Low-cost microcomputer networking: How to get high throughput on a low budget

ADAM V. REED

*Graduate Faculty of Social and Political Science
New School for Social Research, New York, New York 10011*

DANIEL LEWART

Holmdel High School, Holmdel, New Jersey 07733

and

LINDA H. SCHNEIDER

New York University, New York, New York 10003

A very low-cost, high-throughput laboratory data acquisition and experiment control system may be configured by using a star network architecture with a low-cost microcomputer as network controller and one or more microprocessor-based single-board controllers as satellites. A network of this type, using Apple II microcomputer (\$1,500 with 48K RAM and one minidiskette drive) as main node and up to seven KIM-1 microcontrollers (\$159 each) as satellites is described, and its development is discussed in detail.

This paper describes the local network approach to the problem of increasing the throughput of laboratory computer systems. The main advantage of this approach is low cost. A rough rule of thumb used by system planners is that with the traditional single-processor approach, every doubling of throughput triples the cost of the system. With the network approach, each satellite processor adds about 10% to the cost of hardware for the system.

With this kind of cost advantage, it is rather surprising that the network approach is not more widely used in experimental laboratories. One likely explanation for this is the mystique acquired by networking in the early days of computing. According to this mystique, network development requires sophisticated development systems and large amounts of professional effort. One of our goals for this paper is to show how outdated this mystique has become in the last couple of years.

The microcomputer network described in the present paper was developed with the network controller, a standard integer-version Apple II microcomputer, as its own resident development system. The software development effort took a total of 10 h of the first author's time, as well as about 16 h of spare time contributed by the second author while he was a student at Holmdel High School. The hardware interface was built by the third author in slightly under 5 h. While a psychologist who is not also a computer engineer may have to add between \$500 and \$1,000 in consultants' fees to the cost of the network described in this paper, a microcom-

puter network could still constitute the most cost-effective approach to adequate system throughput.

A computer network is a system of two or more independently programmable processors, at least one of which is capable of exerting complete control over all the others under the direction of its own program. Our design objectives were to provide adequate throughput for current experiments, to provide future expansion capability up to twice the maximum requirements of any single foreseeable experiment in cognitive psychology, and to minimize development time for the present system as well as for future experiments. Note that a capability for simultaneous execution of several experiments was not one of our design objectives. In general, the most cost-effective way of running several experiments is to run them on separate systems.

HARDWARE

The Central (Controller) Node

The Apple II was originally chosen as a laboratory computer primarily because its all-socketed construction facilitated the hardware modifications (Reed, 1979) necessary for tachistoscopic stimulus presentation and accurate timing of stimulus-response latencies. Socketed construction also minimizes down time, since most malfunctions may be repaired on site by removing the malfunctioning integrated circuit (IC) from its socket and plugging in a replacement. The Apple also meets both requirements for a central node in a local computer network. The first of these requirements is that the central node be equipped with digital input and output lines capable of communicating with satellite processors.

Daniel Lewart is now at the Massachusetts Institute of Technology.

The other requirement is that the central node be usable as a development system for real-time routines being developed for implementation on the satellite processor. If real-time program development is being done in assembly language, this means that central node software must include a symbolic assembler capable of assembling code to an object (OBJ) location in random-access memory (RAM) other than the actual logical origin (ORG) the program is to have on the system on which it will be eventually executed. In general, any assembler having separate OBJ and ORG pseudooperations or assembler directives will be capable of doing the job. The assembler included in the Microproducts, Inc., development system package for the Apple II is equipped with these features, and it is this package that is currently used on the network to develop real-time software for the KIM-1. Unfortunately, assemblers seldom have the above features in the same package with interactive assembly capabilities necessary for network development.

The networking software for the Apple II was actually developed without a symbolic assembler. We used the interactive miniassembler included in the firmware of the standard integer-version Apple II. The absence of symbolic labeling capability in this firmware was more than made up for by its interactive debugging and structuring features. The integer-version Apple II is equipped with a debugging monitor that has go (run), list (disassemble), trace, single step, register examine, and register fill commands, as well as multiple command sequence capability. Any debugging monitor command sequence may be executed without leaving the miniassembler. Moreover, the go command emulates a JSR subroutine call, a feature that encourages FORTH-like structured programming. An interactive assembler of this type facilitates the segmenting of code into short externally callable subroutines, each of which is fully debugged and tested at the time it is written, and before the programmer goes on to write the next segment.

