

Tp.4 LE THERMOCOUPLE

Introduction

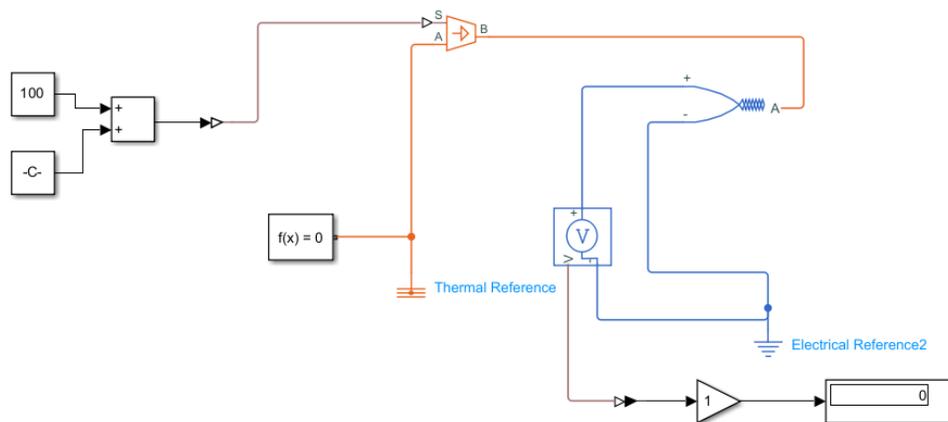
Les thermocouples sont utilisés pour la mesure de températures. Ils sont bon marché et permettent la mesure dans une grande gamme de températures. Leur principal défaut est leur précision : il est relativement difficile d'obtenir des mesures avec une erreur inférieure à 0,1 - 0,2 °C

But

Le but de ce TP est de tester le fonctionnement d'un Thermocouple dans l'environnement simscape de Matlab

Travail Demandé

1. Ouvrir un nouveau model simscape et réalisez le schéma qui est sur la figure suivante :



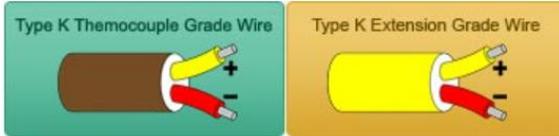
2. Le thermocouple utilisé est un thermocouple de type k. Configurez le selon sa data sheet
 - Pour avoir les valeurs des coefficients du thermocouple ; onglet help → references, puis on suit le lien (<https://srdata.nist.gov/its90/main/>) ; cela est une configuration (conditionnement) du thermocouple

Type K Thermocouples Coefficients in mV
 -270 °C to 0 °C

0 °C to 1372 °C

$c_0 =$	$0.000000000000 \times 10^0$	$-0.176004136860 \times 10^{-1}$
$c_1 =$	$0.394501280250 \times 10^{-1}$	$0.389212049750 \times 10^{-1}$
$c_2 =$	$0.236223735980 \times 10^{-4}$	$0.185587700320 \times 10^{-4}$
$c_3 =$	$-0.328589067840 \times 10^{-6}$	$-0.994575928740 \times 10^{-7}$
$c_4 =$	$-0.499048287770 \times 10^{-8}$	$0.318409457190 \times 10^{-9}$
$c_5 =$	$-0.675090591730 \times 10^{-10}$	$-0.560728448890 \times 10^{-12}$
$c_6 =$	$-0.574103274280 \times 10^{-12}$	$0.560750590590 \times 10^{-15}$
$c_7 =$	$-0.310888728940 \times 10^{-14}$	$-0.320207200030 \times 10^{-18}$
$c_8 =$	$-0.104516093650 \times 10^{-16}$	$0.971511471520 \times 10^{-22}$
$c_9 =$	$-0.198892668780 \times 10^{-19}$	$-0.121047212750 \times 10^{-25}$
$c_{10} =$	$-0.163226974860 \times 10^{-22}$	
$a_0 =$		$0.118597600000 \times 10^0$
$a_1 =$		$-0.118343200000 \times 10^{-3}$
$a_2 =$		$0.126968600000 \times 10^3$

3. Faites entrer des valeurs aléatoires de température à l'entrée du thermocouple, puis visualisez le résultat affiché à la sortie du circuit et comparez le avec les températures indiquées dans la data sheet



