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Hitachi Microcomputer Development Environment System

**H8S/2678, H8S/2678R, H8S/2668,  
H8S/2368, H8S/2378 Series  
E6000 Emulator  
HS2678REPI61H**

Supplementary Information





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- Emulator station
- User system interface cables
- PC interface board
- Optional SIMM memory module

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This emulator product is a software and hardware development tool for systems employing the Hitachi microcomputer H8S/2678 series, H8S/2678R series, H8S/2668 series, H8S/2368 series, H8S/2378 series (hereafter referred to as the MCU). This emulator product must only be used for the above purpose.

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## **Limited Anticipation of Danger:**

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# SAFETY PAGE

## READ FIRST

- **READ** this user's manual before using this emulator product.
- **KEEP** the user's manual handy for future reference.

Do not attempt to use the emulator product until you fully understand its mechanism.

## DEFINITION OF SIGNAL WORDS



This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.



**DANGER** indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.



**WARNING** indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.



**CAUTION** indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.



**CAUTION** used without the safety alert symbol indicates a potentially hazardous situation which, if not avoided, may result in property damage.

**NOTE** emphasizes essential information.

## **WARNING**

**Observe the precautions listed below. Failure to do so will result in a FIRE HAZARD and will damage the user system and the emulator product or will result in PERSONAL INJURY. The USER PROGRAM will be LOST.**

- 1. Do not repair or remodel the emulator product by yourself for electric shock prevention and quality assurance.**
- 2. Always switch OFF the E6000 emulator and user system before connecting or disconnecting any CABLES or PARTS.**
- 3. Always before connecting any CABLES, make sure that pin 1 on both sides are correctly aligned.**
- 4. Supply power according to the power specifications and do not apply an incorrect power voltage. Use only the provided power cable.**

# CAUTION

**This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.**

# Preface

Thank you for purchasing the H8S/2678 series, H8S/2678R series, H8S/2668 series, H8S/2368 series, H8S/2378 series E6000 emulator.

The H8S/2678 series, H8S/2678R series, H8S/2668 series, H8S/2368 series, H8S/2378 series E6000 emulator (hereafter referred to as the E6000) was designed as a software and hardware development tool for systems based on Hitachi's original microcomputers HD64F2676, HD6432675, and HD6412670.

The E6000 provides a CD-R that contains the Hitachi Debugging Interface (HDI) system program, test program, and the user's manual.

There are three manuals for the E6000: the H8S series E6000 Emulator User's Manual, this Supplementary Information, and the Hitachi Debugging Interface User's Manual. The E6000 Emulator User's Manual describes E6000 functions common to all H8S series microcomputers. This Supplementary Information describes the functions specialized for each microcomputer supported by the H8S/2678 series, H8S/2678R series, H8S/2668 series, H8S/2368 series, H8S/2378 series E6000 emulator. Please read this manual before using the E6000.

To connect the E6000 to the user system, a user system interface cable for each package type is available. For details on the user system interface cable, refer to the User System Interface Cable User's Manual.

The following shows the related manuals:

- H8S Series E6000 Emulator User's Manual (HS2000EPI61HE)
- Hitachi Debugging Interface User's Manual (HS6400DIIW5SE)
- User System Interface Cable User's Manual (HS2678RECH61HE, etc)
- The PC interface board user's manual which will be the following manuals:
  - ISA Bus Interface Board User's Manual (HS6000EII01HE)
  - PCI Bus Interface Board User's Manual (HS6000EIC01HE or HS6000EIC02HE)
  - PCMCIA Interface Card User's Manual (HS6000EIP01HE)
  - LAN Adapter User's Manual (HS6000ELN01HE)
- Option Memory Board User's Manual
  - 1M SIMM Memory Board User's Manual (HS6000EMS11HE)
  - 4M SIMM Memory Board User's Manual (HS6000EMS12HE)

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# Section 1 Overview

The H8S/2678 series, H8S/2678R series, H8S/2668 series, H8S/2368 series, H8S/2378 series E6000 emulator (hereafter referred to as the E6000) is an efficient software and hardware development support tool for application systems using Hitachi's original microcomputers H8S/2678 series, H8S/2678R series, H8S/2668 series, H8S/2368 series, H8S/2378 series.

