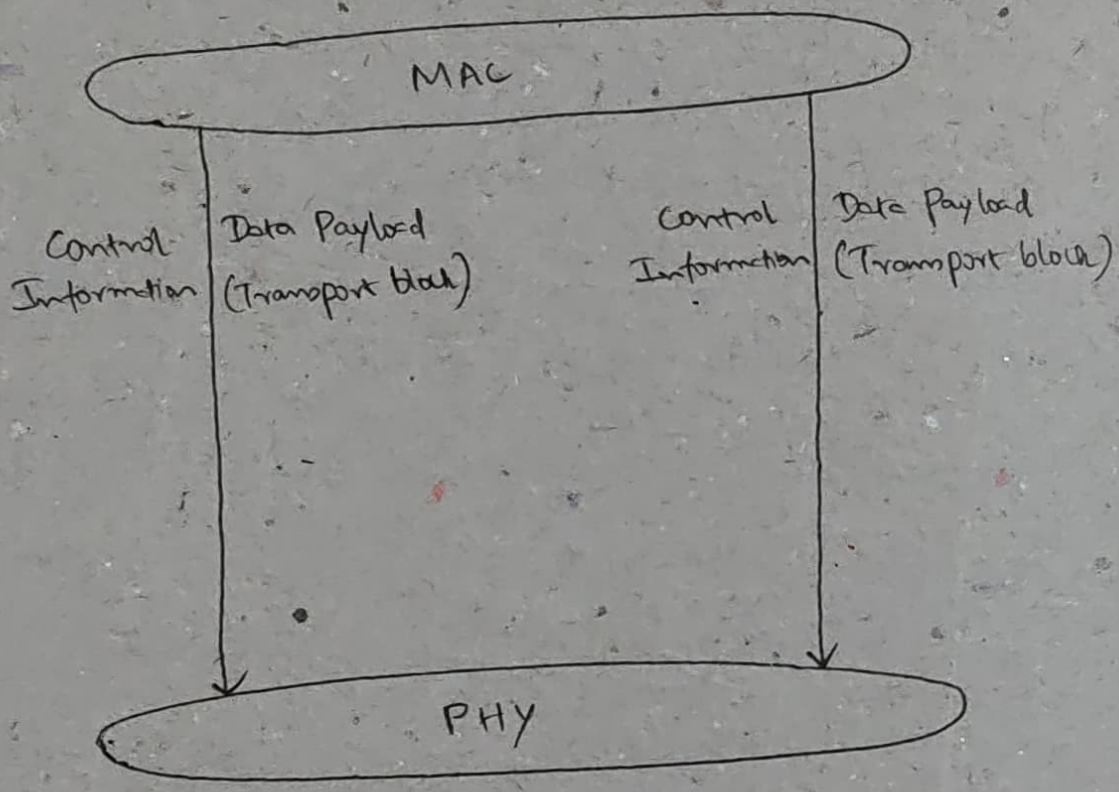
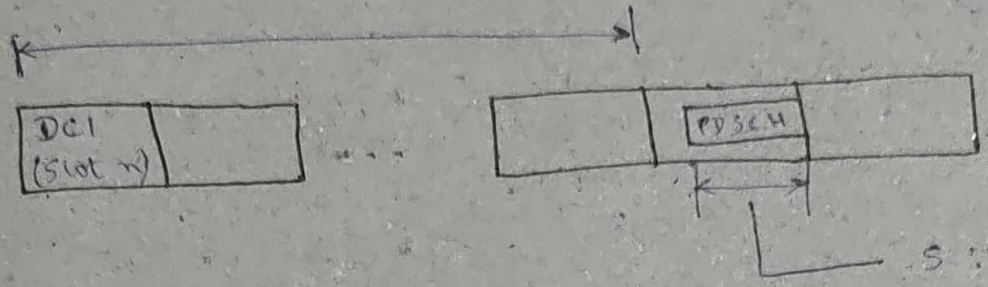
5G Control Chain Details

