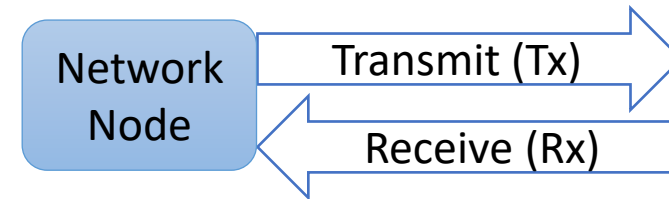
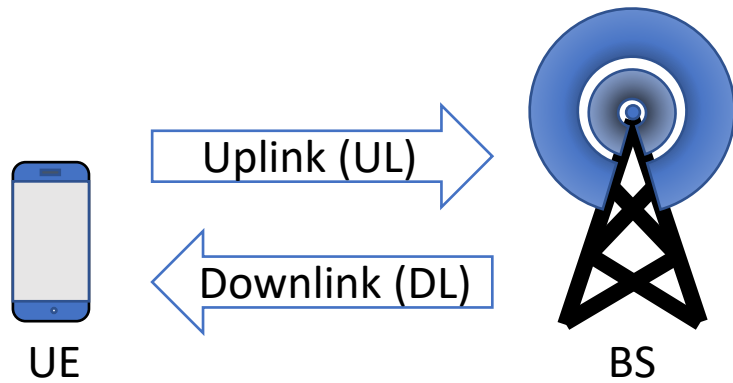


Lab 2

5G NR DL control signals, synchronization signals

UE and RAN

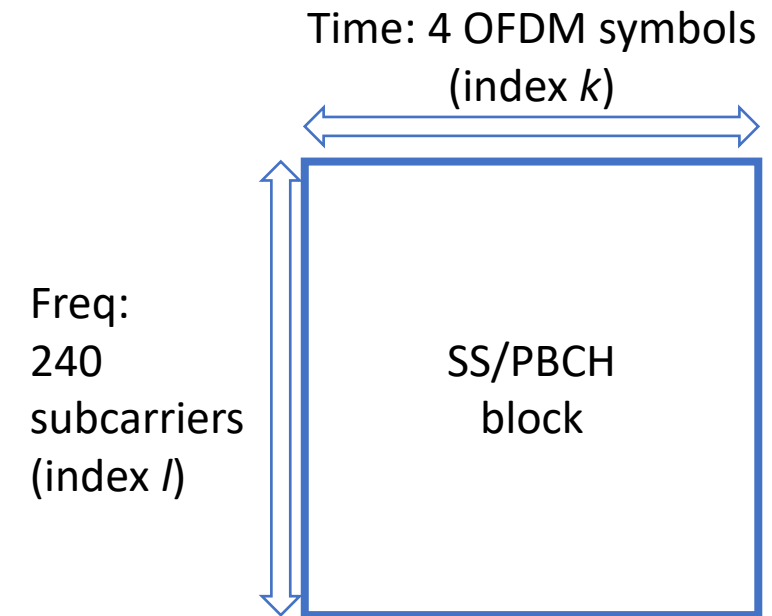


Synchronization

- Uplink synchronization
 - Needed for UE to know when to transmit
 - Random access channel (RACH)
- Downlink synchronization
 - Needed for UE to know when the frame and OFDM symbol starts
 - Synchronization signal block (SSB)

Synchronization signals in DL

- Primary and secondary synchronization signals 3GPP TS 38.211 [1]
 - Primary synchronization signal (PSS), used in DL
 - Secondary synchronization signal (SSS), used in DL
 - SS/PBCH block, used in DL, contains
 - PSS
 - SSS
 - PBCH
 - DM-RS for PBCH
- Synchronization procedures 3GPP TS 38.213 [2]
- SS/PBCH block needs grid of 240 subcarriers and 4 OFDM symbols [1]