## 1.1 Environment Conditions

**Table 1.1 Environment Conditions**

Item	Specifications	
Temperature	Operating: +10 to +35°C	
	Storage: -10 to +50°C	
Humidity	Operating: 35 to 80% RH; no condensation	
	Storage: 35 to 80% RH; no condensation	
Ambient gases	No corrosive gases	
AC Power supply voltage	100 V to 240 V AC 50/60 Hz 0.6 A max.	
AC input cable*	HS2678REPI61H 100 V – 120 V (UL)	HS2678REPI61HB 200 V – 240 V (BS)
User system voltage (UVcc)	Depends on the target MCU within the range 3.0 V to 3.6 V	

Note: HS2678REPI61H must be used at AC100 V-120 V input voltage.  
HS2678REPI61HB must be used at AC200 V-240 V input voltage.

## 1.2 Supported MCUs and User System Interface Cables

Tables 1.2 shows the correspondence between the MCUs and the user system interface cables supported by the E6000.

**Table 1.2 H8S/2678 Series, H8S/2678R Series, H8S/2668 Series, H8S/2368 series, H8S/2378 series MCUs and User System Interface Cable**

No.	MCU Type Number	Package	E6000 User System Interface Cables
1	H8S/2678 series	144-pin QFP (FP-144G)	HS2678RECH61H
2	H8S/2678R series H8S/2668 series	144-pin QFP (FP-144H)	
3	H8S/2368 series	128-pin QFP (FP-128B)	HS2368ECH61H
		120-pin TQFP (TFP-120)	HS2368ECN61H
4	H8S/2378 series	144-pin QFP (FP-144H)	HS2378ECH61H

### 1.3 Operating Voltage and Frequency Specifications

Table 1.3 shows the MCU operating voltage and frequency specifications supported by the E6000. If the E6000 is used in an environment that exceeds the operating voltage range and operating frequency range guaranteed for the MCU operation, normal emulator operation is not guaranteed.

**Table 1.3 Operating Voltage and Frequency Specifications**

<b>MCU Types</b>	<b>Operating Voltage (V)</b>	<b>Operating Frequency (MHz)</b>
H8S/2678 Series	3.0-3.6	2-33
H8S/2678R Series, H8S/2668 Series, H8S/2368 Series, H8S/2378 Series	3.0-3.6	8-33

#### **NOTE**

**For details on the operating voltage and frequency specifications, refer to the MCU hardware manual.**

In the E6000, the clock can be selected by using the Configuration window or the Clock command.

**Table 1.4 Clock Selections**

<b>Clock Command Parameter</b>	<b>Configuration Window Setting</b>	<b>Notes</b>
12	12.5 MHz internal clock	Default
25	25 MHz internal clock	
33	33 MHz internal clock	
t	Target	
t2	Target/2	Not supported by the actual MCU. Use this clock only when the required clock duty cannot be obtained.

## NOTE

The system clock ( $\phi$ ) frequency is the same clock frequency input to the XTAL and EXTAL when external clock t is specified in the HDI CLOCK command. For example, when a 20-MHz crystal oscillator is connected to the XTAL and EXTAL of the user system, the system clock ( $\phi$ ) frequency is 20 MHz. When external clock t2 is specified in the HDI CLOCK command, the system clock ( $\phi$ ) frequency is 1/2 of the clock frequency input to the XTAL and EXTAL.

The frequency of the E6000 internal clock specified with the HDI CLOCK command is applied to the system clock ( $\phi$ ).

## Section 2 User System Interface

All user system interface signals are directly connected to the MCU in the E6000 with no buffering except for those listed below which are connected to the MCU through control circuits:

- NMI
- RESET
- MD2, MD1, MD0
- XTAL
- EXTAL
- WAIT

### 2.1 Signal Protection

All user system interface signals are protected from over- or under-voltage by use of diode arrays except for the AVcc and Vref.

