HIGH-POWER BURN-IN
FOR VLSI AND MEMORY
DEVICES UP TO 150
WATTS

HPB-5A
High-Power Burn-In for VLSI 
And Memory Devices Up to 150 Watts

The wide variations in heat dissipation and the diverse burn-in needs of memory and high-power VLSI devices create significant challenges for manufacturing engineers. Different samples of the same part type can exhibit a wide range in heat dissipation at the same operating point because of variations in the device fabrication process. In addition, the heat dissipation of an IC changes as the device performs different operations. As more gates are involved in the operation, more power is required. As a result, devices of the same part type can exhibit as much as 50 percent variation in heat dissipation during burn-in.

This wide range in the amount of heat generated will cause significant variations in device temperatures during burn-in unless temperature compensation is provided. Devices experiencing extremely high temperatures will be damaged, while other devices will be inadequately stressed. To provide optimum burn-in stress for all devices, the system must individually regulate the temperature of each device.

To address the burn-in challenges presented by high-power VLSI devices, Micro Control Company provides four high-power burn-in test systems. The HPB-1, designed for VLSI devices dissipating up to 20 watts, is described in High-Power Burn-In for VLSI Devices Up to 20 Watts (Micro Control Publication 990219). The HPB-2, which handles VLSI devices dissipating up to 200 watts, is discussed in High-Power Burn-In for VLSI Devices Up to 200 Watts (Micro Control Publication 990206-015D). The HPB-4 dissipates up to 600 watts per device (Micro Control Publication 990279). The HPB-5A provides burn-in for memory and logic devices dissipating up to 150 watts, and is discussed here.

A fully configured HPB-5A, shown in Figure 1, holds 16 burn-in boards with up to 24 devices per board when using individual temperature control, for a total of 384 devices. The burn-in boards are accessible through the door on the front of the system.

Figure 1. HPB-5A System
Burn-In for Improved Product Reliability

The failure rate of semiconductor devices as a function of time exhibits the traditional ‘bathtub’ curve shown in Figure 2. The initial failure rate is very high, but it drops rapidly over the first few hours.

![Figure 2. Failure Rates versus Time](image)

Devices which survive the infant mortality period normally operate very reliably for many years. Eventually the devices reach the end of useful life, as various time- and stress-related mechanisms begin to fail.

The semiconductor industry currently uses a number of burn-in strategies to find those weak devices which would fail during the infant mortality period. Test patterns, elevated voltages, and elevated temperatures are all useful for stressing weak devices.

Burn-in strategies are generally classified as static, dynamic, or burn-in-with-test. **Static burn-in systems** apply extremes of voltage and temperature to each device but do not operate or exercise the device. Thus static burn-in, the least expensive of the burn-in strategies, does not stress all of the potential failure mechanisms.

**Dynamic burn-in systems** exercise the device inputs and properly terminate the outputs, in addition to applying extremes of voltage and temperature. Although dynamic systems are more costly than static, the extra investment is justified because more internal circuits are stressed, causing additional failure mechanisms to occur.

**Burn-in-with-test systems**, the most expensive option, are capable of testing devices while exercising them. The user can compare actual device outputs to expected outputs while the devices are operating at voltage and temperature margins. These systems are superior in several ways. Among the many advantages of burn-in with test is the ability to detect devices that fail under marginal conditions but not at the normal operating point. Elimination of these devices
provides a significant improvement in product reliability. In addition, burn-in with test lets operators determine the time of failure, which is useful in calculating failure rates. It also allows testing of devices after the burn-in cycle without transferring them to a separate tester.

Another important advantage of burn-in-with-test is the ability to verify that the device is actually being exercised. Are all of the pins making contact? Is the device powered up? Are the test vectors really being applied to the device? The increasing complexity of VLSI devices has created device sockets with pin counts of 2000 or more. These sockets are not only expensive but also fragile, making them poorly suited to the insertion/extraction cycles required in production burn-in environments.

Neither static nor dynamic burn-in systems are able to verify that the device is actually being exercised. Testing during burn-in provides verification of device operation as part of testing. This prevents shipping parts that were not actually stressed during burn-in, another significant step in increasing product reliability.

The burn-in process must be carefully controlled, however, to prevent damage. Burn-in uses power and temperature extremes to force infant mortality failures to occur sooner—in the factory instead of in the field—thus saving time and money. And the more extreme the power and temperature, the earlier these failures occur, thus reducing the required burn-in time. But beyond a certain point, power and temperature extremes will damage the device. In the long term, the worst type of damage is not an immediate failure but a weakened part with a shorter operating life. The optimum burn-in temperature is high enough to force infant mortalities and yet low enough to avoid weakening the device. Semiconductor companies spend considerable time and money determining optimum burn-in temperatures for production devices.

