

C-ALL MONITOR

Are your machine language programs 'bugging' you?? C-ALL will help solve your problems, the easy way! This monitor features three distinct modes of operation: the general operation mode, the disassembly mode, and the trace routine mode.

The general operation mode contains machine language tape input/output, user memory and CPU register control, input/output port control, and memory operations such as fill, block move and search.

The disassembly mode allows a dump to the CRT or to the CRT and the printer of assembly language mnemonics for instructions or data of a known format. The options include page formatting and breakpoint control.

The trace routine is controlled by a large number of options. The default mode of operation is the display of four lines of CPU data, the trace address, hex code, and assembly language mnemonic prior to the execution of the instruction. The delay between instructions is one second normally, or 1/16 second with the SHIFT key pressed. The top half of the CRT is used to display the CPU register and memory data, while the bottom half is used to display the last seven instructions executed, and the current instruction to be executed. During any trace routine, you can optionally dump to printer what you're tracing.

This monitor has been written to be extremely useful to anyone interested in understanding the operation of an existing program or troubleshooting a new program.

**THE
ALTERNATE
SOURCE**

Presents . . .

C-ALL

(A Machine Language Program Monitor)

(See reverse side for program description)

----- LIMITED WARRANTY -----

We have, by careful review and testing, attempted to ensure that this program works as specified in this manual. Nevertheless, there may be errors remaining in this program or its documentation. We would appreciate receiving notice of any errors you may find, and you may receive an upgrade of the latest version available at any time and at no charge by sending a diskette or cassette with a postpaid mailer to THE ALTERNATE SOURCE, 1806 Ada Street, Lansing, MI, 48910.

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C-ALL MONITOR

Version 1.0

Written by Michael C. Schulze

OVERVIEW

C-ALL is a RAM based monitor created to debug any RAM or PROM based program. It has been written to be usable by anyone interested in understanding the operation of an existing program or troubleshooting a new program. Programs that require certain timing considerations can be analyzed using the clock option in the trace mode. However, interrupts are always disabled whenever the monitor is entered and any traced portion of code will run slower than normal, depending on the number of options used during the trace.

There are three basic modes of operation with this program. There is a general operation mode, a disassembly mode, and a trace mode of operation. Within these modes there are several commands available which are useful in that particular mode. The menu of these commands can be listed by pressing the "/" key.

The general operation mode contains machine language tape input/output, user memory and CPU register control, input/output port control, and memory operations such as fill, block move and search.

The disassembly mode allows a dump to the CRT or to the printer of assembly language mnemonics for instructions or data of a known format. The options include page formatting and breakpoint control.

The trace routine is controlled by a large number of options. Keep in mind that the speed of the trace depends on the number of options in use. The default mode of operation is the display of four lines of CPU data, the trace address, hex code, and assembly language mnemonic prior to the execution of the instruction. The delay between instructions is one second normally, or 1/16 second with the SHIFT key pressed. The top half of the CRT is used to display the CPU register and memory data, while the bottom half is used to display the last seven instructions executed and the current instruction to be executed. For further expansion of these options, refer to the trace command set description.

This program resides from 5900 to 7FFF in memory unless it is relocated using the L80 linker. The keyboard scan routine and the read and write byte to cassette subroutines in the Level II PROM are used by this program. The RST 40 vector is modified to allow use of the BREAK key with TRSDOS and the RST 48 vector is modified for use in program breakpoints. The minimum required system is LEVEL II BASIC with 16K RAM.

The keyboard entry routine is modified to issue a ↓ every 1/4 second if the SHIFT key is pressed. Any undefined command key pressed will be ignored. When entering a hex or decimal number, any non-hex or non-decimal characters are also ignored. Leading zeros are not necessary on any number and if a mistake is made, then the left arrow (backspace) key can be used, or BREAK can be used to abort the command. Decimal number entry is discerned from hex by having a " prior to the entry.

To load the program, if you have cassette, type SYSTEM after the READY prompt, and press the ENTER key. Get the cassette ready to load, then type CALL and press the enter key. The cassette will load and then you will be prompted with another *?. Type a slash (/) and press the ENTER key. The program will start by printing the title and the menu of general commands.

