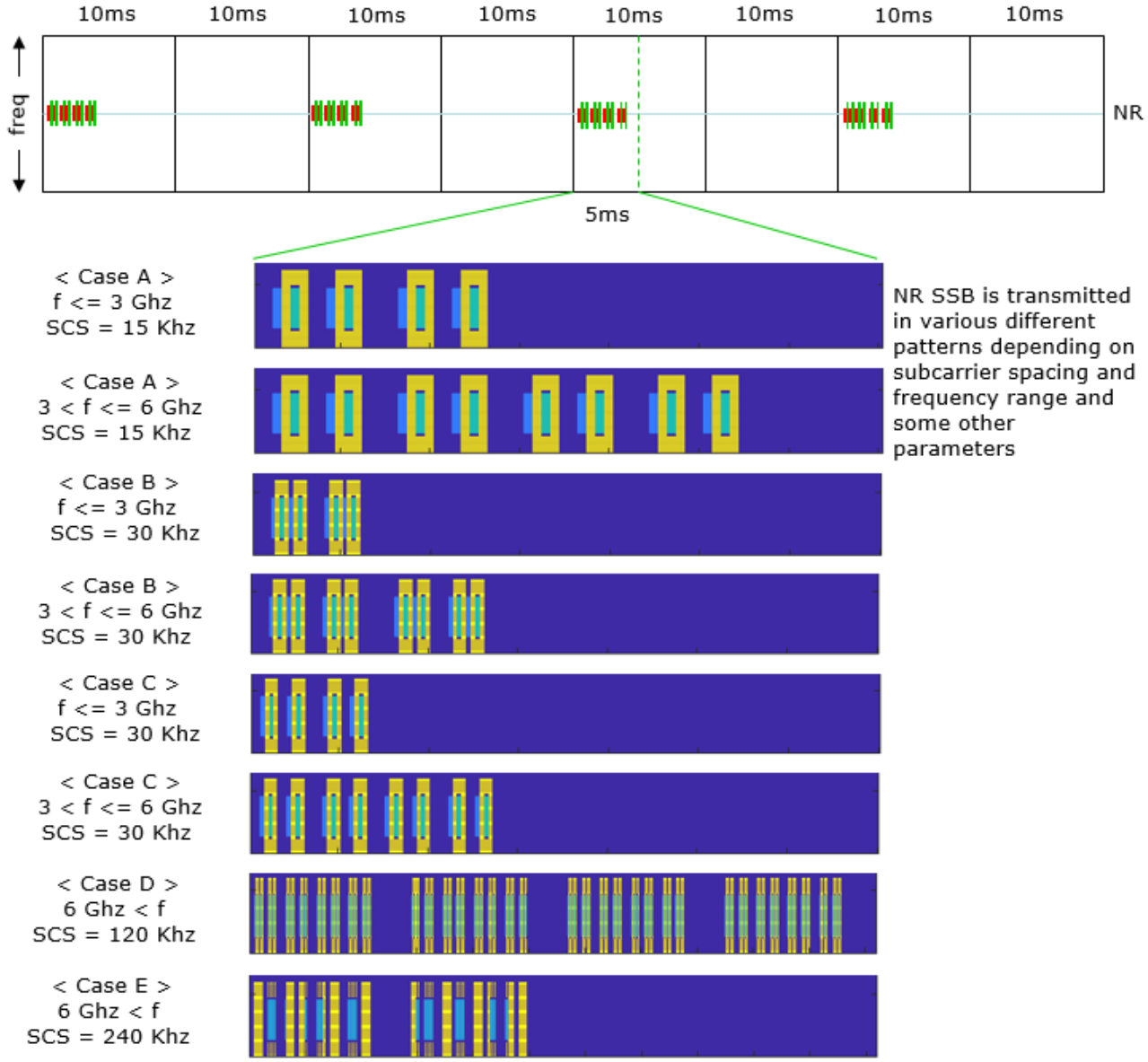
Lab 3

Physical channels in downlink grid

Initial access

- First, UE is doing cell search: UE receives SSB, which contains MIB
- MIB tells where to find SIB1 in PDCCH
  - CORESET contains common and UE specific search spaces for PDCCH candidates
- MIB+SIB1=minimum system information (MSI)
  - RRC message: BCCH (logical)→BCH (transport)→PBCH (physical)

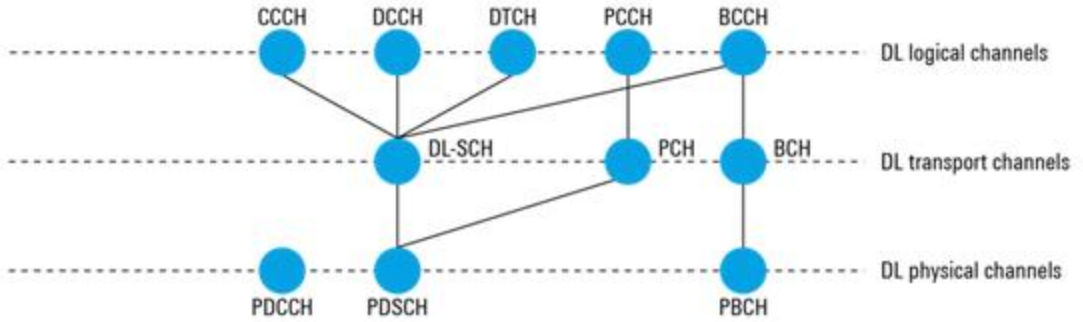


SSB - Synchronization Signal Block
MIB - Master Information Block
SIB1 - System Information Block 1
CORESET - Control resource set
PDCCH - Physical Downlink Control Channel

https://www.sharetechnote.com/html/5G/5G_SS_Block.html

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

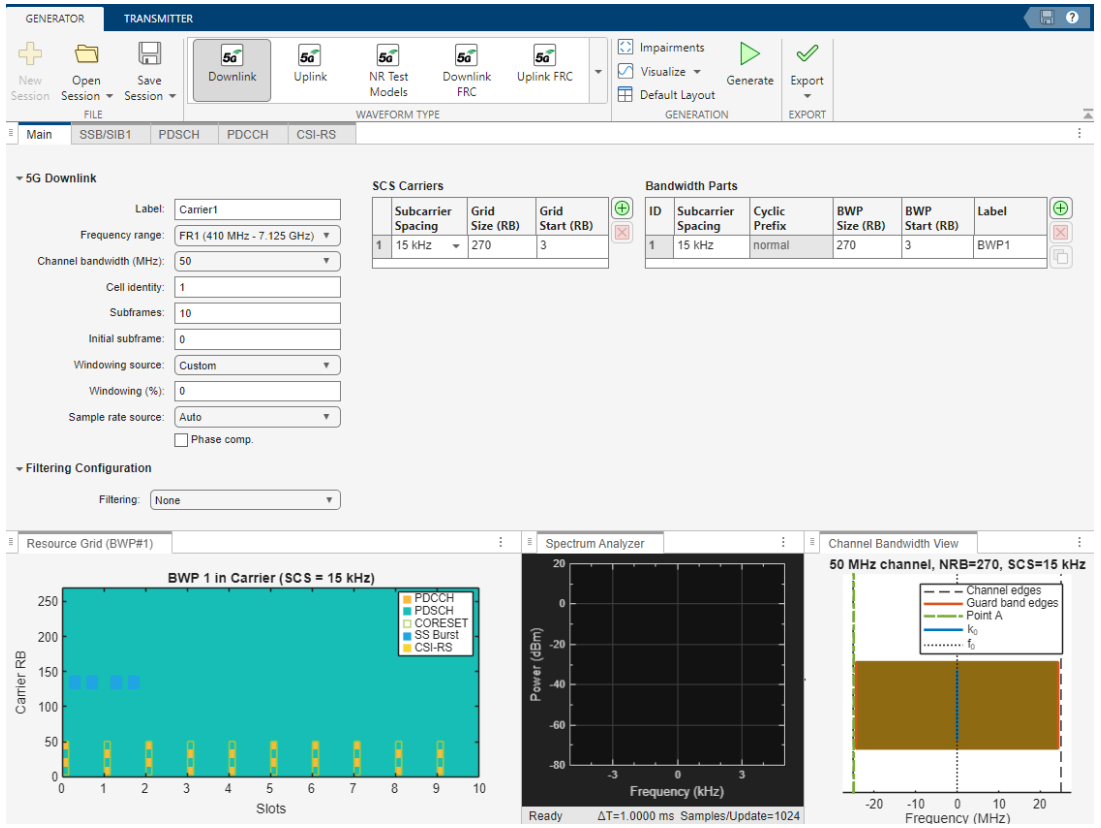
- PBCH – physical broadcast channel
- PDCCH – physical downlink control channel
- PDSCH – physical downlink shared channel



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

Wireless Waveform Generator Downlink

- Main
  - Carrier, SCS carrier, BWP
- SSB/SIB1
  - SS Burst, payload (MIB)
- PDSCH
- PDCCH
  - CORESET, Search spaces, PDCCH
- CSI-RS



