BI-DIRECTIONAL GATES

The gates discussed so far (**nmos**, **pmos**, **rnmos**, **rpmos**, **rcmos**) are all unidirectional gates

When turned ON, the gate establishes a connection and makes the signal at the input side available at the output side

Verilog has a set of primitives for bi-directional switches as well

They connect the nets on either side when ON and isolate them when OFF. The signal flow can be in either direction

None of the continuous-type assignments at higher levels dealt with so far has a functionality equivalent to the bi-directional gates

There are six types of bidirectional gates

- The **tran** gate is a bi-directional gate of two ports. When instantiated, it connects the two ports directly

- Thus the instantiation **tran** (s1, s2);

- connects the signal lines s1 and s2. Either line can be **input**, **inout** or **output**

- **rtran** is the resistive counterpart of **tran**

- **tranif1** is a bi-directional switch turned ON/OFF through a control line
- It is in the ON-state when the control signal is at 1 (high) state
- When the control line is at state 0 (low), the switch is in the OFF state
- A typical instantiation has the form **tranif1** (s1, s2, c);
  - Here c is the control line
  - If c=1, s1 and s2 are connected and signal transmission can be in either direction
- **rtranif1** is the resistive counterpart of **tranif1**. It is instantiated in an identical manner

- **tranif0** and **rtranif0** are again bi-directional switches
- The switch is OFF if the control line is in the 1 (high) state, and it is ON when the control line is in the 0 (low) state
- A typical instantiation has the form **tranif0** (s1, s2, c);
- With the above instantiation, if c = 0, s1 and s2 are connected and signal transmission can be in either direction. If c = 1, the switch is OFF and s1 and s2 are isolated from each other
- **rtranif0** is the resistive counterpart of **tranif0**

OBSERVATIONS:

- Any instantiation of a bi-directional switch of the above types can be given a name. But a name is not essential. It is true of the other switches also.

- With the bi-directional switches the signal on either side can be of **input**, **output**, or **inout** type. They can be nets or appearing as ports in the module. But the type declaration on the two sides has to be consistent.

- The connections to the bi-directional terminals of each of the bi-directional switches have to be scalars or individual bits of vectors and not vector themselves.

- In the above instantiation s1 can be an input port in a module. In that case, s2 has to be a net forming an input to another instantiated module or circuit block. s2 can be of **output** or **inout** type also. But it cannot be another input port.
  - s1 and s2 – both cannot be output ports.
  - s1 and s2 – both can be inout ports.

- With **tran**, **tranif1**, and **tranif0** bi-directional switches if the input signal has strength **supply1** (**supply0**), the output side signal has strength **strong1** (**strong0**). For all other strength values of the input signal, the strength value of the output side signal retains the strength of the input side signal.

- With **rtran**, **rtranif1** and **rtranif0** switches the output side signal strength is less than that of the input side signal. The strength reduction is on the lines shown in Table 10.4 for **rnmos**, **rpmos**, and **rcmos** switches.

Type of Bi-directional switch	Typical instantiation	Condition to be ON	Remarks
2 port	`tran` (a, b);	Always ON (if instantiated)	Acts essentially as a buffer
	`rtran` (a, b);	– do –	Acts essentially as a buffer with reduction in the strength of the signal
3 port	`tranif1` (a, b, c);	ON if c = 1	Acts as a buffer if ON. Otherwise provides isolation
	`tranif0` (a, b, c);	ON if c = 0	– do –
	`rtranif1` (a, b, c);	ON if c = 1	Acts as a buffer if ON. Otherwise provides isolation; signal strength on the output side is lower than that on the input side
	`rtranif0` (a, b, c);	ON if c = 0	– do –