If you have a disk based system, then type CALL and press the enter key after DOS READY is displayed. The program will load and start by printing the title and menu of general commands.

If you have a disk based system and would like to relocate the program to an area of memory other than 5900 to 7FFF using the MICROSOFT L80 linking loader program, then proceed as follows. Start the linker program by typing "L80" and pressing the ENTER key after DOS READY is displayed. After the "*" is printed, type "-P: start address " and press ENTER. Then type "M1,M2,M3,M4,M5,M6,M7,M8,M9,M10" and press ENTER. After an "*" is printed again, then type "CALL-N-E" and press ENTER. A file by the name of CALL/CMD will be created and L80 will return to DOS READY.

If a special printer driver is required for your system, then use SET PRINTER DRIVER command in the C-ALL mode to set the read printer status and write to printer subroutine addresses. The printer status is returned to register A where printer ready is 3F hex and printer not ready can be FF hex. The write data passed to the write to printer subroutine is contained in register A. Any registers used other than A should be saved on the stack. The SET PRINTER DRIVER command modifies the actual program so that C-ALL can be saved along with the printer driver under one filename.

SAMPLE USAGE

If you would like to try some commands before reading the details, here are examples of some of the features.

When the program is started, the first six commands in the C-ALL mode will be printed. If you would like to see more commands, just hit any key and another six additional commands will be printed. If you would like to see the end of the list, hold the SHIFT key down until the last command is printed. Otherwise, just hit the BREAK key and the \$ prompt will appear. This is the prompt whenever you are in the C-ALL mode. The disassembler mode uses an & for a prompt, and the trace mode uses a number sign. If you ever want to see your list of commands, just type a slash (/) after the prompt. Now type 0 and then FILL MEMORY and BEGIN: will be printed. Type 3C00 and press ENTER. The program will respond with END:. Next type 3FFF and press ENTER. DATA: will be printed and you are set to fill the CRT with data. Try typing BF20 and press ENTER. TRANSFER COMPLETE tells you that you command was executed. How would you like to find the MEMORY SIZE message in PROM? Type S for MEMORY SEARCH, enter 0 and 1000 as limits, type A for ASCII STRING and enter MEMORY SIZE. The address of the first letter is then printed along with the string. BREAK will return to the prompt or any other key will continue the search for another string.

If you would like to dump a disassembled listing to your printer in a page format, type D after the \$ prompt and enter the starting address. Type 0 for ENABLE PRINTER? and respond with a Y. Type 1 for SET PRINTER FORMAT? Answer Y, then enter a title. If you want to start at page 1 with a 66 line page length, then press ENTER twice. Press the down arrow key to start the disassembler. When you're tired of looking at the output, hold the BREAK key down until the & prompt appears. To exit back to the C-ALL mode, type Z.

To start the trace, type T for TRACE AT after the \$ prompt. As an example enter 0 for the address and the number sign prompt will appear along with the current state of some CPU registers and memory on the top four lines of the CRT. The printer is still enabled from when data was dumped using the disassembler, so therefore type 0 for ENABLE PRINTER? and respond with an N. Type B for BREAK AT and enter 685. Then type 4 for DISABLE DISPLAY? and respond with Y. Press the down arrow key and watch the screen shudder, which normally occurs faster on power up. Press the left arrow key (backspace) and the last seven instructions traced will be displayed. Now to see exactly what is happening, type 4 for DISABLE DISPLAY? and respond with an N. Type T for TRACE AT and enter 0 (the current value is 685H). Now press the down arrow key and watch as register A decrements by two inside a loop which writes A to output port FFH. To speed up the trace, press the SHIFT key and watch as the screen changes between 64 and 32 characters per line. To abort the trace, press BREAK and the number sign prompt should reappear. The last instruction displayed was not executed, however if the trace is restarted, the program will pick up where it left off. If you aborted the trace while in the 32 character mode, type Z to return to C-ALL mode, then type R for READ CASSETTE. This will reset the output port FFH to 64 character mode. Now press BREAK and read the command set description for more details.

C-ALL COMMAND SET

(/) -- KEY DEFINITIONS

List the menu of commands for the C-ALL mode. BREAK will return to the prompt and any other key will display another six commands.