Data from **Lab3_example_MSI.txt**

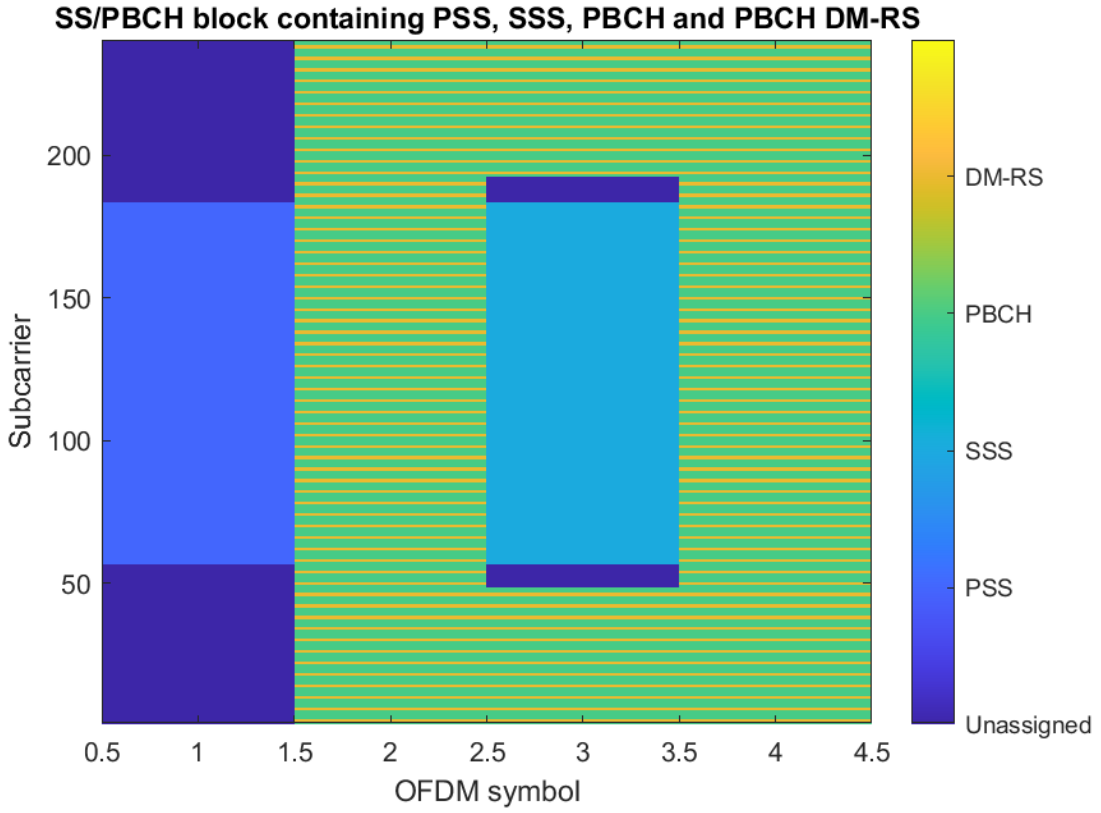
```
MCC: 248, MNC: 27 [1/1]
 5G NR Channel 1#10 @ 3948.960 MHz (663264) [1/1]
 gNodeB - ID:47/177 PCI:1
 Position
 State: not available
 Database: Base Station not in Database
 Provider: MCC: 248, MNC: 27
 GCI: 248 27 1000 47/177
 Subcarrier Spacing: -
 Bands as list: 77
 Carrier Bandwidth: 18.360 MHz
 BWP Bandwidth: 18.360 MHz
 BWP Center Frequency: 3949.98 MHz
 TDD Configuration: DDDFU (2.5 ms) | DDFUU (2.5 ms)
 TDD Configuration(full): D3-d10-f2u2-U1 D2-d10-f2u2-U2
 (N)SA Support: SA Supported
 RAN slicing: no
 RedCap Support: n.a.

 BCCH BCH Message
  _BCCH_BCH_Message message: mib
       systemFrameNumber  (0x37)  '110111'B
       systemFrameNumber[]  (55)  55
       subCarrierSpacingCommon  (1)  scs30or120
       ssb_SubcarrierOffset  0
       dmrs_TypeA_Position  (0)  pos2
       pdcch_ConfigSIB1  2
          controlResourceSetZero  10
          searchSpaceZero  5
       cellBarred  (1)  notBarred
       intraFreqReselection  (0)  allowed
       spare  (0x00)  '0'B

 System Information Block 1
  _SIB1
    cellSelectionInfo  5
      q_RxLevMin  -65
      q_RxLevMin[dBm]  (-130)  -130
    cellAccessRelatedInfo : plmn_IdentityInfoList
         (7)  _PLMN_IdentityInfo
          plmn_IdentityList : _PLMN_Identity
              mcc  3
                 MCC_MNC_Digit  2
                 MCC_MNC_Digit  4
                 MCC_MNC_Digit  8
              mnc  2
                 MCC_MNC_Digit  2
                 MCC_MNC_Digit  7
          trackingAreaCode  (0x0003e8)
'00000000000000001111101000'B
          trackingAreaCode[]  (1000)  1000
          cellIdentity  (0x000002fb10)
'00000000000000000000000010111110110001'B
          cellIdentity[36Bit 28/8]  (12209)  47/177
          cellReservedForOperatorUse  (1)  notReserved
    si_SchedulingInfo  5
       schedulingInfoList : _SchedulingInfo
          si_BroadcastStatus  (0)  broadcasting
          si_Periodicity  (3)  rf64
          sib_MappingInfo  2
            _SIB_TypeInfo
             type  (1)  sibType3
             valueTag  0
            _SIB_TypeInfo
             type  (0)  sibType2
             valueTag  0
       si_WindowLength  (3)  s40
    servingCellConfigCommon  10
      downlinkConfigCommon  5
        frequencyInfoDL  3
          frequencyBandList : _NR_MultiBandInfo
              freqBandIndicatorNR  77
          offsetToPointA  24
          scs_SpecificCarrierList : _SCS_SpecificCarrier
              offsetToCarrier  0
              subcarrierSpacing  (1)  kHz30
              carrierBandwidth  51
        initialDownlinkBWP  (3)  _BWP_DownlinkCommon
          genericParameters  (3)  _BWP
            locationAndBandwidth  13750
            subcarrierSpacing  (1)  kHz30
          pdcch_ConfigCommon setup:
 _PDCCH_ConfigCommon
              controlResourceSetZero  10
              searchSpaceZero  5
              commonSearchSpaceList  3
                 _SearchSpace
                  searchSpaceId  1
                  controlResourceSetId  0
                  monitoringSlotPperiodicityAndOffset sl5: 0
                  duration  2
                  monitoringSymbolsWithinSlot  (0x2000)
 '10000000000000'B
                  nrofCandidates  5
                    aggregationLevel1  (0)  n0
                    aggregationLevel2  (0)  n0
                    aggregationLevel4  (2)  n2
                    aggregationLevel8  (0)  n0
                    aggregationLevel16  (0)  n0
                  searchSpaceType common: 5
                     dci_Format0_0_AndFormat1_0 : No
 Information Element
                 _SearchSpace
                  searchSpaceId  2
                  controlResourceSetId  0
                  monitoringSlotPeriodicityAndOffset sl1: 0
                  monitoringSymbolsWithinSlot  (0x3000)
 '11000000000000'B
                  nrofCandidates  5
                    aggregationLevel1  (0)  n0
                    aggregationLevel2  (0)  n0
                    aggregationLevel4  (2)  n2
                    aggregationLevel8  (0)  n0
                    aggregationLevel16  (0)  n0
                  searchSpaceType common: 5
                     dci_Format0_0_AndFormat1_0 : No
 Information Element
                 _SearchSpace
                  searchSpaceId  3
                  controlResourceSetId  0
                  monitoringSlotPeriodicityAndOffset sl5: 0
                  duration  2
                  monitoringSymbolsWithinSlot  (0x2000)
 '10000000000000'B
                  nrofCandidates  5
                    aggregationLevel1  (0)  n0
                    aggregationLevel2  (0)  n0
                    aggregationLevel4  (2)  n2
                    aggregationLevel8  (0)  n0
                    aggregationLevel16  (0)  n0
                  searchSpaceType common: 5
                     dci_Format0_0_AndFormat1_0 : No
 Information Element
                 searchSpaceSIB1  0
                 searchSpaceOtherSystemInformation  1
                 pagingSearchSpace  3
                 ra_SearchSpace  2
               pdsch_ConfigCommon setup: _PDSCH_ConfigCommon
                 pdsch_TimeDomainAllocationList  4
                   _PDSCH_TimeDomainResourceAllocation
                    k0  0
                    mappingType  (0)  typeA
                    startSymbolAndLength  40
                   _PDSCH_TimeDomainResourceAllocation
                    k0  0
                    mappingType  (0)  typeA
                    startSymbolAndLength  54
                   _PDSCH_TimeDomainResourceAllocation
                    k0  0
                    mappingType  (0)  typeA
                    startSymbolAndLength  53
                   _PDSCH_TimeDomainResourceAllocation
                    k0  0
                    mappingType  (0)  typeA
                    startSymbolAndLength  67
          bcch_Config : modificationPeriodCoeff
             n2
          pcch_Config  6
            defaultPagingCycle  (2)  rf128
            nAndPagingFrameOffset quarterT: 1
            ns  (2)  one
            firstPDCCH_MonitoringOccasionOfPO
 sCS120KHZoneT_SCS60KHZhalfT_SCS30KHZquarterT_SCS15KHZ
 oneEighthT: 1
                 _of27_  3
        uplinkConfigCommon  3
          frequencyInfoUL  5
            scs_SpecificCarrierList : _SCS_SpecificCarrier
               offsetToCarrier  0
               subcarrierSpacing  (1)  kHz30
               carrierBandwidth  51
            p_Max  20
          initialUplinkBWP  (6)  _BWP_UplinkCommon
            genericParameters  (3)  _BWP
               locationAndBandwidth  13750
               subcarrierSpacing  (1)  kHz30
             rach_ConfigCommon setup: _RACH_ConfigCommon
               rach_ConfigGeneric  10
                 prach_ConfigurationIndex  98
                 msg1_FDM  (0)  one
                 msg1_FrequencyStart  13
                 zeroCorrelationZoneConfig  15
                 preambleReceivedTargetPower  -104
                 preambleTransMax  (6)  n10
                 powerRampingStep  (1)  dB2
                 ra_ResponseWindow  (7)  sl80
               ssb_perRACH_OccasionAndCB_PreamblesPerSSB
 one: n56
               ra_ContentionResolutionTimer  (7)  sf64
               rsrp_ThresholdSSB  37
               prach_RootSequenceIndex l139: 0
               msg1_SubcarrierSpacing  (1)  kHz30
               restrictedSetConfig  (0)  unrestrictedSet
             pusch_ConfigCommon setup:
 _PUSCH_ConfigCommon
               pusch_TimeDomainAllocationList  10
                 _PUSCH_TimeDomainResourceAllocation
                  k2  2
                  mappingType  (1)  typeB
                  startSymbolAndLength  27
                 _PUSCH_TimeDomainResourceAllocation
                  k2  2
                  mappingType  (1)  typeB
                  startSymbolAndLength  41
                 _PUSCH_TimeDomainResourceAllocation
                  k2  3
                  mappingType  (1)  typeB
                  startSymbolAndLength  27
                 _PUSCH_TimeDomainResourceAllocation
                  k2  3
                  mappingType  (1)  typeB
                  startSymbolAndLength  41
                 _PUSCH_TimeDomainResourceAllocation
                  k2  4
                  mappingType  (1)  typeB
                  startSymbolAndLength  27
                 _PUSCH_TimeDomainResourceAllocation
                  k2  5
                  mappingType  (1)  typeB
                  startSymbolAndLength  27
                 _PUSCH_TimeDomainResourceAllocation
                  k2  6
                  mappingType  (1)  typeB
                  startSymbolAndLength  27
                 _PUSCH_TimeDomainResourceAllocation
                  k2  9
                  mappingType  (1)  typeB
                  startSymbolAndLength  27
                 _PUSCH_TimeDomainResourceAllocation
                  k2  10
                  mappingType  (1)  typeB
                  startSymbolAndLength  27
                 _PUSCH_TimeDomainResourceAllocation
                  k2  11
                  mappingType  (1)  typeB
                  startSymbolAndLength  27
               msg3_DeltaPreamble  1
               p0_NominalWithGrant  -96
             pucch_ConfigCommon setup:
 _PUCCH_ConfigCommon
                pucch_ResourceCommon  15
                pucch_GroupHopping  (0)  neither
                hoppingId  1
                p0_nominal  -108
           timeAlignmentTimerCommon  (7)  infinity
         ssb_PositionsInBurst : inOneGroup
            '10000000'B
         ssb_PeriodicityServingCell  (2)  ms20
         tdd_UL_DL_ConfigurationCommon  (3)
 _TDD_UL_DL_ConfigCommon
           referenceSubcarrierSpacing  (1)  kHz30
           pattern1  (6)  _TDD_UL_DL_Pattern
             dl_UL_TransmissionPeriodicity  (5)  ms2p5
             nrofDownlinkSlots  3
             nrofDownlinkSymbols  10
             nrofUplinkSlots  1
             nrofUplinkSymbols  2
           pattern2  (6)  _TDD_UL_DL_Pattern
             dl_UL_TransmissionPeriodicity  (5)  ms2p5
             nrofDownlinkSlots  2
             nrofDownlinkSymbols  10
             nrofUplinkSlots  2
             nrofUplinkSymbols  2
         ss_PBCH_BlockPower  -6
       ims_EmergencySupport  (0)  TruE
       ue_TimersAndConstants  7
         t300  (3)  ms400
         t301  (3)  ms400
         t310  (6)  ms2000
         n310  (6)  n10
         t311  (1)  ms3000
         n311  (0)  n1
         t319  (3)  ms400
       nonCriticalExtension _SIB1_v1610_IEs: nonCriticalExtension
          _SIB1_v1630_IEs nonCriticalExtension: _SIB1_v1700_IEs
             redCap_ConfigCommon_r17
 _RedCap_ConfigCommonSIB_r17: cellBarredRedCap_r17
                cellBarredRedCap1Rx_r17  (1)  notBarred
                cellBarredRedCap2Rx_r17  (1)  notBarred
             intraFreqReselectionRedCap_r17  (0)  allowed
```

