Studiu Consum Energetic

Cuprins

1. Introducere

Eficiența energetică este un factor important de proiectare pentru platformele robotice, reducerea consumului de energie al componentelor este o bună metoda de a crește autonomia. Pentru a putea reduce consumul total de energie, este necesară studierea fiecărei componente în parte.

Acest studiu descoperă informații utile despre puterea consumată de componente in diverse scenarii de utilizare si modul in care aceste scenarii influențează consumul de energie total al robotului.

2. Componentele studiate

În acest studiu au fost testate trei componente ale platformei robotice: Raspberry PI 4, Nvidia Jetson Nano și Servomotorul DYNAMIXEL AX-18A având specificațiile descrise in tabelele de mai jos.

Componenta	Descriere
CPU	Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
RAM	4GB LPDDR4-3200 SDRAM
GPU	Broadcom VideoCore VI 500 MHz
Alimentare	5V @ 3A DC

Tabel 1 - Raspberry PI 4 Specificații

Componenta	Descriere
CPU	Quad-core ARM® A57
RAM	4 GB 64-bit LPDDR4; 25.6 gigabytes/second
GPU	128-core NVIDIA Maxwell™ architecture-based GPU
Alimentare	5V @ 2.5A DC

Tabel 2 - Nvidia Jetson Nano Specificații

Componenta	Descriere
Greutate	56 g
Raport de angrenare	254:1
Tensiune alimentare	9V - 12V
Cuplu maxim [Nm]	1.2 @ 12V 2.2A
Viteza mers in gol [rpm]	97 @ 12V
Rezoluție	0.29°

Tabel 3 DYNAMIXEL AX-18A Specificații

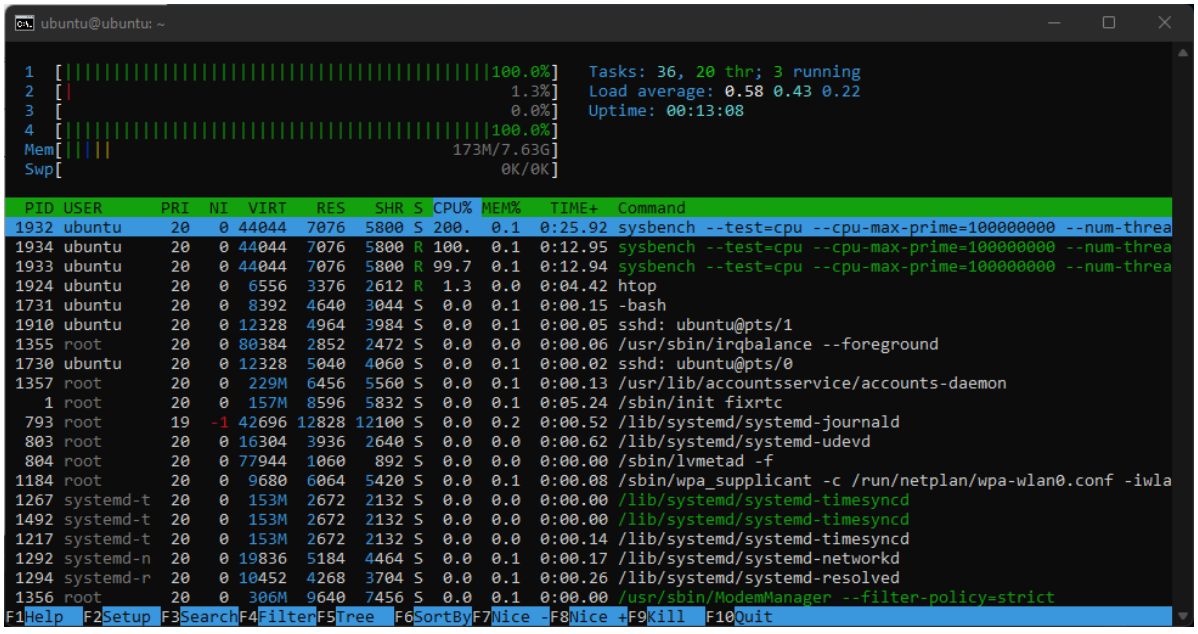
3. Scenariile studiate

Pentru a putea aproxima consumul de energie total al platformei robotice, am măsurat puterea consumată individual de fiecare componentă in diferite scenarii de funcționare.

Nr.	Operația	Descriere
S1	Standby	Componenta este alimentată
S2	Boot	Pornirea dispozitivului pana pana cand apare ecranul principal
S3	Idle	Componenta este pornită dar nu rulează niciun program
S4	Cpu Stress Test 1 core	Utilizare 1 nucleu cpu la 100% din capacitate
S5	Cpu Stress Test 2 cores	Utilizare 2 nuclee cpu la 100% din capacitate
S6	Cpu Stress Test 4 cores	Utilizare 4 nuclee cpu la 100% din capacitate
S7	Motor Standby	Motorul este alimentat cu tensiune
S8	10% Viteza Motor	Mers in gol la 10% din viteza maximă
S9	25% Viteza Motor	Mers in gol la 25% din viteza maximă
S10	50% Viteza Motor	Mers in gol la 50% din viteza maximă
S11	75% Viteza Motor	Mers in gol la 75% din viteza maximă
S12	100% Viteza Motor	Mers in gol la viteza maximă

Tabel 4 Scenarii de funcționare

Scenariile S1-S6 sunt cele în care au fost testate componentele Raspberry PI4 și Nvidia Jetson Nano. Pentru scenariile S4-S6 a fost folosit programul ***sysbench.*** Sysbench este un program ce testează și masoară performanța hardware și software. Acest program este util pentru că poate solicita firele de executie ale procesorului individual sau simultan. Timpul de testare pentru aceste scenarii a fost de 120 de secunde.



Figură 1 Raspberry PI 4 ruland sysbench in scenariul S6

Ultimele scenarii, S7-S12, au fost dedicate testării motorului DYNAMIXEL AX-18A. Tensiunea de alimentare folosită pentru acest motor a fost 11.5V. In timpul testului platforma a stat pe standul de testare, singura sarcina a motorului a fost roata cuplată.

4. Metoda de măsurare

Standul experimental a fost compus dintr-o sursa de curent continuu Twintex TP-30102, multimetrul digital UNI-T UT8802E conectat la PC și componenta hardwear ce urma să fie testată.

Figură 2 Sursa Twintex TP-30102

Figură 3 Multimetru digital UT8802E

La începutul experimentului, multimetrul a fost configurat pentru a înregistra valoarea intensității curentului electric și a fost legat in serie, între sursă de curent continuu și alimentarea componentei

studiată. În timp ce scenariile de utilizare erau aplicate, valorile afișate de multimetru au fost înregistrate la fiecare interval de o secundă.

Pentru a calcula puterea consumată a fost folosită formula $P = U * I_m$, unde U reprezintă tensiunea de alimentare a componentei studiate, iar I_m este media valorilor înregistrate de multimetru.

5. Rezultate

Rezultatele din Tabelul 5 arată că fiecare scenariu de utilizare consumă mai multă energie decât atunci când dispozitivul se află în modul inactiv. Acest lucru implică faptul că utilizarea software-ului și a dispozitivelor conectate hardware au un impact asupra consumului global de energie al platformei robotice.

Nr.	**Puterea medie consumata [W]**		
	Raspberry PI 4	Nvidia Jetson Nano	DYNAMIXEL AX-12
S1	1.85	0.77	-
S2	3.39	3.77	-
S3	2.78	1.63	-
S4	3.8	3.1	-
S5	4.18	3.62	-
S6	5	4.4	-
S7	-	-	0.28
S8	-	-	1.58
S9	-	-	3.08
S10	-	-	4.19
S11	-	-	3.27
S12	-	-	1.43

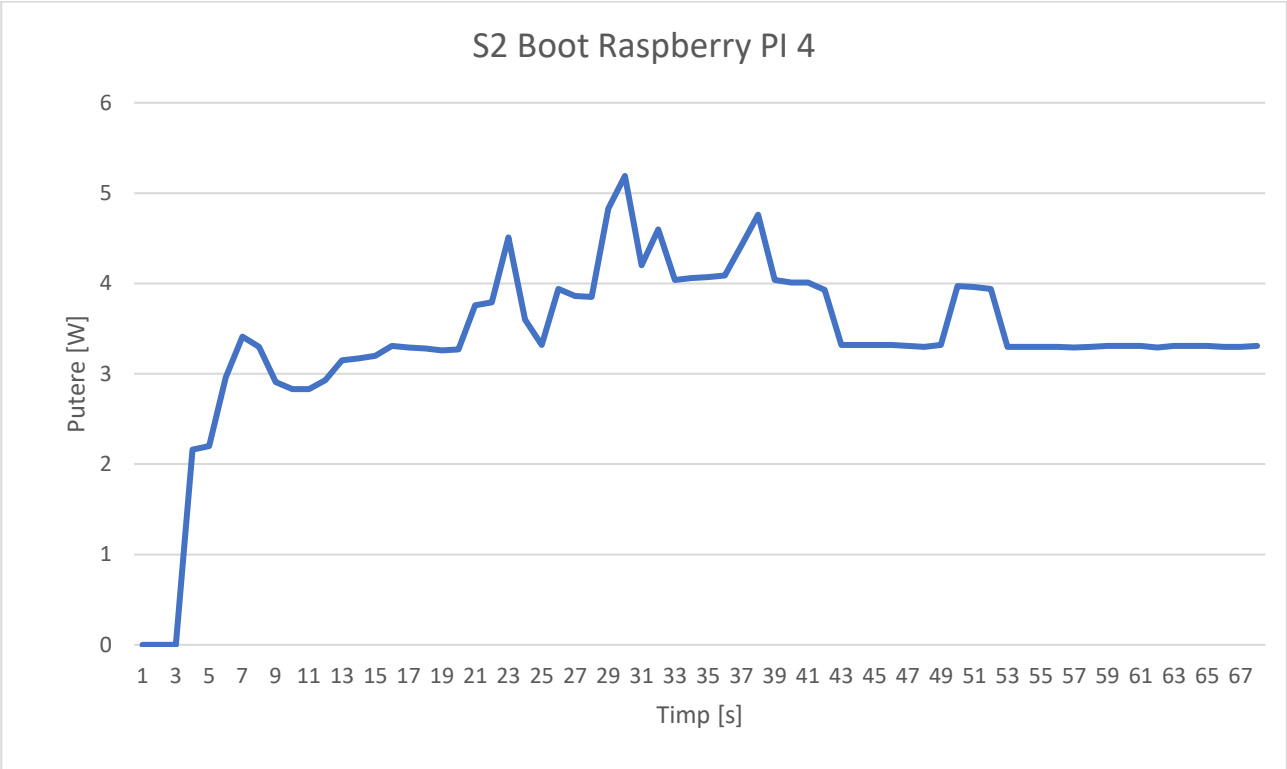
Tabel 5 Rezultate test consum

Exemplu valori obtinute de multimetru:

No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]
1	0	0	18	0.656	3.28	35	0.814	4.07	52	0.788	3.94
2	0	0	19	0.652	3.26	36	0.818	4.09	53	0.66	3.3
3	0	0	20	0.654	3.27	37	0.884	4.42	54	0.66	3.3
4	0.432	2.16	21	0.752	3.76	38	0.952	4.76	55	0.66	3.3
5	0.44	2.2	22	0.758	3.79	39	0.808	4.04	56	0.66	3.3
6	0.592	2.96	23	0.902	4.51	40	0.802	4.01	57	0.658	3.29

7	0.682	3.41	24	0.72	3.6	41	0.802	4.01	58	0.66	3.3
8	0.66	3.3	25	0.664	3.32	42	0.786	3.93	59	0.662	3.31
9	0.582	2.91	26	0.788	3.94	43	0.664	3.32	60	0.662	3.31
10	0.566	2.83	27	0.772	3.86	44	0.664	3.32	61	0.662	3.31
11	0.566	2.83	28	0.77	3.85	45	0.664	3.32	62	0.658	3.29
12	0.586	2.93	29	0.966	4.83	46	0.664	3.32	63	0.662	3.31
13	0.63	3.15	30	1.038	5.19	47	0.662	3.31	64	0.662	3.31
14	0.634	3.17	31	0.84	4.2	48	0.66	3.3	65	0.662	3.31
15	0.64	3.2	32	0.92	4.6	49	0.664	3.32	66	0.66	3.3
16	0.662	3.31	33	0.808	4.04	50	0.794	3.97	67	0.66	3.3
17	0.658	3.29	34	0.812	4.06	51	0.792	3.96	68	0.662	3.31

