88-2SIOJP

Dual Serial Port with Jump-Start and PROM

User's Guide

Rev H PC Boards

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Revision History

Manual	PCB	Date	Author	Notes
6.00	H	14 APR 2022	M. Eberhard	Separate manual version for Rev H boards. • Added assembly and test instructions • Redrew schematics for improved clarity • Describe configuration options (see below) Major changes with Rev H board: • Eliminate rev G rework • Add support for 2764 & 27128 EPROMs & 8K EEPROMs • Change polarity of jump-start address switches, to be consistent with other switches • Relocate several components for improved layout • Relocate options within DIP switches for clarity • Move Phantom enable from a jumper to a DIP switch • Renumber all components, and change IC's from A-B-C-style numbering to U1-U2-U3-style • Put most component values on the silkscreen • Define configuration options: current loop, open collector output, and turnkey support
6.01	H	13 AUG 2022	M. Eberhard	Correct typos on DIP switch locations
6.02	H	7 NOV 2022	M. Eberhard	Correct BOM error
6.03	H	10 JUN 2023	M. Eberhard	Correct J1 settings in Standard Configuration on page 6. Correct J16 assignments on page 24.
6.04	H	17 NOV 2023	M. Eberhard	Fix typo for U1 component
6.05	H	28 JAN 2024	M. Eberhard	Change U24 from a 74LS00 to a 74LS132, to tolerate some glitches on Phi2 signal, from the S-100 bus
6.06	H	29 JAN 2024	M. Eberhard	Correct a few typos. (Thanks Bill!)
6.07	H	11 FEB 2024	M. Eberhard	Correct a more few typos.

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OVERVIEW

The 88-2SIOJP is an enhanced dual serial port board designed for the MITS Altair and compatible computers. It can fully replace the following MITS boards, adding significant functionality to each:

- 88-2SIO dual serial port
- 8800b Turnkey Module
- RMB-II Extended ROM Basic Module with Turnkey support

The 88-2SIOJP provides the following functions:

1. Two serial ports that are software and hardware compatible with the MITS 88-2SIO, with some important enhancements
2. One EPROM/EEPROM socket, providing 2K-bytes to 16K-bytes of non-volatile storage, with write capability for EEPROMs
3. Options for either MITS ROM Basic or Amon (a full-feature ROM monitor that includes all MITS loaders)
4. Altair-compatible automatic EPROM disable, allowing software (such as MITS Disk Basic) to have a full 64K-bytes[1] of RAM
5. Power-on/reset jump-start that is compatible with memory boards (such as all MITS memory boards) that do not support the S-100 PHANTOM signal, as well as memory boards that do support PHANTOM
6. Improved power-on clear circuit, eliminating the need to toggle the Stop and Reset switches on the Altair 8800 and 8800a
7. Compatible with both 8080 and Z-80 CPU boards, up to 4 MHz
8. Optional support for computers with no front panel ("Turnkey" computers)

Design Philosophy

The 88-2SIOJP was designed using only components that were available when the Altair was still being sold. It uses no surface-mount components and no newer integrated circuits[2]. The PC board is a 2-layer board with no fine-line traces. For this reason, an 88-2SIOJP in an original Altair looks very authentic.

Although the PC board was laid out using a relatively modern CAD system, it was entirely hand-routed, using PC board design rules that were achievable in the days of the Altair - nothing smaller than 15 mil traces, 10 mil gaps, 24 mil holes, or 24 mil annular rings.

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[1] The full address range of an Altair is 65,536 bytes. This is abbreviated as 64K here, since it is 1K (1024 bytes) times 64. (65,536 bytes is sometimes referred to as 65K.)

[2] The exception is the EPROM: to fit all of MITS Basic into the available space, a 28-pin 27128 EPROM was necessary. (The MITS RMB-II used eight 2Kx8 PROMs for Basic.)

Experience has shown that early S-100 boards often have poor grounding[3], causing unreliability. To address this problem, the 88-2SIOJP was laid out with special attention to its grounding. It features fully-gridded grounding with oversized traces abundant bypass capacitors and bulk power supply capacitors.

Serial Ports Overview

The serial ports are designed around the Motorola 68A50 or 68B50 ACIA, faster versions of the same communications chip used in the MITS 88-2SIO. The data rate for each serial port is set by a DIP switch, allowing communication from 110 baud through 38.4K (76.8K baud with the 68B50). (For comparison, the maximum data rate for the MITS 88-2SIO is 9600 baud.)

The baud rates are set with DIP switches, rather than soldered wires.

Either port can be set up for RS-232 (with optional hardware handshaking), Optional Teletype (20 mA current loop TTY), or TTL communication.

The serial ports operate without any wait states. (For comparison, the MITS 88-2SIO generates a wait state for every IN instruction.)

The 88-2SIOJP can provide regulated +12V and -12V to an external device.

EPROM and EEPROM Overview

- One EPROM/EEPROM socket that supports a 2716, 2732, 2764, or 27128 EPROM, or a 2816A and 28C64 EEPROM, with write capability
- EPROM accesses use zero wait states. 200 nS EPROMs are required for 4MHz operation. 450 nS EPROMs are adequate for 2 MHz operation.
- The memory address for the EPROM is set with a DIP switch
- The EPROM can also be completely disabled

When the “automatic EPROM disable” feature is enabled, the EPROM is available to the CPU after reset and until the first IN instruction from the Altair’s “sense switches” (port 0FFh). Thereafter, the EPROM is no longer available, and any other RAM at the same address becomes available. (This is similar to the automatic EPROM disable feature on later MITS 8800b Turnkey Modules, and allows e.g. Altair Basic to run in 64K of RAM.)

Jump-Start Overview

When this feature is enabled, the 88-2SIOJP forces a jump upon Reset to the jump-start address (which is set by a DIP switch). The jump-start is implemented in one of two (DIP-switch selectable) ways:

[3] Later IEEE-696 compliant S-100 boards partly addressed this problem by adding additional ground pins to the S-100 bus at pins 53 and 70. Both of these new ground pins conflict with original Altair functions for these pins.

1. The 88-2SIOJP disables the status signals generated by the Altair CPU board, and generates replacement status signals with MEMR held low, so that other memory boards do not respond. This method works with almost all memory boards, including SRAM, DRAM, and PROM boards made by MITS.
2. The 88-2SIOJP generates the PHANTOM signal on the bus, which will disable many S-100 memory boards (though not any MITS memory boards).

Power-On Reset Overview

The Power-On Clear circuit on the Altair 8800 and 8800a CPU board does not work properly, requiring you to toggle the Stop and Reset switches on the front panel of these machines after power-on. MITS fixed this on the Altair 8800b, by synchronizing its reset signal with the system clock.

The 88-2SIOJP's synchronized Power-On Reset circuit is similar to the Altair 8800b's reset circuit. You can optionally connect this Power-On Reset circuit to the S-100 Reset signal to cause the Altair 8800 and 8800a power-on reset to work correctly.

Turnkey Support Overview

The 88-2SIOJP optionally supports computers that do not have a full front panel, including MITS "Turnkey" computers (the Altair 8800bt, the "Foley" Altair, and the iCom Attaché), as well as non-MITS computers that do not have a front panel, providing the same functionality as the MITS 8800b Turnkey Module and the MITS RMB-II:

- MWRITE signal generation (for any computer without a front panel)
- Pullup resistor for -SSW DSB signal (S-100 pin 53)
- Sense Switch register (for software that requires sense switches)
- A Turnkey Interface that connects directly to any of the MITS Turnkey-type computers
- Jump-start at reset (see above)
- The Turnkey Interface also provides easy connection for a reset switch and a few status indicators for use in any non-Altair system without a front panel.

A Note about MITS Extended ROM Basic

The Altair Disk Bootloader is present (though undocumented) in the MITS Extended BASIC ROM. To load Altair DOS, CP/M, etc., use the front panel to examine octal address 177400 (FF00 hex), and then Run.

Since MITS Extended BASIC in ROM leaves only 48K of RAM, you'll need a 48K or smaller CP/M to run with ROM Basic installed. Use MOVCPM and SYSGEN to create a smaller CP/M as required.

Standard Configuration

This is the configuration of the 88-2SIOJP when it ships. See the following sections to understand and change the configuration.

Position	Setting	Page	Jumper function
J1	2-6 & 4-5	16	EPROM Size Select (4K for Amon)
	1-2 & 4-5		EPROM Size Select (16K for Basic)
J2	No Shunt	8-13	Port 0 RS232 CTS/DCD
J3	No Shunt	8-13	Port 1 RS232 CTS/DCD
J4	No Shunt	11-13	R100 Port 0 Current Loop
J5	No Shunt	11-13	R100 Port 0 Current Loop
J6	No Shunt	8-13	Port 0 Current Loop
J7	No Shunt	8-13	Port 1 Current Loop
J8	No Shunt	11-13	R100 Port 1 Current Loop
J9	No Shunt	11-13	R100 Port 1 Current Loop
J10	1-2 (PCB trace)	14	No open-collector RTS output for Port 0
J11	No Shunt	8-13	Port 0 DCD or -12V out
J12	No Shunt	8-13	Port 0 TTL TxD or +12V out
J13	No Shunt	8-13	Port 1 DCD or -12V out
J14	No Shunt	8-13	Port 1 TTL TxD or +12V out
J15	None	14-15	Interrupt configuration
J16	Shunt 1-2	24	Power-on Reset configuration
J19	No Shunt	22	S-100 MWRITE signal
J20	Shunt 8080	29	Z-80 support

Switch	Setting	Page	Switch Function
SW1<8:1>	11111000	19	Jump-start address (Amon)
	11000000		Jump Start Address (Basic)
SW1<9>	Closed	19	Enable Jump-Start
SW2<8:1>	11111111	22	Sense Switch Register (Turnkey Option)
SW2<9>	Open	22	Sense Switch Register disabled
SW3<6:1>	000100	15	Serial Port address
SW3<7>	Closed	20	Use Status Disable method
SW3<8>	Closed	20	Use Phantom
SW4<5:1>	11111	16	EPROM address
SW4<8:6>	001	16	EPROM Size (4K for Amon)
	111		EPROM Size (16K for Basic)
SW4<9>	Open	16	EPROM auto-disable feature disabled
SW5<10:1>	(as needed)	14	Port 0 baud rate
SW6<10:1>	(as needed)	14	Port 1 baud rate

0 always means a closed switch, 1 always means an open switch.

Component	Default	Page	Function
R26: 4.7K	Not installed	23	Pullup required for Altair CPU when used without a front panel

CONFIGURATION OPTIONS

The 88-2SIOJP has several configuration options, explained in this section. These options all involve installing components on the 88-2SIOJP, as described in later sections of this manual. Once installed, you can choose to use each option or not, via shunts or DIP switches.

Turnkey Option

This option adds the necessary hardware for the 88-2SIOJP to function in a computer without a front panel, and is explained in detail in a later section of this manual. When this option is installed, its functionality can be disabled (for use in a computer with a front panel) with a DIP switch setting and removal of a push-on shunt.

TTY Option

This option adds the hardware (for either or both ports) to communicate with a Teletype or other device that has a 20 mA current loop interface. When this option is installed, you can choose between RS-232 and 20 mA current loop communication with a few push-on shunts.

Open-Collector Control Output Option

This option allows Port 0 to enable and disable an external device via an open-collector interface, using Port 0’s RTS handshake signal. For example, this output can be used to control the paper tape reader on some teletypes. This option may be disabled with a push-on shunt.

Serial Port Configuration Options

The 88-2SIOJP is available in two configurations that differ mainly in the kind of connectors used for the serial ports:

1. The M156 option has two 10-pin Molex-type 0.156” connectors that are pin-compatible with the MITS 88-2SIO.
2. The R100 option has two 26-pin ribbon cable connectors that allow simple connection to DB25 connectors on the back of the Altair, using a straight-through (off-the-shelf) IDC ribbon cable assembly.

Both of these configurations provide the same functionality, though setup is a little different for the two. The next two major sections explain the serial port setup for the two 88-2SIOJP configurations. Use the appropriate section for your board.

88-2SIOJP M156 Configuration

The two 10-pin Molex connectors (S1 and S2) are connected as follows:

Pin	Function	Dir.	Port 0 Shunts	Port 1 Shunts
1	RS-232 CTS	In	J2(1-2)	J3(1-2)
2	RS-232 DCD	In	J2(3-4), J11(2-3), Remove all J3	J3 (3-4), J13(2-3), Remove all J2
	-12V	Out	J11(1-2)	J13(1-2)
3	RS-232 RTS	Out	-	-
4	Ground	-	-	-
5	TTY +TxD	Out	-	-
6	TTY -RxD	In	-	-
7	RS-232 RxD	In	Remove J6	Remove J7
	TTL RxD	In	Remove J6	Remove J7
	TTY +RxD	In	J6(1-2)	J7(1-2)
8	RS-232 TxD	Out	-	-
9	TTL TxD	Out	J12(2-3)	J14 (2-3)
	+12V	Out	J12(1-2)	J14(1-2)
10	Ground	-	-	-

If DCD is provided for one port then neither DCD nor CTS is available for the other port. This is because DCD “borrows” the RS-232 line receiver from the CTS circuit of the other port.

