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Group Code (if applicable):

Assignment Title:	VNA Calibration and Measurement
Subject Number:	ELEN90062
Subject Name:	High Speed Electronics
Student Name:	Rui Yuan, Huawang Liu, Haotian Xia
Lecturer/Tutor:	
Due Date:	08/09/2018

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Student signature Rui Yuan Huawang Liu Haotian Xia Date 08/09/2018

University of Melbourne
ELEN90062 High Speed Electronics
WORKSHOP

WORKSHOP 3 REPORT

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September 5, 2018

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1 Task 1

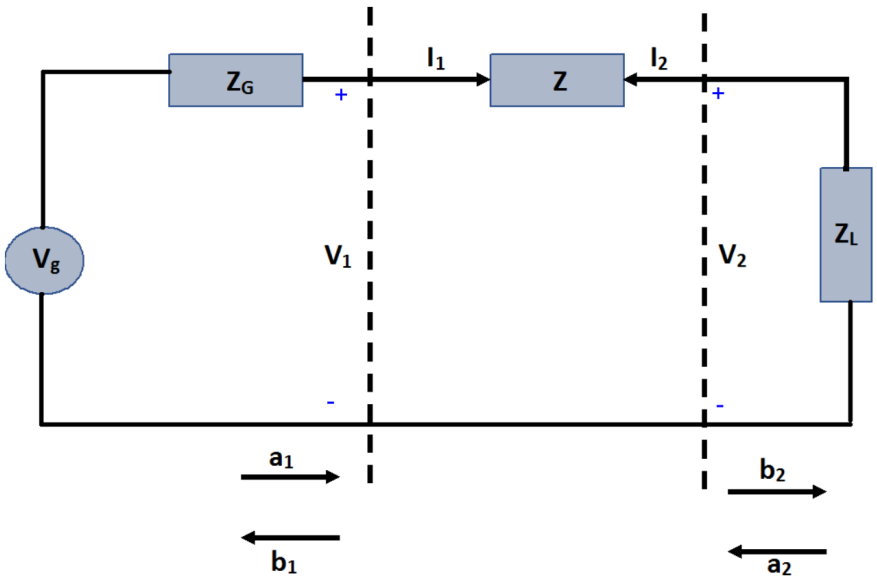

Figure 1: Two port network

Based on the two equations in guidebook, since $Z_G = Z_0$, $Z = 0$, then $V_1 = V_2$, by definition, since no wave coming into port 2, $a_2 = 0$. From the figure, we have:

$$a_1 = \frac{V_1 + I_1 Z_0}{2\sqrt{Z_0}} \tag{1}$$

$$b_1 = \frac{V_1 - I_1 Z_0}{2\sqrt{Z_0}} \tag{2}$$

$$\begin{aligned} S_{11} &= \frac{b_1}{a_1}|_{a_2=0} \\ &= \frac{V_1 - I_1 Z_0}{V_1 + I_1 Z_0} \\ &= \frac{\frac{V_1}{I_1} - Z_0}{\frac{V_1}{I_1} + Z_0} \\ &= \frac{Z + Z_L - Z_0}{Z + Z_L + Z_0} \end{aligned} \tag{3}$$

Since we are given $Z = 0$, we have: $S_{11} = \frac{Z_L - Z_0}{Z_L + Z_0}$

2 Task 2

Under this circumstance, from figure 1, we have:

$$a_2 = \frac{V_2 + I_2 Z_0}{2\sqrt{Z_0}} = \frac{V_2 + I_2 Z_l}{2\sqrt{Z_0}} = 0 \tag{4}$$

$$\begin{aligned} S_{21} &= \frac{b_2}{a_1}|_{a_2=0} \\ &= \frac{V_2 - I_2 Z_0}{V_1 + I_1 Z_0} \\ &= \frac{2V_2}{I_1(Z + Z_L) + I_1 Z_0} \\ &= \frac{2Z_L}{Z + Z_L + Z_0} \\ &= \frac{2Z_0}{Z + 2Z_0} \end{aligned} \tag{5}$$

