % input common mode capa pf AD549
Crc = 5.2e-6; % reaction capacitor
%
Y6 = 1/R6;
Y1 = 1/R1;
Y2 = 1/R2;
Y3 = 1/R3;
Y4 = 1/R4;
jom = 2 * pi * i * f;
YL = jom * CL;
Ya = jom * Ca;
Yb = jom * Cb;
Ymc= jom * Cmc;
Y5 = jom * Crc / (1+jom * R5 * Crc); % reaction admittance
% auxilliary admittances, step 1
Y6a = Y6 + Ya;
Y34 = Y3 + Y4;
Yab = Ya + Yb;
Y25 = Y2 + Y5;
Y4b = Y4 + Yb;
Y3b = Y3 + Yb;
% auxilliary admittances, step 2
Y3ab = Y3+ Yab;
Y34ab = Y34 + Yab;
Y6aL = Y6a + YL;
% input impedance including coupling capacitor Zin = Ve / Ie
% admittance Ie/Ve:
Ai = YL * (Y25 * (Y4 * Y6 * Ya + Y6 * Ya * Yb + Y3ab * Y6 * Ymc + ...
Y4 * Y6a * Ymc + Y3b * Ya * Ymc) + Y1 * (Y4b * Y6 * Ya + Y2 * (Y3 * Y6a + ...
Y4 * Y6a + Y6 * Ya + Y6a * Yb) + (Y3 * Y6a + Y4 * Y6a + Y6 * Ya + ...
Y6a * Yb) * Ymc))/(Y25 * (Y4b * Y6 * Ya + Y34ab * Y6 * YL + ...
(Y3 * Y6aL + Y4 * Y6aL + Y6 * Ya + Y6 * Yb + Ya * Yb + Yab * YL) * Ymc) + ...
Y1 * (Y4b * Y6 * Ya + Y34ab * Y6 * YL + Y2 * (Y3 * Y6aL + Y4 * Y6aL + Y6 * Ya + ...
Y6 * Yb + Ya * Yb + Yab * YL) + (Y3 * Y6aL + Y4 * Y6aL + ...
Y6 * Ya + Y6 * Yb + Ya * Yb + Yab * YL) * Ymc));
Zi = 1/Ai;
% Gain Vs/Ve
G = (Y1 + Y25) * Y34ab * Y6 * YL/(Y25 * (Y4b * Y6 * Ya + Y34ab * Y6 * YL + ...
(Y3 * Y6aL + Y4 * Y6aL + Y6 * Ya + Y6 * Yb + Ya * Yb + Yab * YL) * Ymc) + ...
Y1 * (Y4b * Y6 * Ya + Y34ab * Y6 * YL + Y2 * (Y3 * Y6aL + Y4 * Y6aL + ...
Y6 * Ya + Y6 * Yb + Ya * Yb + Yab * YL) + (Y3 * Y6aL + Y4 * Y6aL + ...
Y6 * Ya + Y6 * Yb + Ya * Yb + Yab * YL) * Ymc) );

```

## ANNEX 2 – PWA – MI – Preamplifier Transfer Function (s)

```

% compute gain & input impedance of preamp PWA
function[gn,gd] = pwapreamp_scoef(CL,CO,LO)
% input
% CL: coupling capa (F)
% CO: common mode capa (F) AD549 & cabling
% LO: cable length (m) [assuming capacitances Ca & Cb proportionnal to lenght]
% output
% rational fraction coefficients of G [ if s = 2 pi i f]
gn = [0 0 0 0 0]; % numerator gn(1) s^0 + gn(2) s^1+ ...           Warning index shift
gd = [0 0 0 0 0]; % denominator gd(1) s^0 + gn(2) s^1+ ...       Warning index shift
% [no zero indexes in Matlab]
% resistors
R6 = 0.332e6 ;
R1 = 1e7;
R2 = 1e7;
R5 = 3010;
R3 = 51;
R4 = 5.1e4;
% triax capacitors
l_capa = LO; % length of triax
cpm_a = 88e-12; % inner capa per meter
cpm_b = 289e-12; % outer capa per meter
Ca = l_capa * cpm_a;
Cb = l_capa * cpm_b;
% other capactioers
%CL is input argument
Cmc = CO; % input common mode capa F AD549
C5 = 5.2e-6; % reaction capacitor
%
% warning: exponent of s is (s-1)
%
gn(2) = 2 * CL * (R3 + R4) / ( R1 * R3 * R4 * R6); % coefficient of s
gn(3) = CL * (2 * (Ca + Cb) * R3 * R4 + C5 * (R3 + R4) * (R1 + 2 * R5)) / ...
( R1 * R3 * R4 * R6);
gn(4) = C5 * (Ca + Cb) * CL * (R1 + 2 * R5) / (R1 * R6);
%
%
gd(1) = (R3 + R4) / (R1^2 * R3 * R4 * R6);
%
gd(2) = ( 1 / (R1^2 * R3 * R4 * R6) ) * ...
(2 * Cmc * R1 * R3 + 2 * Cmc * R1 * R4 + Cb * R4 * R3 + Ca * (2 * R1 + R4) * R3 + ...
C5 * (R3 + R4) * R5 + Ca * (R3 + R4) * R6 + CL * (R3 + R4) * (2 * R1 + R6));
% gd2_s1 = gd(2)
%
gd(3) = ( 1 / (R1^2 * R3 * R4 * R6) ) * ...
(2 * (Cb * (CL + Cmc) + Ca * (Cb + CL + Cmc)) * R1 * R3 * R4 + ...
(2 * (Ca + CL) * Cmc * R1 * R3 + (2 * (Ca + CL) * Cmc * R1 + ...
(Cb * CL + Ca * (Cb + CL)) * R3) * R4) * R6 + ...
C5 * (Ca * R3 * R1^2 + CL * R3 * R1^2 + Cmc * R3 * R1^2 + CL * R4 * R1^2 + ...
Cmc * R4 * R1^2 + 2 * Ca * R3 * R5 * R1 + 2 * CL * R3 * R5 * R1 + ...
2 * Cmc * R3 * R5 * R1 + 2 * CL * R4 * R5 * R1 + 2 * Cmc * R4 * R5 * R1 + ...
Ca * R3 * R4 * R5 + Cb * R3 * R4 * R5 + (Ca + CL) * (R3 + R4) * R5 * R6));
%
gd(4) = ( 1 / (R1^2 * R3 * R4 * R6) ) * ...
(C5 * (Cb * (CL + Cmc) + Ca * (Cb + CL + Cmc)) * R1 * R3 * R4 * (R1 + 2 * R5) + ...
(Cmc * R1 * (2 * (Cb * CL + Ca * (Cb + CL)) * R3 * R4 + C5 * (Ca + CL) * R1 * (R3 + R4)) + ...
C5 * (2 * (Ca + CL) * Cmc * R1 * R3 + (2 * (Ca + CL) * Cmc * R1 + (Cb * CL + Ca * (Cb + ...