RS-232 Communication with the M156 Option

For RS-232 connection, install shunts for either port as follows:

Position	Port 0	Port 1
J2	Shunt 1-2*	
J3		Shunt 1-2*
J6	Remove	
J7		Remove
J11	Remove	
J12	Remove	
J13		Remove
J14		Remove

* If handshaking is not required then the shunt may be removed.

For a standard RS-232 connection, connect the 88-2SIOJP to the Altair rear panel with a wiring harness as follows:

Signal	Direction	S1 or S2 pin	DB25S pin
TxD	Out	8	3
RxD	In	7	2
CTS	In	1	4
RTS	Out	3	5
DCD*	In	2	20
GND		4 (or 10)	7

* If either port requires the DCD handshaking input signal, then it must borrow the other port’s CTS line receiver:

Position	DCD on Port 0	DCD on Port 1
J2	Shunt 3-4	Remove all
J3	Remove all	Shunt 3-4
J11	Shunt 2-3	Remove 2-3
J13	Remove 2-3	Shunt 2-3

Handshaking inputs default to the “active” state if they are not connected. (Usually, only TxD, RxD and GND need to be connected.)

20 mA Current Loop (TTY) Communication with the M156 Option

The 88-2SIOJP supports 20 mA current loop communication on both ports. Current loop (TTY) support is optional, and requires installation of a few components on the board. Once these components are installed, change back to RS232 by removing the shunt.

Port 0 Location	Port 1 Location	Value
Q2	Q3	2N2907
R5 and R13	R10 and R15	220Ω
R6	R9	1.5 KΩ
R12	R14	2.7KΩ
D2 & D3	D4 & D5	1N4148
J6	J7	2-pin header

For 20 mA Current Loop (TTY) communication, install shunts as follows:

Position	Port 0	Port 1
J2	remove	
J3		remove
J6	Shunt	
J7		Shunt
J11	Remove	
J12	Remove	
J13		Remove
J14		Remove

For TTY connection, connect the 88-2SIOJP to the Altair rear panel, and the Altair to the Teletype with wiring harnesses as follows. (This is the same pinout as shown in the MITS 88-2SIO manual.)

Signal	S1 or S2 pin	DB25S pin	Teletype ASR33 Terminal Strip
+TxD	5	3	7
-TxD	4	2	6
+RxD	7	5	4
-RxD	6	4	3
Clip pin		1	

TTL Communication with the M156 Option

For TTL communication, install shunts for either port as follows:

Position	Port 0	Port 1
J2	remove	
J3		remove
J6	remove	
J7		remove
J11	Remove	
J12	Shunt 2-3	
J13		remove
J14		Shunt 2-3

For compatibility with the MITS 88-2SIO, connect the 88-2SIOJP to the Altair rear panel with a wiring harness as follows:

Signal	Dir.	S1 or S2 pin	DB25S pin
TTL TxD	Out	9	3
TTL RxD	In	7	2
GND		4	7

External Device Power with the M156 Option

The 88-2SIOJP can optionally provide up to about 500 mA of regulated +12V and -12V to a device connect to its port, at the expense of other (seldom used) functionality. +12V replaces the TTL output, and -12V replaces the DCD input, if you select these options, as follows:

Function	S1 or S2 pin	Shunt Port 0	Shunt Port 1
+12V	9	J12(1-2)	J14(1-2)
-12V	2	J11(1-2)	J13(1-2)

There is no standard for connecting +12V and -12V to the DB25 connector at the rear of the Altair, so feel free to use whichever pins suit your needs.

88-2SIOJP R100 Configuration

The pins of the two 26-pin ribbon cable connectors (S3 and S4) are assigned such that a straight-through ribbon cable to a DB25S connector will provide normal RS-232 connections, as follows:

S3 or S4 Pin	DB25S Pin	Function	Dir.	Port 0 Shunts	Port 1 Shunts
2	14	TTY -RxD	In	J4(1-2)	J8(1-2)
3	2	RS-232 RxD	In	Remove J6	Remove J7
		TTL RxD	In	Remove J6	Remove J7
		TTY +RxD	In	J6(1-2)	J7(1-2)
5	3	RS-232 TxD	Out	-	-
7	4	RS-232 CTS	In	J2(1-2)	J3(1-2)
9	5	RS-232 RTS	Out	-	-
12	19	TTY +TxD	Out	J5(1-2)	J9(1-2)
13	7	Ground	-	-	-
14	20	RS-232 DCD	In	J2(3-4), J11(2-3), Remove all J3	J3 (3-4), J13(2-3), Remove all J2
		-12V	Out	J11(1-2)	J13(1-2)
24	25	TTL TxD	Out	J12(2-3)	J14 (203)
		+12V	Out	J12(1-2)	J14(1-2)

Note that if DCD is provided for one port, then neither DCD nor CTS is available for the other port. This is because DCD “borrows” the RS-232 line receiver from the CTS circuit of the other port.

RS-232 Communication with the R100 Option

For normal RS-232 connection, install shunts for either port as follows:

Position	Port 0	Port 1
J2	Shunt 1-2*	
J3		Shunt 1-2*
J4	Remove	
J5	Remove	
J6	Remove	
J7		Remove
J8		Remove
J9		Remove
J11	Remove	
J12	Remove	
J13		Remove
J14		Remove

* If handshaking is not required then the shunt may be removed.

Connect the 88-2SIOJP to the Altair rear panel with straight-through ribbon cable, producing the following RS-232 connections:

Signal	Dir.	S3 or S4 pin	DB25S pin
TxD	Out	5	3
RxD	In	3	2
CTS	In	7	4
RTS	Out	9	5
DCD*	In	14	20
GND		13	7

* If either port requires the DCD handshaking input signal, then it must borrow the other port's CTS line receiver, as follows:

Position	DCD on Port 0	DCD on Port 1
J2	Shunt 3-4	Remove all
J3	Remove all	Shunt 3-4
J11	Shunt 2-3	Remove 2-3
J13	Remove 2-3	Shunt 2-3

Handshaking inputs default to the "active" state if they are not connected. (Usually, only TxD, RxD and GND need to be connected.)

20 mA Current Loop (TTY) Communication with the R100 Option

The 88-2SIOJP supports 20 mA current loop communication on both ports. Current loop (TTY) support is optional, and requires installation of a few components on the board. Once these components are installed, change to RS232 by removing the 3 shunts.

Port 0 Location	Port 1 Location	Value
Q2	Q3	2N2907
R5 and R13	R10 and R15	220Ω
R6	R9	1.5 KΩ
R12	R14	2.7KΩ
D2 & D3	D4 & D5	1N4148
J4, J5, and J6	J7, J8, and J9	2-pin headers

For 20 mA Current Loop (TTY) communication, install shunts as follows:

Position	Port 0	Port 1
J2	remove	
J3		remove
J4	Shunt	
J5	Shunt	
J6	Shunt	
J7		Shunt
J8		Shunt
J9		Shunt
J11	Remove	
J12	Remove	
J13		Remove
J14		Remove

Connect the 88-2SIOJP to the Altair rear panel with a straight-through ribbon cable, and connect the Altair to the Teletype with a wiring harness as follows. (Other signals on the DB25 connector should be left unconnected. Note that the DB25 does not have the same pinout as shown in the MITS 88-2SIO manual.)

Signal	S3 or S4 pin	DB25S pin	Teletype ASR33 Terminal Strip
+TxD	12	19	7
-TxD	13	7	6
+RxD	3	2	4
-RxD	2	14	3

TTL Communication with the R100 Option

For TTL communication, install shunts for either port as follows:

Position	Port 0	Port 1
J2	remove	
J3		remove
J4	Remove	
J5	Remove	
J6	remove	
J7		remove
J8		remove
J9		remove
J11	Remove	
J12	Shunt 2-3	
J13		remove
J14		Shunt 2-3

Connect the 88-2SIOJP to the Altair rear panel with a straight-through ribbon cable, and connect as follows. (Other signals on the DB25 connector should be left unconnected.)

Signal	S3 or S4 pin	DB25S pin
TTL TxD	24	25
TTL RxD	3	2
GND	13	7

R100 External Device Power

The 88-2SIOJP can optionally provide up to about 500 mA of regulated +12V and -12V to a device connect to its port, at the expense of other (seldom used) functionality. +12V replaces the TTL output, and -12V replaces the DCD input, if you select these options, as follows:

Function	S3 or S4 pin	DB25S Pin	Shunt Port 0	Shunt Port 1
+12V	24	25	J12(1-2)	J14(1-2)
-12V	14	20	J11(1-2)	J13(1-2)

Open Collector Control Output on Port 0

For applications that require an open-collector control output (such as for controlling the paper tape reader on certain Teletypes), Port 0's RTS signal can be configured to use an open-collector driver, rather than its normal RS-232 driver:

1. Cut trace between pins 1 and 2 of J10, in the solder side
2. Install the following components:

Location	Component
Q1	2N3904
R11	10KΩ
D1	1N4148
J10	Header, 0.1", 3-pin
J10 pins 2 and 3	Shunt, 0.1", 2-pin

(To disable this option, move the shunt on J10 to pins 1 and 2.)

With this option installed, writing 11h to Port 0's Control Port turns on the open-collector driver (pulling the RTS pin to ground). Writing 51h to the Control Port turns off the driver, allowing RTS to float.

Baud Rate Selection

DIP Switch SW5 selects Port 0's baud rate, and DIP Switch SW6 sets Port 1's baud rate. Close the one switch that selects the desired baud rate for each port, and leave all other switches open.

SW5 or SW6 Position	Baud Rate
1	76800
2	38400
3	19200
4	9600
5	4800
6	2400
7	1200
8	600
9	300
10	110

These baud rates assume that the 68B50 ACIAs are configured for ÷16 clocks. Additional baud rates can be achieved by configuring the ACIAs for ÷64 clocks. For example, you can get 150 baud by closing switch 8 and programming the ACIA for a ÷64 clock.

Serial Port Interrupts

The 88-2SIOJP provides 8-level vectored interrupts, single-level interrupts, or no interrupts at all. Interrupts are configured with jumpers in location J15. You can either use a socket and a 16-pin header, or (for single-level interrupts), 2-pin headers (with shunts) between pins 1 and 2 and also between pins 7 and 8.

For single-level interrupts, the software interrupt routine must poll all interrupt devices to resolve the source of each interrupt.

Vectored interrupts require a vectored interrupt controller (such as the MITS 88-VI-RTC board) to be installed in the Altair.

J15 pins are assigned as follows:

J15 Pin	Function
1	S-100 Interrupt Input
2	Port 0 Interrupt Output
3	
4	
5	
6	
7	Port 1 Interrupt Output
8	S-100 Interrupt Input

J15 Pin	Function
16	Vector 7
15	Vector 6
14	Vector 5
13	Vector 4
12	Vector 3
11	Vector 2
10	Vector 1
9	Vector 0

Connect pin 1 to pin 2 for single-level interrupts from Port 0. Connect pin 7 to pin 8 for single-level interrupts from Port 1. (Both ports may be connected to the S-100 Interrupt Input.)

Connect pin 2 to one of the Vector pins for vectored interrupts from Port 0. Connect pin 7 to one of the Vector pins for vectored interrupts from Port 1.

Serial Port Address Selection

The two Serial Port ACIAs occupy four sequential I/O port addresses in the Altair. The first address is Port 0's control and status port; the second is Port 0's data port; the third is Port 1's control and status port; the fourth is Port 1's data port.

DIP Switch SW2 positions 1 through 6 set the serial port address, where closed represents a binary 0, and open represents a binary 1. Switch 6 is the highest-order bit, and switch 1 is the lowest.

Note that MITS software assumes the "terminal" (console) serial port occupies port addresses 10h and 11h (020 and 021 octal). To set the 88-2SIOJP for addresses 10h through 13h, set SW2 as follows:

SW2 Position	Address Bit	Setting
1	A2	Closed
2	A3	Closed
3	A4	Open
4	A5	Closed
5	A6	Closed
6	A7	Closed
7		-
8		-

EPROMS AND EEPROMS

The 88-2SIOJP supports the following EPROM types: 2716 (2K-byte), 2732 (4K-byte) (but not Texas Instruments TMS2532), 2764 (8K-byte), 27128 (16K-byte). It also supports the following EEPROM types: 2816A (2K-byte) and 28C64 (8K-byte)

For 2 MHz operation, the EPROM's access time must be 450 nS or less. For 4 MHz operation, either the EPROM's access time must be 200 nS or less, or the CPU board must be configured to insert a wait state for all memory read cycles. (For example, on the Ithaca Audio 1010 or 1020 CPU, close switch 5 at location IC5.)