Master information block (MIB)

- Data is MIB
- Signals are in SS/PBCH
- SS Burst



MIB processing before transmission

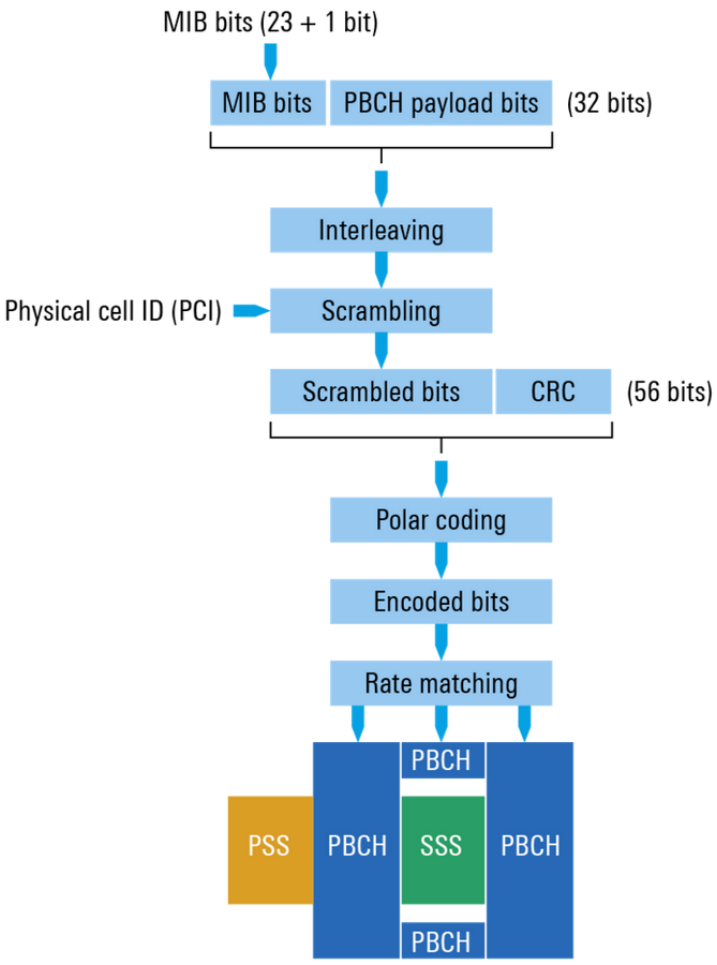
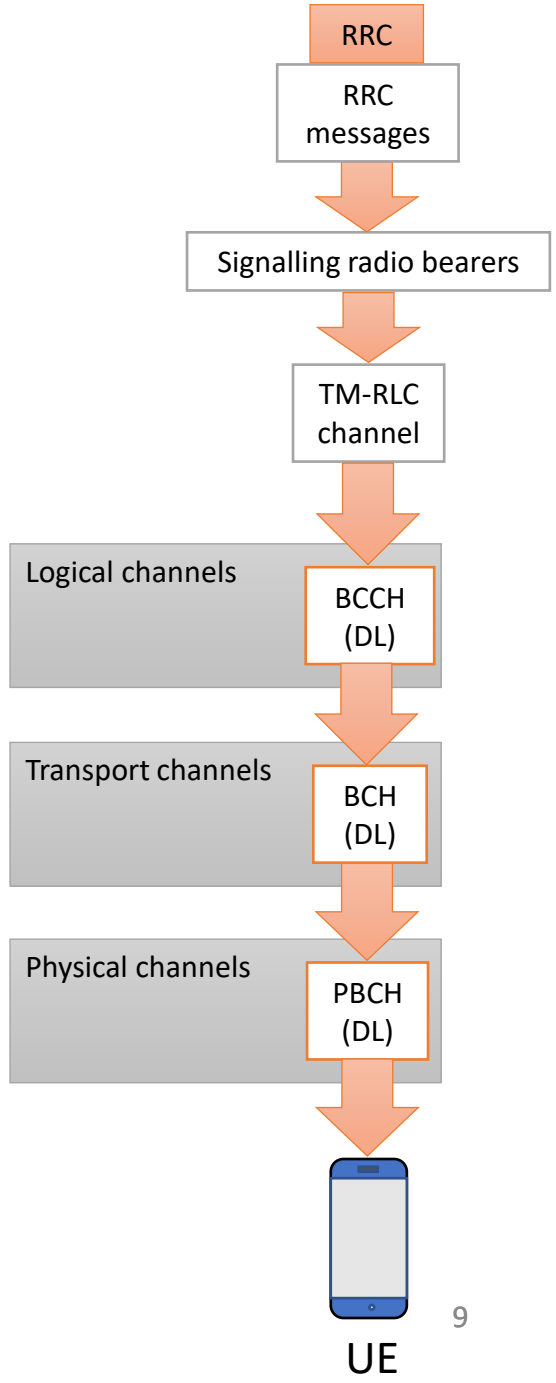


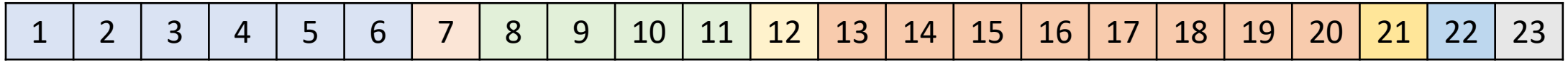
Fig. 2-13 Channel coding chain for the master information block (*MIB*) in 5G *NR*.



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

SFN=System Frame Number

MIB bits (23)



SFN
6 bits

SCS Common
1 bit
0=15 or 60
1=30 or 120

SCS used for
PDCCH and PDSCH

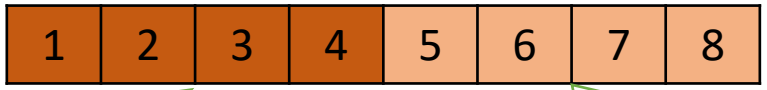
Subcarrier
offset
k_SSB
4 bits
(0-15)

Dmrs-TypeA-
Position
1bit
0=pos2
1=pos3

Pdcch-
ConfigSIB1
8 bits

4 MSBs

4 LSBs



Find based on index: the SSB and CORESET multiplex pattern, num of RBs and symbols for CORESET, and offset RBs

cellBarred
1 bit
0=barred,
1=notBarred

intraFreqReselection
1 bit
0=allowed,
1=notAllowed

Spare
bit
1 bit

O and M used for SFN and slot number to start monitor DL

Find based on index: the O, number of search space sets per slot, M, and 1st symbol index

Tables 13-1 … 13-10 from TS 38.213
Table selected by detected SCS of SSB and obtained SCS Common bit value

Tables 13-11 … 13-12 from TS 38.213
Table selected by SSB and CORESET multiplexing pattern =1 (from tables 13-1…13-10);
Tables 13-13…13-15 from TS 38.213 if pattern=2 or 3

Main: carrier

MCC: 248, MNC: 27 [1/1]

5G NR Channel 1#10 @ 3948.960 MHz (663264) [1/1]

gNodeB - ID:47/177 PCI:1

Position

State: not available

Database: Base Station not in Database

Provider: MCC: 248, MNC: 27

GCI: 248 27 1000 47/177

Subcarrier Spacing: -

Bands as list: 77

Carrier Bandwidth: 18.360 MHz

BWP Bandwidth: 18.360 MHz

BWP Center Frequency: 3949.98 MHz

TDD Configuration: DDDFU (2.5 ms) | DDFUU (2.5 ms)

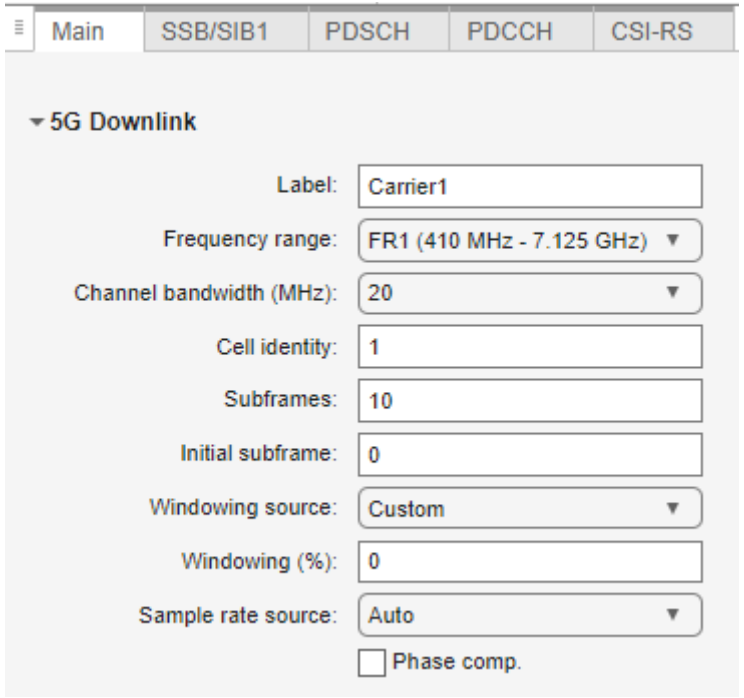
TDD Configuration(full): D3-d10-f2u2-U1 D2-d10-f2u2-U2

(N)SA Support: SA Supported

RAN slicing: no

RedCap Support: n.a.

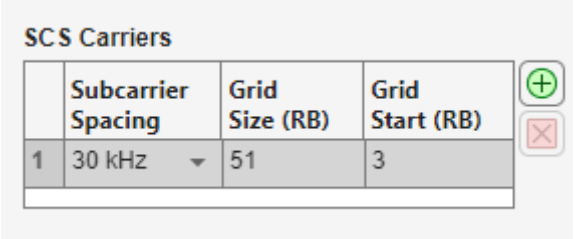
Data from **Lab3_example_MSI.txt**



Main: SCS carrier

```
BCCH BCH Message
 _BCCH_BCH_Message message: mib
      systemFrameNumber  (0x37)   '110111'B
      systemFrameNumber[]  (55)  55
      subCarrierSpacingCommon  (1)  scs30or120
      ssb_SubcarrierOffset  0
      dmrs_TypeA_Position  (0)  pos2
      pdcch_ConfigSIB1  2
         controlResourceSetZero  10
         searchSpaceZero  5
      cellBarred  (1)  notBarred
      intraFreqReselection  (0)  allowed
      spare  (0x00)   '0'B
```

Data from **Lab3_example_MSI.txt**



Main: BWP

MCC: 248, MNC: 27 [1/1]

5G NR Channel 1#10 @ 3948.960 MHz (663264) [1/1]

gNodeB - ID:47/177 PCI:1

Position

State: not available

Database: Base Station not in Database

Provider: MCC: 248, MNC: 27

GCI: 248 27 1000 47/177

Subcarrier Spacing: -

Bands as list: 77

Carrier Bandwidth: 18.360 MHz

BWP Bandwidth: 18.360 MHz

BWP Center Frequency: 3949.98 MHz

TDD Configuration: DDDFU (2.5 ms) | DDFUU (2.5 ms)

TDD Configuration(full): D3-d10-f2u2-U1 D2-d10-f2u2-U2

(N)SA Support: SA Supported

RAN slicing: no

RedCap Support: n.a.

