

UNIVERSITAT POLITÈCNICA DE CATALUNYA

ESCOLA TÈCNICA SUPERIOR D'ENGINYERS DE TELECOMUNICACIÓ

TESI DOCTORAL

" APORTACIÓN AL CONTROL DIGITAL ÓPTIMO DE  
SISTEMAS DE ENERGÍA ELÉCTRICA :  
APLICACIÓN A LA REGULACIÓN POTENCIA -  
FRECUENCIA " .

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Director: JAUME HERRANZ LUIS

BARCELONA, SETEMBRE DE 1985

( 2 toms )



U. P. C.

E.T.S.E. TELECOMUNICACIÓ

Biblioteca

SDD5

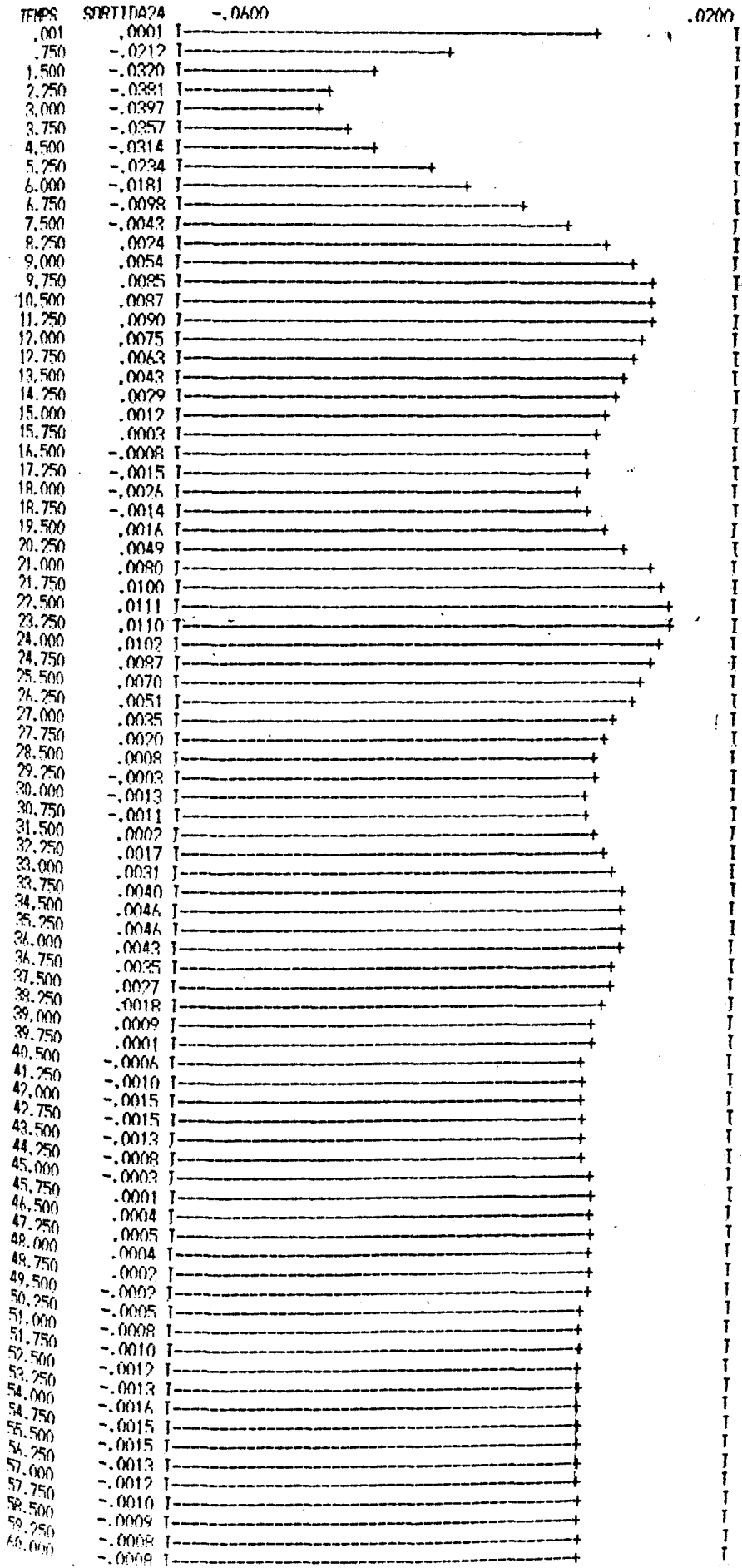
RLO de doble acción con mayor periodo de muestreo ( $\tau = 4$ ,  $T = 12$ ).

Penalización continua, importando tando el esfuerzo de control en  $kT$  como en  $kT + \tau$ .

(simulación con un retardo de cálculo de 1 segundo).

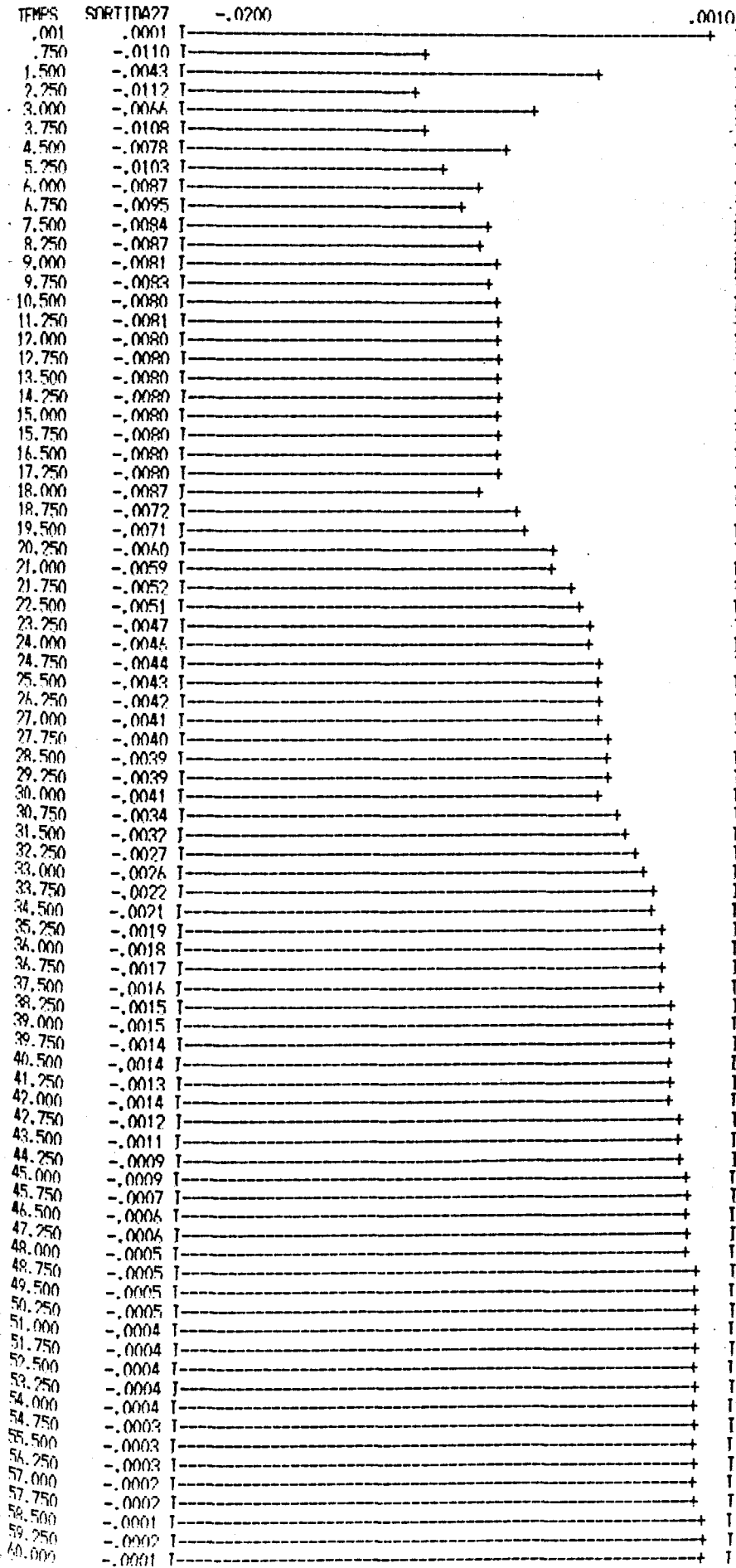
PLC FIX Y (24) MINIM ( -.0600) MAXIM ( .0200)