Thermocouple type K : Nickel-chromium / Nickel – Aluminum

La relation entre température et la tension est donnée par

$$E = \sum_{i=0}^n c_i (t_{90})^i + a_0 e^{a_1(t_{90}-a_2)^2}$$

ITS-90 Table for Type K Thermocouple (Ref Junction 0°C) <http://reotemp.com>

°C	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
Thermoelectric Voltage in mV											
-270	-6.458										
-260	-6.441	-6.444	-6.446	-6.448	-6.450	-6.452	-6.453	-6.455	-6.456	-6.457	-6.458
-250	-6.404	-6.408	-6.413	-6.417	-6.421	-6.425	-6.429	-6.432	-6.435	-6.438	-6.441
-240	-6.344	-6.351	-6.358	-6.364	-6.370	-6.377	-6.382	-6.388	-6.393	-6.399	-6.404
-230	-6.262	-6.271	-6.280	-6.289	-6.297	-6.306	-6.314	-6.322	-6.329	-6.337	-6.344
-220	-6.158	-6.170	-6.181	-6.192	-6.202	-6.213	-6.223	-6.233	-6.243	-6.252	-6.262
-210	-6.035	-6.048	-6.061	-6.074	-6.087	-6.099	-6.111	-6.123	-6.135	-6.147	-6.158
-200	-5.891	-5.907	-5.922	-5.936	-5.951	-5.965	-5.980	-5.994	-6.007	-6.021	-6.035
-190	-5.730	-5.747	-5.763	-5.780	-5.797	-5.813	-5.829	-5.845	-5.861	-5.876	-5.891
-180	-5.550	-5.569	-5.588	-5.606	-5.624	-5.642	-5.660	-5.678	-5.695	-5.713	-5.730
-170	-5.354	-5.374	-5.395	-5.415	-5.435	-5.454	-5.474	-5.493	-5.512	-5.531	-5.550
-160	-5.141	-5.163	-5.185	-5.207	-5.228	-5.250	-5.271	-5.292	-5.313	-5.333	-5.354
-150	-4.913	-4.936	-4.960	-4.983	-5.006	-5.029	-5.052	-5.074	-5.097	-5.119	-5.141

