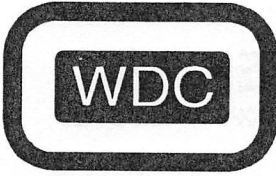


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DEVELOPER GUIDE



July 21, 1994



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Evaluation and Developer System
Mensch [®] Computer_{TM}

The Western Design Center, Inc. , (WDC) founded in 1978 by William D. Mensch Jr. has developed a rechargeable battery powered computer. The Mensch Computer_{TM} is based on the W65C265S, a 16-bit microcomputer which has a W65C816S as its core. The W65C816 is the CPU for the Apple IIs_{TM}, Super Nintendo_{TM} and Digital Book System_{TM} by Franklin Electronic Publishing. The W65C265S also has four serial ports to interface with a printer, keyboard, modem and PC. Two MenschCard (PCMCIA memory card) slots provide user memory upgrade for application software and data storage. The 240X128 LCD 40 column by 16 line monochrome display is ideal for telecommunications, directory, dictionary, digital books, control, game and hobby uses. The keyboard is full-sized for easy data entry. A Sega controller interface can be used for controlling applications and selecting from menus.

This computer is also ideal for evaluating the W65C265S and W65C134S. The CPU module uses the W65C265S. The keyboard module uses the W65C134S as a low power keyboard controller, interfaced through the UART using it's low power CMOS interface.



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W65C Hardware & Software Development Tools and Applications Consultants

SOFTWARE TOOLS

Company	Number	Product(s)	Computer Platform	CPUS Supported	Notes
American Arium Contact: Jeff Acampora	Ph 714-731-1661 Fx 714-731-6344	C Compiler, Assembler, Linker	PC	W65C02S	1
Avocet Contact: Penny Griffith	Ph 800-448-8500 Fx 207-236-6713	Cross Assembler	PC	W65C02S W65C816S	1, 2
Byteworks Contact: Mike Westerfield	Ph 505-898-8183	Assembler, C Compiler, PASCAL Compiler & Debugger	Apple IIgs	W65C02S W65C816S	1, 2, 3
Com Log Co., Inc. Contact: Larry Hittel	Ph 602-248-0769 Fx 602-483-1858	BASIC Interpreter, Monitor, Debugger, BIOS, Libraries	PC	W65C02S W65C816S W65C134S W65C265S	1, 2
Manx Software Contact: Janice Suckow	Ph 800-221-0440 Fx 908-308-3322	Cross Assembler, C Compiler & Debugger	PC	W65C02S	1
PseudoCorp Contact: Susan Akey	Ph 804-873-1947 Fx 804-873-2154	Cross-assembler, simulator, disassembler	PC	W65C02S	1
Roger Wagner Publishing Contact: Jeff Smith	Ph 619-442-0522	Assembler	Apple IIgs	W65C02S W65C816S	1, 2
Speech Technology Contact: Tom Anderson	Ph 206-557-1242 Internet E-mail address: toma@sqi.com	TASM Cross Assembler	PC	W65C02S	1
2500 AD Software Contact: John Taft	Ph 719-395-8683 Fx 719-395-8206	Cross Assembler, C Compiler, Source level simulator/debugger	PC	W65C02S W65C816S	1, 2
Zardoz Software Contact: Jim Goodnow	Ph 916-274-8311 Fx 916-274-8303	C Compiler, Macro Assembler	PC	W65C02S W65C816S	1, 2

- 1 This product will also generate code for the W65C134S and other W65C02S-based applications.
- 2 This product will also generate code for the W65C265S and other W65C816S-based applications.
- 3 This product may have some limitations for general purpose development.



