Lab 21: SBB version of Brd 4

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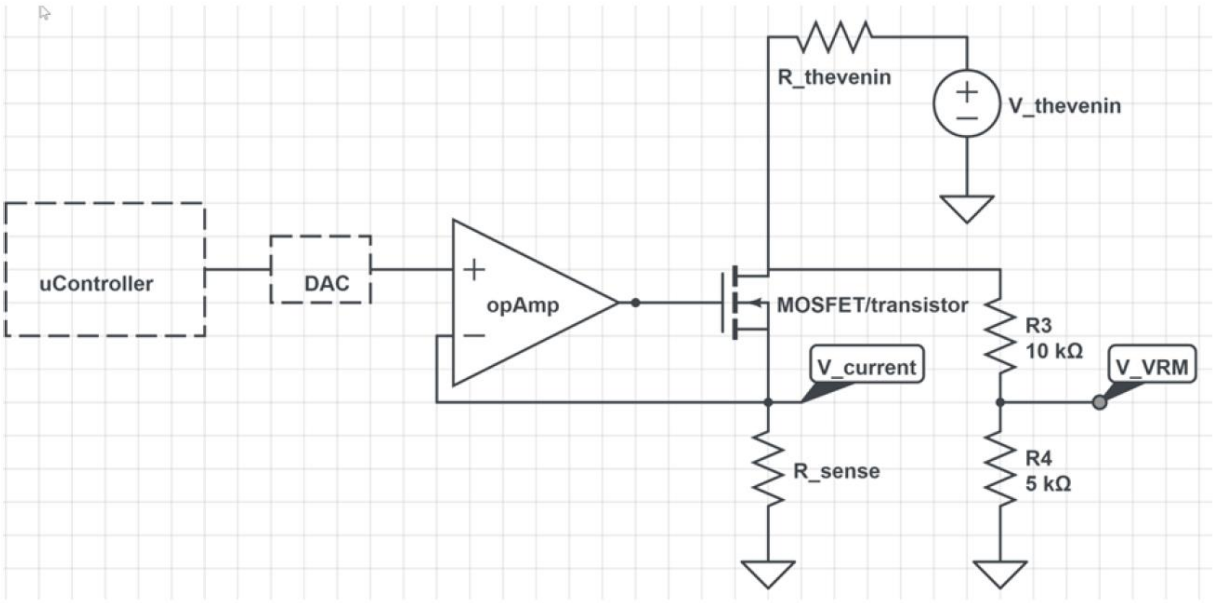
Purpose: To build a solderless breadboard version of board 4 to demonstrate the basic operation and simple code to perform the measurements. An instrument droid is designed and VRM by measuring Thevenin voltage and Thevenin resistance.

Experiment:

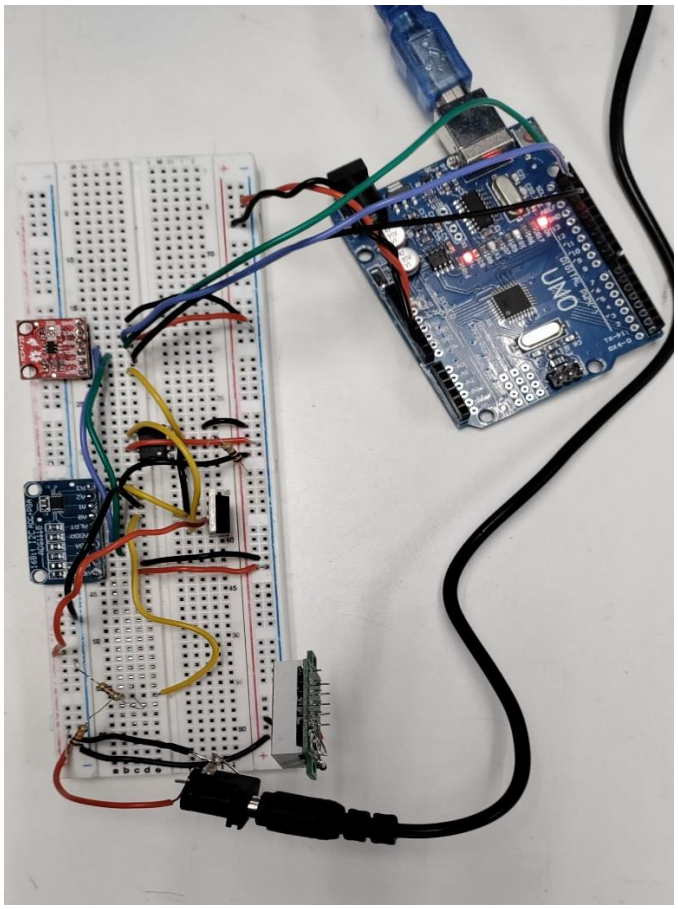
For this experiment, with different VRM input voltages, we try to measure the current through passing through the circuit and the voltage at the divider, to find out the Thevenin's Resistance.