The Satellite Node(s)

The microcomputer/microcontroller selected for the function of a satellite in a laboratory microcomputer network must satisfy four criteria. First, the instruction set of its processor should be the same as that of the central node's, a condition essential to uncomplicated cross-development of real-time software for experiments. Second, an external device, capable of being simulated by the central node processor, should be able to load desired information into the satellite's memory, to obtain a dump of the satellite's memory on demand, and to start program execution at any desired location in the satellite's memory. Our requirement of reducing development effort to the minimum added an extension of this condition: The software for all of the above functions had to be already present as firmware in the satellite's read-only memory (ROM). This would free us from having to write any real-time networking software for any microcomputer other than the central node, on which adequate development software was known to be

available. The third and fourth conditions were the obvious ones: The satellite had to be able to perform the functions necessary to carry out its role in psychological experiments, and it had to fit our budget.

The first of the above conditions narrowed consideration to microcomputers using the 6502 processor used in the Apple II. The second condition narrowed consideration to the several industrial microcomputer/microcontroller boards designed for use with ASR serial terminals, and for using the terminal's local storage facility (originally, the paper-tape facility of the ASR 33 Teletype) for memory loading and dumping and the keyboard of the terminal for control commands, including the command to begin execution at a specified location in memory. The boards in this category included the JOLT and the SUPERJOLT, the KIM-1, the SYM, the SUPERKIM, and the AIM-65. We selected the KIM-1, at \$159 the second cheapest of the above boards, primarily because the second author was already thoroughly familiar with this unit, having used it as the central component of his personal computer system. With 30 digital input/output (I/O) lines and two precision timers, it clearly had the capability for taking over the task of monitoring and recording subject responses while the Apple dealt with precise presentation of experimental stimuli.

The Hardware Interface

While the serial interface of the KIM-1 is designed for 20-mA current-loop operation, serial information is actually sent and received for processing at standard 5-V transistor-to-transistor logic (TTL) levels. Hence, we decided to attach the interface cable to the KIM with clip-on connectors bypassing the 20-mA current-loop circuits. The resulting interface is shown in Figure 1. In keeping with our decision to minimize design time, we did not bother to balance the transmission line. The interface shown in Figure 1 works fine to 3 kbaud. KIM-1 firmware limits transmission rates to 9.6 kbaud in any case, and the relative improvement obtainable by designing a balanced-line interface would have been limited to that rate. Apart from connectors, the interface shown in Figure 1 consists of three wires and one resistor.

On the Apple II side of the interface, a single KIM-1 is attached to Input SW0 and to Output AN0. Three KIM-1s could be connected by using SW0-SW2 and AN0-AN2. A multiplexer routing SW0 and AN0 according to AN1-AN3 may be used with existing software to run a network comprising up to seven KIM-1s, with one of the eight possible multiplexer codes reserved for loading and starting all the satellites simultaneously.

SOFTWARE

Teletype Emulation

In developing network control software for the Apple II, we minimized development work by making maximum use of published software. Sender software for

Network Control

A fourth program for the Apple sends out a synchronization pulse that can be read by the sequence

BPL #FB

other. Finally, we insure the transfer of control back to the Apple by having the Apple wait for its input to go high. The KIM is programmed to return to "TTY" control by ending its program with an unconditional `JMP 1DBC`.

REFERENCE NOTE

- ## REFERENCE

REED, A. V. Microcomputer display timing: Problems and solutions. *Behavior Research Methods & Instrumentation*, 1979, 11, 572-576.

Appendix A Network Software Memory Map (Apple II)

9200-95FF	Map of KIM for next invocation of 8A00 or 8C40
8E00-91FF	Map of KIM from last invocation of 8B00 or 8C40
8A0C	Accept one character from Kim into A.
8A82	Output character in A to KIM.
8B00	Map KIM to Apple (16 sec): 0000-017F to 8E00-8F7F 1780-17FF to 8F80-8FFF 0200-03FF to 9000-91FF.
8C00	Map Apple to KIM (12 sec): 9200-92EF to 0000-00EF 9300-937F to 0100-017F 9380-93EF to 1780-17EF 9400-95FF to 0200-03FF.
8D00	Start KIM at the indicated location. The command format is *HHHH 8D00G, where HHHH is the starting address for the KIM.
8D63	Transfer control back to Apple after KIM does JMP IDBC.
8D33	Send a synchronization pulse to be read by the KIM loop BIT 1740; BPL loop.
8D2A	Synchronize (8D33), then wait until KIM returns control (8D63).
8D40	Map Apple to KIM; start KIM at desired location; wait until KIM returns control; then map KIM to Apple. Command format analogous to 8D00. Takes 30 sec plus time to execute KIM program.

