Lab 1

Resource grid of 5G cellular radio access network of new radio (NR)

Radio resources of 5G NR [1]

- Resource grid (frequency-time plane)
  - Frequency scale:
    - 2 frequency ranges (FR):
      - FR1 is 450-7125 MHz and FR2 is 24250- 52600 MHz (Rel-15).
    - FR contains operating bands
    - Operating band contain bandwidth parts (BWPs)
    - BWP contains a number of Physical Resource Blocks (PRB).
    - One PRB contains 12 subcarriers that are resource elements on the frequency dimension.
  - Time scale:
    - Frame duration is 10 ms.
    - The frame contains 10 subframes.
    - The slot contains 12 or 14 Orthogonal Frequency Division Multiplexing (OFDM) symbols if extended or normal cyclic prefix is used, respectively.
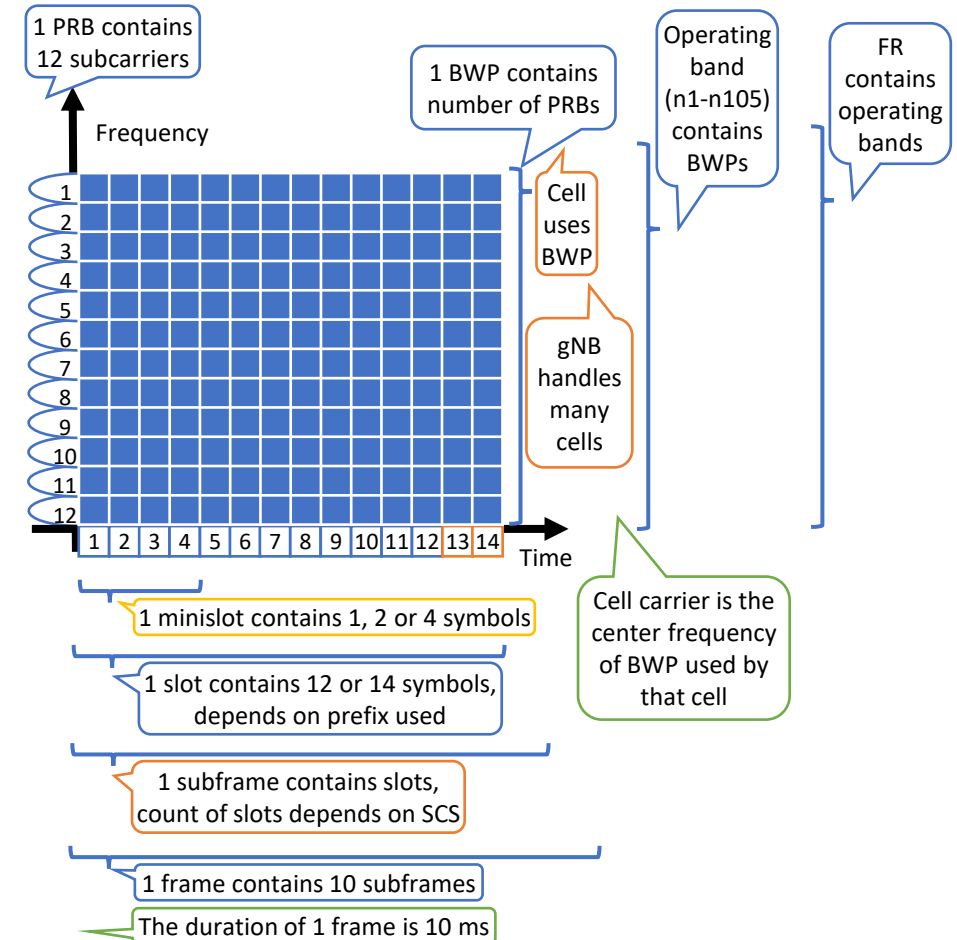
- Numerology μ determines
  - Subcarrier spacing (SCS)
  - Number of slots in subframe

$$\mu \in \{0,1,2,3,4\}$$
$$\Delta f = 2^{\mu} \cdot 15 \ [kHz]$$
$$N_{slot}^{subframe,\mu} = 2^{\mu}$$

1 PRB contains 12 subcarriers

Frequency

1 BWP contains number of PRBs

Operating band (n1-n105) contains BWPs

FR contains operating bands

Cell uses BWP

gNB handles many cells

Time

1 minislot contains 1, 2 or 4 symbols

1 slot contains 12 or 14 symbols, depends on prefix used

Cell carrier is the center frequency of BWP used by that cell

1 subframe contains slots, count of slots depends on SCS

1 frame contains 10 subframes

The duration of 1 frame is 10 ms

[1]   3GPP, "TS 38.104 - NR; Base Station (BS) radio transmission and reception," 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38104.htm

