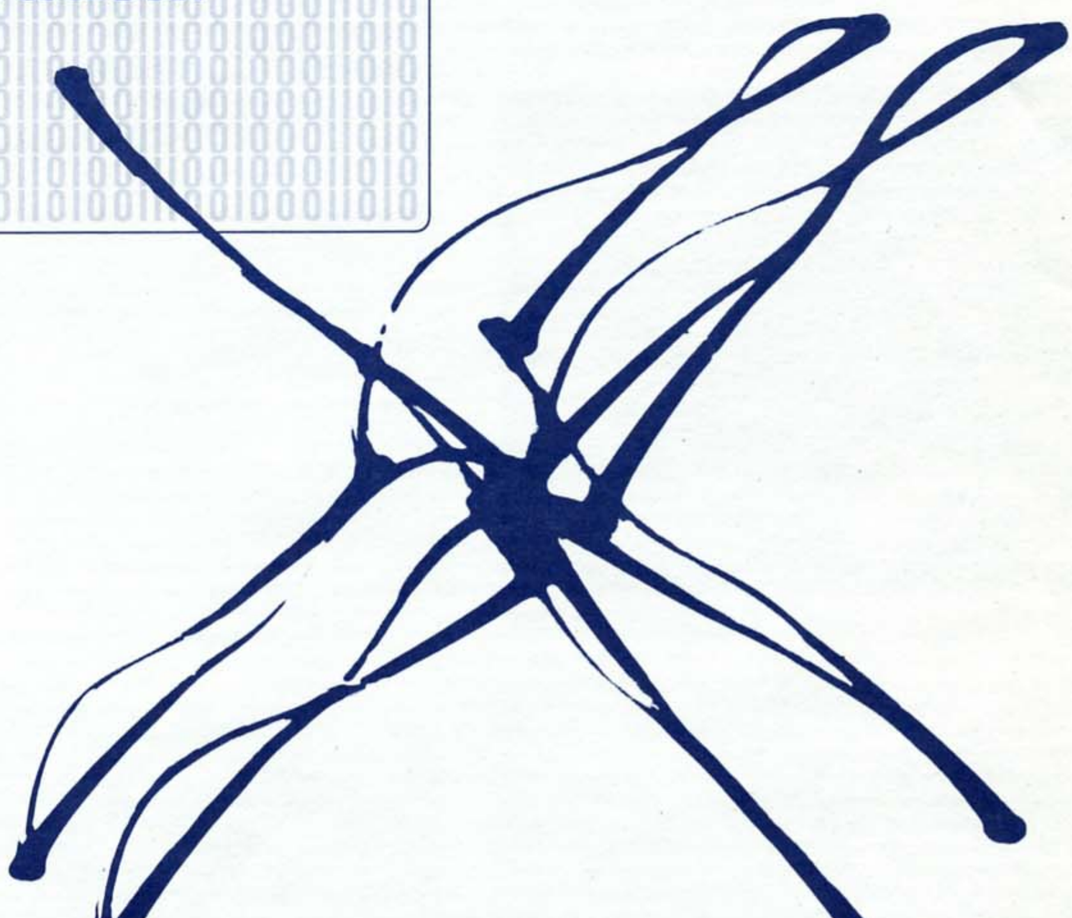
APPLICATION NOTE 167-6
DATA DOMAIN MEASUREMENT SERIES

Mapping, a dynamic display of digital system operation.



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ABSTRACT

This application note discusses a new digital measuring technique called "mapping". Mapping enables the dynamic viewing of digital system operation by providing a pseudo-continuous broadband (or sweep) display of system performance. This digital (sweep) map measurement method can save considerable troubleshooting time by leading the investigator immediately and directly to a specific data sequence within a program. Mapping can also eliminate the tedious task of performing a state-by-state system logic analysis.

INTRODUCTION

The Hewlett-Packard Model 1600A Logic State Analyzer incorporates an analysis technique called "mapping", which provides the digital designer with the capability to review firm-ware performance from a qualitative rather than a quantitative standpoint.

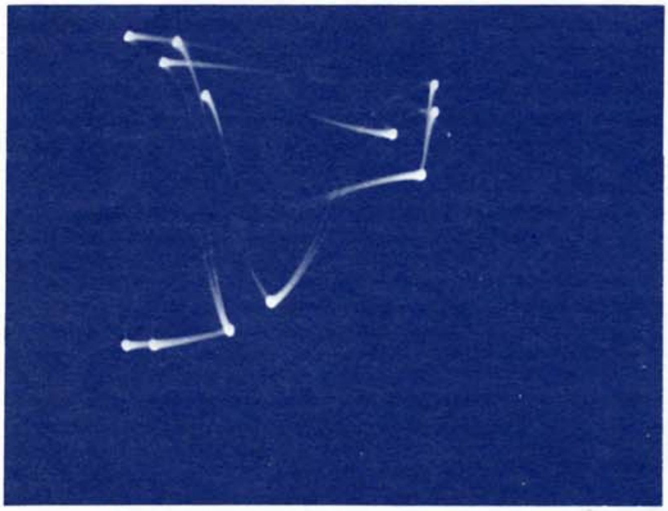

Figure 1. Map display shows the unique pattern of a data sequence.