3 Task 3

The smith charts plotted as below:

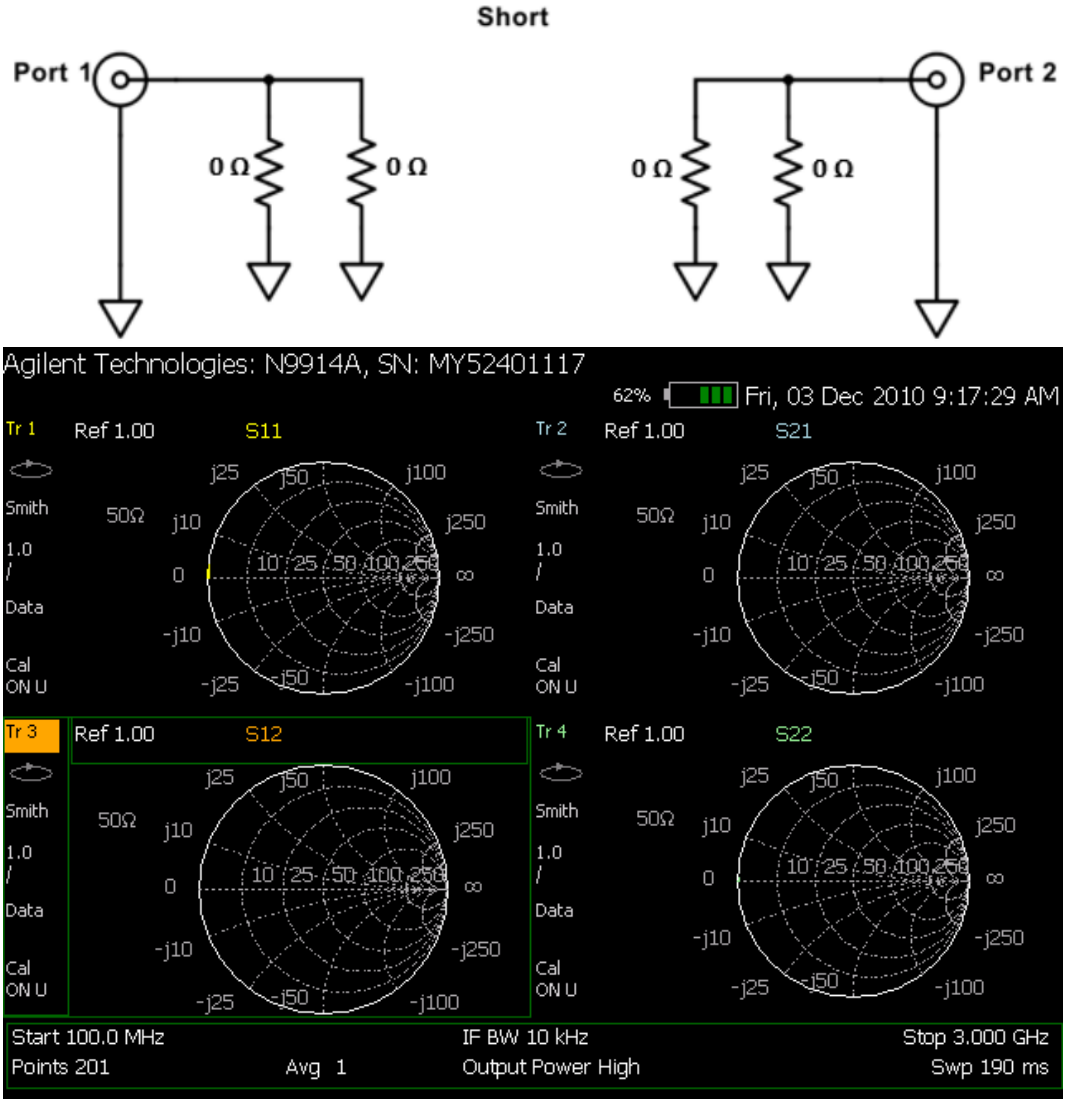

Figure 2: Short circuit SOLT connected

From the figure above, we have calibrated Port extension to make our circuit match. $Z_L = Z_G = 0\Omega$, $Z = \infty$. Hence, $I_1 = I_2 = 0$, $V_1 = 0$. From equation 1, we have $a_1 = 0$, our $S_{22} = 1$. S_{22}

