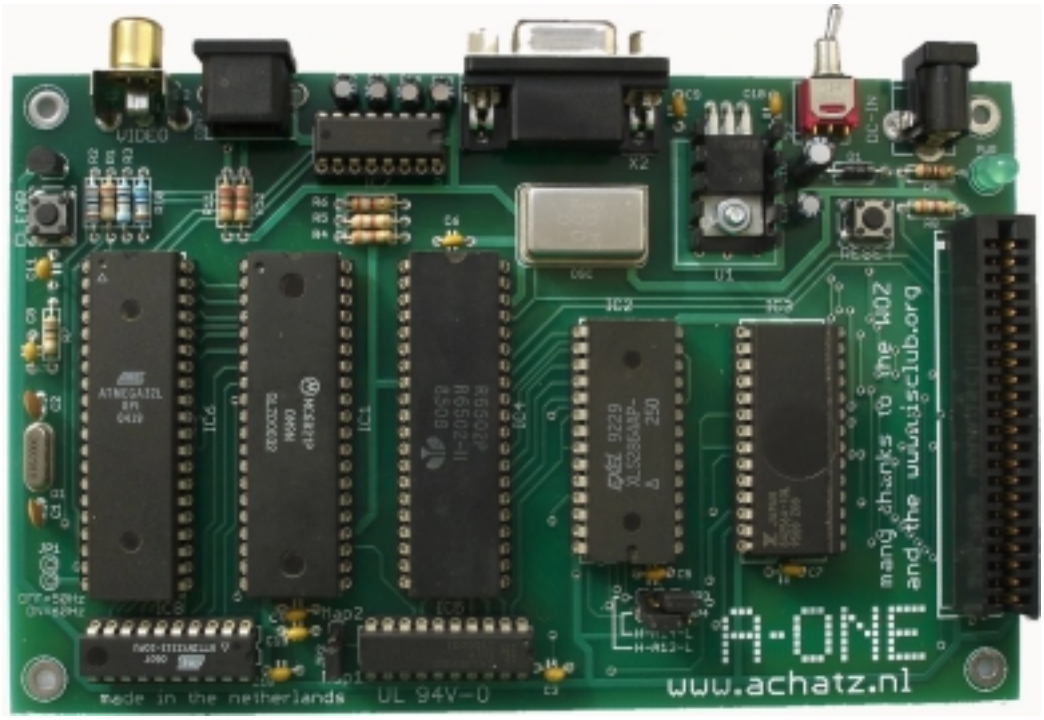
MANUAL

A-ONE

Apple 1 Replica Computer



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A Little Introduction To The Apple 1

Computers and humans do not speak the same language. Fortunately computers have come a long way to learn to understand what we humans want them to do, thanks to graphical user interfaces.
However back in '76 computers were far from being human-friendly. They had to be spoken to in their own native language: binary numbers. Steve Wozniak and his Apple company were among the first to change that a little. His Apple 1 computer came one step closer to us humans. Obviously computers still had a long way to go, but it was considered a giant leap for computer users back then.

Steve Wozniak and Steve Jobs

The Apple 1 was programmable with hexadecimal numbers, instead of binary numbers. It had a real keyboard, instead of a large set of toggle switches and flashing lights. And it had a screen which could show 24 lines of 40 characters each instead of about 6 seven-segment displays (at best). OK we humans were still the ones who had to adapt the most, but from then on computers did their utmost to better integrate with us.
On the Apple 1 this human interface was controlled by the monitor program, better known as the Woz Monitor, named after its creator. A total of 256 bytes of ROM memory were responsible for holding the Woz Monitor and allowing the computer to do something sensible when the RESET switch was pressed. Doesn't sound much, only 256 bytes, but keep in mind that memory was extremely expensive in those days. And hey, it's always 256 bytes more than Apple's main competitor at that time, the Altair 8800, which had no ROM at all and no terminal screen or keyboard!

Introduction To The A-ONE

My main intention was to build a personal computer that could be understood by one single person. Just like Niklaus Wirth designed his Oberon operating system: any one person that knows about programming, can understand all ins and outs of Oberon. The same with me here: I wanted to build a computer that can be understood without having to consult many books and having to listen to many people. So I designed the A-ONE Apple 1 replica. Simple by all means.

Of course, there are people who know just about everything about the original Apple One computer, but never got the chance to work with one. Well, this is your chance.

And for the lawyers among us: I got permission from Steve Wozniak (in writing) for using his original firmware (WOZ-mon and BASIC) for this project.

For this A-one project, I used as many original components as possible:

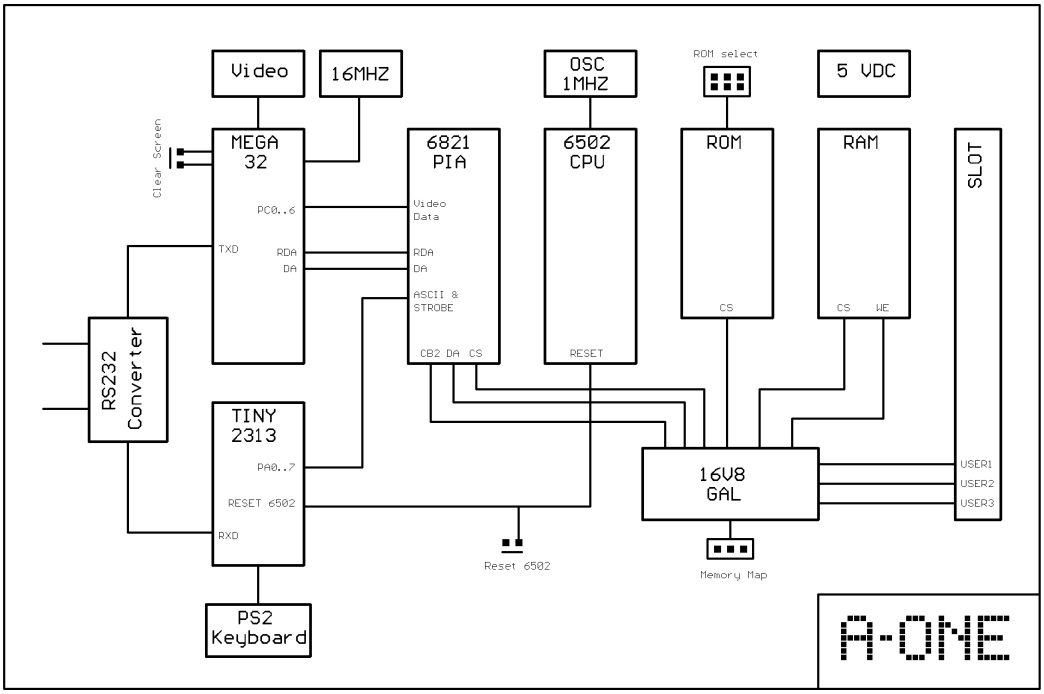
- 6502 CPU
- 6821 PIA
- ROM and RAM (although I used one big instead of many small memories)

