Multipliers — ALU

- Unsigned number multiplication
  - Combinational array multiplier
  - Sequential circuit binary multiplier.

- Booth method.
  - +ve and -ve multiplier
  - Spud ×

Fast Multipliers

Bit pair recoding of multiplier

→ Reduce the number of summands to n/2 for n-bit operands

→ Based on Booth recoding of multipliers
  → Groups pair Booth recoded multiplier bits

M = 5 0 0 0 1 0 1

Q = -11 1 1 0 1 0 1 P = -55

$\bar{Q}$ 0 -1 +1 -1 +1 -1

$M = 111011$

0 0 0 1 0 1

0 −1 +1 −1 +1 −1

1 1 1 1 1 1 1 1 1 0 1 1

0 0 0 0 0 0 0 0 0 1 0 1

1 1 1 1 1 1 1 0 1 1

0 0 0 0 0 0 1 0 1

0 0 1 1 1 0 1 1

0 0 0 0 0 0 0

1 1 1 1 1 1 0 0 1 0 0 1 $= -55$

1 1 1 1 1 1 1 1 1 0 1 1 → $-M$

0 0 0 0 0 0 0 0 1 0 1 0 → $2M$

0 0 0 0 0 0 0 0 0 1 0 1 $= 5$

Left shift

0 0 1 1 $= 3$

0 1 1 0 $= 6 = 2 \times 3$

1 1 0 0 $= 12 = 2 \times 6$

Shifting left ⟶ Multiplying by 2

Booth recoding bit pair: $(+1\ -1)M$

$= 2M - M = \underline{M}$

Booth recoded → (+1 −1)M

↓

Bit pair recoding → (0, +1)×M

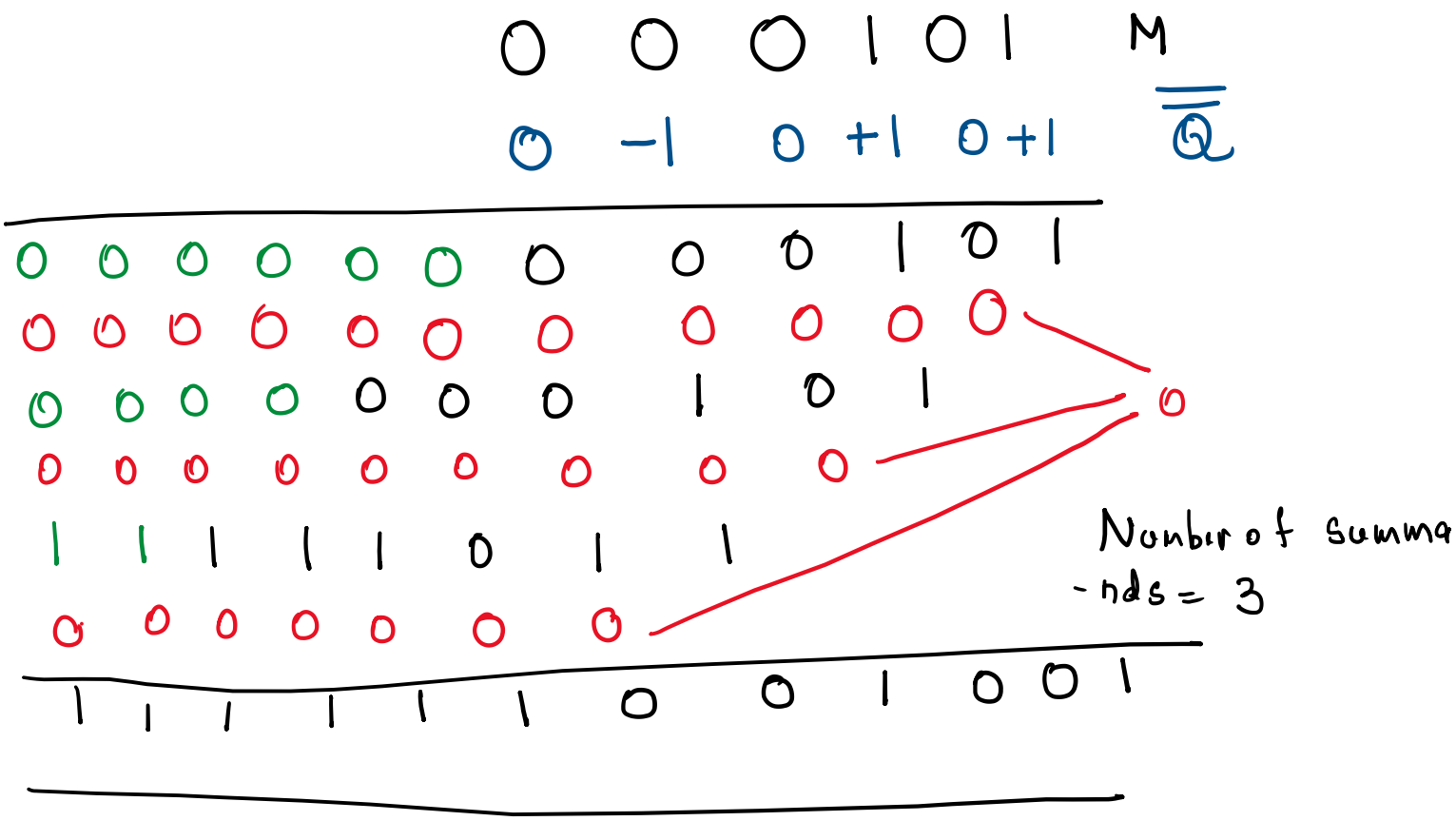
Booth recoded bit pair	Bit pair - recoding
(+1 0)M	(0, +2) M
(−1, +1)M	(0, −1) M
(0, 0)M	(0, 0) M
(0, 1) M	(0, 1)M
(+1 −1)M	(0, +1) M
(−1, 0)M	(0, −2) M.
(0 −1)M	(0, −1) M

