

Loading Basic with the 88-PIO Board

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

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Corrected 12 Jul 2013. Corrected and enhanced 15 Dec 2019.

Standard 88-PIO Bootstrap Loader

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

Important 88-PIO Bootstrap Loader notes:

1. The 88-PIO bootstrap loader in the Basic 4.0 manual is incorrect. The correction is noted below.
2. 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.)
3. MITS changed the standard address of the 88-PIO between Basic 3.X and Basic 4.X. For Basic 3.X, the 88-PIO base address is 000. For Basic 4.X and later, the 88-PIO base address is 004. You must set up the 88-PIO hardware correctly for the version of Basic that you plan to load.
4. The bytes at bootstrap loader addresses 001, 004, and 014 all change with the version of Basic.
5. The byte at bootstrap loader address 002 changes for different sizes of Basic.
6. 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.
7. 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.)
8. The sense switches are set differently depending on the version of Basic. See below.

Octal Address	Octal Data	Mnemonic	Comment
000	041	LXI H,LADDR	Checksum Loader last address
001	302 (256 for Basic 3.X, 302 for Basic 4.X and later)		
002	037 (017 for 4K, 037 for 8K, 077 for Extended Basic)		
003	061	LXI SP,STACK	Used for the following return instructions
004	023		
005	000		
006	333	IN PSTAT	Get 88-PIO status
007	004 (000 for Basic 3.X, 004 for Basic 4.X and later)		
010	346	ANI PDAVAIL	Any received data available?
011	002 <---Altair Basic 4.0 manual had incorrect 001 here		
012	310	RZ	No: loop back to address 003
013	333	IN PDATA	Get 88-PIO data
014	005 (001 for Basic 3.X, 005 for Basic 4.X and later)		
015	275	CMP L	Is this a leader byte?
016	310	RZ	Yes: loop back to address 003
017	055	DCR L	Next address, set Z flag if done
020	167	MOV M,A	Write data to memory
021	300	RNZ	Loop back to address 003 unless done
022	351	PCHL	Jump to loaded checksum loader
023	003		Local stack address for above returns
024	000		

Improved 88-PIO Bootstrap Loader

The 88-PIO will latch and hold its input-port data until the input port is read by software. It is common for the 88-PIO'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-PIO 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-PIO 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-PIO.

Important notes for this modified 88-PIO Bootstrap Loader

1. MITS changed the standard address of the 88-PIO between Basic 3.X and Basic 4.X. For Basic 3.X, the 88-PIO base address is 000. For Basic 4.X and later, the 88-PIO base address is 004. You must set up the 88-PIO hardware correctly for the version of Basic that you plan to load.
2. The bytes at bootstrap loader addresses 001, 004, 011 and 016 all change with the version of Basic.
3. The byte at bootstrap loader address 002 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.) 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.
6. Set the sense switches for loading from the 88-PIO, before running the bootstrap loader. See below.

Octal Address	Octal Data	Mnemonic	Comment
000	041	LXI H,LADDR	Checksum Loader last address
001	302 (256 for Basic 3.X, 302 for Basic 4.X and later)		
002	037 (017 for 4K, 037 for 8K, 077 for Extended Basic)		
003	333	IN PDATA	Read 88-PIO data to clear OP-80
004	005 (001 for Basic 3.X, 005 for Basic 4.X and later)		
005	061	LXI SP,STACK	Used for the following return instructions
006	025		
007	000		
010	333	IN PSTAT	Get 88-PIO status
011	004 (000 for Basic 3.X, 004 for Basic 4.X and later)		
012	346	ANI PDAVAIL	Any received data available?
013	002		
014	310	RZ	No: loop back to address 003
015	333	IN PDATA	Get 88-PIO data
016	005 (001 for Basic 3.X, 005 for Basic 4.X and later)		
017	275	CMP L	Is this a leader byte?
020	310	RZ	Yes: loop back to address 003
021	055	DCR L	Next address, set Z flag if done
022	167	MOV M,A	Write data to memory
023	300	RNZ	Loop back to address 003 unless done
024	351	PCHL	Jump to loaded checksum loader
025	003		Local stack address for above returns
026	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-PIO

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 BIN output from the 88-PIO is active low.

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

88-PIO				DB25	OP-80		
Function	8212 function	Pin	Wire color	Pin	Wire Color	Pin	Function
N/C				1	Orange	7	RDA
SBI	H STB	19	Orange/black	2	Brown	6	/RDA
BIN	H /INT	20	White	3	White	5	/ACK
DI0	H DI0	11	Brown	4	Brown	1	D0
DI1	H DI1	12	Red	5	Red	16	D1
Ground		Note 1	Green/black	6	Green	8	Ground
Vcc		Note 1	Blue/black	7	Blue	9	+5V
				8			
				9			
DO6	G DO6	7	Grey/black	10			
DO7	G DO7	8	Pink	11			
SBO	G STB	9	Light Blue	12			
BO	G /INT	10	Light Green	13			
DI2	H DI2	13	Orange	14	Orange	2	D2
DI3	H DI3	14	Yellow	15	Yellow	15	D3
DI4	H DI4	15	Green	16	Green	3	D4
DI5	H DI5	16	Blue	17	Blue	14	D5
DI6	H DI6	17	Violet	18	Violet	4	D6
DI7	H DI7	18	Grey	19	Grey	13	D7
DO0	G DO0	1	Yellow/black	20	Yellow	10	S1
DO1	G DO1	2	Red/black	21	Red	11	S2
DO2	G DO2	3	Black	22	Black	12	SPARE
DO3	G DO3	4	Brown/black	23			
DO4	G DO4	5	Violet/black	24			
DO5	G DO5	6	White/black	25			

Note 1: The 88-PIO (amazingly) has no ground pin on its interface. (See page 12 of the 88-PIO manual.) Because the OP-80 is powered by the interface, it is necessary to provide both ground and regulated +5V to the DB25, from the 88-PIO. You can do this (without damaging the 88-PIO board) by tack-soldering a 3-pin connector onto the back of the 88-PIO board, at the top, where the +5V trace is parallel to the ground trace. (Use a 3-pin connector so that you can key it, to prevent connecting it the wrong way.) Then put a mating connector on the wires from DB25 pins 06 and 08, and plug this connector into the one that you installed on the 88-PIO.

- 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.