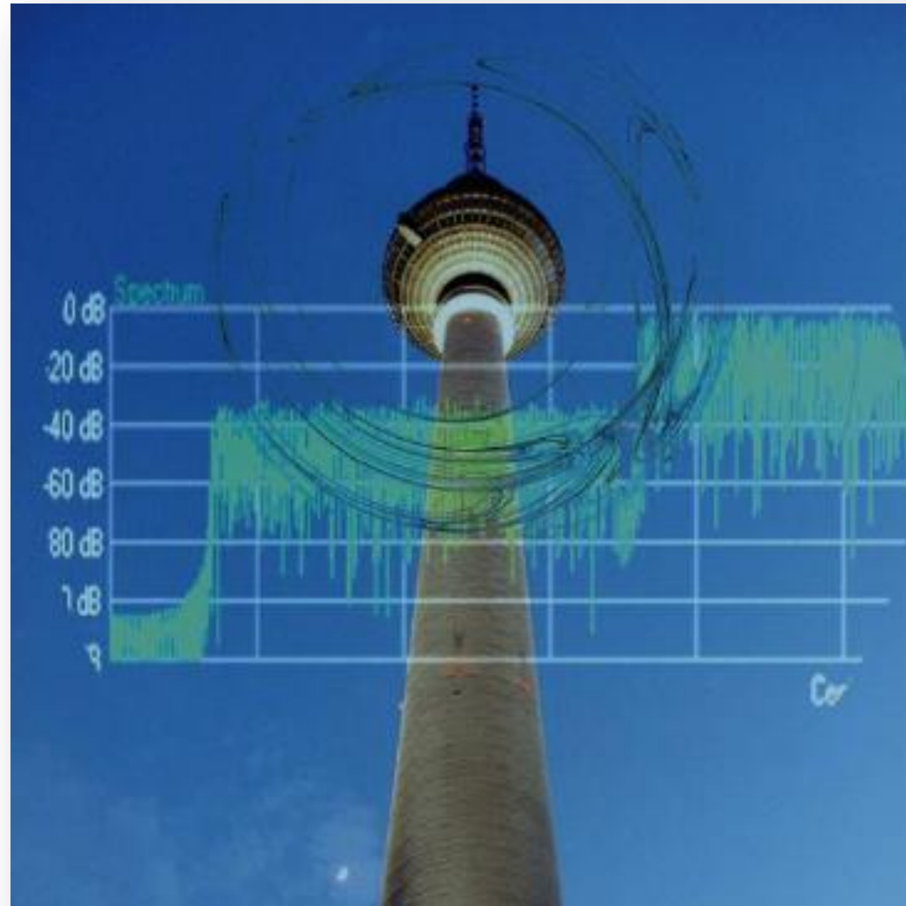
ATSC & ISDB-T TRANSMISSION SYSTEMS



GUY BOUCHARD, CBC / RADIO-CANADA NEW BROADCAST TECHNOLOGIES

Dec 3td 2013

OUTLINE

- Emission Mask Measurment
- Digital Transmission Fundamental
- Transport stream management
- Mobile television
- Video Compression

STANDARDS COMPARISON

Key factor comparison					
Parameter	ATSC	DVB-T	DVB-T2	ISBD-T	
Occupied Bandwidth	6	6,7,8	1,7 to 10	6, 7	MHz
Number of carriers	1	1705 or 6817	1k to 32k	1405, 2809 or 5617	
Guard Interval		1/32 to 1/4	¼ to 1/128	1/32 to ¼	
Equalizer window	Resource dependant				
Max Data range	19.38	31.7	40	23	Mb/s
C/ N threshold for 24 Mb/s		16.7	10.8	17	
Mobility	Clumsy	Good	Excellent	Excellent	

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EMISSION MASK MEASUREMENTS

Broadcast Technology Society

INTRODUCTION

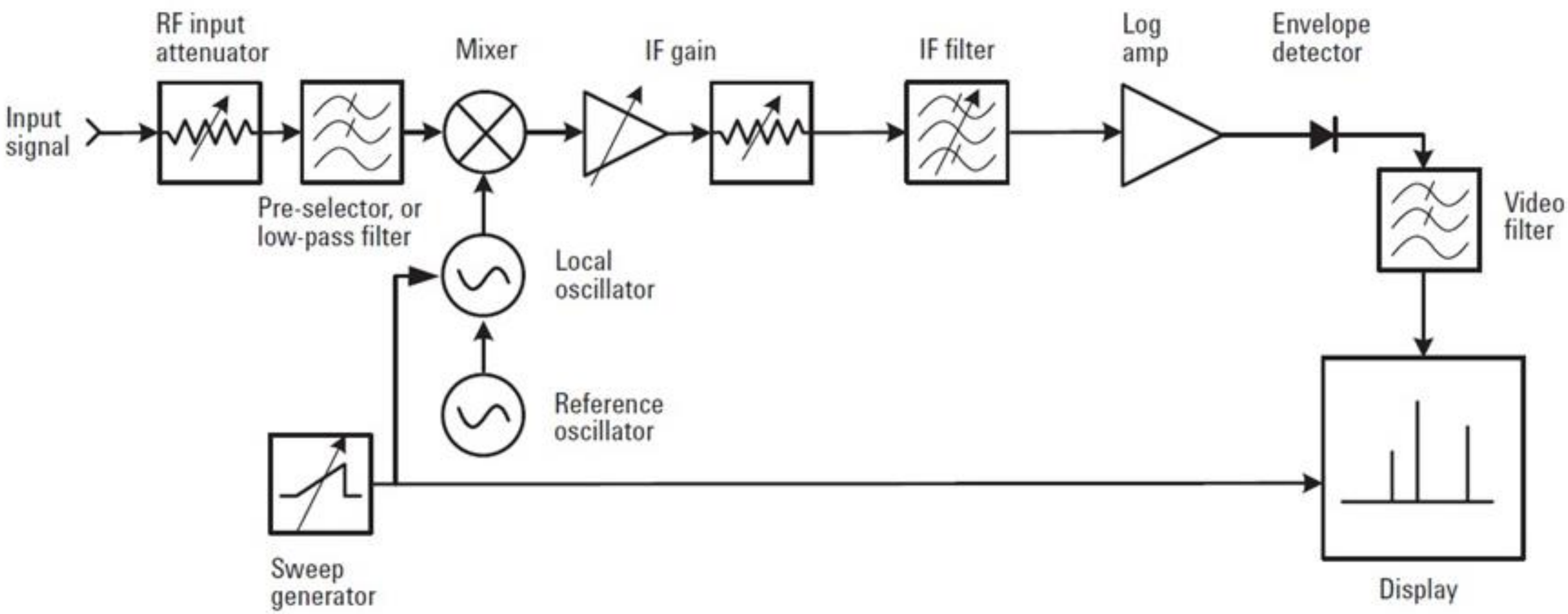
➢**The measurement of the emission mask of any systems with intrinsic energy dispersal is challenging because of:**

- The difficulty of establishing a reference
- The test equipment can't provide you with a plug and play answer
- The dynamic range required far exceed the spec of all spectrum analyzer on the market
- The tests cannot be taken at any level

SCOPE

- **Background:**
  - The ubiquitous spectrum analyzer
  - Energy dispersal issues
  - Dynamic Range issues
- **The emission mask**
  - In-Channel measurement
  - Adjacent channel measurements
- The measurements
  - Establishing a Reference
  - Shoulder measurements
  - Distant measurements
    - Band stop method
    - Emission mask filter method

SPECTRUM ANALYZER ARCHITECTURE



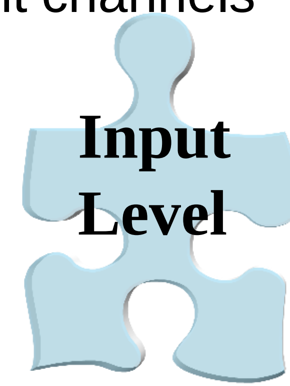
ENERGY DISPERSAL ISSUE

- The SA sees only one resolution at the time
- Look at the pilot to signal ratio
- Double the resolution
- Look at it again, it is 3 dB lower, why?
- The real channel power has to be corected by a factor of 10 log (edbw) – 10 log(rbw)

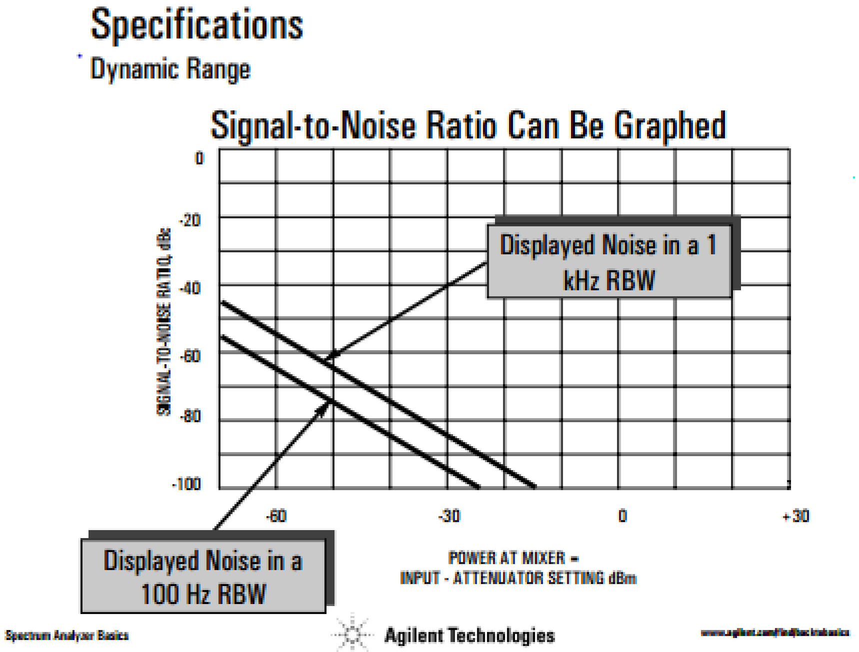
*** Normally a EDBW/RBW ratio of at least 20 is required to ensure a usable spectrum display, 50 is ideal**

THE DYNAMIC RANGE ISSUE

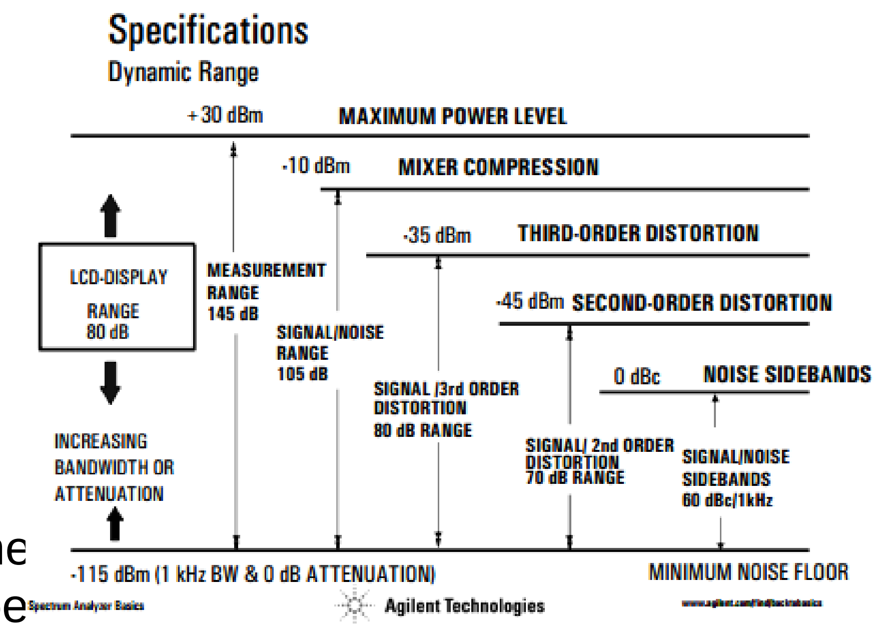
- **The required dynamic range required is in excess of 120 dB**
- **This creates 2 issues:**
  - The input level must be optimized to gte the most dynamic range of the SA
  - The in-channels can be taken, however the adjacent channels are meaningless



DYNAMIC RANGE



THE NET RESULT



- The … lay a result
  doe…

BTS Broadcast Technology Society

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TYPICAL SPECTRUM DYNAMIC RANGE

Input related spurious R&S FSH3 / FSH6	mixer level ≤-40 dBm carrier offset >1 MHz	
Receive frequency Up to 3 GHz 3 GHz to 6 GHz		-70 dBc (nominal)
Receive frequency = signal frequency – 2.0156 GHz	signal frequency 2 GHz to 3.2 GHz	55 dBc (nominal)

(4) Dynamic Range

Characteristics	Description
Average noise level	-113dBm + 2 f (GHz)dB (RBW 1kHz, VBW 10Hz, ATT 0dB, f ≥ 1MHz)
1dB gain compression	> -5dBm (Mixer input level, f ≥ 20MHz)
Secondary harmonic distortion	≤ -70dB (f ≥ 10MHz, Mixer input level -30dBm)
Two-signal third order intermodulation distortion	≤ -70dB (f ≥ 10MHz, Mixer input level -30dBm, Frequency difference between 2 signals)
Other spurious factors related to the input	≤ -60dB (Offset ≥ 20kHz, Mixer input level -30 dBm)
Residual responses	≤ -100dB (f ≥ 10MHz, ATT -0dBm, Input termination with 50Ω)

DYNAMIC RANGE VARIES WITH LEVEL

How can you know we are attacking the Spectrum analyzer at the correct level:

- If it is driven to hight the intermod your are trying to measure will be originated by the front end of the SA
- If it is driven to low the intrinsic noise of the unit will mask most of what you are trying to measure

Procedure to find the optimum level:

OPTIMAL DRIVE LEVEL

- You can use your ISDB-T signal to asses intermods
  - Measure the level of intermod produced by your TX
  - Try to attack the spectrum nanlyzer at a low level (-30 to -40 dBm)
  - Raise level until the intermod has raise by about 5 dB
  - Back off 6 dB, you should be close the the optimum
- Can the sniffer you need to use deliver the optimum level ?

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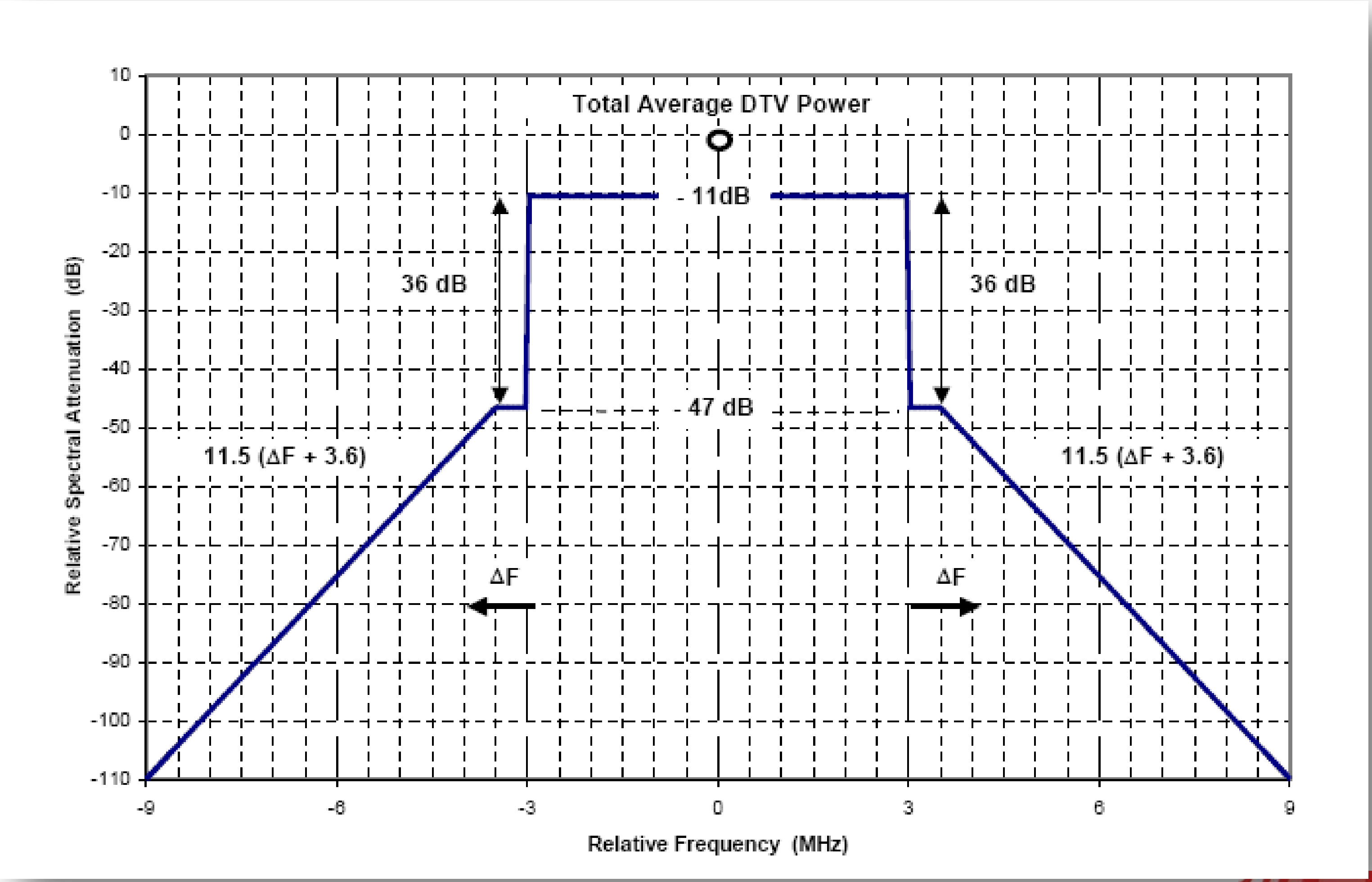
THE ATSC EMISSION MASK



(Based on a 500 kHz RBW)

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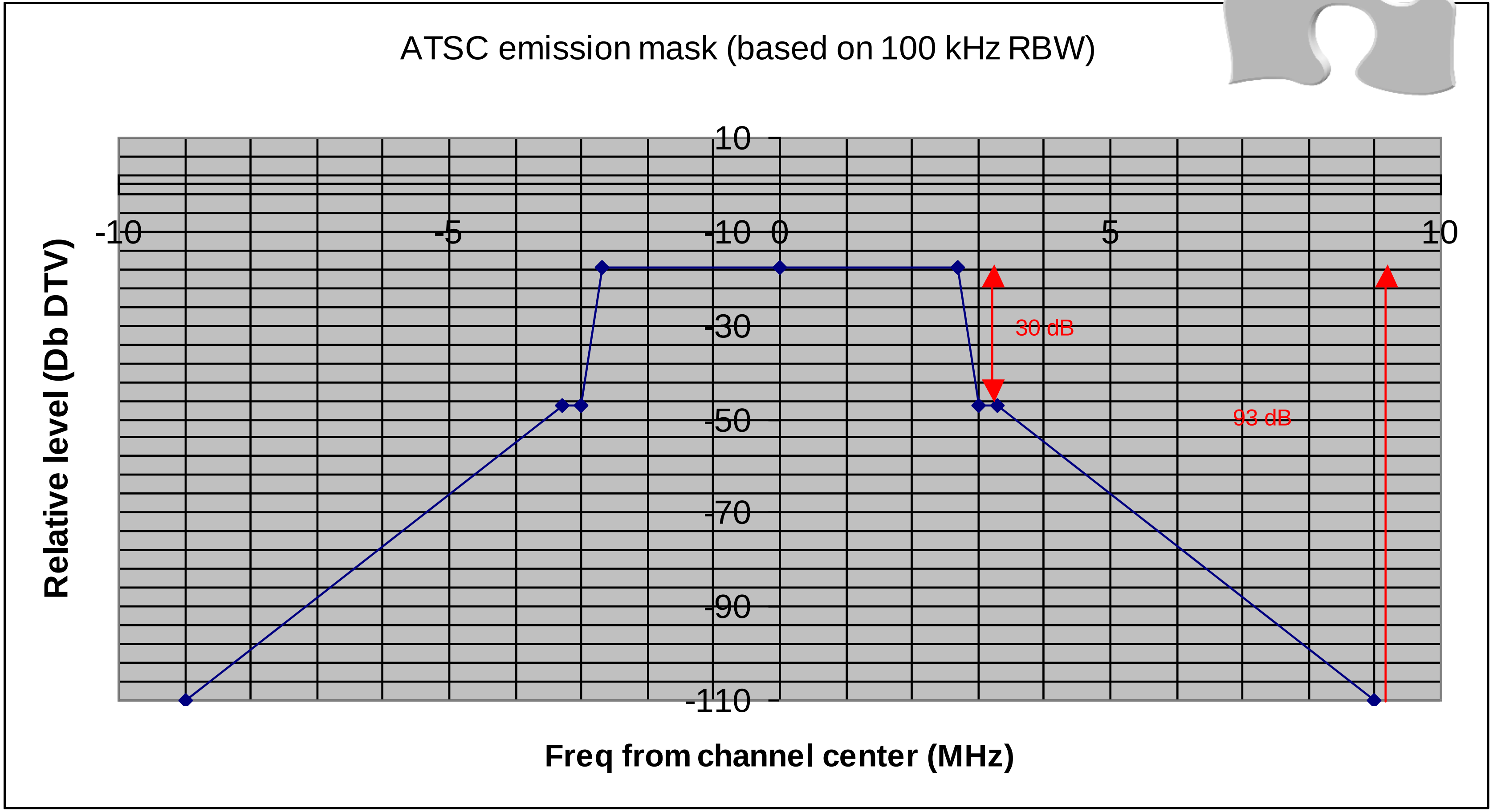
PRACTICAL EMISSION MASK

Practical data



28/12/2013
Guy Bouchard, CBC

Broadcast Technology Society

BRAZILIAN EMISSION MASK

Difference from carrier frequency	Minimum attenuation in relation to average power measured at carrier central frequency		
	Non-critical mask	Sub-critical mask	Critical mask
±2.86 MHz	20.0 dB/10kHz	20.0 dB/10kHz	20.0 dB/10kHz
±3.00 MHz	27.0 dB/10kHz	34.0 dB/10kHz	34.0 dB/10kHz
±3.15 MHz	36.0 dB/10kHz	43.0 dB/10kHz	50.0 dB/10kHz
±4.5 MHz	53.0 dB/10kHz	60.0 dB/10kHz	67.0 dB/10kHz
±9.0 MHz	83.0 dB/10kHz	90.0 dB/10kHz	97.0 dB/10kHz
±15.0 MHz	83.0 dB/10kHz	90.0 dB/10kHz	97.0 dB/10kHz

ISDB-T EMISSION MASK

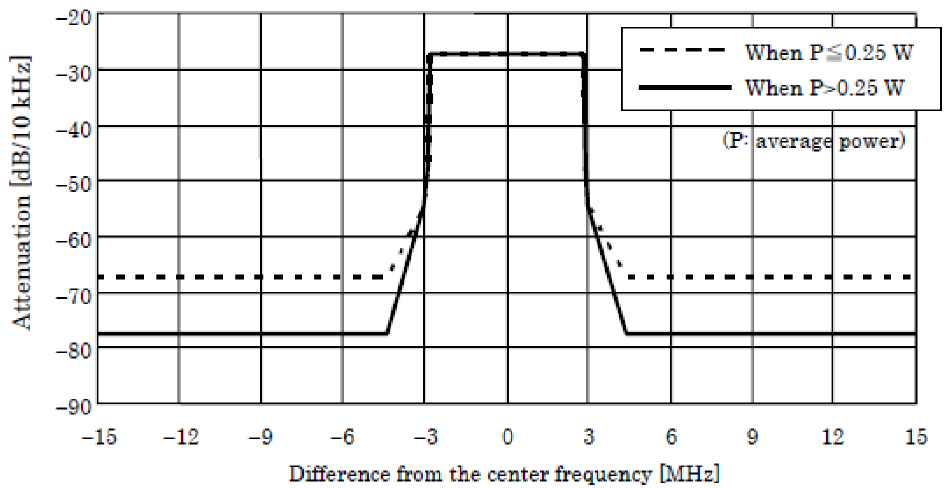


Fig. 4-1 Transmission-spectrum limit mask for digital terrestrial television broadcasting

Table 4-1 Breakpoints for transmission-spectrum mask

Difference from the center frequency (MHz)	Attenuation relative to average power P (dB/10 kHz)	Type of stipulation
±2.79	−27.4	Upper limit
±2.86	−47.4	Upper limit
±3.00	−54.4	Upper limit
±4.36	−77.4*	Upper limit

HIGHLIGHTS:

Rather high noise floor -77 dB DTV

Shoulder at -30 dB DTV (similar to ATSC)

Reference point -27 dB down

Normalized bandwidth at 10 kHz (a practical value)

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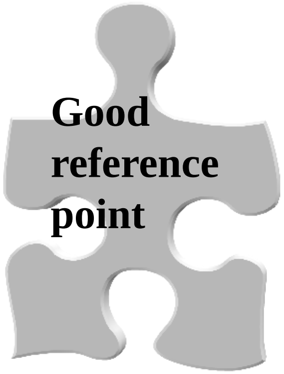
MEASUREMENTS



- **In-Channel measurement**
- **Optimize input level**
  - Start at –20 dBm raise R level until intermod level diminished more than the attenuation provided
  - Establish 0 dB DTV reference (Bar level + 10 log(edbw/rbw)
- **Verify the shoulder level**

ADJACENT CHANNEL MEASUREMENTS

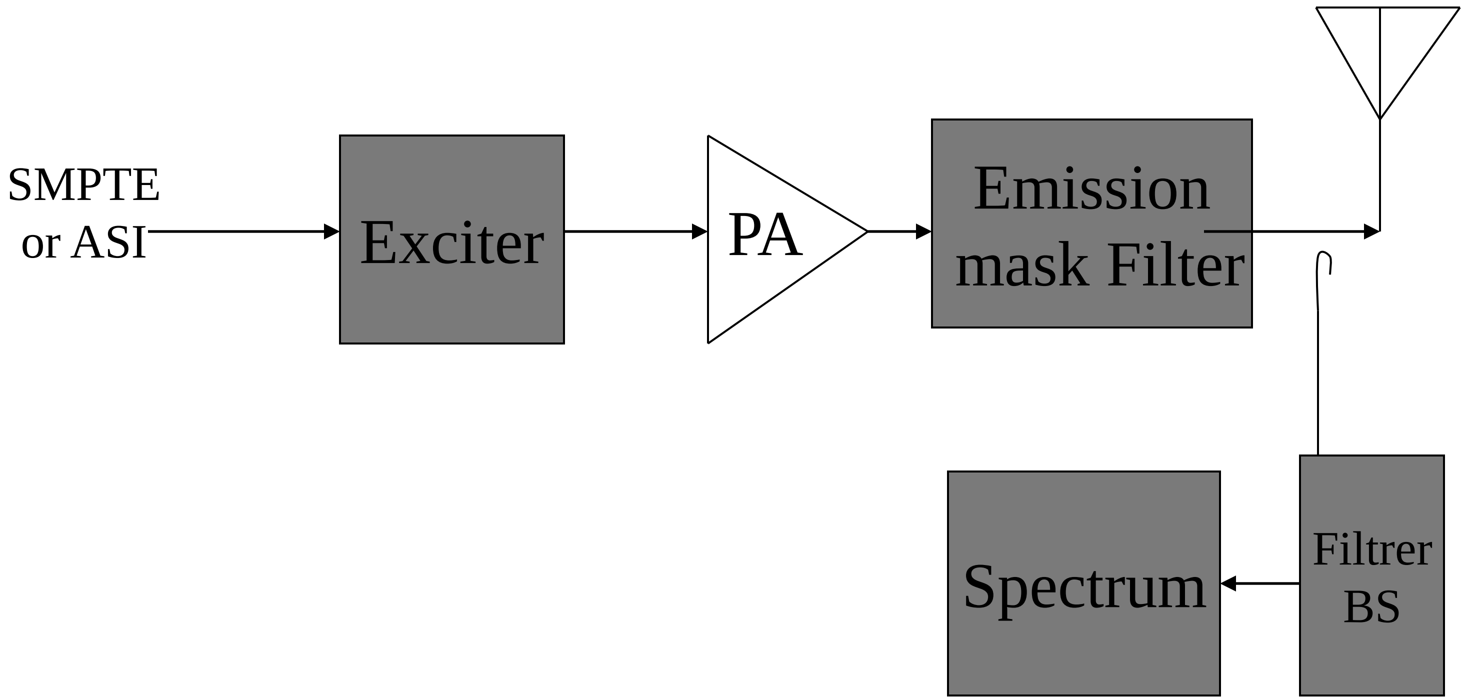
There is an issue with the dynamic range of the spectrum analyzer, the best spectrum analyzer on the market have about 70 to 80 dB of usable dynamic range. The adjacent channel measurements requires about 100 to 120dB of dynamic range

Mitigation technique have to be used

OPTION A – USE A BAND-STOP FILTER

- **A single piece of test Equipment is required SA**
  - The filter cannot be used 500 kHz from the channel edge
  - Requires Judgment and expertise
  - Preclude the measurement of the harmonic response

OPTION A – USING A STOP BAND FILTER (WIDE NOTCH)



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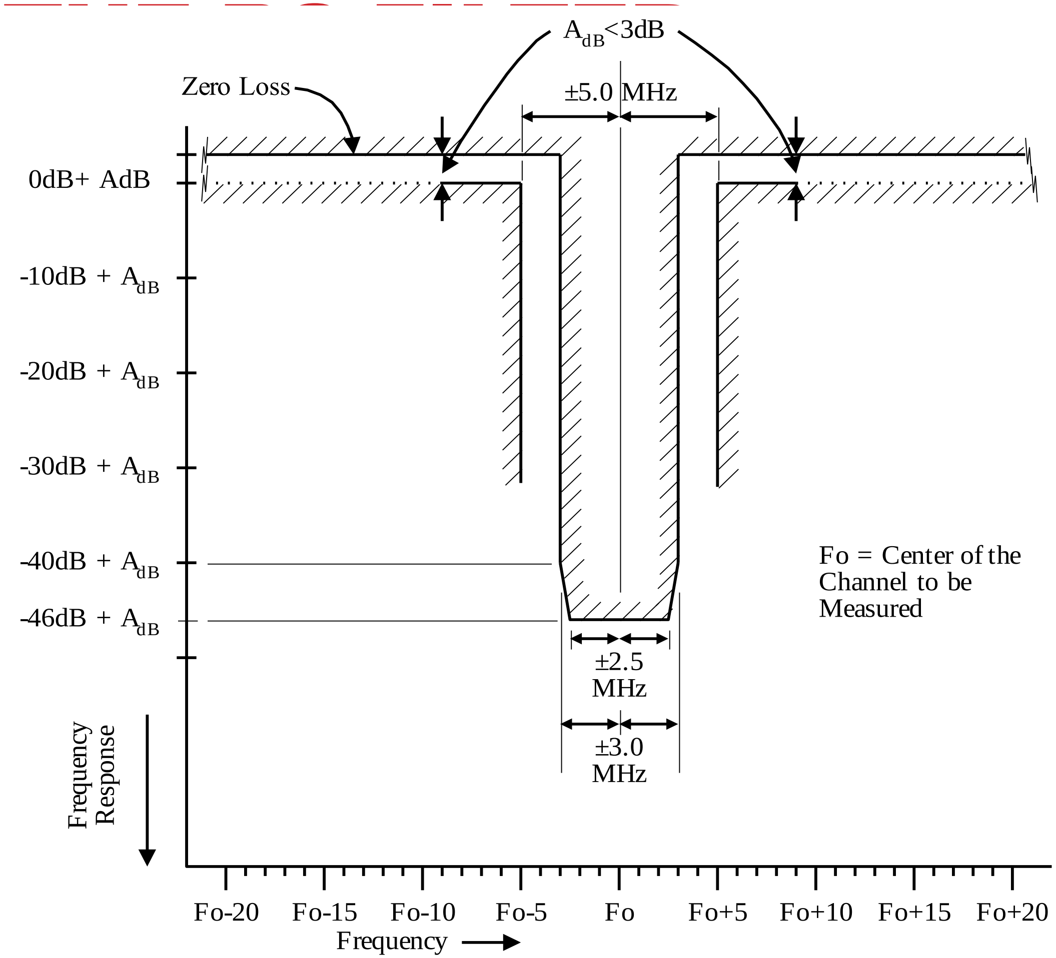
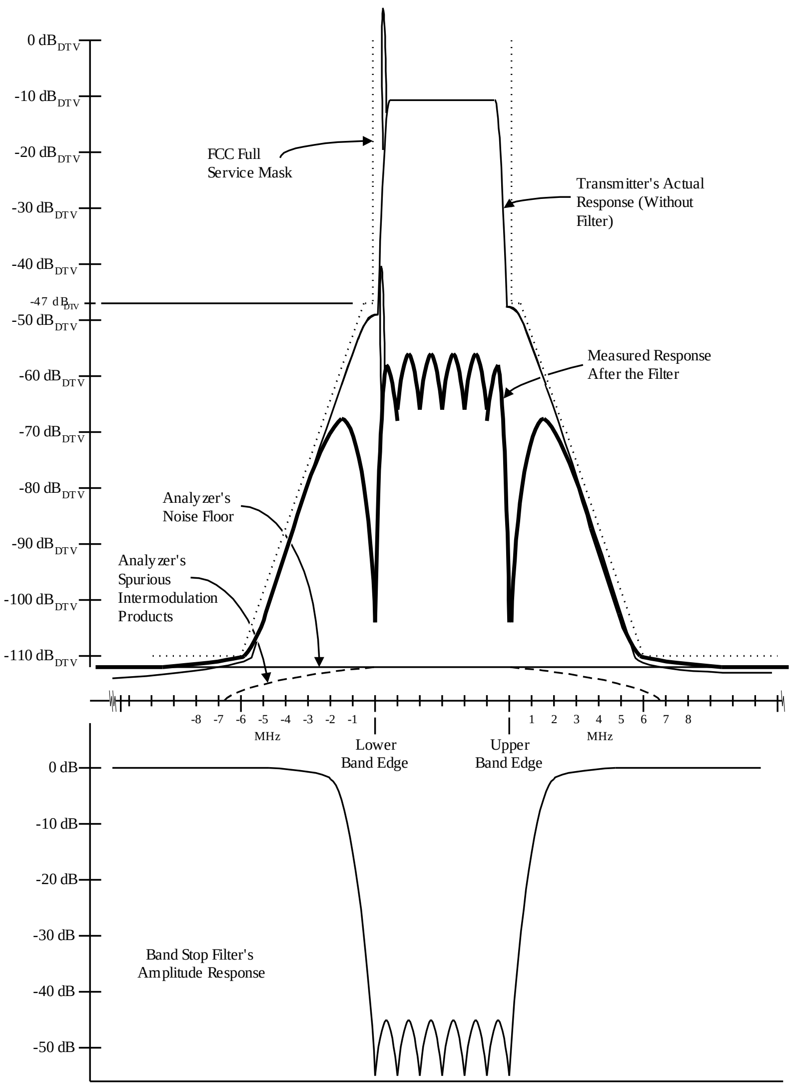
AMPLITUDE RESPONSE REQUIRED FROM



Note: The Attenuation at the edge of the pass band can be any value, A dB up to 3dB at Fo ±9 MHz. However, the required stop-band attenuation is increased by A dB to compensate for the required signal power increase caused by the filter's loss.

TYPICAL RESPONSE



MEASUREMENT FILTER =/- 1 K

Microwave Filter Company, Inc.