Basically, the map displays logic words of up to 16 bits long as single dots on a screen with each dot representing a unique 16 bit word. The position of a dot indicates the binary magnitude of a specific word, and the relative brightness of a dot or group of dots indicates the relative frequency of occurrence (similar to duty cycle). The trace connecting the dots is a vector that indicates both the start and end word for that vector. The map in figure 1 shows the various dot locations and vectors for an applied data sequence.

Map generation is on a sample basis rather than real time. The 16 word contents in the A memory is mapped, and then, another 16 word data block is loaded, stored, and displayed. The display cycle is approximately 200 ms; therefore, data mapping is a repetitive load/store operation.

INPUT DATA

(16 "Words" of 16 bits each from the 'A' memory)

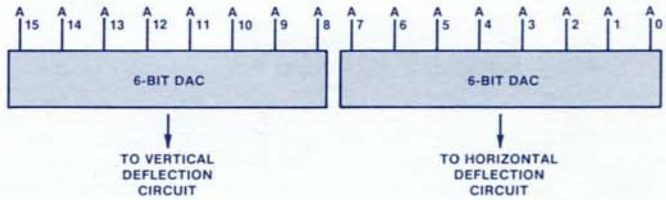

Figure 2. Digital to Analog conversion block diagram for map display.

Each 16 bit parallel word is separated into two bytes of eight bits each as shown in figure 2. The most significant byte is applied through a Digital-to-Analog Converter (DAC) to the vertical deflection axis, and the least significant byte is applied through a DAC to the horizontal deflection axis. The resolution of an eight bit D/A converter far exceeds the useful resolution of the display. Therefore, in the NORMAL map mode, only the six most significant bits (MSB) of each byte position the data dot. When the analyzer is switched to the EXPAND map mode, the six least significant bits (LSB) of each byte position the dot. In the EXPAND mode the two MSB of each byte identifies which quadrant of the Normal mode is selected for display. In either mode, the actual display resolution is 2^6 by 2^6 (4096 states), however, the EXPAND operation increases the effective display resolution to 2^8 by 2^8 ($16 \times 4096 = 65536$ states). Figure 3 shows the data states (in hexadecimal notation) versus general display quadrant location.

MAP DISPLAY

(Positive Logic, Hexadecimal Notation)

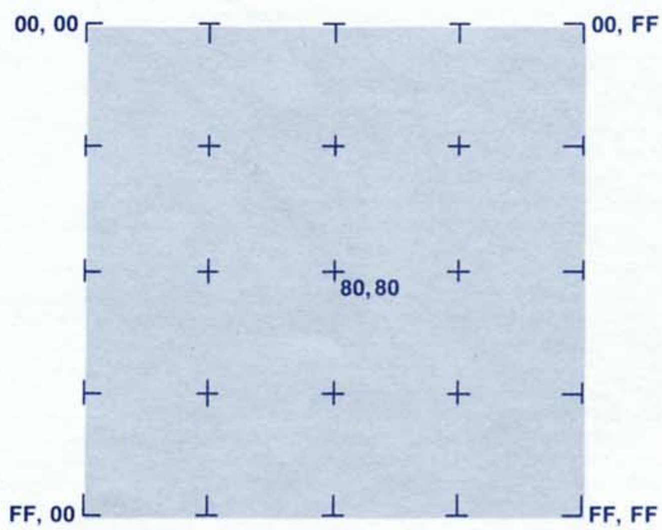

Figure 3. Map Display Quadrants with positive logic in hexadecimal notation.

USING THE MAP MODE

The finger prints of an individual, the musical pattern of a band, and the Logic State Analyzer map of an applied digital program all have one thing in common - each is unique. As a trained ear can detect an off-key note, so the eye can be trained to detect minute map pattern changes. It is amazing how rapidly your eye can learn to interpret a map display as a subroutine operation, as test 15 being performed, as communication with a peripheral, or as an abnormality requiring further investigation. Frequently, the sensitivity of the eye observing a map display for an abnormality can isolate a subtle system problem area faster than a step-by-step, walk-through-the-program technique of other instruments.

A digital system failure investigator can employ the mapping capability in the same way that a crime investigator employs the benefits of fingerprinting by working from a known fingerprint file list. At the commission of a crime, he collects all the prints at the scene, compares them with the file, and, when appropriate, adds new prints to the file.