Some other (non-essential) parts, however, were easier to redesign and produce with current technology chips. We used a 16V8 GAL for the address decoding. The video display subsystem is now made with one Atmel ATmega32 processor and the PS/2 keyboard is handled by one Atmel Tiny2313 processor. This will enable the user to use the old computer with modern (and hence affordable) peripherals like composite video screen and PS/2 keyboard.

Photo 1: The A-One replica

The A-One replica is upward compatible with the original one. As an addition, it has a fast RS-232 port onboard. Sending of data is handled by the ATmega32, whereas receiving is done by the keyboard controller (Atmel Tiny2313).

A running Machine



A-ONE Block Diagram

Memory Map

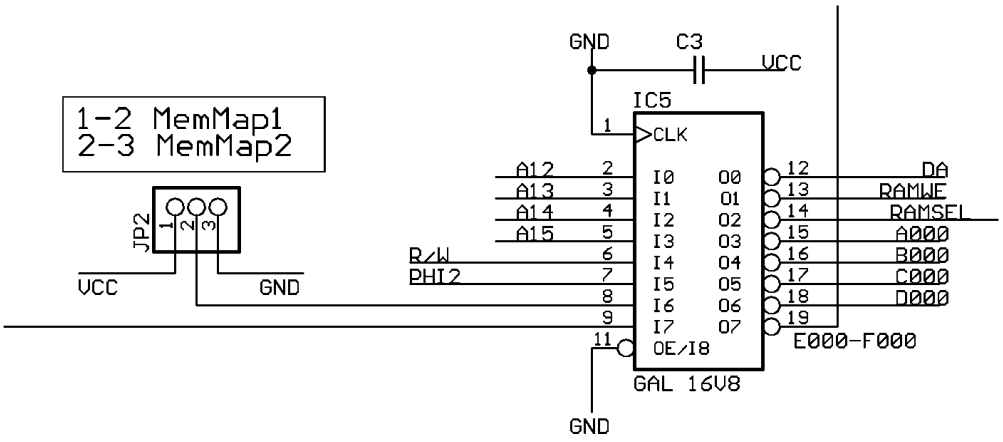
You can choose between two different memory maps:

Option 1:
+ 32 KB RAM bound to address range 0x000 - 0x7FFF
+ WOZ-BASIC in ROM starts at 0xE000
+ WOZ-MON in ROM starts at 0xFF00

Option 2:
+ 4 KB of RAM, originally found at 0x6000 - 0x6FFF is moved to 0xE000 - 0xEFFF

Option 2 corresponds with the original Apple-1 memory map. Since it had 4 KB of RAM at segment 0xE000, there was no ROM-BASIC there.
It had to be loaded by the WOZ-MON..

```
-------------------------------------
      JumperMode=HIGH (Map1)
-------------------------------------

       A15 A14 A13 A12

$0000   0   0   0   0   4K RAM
$1000   0   0   0   1   4K RAM
$2000   0   0   1   0   4K RAM
$3000   0   0   1   1   4K RAM
$4000   0   1   0   0   4K RAM
$5000   0   1   0   1   4K RAM
$6000   0   1   1   0   4K RAM
$7000   0   1   1   1   4K RAM
$8000   1   0   0   0   not used
$9000   1   0   0   1   not used
$A000   1   0   1   0   4K USER
$B000   1   0   1   1   4K USER
$C000   1   1   0   0   4K USER
$D000   1   1   0   1   PIA I/O Control
$E000   1   1   1   0   4k ROM BASIC
$F000   1   1   1   1   4K ROM WOZ-MON

-------------------------------------
      JumperMode=LOW (Map2)
-------------------------------------

       A15 A14 A13 A12

$0000   0   0   0   0   4K RAM
$1000   0   0   0   1   4K RAM
$2000   0   0   1   0   4K RAM
$3000   0   0   1   1   4K RAM
$4000   0   1   0   0   4K RAM
$5000   0   1   0   1   4K RAM
$6000   0   1   1   0   not used
$7000   0   1   1   1   4K RAM
$8000   1   0   0   0   not used
$9000   1   0   0   1   not used
$A000   1   0   1   0   4K USER
$B000   1   0   1   1   4K USER
$C000   1   1   0   0   4K USER
$D000   1   1   0   1   PIA I/O Control
$E000   1   1   1   0   4k RAM
$F000   1   1   1   1   4K ROM WOZ-MON
```



