Multiple Precision Programs for Stretch

The objective of the design of the registers and operations was directed towards a [illegible] [illegible] set for single-precision floating point operations, but additional operational specifications and instructions were inserted to facilitate the programming of multiple precision operations.

The following three programs illustrate the ease with which double precision operations are effected by Stretch. They are nominal accuracy programs, i.e. there is no rounding and low-order bit effects are ignored.

Add: (DE) + (JK)

1. Load A[illegible] (K)
2. nAdd A[illegible] (E)
3. nAdd AE (J)
4. nAdd AE (D)

Multiply: $(DE) \cdot (JK)$

1. Load A (K)
2. MPY and Set T_1 (D)
3. Store A (T_2)
4. Load A (E)
5. MPY and Set T_3 (J)
6. Add AC and Store T_2 (T_2)
7. Load A (T_1)
8. MPY (T_3)
9. Add AB (T_2)

Divide: $(DE) \div (JK)$

1. Load A (D)
2. Load B (E)
3. DIV and Set T_1 (J)
4. Store A (T_2)
5. Store B (T_3)
6. -MPY (K)
7. Add AC T_3
8. DIV T_1
9. Add A T_2

The following program illustrates the case of programming a triple precision addition in floating point with automatic sign control. Note that the only tests necessary are those to find the relative difference between exponents. The problem introduced in most multiple precision programs of interaction (e.g. borrow or carry) between data words which cannot all fit in the accumulator at once is handled by the operation 'Borrow' which subtracts one from the magnitude of the Mantissa and stores the result in the specified register, then replaces A mantissa 47 's and subtracts 47 from the exponent.

Addition: (DEF) + (JKL)

Only two of the four possible paths are shown. The other two paths are the same if the factors (DEF) and (JKL) are interchanged. Further programming effort can considerably reduce the number of steps necessary in these critical paths, but would be extra loss detail to this example.

(DEF) + (JKL)

1. Load A and set T_1 (D)
2. Compare exponents (J)

D ≥ J

3. Store S (T_2)
4. Load A and set T_3 (E)
5. Compare exponents (T_2)

J > E

6. Load A (T_1)
7. n Add A and Store T_1 (T_2)
8. Load A (B)
9. n Add A (T_3)
10. n Add AC (K)
11. Store my B (E)
12. n Add A and Store T_1 (T_1)
13. Store my B (T_2)
14. Load A (F)
15. n Add A (L)
16. n Add AB (T_3)
17. Store my C (T_5)
18. n Add A (T_2)
19. Store my B (T_4)
20. n Add A and Store T_1 (T_1)
21. Load A (B)
22. n Add A (T_4)
23. n Add AB (T_5)

J > D and K ≥ 0. Coupler not shown.

E ≥ J

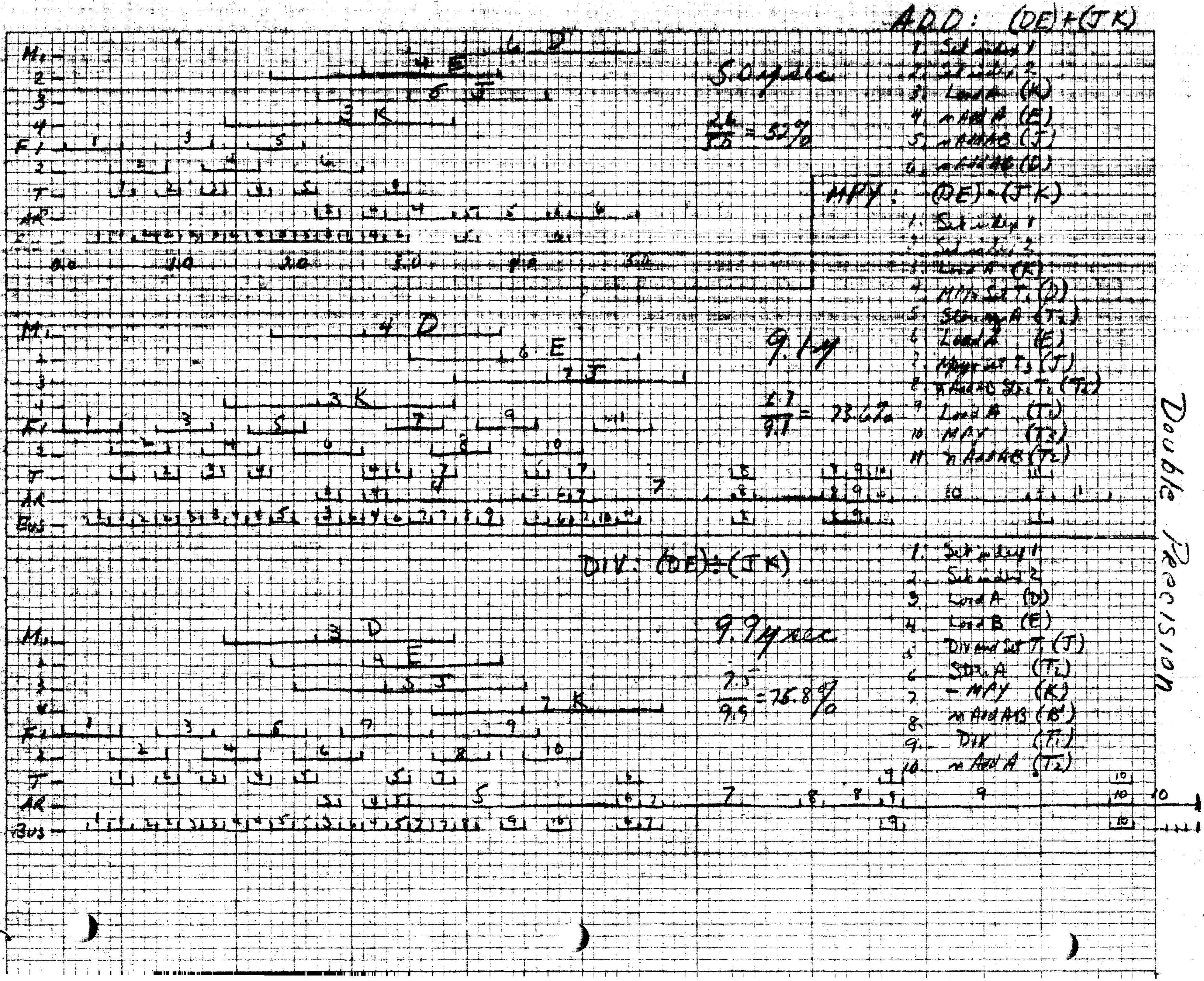
6. Load A (T_1)
7. Comm (T_1)
8. Comm and Store T_3 (T_4)
9. Load A (K)
10. Load B (L)
11. n Add AE (F)
12. n Add AC (T_3)
13. n Add AB (T_2)
14. Store my B (T_5)
15. n Add A (T_3)
16. n Add AC (T_4)
17. Transfer (14.)