SDD5.1



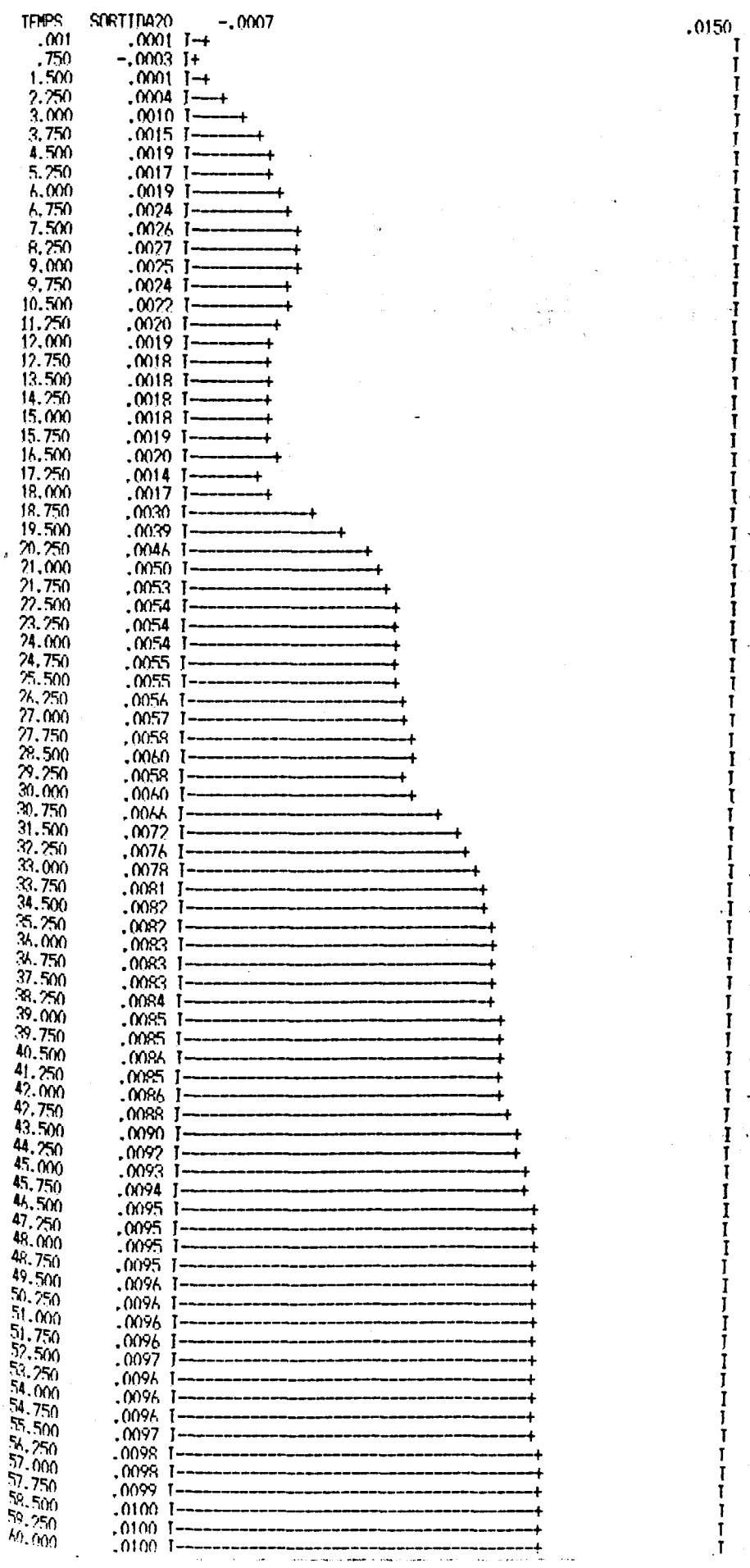
BLOC FIX Y (27) MINIM ( -.0200) MAXIM ( .0010)

SDD5.2



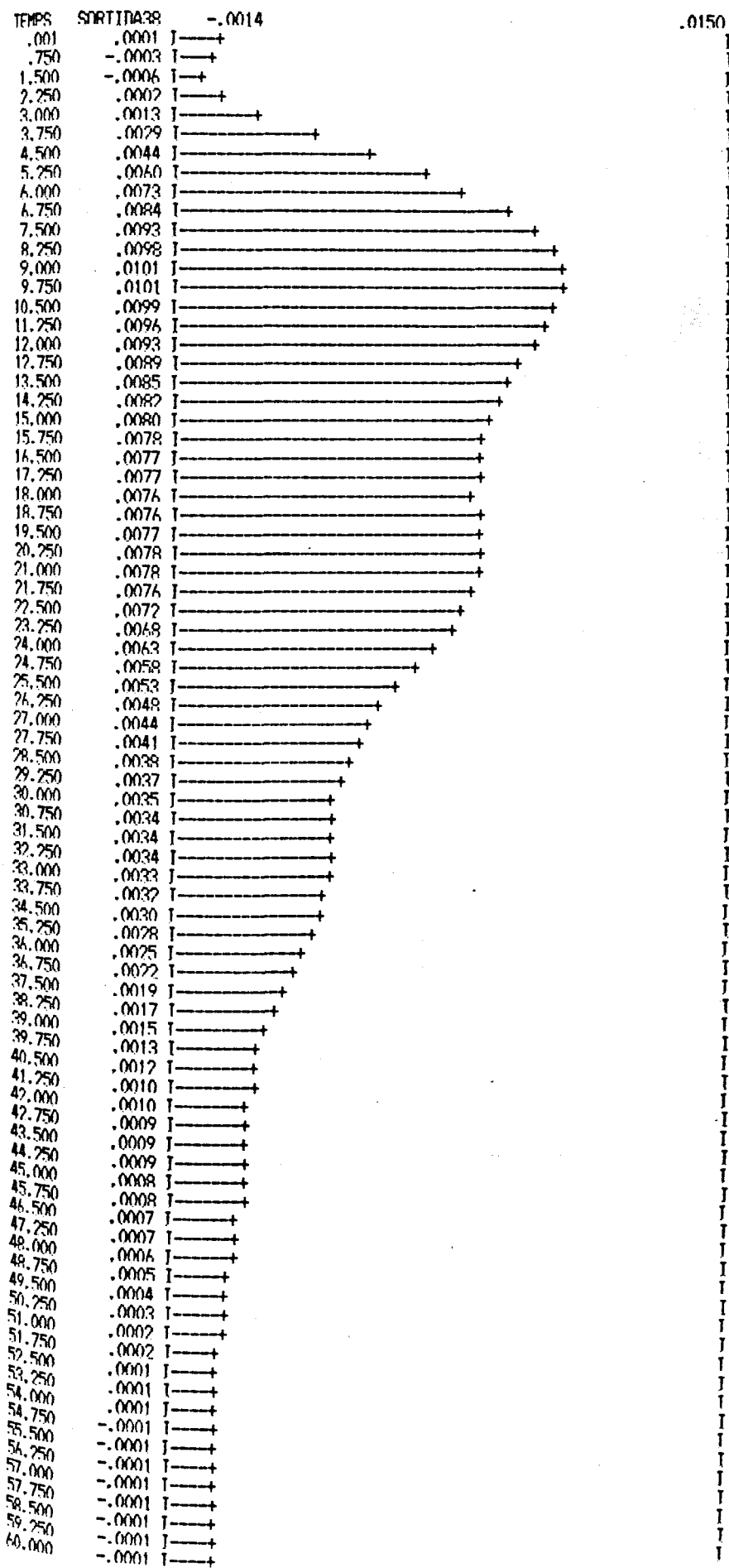
BLOC FIX Y (20) MTNIM ( -.0007) MAXIM ( .0150)

SDD5.3



RUC ETX V (38) MINIM ( -.0014) MAXIM ( .0150)

SDD5.4



TEMPS	SORTIDA44	SORTIDA30	SORTIDA55	SORTIDA 0
.00	.0001	.0001	.0001	.0001
2.00	-.0175	-.0334	.0014	.0001
4.00	-.0428	-.0369	.0043	.0001
6.00	-.0655	-.0168	.0057	.0001
8.00	-.0850	-.0002	.0059	.0001
10.00	-.1005	.0083	.0060	.0001
12.00	-.1149	.0079	.0061	.0001
14.00	-.1299	.0032	.0062	.0001
16.00	-.1456	-.0002	.0062	.0001
18.00	-.1621	-.0032	.0062	.0001
20.00	-.1766	.0031	.0062	.0001
22.00	-.1865	.0103	.0063	.0001
24.00	-.1942	.0100	.0066	.0001
26.00	-.2013	.0057	.0067	.0001
28.00	-.2088	.0015	.0067	.0001
30.00	-.2166	-.0016	.0067	.0001
32.00	-.2234	.0008	.0067	.0001
34.00	-.2277	.0042	.0067	.0001
36.00	-.2307	.0041	.0068	.0001
38.00	-.2334	.0020	.0068	.0001
40.00	-.2361	-.0002	.0068	.0001
42.00	-.2389	-.0016	.0068	.0001
44.00	-.2414	-.0011	.0068	.0001
46.00	-.2430	.0001	.0068	.0001
48.00	-.2440	.0003	.0068	.0001
50.00	-.2449	-.0004	.0068	.0001
52.00	-.2458	-.0011	.0068	.0001
54.00	-.2467	-.0015	.0068	.0001
56.00	-.2476	-.0015	.0068	.0001
58.00	-.2482	-.0011	.0068	.0001
60.00	-.2485	-.0008	.0068	.0001
62.00	-.2488	-.0009	.0068	.0001
64.00	-.2491	-.0011	.0068	.0001
66.00	-.2494	-.0012	.0068	.0001
68.00	-.2497	-.0012	.0068	.0001
70.00	-.2500	-.0010	.0068	.0001
72.00	-.2500	-.0007	.0068	.0001
74.00	-.2501	-.0008	.0068	.0001
76.00	-.2502	-.0009	.0068	.0001
78.00	-.2503	-.0008	.0068	.0001
80.00	-.2505	-.0009	.0068	.0001
82.00	-.2506	-.0008	.0068	.0001
84.00	-.2506	-.0005	.0068	.0001
86.00	-.2506	-.0005	.0068	.0001
88.00	-.2506	-.0006	.0068	.0001
90.00	-.2507	-.0005	.0068	.0001
92.00	-.2508	-.0006	.0068	.0001
94.00	-.2508	-.0005	.0068	.0001
96.00	-.2508	-.0003	.0068	.0001
98.00	-.2508	-.0003	.0068	.0001
100.00	-.2508	-.0004	.0068	.0001
102.00	-.2508	-.0003	.0068	.0001
104.00	-.2508	-.0005	.0068	.0001
106.00	-.2509	-.0004	.0068	.0001
108.00	-.2508	-.0001	.0068	.0001
110.00	-.2508	-.0002	.0068	.0001
112.00	-.2508	-.0003	.0068	.0001
114.00	-.2508	-.0002	.0068	.0001
116.00	-.2508	-.0004	.0068	.0001
118.00	-.2509	-.0003	.0068	.0001
120.00	-.2508	.0001	.0068	.0001
122.00	-.2508	-.0001	.0068	.0001
124.00	-.2508	-.0002	.0068	.0001
126.00	-.2508	-.0001	.0068	.0001
128.00	-.2508	-.0003	.0068	.0001
130.00	-.2509	-.0002	.0068	.0001