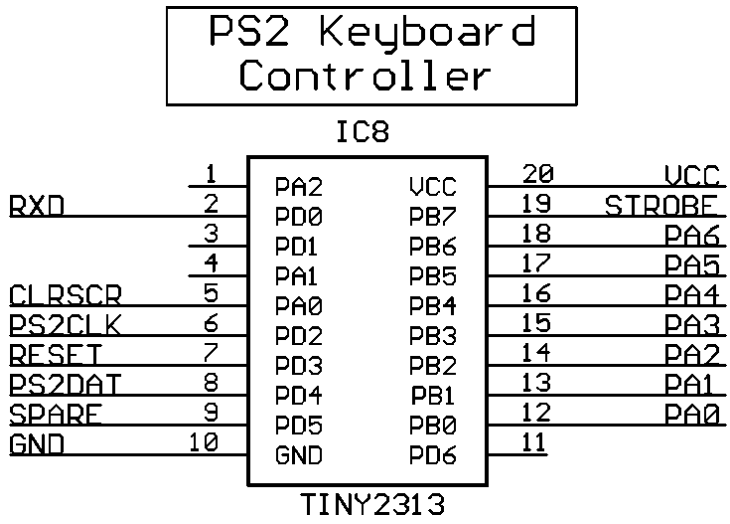
GAL 16V8 Source Code for Address-decoding and Memory Map-select

```
A-ONE GAL 240606 © Achatz

*IDENTIFICATION
    ad_dec;

*TYPE
    GAL16V8;

*PINS
    % Inputs %
    A12   =   2,
    A13   =   3,
    A14   =   4,
    A15   =   5,
    RW    =   6,
    PHI2  =   7,
    JMP   =   8,
    CB2   =   9,
    % Outputs %
    DA     =   12,
    RAMWE  =   13,
    RAMSEL =   14,
    A000   =   15,
    B000   =   16,
    C000   =   17,
    D000   =   18,
    EF00   =   19;

*BOOLEAN-EQUATIONS

    /DA = CB2;
    /RAMWE = PHI2 & /RW;
    /EF00  = (JMP & A12 & A13 & A14 & A15 + JMP & /A12 & A13 & A14 & A15 +
              /JMP & A12 & A13 & A14 & A15);
    /D000  = A12 & /A13 & A14 & A15;
    /C000  = /A12 & /A13 & A14 & A15;
    /B000  = A12 & A13 & /A14 & A15;
    /A000  = /A12 & A13 & /A14 & A15;
    /RAMSEL =  JMP & /A15 +
               /JMP & A15 & A14 & A13 & /A12 + /JMP & /A15 & /A13 + /JMP & /A15 & /A14 +
               /JMP & /A15 & A12;

*END
```

PS2 Keyboard

An industry standard PS/2 keyboard is used by the A-One. It is controlled via the ATtiny2313 processor. The PS/2 clock line is controlled by PortD.2 and the data line is controlled by PortD.4. PortD.3 is used for generating a RESET condition for the A-One processor (the 6502) either when a Ctrl-R is received via RS-232 or when the user presses the F12 function key.
PortB, bits 0 to 6, output the 7 bit keyboard data to the 6821 PIA chip.

All data that is received via RS 232 (at 2400 bps) is directed to PortB, just like the keyboard data.
Additionally, a strobe signal is generated and implemented as PortB.7 This menas that a terminal session on a PC connected to the A-One via serial cable, is treated as direct keyboard input by the A-One.

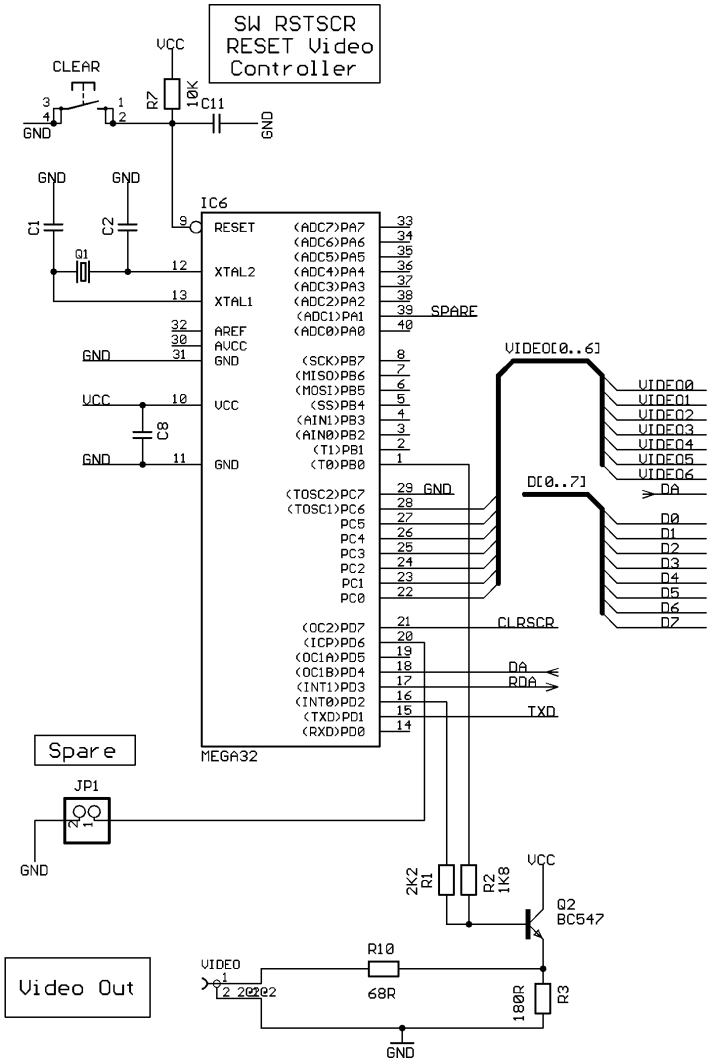


Video Controller

The ATmega32 serves two purposes:

- generating the videodata
- outputting the serial data via the TxD pin (PortD.1, pin 15)

All data that comes from the keyboard is retransmitted instantly via the TxD pin of the ATmega32.
The V-sync routine controls the DA and RDA handshake signals which are required for the 6821 peripheral.
Every 20 ms, a new character can be sent to the videocontroller, which means that maximum 50 characters per second are allowed.



