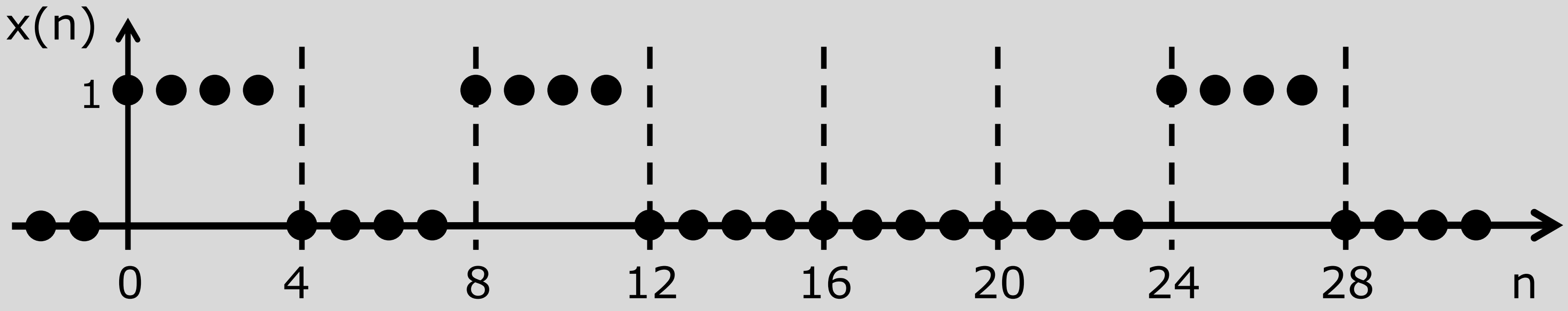
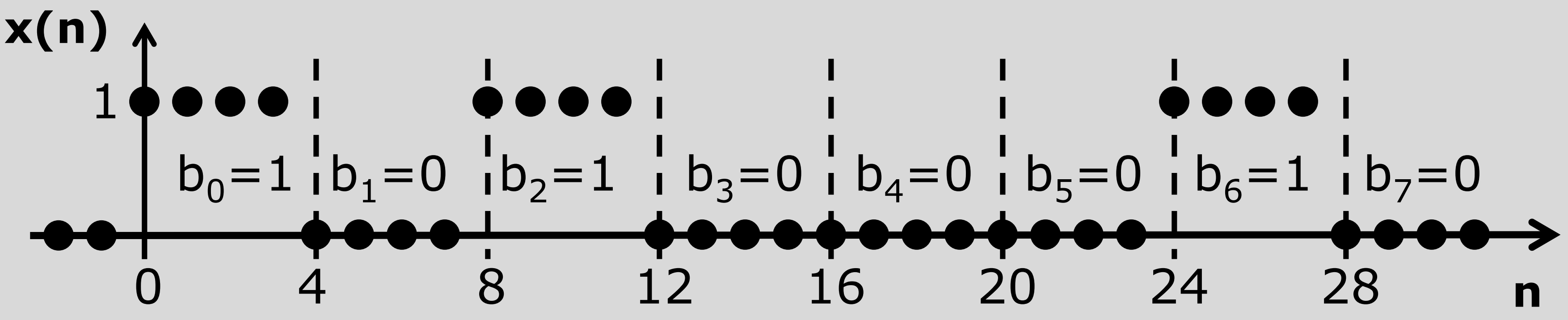
Representing Bit Waveforms

Equivalent Waveform Representations

<table>
<tr><td>Verbal</td><td>“Encoding of the bit sequence 1,0,1,0,0,0,1 at 4 samples per bit”</td></tr>
<tr><td>Graph</td><td>
</td></tr>
<tr><td>List, table or vector of values</td><td>n = [0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 …]
x(n) = [1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 0 0 …]</td></tr>
<tr><td>Sum of unit step functions</td><td>x(n) = u(n) – u(n-4) + u(n-8) – u(n-12) + u(n-24) – u(n-28)</td></tr>
</table>

