

Computer Math

Topics to be covered

- Multiplication
- Division

Multiplication

- Figures 3.5, 3.6, and 3.7 in your text
- On final, you are responsible for figure 3.7

Multiplication

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Multiplication

$$\begin{array}{r} 9 \\ \times 24 \\ \hline 36 \\ 180 \\ \hline 216 \end{array}$$

$$\begin{array}{r} 7 \\ \times 5 \\ \hline 35 \end{array}$$

$$\begin{array}{r} 0000\ 0111 \\ \underline{0000\ 0101} \\ 0000\ 0111 \\ \underline{0000\ 0000} \\ 0000\ 0111 \\ \underline{0001\ 1100} \\ 0010\ 0011 = 35 \end{array}$$

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Figure 3.5

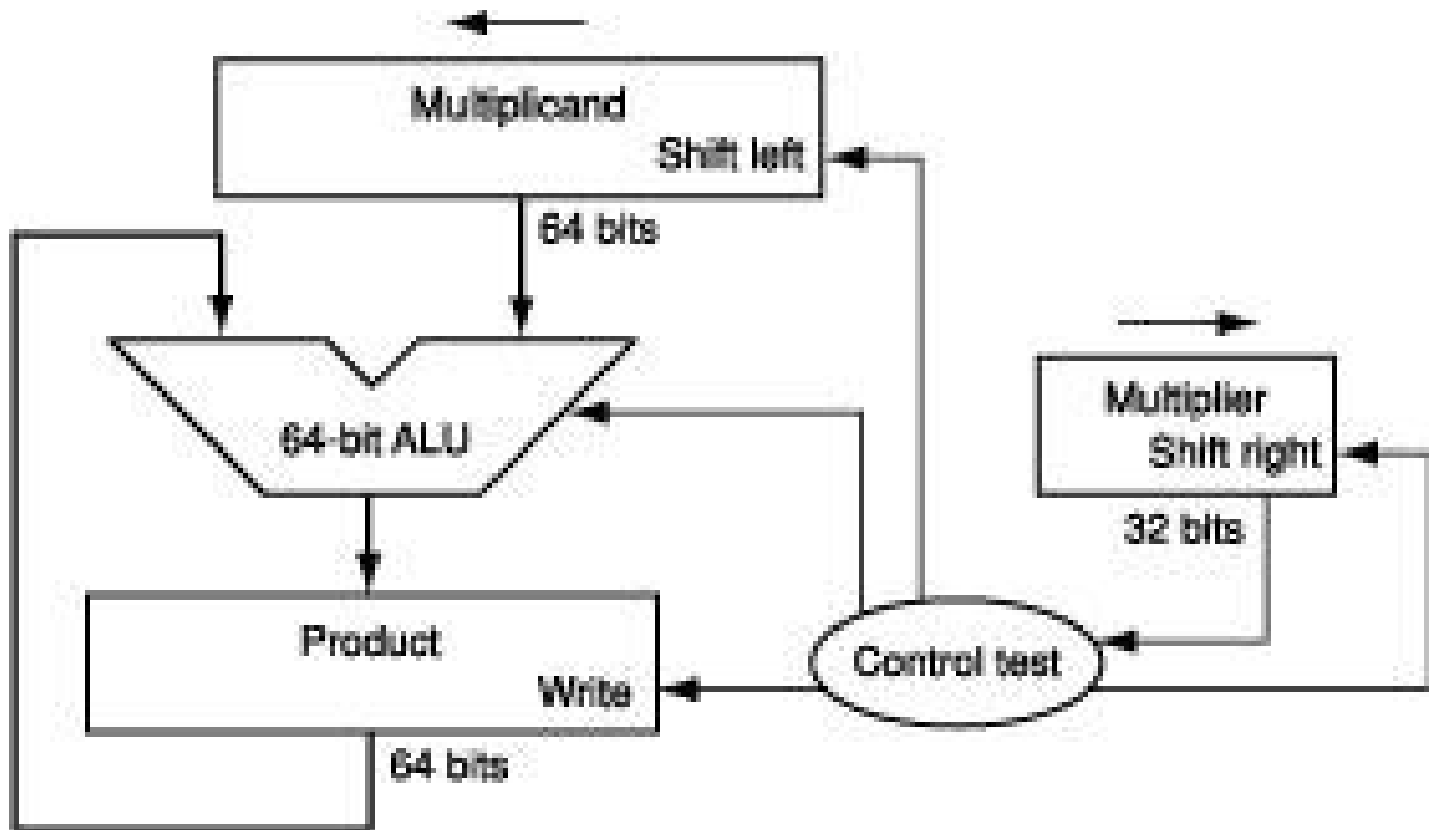
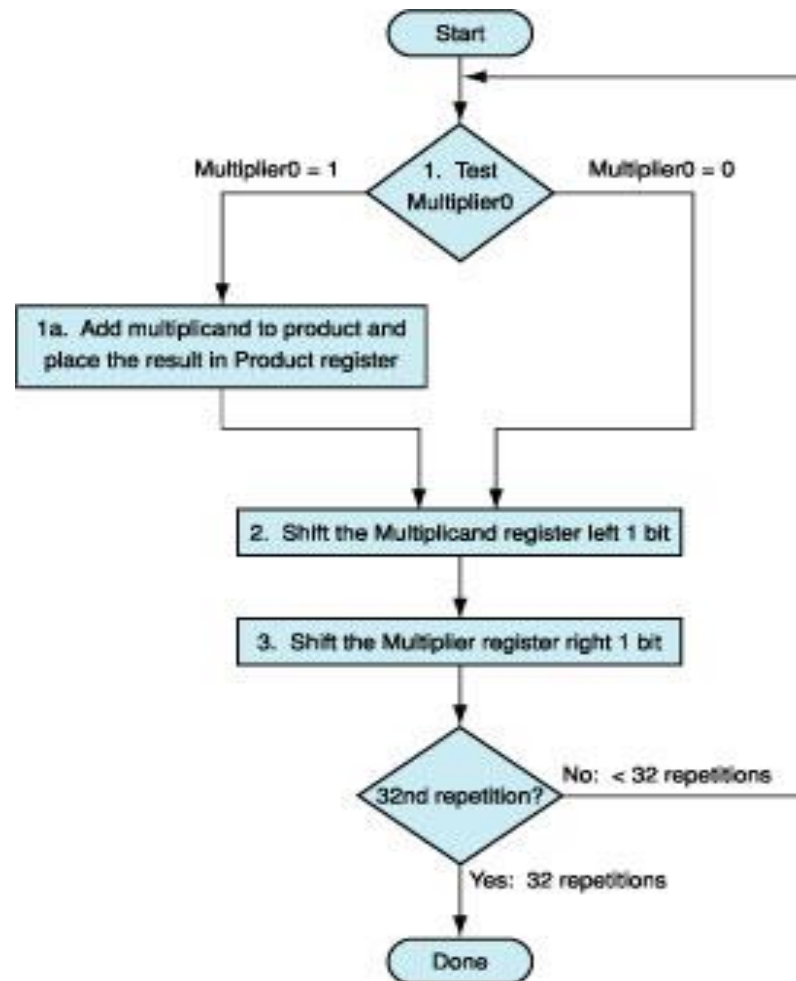


