2's complement code

- Represents signed integers in binary

2's complement code

— Represents signed integers in binary

— n bits $\longrightarrow -2^{n-1}$ to $2^{n-1}-1$

4 bits

-8		0	0000
-1		1	0001
-2		2	0010
-3		3	0011
-4		4	0100
-5		5	0101
-6		6	0110
-7		7	0111

2's complement code

- Represents signed integers in binary
- n bits $\longrightarrow -2^{n-1}$ to $2^{n-1}-1$
- negative number = positive number $\longrightarrow$ complement $\longrightarrow$ add 1

4 bits

−8	1000	0	0000
−1	1111	1	0001
−2	1110	2	0010
−3	1101	3	0011
−4	1100	4	0100
−5	1011	5	0101
−6	1010	6	0110
−7	1001	7	0111

Subtraction

- complement (+1) the subtrahend.

  Add.

  Result is in 2's complement code.

Subtraction

— complement (+1) the subtrahend.

Add.

Result is in 2's complement code.

$$
\begin{array}{r}
0110 \\
-\ 0111 \\
\hline
6 - 7
\end{array}
$$

Subtraction

— complement (+1) the subtrahend.
  Add.
  Result is in 2's complement code.

$$\begin{array}{r} 0\,1\,1\,0 \\ -\;0\,1\,1\,1 \\ \hline 6 - 7 \end{array} \longrightarrow \begin{array}{r} 0\,1\,1\,0 \\ +\;1\,0\,0\,1 \\ \hline 1\,1\,1\,1 \end{array}$$

Subtraction

- complement (+1) the subtrahend.

  Add.

  Result is in 2's complement code.

$$\begin{array}{r} 0110 \\ -\ 0111 \\ \hline 6-7 \end{array} \longrightarrow \begin{array}{r} 0110 \\ +\ 1001 \\ \hline 1111 \end{array} \longleftarrow (-1)$$

$$\begin{array}{r} 0\,1\,0\,0 \\ -\;1\,1\,0\,1 \\ \hline 4-(-3) \end{array}$$

$$\begin{array}{r} 0100 \\ -\,1101 \\ \hline 4-(-3) \end{array} \longrightarrow \begin{array}{r} 0100 \\ +\,0011 \\ \hline 0111 \end{array}$$

$$\begin{array}{r} 0\;1\;0\;0 \\ -\;1\;1\;0\;1 \\ \hline 4-(-3) \end{array} \longrightarrow \begin{array}{r} 0\;1\;0\;0 \\ +\;0\;0\;1\;1 \\ \hline 0\;1\;1\;1 \end{array} \longleftarrow 7$$

$$\begin{array}{r} 0100 \\ -\,1101 \\ \hline 4-(-3) \end{array} \longrightarrow \begin{array}{r} 0100 \\ +\,0011 \\ \hline 0111 \end{array} \longleftarrow 7$$

$$\begin{array}{r} 0100 \\ +\,1101 \\ \hline 0001 \end{array} \longleftarrow (1)$$

$$
\begin{array}{r}
0\,1\,0\,0 \\
-\;1\,1\,0\,1 \\
\hline
4-(-3)
\end{array}
\quad\longrightarrow\quad
\begin{array}{r}
0\,1\,0\,0 \\
+\;0\,0\,1\,1 \\
\hline
0\,1\,1\,1
\end{array}
\quad\longleftarrow\quad 7
$$

$$
\begin{array}{r}
0\,1\,0\,0 \\
+\;1\,1\,0\,1 \\
\hline
0\,0\,0\,1
\end{array}
\quad\longleftarrow\quad (1)
$$

$$
\begin{array}{r}
0\,1\,0\,0 \\
+\;1\,0\,0\,0 \\
\hline
1\,1\,0\,0
\end{array}
\quad\longleftarrow\quad (-4)
$$

$$
\begin{array}{r}
0\ 1\ 1\ 1 \\
+\ 0\ 0\ 1\ 1 \\
\hline
7+3
\end{array}
$$

← does not fit in 4 bit 2's complement

$$
\begin{array}{r}
0\ 1\ 1\ 1 \\
+\ 0\ 0\ 1\ 1 \\
\hline
7+3
\end{array}
$$

← does not fit in 4 bit 2's complement

$$
\begin{array}{r}
0\ 1\ 1\ 1 \\
+\ 0\ 0\ 1\ 1 \\
\hline
1\ 0\ 1\ 0
\end{array}
$$

