

XIV. MCS-4 EVALUATION KIT USING THE 4001-0009

This kit provides both a convenient way of evaluating the MCS-4 parts and an educational vehicle to better understand the MCS-4 operation. The 4001-009 stores a microprogram that exercises the 4004 and 4002's and executes all of the 45 instructions in the MCS-4 instruction set.

Fig. 33 shows the hardware that should be used. The circuit for single pass/continuous can be omitted if only continuous operation is sought. In this case O_0 (RAM #0) should be connected directly to TEST.

The RESET signal can be provided by either a one-shot circuit or by a pulse generator in the "single pulse" mode. The width of the RESET signal must be at least 32×8 clock periods ($\approx 350 \mu\text{sec}$) to fully clear the RAM storage. If the system is operated in the continuous mode, RESET needs to be applied only at power on. If the system works in the single pass mode, when END of SEQUENCE (Pin O_3) is "1", the 4004 will "hang" on a loop where the address to Jump to on a jump on TEST = 1 condition is the address of the same jump on condition. To get out of the loop RESET must be applied.

To monitor the program operation a scope should be used in the "B delayed by A" mode. By using the delay time multiplier the program execution can be easily seen. The synchronization signals for the B and A traces are pin 13 of 4002-1 #0 and SYNC, pin 8 of the 4004, respectively.

The 4001-0009 has been coded with the internal chip select circuit always activated, therefore any address at A_3 time will cause the 4001 to be selected. This is different from the normal operation of the 4001 where only one code (out of 16) at A_3 time selects the 4001. The reason for doing so is that we can show the execution of JMS and JUN instructions to any chip number (the A_3 time code) and still use only 1 ROM chip.

The I/O pins of the 4001-0009 are all connected as inverting inputs with no resistors connected.

The two phase clocks, (\emptyset_1 and \emptyset_2) must be supplied externally according to the MCS-4 data sheet specs.

The program execution is 110 msec, using a clock period of 1.3 usec.

Although the CM-RAM₁ lines are not used in this configuration, they are being pulsed. If a scope is hooked up to these lines the waveforms may be observed.

Both 4002-1's must be used in order to fully execute the program stored in the ROM.

Attached is the program flow (with comments) and the truth table.

4001-0009 MCS-4 EXERCISER PROGRAM

ROM ADDRESS	MNEMONIC	COMMENTS
0	WRR	Check accumulator and carry
1	BBL, 15	Check stack content
2	FIM, 5	Loan pointer 4002-1 #1
3	4, 1	
4	JMS	Jump to LD MK subroutine. This subroutine is used to mark the progress of the program by sending out a pattern on the output lines of 4002-1 #1.
5	(LD MK)	
6	JMS	Jump to CK IDX subroutine
7	(CK IDX)	(Checks the content of all index register locations)
8	FIN 0	Load FIN address
9	254	
10	JMS	Jump to CK FIN subroutine.
11	(CK FIN)	(Loads all index register locations with the data stored in location 254)
12	JMS	
13	(CK IDX)	
14	JMS	Loads all index register locations with the data stored in location 255.
15	(CK FIN)	
16	JMS	
17	(CK IDX)	
18	FIM, 5	Restore pointer 4002-1 #1
19	4, 2	
20	JMS 15	
21	255	Location 255 contains NOP, program counter is incremented to 0; 0; 0
22	JMS 7	
23	26	
24	JUN 8	This portion of the program is used to check JMS and JUN instructions and load the stack with a checkerboard.
25	36	
26	JMS 15	
27	255	
28	JMS 3	
29	32	
30	JUN 12	
31	24	
32	JMS 15	
33	255	
34	JUN 15	
35	255	
36	FIM 1	
37	12, 11	
38	CLB	
39	SRC 5	Reset marker outputs on 4002-1 #1
40	WMP	
41	SRC 0	Send pointer to 4002-1 #0
42	WRM	
43	IAC	Go to next character
44	ISZ 1	
45	41	
46	WR0	
47	IAC	This portion of the program is used to load a checkerboard into 4002-1 #0.
48	WRL	
49	IAC	
50	WR2	
51	IAC	
52	WR3	
53	INC 0	Go to next register
54	ISZ 2	
55	41	
56	STC	