TEMPS	SORTIDA46	SORTIDA30	SORTIDA56	SORTIDA 0
.00	.0001	.0001	.0001	.0001
2.00	-.0175	-.0334	.0002	.0001
4.00	-.0428	-.0369	.0003	.0001
6.00	-.0455	-.0168	.0005	.0001
8.00	-.0850	-.0002	.0006	.0001
10.00	-.1005	.0083	.0008	.0001
12.00	-.1149	.0079	.0009	.0001
14.00	-.1299	.0032	.0010	.0001
16.00	-.1456	-.0002	.0012	.0001
18.00	-.1621	-.0032	.0013	.0001
20.00	-.1766	.0031	.0014	.0001
22.00	-.1865	.0103	.0015	.0001
24.00	-.1942	.0100	.0015	.0001
26.00	-.2013	.0057	.0016	.0001
28.00	-.2088	.0015	.0016	.0001
30.00	-.2166	-.0016	.0016	.0001
32.00	-.2234	.0008	.0016	.0001
34.00	-.2277	.0042	.0017	.0001
36.00	-.2307	.0041	.0017	.0001
38.00	-.2334	.0020	.0017	.0001
40.00	-.2361	-.0002	.0017	.0001
42.00	-.2389	-.0016	.0017	.0001
44.00	-.2414	-.0011	.0017	.0001
46.00	-.2430	.0001	.0017	.0001
48.00	-.2440	.0003	.0017	.0001
50.00	-.2449	-.0004	.0017	.0001
52.00	-.2458	-.0011	.0017	.0001
54.00	-.2467	-.0015	.0017	.0001
56.00	-.2476	-.0015	.0017	.0001
58.00	-.2482	-.0011	.0017	.0001
60.00	-.2485	-.0008	.0017	.0001
62.00	-.2488	-.0009	.0017	.0001
64.00	-.2491	-.0011	.0017	.0001
66.00	-.2494	-.0012	.0017	.0001
68.00	-.2497	-.0012	.0017	.0001
70.00	-.2500	-.0010	.0017	.0001
72.00	-.2500	-.0007	.0017	.0001
74.00	-.2501	-.0008	.0017	.0001
76.00	-.2502	-.0009	.0017	.0001
78.00	-.2503	-.0008	.0017	.0001
80.00	-.2505	-.0009	.0017	.0001
82.00	-.2506	-.0008	.0017	.0001
84.00	-.2506	-.0005	.0017	.0001
86.00	-.2506	-.0005	.0017	.0001
88.00	-.2506	-.0006	.0017	.0001
90.00	-.2507	-.0005	.0017	.0001
92.00	-.2508	-.0006	.0017	.0001
94.00	-.2508	-.0005	.0017	.0001
96.00	-.2508	-.0003	.0017	.0001
98.00	-.2508	-.0003	.0017	.0001
100.00	-.2508	-.0004	.0017	.0001
102.00	-.2508	-.0003	.0017	.0001
104.00	-.2508	-.0005	.0017	.0001
106.00	-.2509	-.0004	.0017	.0001
108.00	-.2508	-.0001	.0017	.0001
110.00	-.2508	-.0002	.0017	.0001
112.00	-.2508	-.0003	.0017	.0001
114.00	-.2508	-.0002	.0017	.0001
116.00	-.2508	-.0004	.0017	.0001
118.00	-.2509	-.0003	.0017	.0001
120.00	-.2508	.0001	.0017	.0001
122.00	-.2508	-.0001	.0017	.0001
124.00	-.2508	-.0002	.0017	.0001
126.00	-.2508	-.0001	.0017	.0001
128.00	-.2508	-.0003	.0017	.0001
130.00	-.2509	-.0002	.0017	.0001
132.00	-.2508	.0001	.0017	.0001
134.00	-.2508	-.0001	.0017	.0001
136.00	-.2508	-.0001	.0017	.0001
138.00	-.2508	-.0001	.0017	.0001
140.00	-.2508	-.0003	.0017	.0001
142.00	-.2509	-.0002	.0017	.0001
144.00	-.2508	.0001	.0017	.0001
146.00	-.2508	.0001	.0017	.0001
148.00	-.2508	-.0001	.0017	.0001
150.00	-.2508	-.0001	.0017	.0001
152.00	-.2508	-.0002	.0017	.0001
154.00	-.2509	-.0002	.0017	.0001
156.00	-.2508	.0002	.0017	.0001
158.00	-.2508	.0001	.0017	.0001
160.00	-.2508	-.0001	.0017	.0001

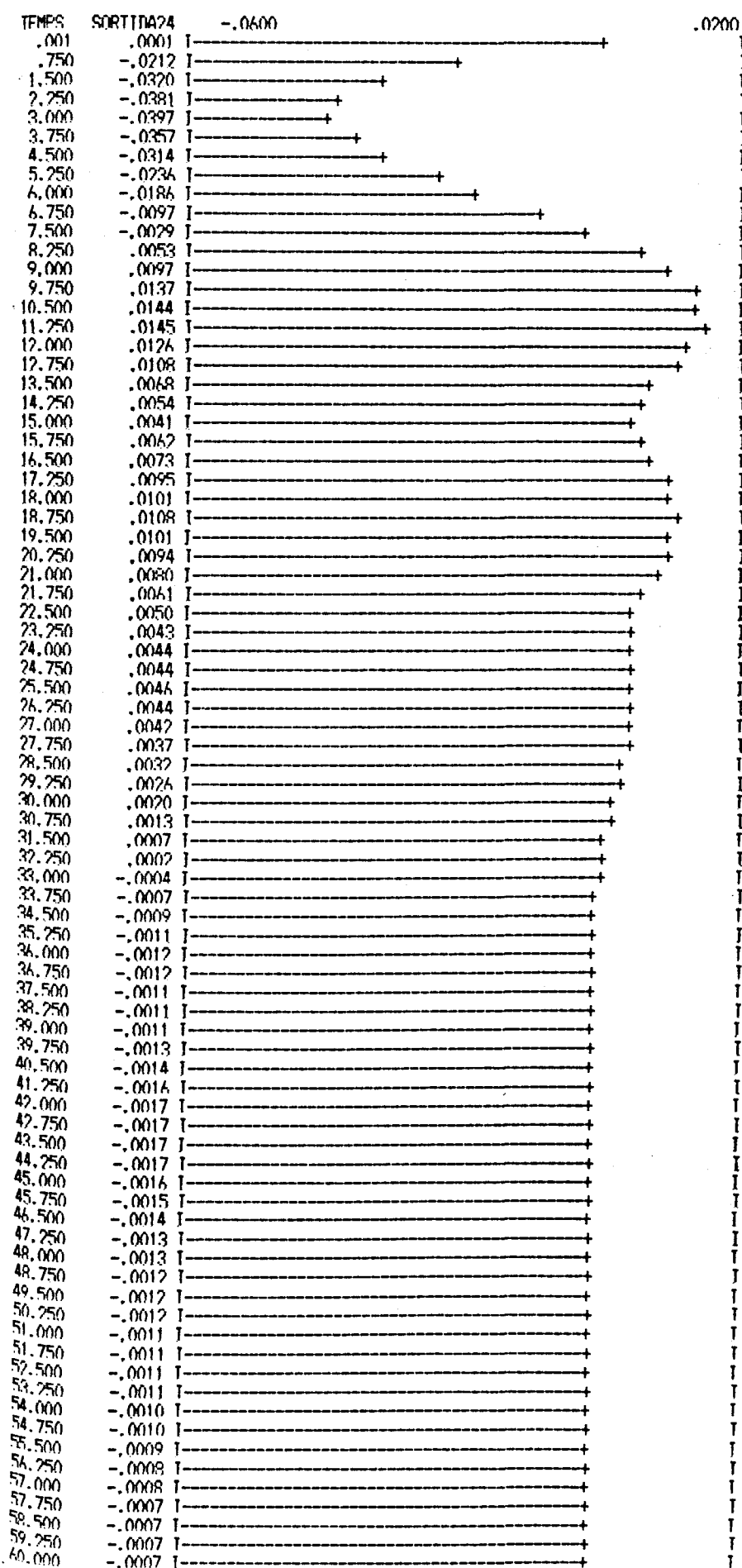


SDA1

Repetición de SDD4 cuando las acciones de control en  $kT$  y  $kT + \tau$  se calculan a partir de las muestras adquiridas en el instante de muestreo anterior  $(k - 1) T$ .