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HARDWARE TOOLS

Company	Number	Product(s)	Computer Platform	CPUS Supported	Notes
Grammar Engine, Inc. Contact: Terry Easton	Ph 415-592-2252 Fx 415-592-2315	Universal Firmware Development System/Romulator	PC	W65C02S W65C816S W65C134S W65C265S	
Hewlett-Packard	Ph 719-590-2077	Logic Analyzer	stand alone	W65C02S W65C816S	1
Noral Micrologics, Ltd. Contact: Keith Norton	Ph 44-254-682092 Fx 44-254-680847	In-Circuit Emulator	PC	W65C02S W65C816S	
Orion Instruments Contact: Jan Liband	Ph 415-327-8800 Fx 415-327-9881	In-Circuit Emulator, Logic Analyzer	PC	W65C02S	2
Parsons Engineering Contact: Steve Parsons	Ph 818-966-5538 Fx 818-966-5538	Romulator/ Firmware Development System	PC Apple IIgs	W65C816S W65C265S	3
Signum Systems Contact: Don Mull	Ph 415-903-2222 Fx 415-903-2221 510-353-1616	In-Circuit Emulator, Source level debugger	PC	W65C02S W65C816S	
Yokogawa Contact: Sanyo Semiconductor, Tom Ohgishi	800 838 8012 Ph 415-960-8582 Fx 415-960-8591	ADVICE (Advanced In- Circuit Emulator)	PC	W65C02S W65C816S	

- 1 HP has not designed these products specifically for the W65C02S and W65C816S. However, they can be adapted to disassemble the core microprocessor's instructions of the W65C134S and W65C265S.
- 2 Orion has not designed these products specifically for the W65C816S. However, they can be adapted to perform emulation/analysis and disassembly.
- 3 W65C265S will be supported by a PCMCIA memory card interface.



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WDC DESIGN PROCESS

	STEP	***WDC TOOLS	CONVERSION STEP TOOLS	CUSTOMER/LICENSEE TOOLS
1	Specification	Word Perfect, CorelDraw	Conversion products	Specification writing tool
2	Circuit design	**PSPICE	Not required	Some version of SPICE
3	*Logic drawing *LOGIC netlist	ICED (**GDS or **CIF) **ASCII text editor	Not required C utility	GDS or CIF input **Verilog
4	Logic simulation	LOGIC, SILOS III	C utility	Sentry test vectors
5	Mask design	ICED (**GDS or **CIF)	Not required	GDS or CIF input
6	Verification	TannerTools (DRC/ERC/LVS)	Not required	**DRACULA
7	Post layout analysis	Tanner Tools (extraction) **PSPICE (simulation)	Not required	Some version of SPICE
8	Process	**Foundry	Not required	Mask/Reticle
9	Wafer test	**Sentry	Foundry tester utility	Sentry, Ando, Trillium
10	Package	**Assembly company	Not required	Foundry specified
11	Final test	**Sentry	Foundry tester utility	Sentry, Ando, Trillium

* WDC designs with only full custom hand-crafted design methods. The logic drawing is used as a floor planning tool. Logic capture is a two-step manual process at WDC. The logic drawing is generated using ICED graphic editor. The netlist is a manually coded rather than an extracted netlist. Other netlists can be generated with a conversion program.

** Industry leading tool or standard.

*** All WDC tools run on 486 platform.



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TOTAL TRANSISTOR COUNT FOR WDC DEVICES

DEVICE	P-CHANNEL TRANSISTORS	N-CHANNEL TRANSISTORS	TOTAL TRANSISTORS	TOTAL GATES
W65C02S	4967	6340	11307	3353
W65C02C	4757	6122	10879	3248
W65C816S	6733	14879	21612	7427
W65C816C	6512	14364	20876	7319
W65C134S	18173	41996	60169	10693
W65C134C	17158	22053 *1	39211	TBD
W65C265S	35054	53107	88161	23539
W65C265C	33627	51974 *1	85601	23760
W65C22S	3024	3114	6138	1595