The following is the circuit to be developed on a solderless breadboard.



The DAC MCP4725 is used to generate a voltage which will match the voltage across the sense resistor. The voltage across the sense resistor and voltage across the potential divider circuit is measured with a 16-bit ADC, ADS1115. A MOSFET is used for switching as the current passing through will be same as in sense resistor.

After connecting the circuit on a solder less breadboard, it looks like the following,



The Arduino code is provided by professor, with setting up the DAC, ADC and calculating the Thevenin's voltage and resistance from the sense resistor and potential divider circuit.

Different VRM inputs:

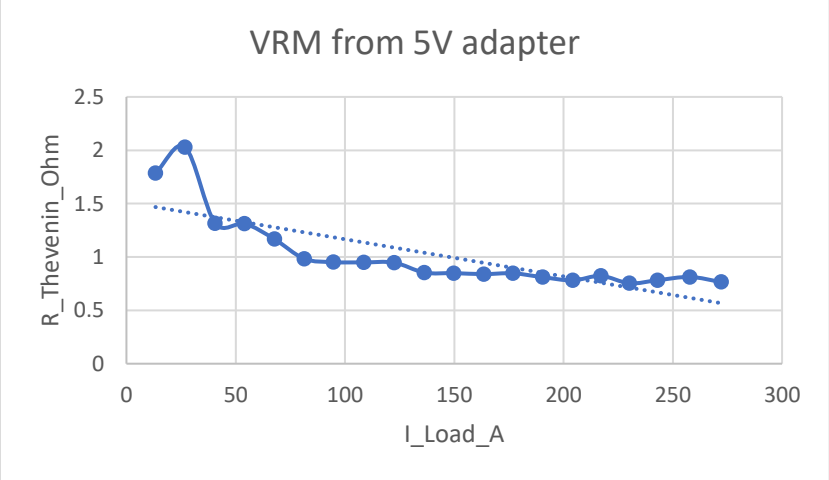
There are different inputs given to VRM for calculating the Thevenins resistance. With this input samples, the current through the load is swept through a particular range and the current vs thevenin's resistance is plotted. The The different VRM values used are,

1. **VRM = 5V input from wall adapter**

The VRM voltage is given to the circuit by a 9V DC supply adapter. The estimated R_Thevenin is around the range of 1.7Ohm to 0.7Ohm. The following is the table for the values.

Sample No.	I_load_A	V_VRM_thevenin_v	V_VRM_loaded_v	R_thevenin
1	13.3	5.3037	5.2799	1.7872
2	26.835	5.3018	5.2474	2.0285
3	40.59	5.3022	5.2488	1.3159
4	54.064	5.3021	5.2311	1.3126
5	67.721	5.3014	5.2224	1.1675
6	81.357	5.3007	5.2207	0.9834
7	94.682	5.302	5.2119	0.9518
8	108.646	5.3023	5.1991	0.9493
9	122.542	5.3028	5.1867	0.9474
10	136.283	5.2999	5.1835	0.8539
11	149.839	5.3031	5.1759	0.8488
12	163.514	5.301	5.1638	0.8395
13	176.802	5.3011	5.1514	0.8472
14	190.433	5.3014	5.1469	0.8111
15	204.22	5.3029	5.1435	0.7808
16	217.088	5.3013	5.1226	0.823
17	230.225	5.3002	5.1267	0.7535
18	243.04	5.3012	5.111	0.7825
19	257.856	5.303	5.0934	0.8127
20	272.184	5.3026	5.0943	0.7653

