Challenges and Prospects of Digital Television

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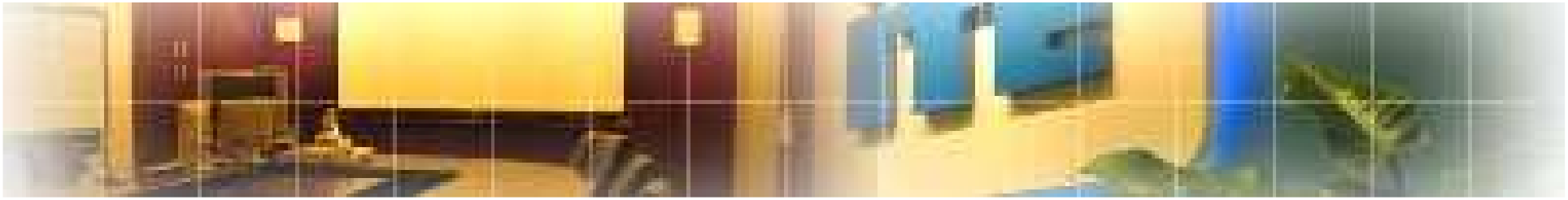


Outline

- What is Digital TV
- Why Digital TV
- Digital TV Physical Layer
- Challenges of Digital TV Reception
- Future of Digital TV

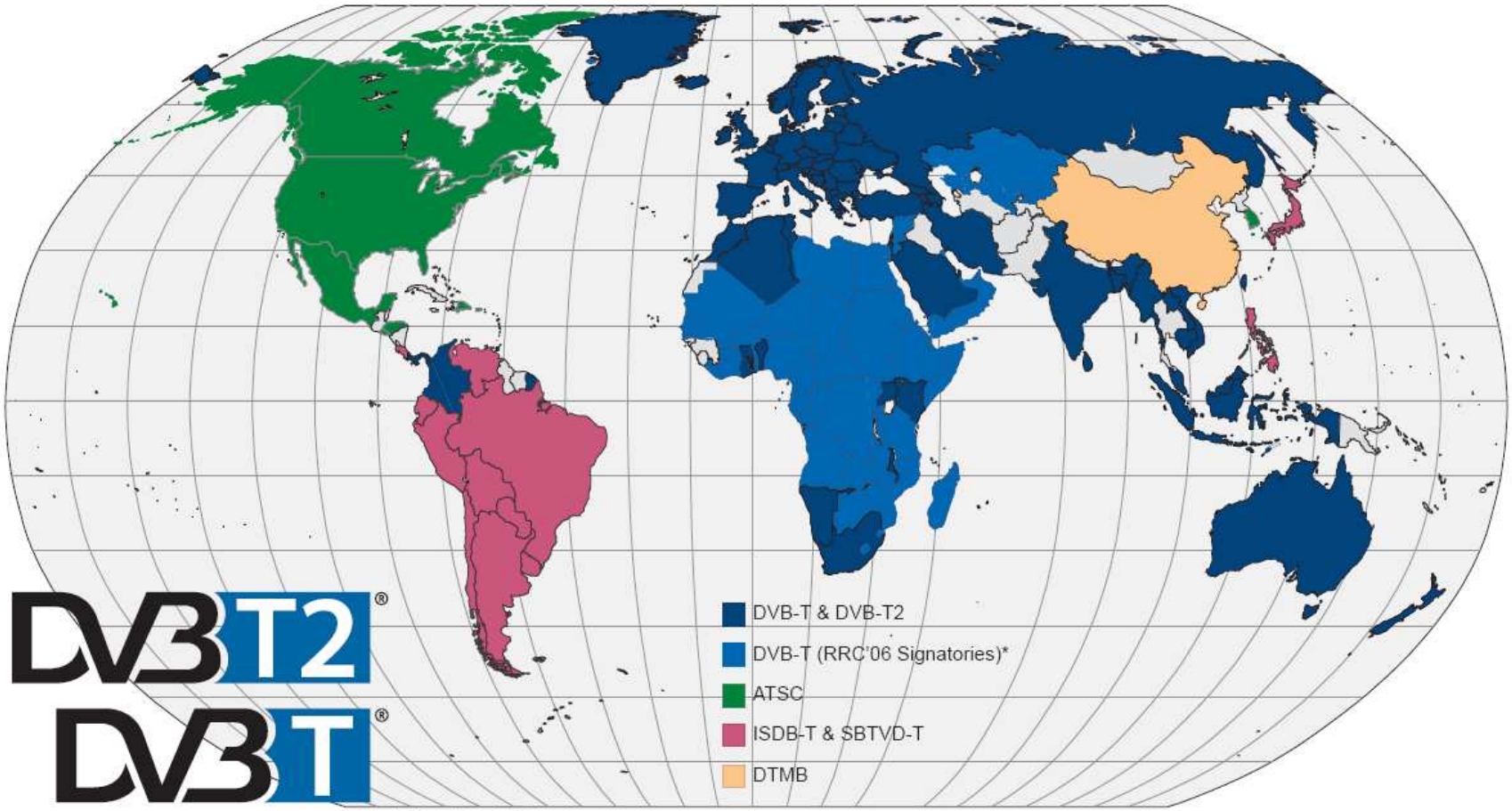
What is Digital TV

- Digitally broadcast TV programs using sophisticated modulation and coding schemes.
- More than one program can be carried on one carrier.
- 台灣的數位電視頻道:
  - 533 MHz – 中視 (3 programs)
  - 545 MHz – 公視 (3 programs)
  - 557 MHz – 民視 (3 programs)
  - 569 MHz – 公視 HiHD (1 program)
  - 581 MHz – 台視 (4 programs)
  - 593 MHz – 華視 (3 programs)

Why Digital TV

- 數位廣播電視是世界趨勢:
  - 技術面優勢:
    - 品質
      - HDTV quality is possible
      - CD quality 音質
    - 頻道數: 一個頻道可播 4 至 5 個節目
    - 無鬼影, 抗雜訊佳
    - 高速移動接收的可能性
    - 單頻網 (Single Frequency Network)的可能性
  - 政策面優勢:
    - 全球回收類比頻道
    - 大尺寸電視強制內建數位電視模組

Worldwide Digital TV Standards



DVB T2®

DVB T®

Countries that have adopted or deployed.

*Signatories of the RRC'06 frequency plan for an all-digital environment based exclusively on DVB-T.

Worldwide Digital TV Standards

- 歐規 DVB-T
  - 使用於歐洲, 南美洲, 澳洲, 亞洲
  - COFDM based, MPEG2 video/audio
  - 可移動接收, 可使用單頻網
- 美規 ATSC-T
  - 使用於北美洲
  - 8-VSB based, MPEG2 video, AC-3 audio
  - 不可移動接收,不可使用單頻網
- 日規 ISDB-T
  - 使用於日本及南美洲
  - COFDM based, MPEG2 video/audio, H.264 HD video/audio
  - 可移動接收, 可使用單頻網
- 中國 DTMB
  - 使用於中國
  - COFDM based, MPEG2 video/audio
  - 可移動接收, 可使用單頻網

Digital TV Physical Layer

Key DTV Physical Layer Parameters

	DVB-T	ISDB-T	DTMB	ATSC
Channel Coding	Convolutional + Reed-Solomon	Convolutional + Reed-Solomon	LDPC	Trellis + Reed-Solomon
Interleaving	Frequency	Frequency and Time	Frequency and Time	Time Interleaving
Modulation	CP-OFDM	CP-OFDM	ZP-OFDM	Single-Carrier
Constellation	QPSK, 16QAM, 64QAM	DQPSK, QPSK, 16QAM, 64QAM	QPSK, 16QAM, 64QAM	8-VSB
Data Prioritization	Hierarchical Transmission	Layered Transmission		Enhanced Services