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BENCHMARKS*					
EXECUTION SPEEDS IN MICROSECONDS AT 8MHZ OPERATING FREQUENCY					
OPERATION	DATA TYPE	WDC 65C02S	WDC 65C816S	INTEL 8086	MOTOROLA MC68000
REGISTER TO REGISTER MOVE	BYTE/WORD	0.25/0.50	0.25/0.25	0.25/0.50	0.50/0.50
	DOUBLE WORD	1.00	0.50	0.50	0.50
MEMORY TO REGISTER MOVE	BYTE/WORD	0.38/0.75	0.38/0.50	2.12/2.12	1.50/1.50
	DOUBLE WORD	1.50	1.00	4.25	2.00
ADD MEMORY TO REGISTER	BYTE/WORD	0.38/0.75	0.38/0.50	4.37/4.37	2.50/2.50
	DOUBLE WORD	1.50	1.25	8.75	3.75
COMPARE MEMORY TO MEMORY	BYTE/WORD	0.75/1.50	0.75/1.00	2.25/2.25	1.50/1.50
	DOUBLE WORD	3.00	2.00	4.50	2.25
CONDITIONAL BRANCH	BRANCH TAKEN	0.38	0.38	1.00	1.25
	NOT TAKEN	0.25	0.25	0.50	1.00
MODIFY INDEX BRANCH IF ZERO	BRANCH TAKEN	0.62	0.62	1.37	1.25
BRANCH TO SUBROUTINE	BRANCH TAKEN	0.75	0.75	2.37	2.25
INTERRUPT LATENCY	INTERRUPT	1.25	1.50	22.75	21.75

COMPARISON OF EMBEDDED CONTROLLERS FOR PDAs**								
	ARM610	HOBBIT	68349	65C816S	65C265S	PC/CHIP	386SL	486SL
FREQUENCY (5V)	25 MHZ	30 MHZ	25 MHZ	8 MHZ	8 MHZ	14.3 MHZ	25 MHZ	-
FREQUENCY (3.3V)	N/A	20 MHZ	16 MHZ	4 MHZ	4 MHZ	8 MHZ	20 MHZ	25 MHZ
POWER (5V)	625 mW	900 mW	960 mW	40 mW	80 mW	216 mW	2500 mW	-
POWER (3.3V)	N/A	250 mW	300 mW	15 mW	30 mW	88 mW	1220 mW	1300 mW
DHRYSTONE MIPS	14 MIPS	20 MIPS	9 MIPS	4 MIPS	4 MIPS	3 MIPS	8 MIPS	18 MIPS
MIPS/WATT (5V)	22 M/W	22 M/W	9 M/W	50 M/W	25 M/W	14 M/W	3 M/W	14 M/W
MATH ON-CHIP	NONE	NONE	NONE	NONE	NONE	NONE	NONE	FPU
MMU ON-CHIP	YES	YES	NO	NO	NO	NO	YES	YES
MEMORY ON-CHIP	4K CACHE	3K CACHE	6K MIXED	NONE	8K MIXED	NONE	TAGS ONLY	8K CACHE
PERIPHS ON-CHIP	NONE	NONE	SOME	NONE	MANY	NONE	SOME	SOME
TRANSISTORS	359,000	419,000	550,000	22,000	89,000	150,000	850,000	1,400,000
DIE AREA	71 mm ²	92 mm ²	98 mm ²	9 mm ²	26 mm ²	51 mm ²	169 mm ²	167 mm ²
IC PROCESS	1.0μ, 2M	0.9μ, 2M	0.8μ, 2M	0.8μ, 2M	0.8μ, 2M	0.8μ, 2M	0.8μ, 2M	0.8μ, 3M
VOLTAGE (VDD)	5V ONLY	3.3V-5V	3.3V-5V	1.0-6.0V	1.0V-6V	3.0V-5V	3.3V-5V	3.3V-5V
LIST PRICE	\$25	\$35	\$28.20	\$5.58	\$17.64	\$25	\$61	\$204
IN QUANTITIES OF:	10,000	10,000	10,000	10,000	10,000	10,000	1,000	1,000

* PARTIAL INFORMATION PROVIDED BY GTE MICROCIRCUITS.