(-) -- SELECT DISPLAY DATA

Select the desired data lines for the P command by using the right arrow key to include that line, or the left arrow key to exclude the line. BREAK will abort the new selections, and the down arrow key will use the current status. Use SHIFT to exit command once the desired change has been made.

(0) -- FILL MEMORY

Enter the hex addresses for the memory limits and then enter a hex data string up to 16 bytes in length for the DATA. BREAK will abort the command at any time and return to the \$ prompt.

(1) -- SET PRINTER DRIVER

This command is used to modify the program for use with a special printer driver. The subroutine addresses should be entered in hex or else use default to display the current driver addresses. BREAK will abort the command and return to the \$ prompt.

(A) -- ADJUST FLAG TO

This command will set one of the primary user CPU flags to the desired mnemonic. Valid mnemonics are Z, NZ, C, NC, M, P, PE, or PO. BREAK will return to the \$ prompt and a default will display the current status of the flags.

(B) -- BREAK AT

This command is used to set a breakpoint in a user program. Enter the hex address of the instruction you wish to stop at. Up to 10 breakpoints can be set at any time and they are stored in a last in, first out stack. Breakpoints set in one mode will remain valid as modes are changed. BREAK will abort the command and return to the \$ prompt. The first default will request the breakpoint in decimal and the second default will set the breakpoint to the user program counter (PC).

(C) -- CALL SUBROUTINE

This command will issue a subroutine call from the monitor of any user subroutine. Enter the start address of the subroutine in hexadecimal. If a breakpoint exists in a non-RAM area the command will abort. The first default requests a decimal starting address and a second default will use the current value of the user program counter (PC). BREAK will return a \$ prompt.

(D) -- DISASSEMBLE AT

This command is used to set the starting address of the disassembly and to enter the disassembler mode. Type a slash (/) after the & prompt to get the new menu of commands. Enter a hex starting address, or default to enter a decimal starting address. A second default will use the current value of the user program counter (PC). BREAK will return to the \$ prompt if hit before the address is entered.

(E) -- EXAMINE MEMORY

This command will display the value of a memory location in hex, decimal, binary, and ASCII; then wait for a further subcommand. Enter the address in hex or default and enter the address in decimal. A second default will use the current value of the user program counter (PC). Using the down arrow key will display the next higher memory location, or using the up arrow key will display the next lower memory location. Pressing the SHIFT key will automatically increment through memory every 1/4 second. For changing memory, press the right arrow key, and enter a string of up to 16 bytes of hex data. If instead you would like to patch ASCII, then type A and enter an ASCII string of up to 32 characters. BREAK will return to the \$ prompt.

(F) -- FILL BREAKPOINT

This command will remove the breakpoint on top of the breakpoint stack and display the value of that breakpoint.

(G) -- GO TO ADDRESS

This command will start execution of the program at the entered address. Enter the start address in hex, or default and enter the start address in decimal. A second default will use the current value of the user program counter (PC). If a breakpoint exists in a non-RAM area, then the command will abort. BREAK will return a \$ prompt.

(H) -- HEX/DECIMAL ARITHMETIC

This command will request a hex number to operate on. The first default will allow decimal number entry and the second default will use the current value of the user program counter (PC). After the first number is entered then choose one of the following commands. Hitting a plus sign or a minus sign will request a second number to add to or subtract from the first number. Enter the second number in the same manner as the first. Hit the right arrow key to convert the number to decimal or the left arrow key to convert the number to hexadecimal. BREAK will return to the \$ prompt.

(I) -- I/O PORT OPERATIONS

This command will request an eight bit hex input/output port address. The default is FFH. Once the address is entered, the data read from the input port is printed in hexadecimal after the port address. Typing an up arrow will decrement the port address and display the input

port status. The port address is incremented by pressing the down arrow key, or it will remain unchanged by pressing the left arrow (backspace) key. Pressing the right arrow key will request an eight bit hex value to write to the output port. The default entry is zero. BREAK will return to the \$ prompt.

(K) -- MOVE MEMORY BLOCK

This command will request the hexadecimal limits on a block of memory and the destination to which it should be moved. This command will move the block of memory without the block overwriting itself. BREAK will abort the command and return to the \$ prompt.

