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THE ENGLISH ELECTRIC CO., LTD.

NELSON RESEARCH LABORATORIES
STAFFORD
MATHEMATICAL PHYSICS LABORATORY
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DEUCE Subroutines Nos. 2, 3, 4 and 5.

Report by
A. Gilmour

SUMMARY

The attached document contains working details of four DEUCE subroutines for signed multiplication. The four subroutines are for signed multiplication without shift or round off, with shift but without round off, with round off but without shift and with both shift and round off respectively. They are first order.

The subroutines were originally prepared at N.P.L., have been tested and corrected on the N.P.L. DEUCE at Blackheath, and have been copied into all instruction delay lines and tested in the upper and lower halves of each.

ENCLOSURES

Sheet 1 - DEUCE Subroutines Nos. 2, 3, 4 and 5.
Figure Sheets S6/10002, S6/10007 and S6/10008.

A. Gilmour.

LW MATHEMATICAL PHYSICS LABORATORY.

AGH.

Description Fast signed multiplication without shift or round off (M1), with round off but without shift (M2), with shift but without round off (M3) and with shift and round off (M4). Available in both upper and lower halves of delay lines. First order.

Data a, b the single length numbers to be multiplied.
s the shift $0 \leqslant s \leqslant 16$.

Result $c = 2^s ab$ (double length (M1, M3) or single length rounded off (M2, M4))

Instructions for use

Stores used	13	14	16	21
Contents at entry	Link	a	b	-
Contents at exit	-	a	b	•

(If single length $c = 2^{s-32}ab$ to the nearest integer is in the odd m.c.)

Occupies	m.c's 0-10 or 18-28 (M1) m.c's 0-11 or 18-29 (M2) m.c's 0-12 or 18-30 (M3 and M4)
Entry	m.c. 0 or 18
Time	For subroutine in upper half of a delay line 3 m.s. (M1 and M2); 4 m.s. (M3 and M4). For subroutine in lower half of a delay line $2\frac{1}{2}$ m.s. (M1 and M2); $3\frac{1}{2}$ m.s. (M3 and M4).
Parameters	Wait number (30 - 2s) in m.c. 12 or m.c. 28 (M3 and M4) for $1 \leqslant s \leqslant 15$. Wait number 30 in m.c. 12 or m.c. 28 (M3 and M4) for s = 16.
Waste instruction	1 0 - 0 0 17 in m.c. 11 for M3 upper. 1 0 - 0 0 1 in m.c. 27 for M3 lower.

M. 1.

2_0 2_{18} $30 - 21_2$	Clear 21_2
2_2 2_{20} $14 - 21_3$	Put multiplier in 21_3
2_5 2_{23} $0 - 24$	Stim. mult.
2_8 2_{26} $13 - 1_{30}$	Plant link

2_1 2_{19} $14 - 27$

\+ −

$_3$ 2_{21} $30 - 13$ 2_4 2_{22} $16 - 13$

2_{10} 2_{28} $16 - 27$ Sign correction

\+ −

$_6$ 2_{24} $30 - 29$ 2_7 2_{25} $14 - 25$

2_9 2_{27} $13 - 23_3$

1_{30}

M. 2.

2_0 2_{18} $30 - 21_2$	Clear 21_2
2_2 2_{20} $14 - 21_3$	Put multiplier in 21_3
2_5 2_{23} $0 - 24$	Stim. mult.
2_8 2_{26} $13 - 1_{30}$	Plant link

2_1 2_{19} $14 - 27$

\+ −

$_3$ 2_{21} $30 - 13$ 2_4 2_{22} $16 - 13$

2_6 2_{24} $16 - 27$ Sign correction

\+ −

$_{10}$ 2_{28} $30 - 29$ 2_{11} 2_{29} $14 - 25$

2_7 2_{25} $13 - 23_3$

2_9 2_{27} $29 - 23_2$ Round off

1_{30}

M. 3.

2_0 2_{18} 30 - 21_2 — Clear 21_2

2_2 2_{20} 14 - 21_3 — Put multiplier in 21_3

2_5 2_{23} 0 - 24 — Stim. mult.

2_8 2_{26} 13 - 1_{30} — Plant link

2_1 2_{19} 14 - 27

+ / −

2_3 2_{21} 30 - 13 2_4 2_{22} 16 - 13

2_6 2_{24} 16 - 27 — Sign correction

+ / −

2_9 2_{29} 30 - 29 2_{10} 2_{30} 14 - 25

2_7 2_{25} 13 - 23_3

2_{12} 2_{28} 21 - 22 (2p m.c) — Shift

2_{11} 2_{27} 0 - 0 — Waste

1_{30}

M. 4.

2_0 2_{18} 30 - 21_2 — Clear 21_2

2_2 2_{20} 14 - 21_3 — Put multiplier in 21_3

2_5 2_{23} 0 - 24 — Stim. mult.