Tabel 6 Valori masurate S2 Boot Raspverry PI 4

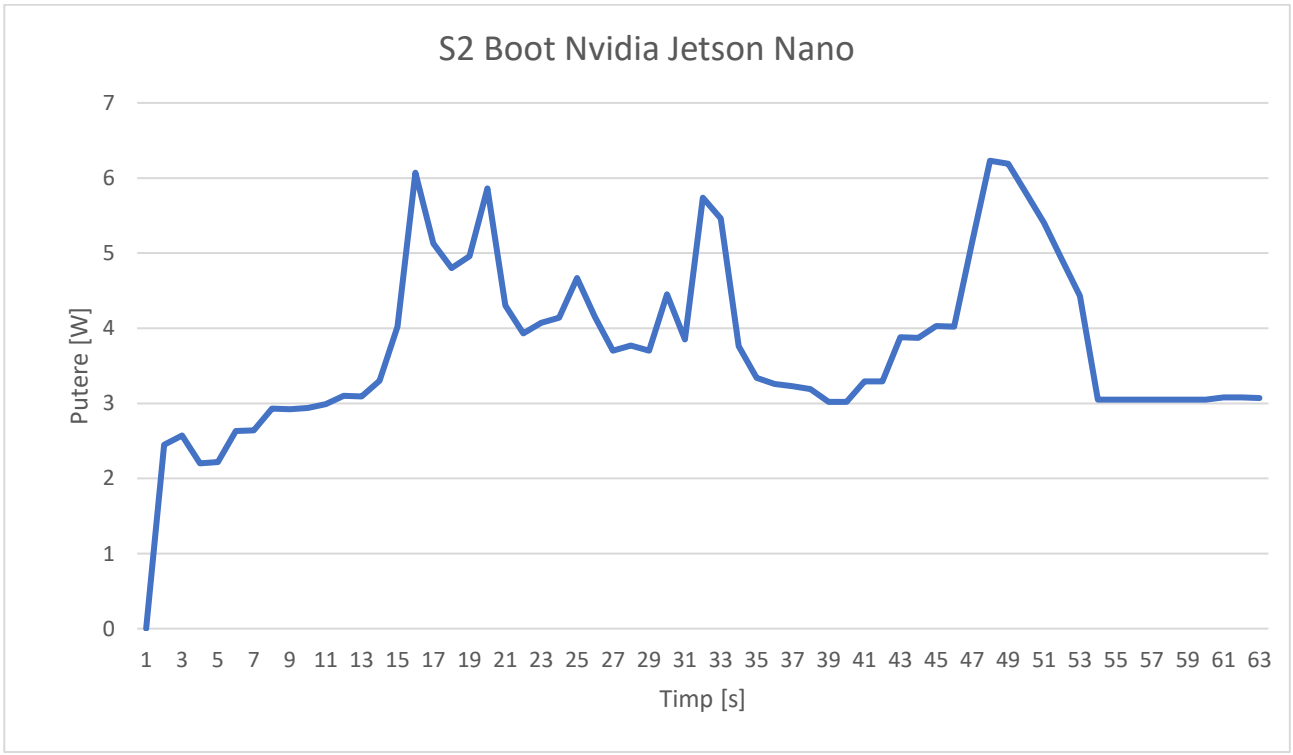


Grafic 1 Evolutie consum S2 Boot Raspberry PI 4

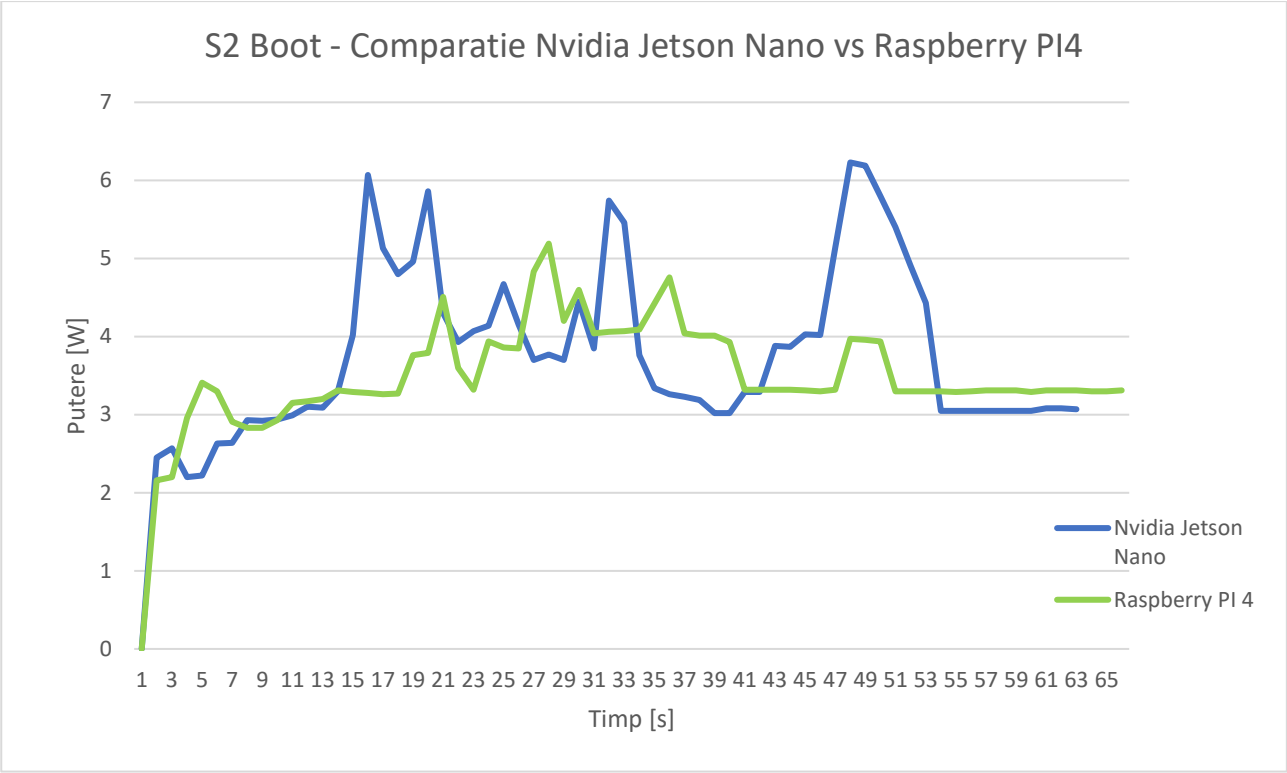
No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]
1	0	0	18	0.96	4.8	35	0.668	3.34	52	0.982	0.982
2	0.49	2.45	19	0.992	4.96	36	0.652	3.26	53	0.886	0.886
3	0.514	2.57	20	1.172	5.86	37	0.646	3.23	54	0.61	0.61

4	0.44	2.2	21	0.86	4.3	38	0.638	3.19	55	0.61	0.61
5	0.444	2.22	22	0.786	3.93	39	0.604	3.02	56	0.61	0.61
6	0.526	2.63	23	0.814	4.07	40	0.604	3.02	57	0.61	0.61
7	0.528	2.64	24	0.828	4.14	41	0.658	3.29	58	0.61	0.61
8	0.586	2.93	25	0.934	4.67	42	0.658	3.29	59	0.61	0.61
9	0.584	2.92	26	0.83	4.15	43	0.776	3.88	60	0.61	0.61
10	0.588	2.94	27	0.74	3.7	44	0.774	3.87	61	0.616	0.616
11	0.598	2.99	28	0.754	3.77	45	0.806	4.03	62	0.616	0.616
12	0.62	3.1	29	0.74	3.7	46	0.804	4.02	63	0.614	0.614
13	0.618	3.09	30	0.89	4.45	47	1.028	5.14			
14	0.66	3.3	31	0.77	3.85	48	1.246	6.23			
15	0.804	4.02	32	1.148	5.74	49	1.238	6.19			
16	1.214	6.07	33	1.092	5.46	50	1.16	5.8			
17	1.026	5.13	34	0.752	3.76	51	1.08	5.4			

Grafic 2 Valori masurate S2 Boot Nvidia Jetson Nano



Grafic 3 - Evoluție consum S2 Boot Nvidia Jetson Nano

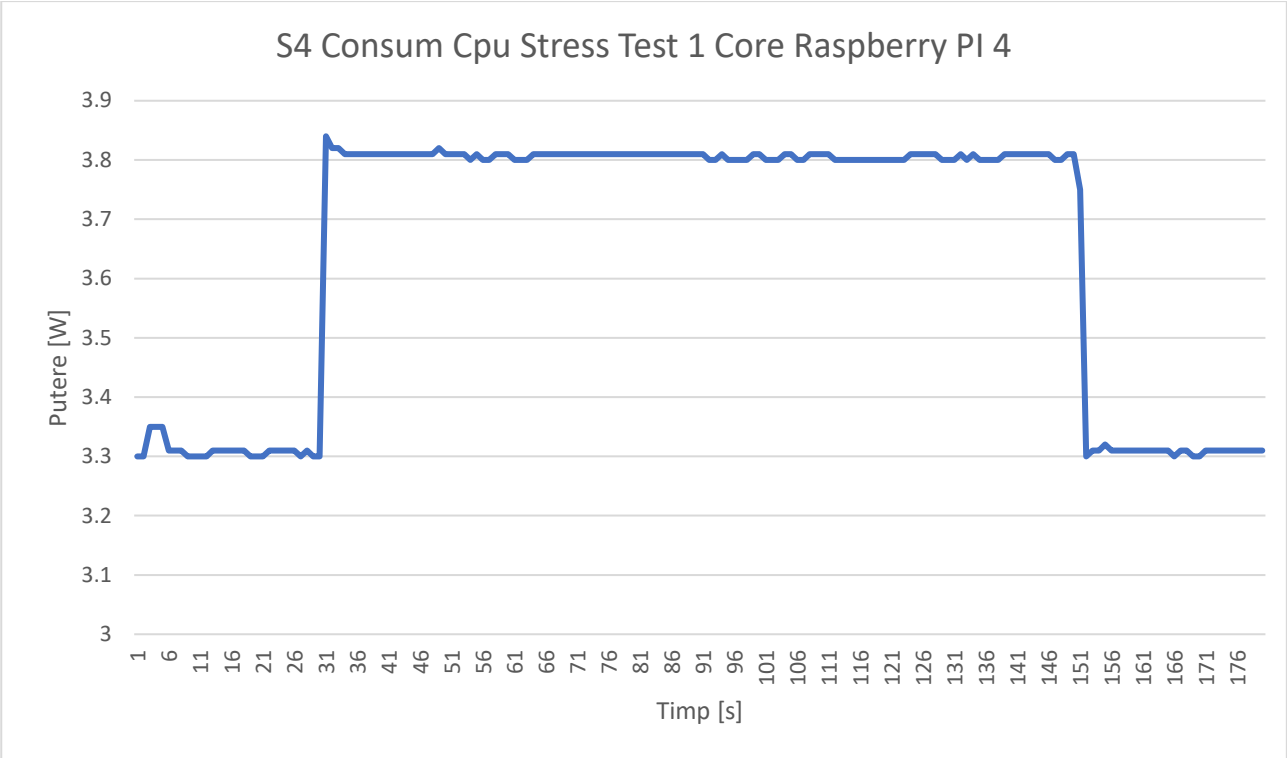


Grafic 4 Comparatie consum

No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]
1	0.66	3.3	46	0.762	3.81	91	0.762	3.81	136	0.76	3.8
2	0.66	3.3	47	0.762	3.81	92	0.76	3.8	137	0.76	3.8
3	0.67	3.35	48	0.762	3.81	93	0.76	3.8	138	0.76	3.8
4	0.67	3.35	49	0.764	3.82	94	0.762	3.81	139	0.762	3.81
5	0.67	3.35	50	0.762	3.81	95	0.76	3.8	140	0.762	3.81
6	0.662	3.31	51	0.762	3.81	96	0.76	3.8	141	0.762	3.81
7	0.662	3.31	52	0.762	3.81	97	0.76	3.8	142	0.762	3.81
8	0.662	3.31	53	0.762	3.81	98	0.76	3.8	143	0.762	3.81
9	0.66	3.3	54	0.76	3.8	99	0.762	3.81	144	0.762	3.81
10	0.66	3.3	55	0.762	3.81	100	0.762	3.81	145	0.762	3.81
11	0.66	3.3	56	0.76	3.8	101	0.76	3.8	146	0.762	3.81
12	0.66	3.3	57	0.76	3.8	102	0.76	3.8	147	0.76	3.8
13	0.662	3.31	58	0.762	3.81	103	0.76	3.8	148	0.76	3.8
14	0.662	3.31	59	0.762	3.81	104	0.762	3.81	149	0.762	3.81
15	0.662	3.31	60	0.762	3.81	105	0.762	3.81	150	0.762	3.81
16	0.662	3.31	61	0.76	3.8	106	0.76	3.8	151	0.75	3.75

17	0.662	3.31	62	0.76	3.8	107	0.76	3.8	152	0.66	3.3
18	0.662	3.31	63	0.76	3.8	108	0.762	3.81	153	0.662	3.31
19	0.66	3.3	64	0.762	3.81	109	0.762	3.81	154	0.662	3.31
20	0.66	3.3	65	0.762	3.81	110	0.762	3.81	155	0.664	3.32
21	0.66	3.3	66	0.762	3.81	111	0.762	3.81	156	0.662	3.31
22	0.662	3.31	67	0.762	3.81	112	0.76	3.8	157	0.662	3.31
23	0.662	3.31	68	0.762	3.81	113	0.76	3.8	158	0.662	3.31
24	0.662	3.31	69	0.762	3.81	114	0.76	3.8	159	0.662	3.31
25	0.662	3.31	70	0.762	3.81	115	0.76	3.8	160	0.662	3.31
26	0.662	3.31	71	0.762	3.81	116	0.76	3.8	161	0.662	3.31
27	0.66	3.3	72	0.762	3.81	117	0.76	3.8	162	0.662	3.31
28	0.662	3.31	73	0.762	3.81	118	0.76	3.8	163	0.662	3.31
29	0.66	3.3	74	0.762	3.81	119	0.76	3.8	164	0.662	3.31
30	0.66	3.3	75	0.762	3.81	120	0.76	3.8	165	0.662	3.31
31	0.768	3.84	76	0.762	3.81	121	0.76	3.8	166	0.66	3.3
32	0.764	3.82	77	0.762	3.81	122	0.76	3.8	167	0.662	3.31
33	0.764	3.82	78	0.762	3.81	123	0.76	3.8	168	0.662	3.31
34	0.762	3.81	79	0.762	3.81	124	0.762	3.81	169	0.66	3.3
35	0.762	3.81	80	0.762	3.81	125	0.762	3.81	170	0.66	3.3
36	0.762	3.81	81	0.762	3.81	126	0.762	3.81	171	0.662	3.31
37	0.762	3.81	82	0.762	3.81	127	0.762	3.81	172	0.662	3.31
38	0.762	3.81	83	0.762	3.81	128	0.762	3.81	173	0.662	3.31
39	0.762	3.81	84	0.762	3.81	129	0.76	3.8	174	0.662	3.31
40	0.762	3.81	85	0.762	3.81	130	0.76	3.8	175	0.662	3.31
41	0.762	3.81	86	0.762	3.81	131	0.76	3.8	176	0.662	3.31
42	0.762	3.81	87	0.762	3.81	132	0.762	3.81	177	0.662	3.31
43	0.762	3.81	88	0.762	3.81	133	0.76	3.8	178	0.662	3.31
44	0.762	3.81	89	0.762	3.81	134	0.762	3.81	179	0.662	3.31
45	0.762	3.81	90	0.762	3.81	135	0.76	3.8	180	0.662	3.31