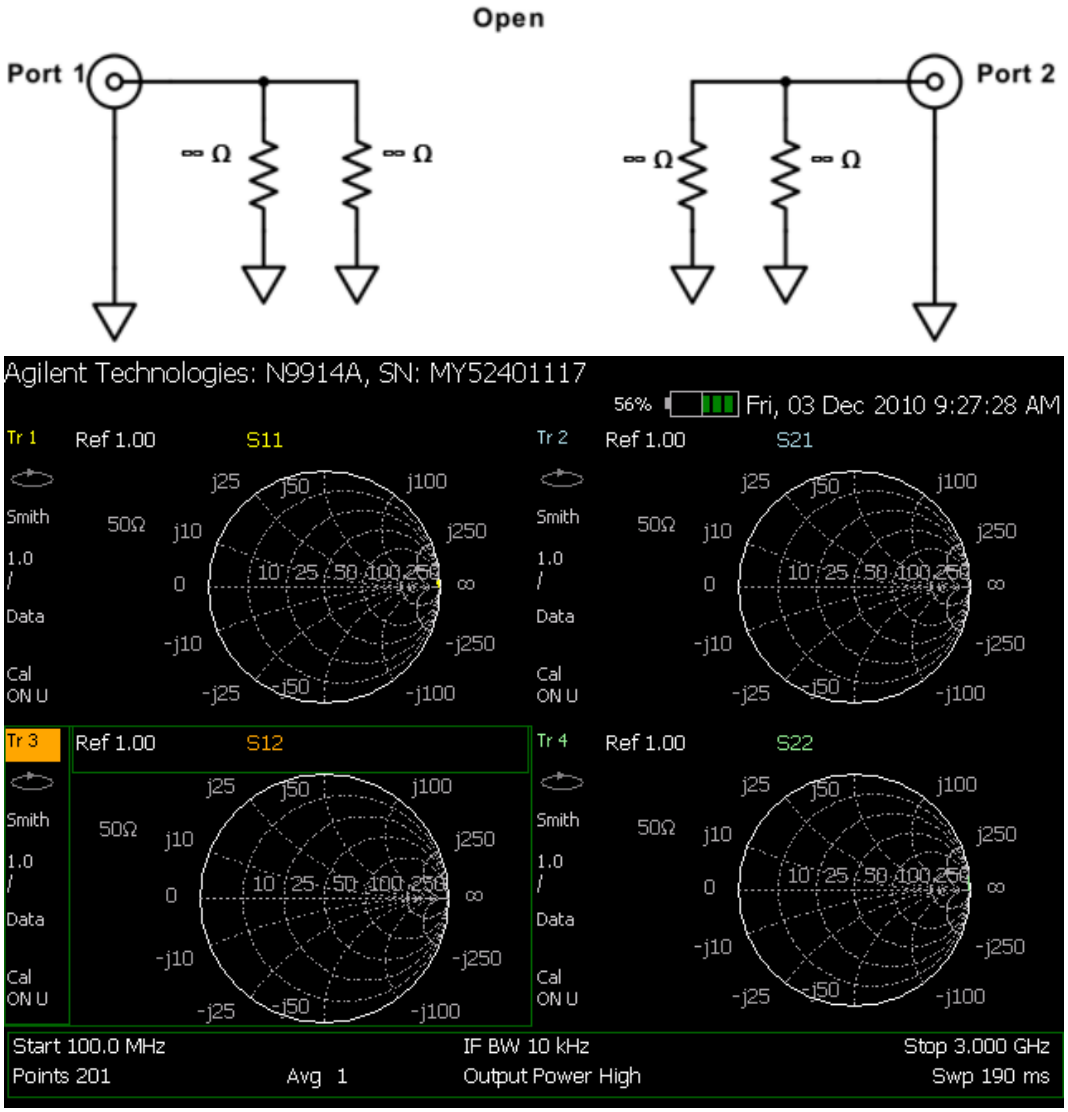

Figure 3: Open circuit SOLT connected

From the figure above, as $Z = Z_L = Z_G = \infty$. Hence, $I_1 = I_2 = 0$, $V_2 = 0$. from equation (4), our $S_{11} = \infty$ why S_{22}