90 Table for Type K Thermocouple (Ref Junction 0°C) <http://reotemp.com>

°C	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
450	18.516	18.558	18.601	18.643	18.686	18.728	18.771	18.813	18.856	18.898	18.941
460	18.941	18.983	19.026	19.068	19.111	19.154	19.196	19.239	19.281	19.324	19.366
470	19.366	19.409	19.451	19.494	19.537	19.579	19.622	19.664	19.707	19.750	19.792
480	19.792	19.835	19.877	19.920	19.962	20.005	20.048	20.090	20.133	20.175	20.218
490	20.218	20.261	20.303	20.346	20.389	20.431	20.474	20.516	20.559	20.602	20.644
500	20.644	20.687	20.730	20.772	20.815	20.857	20.900	20.943	20.985	21.028	21.071
510	21.071	21.113	21.156	21.199	21.241	21.284	21.326	21.369	21.412	21.454	21.497
520	21.497	21.540	21.582	21.625	21.668	21.710	21.753	21.796	21.838	21.881	21.924
530	21.924	21.966	22.009	22.052	22.094	22.137	22.179	22.222	22.265	22.307	22.350
540	22.350	22.393	22.435	22.478	22.521	22.563	22.606	22.649	22.691	22.734	22.776
550	22.776	22.819	22.862	22.904	22.947	22.990	23.032	23.075	23.117	23.160	23.203
560	23.203	23.245	23.288	23.331	23.373	23.416	23.458	23.501	23.544	23.586	23.629
570	23.629	23.671	23.714	23.757	23.799	23.842	23.884	23.927	23.970	24.012	24.055
580	24.055	24.097	24.140	24.182	24.225	24.267	24.310	24.353	24.395	24.438	24.480
590	24.480	24.523	24.565	24.608	24.650	24.693	24.735	24.778	24.820	24.863	24.905
600	24.905	24.948	24.990	25.033	25.075	25.118	25.160	25.203	25.245	25.288	25.330
610	25.330	25.373	25.415	25.458	25.500	25.543	25.585	25.627	25.670	25.712	25.755
620	25.755	25.797	25.840	25.882	25.924	25.967	26.009	26.052	26.094	26.136	26.179
630	26.179	26.221	26.263	26.306	26.348	26.391	26.433	26.475	26.517	26.560	26.602
640	26.602	26.644	26.687	26.729	26.771	26.814	26.856	26.898	26.940	26.983	27.025
650	27.025	27.067	27.109	27.152	27.194	27.236	27.278	27.320	27.363	27.405	27.447
660	27.447	27.489	27.531	27.574	27.616	27.658	27.700	27.742	27.784	27.826	27.869
670	27.869	27.911	27.953	27.995	28.037	28.079	28.121	28.163	28.205	28.247	28.289
680	28.289	28.332	28.374	28.416	28.458	28.500	28.542	28.584	28.626	28.668	28.710
690	28.710	28.752	28.794	28.836	28.877	28.919	28.961	29.003	29.045	29.087	29.129
700	29.129	29.171	29.213	29.255	29.297	29.339	29.380	29.422	29.464	29.506	29.548
710	29.548	29.590	29.631	29.673	29.715	29.757	29.798	29.840	29.882	29.924	29.966
720	29.966	30.007	30.049	30.090	30.132	30.174	30.216	30.257	30.299	30.341	30.383
730	30.383	30.424	30.466	30.507	30.549	30.590	30.632	30.674	30.715	30.757	30.798
740	30.798	30.840	30.881	30.923	30.964	31.006	31.047	31.089	31.130	31.172	31.213
750	31.213	31.255	31.296	31.338	31.379	31.421	31.462	31.504	31.545	31.586	31.628
760	31.628	31.669	31.710	31.752	31.793	31.834	31.876	31.917	31.958	32.000	32.041
770	32.041	32.082	32.124	32.165	32.206	32.247	32.289	32.330	32.371	32.412	32.453
780	32.453	32.495	32.536	32.577	32.618	32.659	32.700	32.742	32.783	32.824	32.865
790	32.865	32.906	32.947	32.988	33.029	33.070	33.111	33.152	33.193	33.234	33.275
800	33.275	33.316	33.357	33.398	33.439	33.480	33.521	33.562	33.603	33.644	33.685
810	33.685	33.726	33.767	33.808	33.848	33.889	33.930	33.971	34.012	34.053	34.094
820	34.093	34.134	34.175	34.216	34.257	34.297	34.338	34.379	34.420	34.460	34.501
830	34.501	34.542	34.582	34.623	34.664	34.704	34.745	34.786	34.826	34.867	34.908
840	34.908	34.948	34.989	35.029	35.070	35.110	35.151	35.192	35.232	35.273	35.313
850	35.313	35.354	35.394	35.435	35.476	35.516	35.556	35.596	35.637	35.677	35.718
1200	48.838	48.875	48.911	48.948	48.984	49.021	49.057	49.093	49.130	49.166	49.202
1210	49.202	49.239	49.275	49.311	49.348	49.384	49.420	49.456	49.493	49.529	49.565
1220	49.565	49.601	49.637	49.674	49.710	49.746	49.782	49.818	49.854	49.890	49.926
1230	49.926	49.962	49.998	50.034	50.070	50.106	50.142	50.178	50.214	50.250	50.286
1240	50.286	50.322	50.358	50.393	50.429	50.465	50.501	50.537	50.572	50.608	50.644
1250	50.644	50.680	50.715	50.751	50.787	50.822	50.858	50.894	50.929	50.965	51.000
1260	51.000	51.036	51.071	51.107	51.142	51.178	51.213	51.249	51.284	51.320	51.355
1270	51.355	51.391	51.426	51.461	51.497	51.532	51.567	51.603	51.638	51.673	51.708
1280	51.708	51.744	51.779	51.814	51.849	51.885	51.920	51.955	51.990	52.025	52.060
1290	52.060	52.095	52.130	52.165	52.200	52.235	52.270	52.305	52.340	52.375	52.410
1300	52.410	52.445	52.480	52.515	52.550	52.585	52.620	52.655	52.690	52.725	52.760
1310	52.760	52.794	52.828	52.863	52.898	52.932	52.967	53.002	53.037	53.071	53.106
1320	53.106	53.140	53.175	53.210	53.244	53.279	53.313	53.348	53.382	53.417	53.451
1330	53.451	53.486	53.520	53.555	53.589	53.623	53.658	53.692	53.727	53.761	53.795
1340	53.795	53.830	53.864	53.898	53.932	53.967	54.001	54.035	54.069	54.104	54.138
1350	54.138	54.172	54.206	54.240	54.274	54.308	54.343	54.377	54.411	54.445	54.479
1360	54.479	54.513	54.547	54.581	54.615	54.649	54.683	54.717	54.751	54.785	54.819
1370	54.819	54.852	54.886								

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°C	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
0	0.000	0.039	0.079	0.119	0.158	0.198	0.238	0.277	0.317	0.357	0.397
10	0.397	0.437	0.477	0.517	0.557	0.597	0.637	0.677	0.718	0.758	0.798
20	0.798	0.838	0.879	0.919	0.960	1.000	1.041	1.081	1.122	1.163	1.203
30	1.203	1.244	1.285	1.326	1.366	1.407	1.448	1.489	1.530	1.571	1.612
40	1.612	1.653	1.694	1.735	1.776	1.817	1.858	1.899	1.941	1.982	2.023
50	2.023	2.064	2.106	2.147	2.188	2.230	2.271	2.312	2.354	2.395	2.436
60	2.436	2.478	2.5								