AccessionIndex: TCD-SCSS-T.20121208.043
Accession Date: 8-Dec-2012
Accession By: Dr.Brian Coghlan
Object name: Western Digital WD90 Pascal Microengine
Vintage: c.1979
Synopsis: Commercial microcoded high-level language machine to execute Pascal p-code, based on WD9000 chipset developed for LSI-11 (see VAX 11/780 Console Processor elsewhere in collection). S/N: 668.

Description:
This unusual commercial microcoded high-level language machine was designed to execute Pascal p-code. It was based on same WD9000 chipset that was developed c.1978 by Western Digital for the DEC LSI-11 (see VAX 11/780 Console Processor elsewhere in collection). The WD90 was introduced by Western Digital in 1979.

WD-9000 five chip microprocessor chip set was based on the MCP-1600 chipset for the LSI-11, with a four-phase 3MHz clock. Early CPU boards had poor power and ground layouts, leading to a justified reputation for unreliability. The CPU chipset included a 16-bit Datapath Chip containing the microcode decoder, ALU and register file, a Control Chip containing the portions of the control processor and I/O logic and the microinstruction counter, and 4kB of microcode ROM in three MICROM Chips, each 512 x 22-bits. The five chips are interconnected to an 18-bit microinstruction bus. The p-code interpreter was implemented in the microcode ROM, so the p-code was, effectively, its native (virtual) machine language, referred to variously as the pseudo-machine or p-machine. The WD90 was the first commercial microprocessor to include floating-point instructions without a separate FPU.

Typically the WD90 was sold with 64kB of RAM (32k x 16-bits, in 32 x 16kbit DRAMs), but could accommodate 128kB by piggybacking extra DRAM and modifying the PCB layout. The last 2kB of RAM address space were reserved for memory mapped I/O. There were two RS-232 serial ports, a DB-25 Centronics printer port, and a floppy disk interface for up to four 5.25-inch or 8-inch soft sectored floppy disk drives, single or double sided, single or double density, packaged in a separate unit of the same size as the WD-90 that sadly has not survived.

It ran the UCSD Pascal operating system (UCSD p-System), special release III, which was not available for any other platforms, although the OS itself was portable and highly machine-independent. This OS was developed by Kenneth Bowles et al at University of California, San Diego (UCSD), based on the Zurich Pascal-P2 release by Niklaus Wirth's group. The UCSD p-System was self-compiling and self-hosting. The OS allowed the system to copy itself to a RAM disk and transfer control to it, with a big speed improvement that enabled its Pascal compiler to compile programs much faster than contemporary microcomputers. It included extensions to standard Pascal for *Units* and *Strings* that influenced the design of the Ada language, and indeed an Ada compiler was developed by TeleSoft for the WD90. James Gosling also cites UCSD Pascal as a key influence on the design of the Java virtual machine.

The WD90 documentation is properly part of the Literature category of this catalog, but is listed here too for convenience.

Accession Index	Object and Identification
TCD-SCSS-T.20121208.043.01	WD90 Pascal Microengine Chassis. S/N: 668
TCD-SCSS-T.20121208.043.02	WD90 Pascal Microengine Power Supply. S/N: ???
TCD-SCSS-T.20121208.043.03	WD90 Pascal Microengine WD90006-E CPU board. S/N: 1297
TCD-SCSS-V.20151001.001	Western Digital Corporation, *WD/90 Pascal Microengine Reference Manual*, including *Pascal Microengine Computer, Pascal Operations Manual* (for UCSD Pascal), 1979, also *Change Notice 79127, Pascal Microengine Computer Users Manual*, both published by Western Digital, and *16-bit Microprocessor Set, NMOS, Pascal Microengine, WD9000*, Electronic Design, Vol.24, pp.102-103, 22-Nov-1979.
TCD-SCSS-V.20151001.002	Kathleen Jenkins and Niklaus Wirth, *Pascal User Manual and Report, Second Edition*, ISBN 0-387-90144-2, Springer-Verlag, New York, 1974.

References:

1. Western Digital Corporation, *WD/90 Pascal Microengine Reference Manual*, including *Pascal Microengine Computer, Pascal Operations Manual* (for UCSD Pascal), published by Western Digital, 1979.

2. Western Digital Corporation, *16-bit Microprocessor Set, NMOS, Pascal Microengine, WD9000*, p.1-2, Electronic Design, Vol.24, pp.102-103, 22-Nov-1979.

3 Western Digital Corporation, *Change Notice 79127, Pascal Microengine Computer User's Manual*, published by Western Digital, 1979.

4. Kathleen Jenkins and Niklaus Wirth, *Pascal User Manual and Report, Second Edition*, ISBN 0-387-90144-2, Springer-Verlag, New York, 1974.

5. Bitsavers WD90 documents and brochures, http://bitsavers.trailing-edge.com/pdf/westernDigital/WD90_Pascal_Microengine/ Downloaded 2-Oct-2015.

See the extensive set of documents in the related folder in this catalog.

Figure 1: WD90 Pascal Microengine top front view

Figure 2: WD90 Pascal Microengine three-quarter right rear view

Figure 3: WD90 Pascal Microengine rear view

Figure 4: WD90 Pascal Microengine manufacturing label
Model: WD90, S/N: 668

Figure 5: WD90 Pascal Microengine left rear view

Figure 6: WD90 Pascal Microengine bottom view, ventilation and power transistors

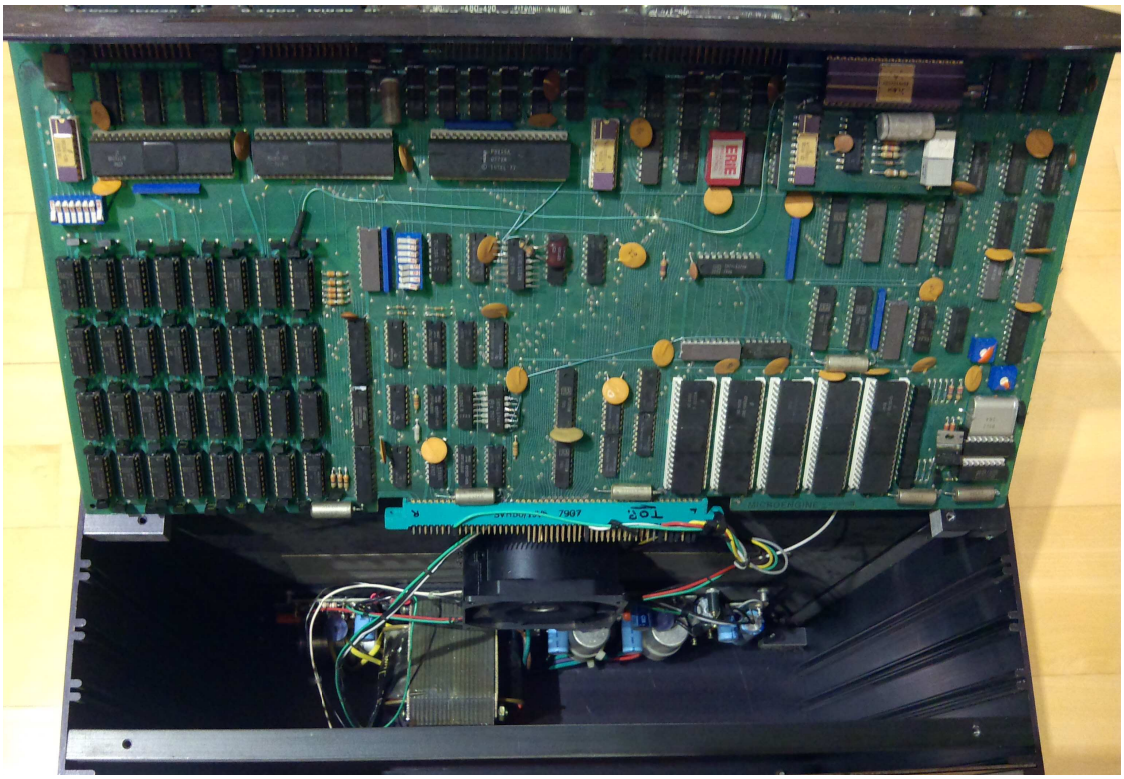


Figure 7: WD90 Pascal Microengine internal front view
CPU board withdrawn showing power supply at inside rear