−11 → 1 1 0 1 0 1

0 −1 | +1 −1 | +1 −1

0 −1 | 0 +1 | 0 +1

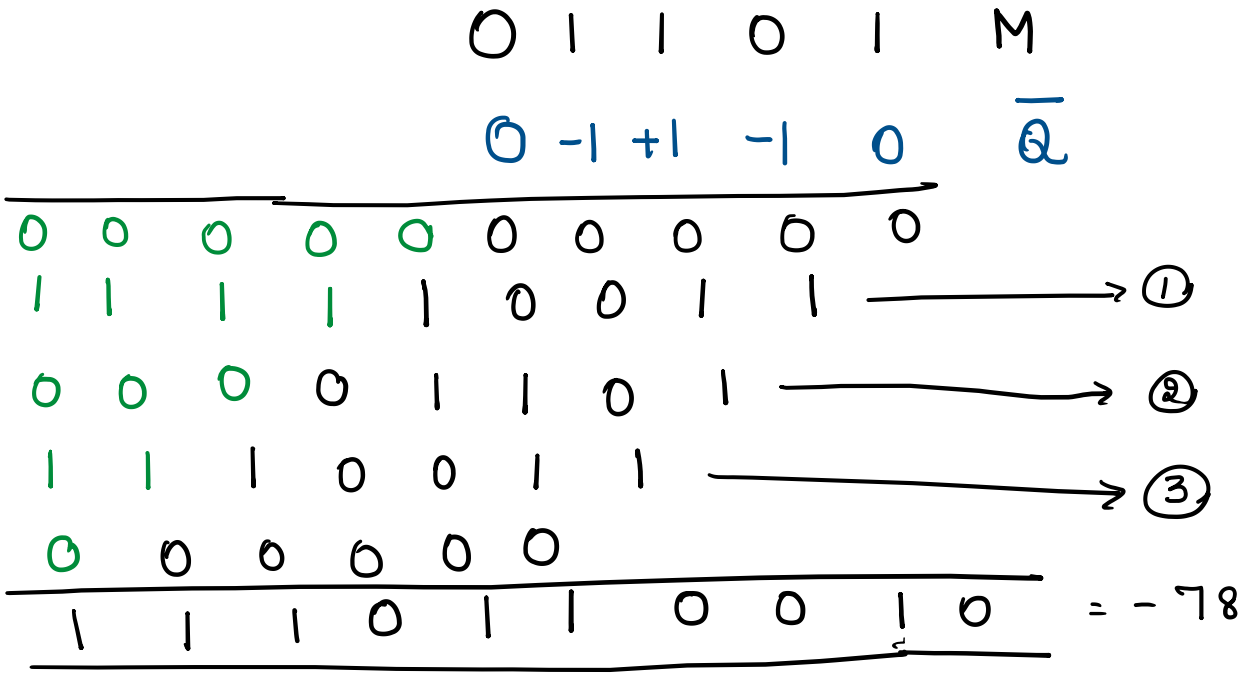
Bit pair recoding

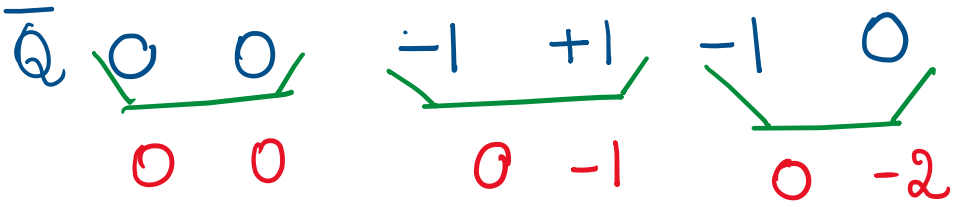


Ex 2: $M = +13$ $\quad 0\ 1\ 1\ 0\ 1$

$Q = -6$ $\quad 1\ 1\ 0\ 1\ 0$

