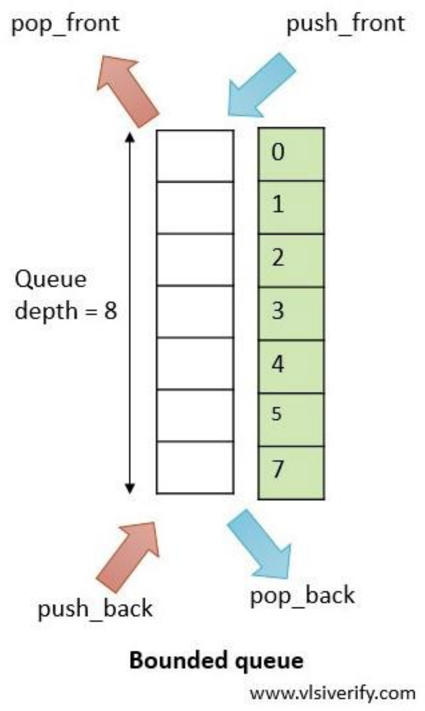
SystemVerilog Queues

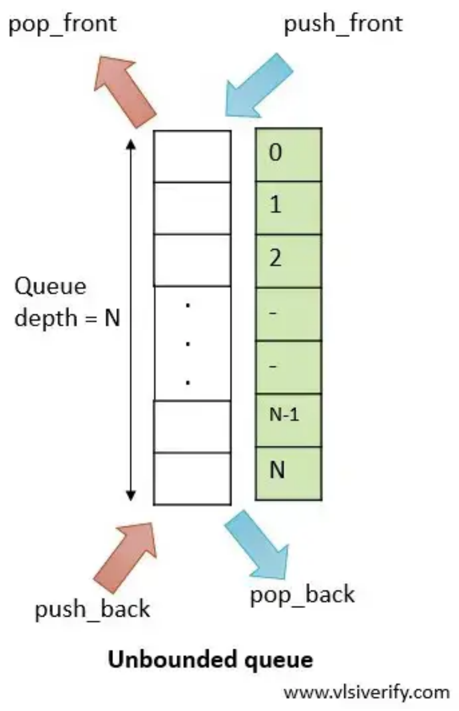
A queue is a variable size and ordered collection of elements (homogeneous element).

To understand it is considered the same as a single-dimensional unpacked array that grows and reduces automatically if it is a bounded queue.

Types of queues in SystemVerilog

1. Bounded queue: Queue having a specific size or a limited number of entries.
2. Unbounded queue: Queue having non-specific queue size or unlimited entries.





Declaration of a queue in SystemVerilog

```
data_type  <queue_name> [$];
```

For Example:

```
bit q_1[$];     // Unbounded queue of bit
byte q_2[$];    // Unbounded queue of byte
int q_3 [$:9];  // Bounded queue with qsize = 10

int q_4[$] = {5,6,7};
```

SystemVerilog Queue methods

Methods (functions)	**Description**
insert (<index>, <item>)	Inserts an item at a specified index.
1. delete(<index>) 2. delete	1. Deletes an item at a specified index 2. Deletes all elements in the queue.
size()	If the queue is not empty, return the number of items in the queue. Otherwise, it returns 0.
push_back(<item>)	Inserts an item at the end of the queue.
pop_back()	Returns and removes the last item of the queue.
push_front(<item>)	Inserts an item at the front of the queue.
pop_front()	Returns and removes the first item of the queue.

shuffle()	Shuffles items in the queue

SystemVerilog Queue Example

```
module queue_example;
  // declaration
  string animal_q[$];

  initial begin
    $display("Initial Size: animal_q = %0d", animal_q.size());

    animal_q = {"TIGER","LION"};
    $display("Size: animal_q = %0d", animal_q.size());
    $display("-----------------------");

    animal_q.insert(1, "ELEPHANT");
    animal_q.insert(3, "FOX");
    animal_q.insert(4, "ZEBRA");
    $display("Size: animal_q = %0d", animal_q.size());

    foreach(animal_q[i]) $display("animal_q[%0d] = %s", i, animal_q[i]);
    $display("-----------------------");

    $display("--- Access queue item ---");
    $display("The second element of animal_q = %s", animal_q[2]);
    $display("The fourth element of animal_q = %s", animal_q[4]);
    $display("-----------------------");

    $display("--- Delete queue item ---");
    animal_q.delete(2);
    foreach(animal_q[i]) $display("animal_q[%0d] = %s", i, animal_q[i]);
    $display("-----------------------");

    $display("--- Delete complete queue ---");
    animal_q.delete();
    $display("Size after queue deletion: animal_q size = %0d", animal_q.size());
    $display("-----------------------");


    animal_q = {"TIGER","LION"};

    $display("--- push_back methods ---");
    animal_q.push_back("ELEPHANT");
    foreach(animal_q[i]) $display("animal_q[%0d] = %s", i, animal_q[i]);
    $display("-----------------------");

    $display("--- push_front methods ---");
    animal_q.push_front("FOX");
    foreach(animal_q[i]) $display("animal_q[%0d] = %s", i, animal_q[i]);
    $display("-----------------------");

    $display("--- pop_back methods ---");
    animal_q.pop_back();
    foreach(animal_q[i]) $display("animal_q[%0d] = %s", i, animal_q[i]);
    $display("-----------------------");

    $display("--- pop_front methods ---");
    animal_q.pop_front();
    foreach(animal_q[i]) $display("animal_q[%0d] = %s", i, animal_q[i]);
    $display("-----------------------");
  end
endmodule
```