CL)) * R3) * R4) * R5) * R6);
%
gd(5) = (C5 * (Cb * CL + Ca * (Cb + CL)) * Cmc * (R1 + 2 * R5)) / R1;

```

## ANNEX B1 – PWA – MI – HP analyser frequency table

1.000	1.026	1.052	1.079	1.107	1.135	1.165	1.195	1.225	1.257
1.289	1.322	1.356	1.391	1.427	1.464	1.501	1.540	1.580	1.620
1.662	1.705	1.748	1.793	1.839	1.887	1.935	1.985	2.036	2.089
2.142	2.197	2.254	2.312	2.371	2.432	2.495	2.559	2.625	2.692
2.762	2.833	2.905	2.980	3.057	3.136	3.216	3.299	3.384	3.471
3.560	3.652	3.746	3.842	3.941	4.042	4.146	4.253	4.362	4.474
4.589	4.707	4.828	4.953	5.080	5.211	5.345	5.482	5.623	5.768
5.916	6.068	6.224	6.384	6.549	6.717	6.890	7.067	7.249	7.435
7.626	7.823	8.024	8.230	8.442	8.659	8.882	9.110	9.345	9.585
9.831	10.084	10.344	10.610	10.883	11.162	11.450	11.744	12.046	12.356
12.674	13.000	13.334	13.677	14.029	14.390	14.760	15.139	15.529	15.928
16.338	16.758	17.189	17.631	18.085	18.550	19.027	19.516	20.018	20.533
21.061	21.603	22.159	22.729	23.313	23.913	24.528	25.159	25.806	26.470
27.150	27.849	28.565	29.300	30.053	30.826	31.619	32.432	33.267	34.122
35.000	35.900	36.823	37.771	38.742	39.739	40.761	41.809	42.884	43.987
45.119	46.279	47.470	48.691	49.943	51.227	52.545	53.897	55.283	56.705
58.163	59.659	61.194	62.768	64.382	66.038	67.736	69.479	71.266	73.099
74.979	76.907	78.885	80.914	82.996	85.130	87.320	89.566	91.869	94.232
96.656	99.142	101.692	104.308	106.991	109.742	112.565	115.460	118.430	121.476
124.600	127.805	131.092	134.464	137.923	141.470	145.109	148.841	152.669	156.596
160.624	164.755	168.993	173.339	177.798	182.371	187.061	191.873	196.808	201.870
207.062	212.388	217.850	223.454	229.201	235.096	241.143	247.345	253.707	260.233
266.926	273.791	280.834	288.057	295.466	303.065	310.860	318.856	327.057	335.469
344.097	352.948	362.026	371.337	380.888	390.685	400.733	411.041	421.613	432.457
443.580	454.989	466.692	478.695	491.007	503.636	516.590	529.877	543.506	557.485
571.824	586.532	601.617	617.091	632.963	649.243	665.942	683.071	700.640	718.660
737.145	756.105	775.552	795.500	815.960	836.947	858.474	880.554	903.203	926.433
950.262	974.703	999.773	1025.488	1051.864	1078.918	1106.669	1135.133	1164.329	1194.276
1224.994	1256.501	1288.819	1321.968	1355.970	1390.846	1426.619	1463.313	1500.950	1539.555
1579.153	1619.770	1661.431	1704.164	1747.996	1792.956	1839.071	1886.373	1934.892	1984.658
2035.705	2088.064	2141.770	2196.858	2253.362	2311.320	2370.768	2431.746	2494.291	2558.446
2624.250	2691.748	2760.981	2831.995	2904.835	2979.549	3056.184	3134.791	3215.420	3298.122
3382.951	3469.963	3559.212	3650.757	3744.656	3840.971	3939.763	4041.095	4145.035	4251.647
4361.002	4473.169	4588.221	4706.233	4827.280	4951.440	5078.793	5209.423	5343.412	5480.847
5621.818	5766.414	5914.729	6066.859	6222.902	6382.958	6547.131	6715.527	6888.254	7065.423
7247.150	7433.550	7624.745	7820.858	8022.014	8228.345	8439.982	8657.063	8879.727	9108.119
9342.384	9582.676	9829.147	10081.960	10341.270	10607.250	10880.080	11159.920	11446.960	11741.380
12043.380	12353.140	12670.870	12996.770	13331.050	13673.930	14025.630	14386.380	14756.410	15135.950
15525.250	15924.570	16334.160	16754.280	17185.210	17627.230	18080.610	18545.650	19022.650	19511.930
20013.780	20528.550	21056.550	21598.140	22153.660	22723.460	23307.920	23907.410	24522.320	25153.050
25800.000									

PWA-MI: tests with HP analyser. Frequency table 401 steps 1Hz - 25800 Hz

## ANNEX B2 – PWA – MI – HP analyser data: TSRX101\_real.txt

-8.4749e-003	-9.0217e-003	-9.6026e-003	-1.0220e-002	-1.0875e-002	-1.1481e-002	-1.2118e-002	-1.2790e-002	-1.3498e-002	-1.4340e-002
-1.5233e-002	-1.6179e-002	-1.7181e-002	-1.8182e-002	-1.9238e-002	-2.0352e-002	-2.1528e-002	-2.2738e-002	-2.4013e-002	-2.5354e-002
-2.6766e-002	-2.8469e-002	-3.0275e-002	-3.2193e-002	-3.4226e-002	-3.6201e-002	-3.8283e-002	-4.0479e-002	-4.2793e-002	-4.5333e-002
-4.8010e-002	-5.0830e-002	-5.3800e-002	-5.7389e-002	-6.1199e-002	-6.5242e-002	-6.9532e-002	-7.3836e-002	-7.8373e-002	-8.3152e-002
-8.8184e-002	-9.3599e-002	-9.9271e-002	-1.0520e-001	-1.1140e-001	-1.1794e-001	-1.2468e-001	-1.3162e-001	-1.3872e-001	-1.4469e-001
-1.5042e-001	-1.5585e-001	-1.6088e-001	-1.6185e-001	-1.6143e-001	-1.5939e-001	-1.5553e-001	-1.4139e-001	-1.2401e-001	-1.0322e-001
-7.8858e-002	-4.6607e-002	-1.2574e-002	2.2996e-002	5.9828e-002	8.9773e-002	1.1874e-001	1.4656e-001	1.7306e-001	1.8896e-001
2.0350e-001	2.1668e-001	2.2849e-001	2.3394e-001	2.3862e-001	2.4254e-001	2.4574e-001	2.4686e-001	2.4762e-001	2.4804e-001
2.4812e-001	2.4756e-001	2.4681e-001	2.4589e-001	2.4480e-001	2.4316e-001	2.4145e-001	2.3967e-001	2.3782e-001	2.3660e-001
2.3534e-001	2.3403e-001	2.3268e-001	2.3195e-001	2.3120e-001	2.3041e-001	2.2960e-001	2.2820e-001	2.2678e-001	2.2536e-001
2.2393e-001	2.2330e-001	2.2265e-001	2.2200e-001	2.2133e-001	2.2057e-001	2.1980e-001	2.1903e-001	2.1824e-001	2.1758e-001
2.1692e-001	2.1625e-001	2.1558e-001	2.1529e-001	2.1499e-001	2.1468e-001	2.1437e-001	2.1390e-001	2.1343e-001	2.1295e-001
2.1248e-001	2.1234e-001	2.1221e-001	2.1207e-001	2.1193e-001	2.1189e-001	2.1186e-001	2.1182e-001	2.1178e-001	2.1135e-001
2.1091e-001	2.1047e-001	2.1003e-001	2.1003e-001	2.1003e-001	2.1004e-001	2.1004e-001	2.1027e-001	2.1051e-001	2.1074e-001
2.1097e-001	2.1071e-001	2.1045e-001	2.1019e-001	2.0993e-001	2.1029e-001	2.1066e-001	2.1103e-001	2.1139e-001	2.1159e-001
2.1178e-001	2.1196e-001	2.1212e-001	2.1266e-001	2.1320e-001	2.1372e-001	2.1424e-001	2.1379e-001	2.1334e-001	2.1289e-001
2.1243e-001	2.1201e-001	2.1160e-001	2.1118e-001	2.1076e-001	2.1079e-001	2.1082e-001	2.1085e-001	2.1087e-001	2.1116e-001
2.1144e-001	2.1172e-001	2.1200e-001	2.1187e-001	2.1174e-001	2.1162e-001	2.1149e-001	2.1145e-001	2.1140e-001	2.1136e-001
2.1132e-001	2.1172e-001	2.1212e-001	2.1252e-001	2.1293e-001	2.1290e-001	2.1286e-001	2.1283e-001	2.1280e-001	2.1293e-001
2.1306e-001	2.1319e-001	2.1332e-001	2.1344e-001	2.1357e-001	2.1369e-001	2.1382e-001	2.1395e-001	2.1408e-001	2.1421e-001
2.1435e-001	2.1435e-001	2.1435e-001	2.1436e-001	2.1436e-001	2.1453e-001	2.1470e-001	2.1488e-001	2.1505e-001	2.1506e-001
2.1507e-001	2.1507e-001	2.1508e-001	2.1512e-001	2.1516e-001	2.1520e-001	2.1524e-001	2.1535e-001	2.1545e-001	2.1556e-001
2.1566e-001	2.1583e-001	2.1600e-001	2.1617e-001	2.1633e-001	2.1635e-001	2.1637e-001	2.1639e-001	2.1640e-001	2.1654e-001