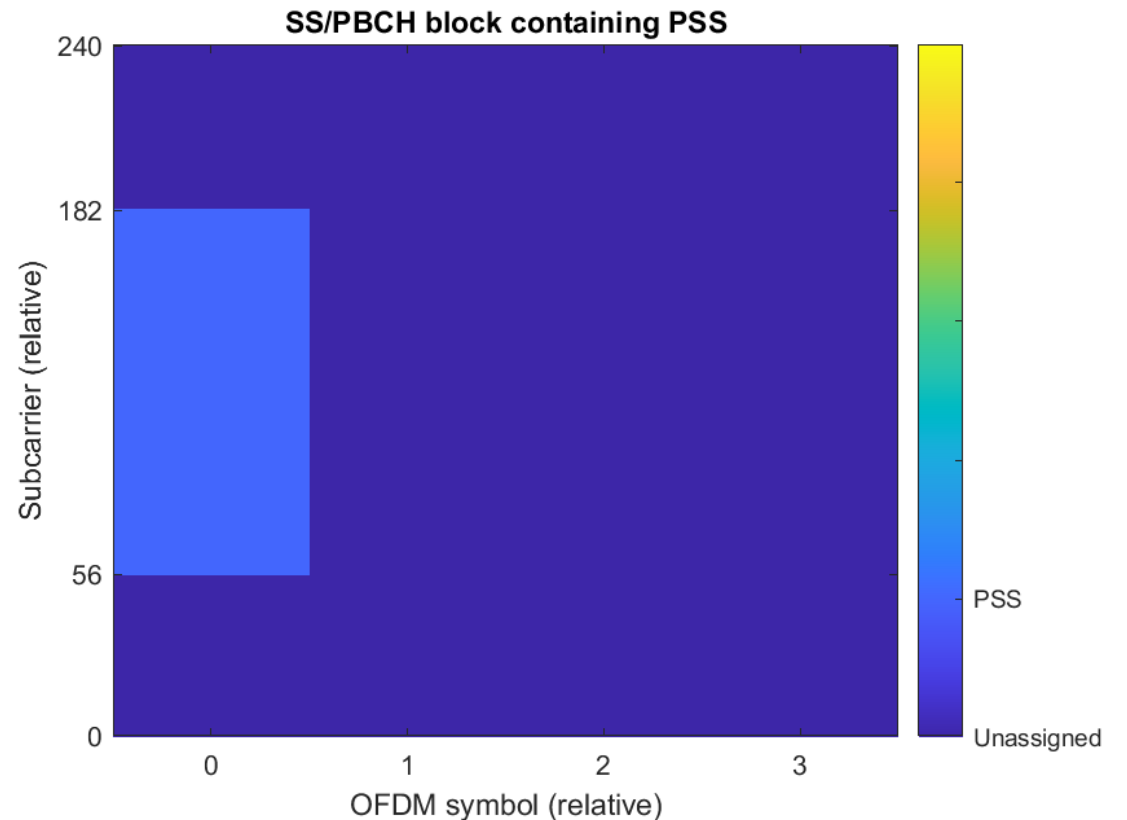


[1] 3GPP, "TS 38.211 - NR; Physical channels and modulation," 2020, [Online]. Available: <https://www.3gpp.org/DynaReport/38211.htm>

[2] 3GPP, "TS 38.213 - NR; Physical layer procedures for control," 2021. [Online]. Available: <https://www.3gpp.org/DynaReport/38213.htm>

Primary synchronization signal (PSS)