5G MAC-PHY interface



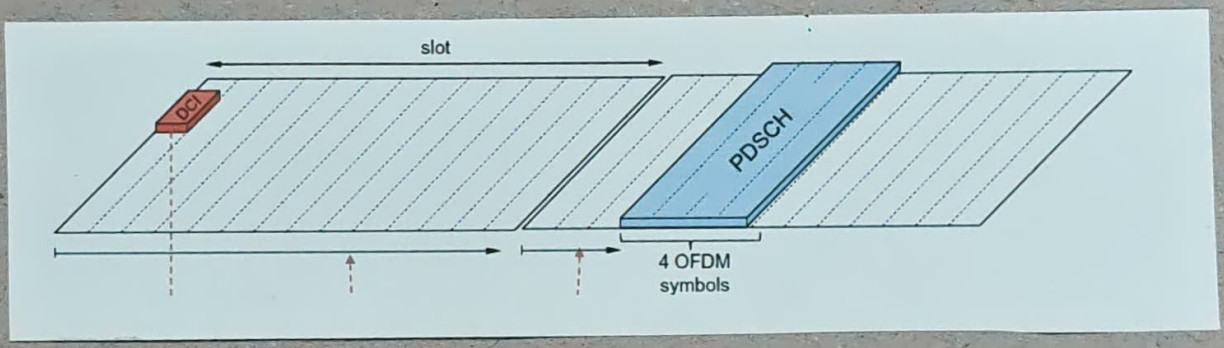
- MAC layer passes data payload and downlink control information (DCI) to PHY layer
- DCI - MCS index, number of resource blocks, location of resource blocks
- PHY layer first encodes DCI at a particular rate
- PHY layer later maps it using 4-QAM

Resource allocation in time domain for Downlink.



- Slot allocated for PDSCH is determined by n + K_0
  - K_0 → Slot offset relative to the slot where DCI was obtained.

- Example allocation with start symbol S=3, L=4 consecutive symbols, and slot offset K_0=1.



- Downlink – slot offsets from 0 to 3 ;
  Uplink – slot offsets from 0 to 7 can be used.

- Not all combinations of start and length fit within one slot.
  For example, starting at OFDM symbol 12 and transmit during 5 OFDM symbols obviously result in crossing the slot boundary and represents an invalid combination.

Time domain resource allocation table for Downlink

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

Table 5.1.2.1.1-2 of 38.214.

There are 3 more tables.

Resource allocation in time domain for Uplink.

- BS informs the user, in the Uplink when to transmit.
- DCI is used to schedule users in the Uplink also. (informally called Uplink scheduling grant)

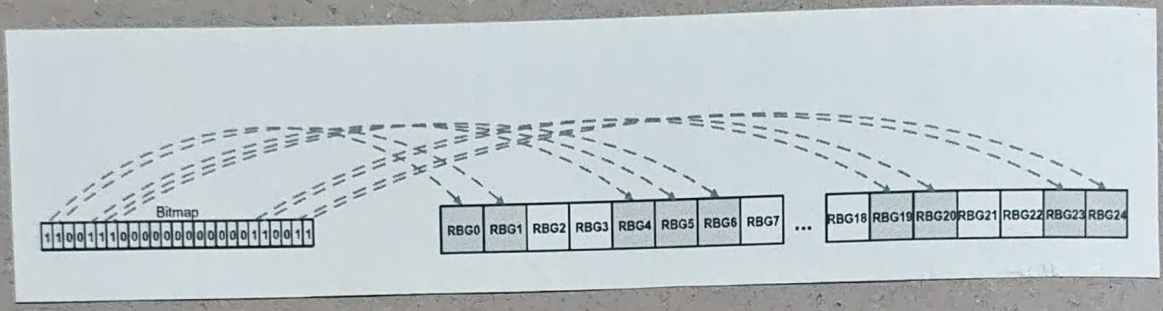
Time domain resource allocation table for Uplink.

Row index	PUSCH mapping type	K_2	S	L
1	Type A	j	0	14
2	Type A	j	0	12
3	Type A	j	0	10
4	Type B	j	2	10
5	Type B	j	4	10
6	Type B	j	4	8
7	Type B	j	4	6
8	Type A	j+1	0	14
9	Type A	j+1	0	12
10	Type A	j+1	0	10
11	Type A	j+2	0	14
12	Type A	j+2	0	12
13	Type A	j+2	0	10
14	Type B	j	8	6
15	Type A	j+3	0	14
16	Type A	j+3	0	10