DVB-T

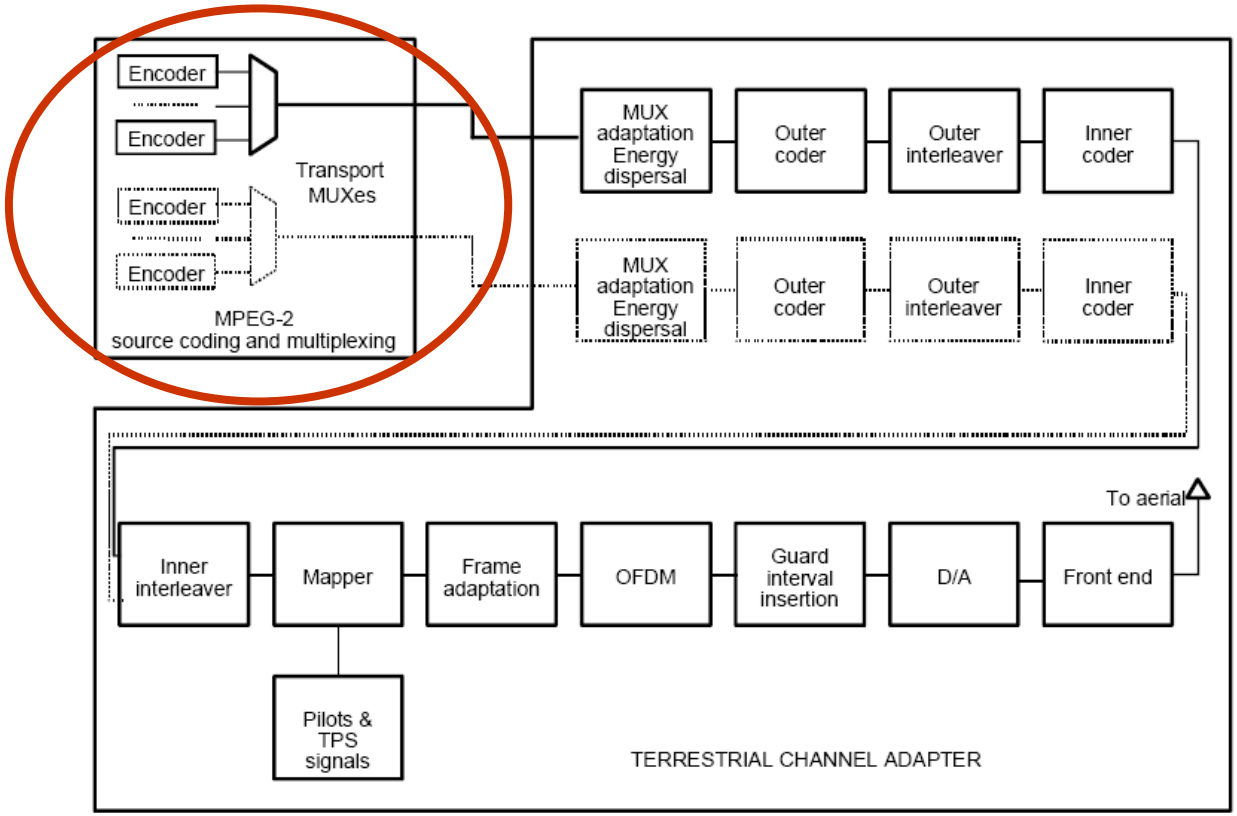
- DVB-T is the European terrestrial digital TV broadcasting standard
  - Video signal is MPEG-2 encoded.
  - Physical layer is coded OFDM-based
  - The physical layer of DVB-T is specified in EN 300-744.
- DVB-T is currently the most widely deployed digital TV standard.
  - In Europe and many other countries (including Taiwan), analog TV will be switched off between 2011 and 2015.
- DVB-T is also adopted in Taiwan
  - Currently there are 5 DVB-T carriers carrying 15 programs.

Advantages of DVB-T

- 高影像品質
- CD quality 音質
- 頻道數: 一個頻道可播 4 至 5 個節目
- 無鬼影, 抗雜訊佳
- 高速移動接收的可能性
- 單頻網 (Single Frequency Network)的可能性

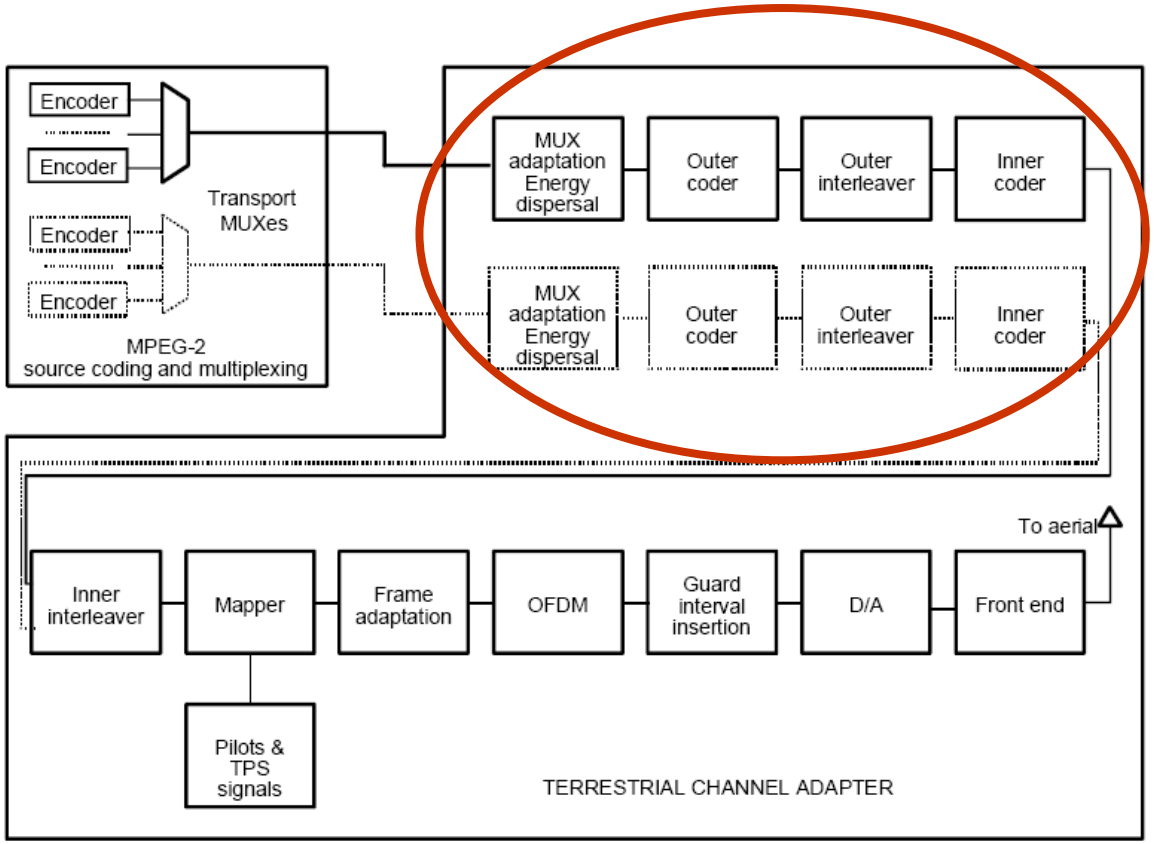
A/V Quality and Multiple Services

- DVB-T uses MPEG-2 encoding, thus providing high-quality audio and video.
- Multiplexing of digitally encoded video enables multiple services (programs) on one RF channel



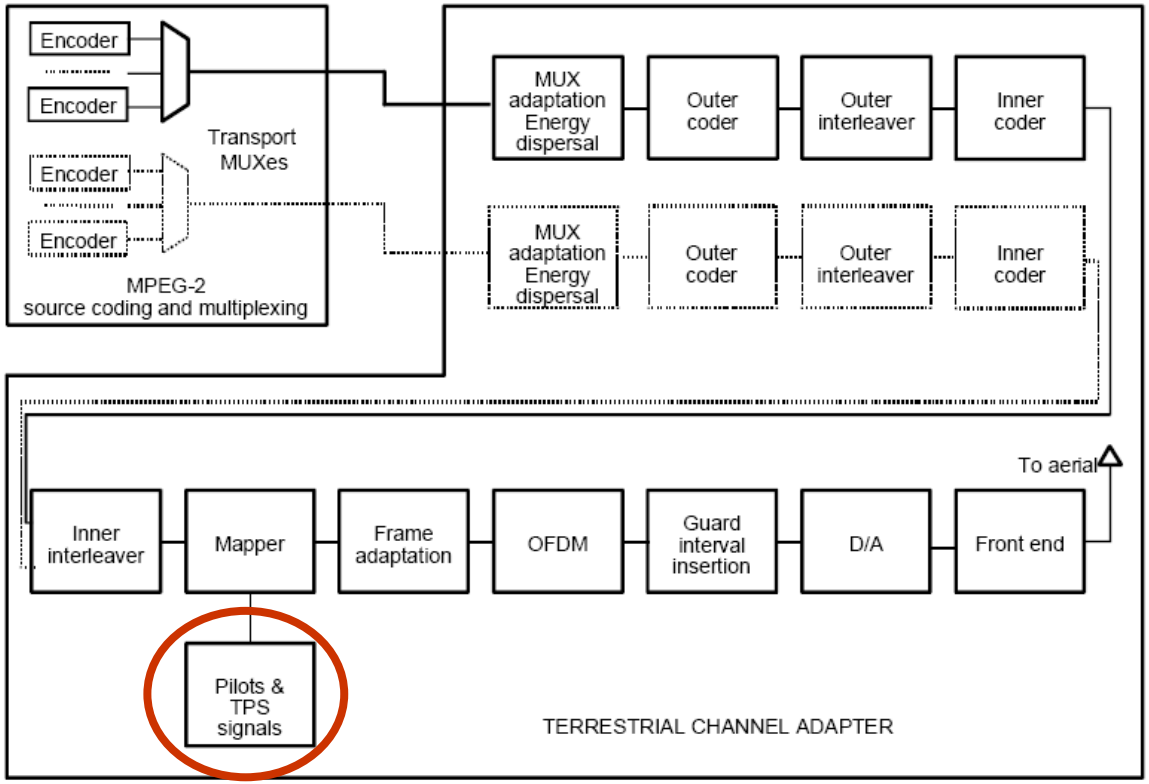
Enhanced Noise Immunity

- **DVB-T uses error correction coding (channel coding) to enhance noise immunity.**