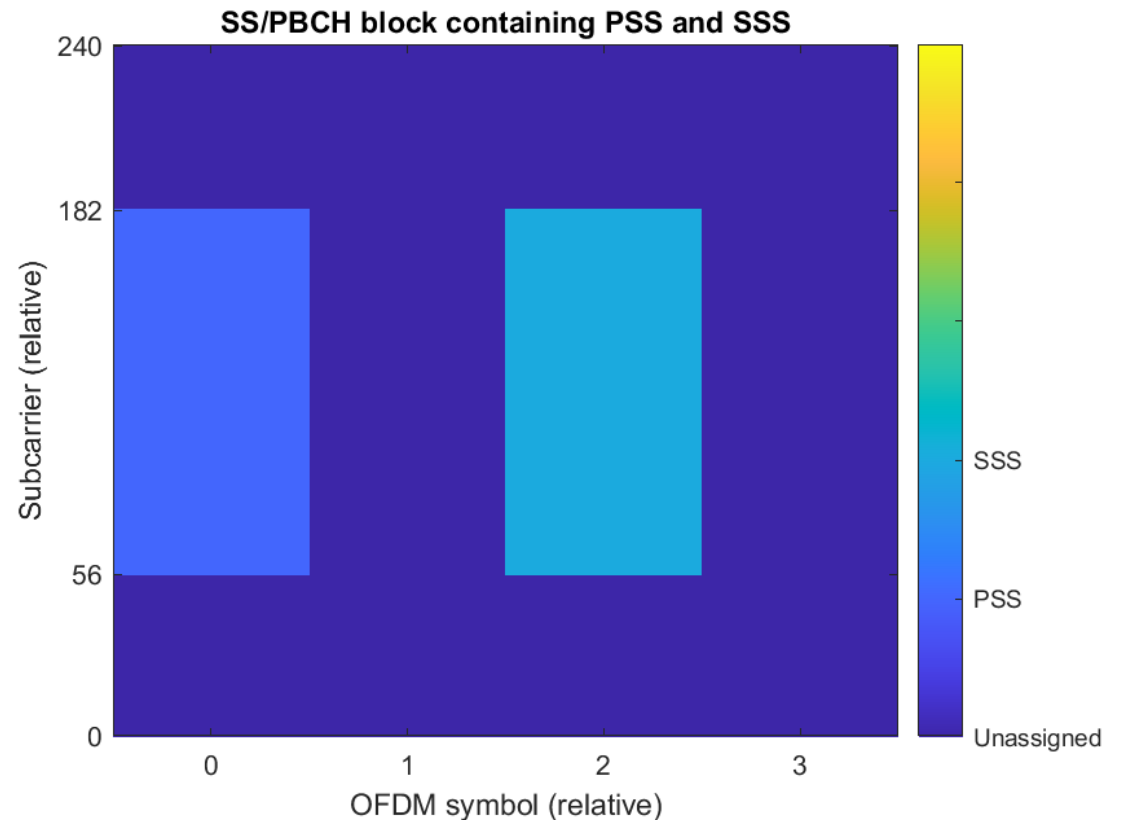
- Contains physical cell identifier (PCI)
- PSS location in resource grid [1]
 - Time: OFDM symbol number 0 relative to the start of SS/PBCH block
 - Frequency: subcarriers number 56-182 relative to the start of SS/PBCH block



[1] 3GPP, "TS 38.211 - NR; Physical channels and modulation," 2020, [Online]. Available: <https://www.3gpp.org/DynaReport/38211.htm>

Secondary synchronization signal (SSS)

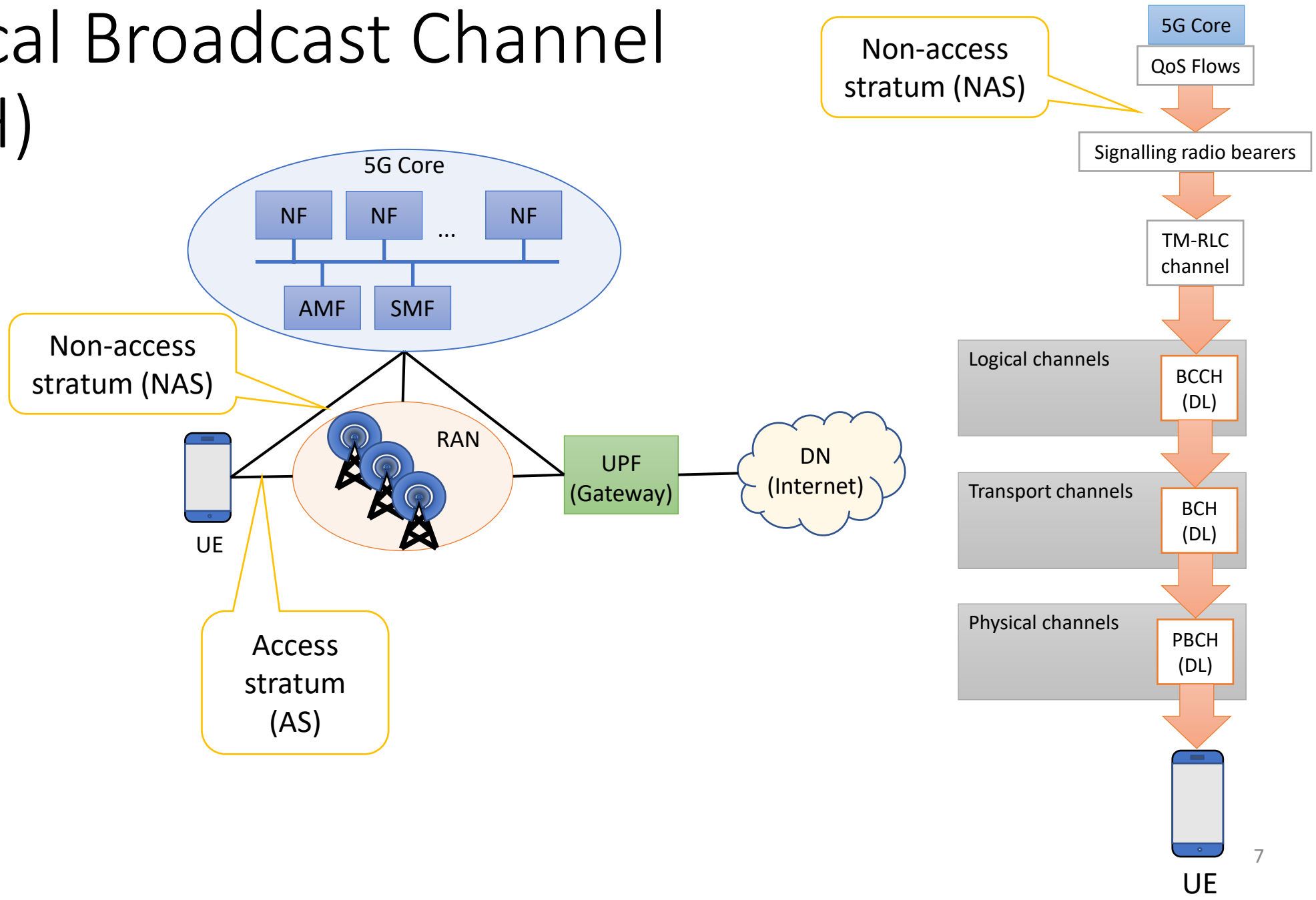
- Contains physical cell identifier (PCI)
- SSS location in resource grid [1]
 - Time: OFDM symbol number 2 relative to the start of SS/PBCH block
 - Frequency: subcarriers number 56-182 relative to the start of SS/PBCH block