Functions to Specify Waveforms

- **Graph**



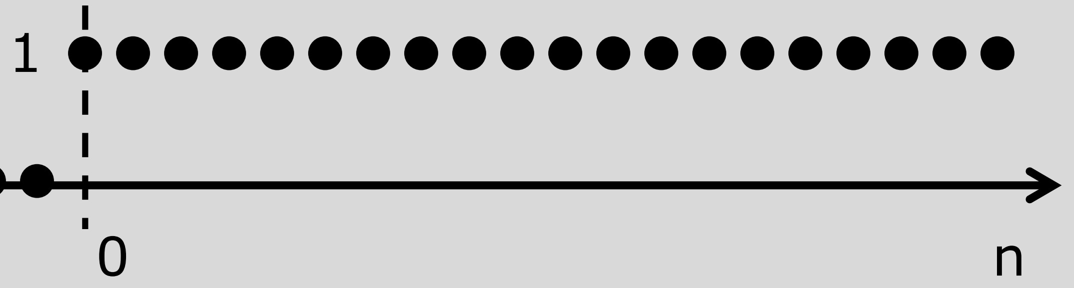
- **One possible formula:**

$$x(n) = \begin{cases} 1 & 0 \le n < 4 \\ 0 & 4 \le n < 8 \\ \vdots & \vdots \\ b_k & k \cdot SPB \le n < (k+1) \cdot SPB \\ \vdots & \vdots \end{cases}$$

Unit Step Function

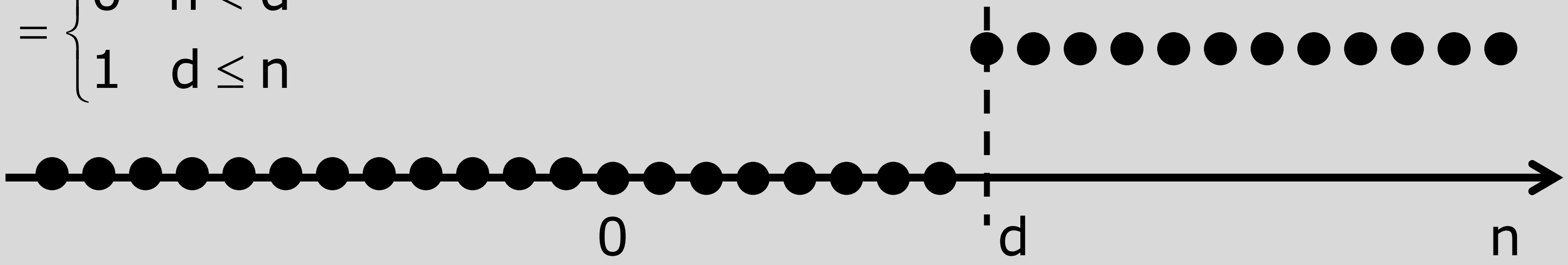
- To get a better formula to define a bit waveform, define the unit step function u(n):