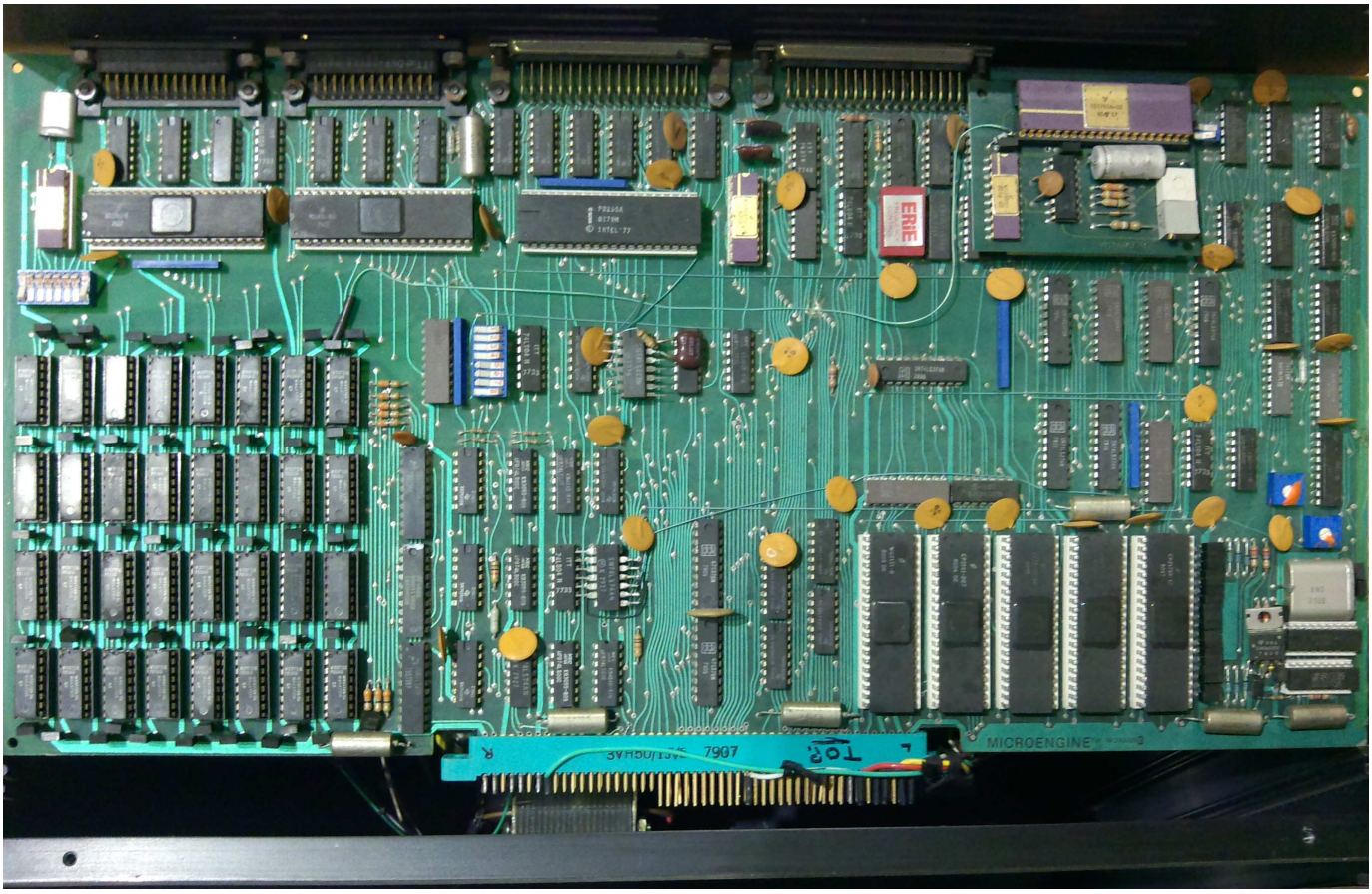


Figure 8a: WD90 Pascal Microengine CPU board

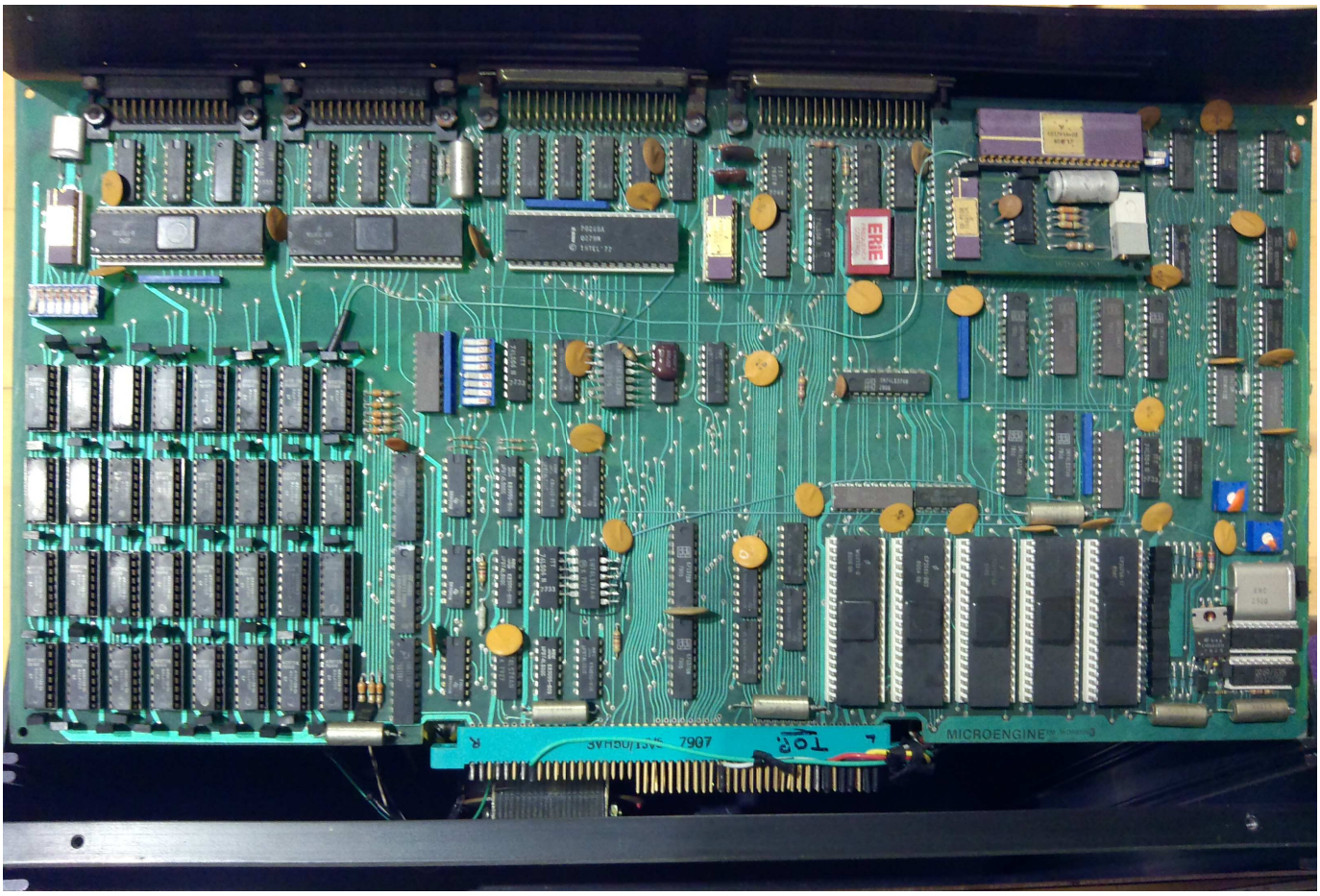


Figure 8b: WD90 Pascal Microengine CPU board

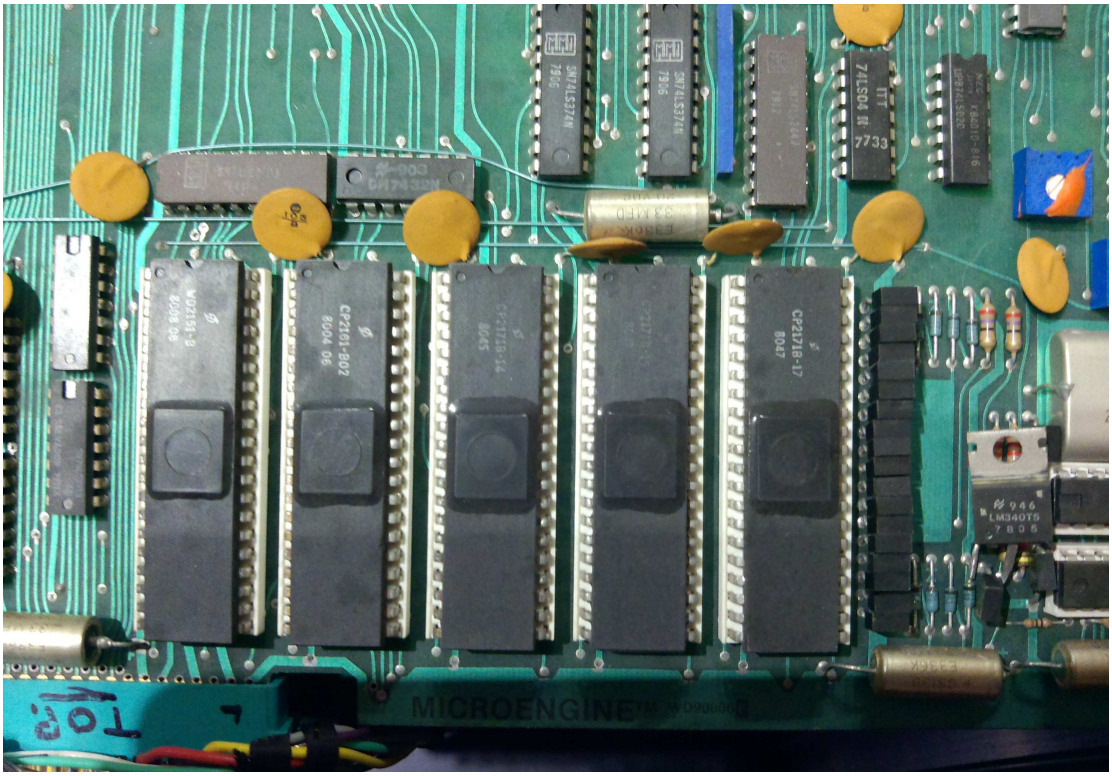