Tabel 7 - Valori masurate S4 Cpu Stress Test 1 Core Raspverry PI 4

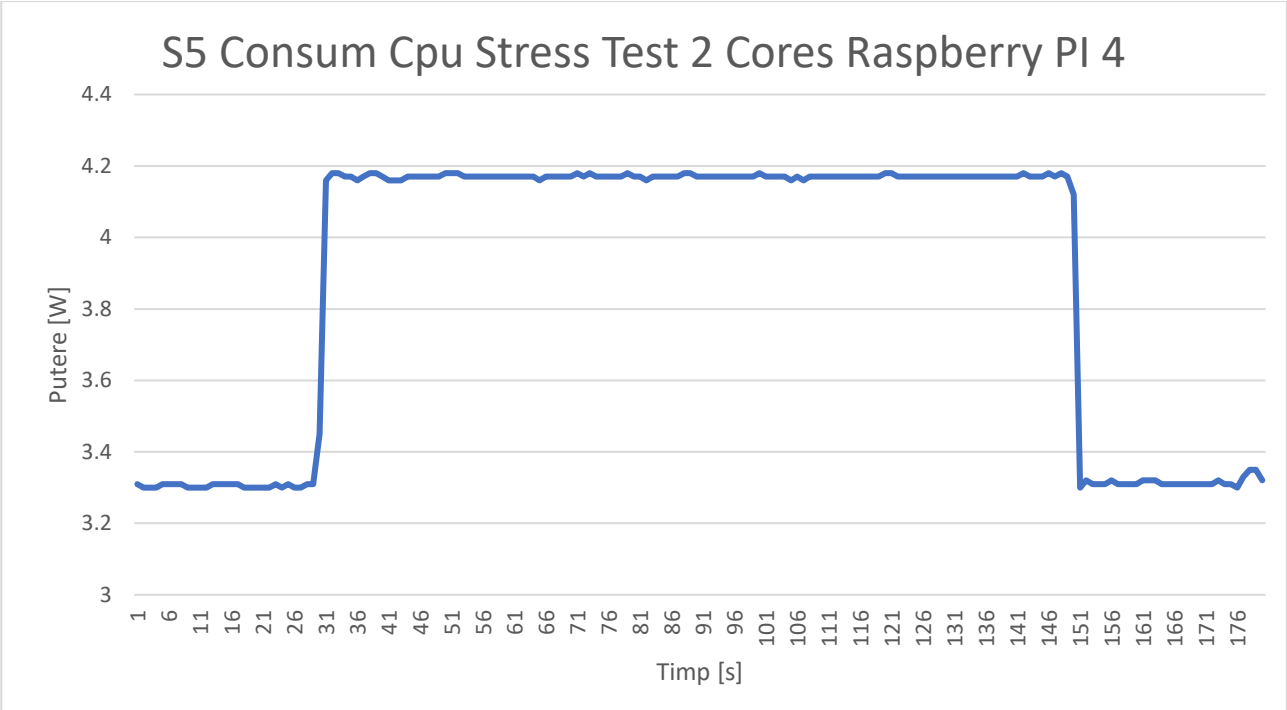


Grafic 5 Evolutie consum S4 Cpu Stress Test 1 core Raspberry PI 4

No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]
1	0.662	3.31	46	0.834	4.17	91	0.834	4.17	136	0.834	4.17
2	0.66	3.3	47	0.834	4.17	92	0.834	4.17	137	0.834	4.17
3	0.66	3.3	48	0.834	4.17	93	0.834	4.17	138	0.834	4.17
4	0.66	3.3	49	0.834	4.17	94	0.834	4.17	139	0.834	4.17
5	0.662	3.31	50	0.836	4.18	95	0.834	4.17	140	0.834	4.17
6	0.662	3.31	51	0.836	4.18	96	0.834	4.17	141	0.834	4.17
7	0.662	3.31	52	0.836	4.18	97	0.834	4.17	142	0.836	4.18
8	0.662	3.31	53	0.834	4.17	98	0.834	4.17	143	0.834	4.17
9	0.66	3.3	54	0.834	4.17	99	0.834	4.17	144	0.834	4.17
10	0.66	3.3	55	0.834	4.17	100	0.836	4.18	145	0.834	4.17
11	0.66	3.3	56	0.834	4.17	101	0.834	4.17	146	0.836	4.18
12	0.66	3.3	57	0.834	4.17	102	0.834	4.17	147	0.834	4.17
13	0.662	3.31	58	0.834	4.17	103	0.834	4.17	148	0.836	4.18
14	0.662	3.31	59	0.834	4.17	104	0.834	4.17	149	0.834	4.17
15	0.662	3.31	60	0.834	4.17	105	0.832	4.16	150	0.824	4.12
16	0.662	3.31	61	0.834	4.17	106	0.834	4.17	151	0.66	3.3

17	0.662	3.31	62	0.834	4.17	107	0.832	4.16	152	0.664	3.32
18	0.66	3.3	63	0.834	4.17	108	0.834	4.17	153	0.662	3.31
19	0.66	3.3	64	0.834	4.17	109	0.834	4.17	154	0.662	3.31
20	0.66	3.3	65	0.832	4.16	110	0.834	4.17	155	0.662	3.31
21	0.66	3.3	66	0.834	4.17	111	0.834	4.17	156	0.664	3.32
22	0.66	3.3	67	0.834	4.17	112	0.834	4.17	157	0.662	3.31
23	0.662	3.31	68	0.834	4.17	113	0.834	4.17	158	0.662	3.31
24	0.66	3.3	69	0.834	4.17	114	0.834	4.17	159	0.662	3.31
25	0.662	3.31	70	0.834	4.17	115	0.834	4.17	160	0.662	3.31
26	0.66	3.3	71	0.836	4.18	116	0.834	4.17	161	0.664	3.32
27	0.66	3.3	72	0.834	4.17	117	0.834	4.17	162	0.664	3.32
28	0.662	3.31	73	0.836	4.18	118	0.834	4.17	163	0.664	3.32
29	0.662	3.31	74	0.834	4.17	119	0.834	4.17	164	0.662	3.31
30	0.69	3.45	75	0.834	4.17	120	0.836	4.18	165	0.662	3.31
31	0.832	4.16	76	0.834	4.17	121	0.836	4.18	166	0.662	3.31
32	0.836	4.18	77	0.834	4.17	122	0.834	4.17	167	0.662	3.31
33	0.836	4.18	78	0.834	4.17	123	0.834	4.17	168	0.662	3.31
34	0.834	4.17	79	0.836	4.18	124	0.834	4.17	169	0.662	3.31
35	0.834	4.17	80	0.834	4.17	125	0.834	4.17	170	0.662	3.31
36	0.832	4.16	81	0.834	4.17	126	0.834	4.17	171	0.662	3.31
37	0.834	4.17	82	0.832	4.16	127	0.834	4.17	172	0.662	3.31
38	0.836	4.18	83	0.834	4.17	128	0.834	4.17	173	0.664	3.32
39	0.836	4.18	84	0.834	4.17	129	0.834	4.17	174	0.662	3.31
40	0.834	4.17	85	0.834	4.17	130	0.834	4.17	175	0.662	3.31
41	0.832	4.16	86	0.834	4.17	131	0.834	4.17	176	0.66	3.3
42	0.832	4.16	87	0.834	4.17	132	0.834	4.17	177	0.666	3.33
43	0.832	4.16	88	0.836	4.18	133	0.834	4.17	178	0.67	3.35
44	0.834	4.17	89	0.836	4.18	134	0.834	4.17	179	0.67	3.35
45	0.834	4.17	90	0.834	4.17	135	0.834	4.17	180	0.664	3.32

Tabel 8 Valori masurate S5 Cpu Stress Test 2 Cores Raspverry PI 4

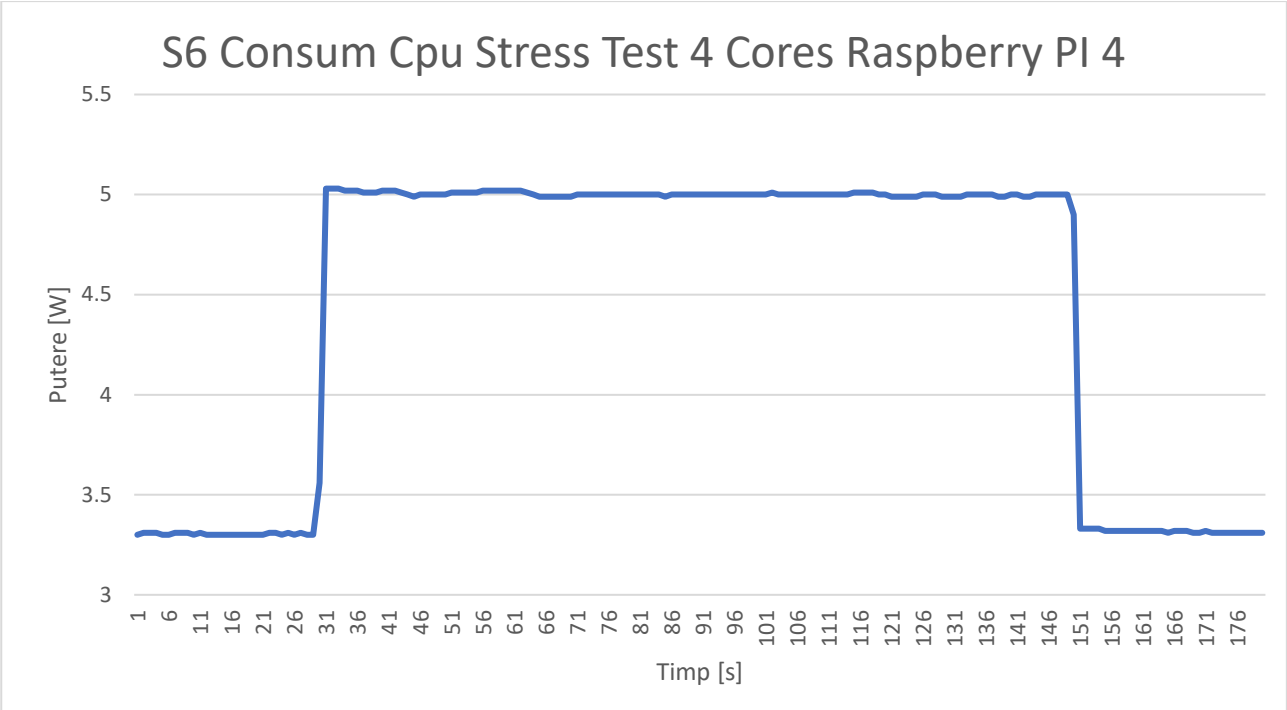


Grafic 6 Evolutie consum S5 Cpu Stress Test 2 Cores Raspberry PI 4

No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]
1	0.66	3.3	46	1	5	91	1	5	136	1	5
2	0.662	3.31	47	1	5	92	1	5	137	1	5
3	0.662	3.31	48	1	5	93	1	5	138	0.998	4.99
4	0.662	3.31	49	1	5	94	1	5	139	0.998	4.99
5	0.66	3.3	50	1	5	95	1	5	140	1	5
6	0.66	3.3	51	1.002	5.01	96	1	5	141	1	5
7	0.662	3.31	52	1.002	5.01	97	1	5	142	0.998	4.99
8	0.662	3.31	53	1.002	5.01	98	1	5	143	0.998	4.99
9	0.662	3.31	54	1.002	5.01	99	1	5	144	1	5
10	0.66	3.3	55	1.002	5.01	100	1	5	145	1	5
11	0.662	3.31	56	1.004	5.02	101	1	5	146	1	5
12	0.66	3.3	57	1.004	5.02	102	1.002	5.01	147	1	5
13	0.66	3.3	58	1.004	5.02	103	1	5	148	1	5
14	0.66	3.3	59	1.004	5.02	104	1	5	149	1	5
15	0.66	3.3	60	1.004	5.02	105	1	5	150	0.98	4.9
16	0.66	3.3	61	1.004	5.02	106	1	5	151	0.666	3.33
17	0.66	3.3	62	1.004	5.02	107	1	5	152	0.666	3.33

18	0.66	3.3	63	1.002	5.01	108	1	5	153	0.666	3.33
19	0.66	3.3	64	1	5	109	1	5	154	0.666	3.33
20	0.66	3.3	65	0.998	4.99	110	1	5	155	0.664	3.32
21	0.66	3.3	66	0.998	4.99	111	1	5	156	0.664	3.32
22	0.662	3.31	67	0.998	4.99	112	1	5	157	0.664	3.32
23	0.662	3.31	68	0.998	4.99	113	1	5	158	0.664	3.32
24	0.66	3.3	69	0.998	4.99	114	1	5	159	0.664	3.32
25	0.662	3.31	70	0.998	4.99	115	1.002	5.01	160	0.664	3.32
26	0.66	3.3	71	1	5	116	1.002	5.01	161	0.664	3.32
27	0.662	3.31	72	1	5	117	1.002	5.01	162	0.664	3.32
28	0.66	3.3	73	1	5	118	1.002	5.01	163	0.664	3.32
29	0.66	3.3	74	1	5	119	1	5	164	0.664	3.32
30	0.712	3.56	75	1	5	120	1	5	165	0.662	3.31
31	1.006	5.03	76	1	5	121	0.998	4.99	166	0.664	3.32
32	1.006	5.03	77	1	5	122	0.998	4.99	167	0.664	3.32
33	1.006	5.03	78	1	5	123	0.998	4.99	168	0.664	3.32
34	1.004	5.02	79	1	5	124	0.998	4.99	169	0.662	3.31
35	1.004	5.02	80	1	5	125	0.998	4.99	170	0.662	3.31
36	1.004	5.02	81	1	5	126	1	5	171	0.664	3.32
37	1.002	5.01	82	1	5	127	1	5	172	0.662	3.31
38	1.002	5.01	83	1	5	128	1	5	173	0.662	3.31
39	1.002	5.01	84	1	5	129	0.998	4.99	174	0.662	3.31
40	1.004	5.02	85	0.998	4.99	130	0.998	4.99	175	0.662	3.31
41	1.004	5.02	86	1	5	131	0.998	4.99	176	0.662	3.31
42	1.004	5.02	87	1	5	132	0.998	4.99	177	0.662	3.31
43	1.002	5.01	88	1	5	133	1	5	178	0.662	3.31
44	1	5	89	1	5	134	1	5	179	0.662	3.31
45	0.998	4.99	90	1	5	135	1	5	180	0.662	3.31