NEW PRODUCT RELEASE

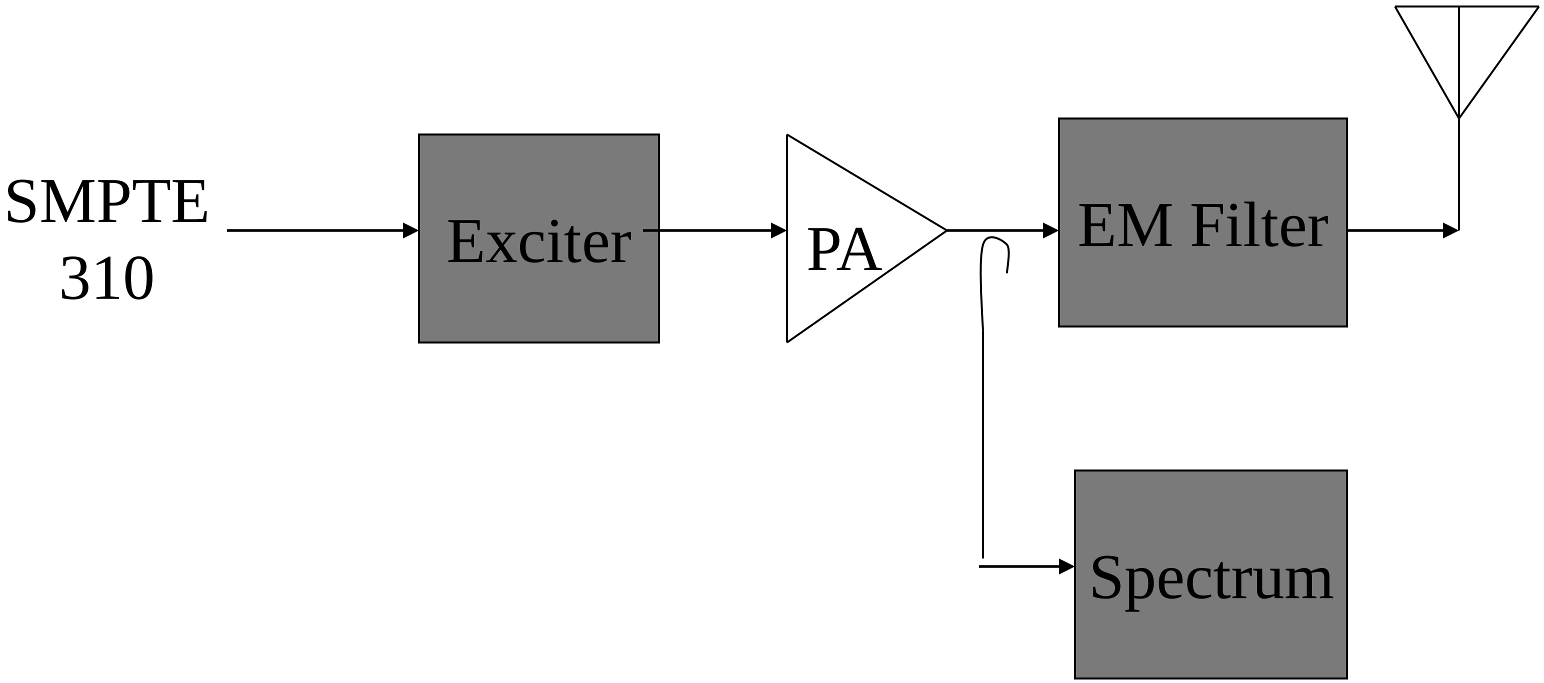
DTV Mask Emission Test (Bandstop) Filters

Choose from one of two new model filters offered by **MFC** - specifically designed for use as the **bandstop test filter** described in the **IEEE** Broadcast Technology Society's preferred test method (#2) from their document **"Practice for Measurement of 8-VSB Digital (US) Television Mask Compliance".**

The information pertaining to these bandstop test filters is as follows :

Model	Test Channel (Fc) Center Frequency Option	Filter Performance			DTV Mask Classification
		Stopband	Stopband	Passband	
16150-(ch)	(54–806) MHz	Fc ± 2.5 MHz 49 dB [Min.]	Fc ± 3 MHz 43 dB [Min.]	Fc ± 5 MHz 3 dB [Max.]	Full Service
16560-(ch)	(54–806) MHz	------------	Fc ± 3 MHz 20 dB [Min.]	Fc ± 5 MHz 3 dB [Max.]	LPTV/Translator

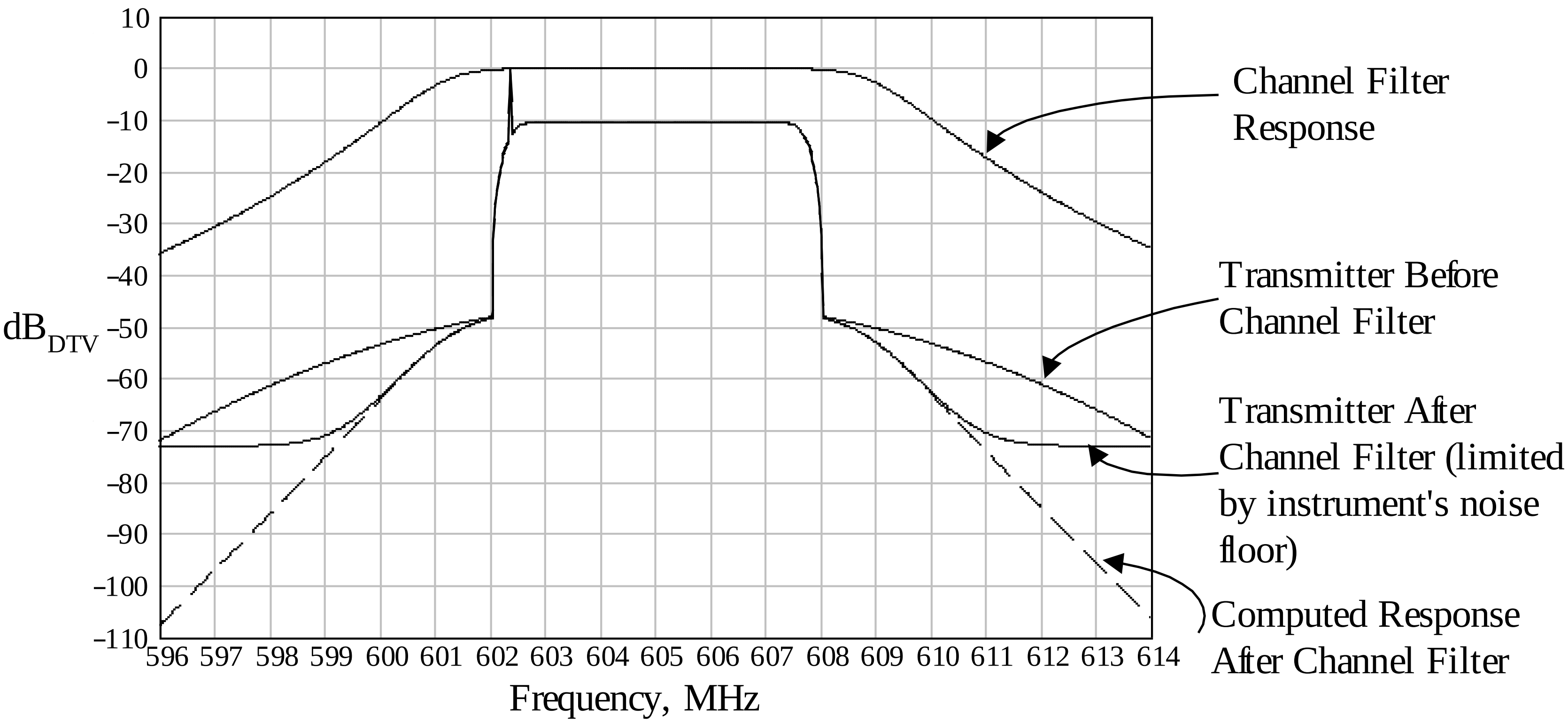
OPTION B- TAKE PRE EMISSION MASK FILTER MEASUREMENTS AND CORRECT FOR IT -



OPTION B - TAKE PRE EMISSION MASK FILTER MEASUREMENTS AND CORRECT FOR IT

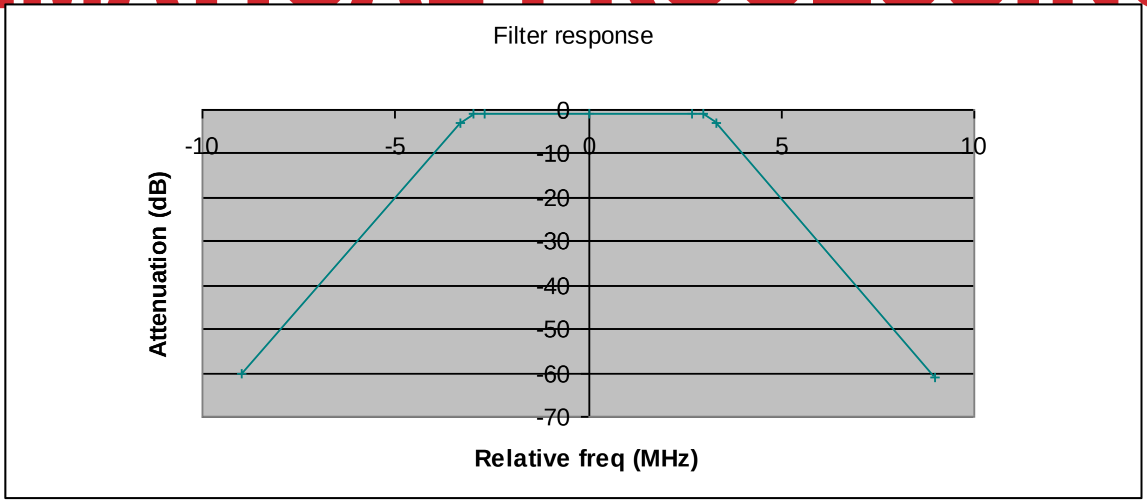
- **2 Instruments are required a network analyzer and a Spectrum Analyzer**
  - The measurement has to be taken on a hot filter to preclude drift error
  - Requires Judgment and expertise
  - Preclude the measurement of the harmonic response , beware of overmoded coupler

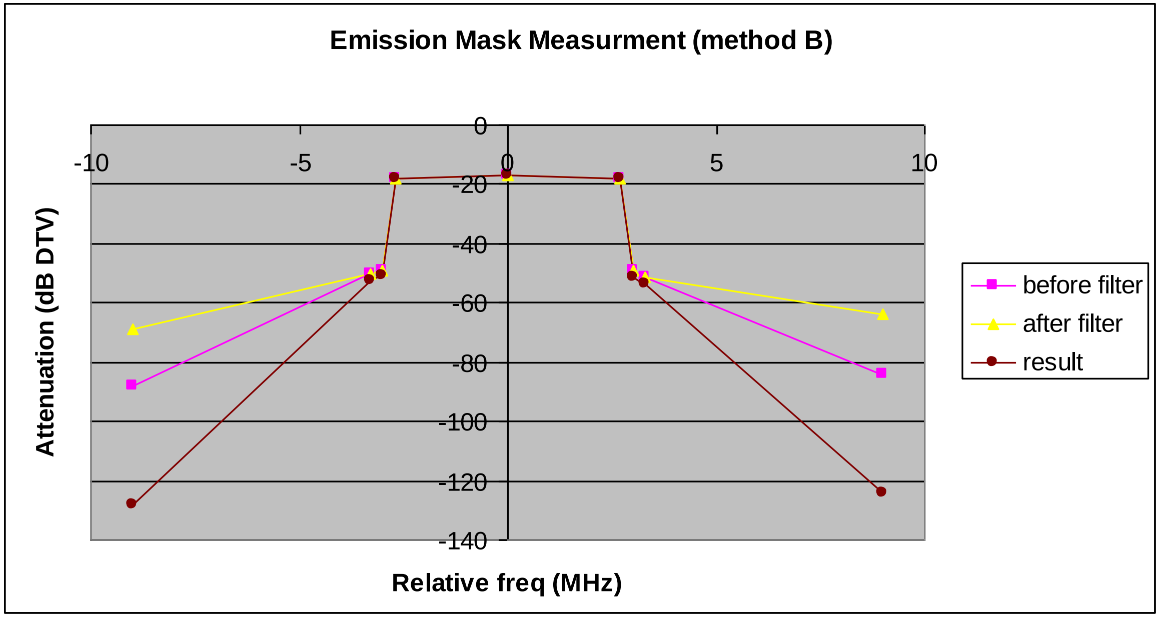
IN PRACTICE



10
0
–10
–20
–30
–40
–50
–60
–70
–80
–90
–100
–110
dB$_{DTV}$
596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614
Frequency, MHz
Channel Filter Response
Transmitter Before Channel Filter
Transmitter After Channel Filter (limited by instrument's noise floor)
Computed Response After Channel Filter

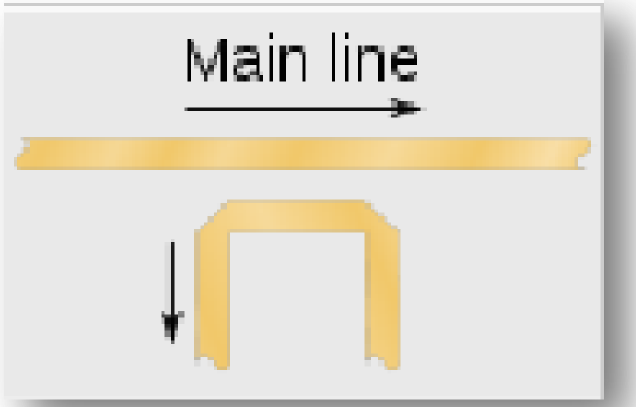
MATHEMATICAL PROCESSING





2ND HARMONIC MEASUREMENTS

- Coupler are a wavelength sensitive device
- At the second harmonic all classic sniffers will be overmoded and will no longer offer a reliable coupling ratio.



CONCLUSION

- Emission mask measurements are tricky
- Test equipment dynamic range is quite an issue
- Results cannot be taken directly from spectrum analyzer
- 0 DB DTV reference has to be established first
- Use filter wisely
- 2nd harmonic measurements cannot be taken from a sniffer

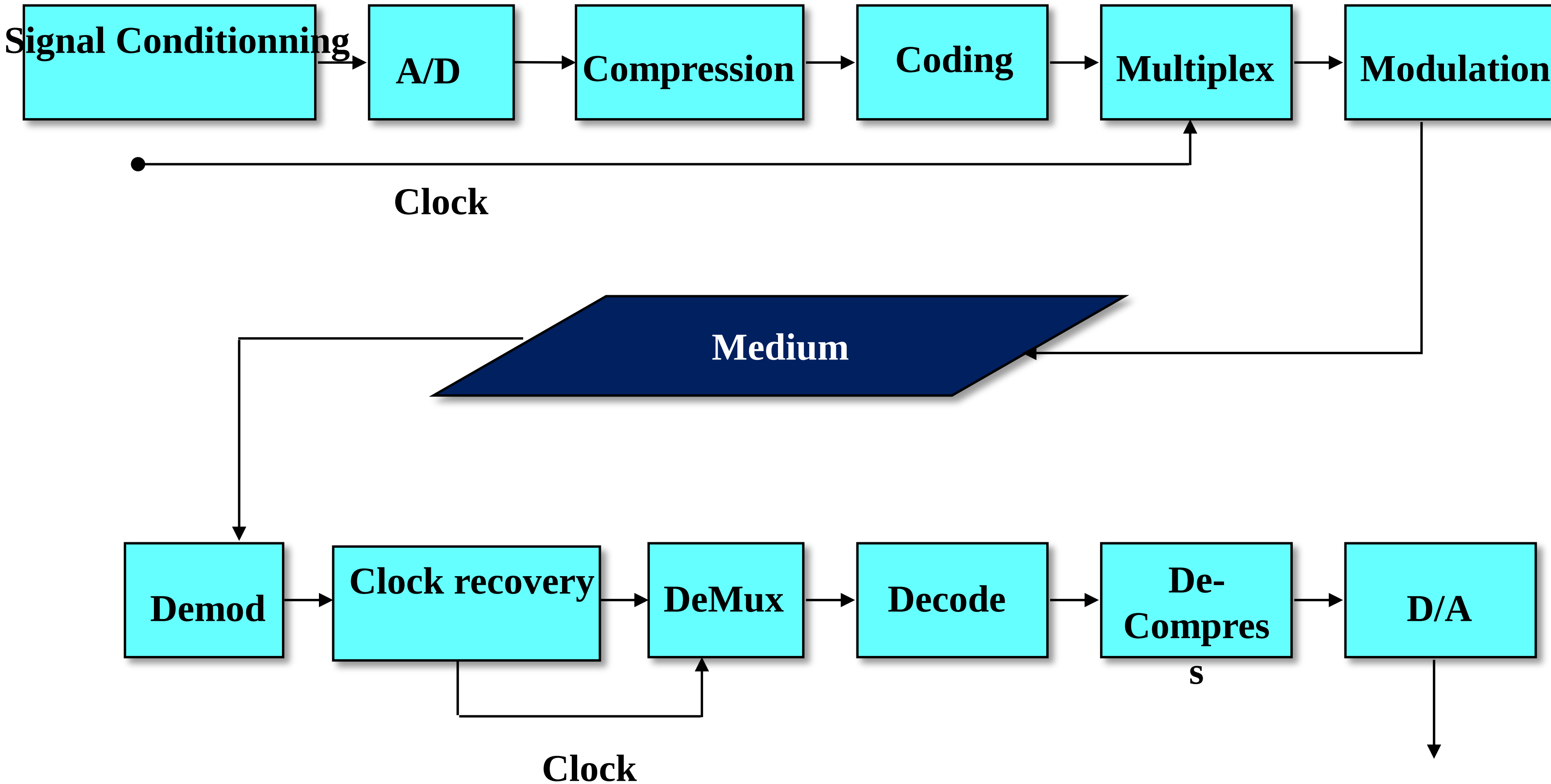
DIGITAL TRANSMISSION

Why convert in digital?

- Better
  - Qualité
  - Spectral efficiency
  - More rugged covreage
  - System integration

BTS

Typical Digital Transmission System



To be successfull in digital transmission you have to be smarter than the avreage bear

Coding

- **Whats coding:**
  Using a code to transfer a message

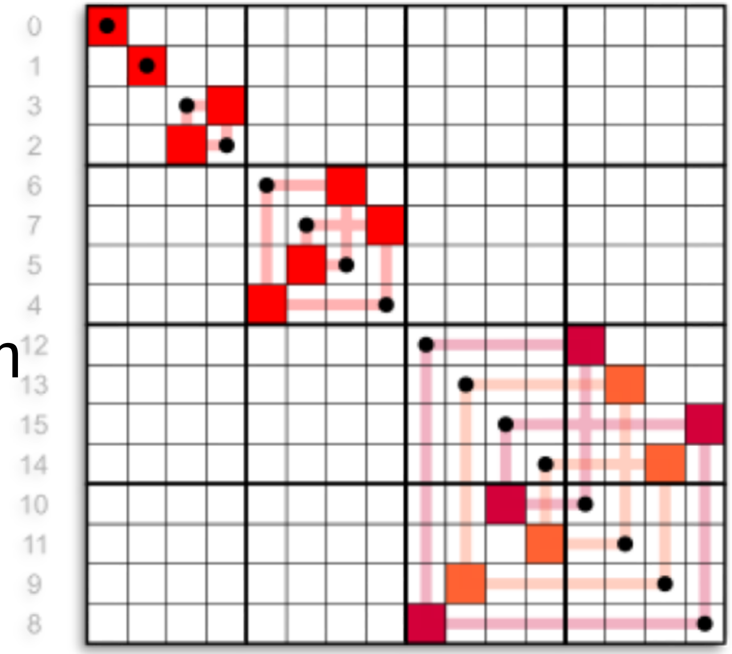
- **Exemple:**
  The catcher and Pitcher are exanging
- Coded messages so the catcher knows
- what type of Ball toexpect

Why Coding?

- Lower the binary rate
- Avoid conflicts
- Alleviate the weight of errors
- Ensure message privacy

Coding Binaire

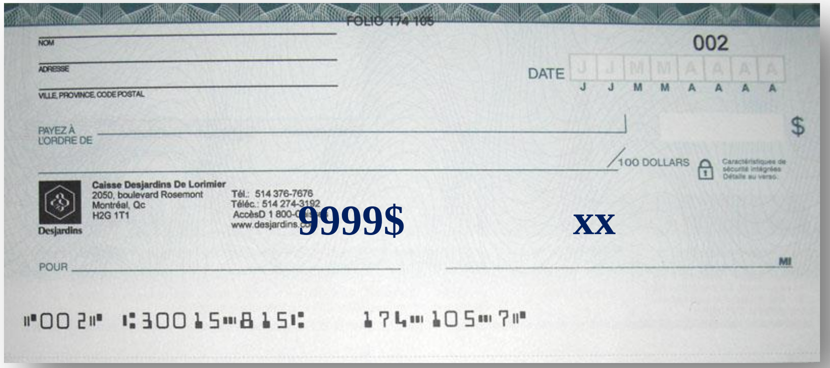
- Ex: gray Code



- Characteristics :
  - All adjacent symbols vary from Only one bits
- Advantages:
  - Alleviate the impact of errors
  - Ex:
    - Binary 7 is (0111) and 8 is (1000) [4 bits changed]
    - Gray 7 is (0100) and 8 is (1100) [1 bit changed]

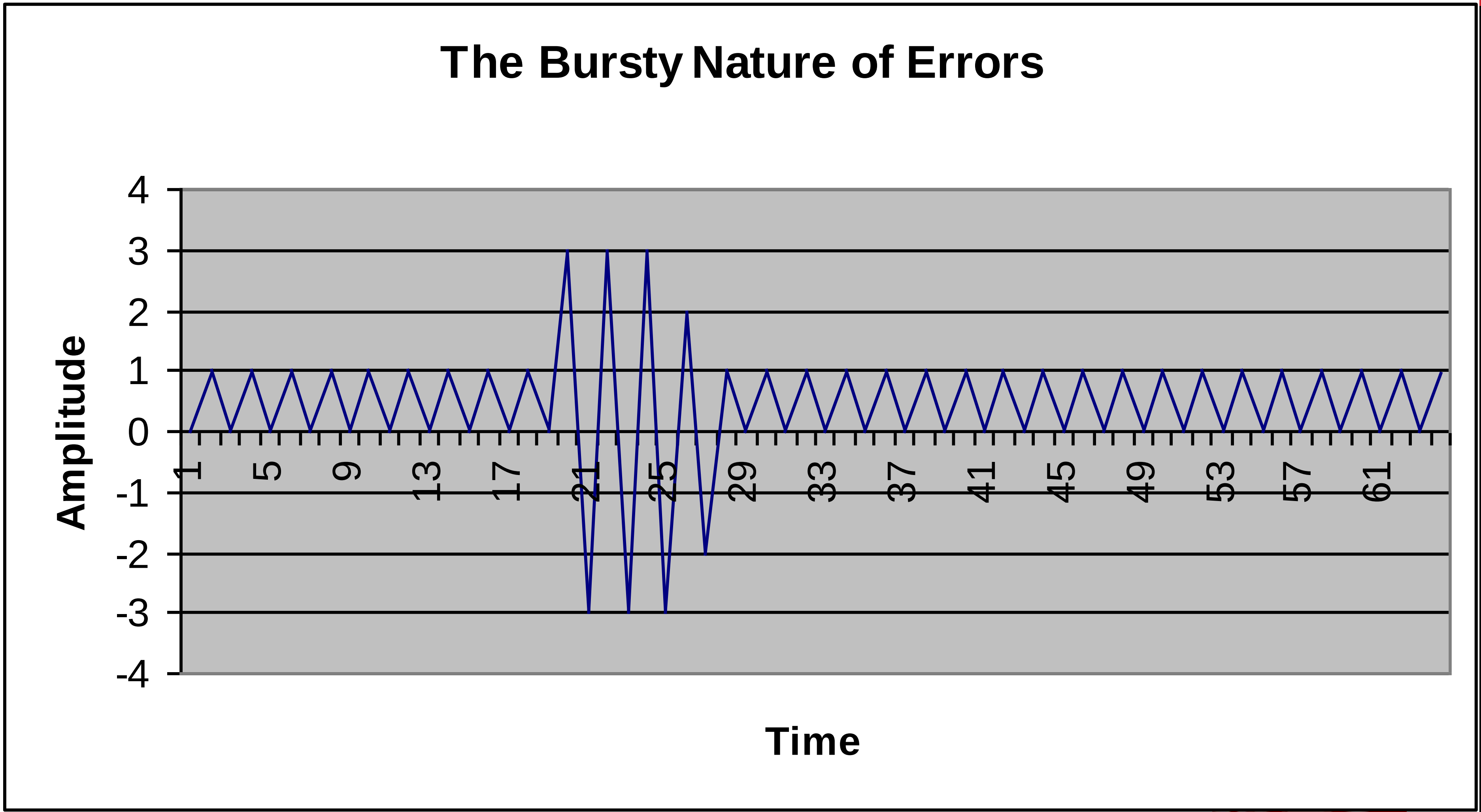
Interleaving

- Imagine that your employer pay system has underwent a burst of error that suddenly changed your paycheck from XXXX $ a 9999$



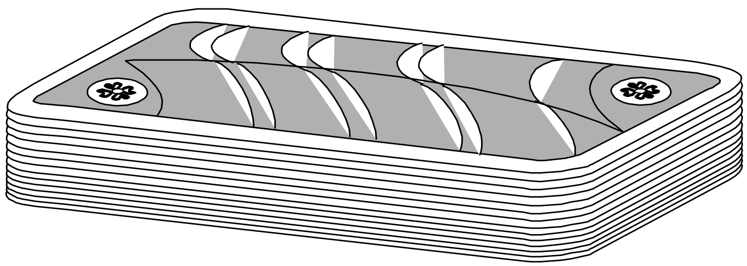
- Sadly a temporal mixing technique called interleaving will distribute the errors on time, so four happy employee will have one of the digit of their paycheck canged to 9

Burst of errors

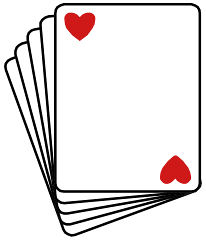


Interleaving

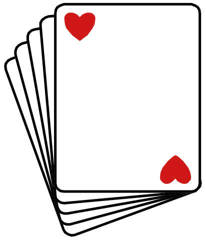
The cards are distributed in orderly stacks: 1,2,3,4,5



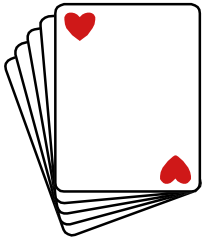
2,000,000 cards



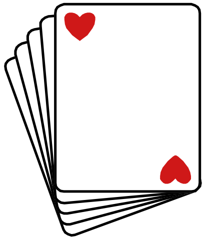
1



2



3



4

2000 stacks of 1000 cards

PRBS

999

3

445

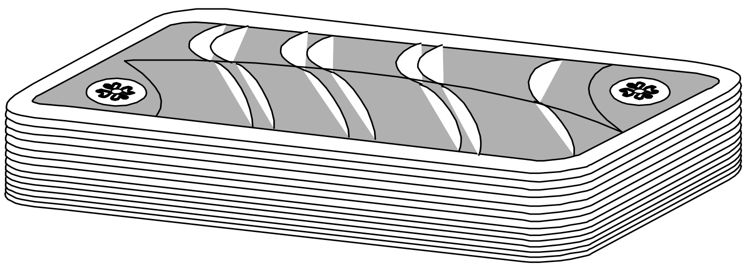
227

784

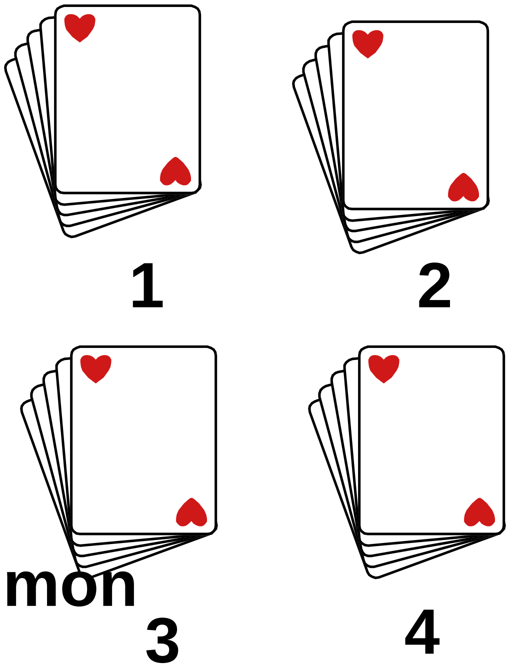
The stacks are then serialized by been picked-up using a pseudo-randon sequence

Inter-décalage

The cards wer distributed in orderly stacks: 1,2,3,4,5



2,000,000 cartes



2000 stacks of 1000 cards

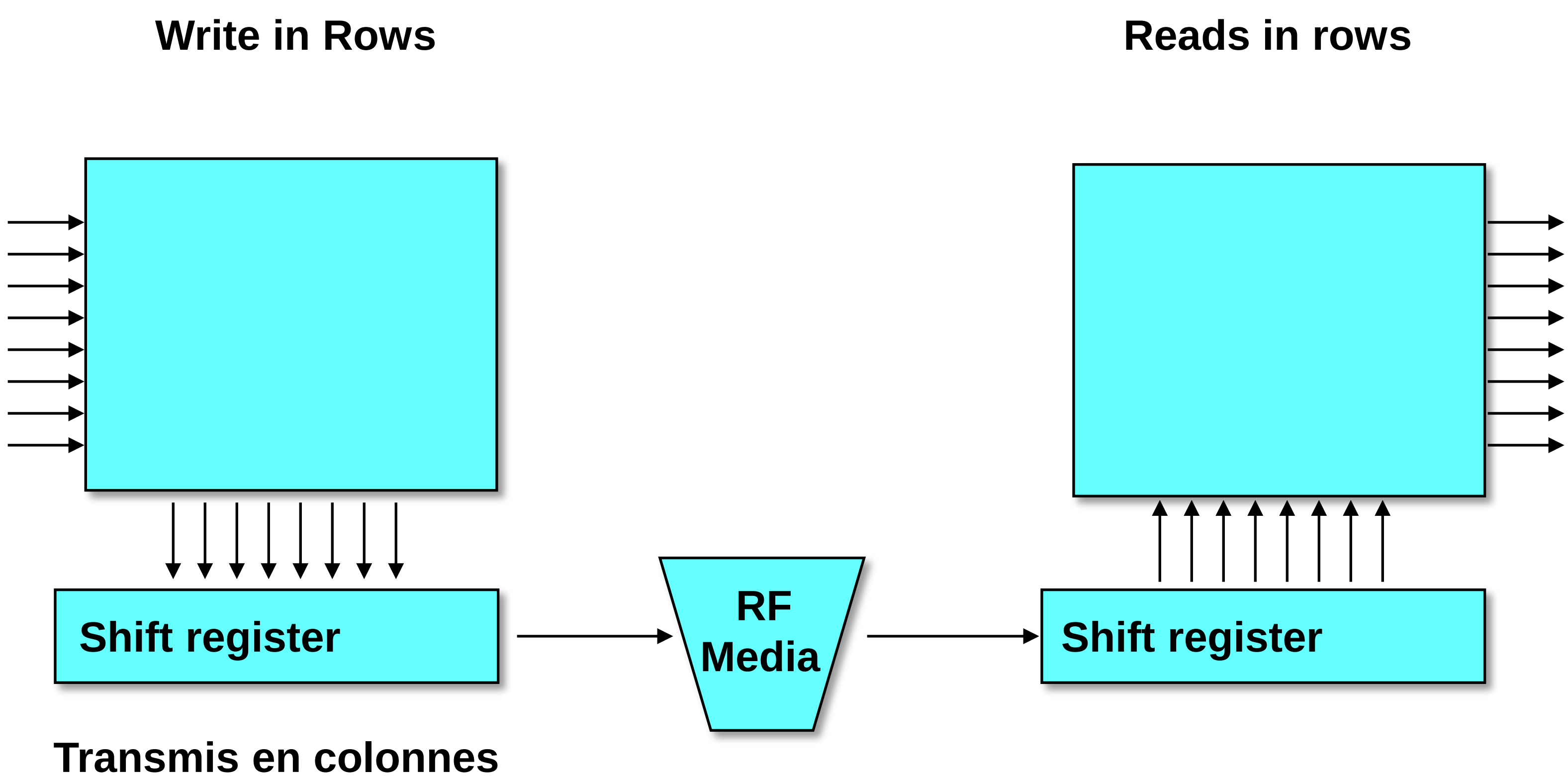
Serialized and de-serialized using a common pseudo random Sequence

Inter-décalage

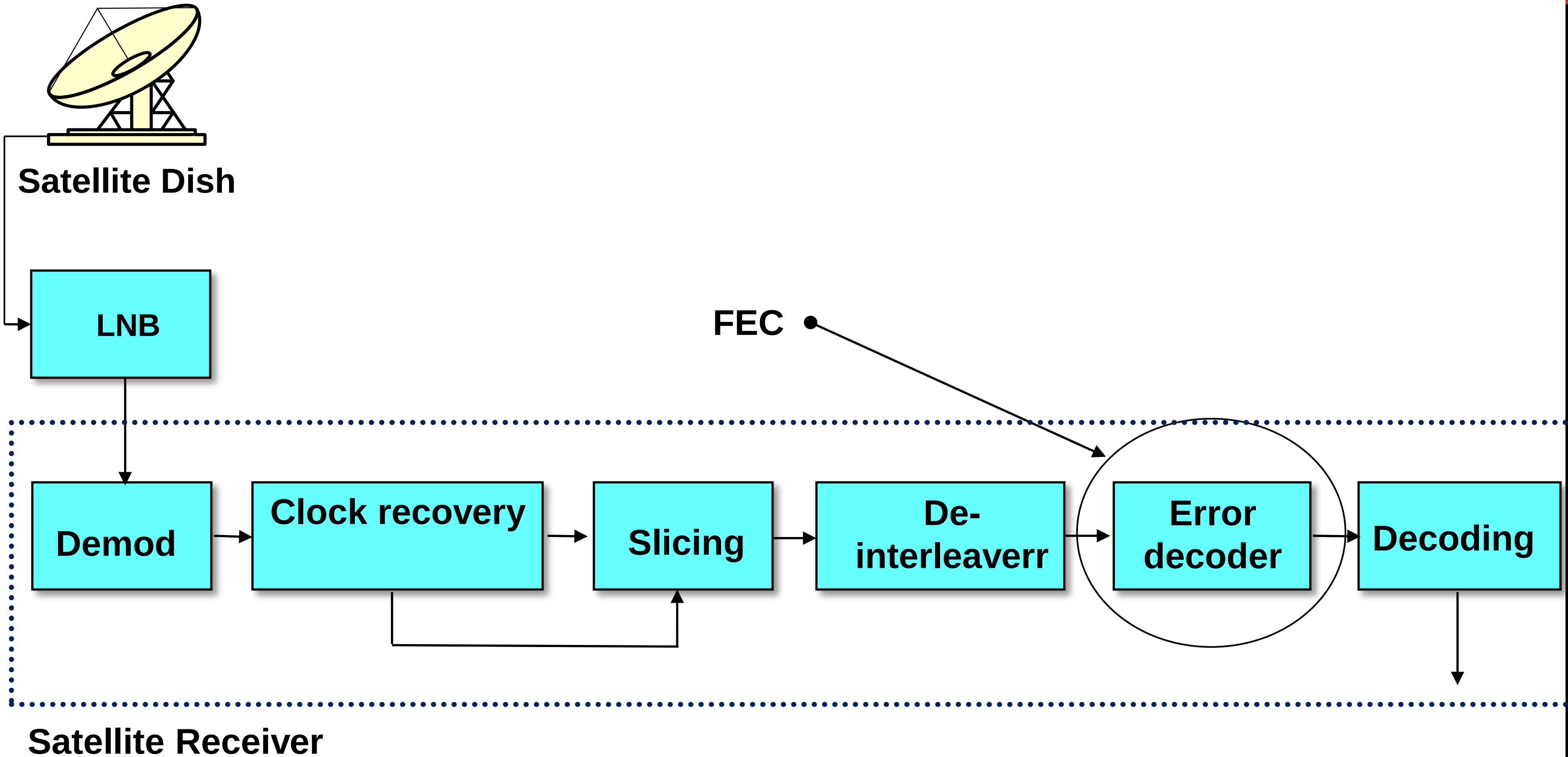
- The burst of error is then spread on the lenght of the interleaver

- So 4 employees will have one of the digit of their paycheck changed to 9
- Another technique called FEC will finalize the process and elkeminate the errors caused by the burst of errors

Interleaving

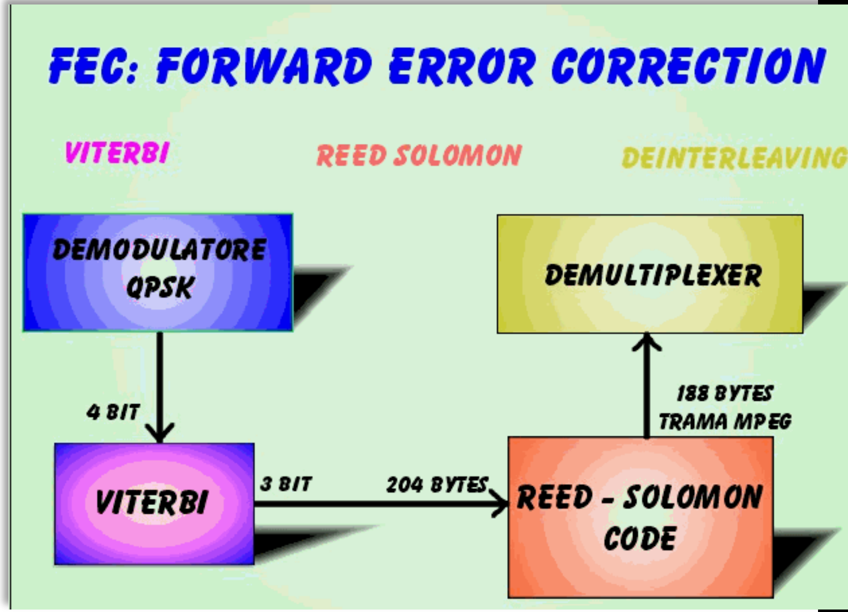


FEC


Satellite Dish
LNB
FEC
Demod
Clock recovery
Slicing
De-interleaverr
Error decoder
Decoding
Satellite Receiver

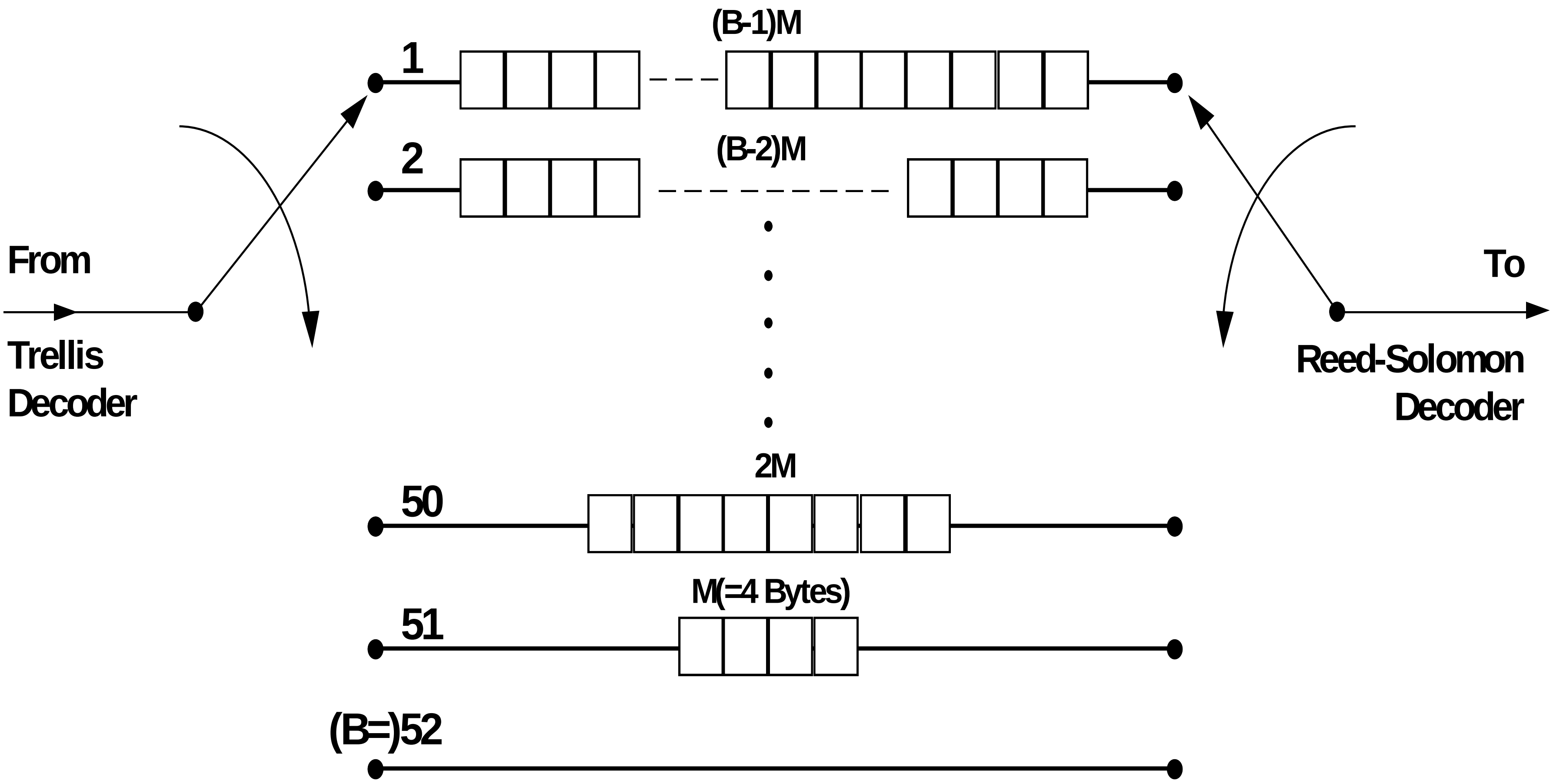
Forward Error Correction

- But: Transmitt startegic codes aimed to reconstruct the signal at the other end
- Types :
  - Viterbi
  - Reed Solomon
  - TCM