[1] 3GPP, "TS 38.211 - NR; Physical channels and modulation," 2020, [Online]. Available: <https://www.3gpp.org/DynaReport/38211.htm>

Physical Broadcast Channel (PBCH)

- PBCH



NR access stratum protocol channels [1]

- QoS Flow [1, section 5.7]
 - QoS Flow ID (QFI)
 - Supports both GBR and non-GBR QoS Flows
 - Characterized by QoS profile

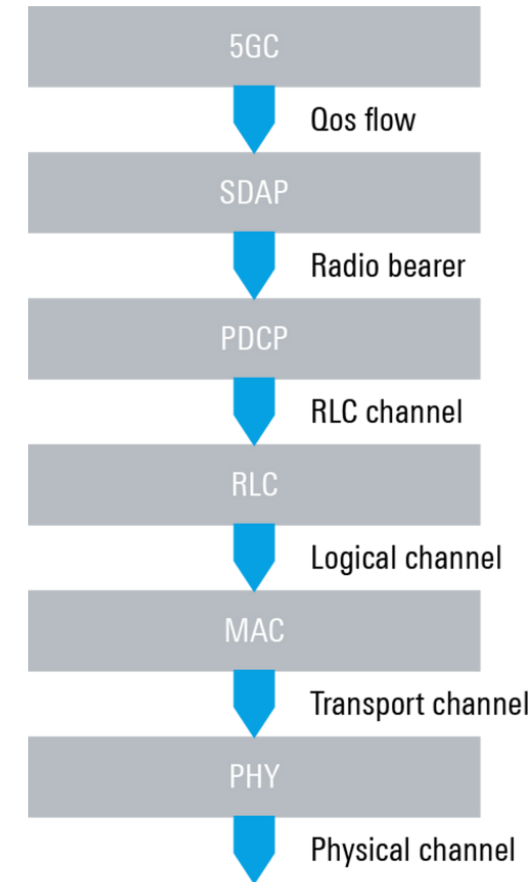


Fig. 1-8 NR Access Stratum Protocol channels.