Working with the A-ONE

WOZ MONITOR

The original Apple 1 did not come with a Reset circuit, which means that the user has to press the RESET switch in order to get the machine started. Once you do that a back slash '\' is printed on the screen and the cursor will drop down one line. The cursor position is represented by a flashing '@' symbol.
You can now type address, data and commands which will be executed as soon as you press the Return key. The input buffer can hold up to 127 character, if you type more characters before hitting the Return key the input line will be erased and will start again from scratch. This is overflow situation is indicated by a new back slash after which the cursor drops one line again.
Because of the primitive nature of the terminal there are not many line-editing features available. You can press the back arrow key to erase characters from the input buffer, but the erased characters will not be erased from the screen nor will the cursor position back-up. You'll have to keep track of the changes yourself. It's obvious that you can easily get confused when a line contains too many corrections or when an error is detected all the way at the other end of the input line. In that case it would be easiest to cancel the input and start all over again. Cancelling the input is done by pressing the ESC key.
Address inputs are truncated to the least significant 4 hexadecimal digits. Data inputs are truncated to the least significant 2 hexadecimal digits.
Thus entering 12345678 as address will result in the address 5678 to be used.
Tip: This can also be used to your advantage to correct typing errors, instead of using the back arrow key.
If an error is encountered during the parsing of the input line then the rest of the line is simply ignored, without warning! Commands executed before the error are executed normally though.

Examining memory (memory dump)

You can examine the contents of a single memory location by typing a single address followed by a `Return`.

```
4F

004F: 0F
```

Note: The **bold** typed characters are what the user types. All other characters are responses from the Apple 1.
Now let us examine a block of memory from the last opened location to the next specified location.

```
.5A

0050: 00 01 02 03 04 05 06 07
0058: 08 09 0A
```

Note: `004F` is still considered the most recently opened location.
We can also combine the previous two examples into one commend:

```
4F.5A

0040: 0F
0050: 00 01 02 03 04 05 06 07
0058: 08 09 0A
```

Note: Only the first location of the block `4F` is considered opened.
You can also examine several locations at once, with all addresses on one command line.

```
4F 52 56

004F: 0F
0052: 02
0056: 06
```

Note: `0056` is considered the most recently opened address.
Let's take this concept into the extremes and combine some block and single address examinations on one command line.

```
4F.52 56 58.5A

004F: 0F
0050: 00 01 02
0056: 06
0058: 08 09 0A
```

Note: By now you won't be surprised that `0058` is considered the most recently opened location.
Finally let's examine some successive blocks of memory. This can be handy if you want to examine a larger block of memory which will not fit on one monitor screen. Remember that there is no way to halt a large examine list other than hitting the RESET button!

```
4F.52

004F: 0F
0050: 00 01 02
.55

0053: 03 04 05
.5A

0056: 06 07
0058: 08 09 0A
```

Depositing memory (changing memory contents)

This is how to change a single memory location (provided it is RAM memory of course).

```
30:A0

0030: FF
```

Note: `FF` is what location `00300` used to contain before the operation, from now on it contains `A0`.
Location `0030` is now considered the most recently opened location.
Now we're going to deposit some more bytes in successive locations, starting from the last deposited location.

```
:A1 A2 A3 A4 A5
```

Note: Location `31` now contains `A1`, location `32` contains `A2` and so on until location `35` which now contains `A5`.

Combining these two techniques will give us the next example.
30:A0 A1 A2 A3 A4 A5

0030: FF
Note: Location 0030 used to contain FF in this example.
Breaking up a long entry into multiple command lines is done like this:
30:A1 A2

0030: FF
:A2 A3

:A4 A5

Note: A colon in a command means "start depositing data from the most recently deposited location, or if none, then from the most recently opened location.
Now we're going to examine a piece of memory and then deposit some new data into it:
30.35

0030: A0 A1 A2 A3 A4 A5
:B0 B1 B2 B3 B4 B5
Note: New data deposited beginning at most recently opened location, which is 0030 in this example.

Running a program

To run a program at a specified address:
10F0R

10F0: A9
Note the cursor is left immediately to the right of the displayed data; it is not returned to the next line. It's the program's responsibility to control the rest of the output.
From now on the user program is in control of the Apple 1. If the user program does not return to the Woz monitor (by jumping to address $FF1F) you'll have to press the RESET key to stop your program and return to the Woz Monitor.
You can also enter a program and run it all from the same command line. Please note that this only works for very short programs of course.
40: A9 0 20 EF FF 38 69 0 4C 40 0 R

40: FF
Note: FF is the previous contents of location 0040.
This little program will continue printing characters to the screen. It can only be stopped by pressing the RESET key.

The Woz Monitor's RAM Use

The monitor needs some RAM memory to perform its tasks. When a user program is running all bytes used by the monitor may be recycled, the monitor doesn't care about the contents of any of the memory locations when it regains control again. Here's the complete list of all the memory the Woz Monitor requires while it is running:

Zero page	**$24 to $2B**	General purpose storage locations. None of the bytes are very important and they may all be changed by the user program.
Stack page	**$0100 to $01FF**	Although the Woz Monitor only uses 3 bytes of stack space at most there is no way of telling where the stack actually is. This is because the stack pointer is not initialized by the Woz Monitor. A user program may use the entire stack for its own purposes. However be careful when entering code on page $01 before the stack pointer is initialized, the monitor may overwrite your code again.
Input buffer	**$0200 to $027F**	This space is used as input buffer. User programs may use this area. However you can not enter code here manually because it will be overwritten by the monitor.

The next addresses are not exactly RAM locations, which doesn't make them less important though. They are the 6821 PIA control registers.

KBD	**$D010**	Keyboard input register. This register holds valid data when b7 of KBDCR is "1". Reading KBD will automatically clear b7 of KBDCR. Bit b7 of KBD is permanently tied to +5V. The monitor expects only upper case characters.
KBDCR	**$D011**	The only bit which we are interested in in this register is the read-only bit b7. It will be set by hardware whenever a key is pressed on the keyboard. It is cleared again when the KBD location is read.
DSP	**$D012**	Bits b6..b0 are the character outputs for the terminal display. Writing to this register will set b7 of DSP, which is the only input bit of this register. The terminal hardware will clear bit b7 as soon as the character is accepted. This may take up to 16.7 ms though!
DSPCR	**$D013**	This register is better left untouched, it contains no useful data for a user program. The Woz Monitor has initialized it for you. Changing the contents may kill the terminal output until you press RESET again.

Useful Routines

Apart from the monitor program itself the Woz Monitor contains only a few useful routines which can be called by user programs.