2.1667e-001	2.1680e-001	2.1693e-001	2.1681e-001	2.1668e-001	2.1655e-001	2.1642e-001	2.1658e-001	2.1674e-001	2.1690e-001
2.1705e-001	2.1712e-001	2.1720e-001	2.1727e-001	2.1734e-001	2.1726e-001	2.1718e-001	2.1710e-001	2.1702e-001	2.1699e-001
2.1695e-001	2.1692e-001	2.1688e-001	2.1673e-001	2.1658e-001	2.1643e-001	2.1627e-001	2.1639e-001	2.1652e-001	2.1664e-001
2.1675e-001	2.1655e-001	2.1635e-001	2.1615e-001	2.1594e-001	2.1575e-001	2.1554e-001	2.1534e-001	2.1512e-001	2.1504e-001
2.1495e-001	2.1485e-001	2.1475e-001	2.1430e-001	2.1385e-001	2.1340e-001	2.1294e-001	2.1262e-001	2.1229e-001	2.1196e-001
2.1161e-001	2.1120e-001	2.1077e-001	2.1034e-001	2.0989e-001	2.0923e-001	2.0856e-001	2.0788e-001	2.0719e-001	2.0650e-001
2.0580e-001	2.0509e-001	2.0438e-001	2.0350e-001	2.0262e-001	2.0173e-001	2.0083e-001	1.9975e-001	1.9865e-001	1.9755e-001
1.9644e-001	1.9522e-001	1.9398e-001	1.9274e-001	1.9149e-001	1.8993e-001	1.8836e-001	1.8679e-001	1.8520e-001	1.8346e-001
1.8171e-001	1.7995e-001	1.7820e-001	1.7618e-001	1.7416e-001	1.7214e-001	1.7010e-001	1.6791e-001	1.6573e-001	1.6354e-001
1.6134e-001	1.5889e-001	1.5644e-001	1.5399e-001	1.5155e-001	1.4890e-001	1.4625e-001	1.4362e-001	1.4100e-001	1.3816e-001
1.3533e-001	1.3253e-001	1.2974e-001	1.2680e-001	1.2390e-001	1.2102e-001	1.1816e-001	1.1505e-001	1.1197e-001	1.0892e-001
1.0591e-001	1.0291e-001	9.9952e-002	9.7035e-002	9.4161e-002	9.1206e-002	8.8301e-002	8.5444e-002	8.2636e-002	7.9760e-002
7.6941e-002	7.4179e-002	7.1473e-002	6.8791e-002	6.6168e-002	6.3604e-002	6.1097e-002	5.8618e-002	5.6201e-002	5.3845e-002
5.1548e-002	4.9308e-002	4.7126e-002	4.5001e-002	4.2933e-002	4.0901e-002	3.8928e-002	3.7013e-002	3.5155e-002	3.3386e-002
3.1672e-002	3.0011e-002	2.8403e-002	2.6847e-002	2.5343e-002	2.3887e-002	2.2480e-002	2.1144e-002	1.9854e-002	1.8609e-002
1.7407e-002	1.6301e-002	1.5236e-002	1.4210e-002	1.3222e-002	1.2279e-002	1.1372e-002	1.0498e-002	9.6582e-003	8.8397e-003
8.0538e-003	7.2994e-003	6.5755e-003	5.8983e-003	5.2501e-003	4.6299e-003	4.0368e-003	3.4641e-003	2.9165e-003	2.3934e-003
1.8938e-003									

PWA-HP-calibrations: file TSRX101\_real.txt

## ANNEX B3 – PWA – MI – HP analyser data: TSRX101\_imag.txt

-1.9988e-003	-2.0243e-003	-2.0452e-003	-2.0606e-003	-2.0698e-003	-2.0608e-003	-2.0446e-003	-2.0205e-003	-1.9877e-003	-1.9363e-003
-1.8711e-003	-1.7906e-003	-1.6932e-003	-1.5693e-003	-1.4255e-003	-1.2599e-003	-1.0706e-003	-8.3532e-004	-5.7041e-004	-2.7333e-004
5.8609e-005	3.9052e-004	7.6443e-004	1.1843e-003	1.6543e-003	2.2067e-003	2.8175e-003	3.4917e-003	4.2344e-003	5.2589e-003
6.3915e-003	7.6412e-003	9.0177e-003	1.0620e-002	1.2398e-002	1.4370e-002	1.6552e-002	1.9153e-002	2.2022e-002	2.5180e-002
2.8652e-002	3.3139e-002	3.8095e-002	4.3558e-002	4.9573e-002	5.7374e-002	6.5999e-002	7.5518e-002	8.6006e-002	9.9332e-002
1.1394e-001	1.2992e-001	1.4736e-001	1.6867e-001	1.9152e-001	2.1593e-001	2.4189e-001	2.6891e-001	2.9604e-001	3.2299e-001
3.4944e-001	3.6263e-001	3.7293e-001	3.8013e-001	3.8404e-001	3.7548e-001	3.6462e-001	3.5157e-001	3.3644e-001	3.1902e-001
3.0105e-001	2.8263e-001	2.6383e-001	2.4817e-001	2.3265e-001	2.1732e-001	2.0218e-001	1.9089e-001	1.7980e-001	1.6890e-001
1.5821e-001	1.4988e-001	1.4171e-001	1.3370e-001	1.2584e-001	1.1982e-001	1.1391e-001	1.0813e-001	1.0246e-001	9.8063e-002
9.3728e-002	8.9458e-002	8.5253e-002	8.2128e-002	7.9033e-002	7.5967e-002	7.2932e-002	7.0323e-002	6.7748e-002	6.5208e-002
6.2703e-002	6.0708e-002	5.8728e-002	5.6763e-002	5.4812e-002	5.3076e-002	5.1353e-002	4.9645e-002	4.7950e-002	4.6836e-002
4.5729e-002	4.4629e-002	4.3536e-002	4.2170e-002	4.0808e-002	3.9452e-002	3.8101e-002	3.7172e-002	3.6248e-002	3.5328e-002
3.4413e-002	3.3644e-002	3.2876e-002	3.2110e-002	3.1345e-002	3.0569e-002	2.9793e-002	2.9018e-002	2.8244e-002	2.7461e-002
2.6681e-002	2.5905e-002	2.5133e-002	2.4742e-002	2.4352e-002	2.3961e-002	2.3571e-002	2.2964e-002	2.2355e-002	2.1745e-002
2.1134e-002	2.1100e-002	2.1066e-002	2.1032e-002	2.0998e-002	2.0529e-002	2.0058e-002	1.9585e-002	1.9111e-002	1.7442e-002
1.5771e-002	1.4098e-002	1.2424e-002	1.3823e-002	1.5231e-002	1.6646e-002	1.8068e-002	1.7120e-002	1.6177e-002	1.5238e-002
1.4304e-002	1.3981e-002	1.3659e-002	1.3339e-002	1.3020e-002	1.2858e-002	1.2695e-002	1.2532e-002	1.2369e-002	1.1957e-002
1.1544e-002	1.1129e-002	1.0714e-002	1.0264e-002	9.8149e-003	9.3664e-003	8.9185e-003	8.6991e-003	8.4798e-003	8.2606e-003
8.0415e-003	7.7701e-003	7.4978e-003	7.2243e-003	6.9499e-003	6.8270e-003	6.7042e-003	6.5815e-003	6.4588e-003	6.1145e-003
5.7698e-003	5.4247e-003	5.0792e-003	4.8123e-003	4.5450e-003	4.2775e-003	4.0097e-003	3.7453e-003	3.4805e-003	3.2155e-003
2.9501e-003	2.5882e-003	2.2262e-003	1.8642e-003	1.5023e-003	1.2868e-003	1.0710e-003	8.5482e-004	6.3831e-004	4.4520e-004
2.5209e-004	5.8954e-005	-1.3419e-004	-4.7437e-004	-8.1467e-004	-1.1551e-003	-1.4957e-003	-1.8262e-003	-2.1571e-003	-2.4883e-003
-2.8198e-003	-3.0779e-003	-3.3364e-003	-3.5953e-003	-3.8547e-003	-4.2583e-003	-4.6620e-003	-5.0658e-003	-5.4697e-003	-5.9971e-003
-6.5253e-003	-7.0541e-003	-7.5836e-003	-7.9641e-003	-8.3443e-003	-8.7240e-003	-9.1033e-003	-9.6909e-003	-1.0279e-002	-1.0869e-002
-1.1459e-002	-1.1884e-002	-1.2310e-002	-1.2736e-002	-1.3162e-002	-1.3853e-002	-1.4544e-002	-1.5234e-002	-1.5924e-002	-1.6436e-002
-1.6947e-002	-1.7459e-002	-1.7971e-002	-1.8839e-002	-1.9707e-002	-2.0574e-002	-2.1440e-002	-2.2263e-002	-2.3087e-002	-2.3913e-002
-2.4739e-002	-2.5456e-002	-2.6173e-002	-2.6888e-002	-2.7602e-002	-2.8536e-002	-2.9468e-002	-3.0399e-002	-3.1329e-002	-3.2386e-002
-3.3444e-002	-3.4501e-002	-3.5558e-002	-3.6477e-002	-3.7394e-002	-3.8306e-002	-3.9216e-002	-4.0414e-002	-4.1609e-002	-4.2802e-002
-4.3993e-002	-4.5377e-002	-4.6757e-002	-4.8134e-002	-4.9507e-002	-5.0862e-002	-5.2211e-002	-5.3553e-002	-5.4888e-002	-5.6189e-002
-5.7482e-002	-5.8770e-002	-6.0050e-002	-6.1485e-002	-6.2909e-002	-6.4325e-002	-6.5730e-002	-6.7321e-002	-6.8898e-002	-7.0461e-002
-7.2011e-002	-7.3586e-002	-7.5145e-002	-7.6688e-002	-7.8215e-002	-7.9868e-002	-8.1498e-002	-8.3107e-002	-8.4692e-002	-8.6133e-002
-8.7550e-002	-8.8943e-002	-9.0311e-002	-9.1933e-002	-9.3522e-002	-9.5078e-002	-9.6603e-002	-9.7958e-002	-9.9280e-002	-1.0057e-001