$$u(n) = \begin{cases} 0 & n < 0 \\ 1 & 0 \le n \end{cases}$$



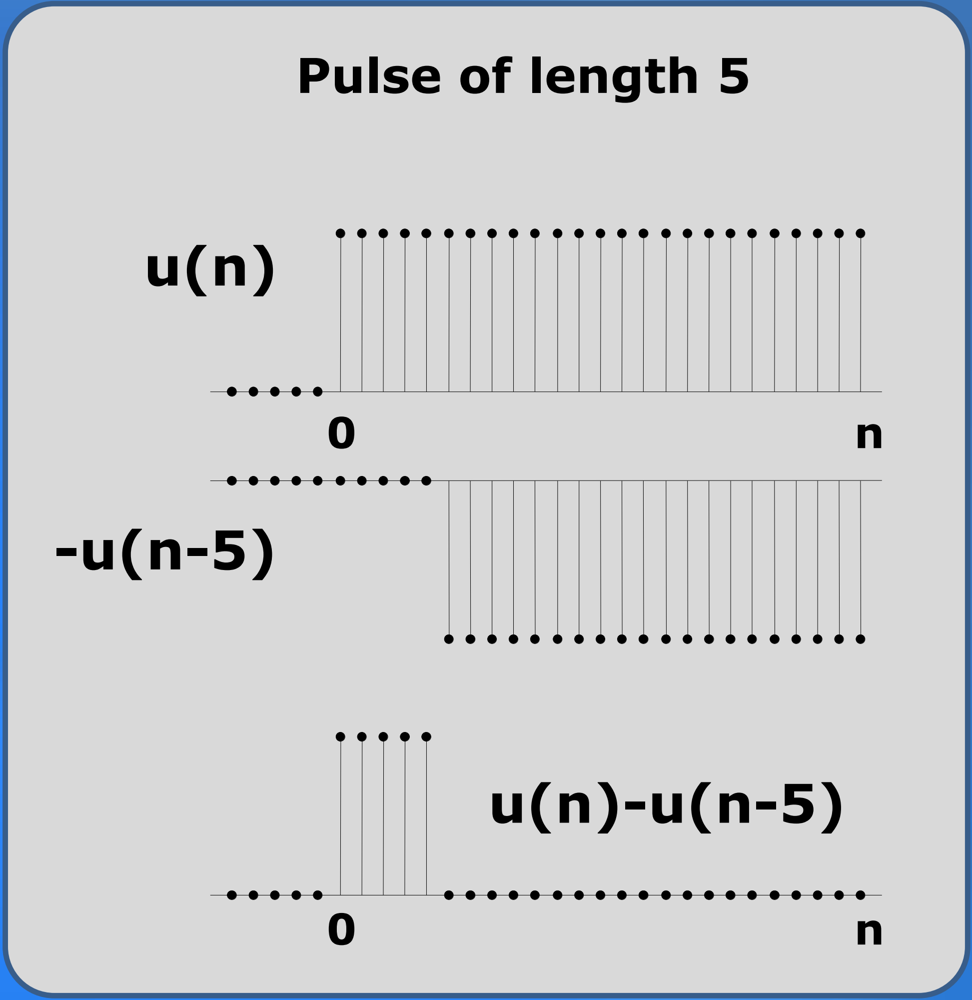
- Delay the step as follows:

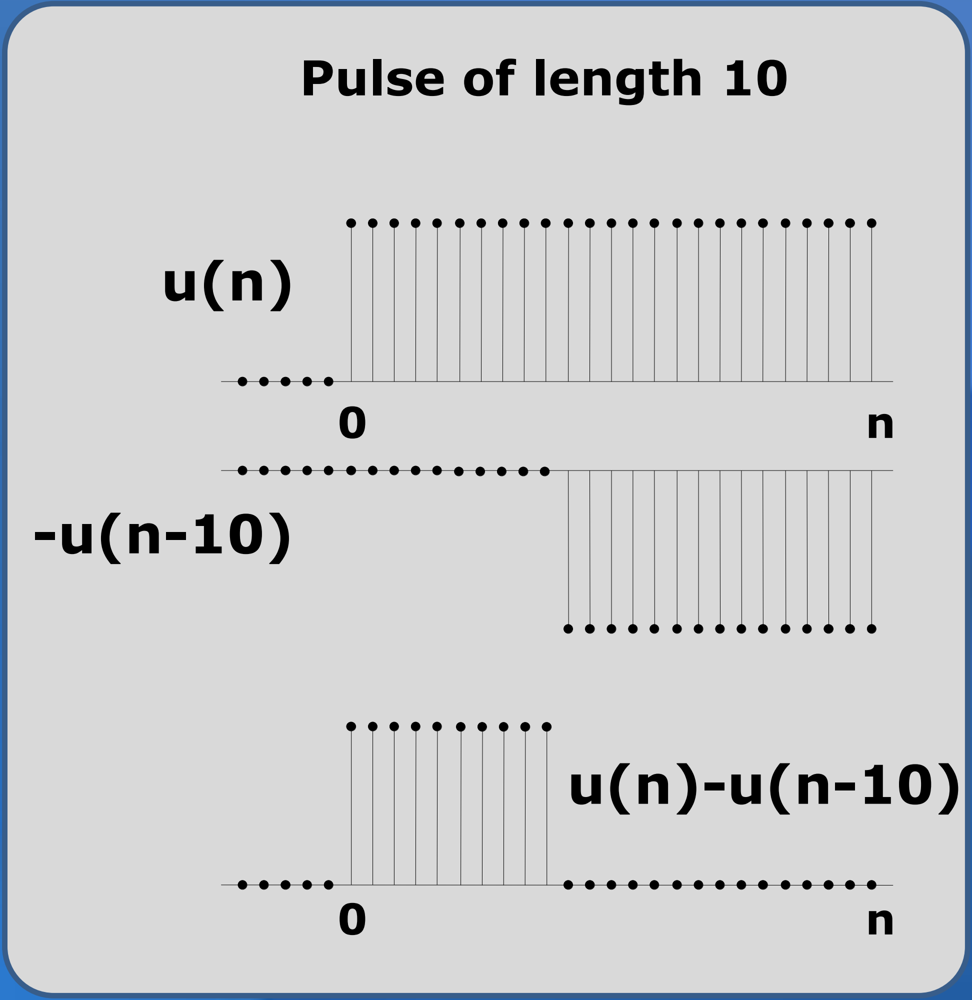
$$u(n-d) = \begin{cases} 0 & n < d \\ 1 & d \le n \end{cases}$$



Combining Step Functions

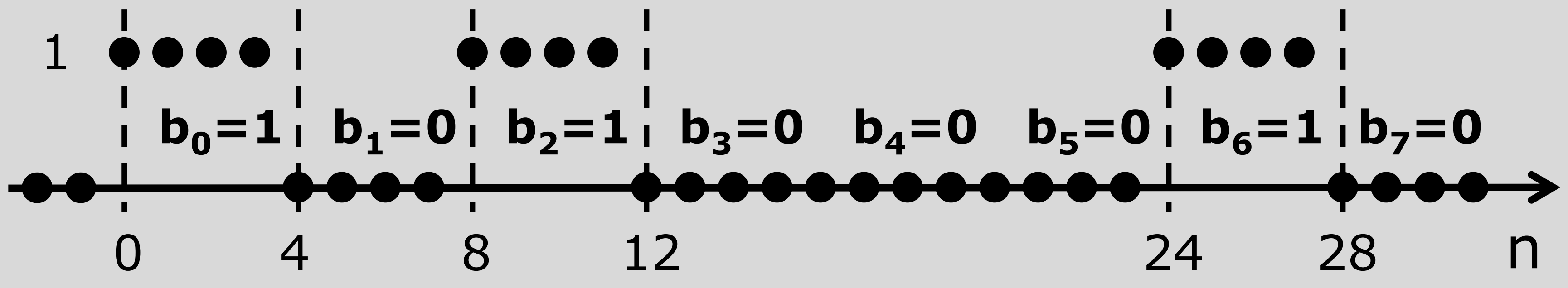
- A single pulse can be described as the difference between two step functions