$FF1F GETLINE This is the official monitor entry point. If your program is finished and you want to return to the monitor you can simply jump to this location. It will echo a CR and from then on you are back in the monitor.

$FFEF ECHO This simple routine prints the character in the Accumulator to the terminal. The contents of the Accumulator are not disrupted, only the flag register will be changed.
Although this is a fairly short routine it may take up to some 16.7 ms before it returns control to the user program. For more details about this behaviour please read the page about the terminal.

$FFDC PRBYTE This routine prints the byte which is held in the Accumulator in hexadecimal format (2 digits). The contents of the Accumulator are disrupted.

$FFE5 PRHEX Prints the least significant 4 bits of the Accumulator in hexadecimal format (1 digit). The contents of the Accumulator are disrupted.

If you want to read a single character from the keyboard from within your own machine language program you can use the following piece of code:

```
KBDIN       LDA     KBDCR       See if there is a character available
            BPL     KBDIN       Not as long as b7 remains low
            LDA     KBD         Get the character and clear the flag
```

WOZ BASIC

I think it goes without saying that you should make sure that Apple 1 Basic is loaded into memory before it can be started. If it's not provided in ROM you'll have to load it into memory locations from $E000 to $EFFF. The Basic interpreter can be started by typing E000R in the Woz Monitor. After printing the contents of address E000 you'll see a **>** symbol followed by the flashing cursor, which is from now on our prompt to enter Basic commands.
E000 is the so called "Cold" entry point to the Basic interpreter, which means that the program is initialized before we can really get going. This also means that there will be no runnable program in memory when we enter the Basic this way. </P
If you had to go back to the Woz monitor for any particular reason and want to return to the Basic interpreter without losing anything you can use the "Warm" entry point by typing E2B3R in the Woz Monitor.
Starting Basic using its Cold entry point initializes the LOMEM and HIMEM pointers to $0800 and $1000 respectively (HIMEM is set to 4k + 1). This means that you'll have a total of 2k of memory for your Basic program and its variables.
On a standard Apple 1 with 8k of RAM, you could lower LOMEM to $0300, giving you an extra 256 bytes of program memory. If you have more than 8k of RAM, which is the case with probably all modern day replicas and the Apple 1 emulation programs, then you can raise HIMEM to whatever memory size you've got. Needles to say of course that you can only use a contiguous block of memory between LOMEM and HIMEM. Changing LOMEM and HIMEM is done with two similar named commands. Please note that these two commands only accept decimal values and that they do NOT test whether your entries are valid. Also note that these commands will erase your existing Basic program from memory!

First make sure Jumper JP2 selects Map1 (we use the BASIC in ROM).

Reset the A-ONE by pressing the Reset-switch or „F12“.

We are ready to start BASIC.

USER TYPES:

E000R[return]

BASIC TYPES:

E000: 4C
>

The A-ONE is showing the BASIC-Prompt „>“

USER TYPES:

PRINT 15+35[return]

BASIC TYPES:

50
>

USER TYPES:

10 A=1
20 PRINT A
RUN

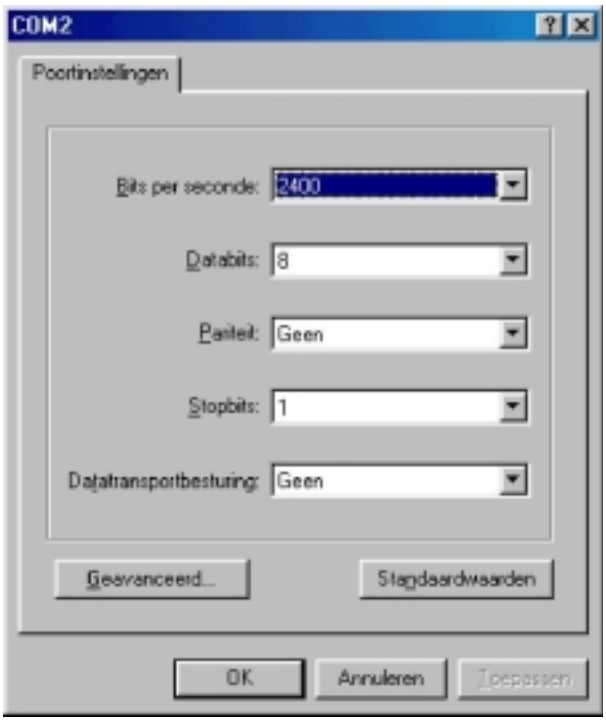
BASIC TYPES:

1
**** END ERR*

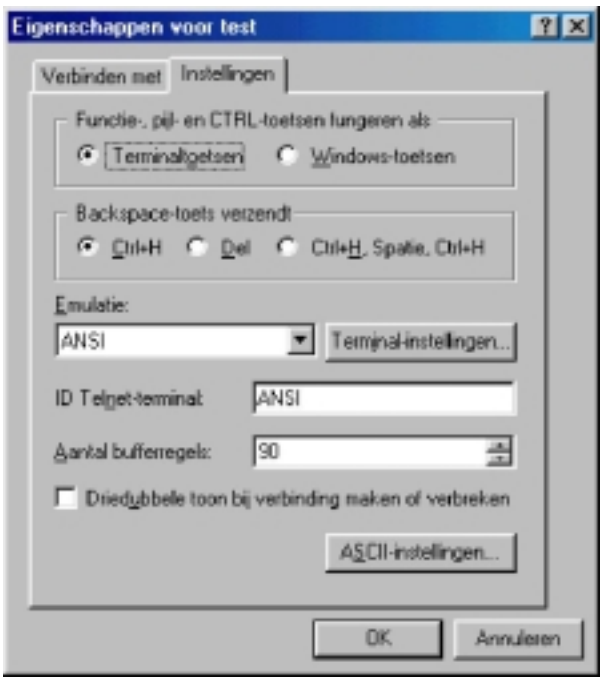
For a detailed description of all BASIC commands and for using the Monitor please consult the links at the end of this document

Hyperterminal settings:

Select the correct com port at your personal computer



2400 Baud, 8 Bits, no parity, 1 stopbit, no handshake

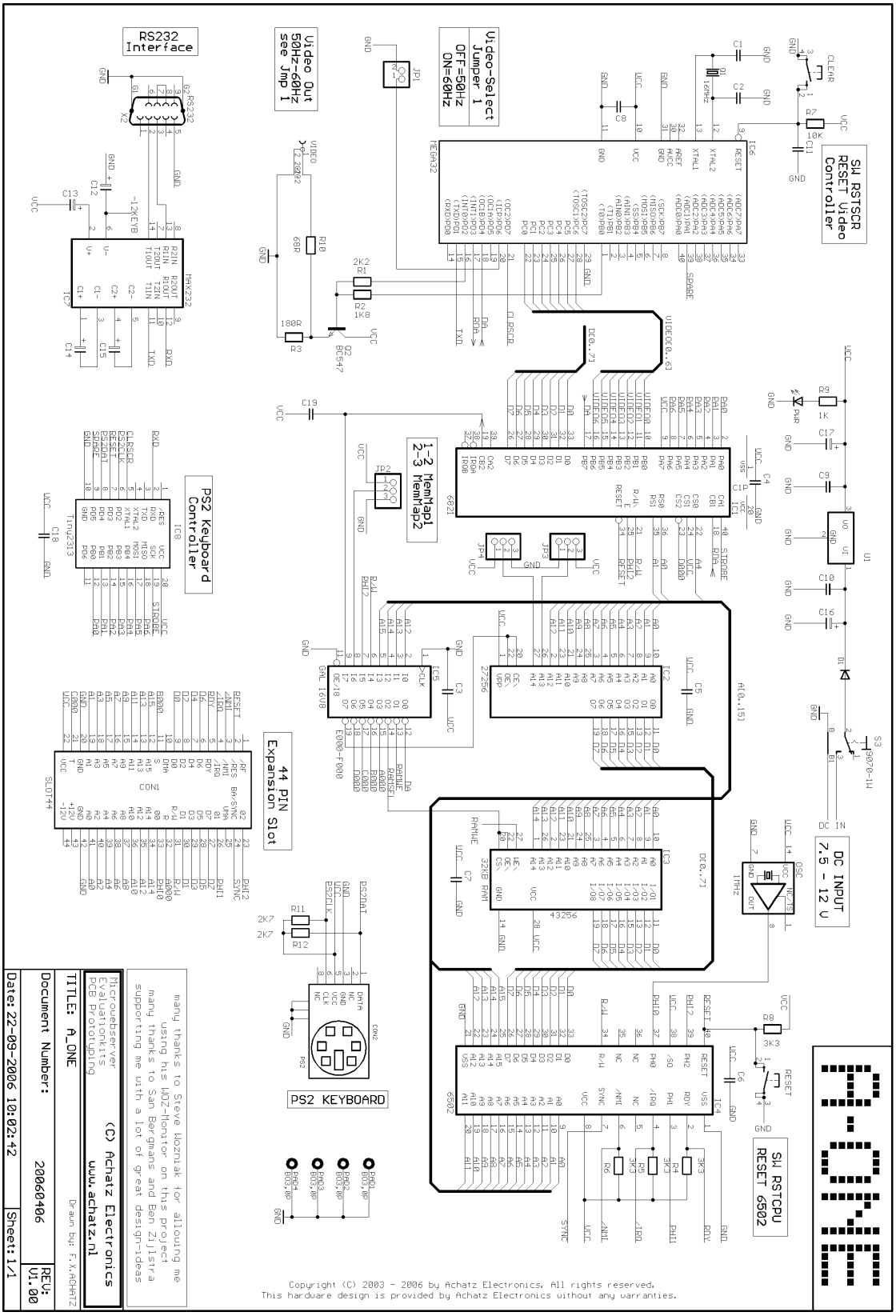


Important: line-delay and char-delay is set to 500ms and 5ms

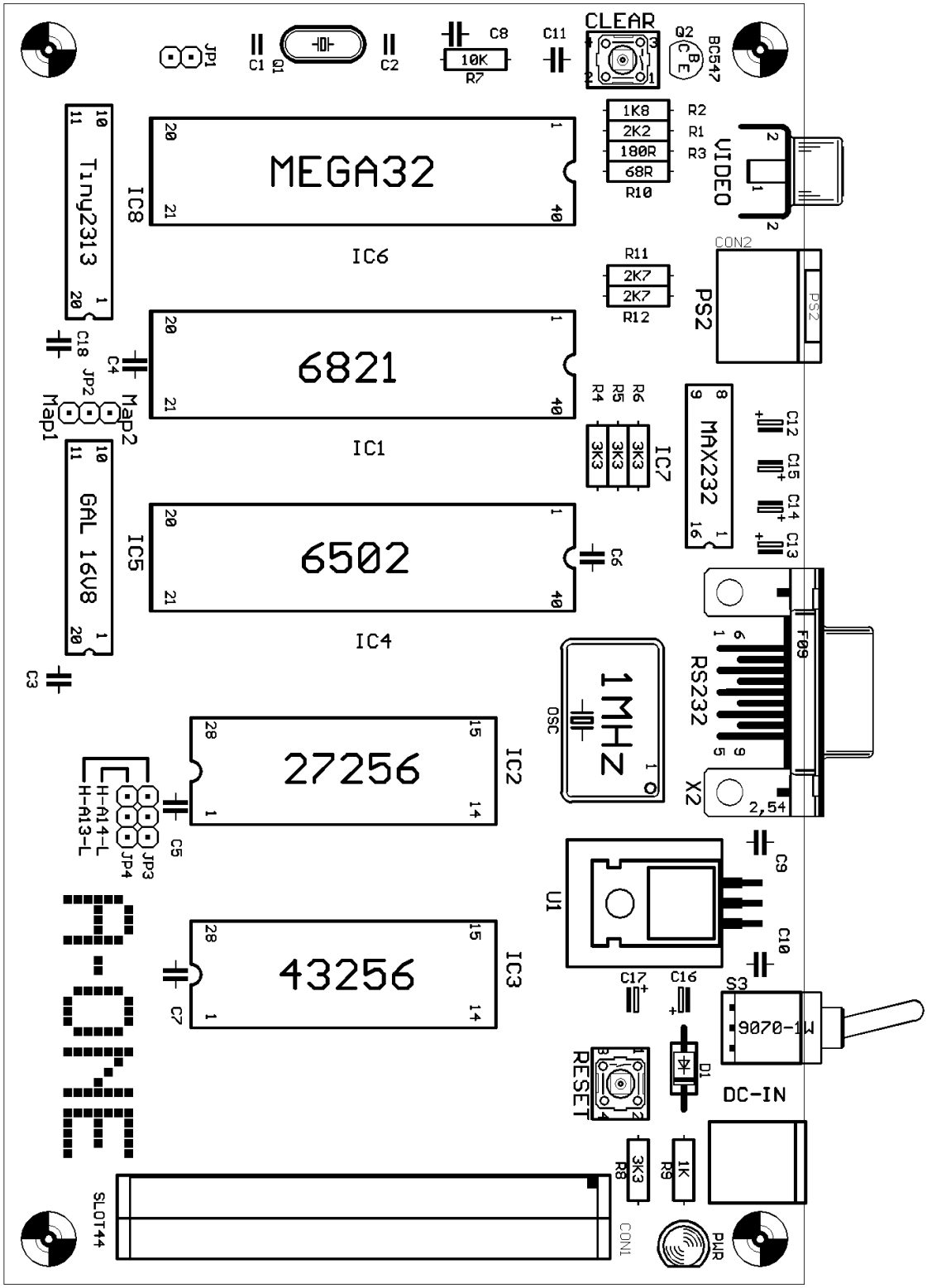
Make sure, using a normal 1:1 serial cable male-female with 9 pins. You can operate the A-ONE via a Terminal exactly the same way using a PS2 keyboard.