Tabel 9 Valori masurate S6 Cpu Stress Test 4 Cores Raspverry PI 4

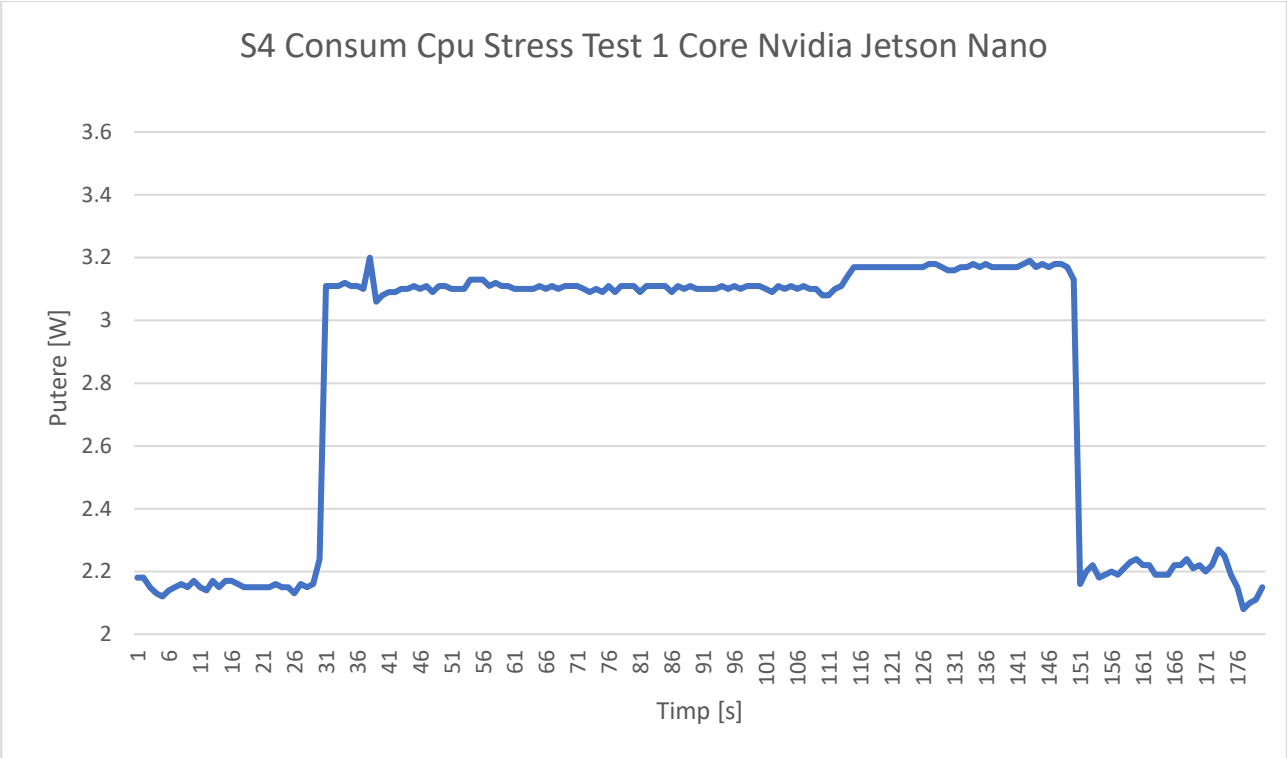


Grafic 7 Evolutie consum S6 Cpu Stress Test 4 Cores Raspberry PI 4

No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]
1	0.436	2.18	46	0.62	3.1	91	0.62	3.1	136	0.636	3.18
2	0.436	2.18	47	0.622	3.11	92	0.62	3.1	137	0.634	3.17
3	0.43	2.15	48	0.618	3.09	93	0.62	3.1	138	0.634	3.17
4	0.426	2.13	49	0.622	3.11	94	0.622	3.11	139	0.634	3.17
5	0.424	2.12	50	0.622	3.11	95	0.62	3.1	140	0.634	3.17
6	0.428	2.14	51	0.62	3.1	96	0.622	3.11	141	0.634	3.17
7	0.43	2.15	52	0.62	3.1	97	0.62	3.1	142	0.636	3.18
8	0.432	2.16	53	0.62	3.1	98	0.622	3.11	143	0.638	3.19
9	0.43	2.15	54	0.626	3.13	99	0.622	3.11	144	0.634	3.17
10	0.434	2.17	55	0.626	3.13	100	0.622	3.11	145	0.636	3.18
11	0.43	2.15	56	0.626	3.13	101	0.62	3.1	146	0.634	3.17
12	0.428	2.14	57	0.622	3.11	102	0.618	3.09	147	0.636	3.18
13	0.434	2.17	58	0.624	3.12	103	0.622	3.11	148	0.636	3.18
14	0.43	2.15	59	0.622	3.11	104	0.62	3.1	149	0.634	3.17
15	0.434	2.17	60	0.622	3.11	105	0.622	3.11	150	0.626	3.13
16	0.434	2.17	61	0.62	3.1	106	0.62	3.1	151	0.432	2.16
17	0.432	2.16	62	0.62	3.1	107	0.622	3.11	152	0.44	2.2

18	0.43	2.15	63	0.62	3.1	108	0.62	3.1	153	0.444	2.22
19	0.43	2.15	64	0.62	3.1	109	0.62	3.1	154	0.436	2.18
20	0.43	2.15	65	0.622	3.11	110	0.616	3.08	155	0.438	2.19
21	0.43	2.15	66	0.62	3.1	111	0.616	3.08	156	0.44	2.2
22	0.43	2.15	67	0.622	3.11	112	0.62	3.1	157	0.438	2.19
23	0.432	2.16	68	0.62	3.1	113	0.622	3.11	158	0.442	2.21
24	0.43	2.15	69	0.622	3.11	114	0.628	3.14	159	0.446	2.23
25	0.43	2.15	70	0.622	3.11	115	0.634	3.17	160	0.448	2.24
26	0.426	2.13	71	0.622	3.11	116	0.634	3.17	161	0.444	2.22
27	0.432	2.16	72	0.62	3.1	117	0.634	3.17	162	0.444	2.22
28	0.43	2.15	73	0.618	3.09	118	0.634	3.17	163	0.438	2.19
29	0.432	2.16	74	0.62	3.1	119	0.634	3.17	164	0.438	2.19
30	0.448	2.24	75	0.618	3.09	120	0.634	3.17	165	0.438	2.19
31	0.622	3.11	76	0.622	3.11	121	0.634	3.17	166	0.444	2.22
32	0.622	3.11	77	0.618	3.09	122	0.634	3.17	167	0.444	2.22
33	0.622	3.11	78	0.622	3.11	123	0.634	3.17	168	0.448	2.24
34	0.624	3.12	79	0.622	3.11	124	0.634	3.17	169	0.442	2.21
35	0.622	3.11	80	0.622	3.11	125	0.634	3.17	170	0.444	2.22
36	0.622	3.11	81	0.618	3.09	126	0.634	3.17	171	0.44	2.2
37	0.62	3.1	82	0.622	3.11	127	0.636	3.18	172	0.444	2.22
38	0.64	3.2	83	0.622	3.11	128	0.636	3.18	173	0.454	2.27
39	0.612	3.06	84	0.622	3.11	129	0.634	3.17	174	0.45	2.25
40	0.616	3.08	85	0.622	3.11	130	0.632	3.16	175	0.438	2.19
41	0.618	3.09	86	0.618	3.09	131	0.632	3.16	176	0.43	2.15
42	0.618	3.09	87	0.622	3.11	132	0.634	3.17	177	0.416	2.08
43	0.62	3.1	88	0.62	3.1	133	0.634	3.17	178	0.42	2.1
44	0.62	3.1	89	0.622	3.11	134	0.636	3.18	179	0.422	2.11
45	0.622	3.11	90	0.62	3.1	135	0.634	3.17	180	0.43	2.15

Tabel 10 Valori masurate S4 Cpu Stress Test 1 Core Nvidia Jetson Nano

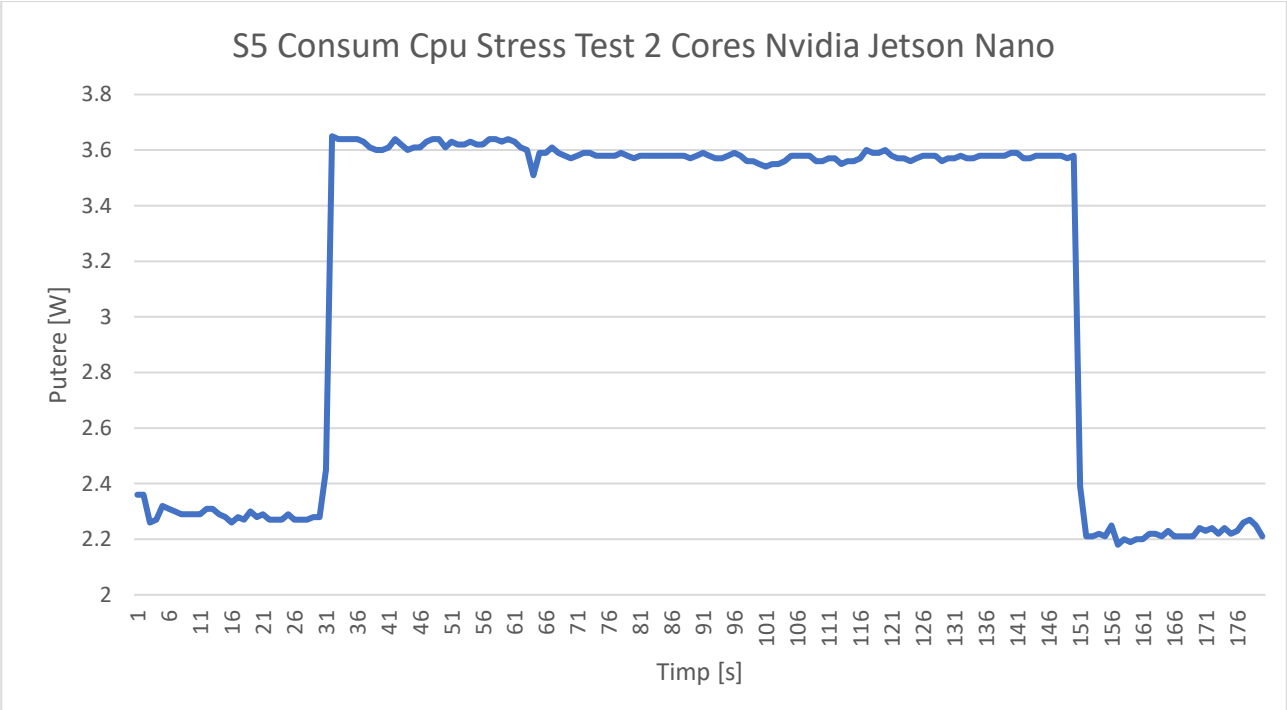


Grafic 8 Evolutie consum S4 Cpu Stress Test 1 Core Nvidia Jetson Nano

No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]
1	0.472	2.36	46	0.722	3.61	91	0.718	3.59	136	0.716	3.58
2	0.472	2.36	47	0.726	3.63	92	0.716	3.58	137	0.716	3.58
3	0.452	2.26	48	0.728	3.64	93	0.714	3.57	138	0.716	3.58
4	0.454	2.27	49	0.728	3.64	94	0.714	3.57	139	0.716	3.58
5	0.464	2.32	50	0.722	3.61	95	0.716	3.58	140	0.718	3.59
6	0.462	2.31	51	0.726	3.63	96	0.718	3.59	141	0.718	3.59
7	0.46	2.3	52	0.724	3.62	97	0.716	3.58	142	0.714	3.57
8	0.458	2.29	53	0.724	3.62	98	0.712	3.56	143	0.714	3.57
9	0.458	2.29	54	0.726	3.63	99	0.712	3.56	144	0.716	3.58
10	0.458	2.29	55	0.724	3.62	100	0.71	3.55	145	0.716	3.58
11	0.458	2.29	56	0.724	3.62	101	0.708	3.54	146	0.716	3.58
12	0.462	2.31	57	0.728	3.64	102	0.71	3.55	147	0.716	3.58
13	0.462	2.31	58	0.728	3.64	103	0.71	3.55	148	0.716	3.58
14	0.458	2.29	59	0.726	3.63	104	0.712	3.56	149	0.714	3.57
15	0.456	2.28	60	0.728	3.64	105	0.716	3.58	150	0.716	3.58
16	0.452	2.26	61	0.726	3.63	106	0.716	3.58	151	0.478	2.39