Appendix B Network Software Listing

*\$8A00-	A9 0C	LDA	#\$0C
8A02-	85 38	STA	#\$38
8A04-	A9 8A	LDA	#\$8A
8A06-	85 39	STA	#\$39
8A08-	60	RTS	
8A09-	00	BRK	
8A0A-	00	BRK	
8A0B-	00	BRK	
8A0C-	8A	TXA	
8A0D-	48	PHA	
8A0E-	98	TYA	
8A0F-	48	PHA	
8A10-	A2 08	LDX	#\$08
8A12-	2C 61 C0	BIT	#\$C061
8A15-	10 FB	BPL	#\$A12
8A17-	20 40 8A	JSR	#\$A40
8A1A-	20 44 8A	JSR	#\$A44
8A1D-	AD 61 C0	LDA	#\$C061
8A20-	49 FF	EOR	#\$FF
8A22-	29 80	AND	#\$80
8A24-	46 4A	LSR	#\$4A
8A26-	05 4A	ORA	#\$4A
8A28-	85 4A	STA	#\$4A
8A2A-	20 40 8A	JSR	#\$A40
8A2D-	CA	DEX	
8A2E-	D0 ED	BNE	#\$A1D
8A30-	20 44 8A	JSR	#\$A44
8A33-	68	PLA	
8A34-	A8	TAY	
8A35-	68	PLA	
8A36-	AA	TAX	
8A37-	A5 4A	LDA	#\$4A
8A39-	09 80	ORA	#\$80
8A3B-	60	RTS	
8A3C-	00	BRK	
8A3D-	00	BRK	
8A3E-	00	BRK	
8A3F-	00	BRK	
8A40-	A9 09	LDA	#\$09
8A42-	D0 02	BNE	#\$A46
8A44-	A9 04	LDA	#\$04

8A46-	48	PHA	
8A47-	A9 20	LDA	#\$20
8A49-	4A	LSR	
8A4A-	90 FD	BCC	#\$A49
8A4C-	68	FLA	
8A4D-	E9 01	SBC	#\$01
8A4F-	D0 F5	BNE	#\$A46
8A51-	60	RTS	
8A55-	86 3F	STX	#\$3F
8A57-	29 7F	AND	#\$7F
8A59-	49 30	EOR	#\$30
8A5B-	C9 0A	CMP	#\$0A
8A5D-	90 02	BCC	#\$A61
8A5F-	69 88	ADC	#\$88
8A61-	A2 03	LDX	#\$03
8A63-	0A	ASL	
8A64-	0A	ASL	
8A65-	0A	ASL	
8A66-	0A	ASL	
8A67-	0A	ASL	
8A68-	26 3E	ROL	#\$3E
8A6A-	CA	DEX	
8A6B-	10 FA	BPL	#\$A67
8A6D-	A6 3F	LDX	#\$3F
8A6F-	60	RTS	
8A70-	A9 82	LDA	#\$82
8A72-	85 36	STA	#\$36
8A74-	A9 8A	LDA	#\$8A
8A76-	85 37	STA	#\$37
8A78-	A9 48	LDA	#\$48
8A7A-	85 21	STA	#\$21
8A7C-	A5 24	LDA	#\$24
8A7E-	8D F8 8A	STA	#\$AF8
8A81-	60	RTS	
8A82-	48	PHA	
8A83-	48	PHA	
8A84-	AD F8 8A	LDA	#\$AF8
8A87-	C5 24	CMP	#\$24
8A89-	68	PLA	
8A8A-	B0 03	BCS	#\$A8F
8A8C-	48	PHA	
8A8D-	A9 A0	LDA	#\$A0
8A8F-	2C C0 8A	BIT	#\$AC0
8A92-	F0 03	BEQ	#\$A97
8A94-	EE F8 8A	INC	#\$AF8
8A97-	20 C1 8A	JSR	#\$AC1
8A9A-	68	PLA	
8A9B-	48	PHA	
8A9C-	90 E6	BCC	#\$A84
8A9E-	49 0D	EOR	#\$0D
8AA0-	0A	ASL	
8AA1-	D0 0D	BNE	#\$AB0
8AA3-	8D F8 8A	STA	#\$AF8
8AA6-	A9 8A	LDA	#\$8A
8AA8-	20 C1 8A	JSR	#\$AC1
8AAB-	A9 58	LDA	#\$58
8AAD-	20 AB FC	JSR	#\$CAF8
8AB0-	AD F8 8A	LDA	#\$AF8
8AB3-	F0 08	BEQ	#\$ABD
8AB5-	E5 21	SBC	#\$21
8AB7-	E9 F7	SBC	#\$F7
8AB9-	90 04	BCC	#\$ABF
8ABB-	69 1F	ADC	#\$1F
8ABD-	85 24	STA	#\$24
8ABF-	68	PLA	
8AC0-	60	RTS	
8AC1-	8C F7 8A	STY	#\$AF7
8AC4-	08	PHP	
8AC5-	A0 0B	LDY	#\$0B
8AC7-	18	CLC	
8AC8-	48	PHA	
8AC9-	B0 05	BCS	#\$AD0
8ACB-	AD 59 C0	LDA	#\$C059
8ACE-	90 03	BCC	#\$AD3
8AD0-	AD 58 C0	LDA	#\$C058
8AD3-	A9 09	LDA	#\$09
8AD5-	48	PHA	
8AD6-	A9 20	LDA	#\$20
8AD8-	4A	LSR	
8AD9-	90 FD	BCC	#\$AD8
8ADB-	68	PLA	
8ADC-	E9 01	SBC	#\$01
8ADE-	D0 F5	BNE	#\$AD5
8AE0-	68	PLA	
8AE1-	6A	ROR	
8AE2-	88	DEY	
8AE3-	D0 E3	BNE	#\$AC8