Configuring the 88-2SIOJP for the EPROM/EEPROM

Switch SW4 positions 1 through 8 configure the EPROM type and its beginning memory address as follows. (Closed is 0 and open is 1 for all address switches.)

EPROM Type	SW4-1 (11)	SW4-2 (12)	SW4-3 (13)	SW4-4 (14)	SW4-5 (15)	SW4-6 (4K)	SW4-7 (8K)	SW4-8 (16K)
2x16	A11	A12	A13	A14	A15	Close	Close	Close
2732	A11	A12	Open	A14	A15	Open	Close	Close
2x64	A11	Open	Open	A14	A15	Open	Open	Close
27128	Open	Open	Open	A14	A15	Open	Open	Open

Jumper J1 must also be set for the EPROM or EEPROM type as follows:

Type	J1 jumpers	Note
2716 or 2816A	2-6 & 4-8	Write disabled for 2816A
2732	2-6 & 4-5	
2764 or 28C64	2-6 & 4-5	Write disabled for 28C64
27128	1-2 & 4-5	
2816A	2-6 & 4-W	Write enabled
28C64	2-W & 4-5	Write enabled

The Amon firmware runs in the highest 4K block of memory starting at address F800h, and MITS Basic runs the top 16K of memory, starting at address C000h, so SW4 is set as follows:

EPROM Type	SW4-1 (11)	SW4-2 (12)	SW4-3 (13)	SW4-4 (14)	SW4-5 (15)	SW4-6 (4K)	SW4-7 (8K)	SW4-8 (16K)
Amon (2732)	Open	Open	Open	Open	Open	Open	Close	Close
BASIC (27128)	Open	Open	Open	Open	Open	Open	Open	Open

EPROM Position in the Socket

When installing a 24-pin EPROM or EEPROM in the 28-pin socket, position the chip downward toward the 88-2SIOJP's edge connector, leaving pins 1,2,27, and 28 of the EPROM socket empty.

To Completely Disable the EPROM

Close SW4-1 (labeled “11”) and open SW4-6 (labeled “4K”)

EPROM Auto-Disable

If EPROM Auto-Disable is enabled (SW4 position 9 “ED” Closed), then the EPROM is enabled when the Altair is reset, and becomes disabled when the Altair executes an IN instruction from the Sense Switches, I/O port address 377 octal (FFh). The only way to re-enable the EPROM is to reset the Altair.

EPROM Address Overlay

The EPROM can overlay other memory in the Altair, occupying the same address space as the other memory. While the EPROM is enabled, the CPU will read from the EPROM instead of any other memory. (See the **System Memory Disable** section for setup.)

Writing to an EEPROM

- Writing to the EEPROM must be done via a program; it cannot be done from the front panel.
- The 88-2SIOJP does not support EEPROMs that require special Vpp programming voltages nor EEPROMs that require long write pulses. These EEPROMs may still be read on the 88-2SIOJP (and treated exactly like 2716 EPROMs), but they must be programmed elsewhere.
- Writing to the EEPROM will also write to any other RAM board on the S-100 bus that shares its memory address with the 88-2SIOJP. The System Memory Disable function that allows the 8-2SIOJP’s EEPROM to overlay other RAM does not block write operations on the S-100 bus.

2816 EEPROMs differ mainly in their write algorithms. This chart shows which of them can and cannot be written to by the 88-2SIOJP.

Manufacturer	Part Number	88-SIOJP Support	Write Completion Method
Atmel	28C16	Yes	Polled
Atmel	28C16E	Yes	Polled
Catalyst	CAT28C16A	Yes	Polled
Exel	EX2816A	Yes	Polled
Exel	EX28C16A	Yes	Polled
Intel	2815	No	21V Vpp
Intel	2816	No	21V Vpp
Intel	2816A	No	Long Write Pulse
Microchip	28C16A	Yes	Polled
Samsung	KM2816A	Yes	Timed
On Semiconductor	CAT28C16A	Yes	Polled
Seeq	2816A	Yes	Timed
Seeq	52B13	No	Long Write Pulse
Seeq	5516A	Yes	Timed
Xicor	X2816B	Yes	Polled

Polled EEPROM Write Completion

EEPROMs with polled write completion output data with data bit 7 inverted until the write has completed. This method also works for most 28C64 8K-byte EEPROMs. Software can test for write completion after each byte is written, as follows:

```
;HL points to the EEPROM address to be written
;B = the data to write
EEWRITE:  MOV   M,B        ;Write to EEPROM
          LXI   D,1860d    ;Set 40 mS timeout timer (decimal value)

LOOP:     DCX   D          ;Bump timeout timer
          MOV   A,D        ;Test for timeout
          ORA   E
          JZ    ERROR

          MOV   A,M        ;Read back from EEPROM
          CMP   B          ;Done?
          JNZ   LOOP       ;n: keep waiting
          RET              ;Successful write
```

Timed EEPROM Write Completion

Timed write completion requires software to wait at least 10 mS after writing to the EEPROM, before accessing the EEPROM again:

```
;HL points to the EEPROM address to be written
;B = the data to write
EEWRITE:  MOV   M,B        ;Write to EEPROM
          LXI   D,917d     ;Set up 11 mS timer (decimal value)

LOOP:     DCX   D          ;Bump completion timer
          MOV   A,D        ;Test for completion
          ORA   E
          JNZ   LOOP
          RET
```

JUMP-START

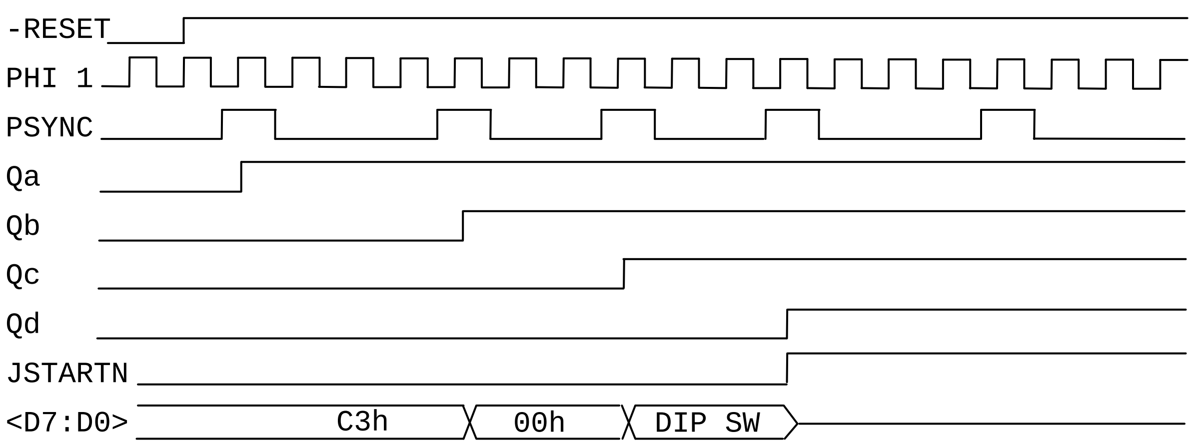
Jump-Start is enabled by setting DIP Switch SW1 position 9 (which is labeled “JS”) to the ON position, and then enabling at least one of the two ways that the 88-2SIOJP can block other memory boards from accessing the S-100 bus. See System Memory Disable section on the next page for details about the SD and PH switches.

When Jump-Start is enabled, the 88-2SIOJP will force a jump to the specified Jump-Start address when the Altair is reset. The high byte of the Jump-Start address is set with DIP Switch SW1, positions 1 through 8, where a closed switch represents a binary 0, and an open switch represents a binary 1. Switch 8 is the highest-order bit, and switch 1 is the lowest. The low byte of the Jump-Start address is always 00h. For example, to set the Jump-Start address to the first address in the Amon EPROM at its standard address of F800h, set SW1 as follows:

SW1 Position	Address Bit	Setting
1	A8	Closed
2	A9	Closed
3	A10	Closed
4	A11	Open
5	A12	Open
6	A13	Open
7	A14	Open
8	A15	Open

Jump-Start Theory of Operation

Jump-Start works by forcing a JMP instruction (C3h followed by two address bytes) onto the bus immediately following Reset. Shift register U10 (a 74LS175) is the state machine that sequences the three machine cycles required for this jump instruction as follows:



SYSTEM MEMORY DISABLE

In order to perform Jump-Start, the 88-2SIOJP must disable other memory in the Altair (starting at address 0000h) for three machine cycles while a JMP instruction is forced onto the bus. Also, in order to overlay the EPROM over other system memory, the 88-2SIOJP must disable any other memory in the Altair that is at the same address as the EPROM, whenever the EPROM is being accessed. The 88-2SIOJP supports two methods of disabling other memory in the Altair.

Memory Disable via Status Signals

The first method is by blocking the SMEMR signal on the S-100 bus when it needs to disable other memory. This method will work with most early S-100 memory boards, including all memory boards made by MITS. To select this method of disabling other memory close DIP switch SW3 position 7 (which is labeled “SD”).

Memory Disable via PHANTOM Signal

The second method of disabling system memory for Jump-Start and EPROM access is via the PHANTOM signal on the S-100 bus. PHANTOM is a newer S-100 signal, created after the Altair. Many S-100 boards, including many early ones, support the PHANTOM signal, though no MITS boards do. To use PHANTOM for disabling other memory, close SW3 position 8 (which is labeled “PH”)

It is okay to enable both methods of disabling memory at the same time, though there is perhaps no good reason to do this.

Memory Disable via Status: Theory of Operation

Most S-100 memory boards, including all memory boards made by MITS, will drive their data onto the S-100 bus only when PDBIN is high and SMEMR is high. (SMEMR is used to distinguish between reads from memory and reads from I/O devices.) The 88-2SIOJP must prevent other memory boards from driving data onto the bus when it is performing the Jump-Start JMP instruction and when the CPU is accessing the 88-2SIOJP’s EPROM (which may overlay other memory in the system). One way to block memory boards from driving data onto the S-100 bus is to block SMEMR.

The 88-2SIOJP blocks SMEMR on the S-100 bus by asserting the Status Disable signal, STSBn. While this signal is asserted, the Altair CPU does not drive any of the 8 status signals. These signals are SINP, SOUT, SINTA, SMEMR, SWON, SHLTA, SSTACK, and SM1. (Note that SMWRITE is not on this list, as it is generated by the Altair front panel.)

The 88-2SIOJP generates its own version of these signals when it asserts STSBn, notably with SMEMR de-asserted. These status signals are driven as follows:

Signal	**Level**
SINP	Low (de-asserted)
SOUT	Low (de-asserted)
SINTA	Low (de-asserted)
SMEMR	Low (de-asserted)
SWOn	As generated by the CPU
SHLTA	As generated by the CPU
SSTACK	As generated by the CPU
SM1	As generated by the CPU

SHLTA, SSTACK, and SM1 are driven to their correct levels only so that the front panel display is correct during Jump-Start and EPROM access.

This method of disabling system memory is cumbersome, and so (sometime after the Altair was created), the PHANTOM signal was added to the S-100 bus. Many memory boards support PHANTOM by not driving data onto the S-100 bus when PHANTOM is low (asserted). The 88-2SIOJP also supports this mechanism, as described in the Configuration section.

Regardless of which method for disabling another RAM board in the system, only read operations are blocked for the other RAM board. Writes to the other RAM board will still write to its memory, while writing to EEPROM on the 88-2SIOJP.

Note that the MITS 8800b Turnkey Module performs Jump-Start by overriding the SMEMR signal on the S-100 bus, using (on earlier versions of the board) a big transistor, or (on later versions of the board) six open-collector buffer elements in parallel. Overdriving a TTL signal in this way is a questionable design practice.

TURNKEY OPTION

Turnkey Altairs are Altairs that do not have a full front panel. These Altairs include the 8800bt, the “Foley” Altair, and the iCom Attaché.

The Turnkey Front Panel option supports such Altairs by adding the following functionality:

- S-100 MWRITE signal generation
- S-100 SNS DSBL signal pullup
- Sense Switch port at I/O port 377 octal (FFh)
- Turnkey front panel interface connector

Install/remove the following components to install the Turnkey Option:

Component	Value	Location	Quantity
*** Remove Resistor ***	2.7K Ω	R16	1
Resistor, 1/4W	4.7K Ω	R26	1
14-pin DIP socket, 0.3" wide	U1		1
16-pin DIP socket, 0.3" wide	U15		1
Connector, Molex 0.156", 10-pin		S5	1
DIP Switch, 9-position, SPST		SW2	1
R-pack, 10-Pin, 9-Resistor	2.2K Ω	RP2	1
Hex Inverter	74LS04	U1	1
Hex Tristate Buffer	74LS367	U15	1
Header, 0.1", 2-pin		J17	
Shunt, 0.1", 2-pin		J17	1

S-100 MWRITE Generation

The S-100 MWRITE signal is generated on the front panel of the Altair 8800, 8800a, and 8800b, so that the front panel can write to memory when the Deposit or Deposit Next switch is toggled. On machines without a full front panel, this signal must be generated elsewhere. MITS generated this signal on their "8800b Turnkey Module" for the Altair 8800bt, the "Foley" Altair, and the iCom Attaché. Other S-100 manufacturers of computers without front panels (e.g. Cromemco, CCS, Dynabyte, and Ithaca Audio) generated this signal on their CPU boards.