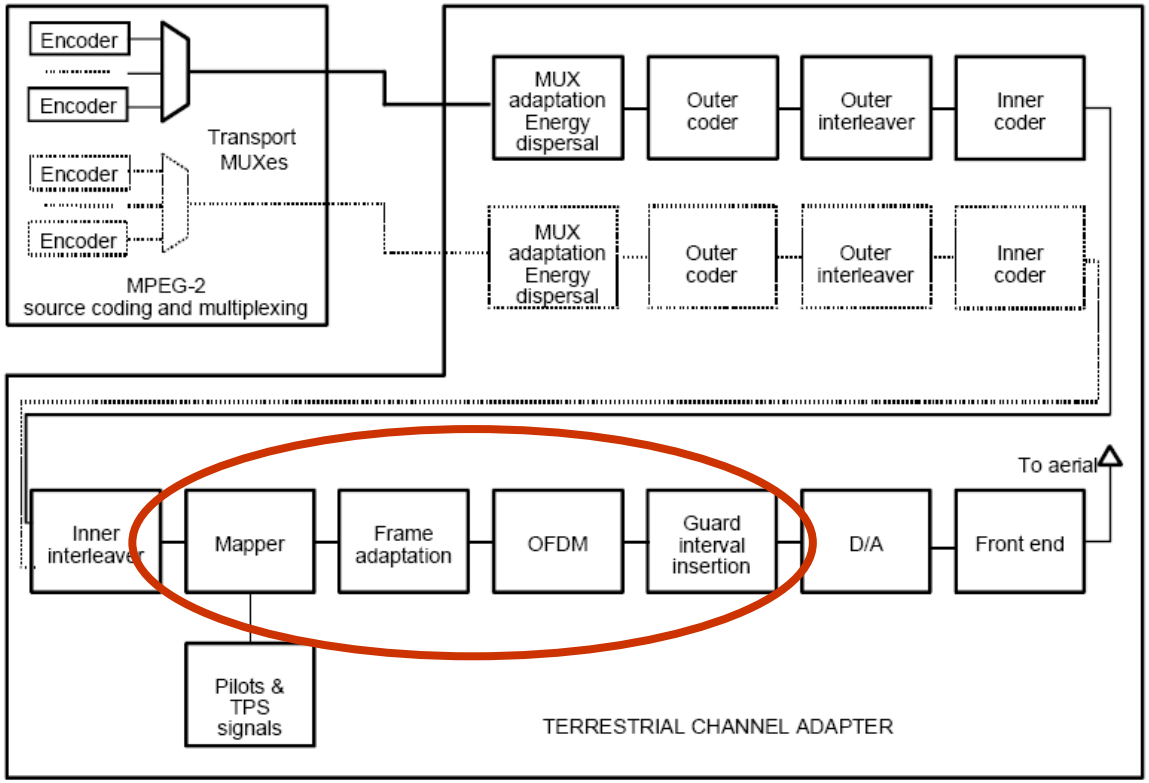
Possibility of Mobile Reception

- **Periodic pilots and short symbol duration of DVB-T make mobile reception possible.**



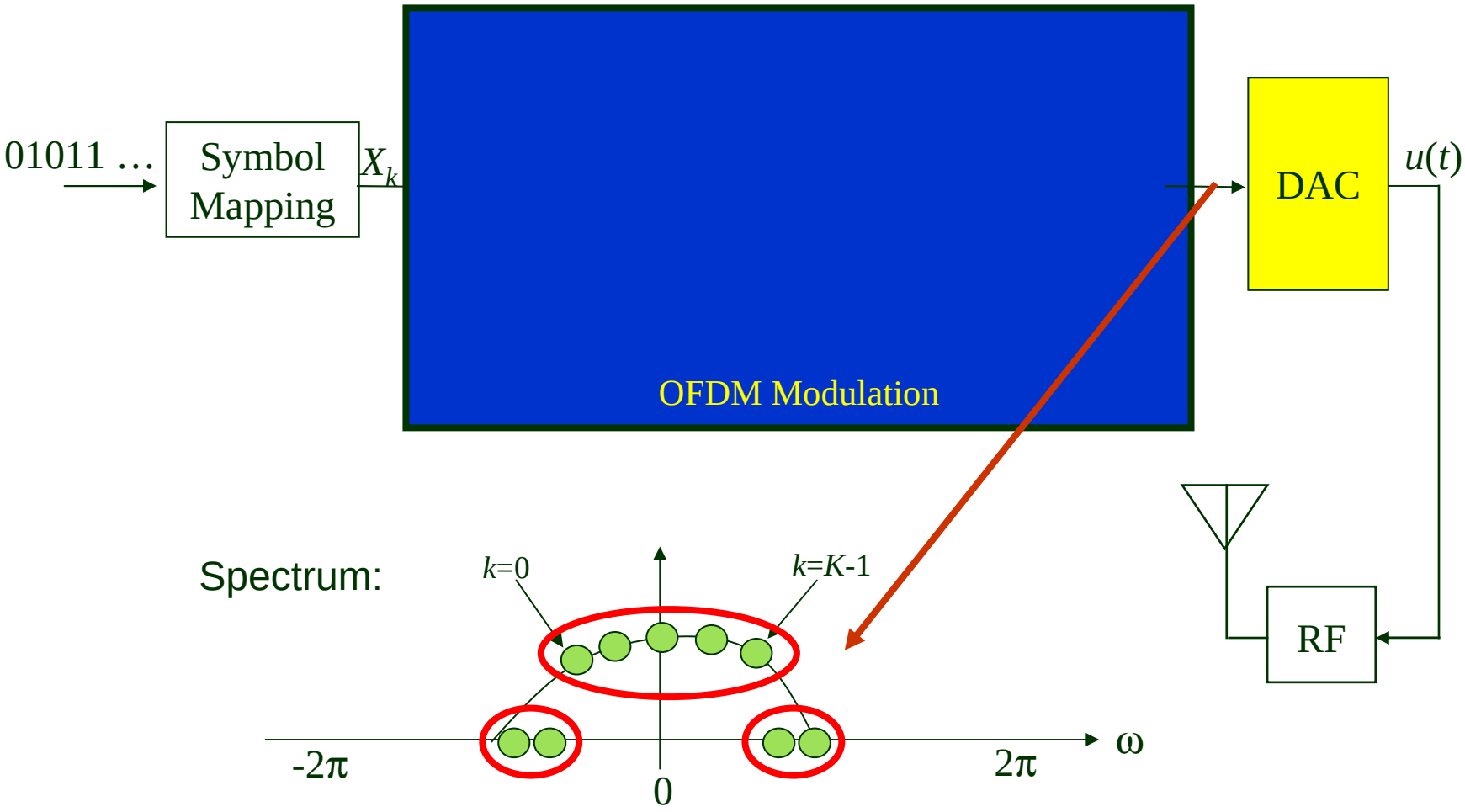
SFN Support

- **DVB-T uses OFDM modulation, making SFN possible.**



Orthogonal Frequency Division Multiplexing (OFDM)

- In OFDM, the transmitted data are loaded on N_u discrete subcarriers on the transmitted spectrum

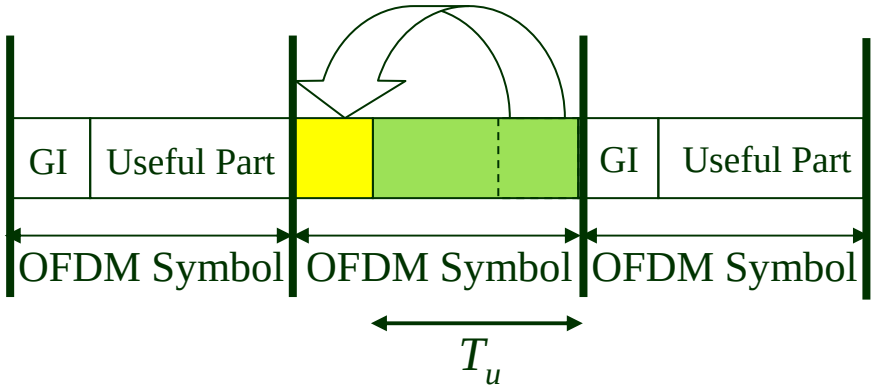


OFDM Parameters

- Number of sub-carriers N_u (FFT size)
- Length of the guard interval (GI)
- CP-OFDM or ZP-OFDM
- Length of the useful part (T_u)

The Guard Interval (GI)

- In OFDM, an OFDM symbol consists of the useful part and the GI.
  - For CP-OFDM, The GI is obtained by duplicating the last N_{GI} samples of the useful part.
  - For ZP-OFDM, the GI is stuffed with a known pattern(zeros or PRBS)
  - The guard interval is necessary for OFDM to work in single frequency networks (SFN)