MATLAB: create empty resource grid

- carrier = nrCarrierConfig - creates NR carrier with selected subcarrier spacing and number of RBs

- info = nrOFDMInfo(carrier) - shows info about carrier

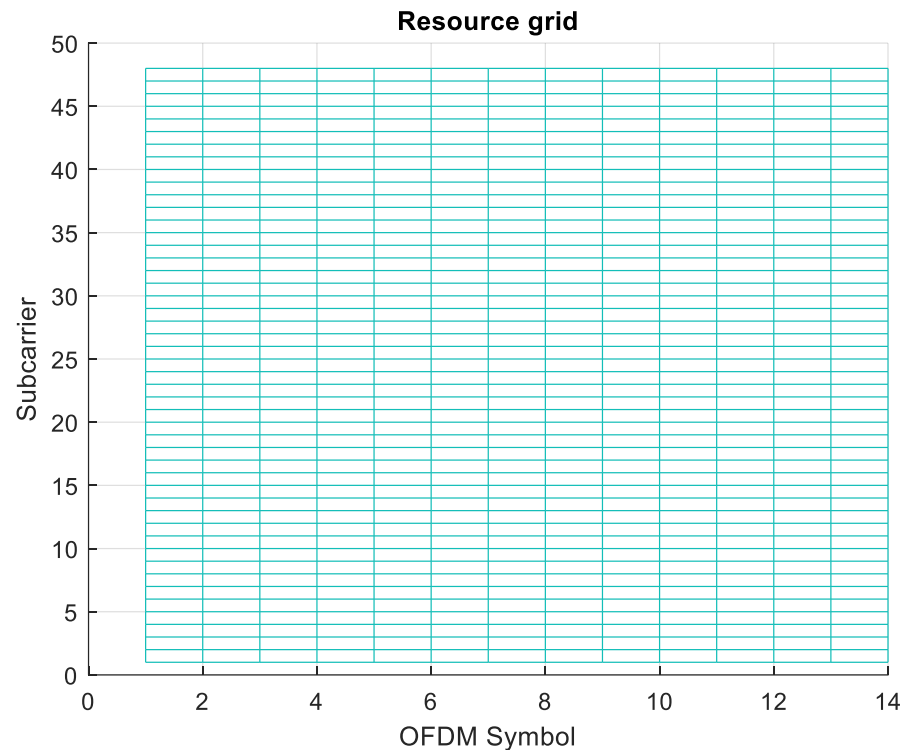- grid = nrResourceGrid(carrier) – creates resource grid for specified number of RBs and one slot time

Display resource grid
μ=0, 4 RBs,one slot time

mesh(abs(grid))

view(2)

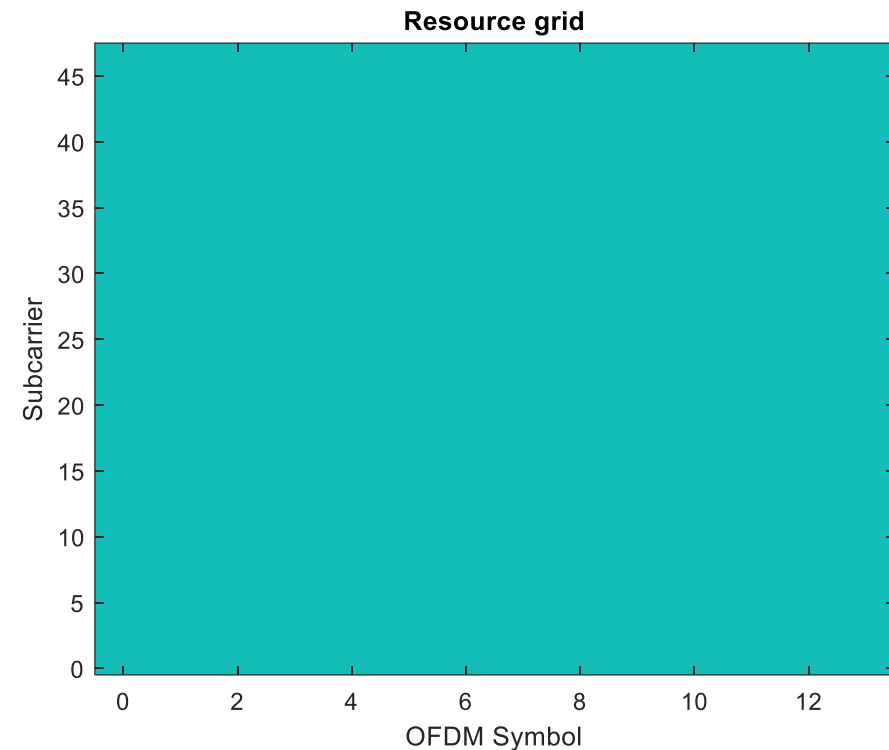axis xy;title("Resource grid");ylabel("Subcarrier");xlabel("OFDM Symbol");