(L) -- LIST BREAKPOINTS

This command will list the breakpoints from the last entered to the first entered. The first breakpoint to be filled is on the top of the list.

(M) -- SET MEMORY DATA ADDRESSES

This command will request the start addresses for the hex data and ASCII data strings printed with the P command. These lines are initially suppressed and must be selected with the "-" command. A default will display the current status and BREAK will return to the \$ prompt.

(P) -- PRINT REGISTER AND MEMORY DATA

This command will display the register and memory data lines selected with the "-" command. Initially this includes all the primary registers and the memory to which they are pointing. An up arrow key is used to indicate that the data is greater than the ASCII upper case character limit and the down arrow key is used to indicate that the data is a control character below the ASCII limit.

(R) -- READ CASSETTE

This command will load a machine language format cassette into memory. The filename is printed followed by the loading address limits of the program. The execution address is printed last and the \$ prompt should return. To rewind the cassette, type R again, which will turn on the cassette. Then when the cassette is rewound, press the BREAK key. BREAK will abort to the \$ prompt any time during the loading process.

(S) -- MEMORY SEARCH

This command will request hexadecimal address limits over which the search will take place. After the limits are entered, then select one of the following search types. Typing an H will request a hex data string to be sought. Enter up to 16 bytes and the address of the first byte will be displayed along with the hex data found. Choosing an A search will indicate an ASCII string of up to 32 characters. Typing the letter O will request the value of an opcode. In each of these cases, the \$ prompt returns if the search fails, or the memory address is printed for a successful search. To continue the search further, type any key except BREAK. The BREAK key will always return the \$ prompt.

Opcodes can be searched for in groups by using one of the following abbreviations. An * will be interpreted as a don't care in the opcode. Also, a number sign will represent any number, and &X means ignore all characters up to X. A space serves as a tab and any opcode that matches just the characters entered will be found. Examples are:

J..... Any opcode starting with J
JP# Any unconditional absolute jump
&1234H Any opcode containing 1234H
J* 234H..... Absolute or relative jump to 234H

(T) -- TRACE AT

This command will request the hex address at which to start the trace. Once the address is entered, the registers and memory displayed by the P command will appear on the top half of the screen and the trace mode is entered. The new menu of commands can be obtained by typing a slash (/) after the number sign prompt. The first default will allow entry of a decimal address, while a second default will use the current value of the user program counter (PC). BREAK will return to the \$ prompt if hit before the address is entered.

(U) -- DUMP MEMORY AT

This command will request the hex address at which to start the memory dump. The first default will allow entry of a decimal address, while a second default will use the current value of the user program counter (PC). The memory will be displayed in groups of eight bytes at a time, with the data displayed in both hex and ASCII. The up arrow key is used to indicate that the data is greater than the upper case ASCII limit, and the down arrow key is used to indicate that the data is a control character. Press any key except BREAK to display another eight bytes. BREAK will return to the \$ prompt. Hold the SHIFT key down to scroll through memory every 1/4 second.

(V) -- VERIFY CASSETTE

This command will verify a cassette that has been loaded with the R command. The filename, program limits, and execution address will be displayed as the cassette is being verified. This command could also be used to verify the LEVEL II PROM if a cassette is made using the W command. If an error is detected, then the address of the error is printed. BREAK will abort the command and return to the \$ prompt.

(W) -- WRITE TO CASSETTE

This command will request the hex program limits, execution address, and filename for a cassette. The transfer to the cassette will begin after the filename is entered. The \$ prompt will return after the transfer is complete. BREAK will abort the command and return to the \$ prompt. The cassette is created in a machine language format.

(X) -- EXAMINE REGISTER

This command will request the mnemonic for a user CPU register or register pair. Valid mnemonics are AF, BC, DE, HL, IX, IY, SP, PC, AF', BC', DE', and HL'. After the mnemonic is entered, the data is printed in hex, binary and decimal. Pressing the down arrow key will display the next register down, or pressing the up arrow key will display the next register up from the current register. To display the top register, press the left arrow key, or to quickly display all registers, hold the SHIFT key down. To modify the register, press the right arrow key, and enter a 16 bit hex number, or press D and enter a 16 bit decimal number. BREAK will return to the \$ prompt.