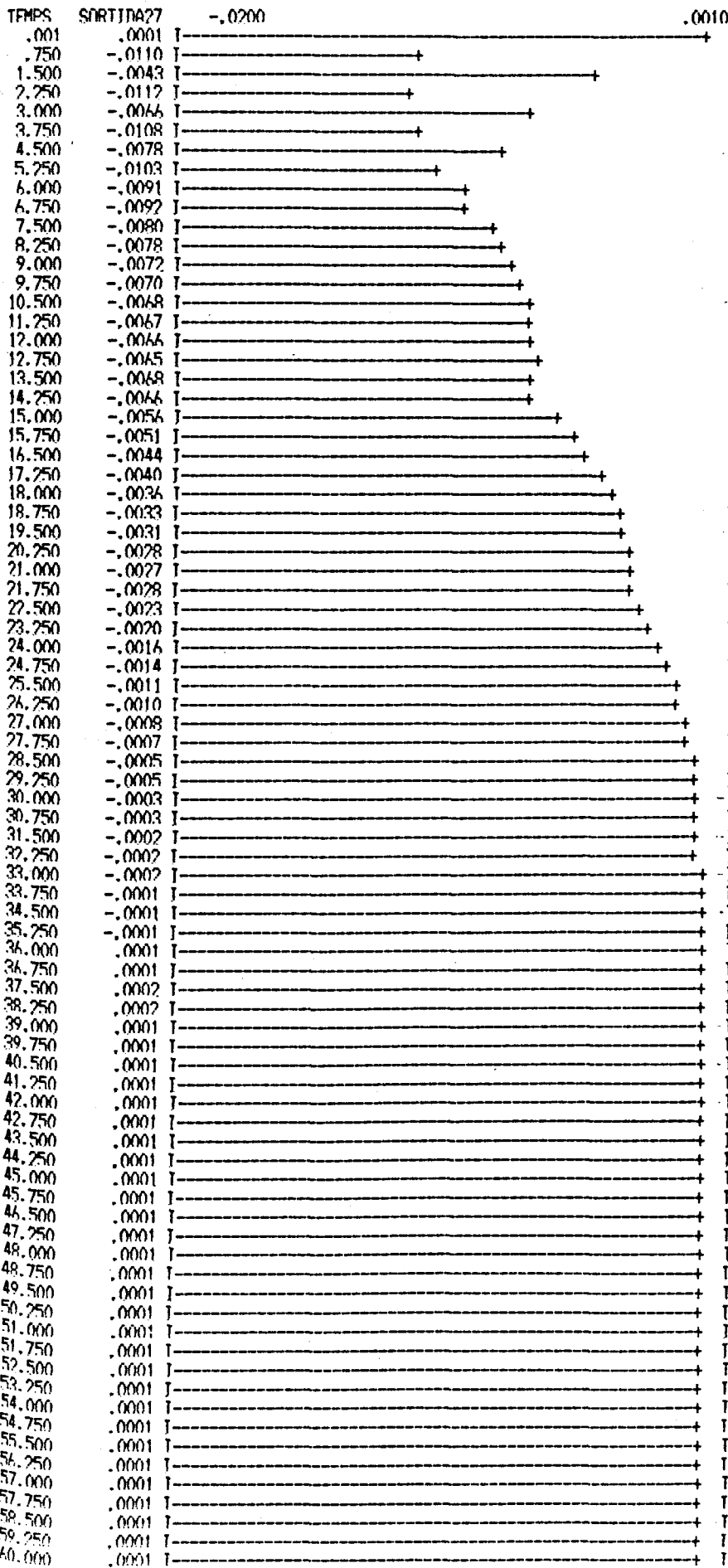
BLDC FIX Y (24) MINIM ( -.0600) MAXIM ( .0200)

SDA1.1



BLOC FIX Y (27) MINIM ( -.0200) MAXIM ( .0010)

SDA1.2



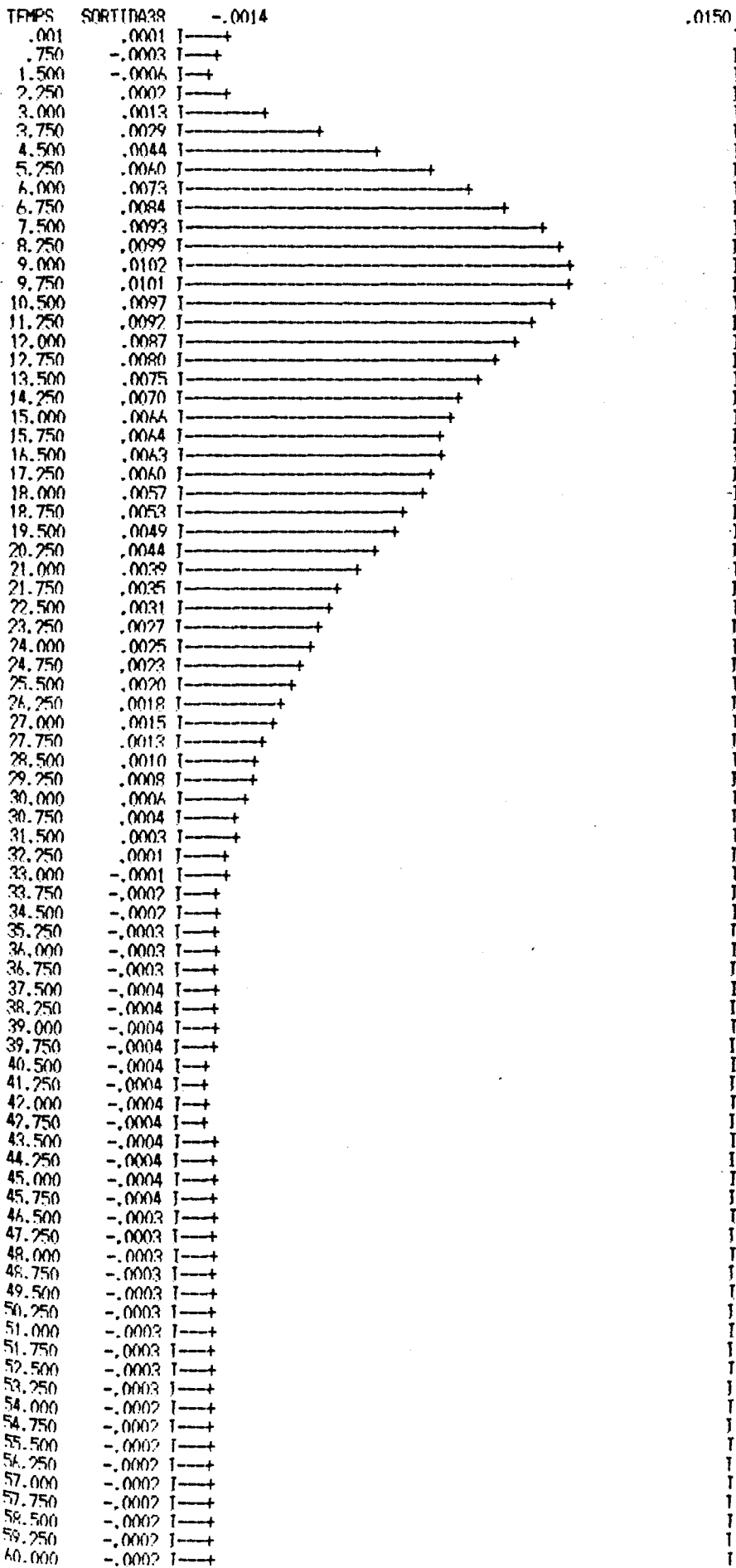
BLDG FIX Y (20) MJNTM ( -.0007) MAXJM ( .0150)