Figure 3.6



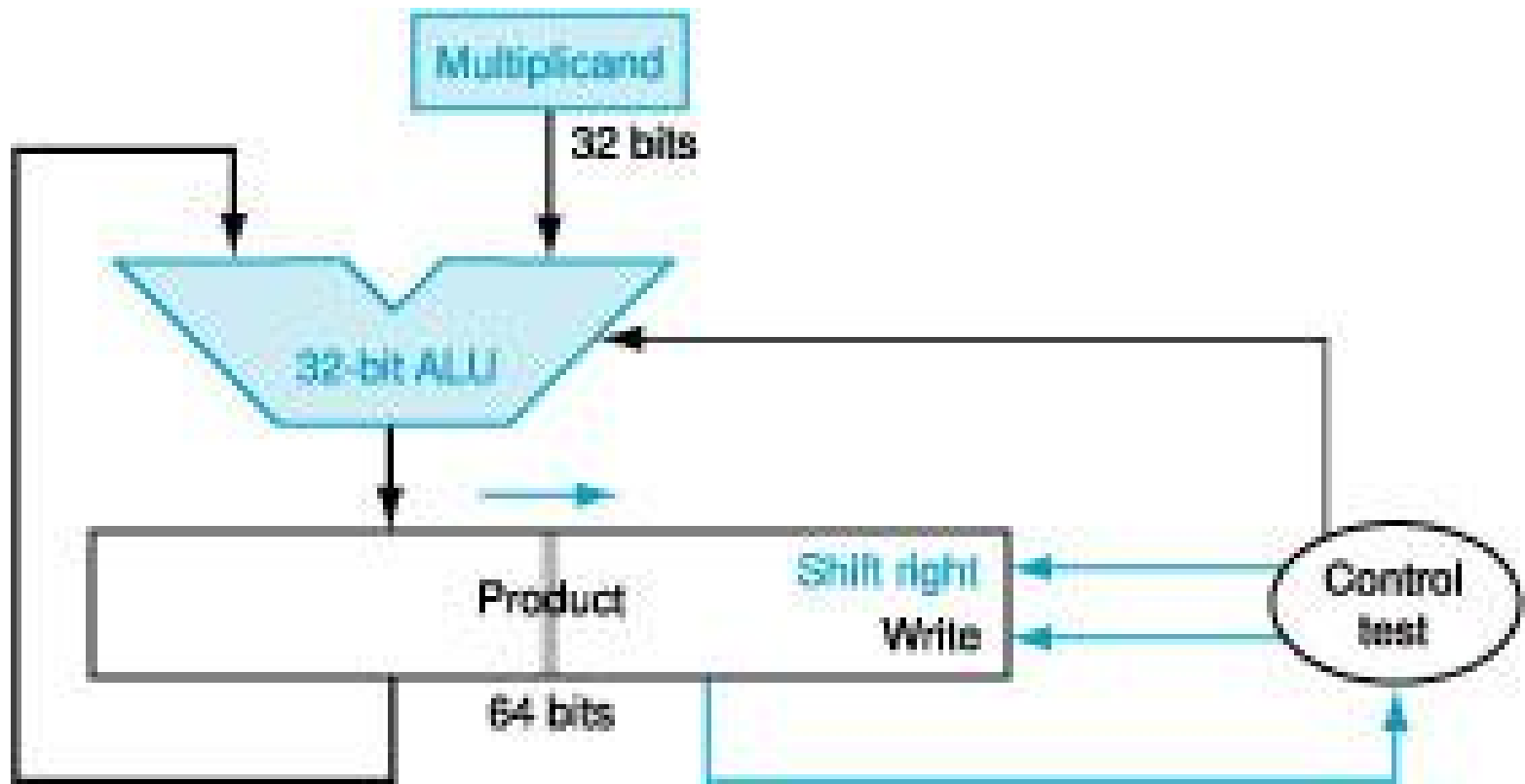
Example (9x11)

Iteration	Multiplier	Multiplicand	Product
0 (Start)	1011	0000 1001	0000 0000
(End of) 1	0101	0001 0010	0000 1001
2	0010	0010 0100	0001 1011
3	0001	0100 1000	0001 1011
4	0000	1001 0000	0110 0011

Problems with this diagram

- Need two 64 bit registers, but one is temporary.
- The Multiplicand must be moved to this temporary register
- The Multiplier is changed, so another register is needed.
- 64 bit adder is used, though only 32 bits should be needed.