Figure 9: WD90 Pascal Microengine WD9000 CPU chipset closeup

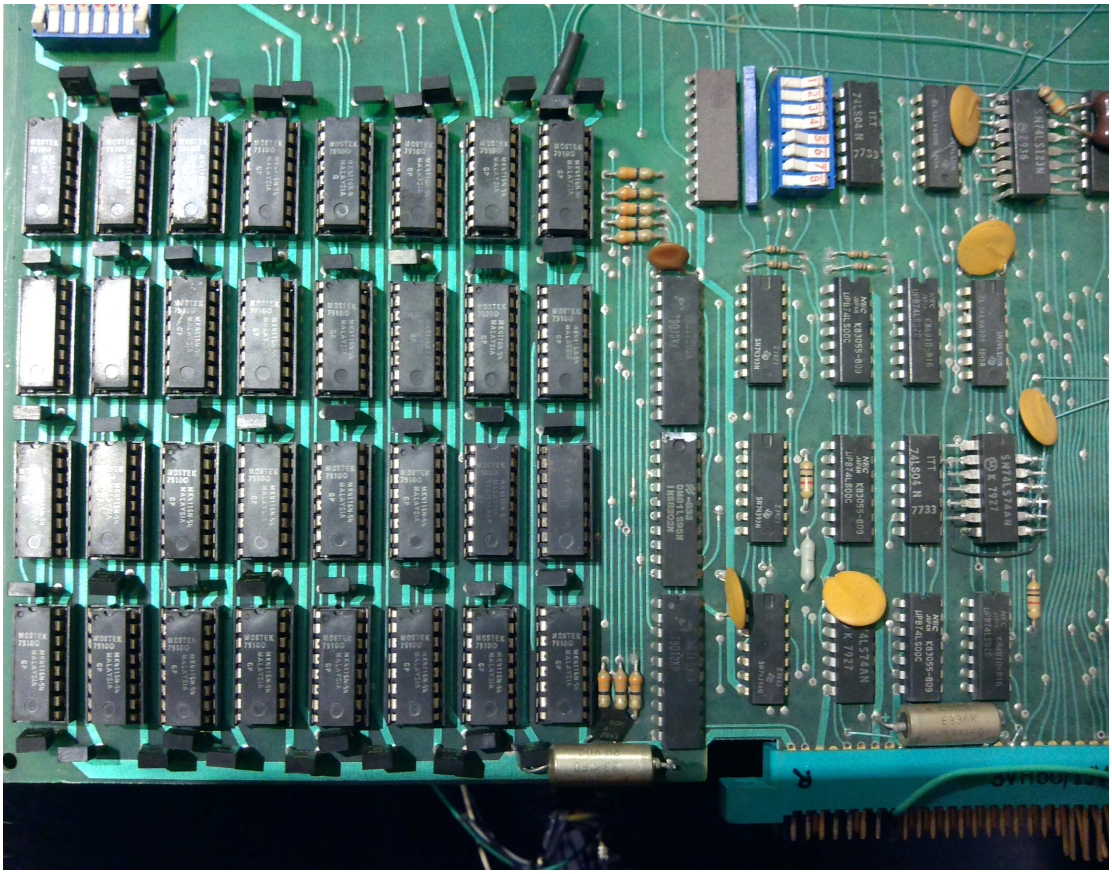


Figure 10: WD90 Pascal Microengine DRAM closeup

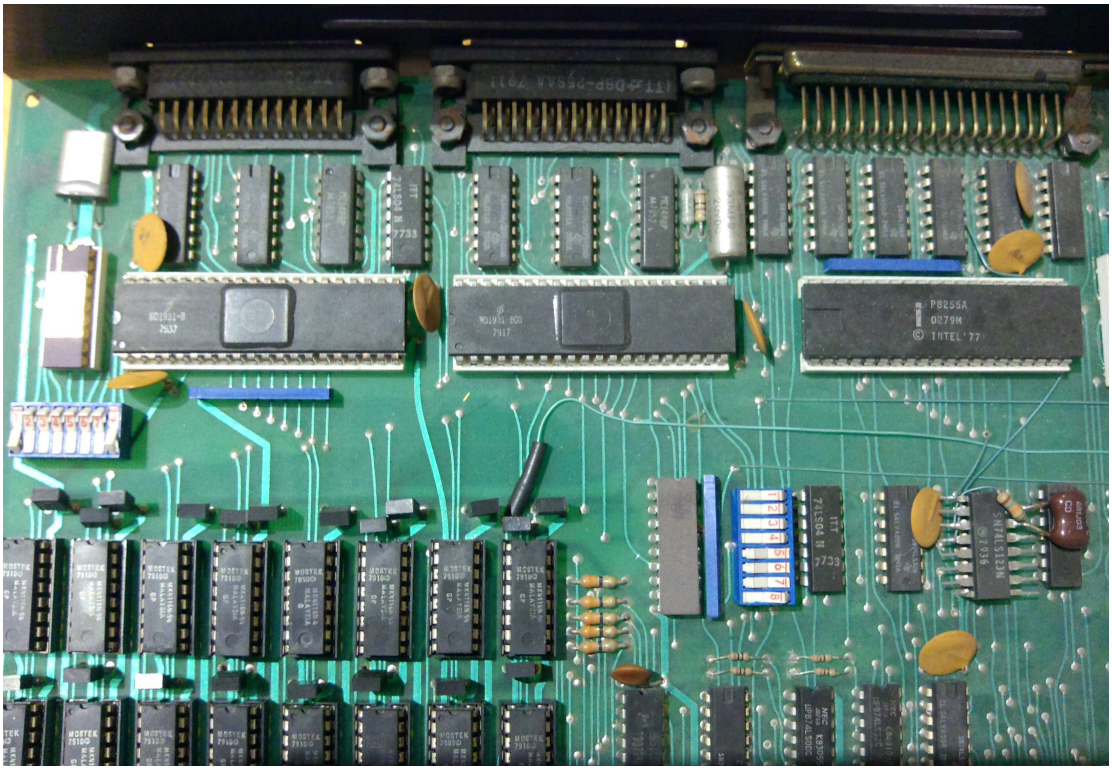


Figure 11: WD90 Pascal Microengine I/O chips closeup
Far left: BR1941-L06 dual baud rate clock generator
Left: WD1931-B, centre: WD1931-B00 (both UARTs)
Right: Intel P8255A parallel I/O

