Single Frequency Networks

Economy in the radio spectrum

HELLO!

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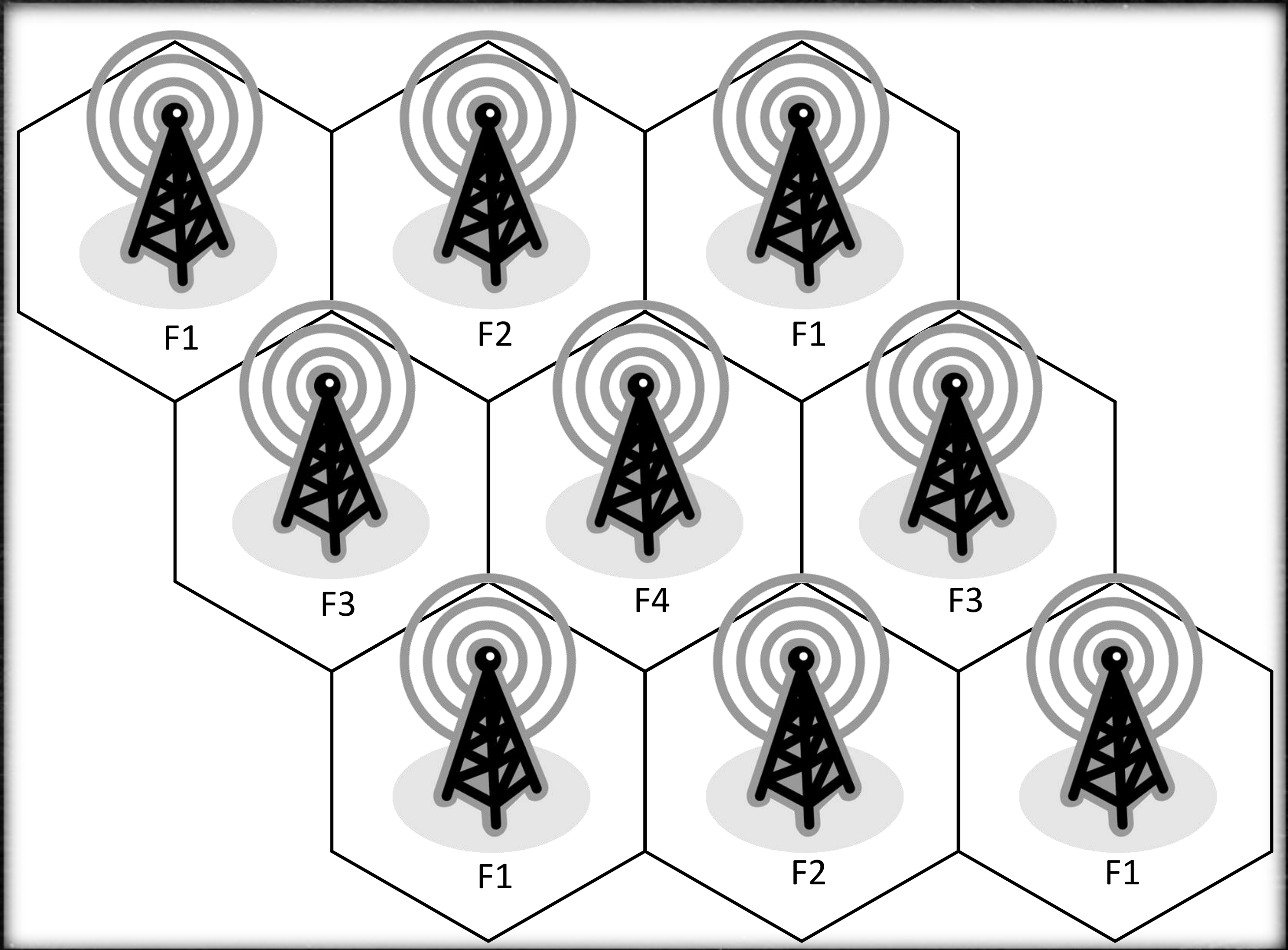
Introduction

- A Single Frequency network (SFN) is a broadcast network where several transmitters simultaneously send the same signal over the same frequency channel.
- This kind of network planning makes a more efficient usage of the radio spectrum than traditional Multi Frequency Networks (MFNs)
  - Also increase the coverage area and decrease the outage probability
- SFNs are not compatible with analogue television , if used results in ghosting due to echoes of the same signal.

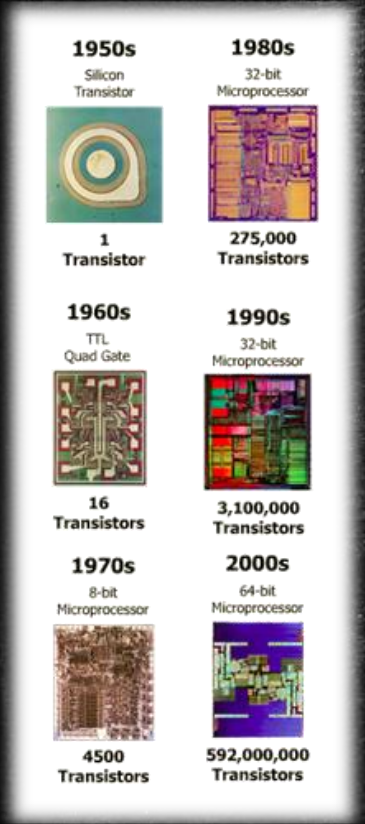
- In traditional MFNs the same program uses different frequencies to be transmitted
- A frequency cannot be reused in a certain distance (reutilization distance)
- For a country as Spain 9 different frequencies were needed for a single channel



- SFN scenarios can be seen as a severe cases of multipath propagation
- The receiver gets several echoes of the same signal with different delays
- The constructive or destructive interference among these echoes (self-interference) may result in fading
- The fading in these scenarios is frequency selective and may result in Inter Symbol Interference (ISI)

A walk through the history

- Communication systems have changed our way of life
  - In the late 60s the germ of internet was an United States Department of Defense project known as ARPANET
  - It is strange nowadays to find someone without an internet connection in the palm of his or her hand
    - Integrated electronics made possible to improve the performance and the computing capacity of electronic device by reducing their size to nanometers



1928

OCTAGON

General Electric made the Octagon in 1928 as part of their experimental TV program in Schenectady, New York. The first TV drama, the Queen's Messenger, was produced in September of that year by GE.

1930

BAIRD

The Baird Televisor was made by Plessey in England from 1930 through the early 30s. It was the first television receiver sold to the public.

1936

EMYVISOR & COSSOR

In the year 1936 two T.V was invented the first was the Emyvisor which picture in black & white. the next TV was the Cossor which not only show picture in black and white but also in color.

1938

MARCONI

Here's a 1938 Marconi 707 Television & All Wave Radio Receiver. Measuring 26" x 19" x 19" and weighing more than 100 pounds, the set was actually considered to be somewhat compact in its day, and though its 7 inch screen would be regarded as miniscule by contemporary standards, in 1938 it was not insubstantial.