-1.0182e-001	-1.0313e-001	-1.0439e-001	-1.0561e-001	-1.0680e-001	-1.0779e-001	-1.0874e-001	-1.0964e-001	-1.1051e-001	-1.1128e-001
-1.1201e-001	-1.1270e-001	-1.1334e-001	-1.1381e-001	-1.1423e-001	-1.1461e-001	-1.1495e-001	-1.1518e-001	-1.1537e-001	-1.1551e-001
-1.1560e-001	-1.1546e-001	-1.1528e-001	-1.1506e-001	-1.1480e-001	-1.1440e-001	-1.1397e-001	-1.1350e-001	-1.1300e-001	-1.1227e-001
-1.1150e-001	-1.1072e-001	-1.0990e-001	-1.0895e-001	-1.0797e-001	-1.0698e-001	-1.0597e-001	-1.0476e-001	-1.0355e-001	-1.0232e-001
-1.0109e-001	-9.9817e-002	-9.8540e-002	-9.7259e-002	-9.5977e-002	-9.4508e-002	-9.3045e-002	-9.1588e-002	-9.0139e-002	-8.8621e-002
-8.7115e-002	-8.5621e-002	-8.4141e-002	-8.2622e-002	-8.1120e-002	-7.9633e-002	-7.8163e-002	-7.6660e-002	-7.5177e-002	-7.3713e-002
-7.2268e-002	-7.0764e-002	-6.9284e-002	-6.7828e-002	-6.6396e-002	-6.4986e-002	-6.3599e-002	-6.2236e-002	-6.0897e-002	-5.9544e-002
-5.8215e-002	-5.6911e-002	-5.5630e-002	-5.4311e-002	-5.3018e-002	-5.1752e-002	-5.0511e-002	-4.9315e-002	-4.8144e-002	-4.6995e-002
-4.5870e-002									

PWA-HP-calibrations: file TSRX101\_imag.txt

## ANNEX B4 – PWA – MI – HP analyser data: TSRX102\_real.txt

-8.0243e-003	-8.4765e-003	-8.9540e-003	-9.4582e-003	-9.9906e-003	-1.0462e-002	-1.0956e-002	-1.1472e-002	-1.2014e-002	-1.2728e-002
-1.3484e-002	-1.4285e-002	-1.5134e-002	-1.5973e-002	-1.6857e-002	-1.7790e-002	-1.8774e-002	-1.9755e-002	-2.0787e-002	-2.1872e-002
-2.3014e-002	-2.4406e-002	-2.5879e-002	-2.7438e-002	-2.9088e-002	-3.0582e-002	-3.2150e-002	-3.3798e-002	-3.5530e-002	-3.7605e-002
-3.9798e-002	-4.2113e-002	-4.4559e-002	-4.7299e-002	-5.0201e-002	-5.3275e-002	-5.6530e-002	-5.9948e-002	-6.3559e-002	-6.7375e-002
-7.1405e-002	-7.5463e-002	-7.9714e-002	-8.4164e-002	-8.8820e-002	-9.3978e-002	-9.9362e-002	-1.0497e-001	-1.1082e-001	-1.1632e-001
-1.2190e-001	-1.2754e-001	-1.3321e-001	-1.3742e-001	-1.4123e-001	-1.4456e-001	-1.4729e-001	-1.4456e-001	-1.4003e-001	-1.3347e-001
-1.2465e-001	-1.0650e-001	-8.5628e-002	-6.1961e-002	-3.5448e-002	-2.8697e-003	3.0973e-002	6.5841e-002	1.0148e-001	1.2896e-001
1.5536e-001	1.8055e-001	2.0440e-001	2.1813e-001	2.3057e-001	2.4174e-001	2.5164e-001	2.5585e-001	2.5938e-001	2.6225e-001
2.6449e-001	2.6487e-001	2.6492e-001	2.6467e-001	2.6413e-001	2.6283e-001	2.6136e-001	2.5972e-001	2.5794e-001	2.5613e-001
2.5427e-001	2.5235e-001	2.5039e-001	2.4928e-001	2.4812e-001	2.4693e-001	2.4569e-001	2.4412e-001	2.4252e-001	2.4090e-001
2.3927e-001	2.3793e-001	2.3659e-001	2.3525e-001	2.3389e-001	2.3289e-001	2.3189e-001	2.3088e-001	2.2986e-001	2.2910e-001
2.2833e-001	2.2755e-001	2.2677e-001	2.2621e-001	2.2564e-001	2.2507e-001	2.2449e-001	2.2424e-001	2.2398e-001	2.2373e-001
2.2348e-001	2.2243e-001	2.2137e-001	2.2028e-001	2.1918e-001	2.1894e-001	2.1870e-001	2.1847e-001	2.1823e-001	2.1807e-001
2.1792e-001	2.1776e-001	2.1760e-001	2.1775e-001	2.1790e-001	2.1804e-001	2.1818e-001	2.1776e-001	2.1735e-001	2.1693e-001
2.1651e-001	2.1690e-001	2.1729e-001	2.1767e-001	2.1806e-001	2.1820e-001	2.1833e-001	2.1845e-001	2.1856e-001	2.1948e-001
2.2038e-001	2.2127e-001	2.2213e-001	2.1840e-001	2.1470e-001	2.1103e-001	2.0738e-001	2.0826e-001	2.0914e-001	2.1002e-001
2.1091e-001	2.1156e-001	2.1222e-001	2.1288e-001	2.1354e-001	2.1409e-001	2.1465e-001	2.1520e-001	2.1576e-001	2.1510e-001
2.1444e-001	2.1378e-001	2.1312e-001	2.1330e-001	2.1349e-001	2.1367e-001	2.1385e-001	2.1385e-001	2.1385e-001	2.1385e-001
2.1385e-001	2.1402e-001	2.1420e-001	2.1438e-001	2.1456e-001	2.1432e-001	2.1408e-001	2.1385e-001	2.1361e-001	2.1367e-001
2.1372e-001	2.1378e-001	2.1384e-001	2.1399e-001	2.1415e-001	2.1430e-001	2.1445e-001	2.1391e-001	2.1338e-001	2.1284e-001
2.1231e-001	2.1281e-001	2.1331e-001	2.1381e-001	2.1431e-001	2.1428e-001	2.1424e-001	2.1421e-001	2.1418e-001	2.1402e-001
2.1386e-001	2.1370e-001	2.1353e-001	2.1343e-001	2.1332e-001	2.1321e-001	2.1310e-001	2.1323e-001	2.1337e-001	2.1350e-001
2.1364e-001	2.1353e-001	2.1342e-001	2.1331e-001	2.1320e-001	2.1311e-001	2.1303e-001	2.1295e-001	2.1287e-001	2.1309e-001
2.1331e-001	2.1354e-001	2.1376e-001	2.1368e-001	2.1360e-001	2.1351e-001	2.1342e-001	2.1307e-001	2.1271e-001	2.1236e-001
2.1200e-001	2.1232e-001	2.1264e-001	2.1296e-001	2.1328e-001	2.1295e-001	2.1262e-001	2.1229e-001	2.1195e-001	2.1184e-001
2.1172e-001	2.1161e-001	2.1148e-001	2.1098e-001	2.1047e-001	2.0996e-001	2.0945e-001	2.0962e-001	2.0979e-001	2.0995e-001
2.1011e-001	2.0988e-001	2.0964e-001	2.0940e-001	2.0915e-001	2.0868e-001	2.0821e-001	2.0773e-001	2.0724e-001	2.0729e-001
2.0734e-001	2.0739e-001	2.0744e-001	2.0683e-001	2.0622e-001	2.0560e-001	2.0497e-001	2.0435e-001	2.0372e-001	2.0309e-001
2.0245e-001	2.0201e-001	2.0156e-001	2.0111e-001	2.0064e-001	1.9988e-001	1.9911e-001	1.9833e-001	1.9755e-001	1.9673e-001
1.9590e-001	1.9507e-001	1.9422e-001	1.9320e-001	1.9217e-001	1.9114e-001	1.9011e-001	1.8890e-001	1.8769e-001	1.8647e-001
1.8523e-001	1.8373e-001	1.8222e-001	1.8070e-001	1.7917e-001	1.7755e-001	1.7593e-001	1.7430e-001	1.7267e-001	1.7088e-001
1.6910e-001	1.6730e-001	1.6550e-001	1.6349e-001	1.6148e-001	1.5946e-001	1.5744e-001	1.5508e-001	1.5273e-001	1.5038e-001
1.4803e-001	1.4566e-001	1.4330e-001	1.4095e-001	1.3860e-001	1.3594e-001	1.3329e-001	1.3066e-001	1.2805e-001	1.2534e-001
1.2264e-001	1.1997e-001	1.1732e-001	1.1441e-001	1.1154e-001	1.0869e-001	1.0588e-001	1.0305e-001	1.0025e-001	9.7486e-002
9.4764e-002	9.1902e-002	8.9087e-002	8.6316e-002	8.3591e-002	8.0887e-002	7.8232e-002	7.5626e-002	7.3069e-002	7.0435e-002
6.7858e-002	6.5339e-002	6.2875e-002	6.0437e-002	5.8055e-002	5.5729e-002	5.3458e-002	5.1243e-002	4.9084e-002	4.6979e-002
4.4927e-002	4.2901e-002	4.0933e-002	3.9022e-002	3.7166e-002	3.5415e-002	3.3715e-002	3.2065e-002	3.0464e-002	2.8892e-002
2.7370e-002	2.5898e-002	2.4472e-002	2.3147e-002	2.1866e-002	2.0628e-002	1.9431e-002	1.8266e-002	1.7142e-002	1.6059e-002
1.5014e-002	1.4052e-002	1.3125e-002	1.2232e-002	1.1371e-002	1.0553e-002	9.7657e-003	9.0091e-003	8.2819e-003	7.5606e-003
6.8682e-003	6.2039e-003	5.5668e-003	5.0044e-003	4.4654e-003	3.9490e-003	3.4546e-003	2.9348e-003	2.4382e-003	1.9639e-003
1.5113e-003									

PWA-HP-calibrations: file TSRX102\_real.txt



## ANNEX B5 – PWA – MI – HP analyser data: TSRX102\_imag.txt

1.0506e-003	1.1466e-003	1.2500e-003	1.3615e-003	1.4817e-003	1.5682e-003	1.6597e-003	1.7563e-003	1.8583e-003	1.9831e-003