8AE5-	AC F7 8A	LDY	\$8AF7	8C11-	A0 E8	LDY	##E8
8AE8-	28	PLP		8C13-	A2 E7	LDX	##E7
8AE9-	60	RTS		8C15-	20 C0 8C	JSR	\$8CC0
8AE9-	60	RTS		8C18-	A2 EA	LDX	##EA
				8C1A-	20 C0 8C	JSR	\$8CC0
				8C1D-	A2 FA	LDX	##FA
8B00-	4C 87 8B	JMP	\$8B87	8C1F-	20 C0 8C	JSR	\$8CC0
8B03-	A9 51	LDA	##51	8C22-	84 FD	STY	\$FD
8B05-	20 82 8A	JSR	\$8A82	8C24-	20 40 8C	JSR	\$8C40
8B08-	A0 00	LDY	##00	8C27-	A4 FD	LDY	\$FD
8B0A-	20 0C 8A	JSR	\$8A0C	8C29-	D0 E8	BNE	\$8C13
8B0D-	29 7F	AND	##7F	8C2B-	A9 00	LDA	##00
8B0F-	C9 3B	CMP	##3B	8C2D-	20 97 8C	JSR	\$8C97
8B11-	D0 F7	BNE	\$8B0A	8C30-	A5 F9	LDA	\$F9
8B13-	A2 06	LDX	##06	8C32-	20 B0 8C	JSR	\$8CB0
8B15-	20 0C 8A	JSR	\$8A0C	8C35-	A5 F8	LDA	\$F8
8B18-	CA	DEX		8C37-	20 B0 8C	JSR	\$8CB0
8B19-	D0 FA	BNE	\$8B15	8C3A-	4C 90 8C	JMP	\$8C90
8B1B-	A2 18	LDX	##18	8C3D-	00	BRK	
8B1D-	20 0C 8A	JSR	\$8A0C	8C3E-	00	BRK	
8B20-	20 55 8A	JSR	\$8A55	8C3F-	00	BRK	
8B23-	20 0C 8A	JSR	\$8A0C	8C40-	A9 00	LDA	##00
8B26-	20 55 8A	JSR	\$8A55	8C42-	85 F6	STA	\$F6
8B29-	A5 3E	LDA	\$3E	8C44-	85 F7	STA	\$F7
8B2B-	91 42	STA	(\$42),Y	8C46-	38	SEC	
8B2D-	C8	INY		8C47-	A5 E7	LDA	\$E7
8B2E-	30 05	BMI	\$8B35	8C49-	E5 FA	SBC	\$FA
8B30-	CA	DEX		8C4B-	AA	TAX	
8B31-	D0 EA	BNE	\$8B1D	8C4C-	A5 E8	LDA	\$E8
8B33-	F0 D5	BEQ	\$8B0A	8C4E-	E5 FB	SBC	\$FB
8B35-	60	RTS		8C50-	D0 07	BNE	\$8C59
8B36-	A9 00	LDA	##00	8C52-	8A	TXA	
8B38-	85 42	STA	\$42	8C53-	F0 3A	BEQ	\$8C8F
8B3A-	A9 8E	LDA	##8E	8C55-	C9 C0	CMP	##C0
8B3C-	85 43	STA	\$43	8C57-	90 02	BCC	\$8C5B
8B3E-	20 03 8B	JSR	\$8B03	8C59-	A9 C0	LDA	##C0
8B41-	84 42	STY	\$42	8C5B-	AA	TAX	
8B43-	A0 00	LDY	##00	8C5C-	20 B0 8C	JSR	\$8CB0
8B45-	20 30 8B	JSR	\$8B30	8C5F-	A5 EB	LDA	\$EB
8B48-	A0 00	LDY	##00	8C61-	20 B0 8C	JSR	\$8CB0
8B4A-	84 42	STY	\$42	8C64-	A5 EA	LDA	\$EA
8B4C-	E6 43	INC	\$43	8C66-	20 B0 8C	JSR	\$8CB0
8B4E-	20 30 8B	JSR	\$8B30	8C69-	A0 00	LDY	##00
8B51-	84 42	STY	\$42	8C6B-	B1 FA	LDA	(\$FA),Y
8B53-	A0 00	LDY	##00	8C6D-	20 B0 8C	JSR	\$8CB0
8B55-	20 30 8B	JSR	\$8B30	8C70-	E6 EA	INC	\$EA
8B58-	60	RTS		8C72-	D0 02	BNE	\$8C76
8B59-	20 36 8B	JSR	\$8B36	8C74-	E6 EB	INC	\$EB
8B5C-	20 48 8B	JSR	\$8B48	8C76-	E6 FA	INC	\$FA
8B5F-	20 48 8B	JSR	\$8B48	8C78-	D0 02	BNE	\$8C7C
8B62-	60	RTS		8C7A-	E6 FB	INC	\$FB
8B63-	A9 A0	LDA	##A0	8C7C-	CA	DEX	
8B65-	85 42	STA	\$42	8C7D-	D0 EA	BNE	\$8C69
8B67-	A9 8B	LDA	##8B	8C7F-	20 90 8C	JSR	\$8C90
8B69-	85 43	STA	\$43	8C82-	A9 3B	LDA	##3B
8B6B-	B1 42	LDA	(\$42),Y	8C84-	20 82 8A	JSR	\$8A82
8B6D-	30 0E	BMI	\$8B7D	8C87-	E6 F8	INC	\$F8
8B6F-	20 82 8A	JSR	\$8A82	8C89-	D0 B5	BNE	\$8C40
8B72-	C8	INY		8C8B-	E6 F9	INC	\$F9
8B73-	D0 F6	BNE	\$8B6B	8C8D-	D0 B1	BNE	\$8C40
8B75-	C8	INY		8C8F-	60	RTS	
8B76-	84 46	STY	\$46	8C90-	A5 F6	LDA	\$F6
8B78-	60	RTS		8C92-	20 97 8C	JSR	\$8C97
8B79-	A0 00	LDY	##00	8C95-	A5 F7	LDA	\$F7
8B7B-	F0 E6	BEQ	\$8B63	8C97-	85 FC	STA	\$FC
8B7D-	29 7F	AND	##7F	8C99-	4A	LSR	
8B7F-	F0 F4	BEQ	\$8B75	8C9A-	4A	LSR	
8B81-	0A	ASL		8C9B-	4A	LSR	
8B82-	20 AB FC	JSR	\$FCA8	8C9C-	4A	LSR	
8B85-	F0 EB	BEQ	\$8B72	8C9D-	20 A2 8C	JSR	\$8CA2
8B87-	20 79 8B	JSR	\$8B79	8CA0-	29 0F	AND	##0F
8B8A-	20 59 8B	JSR	\$8B59	8CA2-	C9 0A	CMP	##0A
8B8D-	A4 46	LDY	\$46	8CA4-	90 02	BCC	\$8CA8
8B8F-	20 63 8B	JSR	\$8B63	8CA6-	69 06	ADC	##06
8B92-	A9 80	LDA	##80	8CA8-	69 30	ADC	##30
8B94-	85 42	STA	\$42	8CAA-	20 82 8A	JSR	\$8A82
8B96-	A9 8F	LDA	##8F	8CAD-	A5 FC	LDA	\$FC
8B98-	85 43	STA	\$43	8CAF-	60	RTS	
8B9A-	20 03 8B	JSR	\$8B03	8CB0-	20 97 8C	JSR	\$8C97
8B9D-	60	RTS		8CB3-	18	CLC	
8C00-	D8	CLD		8CB4-	65 F7	ADC	\$F7
8C01-	A9 4C	LDA	##4C	8CB6-	85 F7	STA	\$F7
8C03-	20 82 8A	JSR	\$8A82	8CB8-	90 02	BCC	\$8CBC
8C06-	A9 3B	LDA	##3B	8CBA-	E6 F6	INC	\$F6
8C08-	20 82 8A	JSR	\$8A82	8CBC-	60	RTS	
8C0B-	A9 00	LDA	##00	8CBD-	00	BRK	
8C0D-	85 F8	STA	\$F8	8CBE-	00	BRK	
8C0F-	85 F9	STA	\$F9	8CBF-	00	BRK	