[1] 5G New Radio. Fundamentals, procedures, testing aspects. 2020. Rohde&Schwarz
[Online]. Available: <https://gloris.rohde-schwarz.com/ebooks/5G>

Logical, transport, physical channels (R&S 5G book)

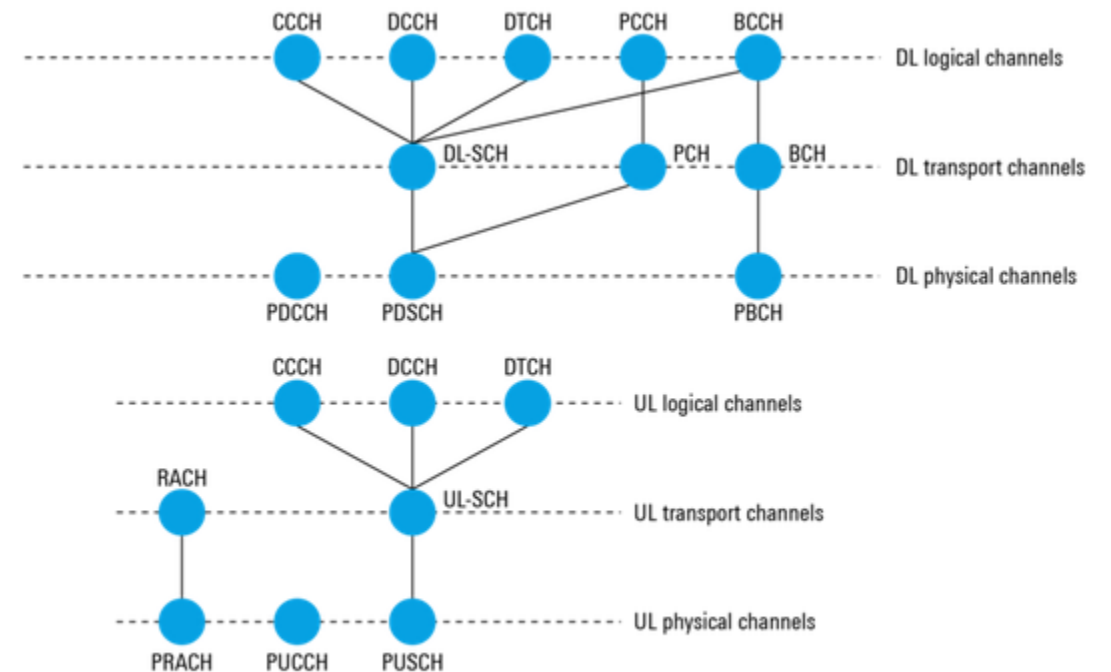
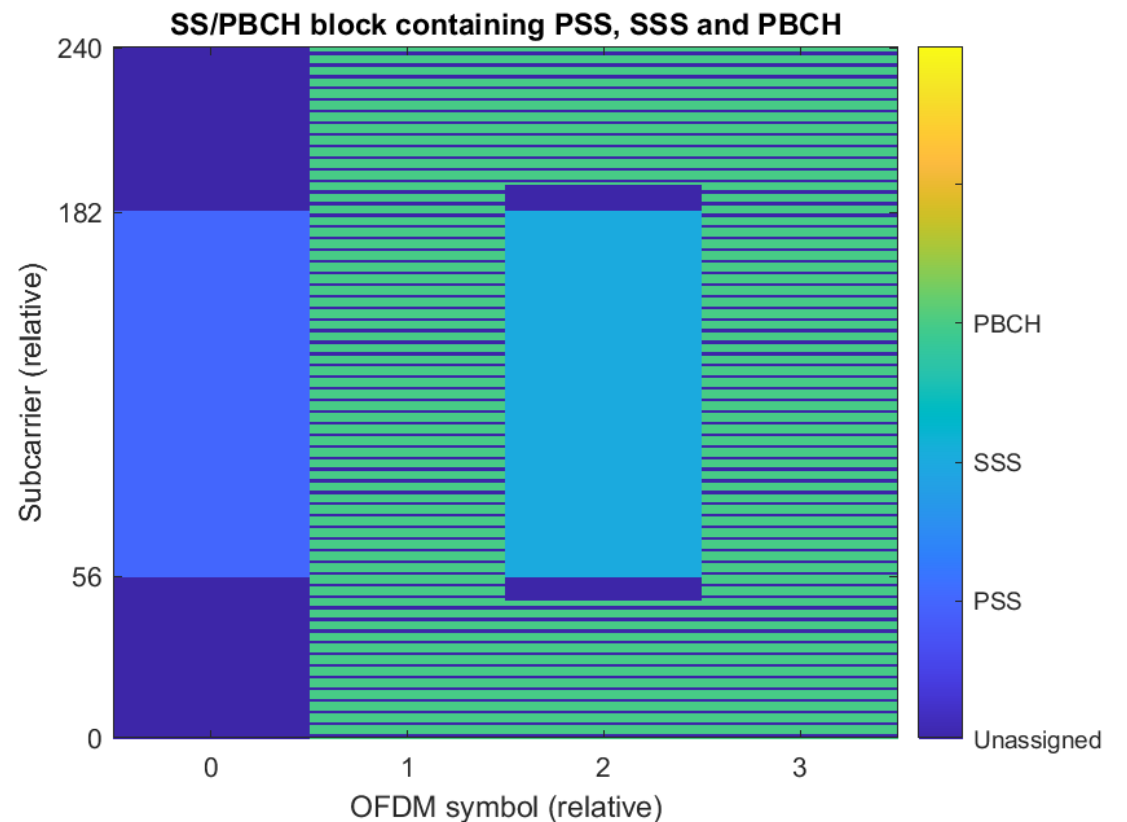