Bandwidth Parts

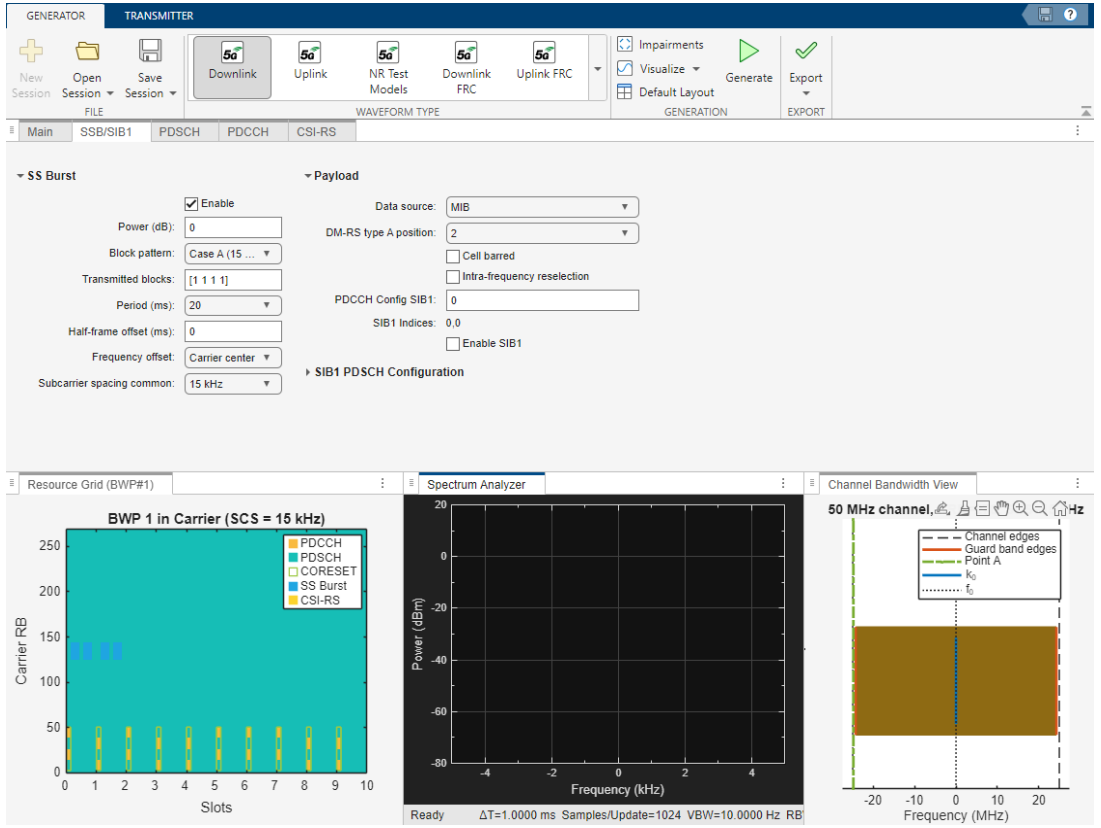
ID	Subcarrier Spacing	Cyclic Prefix	BWP Size (RB)	BWP Start (RB)	Label
1	30 kHz	normal	51	3	BWP1

BCCH BCH Message
_BCCH_BCH_Message message: mib
systemFrameNumber (0x37) '110111'B
systemFrameNumber[] (55) 55
subCarrierSpacingCommon (1) scs30or120
ssb_SubcarrierOffset 0
dmrs_TypeA_Position (0) pos2
pdcch_ConfigSIB1 2
controlResourceSetZero 10
searchSpaceZero 5
cellBarred (1) notBarred
intraFreqReselection (0) allowed
spare (0x00) '0'B

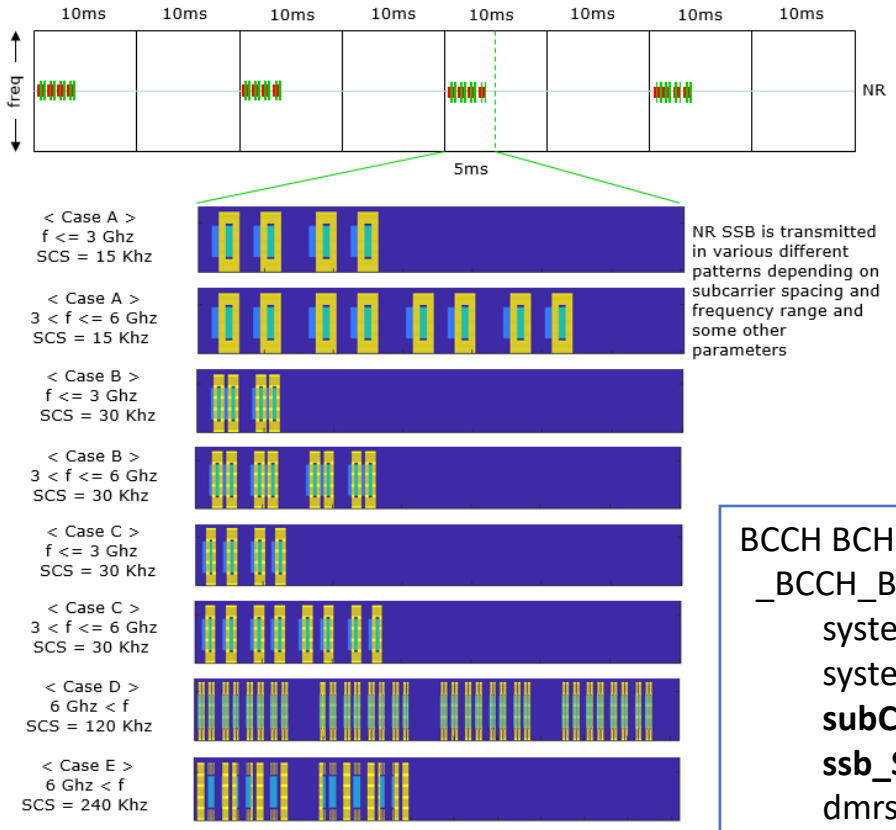
Data from **Lab3_example_MSI.txt**

SS Burst

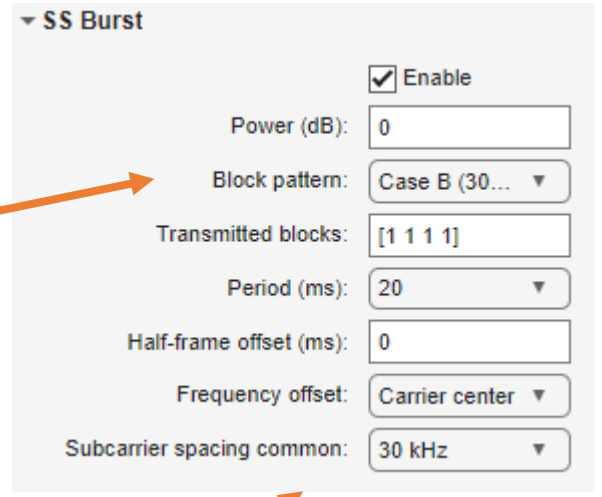
- SS Burst (SS-PBCH)
  - Block pattern – different for FR1 and FR2



SSB



NR SSB is transmitted in various different patterns depending on subcarrier spacing and frequency range and some other parameters

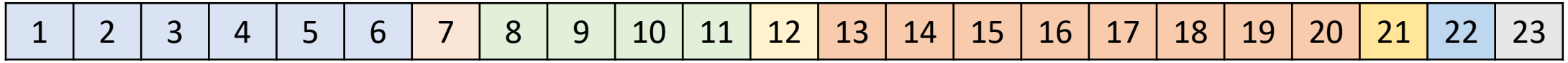


BCCH BCH Message
_BCCH_BCH_Message message: mib
systemFrameNumber (0x37) '110111'B
systemFrameNumber[] (55) 55
subCarrierSpacingCommon (1) scs30or120
ssb_SubcarrierOffset 0
dmrs_TypeA_Position (0) pos2
pdcch_ConfigSIB1 2
controlResourceSetZero 10
searchSpaceZero 5
cellBarred (1) notBarred
intraFreqReselection (0) allowed
spare (0x00) '0'B

Data from **Lab3_example_MSI.txt**

SFN=System Frame Number

How to search where is SIB1 from MIB



SFN
6 bits

SCS Common
1 bit
0=15 or 60
1=30 or 120

SCS used for
PDCCH and PDSCH

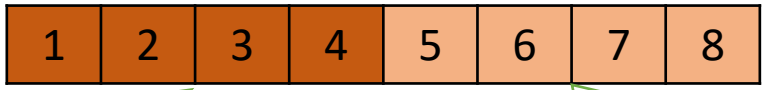
Subcarrier
offset
k_SSB
4 bits
(0-15)

Dmrs-TypeA-
Position
1bit
0=pos2
1=pos3

Pdcch-
ConfigSIB1
8 bits

4 MSBs

4 LSBs



Find based on index: the SSB and CORESET multiplex pattern, num of RBs and symbols for CORESET, and offset RBs

cellBarred
1 bit
0=barred,
1=notBarred

intraFreqReselection
1 bit
0=allowed,
1=notAllowed

Spare
bit
1 bit

O and M used for SFN and slot number to start monitor DL

Find based on index: the O, number of search space sets per slot, M, and 1st symbol index

Tables 13-1 … 13-10 from TS 38.213
Table selected by detected SCS of SSB and obtained SCS Common bit value

Tables 13-11 (FR1) … 13-12 (FR2) from TS 38.213
Table selected by SSB and CORESET multiplexing pattern =1 (from tables 13-1…13-10);
Tables 13-13…13-15 from TS 38.213 if pattern=2 or 3

Location of CORESET0

Data from **Lab3_example_MSI.txt**

```
BCCH BCH Message
  _BCCH_BCH_Message message: mib
        systemFrameNumber  (0x37)  '110111'B
        systemFrameNumber[]  (55)  55
        subCarrierSpacingCommon  (1)  scs30or120
        ssb_SubcarrierOffset  0
        dmrs_TypeA_Position  (0)  pos2
        pdcch_ConfigSIB1  2
           controlResourceSetZero  10
           searchSpaceZero  5
        cellBarred  (1)  notBarred
        intraFreqReselection  (0)  allowed
        spare  (0x00)  '0'B
```

Table 13-4 of 3GPP TS 38.213 V15.15.0

Table 13-11 of 3GPP TS 38.213 V15.15.0

Table 13-4: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {30, 30} kHz for frequency bands with minimum channel bandwidth 5 MHz or 10 MHz

Index	SS/PBCH block and CORESET multiplexing pattern	Number of RBs $N_{RB}^{CORESET}$	Number of Symbols $N_{symb}^{CORESET}$	Offset (RBs)
0	1	24	2	0
1	1	24	2	1
2	1	24	2	2
3	1	24	2	3
4	1	24	2	4
5	1	24	3	0
6	1	24	3	1
7	1	24	3	2
8	1	24	3	3
9	1	24	3	4
10	1	48	1	12
11	1	48	1	14
12	1	48	1	16
13	1	48	2	12
14	1	48	2	14
15	1	48	2	16

Table 13-11: Parameters for PDCCH monitoring occasions for Type0-PDCCH CSS set - SS/PBCH block and CORESET multiplexing pattern 1 and FR1