DISASSEMBLER COMMAND SET

(/) -- KEY DEFINITIONS

List the menu of commands for the DISASSEMBLER mode. BREAK will return to the & prompt and any other key will display another six commands.

(0) -- ENABLE PRINTER

This command will ask if you wish to output the disassembled code to the printer. Type a Y to enable or an N to disable the printer. A default will display the current status. BREAK will return to the & prompt.

(1) -- SET PRINTER FORMAT

This command will ask if a printer page format is desired. Type N to use no format, or Y to enable the page formatting. If you typed Y, then enter a page title up to 32 characters in length. The page number is entered in decimal, and is limited between zero and 255. The lines per page entry is used to adjust the entire page length. If you have 66 lines per page, then just default on this request. The default for all entries will display the current status. BREAK will abort to the & prompt at any time.

(2) -- PAGE AFTER OPCODE

This command will ask if you would like to issue a form feed after an opcode is printed. Respond with Y for yes, or N for no. Enter the opcode in the same manner as described in the C-ALL memory search command. A default will display the current status of each entry. BREAK will abort to the & prompt.

This option is useful to emphasize certain opcodes in the printed output. For example, a page on absolute return will generally separate subroutines in the printout.

(3) -- BREAK AFTER OPCODE

This command will ask if you would like to stop the disassembly after a particular opcode is printed. Type Y for yes, or N for no. A default will display the current status of the entry. Enter the opcode in the same manner as described in the C-ALL memory search routine. BREAK will abort to the & prompt.

(6) -- BREAK AFTER RETURN

This command will ask if you would like to stop the disassembly after an absolute return instruction is printed. Type Y for yes, or N for no. A default will display the current status. BREAK will return the & prompt.

(8) -- SET NORMAL DELAY

This command will ask for a 16 bit hex number to use for the delay between instructions when dumping the disassembled code to the screen only. Increase the number to slowdown, or decrease the number to

speedup the delay between instructions. The number is set initially for an approximate one second delay. A default will display the current status. BREAK will abort to the & prompt.

(9) -- SET SHIFT DELAY

This command will ask for a 16 bit hex number to use for the delay between instructions when the SHIFT key is held down and the disassembled code is being dumped to the screen only. Decrease the number to slow down the delay, or increase the number to speedup the delay between instructions. The number is set initially for an approximate 1/16 second delay. A default will display the current status, and BREAK will abort to the & prompt.

(A) -- SET DATA FORMAT

This command will ask if you want to disassemble instructions or data. Type N for instructions, or Y to disassemble data. The format of the disassembled data will be requested. A default will display the current status, or break will abort to the & prompt. Examples of valid formats are shown below. If an ASCII format cannot be used, the output will default to a byte in hexadecimal.

B Byte in hex
W Word in hex
M ASCII string terminated by non-ASCII
L Single ASCII character
C ASCII string terminated with MSB set
BWW Repeated sequence Byte-Word-Word

(B) -- BREAK AT

This command is used to set a breakpoint in a user program. Enter the hex address of the instruction you wish to stop at. Up to 10 breakpoints can be set at any time and they are stored in a last in, first out stack. Breakpoints set in one mode will remain valid as modes are changed. BREAK will abort the command and return to the & prompt. The first default will request the breakpoint in decimal, and the second default will set the breakpoint to the user program counter (PC).

(D) -- DISASSEMBLE AT

This command is used to set the starting address of the disassembly. Enter a hex address or default to enter a decimal starting address. A second default will use the current value of the user program counter (PC). BREAK will return to the & prompt.

(F) -- FILL BREAKPOINT

This command will remove the breakpoint on top of the breakpoint stack, and display the value of that breakpoint.

(L) -- LIST BREAKPOINTS

This command will list the breakpoints from the last entered to the first. The first breakpoint to be filled is on top of the list.

(S) -- SINGLE STEP MODE

This command will set the disassembly into the single step mode. Type any key except BREAK to disassemble another line, or press BREAK to return to the & prompt. Press the shift key to disassemble a line every 1/4 second.

(Z) -- RETURN TO C-ALL MODE

This command will return to the C-ALL mode and print a \$ prompt.