17	0.456	2.28	62	0.722	3.61	107	0.716	3.58	152	0.442	2.21
18	0.454	2.27	63	0.72	3.6	108	0.716	3.58	153	0.442	2.21
19	0.46	2.3	64	0.702	3.51	109	0.712	3.56	154	0.444	2.22
20	0.456	2.28	65	0.718	3.59	110	0.712	3.56	155	0.442	2.21
21	0.458	2.29	66	0.718	3.59	111	0.714	3.57	156	0.45	2.25
22	0.454	2.27	67	0.722	3.61	112	0.714	3.57	157	0.436	2.18
23	0.454	2.27	68	0.718	3.59	113	0.71	3.55	158	0.44	2.2
24	0.454	2.27	69	0.716	3.58	114	0.712	3.56	159	0.438	2.19
25	0.458	2.29	70	0.714	3.57	115	0.712	3.56	160	0.44	2.2
26	0.454	2.27	71	0.716	3.58	116	0.714	3.57	161	0.44	2.2
27	0.454	2.27	72	0.718	3.59	117	0.72	3.6	162	0.444	2.22
28	0.454	2.27	73	0.718	3.59	118	0.718	3.59	163	0.444	2.22
29	0.456	2.28	74	0.716	3.58	119	0.718	3.59	164	0.442	2.21
30	0.456	2.28	75	0.716	3.58	120	0.72	3.6	165	0.446	2.23
31	0.49	2.45	76	0.716	3.58	121	0.716	3.58	166	0.442	2.21
32	0.73	3.65	77	0.716	3.58	122	0.714	3.57	167	0.442	2.21
33	0.728	3.64	78	0.718	3.59	123	0.714	3.57	168	0.442	2.21
34	0.728	3.64	79	0.716	3.58	124	0.712	3.56	169	0.442	2.21
35	0.728	3.64	80	0.714	3.57	125	0.714	3.57	170	0.448	2.24
36	0.728	3.64	81	0.716	3.58	126	0.716	3.58	171	0.446	2.23
37	0.726	3.63	82	0.716	3.58	127	0.716	3.58	172	0.448	2.24
38	0.722	3.61	83	0.716	3.58	128	0.716	3.58	173	0.444	2.22
39	0.72	3.6	84	0.716	3.58	129	0.712	3.56	174	0.448	2.24
40	0.72	3.6	85	0.716	3.58	130	0.714	3.57	175	0.444	2.22
41	0.722	3.61	86	0.716	3.58	131	0.714	3.57	176	0.446	2.23
42	0.728	3.64	87	0.716	3.58	132	0.716	3.58	177	0.452	2.26
43	0.724	3.62	88	0.716	3.58	133	0.714	3.57	178	0.454	2.27
44	0.72	3.6	89	0.714	3.57	134	0.714	3.57	179	0.45	2.25
45	0.722	3.61	90	0.716	3.58	135	0.716	3.58	180	0.442	2.21

Tabel 11 Valori masurate S5 Cpu Stress Test 2 Cores Nvidia Jetson Nano

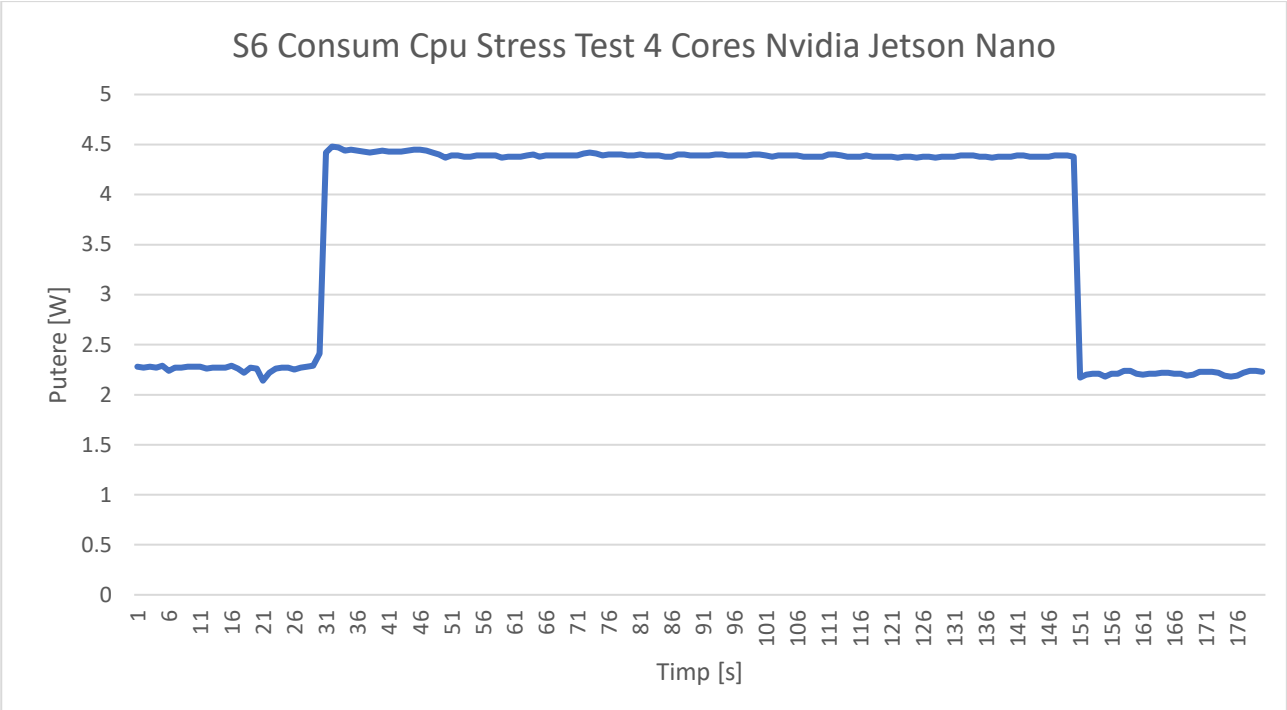


Grafic 9 Evolutie consum S6 Cpu Stress Test 2 Cores Nvidia Jetson Nano

No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]
1	0.456	2.28	46	0.89	4.45	91	0.878	4.39	136	0.876	4.38
2	0.454	2.27	47	0.888	4.44	92	0.878	4.39	137	0.874	4.37
3	0.456	2.28	48	0.884	4.42	93	0.88	4.4	138	0.876	4.38
4	0.454	2.27	49	0.88	4.4	94	0.88	4.4	139	0.876	4.38
5	0.458	2.29	50	0.874	4.37	95	0.878	4.39	140	0.876	4.38
6	0.448	2.24	51	0.878	4.39	96	0.878	4.39	141	0.878	4.39
7	0.454	2.27	52	0.878	4.39	97	0.878	4.39	142	0.878	4.39
8	0.454	2.27	53	0.876	4.38	98	0.878	4.39	143	0.876	4.38
9	0.456	2.28	54	0.876	4.38	99	0.88	4.4	144	0.876	4.38
10	0.456	2.28	55	0.878	4.39	100	0.88	4.4	145	0.876	4.38
11	0.456	2.28	56	0.878	4.39	101	0.878	4.39	146	0.876	4.38
12	0.452	2.26	57	0.878	4.39	102	0.876	4.38	147	0.878	4.39
13	0.454	2.27	58	0.878	4.39	103	0.878	4.39	148	0.878	4.39
14	0.454	2.27	59	0.874	4.37	104	0.878	4.39	149	0.878	4.39
15	0.454	2.27	60	0.876	4.38	105	0.878	4.39	150	0.876	4.38
16	0.458	2.29	61	0.876	4.38	106	0.878	4.39	151	0.434	2.17
17	0.452	2.26	62	0.876	4.38	107	0.876	4.38	152	0.44	2.2

18	0.444	2.22	63	0.878	4.39	108	0.876	4.38	153	0.442	2.21
19	0.454	2.27	64	0.88	4.4	109	0.876	4.38	154	0.442	2.21
20	0.452	2.26	65	0.876	4.38	110	0.876	4.38	155	0.436	2.18
21	0.428	2.14	66	0.878	4.39	111	0.88	4.4	156	0.442	2.21
22	0.444	2.22	67	0.878	4.39	112	0.88	4.4	157	0.442	2.21
23	0.452	2.26	68	0.878	4.39	113	0.878	4.39	158	0.448	2.24
24	0.454	2.27	69	0.878	4.39	114	0.876	4.38	159	0.448	2.24
25	0.454	2.27	70	0.878	4.39	115	0.876	4.38	160	0.442	2.21
26	0.45	2.25	71	0.878	4.39	116	0.876	4.38	161	0.44	2.2
27	0.454	2.27	72	0.882	4.41	117	0.878	4.39	162	0.442	2.21
28	0.456	2.28	73	0.884	4.42	118	0.876	4.38	163	0.442	2.21
29	0.458	2.29	74	0.882	4.41	119	0.876	4.38	164	0.444	2.22
30	0.482	2.41	75	0.878	4.39	120	0.876	4.38	165	0.444	2.22
31	0.884	4.42	76	0.88	4.4	121	0.876	4.38	166	0.442	2.21
32	0.896	4.48	77	0.88	4.4	122	0.874	4.37	167	0.442	2.21
33	0.894	4.47	78	0.88	4.4	123	0.876	4.38	168	0.438	2.19
34	0.888	4.44	79	0.878	4.39	124	0.876	4.38	169	0.44	2.2
35	0.89	4.45	80	0.878	4.39	125	0.874	4.37	170	0.446	2.23
36	0.888	4.44	81	0.88	4.4	126	0.876	4.38	171	0.446	2.23
37	0.886	4.43	82	0.878	4.39	127	0.876	4.38	172	0.446	2.23
38	0.884	4.42	83	0.878	4.39	128	0.874	4.37	173	0.444	2.22
39	0.886	4.43	84	0.878	4.39	129	0.876	4.38	174	0.438	2.19
40	0.888	4.44	85	0.876	4.38	130	0.876	4.38	175	0.436	2.18
41	0.886	4.43	86	0.876	4.38	131	0.876	4.38	176	0.438	2.19
42	0.886	4.43	87	0.88	4.4	132	0.878	4.39	177	0.444	2.22
43	0.886	4.43	88	0.88	4.4	133	0.878	4.39	178	0.448	2.24
44	0.888	4.44	89	0.878	4.39	134	0.878	4.39	179	0.448	2.24
45	0.89	4.45	90	0.878	4.39	135	0.876	4.38	180	0.446	2.23

Tabel 12 Valori masurate S6 Cpu Stress Test 4 Core Nvidia Jetson Nano

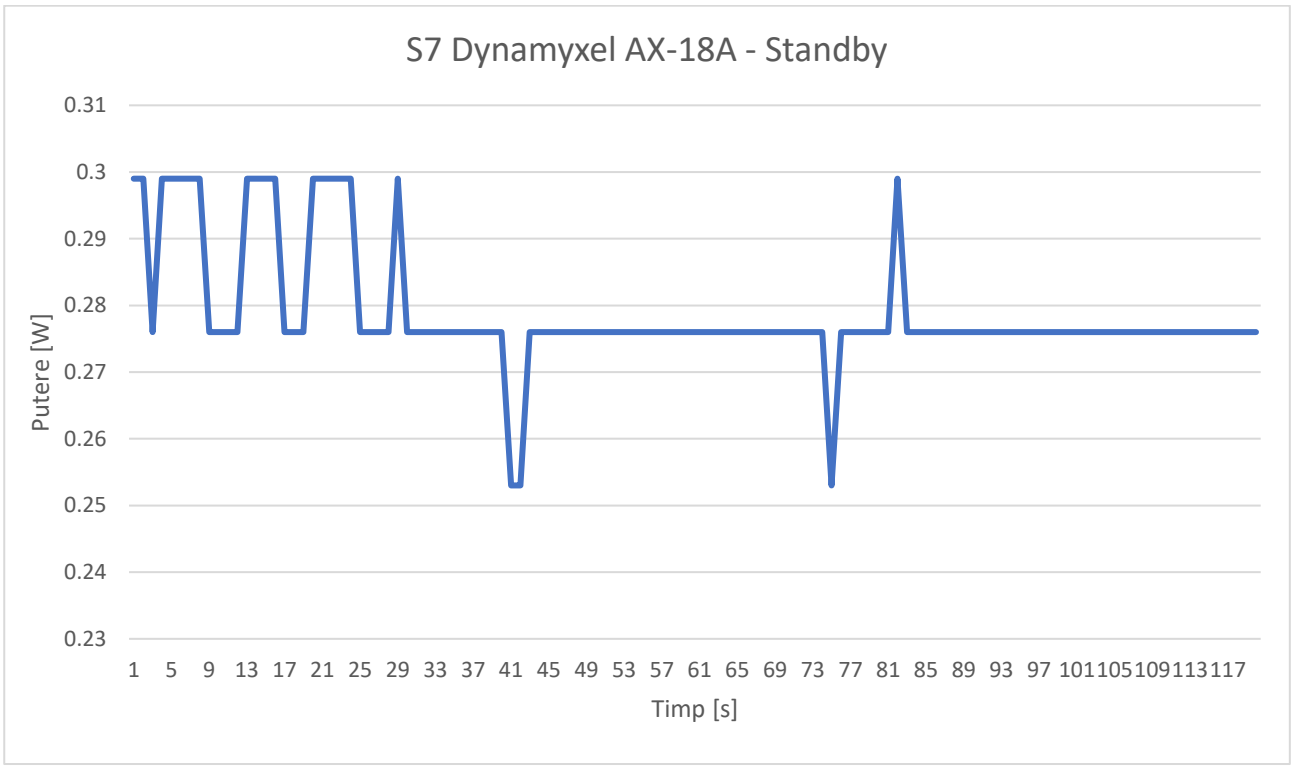


Grafic 10 Evolutie consum S6 Cpu Stress Test 4 cores Nvidia Jetson Nano

No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]
1	0.026	0.299	31	0.024	0.276	61	0.024	0.276	91	0.024	0.276
2	0.026	0.299	32	0.024	0.276	62	0.024	0.276	92	0.024	0.276
3	0.024	0.276	33	0.024	0.276	63	0.024	0.276	93	0.024	0.276
4	0.026	0.299	34	0.024	0.276	64	0.024	0.276	94	0.024	0.276
5	0.026	0.299	35	0.024	0.276	65	0.024	0.276	95	0.024	0.276
6	0.026	0.299	36	0.024	0.276	66	0.024	0.276	96	0.024	0.276
7	0.026	0.299	37	0.024	0.276	67	0.024	0.276	97	0.024	0.276
8	0.026	0.299	38	0.024	0.276	68	0.024	0.276	98	0.024	0.276
9	0.024	0.276	39	0.024	0.276	69	0.024	0.276	99	0.024	0.276
10	0.024	0.276	40	0.024	0.276	70	0.024	0.276	100	0.024	0.276
11	0.024	0.276	41	0.022	0.253	71	0.024	0.276	101	0.024	0.276
12	0.024	0.276	42	0.022	0.253	72	0.024	0.276	102	0.024	0.276
13	0.026	0.299	43	0.024	0.276	73	0.024	0.276	103	0.024	0.276
14	0.026	0.299	44	0.024	0.276	74	0.024	0.276	104	0.024	0.276
15	0.026	0.299	45	0.024	0.276	75	0.022	0.253	105	0.024	0.276
16	0.026	0.299	46	0.024	0.276	76	0.024	0.276	106	0.024	0.276
17	0.024	0.276	47	0.024	0.276	77	0.024	0.276	107	0.024	0.276