SDA1.3

TEMPS	SORTINA20	-.0007	.0150
.001	.0001	I+	I
.750	-.0003	I+	I
1.500	.0001	I+	I
2.250	.0004	I→+	I
3.000	.0010	I→→+	I
3.750	.0015	I→→→+	I
4.500	.0019	I→→→→+	I
5.250	.0015	I→→→+	I
6.000	.0018	I→→→→+	I
6.750	.0028	I→→→→→+	I
7.500	.0035	I→→→→→→+	I
8.250	.0038	I→→→→→→→+	I
9.000	.0039	I→→→→→→→+	I
9.750	.0038	I→→→→→→→+	I
10.500	.0036	I→→→→→→→+	I
11.250	.0035	I→→→→→→→+	I
12.000	.0033	I→→→→→→→+	I
12.750	.0033	I→→→→→→→+	I
13.500	.0025	I→→→→→	I
14.250	.0034	I→→→→→→+	I
15.000	.0044	I→→→→→→→+	I
15.750	.0055	I→→→→→→→→+	I
16.500	.0042	I→→→→→→→→+	I
17.250	.0066	I→→→→→→→→→+	I
18.000	.0068	I→→→→→→→→→+	I
18.750	.0070	I→→→→→→→→→+	I
19.500	.0071	I→→→→→→→→→+	I
20.250	.0072	I→→→→→→→→→+	I
21.000	.0072	I→→→→→→→→→+	I
21.750	.0071	I→→→→→→→→→+	I
22.500	.0077	I→→→→→→→→→→+	I
23.250	.0081	I→→→→→→→→→→→+	I
24.000	.0085	I→→→→→→→→→→→+	I
24.750	.0088	I→→→→→→→→→→→→+	I
25.500	.0090	I→→→→→→→→→→→→+	I
26.250	.0092	I→→→→→→→→→→→→+	I
27.000	.0093	I→→→→→→→→→→→→+	I
27.750	.0094	I→→→→→→→→→→→→+	I
28.500	.0095	I→→→→→→→→→→→→+	I
29.250	.0096	I→→→→→→→→→→→→+	I
30.000	.0097	I→→→→→→→→→→→→+	I
30.750	.0097	I→→→→→→→→→→→→+	I
31.500	.0097	I→→→→→→→→→→→→+	I
32.250	.0098	I→→→→→→→→→→→→+	I
33.000	.0099	I→→→→→→→→→→→→+	I
33.750	.0099	I→→→→→→→→→→→→+	I
34.500	.0100	I→→→→→→→→→→→→+	I
35.250	.0100	I→→→→→→→→→→→→+	I
36.000	.0101	I→→→→→→→→→→→→+	I
36.750	.0101	I→→→→→→→→→→→→+	I
37.500	.0102	I→→→→→→→→→→→→+	I
38.250	-.0102	I→→→→→→→→→→→→+	I
39.000	.0101	I→→→→→→→→→→→→+	I
39.750	.0101	I→→→→→→→→→→→→+	I
40.500	.0101	I→→→→→→→→→→→→+	I
41.250	.0101	I→→→→→→→→→→→→+	I
42.000	.0101	I→→→→→→→→→→→→+	I
42.750	.0101	I→→→→→→→→→→→→+	I
43.500	.0101	I→→→→→→→→→→→→+	I
44.250	.0101	I→→→→→→→→→→→→+	I
45.000	.0101	I→→→→→→→→→→→→+	I
45.750	.0101	I→→→→→→→→→→→→+	I
46.500	.0101	I→→→→→→→→→→→→+	I
47.250	.0101	I→→→→→→→→→→→→+	I
48.000	.0101	I→→→→→→→→→→→→+	I
48.750	.0101	I→→→→→→→→→→→→+	I
49.500	.0101	I→→→→→→→→→→→→+	I
50.250	.0101	I→→→→→→→→→→→→+	I
51.000	.0101	I→→→→→→→→→→→→+	I
51.750	.0101	I→→→→→→→→→→→→+	I
52.500	.0101	I→→→→→→→→→→→→+	I
53.250	.0101	I→→→→→→→→→→→→+	I
54.000	.0101	I→→→→→→→→→→→→+	I
54.750	.0101	I→→→→→→→→→→→→+	I
55.500	.0101	I→→→→→→→→→→→→+	I
56.250	.0101	I→→→→→→→→→→→→+	I
57.000	.0101	I→→→→→→→→→→→→+	I
57.750	.0101	I→→→→→→→→→→→→+	I
58.500	.0101	I→→→→→→→→→→→→+	I
59.250	.0101	I→→→→→→→→→→→→+	I
60.000	.0101	I→→→→→→→→→→→→+	I

BLOC FIX Y (3R) MINIM ( -.0014) MAXIM ( .0150)

SDA1.4



## SDA1.5

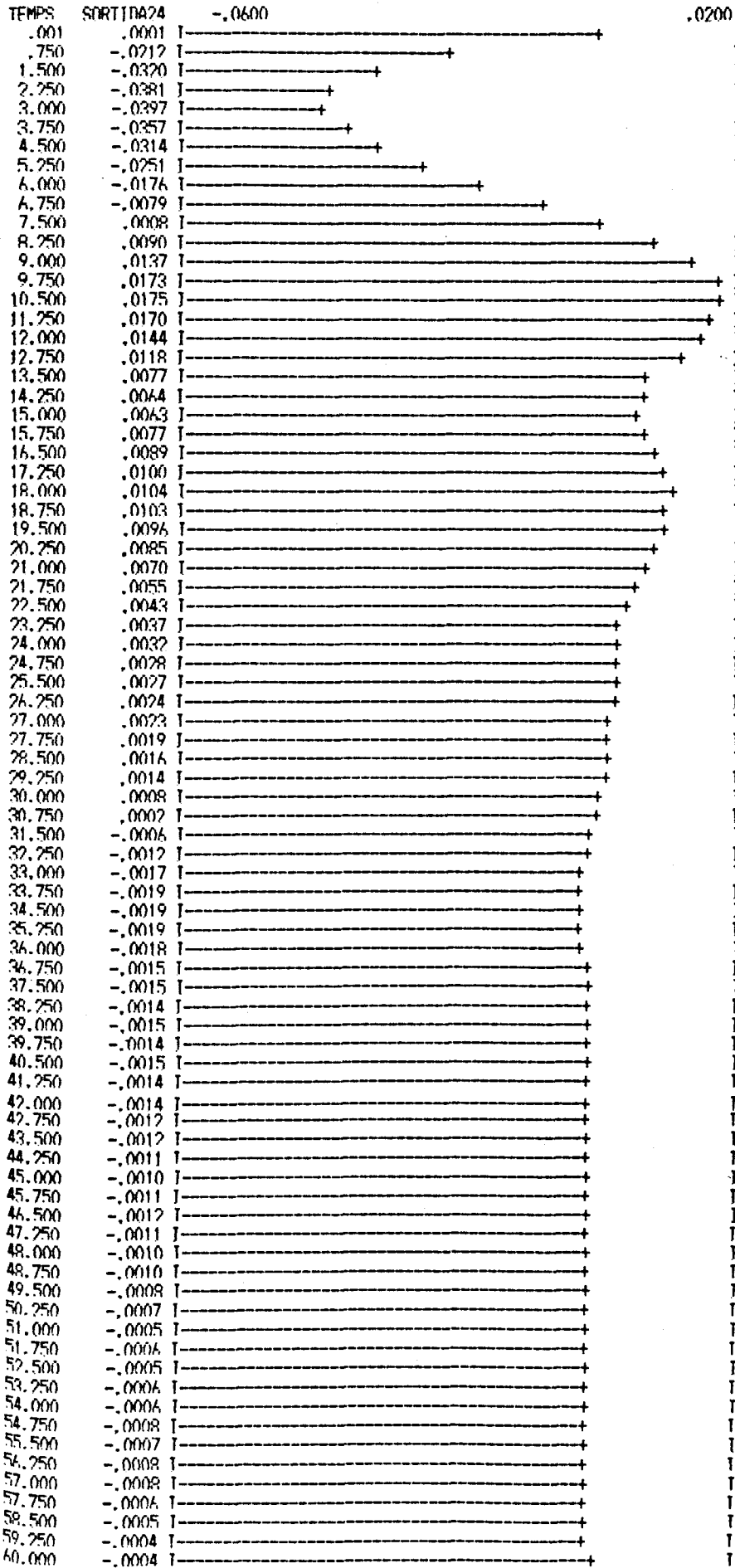
TEMPS	SORTIDA4A	SORTIDA30	SORTIDA55	SORTIDA5A
.00	.0001	.0001	.0001	.0001
2.00	-.0175	-.0334	.0014	.0002
4.00	-.0428	-.0369	.0043	.0003
6.00	-.0657	-.0174	.0057	.0005
8.00	-.0845	.0021	.0059	.0006
10.00	-.0973	.0137	.0061	.0007
12.00	-.1079	.0129	.0065	.0008
14.00	-.1194	.0047	.0067	.0009
16.00	-.1299	.0058	.0068	.0010
18.00	-.1364	.0102	.0069	.0010
20.00	-.1409	.0094	.0071	.0010
22.00	-.1449	.0053	.0072	.0011
24.00	-.1482	.0041	.0073	.0011
26.00	-.1499	.0044	.0073	.0011
28.00	-.1506	.0034	.0074	.0011
30.00	-.1510	.0019	.0074	.0011
32.00	-.1512	.0003	.0074	.0011
34.00	-.1515	-.0008	.0074	.0011
36.00	-.1517	-.0012	.0074	.0011
38.00	-.1518	-.0011	.0074	.0011
40.00	-.1518	-.0013	.0074	.0011
42.00	-.1519	-.0017	.0074	.0011
44.00	-.1521	-.0017	.0074	.0011
46.00	-.1523	-.0015	.0074	.0011
48.00	-.1524	-.0013	.0074	.0011
50.00	-.1526	-.0012	.0074	.0011
52.00	-.1527	-.0011	.0074	.0011
54.00	-.1529	-.0010	.0074	.0011
56.00	-.1530	-.0009	.0074	.0011
58.00	-.1531	-.0007	.0074	.0011
60.00	-.1532	-.0007	.0074	.0011
62.00	-.1532	-.0006	.0074	.0011
64.00	-.1532	-.0006	.0074	.0011
66.00	-.1533	-.0005	.0074	.0011
68.00	-.1533	-.0005	.0074	.0011
70.00	-.1533	-.0005	.0074	.0011
72.00	-.1533	-.0005	.0074	.0011
74.00	-.1533	-.0005	.0074	.0011
76.00	-.1533	-.0004	.0074	.0011
78.00	-.1533	-.0004	.0074	.0011
80.00	-.1533	-.0004	.0074	.0011
82.00	-.1532	-.0003	.0074	.0011
84.00	-.1532	-.0003	.0074	.0011
86.00	-.1532	-.0003	.0074	.0011
88.00	-.1532	-.0003	.0074	.0011
90.00	-.1532	-.0003	.0074	.0011
92.00	-.1532	-.0003	.0074	.0011
94.00	-.1532	-.0002	.0074	.0011
96.00	-.1532	-.0002	.0074	.0011
98.00	-.1532	-.0002	.0074	.0011
100.00	-.1532	-.0002	.0074	.0011
102.00	-.1532	-.0002	.0074	.0011
104.00	-.1532	-.0002	.0074	.0011
106.00	-.1532	-.0002	.0074	.0011
108.00	-.1532	-.0002	.0074	.0011
110.00	-.1532	-.0001	.0074	.0011
112.00	-.1532	-.0001	.0074	.0011
114.00	-.1532	-.0001	.0074	.0011
116.00	-.1532	-.0001	.0074	.0011
118.00	-.1532	-.0001	.0074	.0011
120.00	-.1532	-.0001	.0074	.0011
122.00	-.1532	-.0001	.0074	.0011
124.00	-.1532	-.0001	.0074	.0011
126.00	-.1532	-.0001	.0074	.0011
128.00	-.1532	-.0001	.0074	.0011
130.00	-.1532	-.0001	.0074	.0011
132.00	-.1532	-.0001	.0074	.0011
134.00	-.1532	-.0001	.0074	.0011
136.00	-.1532	-.0001	.0074	.0011
138.00	-.1532	-.0001	.0074	.0011
140.00	-.1532	-.0001	.0074	.0011
142.00	-.1532	-.0001	.0074	.0011
144.00	-.1532	-.0001	.0074	.0011
146.00	-.1532	-.0001	.0074	.0011
148.00	-.1532	-.0001	.0074	.0011
150.00	-.1532	-.0001	.0074	.0011
152.00	-.1532	-.0001	.0074	.0011
154.00	-.1532	-.0001	.0074	.0011
156.00	-.1532	-.0001	.0074	.0011
158.00	-.1532	-.0001	.0074	.0011
160.00	-.1532	.0001	.0074	.0011