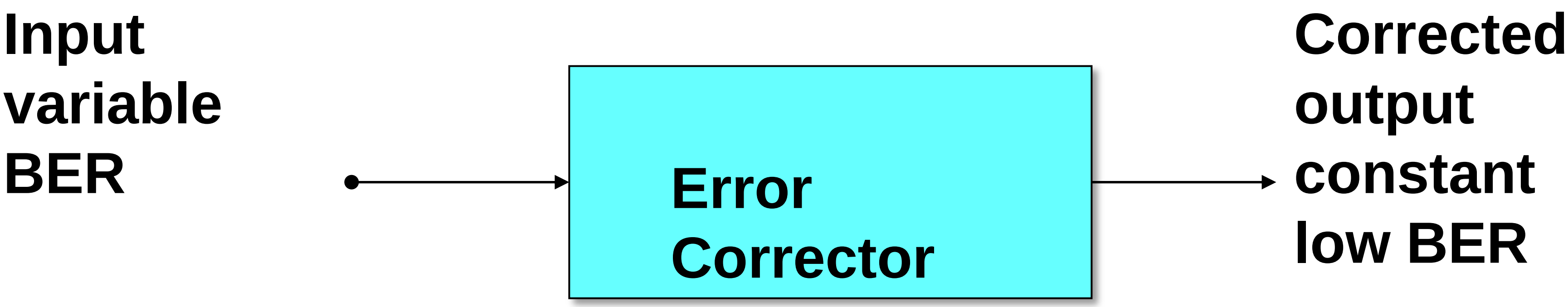
  - Best results tends to be
  - acheived with 2 concateneted layers of coding

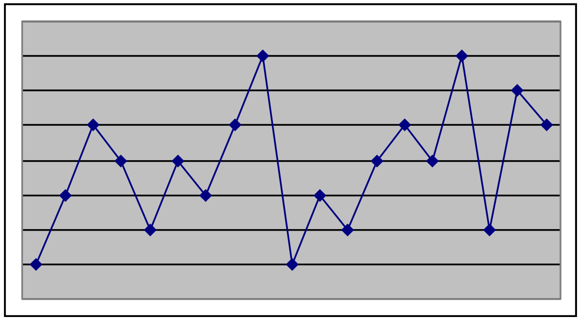
Convolutional Interleaving

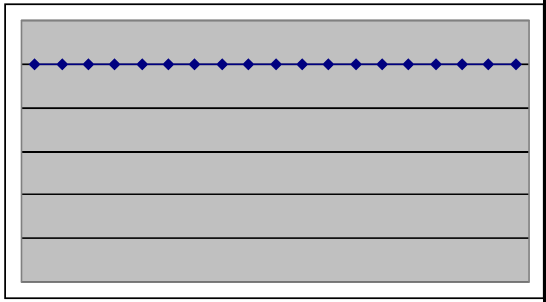


M=4, B=52, N=208, R-S Block =207, BXM=N

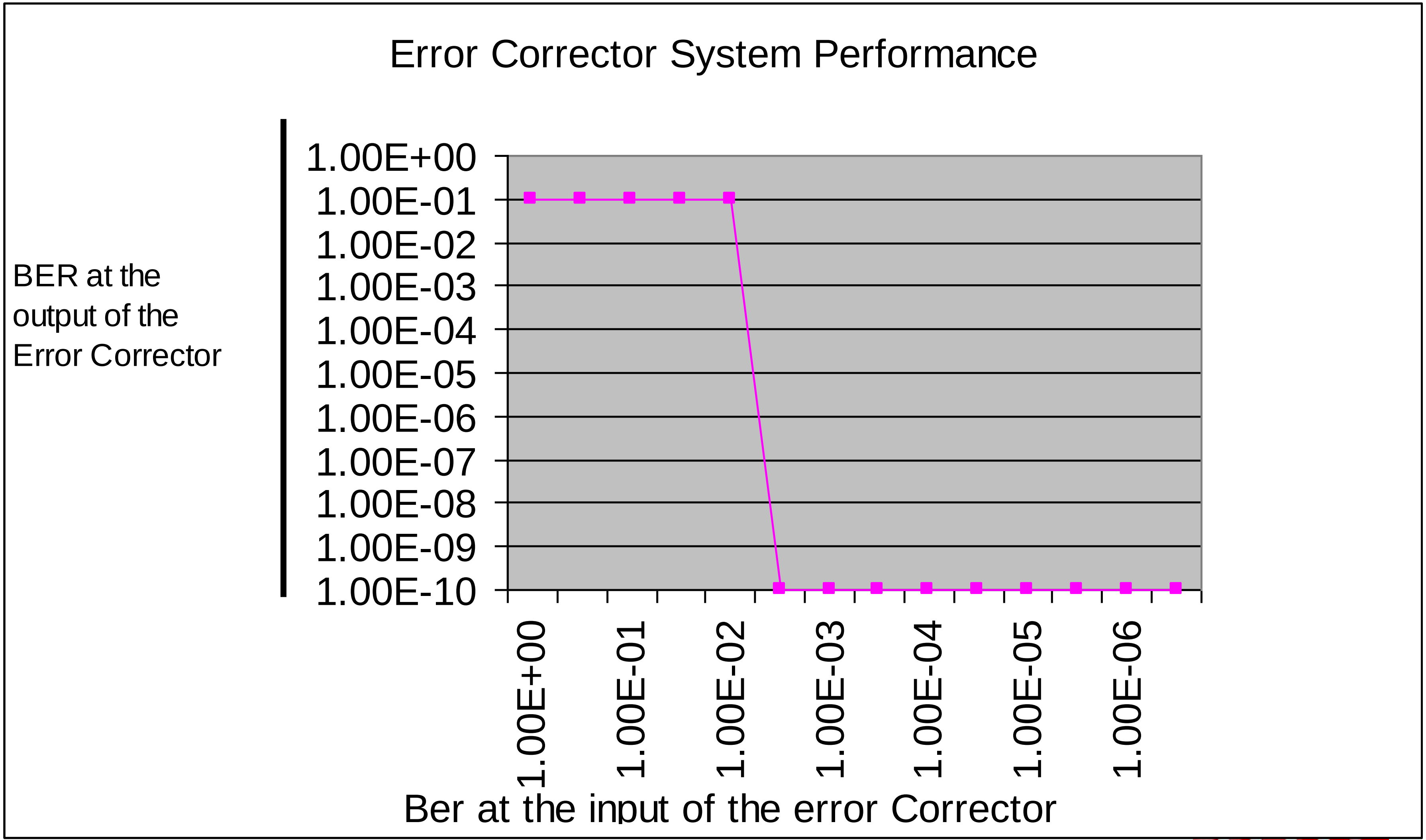
Error corrector



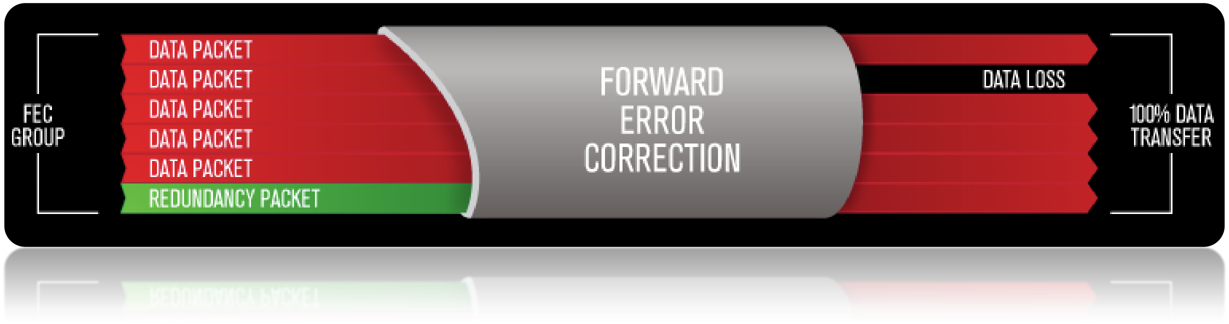




Typical performance of FEC

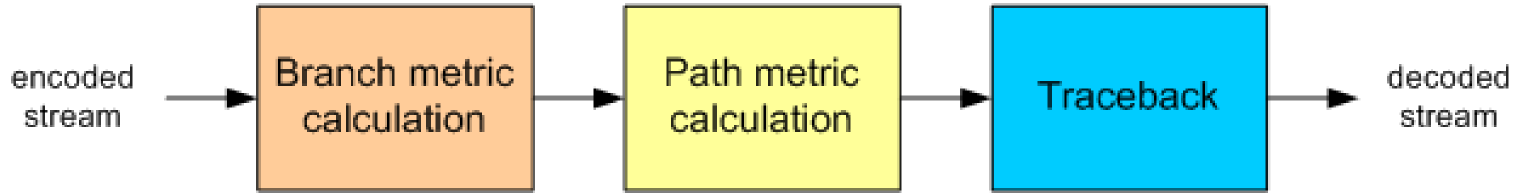


How does FEC gets inserted?



- **By adding the overhead bistream before the interleaver.**
- **The FEC ratio actually represent the share of the payload in an FEC augmented bitstream**
  - 1/2 50% means that 50% of the data is payload 50% F
  - 3/4 75% of the data is payload 25% is FEC
  - 7/8 87.5% of the stream is data 12.5% FEC
  - ¼ means that 25% of the stream is payload and 75% FEC FEC

How the Error correction mechanism works



Viterbri decoder data flow

- A maximum likelyhood decoder, applies a mathematical process that permits to detect and correct errors at the bit level, based on the highest probablility of error

- For tutorial purposes we will explore a simple but effective FEC scheme, obviously todays FEC schemes are much more efficient.

FEC

Imagine a bit block of 64 bits, augmented by the sum of each rows and colums(64 + 2 X (3X8) = 112 Bits

	Data									Sum		
	1	1	0	0	1	1	1	1		1	1	0
	1	0	0	0	0	0	0	1		0	1	0
	1	0	1	0	1	1	0	0		1	0	0
	1	1	1	0	0	0	1	0		1	0	0
	0	0	1	0	1	1	1	1		1	0	1
	0	1	1	1	0	0	1	0		1	0	0
	0	0	0	0	0	0	0	1		0	0	1
	1	1	1	0	1	1	1	1		1	1	1
s	1	1	1	0	1	1	1	1				
u	0	0	0	0	0	0	0	0				
m	1	0	1	1	0	0	1	1				

FEC

Oops an error took place in the payload section

	Data									Sum		
	1	1	0	0	1	1	1	1		1	1	0
	1	0	0	0	0	0	0	1		0	1	0
	1	0	1	0	1	1	0	0		1	0	0
	1	1	1	0	0	0	1	0		1	0	0
	0	0	1	0	1	1	1	1		1	0	1
	0	1	1	0	0	0	1	0		1	0	0
	0	0	0	0	0	0	0	1		0	0	1
	1	1	1	0	1	1	1	1		1	1	1
s	1	1	1	0	1	1	1	1				
u	0	0	0	0	0	0	0	0				
m	1	0	1	1	0	0	1	1				

Toujours septique, essayons insérer l'erreur sur l'une des sommes

FEC

In the Sum section…

	Data									Sum		
	1	1	0	0	1	1	1	1		1	1	0
	1	0	0	0	0	0	0	1		0	1	0
	1	0	1	0	1	1	0	0		1	0	0
	1	1	1	0	0	0	1	0		1	0	0
	0	0	1	0	1	1	1	1		1	0	1
	0	1	1	1	0	0	1	0		1	0	0
	0	0	0	0	0	0	0	1		0	0	1
	1	1	1	0	1	1	1	1		1	0	1
s	1	1	1	0	1	1	1	1				
u	0	0	0	0	0	0	0	0				
m	1	0	1	1	0	0	1	1				

all OK !

FEC

The case of 2 errors

	Data									Sum		
	1	1	0	0	1	1	1	1		1	1	0
	1	0	0	0	0	0	0	1		0	1	0
	1		1	0	1	1	0	0		1	0	0
	1	1	1	0	0	0	1	0		1	0	0
	0	0	1	0	1	1	1	1		1	0	1
	0	1	1	1	0	0	1	0		1	0	0
	0	0	0	0	0	0	0	1		0	0	1
	1	1	1		1	1	1	1		1	0	1
s	1	1	1	0	1	1	1	1				
u	0	0	0	0	0	0	0	0				
m	1	0	1	1	0	0	1	1				

?

?

FEC

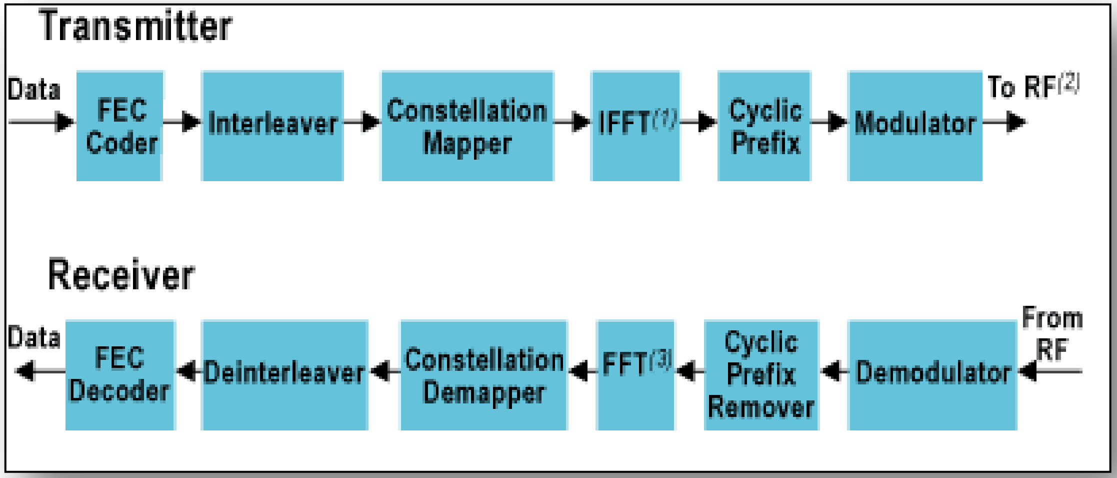
2 errors of the worst kind

	Data									Sum		
	1	1	0	0	1	1	1	1		1	1	0
	1	0	0	0	0	0	0	1		0	1	0
	1		1	0	1	1	0	0		1	0	0
	1	1	1	0	0	0	1	0		1	0	0
	0	0	1	0	1	1	1	1		1	0	1
	0	1	1	1	0	0	1	0		1	0	0
	0	0	0	0	0	0	0	1		0	0	1
	1		1	0	1	1	1	1		1	0	1
s	1	1	1	0	1	1	1	1				
u	0	0	0	0	0	0	0	0				
m	1	0	1	1	0	0	1	1				

?

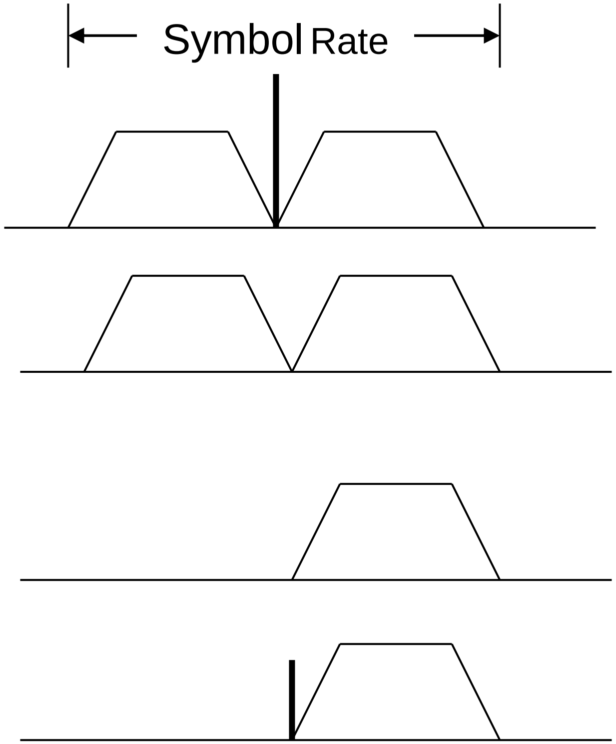
%?*…..

FEC



- In this case we can affirm that our FEC scheme will correct all errors in the block provided they dont exceed one error per block : 1/112 soit un TE de 8 E –3 knowing this we better use an interleaver that is at least 112bits long

Families of Modulations



DSB Double Sideband

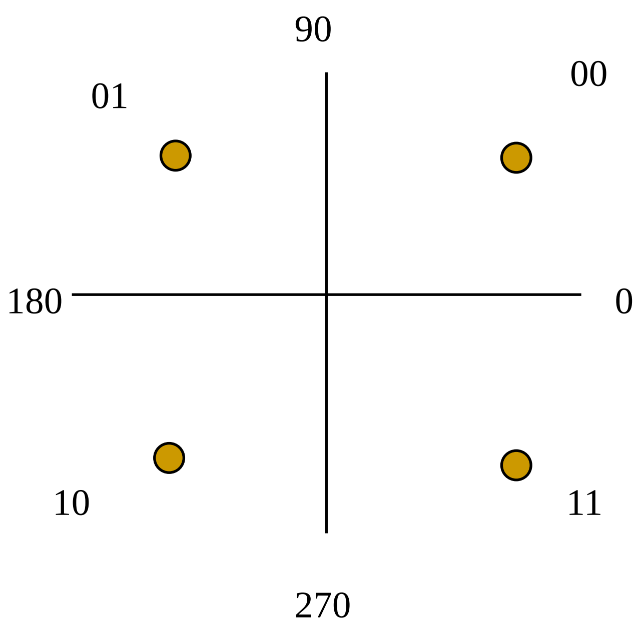
DSB Double Sideband
With supressed Carrier

SSB-SC ingle Sideband
With Supressed carrier

SSB-SC Single Sideband
With Partially Supressed carrier

For DVB modulations, the bandwidth to transmit one symbol is 1 Hz, in the case of SSB, the required bandwidth falls to ½ Hz

Phase Modulation (QPSK)

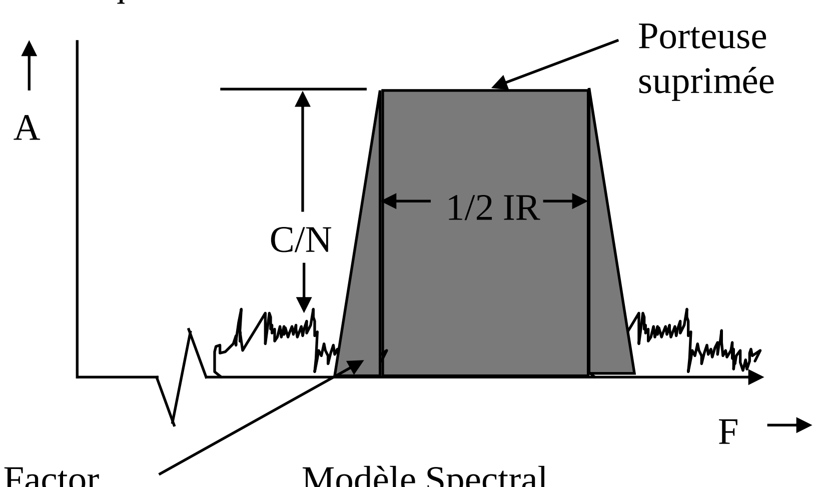


Constellation

Code 2 Bit /Hz

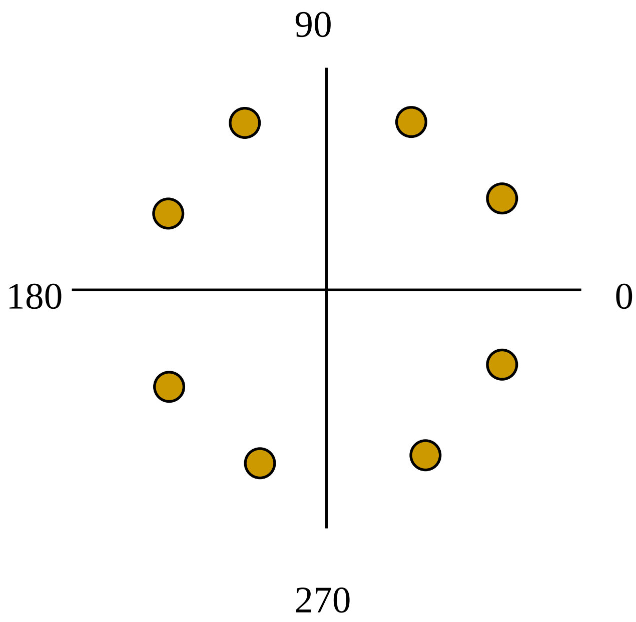
C/N requirement: 5 dB approx.. at 2/3rate FEC

requires tandem intermod 25 dBC



Modèle Spectral

Phase Modulation (8PSK)

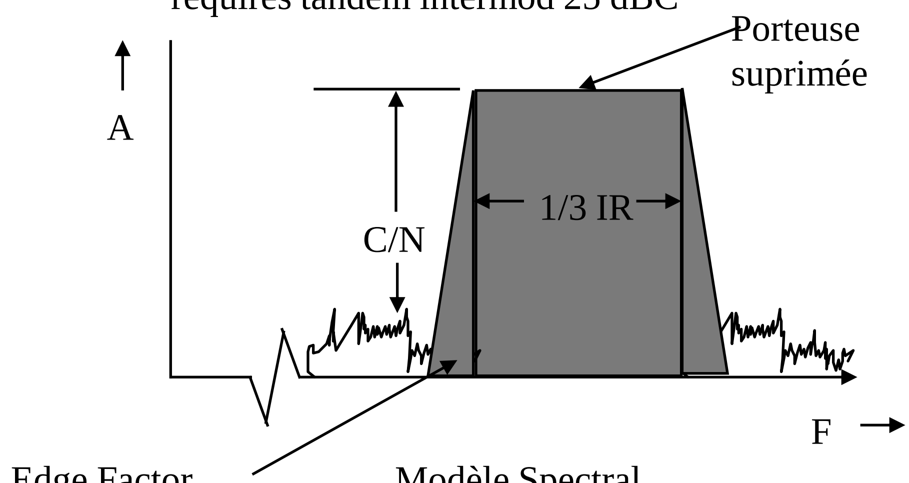


Constellation

Code 3 Bit /Hz

C/N requirement: 7 dB approx.. at 2/3rate FEC

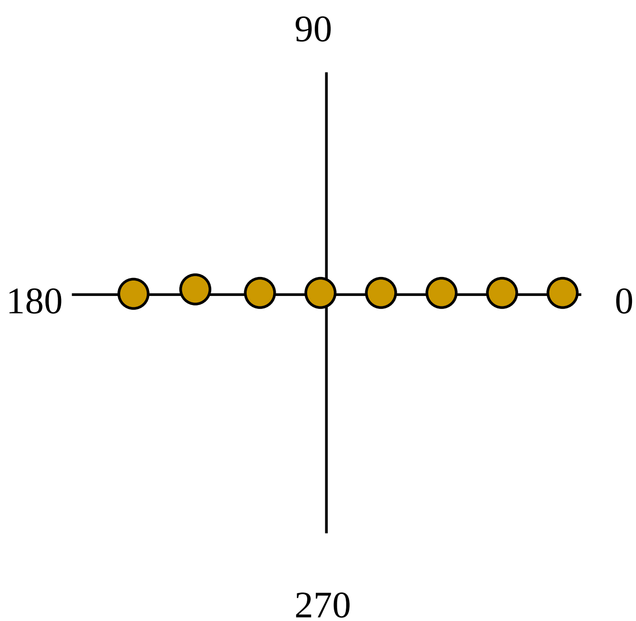
requires tandem intermod 25 dBC



Modèle Spectral

AMPLITUDE MODULATION

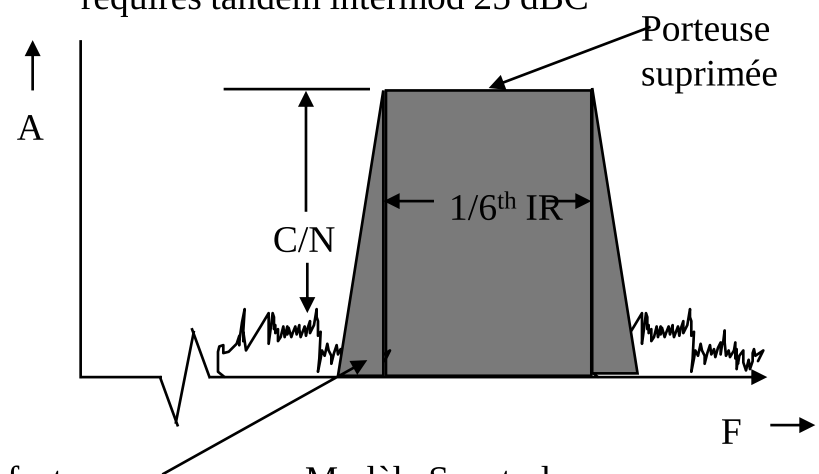
8VSB



Code 3 Bit /Hz

C/N requirement: 716dB approx.. at 2/3rate FEC

requires tandem intermod 25 dBC

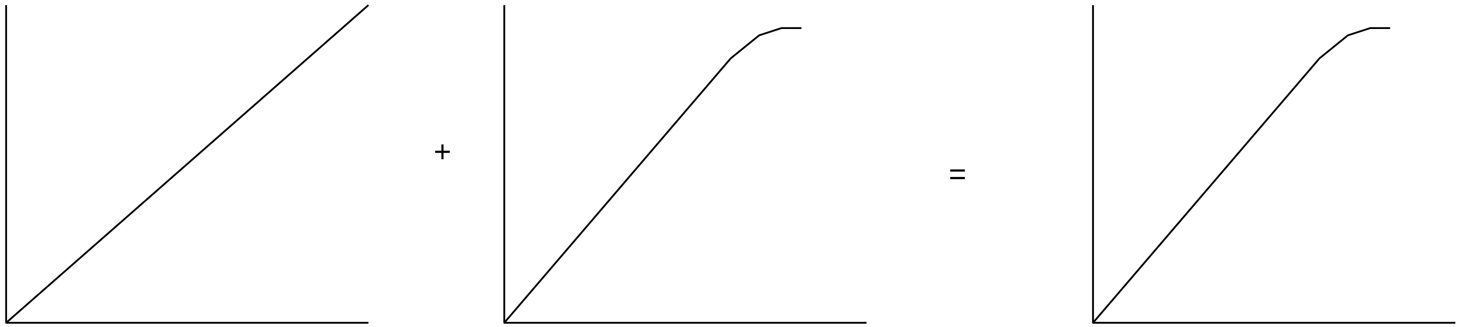


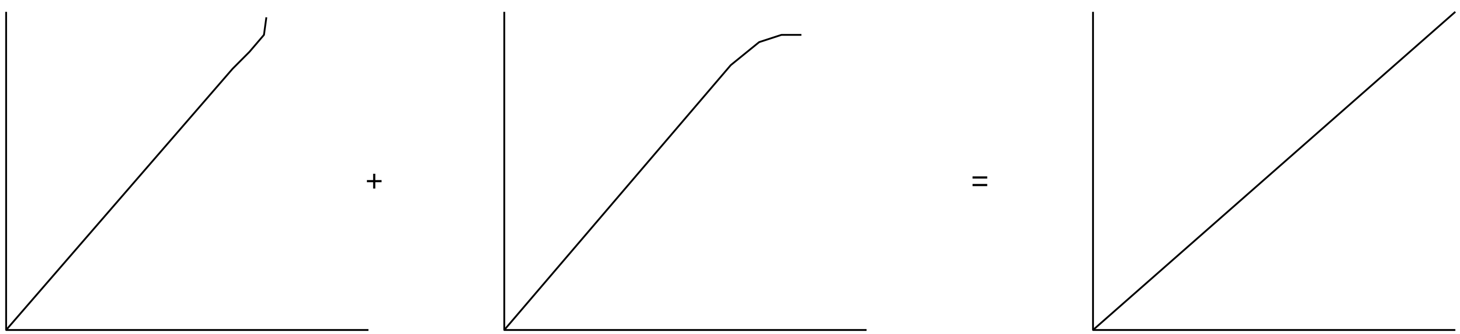
Constellation

Edge factor

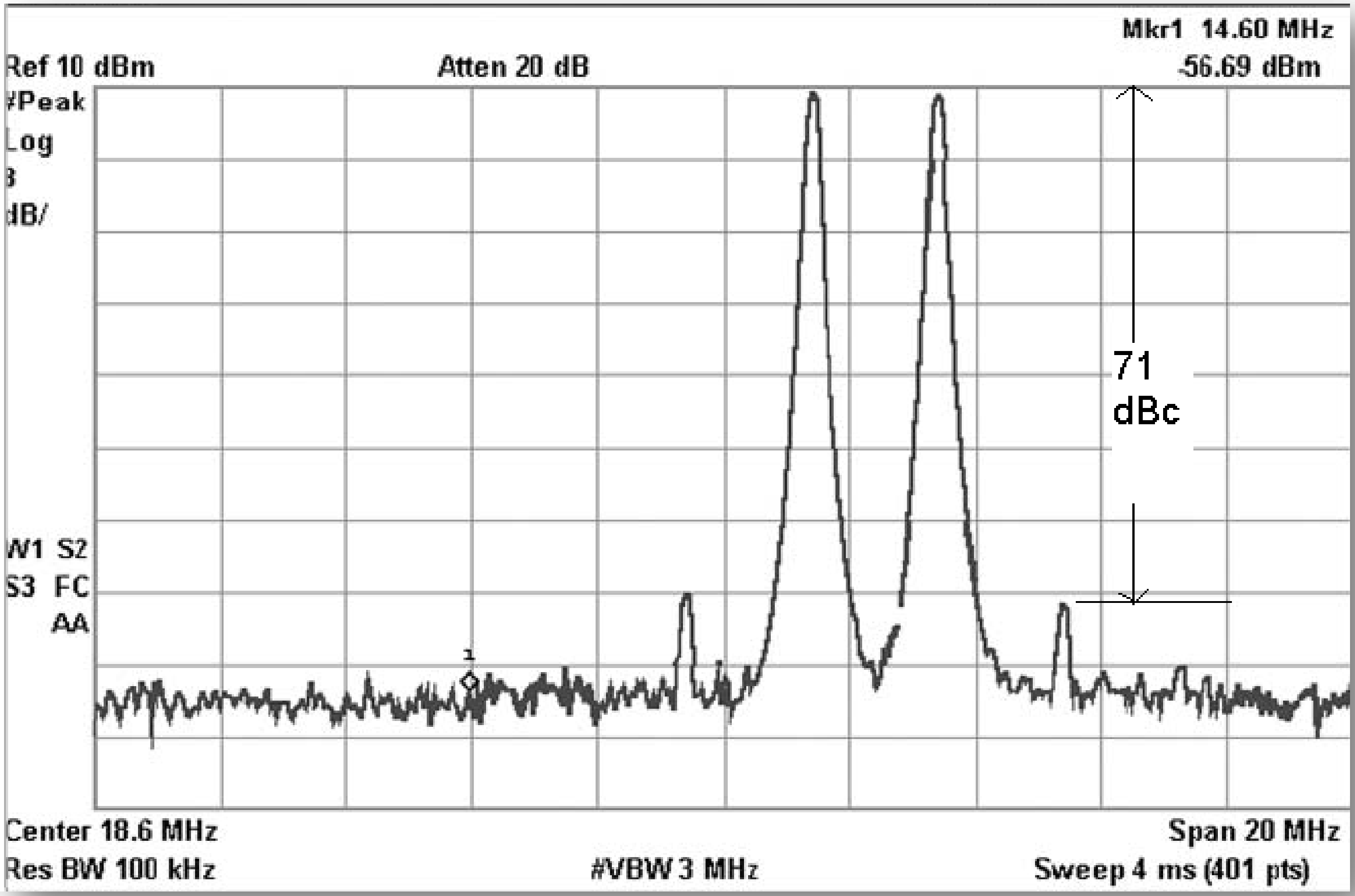
Modèle Spectral

Linearization





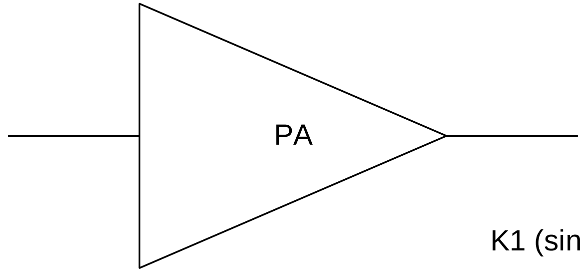
Intermods


Mkr1 14.60 MHz
Ref 10 dBm
Atten 20 dB
-56.69 dBm
#Peak
Log
3
dB/
W1 S2
S3 FC
AA
1
71
dBc
Center 18.6 MHz
Span 20 MHz
Res BW 100 kHz
#VBW 3 MHz
Sweep 4 ms (401 pts)

Amplifier

Entrée

(K0 sin(A)+K0sin(B))



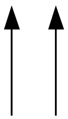
Linéaire

Sortie I= (ga*k0sin(A) + ga k0 sin(B))+
Non-Linéaire

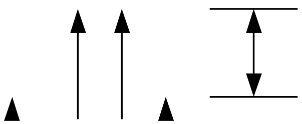
K1 (sin (A+ B)) + K2 (sin (A - B)) + k3(sin (2A-B)) +k4 sin(A+2B).....