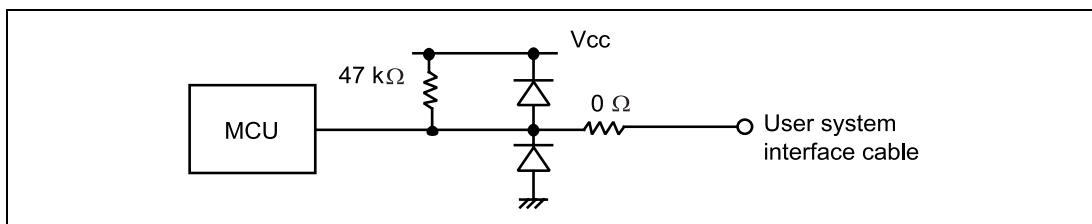
The Vcc pins (except for the AVcc pin) at the head of the user system interface cable are connected together. The E6000 monitors the voltage level of the Vcc pins and displays the power-supply status in the Status Window.

### 2.2 User System Interface Circuits

The interface circuit between the MCU in the E6000 and the user system has a signal delay of about 8 ns due to the user system interface cable. Thus high-impedance signals will be pulled up to the high level by pull-up resistors. When connecting the E6000 to a user system, adjust the user system hardware to compensate for propagation delays.

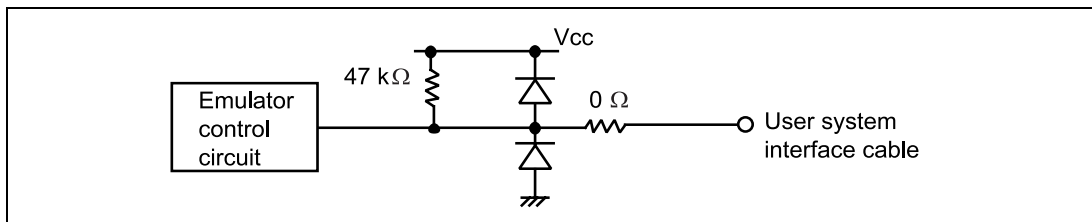
The following diagrams show the interface signal circuits.

## Default:



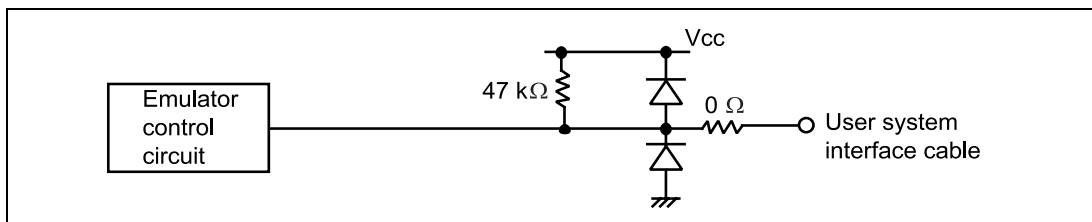
**Figure 2.1 Default User System Interface Circuit**

**Mode Pins (MD2, MD1 and MD0), NMI, and WAIT:** The NMI signal is input to the MCU through the emulator control circuit. The rising/falling time of the NMI signal must be 8 ns/V or less. The mode pins are only monitored. The CPU mode depends on the HDI Configuration settings.



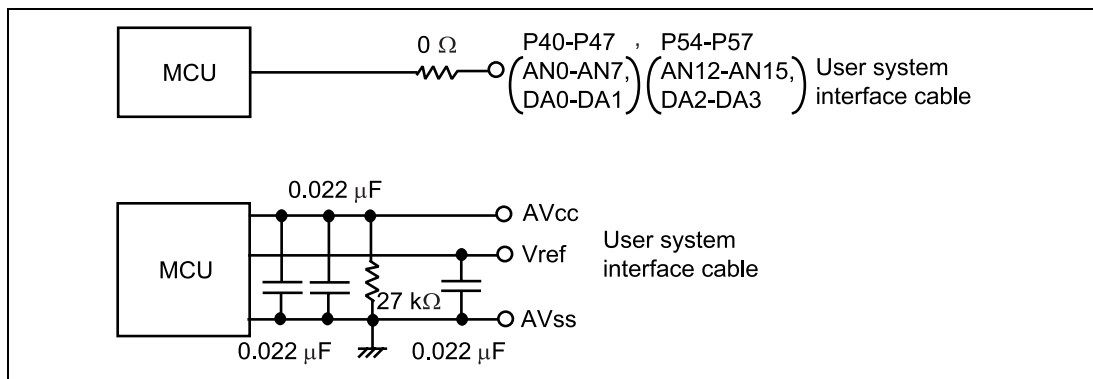
**Figure 2.2 User System Interface Circuit for MD2, MD1, MD0, NMI, and WAIT**