Index	O	Number of search space sets per slot	M	First symbol index
0	0	1	1	0
1	0	2	1/2	{0, if i is even}, { $N_{symb}^{CORESET}$, if i is odd}
2	2	1	1	0
3	2	2	1/2	{0, if i is even}, { $N_{symb}^{CORESET}$, if i is odd}
4	5	1	1	0
5	5	2	1/2	{0, if i is even}, { $N_{symb}^{CORESET}$, if i is odd}
6	7	1	1	0
7	7	2	1/2	{0, if i is even}, { $N_{symb}^{CORESET}$, if i is odd}
8	0	1	2	0
9	5	1	2	0
10	0	1	1	1
11	0	1	1	2
12	2	1	1	1
13	2	1	1	2
14	5	1	1	1
15	5	1	1	2

[1] 3GPP, "TS 38.213 - NR; Physical layer procedures for control," 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38213.htm

MIB → find SIB1

BCCH BCH Message

_BCCH_BCH_Message message: mib

systemFrameNumber (0x37) '110111'B

systemFrameNumber[] (55) 55

subCarrierSpacingCommon (1) scs30or120

ssb_SubcarrierOffset 0

dmrs_TypeA_Position (0) pos2

pdcch_ConfigSIB1 2

controlResourceSetZero 10

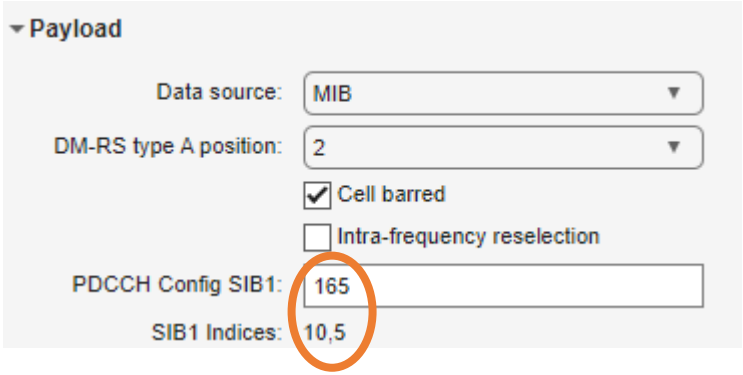
searchSpaceZero 5

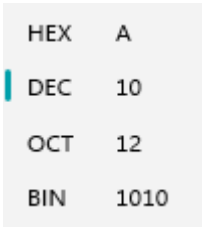
cellBarred (1) notBarred

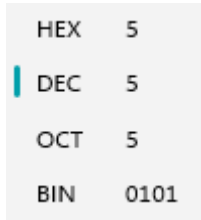
intraFreqReselection (0) allowed

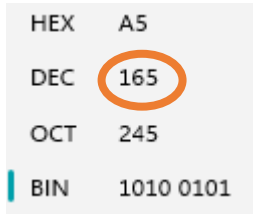
spare (0x00) '0'B

Data from **Lab3_example_MSI.txt**









SIB1

- SIB1 contains (check example **Lab3_example_MSI.txt**):
  - cellSelectionInfo
  - cellAccessRelatedInfo
  - ConnEstFailureControl
  - SI-SchedulingInfo
  - ServingCellCommonSIB
  - Support for IMS emergency support and support for eCall over IMS
  - UE-TimersAndConstants
  - Info related to unified access control (UAC)
- Other system information: UE requests and network sends messages

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

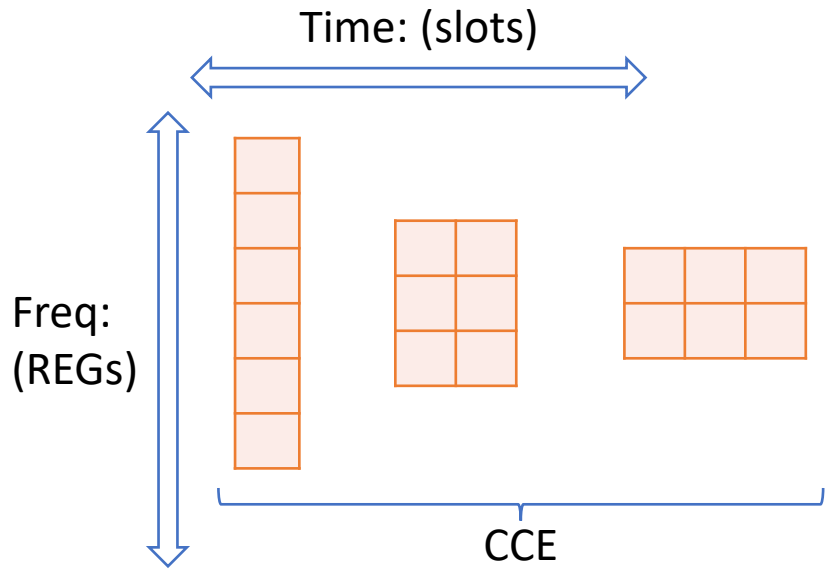
From SIB1 to find → PDCCH

- Physical Downlink Control Channel (PDCCH) contains:
  - Downlink control information (DCI)
  - Signals:
    - Demodulation reference signals (DM-RS)
- Resources in grid:
  - CORESET (a set of PDCCH candidates):
    - 2, 3 or 6 RBs and
    - 1, 2 or 3 symbols
    - 2x3, 3x2 or 6x1 (REG x symbols)
  - Symbols 0 and 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

CORESET

- Control resource set (CORESET)
- Set of candidate resources in search space to search for PDCCH
  - Contains 1 CCE=6 REG
  - On time-frequency scale CCE shape can be:
    - 1 symbol x 6 REGs
    - 2 symbols x 3 REGs
    - 3 symbols x 2 REGs
- Where to search for PDCCH?
  - Search space: common (CSS), UE-specific (USS)
    - A set of candidate CCEs at aggregation level
    - Aggregation level = number of CCEs that can be allocated for PDCCH



- CORESET = control resource set
- CCE = control channel element
- REG = resource element group
  - 12 subcarriers on frequency scale and 1 symbol on time scale is 1 REG
- CSS = common search space
- USS = UE-specific search space

[1] Wireless Explained. Search space and CORESET in 5G, 2023 https://www.youtube.com/watch?v=8vVtPE0qmaQ

Search space

```
commonSearchSpaceList  3
_SearchSpace
 searchSpaceId  1
 controlResourceSetId  0
 monitoringSlotPperiodicityAndOffset  sl5  0
 duration  2
 monitoringSymbolsWithinSlot  (0x2000)  '10000000000000'B
 nrofCandidates  5
   aggregationLevel1  (0)  n0
   aggregationLevel2  (0)  n0
   aggregationLevel4  (2)  n2
   aggregationLevel8  (0)  n0
   aggregationLevel16  (0)  n0
 searchSpaceType common: 5
    dci_Format0_0_AndFormat1_0 : No Information Element
_SearchSpace
 searchSpaceId  2
 controlResourceSetId  0
 monitoringSlotPperiodicityAndOffset  sl1  0
 monitoringSymbolsWithinSlot  (0x3000)  '11000000000000'B
 nrofCandidates  5
   aggregationLevel1  (0)  n0
   aggregationLevel2  (0)  n0
   aggregationLevel4  (2)  n2
   aggregationLevel8  (0)  n0
   aggregationLevel16  (0)  n0
 searchSpaceType common: 5
    dci_Format0_0_AndFormat1_0 : No Information Element
_SearchSpace
 searchSpaceId  3
 controlResourceSetId  0
 monitoringSlotPperiodicityAndOffset  sl5  0
 duration  2
 monitoringSymbolsWithinSlot  (0x2000)  '10000000000000'B
 nrofCandidates  5
   aggregationLevel1  (0)  n0
   aggregationLevel2  (0)  n0
   aggregationLevel4  (2)  n2
   aggregationLevel8  (0)  n0
   aggregationLevel16  (0)  n0
 searchSpaceType common: 5
    dci_Format0_0_AndFormat1_0 : No Information Element
```

monitoringSlotPeriodicityAndOffset : Slots for PDCCH Monitoring configured as periodicity and offset. *For example, if the value is sl1, it mean that UE should monitor the SearchSpace at every slot. if the value is sl4, it mean that UE should monitor the SearchSpace in every fourth slot.*

monitoringSymbolsWithinSlot : Symbols for PDCCH monitoring in the slots configured for PDCCH monitoring. The most significant (left) bit represents the first OFDM in a slot. The least significant (right) bit represents the last symbol. *This indicates the starting OFDM symbols that UE should search for a SearchSpace. For example, if the value is '1000000000000', it mean that UE should start searching from the first OFDM symbol. if the value is '0100000000000', it mean that UE should start searching from the second OFDM symbol.*

Search Spaces

ID	CORESET ID	Type	Start Sym...	Slot Period	Slot Offset	Duration	Candidat... Aggregat...	Label
1	0	common	0	5	0	2	[8 8 4 2 1]	SearchSpa
2	0	common	0	1	0	1	[8 8 4 2 1]	SearchSpa
3	0	common	0	5	0	2	[8 8 4 2 1]	SearchSpa

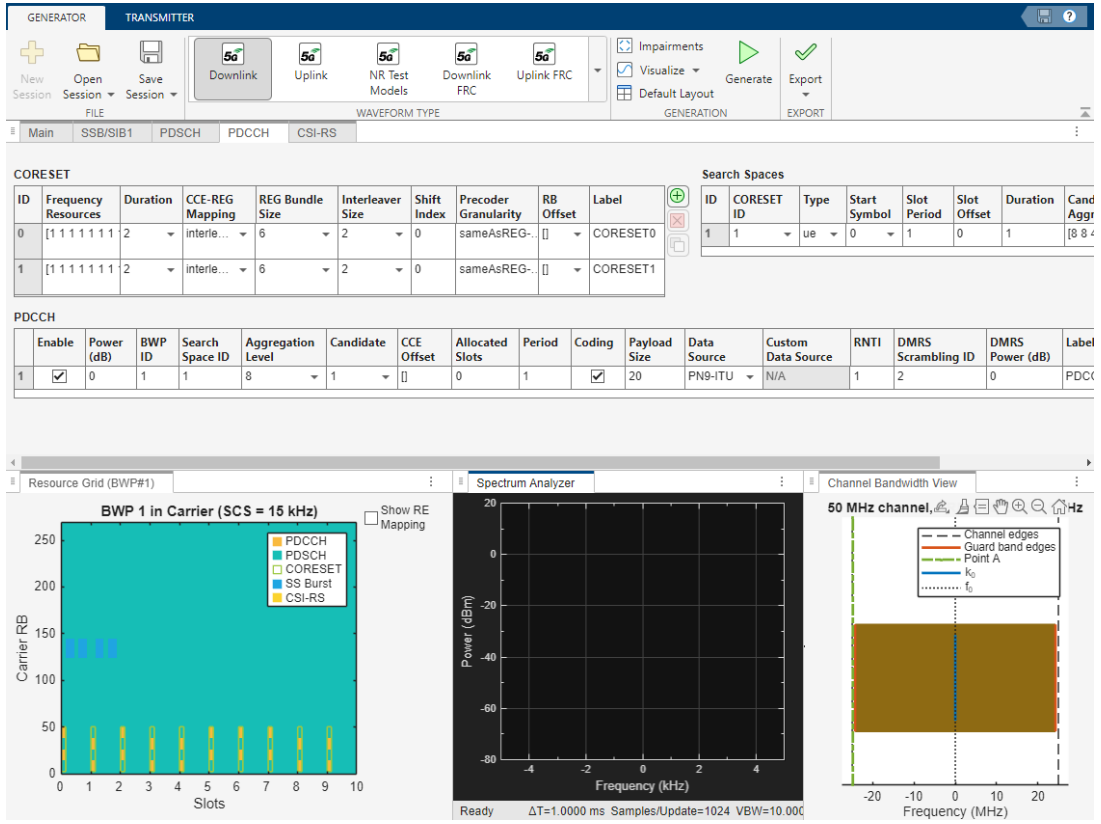
2 PDCCH candidates on aggregation level 4