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8CC0- 20 C4 8C JSR $8CC4
8CC3- E8 INX
8CC4- B9 E8 8B LDA $8BE8,Y
8CC7- 95 00 STA $00,X
8CC9- C8 INY
8CCA- 60 RTS
8CCB- 00 BRK
8CCC- 00 BRK
8D00- AD 00 02 LDA $0200
8D03- 20 82 8A JSR $8A82
8D06- AD 01 02 LDA $0201
8D09- 20 82 8A JSR $8A82
8D0C- AD 02 02 LDA $0202
8D0F- 20 82 8A JSR $8A82
8D12- AD 03 02 LDA $0203
8D15- 20 82 8A JSR $8A82
8D18- AD 04 02 LDA $0204
8D1B- 20 82 8A JSR $8A82
8D1E- A9 A8 LDA $A8
8D20- 20 A8 FC JSR $FCA8
8D23- A9 47 LDA $47
8D25- 20 82 8A JSR $8A82
8D28- 60 RTS
8D29- 00 BRK
8D2A- 20 33 8D JSR $8D33
8D2D- 20 63 8D JSR $8D63
8D30- 60 RTS
8D31- 00 BRK
8D32- 00 BRK
8D33- 2C 59 C0 BIT $C059
8D36- 2C 59 C0 BIT $C059
8D39- 2C 58 C0 BIT $C058
8D3C- 60 RTS
8D3D- 00 BRK
8D3E- 00 BRK
8D3F- 00 BRK
8D40- 20 00 8C JSR $8C00
8D43- A9 FF LDA $FF
8D45- 20 A8 FC JSR $FCA8
8D48- A9 FF LDA $FF
8D4A- 20 A8 FC JSR $FCA8
8D4D- 20 00 8D JSR $8D00
8D50- 20 63 8D JSR $8D63
8D53- A9 FF LDA $FF
8D55- 20 A8 FC JSR $FCA8