The 88-2SIOJP can generate the MWRITE signal for use in systems without a front panel and a CPU that does not generate MWRITE. To enable MWRITE, install a shunt in J17 (which is labeled "MWRITE").

The MWRITE signal is generated from the S-100 PWR and sOUT signals:

MWRITE = PWR and not(sOUT)

Note that the Altair and IMSAI front panels always drive the MWRITE signal on the S-100 bus. This will conflict with the MWRITE signal generate by the 88-2SIOJP if it is also enabled. Be sure that J17 is removed if the 88-2SIOJP is installed in a system with a front panel.

S-100 -SSW DSB Signal

This signal (S-100 pin 53) is normally driven by the front panel, and has no pullup on the Altair CPU. When using the 88-2SIOJP without an Altair front panel, this signal must be pulled up by installing a 4.7K resistor in location R26 (labeled "SNSDSB").

Sense Switches

Many Altair programs (e.g. Basic and several Altair loaders) read the front panel "Sense Switches" (at I/O port 377 octal) to determine which terminal port to use, and many stop bits to use. Like the Turnkey Module, the 88-2SIOJP implements the Sense Switches with a DIP switch, so that such software will work correctly. To enable the Sense Switch port, close SW2 position 9 (which is labeled “SS”). Then set SW2 positions 1 through 8 to the value your software requires. A closed switch on SW2 is a “0”, and an open switch is a “1”. Switch position 1 is the least-significant bit. (Position 1 corresponds to the Altair front panel switch that’s labeled A8, and position 8 corresponds to the Altair front panel switch that’s labeled A15.)

Turnkey Front Panel Interface

S5 (at the top, left-hand side of the 88-2SIOJP) connects directly to the switch/indicator board on the front of the 8800bt or Foley, and connects to the video interface board of the Attaché, providing the necessary signals for the indicator LEDs and the reset and run/stop switches.

The pinout of S5 is compatible with the 8800b Turnkey Module:

Pin	Signal	Function	Dir.
1	+5V	+5 Volts	out
2	-SHLTA	Low indicates a Halt state	out
3	-PINT	Low means Interrupt Requested	out
4	-I/O	Low indicates an I/O cycle	out
5	-PINTE	Low means Interrupts Enabled	out
6	GND	Ground	-
7	-RESET	Low resets the CPU	in
8	-PRDY	Low stops the CPU from running	in
9	N/C	Not connected	-
10	N/C	Not connected	-

Turnkey Serial Port Connector Note

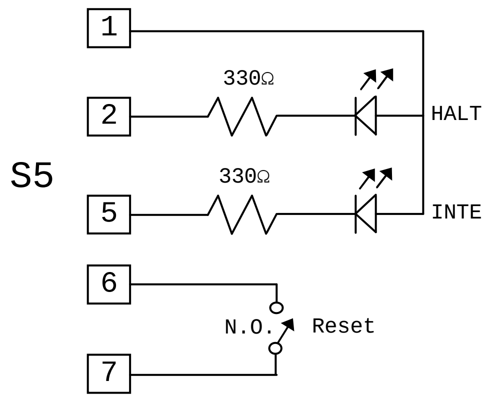
The 10-pin Molex connectors for the 88-2SIOJP-M156 serial ports do not have the same pinout as the serial port connector on the 8800b Turnkey Module. (The 88-2SSIOJP’s pinout is the same as on the MITS 88-2SIO.) If you replace a Turnkey Module with an 88-2SIOJP, then you must change the serial port wiring of the computer appropriately. (This is easy to do, by simply moving the female Molex connector’s contacts.)

No Front Panel Operation, non-Altair

Build a simple Altair-compatible computer without a front panel, with a small S-100 backplane and just 3 boards: an Altair 8800a CPU board (or reproduction), an 88-2SIOJP, and Mike Douglas’s FDC+ (which provides both RAM and an Altair-compatible disk controller).

- Install a 4.7K resistor for the -SNS DBL signal as described above.
- Install a shunt at J16 from pin 1 to 2.
- Connect a momentary switch between pins 6 and 7 of S5. (S5 is the Turnkey interface connector.)
- You can also put LEDs (with appropriate series resistors) between pin 1 and 2 (for HALT) and between 1 and 5 (for INTE) (The INTE light us

useful when running Altair software because MITS loader programs enable interrupts to indicate a load error.)



POWER-ON RESET

The 88-2SIOJP’s Power-On Reset circuit can reset the original Altair’s CPU correctly at power-on, eliminating the need to manually toggle the Stop and Reset front panel switches.

Power-On Reset Setup

If you are installing the 88-2SIOJP in an Altair 8800 or 8800a, then Install a shunt between pins 1 to pin 2 on J16 to connect the 88-2SIOJP’s onboard clock-synchronized power-on clear circuit to the S-100 Reset signal, thereby eliminating the need to toggle the Altair’s Stop and Reset switches after power-on.

The Power-On Clear and reset circuits of the Altair 8800b already work correctly, and only need to be connected together. For installation in an Altair 8800b, install a shunt between pins 2 and 3 of J16 to connect the Altair’s own Power-On Clear circuit to its Reset signal, eliminating the need to toggle the Altair’s Reset switch after power-on. (This same connection is made in the Altair 8800b Turnkey Module.)

Power-On Reset Theory of Operation

In all versions of the Altair 8800, the CPU board generates a Power-On Clear signal that just drives a signal on the S-100 bus - it does not cause a CPU reset on power-on. Only the Altair 8800bt connects the Power-On Clear signal to the Reset signal, causing a Power-On Reset.

The Intel 8080A specification does not provide complete requirements for the 8080A Reset signal. As a result, the Power-On Clear signal in the Altair 8800 and 8800a does not work correctly: if you connect this signal to the Altair’s Reset signal, the CPU will not reset reliably.

Intel addressed this problem by synchronizing the reset signal in the 8080 companion chip, the 8224 Clock Generator. The Altair 8800b family uses this chip, making Power-On Reset possible in these machines.

The improved Power-On Clear circuit of the 88-2SIOJP senses the power supply voltage and begins a clear pulse after the power supply has reached operating voltage. This clear signal is then synchronized with the 8080A’s Phi-2 clock in the same way the Intel 8224 synchronizes Reset. A shunt between J16 pins 1 and 2 connects this synchronized Power-On Clear signal to the S-100 Reset signal, providing a reliable Power-On Reset to the Altair.

Modifying an Altair to Run at Power-On

The Run/Stop flip-flop in the front panel of the Altair 8800 and 8800a is neither set nor cleared at power-on, and so will be in a random state after power-on. If it happens to be in the Stop state, then you will still need to toggle the Altair’s Run switch. A simple, non-destructive modification to the Altair front panel will initialize this flip-flop at power-on to the Run state: Install the following four jumper wires on the Altair front front panel’s PC board:

1. IC H pin 9 to IC E pin 4
2. IC E pin 3 to IC R pin 10
3. IC R pin 9 to IC J pin 6
4. IC R pin 8 to IC R pin 7

The Run/Stop flip-flop of the Altair 8800b is initialized to the Stop state at power-on. Modifying an Altair 8800b to run at power-on requires more extensive modifications, including cutting some traces. (Such modification is not described here.)

PROGRAMMING THE SERIAL PORTS

The 88-2SIOJP’s two serial ports are based on the Motorola MC68B50 ACIA, and are designed to be compatible with the MITS 88-2SIO. See the Motorola MC6850 data sheet (DS9493R4, ©1995 Motorola) for details.

The base I/O address of the ACIAs is set by a DIP switch, as explained in the previous section. The 88-2SIOJP occupies four sequential I/O addresses, starting at this base address. The first two addresses are the control and data ports for Port 0; the second two are the control and data ports for Port 1:

Address		**Port**	**Output Function**	**Input Function**
A1	**A0**			
0	0	0	Control Register	Status Register
0	1	0	Transmit Data Register	Receive Data Register
1	0	1	Control Register	Status Register
1	1	1	Transmit Data Register	Receive Data Register

Data Registers

Data can be written to one of the Transmit Data Registers whenever the TDRE bit in the corresponding Status Register is high. Writing to the Transmit Data Register will clear that TDRE bit, which will remain clear until the ACIA transfers the data to its Transmit Shift Register for serialization.

The RDRF bit in one of the Status Registers will become high when the corresponding ACIA transfers a complete data word from its Receive Shift Register to its Receive Data Register, and will remain high until software reads from that Receive Data Register.

Control Registers

Each Port has an 8-bit control register that allows port configuration under software control. Each bit is defined as follows. (All bits are active-high.)

7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Input Interrupt	Output Interrupt		Transmission Bits			Clock Divide & Reset	

Bits 1 and 0 of each Control Register control the clock divider and master reset as follows:

Bit 1	**Bit 0**	**Function**
0	0	÷ by 1 clock
0	1	÷ by 16 clock
1	0	÷ by 64 clock
1	1	Master Reset

Software should first issue a Master Reset command to each serial port, by setting bits 1 and 0 of each control port to 1. For normal operation, the divide by 16 clock rate is then selected, by setting bits 1 and 0 to 01b. Other (lower) baud rates are possible by selecting the divide by 64 clock rate - in which case the baud rate will be 1/4 of the baud rate printed on the PC board silkscreen.

Bits 4, 3, and 2 of each Control Register set the word length, parity, and number of stop bits:

Data Bit			**Function**		
4	**3**	**2**	**# of Data Bits**	**# of Stop Bits**	**Parity**
0	0	0	7	2	Even
0	0	1	7	2	Odd
0	1	0	7	1	Even
0	1	1	7	1	Odd
1	0	0	8	2	None
1	0	1	8	1	None
1	1	0	8	1	Even
1	1	1	8	1	Odd

Bits 7, 6, and 5 of each Control Register control interrupts and handshaking:

Data Bit			**Function**
7	**6**	**5**	
X	0	0	RTS active, transmit interrupt disabled
X	0	1	RTS active, transmit interrupt enabled
X	1	0	RTS inactive, transmit interrupt disabled
X	1	1	RTS inactive, transmit interrupt disabled, transmits a BREAK on the transmit data line
0	X	X	Receive interrupt disabled
1	X	X	Receive interrupt enabled

The following 8080 code example illustrates initializing Port 0's ACIA (at its standard I/O address) for 8 data bits and 2 stop bits:

```
3E 03   MVI   A,ARESET     ;Reset command
D3 10   OUT   CONTROL0     ;...to the control port
3E 11   MVI   A,ASETUP     ;8 data bits, 2 stop bits,
                           ;RTS active, interrupts disabled
D3 10   OUT   CONTROL0     ;..to the control port
```

Status Registers

Each status register provides 8 status bits for the respective Port, as follows:

Bit	Name	Function
7	IRQ	Interrupt Request
6	PE	Parity Error
5	OVRN	Overrun Error
4	FE	Framing Error
3	-CTS	Clear to Send (active low)
2	-DCD	Data Carrier Detect (active low)
1	TDRE	Transmit Data Register Empty
0	RDRF	Receive Data Register Full

The IRQ bit will be high whenever the ACIA is requesting an interrupt. If transmit interrupt interrupts are enabled, then it will be high if the transmit data register is empty (and the TRDE bit is high). If receive interrupts are enabled, then the IRQ bit will be high if the receive data register is full (and the RDRF bit is high).

The three error conditions (PE, OVRN and FE) apply to the currently-received data in the receive data register, and are valid while the RDRF bit is high.

The -CTS bit will be low whenever the RS-232 CTS signal is true, indicating that the ACIA may transmit data. When this bit is high, the RS-232 signal is false, and data transmission is inhibited by hardware within the ACIA.

The -DCD bit will be low whenever the RS-232 DCD signal is true, indicating that the ACIA may receive data. When this bit is high, the DCD signal is false, and data reception is inhibited by hardware within the ACIA.

A 0-to-1 transition of the -DCD bit generates an interrupt if the receive interrupt is enabled. This interrupt is cleared by first reading the Status Register, and then reading the Data Register, or by issuing a Master Reset command.

The TDRE and RDRF bits are discussed in the Data Registers section above.

COMPATIBILITY WITH Z-80-BASED SYSTEMS

Clock Speed

The 88-2SIOJP will work with CPU speeds up to 4 MHz, provided the EPROM is fast enough. (See previous section.)

Status Signals

The 8080 CPU puts its status signals on the data bus during the PSYNC cycle of every bus operation. The 88-2SIOJP depends on this feature of the 8080 as part of its circuit that disables other RAM boards during Jump-Start and during EPROM accesses. Unfortunately, the Z-80 CPU does not have this feature.