18	0.024	0.276	48	0.024	0.276	78	0.024	0.276	108	0.024	0.276
19	0.024	0.276	49	0.024	0.276	79	0.024	0.276	109	0.024	0.276
20	0.026	0.299	50	0.024	0.276	80	0.024	0.276	110	0.024	0.276
21	0.026	0.299	51	0.024	0.276	81	0.024	0.276	111	0.024	0.276
22	0.026	0.299	52	0.024	0.276	82	0.026	0.299	112	0.024	0.276
23	0.026	0.299	53	0.024	0.276	83	0.024	0.276	113	0.024	0.276
24	0.026	0.299	54	0.024	0.276	84	0.024	0.276	114	0.024	0.276
25	0.024	0.276	55	0.024	0.276	85	0.024	0.276	115	0.024	0.276
26	0.024	0.276	56	0.024	0.276	86	0.024	0.276	116	0.024	0.276
27	0.024	0.276	57	0.024	0.276	87	0.024	0.276	117	0.024	0.276
28	0.024	0.276	58	0.024	0.276	88	0.024	0.276	118	0.024	0.276
29	0.026	0.299	59	0.024	0.276	89	0.024	0.276	119	0.024	0.276
30	0.024	0.276	60	0.024	0.276	90	0.024	0.276	120	0.024	0.276

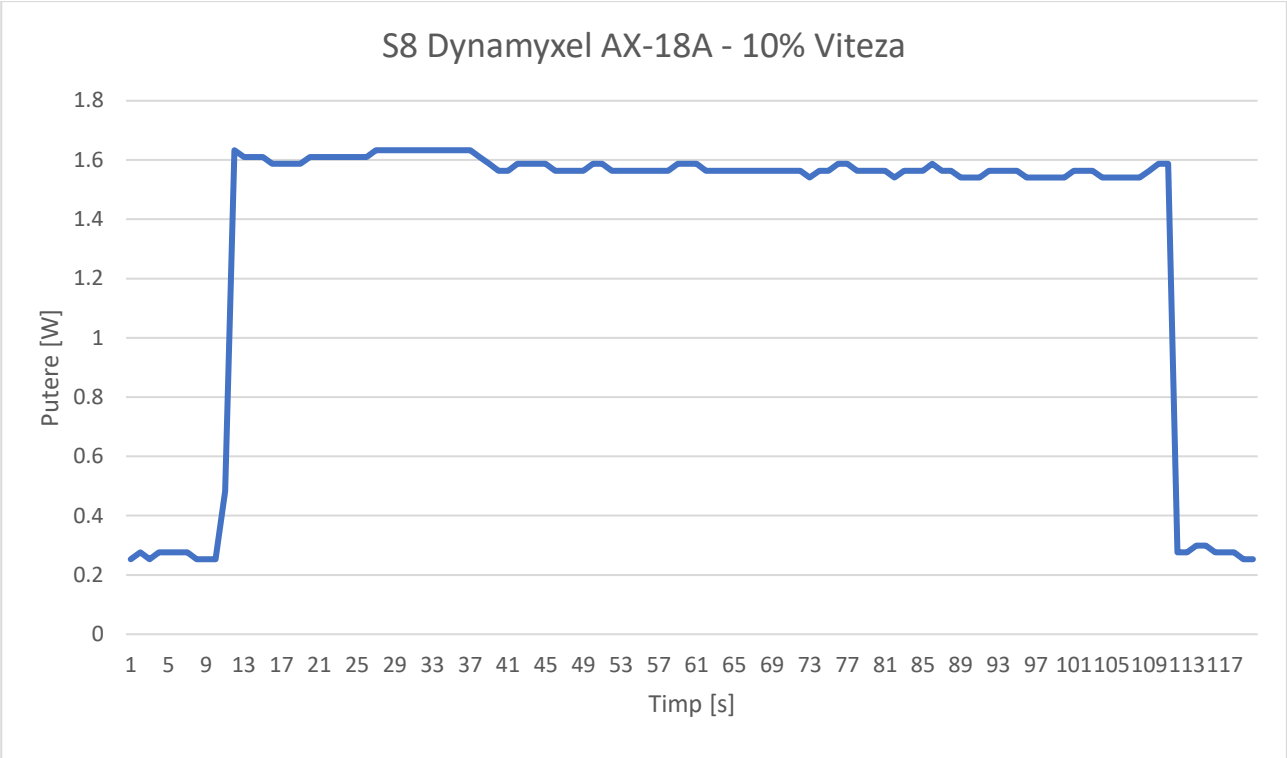
Tabel 13 Valori masurate S7 Motor Standby – Dynamixel AX-18A



Grafic 11 Evolutie consum S7 – Standby Dynamyxel AX-18A

No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]
1	0.022	0.253	31	0.142	1.633	61	0.138	1.587	91	0.134	1.541
2	0.024	0.276	32	0.142	1.633	62	0.136	1.564	92	0.136	1.564
3	0.022	0.253	33	0.142	1.633	63	0.136	1.564	93	0.136	1.564
4	0.024	0.276	34	0.142	1.633	64	0.136	1.564	94	0.136	1.564
5	0.024	0.276	35	0.142	1.633	65	0.136	1.564	95	0.136	1.564
6	0.024	0.276	36	0.142	1.633	66	0.136	1.564	96	0.134	1.541
7	0.024	0.276	37	0.142	1.633	67	0.136	1.564	97	0.134	1.541
8	0.022	0.253	38	0.14	1.61	68	0.136	1.564	98	0.134	1.541
9	0.022	0.253	39	0.138	1.587	69	0.136	1.564	99	0.134	1.541
10	0.022	0.253	40	0.136	1.564	70	0.136	1.564	100	0.134	1.541
11	0.042	0.483	41	0.136	1.564	71	0.136	1.564	101	0.136	1.564
12	0.142	1.633	42	0.138	1.587	72	0.136	1.564	102	0.136	1.564
13	0.14	1.61	43	0.138	1.587	73	0.134	1.541	103	0.136	1.564
14	0.14	1.61	44	0.138	1.587	74	0.136	1.564	104	0.134	1.541
15	0.14	1.61	45	0.138	1.587	75	0.136	1.564	105	0.134	1.541
16	0.138	1.587	46	0.136	1.564	76	0.138	1.587	106	0.134	1.541
17	0.138	1.587	47	0.136	1.564	77	0.138	1.587	107	0.134	1.541
18	0.138	1.587	48	0.136	1.564	78	0.136	1.564	108	0.134	1.541
19	0.138	1.587	49	0.136	1.564	79	0.136	1.564	109	0.136	1.564
20	0.14	1.61	50	0.138	1.587	80	0.136	1.564	110	0.138	1.587
21	0.14	1.61	51	0.138	1.587	81	0.136	1.564	111	0.138	1.587
22	0.14	1.61	52	0.136	1.564	82	0.134	1.541	112	0.024	0.276
23	0.14	1.61	53	0.136	1.564	83	0.136	1.564	113	0.024	0.276
24	0.14	1.61	54	0.136	1.564	84	0.136	1.564	114	0.026	0.299
25	0.14	1.61	55	0.136	1.564	85	0.136	1.564	115	0.026	0.299
26	0.14	1.61	56	0.136	1.564	86	0.138	1.587	116	0.024	0.276
27	0.142	1.633	57	0.136	1.564	87	0.136	1.564	117	0.024	0.276
28	0.142	1.633	58	0.136	1.564	88	0.136	1.564	118	0.024	0.276
29	0.142	1.633	59	0.138	1.587	89	0.134	1.541	119	0.022	0.253
30	0.142	1.633	60	0.138	1.587	90	0.134	1.541	120	0.022	0.253

Tabel 14 Valori masurate S8 10% Viteza – Dynamixel AX-18A

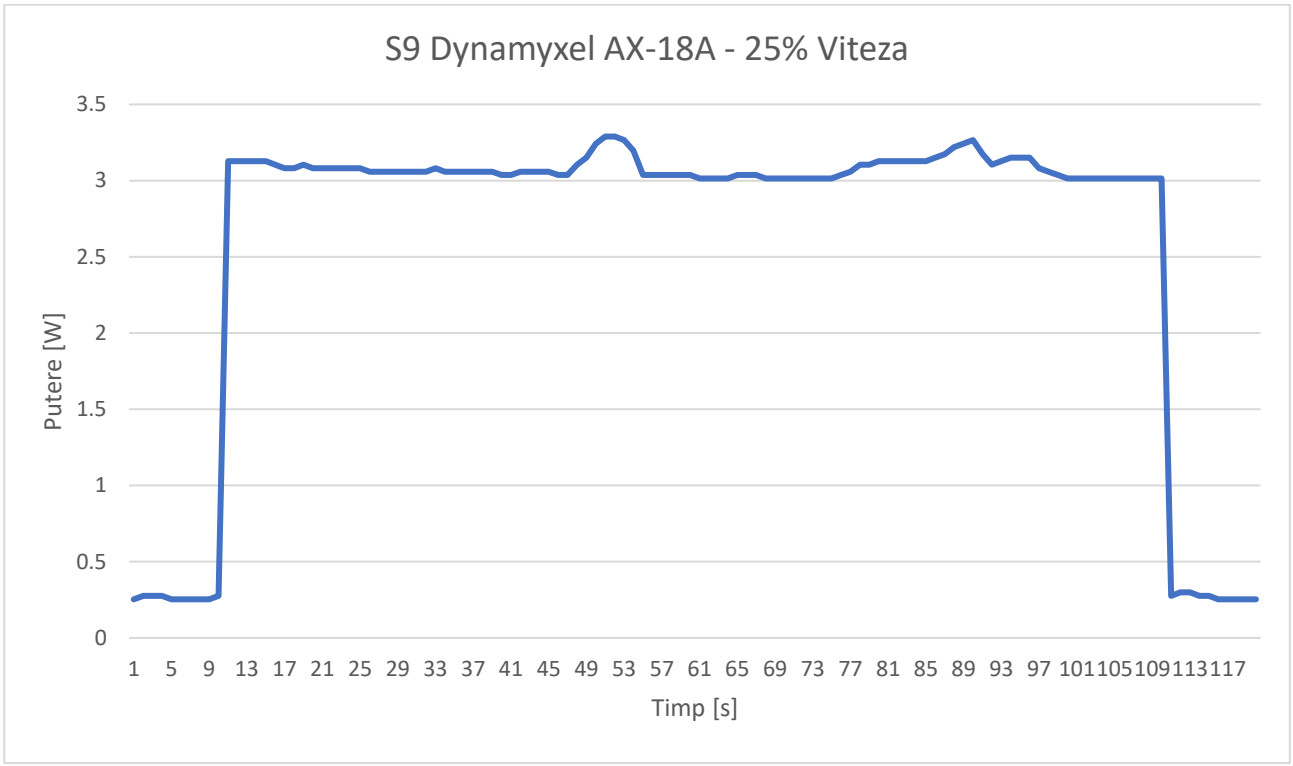


Grafic 12 Evolutie consum S8 10% Viteza – Dynamixel AX-18A

No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]
1	0.022	0.253	31	0.266	3.059	61	0.262	3.013	91	0.276	3.174
2	0.024	0.276	32	0.266	3.059	62	0.262	3.013	92	0.27	3.105
3	0.024	0.276	33	0.268	3.082	63	0.262	3.013	93	0.272	3.128
4	0.024	0.276	34	0.266	3.059	64	0.262	3.013	94	0.274	3.151
5	0.022	0.253	35	0.266	3.059	65	0.264	3.036	95	0.274	3.151
6	0.022	0.253	36	0.266	3.059	66	0.264	3.036	96	0.274	3.151
7	0.022	0.253	37	0.266	3.059	67	0.264	3.036	97	0.268	3.082
8	0.022	0.253	38	0.266	3.059	68	0.262	3.013	98	0.266	3.059
9	0.022	0.253	39	0.266	3.059	69	0.262	3.013	99	0.264	3.036
10	0.024	0.276	40	0.264	3.036	70	0.262	3.013	100	0.262	3.013
11	0.272	3.128	41	0.264	3.036	71	0.262	3.013	101	0.262	3.013
12	0.272	3.128	42	0.266	3.059	72	0.262	3.013	102	0.262	3.013
13	0.272	3.128	43	0.266	3.059	73	0.262	3.013	103	0.262	3.013
14	0.272	3.128	44	0.266	3.059	74	0.262	3.013	104	0.262	3.013
15	0.272	3.128	45	0.266	3.059	75	0.262	3.013	105	0.262	3.013
16	0.27	3.105	46	0.264	3.036	76	0.264	3.036	106	0.262	3.013