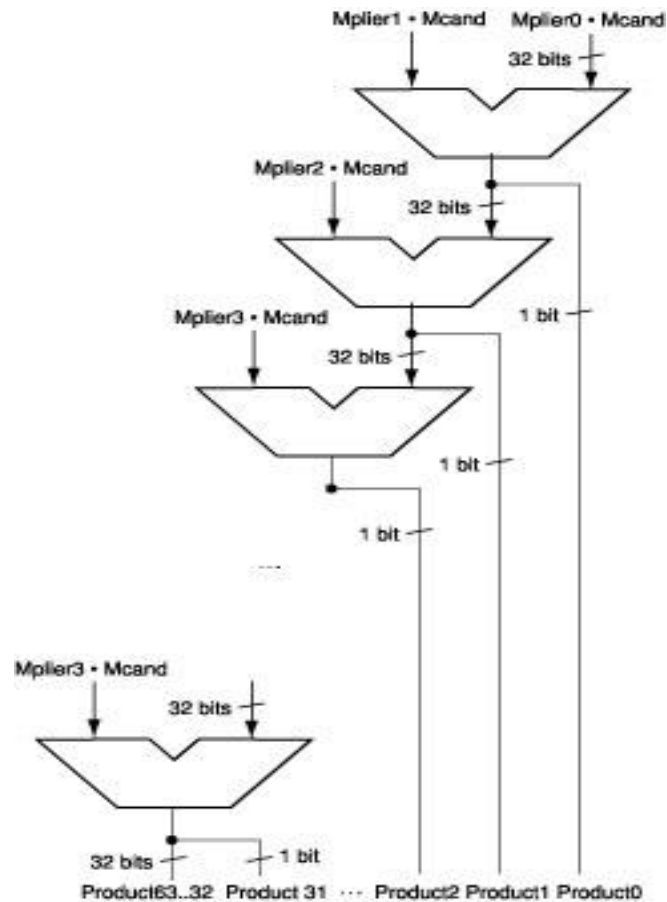
Figure 3.7



Example (9x11)

Iteration	Multiplicand	Product
0 (Start)	1001	0000 1011
1 (Note shift is after add)	1001	0100 1101
2	1001	0110 1110
3	1001	0011 0111
4	1001	0110 0011

Faster Multiplier



Division

$$\begin{array}{r} 068 \text{ r}1 \\ 2 \overline{) 137} \\ \underline{-12} \\ 17 \\ \underline{-16} \\ 1 \end{array}$$

Division

7/2

Step 1: Check to
see if 0010 > 0000
by subtraction

$$\begin{array}{r} 0010 \overline{) 0000 \ 0111} \\ \underline{+111 \ 0} \\ +111 \ 0 \end{array}$$

Negative, so did not
work

Step 2: Right shift
and check to see if
greater than by
subtraction

$$\begin{array}{r} 00 \\ 0010 \overline{) 0000 \ 0111} \\ +11 \ 10 \\ \hline +11 \ 11 \end{array}$$

Negative, so did not
work

Step 3: Right shift
and check to see if
greater than by
subtraction

$$\begin{array}{r} 001 \\ \hline 0010 \overline{) 0000 \ 0111} \\ +1 \ 110 \\ \hline 0 \ 001 \end{array}$$

Positive, so worked.
Leave value, put a 1 in
the quotient and cont.

Division

- Figures 3.10, 3.11, and 3.12 in your book
- You are responsible for figure 3.12
- Math for division
 - Example $74/8$ from text, page 183