2.1163e-003	2.2582e-003	2.4095e-003	2.6301e-003	2.8678e-003	3.1239e-003	3.3997e-003	3.6727e-003	3.9650e-003	4.2780e-003
4.6129e-003	5.1512e-003	5.7382e-003	6.3780e-003	7.0747e-003	7.8217e-003	8.2064e-003	8.8313e-003	9.4990e-003	1.0457e-002
1.1496e-002	1.2622e-002	1.3842e-002	1.5241e-002	1.6763e-002	1.8416e-002	2.0211e-002	2.2329e-002	2.4634e-002	2.7140e-002
2.9864e-002	3.3330e-002	3.7109e-002	4.1227e-002	4.5708e-002	5.1237e-002	5.7292e-002	6.3916e-002	7.1156e-002	8.0165e-002
9.0017e-002	1.0078e-001	1.1251e-001	1.2709e-001	1.4293e-001	1.6011e-001	1.7869e-001	2.0137e-001	2.2540e-001	2.5075e-001
2.7735e-001	3.0005e-001	3.2220e-001	3.4353e-001	3.6379e-001	3.7239e-001	3.7816e-001	3.8093e-001	3.8057e-001	3.6952e-001
3.5651e-001	3.4166e-001	3.2505e-001	3.0701e-001	2.8858e-001	2.6985e-001	2.5089e-001	2.3571e-001	2.2070e-001	2.0588e-001
1.9127e-001	1.8023e-001	1.6940e-001	1.5876e-001	1.4834e-001	1.3980e-001	1.3145e-001	1.2328e-001	1.1528e-001	1.0989e-001
1.0460e-001	9.9409e-002	9.4316e-002	9.0183e-002	8.6103e-002	8.2076e-002	7.8102e-002	7.4661e-002	7.1271e-002	6.7932e-002
6.4643e-002	6.2334e-002	6.0052e-002	5.7798e-002	5.5571e-002	5.3686e-002	5.1818e-002	4.9967e-002	4.8135e-002	4.6447e-002
4.4772e-002	4.3110e-002	4.1460e-002	4.0209e-002	3.8964e-002	3.7726e-002	3.6495e-002	3.5937e-002	3.5380e-002	3.4825e-002
3.4271e-002	3.1638e-002	2.9034e-002	2.6457e-002	2.3909e-002	2.4063e-002	2.4216e-002	2.4370e-002	2.4522e-002	2.4064e-002
2.3607e-002	2.3151e-002	2.2695e-002	2.1602e-002	2.0507e-002	1.9412e-002	1.8316e-002	1.7711e-002	1.7108e-002	1.6508e-002
1.5910e-002	1.5806e-002	1.5806e-002	1.5754e-002	1.5702e-002	1.4272e-002	1.2842e-002	1.1411e-002	9.9782e-003	1.2147e-002
1.4336e-002	1.6543e-002	1.8769e-002	1.5663e-002	1.2660e-002	9.7561e-003	6.9501e-003	7.2626e-003	7.5777e-003	7.8953e-003
8.2155e-003	7.8051e-003	7.3921e-003	6.9765e-003	6.5583e-003	6.0824e-003	5.6040e-003	5.1232e-003	4.6398e-003	4.3891e-003
4.1400e-003	3.8923e-003	3.6461e-003	3.5156e-003	3.3850e-003	3.2541e-003	3.1229e-003	2.6907e-003	2.2584e-003	1.8262e-003
1.3940e-003	1.6480e-003	1.9025e-003	2.1574e-003	2.4127e-003	1.9236e-003	1.4355e-003	9.4858e-004	4.6272e-004	2.6256e-004
6.2290e-005	-1.3809e-004	-3.3858e-004	-5.1878e-004	-6.9924e-004	-8.7996e-004	-1.0609e-003	-1.2375e-003	-1.4133e-003	-1.5881e-003
-1.7620e-003	-2.5196e-003	-3.2808e-003	-4.0457e-003	-4.8141e-003	-4.5058e-003	-4.1976e-003	-3.8896e-003	-3.5816e-003	-3.9920e-003
-4.4018e-003	-4.8110e-003	-5.2196e-003	-5.8036e-003	-6.3870e-003	-6.9698e-003	-7.5522e-003	-7.6348e-003	-7.7175e-003	-7.8003e-003
-7.8832e-003	-8.4552e-003	-9.0267e-003	-9.5976e-003	-1.0168e-002	-1.0470e-002	-1.0771e-002	-1.1072e-002	-1.1374e-002	-1.1686e-002
-1.1999e-002	-1.2312e-002	-1.2627e-002	-1.3284e-002	-1.3941e-002	-1.4597e-002	-1.5253e-002	-1.5732e-002	-1.6209e-002	-1.6685e-002
-1.7159e-002	-1.7413e-002	-1.7668e-002	-1.7924e-002	-1.8180e-002	-1.8878e-002	-1.9573e-002	-2.0267e-002	-2.0959e-002	-2.1714e-002
-2.2469e-002	-2.3223e-002	-2.3977e-002	-2.4395e-002	-2.4811e-002	-2.5225e-002	-2.5637e-002	-2.6432e-002	-2.7230e-002	-2.8028e-002
-2.8829e-002	-2.9811e-002	-3.0791e-002	-3.1770e-002	-3.2747e-002	-3.3726e-002	-3.4701e-002	-3.5673e-002	-3.6640e-002	-3.7306e-002
-3.7972e-002	-3.8639e-002	-3.9306e-002	-4.0613e-002	-4.1914e-002	-4.3208e-002	-4.4497e-002	-4.5545e-002	-4.6588e-002	-4.7626e-002
-4.8659e-002	-4.9917e-002	-5.1171e-002	-5.2422e-002	-5.3669e-002	-5.5028e-002	-5.6380e-002	-5.7724e-002	-5.9060e-002	-6.0424e-002
-6.1780e-002	-6.3127e-002	-6.4466e-002	-6.5574e-002	-6.6672e-002	-6.7760e-002	-6.8837e-002	-7.0388e-002	-7.1923e-002	-7.3442e-002
-7.4945e-002	-7.6428e-002	-7.7889e-002	-7.9330e-002	-8.0750e-002	-8.2174e-002	-8.3575e-002	-8.4954e-002	-8.6310e-002	-8.7682e-002
-8.9028e-002	-9.0349e-002	-9.1644e-002	-9.3012e-002	-9.4349e-002	-9.5655e-002	-9.6930e-002	-9.8105e-002	-9.9243e-002	-1.0034e-001
-1.0141e-001	-1.0238e-001	-1.0331e-001	-1.0421e-001	-1.0508e-001	-1.0580e-001	-1.0649e-001	-1.0713e-001	-1.0774e-001	-1.0832e-001
-1.0886e-001	-1.0935e-001	-1.0981e-001	-1.1009e-001	-1.1033e-001	-1.1053e-001	-1.1068e-001	-1.1063e-001	-1.1054e-001	-1.1041e-001
-1.1025e-001	-1.0994e-001	-1.0959e-001	-1.0921e-001	-1.0880e-001	-1.0821e-001	-1.0760e-001	-1.0696e-001	-1.0630e-001	-1.0538e-001
-1.0445e-001	-1.0351e-001	-1.0254e-001	-1.0152e-001	-1.0048e-001	-9.9436e-002	-9.8378e-002	-9.7221e-002	-9.6058e-002	-9.4890e-002
-9.3717e-002	-9.2332e-002	-9.0952e-002	-8.9577e-002	-8.8207e-002	-8.6853e-002	-8.5506e-002	-8.4168e-002	-8.2837e-002	-8.1386e-002
-7.9948e-002	-7.8525e-002	-7.7116e-002	-7.5672e-002	-7.4247e-002	-7.2840e-002	-7.1451e-002	-7.0013e-002	-6.8596e-002	-6.7200e-002
-6.5825e-002	-6.4467e-002	-6.3132e-002	-6.1817e-002	-6.0525e-002	-5.9201e-002	-5.7901e-002	-5.6624e-002	-5.5371e-002	-5.4126e-002
-5.2905e-002	-5.1706e-002	-5.0530e-002	-4.9362e-002	-4.8218e-002	-4.7097e-002	-4.5999e-002	-4.4901e-002	-4.3825e-002	-4.2770e-002
-4.1738e-002									

PWA-HP-calibrations: file TSRX102\_imag.txt

## ANNEX B6 – PWA – MI – HP analyser data: TSRX103\_real.txt

-9.7531e-003	-1.0235e-002	-1.0740e-002	-1.1271e-002	-1.1827e-002	-1.2415e-002	-1.3032e-002	-1.3679e-002	-1.4358e-002	-1.5137e-002
-1.5957e-002	-1.6822e-002	-1.7734e-002	-1.8742e-002	-1.9808e-002	-2.0933e-002	-2.2123e-002	-2.3256e-002	-2.4448e-002	-2.5699e-002
-2.7015e-002	-2.8551e-002	-3.0172e-002	-3.1883e-002	-3.3690e-002	-3.5659e-002	-3.7742e-002	-3.9944e-002	-4.2273e-002	-4.4638e-002
-4.7130e-002	-4.9756e-002	-5.2523e-002	-5.5794e-002	-5.9257e-002	-6.2924e-002	-6.6805e-002	-7.0644e-002	-7.4680e-002	-7.8921e-002
-8.3376e-002	-8.8272e-002	-9.3389e-002	-9.8733e-002	-1.0431e-001	-1.0969e-001	-1.1519e-001	-1.2080e-001	-1.2649e-001	-1.3130e-001
-1.3584e-001	-1.4005e-001	-1.4384e-001	-1.4235e-001	-1.3938e-001	-1.3474e-001	-1.2822e-001	-1.1162e-001	-9.1936e-002	-6.9016e-002
-4.2731e-002	-9.8702e-003	2.4528e-002	6.0222e-002	9.6950e-002	1.2716e-001	1.5604e-001	1.8343e-001	2.0917e-001	2.2244e-001
2.3428e-001	2.4471e-001	2.5376e-001	2.5759e-001	2.6076e-001	2.6328e-001	2.6519e-001	2.6468e-001	2.6387e-001	2.6275e-001
2.6136e-001	2.5921e-001	2.5696e-001	2.5459e-001	2.5211e-001	2.5042e-001	2.4866e-001	2.4684e-001	2.4496e-001	2.4303e-001