## RESET:



**Figure 2.3 User System Interface Circuit for RESET**

**P40 to P47 (pins used for AN0 to AN7 and DA0 to DA1), P54 to P57 (pins used for AN12 to AN15 and DA2 to DA3) Vcc, AVcc, AVss, and Vref:** Pins P50 to P57 are also used for interrupt inputs. When the user system is not connected and pull-up resistors are removed, input will be undefined and may illegally detect an interrupt. When P50 to P57 are used to input interrupt signals, it is recommended to connect the pull-up resistors to these pins.



**Figure 2.4 User System Interface Circuit for P40 to P47, P54 to P57, Vcc, AVcc, AVss, and Vref Signals**





## Section 3 Notes on Use

### 3.1 I/O Register Differences between Actual MCU and E6000

In the E6000, one evaluation chip emulates several types of MCU. Therefore, there are some differences in I/O registers between an actual MCU and the E6000. Note these differences when accessing the I/O registers.

I/O port is in the input state at default. The I/O register contents indicate the emulator port status. When the user system interface cable is not connected, the read value is 1 due to the E6000 pull-up resistors.

In the E6000, accesses to the following registers for controlling the flash memory are invalid.

- RAM emulation register (RAMER: H'FEDB)
- System control register 2 (SYSCR2: H'FF42)
- Flash memory control register 1 (FLMCR1: H'FFC8)
- Flash memory control register 2 (FLMCR2: H'FFC9)
- Erase block register 1 (EBR1: H'FFCA)
- Erase block register 2 (EBR2: H'FFCB)

### 3.2 Access to the Reserved Area

When accessing the reserved area, note the following:

If the reserved area is used, the operation in the actual MCU cannot be guaranteed. If the user program extends to the reserved area during debugging, select the MCU having the largest ROM capacity (for example, debug the program for the H8S/2675R with the H8S/2676R memory mapping).

### **3.3 Use of an Internal RAM Area as External Memory**

An internal RAM area can be used as an external address when the RAME bit of the SYSCR is cleared to "0". Emulator (option memory) cannot be selected for the internal RAM area. Only user memory can be accessed as an external address. Option memory cannot be accessed as an external address. In this case, Memory Mapping setting is the same as the Internal RAM setting.

### **3.4 Support of Flash Memory**

The E6000 does not emulate the flash memory control operation in the MCU.

### **3.5 Hardware Standby**

When the User Standby enable check box is selected in the Configuration window, the STBY signal of the user system is directly input to the E6000, and the MCU operation stops.

When disabling the STBY signal, be sure to keep the oscillator stabilization time and the timing specifications of the  $\overline{\text{RES}}$  signal.

### **3.6 EXDMA controller**

The H8S/2678 series, H8S/2678R series, H8S/2668 series, H8S/2368 series, H8S/2378 series includes an EXDMA controller that performs direct memory access (DMA) transfers between external addresses. The EXDMA controller can only access User (user memory) and cannot access Emulator (option memory).

### **3.7 SIMM Memory Module Access**

When SIMM memory module is used for the external area, memory will always be accessed via 16-bit bus in 3 cycles regardless of the setting of the bus controller.

### **3.8 Power Supply Follower Circuit**

If the Configuration dialog box is used to set [User Vcc Threshold], set the Vcc between 2.7 V to 3.6 V.

## Section 4 HDI Parameters

### 4.1 Address Areas

Table 4.1 lists the parameters for address areas (Area) that can be specified with HDI command line interface or displayed as trace results.