1939

RCA

RCA introduced television to the American public at the 1939 World's Fair. Before the fair, they published a brochure for their dealers to explain television.

1946

RCA

The RCA 630TS television became an immediate hit when it was introduced in 1946, right after World War II.

1948

MOTOROLA

Motorola's "Golden View" was the most popular 7-inch television in the late 1940s and early 1950s. It came in both tabletop and portable cabinets and it was one of the cheapest TVs available at the time.

1949

RAYTHEON

The Raytheon M-1101 is an American TV set manufactured in Raytheon's Belmont Radio plant in Chicago on October 1949, the CRT face was more or less masked to give a rectangular appearance), this style of TV is known as "porthole", like the "windows" on a ship.

1953

SHARP

Sharp started producing as the first Japanese television in mass production. The 14-inch TV was the standard in the first Japanese households for years. With its wooden frame, it precisely met the design aesthetic taste of the fifties.

1958

PHILCO

Is this the ultimate TV? Love it or hate it, the Philco Predicta television is unarguably one of the design icons of the 20th Century.

1962

MEIDENSHA

Meidensha TV's were really contemporary in style and design. The wooden frame and high voltage tubes were considered as a great combo back then.

1973

PHILCO-FORD

1973 Philco-Ford - Model B450ETG - One of the last 'vacuum tube' sets. It was in this time period that the American television set industry migrated to a transistorized TV chassis.

1998

SONY

The Sony T.V was created in 1998, it was the first television that had a built in VCR and DVD player. The Sony t.v had better picture and a lot more channel with color.

2007

SAMSUNG

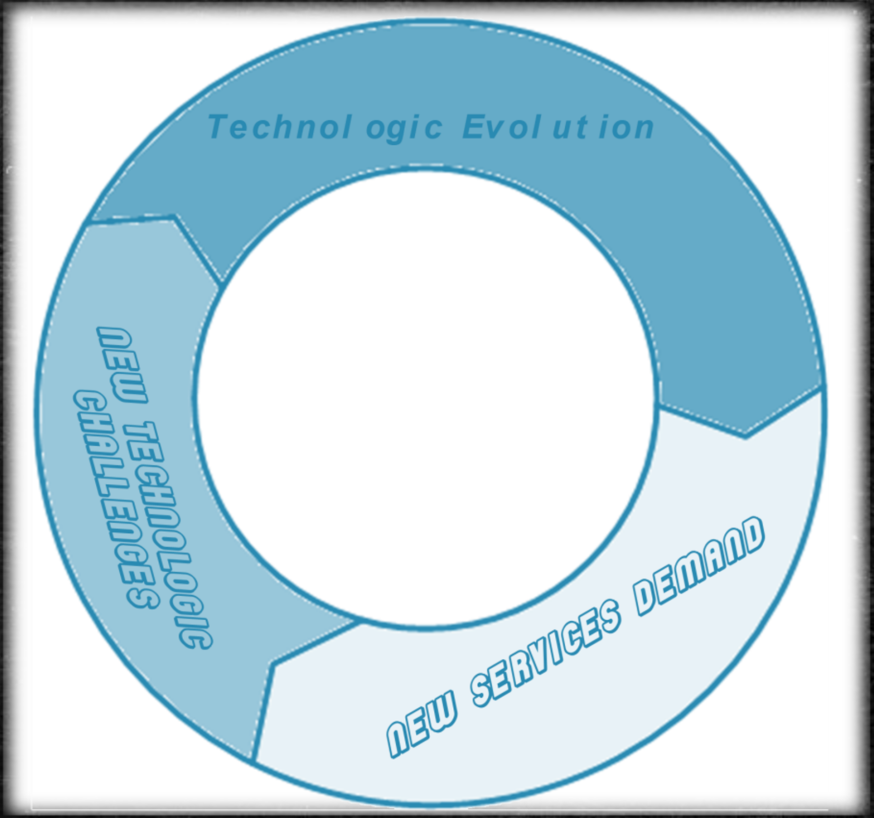
Samsung emerged as one of the largest flat panel TV producer worldwide. Samsung also introduced a ten-millimeter thick only, 40-inch LCD television panel for the first time too.

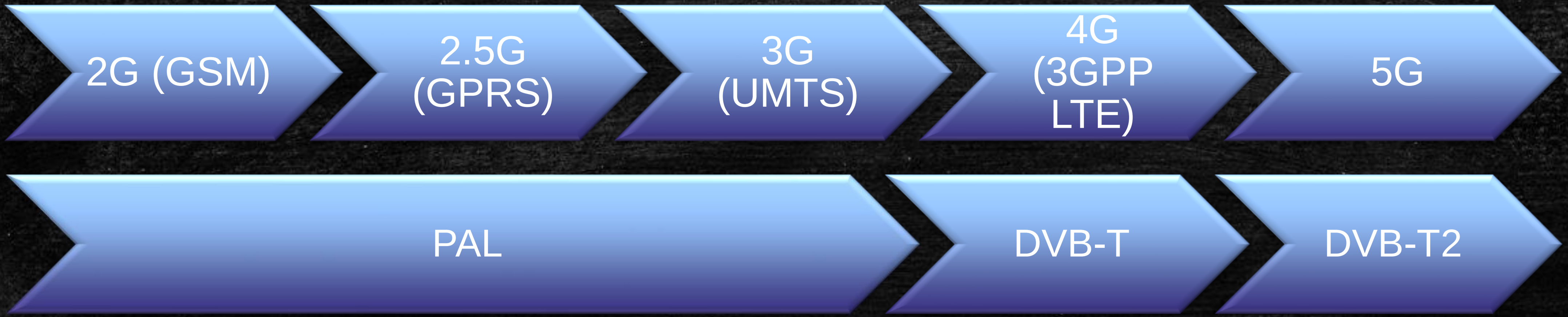
2014

SAMSUNG

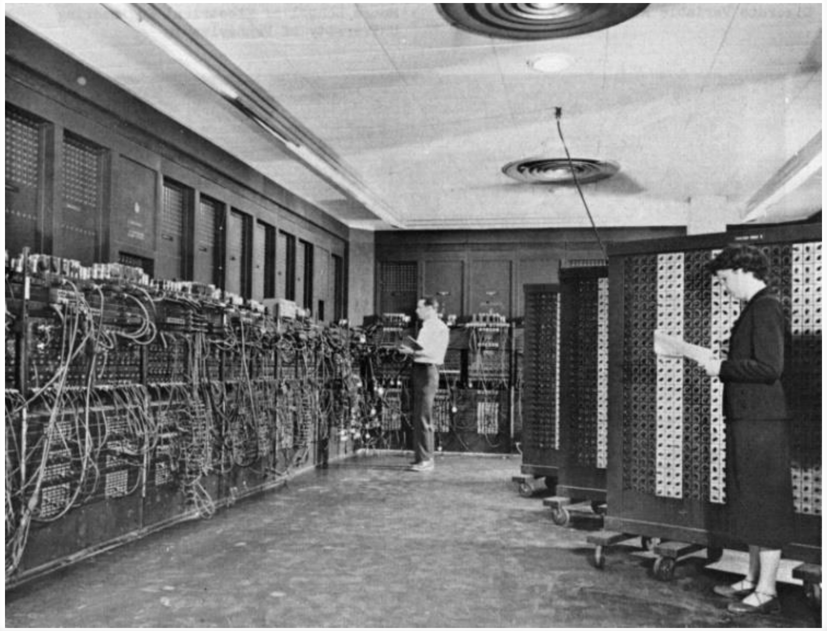
Samsung started selling commercial curved smart TVs. In the IFA2014, Samsung also displayed the first bendable TV with 5,120 x 2,160 resolutions.