2.4109e-001	2.3911e-001	2.3712e-001	2.3581e-001	2.3448e-001	2.3313e-001	2.3177e-001	2.3036e-001	2.2893e-001	2.2751e-001
2.2608e-001	2.2492e-001	2.2376e-001	2.2259e-001	2.2142e-001	2.2089e-001	2.2034e-001	2.1980e-001	2.1924e-001	2.1853e-001
2.1781e-001	2.1709e-001	2.1637e-001	2.1611e-001	2.1585e-001	2.1558e-001	2.1531e-001	2.1435e-001	2.1338e-001	2.1242e-001
2.1147e-001	2.1012e-001	2.0878e-001	2.0743e-001	2.0608e-001	2.0561e-001	2.0515e-001	2.0468e-001	2.0422e-001	2.0624e-001
2.0827e-001	2.1033e-001	2.1241e-001	2.1180e-001	2.1119e-001	2.1058e-001	2.0997e-001	2.0942e-001	2.0887e-001	2.0832e-001
2.0778e-001	2.0767e-001	2.0756e-001	2.0745e-001	2.0733e-001	2.0711e-001	2.0688e-001	2.0665e-001	2.0642e-001	2.0757e-001
2.0872e-001	2.0988e-001	2.1103e-001	2.0902e-001	2.0702e-001	2.0504e-001	2.0306e-001	2.0382e-001	2.0459e-001	2.0535e-001
2.0612e-001	2.0647e-001	2.0682e-001	2.0716e-001	2.0751e-001	2.0778e-001	2.0804e-001	2.0831e-001	2.0856e-001	2.0828e-001
2.0800e-001	2.0771e-001	2.0743e-001	2.0789e-001	2.0835e-001	2.0882e-001	2.0928e-001	2.0902e-001	2.0877e-001	2.0851e-001
2.0826e-001	2.0863e-001	2.0901e-001	2.0938e-001	2.0975e-001	2.0976e-001	2.0977e-001	2.0978e-001	2.0978e-001	2.0980e-001
2.0981e-001	2.0983e-001	2.0984e-001	2.1007e-001	2.1030e-001	2.1053e-001	2.1075e-001	2.1081e-001	2.1088e-001	2.1094e-001
2.1100e-001	2.1122e-001	2.1144e-001	2.1166e-001	2.1188e-001	2.1177e-001	2.1166e-001	2.1156e-001	2.1145e-001	2.1166e-001
2.1188e-001	2.1209e-001	2.1231e-001	2.1242e-001	2.1253e-001	2.1264e-001	2.1274e-001	2.1262e-001	2.1250e-001	2.1238e-001
2.1225e-001	2.1224e-001	2.1224e-001	2.1223e-001	2.1222e-001	2.1225e-001	2.1281e-001	2.1310e-001	2.1340e-001	2.1344e-001
2.1349e-001	2.1354e-001	2.1358e-001	2.1371e-001	2.1384e-001	2.1397e-001	2.1410e-001	2.1421e-001	2.1433e-001	2.1444e-001
2.1456e-001	2.1467e-001	2.1478e-001	2.1489e-001	2.1499e-001	2.1475e-001	2.1451e-001	2.1427e-001	2.1403e-001	2.1438e-001
2.1473e-001	2.1508e-001	2.1543e-001	2.1523e-001	2.1504e-001	2.1483e-001	2.1463e-001	2.1456e-001	2.1450e-001	2.1444e-001
2.1437e-001	2.1421e-001	2.1405e-001	2.1388e-001	2.1372e-001	2.1386e-001	2.1400e-001	2.1414e-001	2.1427e-001	2.1412e-001
2.1397e-001	2.1380e-001	2.1364e-001	2.1314e-001	2.1264e-001	2.1214e-001	2.1162e-001	2.1133e-001	2.1104e-001	2.1074e-001
2.1043e-001	2.0994e-001	2.0945e-001	2.0894e-001	2.0843e-001	2.0787e-001	2.0729e-001	2.0671e-001	2.0612e-001	2.0548e-001
2.0483e-001	2.0417e-001	2.0350e-001	2.0265e-001	2.0178e-001	2.0090e-001	2.0001e-001	1.9899e-001	1.9796e-001	1.9692e-001
1.9587e-001	1.9465e-001	1.9342e-001	1.9217e-001	1.9091e-001	1.8941e-001	1.8791e-001	1.8639e-001	1.8486e-001	1.8315e-001
1.8142e-001	1.7969e-001	1.7796e-001	1.7601e-001	1.7405e-001	1.7209e-001	1.7012e-001	1.6792e-001	1.6572e-001	1.6352e-001
1.6132e-001	1.5896e-001	1.5659e-001	1.5423e-001	1.5187e-001	1.4917e-001	1.4647e-001	1.4378e-001	1.4110e-001	1.3819e-001
1.3529e-001	1.3241e-001	1.2955e-001	1.2674e-001	1.2395e-001	1.2118e-001	1.1844e-001	1.1529e-001	1.1218e-001	1.0910e-001
1.0606e-001	1.0301e-001	1.0001e-001	9.7055e-002	9.4141e-002	9.1171e-002	8.8251e-002	8.5381e-002	8.2560e-002	7.9763e-002
7.7018e-002	7.4326e-002	7.1686e-002	6.8948e-002	6.6270e-002	6.3654e-002	6.1097e-002	5.8598e-002	5.6161e-002	5.3784e-002
5.1466e-002	4.9280e-002	4.7151e-002	4.5078e-002	4.3060e-002	4.1004e-002	3.9007e-002	3.7069e-002	3.5189e-002	3.3380e-002
3.1627e-002	2.9930e-002	2.8288e-002	2.6765e-002	2.5292e-002	2.3868e-002	2.2490e-002	2.1171e-002	1.9896e-002	1.8664e-002
1.7475e-002	1.6338e-002	1.5241e-002	1.4185e-002	1.3167e-002	1.2172e-002	1.1215e-002	1.0296e-002	9.4134e-003	8.6313e-003
7.8807e-003	7.1606e-003	6.4700e-003	5.7955e-003	5.1489e-003	4.5294e-003	3.9361e-003	3.3485e-003	2.7870e-003	2.2509e-003
1.7392e-003	PWA-HP-calibrations:	file	TSRX103_real.txt						

## ANNEX B7 – PWA – MI – HP analyser data: TSRX103\_imag.txt

2.1900e-003	2.3048e-003	2.4256e-003	2.5527e-003	2.6865e-003	2.8672e-003	3.0593e-003	3.2635e-003	3.4804e-003	3.7296e-003
3.9956e-003	4.2796e-003	4.5826e-003	4.9093e-003	5.2584e-003	5.6313e-003	6.0298e-003	6.4327e-003	6.8613e-003	7.3169e-003
7.8014e-003	8.4673e-003	9.1843e-003	9.9559e-003	1.0786e-002	1.1676e-002	1.2633e-002	1.3663e-002	1.4770e-002	1.6082e-002
1.7497e-002	1.9021e-002	2.0663e-002	2.2771e-002	2.5066e-002	2.7563e-002	3.0279e-002	3.3400e-002	3.6790e-002	4.0471e-002
4.4464e-002	4.9717e-002	5.5468e-002	6.1758e-002	6.8632e-002	7.7021e-002	8.6195e-002	9.6218e-002	1.0715e-001	1.2101e-001
1.3615e-001	1.5264e-001	1.7057e-001	1.9161e-001	2.1397e-001	2.3765e-001	2.6263e-001	2.8770e-001	3.1261e-001	3.3707e-001
3.6077e-001	3.7109e-001	3.7852e-001	3.8288e-001	3.8399e-001	3.7187e-001	3.5742e-001	3.4078e-001	3.2209e-001	3.0252e-001
2.8267e-001	2.6262e-001	2.4246e-001	2.2743e-001	2.1257e-001	1.9792e-001	1.8349e-001	1.7210e-001	1.6096e-001	1.5008e-001
1.3947e-001	1.3160e-001	1.2392e-001	1.1644e-001	1.0914e-001	1.0354e-001	9.8039e-002	9.2646e-002	8.7358e-002	8.3352e-002
7.9418e-002	7.5554e-002	7.1762e-002	6.8882e-002	6.6039e-002	6.3233e-002	6.0464e-002	5.8300e-002	5.6164e-002	5.4055e-002
5.1973e-002	5.0196e-002	4.8437e-002	4.6697e-002	4.4976e-002	4.3540e-002	4.2113e-002	4.0693e-002	3.9282e-002	3.8048e-002
3.6824e-002	3.5608e-002	3.4400e-002	3.3135e-002	3.1874e-002	3.0618e-002	2.9365e-002	2.8576e-002	2.7794e-002	2.7018e-002
2.6250e-002	2.4556e-002	2.2884e-002	2.1234e-002	1.9606e-002	1.9203e-002	1.8803e-002	1.8404e-002	1.8007e-002	1.8200e-002
1.8396e-002	1.8594e-002	1.8795e-002	1.8697e-002	1.8599e-002	1.8502e-002	1.8405e-002	1.7657e-002	1.6914e-002	1.6174e-002
1.5438e-002	1.4955e-002	1.4473e-002	1.3991e-002	1.3510e-002	1.3730e-002	1.3950e-002	1.4169e-002	1.4388e-002	1.5376e-002
1.6375e-002	1.7385e-002	1.8406e-002	1.7134e-002	1.5885e-002	1.4660e-002	1.3456e-002	1.3232e-002	1.3006e-002	1.2779e-002
1.2549e-002	1.2103e-002	1.1656e-002	1.1207e-002	1.0756e-002	9.8034e-003	8.8484e-003	7.8911e-003	6.9316e-003	7.1587e-003
7.3852e-003	7.6110e-003	7.8362e-003	7.4708e-003	7.1038e-003	6.7351e-003	6.3647e-003	6.7095e-003	7.0535e-003	7.3967e-003
7.7390e-003	7.0402e-003	6.3389e-003	5.6351e-003	4.9289e-003	4.9617e-003	4.9946e-003	5.0274e-003	5.0603e-003	4.8906e-003
4.7210e-003	4.5513e-003	4.3816e-003	3.8863e-003	3.3899e-003	2.8925e-003	2.3940e-003	2.5140e-003	2.6341e-003	2.7542e-003