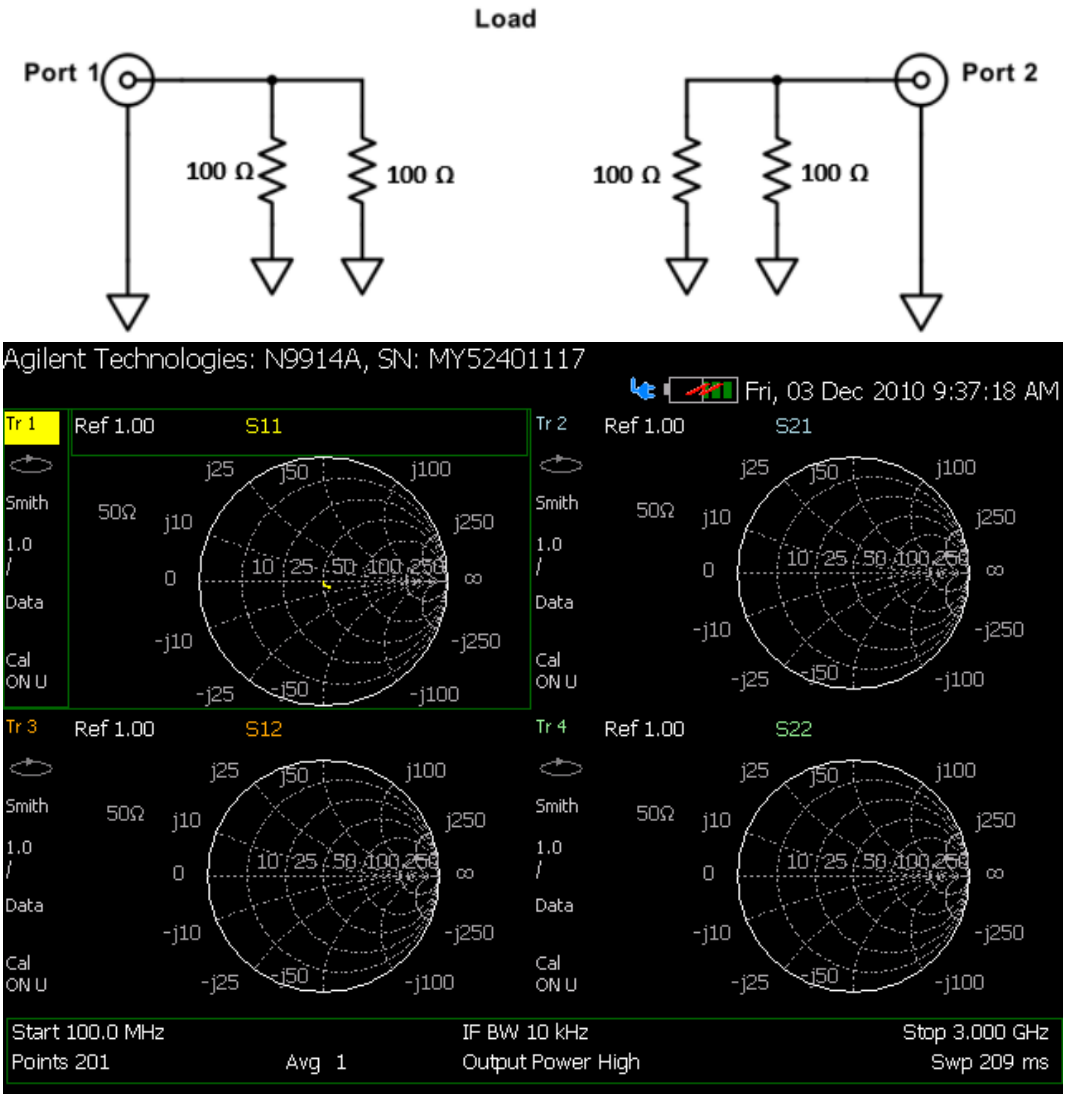

Figure 4: Load circuit SOLT connected

From the figure above, as $Z_0 = Z_L = Z_G = 50\Omega$, $Z = 0\Omega$. Hence, from equation (3), our $S_{11} = 0$. S_{22}