Data from **Lab3_example_MSI.txt**

https://www.sharetechnote.com/html/5G/5G_SearchSpace.html

PDCCH

- CORESET → Search space → candidates → PDCCH



PDCCH content

- PDCCH contains DCI - downlink control information
- DCI contains (Rel-15) [1]
  - scheduling of UE or UE groups in one cell in UL (DCI type 0) and DL (DCI type 1),
  - UE group notification of slot format or PRBs and symbols of no transmission for UE (DCI type 2)
  - UE and UE group transmit power management for UL (DCI type 2)
  - CRC scrambled with Cell-RNTI (C-RNTI) of the UE
- Radio Network Temporary Identifier (RNTI): some are common (known for each UE), some are UE-specific and allocated during initial access, or RRC connection setup or reconfiguration

[1] MATLAB, 5G Explained: Downlink Control Information in 5G NR, 11.07.2019
https://www.youtube.com/watch?v=HBB2nKIDXSo
[2] 3GPP, “TS 38.212 - NR; Multiplexing and channel coding,” 2022. [Online].
Available: https://www.3gpp.org/DynaReport/38212.htm

DCI for DL scheduling (PDSCH), formats 1_0 and 1_1 ([1], section 2.2.3)

Format 1_0	Format 1_1
Identifier, 1 bit=1	Identifier, 1 bit=1
	Carrier indicator (0 or 3 bits)
	BWP indicator
Freq domain resource assignment	Freq domain resource assignment
Time domain resource assingment	Time domain resource assingment
	Virtual to phy RB mapping valid flag
	PRB bundling size indicator
MCS	Rate matching indicator
New data indicator (NDI)	For transport block 1: MCS, NDI, redundancy version
Redundancy version	For TB 2 MCS, NDI, redundancy
HARQ process number	HARQ process number
DL assingment index (DAI)	DL assingment index
TPC	TPC command for scheduled PUCCH
PUCCH resource indicator	PUCCH resource indicator
PDSCH-to-HARQ feedback timing indicator	PDSCH-to-HARQ feedback timing indicator
	Antenna ports
	Transmission configuration indications (TCI)
	SRS request
	Code Block Group (CBG) transmission information
	CBG flushing out information
	DMRS sequence initialisation

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

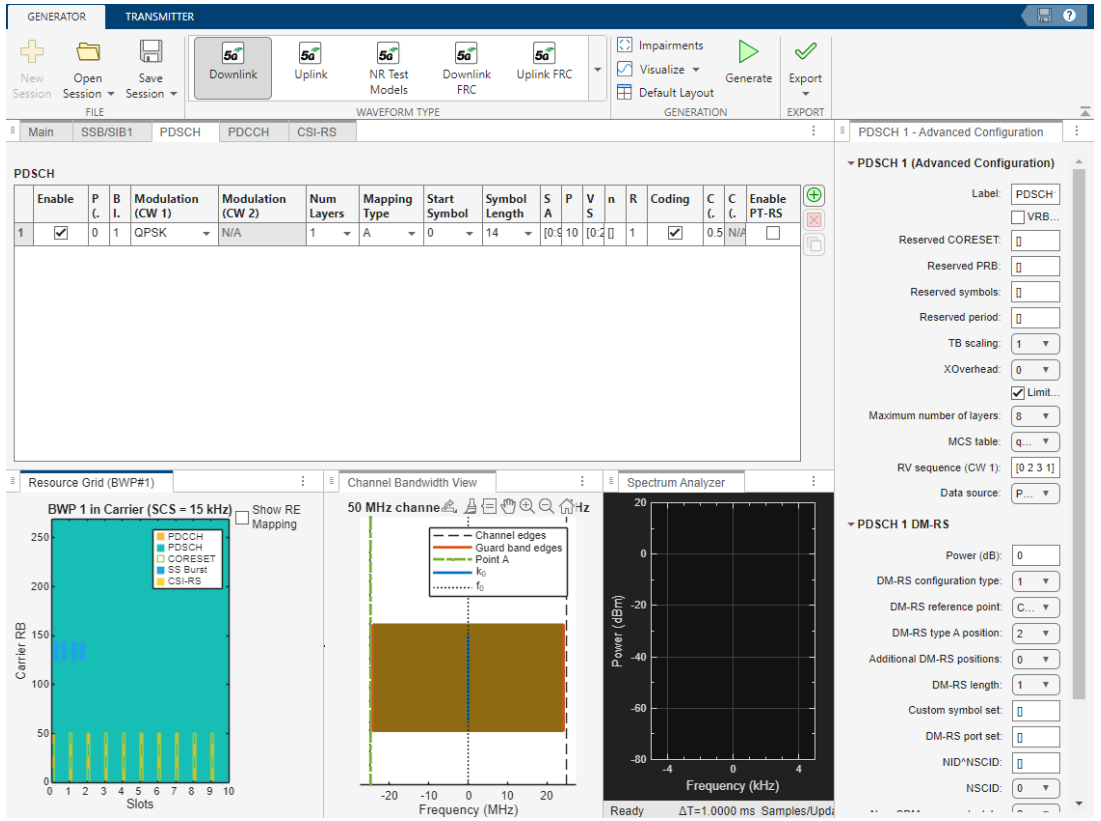
DCI for UL scheduling ([1], section 2.2.7)

Format 0_0	Format 0_1
DCI format identifier 1 bit	DCI format identifier
	Carrier indicator
	UL/SUL indicator
	BWP indicator
Frequency domain resource assignment	Frequency domain resource assignment
Time domain resource allocation	Time domain resource allocation
Frequency hopping flag	Frequency hopping flag
MCS	MCS and puncturing rate or code rate
NDI (new data indicator) 1 bit	New data indicator
Redundancy version	Redundancy version
HARQ process number	HARQ process number
	1st DL assingment index for HARQ
	2nd DL assingment index for HARQ if needed
TPC command for scheduled PUSCH	TPC command for scheduler PUSCH
Padding bits if required	SRS resource indicator
UL/SUL indicator	Precoding information and number of layers
	Antenna port
	SRS requests
	CSI request
	CBG transmission information
	PTRS and DMRS association for UL

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

Physical Downlink Shared Channel (PDSCH)

- PDSCH Contains
  - UE data
  - Signals:
    - Demodulation reference signal (DM-RS)
    - Phase tracking reference signal (PT-RS)
    - Channel state information reference signal (CSI-RS)
- PDSCH resources in grid
  - Periodicity can be 1, 2, 4, 5, 8, 10, 20 or 40 ms
  - If full slot allocated, then symbols 0-13
  - If partial slot allocated, then symbols 8-11



[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

PDSCH: location on time scale from SIB1

pdsch_ConfigCommon setup: _PDSCH_ConfigCommon
pdsch_TimeDomainAllocationList 4
_PDSCH_TimeDomainResourceAllocation
k0 0
mappingType (0) typeA
startSymbolAndLength 40
_PDSCH_TimeDomainResourceAllocation
k0 0
mappingType (0) typeA
startSymbolAndLength 54
_PDSCH_TimeDomainResourceAllocation
k0 0
mappingType (0) typeA
startSymbolAndLength 53
_PDSCH_TimeDomainResourceAllocation
k0 0
mappingType (0) typeA
startSymbolAndLength 67

Data from **Lab3_example_MSI.txt**

- startSymbolAndLength: one value describes 2 parameters

startSymbolAndLength [1]

SLIV Start and length indicator value

if (L-1) <= 7 then

SLIV = 14 x (L-1) + S

else

SLIV = 14 x (14-L+1) + (14-1-S)

, where 0 < L <= 14 – S

S = Start Symbol Index

L = Number of Consecutive Symbols

Table 5.1.2.1.1-2: Default PDSCH time domain resource allocation A for normal CP

Row index	*dmrs-TypeA-Position*	PDSCH mapping type	K_0	*S*	*L*
1	2	Type A	0	2	12
	3	Type A	0	3	11
2	2	Type A	0	2	10
	3	Type A	0	3	9
3	2	Type A	0	2	9
	3	Type A	0	3	8
4	2	Type A	0	2	7
	3	Type A	0	3	6
5	2	Type A	0	2	5
	3	Type A	0	3	4
6	2	Type B	0	9	4
	3	Type B	0	10	4
7	2	Type B	0	4	4
	3	Type B	0	6	4
8	2,3	Type B	0	5	7
9	2,3	Type B	0	5	2
10	2,3	Type B	0	9	2
11	2,3	Type B	0	12	2
12	2,3	Type A	0	1	13
13	2,3	Type A	0	1	6
14	2,3	Type A	0	2	4
15	2,3	Type B	0	4	7
16	2,3	Type B	0	8	4

[1] 3GPP, „TS 38.214 – NR; Physical layer procedures for data“, 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38214.htm

startSymbolAndLength tables (SLIV) for PDSCH location

S	L	L-1	Last Symbol	SLIV	Valid Mapping Type (Normal CP) PDSCH
0	2	1	1	14	Type B
	3	2	2	28	Type A
	4	3	3	42	Type A,Type B
	5	4	4	56	Type A
	6	5	5	70	Type A
	7	6	6	84	Type A,Type B
	8	7	7	98	Type A
	9	8	8	97	Type A
	10	9	9	83	Type A
	11	10	10	69	Type A
	12	11	11	55	Type A
	13	12	12	41	Type A
	14	13	13	27	Type A
1	2	1	2	15	TypeB
	3	2	3	29	Type A
	4	3	4	43	Type A,Type B
	5	4	5	57	Type A
	6	5	6	71	Type A
	7	6	7	85	Type A,Type B
	8	7	8	99	Type A
	9	8	9	96	Type A
	10	9	10	82	Type A
	11	10	11	68	Type A
	12	11	12	54	Type A
	13	12	13	40	Type A

S	L	L-1	Last Symbol	SLIV	Valid Mapping Type (Normal CP) PDSCH
2	2	1	3	16	Type B
	3	2	4	30	Type A
	4	3	5	44	Type A,Type B
	5	4	6	58	Type A
	6	5	7	72	Type A
	7	6	8	86	Type A,Type B
	8	7	9	100	Type A
	9	8	10	95	Type A
	10	9	11	81	Type A
	11	10	12	67	Type A
	12	11	13	53	Type A
3	2	1	4	17	Type B
	3	2	5	31	Type A
	4	3	6	45	Type A,Type B
	5	4	7	59	Type A
	6	5	8	73	Type A
	7	6	9	87	Type A,Type B
	8	7	10	101	Type A
	9	8	11	94	Type A
	10	9	12	80	Type A
	11	10	13	66	Type A

S	L	L-1	Last Symbol	SLIV	Valid Mapping Type (Normal CP) PDSCH
4	2	1	5	18	TypeB
	4	3	7	46	Type B
	7	6	10	88	Type B
5	2	1	6	19	TypeB
	4	3	8	47	Type B
	7	6	11	89	Type B
6	2	1	7	20	TypeB
	4	3	9	48	Type B
	7	6	12	90	Type B
7	2	1	8	21	Type B
	4	3	10	49	Type B
	7	6	13	91	Type B
8	2	1	9	22	Type B
	4	3	11	50	Type B
9	2	1	10	23	Type B
	4	3	12	51	Type B
10	2	1	11	24	Type B
	4	3	13	52	Type B
11	2	1	12	25	Type B
12	2	1	13	26	Type B