2.8744e-003	2.6177e-003	2.3603e-003	2.1025e-003	1.8441e-003	1.2917e-003	7.3993e-004	1.8868e-004	-3.6200e-004	-1.2372e-004
1.1503e-004	3.5428e-004	5.9401e-004	-4.7398e-005	-6.8948e-004	-1.3322e-003	-1.9756e-003	-2.4343e-003	-2.8925e-003	-3.3502e-003
-3.8073e-003	-4.0128e-003	-4.2183e-003	-4.4237e-003	-4.6291e-003	-4.7855e-003	-4.9423e-003	-5.0996e-003	-5.2573e-003	-5.6530e-003
-6.0489e-003	-6.4450e-003	-6.8413e-003	-7.3193e-003	-7.7979e-003	-8.2771e-003	-8.7569e-003	-8.9120e-003	-9.0673e-003	-9.2227e-003
-9.3784e-003	-1.0262e-002	-1.1147e-002	-1.2033e-002	-1.2920e-002	-1.3202e-002	-1.3484e-002	-1.3765e-002	-1.4045e-002	-1.4797e-002
-1.5551e-002	-1.6308e-002	-1.7068e-002	-1.8053e-002	-1.9037e-002	-2.0019e-002	-2.1000e-002	-2.1474e-002	-2.1947e-002	-2.2421e-002
-2.2894e-002	-2.3694e-002	-2.4493e-002	-2.5292e-002	-2.6089e-002	-2.6884e-002	-2.7680e-002	-2.8477e-002	-2.9276e-002	-3.0455e-002
-3.1633e-002	-3.2810e-002	-3.3986e-002	-3.5141e-002	-3.6292e-002	-3.7438e-002	-3.8580e-002	-3.9635e-002	-4.0688e-002	-4.1739e-002
-4.2788e-002	-4.3999e-002	-4.5205e-002	-4.6407e-002	-4.7605e-002	-4.8892e-002	-5.0173e-002	-5.1450e-002	-5.2721e-002	-5.4176e-002
-5.5625e-002	-5.7067e-002	-5.8502e-002	-6.0031e-002	-6.1551e-002	-6.3061e-002	-6.4561e-002	-6.6023e-002	-6.7474e-002	-6.8913e-002
-7.0340e-002	-7.2050e-002	-7.3743e-002	-7.5420e-002	-7.7080e-002	-7.8706e-002	-8.0312e-002	-8.1896e-002	-8.3458e-002	-8.4939e-002
-8.6395e-002	-8.7826e-002	-8.9234e-002	-9.0844e-002	-9.2424e-002	-9.3973e-002	-9.5491e-002	-9.6891e-002	-9.8257e-002	-9.9588e-002
-1.0088e-001	-1.0211e-001	-1.0330e-001	-1.0445e-001	-1.0557e-001	-1.0662e-001	-1.0763e-001	-1.0860e-001	-1.0952e-001	-1.1041e-001
-1.1125e-001	-1.1204e-001	-1.1279e-001	-1.1329e-001	-1.1376e-001	-1.1418e-001	-1.1456e-001	-1.1479e-001	-1.1496e-001	-1.1509e-001
-1.1517e-001	-1.1504e-001	-1.1487e-001	-1.1466e-001	-1.1441e-001	-1.1400e-001	-1.1356e-001	-1.1308e-001	-1.1256e-001	-1.1189e-001
-1.1120e-001	-1.1047e-001	-1.0972e-001	-1.0875e-001	-1.0776e-001	-1.0675e-001	-1.0572e-001	-1.0455e-001	-1.0338e-001	-1.0219e-001
-1.0100e-001	-9.9690e-002	-9.8380e-002	-9.7069e-002	-9.5759e-002	-9.4317e-002	-9.2880e-002	-9.1448e-002	-9.0021e-002	-8.8489e-002
-8.6969e-002	-8.5462e-002	-8.3967e-002	-8.2441e-002	-8.0933e-002	-7.9441e-002	-7.7966e-002	-7.6487e-002	-7.5027e-002	-7.3586e-002
-7.2163e-002	-7.0688e-002	-6.9236e-002	-6.7805e-002	-6.6397e-002	-6.4947e-002	-6.3521e-002	-6.2119e-002	-6.0741e-002	-5.9362e-002
-5.8009e-002	-5.6682e-002	-5.5380e-002	-5.4118e-002	-5.2881e-002	-5.1667e-002	-5.0476e-002	-4.9271e-002	-4.8091e-002	-4.6934e-002
-4.5801e-002									

PWA-HP-calibrations: file TSRX103\_imag.txt

## ANNEX B8 – PWA – MI – HP processed data: PWA\_MI\_preamp\_HP\_COLD\_dB.txt

-41.764	-41.338	-40.904	-40.465	-40.019	-39.569	-39.113	-38.654	-38.191	-37.725
-37.257	-36.795	-36.333	-35.868	-35.398	-34.915	-34.427	-33.938	-33.451	-32.973
-32.497	-32.022	-31.545	-31.066	-30.585	-30.102	-29.613	-29.119	-28.622	-28.120
-27.616	-27.110	-26.596	-26.073	-25.539	-24.997	-24.450	-23.900	-23.348	-22.795
-22.239	-21.678	-21.112	-20.543	-19.968	-19.388	-18.801	-18.207	-17.607	-17.002
-16.393	-15.770	-15.141	-14.514	-13.894	-13.273	-12.662	-12.069	-11.502	-10.957
-10.445	-9.976	-9.556	-9.186	-8.871	-8.616	-8.421	-8.284	-8.205	-8.179
-8.197	-8.252	-8.347	-8.474	-8.623	-8.781	-8.956	-9.141	-9.328	-9.508
-9.691	-9.872	-10.047	-10.214	-10.377	-10.534	-10.684	-10.825	-10.959	-11.085
-11.204	-11.314	-11.423	-11.524	-11.621	-11.714	-11.804	-11.887	-11.968	-12.046
-12.118	-12.187	-12.251	-12.312	-12.370	-12.423	-12.474	-12.523	-12.572	-12.620
-12.664	-12.708	-12.748	-12.788	-12.824	-12.857	-12.889	-12.919	-12.947	-12.974
-12.999	-13.023	-13.045	-13.065	-13.084	-13.102	-13.119	-13.134	-13.149	-13.162
-13.174	-13.186	-13.196	-13.207	-13.217	-13.225	-13.235	-13.242	-13.252	-13.262
-13.267	-13.273	-13.280	-13.286	-13.292	-13.298	-13.304	-13.309	-13.313	-13.317
-13.321	-13.325	-13.329	-13.333	-13.336	-13.339	-13.340	-13.343	-13.346	-13.349
-13.351	-13.352	-13.354	-13.357	-13.360	-13.363	-13.367	-13.371	-13.374	-13.378
-13.381	-13.384	-13.386	-13.388	-13.390	-13.391	-13.393	-13.394	-13.396	-13.397
-13.398	-13.399	-13.400	-13.401	-13.402	-13.403	-13.403	-13.404	-13.404	-13.404
-13.404	-13.403	-13.403	-13.403	-13.403	-13.403	-13.403	-13.403	-13.403	-13.403
-13.403	-13.403	-13.402	-13.401	-13.401	-13.401	-13.401	-13.401	-13.402	-13.404
-13.405	-13.405	-13.406	-13.406	-13.406	-13.406	-13.406	-13.406	-13.406	-13.405
-13.404	-13.403	-13.402	-13.402	-13.402	-13.402	-13.404	-13.404	-13.405	-13.406
-13.406	-13.406	-13.407	-13.407	-13.409	-13.411	-13.414	-13.416	-13.417	-13.419
-13.421	-13.422	-13.423	-13.425	-13.426	-13.427	-13.429	-13.431	-13.433	-13.435
-13.438	-13.441	-13.445	-13.448	-13.451	-13.454	-13.458	-13.461	-13.466	-13.470
-13.475	-13.479	-13.484	-13.489	-13.493	-13.498	-13.503	-13.508	-13.513	-13.519
-13.525	-13.531	-13.539	-13.546	-13.554	-13.561	-13.569	-13.577	-13.585	-13.595
-13.605	-13.616	-13.627	-13.640	-13.652	-13.666	-13.682	-13.698	-13.716	-13.734
-13.752	-13.771	-13.791	-13.812	-13.835	-13.858	-13.882	-13.908	-13.935	-13.964
-13.993	-14.024	-14.056	-14.089	-14.124	-14.160	-14.198	-14.237	-14.278	-14.321
-14.366	-14.414	-14.462	-14.513	-14.566	-14.620	-14.677	-14.735	-14.796	-14.859
-14.924	-14.992	-15.061	-15.133	-15.207	-15.284	-15.364	-15.446	-15.531	-15.619
-15.710	-15.802	-15.898	-15.996	-16.097	-16.201	-16.308	-16.418	-16.531	-16.647
-16.765	-16.886	-17.010	-17.137	-17.266	-17.398	-17.532	-17.669	-17.809	-17.951
-18.096	-18.244	-18.394	-18.546	-18.701	-18.858	-19.018	-19.180	-19.344	-19.510
-19.678	-19.849	-20.021	-20.195	-20.371	-20.549	-20.729	-20.910	-21.093	-21.278
-21.464	-21.652	-21.841	-22.032	-22.224	-22.418	-22.613	-22.809	-23.007	-23.205
-23.405	-23.606	-23.808	-24.011	-24.215	-24.420	-24.626	-24.833	-25.041	-25.249
-25.458	-25.668	-25.878	-26.089	-26.300	-26.512	-26.725	-26.938	-27.151	-27.364
-27.578									

PWA-MI: tests with HP analyser. Amplitude transfer function (dB); COLD temperature (ESTEC cryo test: -180°C);  
Corrected from 50 Hz and machine noise + filtering

## ANNEX B9 – PWA – MI – HP processed data: PWA\_MI\_preamp\_HP\_WARM\_dB.txt

-40.750	-40.308	-39.860	-39.407	-38.948	-38.484	-38.015	-37.543	-37.068	-36.589