The sample plot is given by,

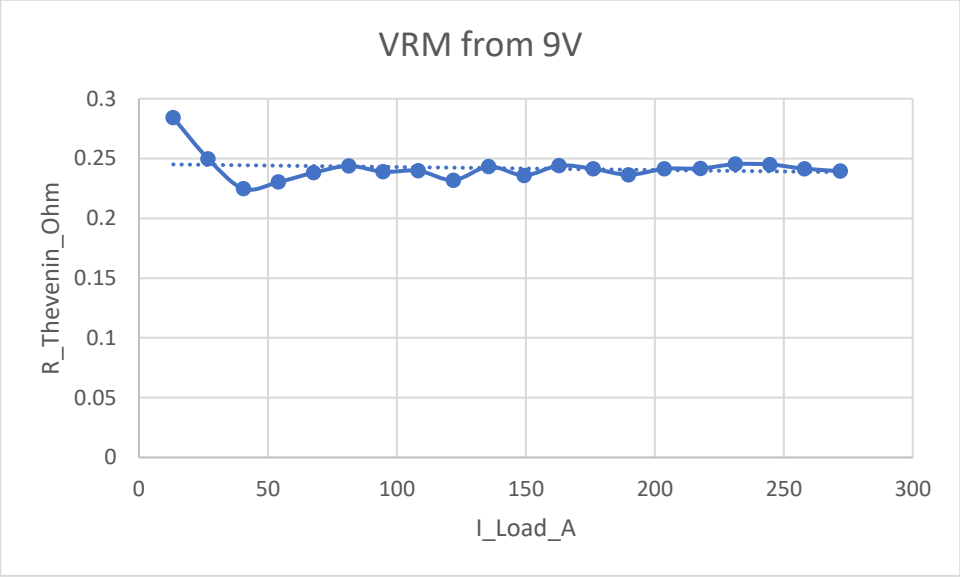


2. VRM = 9V from Wall adapter

The VRM voltage is given to the circuit by a 9V DC supply adapter. The estimated R_Thevenin is around the range of 0.28Ohm to 0.22Ohm. The following is the table for the values.

Sample No.	I_load_A	V_VRM_thevenin_v	V_VRM_loaded_v	R_thevenin
1	13.317	9.1942	9.1905	0.2841
2	26.853	9.1943	9.1876	0.2497
3	40.576	9.1942	9.1851	0.2247
4	54.064	9.1942	9.1817	0.2303
5	67.727	9.1944	9.1782	0.2381
6	81.358	9.1943	9.1744	0.2438
7	94.694	9.1939	9.1713	0.2389
8	108.313	9.1944	9.1684	0.2398
9	121.923	9.1942	9.1659	0.2319
10	135.681	9.1946	9.1616	0.2433
11	149.339	9.1942	9.159	0.2359
12	162.867	9.1945	9.1547	0.2441
13	176.246	9.1944	9.1518	0.2414
14	189.877	9.1943	9.1494	0.2364
15	203.78	9.194	9.1448	0.2414
16	217.719	9.1943	9.1417	0.2417
17	231.231	9.1943	9.1376	0.2453
18	244.661	9.1942	9.1343	0.245
19	258.086	9.1943	9.132	0.2415
20	271.971	9.1945	9.1294	0.2394