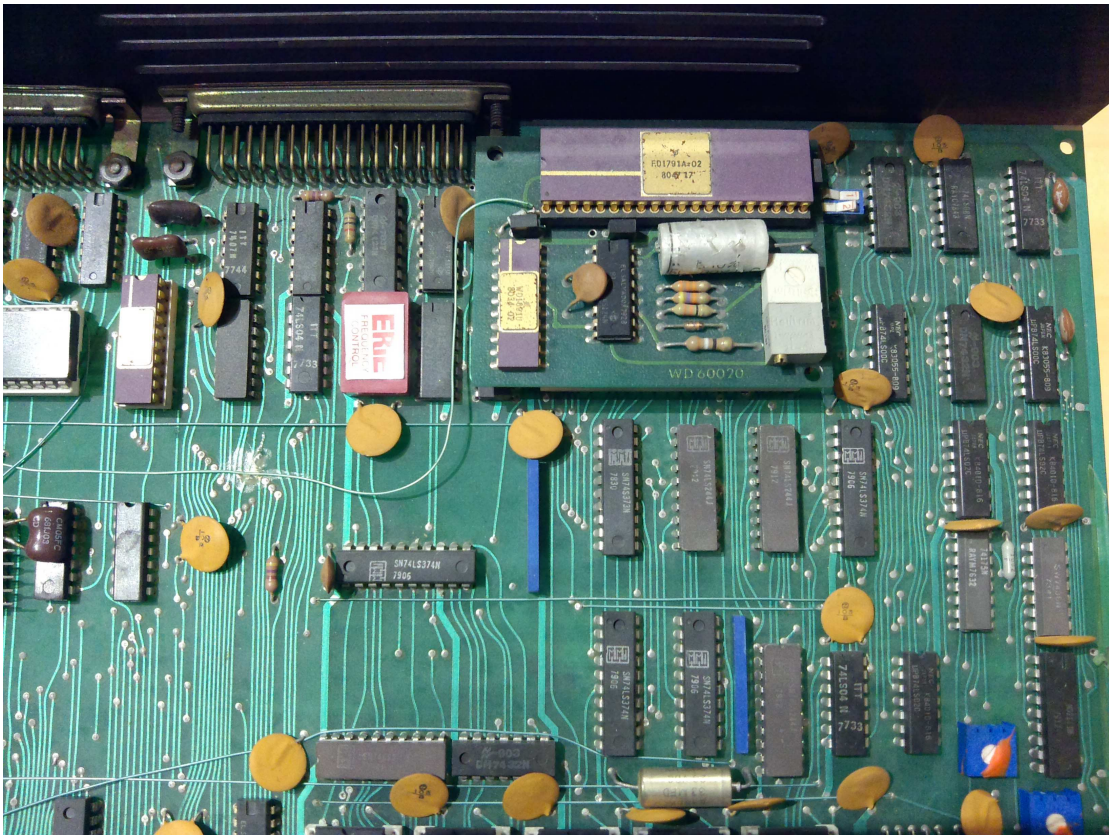


Figure 12: WD90 Pascal Microengine floppy disk controller closeup

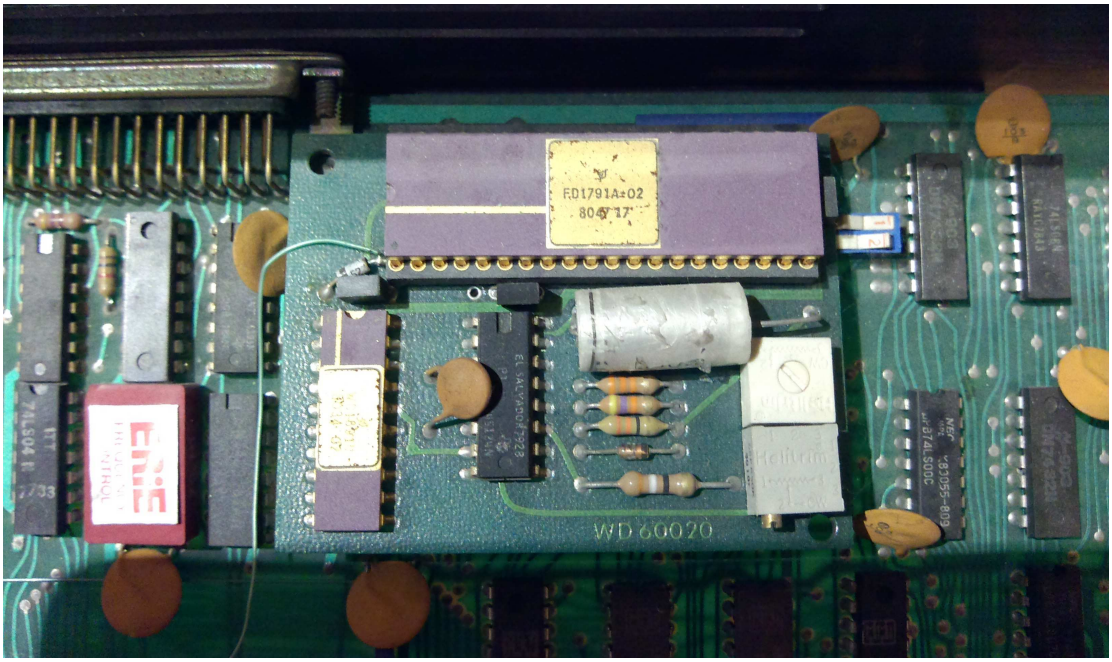


Figure 13: WD90 Pascal Microengine floppy disk controller closeup
Left: WD1691U floppy disk extra logic, top: FD1791A-02 floppy disk controller
Beneath: WD1883 DMAC direct memory access controller

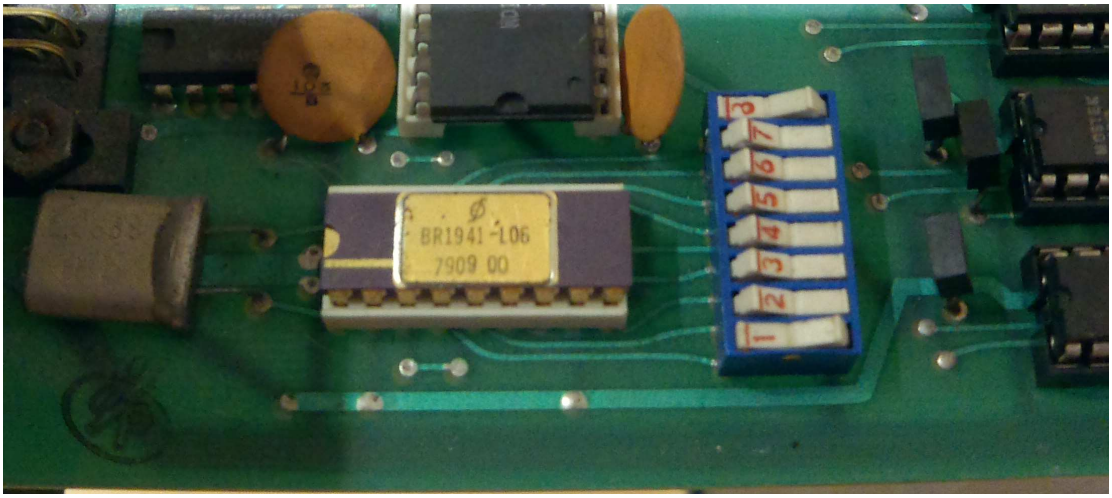


Figure 14: WD90 Pascal Microengine BR1941-L06 dual baud rate clock generator closeup

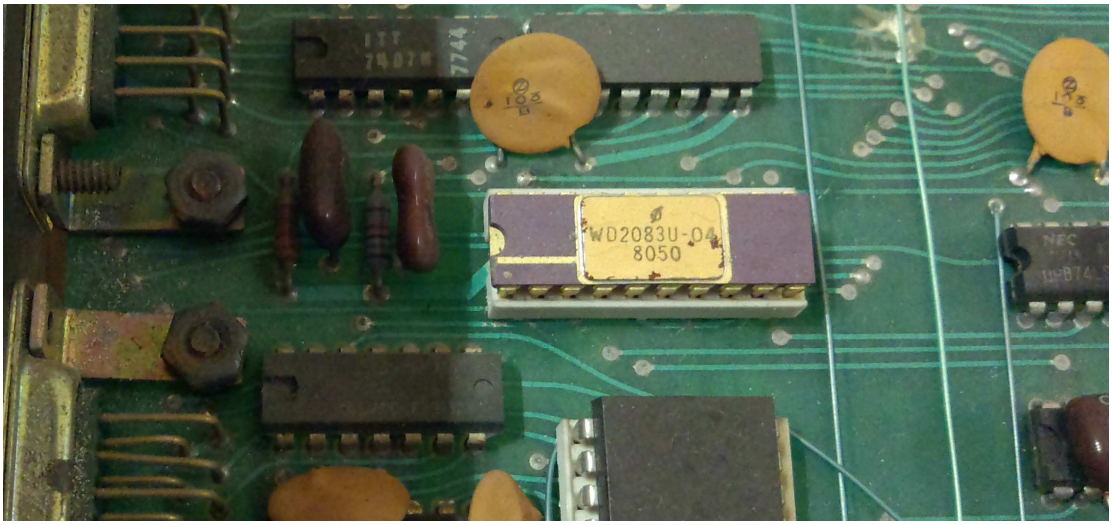


Figure 15: WD90 Pascal Microengine WD2083U-04 closeup (part of the interrupt logic)