An effective production burn-in cycle should force all of the devices to stay very close to the optimum temperature. Most burn-in-with-test systems cannot achieve this. Because of fabrication variations, the devices will be at widely varying temperatures at any given point in time. Moreover, the application of different test vectors will cause the temperature of each device to change with time. The HPB-5A meets this challenge by providing individual temperature control for each device.
Micro Control Company’s HPB-5A System

The HPB-5A provides precise temperature control for each device under test, causing the specified thermal stress to be applied during burn-in with test. Individual temperature control protects the parts and ensures that they are sufficiently burned in. Each of the 16 burn-in boards hold up to 24 devices when using individual temperature control, each providing a system capacity of 384 devices. The programmable power supplies provide up to 150 watts of regulated power to each device for a partially-loaded system and 65 watts for a fully-loaded system. The flexible pattern generator controls the 128 I/O lines to each burn-in board.

Devices dissipating up to 150 watts are individually controlled to within ±5°C of the specified temperature by a temperature sensor, heater, and cool air flowing over an air control tray, through an air impingement device and onto the device under test, as shown in Figure 3.

![Figure 3. HPB-5A Heat Sink and Socket](image)

An air control tray (either a slotted vent, baffle tray, or valve tray) directs the airflow over the DUTs. The temperature control board monitors the temperature of each device via the temperature sensor that is built into the heat sink assembly or by a diode or a transistor built into the DUT itself. The temperature is maintained at the set point by blowing air from the cool air duct of a valve, vent, or baffle tray down across the heat sink, by adjusting power to the heater built into the heat sink, or by adjusting the cooling air temperature. This holds device package temperature to within ±5°C of the set point. The heater in the heat sink is chosen to maintain the required device temperature when little or no heat is being generated by the device. At higher device power levels, the heater has a much lower duty cycle to maintain device temperature.
The **valve** tray controls the temperature of the burn-in devices. Each valve tray holds up to 24 valves, which, in conjunction with the heater/heat sink assembly add or remove heat as necessary to maintain set point. Adding heat can be accomplished with cartridge heaters inside the heat sink. Removing heat is done by circulating cool air through heat exchangers over the valve tray through valves and onto the burn-in board.

A low thermal resistance between the device and the thermal head is required for optimal performance. The HPB-5A regulates the cooling with valves on the valve tray (see Figure 3-21). These valves are regulated by the temperature control board, which opens and closes the valves as cooling is required. The valve tray on an HPB-5A can only withstand chamber temperatures of up to 70°C.

The **baffle** tray is used in high temperature mode and when individual device control is not desired. This allows more than 24 devices to be tested at once. Air flow is diffused by the baffle tray to produce uniform air flow over the BIB.

The **vent** tray allows for the devices to be heated individually, while the cooling is achieved by air that flows into slots above each DUT and over the burn-in board.

**Cooling Air Temperature** – The cooling air temperature is programmable down to 5°C.

**Device-to-Air Thermal Resistance** – This includes the thermal resistance of the device to heat sink and the heat sink to air. This is affected by the device area and the quality of the mechanical contact between the device and the heat sink. Also factoring in are the heat sink design, the airflow past the heat sink, and the cooling air temperature. Note that a taller socket allows less room for the heat sink and may increase the heat-sink-to-air thermal resistance. Typical values range from 0.5°C to 2.5°C per watt.

**Maximum Power Dissipated** – Since two devices of the same type may dissipate different amounts of heat under the same conditions, test design must consider the maximum power dissipated by any good device under the conditions encountered in the test. This ensures that all devices can be maintained at or below the maximum allowable test temperature.
Example

Thus the device temperature can be maintained as low as the following example:

- Device-to-air thermal resistance for a particular device must be 0.6°C per watt or less
- Input cooling air is 25°C
- 150-watt operation

Minimum device temperature = 25°C
+ ((0.6°C per watt) * (150 watts))
= 25°C + 90°C
= 115°C

The importance of low thermal resistance between is easily seen. Each increase of 0.1°C per watt in the heat flow path increases the lowest operation of the device by 15°C at 150 watts. This underscores the importance of heat sink and socket design to maximize oven capabilities.

Test Chamber. Burn-in boards are placed into the test chamber. Figure 5 represents a simplified view of one column of test electronics in the test chamber of the HPB-5A. Figure 6 shows a simplified cross-section of an HPB-5A system.
**Test System.** The vector store board, coupled with the high performance driver/receiver boards, provides step-by-step control of the device and application of complex test patterns. Figure 7 contains a simplified block diagram of the HPB-5A test chamber. Each of the 16 burn-in boards in the test chamber is connected to a driver/receiver board, a temperature control board, and a voltage regulator board. Each vector store board directs and monitors 8 driver/receiver boards.

The vector store board, containing a memory with up to 64M words of storage, directs the test sequences and provides the test patterns. Vector storage depth options (128K to 64M words) let the user run large numbers of test vectors without time-consuming reloads.

A portion of the wide word contains instructions (Load, Increment, Jump, Call, Return, etc.) that direct the test sequence. The rest of this word directs the driver/receiver board in applying test patterns and signals to the devices on the burn-in board and in testing the device outputs.

