Formal verification
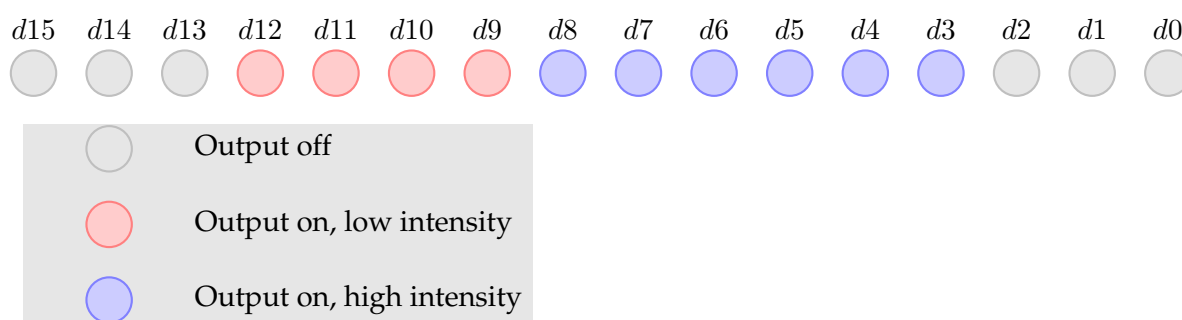**Verification of a linear display**
CERN training - July 2025

Module to verify

We want to test a system that allows the linear display of a value. The display will be controlled to indicate where this value is in relation to two limits, Min and Max.
The example below shows the output for the following values :
- `Max_i = 12`
- `Min_i = 3`
- `Val_i = 8`

$d15$	$d14$	$d13$	$d12$	$d11$	$d10$	$d9$	$d8$	$d7$	$d6$	$d5$	$d4$	$d3$	$d2$	$d1$	$d0$

○ Output off

○ Output on, low intensity

○ Output on, high intensity

Input/output

The input/outputs are :

Name	Size	Dir.	Description
Com_i	2	in	Mode of operation, on 2 bits
Val_i	4	in	Input value to be displayed on the linear display
Min_i	4	in	Lower bound
Max_i	4	in	Higher bound
Osc_i	1	in	Oscillatory signal for obtaining a low intensity
Leds_o	16	out	Linear display to be connected to 16 leds

```
Osci_i
2  Com_i
4  Val_i        Min_Max_top        Leds_o  16
4  Min_i
4  Max_i
```
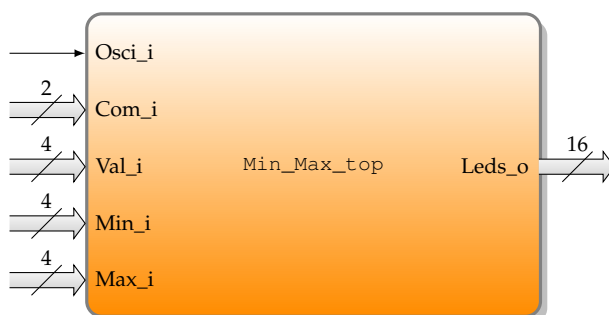
Behavior

A LED at high intensity corresponds to constant activation of its corresponding output. A LED at low intensity is achieved by alternating 1-0 activation of the LED with the `Osci_i` signal.

Thus, the emitted power is lower. Therefore, in the case of low intensity, the activation is combined with the `Osci_i` signal thanks to an `and` gate.

The following table presents the mode of operation :

Command	Function	Description
00	Normal mode	If `Val_i` is in the interval $[Min\_i, Max\_i]$ — LEDs from `Min_i` to `Val_i` are on at high intensity — LEDs from (`Val_i`+1) to `Max_i` are on at low intensity — All other LEDs are off If `Val_i` is out of $[Min\_i, Max\_i]$, then all LEDs are off
01	Linear mode	Display of `Val_i` as a linear value, LEDs from `0` to `Val_i` are on with high intensity.
10	All off mode	All LEDs are off ('`0`')
11	All on mode	All LEDs are on at high intensity ('`1`')

⚠️ When in normal mode, Max shall be greater than Min. If this is not the case, the output is undefined !

A generic parameter `ERRNO` allows to inject errors in the design. Its behavior is the following :

1. When in the $[0, 15]$ interval the result is valid;

2. When in the $[16, 21]$ interval, the result is unvalid.

This generic parameter allows to test your assertions by trying various `ERRNO` values thanks to modifications to the `.sby` file.