(↓) -- START DISASSEMBLY

This command will start an automated disassembly of instruction or data mnemonics. If the printer is enabled, then lines will be printed as fast as the printer allows. If the output is only to the CRT, then the delay between lines is selected by the normal delay and shift delay parameters. Hold the @ key down to suspend the disassembly or hold the BREAK key down to abort to the & prompt. To abort the output to the printer anywhere in the line, press the BREAK and @ keys simultaneously. Anytime a breakpoint is encountered, the & prompt will return.

(↑) -- TOP OF PAGE

This command will set the printer to the top of the page and return the & prompt. If no printer format is specified then the lines per page parameter is used to determine the number of linefeeds.

TRACE COMMAND SET

(/) -- KEY DEFINITIONS

List the menu of commands for the TRACE mode. BREAK will return to the number sign prompt, and any other key will display another six commands.

(0) -- ENABLE PRINTER

This command will ask you if you wish to output the traced code to the printer. Type a Y to enable or an N to disable the printer. A default will display the current status. BREAK will return the number sign prompt.

(1) -- SET PRINTER FORMAT

This command will ask if a printer page format is desired. Type N to use no format, or Y to enable the page formatting. If you typed Y, then enter a page title up to 32 characters in length. The page number is entered in decimal, and is limited between zero and 255. The lines per page entry is used to adjust the entire page length. If you have 66 lines per page, then just default on this request. The default for all entries will display the current status. BREAK will abort to the number sign prompt at any time.

(2) -- PAGE AFTER OPCODE

This command will ask if you would like to issue a form feed after an opcode is printed. Respond with Y for yes or N for no. Enter the opcode in the same manner as described in the C-ALL memory search command. A default will display the current status of each entry. BREAK will abort to the number sign prompt.

This option is useful to emphasize certain opcodes in the printed output. For example, a page on absolute return will generally separate subroutines in the printout.

(3) -- BREAK AFTER OPCODE

This command will ask if you would like to stop the trace after a particular opcode is printed. Type Y for yes or N for no. A default will display the current status of the entry. Enter the opcode in the same manner as described in the C-ALL memory search routine. BREAK will abort to the number sign prompt. Note that the opcode must be displayed in order to stop the trace.

(4) -- DISABLE DISPLAY

This command will ask if you would like to disable all output to the CRT or printer during the trace. Respond with a Y for yes or an N for no. A default will display the current status and BREAK will abort to the number sign prompt. The last seven lines traced can still be displayed with the left arrow command.

(5) -- SET SUBROUTINE CALL LIMITS

This command will ask if you would like to have limits on the user program subroutine calls. Type Y for yes or N for no. Enter the subroutine nest level and nest limit as a decimal number between zero and 255. Enter the subroutine call level increment, decrement, and reset addresses in hexadecimal. A default will display the current status, or BREAK will abort to the number sign prompt. If you choose not to break or trace at the call limit, the subroutine will be executed (not traced) when the call level reaches the call limit. If you choose to trace but not break at the call limit, then the subroutine will be traced with the display disabled if the call level equals or exceeds the call limit. If you choose to trace and break at the call limit, the trace will be halted when the call level exceeds or equals the call limit. Indirect calls and stack pointer resets must be handled with the memory address parameters. The trace is halted if a return is attempted from a nest level zero.

(6) -- BREAK ON RETURN

This command will ask if you want to break on a subroutine return or a call level decrement. Type Y for yes or N for no. A default displays the status and BREAK will return to the number sign prompt.

(7) -- TRACE DATA TO PRINTER

This command will ask if you would like the data printed with the P command to be output to the printer before each instruction. Type Y for yes or N for no. The default displays the current status and BREAK will abort to the number sign prompt. This output can have limits over a range of addresses as set up with the Y command.

(8) -- SET NORMAL DELAY

This command will ask for a 16 bit hex number to use for the delay between instructions when dumping the traced code to the screen only. Increase the number to slow down or decrease the number to speedup the delay between instructions. The number is set initially for an approximate one second delay. A default will display the current status. BREAK will abort to the number sign prompt.

(9) -- SET SHIFT DELAY

This command will ask for a 16 bit hex number to use for the delay between instructions when the SHIFT key is held down and the traced code is being dumped to screen only. Increase the number to slow down or decrease the number to speedup the delay between instructions. The

number is set initially for an approximate 1/16 second delay. A default will display the current status and BREAK will abort to the number sign prompt.