** PARTIAL INFORMATION PROVIDED BY HITACHI.



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DIE SIZES

SCALING FACTOR		0.4		
WDC RULES FOUNDRY RULES		WDC12 0.8 μ =0.6 μ		
PART/DESCRIPTION		SIZE IN MICRONS (DRAWN)	SIZE IN MILLIMETERS (SCALED)	SIZE IN MILS (SCALED)
8-BIT MICROPROCESSOR CORE				
W65C02C	8-BIT STATIC μ P	4182 X, 3072 Y	1.67X, 1.23Y	65.86 X, 48.38 Y
16-BIT MICROPROCESSOR CORE				
W65C816C	16-BIT STATIC μ P	6918 X, 3764 Y	2.76 X, 1.51 Y	108.94 X, 59.28 Y
8-BIT MICROCOMPUTER CORE				
W65C134C	8-BIT STATIC μ C	6724 X, 7774 Y	2.69 X, 3.11 Y	105.89 X, 122.43 Y
16-BIT MICROCOMPUTER CORE				
W65C265C	16-BIT STATIC μ C	10,996 X, 9,800 Y	4.40 X, 3.92 Y	173.17 X, 154.33 Y

8-BIT MICROPROCESSOR STANDARD PRODUCT				
W65C02S W/SCRIBE LANE	8-BIT STATIC μ P	7375 X, 6275 Y	2.95 X, 2.51 Y	116.14 X, 98.82 Y
W65C02S	8-BIT STATIC μ P	6924 X, 5832 Y	2.77 X, 2.33 Y	109.04 X, 91.84 Y
16-BIT MICROPROCESSOR STANDARD PRODUCT				
W65C816S W/SCRIBE LANE	16-BIT STATIC μ P	9575 X, 6400 Y	3.83 X, 2.56 Y	150.79 X, 100.79 Y
W65C816S	16-BIT STATIC μ P	9114 X, 5960 Y	3.65 X, 2.38 Y	143.53 X, 93.86 Y
8-BIT MICROCOMPUTER STANDARD PRODUCT				
W65C134S	8-BIT STATIC μ C	9200 X, 10275 Y	3.68 X, 4.11 Y	145 X, 162 Y
16-BIT MICROCOMPUTER STANDARD PRODUCT				
W65C265S	16-BIT STATIC μ C	13,236 X, 12,064 Y	5.29 X, 4.83 Y	208.44 X, 189.98 Y



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MICROCOMPUTERS

W65C134S - CMOS 8-BIT MICROCOMPUTER

THE W65C134S HAS A W65C02S CORE MICROPROCESSOR THAT IS A FULLY STATIC VERSION OF THE 65C02; THE PART CAN RUN AT VERY LOW CLOCK FREQUENCIES FOR LOW POWER OPERATION. THE W65C134S HAS THE FOLLOWING FUNCTIONS BUILT ON-CHIP WITH THE MICROPROCESSOR: 192 BYTE STATIC RAM, 4K BYTE MASK ROM, SEVEN 8-BIT BIDIRECTIONAL I/O PORTS (56 I/O PINS), AND FOUR 16-BIT TIMERS. THE 56 I/O PINS CAN BE RE-CONFIGURED IN SOFTWARE TO PROVIDE THE FOLLOWING ADDITIONAL FUNCTIONS: EXTERNAL MEMORY BUS (8-BIT DATA, 16-ADDRESS), HARDWARE INTERRUPTS (1 NMI, 2 IRQ, 7 POSITIVE EDGE, 5 NEGATIVE EDGE), EIGHT CHIP SELECT OUTPUTS (FOR EXTERNAL STATIC MEMORIES AND I/O), A UART, AND A SERIAL INTERFACE BUS (SIB). IN ADDITION, THE W65C134S HAS THE FOLLOWING FEATURES: VECTORED INTERRUPT SYSTEM (22 PRIORITY ENCODED INTERRUPTS), TWO CLOCK INPUTS (SOFTWARE SWITCHABLE BETWEEN LOW FREQUENCY AND HIGH FREQUENCY), WIDE POWER SUPPLY RANGE (1.0VOLTS TO 6.0 VOLTS), AND SOFTWARE DEBUG MONITOR ROM SUPPORT ON-CHIP. THE STANDARD W65C134S PACKAGES ARE 68 LEAD PLCC AND 80 LEAD QFP SURFACE MOUNT.