-36.109	-35.635	-35.161	-34.684	-34.201	-33.706	-33.206	-32.704	-32.204	-31.713
-31.225	-30.735	-30.244	-29.751	-29.256	-28.756	-28.252	-27.742	-27.227	-26.707
-26.184	-25.659	-25.125	-24.581	-24.025	-23.460	-22.890	-22.315	-21.737	-21.157
-20.572	-19.982	-19.386	-18.785	-18.181	-17.565	-16.944	-16.311	-15.673	-15.035
-14.403	-13.765	-13.130	-12.510	-11.913	-11.334	-10.784	-10.276	-9.817	-9.408
-9.055	-8.764	-8.537	-8.373	-8.274	-8.235	-8.251	-8.312	-8.418	-8.558
-8.721	-8.893	-9.083	-9.283	-9.484	-9.677	-9.871	-10.063	-10.248	-10.422
-10.592	-10.755	-10.912	-11.063	-11.207	-11.345	-11.475	-11.595	-11.707	-11.813
-11.914	-12.008	-12.102	-12.188	-12.269	-12.345	-12.418	-12.487	-12.553	-12.616
-12.672	-12.728	-12.779	-12.828	-12.873	-12.915	-12.957	-12.998	-13.040	-13.080
-13.115	-13.152	-13.185	-13.218	-13.247	-13.273	-13.299	-13.322	-13.345	-13.366
-13.385	-13.404	-13.421	-13.438	-13.453	-13.466	-13.479	-13.491	-13.502	-13.512
-13.520	-13.529	-13.536	-13.544	-13.551	-13.554	-13.563	-13.566	-13.573	-13.576
-13.578	-13.580	-13.583	-13.585	-13.587	-13.589	-13.590	-13.592	-13.591	-13.591
-13.591	-13.590	-13.590	-13.589	-13.587	-13.585	-13.583	-13.581	-13.579	-13.577
-13.575	-13.574	-13.572	-13.571	-13.570	-13.568	-13.567	-13.565	-13.563	-13.561
-13.559	-13.556	-13.554	-13.551	-13.548	-13.545	-13.542	-13.539	-13.536	-13.529
-13.526	-13.523	-13.520	-13.516	-13.513	-13.509	-13.506	-13.502	-13.498	-13.495
-13.491	-13.488	-13.484	-13.481	-13.477	-13.470	-13.466	-13.462	-13.458	-13.455
-13.451	-13.448	-13.444	-13.441	-13.437	-13.434	-13.430	-13.427	-13.424	-13.420
-13.417	-13.409	-13.406	-13.402	-13.398	-13.395	-13.393	-13.390	-13.387	-13.384
-13.380	-13.377	-13.373	-13.370	-13.367	-13.364	-13.361	-13.354	-13.352	-13.348
-13.345	-13.342	-13.339	-13.336	-13.333	-13.331	-13.328	-13.325	-13.322	-13.320
-13.317	-13.314	-13.311	-13.305	-13.303	-13.300	-13.297	-13.295	-13.292	-13.290
-13.288	-13.286	-13.284	-13.282	-13.281	-13.279	-13.278	-13.277	-13.277	-13.276
-13.276	-13.276	-13.276	-13.276	-13.277	-13.277	-13.278	-13.280	-13.281	-13.283
-13.286	-13.288	-13.291	-13.294	-13.297	-13.304	-13.309	-13.313	-13.318	-13.324
-13.330	-13.336	-13.343	-13.351	-13.359	-13.367	-13.376	-13.386	-13.397	-13.408
-13.420	-13.447	-13.462	-13.477	-13.493	-13.510	-13.528	-13.547	-13.567	-13.588
-13.611	-13.635	-13.660	-13.687	-13.715	-13.745	-13.776	-13.809	-13.844	-13.880
-13.918	-13.958	-13.999	-14.043	-14.088	-14.135	-14.185	-14.237	-14.291	-14.347
-14.405	-14.466	-14.529	-14.595	-14.663	-14.733	-14.806	-14.881	-14.959	-15.040
-15.123	-15.210	-15.298	-15.390	-15.485	-15.582	-15.682	-15.784	-15.890	-15.998
-16.109	-16.223	-16.340	-16.459	-16.582	-16.707	-16.835	-16.966	-17.100	-17.237
-17.376	-17.518	-17.663	-17.810	-17.960	-18.112	-18.266	-18.423	-18.582	-18.744
-18.908	-19.074	-19.242	-19.413	-19.585	-19.759	-19.936	-20.114	-20.294	-20.476
-20.659	-20.845	-21.033	-21.222	-21.412	-21.604	-21.798	-21.993	-22.189	-22.387
-22.586	-22.786	-22.988	-23.191	-23.394	-23.599	-23.805	-24.012	-24.219	-24.428
-24.637	-24.847	-25.058	-25.270	-25.482	-25.694	-25.908	-26.121	-26.335	-26.550
-26.765									

PWA-MI: tests with HP analyser. Amplitude transfer function (dB); ROOM temperature (ESTEC cryo test);  
Corrected from 50 Hz and machine noise + filtering

## ANNEX B10 – PWA – MI – HP processed data: PWA\_MI\_preamp\_HP\_CmW\_dB . txt

-1.015	-1.029	-1.044	-1.058	-1.072	-1.085	-1.098	-1.111	-1.123	-1.136
-1.148	-1.160	-1.172	-1.184	-1.197	-1.209	-1.221	-1.234	-1.246	-1.259
-1.273	-1.286	-1.300	-1.315	-1.330	-1.345	-1.361	-1.378	-1.395	-1.413
-1.431	-1.451	-1.471	-1.492	-1.514	-1.537	-1.560	-1.585	-1.611	-1.638
-1.666	-1.696	-1.726	-1.758	-1.787	-1.822	-1.857	-1.897	-1.935	-1.967
-1.989	-2.005	-2.011	-2.004	-1.981	-1.940	-1.878	-1.793	-1.685	-1.550
-1.390	-1.211	-1.019	-0.813	-0.597	-0.380	-0.170	0.028	0.213	0.380
0.524	0.641	0.736	0.809	0.861	0.896	0.915	0.922	0.920	0.914
0.900	0.883	0.864	0.849	0.830	0.811	0.791	0.770	0.749	0.729
0.710	0.694	0.679	0.664	0.647	0.630	0.615	0.600	0.585	0.570
0.555	0.541	0.528	0.515	0.503	0.492	0.483	0.475	0.467	0.459
0.452	0.444	0.437	0.430	0.423	0.416	0.410	0.404	0.398	0.392
0.386	0.381	0.377	0.372	0.368	0.364	0.360	0.357	0.353	0.350
0.346	0.343	0.340	0.337	0.334	0.330	0.328	0.324	0.321	0.314
0.311	0.307	0.303	0.299	0.295	0.291	0.287	0.283	0.278	0.274
0.270	0.265	0.261	0.256	0.251	0.246	0.243	0.238	0.233	0.229
0.225	0.221	0.218	0.214	0.210	0.205	0.199	0.194	0.189	0.183
0.178	0.173	0.167	0.163	0.159	0.154	0.150	0.145	0.140	0.132
0.128	0.124	0.119	0.115	0.111	0.106	0.102	0.098	0.095	0.091
0.088	0.084	0.081	0.078	0.074	0.067	0.063	0.059	0.055	0.052
0.048	0.045	0.042	0.039	0.036	0.033	0.030	0.026	0.021	0.017
0.012	0.004	0.000	-0.004	-0.007	-0.010	-0.013	-0.016	-0.019	-0.021
-0.024	-0.026	-0.029	-0.032	-0.035	-0.039	-0.043	-0.050	-0.054	-0.057
-0.061	-0.064	-0.067	-0.071	-0.075	-0.080	-0.086	-0.090	-0.095	-0.099
-0.103	-0.108	-0.112	-0.120	-0.123	-0.128	-0.132	-0.136	-0.141	-0.146
-0.151	-0.156	-0.161	-0.165	-0.170	-0.175	-0.179	-0.184	-0.189	-0.194
-0.199	-0.204	-0.208	-0.213	-0.217	-0.220	-0.224	-0.228	-0.232	-0.235
-0.239	-0.243	-0.248	-0.252	-0.257	-0.257	-0.260	-0.264	-0.267	-0.271
-0.275	-0.280	-0.284	-0.289	-0.293	-0.299	-0.306	-0.312	-0.319	-0.326
-0.332	-0.324	-0.330	-0.335	-0.341	-0.347	-0.354	-0.360	-0.368	-0.376
-0.383	-0.389	-0.396	-0.403	-0.409	-0.415	-0.421	-0.428	-0.434	-0.441
-0.448	-0.456	-0.463	-0.470	-0.478	-0.485	-0.492	-0.499	-0.506	-0.512
-0.519	-0.525	-0.532	-0.538	-0.545	-0.551	-0.558	-0.565	-0.572	-0.579
-0.586	-0.593	-0.599	-0.606	-0.613	-0.620	-0.627	-0.634	-0.642	-0.649
-0.657	-0.664	-0.671	-0.678	-0.684	-0.691	-0.697	-0.703	-0.709	-0.714
-0.720	-0.725	-0.731	-0.736	-0.742	-0.747	-0.752	-0.757	-0.761	-0.766
-0.770	-0.775	-0.779	-0.782	-0.786	-0.789	-0.793	-0.796	-0.799	-0.802
-0.805	-0.807	-0.809	-0.811	-0.812	-0.814	-0.815	-0.816	-0.817	-0.818
-0.819	-0.820	-0.820	-0.821	-0.821	-0.821	-0.821	-0.821	-0.821	-0.821
-0.821	-0.820	-0.820	-0.819	-0.819	-0.818	-0.817	-0.816	-0.815	-0.815
-0.813									

PWA-MI: tests with HP analyser. Amplitude transfer function (dB); COLD (-180°C) - ROOM temperature (ESTEC cryo test);