Memorandum

COMPARATIVE EVALUATION OF
DIGITAL EQUIPMENT CORPORATION'S 340 AND 330 DISPLAY CONTROLS

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This evaluation was compiled during the development of the display specifications for one of the remote display consoles at The University of Michigan.

The DEC 330 Display is the name given the DEC 338 Buffered Display when it is supplied without the PDP-8. For purposes of this evaluation, the 330 and 340 are configured with standard options to have, as much as possible, the same capabilities.

The evaluation is divided into three basic sections. The first is a cost comparison. The second is a comparison of the execution time and instruction size for the basic operations causing display of information. The final section, which comprises the bulk of the evaluation, compares the equivalent instructions in each display.

The 330 Display Control is clearly the best display on an economic and technical basis. When these displays are compared in the environment of a PDP-7, one more factor should be noted. The 340 Display has a fair amount of software support on the PDP-7. The 330 Display can use the same display programs as the 338, but the control programs must be translated to the PDP-7 from the PDP-8. When the 330 Display is used on the PDP-7, only the low order 12 bits of the 18 bit word are used for display programs. This fact allows the display structure to be imbedded in a higher order data structure which could use the high order 6 bits for other information pertinent to the data structure. Thus, the 330 Display is probably the best display to connect to the PDP-7 in a research environment. In a production environment, more weight will probably have to be given to the software support of the 340.
<table>
<thead>
<tr>
<th>Cost</th>
<th>340 Display</th>
<th>Subtotal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display</td>
<td>$25,800</td>
<td>$37,000</td>
</tr>
<tr>
<td>Subroutine Interface</td>
<td>$3,385</td>
<td>$3,385</td>
</tr>
<tr>
<td>Light Pen</td>
<td>$1,625</td>
<td>$1,625</td>
</tr>
<tr>
<td>Pushbutton Box</td>
<td>NA</td>
<td>$3,383</td>
</tr>
<tr>
<td>Character Generator</td>
<td>$11,600</td>
<td>$11,600</td>
</tr>
<tr>
<td>Interface to PDP-7</td>
<td>$900</td>
<td>$900</td>
</tr>
<tr>
<td></td>
<td>$43,283*</td>
<td>$43,283</td>
</tr>
<tr>
<td></td>
<td>$44,000 (U of M Interface)</td>
<td>$44,000</td>
</tr>
</tbody>
</table>

Note: If the $15,000 cost of an additional pushbutton box on the 340 Display is used as an estimate for a pushbutton box on the 340 Display, the total 340 Display cost is $48,283.
<table>
<thead>
<tr>
<th>Display Mode</th>
<th>Condition</th>
<th>No. of Core Accesses</th>
<th>Speed (μsec)</th>
<th>Speed per Point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>340</td>
<td>330</td>
<td>340</td>
</tr>
<tr>
<td>Point</td>
<td>Points close together</td>
<td>2</td>
<td>1 or 2</td>
<td>36.8</td>
</tr>
<tr>
<td>(including</td>
<td>Points far apart</td>
<td>2</td>
<td>1 or 2</td>
<td>36.8</td>
</tr>
<tr>
<td>graph)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short</td>
<td>(7 bits)</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Vector</td>
<td>(4 bits)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vector and</td>
<td>(7 bits)</td>
<td>1</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>vector</td>
<td>(10 bits)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>continue</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increment</td>
<td>1/4</td>
<td>1/2</td>
<td>2.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Character</td>
<td>Character</td>
<td>1/3</td>
<td>1/2 + ~5</td>
<td>~35</td>
</tr>
</tbody>
</table>
NOTES:
Requires two words if both coordinates are to change.
Note of the next instruction must be specified.

TIMING:
Nonintensified = 36.8 usec.
Intensified = 36.8 - 71.6 usec.
(regardless of position relative to the last point)
#330

- X or Y coordinate (10 bit)
- 0, Set Y, Incr. X;
- 1, Set X, Incr. Y
- Escape (to control state)

**NOTES**
- Requires one word.
- Next instruction assumed to be a graph.
- Flight unless the escape bit is set.

**TIMING**
- Multiscanned = 0.3 usec
- Intensified close to last = 6.3 usec
- Intensified far from last = 35.3 usec
VECTOR #1
and
VECTOR CONTINUE

NOTES:
On times one scale, maximum vector size is 1/8 of raster size.
Only one core word required.
Mode of next same unless escape.

TIMING (per point):
Nonintensified or intensified = 1.5 μsec.

340

330

NOTES:
On times one scale, maximum vector size is the full raster size.
Two core words required.
Mode of next is same unless escape.

TIMING (per point):
Nonintensified = 0.25 μsec.
Intensified = 1.2 μsec.
SHORT  Not Available
VECTOR  (Use Vector)

NOTES:
On time one scale, maximum vector size is
1/64 raster size.
Requires only one word of core.