(A) -- ADJUST FLAG TO

This command will set one of the primary user CPU flags to the desired mnemonic. Valid mnemonics are Z, NZ, C, NC, M, P, PE, or PO. BREAK will return to the number sign prompt and a default will display the current status of the flags.

(B) -- BREAK AT

This command is used to set a breakpoint in a user program. Enter the hex address of the instruction you wish to stop at. Up to 10 breakpoints can be set at any time and they are stored in a last in, first out stack. Breakpoints set in one mode will remain valid as modes are changed. BREAK will abort the command and return to the number sign prompt. The first default will request the breakpoint in decimal and the second default will set the breakpoint to the user program counter (PC).

(C) -- TRACE CLOCK

This command will ask if a clock is desired to keep track of the number of machine states for the traced code. Type Y for yes or N for no. Enter the clock and overflow time as a 16 bit decimal number. A default displays the status and BREAK will return the number sign prompt. If you choose to break on clock overflow, the trace will be halted when the clock overflows. If you choose not to break, then the overflow counter will increment on every clock overflow, with the actual clock retaining the overflow bits. A clock overflow is reset by an instruction display with the clock time given as the overflow counter value followed by &. Remember that untraced subroutines do not get included in the clock time. To calculate the actual execution time, multiply the clock time by the processor clock period.

(E) -- EXAMINE MEMORY

This command will display the value of a memory location in hex, decimal, binary and ASCII; then wait for a further subcommand. Enter the address in hex, or default and enter the address in decimal. A second default will use the current value of the user program counter (PC). Using the down arrow key will display the next higher memory location, or using the up arrow key will display the next lower memory location. A left arrow (backspace) key will re-examine the memory location. Pressing the SHIFT key will automatically increment through memory every 1/4 second. For changing memory, press the right arrow key and enter a string of up to 16 bytes of hex data. If instead you would like to patch ASCII, then type A and enter an ASCII string of up to 32 character. BREAK will return to the number sign prompt.

(F) -- FILL BREAKPOINT

This command will remove the breakpoint on top of the breakpoint stack, and display the value of that breakpoint.

(L) -- LIST BREAKPOINTS

This command will list the breakpoints from the last entered to the first. The first breakpoint to be filled is on the top of the list.

(M) -- SET MEMORY DATA ADDRESSES

This command will request the start addresses for the hex data and ASCII data strings printed with the P command. These lines are initially suppressed and must be selected with the "-" command. A default will display the current status and BREAK will return to the number sign prompt.

(P) -- PRINT REGISTER AND MEMORY DATA

This command will display the register and memory data lines selected with the "-" command. Initially, this includes all the primary registers and the memory to which they are pointing. An up arrow key is used to indicate that the data is greater than the ASCII upper case character limit and the down arrow key is used to indicate that the data is a control character below the ASCII limit.

(S) -- SINGLE STEP MODE

This command will trace lines one at a time. Type any key except BREAK to trace the next line. BREAK will return to the number sign prompt. Hold the SHIFT key down and lines will be traced every 1/4 second. Note that the instruction is displayed but not executed until the next instruction is displayed.

(T) -- TRACE AT

This command will request the hex address at which to start the trace. Once the address is entered, the registers and memory displayed by the P command will appear on the top half of the screen. The first default will allow entry of a decimal address while a second default will use the current value of the user program counter (PC). BREAK will return to the number sign prompt.

(X) -- EXAMINE REGISTER

This command will request the mnemonic for a user CPU register or register pair. Valid mnemonics are AF, BC, DE, HL, IX, IY, SP, PC, AF', BC', DE', and HL'. After the mnemonic is entered, the data is printed in hex, binary, and decimal. Pressing the down arrow key will display the next register down, or the up arrow key will display the next register up from the current register. To display the top register, press the left arrow key, or to quickly display all registers, hold the SHIFT key down. To

modify the register press the right arrow key and enter a 16 bit hex number or press D and enter a 16 bit decimal number. BREAK will return to the number sign prompt.

