

Loading Basic with the 88-4PIO Board

Including support for the Oliver Audio Engineering OP-80 Paper Tape Reader

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Standard 88-4PIO Bootstrap Loader

Below is the standard Altair Basic 3.X and 4.X 88-4PIO bootstrap loader, to be toggled in via the front panel.

Important 88-4PIO Bootstrap Loader notes:

1. This loader will fail if the reader generates any strobe pulses on the parallel port interface before the data load. For example, it is common for a paper tape reader to generate strobe pulses while loading paper tape into the reader. (See the next section for an improved bootstrap loader.)
2. The byte at bootstrap loader address 012 changes with the version of Basic.
3. The byte at bootstrap loader address 013 changes for different sizes of Basic.
4. Basic 3.X uses the same port for loading Basic as it does for the Basic console. This makes loading Basic 3.X from a stand-alone paper tape reader tricky.
5. The "leader" portion of the paper tape should be positioned in the reader before running the bootstrap loader. The leader is octal 256 for Basic 3.X, and octal 302 for Basic 4.X and later. (Paper tapes often have several inches of nulls before the leader. Nulls have only the sprocket holes punched.)
6. The sense switches are set differently depending on the version of Basic. See below.

Octal Address	Octal Data	Mnemonic	Comment
000	257	XRA A	
001	323	OUT CTRL0A	Clear control register
002	040		
003	323	OUT DDR0A	Set all bits for input
004	041		
005	076	MVI A,054	
006	054		
007	323	OUT CTRL0A	Set up port control signals
010	040		
011	041	LXI H,LADDR	
012	302	(256 for Basic 3.X, 302 for Basic 4.X and later)	
013	037	(017 for 4K, 037 for 8K, 077 for Extended Basic)	
014	061	LXI SP,STACK	Used for the following return instructions
015	033		
016	000		
017	333	IN STAT0A	Data available?
020	040		
021	007	RLC	Put status bit into carry
022	330	RC	No data: keep waiting
023	333	IN DATA0A	Get data byte
024	041		
025	275	CMP L	Leader?
026	310	RZ	Y: Ignore a leader byte
027	055	DCR L	Next memory address
030	167	MOV M,A	Write data byte into memory
031	300	RNZ	Done loading bootstrap loader?
032	351	PCHL	Y: Execute loaded code
033	014		Return address on the stack
034	000		

Improved 88-4PIO Bootstrap Loader

The 88-4PIO will latch and hold its input-port data until the input port is read by software. It is common for the 88-4PIO's data latch to contain a garbage data byte that was generated, for example, by loading paper tape into the reader. (It is nearly impossible not to create a garbage byte while setting up an OP-80 paper tape reader.)

If the 88-4PIO input port does contain a garbage byte at the beginning of the load, then the load will fail – since the MITS bootstrap loader will interpret the garbage byte as the first byte of the paper tape data.

The simple solution (implemented in the following bootstrap loader) is for the bootstrap loader to perform one read of the 88-4PIO data port during its initialization phase, to clear out any potential garbage data. This improvement should work for any device that is attached to the 88-4PIO.

Important notes for this modified 88-4PIO Bootstrap Loader

1. The byte at bootstrap loader addresses 014 changes with the version of Basic.
2. The byte at bootstrap loader address 015 changes for different sizes of Basic.
3. Basic 3.X uses the same port for loading Basic as it does for the Basic console. This makes loading Basic 3.X from a stand-alone paper tape reader tricky.
4. Position the "leader" of the paper tape in the reader before running the bootstrap loader. The leader is octal 256 for Basic 3.X, and octal 302 for Basic 4.X and later. (Paper tapes often have several inches of nulls before the leader. Nulls have only the sprocket holes punched.) For an OP-80 reader, position the tape such that the optical sensors are blocked by paper tape (between holes in the leader) before running the bootstrap loader.
5. Set the sense switches for loading from the 88-4PIO, before running the bootstrap loader. See below.

Octal Address	Octal Data	Mnemonic	Comment
000	257	XRA A	
001	323	OUT CTRL0A	Clear control register
002	040		
003	323	OUT DDR0A	Set all bits for input
004	041		
005	076	MVI A,054	
006	054		
007	323	OUT CTRL0A	Set up port control signals
010	040		
011	333	IN DATA0A	Flush data port
012	041		
013	041	LXI H,LADDR	
014	302 (256 for Basic 3.X, 302 for Basic 4.X and later)		
015	037 (017 for 4K, 037 for 8K, 077 for Extended Basic)		
016	061	LXI SP,STACK	Used for the following return instructions
017	033		
020	000		
021	333	IN STAT0A	Data available?
022	040		
023	007	RLC	Put status bit into carry
024	330	RC	No data: keep waiting
025	333	IN DATA0A	Get data byte
026	041		
027	275	CMP L	Leader?
030	310	RZ	Y: Ignore a leader byte
031	055	DCR L	Next memory address
032	167	MOV M,A	Write data byte into memory

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033	300	RNZ	Done loading bootstrap loader?
034	351	PCHL	Y: Execute loaded code
035	016		Return address on the stack
036	000		

Basic 3.X Sense Switch Settings

The Basic 3.X loader uses the same port for loading Basic and for the Console.