Technical Datas:

CPU:	MOS TECHNOLOGIE 6502
System-Clock:	1 MHZ
RAM Memory:	32 KB SRAM standard (optional 32KB ZeroPowerRAM) (optional 32KB Time-Keeper-RAM)
ROM Memory:	8KB standard 8/16/32KB-Types supported using jumperselect
Videocontroller:	ATMEGA32-16 40 Chars/line at 24 Video-Lines, 50 Chars/per second at max, with automatic scrolling, Clear-Screen Function when receiving a CTRL-L
Video Output:	Composite positiv video, 75 Ohms, Frame-Rate 50 Hz
Keyboardcontroller:	Attiny2313 (8MHZ intern) Software designed for a standard PS2 Keyboard using a US-Keyboard-Layout, 6502 Reset-Function when receiving a CTRL-R
Adressdecoding:	GAL16V8 two Memory-Maps available using jumperselect
RS232:	9-pin SubD Female-connector, 2400 Bd transmit/receive
Expansionconnector:	2x22 Edge Connector (Apple 1 compatible)
Switches:	Reset-switch for 6502 CPU, Clear-switch for Video
Powersupply:	recommended single universial AC-DC Adapter
Voltage:	DC 9 – 12 VDC
Supply Current:	250 mA
PCB-Size:	160 x 100 mm (Euro-Format)



A-ONE Schematic



A-ONE COMPONENT SIDE

Parts list:

C1	22pf
C2	22pf
C3	100nf
C4	100nf
C5	100nf
C6	100nf
C7	100nf
C8	100nf
C9	100nf
C10	100nf
C11	100nf
C12	10uf
C13	10uf
C14	10uf
C15	10uf
C16	10uf
C17	10uf
C18	100nf
C19	100nf
R1	2K2
R2	1K8
R3	100R
R4	3K3
R5	3K3
R6	3K3
R7	10K
R8	3K3
R9	1K
R10	68R
R11	2K7
R12	2K7

IC1	6821 PIA
IC2	27256 EPROM
IC3	43256 RAM
IC4	6502 CPU
IC5	GAL 16V8
IC6	ATMEGA32
IC7	MAX232
IC8	ATTiny2313
U1	7805 with heatsink
D1	1N4004
Q1	16MHz
Q2	BC547
OSC	1MHZ
PWR	LED 5mm
JP1	1X02
JP2	1X03
JP3	1X03
JP4	1X03
CON1	SLOT44
CON2	PS2
VIDEO	TOBU3
X2	F09HP
RESET	Key OMRON
CLEAR	Key OMRON
S3	SWITCH
IC socket	40 pins (3pcs)
IC socket	28 pins (2pcs)
IC socket	20 pins (2pcs)
IC socket	16 pins (1pcs)

The A-ONE is shipped with a SRAM (IC3). In place of the SRAM a NVRAM can be used, as well. One such RAM is the M48Z35Y-70. Or when installing a M48T35Y-70 (TimeKeeperRAM) it will give you a Realtime Clock on the A-ONE.

Please handle the A-ONE board and/or the micro-chips with care.

Follow the instructions for using Electrostatic Sensitive Devices (ESD)

Assembling the Kit version:

Step1:
First locate all delivered parts. Check if everything is in the bag (use the parts list).

Step2:
Start soldering the resistors (R1 - R12) and the diode (D1).

Step3:
Install and solder the IC-sockets.

Step4:
Solder the 100nf and the 22pf capacitors (C1 – C11,C18,C19)

Step5:
Install the pinheaders and the cristals. Take care about the 1 MHZ Oscillator.
The direction of this part is important.

Step6:
Complete the board by installing the connectors, switches, Regulator with Heatsink, Electrolytic capacitors (C12-C17) and the LED

Step7:
Check your work. Re-check the right values of the parts.

Step8:
Before installing the IC's we use a AC-DC poweradapter, switch it to 9 ...12VDC and power-up the A-ONE board. The LED should light and nothing should get hot or smoke. If this is done, then disconnect the Poweradapter !!!!!

Step9:
Carefully install the IC's in their right places. Jumper 2 selects Map 1.
Jumper 3 selects (A13 – L) and Jumper 4 selects (H – A14).

Step10:
Re-check your work again. Take care about the directions of the installed micro-chips.