TIMING (per point):
Nonintensified  =  0.25 \mu sec.
Intensified    =  1.2 \mu sec.
NOTES:

Only one move may be made in one of the eight primary directions for each increment instruction.

Four instructions are packed per word.

Mode of next same unless escape.

TIMING (per point):
Nonintensified or intensified = 2.25 μsec.

NOTES:

One, two, or three moves in one of the eight primary directions.

Two instructions are packed per word.

Mode of next same unless escape.

TIMING (per point):
Nonintensified = 0.25 μsec.
Intensified = 1.2 μsec.
NOTES:
Character generator is a fixed character set. Characters are drawn by moves around a 5 x 7 matrix.

TIMING (per character):
Variable - average time 35-40 usec.
PARAMETER #1

Intensity
- Enable Intensity Set
- Light Pen Enable Status
- Enable Light Pen Status Set

Scale
- Enable Scale Set

0 (Control State op Code for Parameters)

PARAMETER #2

Intensity
- Enable Intensity Change

Scale
- Enable Scale Change

Not Used
- Stop Display and Generate an interrupt (or not)
- Light Pen Enable Status
- Inhibit Change of Light Pen Status

Mode of next instruction

Not used

NOTES:
The display is stopped and an interrupt is generated
in the processor if interrupt control location
is set in the automatically decoded control
state instructions.
SLAVES
(Optional)

- Intensify
- Light Pen Activate
- Set Unit 1
- Intensify
- Light Pen Activate
- Set Unit 0
  \[
  \begin{array}{c}
  \text{Slave Group Number} \\
  \text{(Control state op code for set slaves)}
  \end{array}
  \]

\[01234567891011\]

\[330\]

\[01234567891011\]

\[340\]

- Intensify
- Light Pen Activate
- Set Slave Unit 4
- Intensify
- Light Pen Activate
- Set Slave Unit 3
- Intensify
- Light Pen Activate
- Set Slave Unit 2
- Intensify
- Light Pen Activate
- Set Slave Unit 1
- Not Used

\[\text{Mode of next instruction}\]

\[\text{Slave Group Number}\]
SUBROUTINE MODE
(JUMP)

00 Not Used
01 Stored the number in the address save register as a jump instruction with that number as address in the address specified
10 Display Jump (simple control jump)
11 Display jump and save the address of this instruction plus one in the address save register.

NOTES:
No provision for saving display status on subroutine entry.

NOTES:
Requires 2 words.
The total jump address size is 15 bits.
The push saves the (current address plus one), light pen status, scale, mode, and intensity on a pushdown list.
The pop jump transfers control to the address in the last entry on the pushdown list.

Scale and Light Pen Setting overrides the inhibits.

The inhibits override the automatic restoration of mode, light pen, scale, and intensity from the last entry on the pushdown list.
- Not Used
- Not Used
- Up (0), Down (1)
- Count Intensity
- Up (0), Down (1)
- Count Scale
- (Control State Op Code)

- Enter Data State
- Clear Coordinate Bits (low order 10 bits of 13 bit display address)
- Clear Sector Bits (high order 3 bits of 13 bit display address)
- Display State Mode
- Enable Display State Mode Set
- Clear Display Flags
- Stop Display (& Generate Processor Interrupt)
- 1 (A Control State Op Code)

NOTES:
The intensity and mode registers will not overflow or underflow.
INSTRUCTIONS AVAILABLE ON THE 330
( NOT AVAILABLE ON THE 340 )

CONDITIONAL

SKIP
(On pushbuttons)

ARITHMETIC

COMPARE
(On pushbuttons)

NOTES:
This instruction skips two core locations.

NOTES:
This instruction skips two core locations if comparison is unsuccessful.
INSTRUCTIONS AVAILABLE ON THE 330
( NOT AVAILABLE ON THE 340 )

SKIP ON

0 1 2 3 4 5 6 7 8 9 10 11

FLAGS

Control State Op Code

AUTOMATIC SCISSORING:
The capability of automatic scissoring and specification of "paper" size is provided with the 15 bit X and Y address registers.
1. Read display address counter
2. Skip on edge violation
3. Display resume
4. Skip on stop interrupt
5. Clear display address counter
6. Load display address counter (display start)
7. Skip on light pen flag
8. Read display coordinates (9 high order bits only)
9. Clear flags

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5. Load display address counter (start display)
6. Skip on light pen flag
7. Read X coordinates
8. Read Y coordinates (read status 2 for high order X & Y bits)
9. Read push down pointer
10. Read status 1
11. Read status 2
12. Read status 3
13. Read status 4
14. Read status 5
15. Set push down pointer
16. Set initial conditions
17. Skip on slave light pen
18. Load break field, 6 pushbutton, stop display
19. Special options
20. Skip on manual interrupt