(Y) -- SET MEMORY LIMITS

This command will ask if you want to apply memory limits to the trace operation. Type Y for yes, or N for no. Enter the address limits in hexadecimal, or default to display the current status. BREAK will return to the number sign prompt. If the traced program goes outside the execution limits, the trace will be halted. If the trace goes outside the instruction display limits, no instructions will be output to the CRT or printer until the trace re-enters the limits. If the trace goes outside the register display limits then no registers or memory will be output to the CRT or the printer until the trace re-enters the set limits. If a subroutine is called outside of the set memory limits and the subroutine call limits are active, then the resulting action will be the same as having the call level equal to the call limit.

(Z) -- RETURN TO C-ALL

This command will re-enter the C-ALL command mode and return a \$ prompt.

(:) -- CLEAR CRT

This command will clear the CRT and return to the number sign prompt.

(←) -- DISPLAY LAST 7 LINES TRACED

This command will display the last seven lines traced and return to the number sign prompt.

(↑) -- TOP OF PAGE

This command will set the printer to the top of the next page. If there is no printer format, then the lines per page parameter is used to determine the number of linefeeds issued.

(↓) -- START TRACE

This command will start the trace in the automatic mode. If the printer is enabled, then the lines will be printed as fast as the printer allows. If the output is only to the CRT, then the delay between lines is determined from the normal or shift delay parameters. Hold the @ key down to suspend the trace, or hold the BREAK key down to abort the trace and return to the number sign prompt. If you wish to abort the printed output, regardless of where it is printing, press the BREAK and @ keys simultaneously. In addition to the optional breaks, the trace will be halted if an illegal opcode or a HALT instruction is encountered.

DISASSEMBLER -- SAMPLE PRINTOUT

ADDRESS	HEX CODE	MNEMONIC CODE	EXEC TIME
0000	F3	DI	04
0001	AF	XOR A	04
0002	C3 74 06	JP 674H	10
0005	C3 00 00	JP 4000H	10
0008	C3 00 40	JP 4000H	10
000B	E1	POP HL	10
000C	E9	JP (HL)	04
000D	C3 9F 06	JP 69FH	10
0010	C3 03 40	JP 4003H	10
0013	C5	PUSH BC	11
0014	06 01	LD B,1H	07
0016	18 2E	JR 046H	12
0018	C3 06 40	JP 4006H	10
001B	C5	PUSH BC	11
001C	06 02	LD B,2H	07
001E	18 26	JR 046H	12
0020	C3 09 40	JP 4009H	10
0023	C5	PUSH BC	11
0024	06 04	LD B,4H	07
0026	18 1E	JR 046H	12
0028	C3 0C 40	JP 400CH	10
002B	11 15 40	LD DE,4015H	10
002E	18 E3	JR 013H	12
0030	C3 0F 40	JP 400FH	10

TRACE -- SAMPLE PRINTOUT

ADDRESS	HEX CODE	MNEMONIC CODE	EXEC TIME	LEVEL	CLOCK
002B	11 15 40	LD DE,4015H	10	000	00000
002E	18 E3	JR 013H	12	000	00010
0013	C5	PUSH BC	11	000	00022
0014	06 01	LD B,1H	07	000	00033
0016	18 2E	JR 046H	12	000	00040
0046	C3 C2 03	JP 3C2H	10	000	00052
03C2	E5	PUSH HL	11	000	00062
03C3	DD ES	PUSH IX	15	000	00073
03C5	D5	PUSH DE	11	000	00088
03C6	DD E1	POP IX	14	000	00099
03C8	D5	PUSH DE	11	000	00113
03C9	21 DD 03	LD HL,3DDH	10	000	00124
03CC	E5	PUSH HL	11	000	00134
03CD	4F	LD C,A	04	000	00145
03CE	1A	LD A,(DE)	07	000	00149
03CF	A0	AND B	04	000	00156
03D0	B8	CP B	04	000	00160
03D1	C2 33 40	JP NZ,4033H	10, 10	000	00164
03D4	FE 02	CP 2H	07	000	00174
03D6	DD 6E 01	LD L,(IX+1)	19	000	00181
03D9	DD 66 02	LD H,(IX+2)	19	000	00200
03DC	E9	JP (HL)	04	000	00219
FE5E	21 36 40	LD HL, 4036H	10	001	00223
FE61	01 01 38	LD BC, 3801H	10	001	00233