

KIDSGROVE

No.

Ref.

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Programmes to Investigate Timings on KDF9.

Report by

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SUMMARY.

A recent tender required the tenderer to write certain programs to illustrate the speed of the computer offered. In order to verify the theoretical times the customer requested that the programs written should be run on KDF9. This report contains the details of these programs and both theoretical and observed times for each program. The times were measured by using the OUT 3 Director facility and in one instance an oscilloscope was used to obtain confirmation of these times.

The report concludes with some possible reasons for the discrepancy between theoretical and observed times

1. INTRODUCTION.

These programmes were originally written for a Tender and it is thought that they may be of interest to other prospective customers.

The time taken by each programme is found by the OUT 3 Director facility and is printed in binary on paper tape.

2. PROGRAM 86(a) TIMING OF SIMPLE ARITHMETIC OPERATIONS (FIXED POINT).

86(a) The average time for completing the operations:

$$A = B + C$$

$$D = E + F + G$$

$$H = J \times K$$

where B,C,E,F,G,J,K are single length numbers and arithmetic operations are fixed point.

$$Yb; Yc; +; = Ya;$$

$$Ye; Yf; +; Yg; +; = Yd;$$

$$Yj; Yk; \times; = Yh;$$

Theoretical time 101 /usecs

Actual time 64.98 /usecs for 60 sequences

108.3 /usecs for 1 sequence

The operations are repeated 60 times. This allows the first instruction of each sequence to begin in each alternate syllable of a word and so the final average time for one sequence is not affected by the position of the first instruction of the sequence.

Also the repetition minimises the effect of the extra instruction (REV) needed to time the operations.

3. PROGRAM 86(b) TIMING OF SIMPLE ARITHMETIC OPERATIONS (FLOATING POINT).

86(b) As for 86(a) with floating point arithmetic operations.

Theoretical time 101 /usecs

Actual time 6570 /usecs for 60 sequences

109.5 /usecs for 1 sequence

4. PROGRAM 86(c) TIMING OF SIMPLE ARITHMETIC OPERATIONS IN REPEATED LOOP.

86(c) Repeated calculations of 86(b) 10,000 times by means of a loop of instructions.

$$\text{SET } +10000; = C1; \text{IMOTOQ1};$$

$$1; YbM1Q; Yc; + F; = Ya;$$

$$Ye; Yf; + F; Yg; + F; = Yd;$$

$$Yj; Yk; \times F; = Yh; J1C1NZ;$$

Theoretical time 1.17 secs

Actual time 1.25 secs

Oscilloscope time (inner loop only) 123 /usecs.

Time using fixed point operations 1.24 secs.

5. PROGRAM 86(c) USE OF SHORT LOOP FACILITY.

.86(c) Short Loop.

As for 86(c) but the operations are performed by three separate loops using the short loop jump facility.

```
*1; Yb; YcM1Q; + F; = Ya; J1C1NZS;
*2; MOM2; MOM3Q; + F; MOM4; + F; = MOM5; J2C3NZS;
*3; Yj; YkM6Q; x F; = Yh; J3C6NZS;
```

```
Theoretical time .85 secs
Actual time .92 secs
Oscilloscope time Loop 1 27 /usecs
                  Loop 2 36.4 /usecs
                  Loop 3 27 /usecs
```

6. PROGRAM 86(d) SIMPLE ARITHMETIC OPERATIONS USING VARIABLES STORED IN SUCCESSIVE LOCATIONS.

```
86(d) For i = 1(1) 100
calculate Ai = Bi + Ci
          Di = Ei + Fi + Gi
          Hi = Ai x Di
```

with storage in serial addresses of

```
B1, B2, B3 ----- B100,
C1, C2, C3 ----- C100,
E1, F1, G1, E2, F2, G2 ----- G100,
A1, D1, A2, D2 ----- D100,
H1, H2, H3 ----- H100,
```

using floating point arithmetic

```
SETAYb; =RM1; (Q1 = 0/1/address of B1);
SET+100; DUP; =RM2; (Q2 = 0/1/100); DUP; SHA+1;
Q1TOQ3; =+M3; (Q3 = 0/1/address of E1); DUP; DUP; SHA+1;
Q3TOQ4;
=+M4; (Q4 = 0/1/address of A1); DUP; SHA+1; Q4TOQ5; =+M5;
=C5; (Q5 = 100/1/address of H1);
*1; MOM3Q; (E); MOM3Q; (F); +F; (E+F); MOM3Q; (G); +F; (E+F+G=D);
MOM1; (B); M2M1Q; (C); +F; (B+C=A); DUPD; (COPY A AND D);
=MOM4Q; =MOM4Q; (STORE A AND D);
x F; =MOM5Q; (H=AxD); J1C5NZ;
```

```
Theoretical time 8.5 msec
Actual time 10.34 msec
```