In the routine of developing a digital system, the engineer can use the map display to obtain a quick overall view of the system's performance. Each time he uses the map display, the proper map image will be refreshed in more detail in his mind. In addition, a photograph of the map, documented and added to the file, can be used for future reference.

When a malfunction does occur, the associated change in a map pattern is easily detected by the eye. The erroneous pattern can be photographically or mentally compared to previous map displays in the file list. In a short period of time, a "signature" map file of both proper operations and failure modes will enable rapid troubleshooting and solution verification of system malfunctions.

MAP AND TABLE COMPARISON

The same data, 16 words (16 bits per word), are in tabular format in figure 4a and plotted in map format

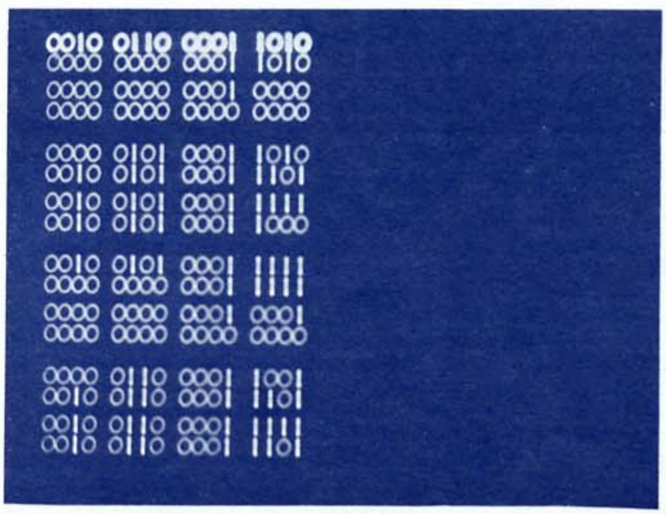

Figure 4a.

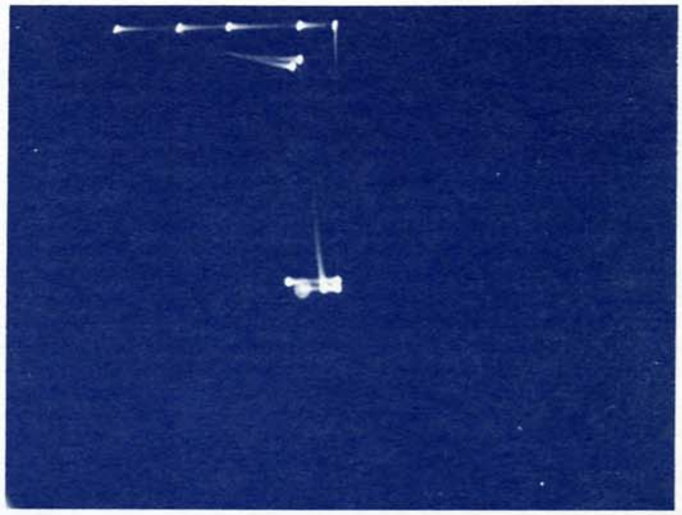

Figure 4b.

Figure 4. Table and Map display of the same applied data sequence.

in figure 4b. In a dynamic situation with rapidly changing data, it is difficult to detect changes with the 256 one's and zero's in a tabular display (figure 4a). However, with the map display (figure 4b), variations in the pattern are easily and quickly detected, which is the value of the map mode. As can be seen by this comparison, the map display provides a rapid means of obtaining a qualitative "feel" of machine activity. The characteristic map pattern, or "signature", becomes easy to recognize, just as a telephone man obtains a qualitative "feel" of line characteristics by listening to the line.

Figure 5, 6, and 7 are Examples of map signatures that provide an overall qualitative view of a systems performance. These photographs were obtained from a Logic State Analyzer while monitoring the multi-purpose (S) bus of the HP-2100 Computer during a Direct Memory Access diagnostic program.

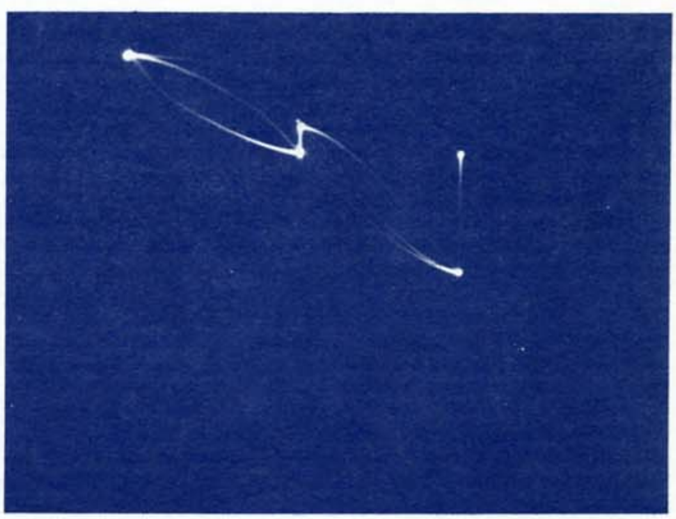

Figure 5. Computer communicating with a teletypewriter.