Figure 3.10

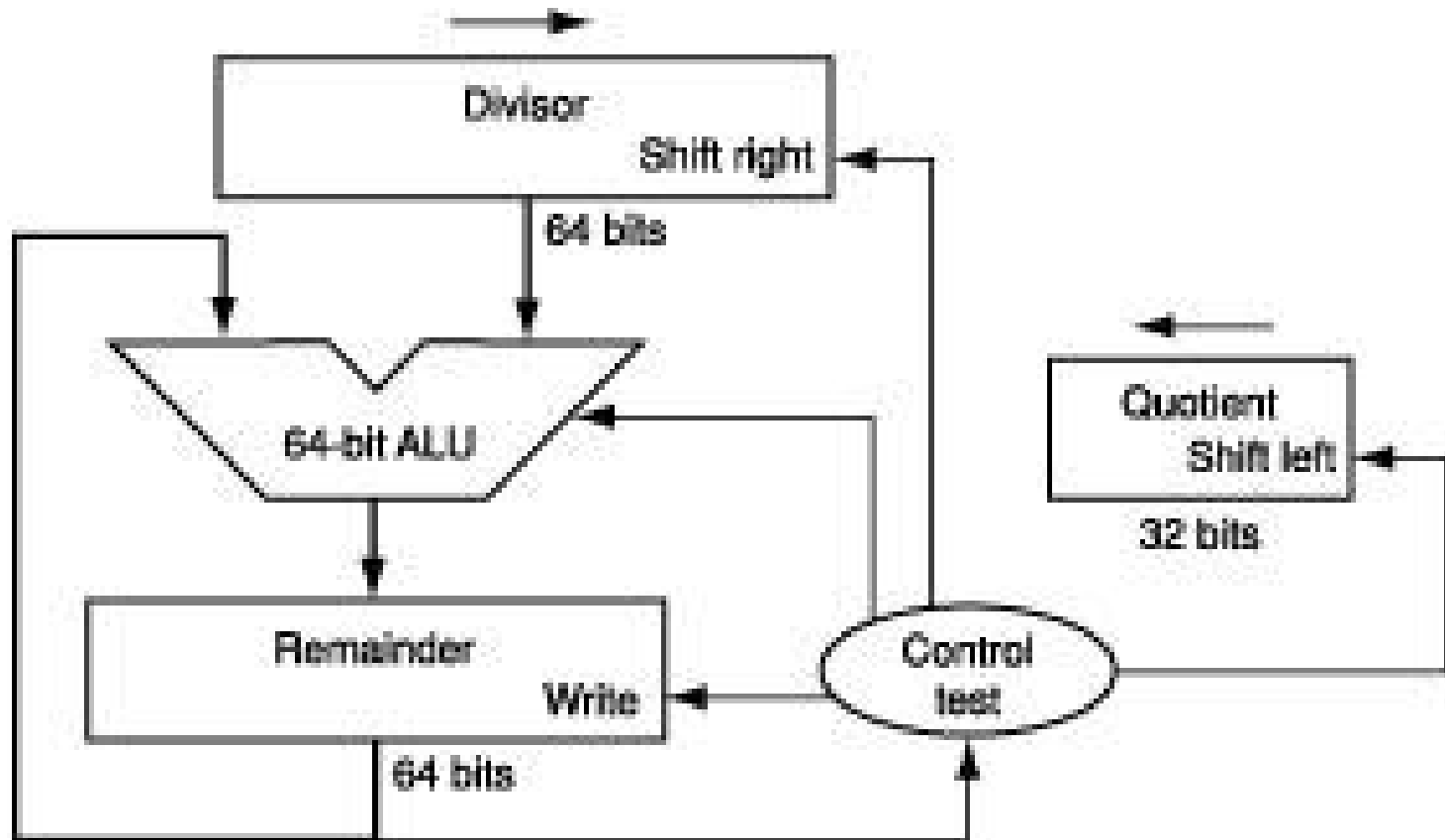
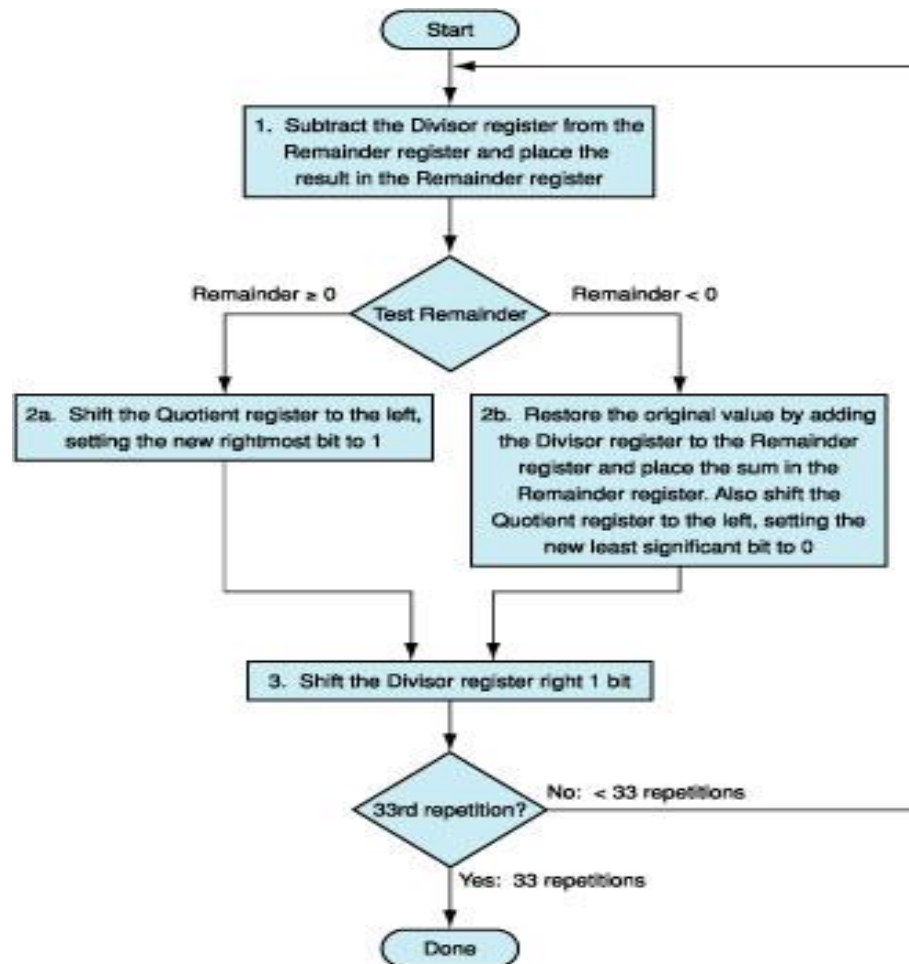