- There is a very close relationship between technology and users demands
  - The evolution of technology produces new services demand
  - The demand of new services produces new technologic challenges
  - The new technologic challenges are translated into technologic evolution



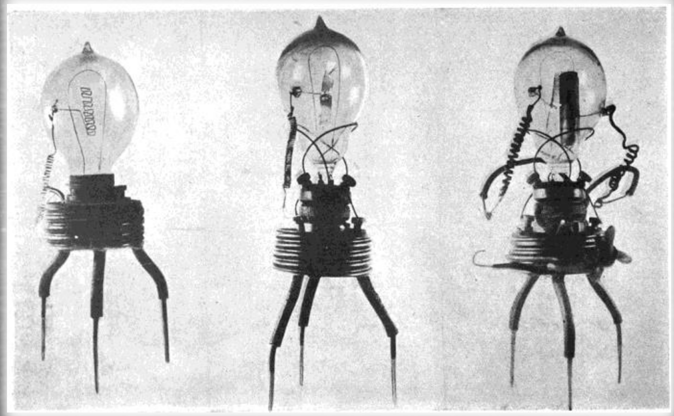


- The evolution of communication systems cannot be conceived without the evolution of electronics
  - In the 40s computers had the size of a whole room
    - ENIAC was the first electronic general purpose computer

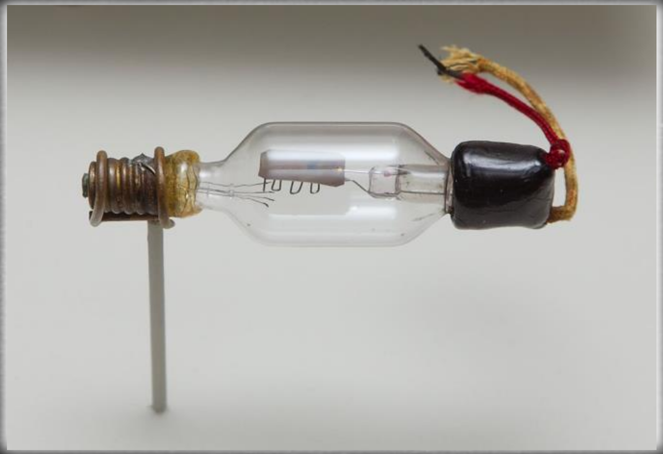


    - It was mainly used to calculate artillery firing tables for the United States Army's Ballistic Research Laboratory

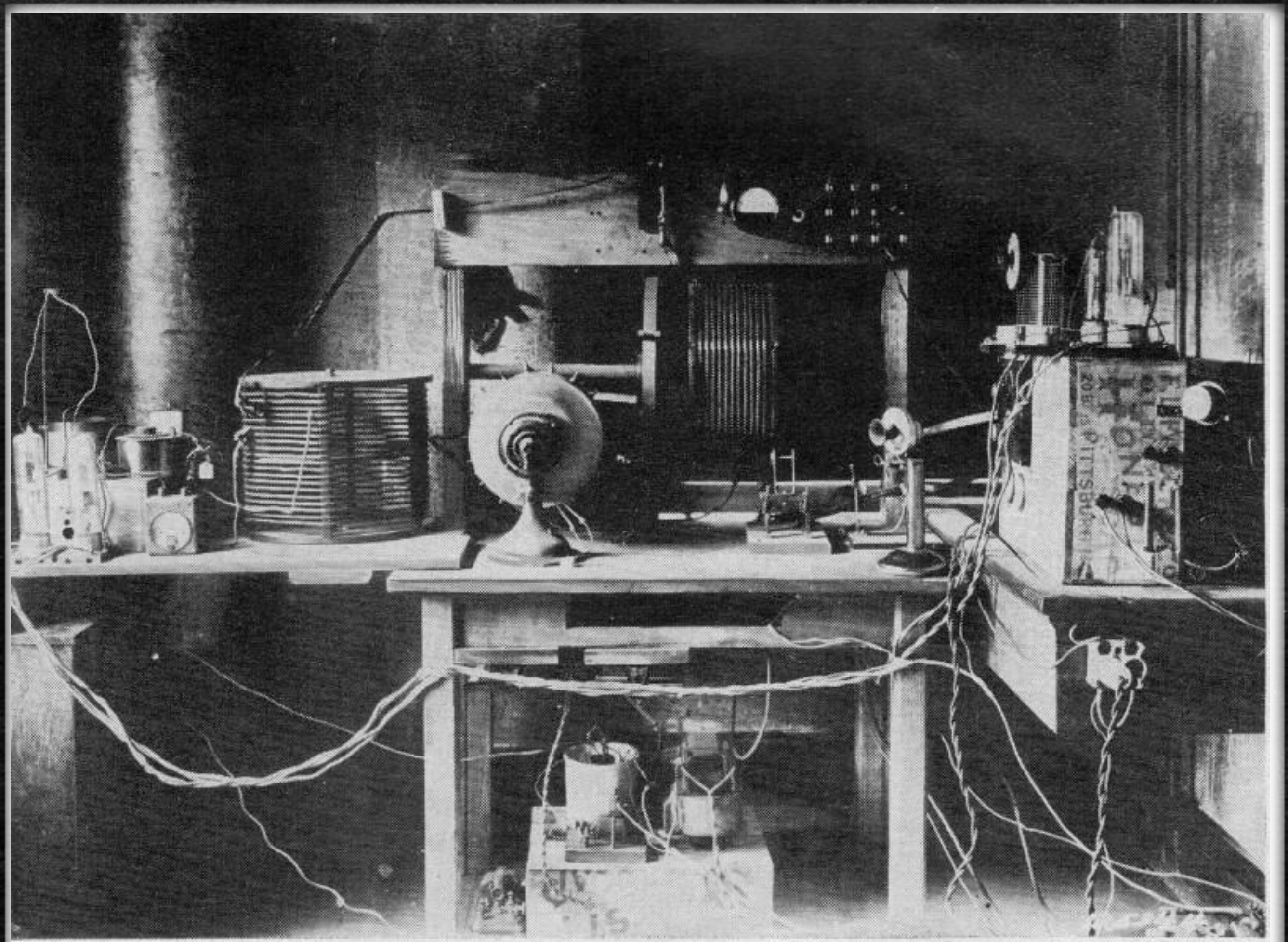
- The evolution of electronics had very marked milestones
  - **1904:** Diode or vacuum tube was invented by Fleming (rectification)



  - **1906:** Triode was invented by De Forest (rectification, amplification)