**Table 4.1 Address Area Parameters**

HDI Parameter (Trace Display)	Address Area	Description
rom	On-chip ROM	MCU's on-chip ROM, which can be read but cannot be written to.
ram	On-chip RAM	MCU's on-chip RAM (except for DTC RAM), which can be read and written to.
IO16 (I/O-16)	Internal I/O registers (16-bit bus)	MCU's internal I/O registers for the 16-bit bus.
IO8 (I/O-8)	Internal I/O registers (8-bit bus)	MCU's internal I/O registers for the 8-bit bus.
ext16 (EXT-16)	External area (16-bit bus)	External area for the 16-bit bus, which can be allocated to the user system memory or the optional SIMM memory module in the E6000.
ext8 (EXT-8)	External area (8-bit bus)	External area for the 8-bit bus, which can be allocated to the user system memory or the optional SIMM memory module in the E6000.*
Dtcram (RAM/DTC)	DTC RAM	MCU's on-chip RAM for DTC.

Note: When SIMM memory module is used for the external area, memory will always be accessed via 16-bit bus. Therefore, the Trace window will always display EXT-16.

## 4.2 Access Status

Table 4.2 lists the parameters for access status (Status) that can be specified with HDI command line interface or displayed as trace results.

**Table 4.2 Access Status Parameters**

HDI Parameter (Trace Display)	Access Status	Description
dmac	On-chip DMAC	Access by the MCU's DMAC (Cannot be accessed by the EXDMA controller.)
dtc	On-chip DTC	Access by the MCU's DTC
refresh	Refresh	Refresh cycle by the MCU's refresh controller
prefetch (PROG)	CPU prefetch	Instruction prefetch cycle by the CPU
data (DATA)	CPU data access	Data access for instruction execution by the CPU

## 4.3 IRQ Signal Trace

The H8S/2678 series, H8S/2678R series, H8S/2668 series, H8S/2368 series, H8S/2378 series MCU has 16 interrupt input pins IRQ0 to IRQ15. The E6000 can trace the state of eight interrupt pins simultaneously. To do this, select the IRQ0 to IRQ7 or IRQ8 to IRQ15 checkbox in the configuration window.

## Section 5 Diagnostic Test Procedure

This section describes the diagnostic test procedure using the E6000 test program.

### 5.1 System Set-Up for Test Program Execution

To execute the test program, use the following hardware; do not connect the user system interface cable and user system.

- E6000 (HS2678REPI61H)
  - Host computer
  - The E6000 PC interface board which will be one of the following boards or card:  
Select one interface board from the following depending on the PC interface specifications.  
ISA bus interface board (HS6000EII01H)  
PCI bus interface board (HS6000EIC01H or HS6000EIC02H)  
PCMCIA interface card (HS6000EIP01H)  
LAN adapter (HS6000ELN01H)
1. Install the E6000 PC interface board in the host computer and connect the supplied PC interface cable to the board.
  2. Connect the PC interface cable to the E6000.
  3. Connect the supplied AC adapter to the E6000.
  4. Initiate the host computer to make it enter DOS prompt command input wait state.
  5. Turn on the E6000 switch.

## 5.2 Diagnostic Test Procedure Using the Test Program

Insert the CD-R (HS2678REPI61SR supplied with the E6000) into the CD-ROM drive of the host computer by pressing the Shift key, move the current directory to <Drive>:\Diag with a command prompt, and enter one of the following commands according to the PC interface board used to initiate the test program:

1. ISA bus interface board (HS6000EII01H)  
    > TM2678R -ISA (RET)
2. PCI bus interface board (HS6000EIC01H or HS6000EIC02H)  
    > TM2678R -PCI (RET)
3. PCMCIA interface card (HS6000EIP01H)  
    > TM2678R -PCCD (RET)
4. LAN adapter (HS6000ELN01H)  
    > TM2678R -ELN (RET)

The HDI must be installed before the test program is executed.

Be sure to initiate the test program from <Drive>:\Diag. Do not initiate it from a directory other than <Drive>:\Diag, such as > <Drive>:\Diag\TM2678R -ISA (RET). If the test program is initiated when the current directory is not <Drive>:\Diag, the test program will not operate correctly.