ROM ADDRESS	MNEMONIC	COMMENTS	
57	JMS	CK DCL subroutine is used to check CM-RAM lines switching.	
58	(CK DCL)		
59	ISZ 3	5 times 1, 5, 9 6 2 3 4, 8 7 10	
60	57		
61	SRC 2		
62	STC		
63	RAL		
64	WMP		
65	JCN CY=0		
66	71		
67	JCN A ≠ 0		
68	79		
69	JCN T=1	Pointer to 4002-1 #0 This section is used to check the jump on condition instruction. The numbers refer to the sequence to which the jumps occur. Load address for following JIN	
70	80		
71	JCN CY=1		
72	80		
73	JCN A=0		
74	82		
75	JCN T=0		
76	67		
77	JUN 0		
78	69		
79	CLB	Restore 4002-1 #0 pointer	
80	JUN 0		
81	63		
82	FIM 6		
83	102		
84	FIM 7		
85	89		
86	FIM 0		
87	0 0		
88	JIN 6		Check Add Load markers
89	SRC 0		
90	ADD 4		
91	ADD 5		
92	WRM		
93	RAR		
94	ISZ 4		
95	89		
96	ISZ 5		
97	89		
98	JMS	Load markers Check SUB instruction	
99	(LD MK)		
100	JUN 0		
101	117		
102	JMS		
103	(LD MK)		
104	SRC 0		
105	SUB 4		
106	SUB 5		
107	WRM		
108	CLB		
109	ISZ 4	Clear Markers	
110	104		
111	ISZ 5		
112	104		
113	CLB		
114	SRC 5		
115	WMP		
116	JIN 7		
117	STC		
118	INC 8		Check INC, LD, XCH, DAA instructions
119	LD 8		
120	WRM		
121	XCH 9		
122	LD 9		
123	WRR		
124	DAA		
125	WRM		
126	ISZ 4		
127	117		
128	CLB	Check DAC, KBP instructions	
129	DAC		
130	WRM		
131	KBP		
132	WRM		
133	ISZ 4		
134	129		
135	CLB		
136	DAA		Check DAA, IAC instructions
137	WRM		
138	IAC		
139	ISZ 4		
140	136		

ROM ADDRESS	MNEMONIC	COMMENTS
→ 141	LDM 15	Check TCC instruction
142	WRM	
143	TCC	
144	WRM	
145	JCN A ≠ 0	
146	141	Clear markers
147	CLB	
148	SRC 5	
149	WMP	
150	LDM 15	Check TCS instruction
151	TCS	
152	WRM	Check TCC, CMC, RAR instructions
153	STC	
154	TCS	
155	WRM	
→ 156	CMC	
157	RAR	
158	WRM	
159	ISZ 4	Read content of all memory locations
160	156	
161	FIM 2	
162	12 0	
→ 163	SRC 0	
164	RDM	
165	ISZ 1	
166	163	
167	RDØ	
168	RD1	
169	RD2	
170	RD3	
171	INC 0	Check SBM instruction
172	ISZ 4	
173	163	
174	FIM 0	
175	2 0	
176	FIM 1	
177	3 0	
→ 178	SRC 0	
179	SBM	
180	INC 1	
181	SRC 1	
182	SBM	
183	WRM	
184	ISZ 3	
185	178	Check ADM instruction
186	FIM 0	
187	0 0	
188	FIM 0	
189	1 0	
190	CLB	
191	SRC 5	
192	WMP	
→ 193	SRC 0	
194	ADM	
195	INC 1	
196	SRC 1	
197	ADM	
198	WRM	
199	ISZ 3	
200	193	This portion controls the cycle. Status character Ø stores the cycle number. At the end of the 2nd cycle, if pin 13 of the 4002-1 #0 is connected to test of the 4004, the program will stop. To start again RESET signal must be applied to the system (single pass operation). If pin 13 is not connected to TEST the program will be in continuous mode.
201	SRC 5	
202	RDØ	
203	JCN A=0	
204	215	
205	LDM 8	
206	SRC 0	
207	WMP	
208	CLB	
209	SRC 5	
210	WRØ	
→ 211	JCN T=1	
212	211	
213	JUN 0	
214	2	
→ 215	IAC	
216	WRØ	
217	LDM 2	
218	SRC 0	
219	WMP	
220	JUN 0	
221	2	

SUBROUTINES

	222	SRC 5
	223	LD 11
	224	CLC
LD MK	225	WMP
	226	RAL
	227	XCH 11
	228	BBL, 0
	229	SRC 0
	230	SRC 1
	231	SRC 2
CK IDX	232	SRC 3
	233	SRC 4
	234	SRC 5
	235	SRC 6
	236	SRC 7
	237	BBL, 0
	238	FIN 1
	239	FIN 2
	240	FIN 3
	241	FIN 4
CK FIN	242	FIN 5
	243	FIN 6
	244	FIN 7
	245	FIN 0
	246	BBL, 0
	247	LD 4
	248	RAL
CK DCL	249	DCL
	250	XCH 4
	251	RDR
	252	BBL, 0
	253	NOP
Data	254	1111 1111
	255	0000 0000 (NOP)