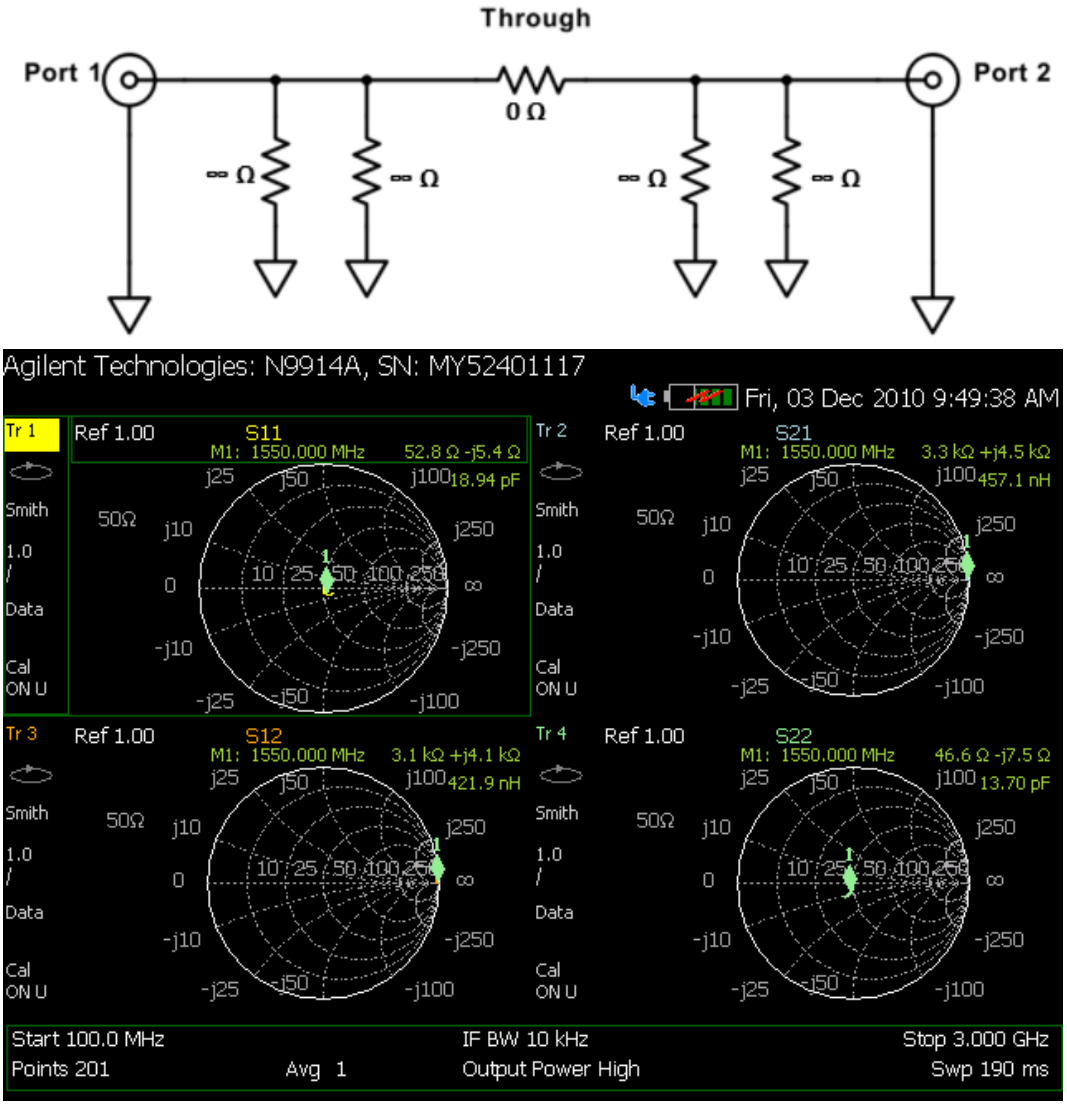

Figure 5: Through circuit SOLT connected

From the figure 5 above, $Z_G = Z_L = Z_0 = 50\Omega$, $Z = 0\Omega$, based on equation (3), $S_{11} = 0$

4 Task 4

Open the data file with excel, we have the figure 6, by checking

4.1 Shunt1

!S2P	File:	Measurem	S21	S12	S22:			
#	Hz	S	DB	R	50			
1E+08	-0.00155	-19.7431	-80.79	-145.367	-82.8349	45.94263	0.029643	7.732607
1.15E+08	-0.06393	-22.2874	-86.1061	87.81405	-75.2582	-32.3697	0.021865	8.925692
1.29E+08	-0.14092	-24.9997	-71.7224	169.6007	-81.044	143.8072	0.003878	10.03125
1.44E+08	-0.17129	-27.8953	-79.5867	-57.6529	-78.1726	112.8304	-0.00834	11.04866
1.58E+08	-0.14915	-30.7957	-79.0712	80.20201	-75.3253	-83.403	0.016574	12.09898
1.73E+08	-0.09048	-33.6225	-92.6586	-124.22	-77.1235	139.5885	0.030625	13.15535
1.87E+08	-0.04318	-36.1847	-80.4571	110.8596	-80.7933	139.6903	0.0428	14.27817
2.02E+08	-0.07476	-38.4871	-87.5648	-135.034	-78.3288	-68.5177	0.05715	15.56697
2.16E+08	-0.14338	-41.0119	-84.7827	179.5088	-89.1524	67.79482	0.044337	16.69759
2.31E+08	-0.20487	-43.4405	-72.6304	-45.5363	-80.5562	-120.055	0.03487	17.73499
2.45E+08	-0.21509	-46.209	-76.7595	96.67597	-80.7322	-38.9185	0.031068	18.77086