17	0.268	3.082	47	0.264	3.036	77	0.266	3.059	107	0.262	3.013
18	0.268	3.082	48	0.27	3.105	78	0.27	3.105	108	0.262	3.013
19	0.27	3.105	49	0.274	3.151	79	0.27	3.105	109	0.262	3.013
20	0.268	3.082	50	0.282	3.243	80	0.272	3.128	110	0.262	3.013
21	0.268	3.082	51	0.286	3.289	81	0.272	3.128	111	0.024	0.276
22	0.268	3.082	52	0.286	3.289	82	0.272	3.128	112	0.026	0.299
23	0.268	3.082	53	0.284	3.266	83	0.272	3.128	113	0.026	0.299
24	0.268	3.082	54	0.278	3.197	84	0.272	3.128	114	0.024	0.276
25	0.268	3.082	55	0.264	3.036	85	0.272	3.128	115	0.024	0.276
26	0.266	3.059	56	0.264	3.036	86	0.274	3.151	116	0.022	0.253
27	0.266	3.059	57	0.264	3.036	87	0.276	3.174	117	0.022	0.253
28	0.266	3.059	58	0.264	3.036	88	0.28	3.22	118	0.022	0.253
29	0.266	3.059	59	0.264	3.036	89	0.282	3.243	119	0.022	0.253
30	0.266	3.059	60	0.264	3.036	90	0.284	3.266	120	0.022	0.253

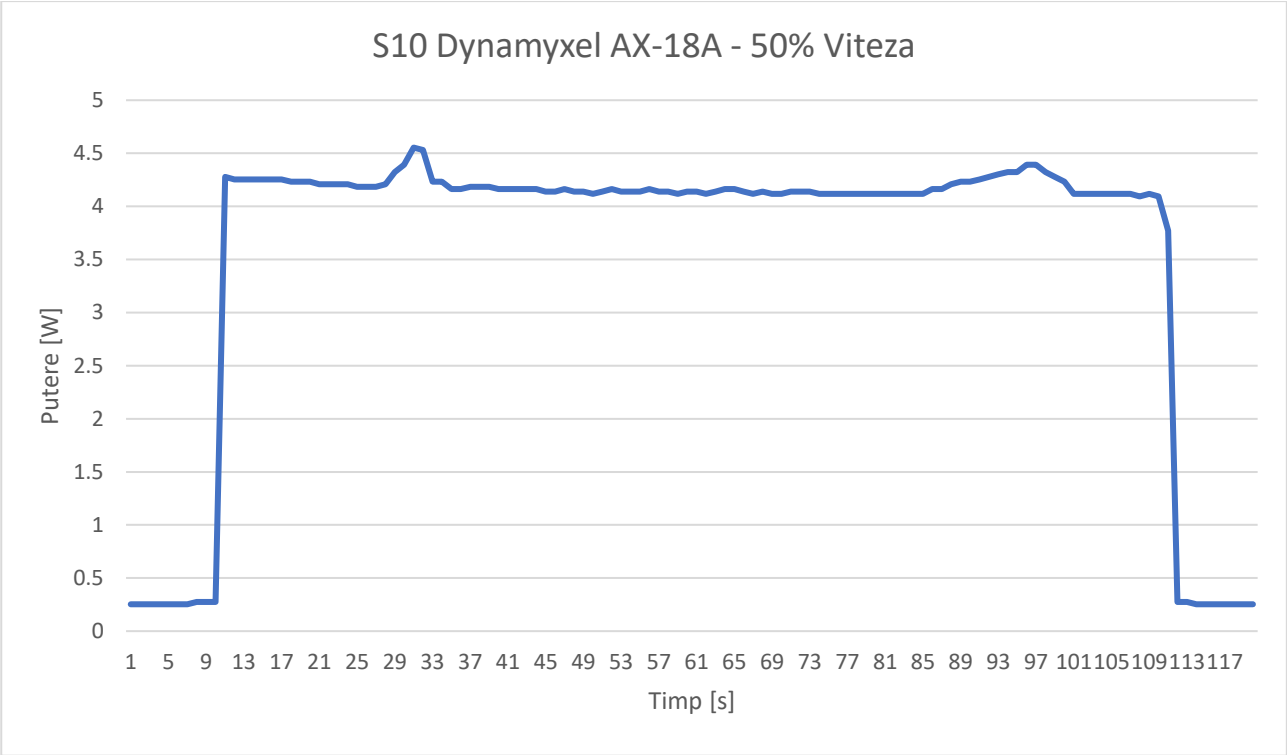
Grafic 13 Valori masurate S9 25% Viteza – Dynamixel AX-18A



Grafic 14 Evolutie consum S9 25% Viteza – Dynamixel AX-18A

No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]
1	0.022	0.253	31	0.396	4.554	61	0.36	4.14	91	0.37	4.255
2	0.022	0.253	32	0.394	4.531	62	0.358	4.117	92	0.372	4.278
3	0.022	0.253	33	0.368	4.232	63	0.36	4.14	93	0.374	4.301
4	0.022	0.253	34	0.368	4.232	64	0.362	4.163	94	0.376	4.324
5	0.022	0.253	35	0.362	4.163	65	0.362	4.163	95	0.376	4.324
6	0.022	0.253	36	0.362	4.163	66	0.36	4.14	96	0.382	4.393
7	0.022	0.253	37	0.364	4.186	67	0.358	4.117	97	0.382	4.393
8	0.024	0.276	38	0.364	4.186	68	0.36	4.14	98	0.376	4.324
9	0.024	0.276	39	0.364	4.186	69	0.358	4.117	99	0.372	4.278
10	0.024	0.276	40	0.362	4.163	70	0.358	4.117	100	0.368	4.232
11	0.372	4.278	41	0.362	4.163	71	0.36	4.14	101	0.358	4.117
12	0.37	4.255	42	0.362	4.163	72	0.36	4.14	102	0.358	4.117
13	0.37	4.255	43	0.362	4.163	73	0.36	4.14	103	0.358	4.117
14	0.37	4.255	44	0.362	4.163	74	0.358	4.117	104	0.358	4.117
15	0.37	4.255	45	0.36	4.14	75	0.358	4.117	105	0.358	4.117
16	0.37	4.255	46	0.36	4.14	76	0.358	4.117	106	0.358	4.117
17	0.37	4.255	47	0.362	4.163	77	0.358	4.117	107	0.358	4.117
18	0.368	4.232	48	0.36	4.14	78	0.358	4.117	108	0.356	4.094
19	0.368	4.232	49	0.36	4.14	79	0.358	4.117	109	0.358	4.117
20	0.368	4.232	50	0.358	4.117	80	0.358	4.117	110	0.356	4.094
21	0.366	4.209	51	0.36	4.14	81	0.358	4.117	111	0.328	3.772
22	0.366	4.209	52	0.362	4.163	82	0.358	4.117	112	0.024	0.276
23	0.366	4.209	53	0.36	4.14	83	0.358	4.117	113	0.024	0.276
24	0.366	4.209	54	0.36	4.14	84	0.358	4.117	114	0.022	0.253
25	0.364	4.186	55	0.36	4.14	85	0.358	4.117	115	0.022	0.253
26	0.364	4.186	56	0.362	4.163	86	0.362	4.163	116	0.022	0.253
27	0.364	4.186	57	0.36	4.14	87	0.362	4.163	117	0.022	0.253
28	0.366	4.209	58	0.36	4.14	88	0.366	4.209	118	0.022	0.253
29	0.376	4.324	59	0.358	4.117	89	0.368	4.232	119	0.022	0.253
30	0.382	4.393	60	0.36	4.14	90	0.368	4.232	120	0.022	0.253

Tabel 15 Valori masurate S10 50% Viteza – Dynamixel AX-18A

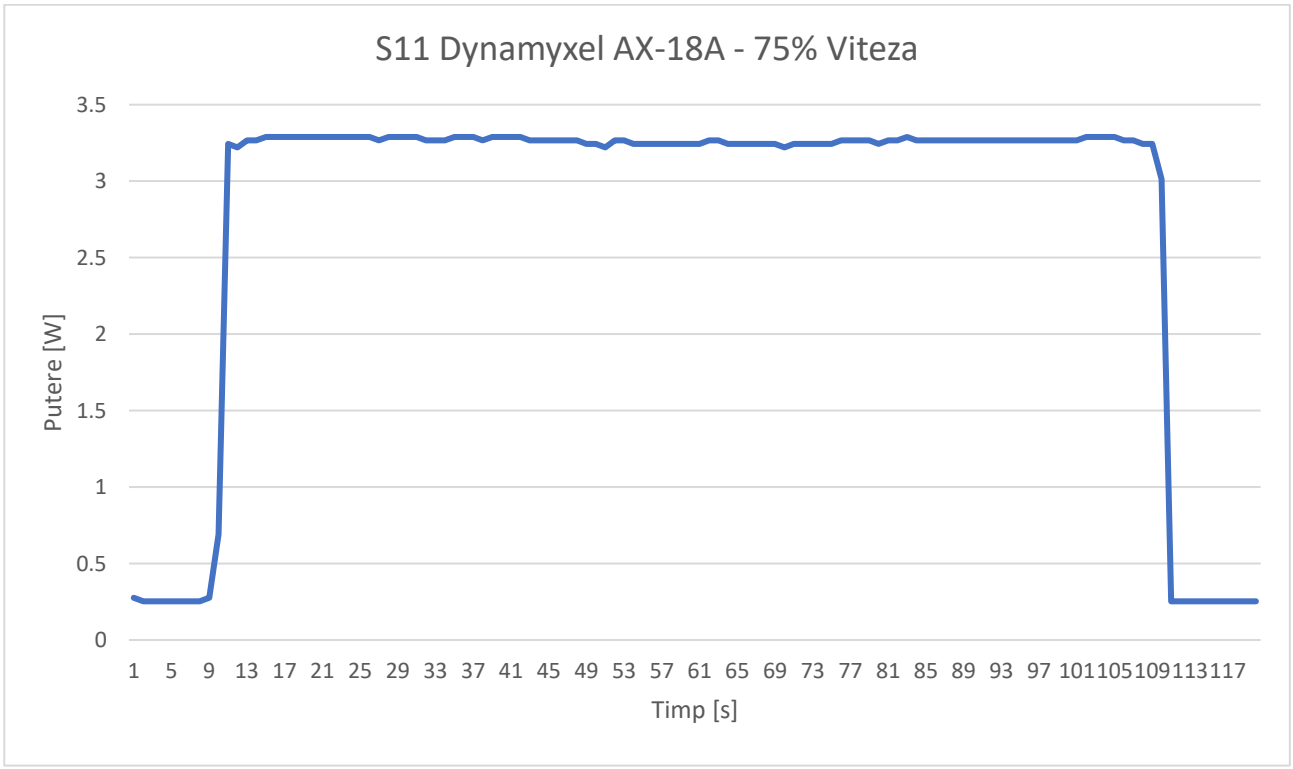


Grafic 15 Evolutie consum S10 50% Viteza - Dynamyxel AX-18A

No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]
1	0.024	0.276	31	0.286	3.289	61	0.282	3.243	91	0.284	3.266
2	0.022	0.253	32	0.284	3.266	62	0.284	3.266	92	0.284	3.266
3	0.022	0.253	33	0.284	3.266	63	0.284	3.266	93	0.284	3.266
4	0.022	0.253	34	0.284	3.266	64	0.282	3.243	94	0.284	3.266
5	0.022	0.253	35	0.286	3.289	65	0.282	3.243	95	0.284	3.266
6	0.022	0.253	36	0.286	3.289	66	0.282	3.243	96	0.284	3.266
7	0.022	0.253	37	0.286	3.289	67	0.282	3.243	97	0.284	3.266
8	0.022	0.253	38	0.284	3.266	68	0.282	3.243	98	0.284	3.266
9	0.024	0.276	39	0.286	3.289	69	0.282	3.243	99	0.284	3.266
10	0.06	0.69	40	0.286	3.289	70	0.28	3.22	100	0.284	3.266
11	0.282	3.243	41	0.286	3.289	71	0.282	3.243	101	0.284	3.266
12	0.28	3.22	42	0.286	3.289	72	0.282	3.243	102	0.286	3.289
13	0.284	3.266	43	0.284	3.266	73	0.282	3.243	103	0.286	3.289
14	0.284	3.266	44	0.284	3.266	74	0.282	3.243	104	0.286	3.289
15	0.286	3.289	45	0.284	3.266	75	0.282	3.243	105	0.286	3.289
16	0.286	3.289	46	0.284	3.266	76	0.284	3.266	106	0.284	3.266

17	0.286	3.289	47	0.284	3.266	77	0.284	3.266	107	0.284	3.266
18	0.286	3.289	48	0.284	3.266	78	0.284	3.266	108	0.282	3.243
19	0.286	3.289	49	0.282	3.243	79	0.284	3.266	109	0.282	3.243
20	0.286	3.289	50	0.282	3.243	80	0.282	3.243	110	0.262	3.013
21	0.286	3.289	51	0.28	3.22	81	0.284	3.266	111	0.022	0.253
22	0.286	3.289	52	0.284	3.266	82	0.284	3.266	112	0.022	0.253
23	0.286	3.289	53	0.284	3.266	83	0.286	3.289	113	0.022	0.253
24	0.286	3.289	54	0.282	3.243	84	0.284	3.266	114	0.022	0.253
25	0.286	3.289	55	0.282	3.243	85	0.284	3.266	115	0.022	0.253
26	0.286	3.289	56	0.282	3.243	86	0.284	3.266	116	0.022	0.253
27	0.284	3.266	57	0.282	3.243	87	0.284	3.266	117	0.022	0.253
28	0.286	3.289	58	0.282	3.243	88	0.284	3.266	118	0.022	0.253
29	0.286	3.289	59	0.282	3.243	89	0.284	3.266	119	0.022	0.253
30	0.286	3.289	60	0.282	3.243	90	0.284	3.266	120	0.022	0.253