DEVICE	MPU TYPE	ROM (BYTE)	RAM (BYTE)	I/O PORTS	TONE GENERATORS	TIMER/COUNTER (16 BIT)	UARTs	PACKAGE TYPES
W65C134S	8-BIT	4096	192	56	0	4	1	68 PLCC, 80 QFP
W65C265S	16-BIT	8192	576	64	2	8	4	84 PLCC, 100 QFP

W65C265S - CMOS 16-BIT MICROCOMPUTER

THE W65C265S HAS A W65C816S CORE MICROPROCESSOR THAT IS A FULLY STATIC VERSION OF THE W65C816S; THE PART CAN RUN AT VERY LOW CLOCK FREQUENCIES FOR LOW POWER OPERATION. THE W65C265S HAS THE FOLLOWING FUNCTIONS BUILT ON-CHIP WITH THE MICROPROCESSOR: 576 BYTE STATIC RAM, 8K BYTE MASK ROM, EIGHT 8-BIT BIDIRECTIONAL I/O PORTS (64 I/O PINS), AND EIGHT 16-BIT TIMERS. THE 64 I/O PINS CAN BE RE-CONFIGURED IN SOFTWARE TO PROVIDE THE FOLLOWING ADDITIONAL FUNCTIONS: EXTERNAL MEMORY BUS (8-BIT DATA, 24-BIT UNMULTIPLIED ADDRESS), HARDWARE INTERRUPTS (1 NMI OR ABORT, 1 IRQ, 1 POSITIVE EDGE, 3 NEGATIVE EDGE), EIGHT CHIP SELECT OUTPUTS (FOR EXTERNAL STATIC MEMORIES AND I/O), FOUR UART'S, AND A PARALLEL INTERFACE BUS (PIB). IN ADDITION, THE W65C265S HAS THE FOLLOWING FEATURES: VECTORED INTERRUPT SYSTEM (29 PRIORITY ENCODED INTERRUPTS), TWO CLOCK INPUTS (SOFTWARE SWITCHABLE BETWEEN LOW FREQUENCY AND HIGH FREQUENCY), WIDE POWER SUPPLY RANGE (1.0 VOLTS TO 6.0 VOLTS), AND SOFTWARE DEBUG MONITOR ROM SUPPORT ON-CHIP. THE STANDARD W65C265S PACKAGES ARE 84 LEAD PLCC AND 100 LEAD QFP SURFACE MOUNT.



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MICROPROCESSORS

W65C02S - CMOS 8-BIT MICROPROCESSOR

THE W65C02S HAS 66 INSTRUCTIONS, 180 OPERATIONAL CODES, AND 15 ADDRESSING MODES WITH ONE 8-BIT ACCUMULATOR, TWO 8-BIT INDEX REGISTERS, AND AN 8-BIT STACK POINTER (256 BYTE STACK). THE STANDARD PART HAS AN 8-BIT DATA BUS AND A 16-BIT ADDRESS BUS (64K BYTE ADDRESS SPACE). WIDE OPERATING VOLTAGE RANGE (1.0-6.0V) AND STATIC CLOCK RATES TO 10MHZ ARE AVAILABLE. THE CLOCK INPUT IS NOT DIVIDED INTERNALLY; THE MEMORY BUS RUNS AT ONE CLOCK CYCLE PER MEMORY CYCLE. THE W65C02S IS COMPATIBLE WITH THE NMOS 6502 MICROPROCESSOR USED IN EARLY APPLE, ATARI, NINTENDO, AND COMMODORE CONSUMER COMPUTERS. AVAILABLE IN A 40-LEAD PLASTIC DIP, 44-LEAD PLCC, 44-LEAD QFP OR AS DIE.

DEVICE	MPU TYPE	INSTRUCTIONS	OpCodes	ADDRESSING MODES	ADDRESS SPACE	PACKAGE TYPES	LICENSED CORE USE AVAIL.
W65C02S	8-BIT	66	180	15	64K	44 PLCC, 44 QFP	YES
W65C816S	16-BIT	91	255	24	16MBYTE	44 PLCC, 44 QFP	YES