2.6E+08	-0.16701	-48.8092	-86.0454	-76.9514	-77.6622	68.55026	0.052749	19.81303
2.74E+08	-0.11001	-51.3164	-77.7181	-51.9178	-78.7879	175.7009	0.073038	20.94815
2.89E+08	-0.12318	-53.6266	-79.8211	-49.2857	-78.5502	145.8896	0.093835	22.12992
3.03E+08	-0.16318	-55.6441	-68.6995	-128.783	-77.0061	-132.134	0.095951	23.37715
3.18E+08	-0.23166	-57.643	-76.5221	-123.103	-85.883	134.3924	0.079685	24.43528
3.32E+08	-0.27237	-59.9851	-81.1789	93.79252	-70.246	160.7273	0.065101	25.47345
3.47E+08	-0.28491	-62.3539	-81.4632	-167.501	-75.0175	-76.6009	0.076678	26.53218
3.61E+08	-0.22498	-64.6918	-78.301	91.61384	-80.2436	-119.778	0.104399	27.57803
3.76E+08	-0.19423	-66.6771	-80.3931	-74.7146	-89.1061	-78.058	0.12916	28.70275
3.9E+08	-0.20643	-68.5889	-88.4409	179.9353	-85.924	1.12408	0.145411	29.95759
4.05E+08	-0.27135	-70.341	-79.961	104.8055	-78.3824	-161.725	0.148569	31.21896
4.19E+08	-0.32825	-72.0813	-72.606	-72.772	-83.7169	88.90123	0.139017	32.33455
4.34E+08	-0.34964	-74.2057	-85.9524	51.02423	-76.3326	8.911616	0.128271	33.36544
4.48E+08	-0.32756	-76.2046	-81.6856	-169.456	-82.832	-136.499	0.141123	34.40829
4.63E+08	-0.28727	-78.2469	-79.028	35.01264	-78.0834	-114.852	0.165747	35.50906
4.77E+08	-0.27304	-79.8556	-86.1182	128.1715	-75.1437	89.77458	0.187567	36.64943