Output:

```
Initial Size: animal_q = 0
Size: animal_q = 2
-----------------------
Size: animal_q = 5
animal_q[0] = TIGER
animal_q[1] = ELEPHANT
animal_q[2] = LION
animal_q[3] = FOX
animal_q[4] = ZEBRA
-----------------------
--- Access queue item ---
The second element of animal_q = LION
The fourth element of animal_q = ZEBRA
-----------------------
--- Delete queue item ---
animal_q[0] = TIGER
animal_q[1] = ELEPHANT
animal_q[2] = FOX
animal_q[3] = ZEBRA
-----------------------
--- Delete complete queue ---
Size after queue deletion: animal_q size = 0
-----------------------
--- push_back methods ---
animal_q[0] = TIGER
animal_q[1] = LION
animal_q[2] = ELEPHANT
-----------------------
--- push_front methods ---
animal_q[0] = FOX
animal_q[1] = TIGER
animal_q[2] = LION
animal_q[3] = ELEPHANT
-----------------------
--- pop_back methods ---
animal_q[0] = FOX
animal_q[1] = TIGER
animal_q[2] = LION
-----------------------
--- pop_front methods ---
animal_q[0] = TIGER
animal_q[1] = LION
-----------------------
```

Example for shuffle method

Let’s see how the shuffle method shuffles queue’s items.

```
module queue_example;
  // declaration
  int num_q[$];

  initial begin
    for(int i = 0; i < 10; i++) num_q.push_back(i);
    $display("--- Before shuffle ---");
    foreach(num_q[i]) $display("num_q[%0d] = %0d", i, num_q[i]);
    num_q.shuffle();
    $display("----------------------");
    $display("--- After shuffle ---");
    foreach(num_q[i]) $display("num_q[%0d] = %0d", i, num_q[i]);
  end
endmodule
```

Output:

```
--- Before shuffle ---
num_q[0] = 0
num_q[1] = 1
num_q[2] = 2
num_q[3] = 3
num_q[4] = 4
num_q[5] = 5
num_q[6] = 6
num_q[7] = 7
num_q[8] = 8
num_q[9] = 9
----------------------
--- After shuffle ---
num_q[0] = 1
num_q[1] = 3
num_q[2] = 9
num_q[3] = 6
num_q[4] = 8
num_q[5] = 5
num_q[6] = 2
num_q[7] = 4
num_q[8] = 0
num_q[9] = 7
```

Array of queues

An array can store queues. In the below example,

array[0] stores a queue of even numbers.

array[1] stores a queue of odd numbers.

array[2] stores a queue of multiple hundreds.

Initialization of array of queues

- Based on array index

```
array[0] = {2, 4, 6, 8};
array[1] = {1, 3, 5, 7};
array[2] = {100, 200, 300};
```

- Without using an array index

```
array = '{ {2, 4, 6, 8},
           {1, 3, 5, 7},
           {100, 200, 300}
         };
```

Array of queues Example

```
module array_example;
  int array [3][$];

  initial begin
    //array[0] = {2, 4, 6, 8};
    //array[1] = {1, 3, 5, 7};
    //array[2] = {100, 200, 300};
    //or
    array = '{ {2, 4, 6, 8},
               {1, 3, 5, 7},
               {100, 200, 300}
             };

    // Print array of queues
    foreach (array[i,j]) $display("array[%0d][%0d] = %0d", i, j, array[i][j]);
    $display("------------------");

    array[0].push_back(10);
    array[1].push_back(9);
    array[2].push_back(400);

    $display("After push_back operation");
    // Print array of queues
    foreach (array[i,j]) $display("array[%0d][%0d] = %0d", i, j, array[i][j]);

  end
endmodule
```

Output:

```
array[0][0] = 2
array[0][1] = 4
array[0][2] = 6
array[0][3] = 8
array[1][0] = 1
array[1][1] = 3
array[1][2] = 5
array[1][3] = 7
array[2][0] = 100
array[2][1] = 200
array[2][2] = 300
------------------
After push_back operation
array[0][0] = 2
array[0][1] = 4
array[0][2] = 6
array[0][3] = 8
array[0][4] = 10
array[1][0] = 1
array[1][1] = 3
array[1][2] = 5
array[1][3] = 7
array[1][4] = 9
array[2][0] = 100
array[2][1] = 200
array[2][2] = 300
array[2][3] = 400
```

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