Some Z-80 CPU boards (such as the Cromemco ZPU) simulate the 8080 status signals correctly, while others (such as the Ithaca Audio 1010 and 1020 Z-80 CPU boards) do not. If your CPU board simulates 8080 behavior, then the 88-2SIOJP will work without modification.

However, the 88-2SIOJP can be set up to work with Z-80 boards that do not fully emulate the 8080 status signals on the S-100 bus, so long as your RAM boards support the PHANTOM signal:

1. Open SW3 position 7 (which is labeled “SD”)
2. Close SW3 position 8 (which is labeled “PH”)
3. Move shunt at J18 from the “8080” position to the “Z80” position

EXTENDER BOARDS IN EARLY ALTAIRS

The original Altair 8800 came with a 4-slot backplane. If you wanted more than 4 slots, then additional 4-slot backplanes could be added, connecting to each other via 100 short pieces of wire. Later Altairs (including the Altair 8800a and 8800b, as well as some 8800’s) came with an 18-slot backplane.

If your Altair has the original 4-slot backplane with additional backplane sections added, then testing the 88-2SIOJP (or for that matter, any S-100 board) on an S-100 extender board will probably not work reliably. This is because the S-100 signal quality is already compromised by the 100 jumper wires that connect the bus sections together. The additional signal degradation caused by the extender board will cause some signals to be too far out of spec to work correctly.

ASSEMBLY AND TEST INSTRUCTIONS

General Assembly Tips

Components are installed according to their height from the PC board, starting with the lowest components and working up to the highest components. This makes assembly a lot easier because your workbench surface will keep the components close to the PC board when it is inverted for soldering.

The PC board silkscreen gives you hints for almost every component on the board - resistor values, abbreviated part numbers for transistors and diodes, IC types, etc.

I recommend first inserting all of one type of component (e.g. all resistors, all IC sockets, or all ceramic capacitors). Then lay a small flat board on top of the components. Hold the PC board and this flat board together, with the newly-inserted components between them. Flip this assembly over and set it on your work bench for soldering.

When installing DIP devices (IC sockets and DIP switches), it is important that they are completely against the PC board. Initially solder only two diagonally-opposite pins on each device. Once all of these components are held in place this way, gently press down on each component while re-melting the solder for the two soldered pins. You will hear several sockets “tick” as they come in full contact with the PC board. It is important that you do not press too hard as you re-melt the solder, or you will push the pin out of the plastic socket.

Solder the remaining DIP device pins once all of the DIP devices are completely against the PC board.

If you are using “organic core” solder or solder with water soluble flux, then you must wash the flux off of the board, because this kind of flux is mildly conductive, and will interfere with correct circuit operation. (It is okay to leave rosin from rosin-core solder on the board. It is not pretty as it turns brown from aging, but it will not affect circuit operation.)

Assembly

Step 1 Install Diodes and Resistors

Component	Value	Location	Quantity
Diode, 3.9V Zener	1N4730	D6	1
Resistor, 1/4W	220 Ω	R17	1
Resistor, 1/4W	330 Ω	R24,R25	2
Resistor, 1/4W	2.7K Ω	R18,R19,R21-R23	5
Resistor, 1/4W	10K Ω	R1-R4,R7,R8,R20	7

Pay attention to the diode’s orientation. The stripe on the diode should be toward the bottom.

If you are not going to use the Turnkey Option, then also install a 2.7K resistor in location R16 (which occupies the same PC board space as DIP Switch SW2).

Component	Value	Location	Quantity
Resistor, 1/4W	2.7K Ω	R16	1

For the Turnkey Option

If you are installing the Turnkey Option, then also install a 4.7K-ohm resistor in location R26.

Component	Value	Location	Quantity
Resistor, 1/4W	4.7K Ω	R26	1

Step 2 Install the resistor packs

Component	Value	Location	Quantity
R-pack, 10-Pin, 9-Resistor	2.2K Ω	RP1,RP3,RP4	3

Make sure the resistor packs are oriented correctly, with their pin-1 mark toward the top of the PC board (with the square solder pad). Make sure they are straight and all the way against the board.

For the Turnkey Option

If you are installing the Turnkey Option, then also install a resistor pack in location RP2.

Component	Value	Location	Quantity
R-pack, 10-Pin, 9-Resistor	2.2K Ω	RP2	1

Step 3 Install the crystal

Component	Value	Location	Quantity
Crystal	4.9152 MHz	CR1	1

Bend the crystal’s leads so that the crystal value will still be readable, and solder it in place. Make a strap to hold the crystal against the PC board, using a resistor lead. Pull the strap tight and solder it in place in the two holes on the sides of the crystal.

Step 4 Install the DIP sockets

Component	Location	Quantity
14-pin DIP socket, 0.3" wide	U2,U6,U7,U11-U14,U18-U24,U26, U33,U35	17
16-pin DIP socket, 0.3" wide	U8-U10,U16,U17,U25,U27-32,U34	13
24-pin DIP socket, 0.6" wide	U4,U5	2
28-pin DIP socket, 0.6" wide	U3	1

See General Assembly Tips above. (Do not install sockets for the DIP switches.) Tack the sockets in place with 2 diagonally-opposite pins, and complete their soldering after the DIP switches are also tacked in place.

For the Turnkey Option

If you are installing the Turnkey Option, then also install the following 2 sockets.

Component	Location	Quantity
14-pin DIP socket, 0.3" wide	U1	1
16-pin DIP socket, 0.3" wide	U15	1

Step 5 Install the DIP switches

Component	Location	Quantity
DIP Switch, 8-Position SPST	SW3	1
DIP Switch, 9-Position SPST	SW1,SW4	2
DIP Switch, 10-Position SPST	SW5,SW6	2

For the Turnkey Option

If you are installing the Turnkey Option, then also install a 9-pin DIP switch in location SW2.

Component	Location	Quantity
DIP Switch, 9-Position SPST	SW2	1

Step 6 Install the ceramic capacitors

Component	Value	Location	Quantity
Capacitor, Ceramic	120 pF	C35	1
Capacitor, Ceramic	0.1 uF	C2-C7,C9-15, C17-C19,C21-C34,C36,C37	31

For the Turnkey Option

If you are installing the Turnkey Option, then also install

Component	Value	Location	Quantity
Capacitor, Ceramic	0.1 uF	C1,C16	2

Step 7 Install the electrolytic capacitors

Component	Value	Location	Quantity
Capacitor, Electrolytic, 35V, Axial	10 uF	C8,C20,C38-C40	5

Pay attention to the orientation of these capacitors. The positive end is either at the bottom or at the left.

Step 8 Install the headers

Make sure each of these headers is flush with the PC board and straight up. I recommend first soldering just one pin. The re-melt the solder on this pin, while you straighten the header in place. Once the header is nice and straight, solder the other pins.

Component	Location	Quantity
Header, 0.1", 3-pin	J1,J11-J14,J16,J18	7
Header, 0.1", 4-pin	J2,J3	2
Header, 0.1”, 5-pin	J1	1

For the Turnkey Option

Also install a 2-pin header at J17

Component	Location	Quantity
Header, 0.1", 2-pin	J17	1

Step 9 Install the transistors

Component	Value	Location	Quantity
Transistor, NPN, TO-92	2N3904	Q4-Q6	3

Push these transistors as far down as they will go before soldering them.

Step 10 Install the voltage regulators

These regulators are bolted to the PC board with 6-32 machine screws and nuts. The screws should be inserted from the solder side of the board, with the nuts on the regulators. V1 is bolted together with a heat sink, and with a very thin coating of heat sink grease on the back of the regulator. (Try not to get grease all over the place.) V2 and V3 are bolted directly to the PC board, without any heat sink or heat sink grease.

Bend the regulator leads so that the regulator can lie flat on the PC board, with the regulator’s hole aligning with the PC board hole. Insert the regulator’s leads into the PC board, and lightly bolt it in place, making sure the regulator is straight. Then solder and clip the regulator leads. Finally, tighten the screws thoroughly.

Component	Value	Location	Quantity
Regulator, +12V, TO-220	7812	V3	1
Regulator, -12V, TO-220	7912	V2	1
Regulator, +5V, TO-220	7805	V1	1
Heat Sink, TO-220		V1	1
Machine Screw	6-32, 1/2"	V1-V3	3
Nut	6-32	V1-V3	3

Step 11 Install the connectors

The specific connectors depend on whether you are building an -R100 version or an -M156 version of the 88-2SIOJP.

For the -R100 version

Make sure the connectors are completely against the PC board before soldering them in place.

Component	Location	Quantity
Male right-angle connector, Ribbon cable, 26-pin	S3 & S4	2

For the -M156 version

Install these connectors with their pins facing downward. Make sure their plastic bodies are firmly against the PC board and that their pins are parallel to the PC board

Component	Location	Quantity
Male right-angle connector, Connector, Molex 0.156", 10-pin	S1 & S2	2

For the Turnkey option

Also install a Molex connector in S5. This one is installed with its pins facing upward. (Note: you can use an 8-pin Molex connector here, since pins 9 and 10 are not connected to anything.)

Component	Location	Quantity
Male right-angle connector, Connector, Molex 0.156", 10-pin	S5	1

Step 12 Install Option Components

For the Port 0 TTY Option

Install the following components, installing diodes with their stripes at the bottom:

Component	Value	Location	Quantity
Diode, Signal	1N4148	D2, D3	2
Resistor, 1/4W	220 Ω	R5, R13	2
Resistor, 1/4W	1.5K Ω	R6	1
Resistor, 1/4W	2.7K Ω	R12	1
Transistor, PNP, TO-92	2N2907	Q2	1
Header, 0.1”, 2-pin		(J4, J5),J6	1 for M156, 3 for R100

For the Port 1 TTY Option

Install the following components, installing diodes with their stripes at the bottom:

Component	Value	Location	Quantity
Diode, Signal	1N4148	D4, D5	2
Resistor, 1/4W	220 Ω	R10,R15	2
Resistor, 1/4W	1.5K Ω	R9	1
Resistor, 1/4W	2.7K Ω	R14	1
Transistor, PNP, TO-92	2N2907	Q3	1
Header, 0.1”, 2-pin		(J4, J5),J6	1 for M156, 3 for R100

For the Port 0 Open-Collector RTS Option

1. Cut the PCB trace on the solder side between pins 1 and 2 of header J10.
2. Install the following components, installing the diode with their stripes at the bottom:

Component	Value	Location	Quantity
Diode, Signal	1N4148	D1	1
Resistor, 1/4W	10K Ω	R11	1
Transistor, NPN, TO-92	2N3904	Q1	1
Header, 0.1", 3-pin		J10	1

Step 13 Inspect your work

1. Visually inspect your soldering, looking especially for missed solder joints and solder bridges.
2. Use an ohmmeter to check for shorts between the following points. (Note that you will see measurable resistances because of the installed components, but not low-ohm short circuits.) **If you find any short circuits, do not continue until these are resolved!**
   - Pin 7 and pin 14 of U35 (testing for +5V to ground shorts)
   - Pin 1 to pin 3 of V2 (testing for -12V to ground shorts)
   - Pin 2 to pin 3 of V3 (testing for +12V to ground shorts)
   - Pin 1 and pin 50 of the S-100 connector (testing for unregulated +8V to ground shorts)
   - Pin 2 to pin 50 of the S-100 connector (testing for unregulated +16V to ground shorts)
   - Pin 1 to pin 2 of the S-100 connector (testing for unregulated +8V to unregulated +16V shorts)
   - Pin 52 to pin 50 of the S-100 connector (Pin 52 is on the other side of the board from pin 2. Testing here for shorts from unregulated -16V to ground)
   - Pin 52 to pin 1 of the S-100 connector (testing for unregulated -16V to unregulated +8V shorts)

- Pin 52 to pin 2 of the S-100 connector (testing for unregulated -16V to unregulated +16V shorts)

3. Install the board in an S-100 computer, power it on, and measure the following voltages, using the "GND" test point in the upper-left corner of the board as the ground reference. **If any of these voltages is incorrect, do not continue until they are corrected!**
   - Pin 14 of U35 should measure between +4.9 and +5.2V
   - Pin 3 of V2 should measure between -11.8V and -12.2V
   - Pin 3 of V3 should measure between +11.8V and +12.2V

Step 14 Clean the board

If you are using "organic core" solder or solder with water soluble flux, then cleaning is mandatory. To clean water-soluble flux:

1. Wash the board once the soldering is done, but before any ICs are inserted in their sockets. Hold the board under running <u>hot</u> water and scrub it with a toothbrush for a few minutes.
2. Blow off all the water using compressed air, especially from under components and from inside IC sockets. (A real air compressor works a <u>lot</u> better than those "duster" cans.)
3. Bake the boards for 30 minutes or so. I just set them in front of the heater registers in my house for a while. But a small electric space heater works great too.