The plot is given by,

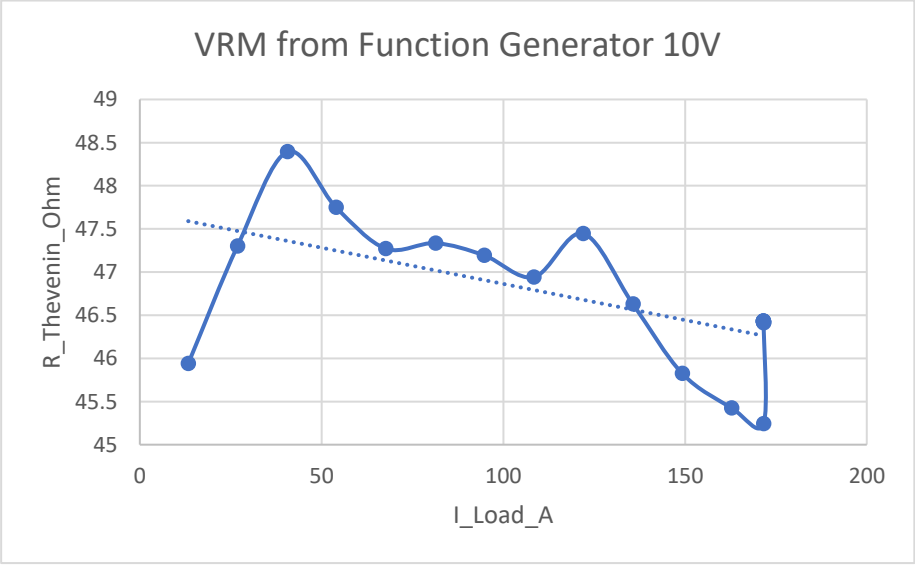


3. VRM = 10V from Function generator

The VRM voltage is connected to function generator and configured to DC voltage 10V signal and 50Ohms load resistance. The estimated R_Thevenin is around the range of 0.28Ohm to 0.22Ohm. The following is the table for the values.

Sample No.	I_load_A	V_VRM_thevenin_v	V_VRM_loaded_v	R_thevenin
1	13.307	9.5709	8.9596	45.9385
2	26.854	9.6073	8.3371	47.2999
3	40.6	9.5997	7.635	48.3935
4	54.024	9.6034	7.0239	47.7475
5	67.674	9.5936	6.3946	47.2716
6	81.328	9.5843	5.7346	47.3353
7	94.758	9.5859	5.1139	47.1938
8	108.417	9.5882	4.4989	46.9421
9	121.946	9.592	3.806	47.4469
10	135.657	9.6031	3.2775	46.6296
11	149.214	9.5858	2.7482	45.8248
12	162.852	9.5942	2.1967	45.4245
13	171.592	9.5957	1.8326	45.2415
14	171.586	9.7966	1.8333	46.41
15	171.57	9.7967	1.8325	46.4193
16	171.562	9.7965	1.8317	46.4253
17	171.553	9.7964	1.8321	46.4245
18	171.539	9.7963	1.8321	46.4275
19	171.522	9.7962	1.8324	46.4303
20	171.519	9.7963	1.8322	46.4324

The sample plot is given by,



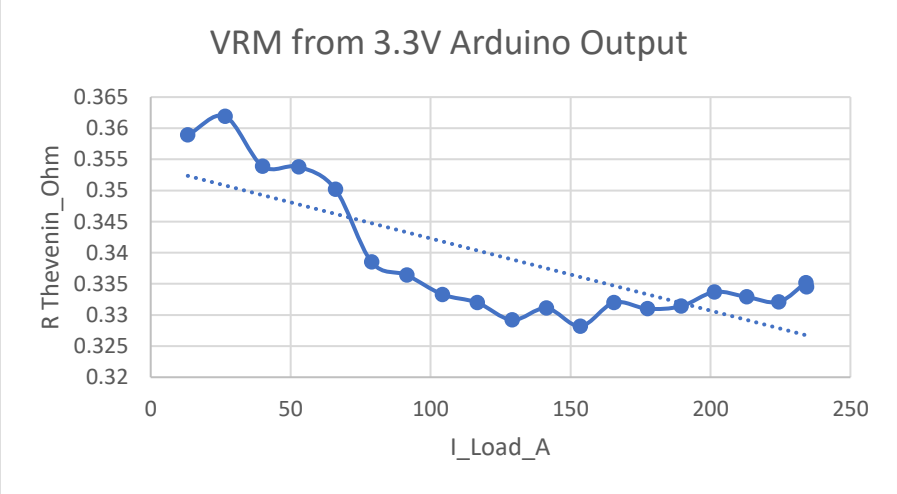
This is a known expected value of the resistance. A 50Ohms is the output given in the function generator. The R_Thevenin is around 46 ohms. Hence, the SBB for instrument droid can be validated.

4. VRM = 3.3V from Arduino

The VRM voltage is connected to 3.3V of the Arduino board. The estimated R_Thevenin is around the range of 0.35Ohm to 0.33Ohm. The following is the table for the values.