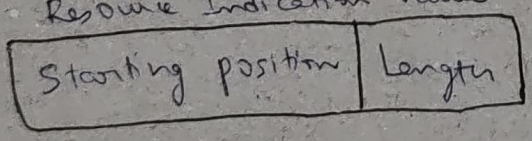
Table 6.1.2.1.1-2 of 38.214

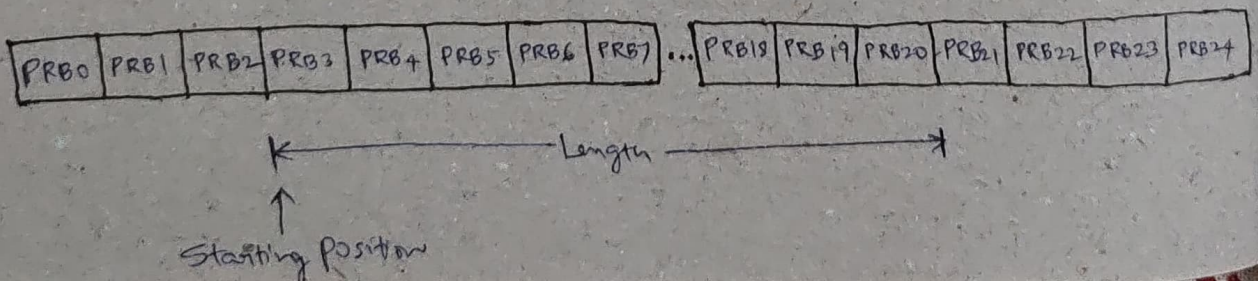
Downlink resource allocation in Frequency domain

- A UE determines the frequency domain resources on which it transmits or receives data by examining the resource-block allocation
- Base station can signal the allocated resources to a UE using resource allocation type 0 or type 1
- Type 0 is a bitmap-based allocation scheme



  - * Indicates set of resource block groups that UE is supposed to receive in the downlink
  - * Size of the bitmap is equal to the number of resource block group
- Type 1 combines starting position and length of resource allocation values into a single value.





Contents of DCI

⊙ DCI is used for both downlink and Uplink scheduling

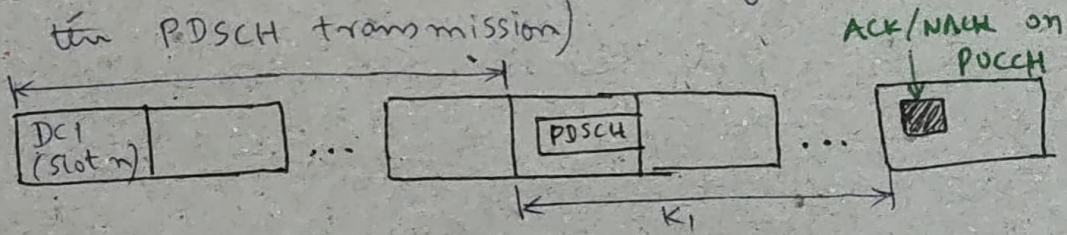
⊙ Multiple DCI formats

Example: DCI Format 1_0 → Used for downlink scheduling.

⊙ Length of this format is around 35 bits

- Modulation and Coding Scheme (5 bits)
- New data indicator (1 bit)
- Redundancy version (2 bits)
- Time-domain resource assignment (4 bits)
- Frequency domain resource assignment
- VRB-to-PRB mapping (1 bit)
  - Continuous / interleaved
- Identifier for DCI format (1 bit)
  - downlink assignment / uplink grant

- PDSCH-to-HARQ feedback timing indicator (3 bits)
  (indicates HARQ ACK/NAK timing relative to the PDSCH transmission)



- Few other fields.

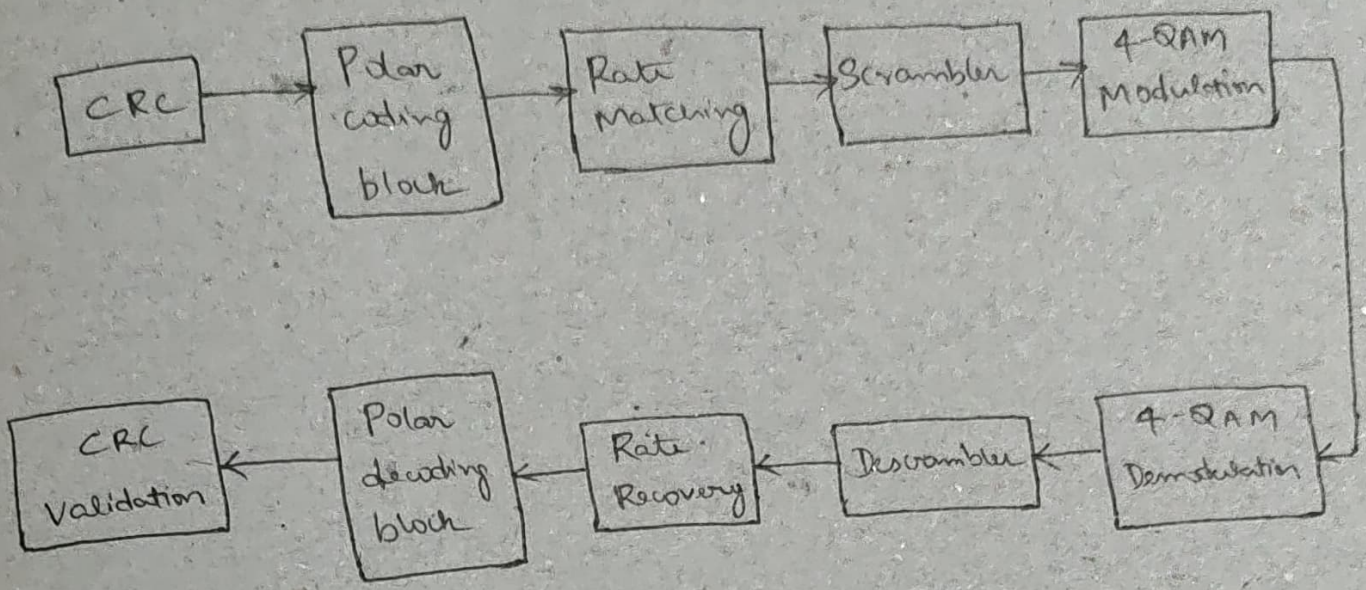
Comparison of two different DCI types for Downlink