Gain Linéaire ga

Pré-correction manuelle



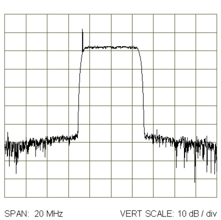
Signal d'entrée



produits
Intermods

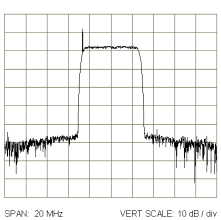
general specs: IMD= 2 X (OPBO) - 16 dB

Pré-correction automatique et fine tuning manuel



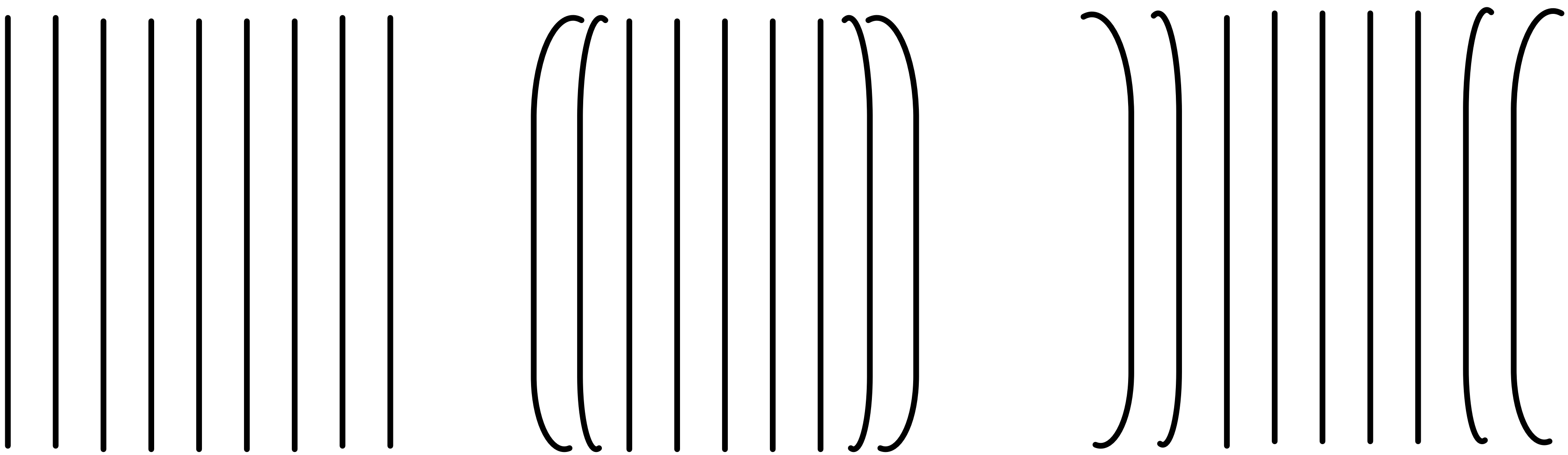
Signal d'entrée

Mer> 36 dB
wo pre-cor



Mer> 28 dB
avec pre-cor

Linearization



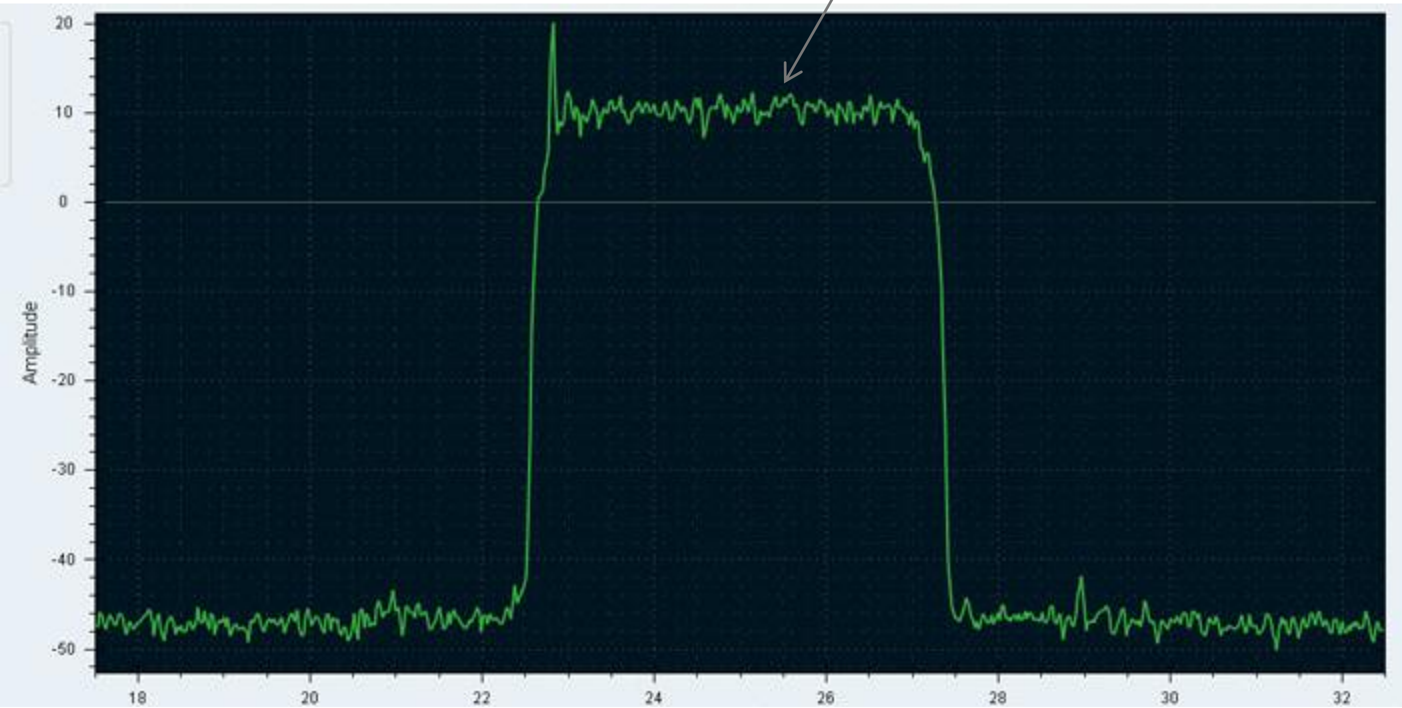
Parfaite

Compression

Sur-corigée

POWER MEASURMENTS

-20 dBm



RBw 30 kHz

ATSC POWER MEASURMENT

We can read the power of an energy dispersed carrier by adding the following correction factor

- 10 Log (EDBw) – 10 Log(res bw)
- 10 Log (5.38e6) – 10 log(res bw)

- An aplidude marker on top of the waveform shows -20 dBm, the analyzer is running at a resolution bandwidth of 30 kHz

- Puiss: - 20 + 10 log (5.38e6) – 10 log(3e4)= 2.53 dbm
- On peut aussi utiliser la fonction power Window de l'analyseur

ATSC STANDARD

Parameters for VSB Transmission Modes

Parameter	Terrestrial mode	High data rate mode
Channel bandwidth	6 MHz	6 MHz
Excess bandwidth	11.5%	11.5%
Symbol rate	10.76 Msymbols/s	10.76 Msymbols/s
Bits per symbol	3	4
Trellis FEC	2/3 rate	None
Reed-Solomon FEC	T=10 (207,187)	T=10 (207,187)
Segment length	832 symbols	832 symbols
Segment sync	4 symbols per segment	4 symbols per segment
Frame sync	1 per 313 segments	1 per 313 segments
Payload data rate	19.28 Mbps	38.57 Mbps
NTSC co-channel rejection	NTSC rejection filter in receiver	N/A
Pilot power contribution	0.3 dB	0.3 dB
C/N threshold	14.9 dB	28.3 dB

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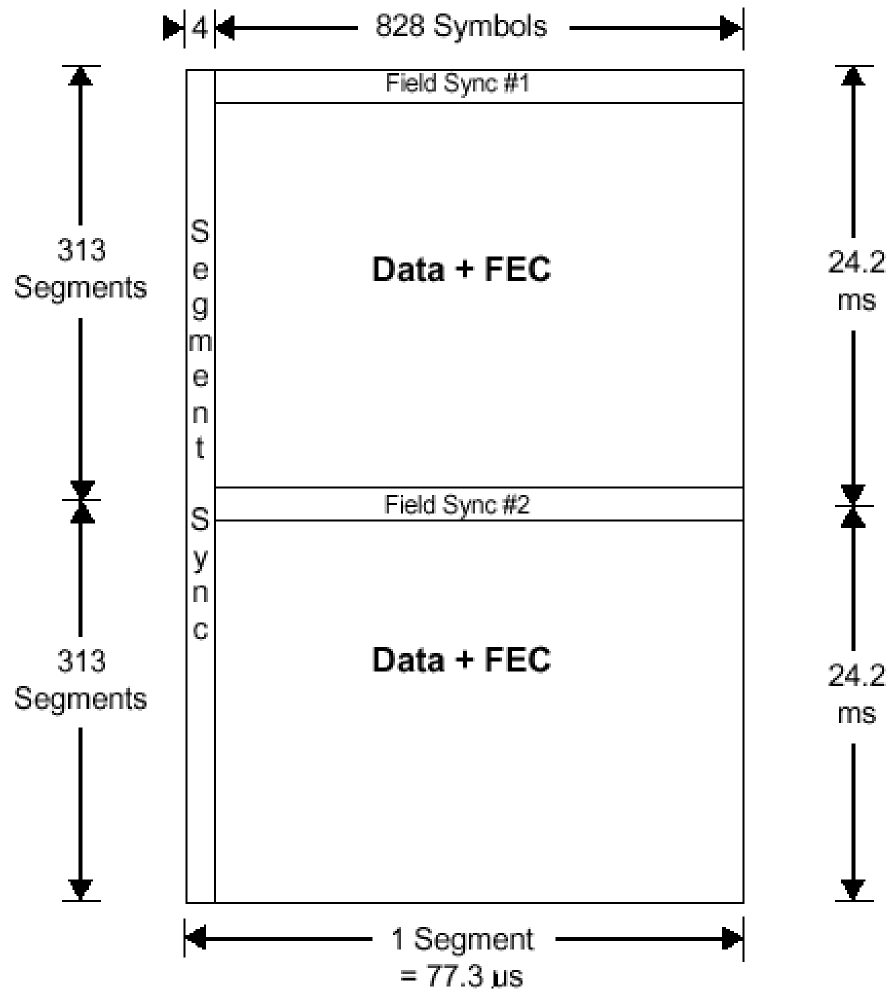
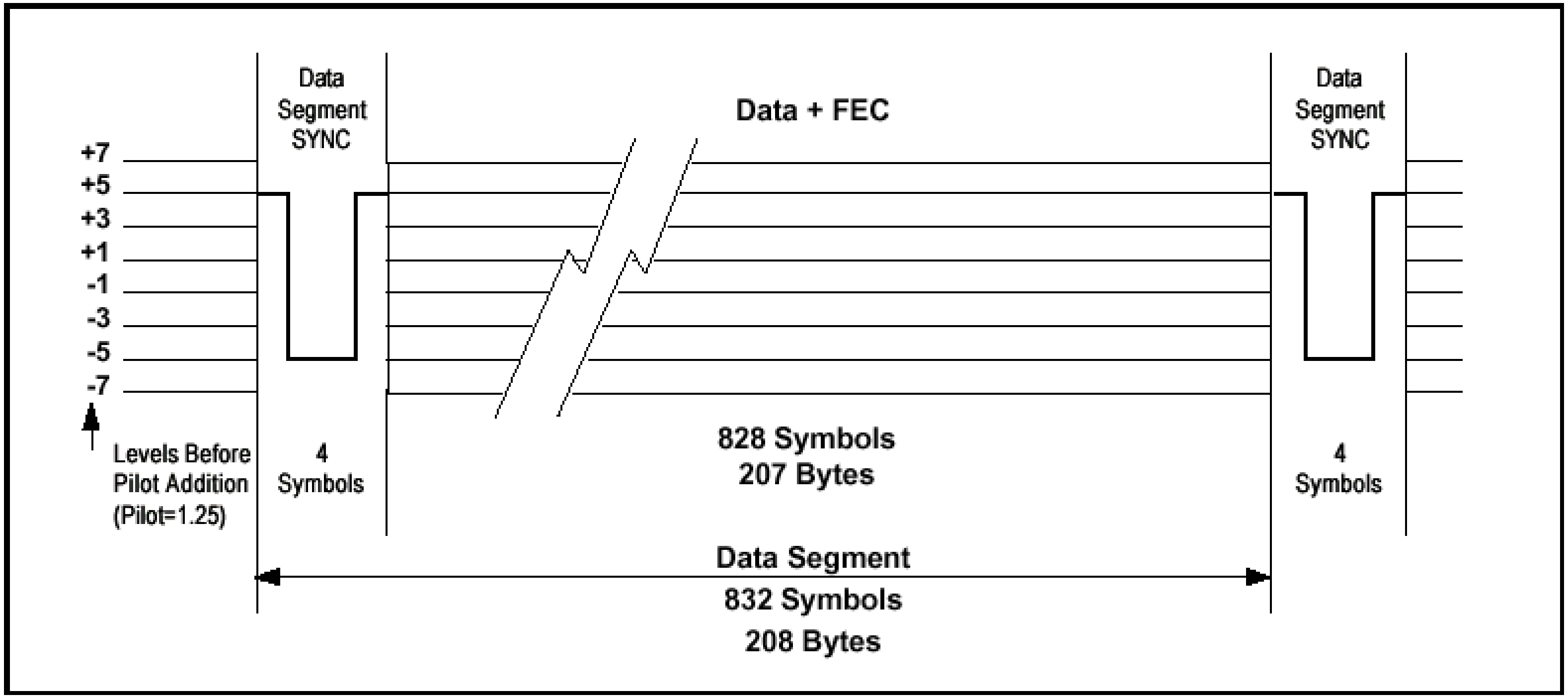
ATSC FRAME STRUCTURE



ATSC SEGMENT



DATA SEGMENT

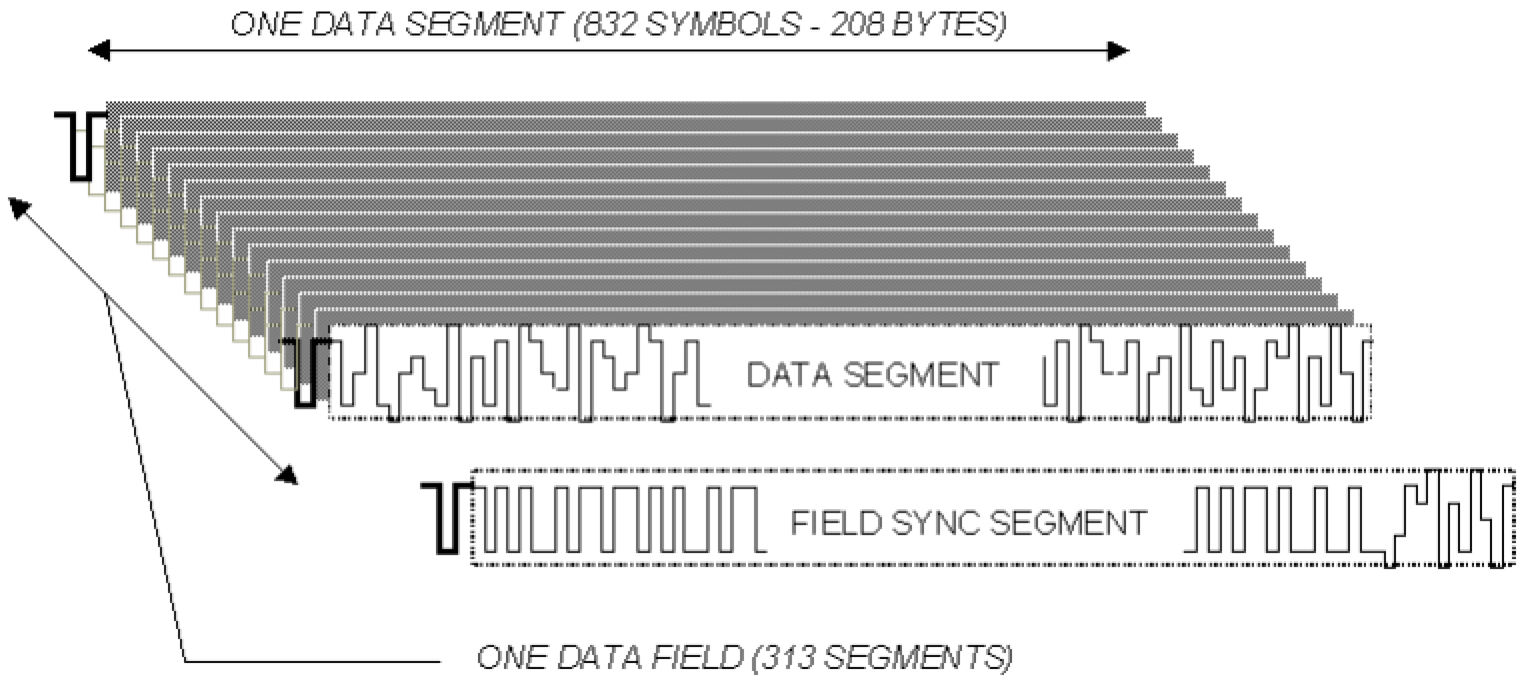


FIGURE 3: ATSC BASEBAND DATA FIELD

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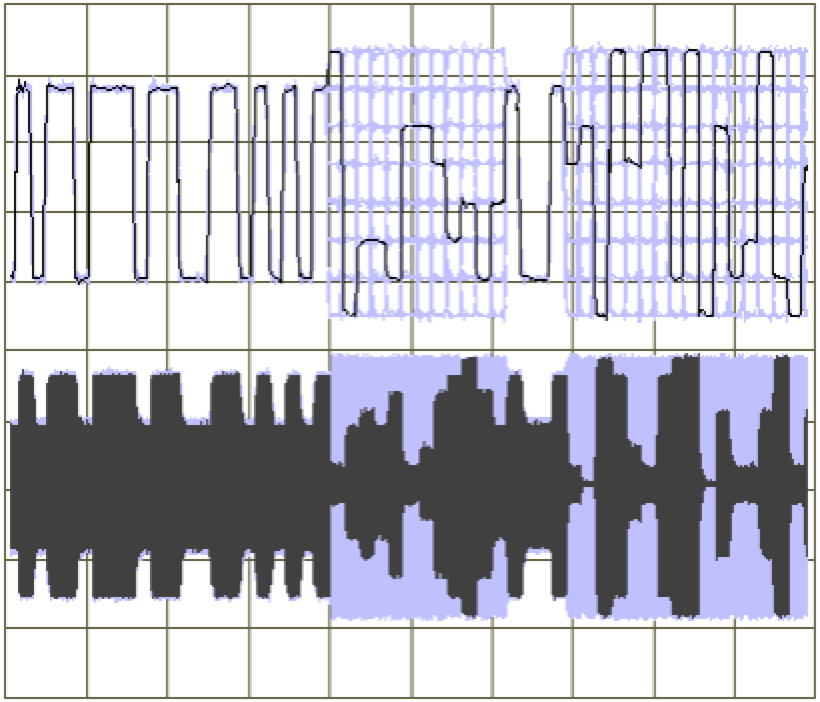
PEAK TO AVREAGE RATIO



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ADAPTIVE TAP EQUALIZER

Aimed at removing unwanted Multipath components

Based on the impulse response of known part of the signal

Synthetize and cancel known undesired multipath components

The length of the equalizer is resources dependent and vary fro -20 uS to 120 us

Beware that the speed of light is 3.16 us per km

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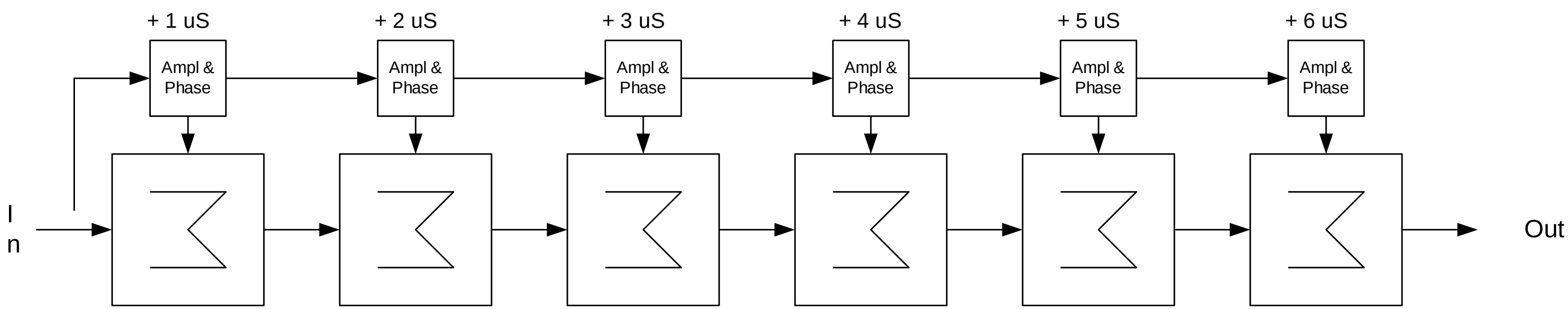
INTERFERENCE ISSUES

- **Static mutlipath is no longueur an issue for ATSC receivers neither should it be for ISDB-T**
- **Overload is often the issue, beware the overload may be out of band**
  - Active antennas may be saturating as their input circuit is fairly wideband
  - Digital demods are sensitive to:
    - Image frequency
    - Microphonics
  - Multiple Receive antennas are an efficient work-around as the receiver may not see part of the signal due to multipath, Giving the equalizer more meat to deal with is often a good measure.

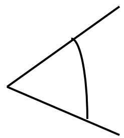
ADAPTIVE EQUALIZER

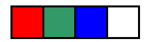


TRANSPORT STREAM MANAGEMENT

SIGNAL LEVEL

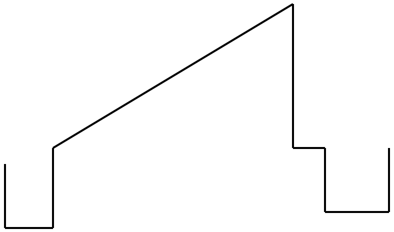
Visual layer





Pixels

baseband layer



SDI

Transport layer

MPEG

RF layer

WHAT IS A TRANSPORT STREAM?

A transport stream is a formatted data stream aimed at carrying compressed broadcast signals in a a fully addressable format.

A Transport Stream is la logical entity carried on a Physical layer

TRANSPORT STREAMS

Transport streams are the vehicle over witch the necessary information is multiplexed to allow a receiving devices (ex: an ATSC receiver) to fully decode a compressed service including:

- Video
- Audio
- Caption
- Navigational Information (ex: program guide)

T.S.

Transport streams are mostly carried on the following Physical layer:

- **SMPTE-310**
  - relies on a coax transmission system based on a synchronous feed @ 19.39 Mb/s

DVB-ASI

- DVB-ASI relies on a coax transmission based on a subset of the SDI specification. The signal is always transmitted @ 270 Mb/s. However a clever stuffing protocol permits transmission from 1 to 214 Mb/s.

Ethernet

- The Ethernet physical layer can be used to carry encapsulated MPEG transport stream

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SMPTE-310

Coax interface

SDI like signal (800 mV p-p)

Polarity sensitive

Synchronous @ 19.392658 Mb/s

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DVB-ASI

Coax interface

SDI like signal (800 mV p-p)

Polarity sensitive

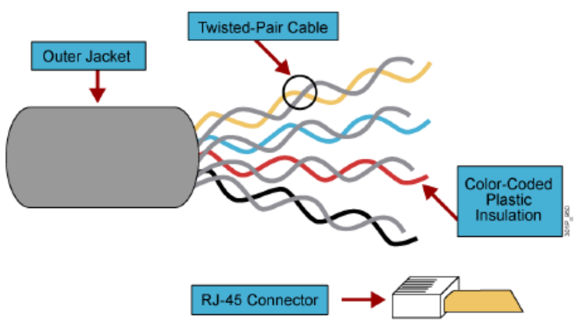
Synchronous @ 270 Mb/s

Stuffed for the difference between the payload (1 to 218 mb/s and 270 mb/s)

ETHERNET

Ethernet

- IP mostly relies on Unshielded Twisted Pair (UTP, or cat-5) cable, Transport streams are encapsulated in 1388 bytes packets, carried mostly as UDP traffic.

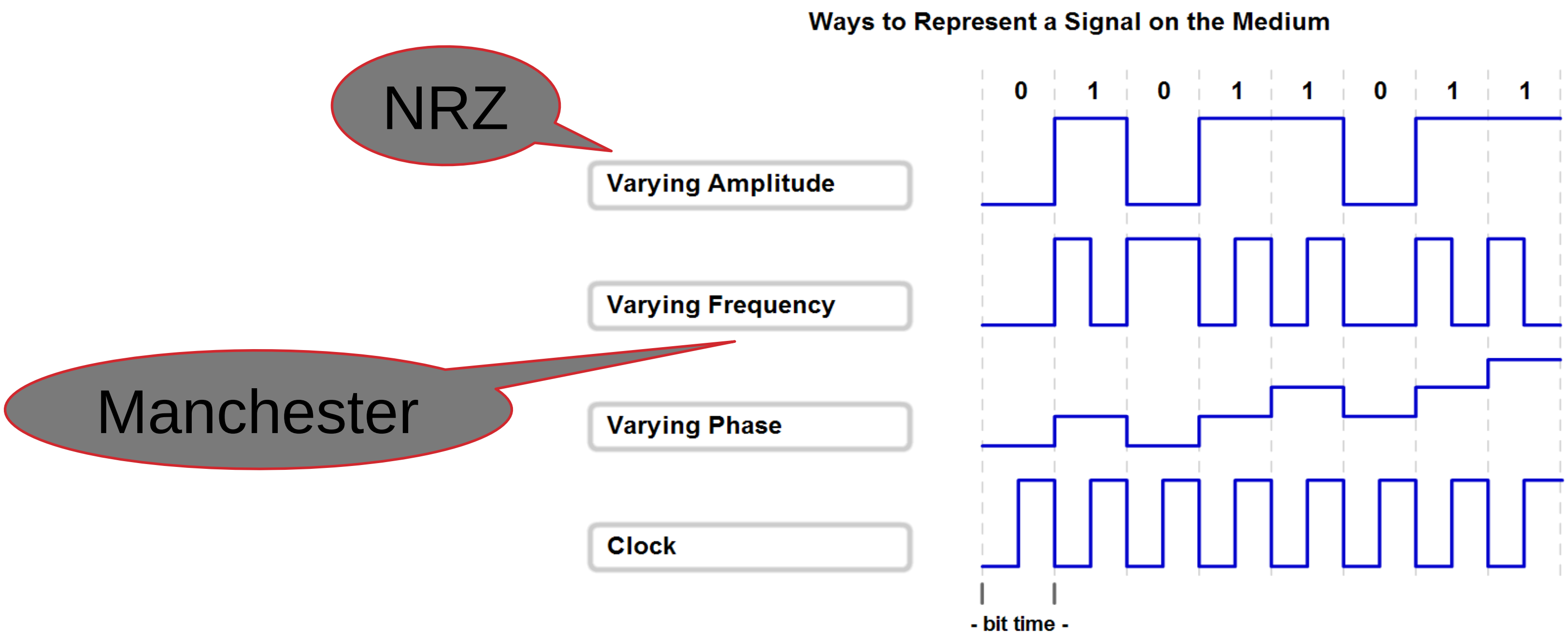


OSI Model			
	Data unit	Layer	Function
Host layers	Data	7. Application	Network process to application
		6. Presentation	Data representation, encryption and decryption, convert machine dependent data to machine independent data
		5. Session	Interhost communication, managing sessions between applications
	Segments	4. Transport	Reliable delivery of packets between points on a network.
Media layers	Packet/Datagram	3. Network	Addressing, routing and (not necessarily reliable) delivery of datagrams between points on a network.
	Bit/Frame	2. Data link	A reliable direct point-to-point data connection.
	Bit	1. Physical	A (not necessarily reliable) direct point-to-point data connection.

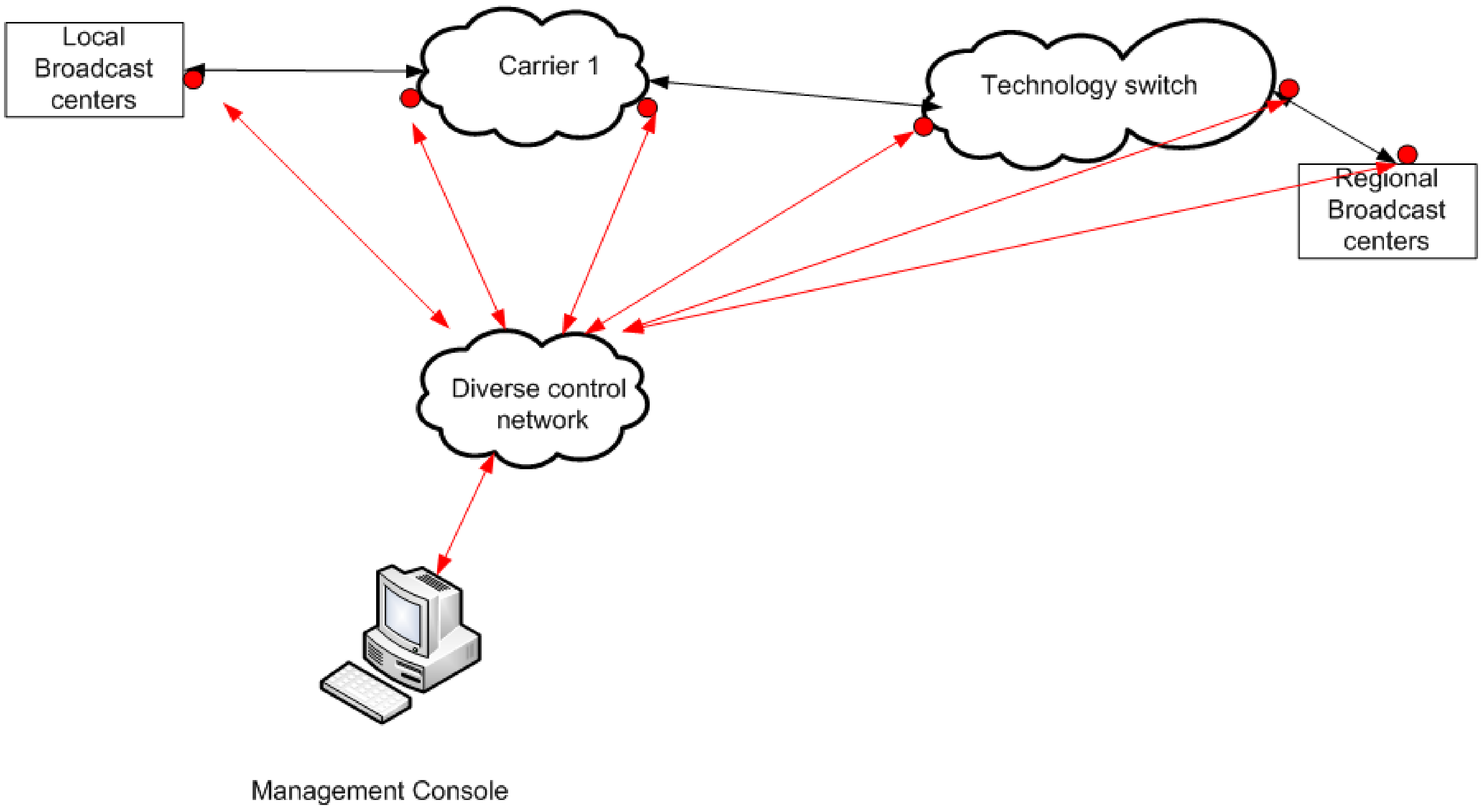
BASIC ENCODING TECHNIQUES

Non Return Zero – NRZ – low voltage=0, high voltage=1 Good for slow speed data links,Very susceptible to interference

Manchester encoding – voltage transitions (low > high=1, high<low=0) - Good for 10BaseT Ethernet



MONITORING THE ENTIRE NETWORK



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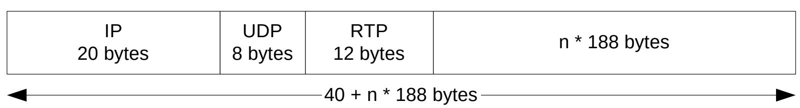
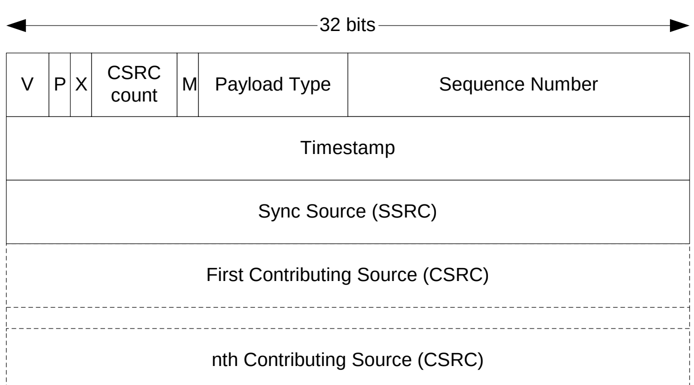
TS ON IP

Typical TS over IP implementation, we encapsulate 5 or 7 MPEG packets per IP packets



UDP header



V = Version (RTP = 2)
P = Padding
X = Extended Header
M = Marker bit

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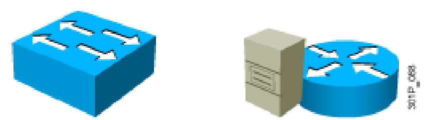
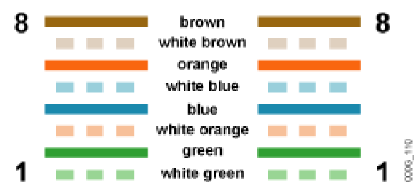
UTP CABLE

Cable 10BASE-T/
100BASE-TX Straight-Through



Pin	Label		Pin	Label
1	TX+	⟷	1	TX+
2	TX-	⟷	2	TX-
3	RX+	⟷	3	RX+
4	NC		4	NC
5	NC		5	NC
6	RX-	⟷	6	RX-
7	NC		7	NC
8	NC		8	NC

Straight-Through Cable

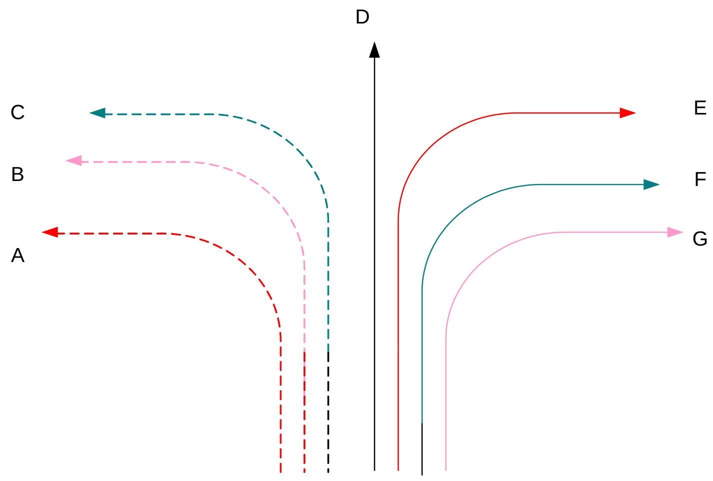


Wires on cable ends
are in same order.

UNICAST OR MULTICAST

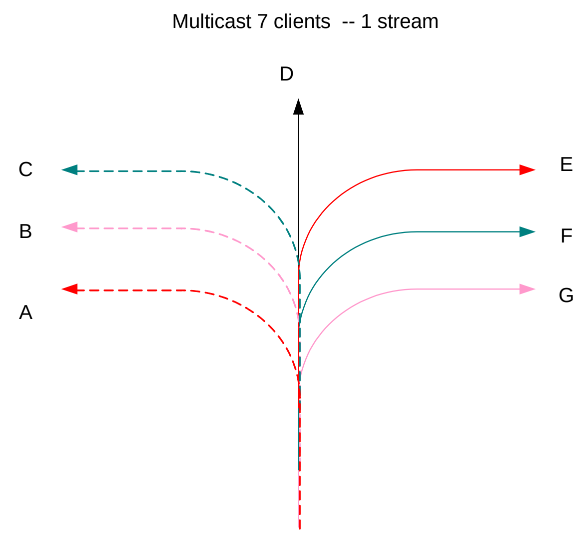
Unicast represent a private conversation, it implies a one for one relationship.

Unicast 7 clients -- 7 streams



MULTICAST

Presume a non private relationship between one stream and multiple clients.



SERIAL FORMAT

The MPEG data has to be serialized in order to be transmissible over cable or RF. The serialization process is made according to a strict protocol based on Packet based multiplexing.

The encoder has to fit all program elements in the transport stream:

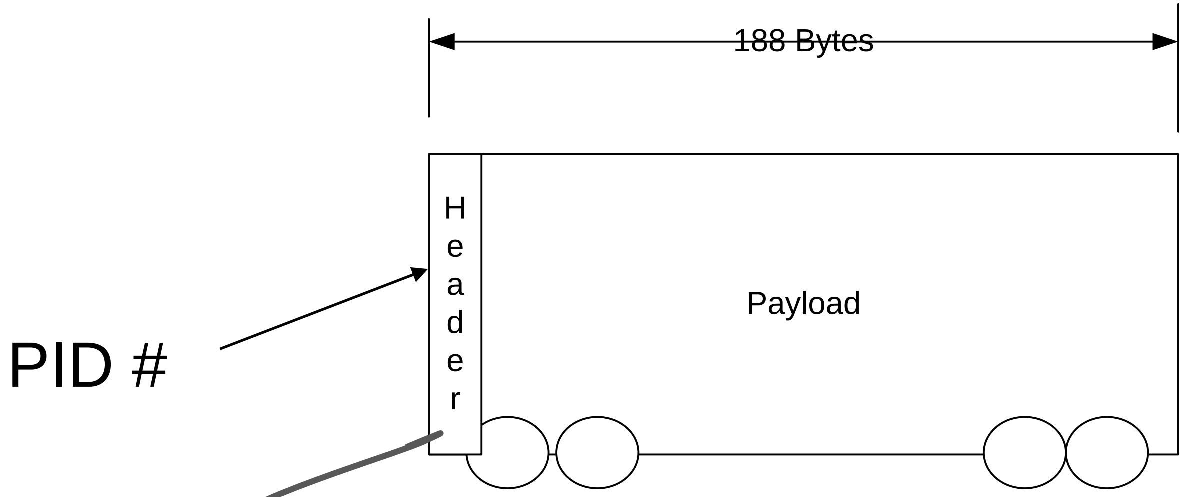
- Audio
- Video
- Data

MPEG PACKETS

The MPEG transport stream relies, unlike IP, on fixed length packets. The length of a standard MPEG packet is 188 bytes

The best human scale model for a data packet is a train wagon. The wagon carries a certain payload. In data terms it can be expressed in the number of bytes it carries. In the specific case of MPEG it is 188 Bytes. Bytes look all the same so a header has to be added to the packet so the de-multiplexer can know what is the content or the destination of the data packet.

MPEG PACKETS TRANSPORT



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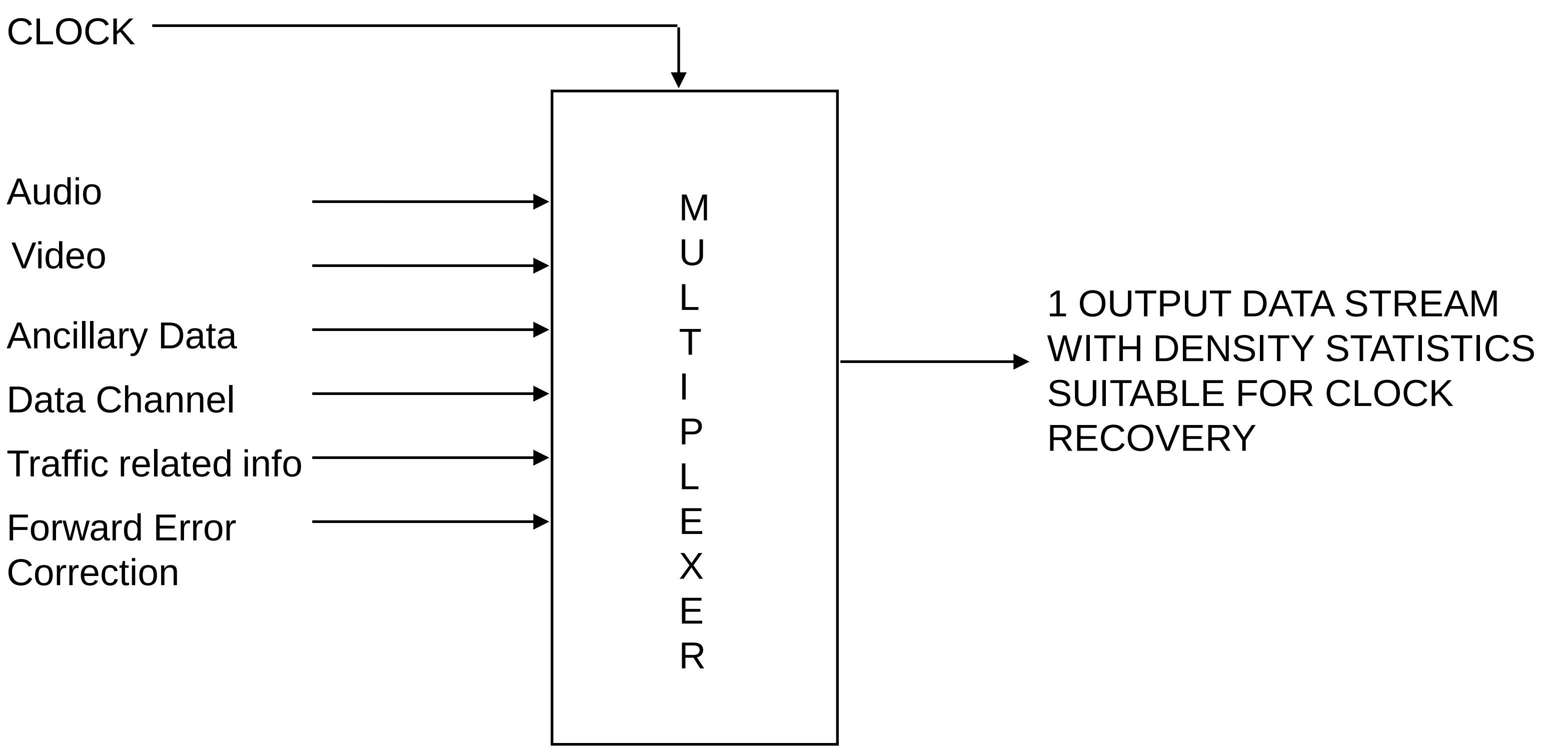
MULTIPLEXING



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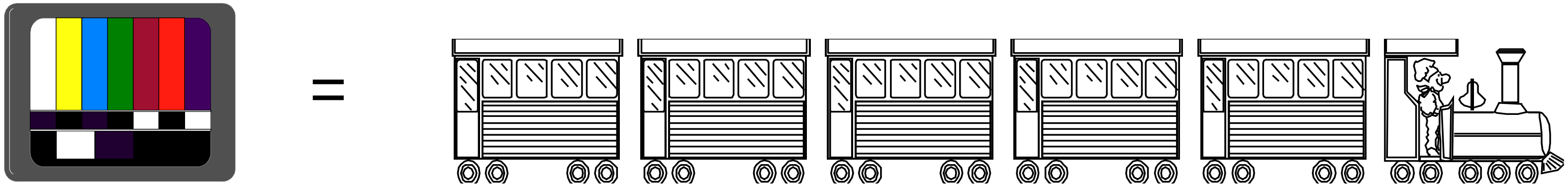
MULTIPLEXING

MPEG SIGNAL TRANSPORT

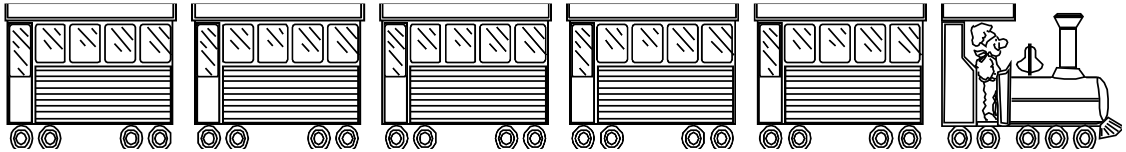
The MPEG compression take place

Mpeg encapsulate video in a compressed transport stream that is segmented in packets, each packets may be compared to a train wagon



NETWORKING

You may decide to decode the MPEG signal at any time and get the video and audio back:



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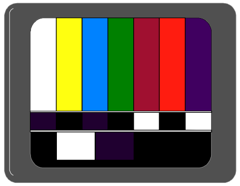


CC1 CC2 CC3 CC4 CC5

=

MPEG MULTIPLEXER

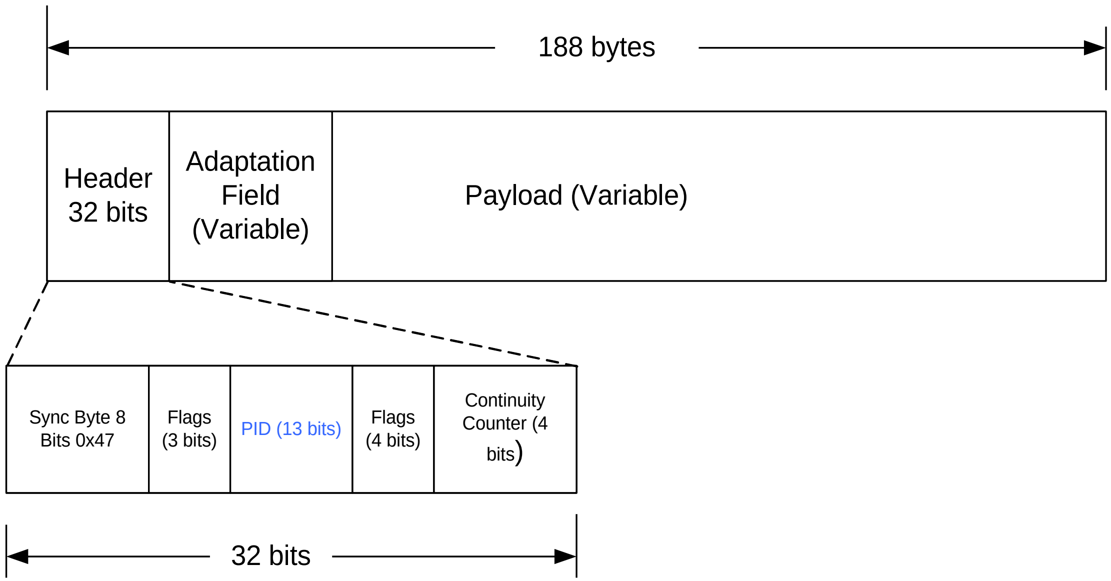
An Mpeg Multiplexer Can:

- Select Packets
- Rename packets
- Filter unwanted PID’s
- Carrousel Table information

PID

The PID or Program Identifier is a number (13 bit integer) located in the transport packet header. The latter is used to index MPEG packets. Just like IP routers, the MPEG TS handling equipment doesn't have to read all the 188 bytes packets it relies solely on the PID number to elect if the packet is required, and where it shall be routed to.