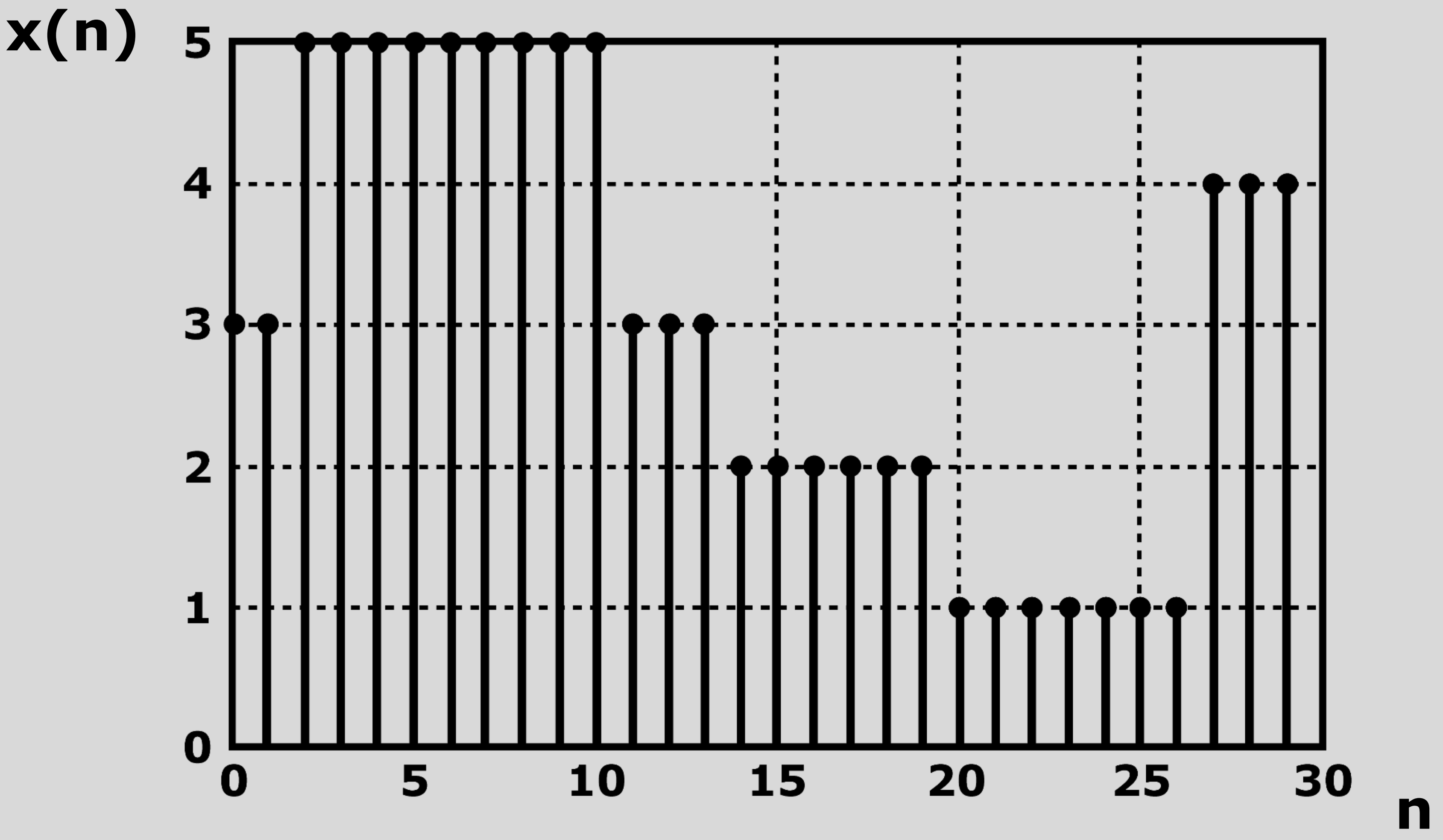
Representing Bit Waveforms

- Any bit sequence can be described as the sum and difference of unit step functions.
- Use one step function per bit change
  - If the bit changes from 0 to 1 at sample *D*, add *u(n-D)*
  - If the bit changes from 1 to 0 at sample *D*, subtract *u(n-D)*
  - If there is no change, add nothing



$$x(n) = u(n) - u(n-4) + u(n-8) - u(n-12) + u(n-24) - u(n-28)$$

Example



$$x(n) = 3 \cdot u(n) + 2 \cdot u(n-2) - 2 \cdot u(n-11) - u(n-14) - u(n-20) + 3 \cdot u(n-27)$$