If you used rosin-core colder, then cleaning is optional. Use an appropriate chemical flux remover to wash the flux from the board. A toothbrush sometimes helps to loosen the flux.

Once clean do another visual inspection of your soldering.

Step 15 Install the ICs

Be careful not to fold any pins under as you install the ICs in their sockets, and make sure pin 1 is toward the top for all ICs. It is a good idea to use your workbench surface to bend the IC pins until they are straight. Hold the IC against the workbench, and push it firmly to bend all of the pins on one side. Turn the IC over and do the same for the other side.

Note: U24 is labeled 74LS00 on the board, but should be a 74LS132.

Component	Value	Location	Quantity
IC, DIP, Quad 2-Input NAND Gate	74LS00	U14,U35	2
IC, DIP, Hex Inverter	74LS04	U11,U23,U26	3
IC, DIP, Hex Open-Collector Buffer	74LS07	U20	1
IC, DIP, Triple 3-Input NAND gate	74LS10	U12	1
IC, DIP, 8-Input NAND Gate	74LS30	U2	1
IC, DIP, Quad 2-input OR gate	74LS32	U22	1
IC, DIP, Dual D Flip-Flop	74LS74	U13,U19	2
IC, DIP, 4-bit Magnitude Comparator	74LS85	U16,U17	2
IC, DIP, Quad Exclusive-Or Gate	74LS86	U21	1

Component	Value	Location	Quantity
IC, DIP, Quad 2-inout Schmitt NAND	**74LS132**	**U24**	1
IC, DIP, 4-Bit Loadable Counter[4]	74LS161	U34	1
IC, DIP, Hex D Flip-Flip with Clear	74LS175	U10,U32	2
IC, DIP, Quad 2-1 Inverting MUX	74LS257	U8,U9	2
IC, DIP, Hex Tristate Buffer	74LS367	U25,U27-U31	6
IC, DIP, 4-Bit Ripple Counter	74LS393	U18,U33	2
IC, DIP, Quad RS232 Line Driver	1488	U7	1
IC, DIP, Quad RS232 Line Receiver	1489	U6	1
IC, DIP, EPROM, ≤350 nS, 4Kx8, Programmed with Amon Firmware	2732A or 2732B	U3 (Amon Option) Positioned toward the bottom of the board!	(1)
IC, DIP, EPROM, ≤350 nS, 16Kx8, Programmed with MITS ROM Basic	27128	U3 (Basic Option)	(1)
IC, DIP, ACIA	MC68B50	U4,U5	2

For the Turnkey option

Install the following additional ICs:

Component	Value	Location	Quantity
Hex Inverter	74LS04	U1	1
Hex Tristate Buffer	74LS367	U15	1

Step 16 Configuration

Install 2-pin shunts in the following locations. (This assumes that you will use RS-232 devices for testing the 88-2SIOJP.)

Configuration	Location	Shunt	Purpose
Amon	J1	2-6 & 4-5	Select 2732-type EPROM
ROM Basic		1-2 & 4-5	Select 27128-type EPROM
Functional reset	J16	1-2	Use 88-2SIOJP's improved reset circuit
8080 CPU	J18	2-3	Select 8080-style status signals on the S-100 bus
Z-80 CPU		1-3	No 8080-style status signals on the S-100 bus

Set the DIP switches as follows. 0 means a closed, 1 means open.

Switch	Setting	Switch Function
SW1<8:1>	11111000	Jump-start address (Amon)
	11000000	Jump Start Address (Basic)
SW1<9>	Closed	Enable Jump-Start
SW2<8:1>	11111111	Sense Switch Register (Turnkey Option)
SW2<9>	Open	Sense Switch Register disabled
SW3<6:1>	000100	Serial Port address
SW3<7>	Closed	J18=8080: Use Status Disable method
	Open	J18=Z80: Don't use Status Disable Method
SW3<8>	Closed	Use Phantom

[4] U34 (74LS161) is only required if you are using 110 baud on either port.

Switch	Setting	Switch Function
SW4<5:1>	11111	EPROM address
SW4<8:6>	001	EPROM Size (4K for Amon)
	111	EPROM Size (16K for Basic)
SW4<9>	Open	EPROM auto-disable feature
SW5<10:1>	As needed	Port 0 baud rate (I suggest 9600 baud.)
SW6<10:1>	As needed	Port 1 baud rate

Step 17 Inspect your work

Visually inspect the board, looking especially for these errors:

- IC inserted backwards
- Bent-under IC pins
- Incorrect IC in any position
- 24-pin EPROM not positioned to the bottom of the 28-pin socket
- Incorrect jumper or switch setting

Testing

This section provides some guidance for testing the 88-2SIOJP in your system. It is not meant to be an exhaustive debugging guide. Debugging a non-functioning system is really beyond the scope of this manual.

Step 1 Installation

Install only the following boards in an Altair or other S-100 computer:

- An 8080 or Z-80 CPU board. (If the CPU board has an onboard ROM, make sure it is disabled. If it has a jump-start circuit, disable this, too.)
- A RAM board, with its first address at address 0. For Amon, any size RAM board will do. For Basic, you will need at least 8K-bytes of RAM, starting at address 0.
- The 88-2SIOJP
- If the computer is an 8800b, then also install the front panel interface board, connected to the front panel

Step 2 Internal Cabling

Install cables from the 88-2SIOJP to the rear panel of the computer.

For the -M156 version, the cables should be constructed like this:

Signal	Direction	S1 or S2 pin	DB25S pin
TxD	Out	8	3
RxD	In	7	2
GND		4	7

For the -R100 version, use a standard 26-pin ribbon cable to DB25S connector. (This type of cable was commonly used on PCs for the parallel port, and are still readily available in several lengths.)

Step 3 External Cabling

You will need a cable from the rear of the Altair to whatever terminal you will use for testing. If you are using a terminal emulator on a PC, then you probably have a standard male 9-pin connector for serial communication, requiring a cable like this. (The other pins don't matter.) This is a standard cable that you can either buy or make.

88-2SIOJP Signal	Altair DB25P (Male)	Direction	PC DB9S (Female)
TxD	3	→	2
RxD	2	←	3
GND	7	-	5

Connect this cable to the 88-2SIOJP's Port 0 and to your terminal or PC.

Step 4 Setting up your terminal or terminal program

Set up your terminal or terminal program for the same baud rate as the 88-2SIOJP's port 0. Select full duplex, no handshaking, 8 bit data, no parity. (Stop bits don't matter.) If you are using a terminal emulator on a PC, be sure to select the correct COM port.

Step 5 Testing the jump-start circuit

Turn on the Altair. Toggle the Stop and the Reset switches. The data lights on the Altair should show 303(octal)(Lights D0, D1, D6, and D7 lit). If not, there is a problem in the jump-start circuit. You should see this pattern whenever you toggle the Reset switch (and the Altair is Stopped).

Toggle the Single-Step switch. The data lights should show 0 (lights D0 through D7 are off). If not, again, there is a problem in the jump-start circuit.

Toggle the Single-Step switch again. The data lights should show the setting on S2. For Amon, this would be 370(octal) (lights D3 through D7 lit). If not, again, there is a problem in the jump-start circuit.

Toggle the Single-Step switch again. The address lights should show the address selected by S2. For Amon, this would be A0 through A10 off, and A11 through A15 on.

For Amon, the data lights should show 001(octal) (light D0 lit). If not, there is a problem probably a problem in the EPROM circuit.

For Amon, toggle the Single-Step switch again. The data lights should show 277(octal). If not, again, there is a problem probably a problem in the EPROM circuit.

Step 7 Testing RAM presence

1. From the Altair front panel, Examine address 0
2. Deposit 303(octal) into address 0
3. Deposit 0 into address 1 (use Deposit Next)
4. Deposit 0 into address 2 (use Deposit Next)
5. Examine address 0. you should see 303(octal)
6. Examine the next two addresses, and confirm they are both 0

If these tests don’t work, then you have a problem with your memory board. Correct this before continuing.

Step 8 Verify CPU operation

1. Examine address 0
2. Use Single-Step and confirm that operation loops through addresses 0, 1, and 2 only.

If this fails, then you either have a memory problem or a CPU problem.

3. toggle the Run switch
4. Toggle the Stop switch

If the address is anything except 0, 1, or 2, then you either have a memory problem or a CPU problem.

Correct ant problems before continuing.

Step 9 Testing the console port with Amon

Toggle the Reset and then the Run switches on the Altair. You should see the Amon prompt on the screen of your terminal or terminal emulator. If not, check the following:

- Port 0 baud rate setting matches the terminal baud rate
- Double-check all jumper and switch settings
- Serial cable connections are correct
- Baud clock working correctly
- Port 0 68B50 and Rs232 drivers/receivers

Step 10 Testing the transfer port with Amon

1. Connect another terminal (or PC serial port with terminal emulator) to Port 1. Set up the baud rates to match.
2. Type “TE” at the Amon prompt.
3. Everything you type on the console port should be printed on the transfer port screen. Everything you type on the transfer port should be printed on the console screen.
4. type Control-C to exit terminal mode

If not, check the following:

- Port 1 baud rate setting matches the terminal baud rate
- Serial cable connections are correct
- Port 1 68B50 and Rs232 drivers/receivers

SPECIFICATIONS

General

Bus Compatibility:	Early S-100 machines including MITS Altairs, IMSAI 8080, Processor Technology Sol-20, Polymorphic Systems Poly-88. Not fully IEEE-696 compliant.
CPU Compatibility:	8080 and Z-80
Max CPU speed:	4 MHz (requires 200 nS EPROM above 2.2 MHz.)

PC Board

Material:	FR-4 material, green solder-mask over bare copper
Thickness:	0.062” +/- 0.006”
Traces:	13 mil minimum width, 1-oz copper
Silkscreen:	White, component-side only
Layers:	2
Edge Connector:	100-pin electroless nickel immersion gold plate, 15° bevel

Serial Ports

Serial ports:	2
UART Type:	Motorola MC68B50
Baud Rates:	110, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 76800 (DIP switch selectable)
Protocol:	RS232, 20 mA current loop (TTY), TTL
Handshaking:	RS-232 CTS, RTS, DCD Open-Collector RTS on Port 0 only
Aux Power Out:	Regulated +/-12V, 500 mA each
Wait States:	0
Connectors:	10-pin MOLEX (M156 option) or 26-pin header (M100 option for straight-through ribbon cable to DB25)
Compatibility:	MITS 88-2SIO, MITS 8800b Turnkey Module, MITS 88-UIO

EPROM

EPROM/EEPROM Type:	2716, 2732, 2764, or 27128/2816A, 28C64
Max access time:	2 MHz system: 450 nS 4 MHz Z-80 system: 200 nS
Wait states:	0
Auto-disable:	Optional EPROM disabled on IN instruction from port FFh (Compatible with MITS software and 8800b Turnkey Module.)

Jump-Start

Start address:	DIP switch selectable to 256-byte page boundary
Compatibility:	* Status Disable compatible with early S-100 memory boards, including those made by MITS * PHANTOM compatible with memory boards that support PHANTOM

Power-On Clear

Trigger:	POC is triggered whenever Vcc falls below ~4.6V
Synchronization:	Positive edge of Phi-2 (Same as Intel 8224)

Turnkey Support

Connector:	10-pin Molex, same type and pinout at MITS 8800B Turnkey Module (Status, Run/Stop, Reset, +5V)
Sense Switches:	8-Position DIP switch for port FFh (disableable)
MWRITE Signal:	Shunt-selectable MWRITE generation