PID NUMBER


188 bytes
Header 32 bits
Adaptation Field (Variable)
Payload (Variable)
Sync Byte 8 Bits 0x47
Flags (3 bits)
PID (13 bits)
Flags (4 bits)
Continuity Counter (4 bits)
32 bits

MPEG TABLES

PAT(Program Association Table): (pid 0)

- List the services in the TS
- Points to the PMT of Each PMT

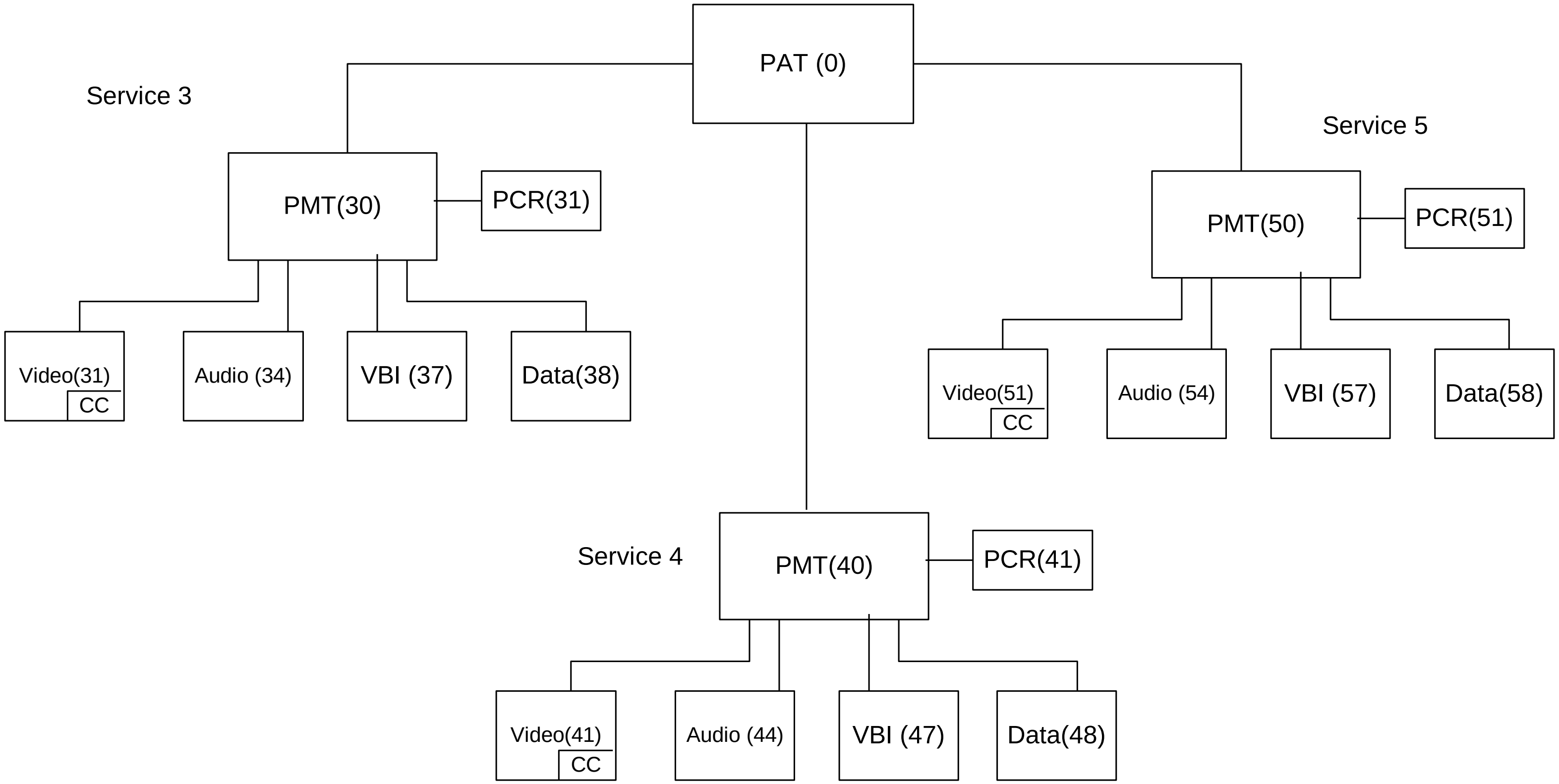
PMT: (Program Map table)(Pid variable)

- One PMT per service
- Points to the location of each program elements
- Gives service info (Tittle, TSID etc)

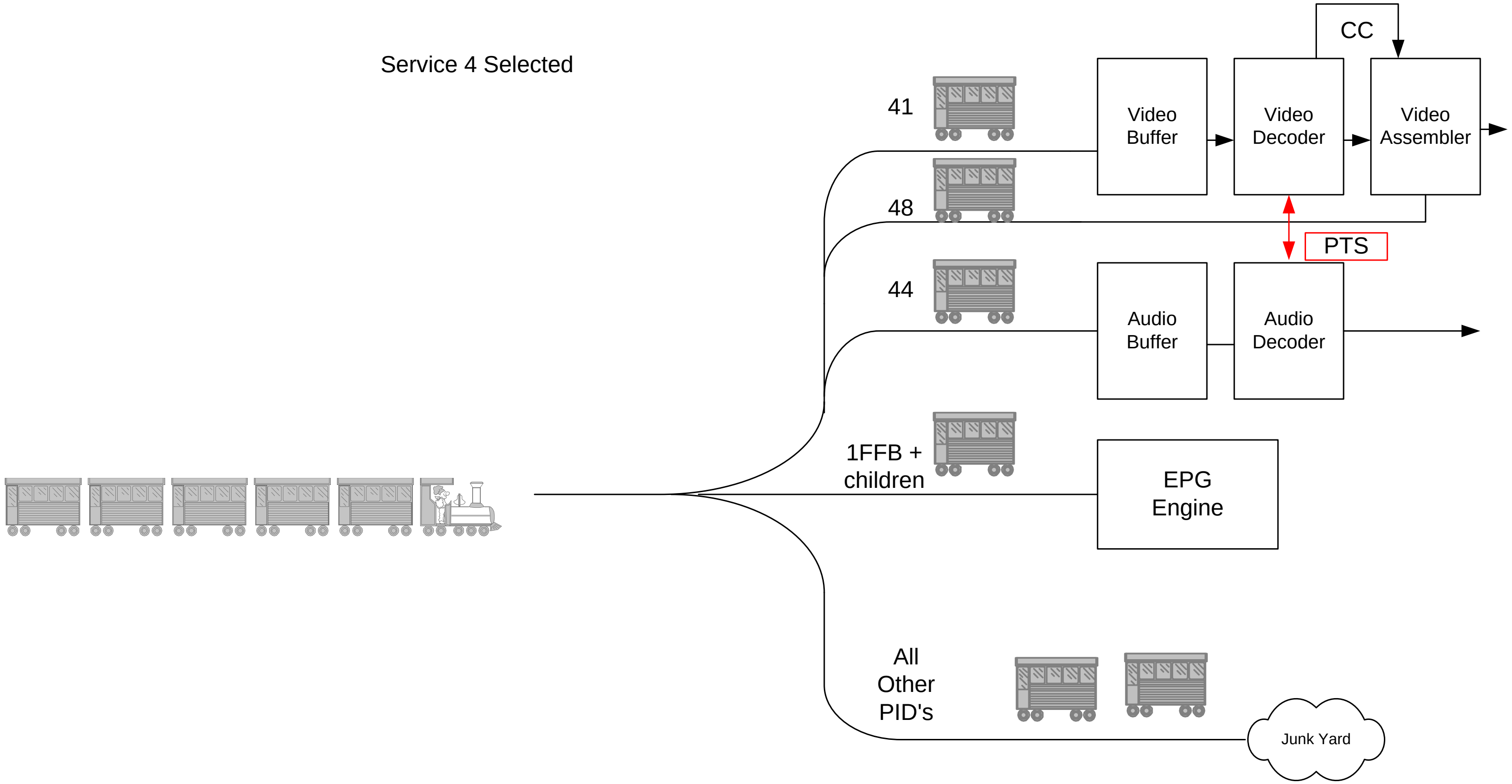
MGT (Master Guide Table) or Si (service information table)

- fixed PID Location (1FFB or 16)
- Points to program guide information

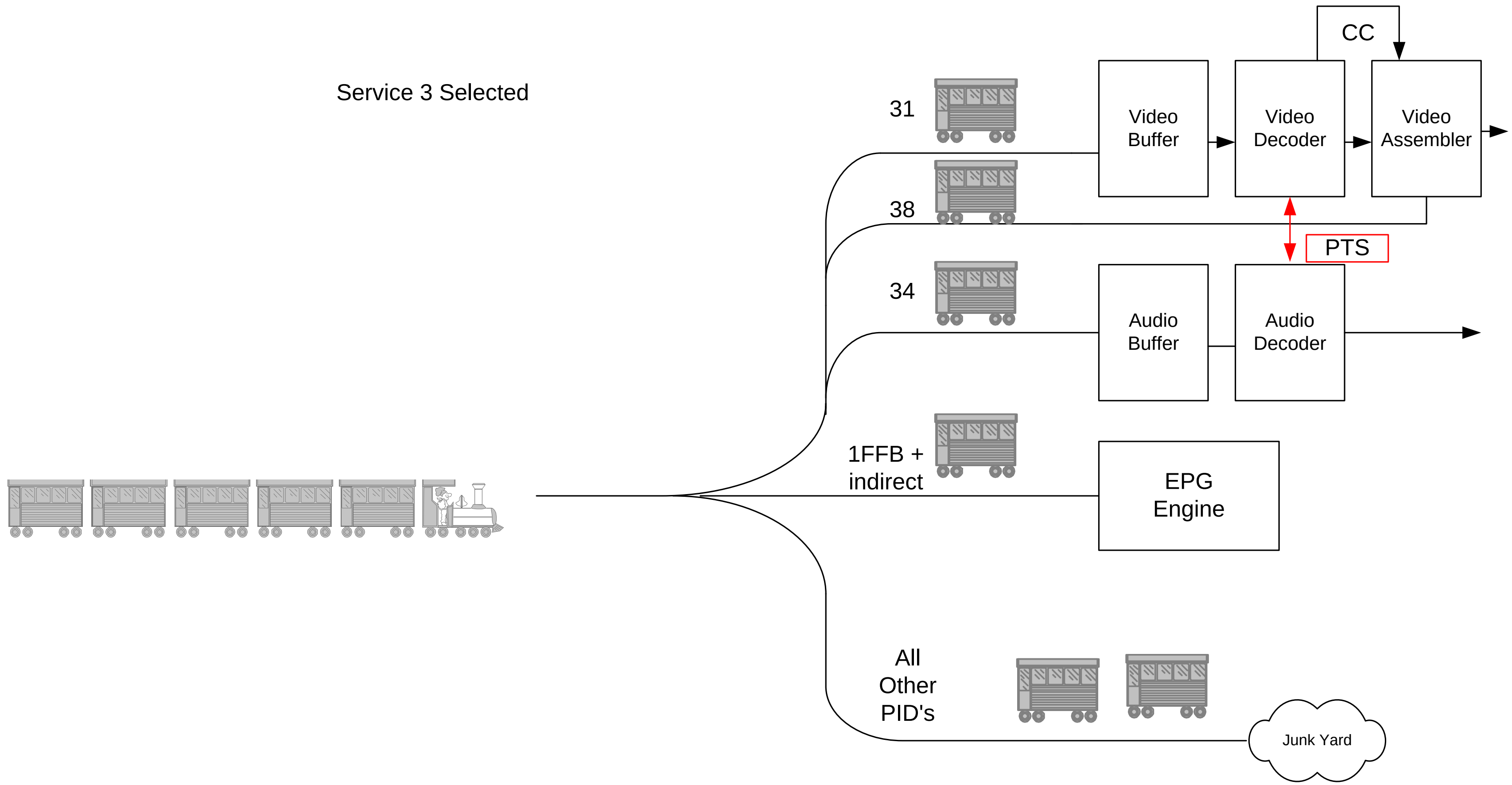
MPEG Structure



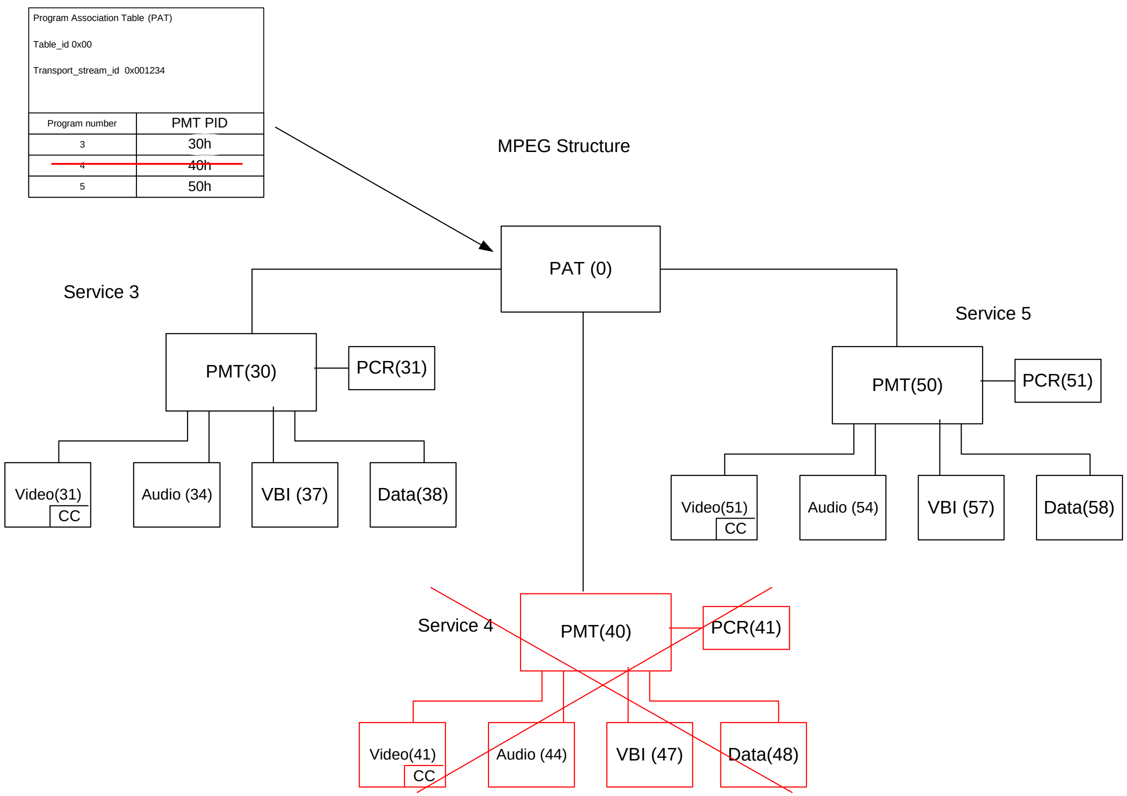
Service 4 Selected



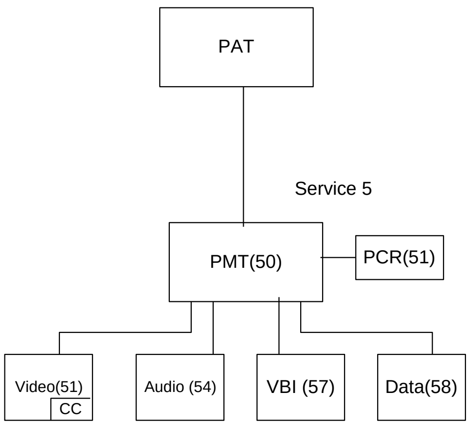
Service 3 Selected



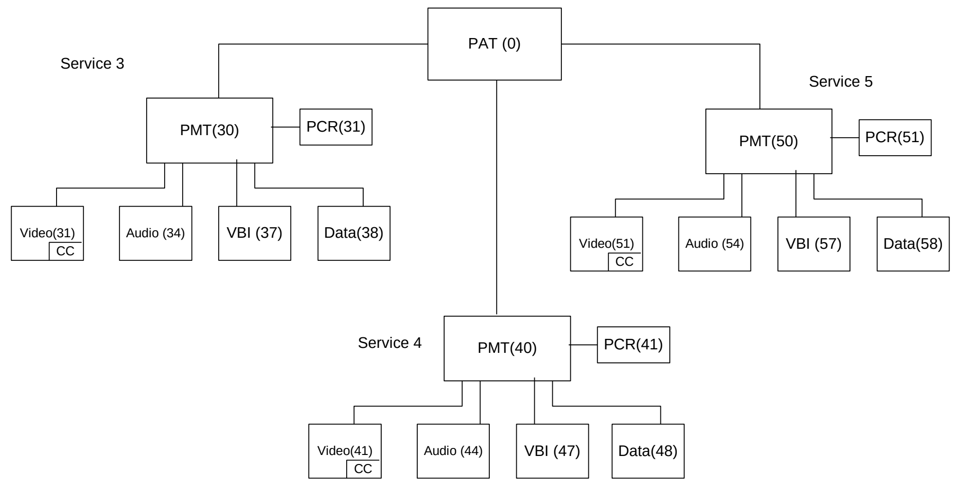
MPEG FILTERING



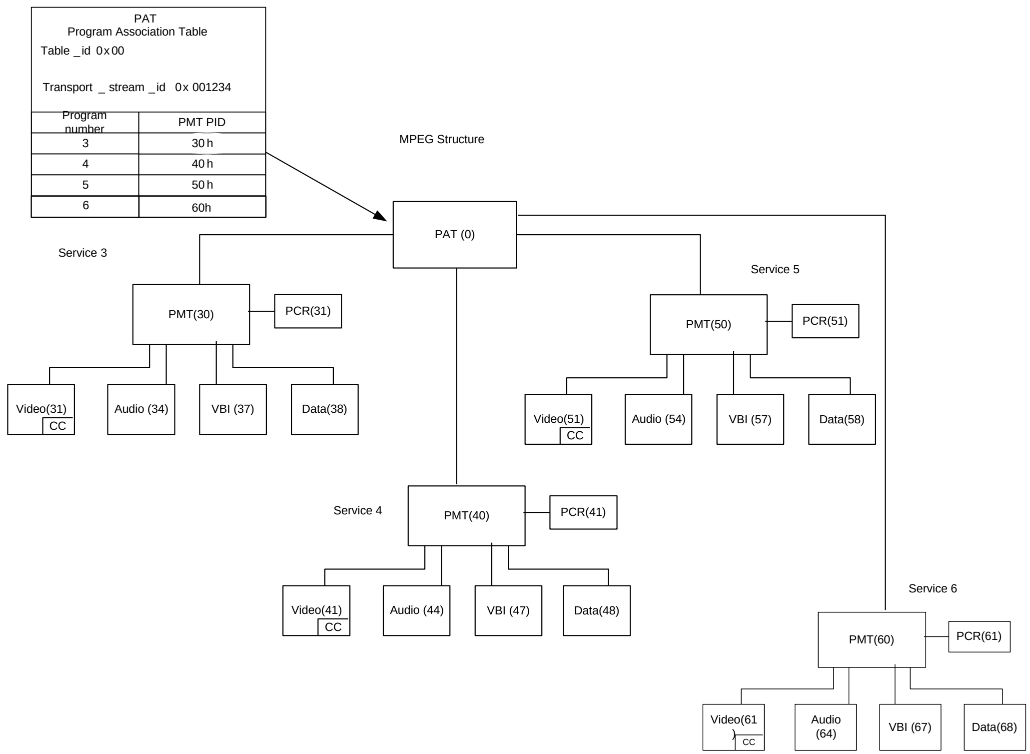
MPEG MULTIPLEXING



MPEG Structure



CBC Radio-Canada



Service descriptor:

Now that the audio decoder has the audio packets and the video decoder has the video packets, does the decoder have sufficient information to decode the stream?

Not quite, the decoders needs to know a little more about the signals like (the standard the packets were coded), the language, etc :

- Coding standards:
  - Audio (MPEG layer 1, Dolby AC-3, etc)
  - Video:(MPEG-1, MPEG-2, AVC, etc)

This information is carried on a 8 bit number called a service descriptor

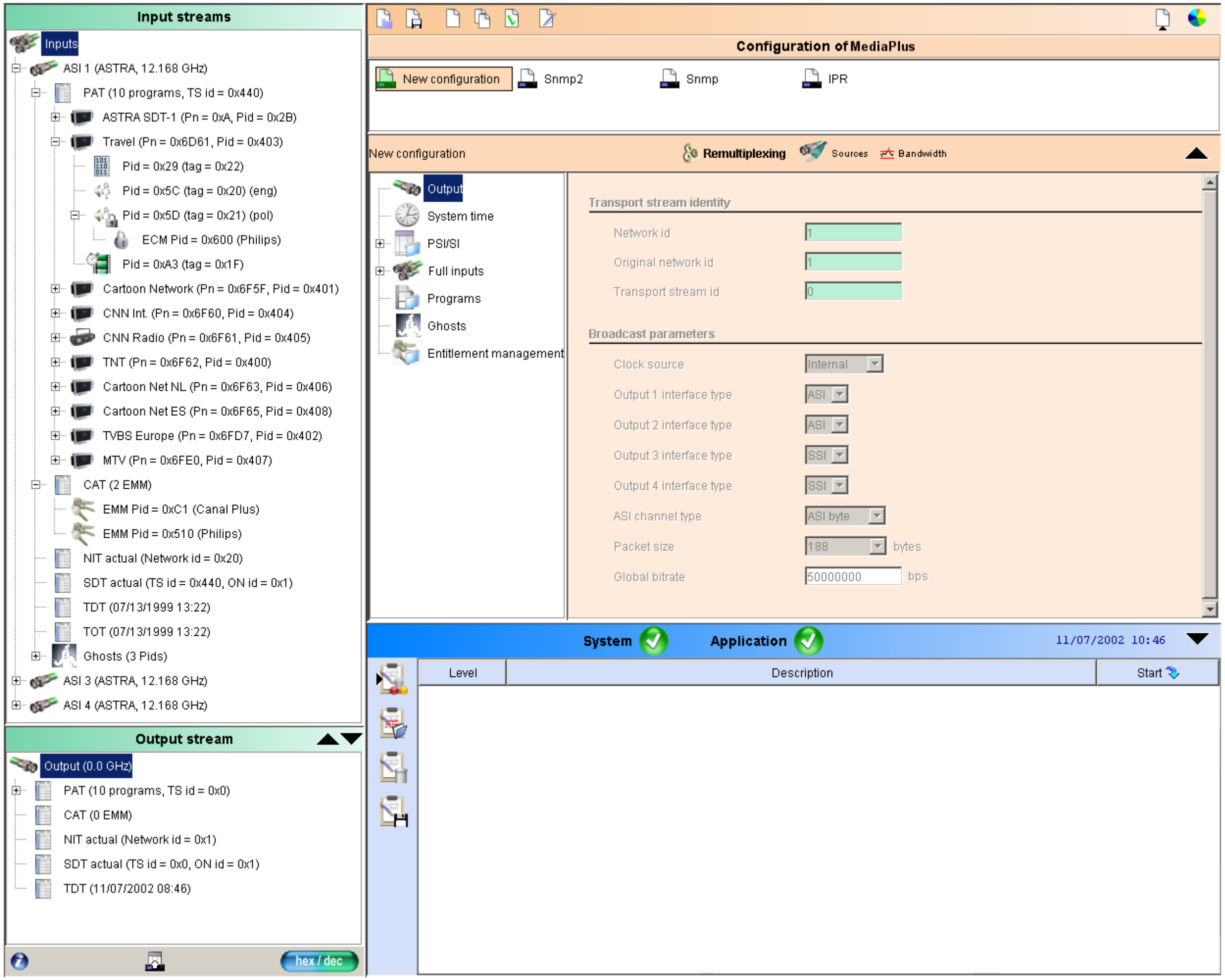
Service	Descriptor
Mpeg-2 video	01h
Mpeg layer 2 audio	03h
Dolby AC-3	81h

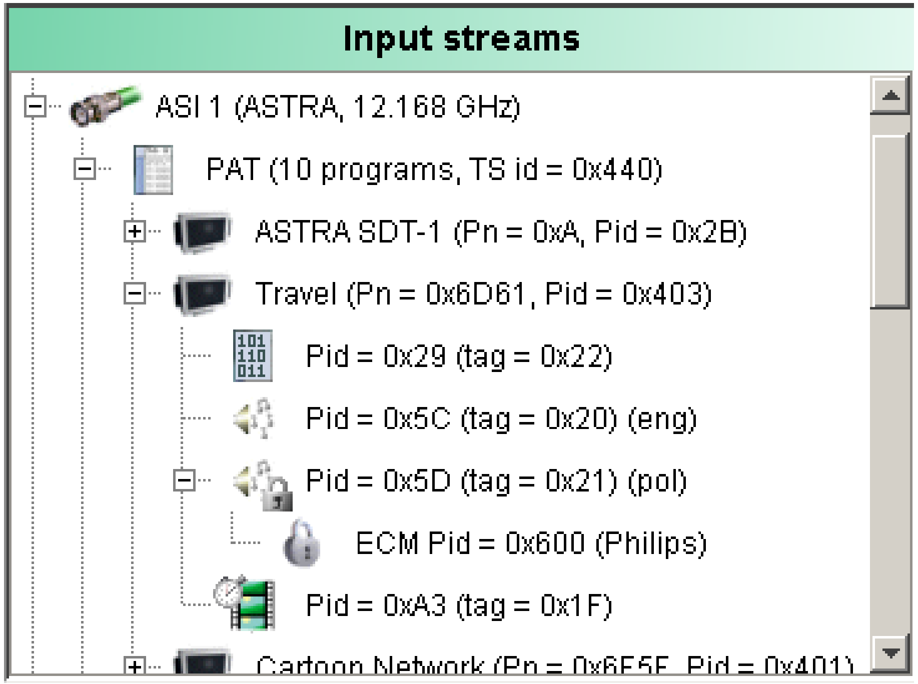
Figure 7 MPEG service descriptors

Language Descriptor

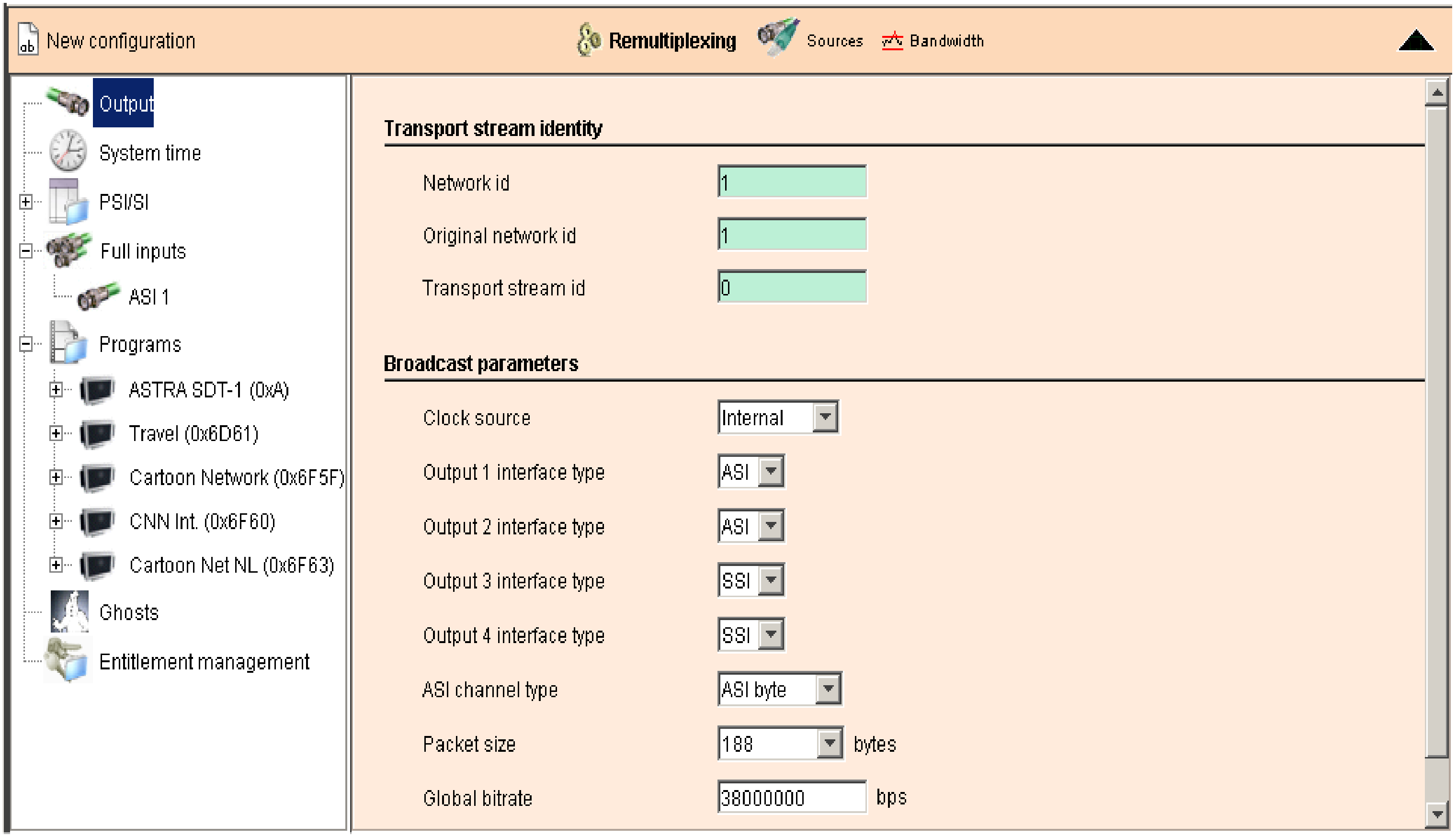
The language selection is made using a worldwide standard that defines languages called ISO-639, the latter defines a 2 letter codes for most known languages, The so called “Language Descriptor” permits to encode audio in several languages for the user selection. On most ATSC receivers the MTS key permits to toggle between languages.

Language	ISO 639 Descriptor
English	en
French	Fr
German	de
Finnish	fi
Polish	Pl
Portuguese	Pt
Russian	ru


Input streams
Inputs
ASI 1 (ASTRA, 12.168 GHz)
PAT (10 programs, TS id = 0x440)
ASTRA SDT-1 (Pn = 0xA, Pid = 0x2B)
Travel (Pn = 0x6D61, Pid = 0x403)
Pid = 0x29 (tag = 0x22)
Pid = 0x5C (tag = 0x20) (eng)
Pid = 0x5D (tag = 0x21) (pol)
ECM Pid = 0x600 (Philips)
Pid = 0xA3 (tag = 0x1F)
Cartoon Network (Pn = 0x6F5F, Pid = 0x401)
CNN Int. (Pn = 0x6F60, Pid = 0x404)
CNN Radio (Pn = 0x6F61, Pid = 0x405)
TNT (Pn = 0x6F62, Pid = 0x400)
Cartoon Net NL (Pn = 0x6F63, Pid = 0x406)
Cartoon Net ES (Pn = 0x6F65, Pid = 0x408)
TVBS Europe (Pn = 0x6FD7, Pid = 0x402)
MTV (Pn = 0x6FE0, Pid = 0x407)
CAT (2 EMM)
EMM Pid = 0xC1 (Canal Plus)
EMM Pid = 0x510 (Philips)
NIT actual (Network id = 0x20)
SDT actual (TS id = 0x440, ON id = 0x1)
TDT (07/13/1999 13:22)
TOT (07/13/1999 13:22)
Ghosts (3 Pids)
ASI 3 (ASTRA, 12.168 GHz)
ASI 4 (ASTRA, 12.168 GHz)
Output stream
Output (0.0 GHz)
PAT (10 programs, TS id = 0x0)
CAT (0 EMM)
NIT actual (Network id = 0x1)
SDT actual (TS id = 0x0, ON id = 0x1)
TDT (11/07/2002 08:46)
hex / dec
Configuration of MediaPlus
New configuration
Snmp2
Snmp
IPR
New configuration
Remultiplexing
Sources
Bandwidth
Output
System time
PSI/SI
Full inputs
Programs
Ghosts
Entitlement management
Transport stream identity
Network id
Original network id
Transport stream id
Broadcast parameters
Clock source
Internal
Output 1 interface type
ASI
Output 2 interface type
ASI
Output 3 interface type
SSI
Output 4 interface type
SSI
ASI channel type
ASI byte
Packet size
188
bytes
Global bitrate
50000000
bps
System
Application
11/07/2002 10:46
Level
Description
Start


Input streams
ASI 1 (ASTRA, 12.168 GHz)
PAT (10 programs, TS id = 0x440)
ASTRA SDT-1 (Pn = 0xA, Pid = 0x2B)
Travel (Pn = 0x6D61, Pid = 0x403)
Pid = 0x29 (tag = 0x22)
Pid = 0x5C (tag = 0x20) (eng)
Pid = 0x5D (tag = 0x21) (pol)
ECM Pid = 0x600 (Philips)
Pid = 0xA3 (tag = 0x1F)

CBC Radio-Canada



TRANSPORT STREAMS HAVE A LANGUAGE OF THEIR OWN

The receiving device expect to receive information in a known order, (just like a sentence where a subject, a verb and a complement are expected in order).

The language or Syntax required varies with the application:

- 2 MPEG devices in a lab environment don't need much of Shakespeare language, in fact a few commands are sufficient.
- The basic MPEG syntax is used

SYNTAXES

A satellite receiver needs a little more information (carrier freq, FEC, number of services etc)

- The DVB syntax is used in this case, please note that all the elements of the basic MPEG syntax are also included in the DVB syntax.

An ATSC receiver also requires more information (program title, program Info, Vchip, caption)

- The ATSC syntax is used in this case, note that all the elements of the basic MPEG syntax are also included in the ATSC syntax.

