Computer Arithmetic: Part 3 (Division Algorithms)

Division

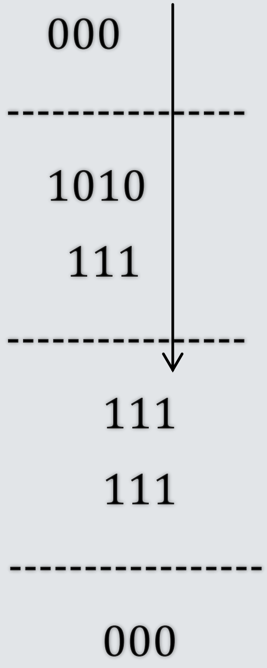
- Implemented on computer systems by repeatedly subtracting the divisor from the dividend
- Counting the number of times that the divisor can be subtracted from the dividend before the dividend becomes smaller than the divisor
- Example: Division of 21 by 7
  - Subtract repeatedly from 21, getting 14, 7, and 0 as intermediate results
  - The quotient, 3, is the number of subtractions that had to be performed before the intermediate result became less than the dividend

TERMS to know

Terms	Dividend	:	7
	Divisor	:	÷ 3
	Quotient	:	2
	Remainder	:	1

Example and Analysis

- 0111) 10101 (011

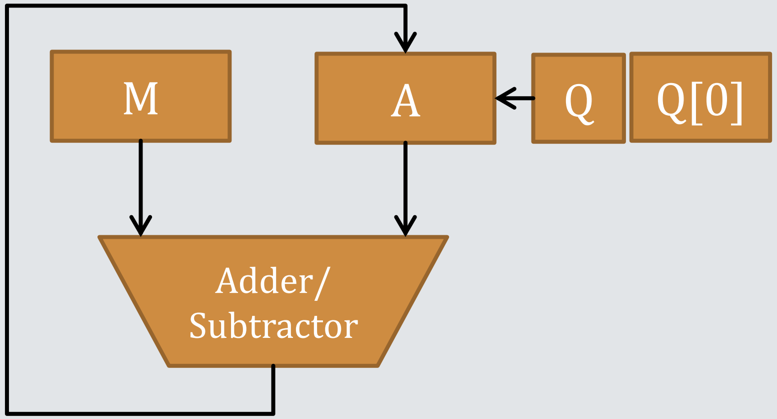


```
      000
   ---------------
      1010
       111
   ---------------
          111
          111
   ----------------
          000
```

- If we divide a large number by a small number then we have to performed many subtraction
- 2^{24} divided by 2 is 2^{23}, which implies 2^{23} subtractions!

Division using restoring algorithm

- Restoring algorithm is performed on fixed point fractional numbers
- Here we are going to performed restoring algorithm of an unsigned integer
- Initially
  - M = Divisor
  - A (Accumulator)= 0
  - Q = Dividend
- After restoring division
  - Q = Quotient
  - A = Remainder