Step11:
Connect a PS 2 Keyboard at the PS 2 connector and connect a composite TV or a composite video monitor at the cinch connector (video-connector).
Switch on the TV monitor and powerup the A-ONE board.
A blinking „@" must appear at top of the video-screen. Now press the A-ONE Reset-button and a „\" comes up in the first line, followed by a blinking „@" in the second line.

It's time to say congratulations, you did a great job.

Special Functions:

PS2 KEYBOARD:

[ESC] = escaping auto line numbering (SB Assembler)
[SHIFT]+[ESC} = escaping auto line numbering (WOZ-BASIC)
[F1] = CLEAR SCREEN
[F12] = RESET 6502 CPU

HYPER TERMINAL:

[ESC] = escaping auto line numbering (SB Assembler)
[CRTL]+[D] = escaping auto line numbering (BASIC)
[CTRL]+[L] = CLEAR SCREEN
[CTRL]+[R] = RESET 6502 CPU

CLEAR SCREEN

The Apple 1 does not support a software-controlled clear-screen function and the video-output is scrolling. We have implemented a clear-screen function in the video-controller by sending a HEX [0C].

Example:

LOAD THIS SEQUENZ INTO RAM:

0000: A9 0C 2C 12 D0 30 FB 8D
0008: 12 D0 60

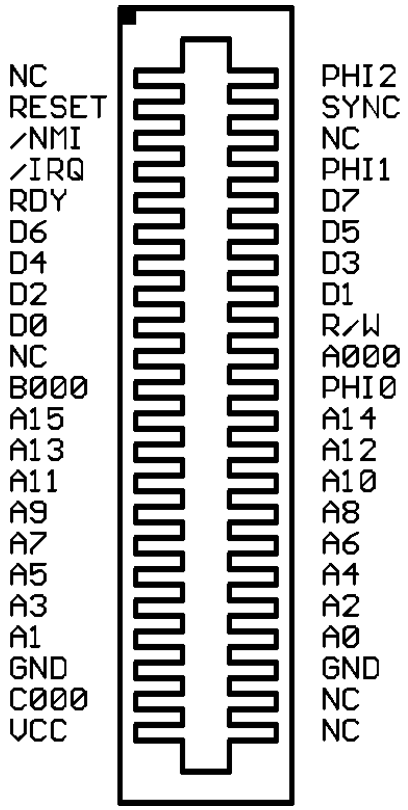
Make a [CALL 0] within BASIC for Clear Screen and Cursor Home

JUMPER SETTINGS

JP1 not used at this moment
JP2 selects Map1 or Map2
JP3 A13 - L
JP4 H – A14

Expansion slot:

The A-ONE can be expanded with I/O devices via a 44 pin edge connector.
All address lines, data lines, control signals and clock signals are available.



Top view

System Monitor:

The Hex Monitor is a program in location FF00 to FFFF (hex) and is entered by hitting reset and a backslash is displayed. It performs frontpanel functions of examing memory and running programs.

```
FF00: D8 58 A0 7F 8C 12 D0 A9
FF08: A7 8D 11 D0 8D 13 D0 C9
FF10: DF F0 13 C9 9B F0 03 C8
FF18: 10 0F A9 DC 20 EF FF A9
FF20: 8D 20 EF FF A0 01 88 30
FF28: F6 AD 11 D0 10 FB AD 10
FF30: D0 99 00 02 20 EF FF C9
FF38: 8D D0 D4 A0 FF A9 00 AA
FF40: 0A 85 2B C8 B9 00 02 C9
FF48: 8D F0 D4 C9 AE 90 F4 F0
FF50: F0 C9 BA F0 EB C9 D2 F0
FF58: 3B 86 28 86 29 84 2A B9
FF60: 00 02 49 B0 C9 0A 90 06
FF68: 69 88 C9 FA 90 11 0A 0A
FF70: 0A 0A A2 04 0A 26 28 26
FF78: 29 CA D0 F8 C8 D0 E0 C4
FF80: 2A F0 97 24 2B 50 10 A5
FF88: 28 81 26 E6 26 D0 B5 E6
FF90: 27 4C 44 FF 6C 24 00 30
FF98: 2B A2 02 B5 27 95 25 95
FFA0: 23 CA D0 F7 D0 14 A9 8D
FFA8: 20 EF FF A5 25 20 DC FF
FFB0: A5 24 20 DC FF A9 BA 20
FFB8: EF FF A9 A0 20 EF FF A1
FFC0: 24 20 DC FF 86 2B A5 24
FFC8: C5 28 A5 25 E5 29 B0 C1
FFD0: E6 24 D0 02 E6 25 A5 24
FFD8: 29 07 10 C8 48 4A 4A 4A
FFE0: 4A 20 E5 FF 68 29 0F 09
FFE8: B0 C9 BA 90 02 69 06 2C
FFF0: 12 D0 30 FB 8D 12 D0 60
FFF8: 00 00 00 0F 00 FF 00 00
```

Hardware notes:

Page 0 Variables

XAML	24
XAMH	25
STL	26
STH	27
L	28
H	29
YSAV	2A
MODE	2B

Other Variables PIA

IN	200-27F
KBD	D010
KBD CR	D011
DSP	D012
DSP CR	D013

Power Supply:

For operating the A-ONE you need a universal AC-DC Adapter.
Before plugging the adapter into the Wall Socket, please follow the
Instructions shown below:

VOLTAGE: Set the voltage selector switch to the required voltage (9-12VDC)

CURRENT: Ensure that the device to be powered is suitable for use with 350mA

INPUT PLUG: Select the correct size Input Plug (2.1mm barrel connector)

POLARITY: Make sure that the center of the Barrel Connector is set to +12VDC

PROTECTION: The A-ONE is protected agains a wrong selected polarity

Links and downloads:

http://www.sbprojects.com

http://www.applefritter.com/apple1

http://www.achatz.nl

http://www.brielcomputers.com

Many thanks to Jan Verhoeven for helping me on this Manual

Thanks to San Bergmans for his great design-ideas and for making his SB Assembler available for the A-ONE and for the Apple 1.

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This unit has been thoroughly tested and inspected to assure proper performance and operation

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