Figure 3.11

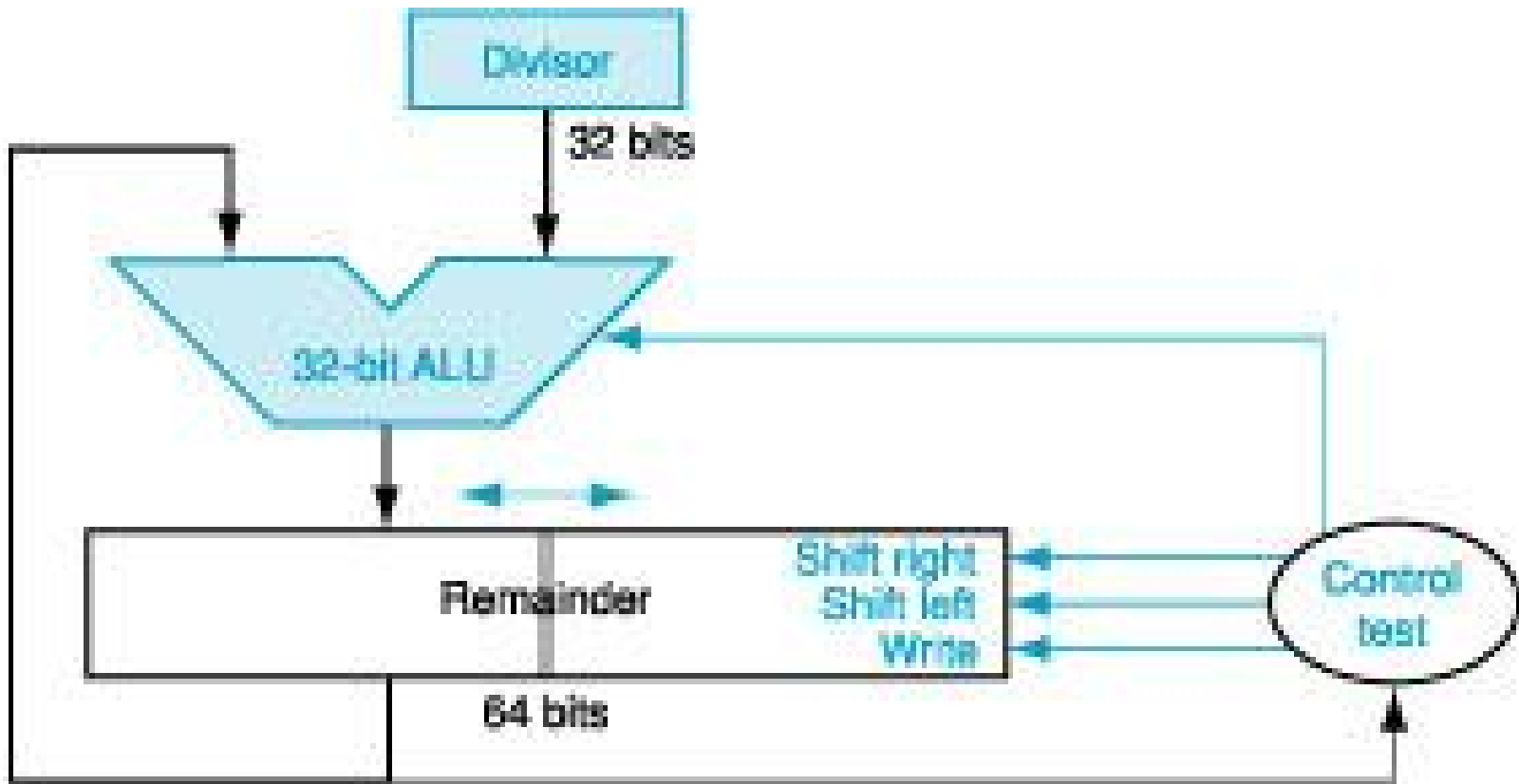


Example Division (7/2)