Fig. 1-10 NR logical, transport and physical channel mapping for the uplink and downlink.

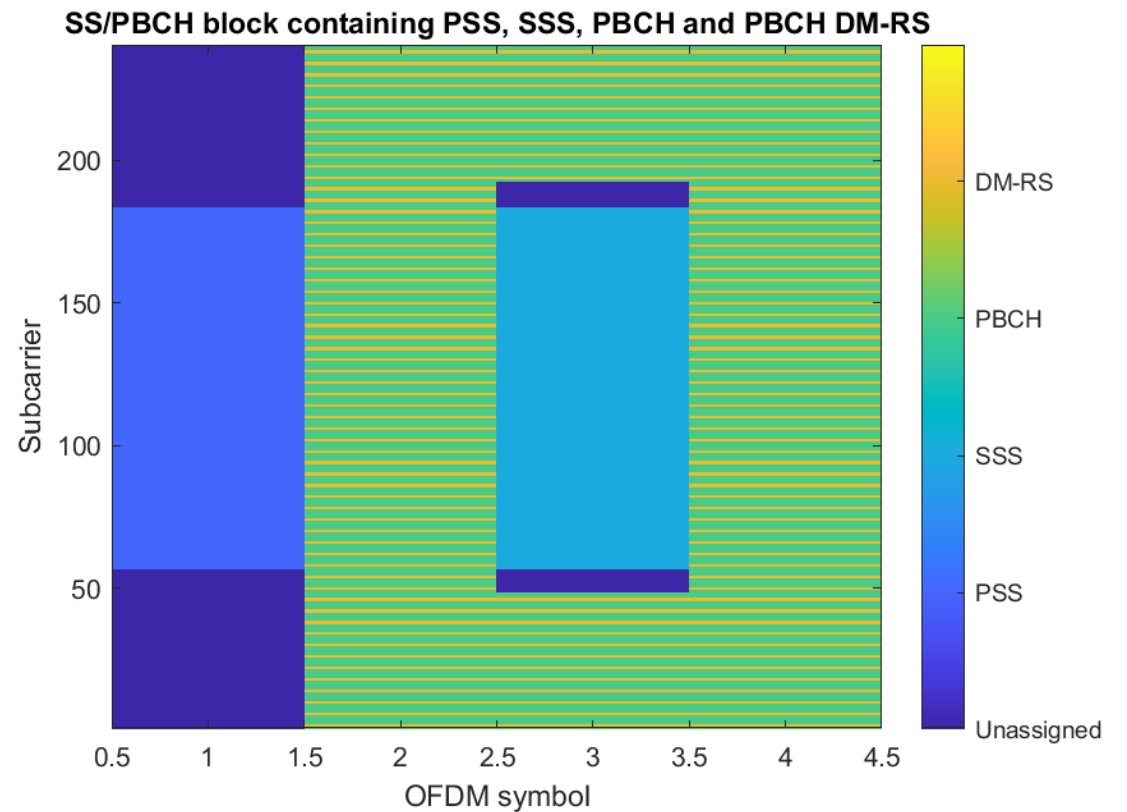
Physical Broadcast Channel (PBCH)