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8D58- A9 FF LDA $FF
8D5A- 20 A8 FC JSR $FCA8
8D5D- 20 00 8B JSR $8B00
8D60- 60 RTS
8D61- 00 BRK
8D62- 00 BRK
8D63- 20 0C 8A JSR $8A0C
8D66- 29 7F AND $7F
8D68- C9 20 CMP $20
8D6A- D0 F7 BNE $8D63
8D6C- 60 RTS
8D6D- 00 BRK
8BA0- 31 37 46 37 20 D4 46 46
8BA8- 2E D4 30 33 2E D4 30 20
8BB0- D4 80 FF FF 31 37 46 37
8BB8- 20 D4 46 46 2E D4 31 37
8BC0- 2E D4 31 37 38 30 20 D3
8BC8- 80 00 00 00 00 00 00 00

```

```

8CD0- F0 92 00 00 00 92 80 93
8CD8- 00 01 00 93 F0 93 80 17
8CE0- 80 93 00 C0 00 02 00 94
8CE8- 00 00 00 00 00 00 00 00
8CF0- 00 00 00 00 00 00 00 00
8CF8- 00 00 00 00 00 00 00 00

```

Appendix C

Network Initialization Procedure for Satellites

1. Set KIM-1 KBD-TTY switch to KBD.
 2. Press the following sequence of keys on the KIM keyboard:
(RS) (AD) 17F2 (DA) 18 (+) 00 (AD)
This sequence sets the baud rate to 3,000 baud.
 3. Set the KBD-TTY switch to TTY.
 4. Run appropriate network software from the Apple II.
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