When -S is added to the command line such as > TM2678R -ISA -S (RET), steps 1 to 19 will be repeatedly executed. To stop the execution, enter Q. When -Lfilename is added to the command line such as > TM2678R -ISA -Lfilename (RET), the log name at the execution is saved in filename. When -? is added to the command line such as > TM2678R -ISA -? (RET), online help (option) is displayed.

- Notes:
1. When the CD-R is inserted into the CD-ROM drive without pressing the Shift key, the HDI installation wizard is automatically started.  
    In such a case, exit the HDI installation wizard.
  2. <Drive> is a drive name for the CD-ROM drive.
  3. Do not remove the CD-R from the CD-ROM drive during test program execution.

## Message

## Description

Test program start message.  
x.x shows the version number.

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```
Option memory board fitted? ( 1. None  2. 1MB  3. 4MB ) : 1
```

Enter 1 and press the Enter key because the SIMM memory module is not installed in this example.

```
Loading driver .....OK (Use ISA)
```

Shows that driver software has been correctly loaded.

```

Initializing driver .....OK

```

Shows that driver software has been correctly initialized.

```
Searching for interface card .....OK
```

Shows that the PC interface board is correctly installed in the host computer.

```
Checking emulator is connected .....OK
```

Shows that the E6000 is correctly connected to the host computer.

Emulator board information:

Main board ID: H'5

Emulation board ID: H'18

Shows the ID number of the lower board of the E6000 (always 5) and the upper board of the E6000 (always 18).

Companion chip ID:     None

Option memory board: None

Shows the ID number of the companion chip and whether the SIMM memory board is installed.

01) Test Register

Shows the check results for the registers in the E6000 (normal completion).

A) IDR0 Register .....OK  
B) PAGE Register .....OK  
C) TRACE G/A Register .....OK  
D) PERFM G/A Register .....OK  
E) CES G/A Register .....OK  
F) IDR1 Register .....OK  
G) IDR2 Register .....OK

02) Test DPRAM

Shows the results of decoding test and step test for the dual-port RAM in the E6000 (normal completion).

A) Decode Test .....OK  
B) Marching Test .....OK

03) Test Firmware RAM

A) Decode Test     page[H'700 - H'71f] .....OK

Shows the results of decoding test for the firmware RAM in the E6000 (normal completion).

B) Marching test   page[H'700 - H'71f] .....OK

Shows the results of step test for the firmware RAM in the



E6000 (normal completion).

04) Test Trace memory

A) Decode Test      page[H'000 - H'04f] (Lower 32K)      . . . . .OK

Shows the results of decoding test for the trace RAM (first half) in the E6000 (normal completion).

B) Marching test    page[H'000 - H'04f] (Lower 32K)      . . . . .OK

Shows the results of step test for the trace RAM (first half) in the E6000 (normal completion).

C) Decode Test      page[H'000 - H'04f] (Upper 32K)      . . . . .OK

Shows the results of decoding test for the trace RAM (last half) in the E6000 (normal completion).

D) Marching test    page[H'000 - H'04f] (Upper 32K)      . . . . .OK

Shows the results of step test for the trace RAM (last half) in the E6000 (normal completion).

05) Test Map control memory

Shows the results of decoding test for the mapping RAM in the E6000 (normal completion).

A) Decode Test      page[H'200 - H'27f]      . . . . .OK

B) Marching test    page[H'200 - H'27f]      . . . . .OK

Shows the results of step test for the mapping RAM in the E6000 (normal completion).

06) Test Internal ROM and RAM

Shows the results of decoding test and step test for internal

A) Decode Test	(Internal ROM)	.....OK	ROM and RAM in the E6000 (normal completion).
B) Marching test	(Internal ROM)	.....OK	
C) Decode Test	(Internal RAM)	.....OK	