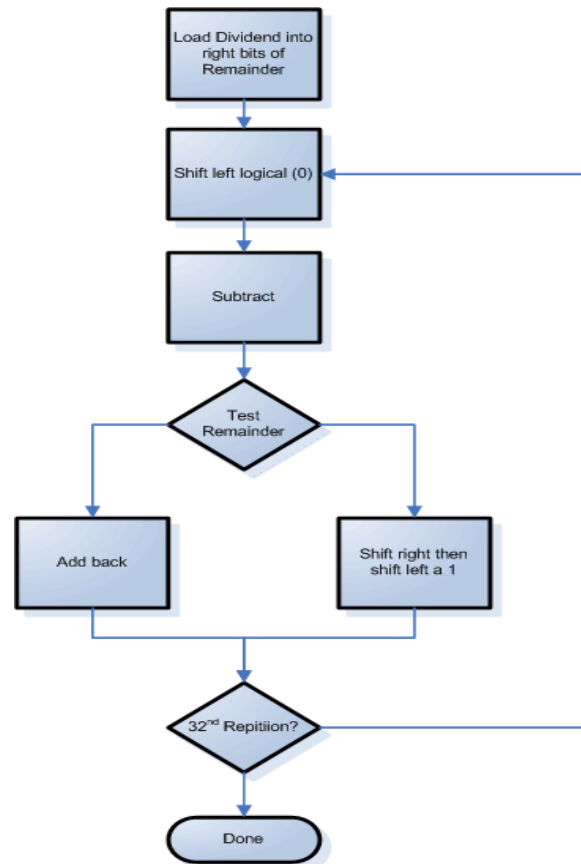
(note: obviously must only effect last
2 bits)

Iteration (end of step)	Quotient	Divisor	Remainder
0	0000	0010 0000	0000 0111
1	0000	0001 0000	0000 0111
2	0000	0000 1000	0000 0111
3	0000	0000 0100	0000 0111
4	0001	0000 0010	0000 0011
5	0011	0000 0001	0000 0001

Figure 3.13 (note: Same hardware as Figure 3.7)



Flow Chart



Example 1 (7/2)

Iteration	Divisor	Complement	Remainder
0	0010	1110	0000 0111
1a	0010	1110	0000 1110
1b	0010	1110	<u>1</u> 110 1110
1c	0010	1110	0000 111 <u>0</u> (note minus removed)
2a	0010	1110	0001 1100
2b	0010	1110	<u>1</u> 111 1100
2c	0010	1110	0001 110 <u>0</u> (note minus removed)
3a	0010	1110	0011 1000
3b	0010	1110	<u>0</u> 001 1000
3c	0010	1110	0001 100 <u>1</u> (note 2 shifts)
4a	0010	1110	0011 0010
4b	0010	1110	<u>0</u> 001 0010
4c	0010	1110	0001 001 <u>1</u> (note 2 shifts)

Example 2 (9/2)

Iteration	Divisor	Complement	Remainder
0	0010	1110	0000 1001
1a	0010	1110	0001 0010
1b	0010	1110	1111 0010
1c	0010	1110	0001 0010
2a	0010	1110	0010 0100
2b	0010	1110	0000 0100
2c	0010	1110	0000 0101
3a	0010	1110	0000 1010
3b	0010	1110	1110 1010
3c	0010	1110	0000 1010
4a	0010	1110	0001 0100
4b	0010	1110	1111 0100
4c	0010	1110	0001 0100

Floating Point Numbers

- Floating point numbers are numbers that have a single digit to the left of the decimal point.
- Normalized number has no leading 0s
- Floating point numbers have a base 2 representation

Terms

- Fraction (or mantissa in normalized floating point numbers, since as we will see only the part to the left of the decimal is kept).
- Exponent
- Overflow and underflow
- Single precision and Double precision

Constants

- MAX_VALUE
- MIN_VALUE
- NEGATIVE_INFINITY
- POSITIVE_INFINITY
- NAN

Floating Point format and Examples