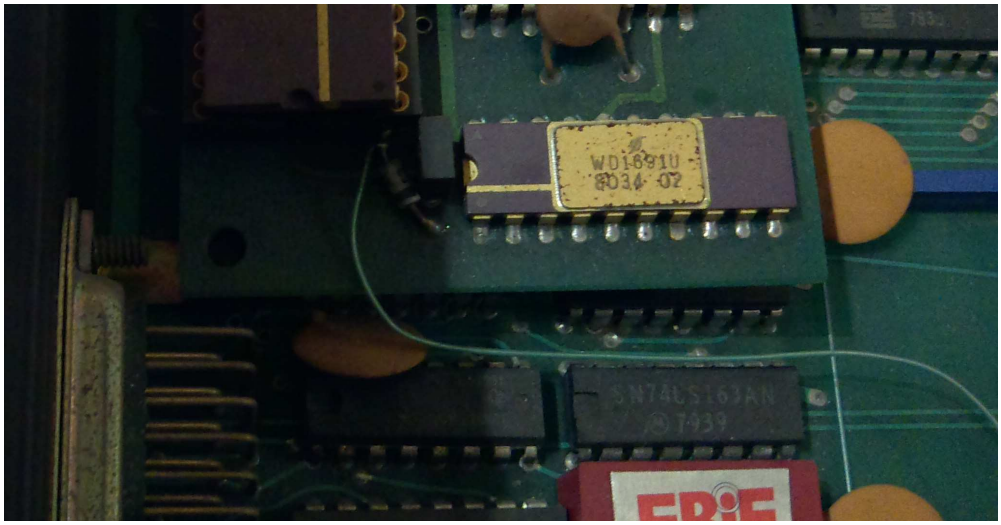


Figure 16: WD90 Pascal Microengine WD1691U floppy disk extra logic closeup

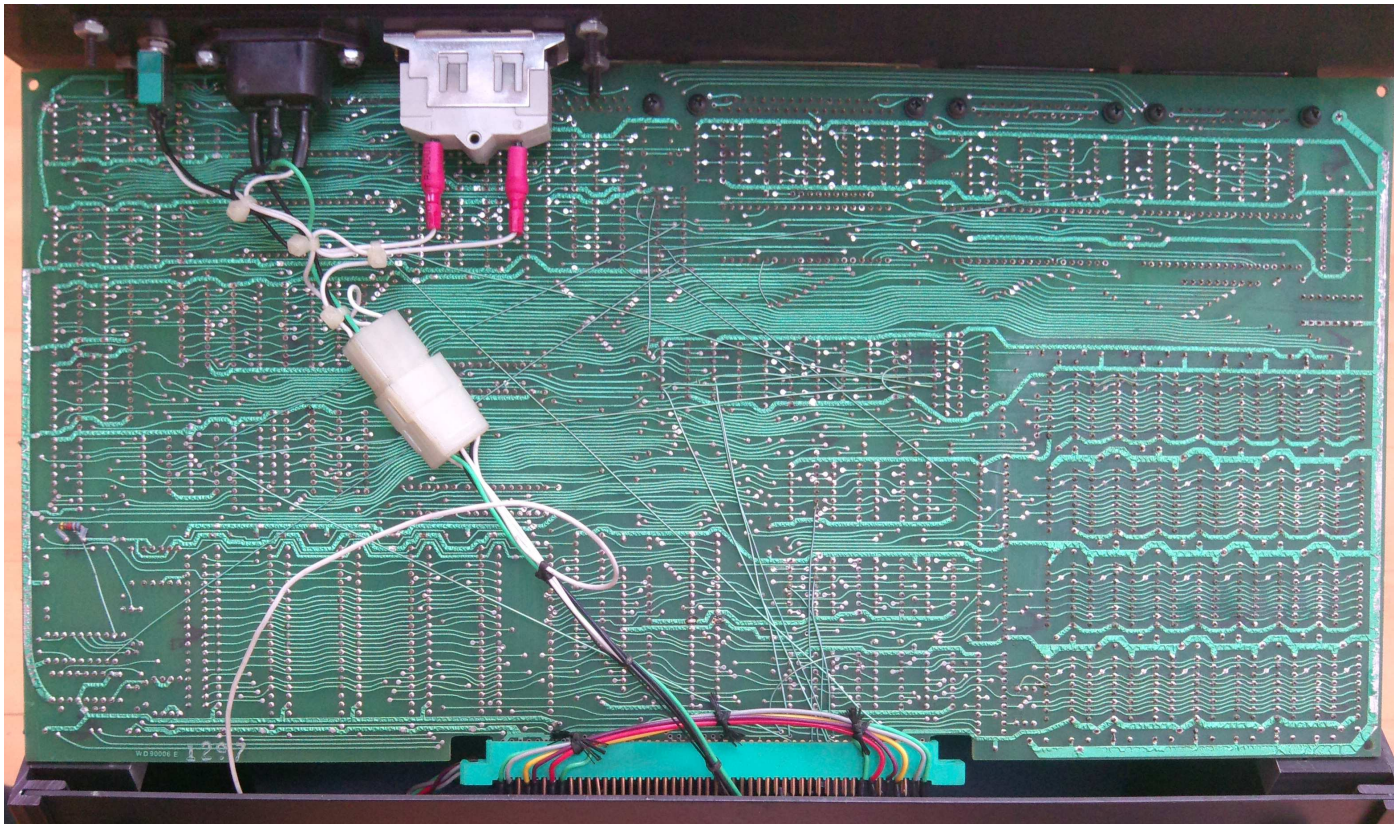


Figure 17: WD90 Pascal Microengine CPU board bottom view

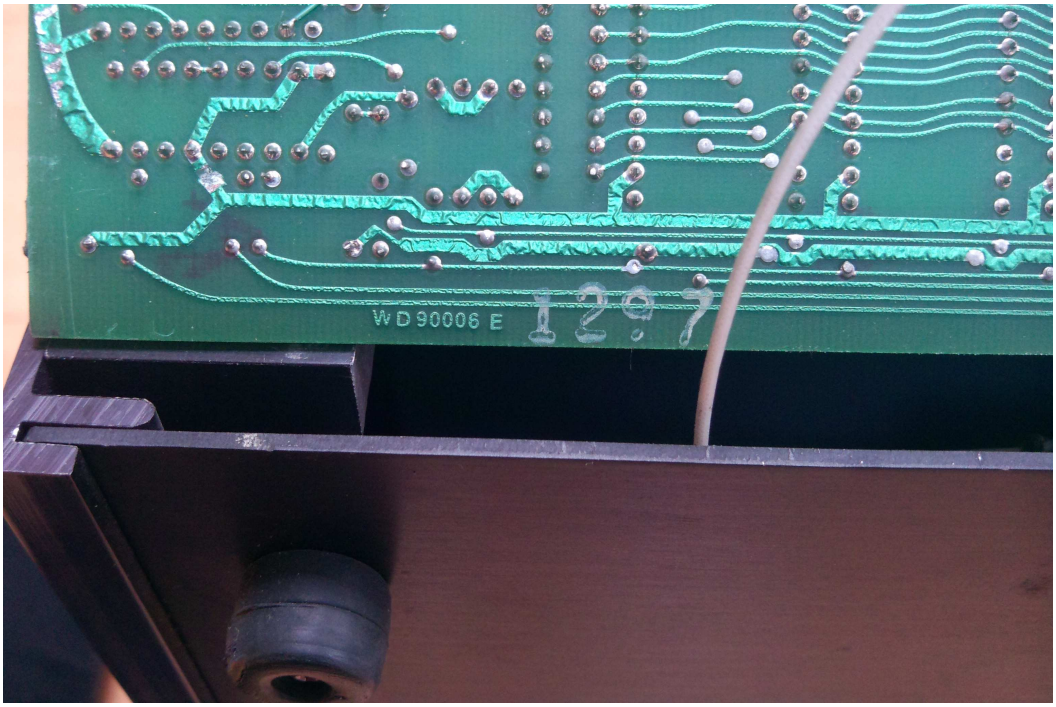


Figure 18: WD90 Pascal Microengine CPU board manufacturing label
Model: WD90006-E, S/N: 1297