PC BOARD COMPONENTS

Component	Value	Location	Quantity
PC Board, 88-2SIOJP, Rev H			1
Diode, 3.9V Zener	1N4730	D6	1
Resistor, 1/4W	220 Ω	R17	1
Resistor, 1/4W	330 Ω	R24,R25	2
Resistor, 1/4W	2.7K Ω	R16,R18,R19,R21-R23	6
Resistor, 1/4W	10K Ω	R1-R4,R7,R8,R20	7
R-pack, 10-Pin, 9-Resistor	2.2K Ω	RP1,RP3,RP4	3
Crystal	4.9152 MHz	CR1	1
14-pin DIP socket, 0.3" wide		U2,U6,U7,U11-U14,U18-U24,U26,U33,U35	17
16-pin DIP socket, 0.3" wide		U8-U10,U16,U17,U25,U27-U32,U34	13
24-pin DIP socket, 0.6" wide		U4,U5	2
28-pin DIP socket, 0.6" wide		U3	1
DIP Switch, 8-Position SPST		SW3	1
DIP Switch, 9-Position SPST		SW1,SW4	2
DIP Switch, 10-Position SPST		SW5,SW6	2
Capacitor, Ceramic	120 pF	C35	1
Capacitor, Ceramic	0.1 uF	C2-C7,C9-C15,C17-C19,C21-C34,C36,C37	31
Capacitor, Electrolytic, 35V, Axial	10 uF	C8,C20,C38-C40	5
Header, 0.1", 3-pin		J1,J11-J14,J16,J18	7
Header, 0.1", 4-pin		J2,J3	2
Header, 0.1", 5-pin		J1	1
Transistor, NPN, TO-92	2N3904	Q4-Q6	3
Regulator, +12V, TO-220	7812	V3	1
Regulator, -12V, TO-220	7912	V2	1
Regulator, +5V, TO-220	7805	V1	1
Heat Sink, TO-220		V1	1
Machine Screw	6-32, 1/2"	V1-V3	3
Nut	6-32	V1-V3	3
Male right-angle connector, Connector, Ribbon cable, 26-pin		S3,S4 (-R100 version)	(2)
Male right-angle connector, Connector, Molex 0.156", 10-pin		S1,S2 (-M156 version)	(2)
Shunt, 0.1", 2-Pin		J1,J16,J18	3
IC, DIP, Quad 2-Input NAND Gate	74LS00	U14,U35	2
IC, DIP, Hex Inverter	74LS04	U11,U23,U26	3
IC, DIP, Hex Open-Collector Buffer	74LS07	U20	1
IC, DIP, Triple 3-Input NAND gate	74LS10	U12	1
IC, DIP, 8-Input NAND Gate	74LS30	U2	1
IC, DIP, Quad 2-input OR gate	74LS32	U22	1

Component	Value	Location	Quantity
IC, DIP, Dual D Flip-Flop	74LS74	U13,U19	2
IC, DIP, 4-bit Magnitude Comparator	74LS85	U16,U17	2
IC, DIP, Quad Exclusive-Or Gate	74LS86	U21	1
IC,DIP, Quad 2-Input Schmitt NAND	74LS132	U24	1
IC, DIP, 4-Bit Loadable Counter	74LS161	U34	1
IC, DIP, Hex D Flip-Flip with Clear	74LS175	U10,U32	2
IC, DIP, Quad 2-1 Inverting MUX	74LS257	U8,U9	2
IC, DIP, Hex Tristate Buffer	74LS367	U25,U27-U31	6
IC, DIP, 4-Bit Ripple Counter	74LS393	U18,U33	2
IC, DIP, Quad RS232 Line Driver	1488	U7	1
IC, DIP, Quad RS232 Line Receiver	1489	U6	1
IC, DIP, EPROM, ≤300 nS, 4Kx8, Programmed with Amon Firmware	2732A or 2732B	U3 (Amon option)	(1)
IC, DIP, EPROM, ≤300 nS, 16Kx8, Programmed with MITS ROM Basic	27128	U3 (Basic option)	(1)
IC, DIP, ACIA	MC68B50	U4,U5	2

Turnkey Front Panel Option

Component	Value	Location	Quantity
*** Remove Resistor ***	2.7K Ω	R16	1
Resistor, 1/4W	4.7K Ω	R26	1
14-pin DIP socket, 0.3" wide	U1		1
16-pin DIP socket, 0.3" wide	U15		1
Connector, Molex 0.156", 10-pin		S5	1
DIP Switch, 9-position, SPST		SW2	1
R-pack, 10-Pin, 9-Resistor	2.2K Ω	RP2	1
Capacitor, Ceramic	0.1 uF	C1,C16	2
Hex Inverter	74LS04	U1	1
Hex Tristate Buffer	74LS367	U15	1
Header, 0.1”, 2-pin		J17	
Shunt, 0.1", 2-pin		J17	1

Port 0 20 mA Current Loop (TTY) Option

Component	Value	Location	Quantity
Diode, Signal	1N4148	D2, D3	2
Resistor, 1/4W	220 Ω	R5, R13	2
Resistor, 1/4W	1.5K Ω	R6	1
Resistor, 1/4W	2.7K Ω	R12	1
Transistor, PNP, TO-92	2N2907	Q2	1
Header, 0.1”, 2-pin		(J4, J5),J6	1 for M156, 3 for R100
Shunt, 0.1", 2-pin		(J4, J5),J6	1 for M156, 3 for R100

Port 1 20 mA Current Loop (TTY) Option

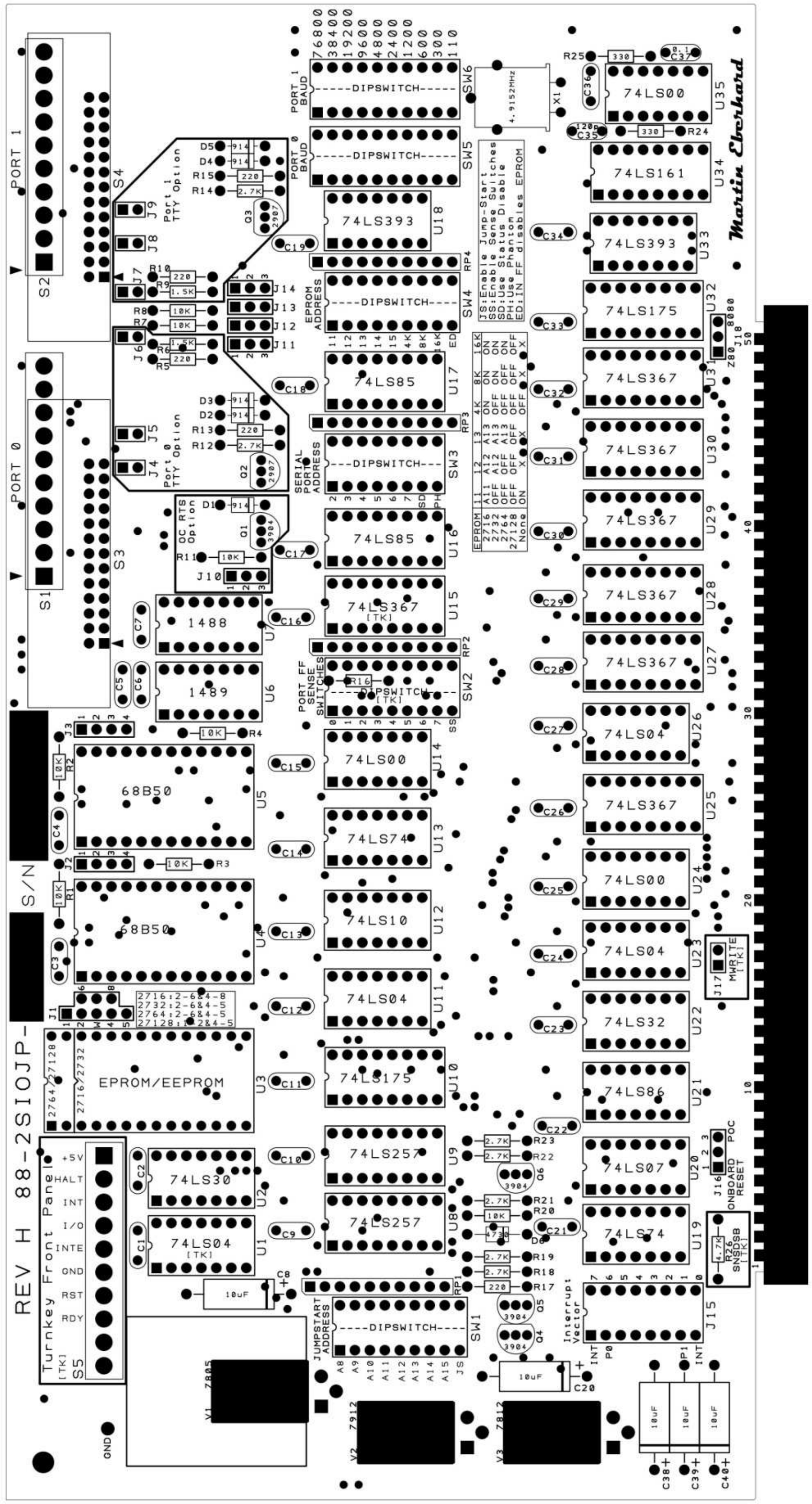
Component	Value	Location	Quantity
Diode, Signal	1N4148	D4, D5	2
Resistor, 1/4W	220 Ω	R10,R15	2
Resistor, 1/4W	1.5K Ω	R9	1
Resistor, 1/4W	2.7K Ω	R14	1
Transistor, PNP, TO-92	2N2907	Q3	1
Header, 0.1”, 2-pin		(J4, J5),J6	1 for M156, 3 for R100
Shunt, 0.1", 2-pin		(J4, J5),J6	1 for M156, 3 for R100

Open Collector RTS Option

Component	Value	Location	Quantity
Diode, Signal	1N4148	D1	1
Resistor, 1/4W	10K Ω	R11	1
Transistor, NPN, TO-92	2N3904	Q1	1
Header, 0.1", 3-pin		J10	1
Shunt, 0.1", 2-Pin		J10 pins 2-3	1

PC BOARD DRAWINGS

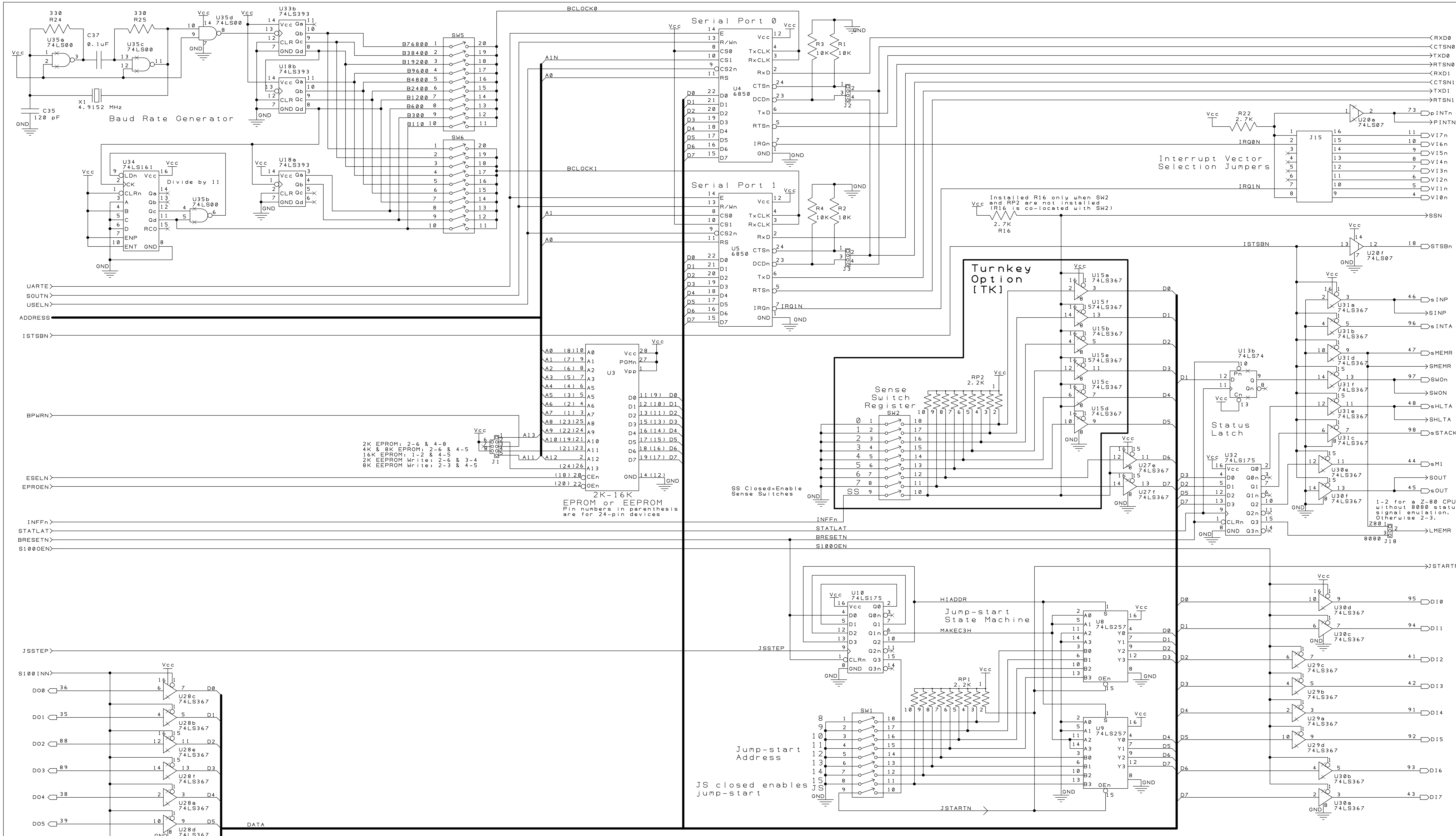
The following pages show the component placements for Rev H PC boards.



Rev H PC Board Component Placement

SCHEMATIC DRAWINGS

The following pages are the schematic drawings for Rev H PC boards.