Sample No.	I_load_A	V_VRM_thevenin_v	V_VRM_loaded_v	R_thevenin
1	13.246	3.1411	3.1363	0.3589
2	26.571	3.1415	3.1318	0.3619
3	39.956	3.1416	3.1274	0.3539
4	52.928	3.1416	3.1229	0.3538
5	65.982	3.1418	3.1187	0.3502
6	78.921	3.142	3.1153	0.3385
7	91.504	3.1422	3.1114	0.3364
8	104.203	3.1422	3.1075	0.3333
9	116.643	3.1422	3.1034	0.332
10	129.125	3.1421	3.0996	0.3292
11	141.406	3.1424	3.0956	0.3311
12	153.519	3.1423	3.0919	0.3282
13	165.518	3.1425	3.0875	0.332
14	177.474	3.1426	3.0839	0.331
15	189.487	3.1428	3.08	0.3314
16	201.415	3.1431	3.0759	0.3337
17	212.908	3.1432	3.0723	0.3329
18	224.42	3.1429	3.0684	0.3321
19	234.081	3.1431	3.0647	0.3352
20	234.315	3.1433	3.0649	0.3345

The sample plot is given by,

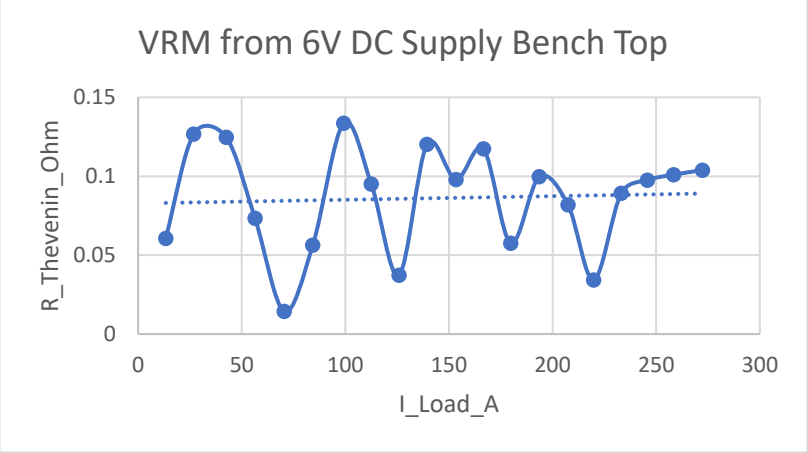


5. **VRM = 6V from bench top power supply**

The VRM voltage is set to 6V from a bench top power supply with constant Voltage configuration. The estimated R_Thevenin is around the range of 0.01Ohm to 0.13Ohm. The following is the table for the values.