Multiplication $(DEF) \cdot (JKL)$

Of the nine possible products only six are considered. These are

$$\begin{array}{rl} & D \cdot J \\ + & D \cdot K \\ + & E \cdot J \\ + & D \cdot L \\ + & E \cdot K \\ + & F \cdot J \end{array}$$

1. Load A, set T_1 (D)
2. nMPY A, set T_2 (K)
3. Store A (T_5)
4. Store B. (T_6)
5. Load A, set T_4 (J)
6. nMPY A, set T_3 (E)
7. Store A (T_7)
8. Store B (T_8)
9. Load A (T_1)
10. nMPY A (T_4)
11. $\overline{n}$ Add AB (T_5)
12. $\overline{n}$ Add AC, Store T_5 (T_7)
13. Store B (T_8)
14. $\overline{n}$ Sub S from AB (S)
15. Load A (B)
16. $\overline{n}$ Add A (T_6)
17. $\overline{n}$ Add AB, Store T_6 (T_8)
18. Store B (T_8)
19. Load A (T_2)
20. nMPY A, Store T_2 (T_3)
21. Store B (T_5)
22. Load A (T_4)
23. nMPY A (F)
24. $\overline{n}$ Add AC (T_3)
25. $\overline{n}$ Add AB, Store T_2 (T_2)
26. Store B (T_3)
27. Load A (T_1)
28. nMPY A (L)
29. $\overline{n}$ Add AC (T_2)
30. $\overline{n}$ Add AC (T_3)
31. $\overline{n}$ Add AB (T_6)
32. $\overline{n}$ Add AB (T_7)
33. Store B (T_8)
34. $\overline{n}$ Add A (T_7)
35. $\overline{n}$ Add AC (T_5)


ADD: (DE)+(JK)
5.0 μsec
2.6/5.0 = 52%
1. Set index 1
2. Set index 2
3. Load A (K)
4. n Add A (E)
5. n Add AB (J)
6. n Add AB (D)
MPY: (DE)×(JK)
1. Set index 1
2. Set index 2
3. Load A (K)
4. MPY Set T1 (D)
5. Store A (T2)
6. Load A (E)
7. Mpy set T3 (J)
8. n Add AB Store T2 (T2)
9. Load B (T1)
10. MPY (T3)
11. n Add AB (T2)
9.1 μ
6.7/9.1 = 73.6%
DIV: (DE)÷(JK)
1. Set index 1
2. Set index 2
3. Load A (D)
4. Load B (E)
5. DIV and Set T1 (J)
6. Store A (T2)
7. MPY (K)
8. n Add AB (B)
9. DIV (T1)
10. n Add A (T2)
9.9 μsec
7.5/9.9 = 75.8%
Double Precision
M1
2
3
4
F1
2
T
AR
Bus
0.0
1.0
2.0
3.0
4.0
5.0