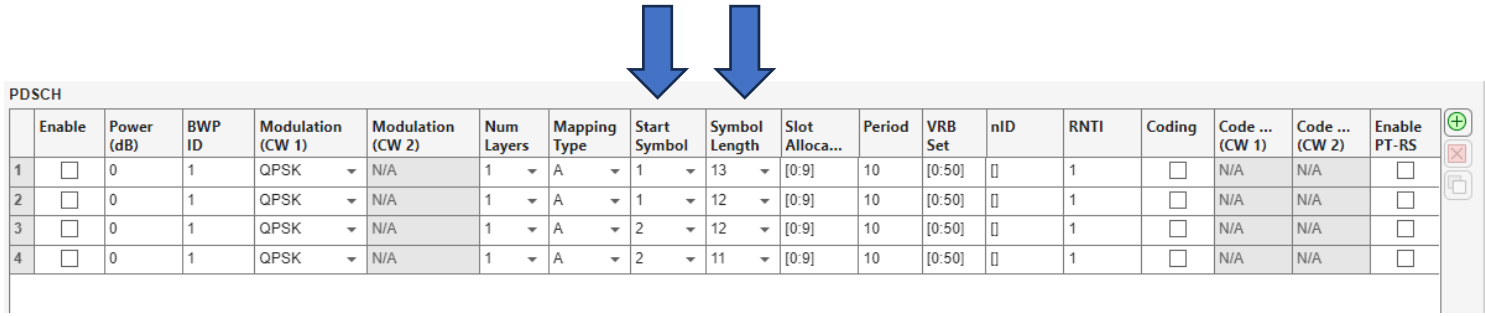
https://www.sharetechnote.com/html/5G/5G_SLIV.html#SLIV_Mapping_Table

40 54 53 67

PDSCH: location of time scale (from SIB1)

pdsch_ConfigCommon setup: _PDSCH_ConfigCommon
pdsch_TimeDomainAllocationList 4
_PDSCH_TimeDomainResourceAllocation
k0 0
mappingType (0) typeA
startSymbolAndLength 40 — S=1, L=13
_PDSCH_TimeDomainResourceAllocation
k0 0
mappingType (0) typeA
startSymbolAndLength 54 — S=1, L=12
_PDSCH_TimeDomainResourceAllocation
k0 0
mappingType (0) typeA
startSymbolAndLength 53 — S=2, L=12
_PDSCH_TimeDomainResourceAllocation
k0 0
mappingType (0) typeA
startSymbolAndLength 67 — S=2, L=11

Data from **Lab3_example_MSI.txt**

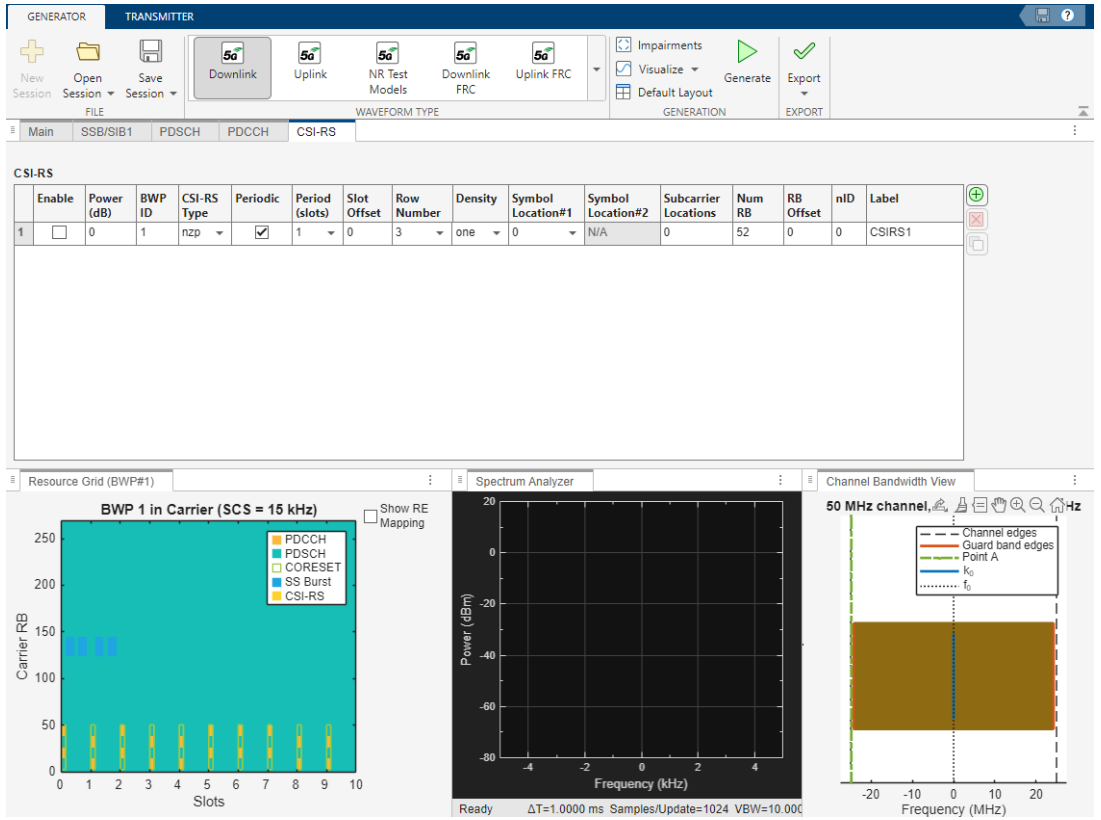


PDSCH

	Enable	Power (dB)	BWP ID	Modulation (CW 1)	Modulation (CW 2)	Num Layers	Mapping Type	Start Symbol	Symbol Length	Slot Alloca...	Period	VRB Set	nID	RNTI	Coding	Code ... (CW 1)	Code ... (CW 2)	Enable PT-RS
1	☐	0	1	QPSK	N/A	1	A	1	13	[0:9]	10	[0:50]	[]	1	☐	N/A	N/A	☐
2	☐	0	1	QPSK	N/A	1	A	1	12	[0:9]	10	[0:50]	[]	1	☐	N/A	N/A	☐
3	☐	0	1	QPSK	N/A	1	A	2	12	[0:9]	10	[0:50]	[]	1	☐	N/A	N/A	☐
4	☐	0	1	QPSK	N/A	1	A	2	11	[0:9]	10	[0:50]	[]	1	☐	N/A	N/A	☐

CSI-RS

- Channel state information reference signal (CSI-RS)
- Sent by BS to UE if BS requests UE to report channel information
- Types:
  - Zero-power (ZP) – used inside PDSCH
  - non-zero-power (NZP) – outside PDSCH



Other reference signals inside PDSCH

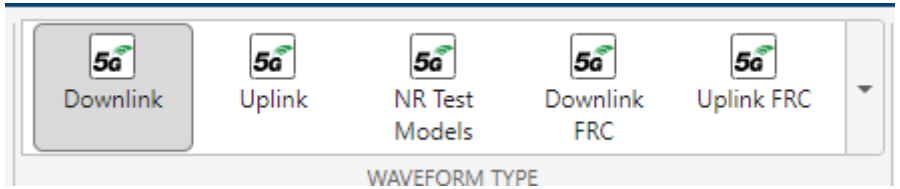
- Demodulation reference signal (DM-RS)
- Phase tracking reference signal (PT-RS)

- **NR PDSCH Resource Allocation and DM-RS and PT-RS Reference Signals example**

Tasks

- Use 5G Waveform Generator for DL
- Explain and illustrate the contents of scanner decoded MSI (Lab3_example_MSI.txt)
  - Carrier
  - SCSCarrier
  - BWP
  - CORESET0
  - Search spaces
  - PDCCH
  - PDSCH

MATLAB→
Apps→
5G Waveform Generator



Lab report (1 page PDF)

- Lab number, title, author, date
- Explain and illustrate the contents of scanner decoded MSI (Lab3_example_MSI.txt)
  - Carrier, SCSCarrier, BWP
  - CORESET0
  - Search spaces
  - PDCCH
  - PDSCH
- Summary and conclusions

Appendix

3GPP TS 38.213 tables in section 13

Table 13-1 of 3GPP TS 38.213 V15.15.0

Table 13-1: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {15, 15} kHz for frequency bands with minimum channel bandwidth 5 MHz or 10 MHz

Index	SS/PBCH block and CORESET multiplexing pattern	Number of RBs $N_{RB}^{CORESET}$	Number of Symbols $N_{symb}^{CORESET}$	Offset (RBs)
0	1	24	2	0
1	1	24	2	2
2	1	24	2	4
3	1	24	3	0
4	1	24	3	2
5	1	24	3	4
6	1	48	1	12
7	1	48	1	16
8	1	48	2	12
9	1	48	2	16
10	1	48	3	12
11	1	48	3	16
12	1	96	1	38
13	1	96	2	38
14	1	96	3	38
15	Reserved			

[1] 3GPP, “TS 38.213 - NR; Physical layer procedures for control,” 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38213.htm

Table 13-2 of 3GPP TS 38.213 V15.15.0

Table 13-2: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {15, 30} kHz for frequency bands with minimum channel bandwidth 5 MHz or 10 MHz

Index	SS/PBCH block and CORESET multiplexing pattern	Number of RBs $N_{RB}^{CORESET}$	Number of Symbols $N_{symb}^{CORESET}$	Offset (RBs)
0	1	24	2	5
1	1	24	2	6
2	1	24	2	7
3	1	24	2	8
4	1	24	3	5
5	1	24	3	6
6	1	24	3	7
7	1	24	3	8
8	1	48	1	18
9	1	48	1	20
10	1	48	2	18
11	1	48	2	20
12	1	48	3	18
13	1	48	3	20
14	Reserved			
15	Reserved			

[1] 3GPP, “TS 38.213 - NR; Physical layer procedures for control,” 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38213.htm

Table 13-3 of 3GPP TS 38.213 V15.15.0

Table 13-3: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {30, 15} kHz for frequency bands with minimum channel bandwidth 5 MHz or 10 MHz

Index	SS/PBCH block and CORESET multiplexing pattern	Number of RBs $N_{RB}^{CORESET}$	Number of Symbols $N_{symb}^{CORESET}$	Offset (RBs)
0	1	48	1	2
1	1	48	1	6
2	1	48	2	2
3	1	48	2	6
4	1	48	3	2
5	1	48	3	6
6	1	96	1	28
7	1	96	2	28
8	1	96	3	28
9	Reserved			
10	Reserved			
11	Reserved			
12	Reserved			
13	Reserved			
14	Reserved			
15	Reserved			

[1] 3GPP, “TS 38.213 - NR; Physical layer procedures for control,” 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38213.htm

Table 13-4 of 3GPP TS 38.213 V15.15.0

Table 13-4: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {30, 30} kHz for frequency bands with minimum channel bandwidth 5 MHz or 10 MHz

Index	SS/PBCH block and CORESET multiplexing pattern	Number of RBs $N_{RB}^{CORESET}$	Number of Symbols $N_{symb}^{CORESET}$	Offset (RBs)
0	1	24	2	0
1	1	24	2	1
2	1	24	2	2
3	1	24	2	3
4	1	24	2	4
5	1	24	3	0
6	1	24	3	1
7	1	24	3	2
8	1	24	3	3
9	1	24	3	4
10	1	48	1	12
11	1	48	1	14
12	1	48	1	16
13	1	48	2	12
14	1	48	2	14
15	1	48	2	16

[1] 3GPP, “TS 38.213 - NR; Physical layer procedures for control,” 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38213.htm