Field		Format 1–0	Format 1–1
Format identifier		•	•
Resource information	CFI		•
	BWP indicator		•
	Frequency domain allocation	•	•
	Time-domain allocation	•	•
	VRB-to-PRB mapping	•	•
	PRB bundling size indicator		•
	Reserved resources		•
	Zero-power CSI-RS trigger		•
Transport-block related	MCS	•	•
	NDI	•	•
	RV	•	•
	MCS, 2nd TB		•
	NDI, 2nd TB		•
	RV, 2nd TB		•
Hybrid-ARQ related	Process number	•	•
	DAI	•	•
	PDSCH-to-HARQ feedback timing	•	•
	CBGTI		•
	CBGFI		•
Multi-antenna related	Antenna ports		•
	TCI		•
	SRS request		•
	DM-RS sequence initialization		•
PUCCH-related information	PUCCH power control	•	•
	PUCCH resource indicator		•

Comparison of two different DCI types for Uplink

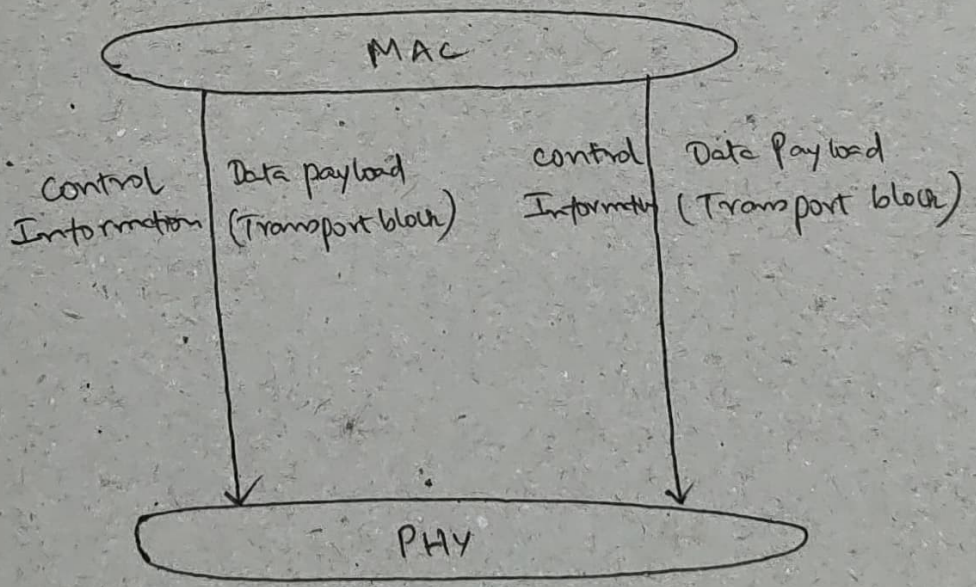
Field		Format 0–0	Format 0–1
Identifier		•	•
Resource information	CFI		•
	UL/SUL	•	•
	BWP indicator		•
	Frequency domain allocation	•	•
	Time-domain allocation	•	•
	Frequency hopping	•	•
Transport-block-related	MCS	•	•
	NDI	•	•
	RV	•	•
Hybrid-ARQ-related	Process number	•	•
	DAI		•
	CBGTI		•
Multi-antenna-related	DM-RS sequence initialization		•
	Antenna ports		•
	SRI		•
	Precoding information		•
	PTRS–DMRS association		•
	SRS request		•
	CSI request		•
Power control	PUSCH power control	•	•
	Beta offset		•

PHY Layer processing of DCI - Overview



- Polar decoding block is the most complicated block
- Low BLER for short block lengths
- Low power and hardware consumption for PDCCH decoding, which a user performs.

5G PHY processing summary



- Understood in detail PHY layer processing of PDSCH
- Had a Overview of PDCCH PHY layer processing