2_8 2_{26} 13 - 1_{30} — Plant link

2_1 2_{19} 14 - 27

+ / −

2_3 2_{21} 30 - 13 2_4 2_{22} 16 - 13

2_6 2_{24} 16 - 27 — Sign correction

+ / −

2_9 2_{29} 30 - 29 2_{10} 2_{30} 14 - 25

2_7 2_{25} 13 - 23_3

2_{12} 2_{28} 21 - 22 (2p m.c) — Shift

2_{11} 2_{27} 29 - 23_2 — Round off

1_{30}

Flow diagrams for multiplication subroutines M1 - M4.

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Sheet No. S6/10007

Deuce Programme

Coding for Signed Multiplication

Subroutines M1 - M3

M1

D. L. Track

Card Nos.

mc	NIS	S	D	C	W	T
0	2	30	21		0	0
1	2	14	27		0	0
2	2	14	21		1	1
3	2	30	13		0	5
4	2	16	13		0	4
5	2	0	24		0	
6	2	30	29		0	1
7	2	14	25		0	0
8	2	13	1		20	23
9	1	13	23		0	19
10	2	16	27		0	26
11						
12						
13						
14						
15						
16						
17						
18	2	30	21		0	0
19	2	14	27		0	0
20	2	14	21		1	1
21	2	30	13		0	5
22	2	16	13		0	4
23	2	0	24		0	1
24	2	30	29		0	1
25	2	14	25		0	0
26	2	13	1		2	23
27	1	13	23		0	1
28	2	16	27		0	26
29						
30						
31						

M2

D. L. Track

Card Nos.

mc	NIS	S	D	C	W	T
0	2	30	21		0	0
1	2	14	27		0	0
2	2	14	21		1	1
3	2	30	13		0	1
4	2	16	13		0	0
5	2	0	24		0	1
6	2	16	27		0	2
7	2	13	23		0	0
8	2	13			20	23
9	1	29	23			19
10	2	30	29		0	27
11	2	14	25		0	26
12						
13						
14						
15						
16						
17						
18	2	30	21		0	0
19	2	14	27		0	0
20	2	14	21		1	1
21	2	30	13		0	1
22	2	16	13		0	0
23	2	0	24		0	1
24	2	16	27		0	2
25	2	13	23		0	0
26	2	13	1		2	23
27	1	29	23		1	1
28	2	30	29		0	27
29	2	14	25		0	26
30						
31						

M3

D. L. Track

Card Nos.

mc	NIS	S	D	C	W	T	
							Y
							X
							0
							1
0	2	30	21		0	0	2
1	2	14	27		0	0	3
2	2	14	21		1	1	4
3	2	30	13		0	1	5
4	2	16	13		0	0	6
5	2	0	24		0	1	7
6	2	16	27		0	1	8
7	2	13	23		2	3	9
8	2	13	1		20	23	Y
9	2	30	29		0	28	X
10	2	14	25		0	27	0
11	1	0	0		0	17	1
12	2	21	22	ℓ	$(30-2_p)$	29	2
13							3
14							4
15							5
16							6
17							7
18	2	30	21		0	0	8
19	2	14	27		0	0	9
20	2	14	21		1	1	Y
21	2	30	13		0	1	X
22	2	16	13		0	0	0
23	2	0	24		0	1	1
24	2	16	27		0	3	2
25	2	13	23		0	1	3
26	2	13	1		2	23	4
27	1	0	0		0	1	5
28	2	21	22	ℓ	$(30-2_p)$	29	6
29	2	30	29		0	26	7
30	2	14	25		0	25	8
31							9

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Sheet No. S6/10008

Deuce Programme

Coding for Signed Multiplication

Subroutine M4

M4

D. L. Track

Card Nos.

D. L. Track

Card Nos.

D. L. Track

Card Nos.

mc	NIS	S	D	C	W	T	
							Y
							X
							0
							1
0	2	30	21		0	0	2
1	2	14	27		0	0	3
2	2	14	21		1	1	4
3	2	30	13		0	1	5
4	2	16	13		0	0	6
5	2	0	24		0	1	7
6	2	16	27		0	1	8
7	2	13	23		2	3	9
8	2	13	1		20	23	Y
9	2	30	29		0	28	X
10	2	14	25		0	27	0
11	1	29	23		1	17	1
12	2	21	22	ℓ	$(30-2p)$	29	2
13							3
14							4
15							5
16							6
17							7
18	2	30	21		0	0	8
19	2	14	27		0	0	9
20	2	14	21		1	1	Y
21	2	30	13		0	1	X
22	2	16	13		0	0	0
23	2	0	24		0	1	1
24	2	16	27		0	3	2
25	2	13	23		0	1	3
26	2	13	1		2	23	4
27	1	29	23		1	1	5
28	2	21	22	ℓ	$(30-2p)$	29	6
29	2	30	29		0	26	7
30	2	14	25		0	25	8
31							9