PHYSICAL LAYER AND SYNTAX

Physical Layer and syntax are independent variables: so you can end up with:

Physical layer	Syntax
SMPTE-310	ATSC
DVB-ASI	DVB
Ethernet	SCTE

SYNTAXES DVB/ ATSC / SCTE

Digital Video Broadcasting (DVB) is a worldwide standard defining Digital Video transmission across various media's:

- Satellite DVB-s
- Cable DVB -C
- Terrestrial transmission DVB-T
- SCTE for North American Cable

»**ATSC is terrestrial Only**

TABLES

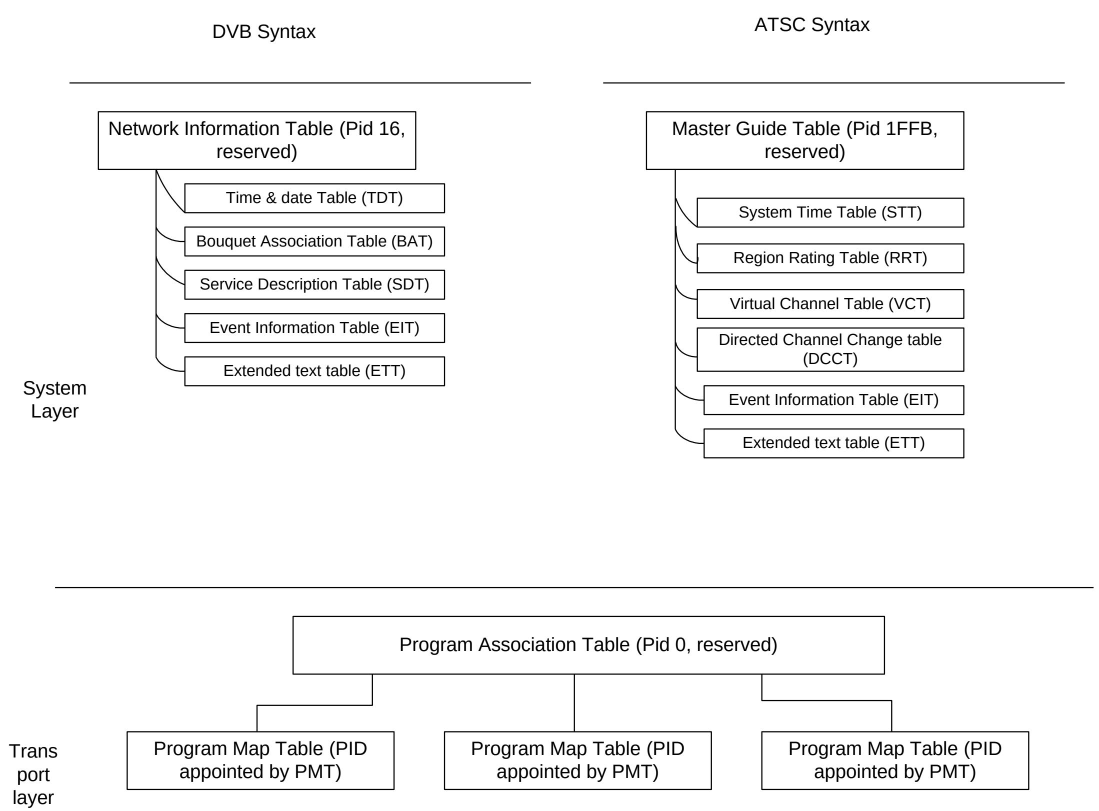
Each syntaxes defines a number of tables into which the information is stored in an orderly manner:

Ex: The MPEG syntax defines 2 types of tables:

- Program Association Table (PAT) (always located at PID 0): defines how many services are multiplexed in the current stream, their name or ID and the location (in Pid no) of each services index table or PMT
- Program Map Table (PMT); defines the location of the video, audio and ancillary information for one service, it is located in a PID number defined in the PAT

TABLES

Each syntax defines a variety of system tables as follows:



TS OVER IP

Used as an ASI coax replacement

Not made to resist dropped or delayed packets

Prefers to be routed over simple routes with dum switches

Not the protocol we streamed content over the internet

NETWORK DIAGRAM

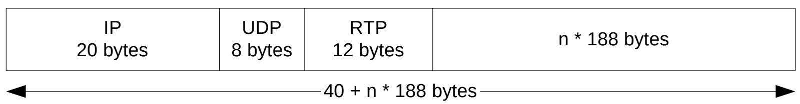
Every Television station shall have:

- A Video functional
- And audio functional
- A TS functional
- A control functional
- Where is your network diagram ?

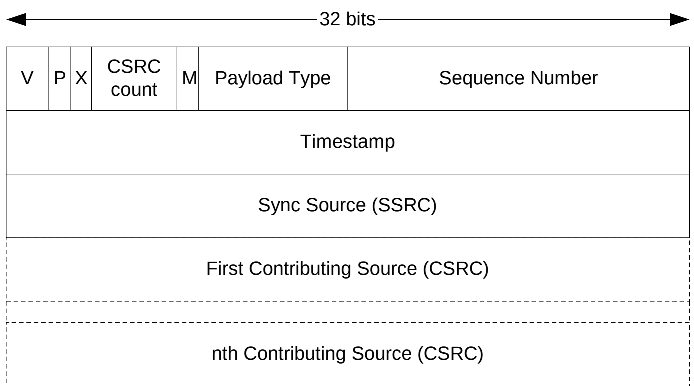
NOT ALL SWITCHES ARE CREATED EQUAL

TS ON IP

Typical TS over IP implementation, we encapsulate 5 or 7 MPEG packets per IP packets

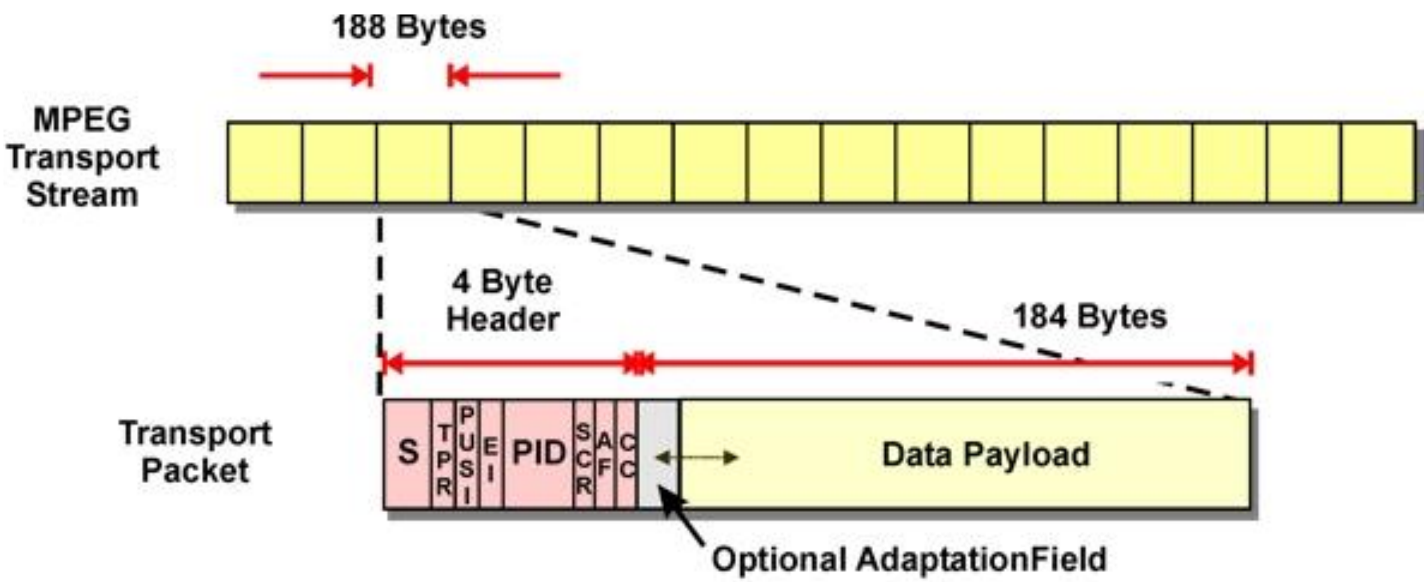


UDP header



V = Version (RTP = 2)
P = Padding
X = Extended Header
M = Marker bit

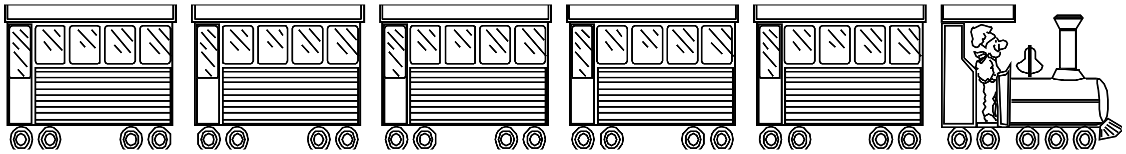
MPEG TS PACKET HEADER



S - Sync
TPR - Transport Priority
PUSI - Payload Start
EI - Error Indicator

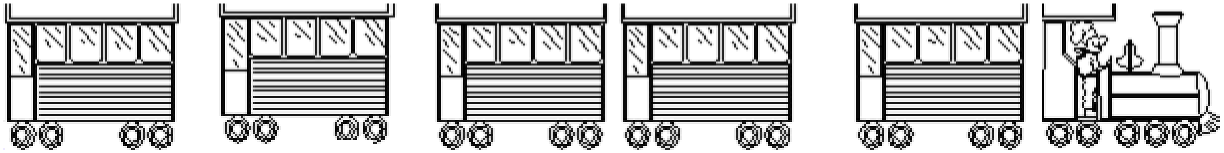
PID - Packet Identifier (stream ID)
SCR - Scrambling Control
AF - Adaptation Field
CC - Continuity Check Index

BROADCAST TRAFFIC ENEMY NO 1: JITTER



Jitter originates from a speed differential between parts of a serialized stream

- This train symbolizes a stream of IP packets, imagine for a minute that those wagons are tied together by steel joints with very little expansion contraction, all wagons will travel at precisely the same instantaneous speed
- Imagine now that the wagon are tied with bungee cords



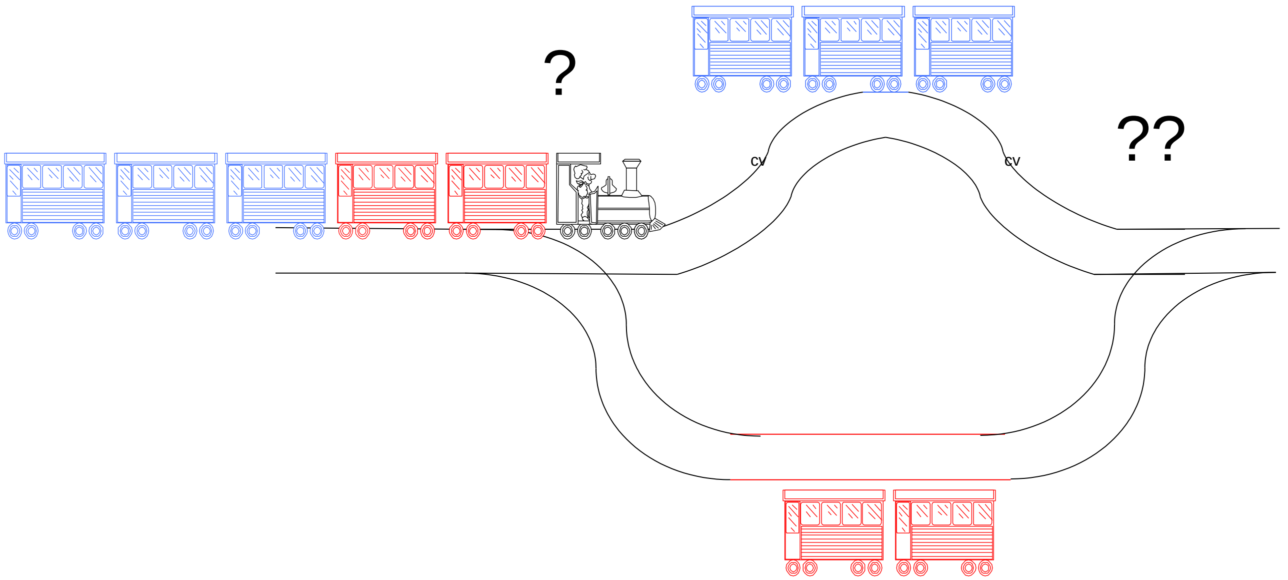
SOURCE OF IP JITTER

Each time the traffic is exposed to route switching

Each time a switch has to take a decision it take some time to do so, not exactly the same time at each occurence

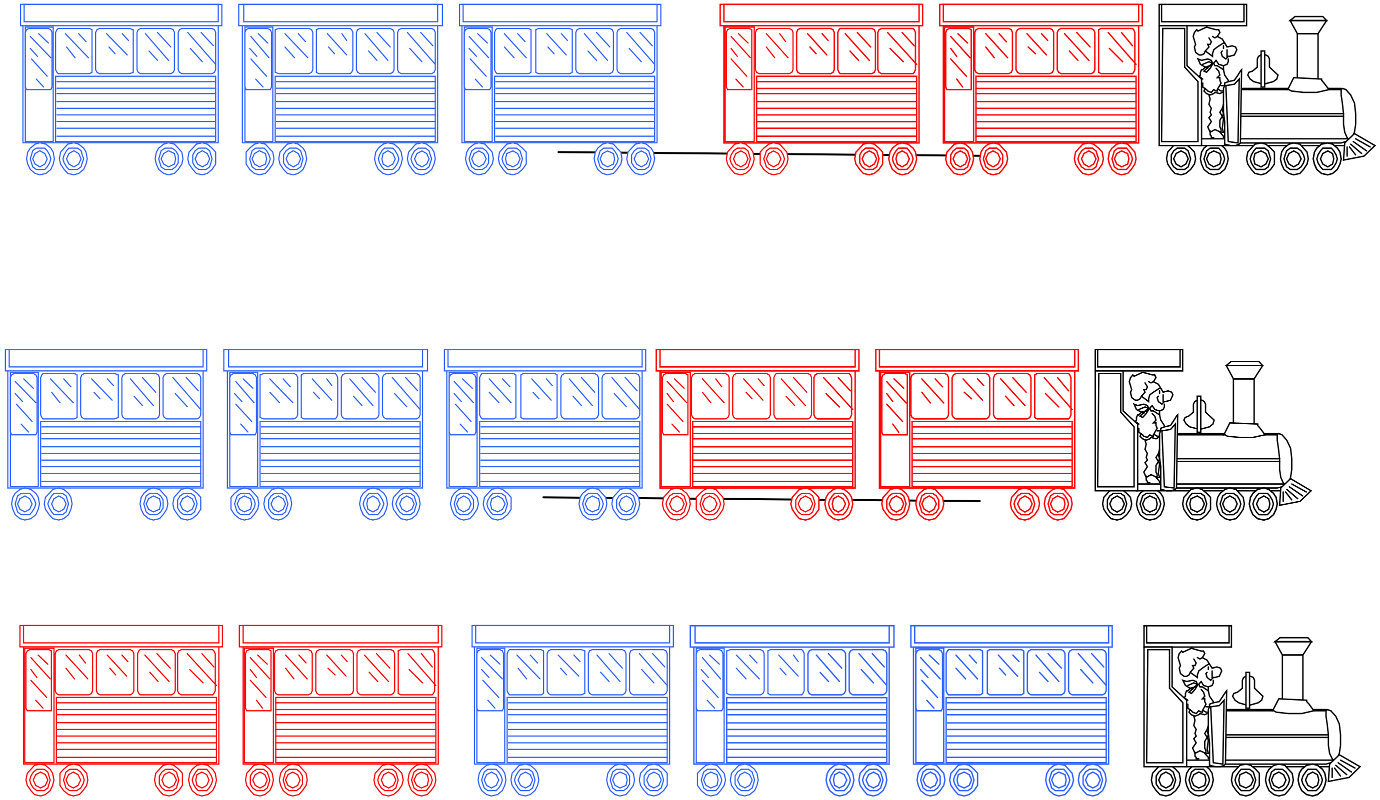
CBC Radio-Canada

DECISION TIME



CBC Radio-Canada

RESULTS



MINIMIZING JITTER

Minimize multipath

Equalize paths

Uses fastest switch available

Create dum network segments

PCR

The PCR is a signal sent from the encoder to the decoder to synchronize the decoder 27 MHz clock

The PCR is sent over standards 188bytes MPEG packets just like any other MPEG payload

PCR packets is sent at a fixed repetition rate

PCR

The PCR signal is carried over either a private PID, or embedded in the video PID

PCR occupies about 45 kbs

The PCR packets are sent at a minimum frequency

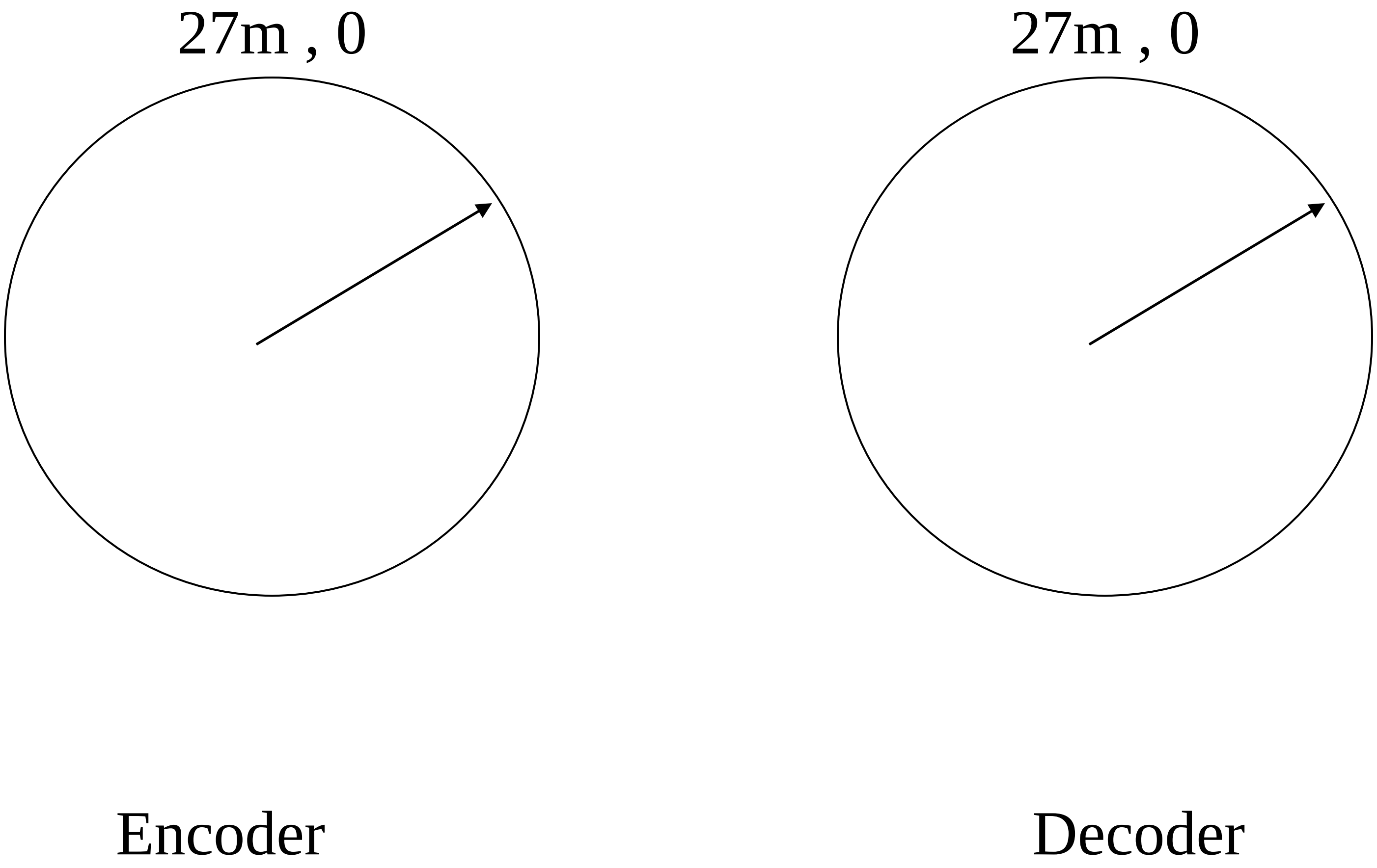
If the encoder doesn't sent PCR often enough, a PCR repetition error will be generated

PCR is required to be accurate within 226 Hz

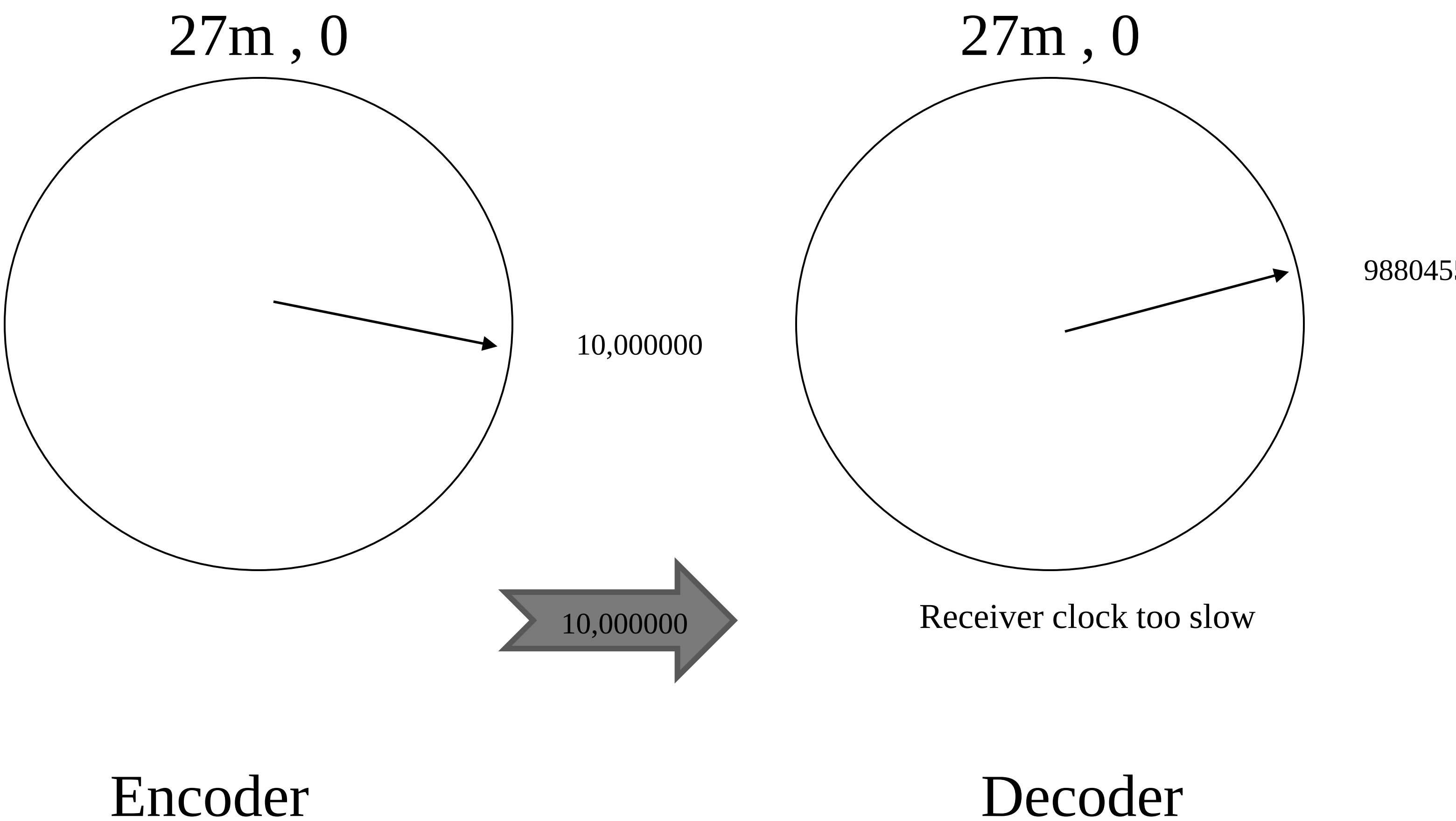
If the result of PCR synchronization is not within limits a PCR accuracy error will be generated

If the some PCR packet s are delayed from a variable amount of time (typical of switched network) A PCR clock Jitter error will be recorded

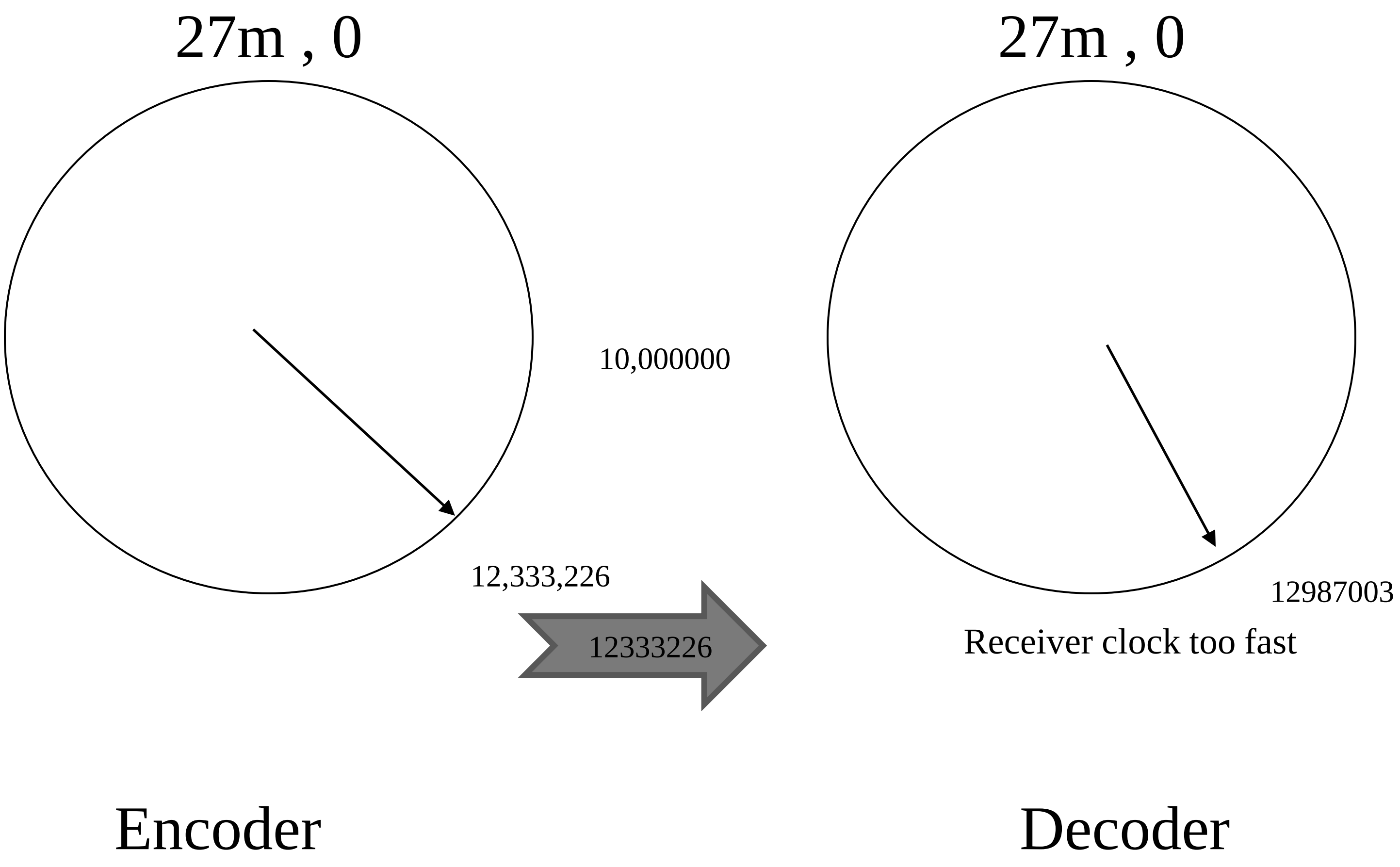
PCR ISSUES



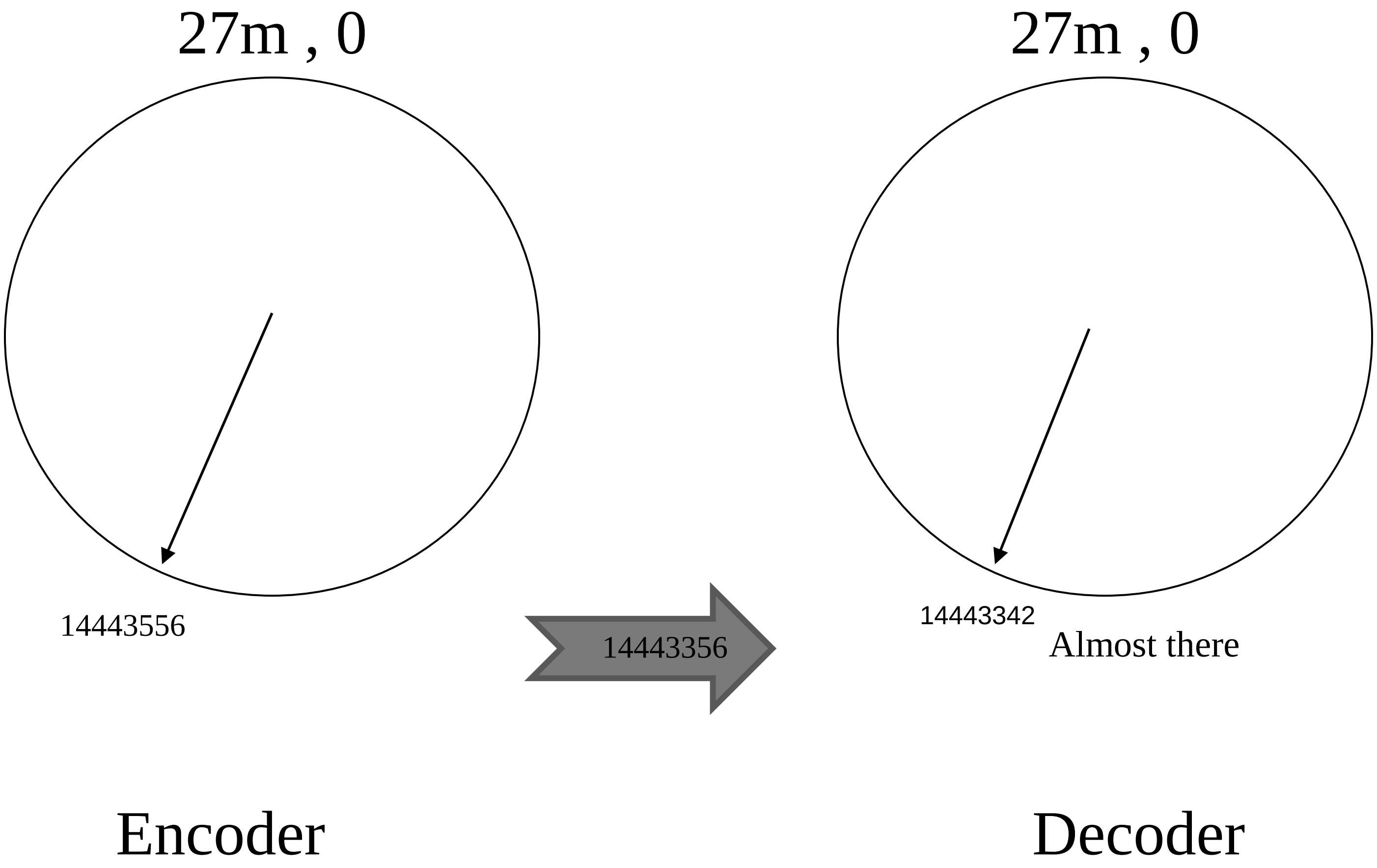
PCR


27m , 0
27m , 0
10,000000
9880455
10,000000
Receiver clock too slow
Encoder
Decoder

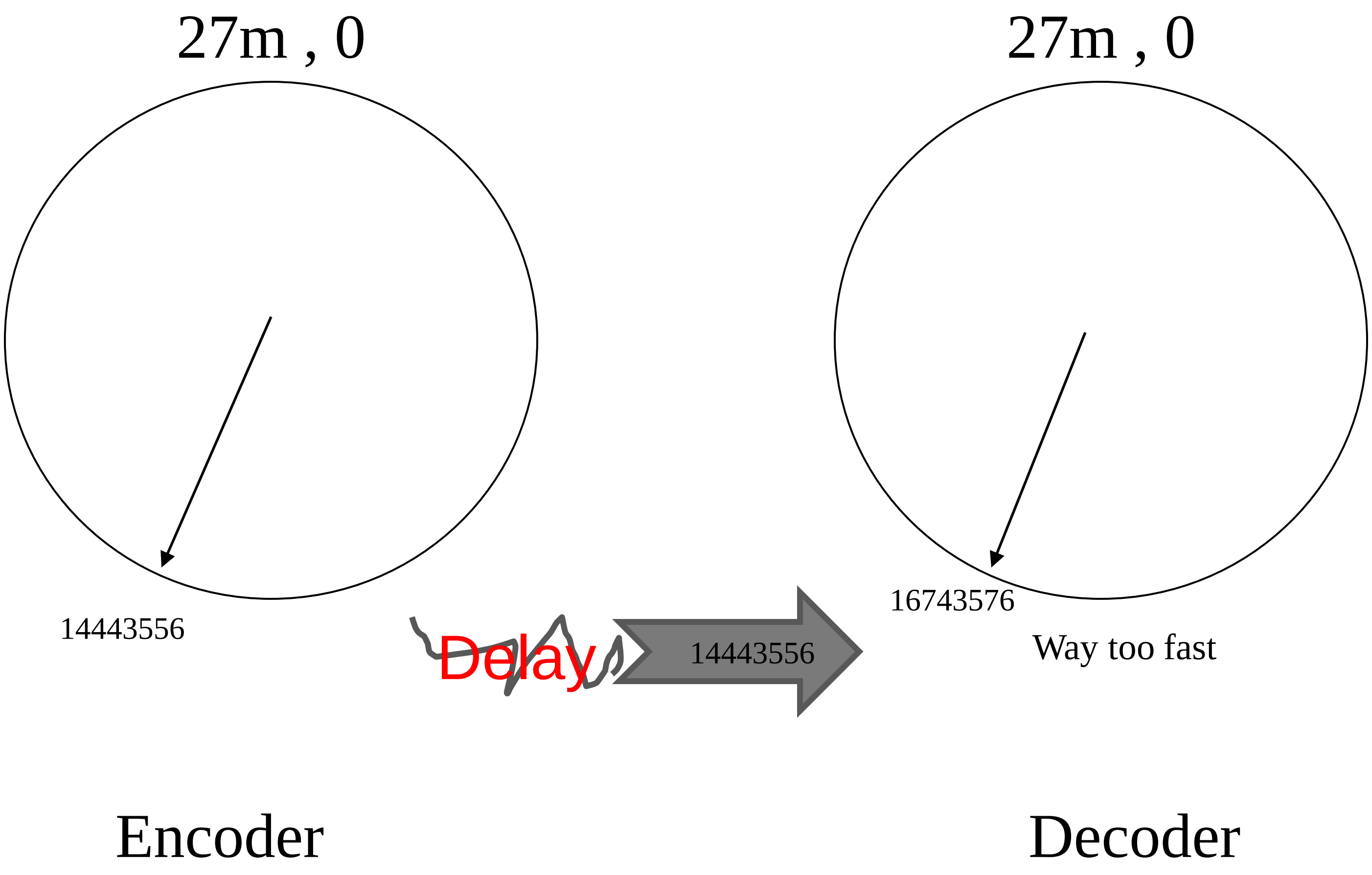
PCR


27m , 0
27m , 0
10,000000
12,333,226
12333226
12987003
Receiver clock too fast
Encoder
Decoder

PCR


27m , 0
27m , 0
14443556
14443356
14443342
Almost there
Encoder
Decoder

PCR


27m , 0
27m , 0
14443556
Delay
14443556
16743576
Way too fast
Encoder
Decoder

CBC Radio-Canada

PCR

The PCR signal is carried over either a private PID, or embedded in the video PID

PCR occupies about 45 kbs

The PCR packets are sent at a minimum frequency

If the encoder doesn't sent PCR often enough, a PCR repetition error will be generated

PCR is required to be accurate within 226 Hz

If the result of PCR synchronization is not within limits a PCR accuracy error will be generated

If the some PCR packet s are delayed from a variable amount of time (typical of switched network) A PCR clock Jitter error will be recorded

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New Vehicles

TRANSPORT LAYER

NEW WAYS TO CARRY TS IN IN OUTSIDE THE BROADCAST PLANT?

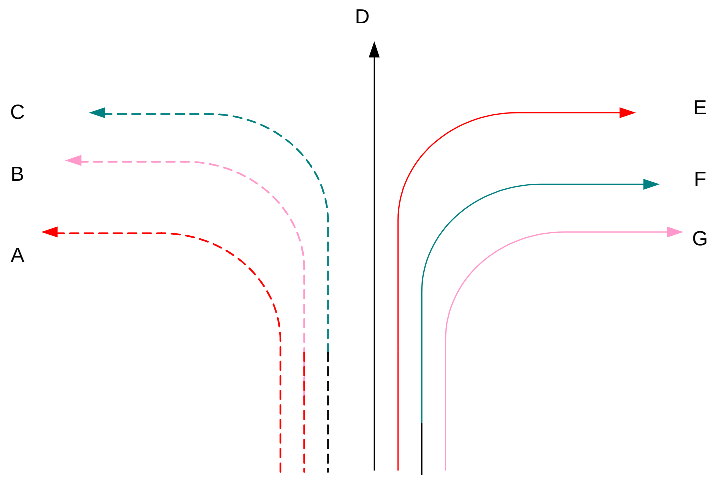
OSI Model

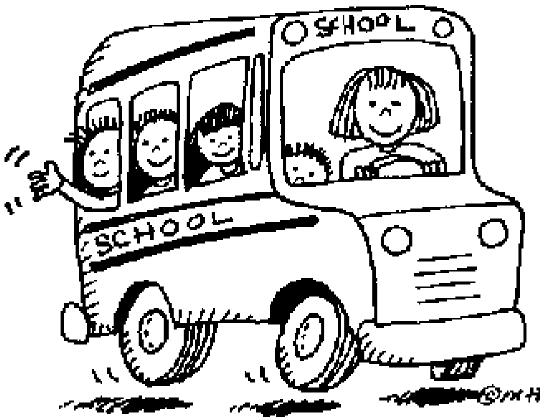
	Data unit	Layer	Function
Host layers	Data	7. Application	Network process to application
		6. Presentation	Data representation, encryption and decryption, convert machine dependent data to machine independent data
		5. Session	Interhost communication, managing sessions between applications
	Segments	4. Transport	Reliable delivery of packets between points on a network.
Media layers	Packet/Datagram	3. Network	Addressing, routing and (not necessarily reliable) delivery of datagrams between points on a network.
	Bit/Frame	2. Data link	A reliable direct point-to-point data connection.
	Bit	1. Physical	A (not necessarily reliable) direct point-to-point data connection.

UNICAST OR MULTICAST

Unicast represent a private conversation, it implies a one for one relationship.

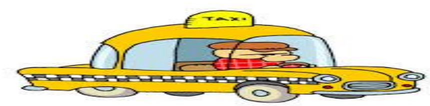
Unicast 7 clients -- 7 streams



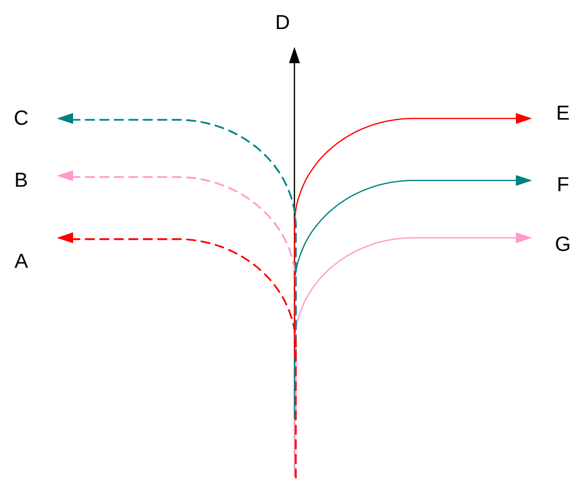


MULTICAST

Presume a non private relationship between one stream and multiple clients.