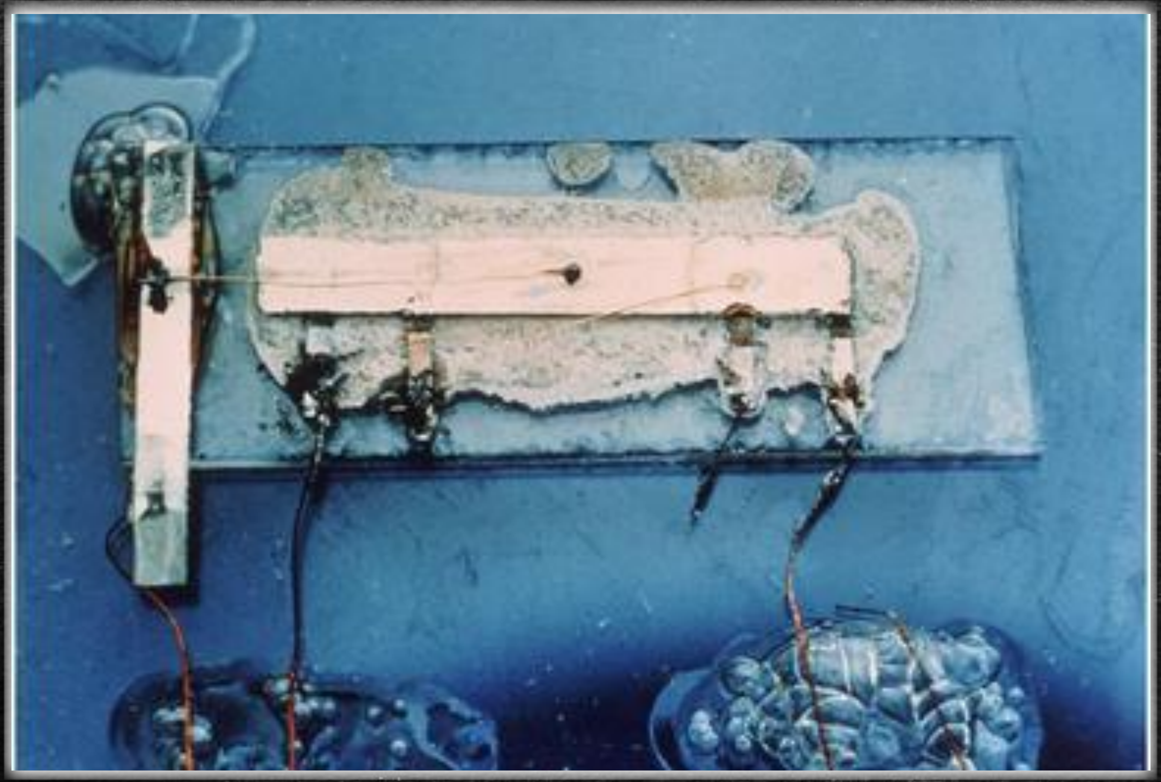
- **1920:** First radio broadcasting service (Westinghouse Electric Corp.)



Brown Bros. Photos

- **1948:** First transistor is invented in Bell Labs

- **1958:** Integrated circuit was invented by Kilby



  - Awarded with the Nobel Price in 2000
  - His work was named an IEEE Milestone in 2009

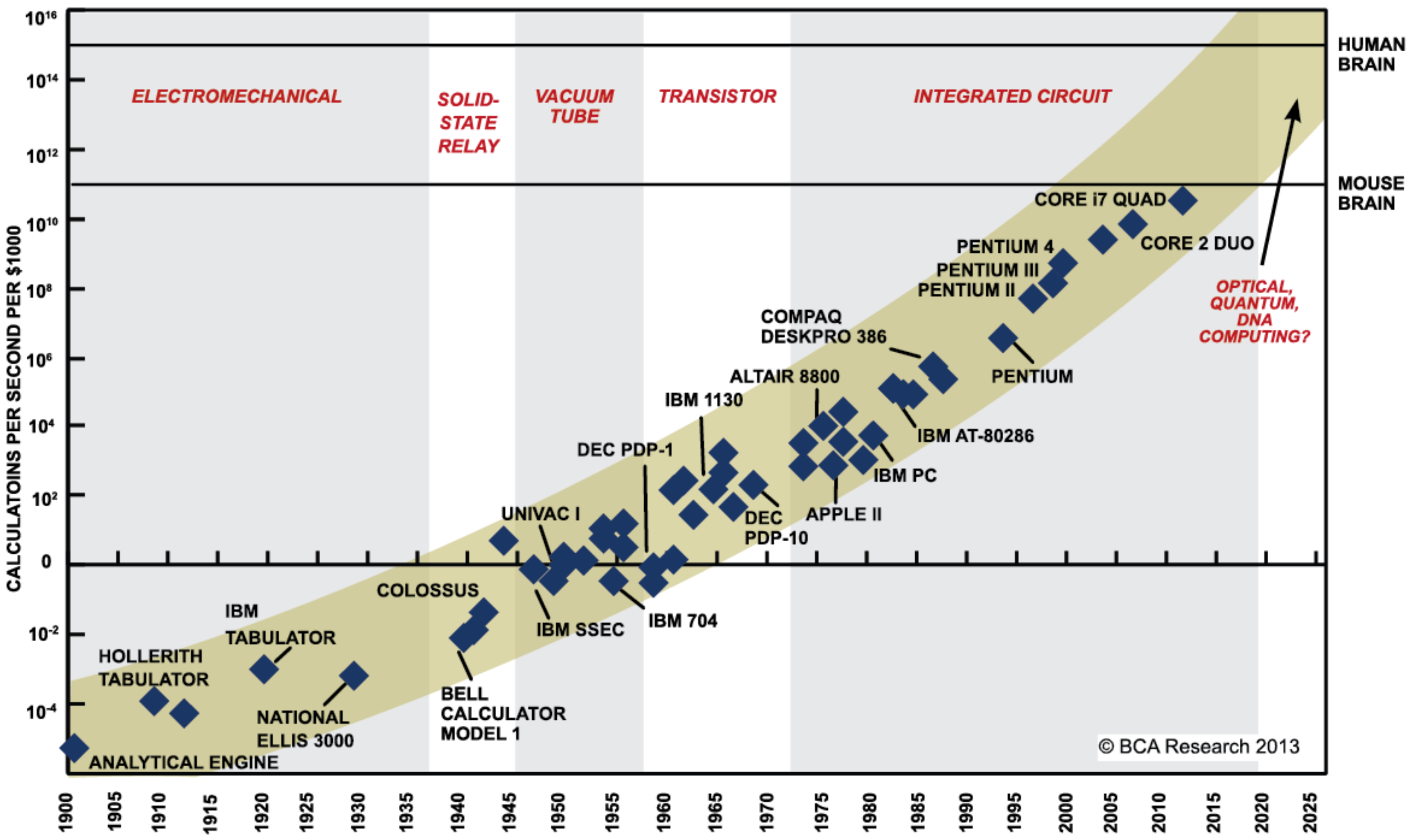
- **1924:** Two-way radio telephone for car (Bell Labs)

- **1973:** First mobile phone (Motorola, Martin Cooper)

- **1928**: Octagon (General electric)

- **2019**: 4K television

- Moore's Law



SOURCE: RAY KURZWEIL, "THE SINGULARITY IS NEAR: WHEN HUMANS TRANSCEND BIOLOGY", P.67, *THE VIKING PRESS*, 2006. DATAPOINTS BETWEEN 2000 AND 2012 REPRESENT BCA ESTIMATES.