SDA2

Repetición de SDD5 cuando las acciones de control en  $kT$  y  $kT + h$  se calculan a partir de las muestras adquiridas en el instante de muestreo anterior  $(k - 1) T$ .

BLDC FIX Y (24) MINIM ( -.0600) MAXIM ( .0200)

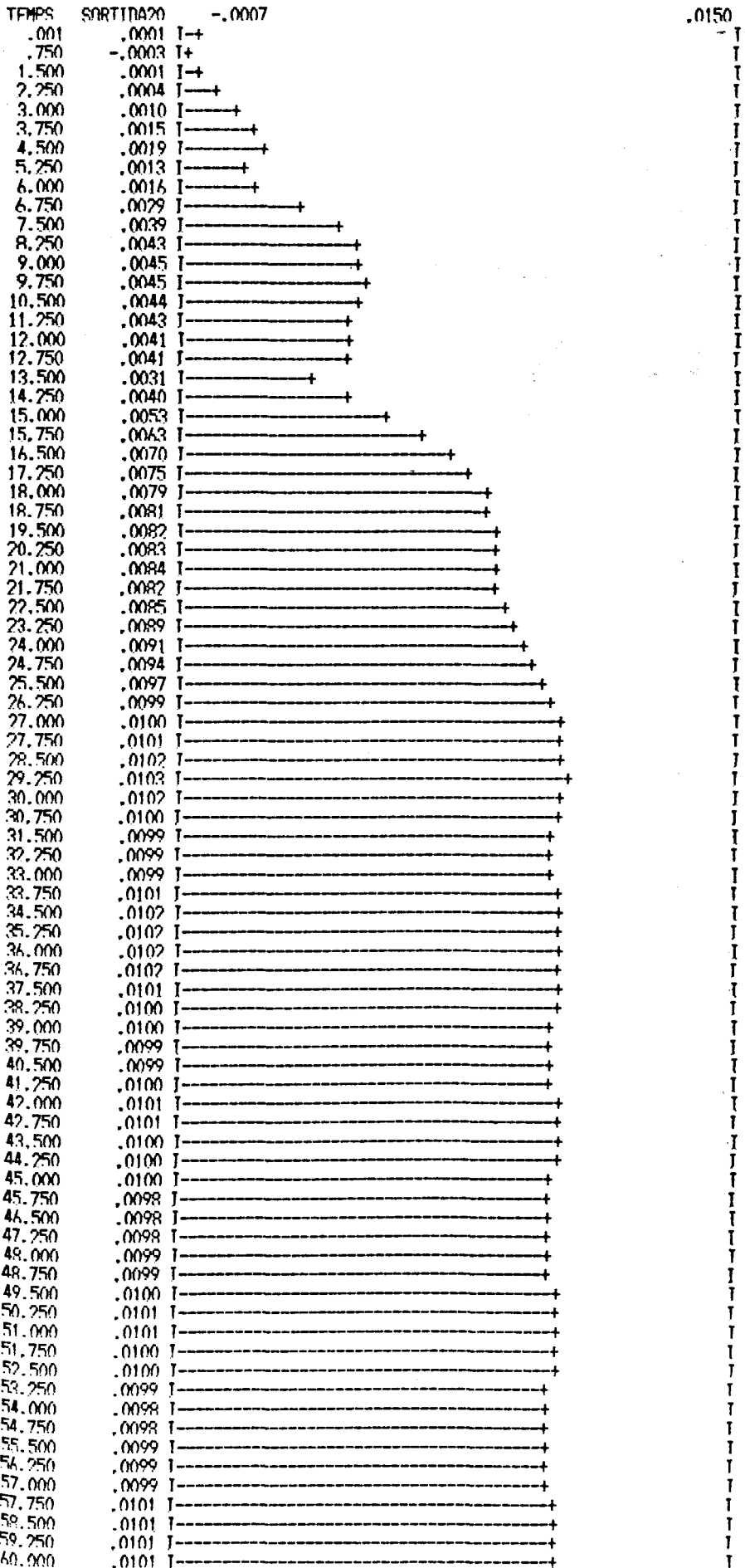
SDA2.1





IFMPS	SORTIDA4A	SORTIDA30	SORTIDA55	SORTIDA56
.00	.0001	.0001	.0001	.0001
2.00	-.0175	-.0334	.0014	.0002
4.00	-.0428	-.0349	.0043	.0003
6.00	-.0658	-.0180	.0057	.0005
8.00	-.0843	.0031	.0059	.0006
10.00	-.0956	.0164	.0062	.0007
12.00	-.1042	.0158	.0068	.0008
14.00	-.1136	.0065	.0071	.0009
16.00	-.1220	.0045	.0072	.0009
18.00	-.1264	.0108	.0074	.0009
20.00	-.1285	.0103	.0076	.0009
22.00	-.1299	.0063	.0078	.0009
24.00	-.1310	.0034	.0078	.0009
26.00	-.1313	.0025	.0078	.0009
28.00	-.1309	.0070	.0078	.0009
30.00	-.1301	.0014	.0078	.0009
32.00	-.1295	-.0009	.0078	.0009
34.00	-.1295	-.0026	.0078	.0009
36.00	-.1296	-.0024	.0079	.0009
38.00	-.1296	-.0017	.0079	.0009
40.00	-.1298	-.0018	.0079	.0009
42.00	-.1301	-.0019	.0079	.0009
44.00	-.1304	-.0015	.0079	.0009
46.00	-.1307	-.0013	.0079	.0009
48.00	-.1311	-.0012	.0079	.0009
50.00	-.1314	-.0008	.0079	.0009
52.00	-.1315	-.0004	.0079	.0009
54.00	-.1316	-.0005	.0079	.0009
56.00	-.1318	-.0008	.0079	.0009
58.00	-.1319	-.0006	.0079	.0009
60.00	-.1318	-.0002	.0079	.0009
62.00	-.1317	-.0005	.0079	.0009
64.00	-.1318	-.0005	.0079	.0009
66.00	-.1317	-.0004	.0079	.0009
68.00	-.1316	-.0003	.0079	.0009
70.00	-.1316	-.0005	.0079	.0009
72.00	-.1316	-.0006	.0079	.0009
74.00	-.1316	-.0004	.0079	.0009
76.00	-.1315	-.0003	.0079	.0009
78.00	-.1315	-.0004	.0079	.0009
80.00	-.1316	-.0004	.0079	.0009
82.00	-.1316	-.0002	.0079	.0009
84.00	-.1315	-.0001	.0079	.0009
86.00	-.1315	-.0003	.0079	.0009
88.00	-.1315	-.0004	.0079	.0009
90.00	-.1315	-.0002	.0079	.0009
92.00	-.1315	-.0001	.0079	.0009
94.00	-.1314	-.0002	.0079	.0009
96.00	-.1315	-.0003	.0079	.0009
98.00	-.1315	-.0001	.0079	.0009
100.00	-.1315	.0001	.0079	.0009
102.00	-.1314	-.0002	.0079	.0009
104.00	-.1315	-.0003	.0079	.0009
106.00	-.1315	-.0001	.0079	.0009
108.00	-.1314	.0001	.0079	.0009
110.00	-.1314	-.0002	.0079	.0009
112.00	-.1315	-.0002	.0079	.0009
114.00	-.1315	.0001	.0079	.0009
116.00	-.1314	.0001	.0079	.0009
118.00	-.1314	-.0002	.0079	.0009
120.00	-.1315	-.0002	.0079	.0009
122.00	-.1315	.0001	.0079	.0009
124.00	-.1314	.0001	.0079	.0009
126.00	-.1314	-.0001	.0079	.0009
128.00	-.1315	-.0002	.0079	.0009
130.00	-.1315	.0001	.0079	.0009
132.00	-.1314	.0001	.0079	.0009
134.00	-.1314	-.0001	.0079	.0009
136.00	-.1315	-.0002	.0079	.0009
138.00	-.1315	.0001	.0079	.0009
140.00	-.1314	.0002	.0079	.0009
142.00	-.1314	-.0001	.0079	.0009
144.00	-.1315	-.0002	.0079	.0009
146.00	-.1315	.0001	.0079	.0009
148.00	-.1314	.0002	.0079	.0009
150.00	-.1314	-.0001	.0079	.0009
152.00	-.1315	-.0002	.0079	.0009
154.00	-.1315	.0001	.0079	.0009
156.00	-.1314	.0002	.0079	.0009
158.00	-.1314	-.0001	.0079	.0009
160.00	-.1315	-.0002	.0079	.0009