Figure 6: S2P data for shunt 1

By observation, the first shunt is a capacitor. Based on equation 3:

$$S_{11} = \frac{\frac{1}{j2\pi fc} - Z_0}{\frac{1}{j2\pi fc} + Z_0} \qquad Z_0 = 50\Omega \tag{6}$$

$$c = \frac{1 - S_{11}}{100j\pi f(1 + S_{11})} \tag{7}$$

We cannot get the answer with only the abs of S_{11}, the abs should always be 1 no matter what c value it is!!. Magnitude-phase.

4.2 Shunt2

Since this load is a pure resistor:

$$S_{11} = \frac{R - Z_0}{R + Z_0} \tag{8}$$

$$R = \frac{Z_0(1 + S_{11})}{1 - S11} \tag{9}$$

Then we measure the value of the resistor (shadow column) based on equation 10.

K13 =50*(1+10^(0.1*B13))/(1-10^(0.1*B13))

	A	B	C	D	E	F	G	H	I	J	K
13	100000000	-9.52406	3.213022	-82.1574	-69.1368	-85.4357	-63.027	0.029434	7.772037		62.55962
14	114500000	-9.55528	3.937568	-84.6159	-108.147	-75.2537	-125.471	0.020769	8.939092		62.45846
15	129000000	-9.60176	4.440008	-75.7615	149.7483	-75.8898	42.27422	0.008194	10.05047		62.30949
16	143500000	-9.63811	4.737804	-85.3826	-152.206	-81.8498	151.4072	5.04E-05	11.0617		62.19439
17	158000000	-9.60021	5.141258	-75.9402	50.57766	-86.4756	-27.5499	0.020143	12.12276		62.31445
18	172500000	-9.54529	5.510593	-73.7202	-59.3425	-80.8925	-2.95144	0.032731	13.19606		62.49074
19	187000000	-9.50509	6.182516	-84.312	16.73516	-76.5911	-29.0245	0.042096	14.32463		62.62153
20	201500000	-9.52091	7.059514	-77.3867	-162.946	-89.2959	-59.5553	0.055347	15.58054		62.56988
21	216000000	-9.58584	7.645712	-83.1544	130.705	-96.2905	-149.085	0.043833	16.71095		62.36029
22	230500000	-9.64219	7.851937	-78.8479	-11.0823	-77.2932	30.83391	0.03434	17.73884		62.18154
23	245000000	-9.64028	8.166442	-74.9536	87.05319	-73.6091	-158.632	0.036413	18.80867		62.18756
24	259500000	-9.6023	8.485704	-75.1226	-79.9839	-72.2247	-174.151	0.053805	19.84746		62.30778
25	274000000	-9.53099	9.076291	-87.6198	-178.305	-75.9748	-161.369	0.072043	20.98813		62.5371
26	288500000	-9.50915	9.693895	-84.3162	111.6014	-78.1265	-123.721	0.090413	22.20215		62.60825
27	303000000	-9.54787	10.61368	-73.1049	-97.8293	-77.2727	-149.79	0.094591	23.4481		62.48237
28	317500000	-9.63841	10.96254	-71.2097	-75.9692	-88.6694	92.63804	0.080544	24.52527		62.19344
29	332000000	-9.65102	11.23558	-81.9437	-126.636	-70.7395	-111.505	0.06987	25.57856		62.15379