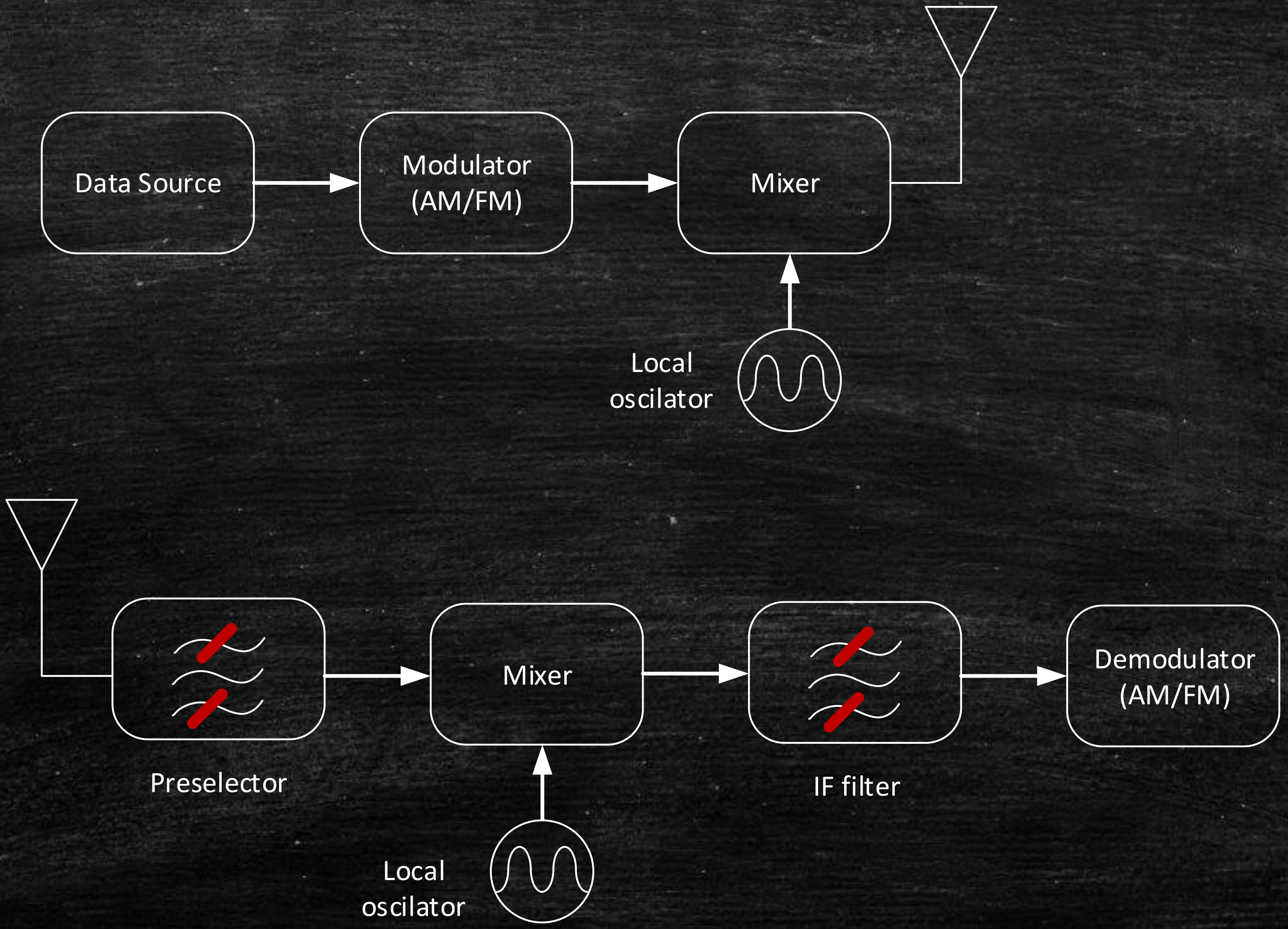
- The improvement of the scale of integration boosted the computation capabilities of integrated circuits
  - More complex operations to be performed in the same time and space
  - Very complex techniques available for real time data processing
    - Fast Fourier Transform (1805, Gauss-1965, Cooley and Tukey)
    - Low Density Parity Check codes (1963, Gallager)

- **Our imagination runs faster than the technology that can bring it to the real world!**

Communication systems concepts

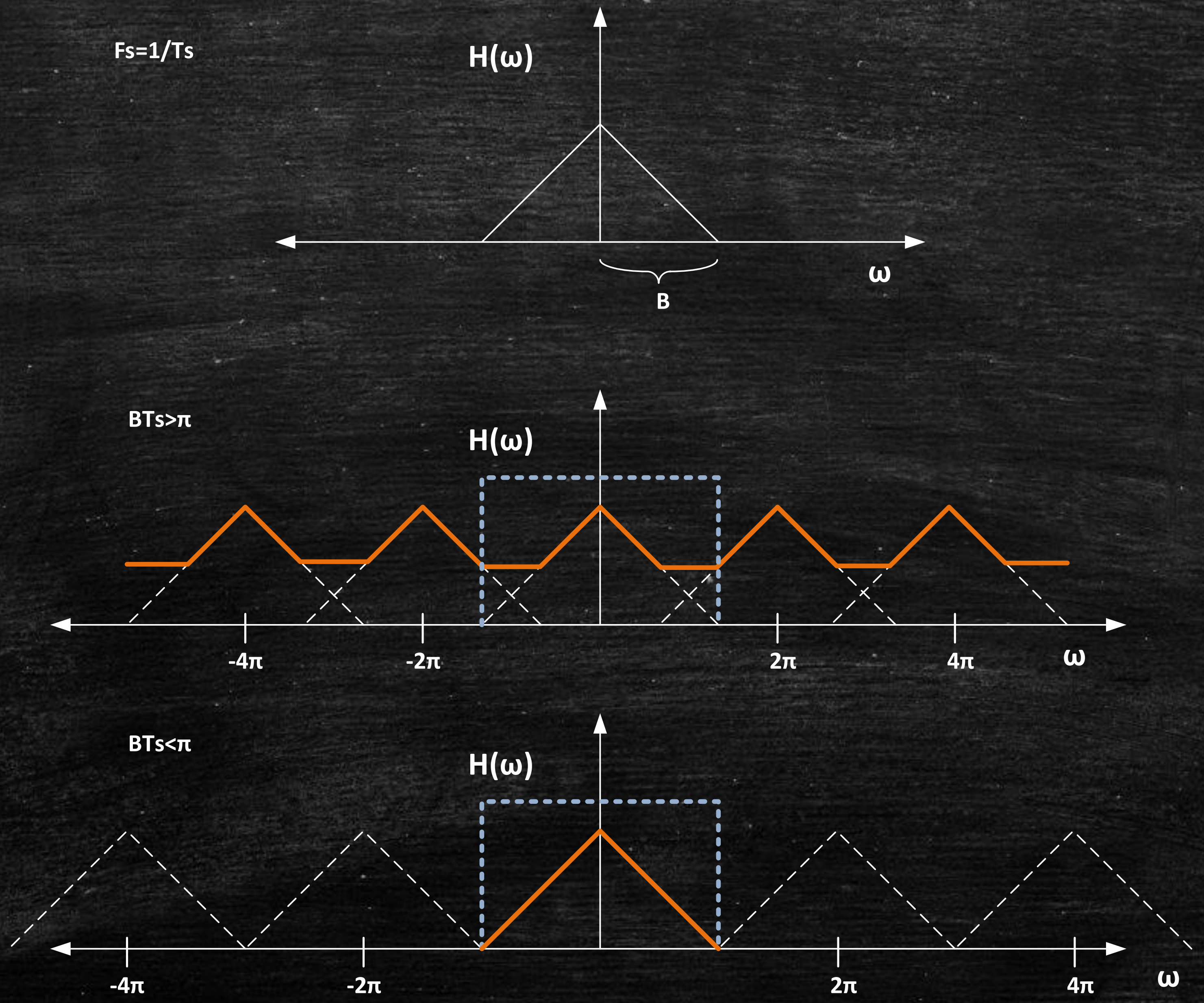
- There are many structures and classifications of communication systems as
  - Type of data processing: digital or analogue (these last ones not very used today, AM and FM radio, PAL TV)
  - Information flux: point to point, broadcast, …
- The ones we will focus on in this subject are the broadcast systems
  - DTV is a clear example
  - DVB-T2 is one of the most advanced communication systems used nowadays