$\overline{Q}$ $\quad 0\ -1\ +1\ -1\ 0$





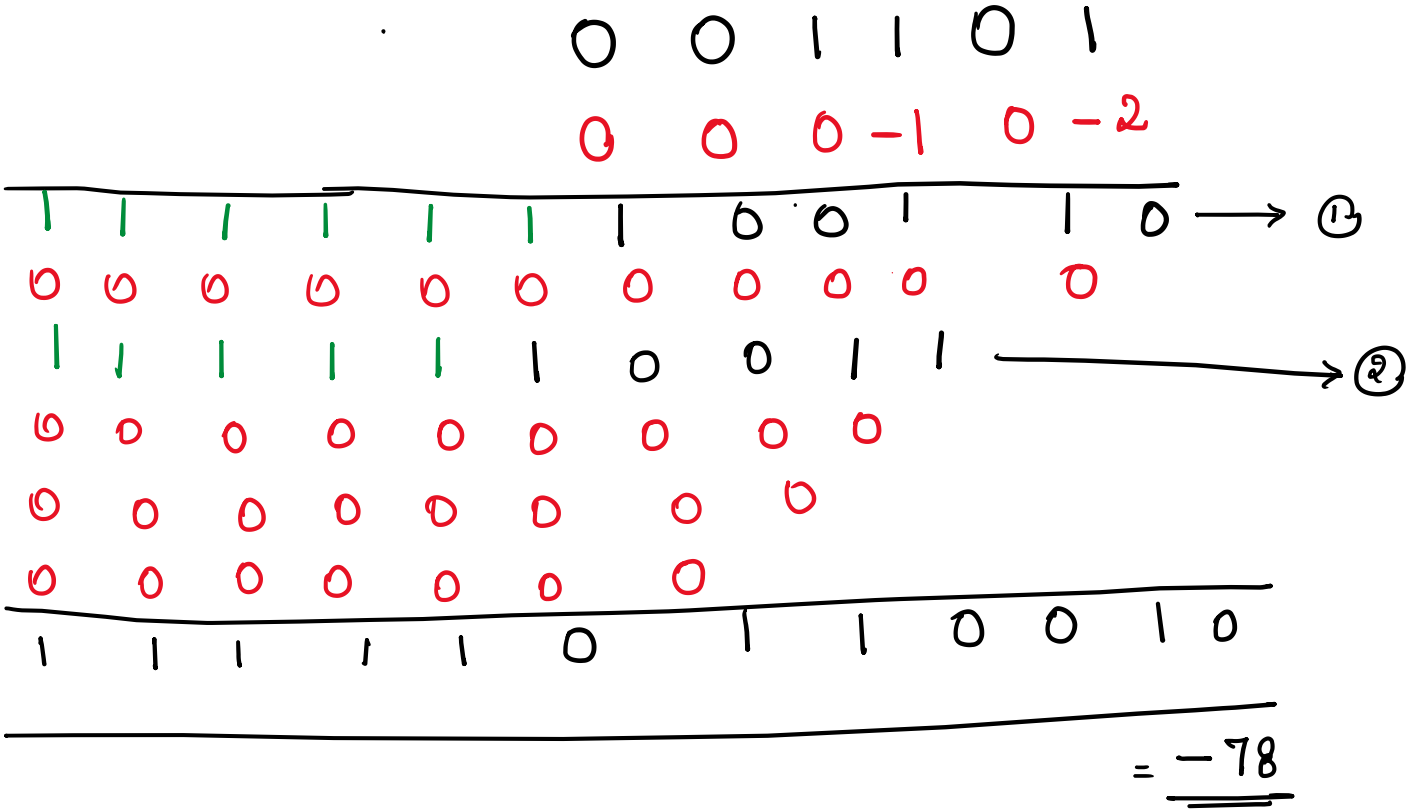
M = 13

2M = 26

011010

-2M ↓

100110



= −78

Bit pair recoding ⟶ Reduce the number of summands to half

$n \longrightarrow n/2$