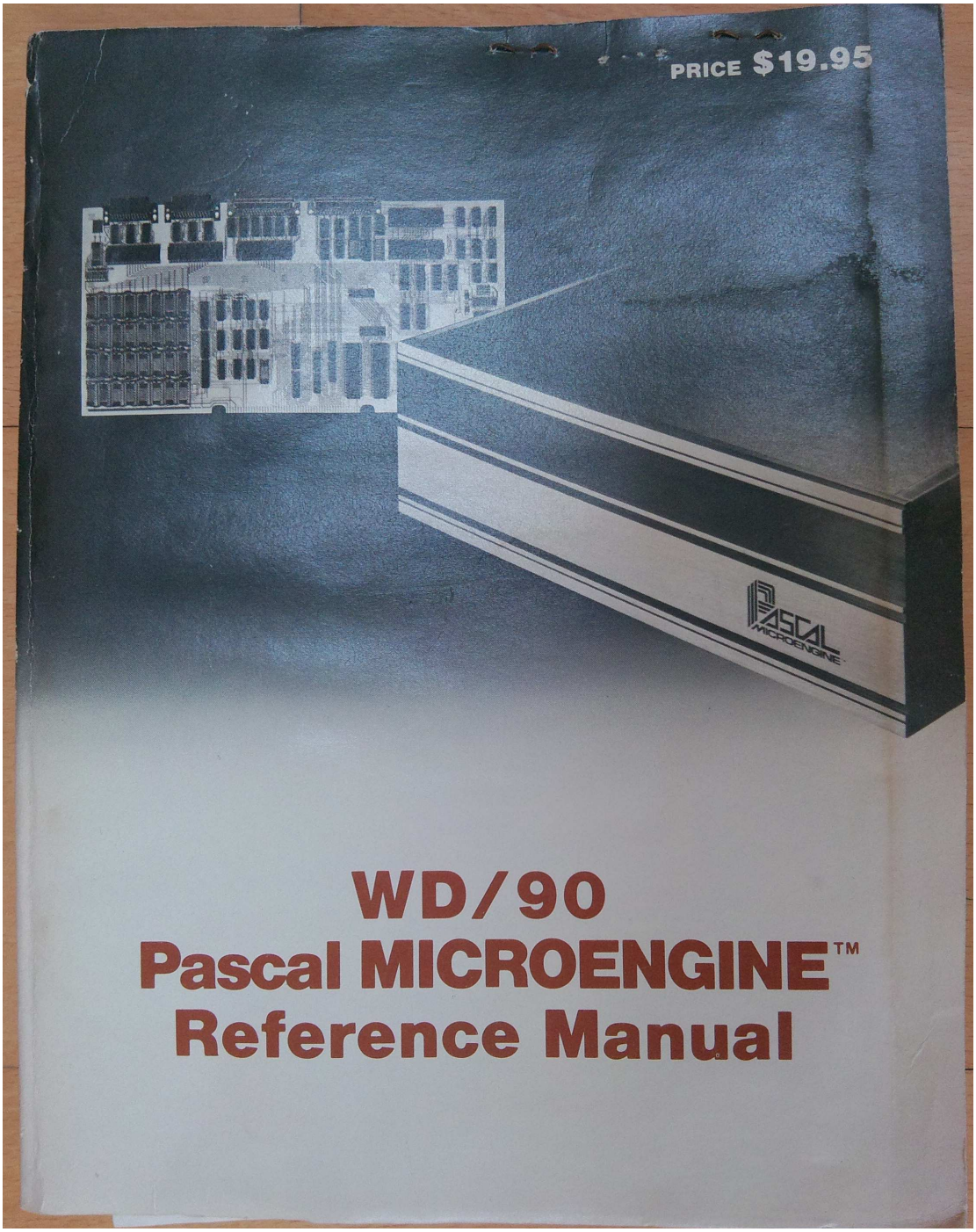
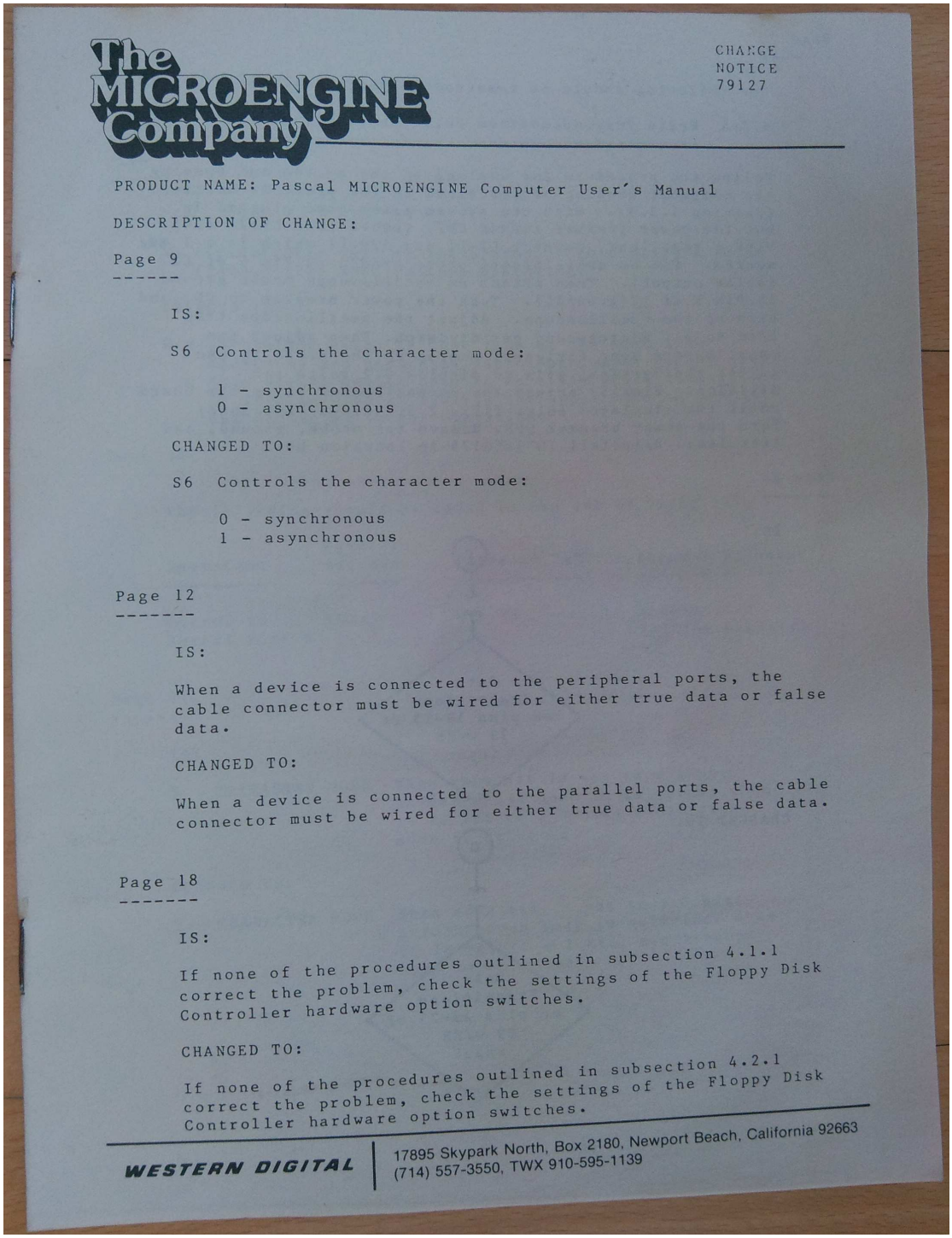


Figure 19: WD/90 Pascal Microengine Reference Manual



The MICROENGINE Company

CHANGE
NOTICE
79127

PRODUCT NAME: Pascal MICROENGINE Computer User's Manual

DESCRIPTION OF CHANGE:

Page 9

IS:

S6 Controls the character mode:

1 - synchronous
0 - asynchronous

CHANGED TO:

S6 Controls the character mode:

0 - synchronous
1 - asynchronous

Page 12

IS:

When a device is connected to the peripheral ports, the cable connector must be wired for either true data or false data.

CHANGED TO:

When a device is connected to the parallel ports, the cable connector must be wired for either true data or false data.

Page 18

IS:

If none of the procedures outlined in subsection 4.1.1 correct the problem, check the settings of the Floppy Disk Controller hardware option switches.