- As an example a simple analogue AM/FM scheme



- Digital Systems have a very interesting advantage, after sampling the signal we can perform whatever operation we want
  - Mathematical operations don’t need discrete physical components to implement them (don’t decay, don’t have tolerance in the manufacturing process …)
- However there is a drawback, we need to sample the signal
  - Sampling frequency must be higher than 2 times the higher frequency in the data to be able to recover the original data (Nyquist theorem)
  - Discretizing the signal carries information loss

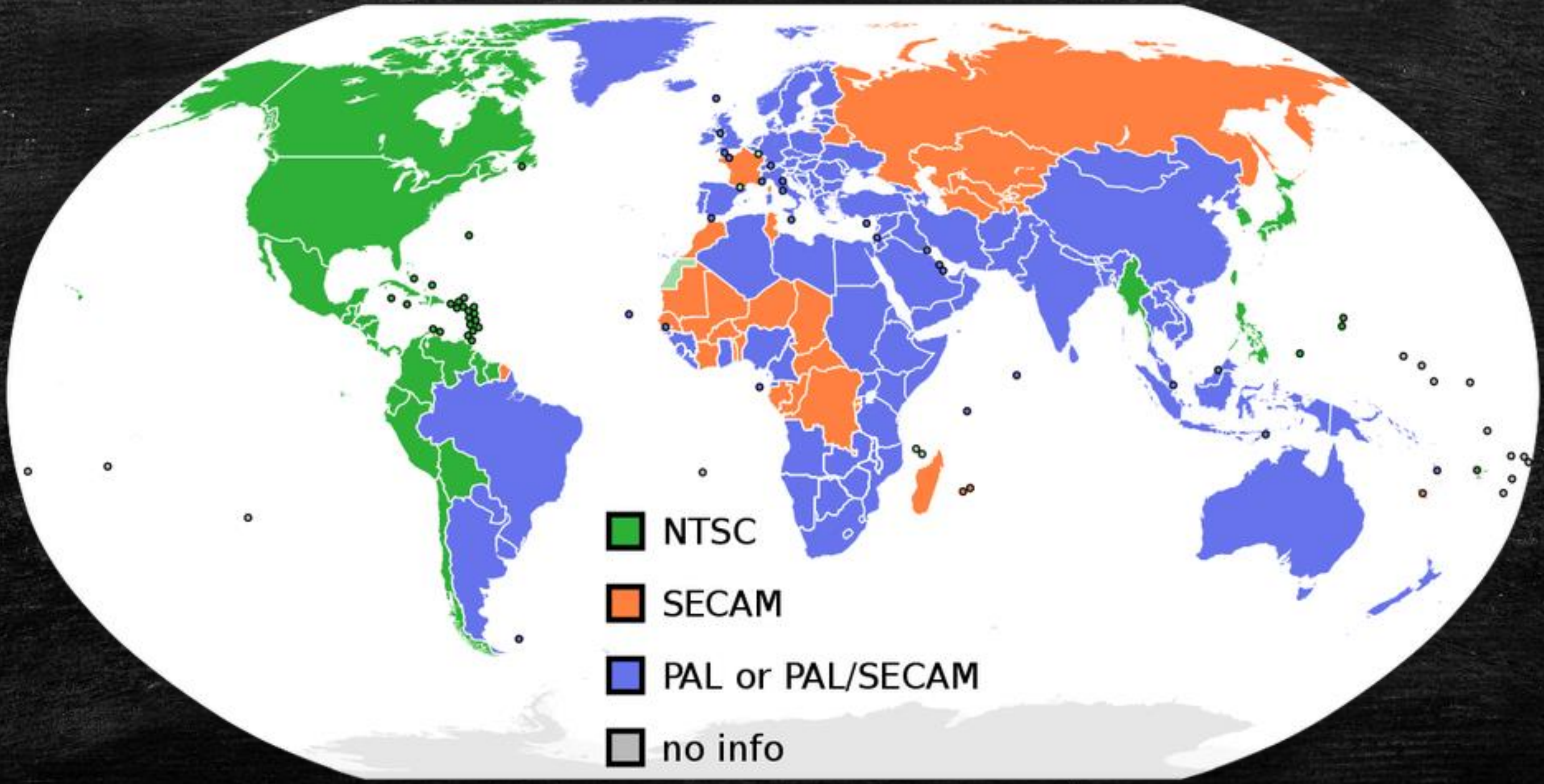
- Nyquist theorem in the frequency domain



- The extreme case of a digital system would be what is know as Software Define Radio
  - Only an acquisition and sampling system
  - The rest of the operations are done in the digital domain defined by a “program”
- High frequency systems need at least twice higher sampling frequency and thus Analogue to Digital Converters
  - Very expensive or inexistent for determinate uses