W65C816S - CMOS 16-BIT MICROPROCESSOR

THE W65C816S HAS 91 INSTRUCTIONS, 255 OPERATIONAL CODES, AND 24 ADDRESSING MODES WITH ONE 16-BIT ACCUMULATOR, TWO 16-BIT INDEX REGISTERS, AND A 16-BIT STACK POINTER (64K BYTE STACK). THE STANDARD PART HAS AN 8-BIT DATA BUS AND A 24-BIT ADDRESS BUS (16M BYTE ADDRESS SPACE). WIDE OPERATING VOLTAGE RANTE (1.0-6.0V) AND STATIC CLOCK RATES TO 10MHZ ARE AVAILABLE. THE CLOCK INPUT IS NOT DIVIDED INTERNALLY; THE MEMORY BUS RUNS AT ONE CLOCK CYCLE PER MEMORY CYCLE. THE W65C816S HAS A SOFTWARE-SWITCHABLE EMULATION MODE THAT ALLOWS IT TO RUN ALL 6502 AND 65C02 SOFTWARE WITHOUT MODIFICATION. AVAILABLE IN A 40-LEAD PLASTIC DIP, 44-LEAD PLCC, 44-LEAD QFP OR AS DIE.

PERIPHERAL

W65C22S - CMOS VERSATILE INTERFACE ADAPTOR

THE W65C22S VERSATILE INTERFACE ADAPTOR (VIA) IS A MULTIFUNCTION I/O DEVICE, A DIRECT REPLACEMENT FOR THE NMOS 6522. THE W65C22S HAS THE FOLLOWING FEATURES: TWO 8-BIT BIDIRECTIONAL I/O PORTS, TWO 16-BIT TIMERS, A SERIAL PORT, INTERRUPT POLLING/IRQ GENERATION, AND HANDSHAKING. THE PART'S INTERNAL REGISTERS OCCUPY 16 BYTE ADDRESSES. CLOCK RATES STATIC TO 10MHZ ARE AVAILABLE. THE W65C22S HAS A W65C MICROPROCESSOR INTERFACE WITH AN 8-BIT DATA BUS, R/W PIN, AND CHIP SELECT INPUT(S); PERIPHERAL ADDRESSES ARE MEMORY MAPPED INTO THE MICROPROCESSOR ADDRESS SPACE. AVAILABLE IN A 40-PIN PLASTIC DIP, 44-LEAD PLCC, 44-LEAD QFP.



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DEVELOPERS, CONSULTANTS AND DESIGN CENTERS

COMPANY	NUMBER	SPECIALTY	CPUS SUPPORTED
COM LOG Co., Inc. CONTACT: LARRY HITTEL	PH 602-248-0769 FX 602-483-1858	CONTROLS, TELECOM	W65C02S, W65C816S, W65C134S, W65C265S
FIJI INSTITUTE OF TECHNOLOGY CONTACT: JOHN LAI	PO Box 15802 SUVA, FIJI FX 011-679-370375, ATTN: THE COMPUTER ENGINEERING DEPT. OF THE ELECTRICAL SCHOOL	DESIGNER/LECTURER	W65C02S, W65C816S
PROCONTROL CONTACT: MARTIN VUILLE	PH 613-258-0021 FX 613-258-2542	HARDWARE DESIGN, SOFTWARE DEVELOPMENT, R & D	W65C02S W65C816S
QUADIC SYSTEMS CONTACT: DAVID FERRIS	PH 207-856-6960 FX 207-854-0082	DESIGN CENTER	W65C02S, W65C816S, W65C134S, W65C265S
DOUGLAS K. VAN BUSKIRK	PH 612-888-2230	PROGRAMMING	W65C02S, W65C816S

WDC OFFERS A SOFTWARE MANUAL WHICH SUPPORTS THE W65C02 AND W65C816. THIS MANUAL IS MORE WIDELY KNOWN AS THE **PROGRAMMING THE 65816, INCLUDING THE 6502, 65C02 AND 65802**, WRITTEN BY DAVID EYES AND RON LICHTY, PUBLISHED BY SIMON & SCHUSTER IN 1986. THIS BOOK IS NO LONGER IN PRINT AND WE HAVE ACQUIRED THE RIGHTS, FROM THE AUTHORS, TO PUBLISH THE BOOK. IT IS AVAILABLE IN A THREE-RING BINDER FORMAT AT \$65.00.