OFDM Parameters

- **Comments**
  - **Longer GI supports longer channel**
    - Better SFN support
  - **Shorter T_u has better inter-carrier interference (ICI) tolerance**
    - Better mobility support

OFDM Parameters

- Three possible number of sub-carriers in DVB-T
  - $N_u = 2048$
  - $N_u = 4096$
  - $N_u = 8192$

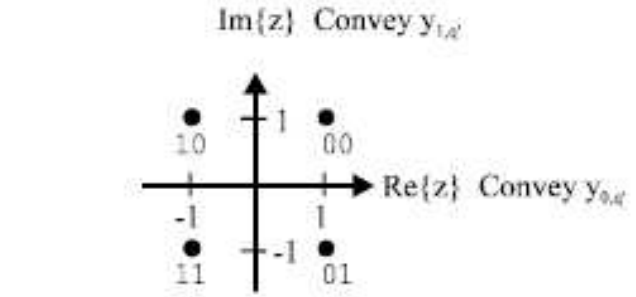
OFDM Parameters

- **Four possible length of guard interval (GI) in DVB-T**
  - $N_{GI} = N_u/4$
  - $N_{GI} = N_u/8$
  - $N_{GI} = N_u/16$
  - $N_{GI} = N_u/32$

Signal Constellations

- Possible constellations in DVB-T
  - QPSK
  - Uniform 16-QAM
  - Uniform 64-QAM
  - Non-Uniform 16-QAM with α=1 (same as Uniform 16-QAM)
  - Non-Uniform 16-QAM with α=2
  - Non-Uniform 16-QAM with α=4
  - Non-Uniform 64-QAM with α=1 (same as Uniform 64-QAM)
  - Non-Uniform 64-QAM with α=2
  - Non-Uniform 64-QAM with α=4

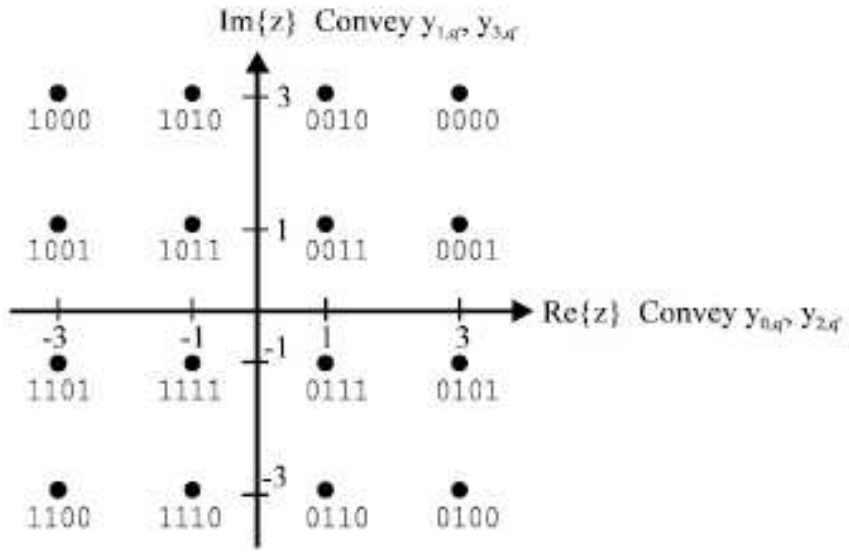
Uniform Constellations



QPSK

Bit ordering:

$y_{0,q}$, $y_{1,q}$

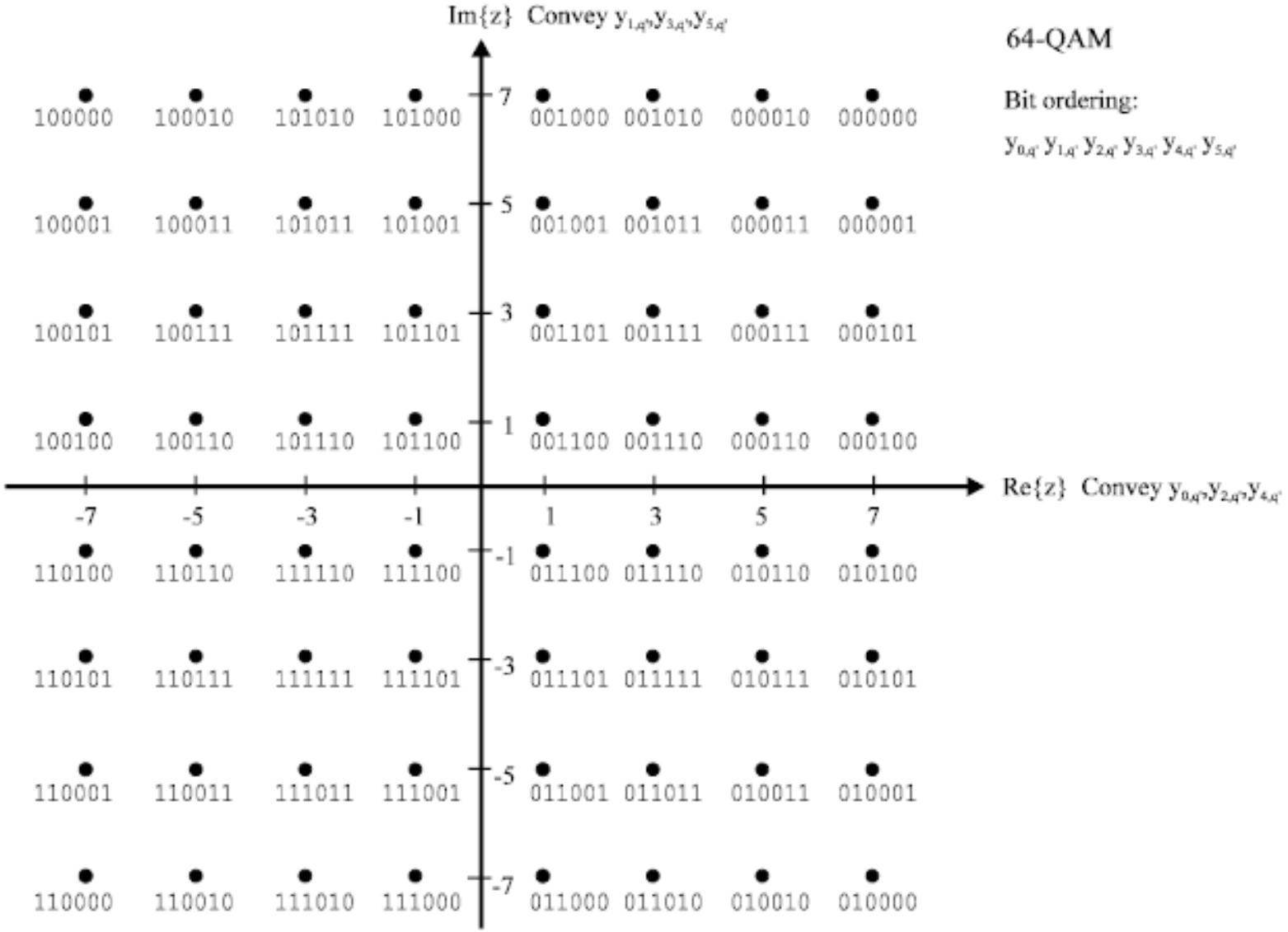


16-QAM

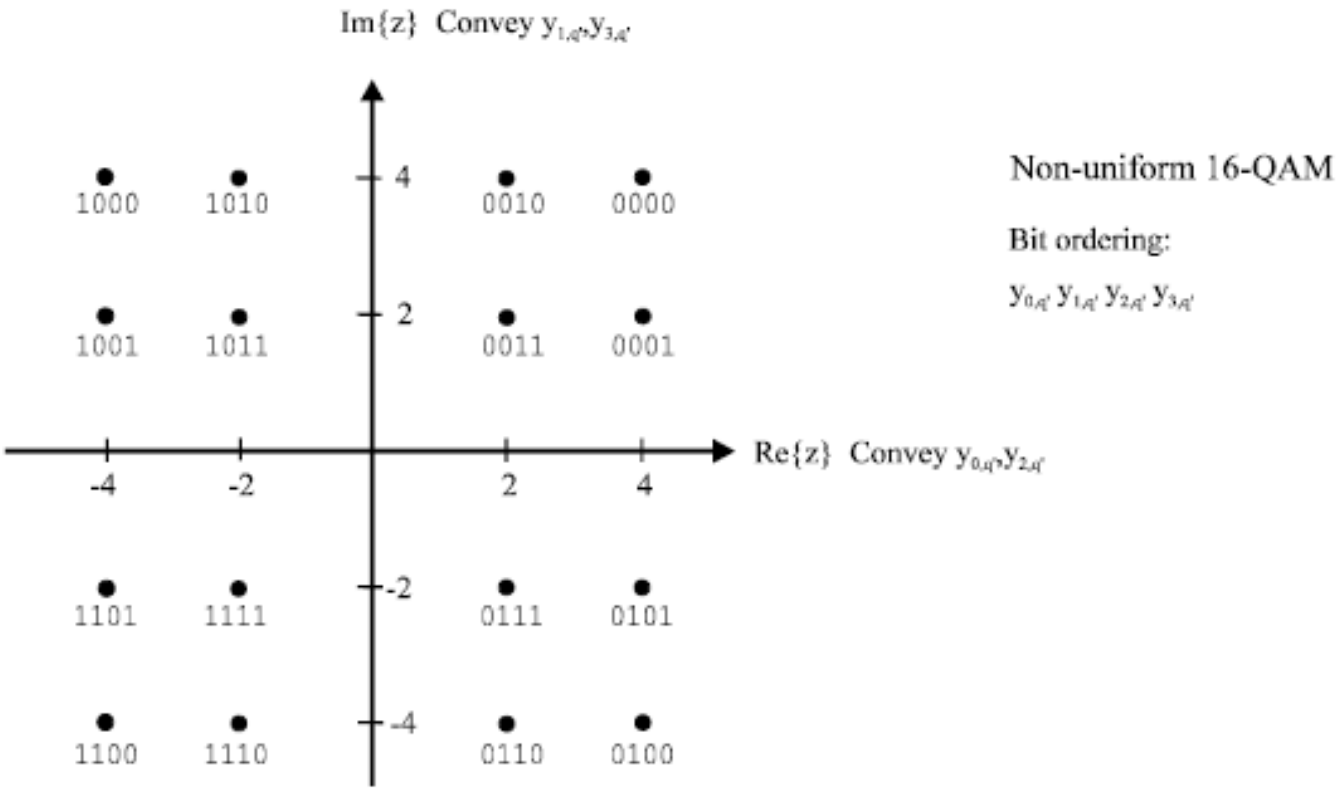
Bit ordering:

$y_{0,q}$, $y_{1,q}$, $y_{2,q}$, $y_{3,q}$

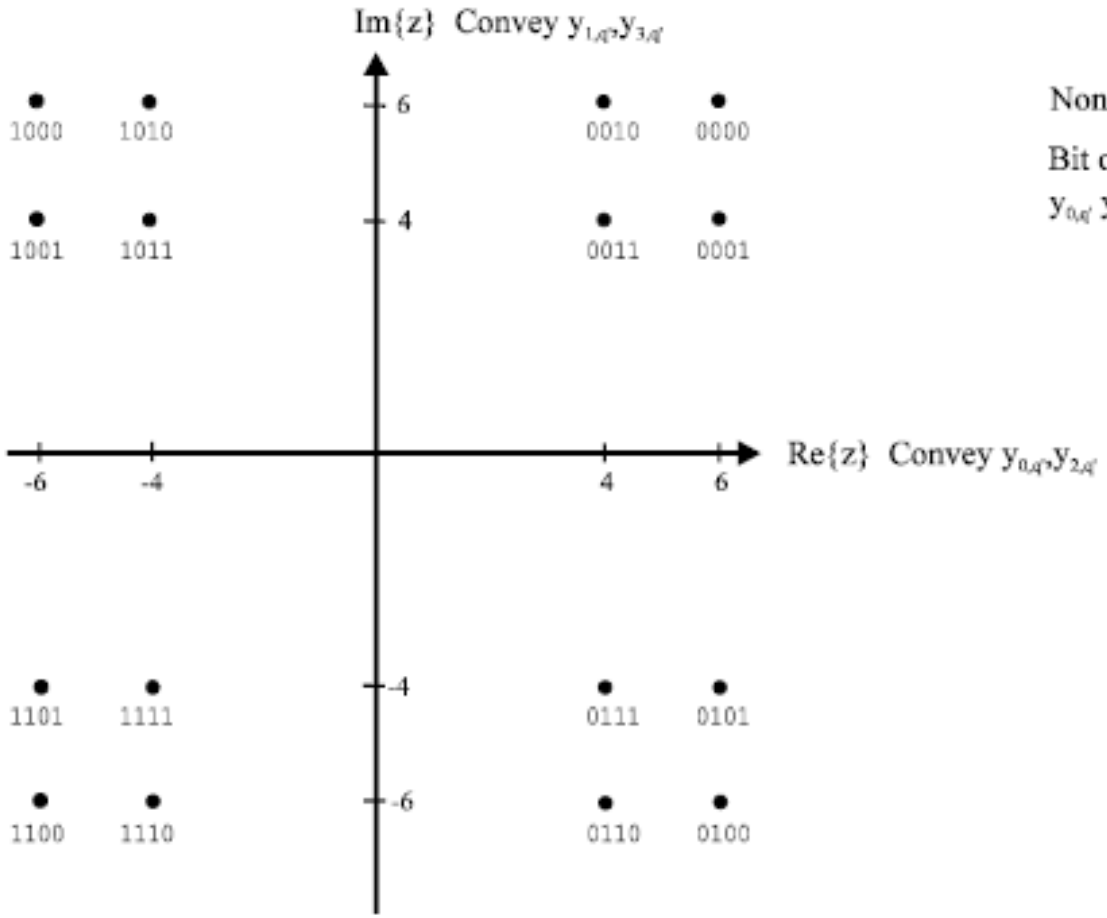
Uniform Constellations



Non-Uniform Constellations



Non-Uniform Constellations

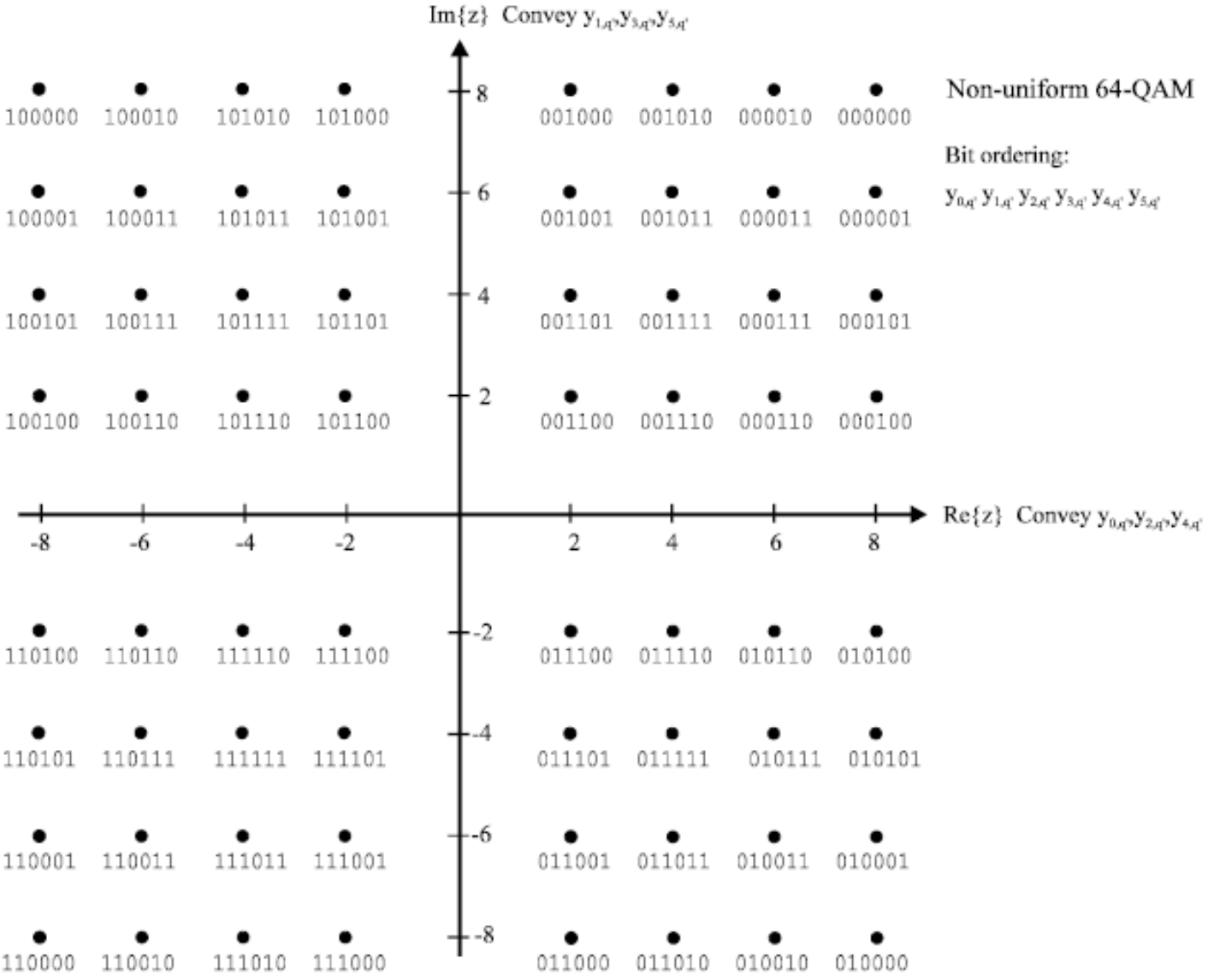


Non-uniform 16-QAM

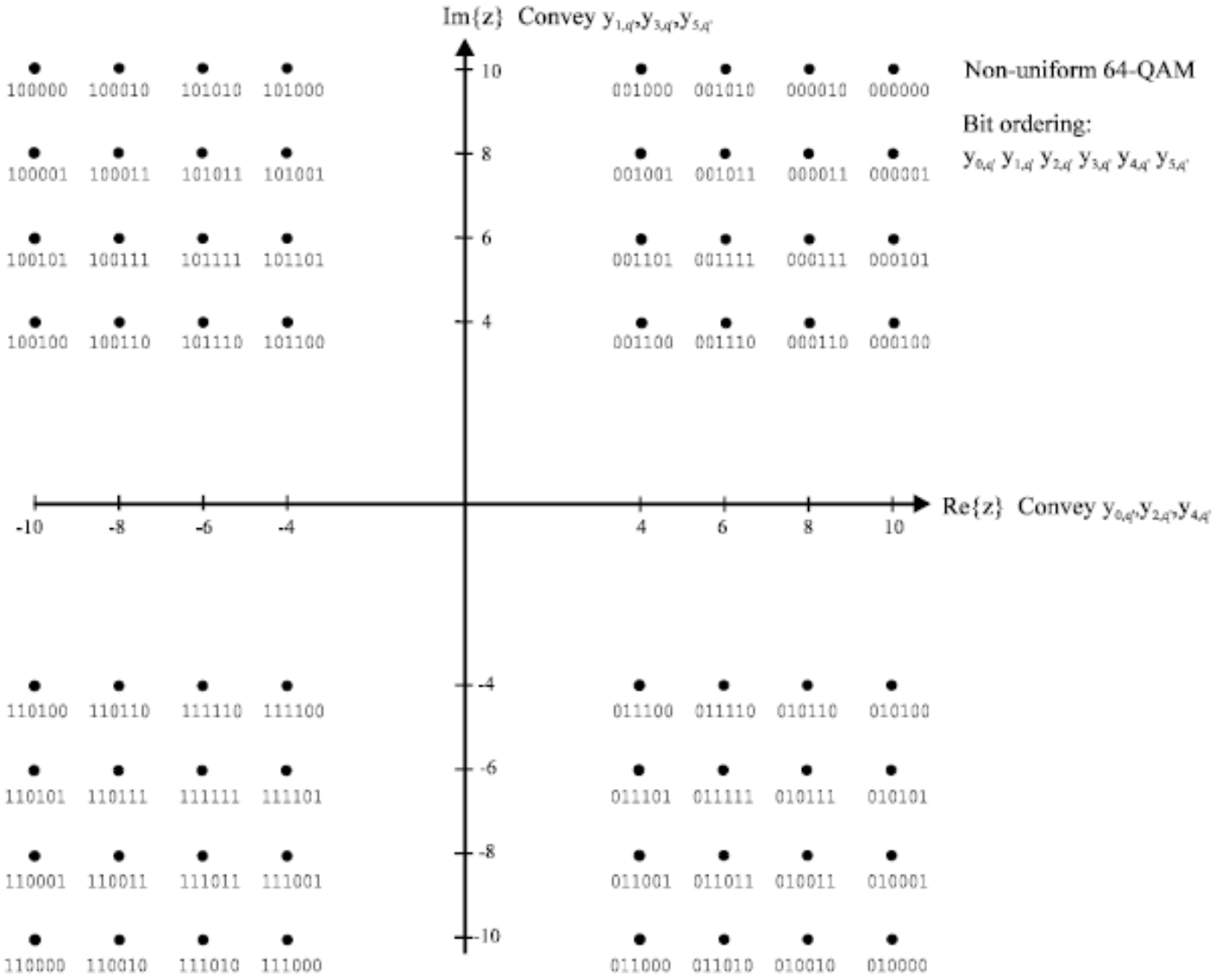
Bit ordering:

$y_{0,Q}$ $y_{1,Q}$ $y_{2,Q}$ $y_{3,Q}$

Non-Uniform Constellations



Non-Uniform Constellations



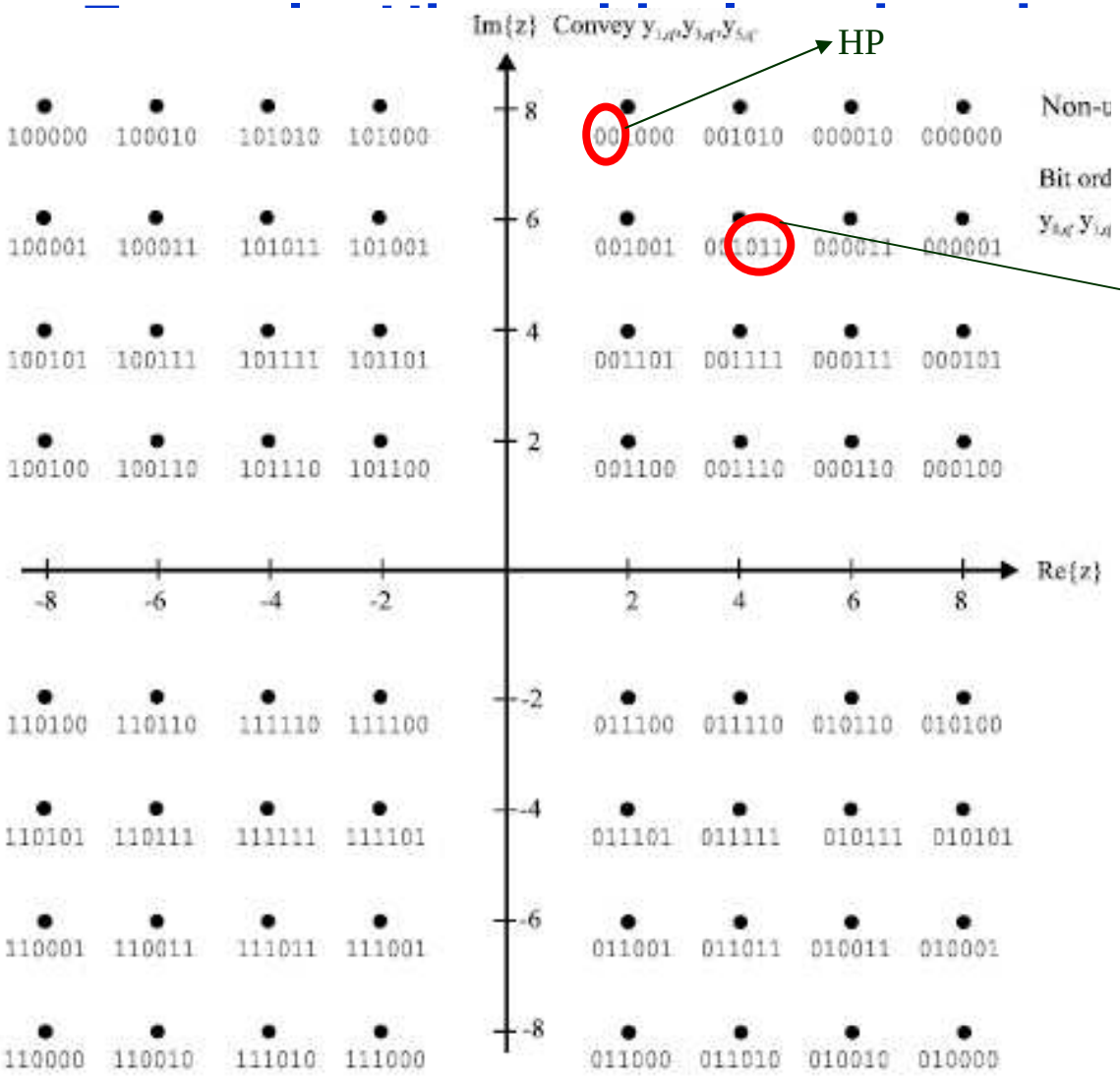
Hierarchical Symbol Mapping

- Two DVB-T transmission modes:
  - Non-Hierarchical transmission
  - Hierarchical transmision
- In non-hierarchical transmission, one transport stream (TS) is encoded and interleaved, and mapped onto uniform constellations.

Hierarchical Symbol Mapping

- In Hierarchical transmission, the same program content is source-encoded into independent high-priority (HP) and low-priority (LP) TS streams.
  - HP and LP streams are independently encoded and interleaved.
  - Only non-uniform constellations are used.
  - HP stream is mapped onto the first two bits of the constellation labels.
  - LP stream is mapped onto the remaining bits of the constellation labels.