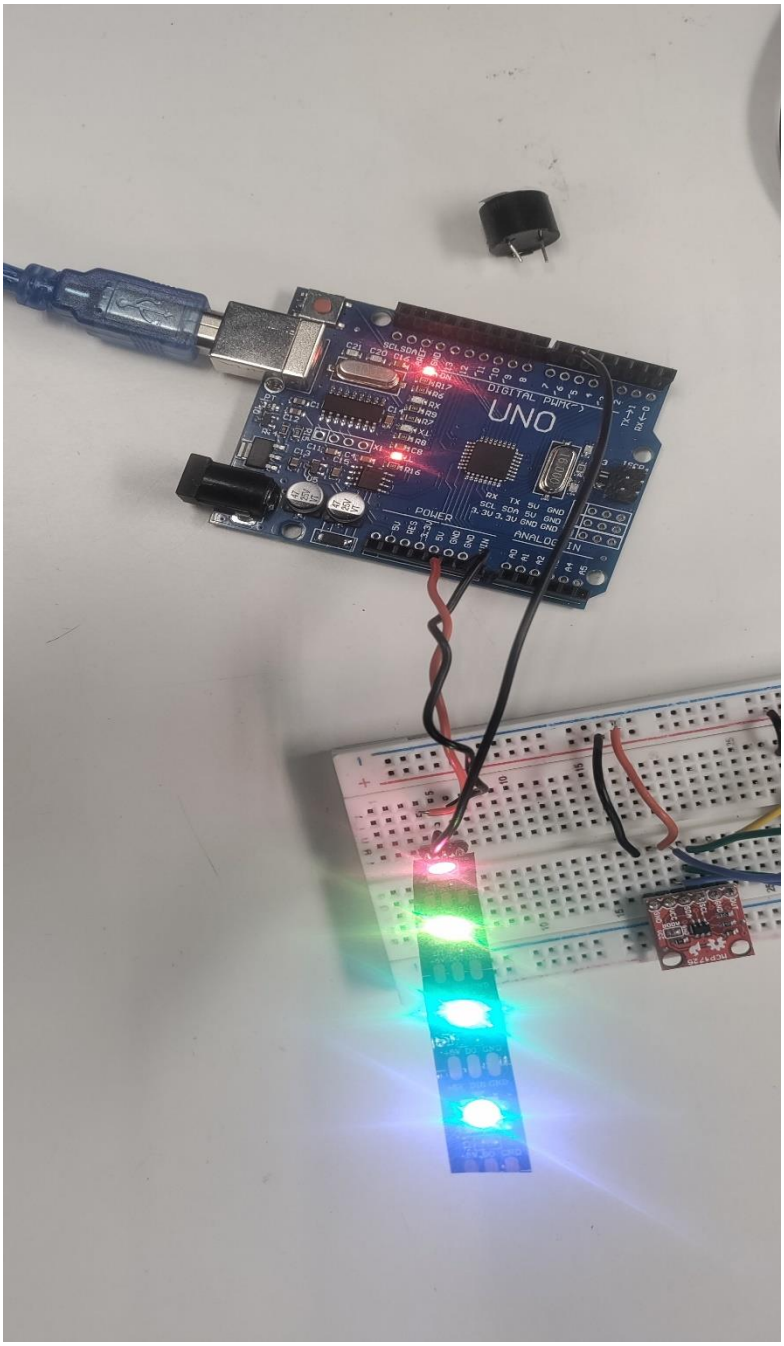
Sample No.	I_load_A	V_VRM_thevenin_v	V_VRM_loaded_v	R_thevenin
1	13.337	5.9532	5.9524	0.0607
2	26.871	5.9535	5.9501	0.1268
3	42.577	5.9534	5.9481	0.1246
4	56.44	5.9532	5.949	0.0733
5	70.536	5.9533	5.9523	0.0144
6	84.325	5.9531	5.9484	0.0564
7	99.198	5.953	5.9398	0.1337
8	112.569	5.953	5.9423	0.095
9	125.874	5.9531	5.9484	0.0373
10	139.432	5.9532	5.9364	0.1203
11	153.397	5.9528	5.9378	0.0979
12	166.656	5.953	5.9334	0.1173
13	179.827	5.9532	5.9429	0.0576
14	193.604	5.9532	5.9338	0.0997
15	207.431	5.953	5.936	0.082
16	219.862	5.9529	5.9454	0.0343
17	233.078	5.9529	5.9322	0.0891
18	245.782	5.9529	5.9289	0.0976
19	258.364	5.9528	5.9267	0.101
20	272.258	5.953	5.9247	0.1039

The sample plot is given by,



Smart LED and Buzzer:

As per the lab manual, the smart LED is switched as per the Arduino example code on Adafruit Neopixel library. The Digital input/ output D6 pin. The following is the picture of LED setup working as per the lab manual.



The buzzer is also checked on the digital input/ output D12 pin from the Arduino and the sound is observed.

Conclusion:

The Thevenin's resistance is obtained for various VRM inputs. The Thevenin resistance is not the same for different VRM inputs. The VRM from function generator works as expected with around 50 ohms of resistance. The bench top power supply has the least Thevenin's resistance of all the VRM inputs. The 5V given from the wall adapter has the highest Thevenin voltage when compared with the different VRM voltages given in the system, which is expected. A fluctuation is observed in the Thevenin's resistance of the 6V power supply, but it is comparatively very less change. A more constant Thevenin's resistance can be observed in 9V wall adapter.

Hence, by this experiment, we can analyze the Thevenin's resistance over a range of current values and where it exactly stabilizes for a circuit. This helps in understanding the design of future circuits and changes to be made according to the input voltages to the circuit.