![Figure 6. Simplified Side View of System](image)

The **vector store board**, coupled with the driver/receiver boards, provides very flexible, sophisticated testing up to a 10-MHz repetition rate.

Each **driver/receiver board** is capable of the following functions:
• Formatting data from vector memory and combining it with programmed timing
• Generating up to 128 separately programmable clock pulses
• Forming drive pulses with programmable amplitudes
• Providing 128 I/O signals
• Receiving data from the device under test via dual comparators
• Comparing received data to expected data
• Logging device failures

Each high-performance driver/receiver board contains 128 driver/receivers. A driver delivers a pulse, programmable from 0 to 4.0 volts in steps of 1.2 millivolts, with fast rise and fall time. These drivers are located close to the burn-in board to minimize line length. Overshoot and undershoot are also minimized.

Each voltage regulator board provides eight individual device power supplies programmable from 0 to 4 volts, with up to 100 amps of current (200 watt maximum up to 3.0 volts). Three additional 0- to 6-volt low-current supplies are also provided for powering other burn-in board circuits.

One of the many advantages of the temperature control utilized in this burn-in system is the low temperature of the air stream at the BIB. This provides an environment conducive to long-term, trouble-free operation of the support circuitry and connectors.
Advanced Software. Micro Control Company’s powerful software supports both engineering and production environments. Sophisticated, user-friendly interfaces provide maximum efficiency and convenience. The software runs under Microsoft Windows NT/2000, to provide maximum stability as well as ease of use. The software includes the following features:

- User-friendly interfaces, with dialog boxes and pull-down menus
- Built-in database for quick, efficient data management
- Simplified construction of complex tests by defining a set of small, manageable test steps
- Easily specified voltage, temperature, and test sequences
- Device temperature control at each test step
- System interrupts for test system malfunctions
- Test-in-progress monitoring, including device temperature at each socket
- Management of production burn-in programs
- User-defined product disposition of devices under test
- Convenient activity reporting
- Password protection
- Diagnostics to test all aspects of hardware

**Figure 8** illustrates a typical interface provided by Micro Control's C-Breez™ software. This window displays the temperature, power being dissipated, and the disposition of the devices at the last sampling. The data is displayed at intervals set by the user in the Refresh Display and Record dialogs.

Temperatures and electrical data can also be displayed as a function of time, as in **Figure 9**. This window displays the actual temperatures for one zone over a 44-minute period.
Summary

The Micro Control Company HPB-5A system provides precise temperature control for each device under test, causing the proper thermal stress to be applied to each device during burn-in with test. The programmable power supplies can provide up to 150 watts of regulated power to each device. The flexible pattern generator controls the 128 I/O lines to each burn-in board. With all of these resources, the test system also supports a wide range of test strategies.

High-power burn-in with test is part of a complex engineering analysis that manufacturers must continually monitor to produce high-quality products at minimum costs. This analysis includes purchase cost, service life, repair costs, operating costs, and through-put of the high-power burn-in system, in addition to many other factors. Micro Control Company’s HPB-5A is an affordable component in the production of reliable memory and high-power VLSI devices.
System Specification Overview

General Characteristics

Number of Burn-In Boards .......... 16
Size of Burn-In Boards .............. 22.5 inches deep x 24 inches (572 x 609 mm)
Devices per Test Board ............. 24 maximum
Total Devices per System .......... 384 maximum
Repetition Rate .................. 10 MHz maximum
Vector Memory Depth ............. 128K to 64M
Pattern Zones .................... 2
Operating System ................ Microsoft Windows NT/2000®
PC Type .......................... Intel compatible
System MTBF ..................... 2,000 hours minimum
System Mean Time To Repair ...... 2 hours maximum
System Size (nominal) ............ 87.2 H x 98.4 W x 124.7 D inches (2215 x 2500 x 3166.3 mm)

Programmable Device Package Temperature

Range .............................. 50° to 150°C
Accuracy .......................... ±5°C of set point
Resolution ....................... 0.2°C
DUT Power Dissipation .......... 150 watts per device maximum partially-loaded, 65 watts per
device for a fully-loaded (24 DUT per board) system.

Programmable Power Supplies (for Each Burn-In Board)

8 Supplies ......................... 0 to +4.095 volts at 115 amps, 1 mV resolution, 200 watts
maximum up to 3.0 volts
3 Supplies ......................... 0 to +6.14 volts at 8 amps, 1.5 mV resolution, 50 watts maximum
Accuracy ......................... ±30 millivolts
Ripple and Noise .................. 40 millivolts maximum

Driver/Receiver Board

I/O Channels .......................... 128 per driver/receiver board
Programmable High Level ........ 0 to 4.0 volts in steps of 1.22 mV
Driver Current ..................... 100 milliamps DC, 250 milliamps transient
 Rise/Fall Time ................... 5 to 25 nanoseconds
Dual and Single Comparators .... Yes
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