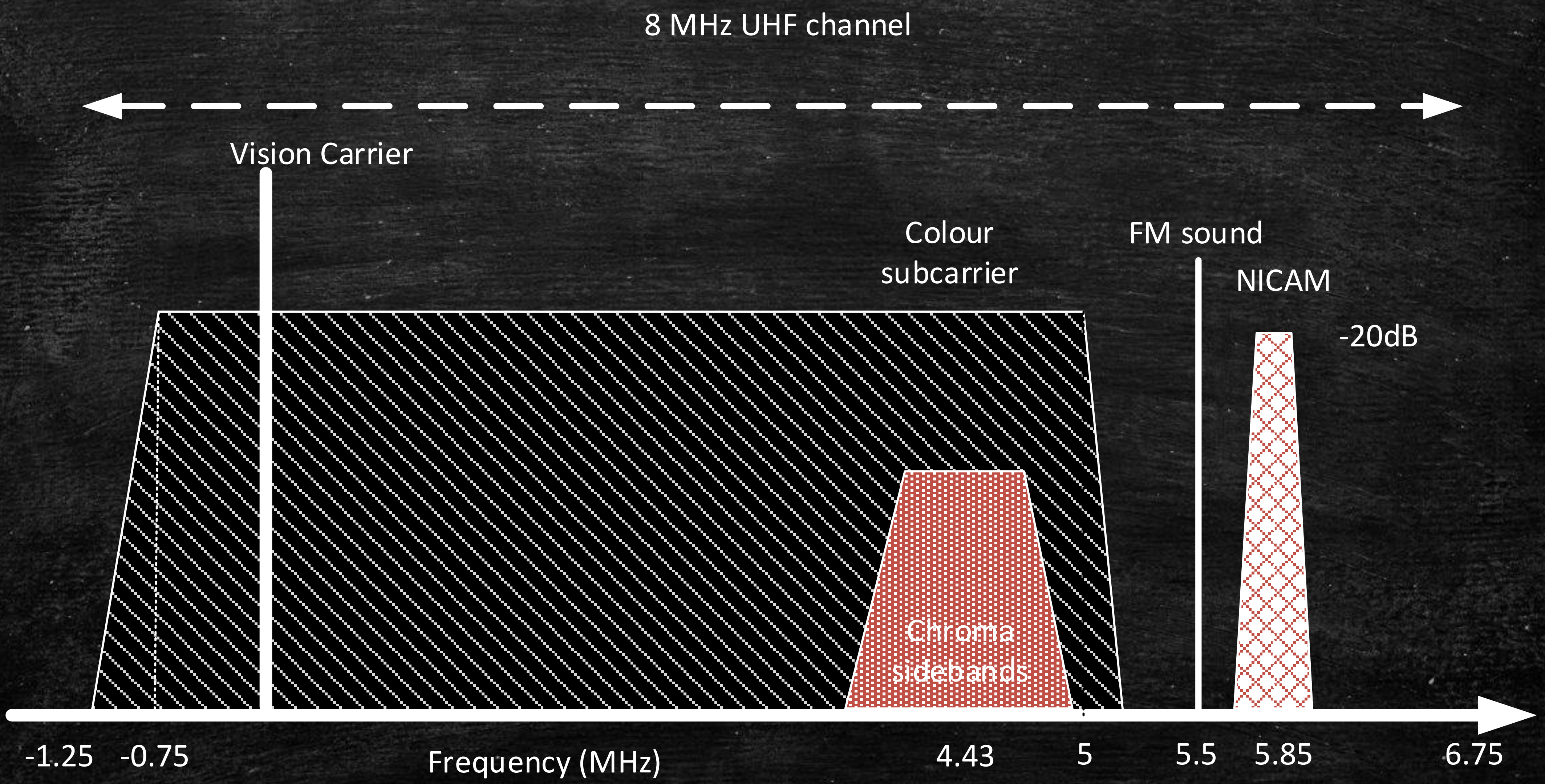
Television Standards in the world

- Analogue television standards in the world

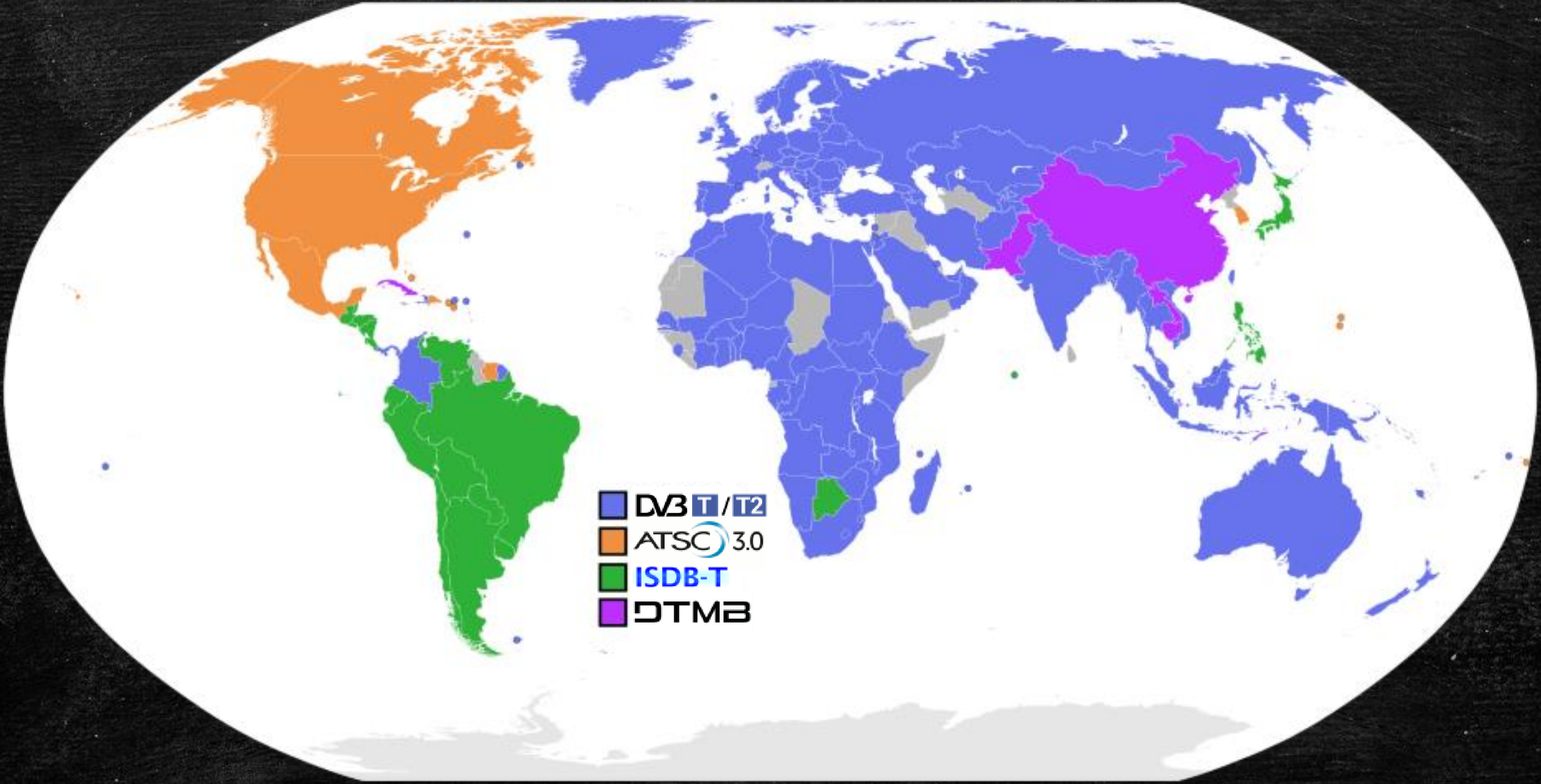


Standard	Launch	Lines	Frame rate	Channel bandwidth (MHz)	Video bandwidth (MHz)	Vision sound carrier separation (MHz)	Vestigial sideband (MHz)	Vision modulation	Sound modulation	Frequency of chrominance subcarrier (MHz)	Vision / sound power ratio	Usual colour
A	1936	405	25	5	3	−3.5	0.75	pos.	AM		4:1	none
B	1950	625	25	7	5	+5.5	0.75	neg.	FM	4.43		PAL/SECAM
C	1953	625	25	7	5	+5.5	0.75	pos.	AM			none
D	1948	625	25	8	6	+6.5	0.75	neg.	FM	4.43		SECAM/PAL
E	1949	819	25	14	10	±11.15	2.00	pos.	AM			none
F		819	25	7	5	+5.5	0.75	pos.	AM			none
G		625	25	8	5	+5.5	0.75	neg.	FM	4.43	5:1	PAL/SECAM
H		625	25	8	5	+5.5	1.25	neg.	FM	4.43	5:1	PAL
I	1962	625	25	8	5.5	+5.9996	1.25	neg.	FM	4.43	5:1	PAL
J	1953	525	30	6	4.2	+4.5	0.75	neg.	FM	3.58		NTSC
K		625	25	8	6	+6.5	0.75	neg.	FM	4.43	5:1	SECAM/PAL
K'		625	25	8	6	+6.5	1.25	neg.	FM	4.43		SECAM
L	1970s	625	25	8	6	-6.5	1.25	pos.	AM	4.43	8:1	SECAM
M	1941	525	30	6	4.2	+4.5	0.75	neg.	FM	3.58		NTSC