D) Marching Test	(Internal RAM)	.....OK	
07) Test Option RAM			Shows the check results for the optional SIMM memory module in the E6000 (not installed).
No option memory board fitted - test skipped			

08) Test Emulation RAM STEP Operation		Shows the check results for the step execution controlling circuits in the E6000 (normal completion).
A) Step Operation .....	OK	
09) Test Keybreak		Shows the check results for the forced break controlling circuits in the E6000 (normal completion).
A) Key Break .....	OK	
10) Test Emulation RAM Hardware Break		Shows the check results for the illegal access break controlling circuits in the E6000 (normal completion).
A) GRD Break .....	OK	
B) WPT Break .....	OK	
C) WPT(ROM) Break .....	OK	
11) Test Internal ROM Write Protect		Shows the check results for the internal ROM write-protection controlling circuits in the E6000 (normal completion).
A) Write-Protect .....	OK	
12) Test Hardware Break		Shows the check results for the hardware break control circuits in the E6000 (normal completion).
A) Break Point Initialized .....	OK	
B) Event Detectors CES channel 1-12 .....	OK	
C) Test Sequencing 1 .....	OK	
D) Check Range Break .....	OK	
E) Range Break Test for Data .....	OK	
F) Check Compare Either .....	OK	
13) Test Emulation RAM Trace		Shows the check results for the trace controlling circuits in the E6000 (normal completion).
A) Free Trace .....	OK	

- B) Range Trace .....OK
  - C) Point to Point Trace .....OK
  - D) Start and Stop Event Trace .....OK
  - E) Trace memory Overflow .....OK
  - F) Time STAMP Trace (33MHz) .....OK
  - G) Time STAMP Trace (25MHz) .....OK
  - H) Time STAMP Trace (12.5MHz) .....OK
- 14) Test Runtime Counter Shows the check results for the  
run-time counter in the E6000  
(normal completion).
- A) Runtime Counter (33.0MHz) .....OK
  - B) Runtime Counter (25.0MHz) .....OK
  - C) Runtime Counter (12.5MHz) .....OK

15) Test Emulation Monitor

- A) EMA23-EMA0 .....OK
- B) ACST2-ACST0 .....OK
- C) ASEST3-ASEST0 .....OK
- D) ASEBRKACK .....OK
- E) CNN .....OK
- F) NOCLK .....OK
- G) WINDOW .....OK

Shows the check results for the emulation monitor controlling circuits in the E6000 (normal completion).

16) Test PERFM G/A

- A) Time Measurement .....OK
- B) RESERVED
- C) Subroutine Count Measurement .....OK
- D) Timeout Function (TIMOT Bit) .....OK
- E) Timeout Function (TIMOP Bit) .....OK

Shows the check results for the performance analysis controlling circuits in the E6000 (normal completion).

17) Test Bus Monitor

- A) Register .....OK
- B) Parallel RAM .....OK
- C) SPRSEL2 .....OK
- D) RAM Monitor .....OK

Shows the check results for the bus monitor controlling circuits in the E6000 (normal completion).

## 18) Test Parallel Access

A) Internal ROM Parallel Read Access(WORD) .....OK  
B) Internal ROM Parallel Write Access(WORD) .....OK  
C) Internal ROM Parallel Write Access(High Byte) ...OK  
D) Internal ROM Parallel Write Access(Low Byte) ....OK  
E) Internal RAM Parallel Read Access(WORD) .....OK  
F) Internal RAM Parallel Write Access(WORD) .....OK  
G) Internal RAM Parallel Write Access(High Byte) ...OK  
H) Internal RAM Parallel Write Access(Low Byte) ....OK  
I) Option RAM Parallel Read Access(WORD) .....SKIP  
J) Option RAM Parallel Write Access(WORD) .....SKIP  
K) Option RAM Parallel Write Access(High Byte) .....SKIP  
L) Option RAM Parallel Write Access(Low Byte) .....SKIP

Shows the check results for the parallel access controlling circuits in the E6000 (normal completion).

## 19) Test RTC

A) RTC .....OK

Shows the check results for the RTC controlling circuits in the E6000 (normal completion).

Tests run for xH:xM:xS

Shows the check time.

Tests passed, emulator functioning correctly

Shows that the E6000 is correctly operating.

When -S is added to the command line, step 1 will be executed again after step 19.