Hierarchical Symbol Mapping



non-uniform

Effective constellation for HP is QPSK
Effective constellation for LP is 16QAM

Challenges of Digital TV Reception

Roots of All Evils

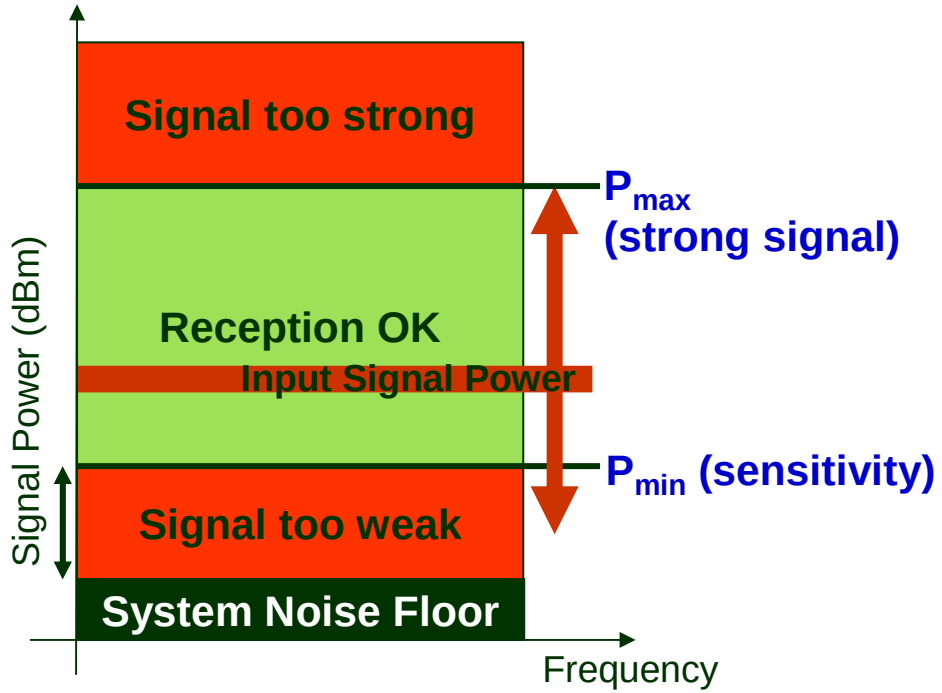
- Difficulty of digital signal reception arises from the combination three major factors
  - Propagation loss
  - Multipath propagation
  - Interference

Propagation Loss

- In free space, the power of the received signal is inversely proportional to d^2, where d is the distance between the transmitter and receiver.
- In terrestrial applications, the power of the received signal is inversely proportional to d^n, where n is a number that depends on the environment.
- In typical wireless communications applications, we deal with very low signal power, e.g.,
  - -90dBm = 10^{-12} Watt (terrestrial DTV)
  - -120 dBm = 10^{-15} Watt (satellite signals)
- The very low signal power makes wireless communication receiver difficult to design.

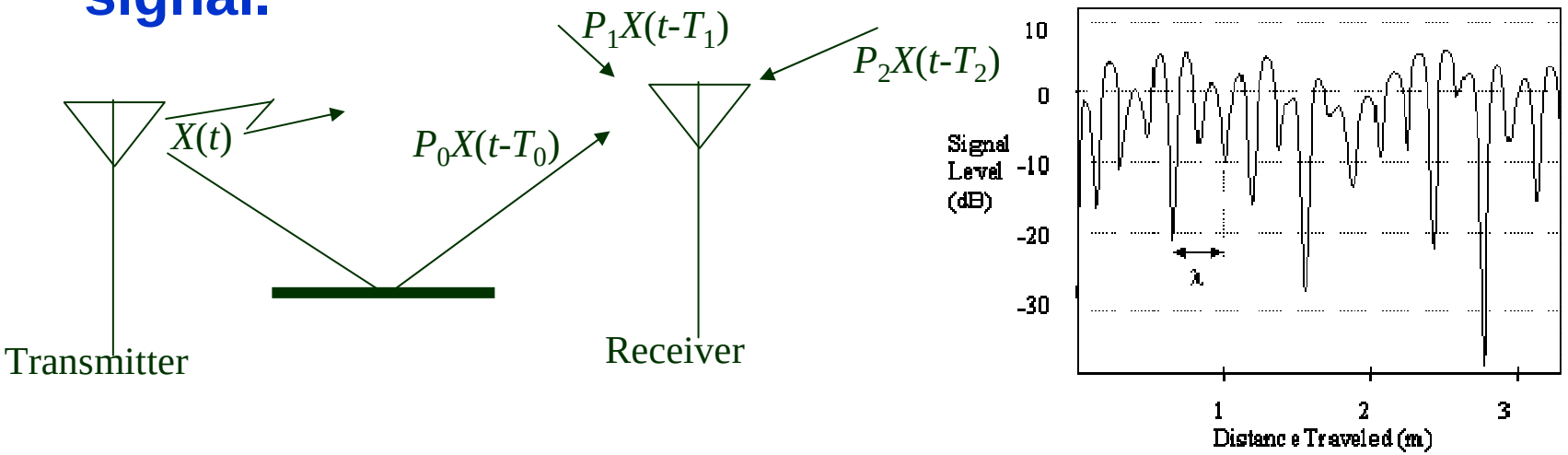
Receiver Sensitivity

- Receiver sensitivity is the minimum input power required for the receiver to work properly.
- The lower the number, the better the receiver (more sensitive)
- Typical numbers depend on application and receiver design.
  - -80dBm ~ -100 dBm for DVB-T, depending on the mode of transmission.



Multipath Propagation

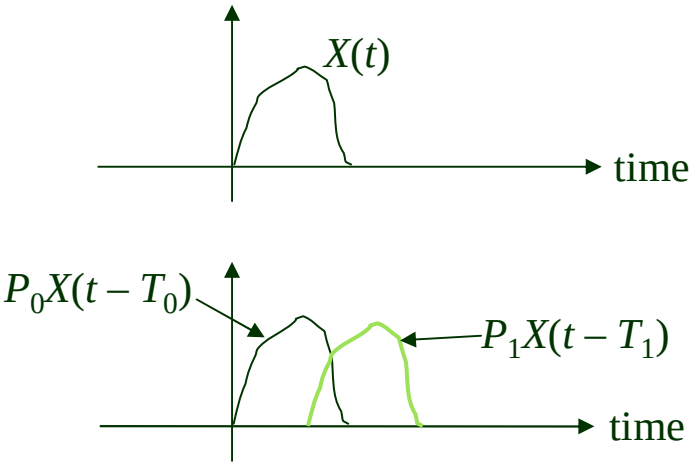
- Multipath propagation, also called “echoes”, is caused by multiple reflection of the transmitted signal.

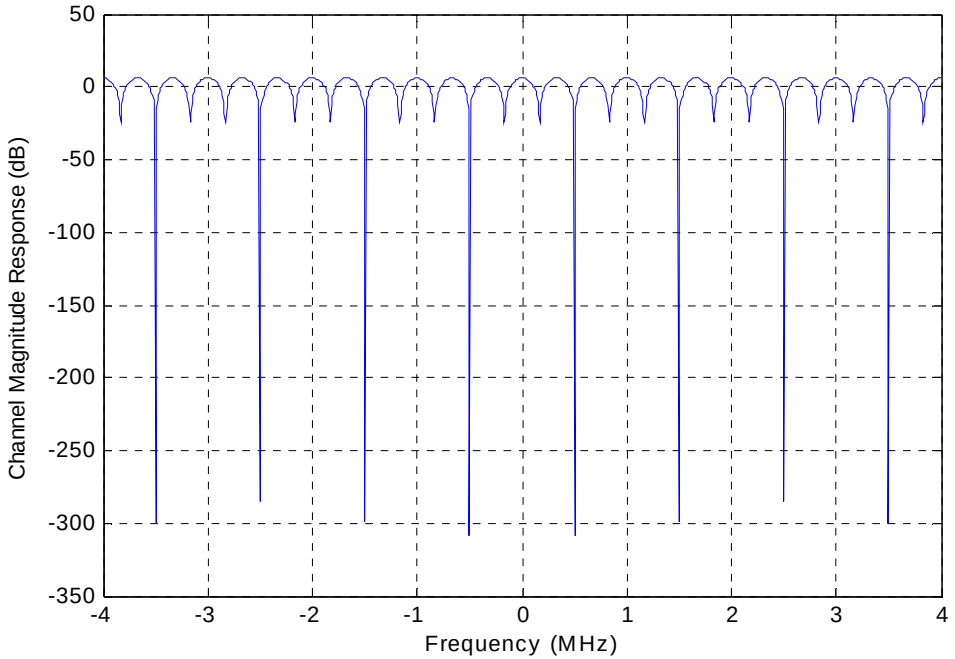


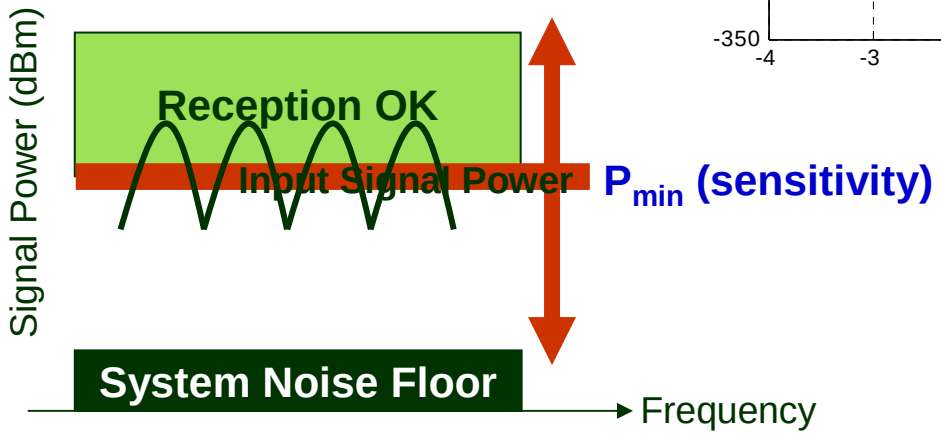
- Two consequences of multipath propagation
  - Microscopic fading – constructive and destructive interference between echoes causes rapid spatial signal level fluctuation
  - Signal distortion, especially for wideband signals