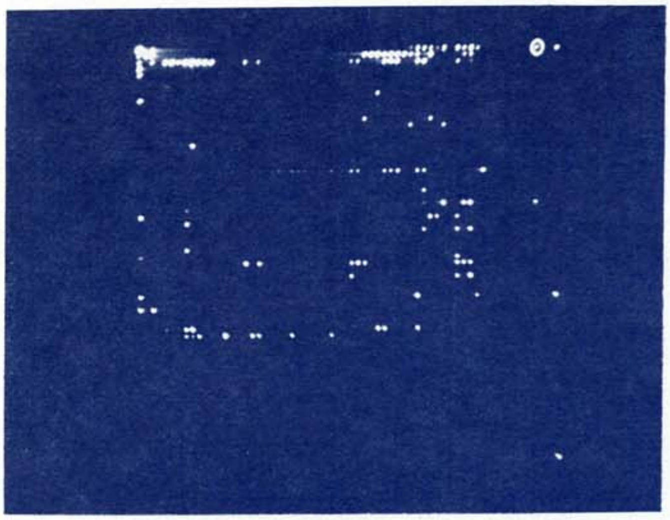

Figure 6. Bright dots near the top are program register states, mid-screen horizontal dots are memory address states, and the remaining dots are program instruction states.

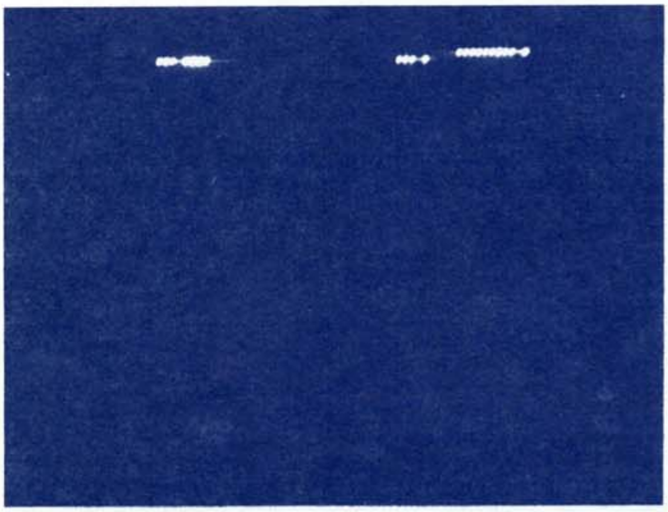

Figure 7. Qualification of the data to be displayed permits the Program Counter Register operation to be extracted from a multi-purpose bus containing memory addresses and program instruction states.

The map display as the computer communicates with a peripheral is shown in figure 5. There are many jumps, jump sub, and clear control commands during the initialization part of this program as represented by the bright dots on the map.

Data mapping also provides a quick method of locating "trouble spots" for table display and detailed electrical analysis. Assume that the map display indicates an erroneous word sequence within a particular data program. The exact point where the erroneous sequence occurs can be located and displayed in tabular logic state form for a more detailed analysis.

In the WORD trigger mode, the Analyzer generates a circular cursor that is positioned with the TRIGGER WORD (TW) switches. Switches 0 through 7 move the cursor horizontally, and switches 8 through 15 move the cursor vertically.

First, the cursor is positioned over the data word dot of interest with the trigger word switches. Then, the Map EXPAND mode is used to ensure final cursor positioning with the trigger word switches. The NO TRIG indicator will go off when the switches are properly set. Now, the exact logic pattern of the erroneous data word has been set on the trigger word switches. Now, by switching to one of the 1600A table display modes with this TRIGGER WORD data pattern used as the trigger word, the logic states of the words before, after, or before and after the suspect data word can be analyzed in detail.

By way of review, the map display feature of the Hewlett-Packard Model 1600A Logic State Analyzer offers the following benefits:

(1) A time-saving method to review or preview the overall performance of your digital system.

(2) Reduces troubleshooting time when used with a map file of proper operation and typical problems for isolating problems to particular routines.

(3) Analyzing the bright-dot display for potential improvements in program efficiency.

(4) With the 1600A qualifying capability, selective mapping and analysis of one function on a complex system multi-purpose bus is possible.

(5) Rapid conversion of the map display to a logic state display with the cursor feature for a state-by-state detailed logic analysis of the malfunction.

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