7. PROGRAM 86(e) EVALUATION OF 15TH DEGREE POLYNOMIAL USING SINGLE LENGTH FIXED POINT ARITHMETIC.

86(e) Evaluation of a 15th degree polynomial using single length fixed point arithmetic and assuming the coefficients are stored in serial locations of core store and x is stored to p integer places in the nesting store.

VO = Q16/-4/15;

VO; = Q1;

SETAYO; =Q2; =Q3; (x); ZERO; (Set Accumulator to zero); J3;

*1; Q3; xD; SHAD+p; ROUND; (mult by x);

3; M2M1Q; +; J1C1NZS; (add in a_n);

Theoretical time 425 /usecs

Actual time 514.5 /usecs

8. PROGRAM 86(f) EVALUATION OF 30TH DEGREE POLYNOMIAL USING COMPLEX DOUBLE LENGTH FLOATING POINT ARITHMETIC.

86(f) Evaluation of 30th degree polynomial using complex double length floating point arithmetic and coefficients stored in serial locations of core store.

VO = AY128; (address of x);

V1 = Q31/-4/AY124; (address of real part of nth coefficient);

V2 = Q0/-4/AY126; (address of imaginary part of nth coefficient);

V3 = AWO;

VO; DUP; =RM3; (Q3=0/1/address of real part of x);

SET+2; DUP; CAB; +; =RM4; (Q4=0/1/address of imaginary part of x);

V1; =Q5; (Q5=n+1/-4/address of real part of nth coefficient);

V2; =Q6; (Q6=0/-4/address of imaginary part of nth coefficient);

V3; DUP; =RM7; (Q7=0/1/address of real part of temporary store);

+; =RM8; (Q8=0/1/address of imaginary part of temporary store);

ZERO; DUP; DUPD; (set accumulator to zero);

J1;

2; Q3TOQ1; Q7TOQ2; JSP1;

Q4TOQ1; Q8TOQ2; JSP1; -DF;

* Q3TOQ1; JSP1; Q4TOQ1; Q7TOQ2; JSP1;

1; MOM6N; MOM6Q; +DF; =MOM8; =MOM8N; (add in the nth coefficient);

MOM5N; MOM5Q; +DF; =MOM7; =MOM7N; J2C5NZ;

P1; MOM1; MOM2; DUPD; xDF; REVD; MOM1N; DUP; CAB; xDF;

REVD; REV; MOM2N; DUP; CAB; xDF; REVD; xDF; +DF;

DUMMY; +DF; +DF; EXIT1; (mult by x);

Theoretical time 21 msecs.

Actual time 26.24 msecs.

9. REASONS FOR DIFFERENCE BETWEEN THEORETICAL AND OBSERVED TIMES.

The differences between the theoretical time and the actual time can be attributed to four main factors.

(1) Standardisation Time.

After each floating point operation the number has to be standardised. As the time taken to standardise a number varies with the number only a minimum theoretical time can be estimated.

In practice the time taken can be larger than the time allowed for.

(2) Additional Instructions.

Extra instructions are needed to time the operations i.e. REV occurs at the beginning of each sequence to store the time in N2.

(3) In theory each sequence of instructions began in the first syllable of a word. In practice this was not always the case and so an extra instruction fetch was needed.

(4) Shift Instructions.

The time taken for a shift instruction depends on the amount of shift required.

In theory this was denoted by 'p' places and a minimum time was estimated.

In 86(e) the shift instruction was SHAD+23. The minimum time for an instruction of the form SHAD is 3 μ secs and the time for SHAD+23 is 5 μ secs.

Each programme was also timed using zero data and in general took longer as the time taken to standardise floating point operations on zero numbers is slightly greater than the normal standardisation time.

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