Spare Gates

U33a 74LS393

Martin Eberhard

Project	88-2SIOJP
Engineer	M. Eberhard
Sheet Title	Data Paths Jump Start and Baud Rate Generator
Filename	DATAPATHS.SCH
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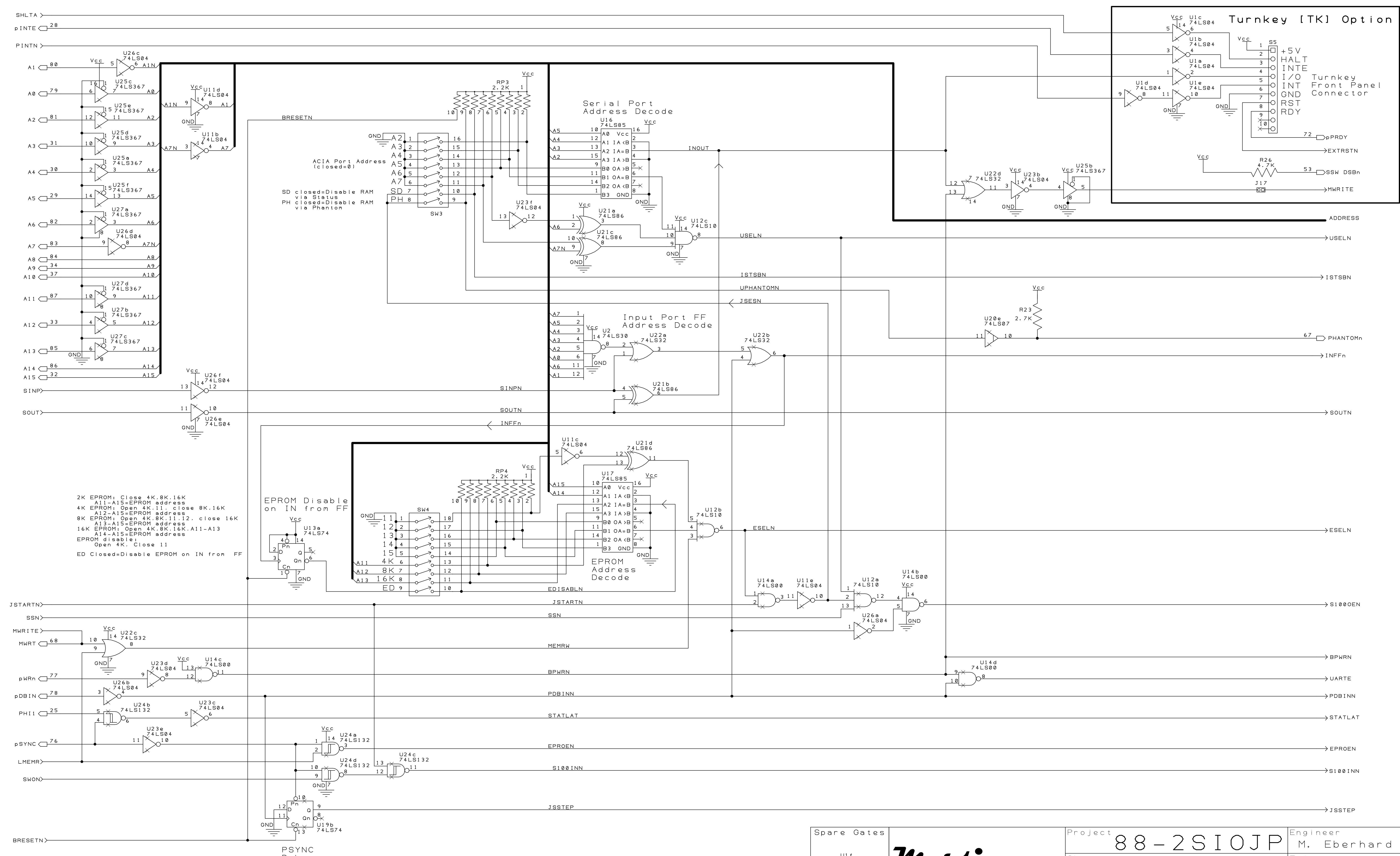


Project: 88-2SIOJP

Engineer: M. Eberhard

Sheet Title: Control Logic and Turnkey Interface

Filename: CONTROL.SCH

Martin Eberhard

Date: 28 January 2024

Revision: H

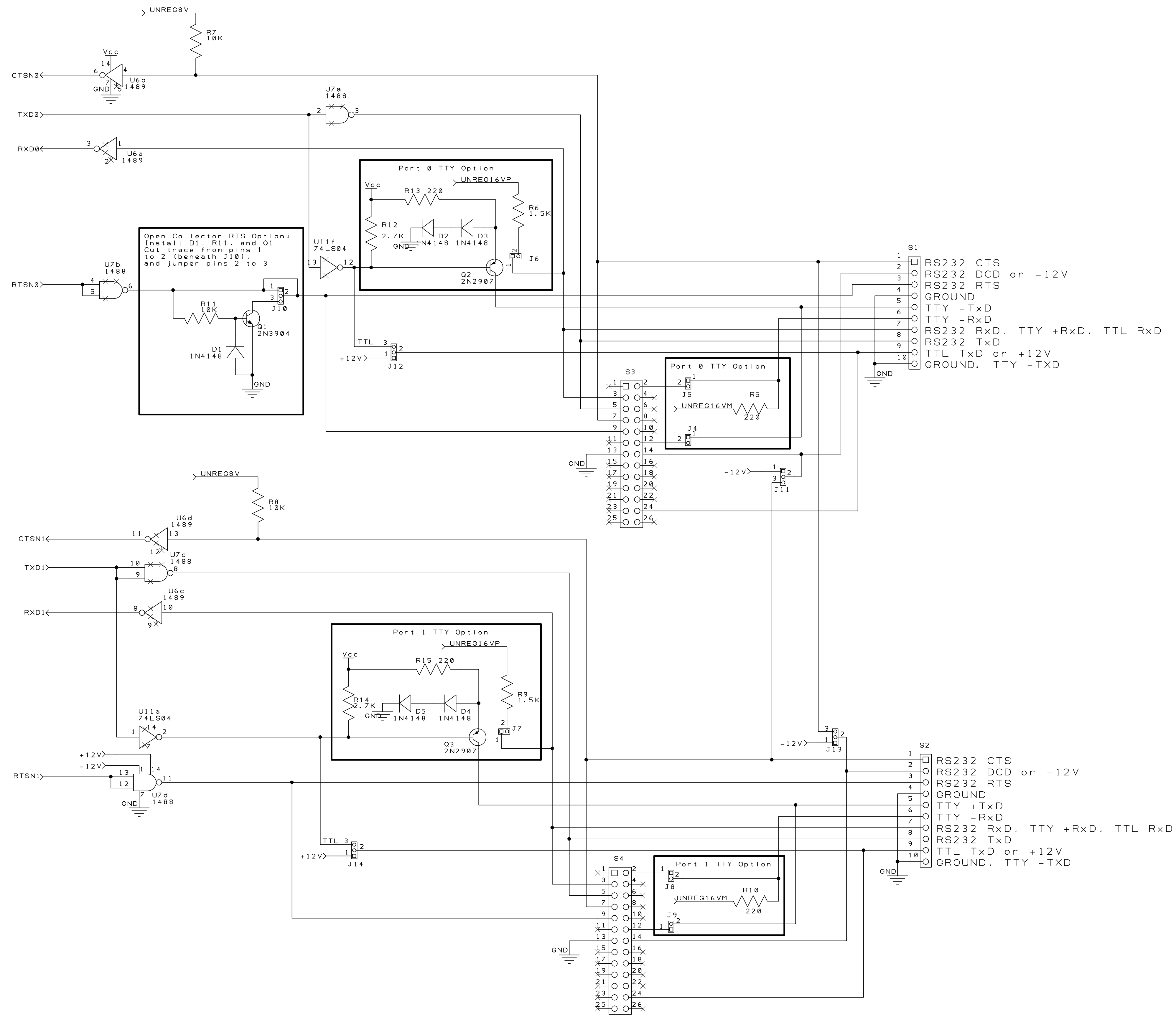
Sheet: 2 of 3

Port 0 M156 (Molex 0.156" connector) Option:
Delete S3, J4, J5
Install TE Connectivity P/N 1-640-385-0 at S1

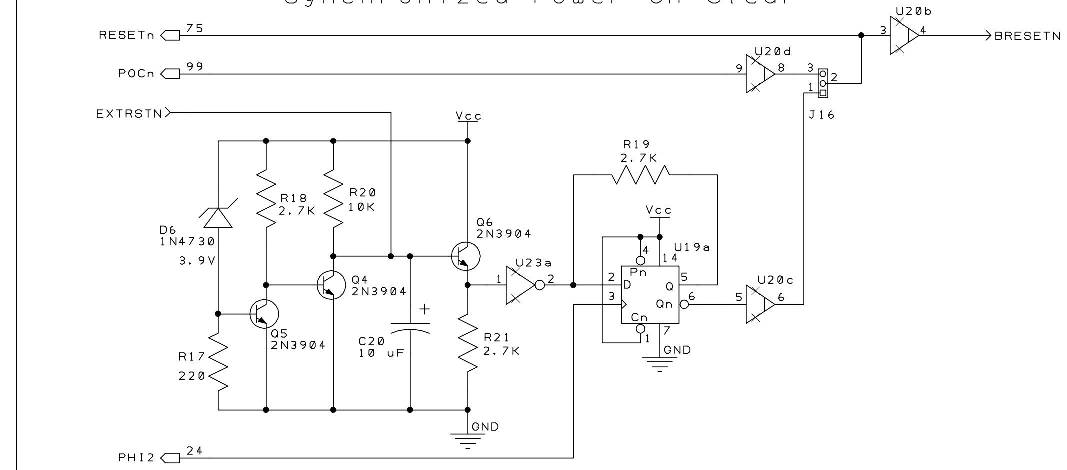
Port 0 R100 (Ribbon Cable Connector) Option:
Delete S1
Install TE Connectivity P/N 2-5499141-6 at S3
Install TE Connectivity P/N 87224-2 at J4, J5

Port 1 M156 (Molex 0.156" connector) Option:
Delete S4, J8, J9
Install TE Connectivity P/N 1-640-385-0 at S3

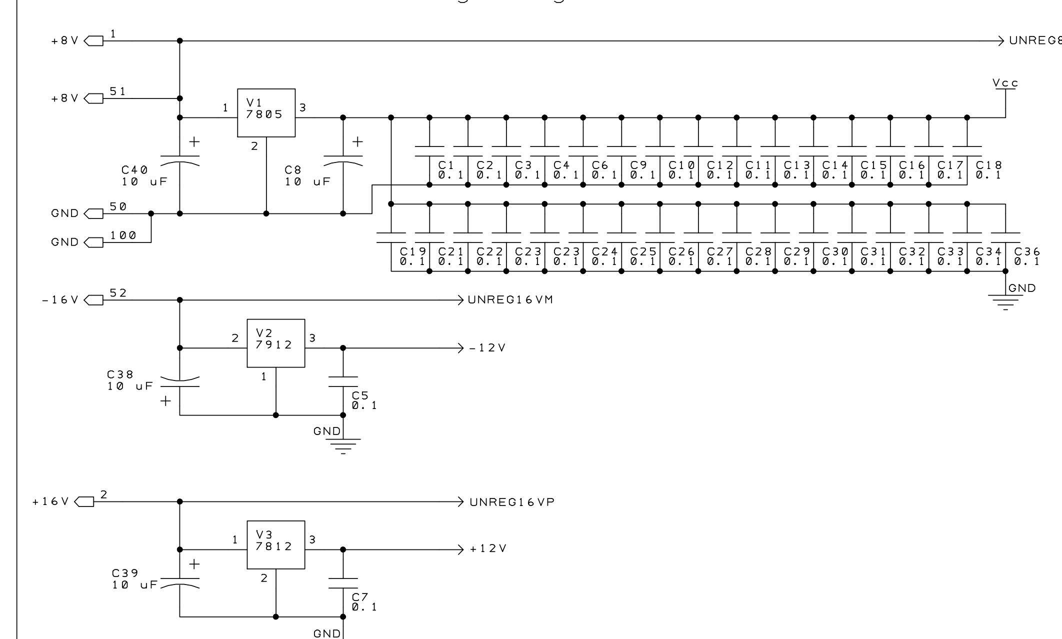
Port 1 R100 (Ribbon Cable Connector) Option:
Delete S3
Install TE Connectivity P/N 2-5499141-6 at S4
Install TE Connectivity P/N 87224-2 at J8, J9



Synchronized Power-On Clear



Voltage Regulation



Martin Eberhard	Project: 88-2SIOJP	Engineer: M. Eberhard
	Sheet Title: Input/Output Buffers Power-On Clear and Voltage Regulation	Filename: INPUTOUTPUT.SCH
	Date: 7 March 2022	Revision: H / Sheet: 3 of 3