RLOC ETX Y (20) MINIM ( -.0007) MAXIM ( .0150)



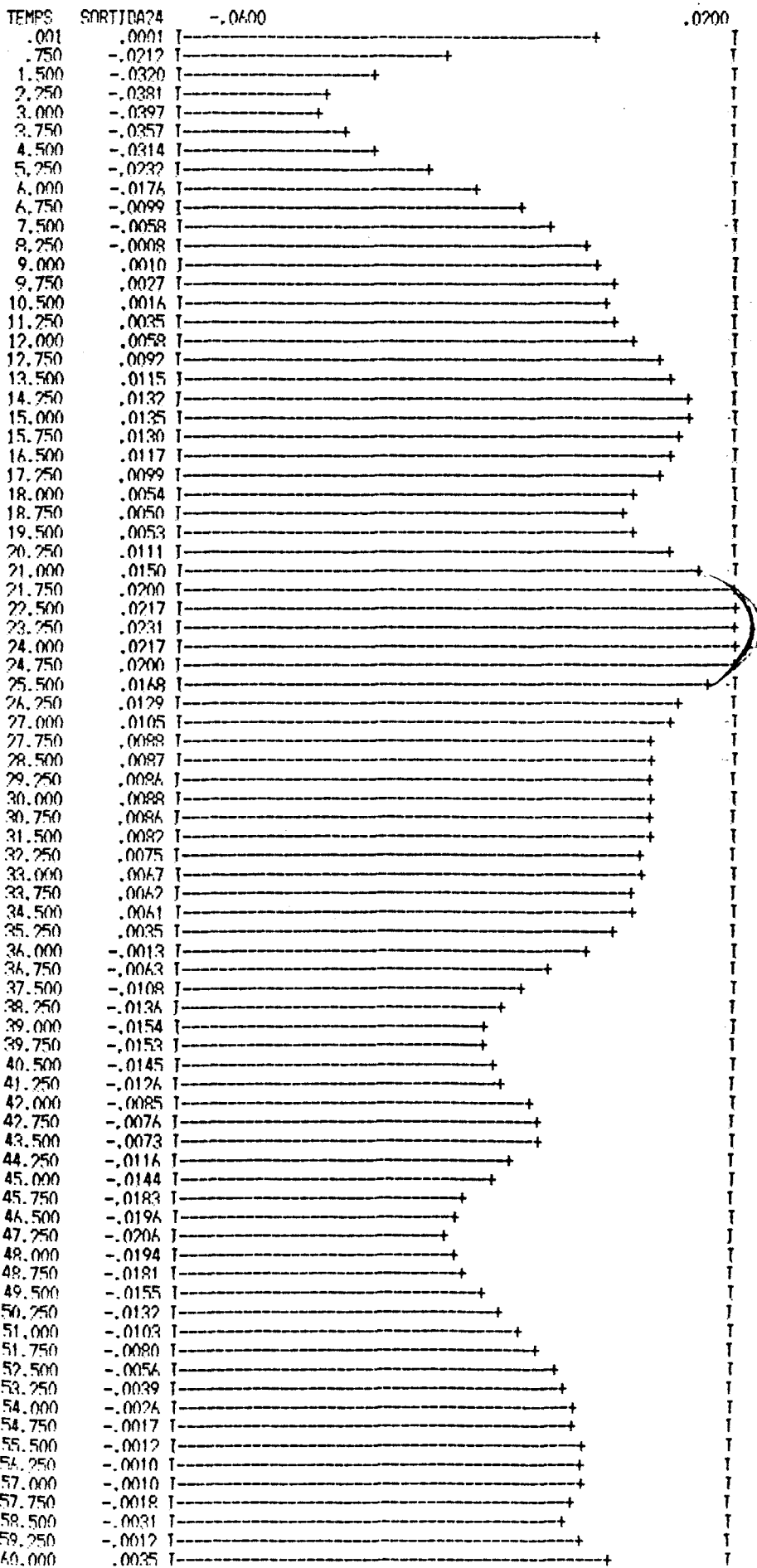
SDA2.3

SDA3

Repetición de SD3 cuando la acción de control en  $kT$  se calcula a partir de los valores muestreados en  $(k - 1) T$ .

BLOC EIX Y (24) MINIM ( -.0600) MAXIM ( .0200)