Table 13-5 of 3GPP TS 38.213 V15.15.0

Table 13-5: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {30, 15} kHz for frequency bands with minimum channel bandwidth 40MHz

Index	SS/PBCH block and CORESET multiplexing pattern	Number of RBs $N_{RB}^{CORESET}$	Number of Symbols $N_{symb}^{CORESET}$	Offset (RBs)
0	1	48	1	4
1	1	48	2	4
2	1	48	3	4
3	1	96	1	0
4	1	96	1	56
5	1	96	2	0
6	1	96	2	56
7	1	96	3	0
8	1	96	3	56
9	Reserved			
10	Reserved			
11	Reserved			
12	Reserved			
13	Reserved			
14	Reserved			
15	Reserved			

[1] 3GPP, “TS 38.213 - NR; Physical layer procedures for control,” 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38213.htm

Table 13-6 of 3GPP TS 38.213 V15.15.0

Table 13-6: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {30, 30} kHz for frequency bands with minimum channel bandwidth 40MHz

Index	SS/PBCH block and CORESET multiplexing pattern	Number of RBs $N_{RB}^{CORESET}$	Number of Symbols $N_{symb}^{CORESET}$	Offset (RBs)
0	1	24	2	0
1	1	24	2	4
2	1	24	3	0
3	1	24	3	4
4	1	48	1	0
5	1	48	1	28
6	1	48	2	0
7	1	48	2	28
8	1	48	3	0
9	1	48	3	28
10	Reserved			
11	Reserved			
12	Reserved			
13	Reserved			
14	Reserved			
15	Reserved			

[1] 3GPP, “TS 38.213 - NR; Physical layer procedures for control,” 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38213.htm

Table 13-7 of 3GPP TS 38.213 V15.15.0

Table 13-7: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {120, 60} kHz

Index	SS/PBCH block and CORESET multiplexing pattern	Number of RBs $N_{RB}^{CORESET}$	Number of Symbols $N_{symb}^{CORESET}$	Offset (RBs)
0	1	48	1	0
1	1	48	1	8
2	1	48	2	0
3	1	48	2	8
4	1	48	3	0
5	1	48	3	8
6	1	96	1	28
7	1	96	2	28
8	2	48	1	-41 if $k_{SSB}=0$ -42 if $k_{SSB}>0$
9	2	48	1	49
10	2	96	1	-41 if $k_{SSB}=0$ -42 if $k_{SSB}>0$
11	2	96	1	97
12	Reserved			
13	Reserved			
14	Reserved			
15	Reserved			

[1] 3GPP, “TS 38.213 - NR; Physical layer procedures for control,” 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38213.htm

Table 13-8 of 3GPP TS 38.213 V15.15.0

Table 13-8: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {120, 120} kHz

Index	SS/PBCH block and CORESET multiplexing pattern	Number of RBs $N_{RB}^{CORESET}$	Number of Symbols $N_{symb}^{CORESET}$	Offset (RBs)
0	1	24	2	0
1	1	24	2	4
2	1	48	1	14
3	1	48	2	14
4	3	24	2	-20 if $k_{SSB}=0$ -21 if $k_{SSB}>0$
5	3	24	2	24
6	3	48	2	-20 if $k_{SSB}=0$ -21 if $k_{SSB}>0$
7	3	48	2	48
8	Reserved			
9	Reserved			
10	Reserved			
11	Reserved			
12	Reserved			
13	Reserved			
14	Reserved			
15	Reserved			

[1] 3GPP, “TS 38.213 - NR; Physical layer procedures for control,” 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38213.htm

Table 13-9 of 3GPP TS 38.213 V15.15.0

Table 13-9: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {240, 60} kHz

Index	SS/PBCH block and CORESET multiplexing pattern	Number of RBs $N_{RB}^{CORESET}$	Number of Symbols $N_{symb}^{CORESET}$	Offset (RBs)
0	1	96	1	0
1	1	96	1	16
2	1	96	2	0
3	1	96	2	16
4	Reserved			
5	Reserved			
6	Reserved			
7	Reserved			
8	Reserved			
9	Reserved			
10	Reserved			
11	Reserved			
12	Reserved			
13	Reserved			
14	Reserved			
15	Reserved			

[1] 3GPP, “TS 38.213 - NR; Physical layer procedures for control,” 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38213.htm

Table 13-10 of 3GPP TS 38.213 V15.15.0

Table 13-10: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {240, 120} kHz

Index	SS/PBCH block and CORESET multiplexing pattern	Number of RBs $N_{RB}^{CORESET}$	Number of Symbols $N_{symb}^{CORESET}$	Offset (RBs)
0	1	48	1	0
1	1	48	1	8
2	1	48	2	0
3	1	48	2	8
4	2	24	1	-41 if $k_{SSB}=0$ -42 if $k_{SSB}>0$
5	2	24	1	25
6	2	48	1	-41 if $k_{SSB}=0$ -42 if $k_{SSB}>0$
7	2	48	1	49
8	Reserved			
9	Reserved			
10	Reserved			
11	Reserved			
12	Reserved			
13	Reserved			
14	Reserved			
15	Reserved			

[1] 3GPP, “TS 38.213 - NR; Physical layer procedures for control,” 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38213.htm

Table 13-11 of 3GPP TS 38.213 V15.15.0

Table 13-11: Parameters for PDCCH monitoring occasions for Type0-PDCCH CSS set - SS/PBCH block and CORESET multiplexing pattern 1 and FR1

Index	O	Number of search space sets per slot	M	First symbol index
0	0	1	1	0
1	0	2	1/2	{0, if i is even}, { $N_{\text{symb}}^{\text{CORESET}}$, if i is odd}
2	2	1	1	0
3	2	2	1/2	{0, if i is even}, { $N_{\text{symb}}^{\text{CORESET}}$, if i is odd}
4	5	1	1	0
5	5	2	1/2	{0, if i is even}, { $N_{\text{symb}}^{\text{CORESET}}$, if i is odd}
6	7	1	1	0
7	7	2	1/2	{0, if i is even}, { $N_{\text{symb}}^{\text{CORESET}}$, if i is odd}
8	0	1	2	0
9	5	1	2	0
10	0	1	1	1
11	0	1	1	2
12	2	1	1	1
13	2	1	1	2
14	5	1	1	1
15	5	1	1	2

[1] 3GPP, “TS 38.213 - NR; Physical layer procedures for control,” 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38213.htm

Table 13-12 of 3GPP TS 38.213 V15.15.0

Table 13-12: Parameters for PDCCH monitoring occasions for Type0-PDCCH CSS set - SS/PBCH block and CORESET multiplexing pattern 1 and FR2

Index	O	Number of search space sets per slot	M	First symbol index
0	0	1	1	0
1	0	2	1/2	{0, if i is even}, {7, if i is odd}
2	2.5	1	1	0
3	2.5	2	1/2	{0, if i is even}, {7, if i is odd}
4	5	1	1	0
5	5	2	1/2	{0, if i is even}, {7, if i is odd}
6	0	2	1/2	{0, if i is even}, { $N_{\text{symb}}^{\text{CORESET}}$, if i is odd}
7	2.5	2	1/2	{0, if i is even}, { $N_{\text{symb}}^{\text{CORESET}}$, if i is odd}
8	5	2	1/2	{0, if i is even}, { $N_{\text{symb}}^{\text{CORESET}}$, if i is odd}
9	7.5	1	1	0
10	7.5	2	1/2	{0, if i is even}, {7, if i is odd}
11	7.5	2	1/2	{0, if i is even}, { $N_{\text{symb}}^{\text{CORESET}}$, if i is odd}
12	0	1	2	0
13	5	1	2	0
14	Reserved			
15	Reserved			

[1] 3GPP, “TS 38.213 - NR; Physical layer procedures for control,” 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38213.htm

Table 13-13 of 3GPP TS 38.213 V15.15.0

Table 13-13: PDCCH monitoring occasions for Type0-PDCCH CSS set - SS/PBCH block and CORESET multiplexing pattern 2 and {SS/PBCH block, PDCCH} SCS {120, 60} kHz

Index	PDCCH monitoring occasions (SFN and slot number)	First symbol index (k = 0, 1, … 15)
0	$\mathrm{SFN}_{\mathrm{C}} = \mathrm{SFN}_{\mathrm{SSB},i}$ $n_{\mathrm{C}} = n_{\mathrm{SSB},i}$	0, 1, 6, 7 for $i = 4k$, $i = 4k+1$, $i = 4k+2$, $i = 4k+3$
1	Reserved	
2	Reserved	
3	Reserved	
4	Reserved	
5	Reserved	
6	Reserved	
7	Reserved	
8	Reserved	
9	Reserved	
10	Reserved	
11	Reserved	
12	Reserved	
13	Reserved	
14	Reserved	
15	Reserved	

[1] 3GPP, “TS 38.213 - NR; Physical layer procedures for control,” 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38213.htm

Table 13-14 of 3GPP TS 38.213 V15.15.0

Table 13-14: PDCCH monitoring occasions for Type0-PDCCH CSS set - SS/PBCH block and CORESET multiplexing pattern 2 and {SS/PBCH block, PDCCH} SCS {240, 120} kHz

Index	PDCCH monitoring occasions (SFN and slot number)	First symbol index (k = 0, 1, …, 7)
0	$\mathrm{SFN}_{\mathrm{C}} = \mathrm{SFN}_{\mathrm{SSB},i}$ $n_{\mathrm{C}} = n_{\mathrm{SSB},i}$ or $n_{\mathrm{C}} = n_{\mathrm{SSB},i} - 1$	0, 1, 2, 3, 0, 1 in $i = 8k$, $i = 8k+1$, $i = 8k+2$, $i = 8k+3$, $i = 8k+6$, $i = 8k+7$ ($n_{\mathrm{C}} = n_{\mathrm{SSB},i}$) 12, 13 in $i = 8k+4$, $i = 8k+5$ ($n_{\mathrm{C}} = n_{\mathrm{SSB},i} - 1$)
1	Reserved	
2	Reserved	
3	Reserved	
4	Reserved	
5	Reserved	
6	Reserved	
7	Reserved	
8	Reserved	
9	Reserved	
10	Reserved	
11	Reserved	
12	Reserved	
13	Reserved	
14	Reserved	
15	Reserved	

[1] 3GPP, “TS 38.213 - NR; Physical layer procedures for control,” 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38213.htm

Table 13-15 of 3GPP TS 38.213 V15.15.0

Table 13-15: PDCCH monitoring occasions for Type0-PDCCH CSS set - SS/PBCH block and CORESET multiplexing pattern 3 and {SS/PBCH block, PDCCH} SCS {120, 120} kHz

Index	PDCCH monitoring occasions (SFN and slot number)	First symbol index (k = 0, 1, … 15)
0	$\mathrm{SFN}_{\mathrm{C}} = \mathrm{SFN}_{\mathrm{SSB},i}$ $n_{\mathrm{C}} = n_{\mathrm{SSB},i}$	4, 8, 2, 6 in $i = 4k$, $i = 4k+1$, $i = 4k+2$, $i = 4k+3$
1	Reserved	
2	Reserved	
3	Reserved	
4	Reserved	
5	Reserved	
6	Reserved	
7	Reserved	
8	Reserved	
9	Reserved	
10	Reserved	
11	Reserved	
12	Reserved	
13	Reserved	
14	Reserved	
15	Reserved	

[1] 3GPP, “TS 38.213 - NR; Physical layer procedures for control,” 2022, [Online]. Available: https://www.3gpp.org/DynaReport/38213.htm