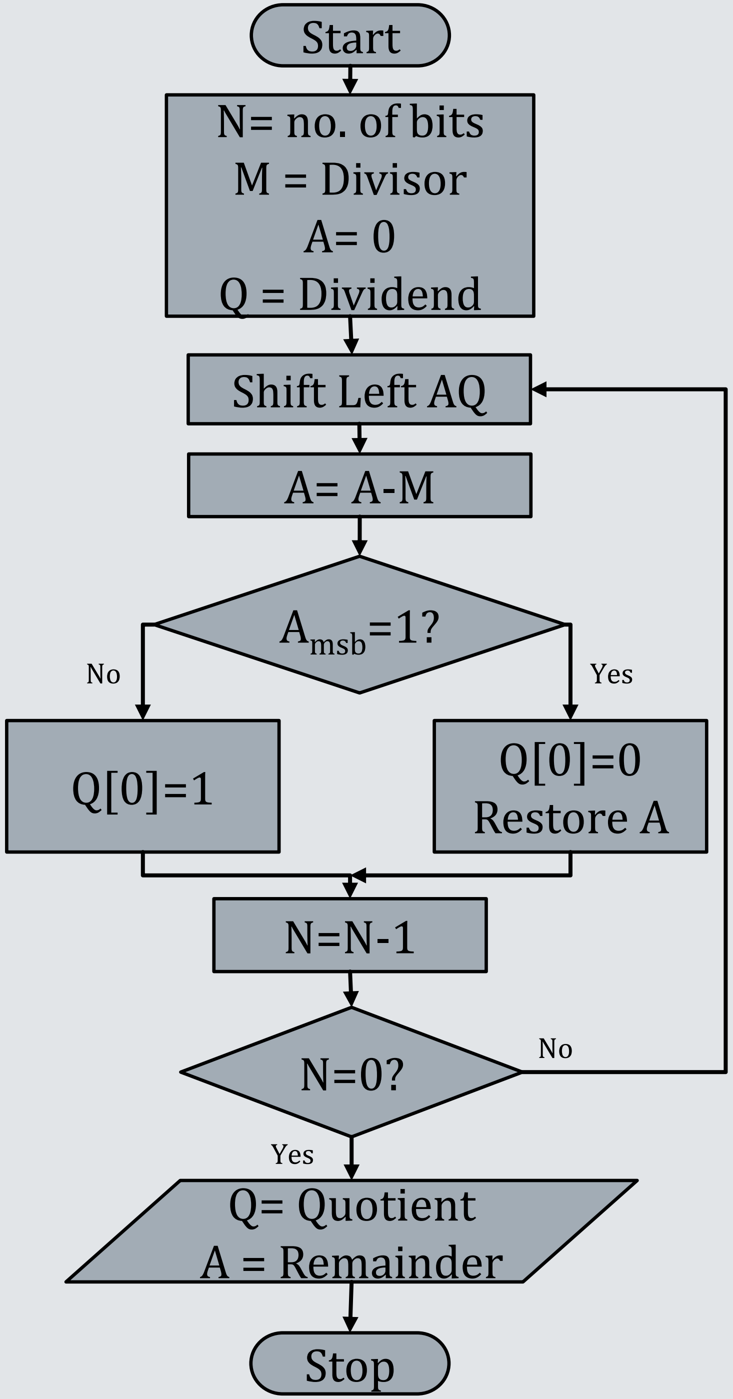
Example Restoring Algorithm

11÷3

N	A	Q	Action
4	00000	1011	Initial Configuration
	00001	011_	Shift Left AQ
	11110	011_	A= A-M
	00001	0110	Q[0]= 0; Restore A (Since A_{msb}=1)
3	00010	110_	Shift Left AQ
	11111	110_	A = A-M
	00010	1100	Q[0]= 0; Restore A (Since A_{msb}=1)
2	00101	100_	Shift Left AQ
	00010	100_	A = A-M
	00010	1001	Q[0]= 1 (Since A_{msb}=0)
1	00101	001_	Shift Left AQ
	00010	001_	A= A – M
	00010	0011	Q[0]= 1 (Since A_{msb}=0)

Remainder

Quotient



Non Restoring Algorithm

- Non-restoring division algorithm is more complex than the restoring division algorithm.
- However, it has less hardware complexity as compared to restoring algorithm.
- It has only addition/subtraction per quotient bit and no restoring is required.
- Task performed is almost half as compared to restoring division
- Faster than restoring division

Example: Non-Restoring Algorithm

11÷3

N	A	Q	Action

4	00000
	00001
	11110
	11110
		1011
		011_
		011_
		0110
			Initial configuration
			Shift Left AQ
			A = A-M
			Q[0] = 0