N	1951	625	25	6	4.2	+4.5	0.75	neg.	FM			PAL

- Example of PAL signal

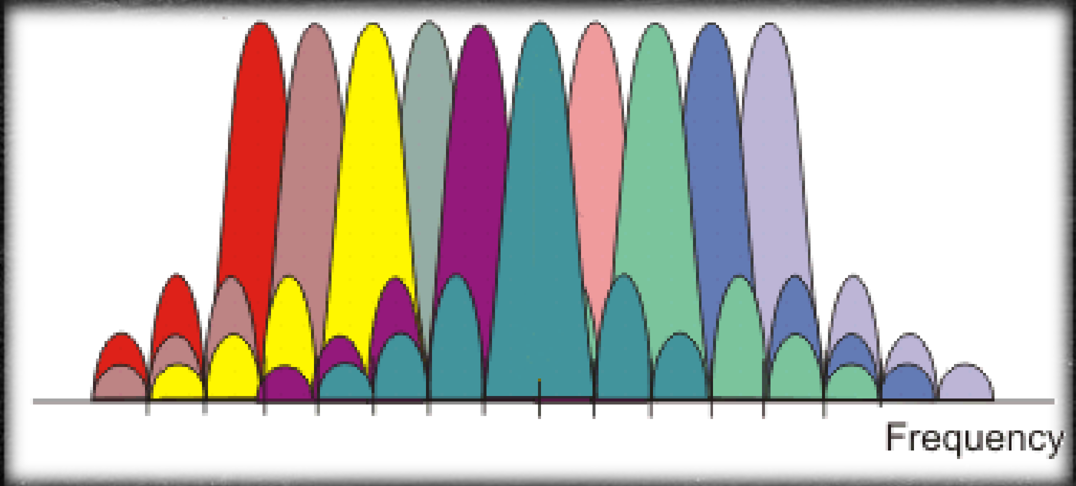


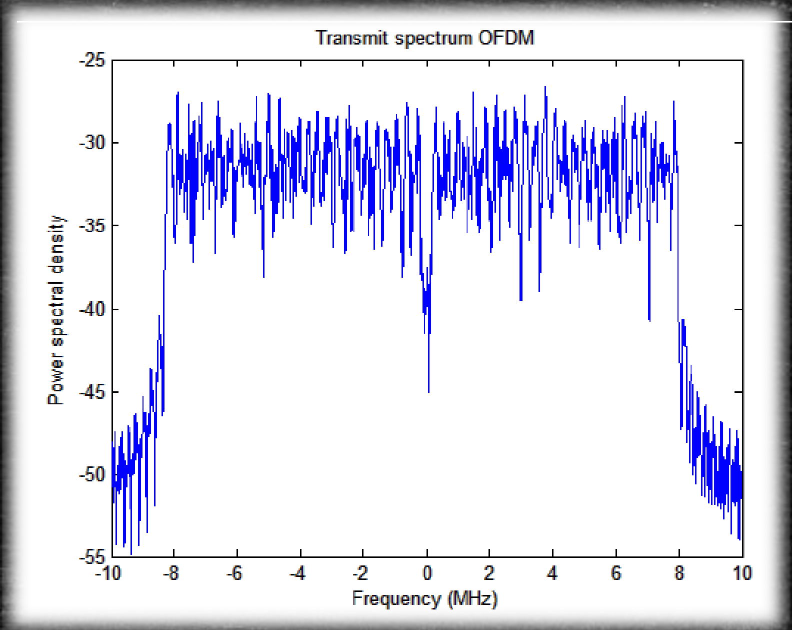
- Digital television standards in the world



Standard	DVB-T	DVB-T2	ISDB-T	DTMB	ATSC	ATSC 3.0
Transmission Modes	OFDM 2k, 8k	OFDM 1k, 4k, 16k, 32k	BST-OFDM 2k, 4k, 8k	TDS-OFDM 3780, Single carrier	Single carrier	OFDM 8k, 16k, 32k
Guard intervals	1/4, 1/8, 1/16, 1/32	19/256, 19/128, 1/128	1/4, 1/8, 1/16, 1/32	1/4, 1/7, 1/9	-	192, 384, 512, 768, 1024, 1536, 2048, 2432, 3072, 3648, 4096, 4864
Constellation Order	QPSK, 16QAM, 64QAM	256QAM	QPSK, 16QAM, 64QAM	8-VSB	4/16/32/64 QAM	QPSK, 16QAM, 64QAM, 256QAM, 1024QAM, 4096QAM
Bandwidth	5, 6, 7, 8 MHz	1.712 , 10 MHz	6, 7, 8 MHz	6, 7, 8 MHz	6, 7, 8 MHz	6, 7, 8 MHz
External code	RS (204, 188)	BCH	RS (204, 188)	BCH (762, 752)	RS (207,187)	BCH
Internal code	Convolutional	LDPC	Convolutional	LDPC	Trellis 2/3	LDPC
Capacity	4.98-31.67	7.44-50.32	3.65-23.23	4.81-32.49	19.39	1-57

- OFDM spectrum example





THANKS !

Any questions?

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