Multicast 7 clients -- 1 stream



VIRTUAL CHANNEL

Global Variable identified by a number holding all pointers to a group of service selectable at the receiver

Imagine a system having 2 Videos (A,B) and 6 audio's (1 to 6) and 2 VBI signals

The virtual Channel table may look like this

Selecting any of these numbers will provide the associated services

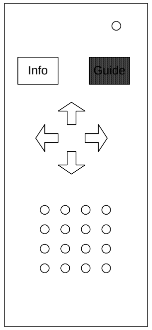
VIRTUAL CHANNEL

Service distribution exemple

V Chan	Vidéo	A1	A2	A3	A4	VBI	
100	1	1	2	3	4	1	1
101	1	1	2	7	8	none	2
103	1	1	4	6	7	1	none
201	2	1	2	none	none	2	3
202	2	1	4	7	3	none	4

CBC Radio-Canada

EPG



	07:00	07:30	08:00
2-0 SRC	Infoman	Palmares	La Fureur
2-1 SRC / HD	Palmares Plus		La Fureur
2-4 O RDI	Capital Action	Enjeux	Pascale Nadeau Live
6-0 CBC	This Hour has 33 minutes	Venture	Air Farce
2-1 CBC / HD	Super Sports Wrap		Air Farce Interactive
6-4 NW	Eng	The old timers with Knolton Nash	Venture Extra

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CBC Radio-Canada

EPG + (ETT)

	07:00	07:30	08:00
2-0 SRC	Infoman	Palmares	La Fureur
2-1 SRC / HD	Palmares Plus		La Fureur
2-4 O RDI	Capital Action	Enjeux	Pascale Nadeau Live
6-0 CBC	This Hour has 33 minutes	Venture	Air Farce
2-1 CBC / HD	Super Sports Wrap		Air Farce Interactive
6-4 NW	Eng	The old timers with Knolton Nash	Venture Extra

Thême: les grands incompris
Ce soir Pascal recoit:
Le colonel Kadaphi, Bill Gates, Margaret Tacher et le docteur Mailloux

OK

BTS
Broadcast Technology Society

VCHIP

Each Program is V-Chip coded in reference with the rating code applicable in the province (dynamic psip)

The Rating code is downloaded in the Static PSIP section (Regional Rating Tables)

Today's receiver have the US RRT hard coded (issue pending at CEMA & CRTC)

SYSTEM ISSUES

PSIP is unique to each market

95 % of the PSIP is common to all program stream of the same root.

Static PSIP needs to be tailored to the local market.

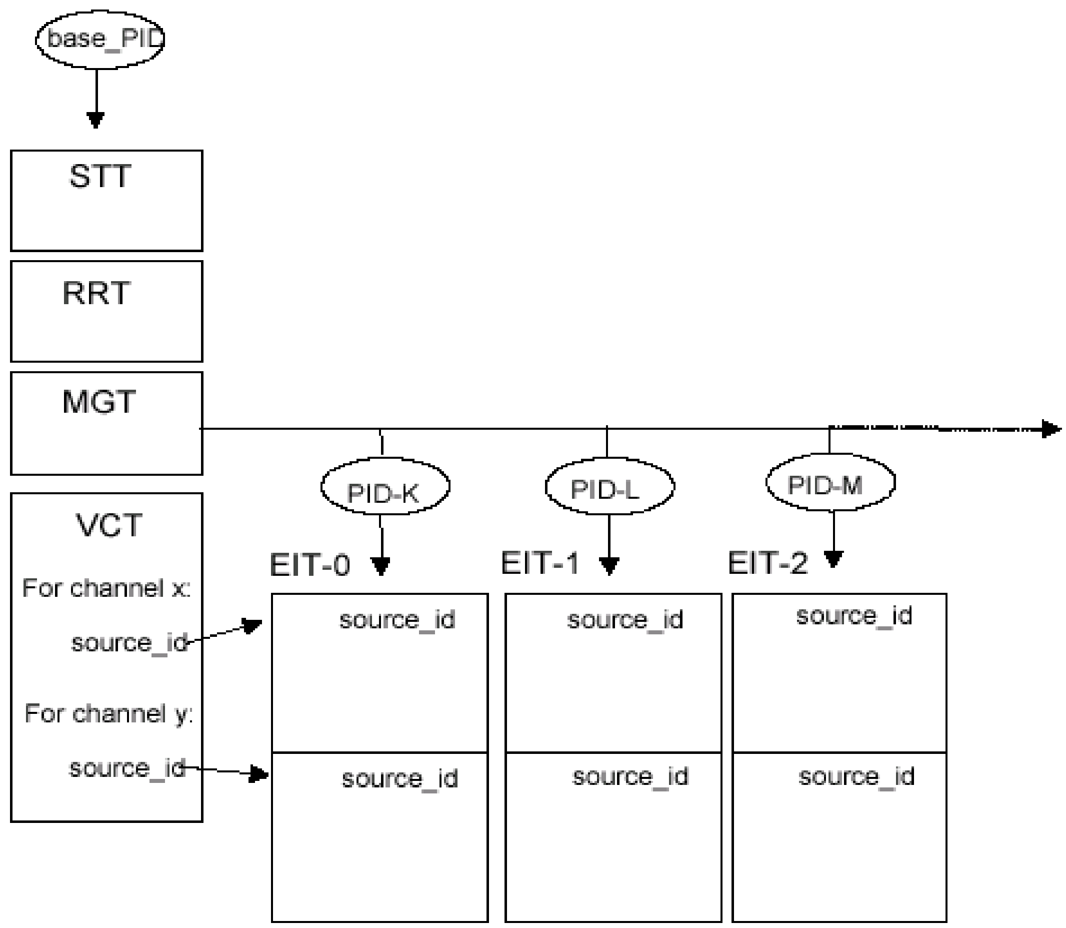
Detailed RF information has to be entered in the static PSIP tables

SYSTEM MANAGEMENT ISSUES

If the info in The MGT is incorrect receiver may not lock up, generating a service call at the NAC

The Transmission Services staff have to be aware of each mux configuration at all times, otherwise they can't locate the faults.

TABLE STRUCTURE



• Major Channel. The previously assigned, paired NTSC channel is the major channel number. See Section 6.3.1 for more detail and rare exceptions.

• Service Type. The service type selects DTV, NTSC, audio only, data, etc., and must be set as operating modes require. See Section 6.3.1.

• Modulation Mode. A code for the RF modulation of the virtual channel. See Section 6.3.2.

• Source ID. The Source ID is a number that associates virtual channels to events on those channels. It typically is automatically updated by PSIP equipment or updated from an outside vendor. Proper operation of this feature should be confirmed. See Section 6.3.4.

• Service Location Descriptor (SLD). Contains the MPEG references to the contents of each component of the programs plus a language code for audio (ISO 639-2, [9]). See Section 6.9. The PID values for the components identified here and in the PMT must be the same for the elements of an event/program. Some deployed systems require separate manual setup, but PID values assigned to a VC should seldom change.

PSIP REPETITION REQUIREMENTS

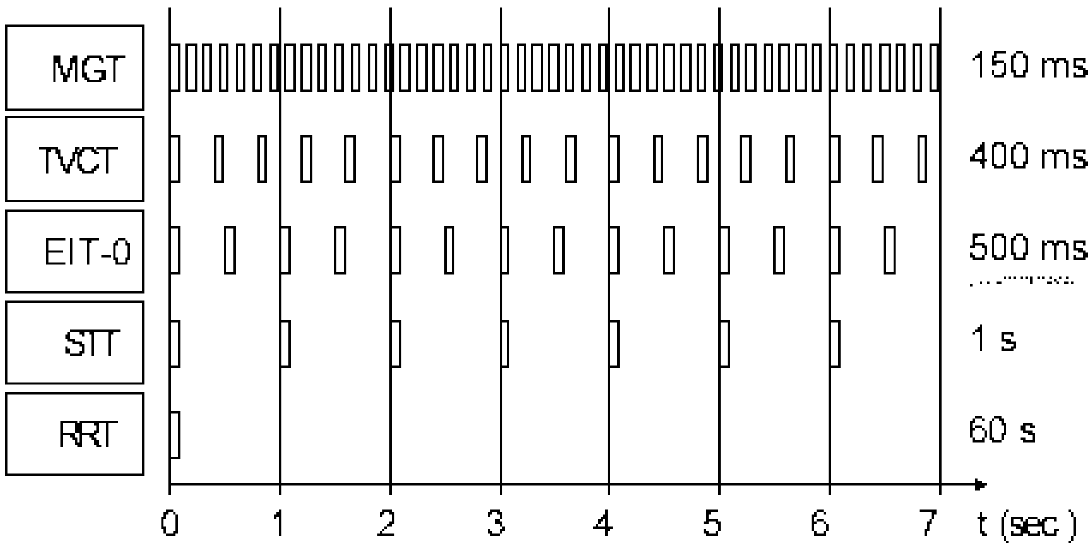


Figure 5.1 Recommended PSIP table cycle times.

ETHERNET

Outline

- **Multiple Access and Ethernet Intro**
- **Ethernet Framing**
- **CSMA/CD protocol**
- **Exponential backoff**

New operation Paradigm

HOW CAN WE KNOW SOMETHING WENT WRONG?

MONITORING

REAL-TIME WORLD REALITY

What happened already happened…

We need to understand what it
To avoid re-occurence

HOW DO YOU KNOW SOMETHING WENT WRONG

A Stream Monitor can show-up a whole stack of transport & set-up errors

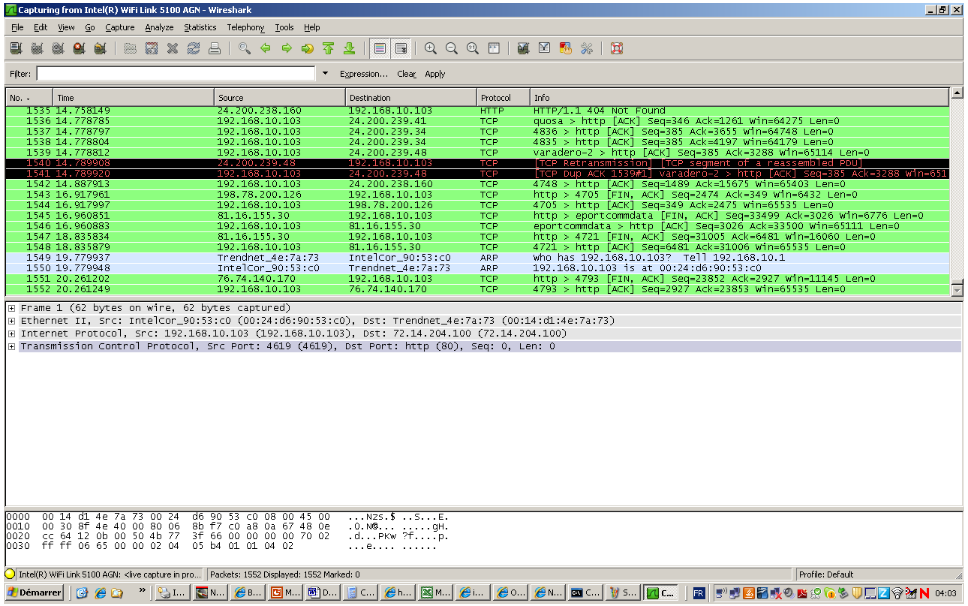
One of the most common is the MPEG Continuity Count error:

- Hidden in the of each MPEG packets a 4 bit counter called the continuity counter is present
- If any packets is dropped an ETR 290 layer 1 alarm will show up on your TS analyzer screen
- Mpeg continuity count error, expected 3 found 7
    - This means that you lost (7-3=4) packets or 4 packets plus a multiple of 16 as the counter may have overrunned a few times before the ts retrieved synch

MONITORING THE IP LAYER

A sniffer program will:

- Capture and displays every things that happens in your segment
- Requires L1 visibility



MOBILE TELEVISION

ALL ABOUT ME!

Today`s viewers wants to consume contents:

- The content they want to watch
    - **<u>When</u>** they want to watch it
    - **<u>Where</u>** they want to watch it

- Linear television is somewhat limited in this aspect. This presentation is all about what we can do about the **<u>where</u>** component.

A LOOK AT THE MOBILE MEDIA LANDSCAPE

Real time mobile services:

- FM Radio + RBDS (multicast)
- Cell Phone streaming (unicast)
- Wifi streaming (mostly unicast)

UNICAST VEHICLES

Unicast transport vehicles carries a copy of the content for each requestor

Typical from bi-directional environment

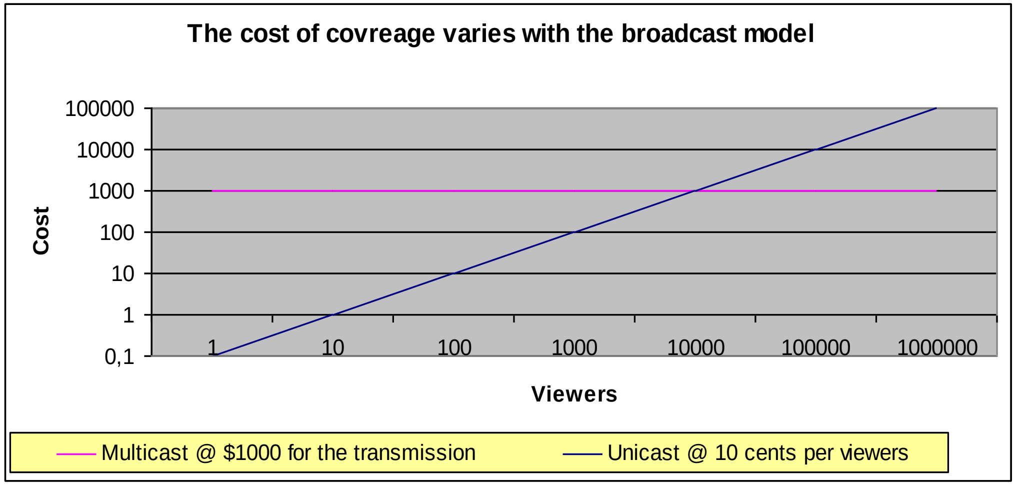
- The cost model is linear. The more viewers the most ressources is tied-up.
  - Tends to overflow bandwidth limited pipes

Broadcast Technology Society

MULTICAST VEHICLES

Ties up the same volume of resources whether they have one client of a million.

- Typical of unidirectional environnement
- Quickly becomes bandwidth efficient



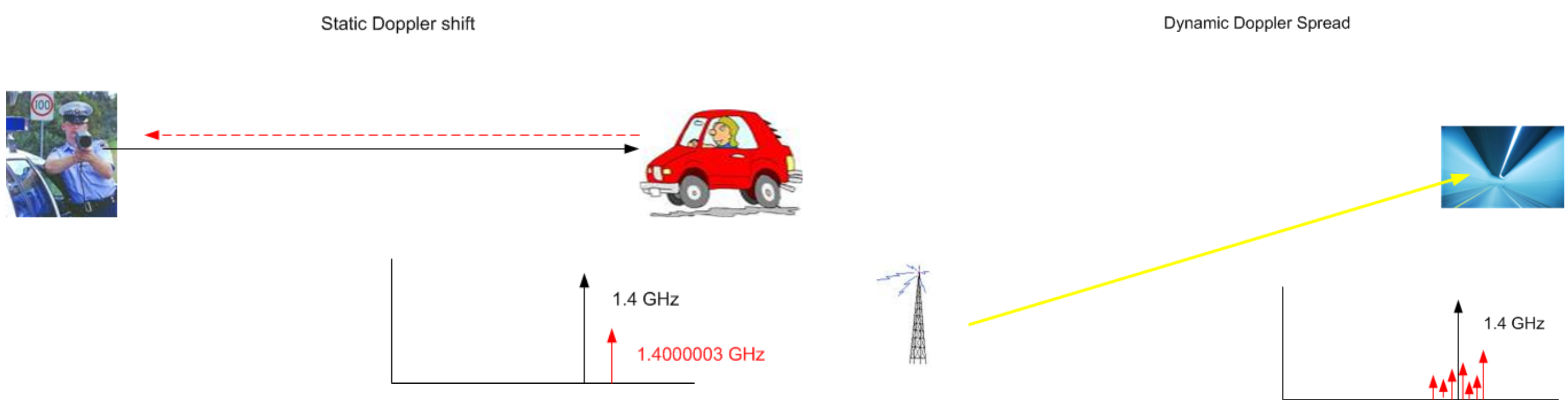
ATSC TO ATSC MOBILE

ATSC is the North American Digital Television Standard, it is in use in USA Canada, Mexico, Korea and 19 other countries, it is aimed at:

- Providing a service that is spectrally compatible with NTSC
- Minimizing interference to NTSC
- Be spectrally efficient
- Delivering HDTV to fixed receiver

CBC Radio-Canada

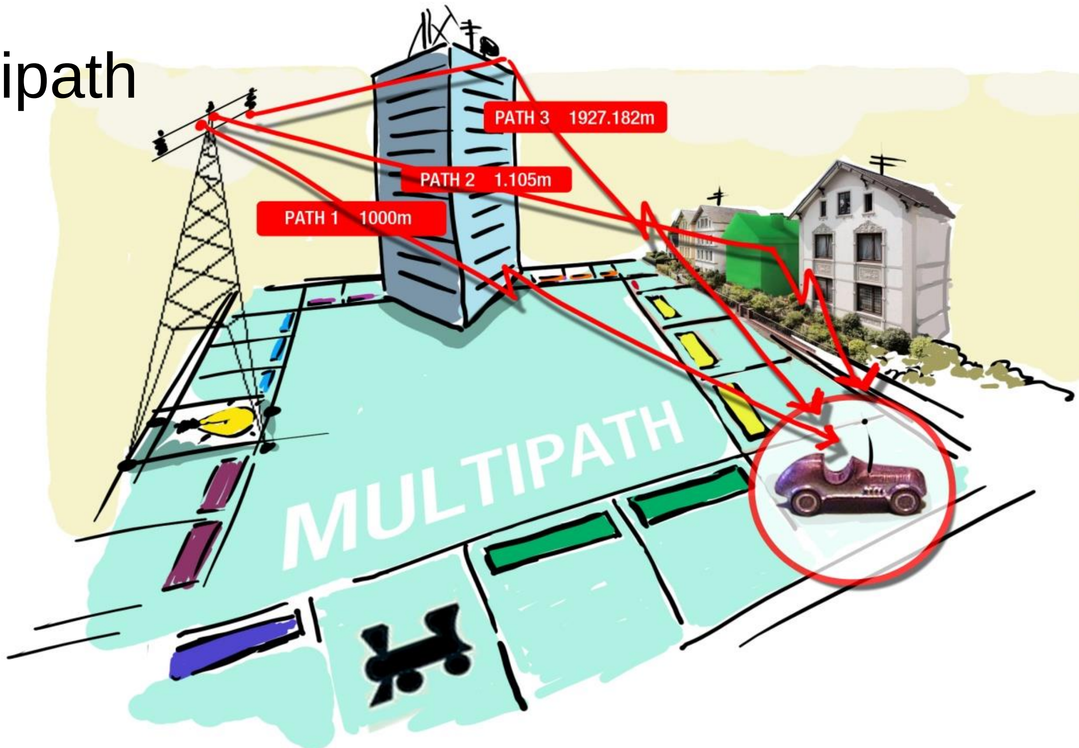
CHALLENGES OF A MOBILE ENVIRONMENT: DOPPLER



BTS Broadcast Technology Society

CHALLENGE OF A MOBILE ENVIRONMENT: MULTIPATH

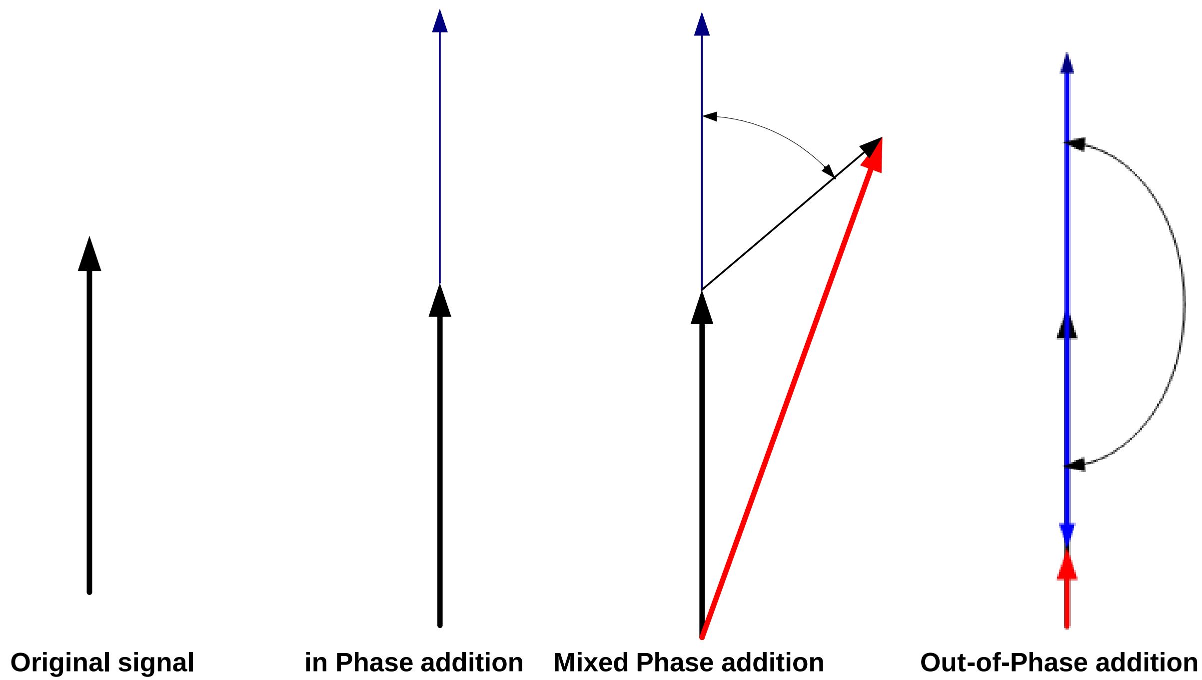
Multipath



Broadcast Technology Society

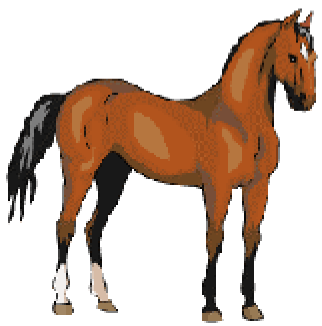
CHALLENGES OF A MOBILE ENVIRONMENT

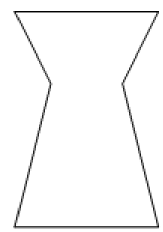
Multipath



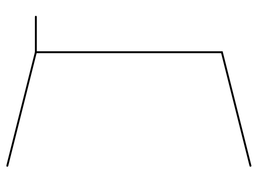
CHALLENGES OF A MOBILE ENVIRONNEMENT

Multipath Fading

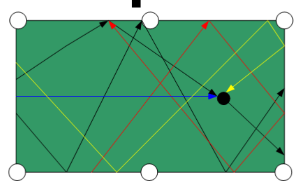


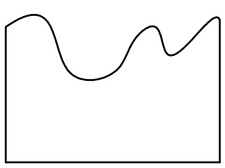


genetically modification process



+ Multipath =

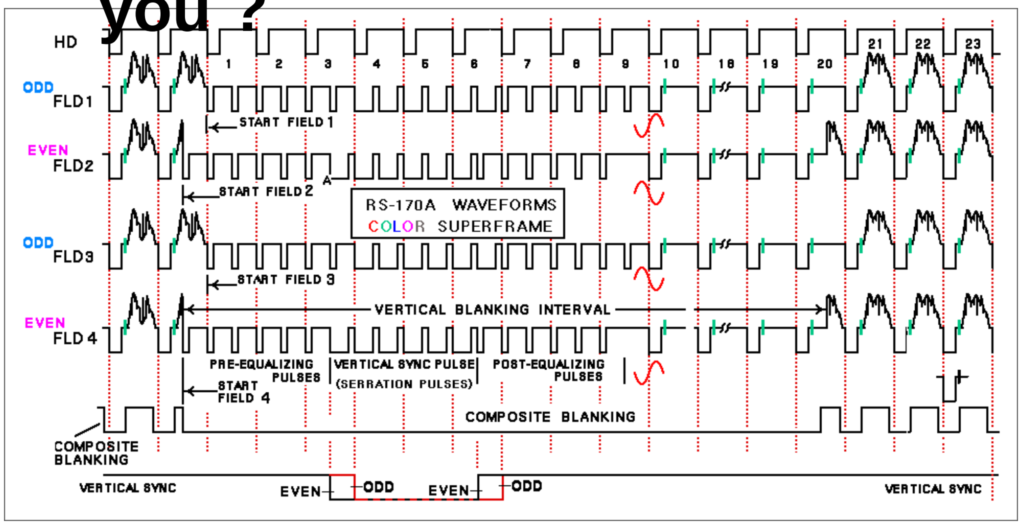


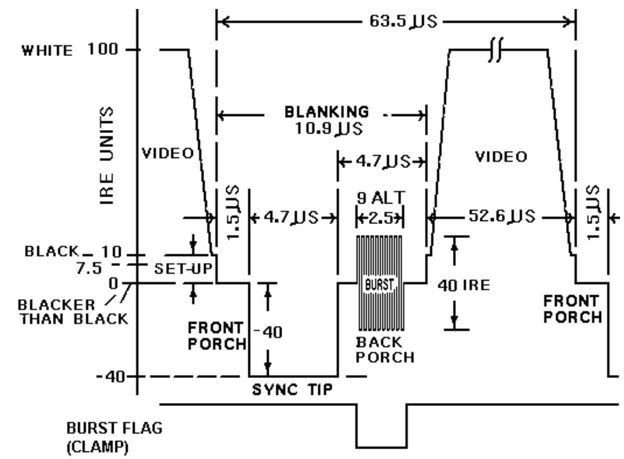


ANALOG TELEVISION HAD A BULLET PROOF SYNCHRONIZATION SYSTEM

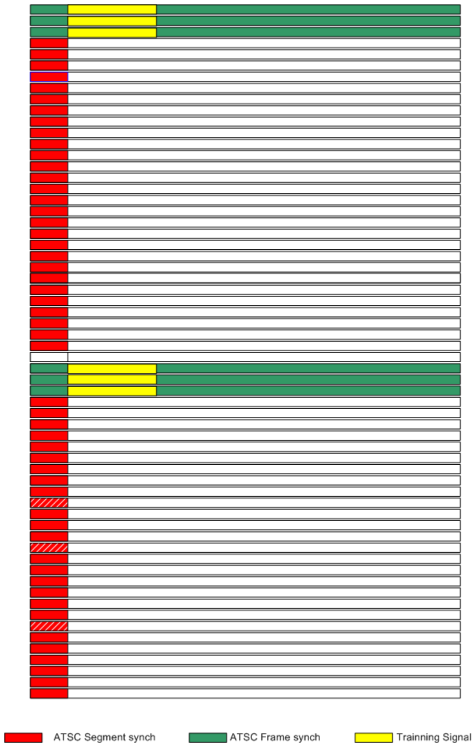
MULTIPATH CANCELLATION

Does it Rings a Bell to you ?

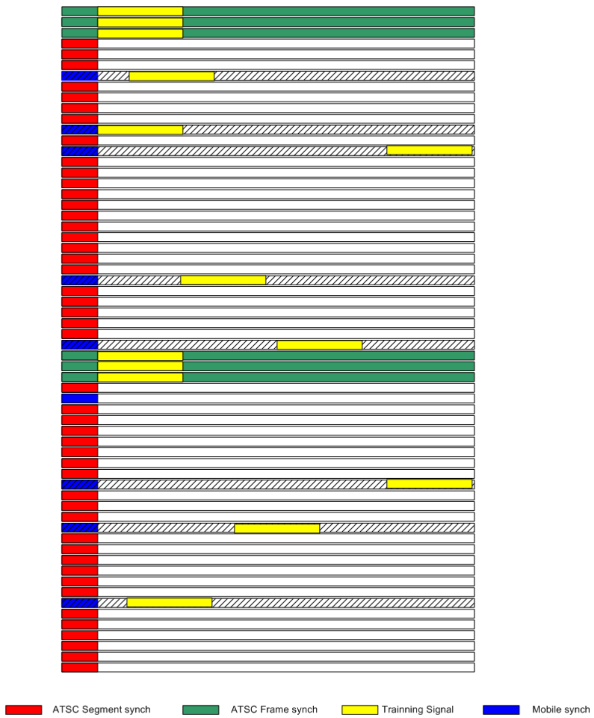




ATSC ALSO HAS A SYNCH STRUCTURE



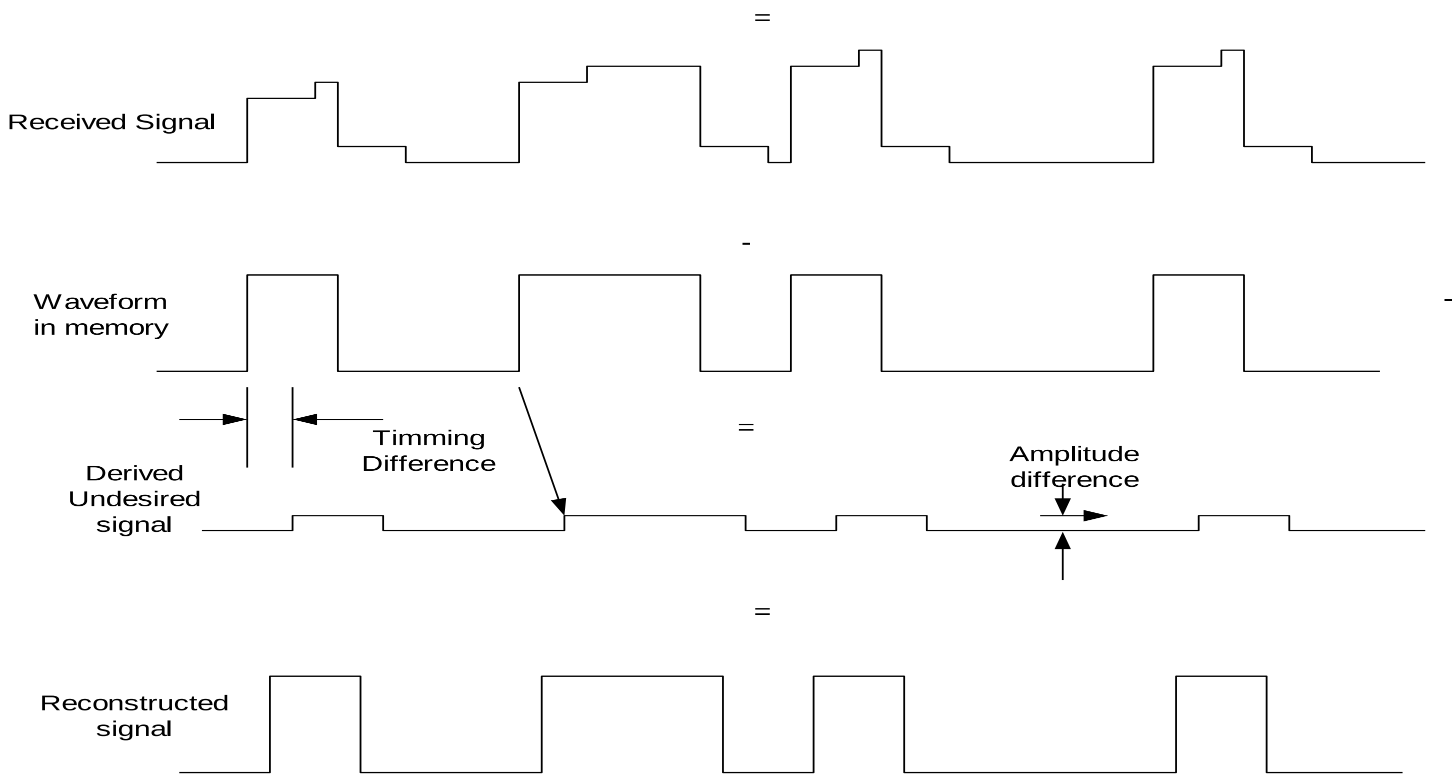
ATSC Standard



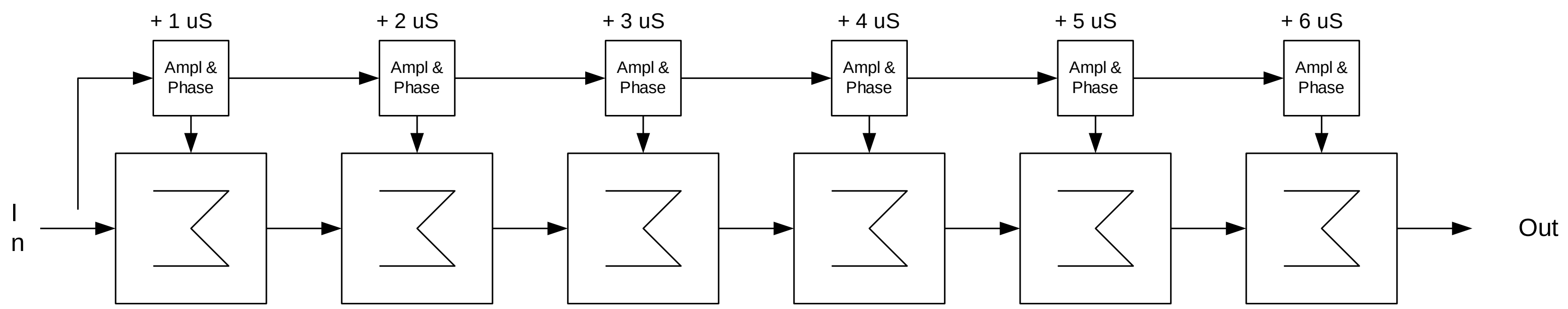
ATSC Mobile

CBC Radio-Canada

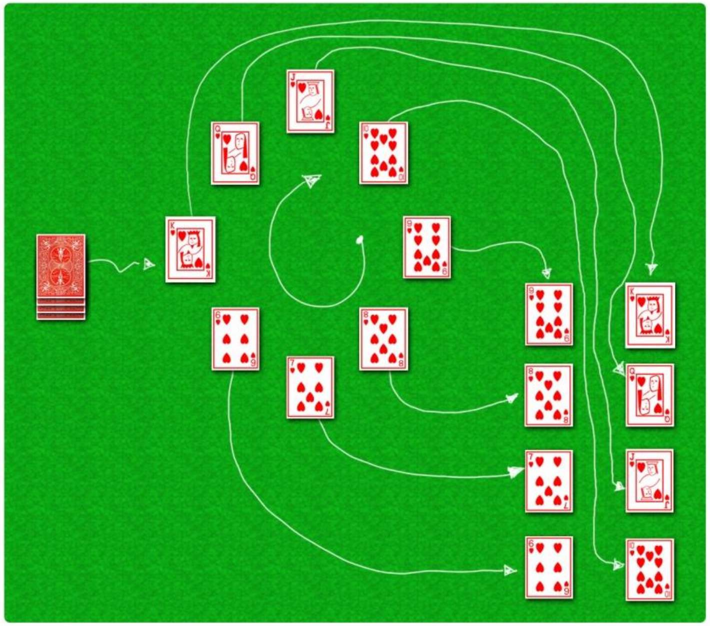
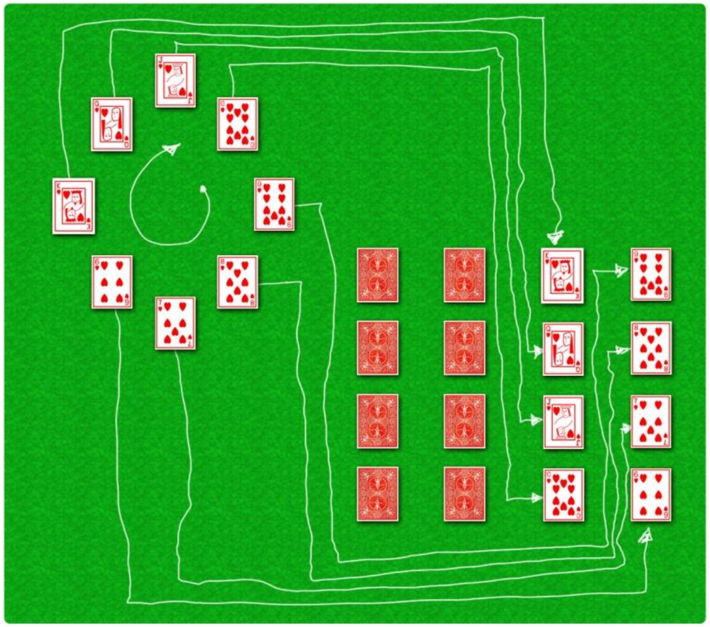
ADAPTIVE TAP EQUALIZER



ADAPTIVE TAP EQUALIZER

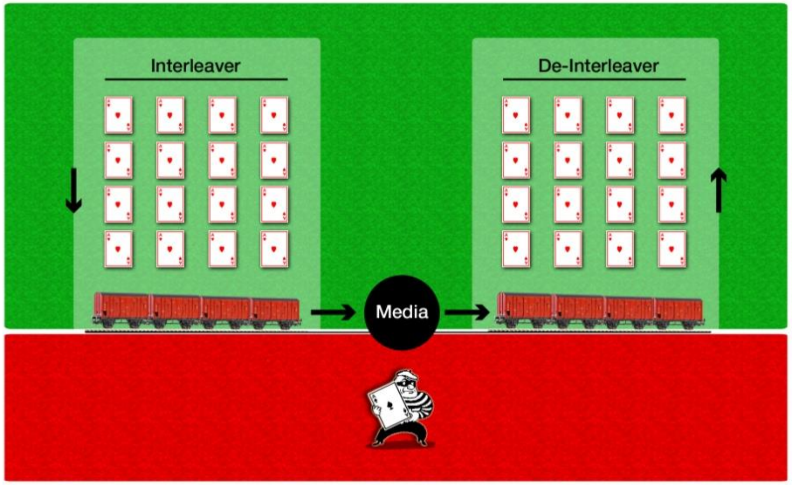


DEFEATING INTERFERENCE INTERLEAVING

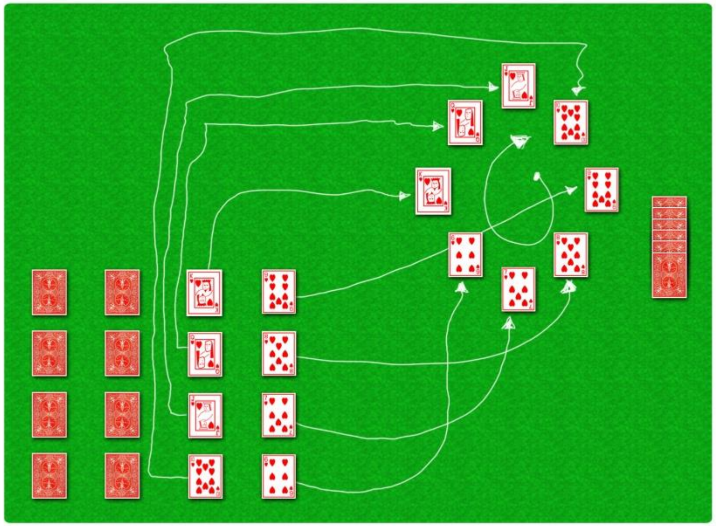



CBC Radio-Canada

DEFEATING INTERFERENCE: INTERLEAVING



SIGNAL DE-INTERLEAVING



DEFEATING INTERFERENCE FREE– RUNNING INTERLEAVED FEC

Reed-salomon

TCM

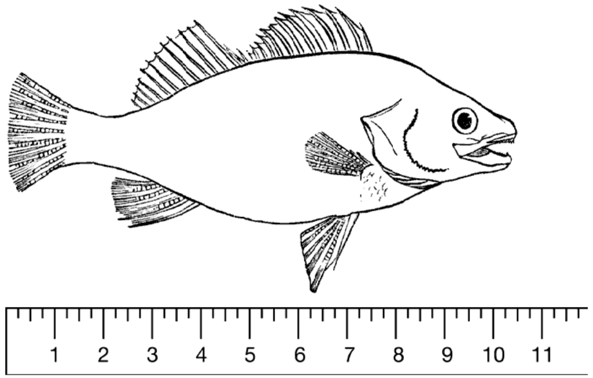
TPC

Broadcast Technology Society

MAXIMUM LIKELIHOOD DECODERS

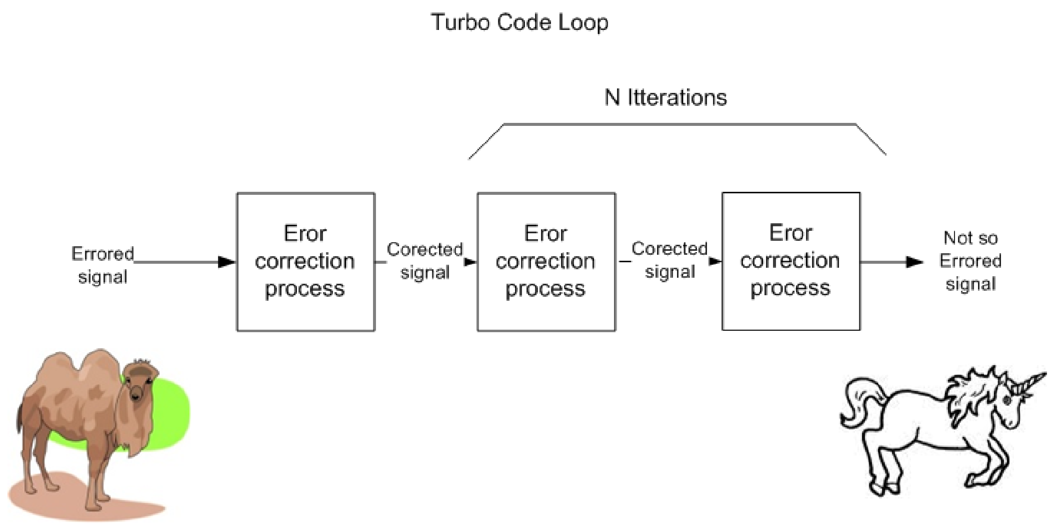
Maximum likelihood decoding is a process by witch errors are corrected by a probability algorithm that makes educated guesses on the nature of the error

How long is this Fish?
If your answer is wrong, what is the most likely error you may have done?