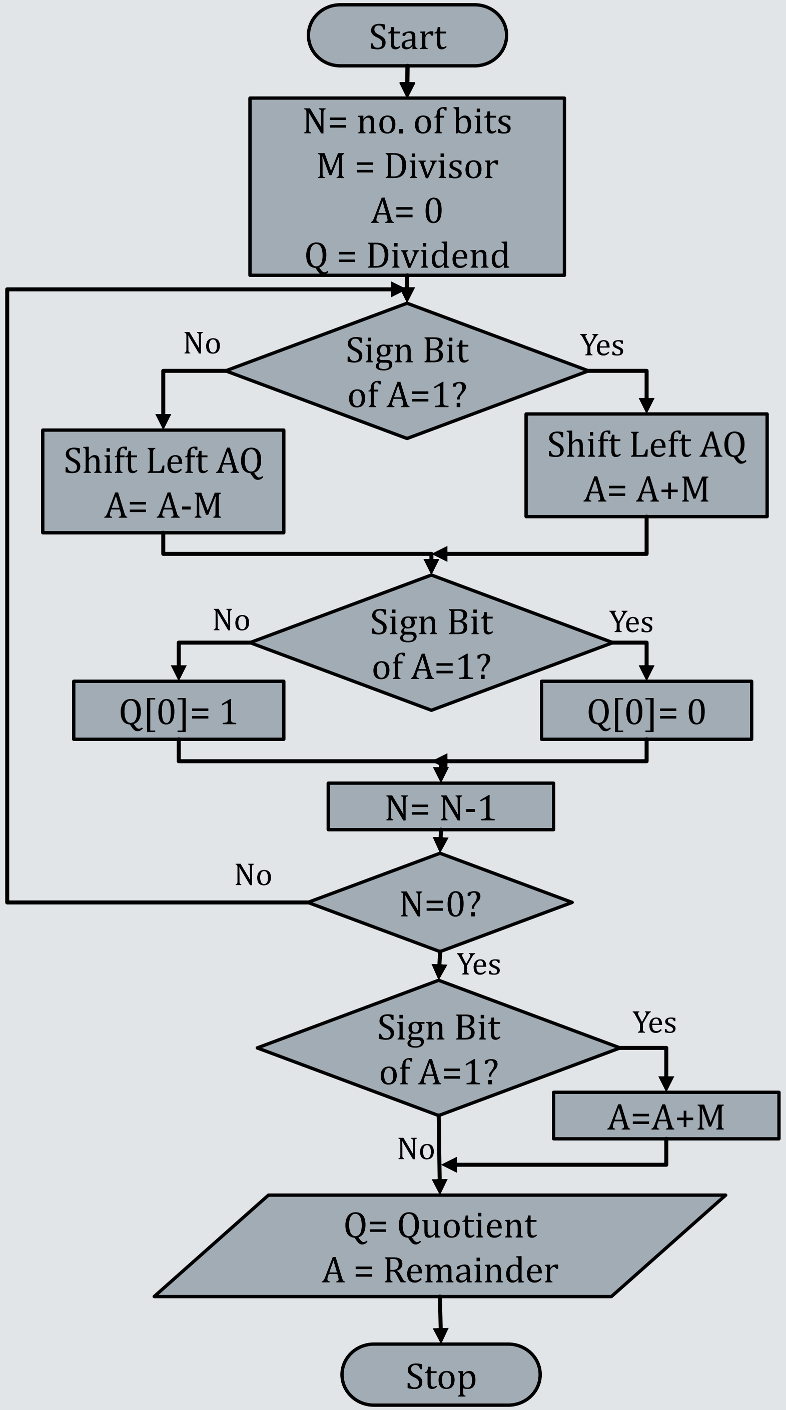
3	11100
	11111
	11111
		110_
		110_
		1100
			Shift Left AQ
			A= A+M
			Q[0] = 0

2	11111
	00010
	00010
		100_
		100_
		1001
			Shift Left AQ
			A = A+M
			Q[0] =1

1	00101
	00010
	00010
		001_
		001_
		0011
			Shift Left AQ
			A=A-M
			Q[0]=1

Remainder

Quotient



Start

N= no. of bits
M = Divisor
A= 0
Q = Dividend

Sign Bit of A=1?

No

Yes

Shift Left AQ
A= A-M

Shift Left AQ
A= A+M

Sign Bit of A=1?

No

Yes

Q[0]= 1

Q[0]= 0

N= N-1

N=0?

No

Yes

Sign Bit of A=1?

Yes

A=A+M

No

Q= Quotient
A = Remainder

Stop

Thank You