30	346500000	-9.66033	11.50713	-68.4703	-43.3436	-67.263	-6.95158	0.079225	26.621		62.12462
31	361000000	-9.57656	11.82647	-77.3227	-166.366	-89.9712	108.4458	0.103221	27.65409		62.39001
32	375500000	-9.51657	12.62716	-79.8365	156.1506	-82.8279	-88.1652	0.124545	28.76952		62.58402
33	390000000	-9.52992	13.34248	-79.274	-166.028	-96.3105	173.2864	0.140906	30.03156		62.54057
34	404500000	-9.58721	14.03018	-75.3515	-157.671	-80.2852	-153.442	0.144625	31.27474		62.35591
35	419000000	-9.68303	14.30792	-78.5482	-84.621	-79.9485	-42.0291	0.139522	32.39247		62.05379
36	433500000	-9.6656	14.4929	-82.7919	122.7161	-72.2521	176.5281	0.128914	33.45513		62.10814
37	448000000	-9.63599	14.77913	-66.6762	55.953	-71.0395	171.4639	0.140904	34.5164		62.20107
38	462500000	-9.5535	15.23488	-78.3499	-155.058	-92.4228	-153.6	0.165563	35.61008		62.46419
39	477000000	-9.51086	16.1963	-97.7324	-175.213	-82.4659	-67.565	0.184324	36.75836		62.60267
40	491500000	-9.55249	16.95412	-77.4406	14.54493	-78.5571	-129.888	0.201983	38.03337		62.46744
41	506000000	-9.67139	17.55638	-81.5246	5.32927	-80.3835	-97.9055	0.196977	39.21646		62.09006
42	520500000	-9.69661	17.67423	-73.9185	70.81362	-77.8012	-114.035	0.187197	40.37915		62.01163
43	535000000	-9.69512	17.79109	-74.1617	-32.7172	-85.7047	-47.88	0.182537	41.50067		62.01627
44	549500000	-9.61303	18.11695	-78.3099	-163.718	-79.4525	-8.46142	0.208828	42.55917		62.27368
45	564000000	-9.527	18.94547	-77.5405	148.1944	-78.0451	-118.917	0.218787	43.60645		62.55004
46	578500000	-9.51852	19.6625	-79.8899	-42.2419	-75.8865	-148.808	0.247516	44.82776		62.57767
47	593000000	-9.58715	20.60423	-75.3456	-83.2462	-85.0124	86.28744	0.257535	45.96852		62.3561
48	607500000	-9.69506	20.77704	-89.144	-98.569	-75.876	-73.2698	0.25689	47.11617		62.01642
49	622000000	-9.71268	20.99672	-72.285	-24.8753	-77.5079	33.08153	0.253493	48.27071		61.96198
50	636500000	-9.6751	21.19957	-86.1563	-29.551	-87.8935	-157.419	0.270555	49.36842		62.07847
51	651000000	-9.58101	21.73474	-87.9873	20.52916	-78.0442	70.4161	0.287314	50.585		62.37574
52	665500000	-9.53858	22.56435	-82.3279	87.76836	-88.1169	-156.413	0.288464	51.70061		62.51244
53	680000000	-9.58768	23.43225	-86.4006	-23.9194	-85.5651	165.6773	0.306795	52.85875		62.35441

Figure 7: S2P data for shunt 2

WHY NOT 100!!!!!!!!!!!!!!!!!!!!!!!!!!!!

5 Task 5