- UE acquires time and frequency synchronization with the serving cell based on receptions of SS/PBCH blocks
- PBCH contains system frame number (SFN)
- PBCH location in resource grid relative to SS/PBCH
 - OFDM symbols number 1 and 3, and subcarriers number 0-239
 - OFDM symbol number 2 and subcarriers number 0-47 and 192-239
- PBCH carries system information
 - master information block (MIB) periodically



Demodulation reference signals (DM-RS)

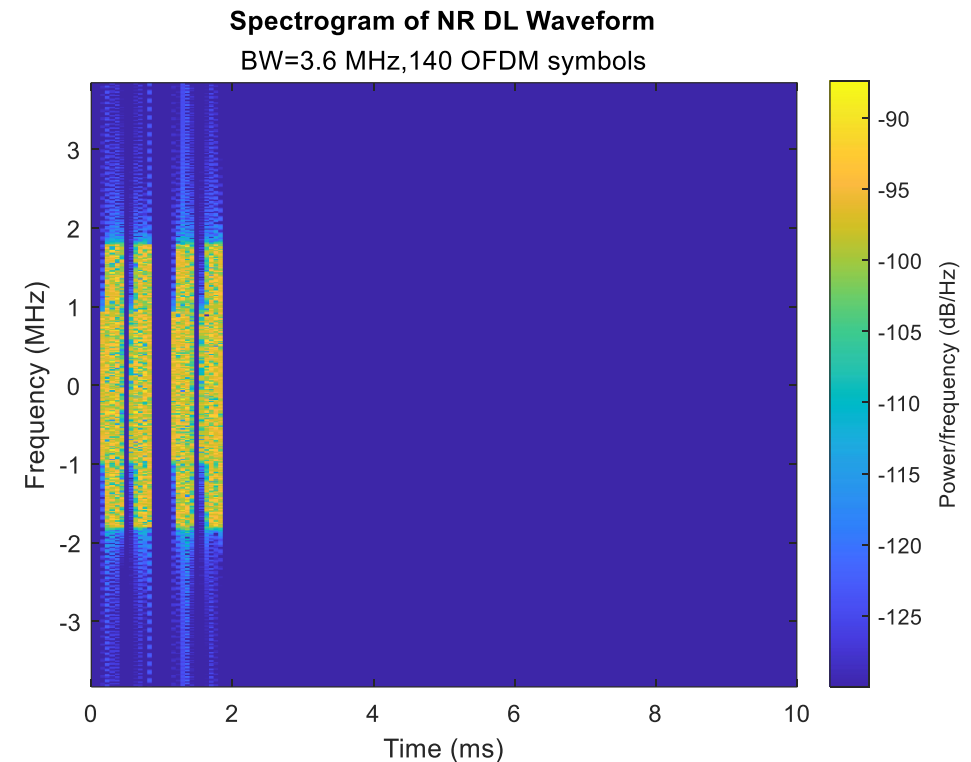
- DM-RS are for reference of demodulation of MIB
- DM-RS use each 4th subcarrier of PBCH
 - Subcarriers calculated by: $\text{cell id mod } 4$



SS/PBCH on waveform image

For Waveform

- [ssb = nrWavegenSSBurstConfig](#)
 - Creates complete SS/PBCH block



[1] Synchronization Signal Blocks and Bursts [MATLAB]

<https://se.mathworks.com/help/5g/gs/synchronization-signal-blocks-and-bursts.html>

[2] <https://se.mathworks.com/videos/5g-explained-synchronization-signal-blocks-in-5g-nr-1577445332091.html>

Tasks for lab 2 (report deadline 25.02.2025)

- Use MATLAB code in moodle [Lab 2 MATLAB code for starting point](#)
- $\mu=2$
 - Compare resource grid for frame and waveform, if cyclic prefix is normal and extended.
- 4 figures:
 1. Fig.1 grid for normal CP
 2. Fig.2 grid for extended CP
 3. Fig.3 DL waveform for normal CP
 4. Fig.4 DL waveform for extended CP
- Create SS/PBCH block which contains
 1. PSS
 2. SSS
 3. PBCH
 4. DM-RS
- Calculate how many REs can be used for UE data transmission in RB (12 subcarriers and 1 slot) which contains any or all of the synchronization signals