CHANGED TO:

If none of the procedures outlined in subsection 4.2.1 correct the problem, check the settings of the Floppy Disk Controller hardware option switches.

WESTERN DIGITAL | 17895 Skypark North, Box 2180, Newport Beach, California 92663
(714) 557-3550, TWX 910-595-1139

Figure 20: Change Notice 79127, Pascal Microengine Computer User's Manual

16-bit microprocessor set, NMOS

Pascal Microengine, WD9000

Alternate sources: None

Western Digital Corp.
3128 Red Hill Ave.
Box 2180
Newport Beach, CA 92663
(714) 557-3550

A five-chip set, the Pascal Microengine directly executes Pascal object programs written in UCSD (University of California at San Diego) Pascal p-code. The five chips are an arithmetic processor, a microsequencer and I/O controller, and three microprogram ROMs that hold the microinstructions and diagnostics. The chip set also features four levels of interrupt, single-byte and multibyte instructions, hardware floating-point math operations, a stack architecture, a 3-MHz four-phase clock (75 ns/phase) and a TTL-compatible three-state interface.

Comments

The instruction set of the Microengine executes the Pascal p-code instructions, as defined by UCSD specifications. Execution times are about five times faster with the p-code than with conventional software implementation. A host operating system and interpreter are not needed.

Software features include direct execution of UCSD Pascal operating system, Version III,0 and the reduction of the host system memory requirements by at least 25% (because a host operating system and interpreter are unnecessary). Additionally, the microprogram ROMs contain some microdiagnostic routines to help ensure system operation.

Software support will be available from both Western Digital and UCSD. Many other companies offer compatible Pascal software, but the system package comes with Pascal and Basic compilers, a file manager, an editor, a debugger and a graphics package.

Hardware support consists of a development desktop computer that contains the Microengine chip set, 32 kwords of RAM, full DMA control, floppy-disk controller, two RS-232 asynchronous ports and two 8-bit parallel ports—all on a 8 × 16-in. board. In turn, the board and three power supplies are housed in a stylized enclosure, 5.25 × 16.25 × 13.5 in.

Specifications

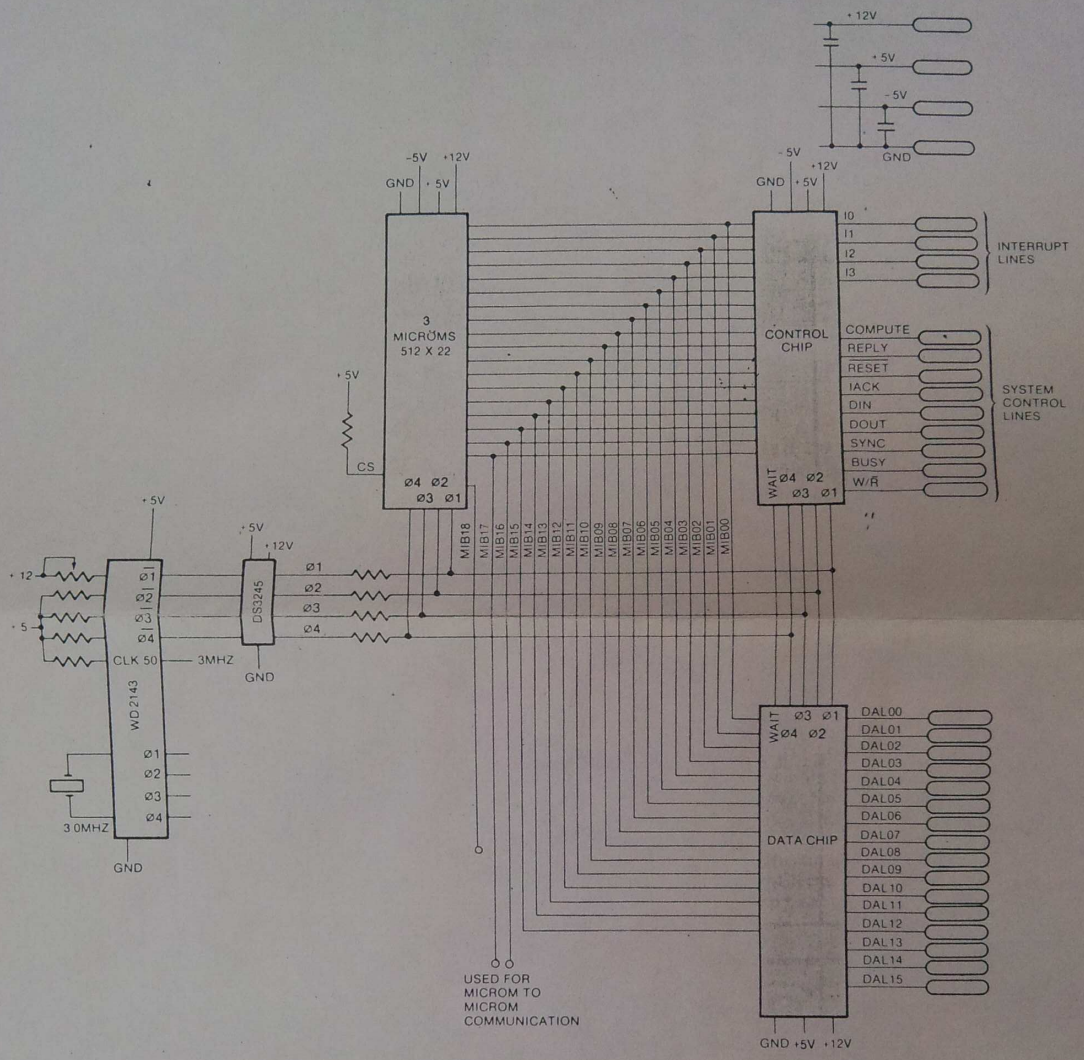
Data word size	16 bits
Address bus size	16 bits
Direct addressing range	65,536 words
Instruction word size	1 to 5 bytes
Number of basic instructions	90
Shortest instruction time (Load constant)	2.4 μs
Longest instruction time	N/A
Clock frequency (min/max)	3 MHz
Clock phases/voltage swing	4/12 V
Dedicated I/O control lines	None
Package size	Five 40-pin DIPs
Power requirements	5 V/192 mA
	−5 V/3.5 mA
	12 V/250 mA

Hardware

Model	Description	Price (100 qty)
CP9008B-01	CPU chip set	$129.50*
FD1771	Single-density FDC	24.00
FD1791/93	Dual-density FDC	48.00
TR1602	UART (mult supp)	3.35
TR1931	UART	12.00
WD2143	Clock generator	8.00
DM1883	DMA controller	9.60
SD1983	SDLC controller	24.00*
BR1941L	Band rate generator	8.00
Desktop computer	Complete CPU system	2995.00*
Additional general-purpose communication circuits are also available.		

*Single unit qty

Figure 21: 16-bit Microprocessor Set, NMOS, Pascal Microengine, WD9000, page 1



Western Digital Corp.

The Pascal Microengine architecture is an extension of the MCP-1600 chip set originally developed for the LSI-11. Similar to bit-slice architectures, the processing chip requires an external microprogram sequencer and external microprogram ROMs to store the microinstructions that perform the p-code macroinstructions.

Figure 21: 16-bit Microprocessor Set, NMOS, Pascal Microengine, WD9000, page 2

Figure 23: Pascal User Manual and Report, Second Edition