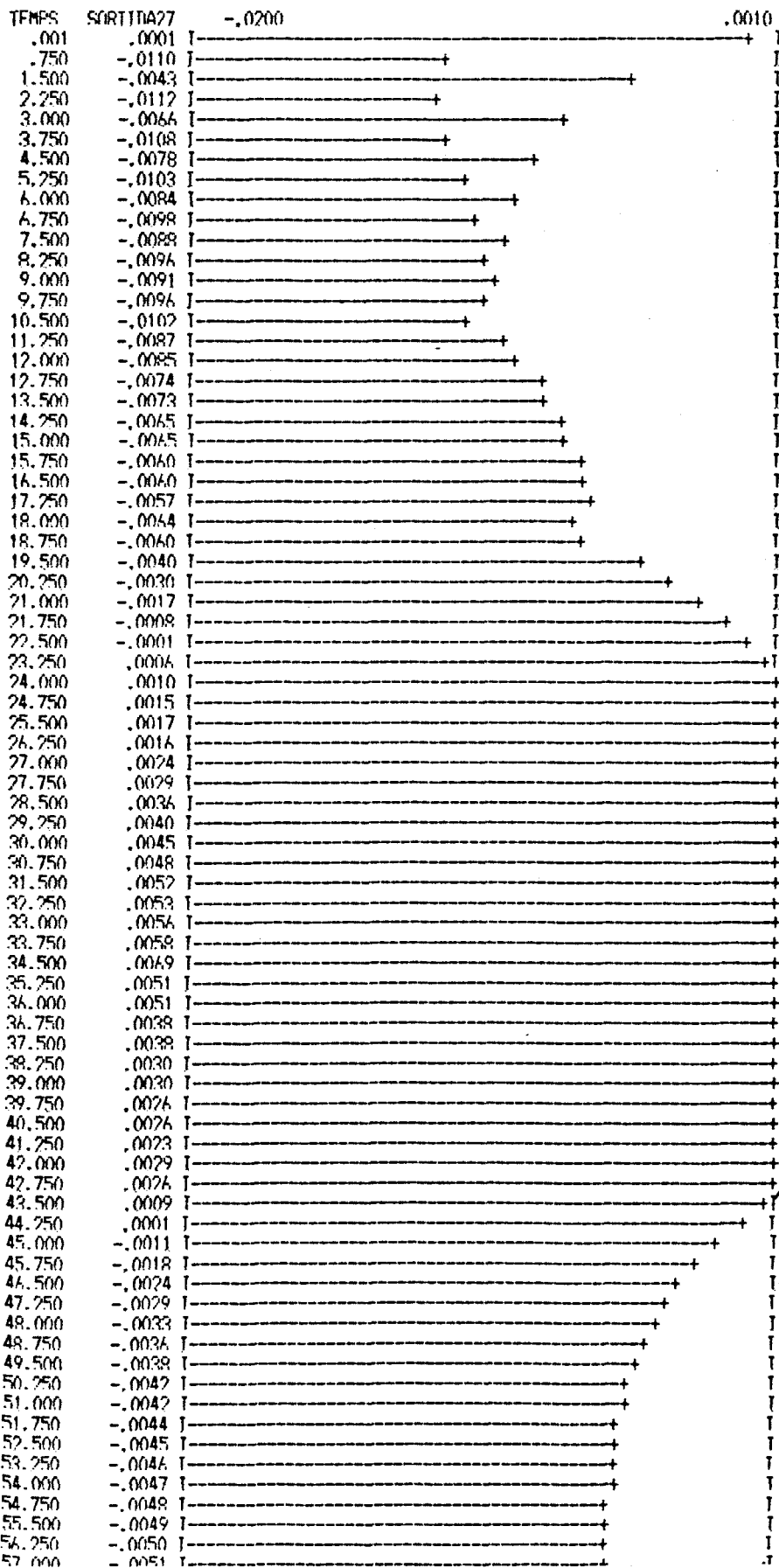
SDA3.1





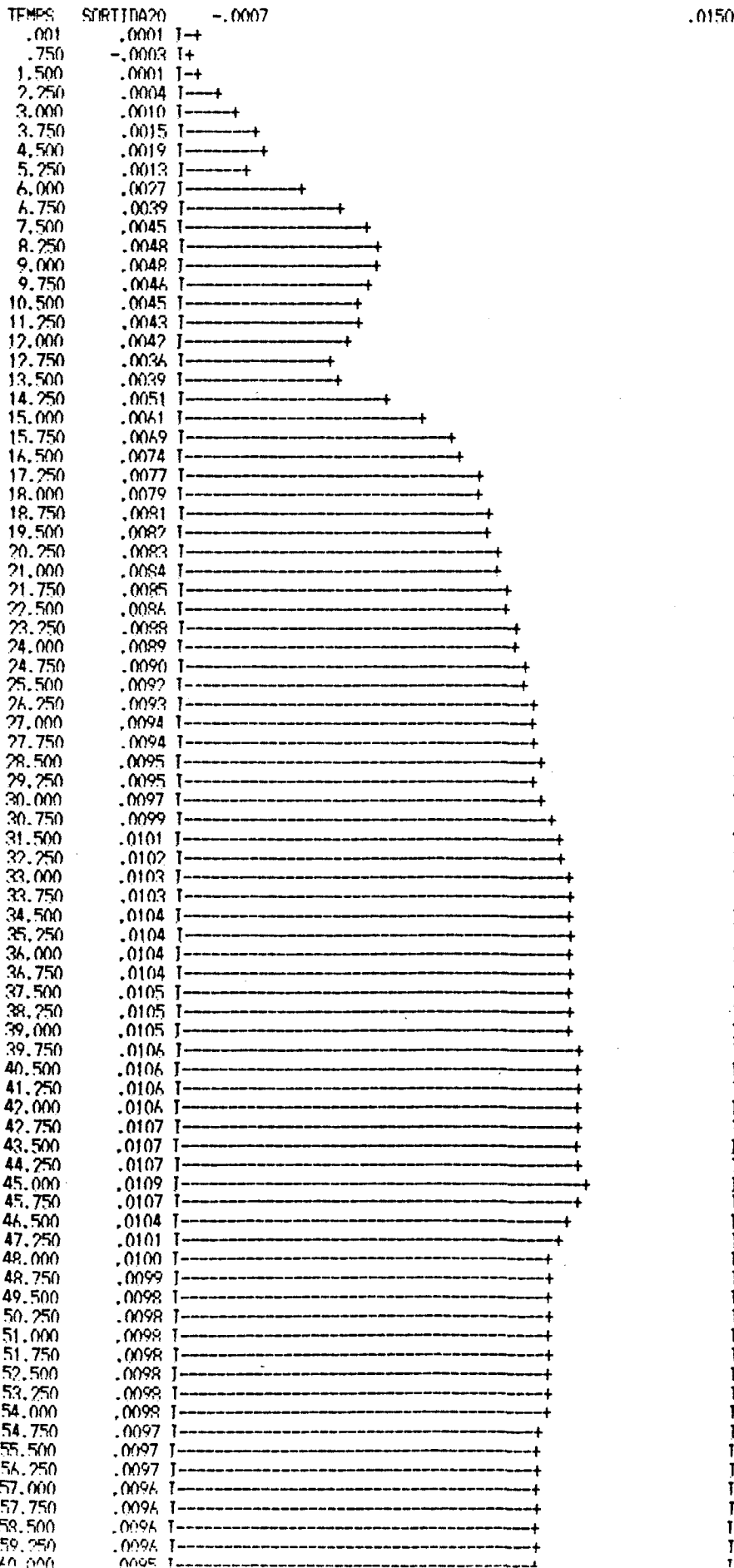
SDA3.3

RUN: FIX V (27) MINIM ( -.0200) MAXIM ( .0010)

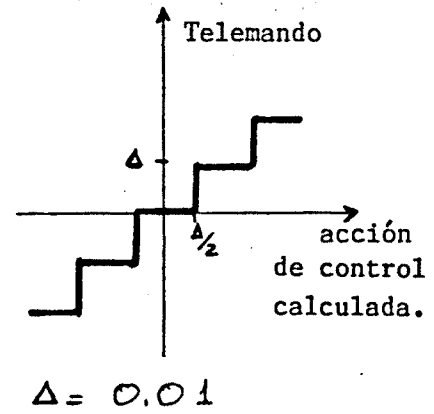


RUC ETX Y (20) MINIM ( -.0007) MAXIM ( .0150)

SL1

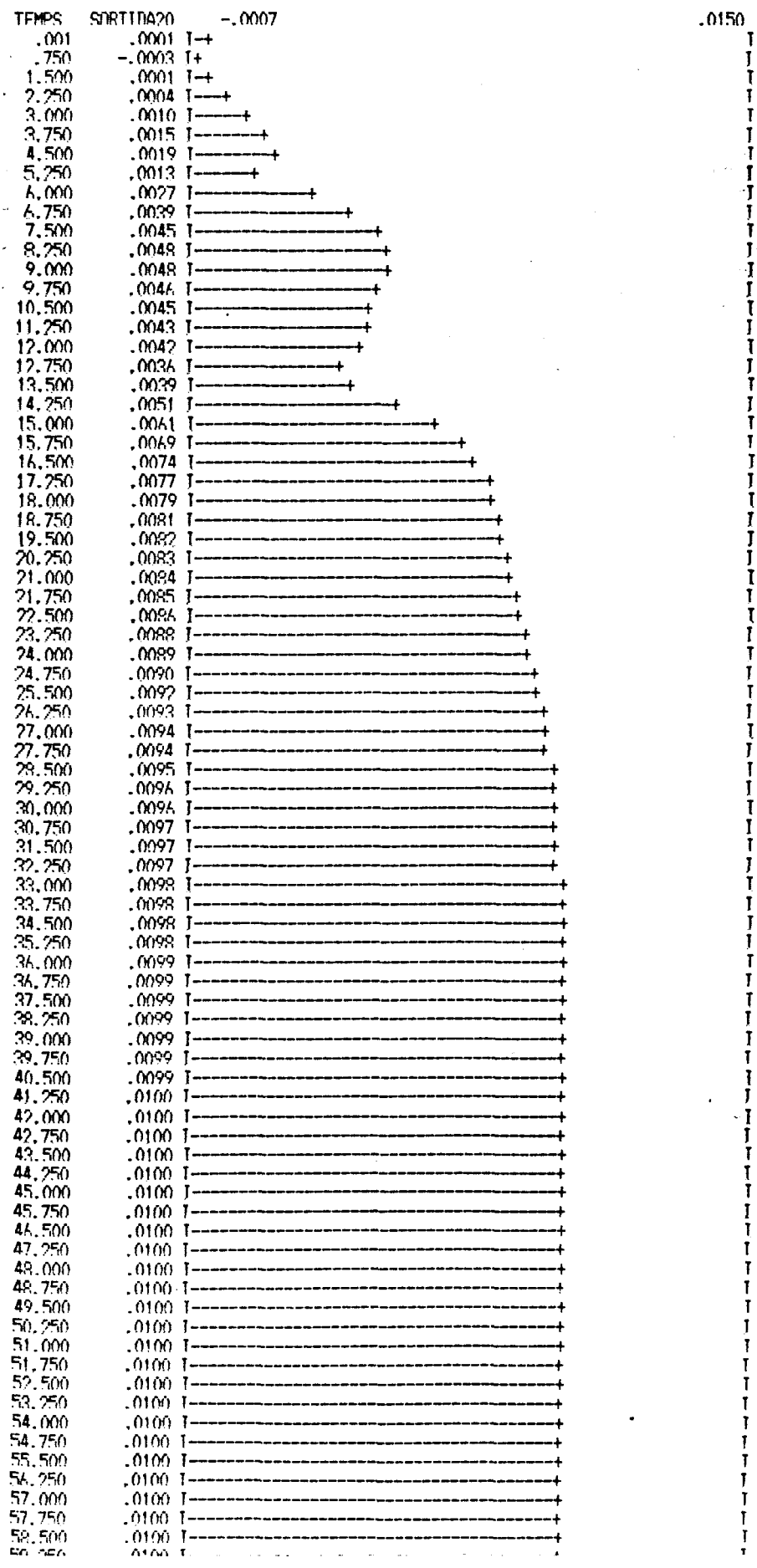


Repetición de SD3 con la limitación de generación  $\mu$  del Capítulo 5 (alinealidad de cuantificación).



SL2

RIG. FTX Y (20) MINIM ( -.0007) MAXIM ( .0150)



Δ = 0.04