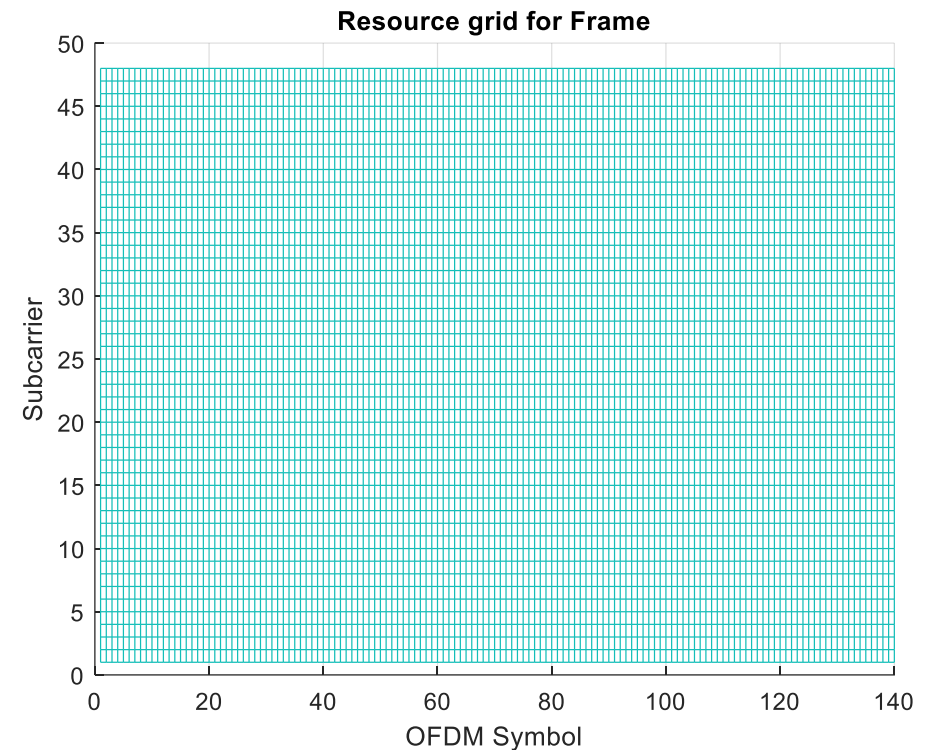imagesc([0 carrier.SymbolsPerSlot-1],[0 carrier.NSizeGrid*12-1],abs(grid(:,:,1)));

axis xy;title("Resource grid");ylabel("Subcarrier");xlabel("OFDM Symbol");

Create resource grid for a frame μ=0, 4 RBs,one frame time
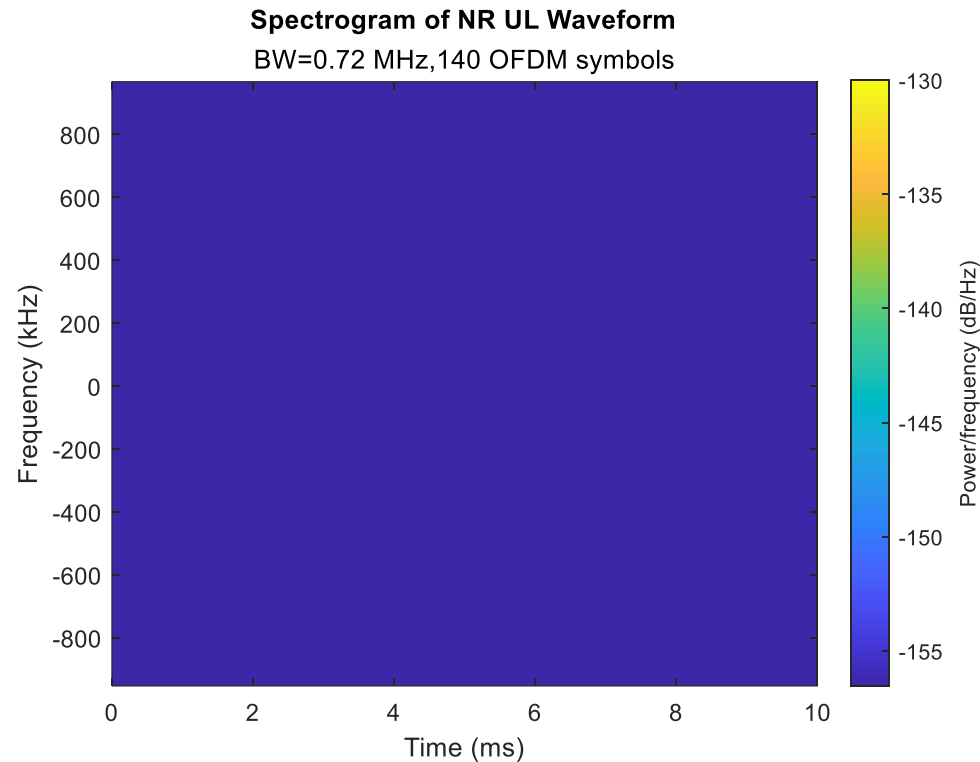
Combine slot grids