Multipath Fading

- **Wideband signal distortion caused by multipath propagation is called frequency-selective fading**

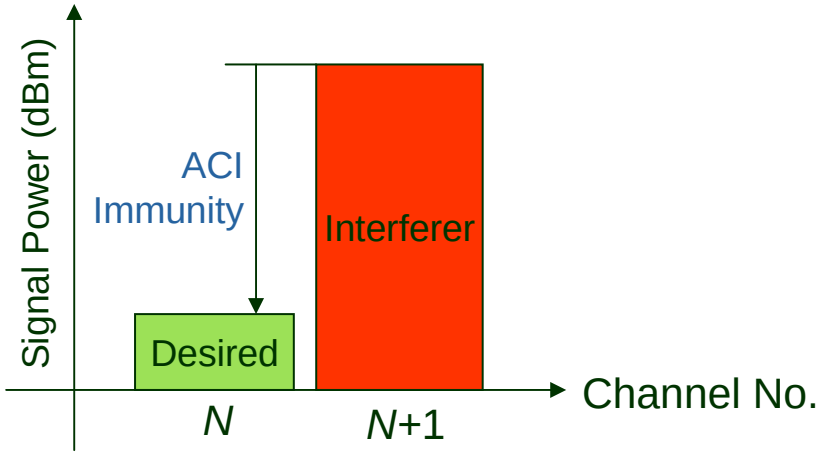


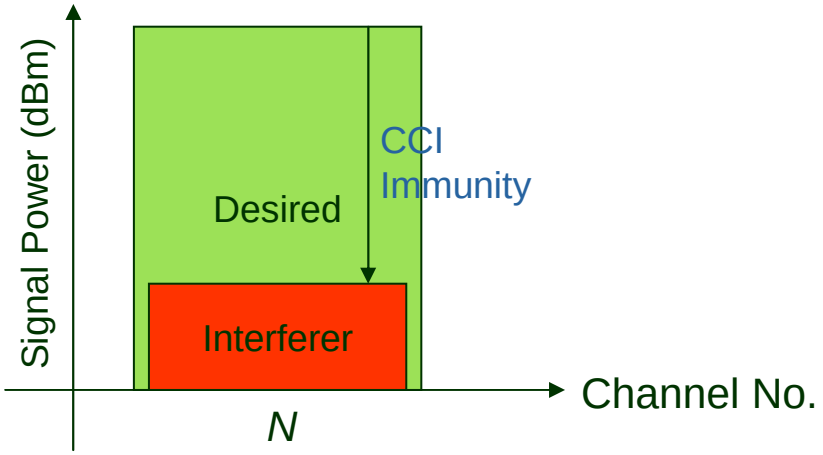




Interference

- **Interference is caused by more than one transmitter transmitting at nearby (or the same) frequencies**





The Future of Digital TV

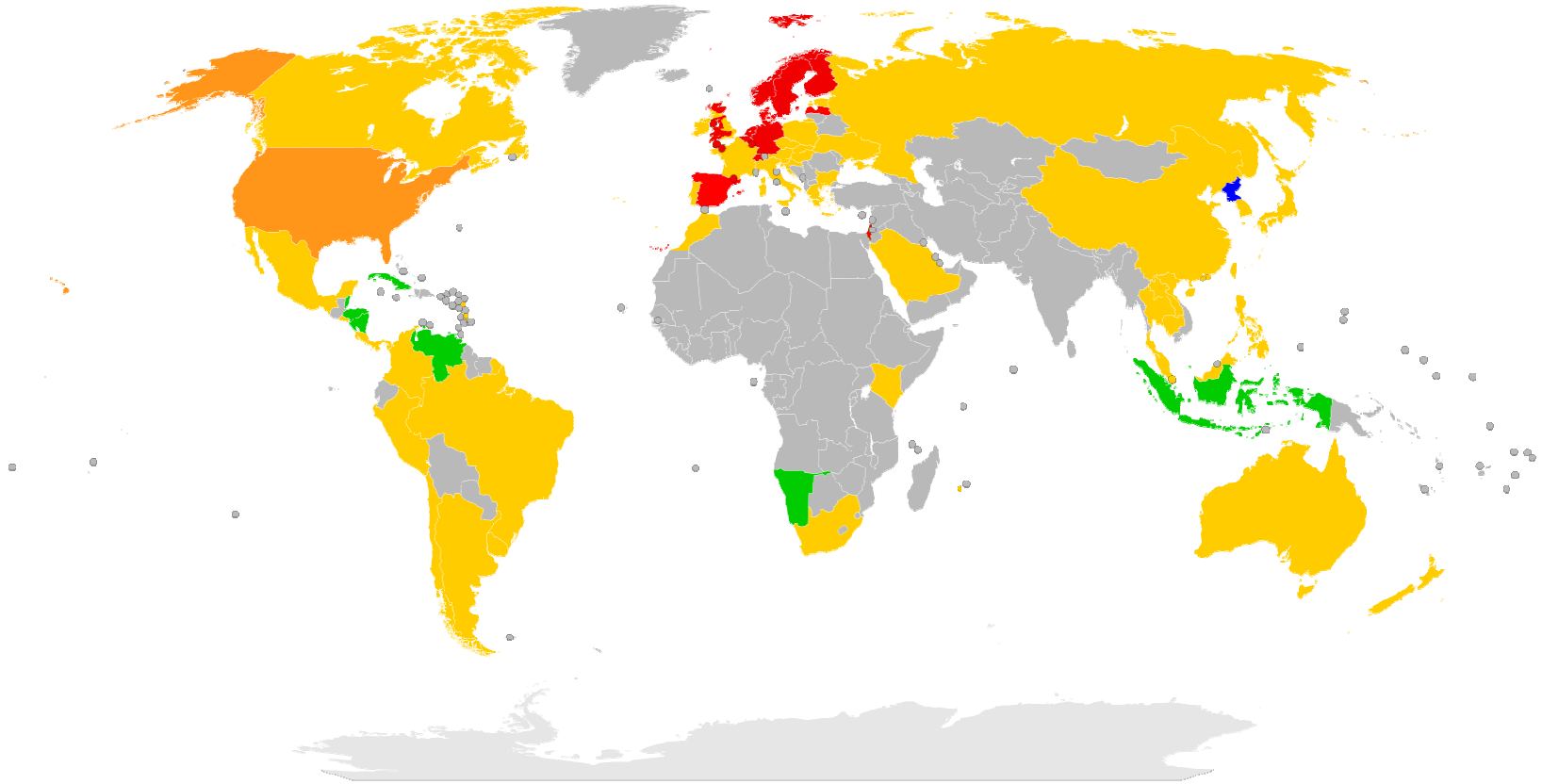
“Next Generation” Digital TV Broadcast

- DVB-H
  - 前身: DVB-T
  - COFDM based, H.264 video/AAC audio, IP datacast (IPDC)
  - 省電技術: Time Slicing
- T-DMB
  - 前身: DAB
  - COFDM based, H.264 video, raw MPEG4 data
  - 省電技術: Bandwidth shrinking
- MediaFLO
  - Qualcomm proprietary, H.264 video
  - COFDM based

“Next Generation” Digital TV Broadcast

- ATSC-M/H
  - 前身: ATSC
  - 8-VSB based, H.264 AVC and SVC video, AAC audio
  - 省電技術: Time Slicing
  - 可移動接收
- ISDB-T 1seg
  - COFDM based, H.264 video
  - 省電技術: Bandwidth shrinking
  - 可移動接收
- CMMB
  - Based on STiMi
  - COFDM based, H.264 video, AAC audio
  - 省電技術: Time Slicing
  - 可移動接收,
- DVB-T2
  - 前身: DVB-T
  - Focuses on coverage improvement
    - **MIMO**
    - **ST coding**
    - **Frequency hopping**
  - HD broadcasting.
  - 移動接收難度高

Analog Switch-Off (ASO)



Transition completed
Transition completed for full-power stations only.
Transition ongoing
Transition not yet started
No intention to transition
No information