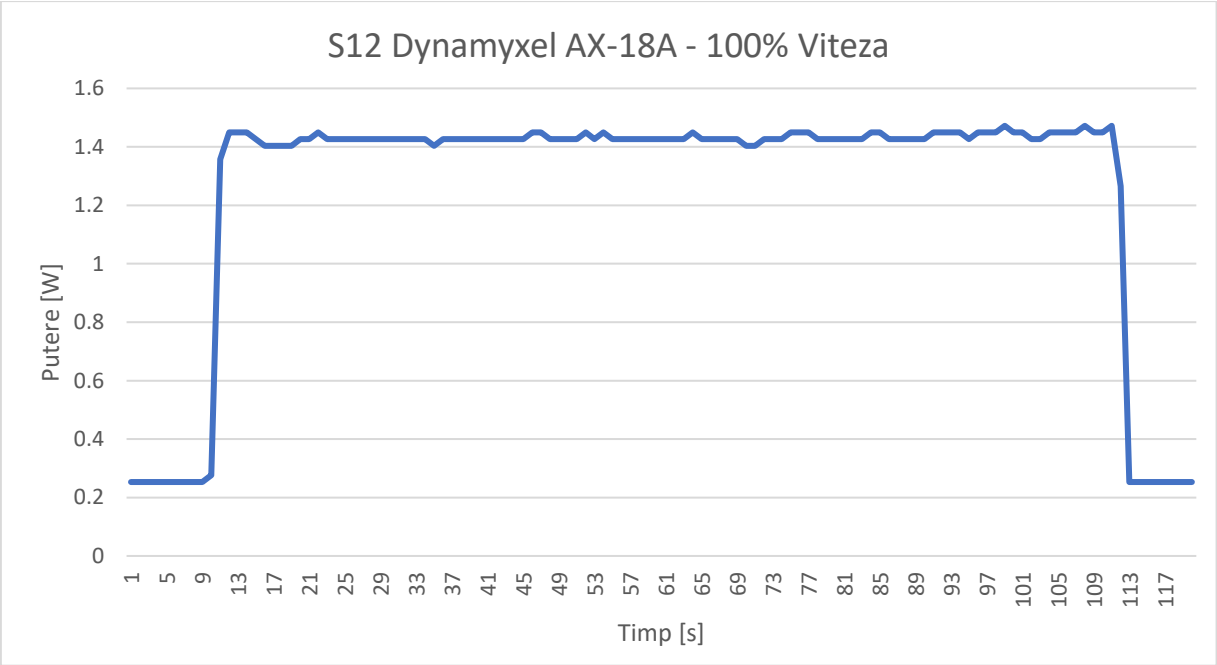
Tabel 16 Valori masurate S11 75% Viteza – Dynamixel AX-18A



Grafic 16 Evolutie consum S11 75% Viteza - Dynamyxel AX-18A

No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]	No.	Curent [A]	Putere [W]
1	0.022	0.253	31	0.124	1.426	61	0.124	1.426	91	0.126	1.449
2	0.022	0.253	32	0.124	1.426	62	0.124	1.426	92	0.126	1.449
3	0.022	0.253	33	0.124	1.426	63	0.124	1.426	93	0.126	1.449
4	0.022	0.253	34	0.124	1.426	64	0.126	1.449	94	0.126	1.449
5	0.022	0.253	35	0.122	1.403	65	0.124	1.426	95	0.124	1.426
6	0.022	0.253	36	0.124	1.426	66	0.124	1.426	96	0.126	1.449
7	0.022	0.253	37	0.124	1.426	67	0.124	1.426	97	0.126	1.449
8	0.022	0.253	38	0.124	1.426	68	0.124	1.426	98	0.126	1.449
9	0.022	0.253	39	0.124	1.426	69	0.124	1.426	99	0.128	1.472
10	0.024	0.276	40	0.124	1.426	70	0.122	1.403	100	0.126	1.449
11	0.118	1.357	41	0.124	1.426	71	0.122	1.403	101	0.126	1.449
12	0.126	1.449	42	0.124	1.426	72	0.124	1.426	102	0.124	1.426
13	0.126	1.449	43	0.124	1.426	73	0.124	1.426	103	0.124	1.426
14	0.126	1.449	44	0.124	1.426	74	0.124	1.426	104	0.126	1.449
15	0.124	1.426	45	0.124	1.426	75	0.126	1.449	105	0.126	1.449
16	0.122	1.403	46	0.126	1.449	76	0.126	1.449	106	0.126	1.449
17	0.122	1.403	47	0.126	1.449	77	0.126	1.449	107	0.126	1.449
18	0.122	1.403	48	0.124	1.426	78	0.124	1.426	108	0.128	1.472
19	0.122	1.403	49	0.124	1.426	79	0.124	1.426	109	0.126	1.449
20	0.124	1.426	50	0.124	1.426	80	0.124	1.426	110	0.126	1.449
21	0.124	1.426	51	0.124	1.426	81	0.124	1.426	111	0.128	1.472
22	0.126	1.449	52	0.126	1.449	82	0.124	1.426	112	0.11	1.265
23	0.124	1.426	53	0.124	1.426	83	0.124	1.426	113	0.05	0.253
24	0.124	1.426	54	0.126	1.449	84	0.126	1.449	114	0.05	0.253
25	0.124	1.426	55	0.124	1.426	85	0.126	1.449	115	0.052	0.253
26	0.124	1.426	56	0.124	1.426	86	0.124	1.426	116	0.052	0.253
27	0.124	1.426	57	0.124	1.426	87	0.124	1.426	117	0.052	0.253
28	0.124	1.426	58	0.124	1.426	88	0.124	1.426	118	0.052	0.253
29	0.124	1.426	59	0.124	1.426	89	0.124	1.426	119	0.052	0.253
30	0.124	1.426	60	0.124	1.426	90	0.124	1.426	120	0.052	0.253

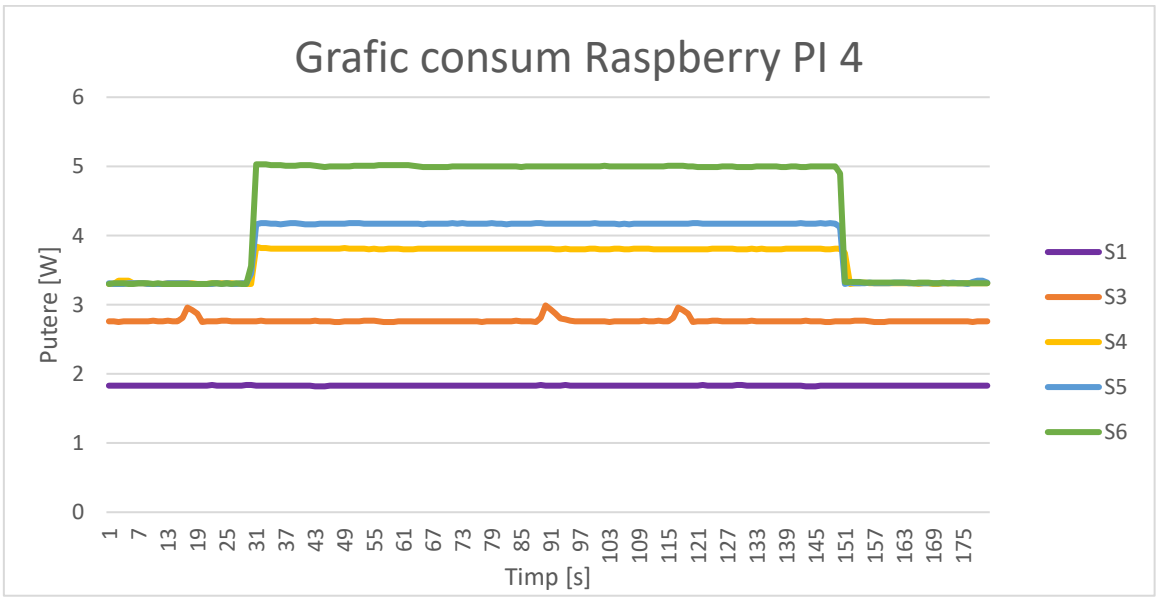
Tabel 17 Valori masurate S12 100% Viteza – Dynamixel AX-18A



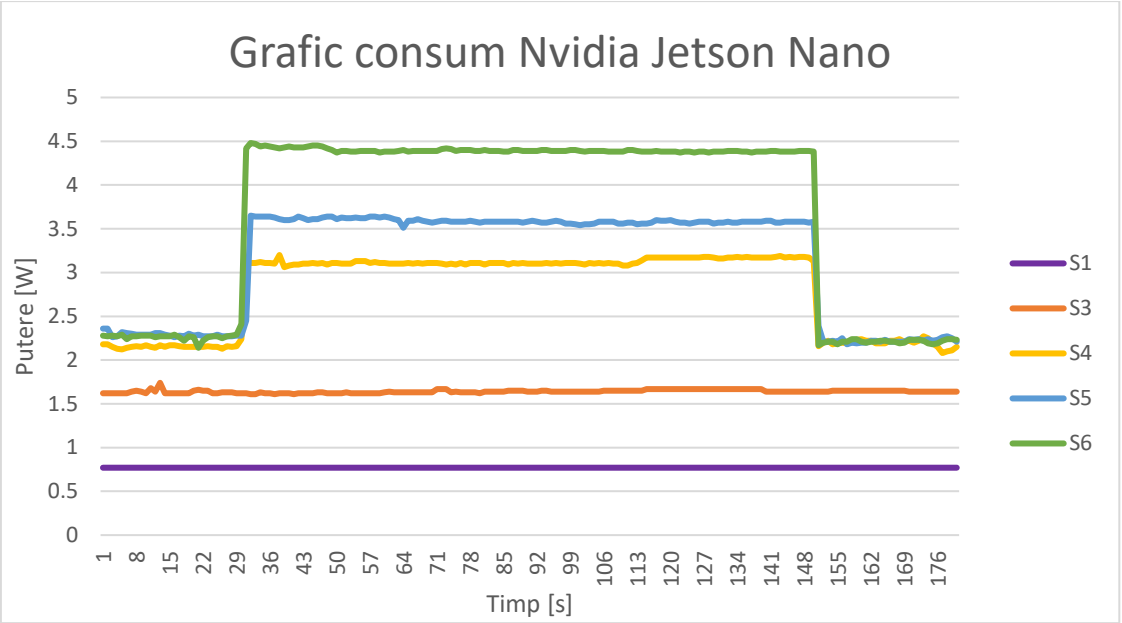
Grafic 17 Evolutie consum S12 100% Viteza - Dynamyxel AX-18A

6. Concluzii

În graficele 9 si 10 este prezentată evoluția consumului componentelor Raspberry Pi și Nvidia Jetson Nano. În cazul ambelor componente se observă că cel mai mare consum este înregistrat în scenariul S6 când toate firele de execuție ale procesorului sunt utilizate la capacitate maximă.



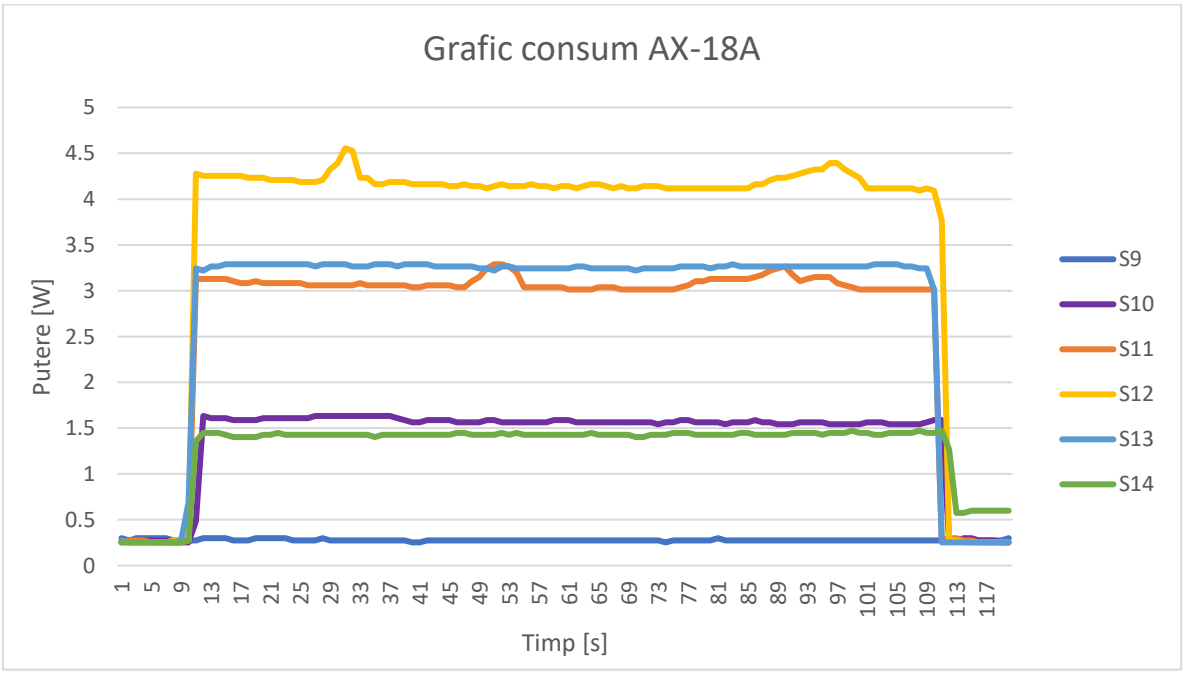
Grafic 18 Comparatie consum Raspberry Pi 4



Grafic 19 Comparatie consum Nvidia Jetson Nano

Comparand cele doua grafice se observa ca Nvidia Jetson Nano consuma mai putin decat Raspberry PI 4 in toate cele 5 scenarii studiate.

Cel mai mic consum este inregistrat cand ambele componente se afla in modul standby, Nvidia Jetson Nano consuma doar 0.77W, mai putin cu 58% decat consumul inregistrat de Raspberry PI 4 (1.83w).



Grafic 20 Comparatie consum Dynamixel AX-18A

În cazul motorului Dynamixel AX-18A, se observă că acesta are un consum constant in modul standby de aproximativ 0.28W, deci consumă curent chiar și atunci când nu este acționat. Acest fenomen este normal, motorul consuma curent pentru a menține roata cuplată in echilibru.

Bibliografie

[1] Raspberry Pi 4 Model B – Raspberry Pi

[2] NVIDIA Jetson Nano Developer Kit | NVIDIA Developer

[3] AX-18A (robotis.com)

[4] UNI-T Voltage Meter, Multimeter, Oscilloscope | UNI-T (uni-trend.com)