$$\begin{array}{r} 0111 \\ +\,0011 \\ \hline \end{array}$$

$7+3$ ← does not fit in 4 bit 2's complement

$$\begin{array}{r} 0111 \\ +\,0011 \\ \hline 1010 \end{array} \quad (-6)$$

$$7 \xrightarrow{1} (-8) \xrightarrow{1} (-7) \xrightarrow{1}$$

$$\begin{array}{r} 1000 \\ +\ 1111 \\ \hline \end{array}$$

$(-8) + (-1)$ ← does not fit in 4 bit 2's complement

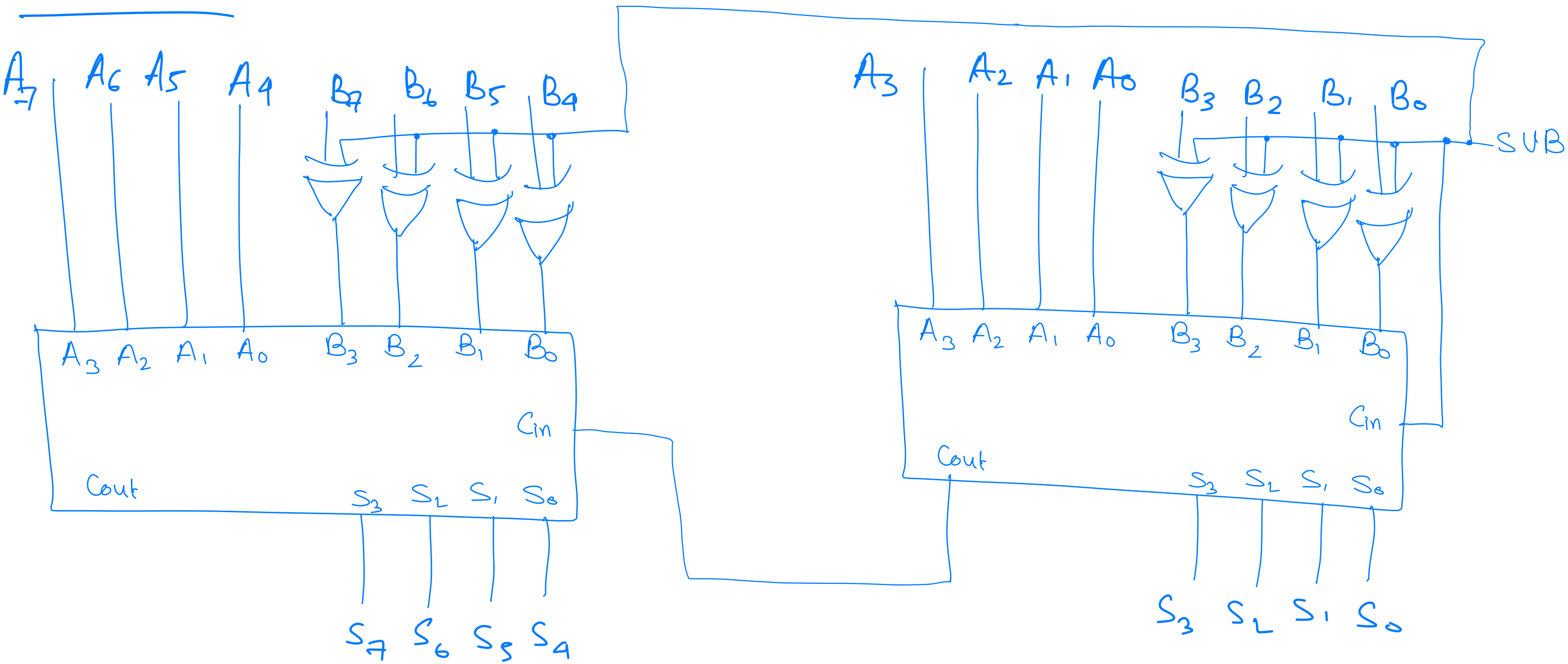
$$\begin{array}{r} 1000 \\ +\ 1111 \\ \hline 0111 \end{array} \quad (7) \rightarrow (-8)$$

1

Circuit

$$1 \oplus A = \overline{A}$$

$$0 \oplus A = A$$



7483

Subtraction

- complement (+1) the subtrahend.
  Add.
  Result is in 2's complement code.

- interesting properties of interesting codes — coding theory, information theory.