- numSlotsPerFrame=info.SlotsPerFrame;

- RBgrid = [];
- for nslot = 0:(numSlotsPerFrame - 1)
-     carrier.NSlot = nslot;
-     slotGrid = nrResourceGrid(carrier);
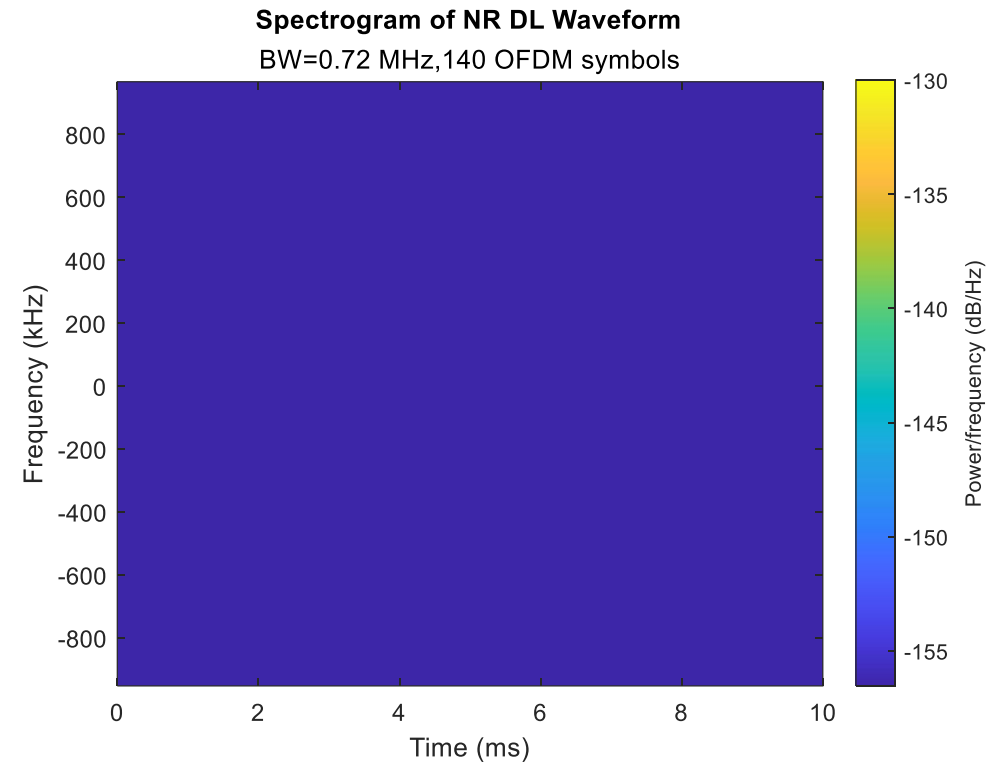-   RBgrid = [RBgrid slotGrid];
- end
-

Resource grid for Frame

Waveform (time-frequency plane) μ=0, 4 RBs,one frame time

For UL

Spectrogram of NR UL Waveform
BW=0.72 MHz,140 OFDM symbols

For DL

Spectrogram of NR DL Waveform
BW=0.72 MHz,140 OFDM symbols

Tasks for lab1

- Generate resource grid
- Select numerology μ=0, frequency scale 4 RBs, time scale 1 slot
  - Show the resource grid on figure
  - Calculated bandwidth and time for resource element (subcarrier and symbol)
  - Calculate allocated bandwidth and allocated time for 4 RBs and 1 slot
- Select one other numerology μ=1, μ=2, or μ=3
  - Show the resource grid on figure
  - Calculate bandwidth and time for resource element (subcarrier and symbol)
  - Calculate allocated bandwidth and allocated time for 4 RBs and 1 slot
- How do the allocated resources change if numerology changes?
  - Calculate number of subcarriers in 50 MHz (without guardbands)
  - Calculate number of slots used in 1 s
  - Compare results if μ=0 and selected value of μ: change in number of slots and subcarriers, bandwidth consumption.
- Optional: display resource grid in units of MHz and ms.

Lab report

- 1 page PDF, minimum text size 10 pt
- Contents:
  - Lab number, title, author, date
  - Introduction
  - Tasks, results
  - Summary and conclusions