Load & Console	A15	A14	A13	A12	A11	A10	A9	A8
88-SIOA,B,C (not rev 0)	0	0	0	0	0	0	0	0
88-SIOA,B,C (rev 0)	0	1	0	0	0	0	0	0
88-PIO	0	0	1	0	0	0	0	0
88-4PIO	0	0	0	1	0	0	0	0
88-2SIO-0 (1 stop bit)	0	0	0	0	1	1	0	0
88-2SIO-0(2 stop bits)	0	0	0	0	1	0	0	0

Basic 4.X Sense Switch Settings

The Basic 4.X loader makes a distinction between the Load Source and the Console Device, allowing you to load from one device, and use another for the Basic console.

Load Source	A11	A10	A9	A8	Console Device	A15	A14	A13	A12
88-2SIO-0 (2 stop bits)	0	0	0	0	88-2SIO-0 (2 stop bits)	0	0	0	0
88-2SIO-0 (1 stop bit)	0	0	0	1	88-2SIO-0 (1 stop bit)	0	0	0	1
88-SIO	0	0	1	0	88-SIO	0	0	1	0
88-ACR	0	0	1	1	(not allowed)	0	0	1	1
88-4PIO	0	1	0	0	88-4PIO	0	1	0	0
88-PIO	0	1	0	1	88-PIO	0	1	0	1
HSR	0	1	1	0	(not allowed)	0	1	1	0

Basic 4.X Loader Error Messages

Error Code	Meaning
C	Checksum error. Bad tape data.
M	Memory error. Data won't store properly.
O	Overlay error. Attempt to overwrite checksum loader.
I	Invalid Load source. Illegal sense -switch setting.

Basic 4.X Initialization Dialog

4K Basic

MEMORY SIZE? (<RETURN> to use all memory. Basic uses 3.4K.)
 TERMINAL WIDTH? (<RETURN> for 72 columns)
 SIN? (Y saves SIN, SQR and RND. N deletes SIN and brings next question.)
 SQR? (Y saves SQR and RND. N deletes SQR and brings next question.)
 RND? (Y saves RND, N deletes RND.)

8K Basic

MEMORY SIZE? (<RETURN> to use all memory. Basic uses 6.2K.)
 TERMINAL WIDTH? (<RETURN> for 72 columns)
 WANT SIN-COS-TAN-ATN? (Y or N)

Extended Basic

MEMORY SIZE? (<RETURN> to use all memory. Basic uses 14.6K.)
 LINEPRINTER? (O for 80LP, C for C700, Q for Q70)
 WANT SIN-COS-TAN-ATN? (Y or N)

Connecting the OP-80 to the 88-4PIO

The OP-80 has just one configuration jumper, that selects either active-high or active-low acknowledge. This jumper should be set for active-low acknowledge, since the CA2 output from the 88-4PIO is set up to be active low.

Connect the OP-80 to the 88-4PIO via a DB25 connector set on the back of the Altair, as follows. The wire colors for the 88-PIO are just suggestions. The wire colors for the OP-80 are those found on its rainbow ribbon cable.

88-4PIO			DB25	OP-80		
MC6820 function	Pin	Wire color	Pin	Wire Color	Pin	Function
N/C			1	Orange	7	RDA
CA1	1	Brown	2	Brown	6	/RDA
CA2	2	Orange	3	White	5	/ACK
PA0	3	Green	4	Brown	1	D0
PA1	4	Violet	5	Red	16	D1
GND	5	White	6	Green	8	Ground
Vcc	6	Brown	7	Blue	9	+5V
GND	7	Orange	8			
GND	8	Green	9			
DO6	9	Violet	10			
DO7	10	White	11			
CB1	11	Brown	12			
CB2	12	Orange	13			
PA2	24	Red	14	Orange	2	D2
PA3	23	Yellow	15	Yellow	15	D3
PA4	22	Blue	16	Green	3	D4
PA5	21	Gray	17	Blue	14	D5
PA6	20	Black	18	Violet	4	D6
PA7	19	Red	19	Grey	13	D7
PB0	18	Yellow	20	Yellow	10	S1
PB1	17	Blue	21	Red	11	S2
PB2	16	Gray	22	Black	12	SPARE
PB3	15	Black	23			
PB4	14	Red	24			
PB5	13	Yellow	25			

- Pins 5 and 6 of the 88-4PIO's 24-pin connectors are connected to ground and +5V on the 88-4PIO, though these connections are not documented in any version of the 88-4PIO manual. They are, however, documented in the description of the 88-4PIO that is included on page 111 in the 88-HDSK "Preliminary Documentation" (October, 1977)
- Since Basic 3.X uses the same port for loading Basic as it does for the console, the OP-80 (or any stand-alone paper tape reader) is not practical for loading Basic 3.X. However, the OP-80 works great for loading Basic 4.X.
- Pull the paper tape through the OP-80 at about 2 feet per second. A crank-driven paper tape winder is an excellent addition to the OP-80.