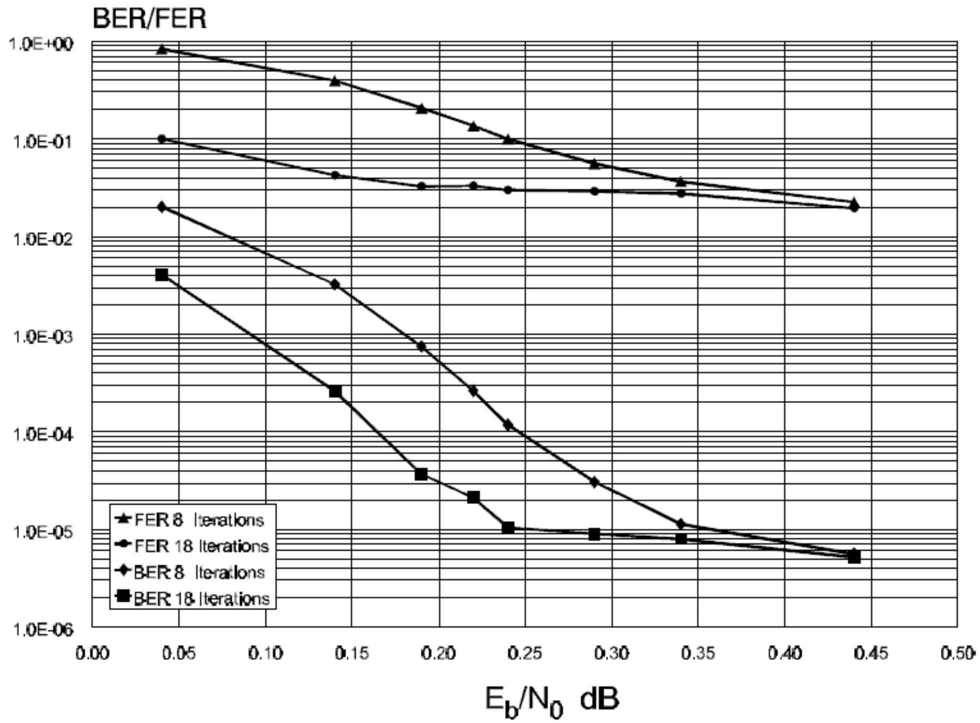


TURBO CODES

Turbo is a forward error correction technique witch uses the MLD in an iterative manner, over witch already corrected signals are getting fed back to the input of the error corrector.



TURBO CODES PERFORMANCE



TYPICAL RECEIVERS PERFORMANCE:

Receiver Treshold (AWGN) **ATSC:** **16.0 dB**

ATSC Mobile ¼ FEC: 3 .5 dB

ATSC Mobile ½ FEC: 7.0 dB

Ability to cope with Multipath: ATSC: echoes at – 3dB from -10 to + 15 us

ATSC Mobile: echoes at – 3dB from -10 to + 45 us

Doppler resistance: ATSC: 4 Hz

ATSC Mobile 16 Hz

IMPACT ON LEGACY RECEIVERS

From The RF standpoint: none

From the picture quality standpoint: there is a perceptible loss of quality due to the lower video rate that the use of ATSC Mobile dictates. This quality restriction will be applicable to all receivers tuning to this ATSC channels whether they decode the ATSC mobile signals or not.

MOBILE DTV RECEIVERS

ABOUT THE WHEN COMPONENT

All about ME!

- Today`s viewers wants to consume:
  - The contents they want to watch
    - When they want to watch it
    - Where they want to watch it

Storage is becoming a comodity, it now retails around 2.1 /GB

Watch for ATSC Non-Real-time Service in a Mobile device near you

VIDEO COMPRESSION

VIDEO COMPRESSION

Why Compress:

Because the resources required to transmit uncompressed Video is higher than analog

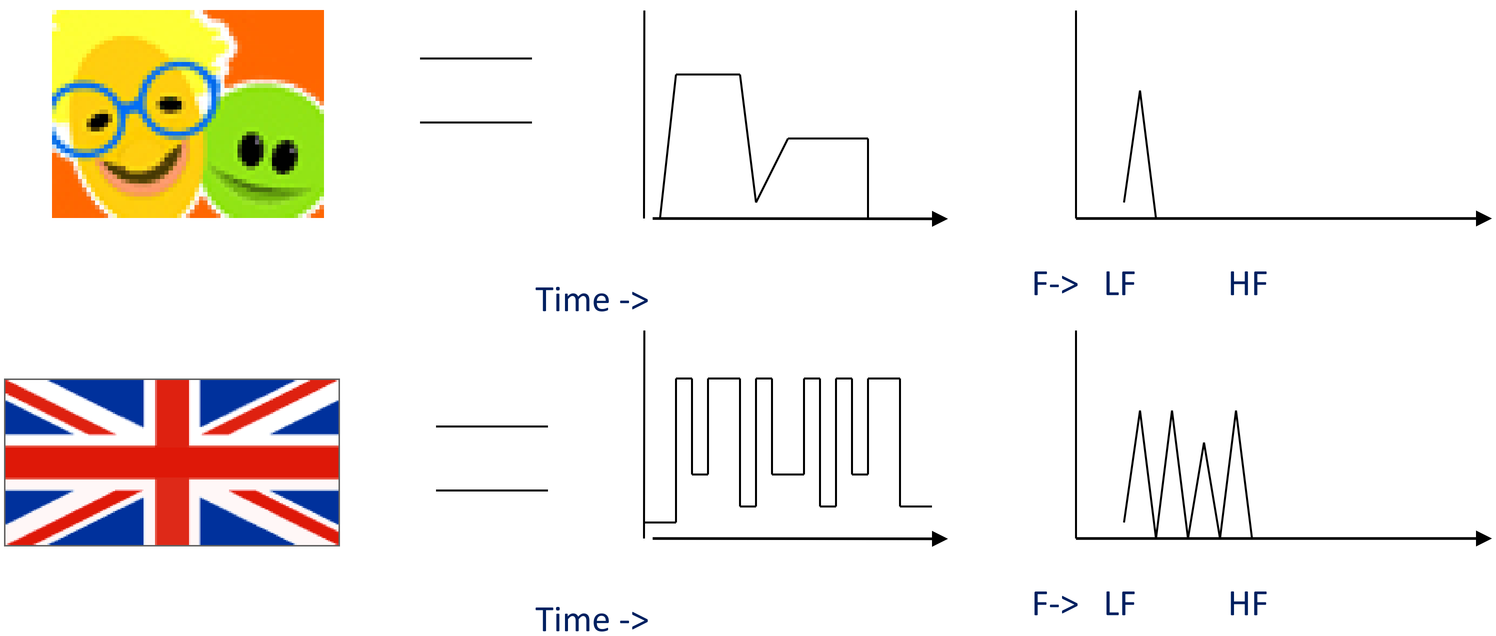
and is clearly not cost efficient.

- **CCIR 601 704 X 480 4:2:2 takes 243 MB/s**
- **SMPTE 292 1980 X 1080i30 tkes 1.485 Gbps**

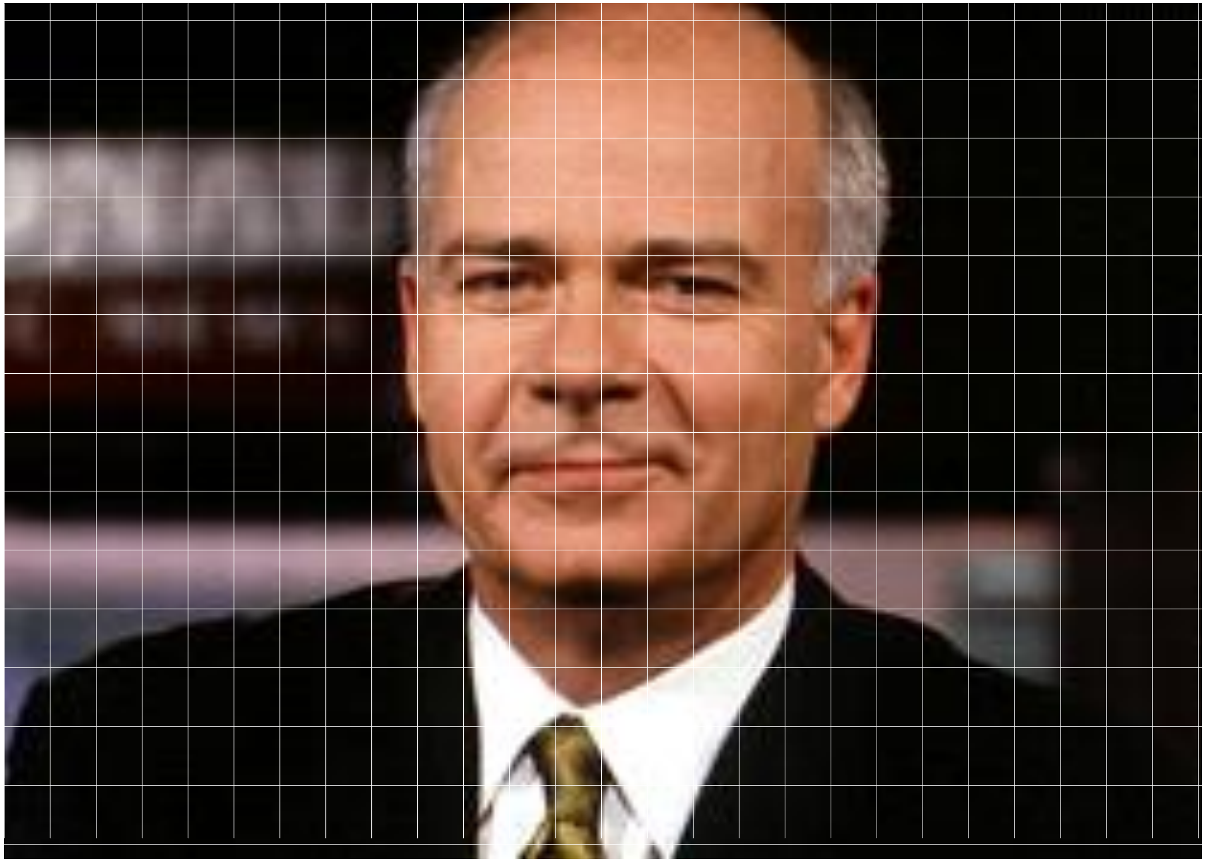
For satellite SCPC:

- **243MB/s X 2 bit/Hz (QPSK)/1/2 rate FEC 243 MHz (5 Ku band transponders)**
- **An Analog signal @ 9.2 MHz dev makes 20 MHz (Carson rule)**

Spectral content of an Image

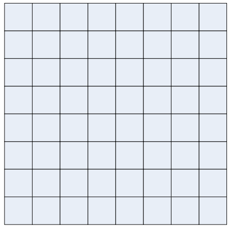


One image, its way too large

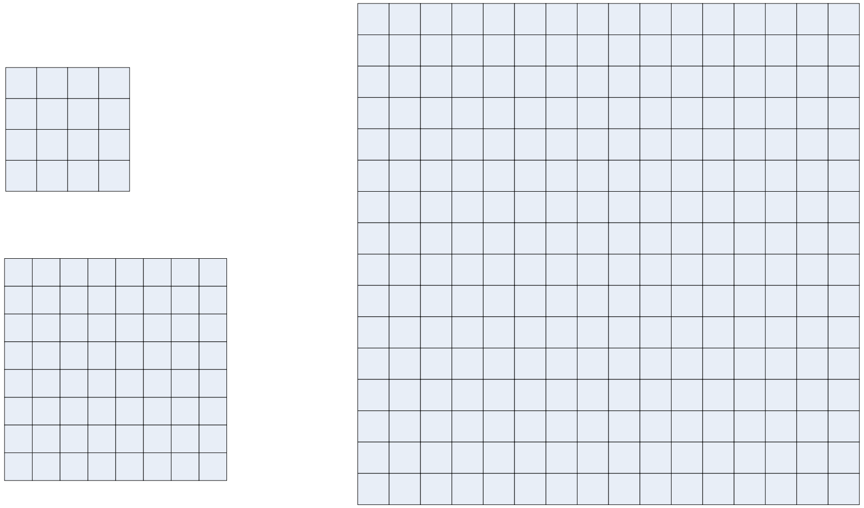


Structured Macro-blocks

- MPEG-2
- 8X8

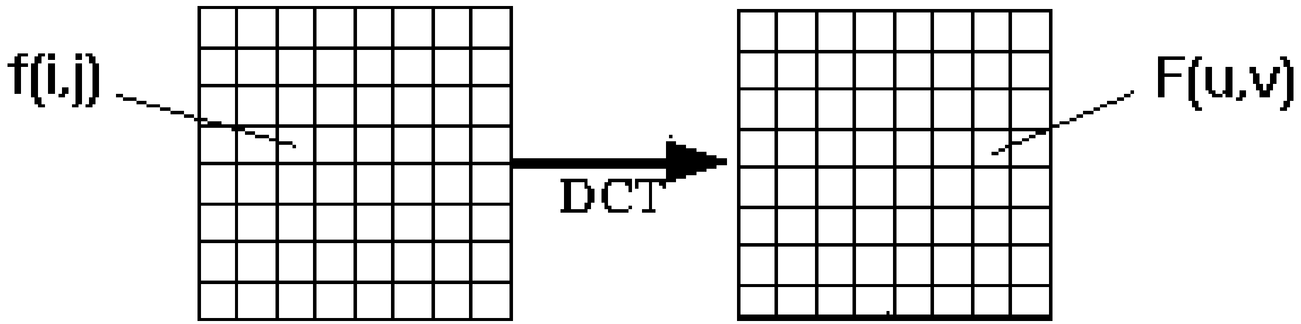


- MPEG-4
- 8X8
- 4X4 or 16X16



DCT

Time to Frequency transmform



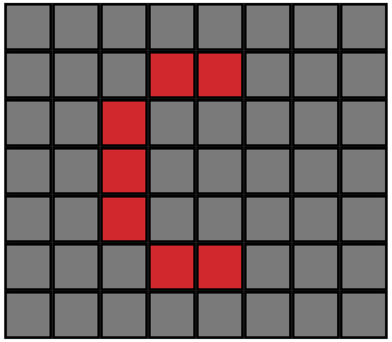
$$F(u) = \left(\frac{2}{N}\right)^{\frac{1}{2}} \sum_{i=0}^{N-1} \Lambda(i).cos\left[\frac{\pi.u}{2.N}(2i+1)\right] f(i)$$

Ex Bank record vs a Quicken categorised report

BTS

D.C.T.

Original 8 X 8 Pixel block



Quantized * X * pixel Block

9	9	9	9	9	9	9	9
9	9	9	1	1	9	9	9
9	9	1	9	9	9	9	9
9	9	1	9	9	9	9	9
9	9	1	9	9	9	9	9
9	9	9	1	1	9	9	9
9	9	9	9	9	9	9	9

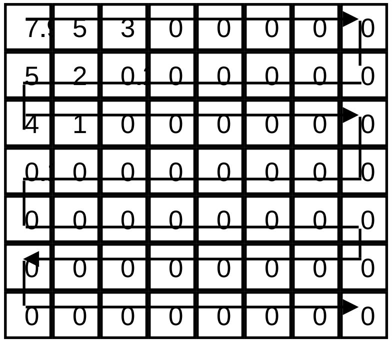
Quantized * X * pixel Block after DC

ave D.C level

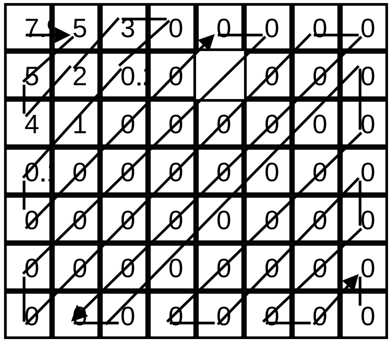
7.	5	3	0	0	0	0	0
5	2	0.	0	0	0	0	0
4	1	0	0	0	0	0	0
0.	9	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Les coffécients are getting classified in frequency order, a picture such as a cartoon will have very few coofecients

D.C.T.



A typewriter scal will deliver 64 coeficients, 38 in a row wich are null

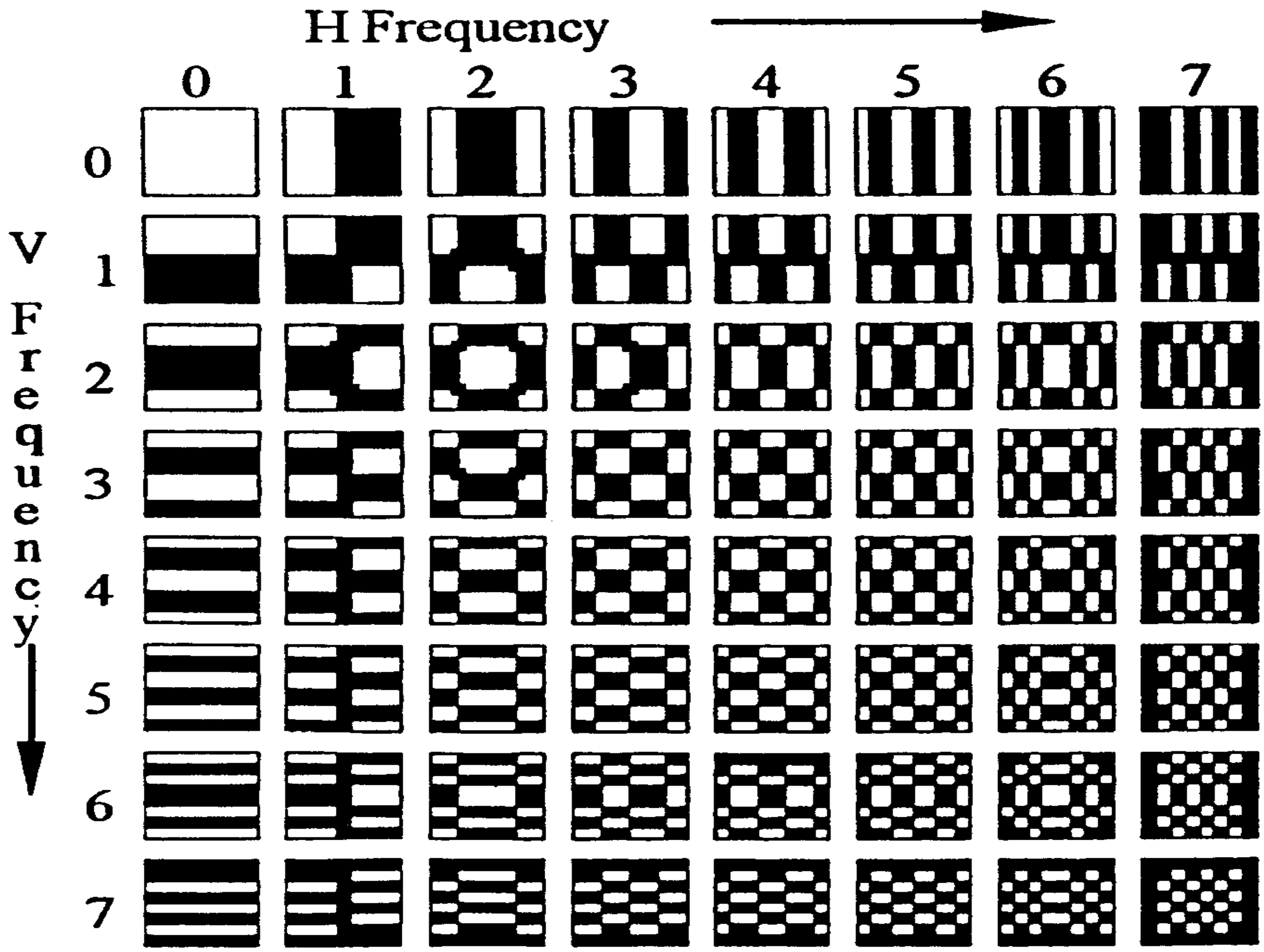


A Zig-zag scan still delivers 64 coeficients,, however we have 54 null coeficients in a row

Série 10, 7.9,5,5,4,2,3,0,0.2,1,0.1

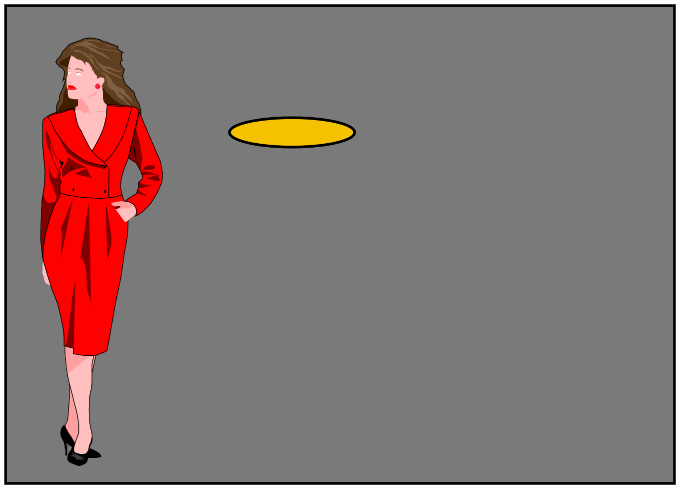
As the tail of zeros is not transmitted the compression rate reachesde (64-11)/64 = 83 %

DCT

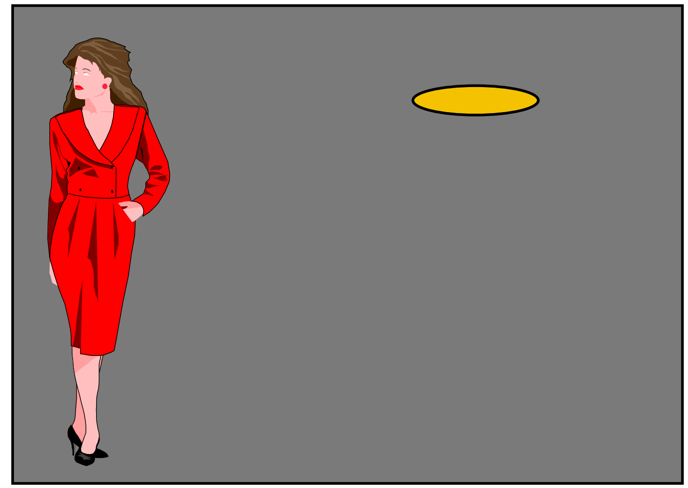


Compression d’image

Temporal compression , Motion Vectors



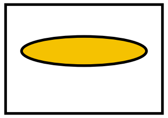
Previous frame



Current frame

Info to code

Motion vector



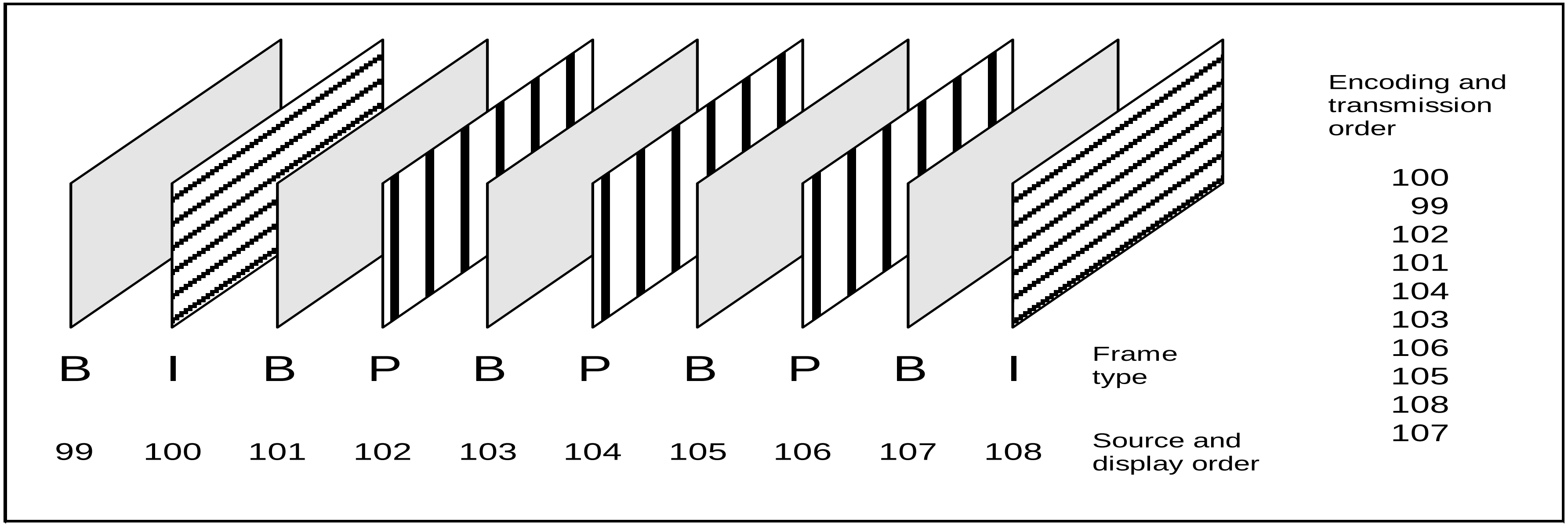
Flying Saucer

Frame structure

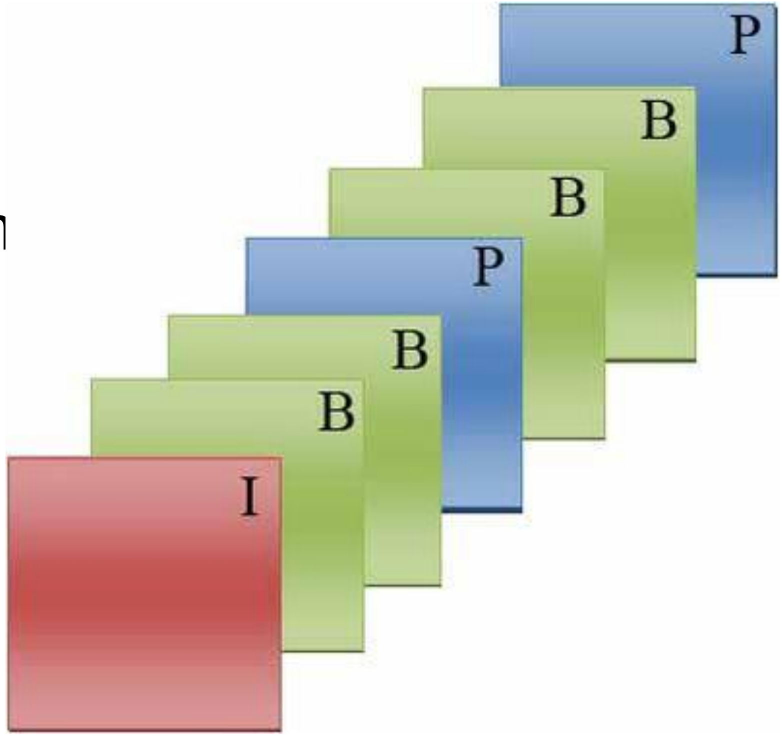
- A frame structure is required to allow some borrowing of information.

- The structure defines 3 types of frame:
  - I (incident Frame) is a complete frame
  - P (predicted or past frame) Is based on a prediction of what the previous frame was
  - B (Bi Directional) Borrows elements from both past and future frame

Transmission order



Structure de trame



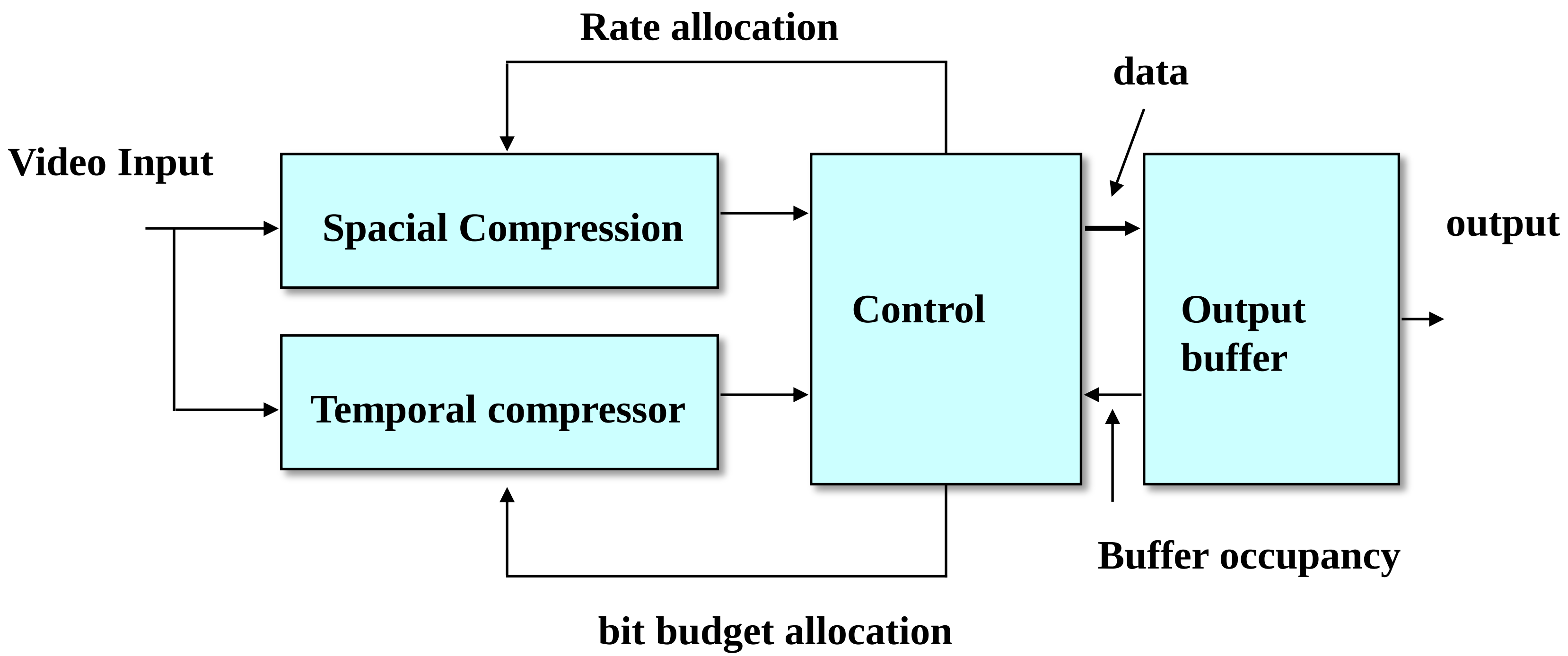
- A new term is defined the GOP is the distance in frames between 2 I frames.
- The longuer the GOP, the best coding efficiency
- The Longuer the GOP the most ugly each individual frames

  The longueur the Gop, the longuest latency

- The shortest the GOP, the best individual
- Frames quality.

Image Compression

Image compression takes place in a dynamic manner:



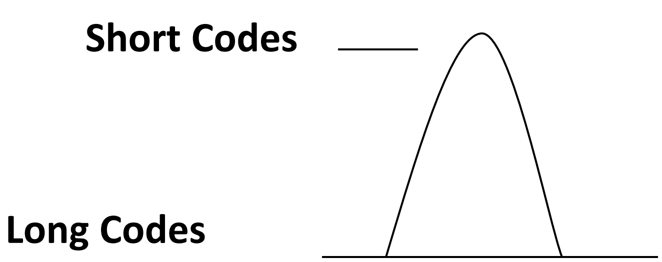
Masquage Vidéo

- **Have you notice how fast superman moves?**
- **Have you notice if he was in focus while moving?**

  Probably not, but you would notice a picture freeze or a steppy motion much before.
- **When the encoder is faced with an allocation issue between giving bits to definition or motion, it will always favors the motion compensation**

Entropy Coding

- Variable Length Coding VLC
- Based on a probability scale
- The values that repeats themselves often get short codes assigned
- The value that don't repeat very often gets long codes assigned



Vidéo Artifacts

- **What you may see:**
  - Picture freeze
  - Macroblocking
  - Aliasing
  - Washed-out Picture

- **What you may not see**
  - Interférence

H.264

- **Profiles and Levels for particular applications**
  - Profile : a subset of entire bit stream of syntax,
  - different decoder design based on the Profile
    - Four profiles : Baseline, Main, Extended and High

Profile	Applications
Baseline	Video Conferencing Videophone
Main	Digital Storage Media Television Broadcasting
Extended	Streaming Video
High	Content contribution Content distribution Studio editing Post processing

H.264 Profiles

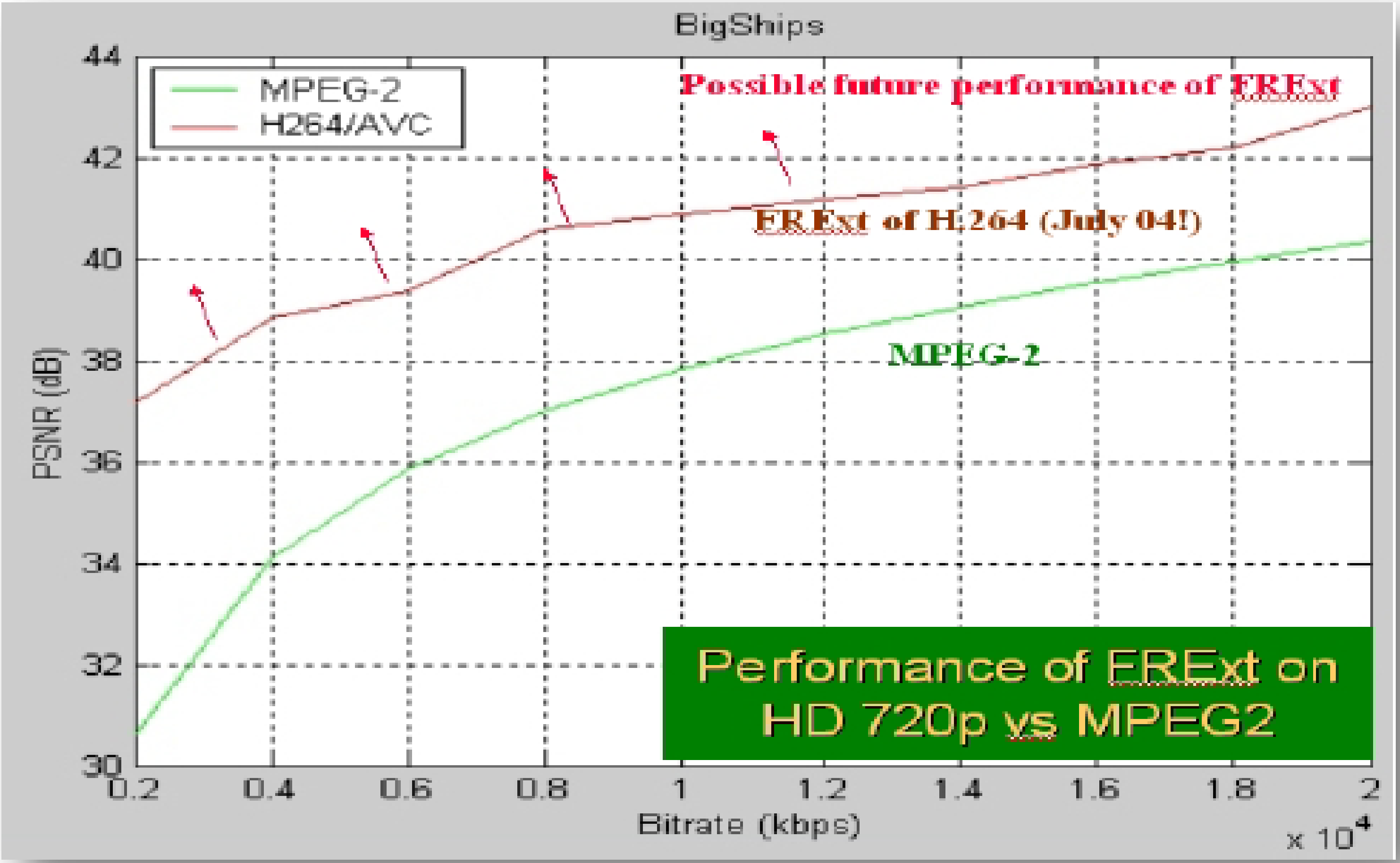
	Baseline	Main	Extended	High
I & P Slices	X	X	X	
Deblocking Filter	X	X	X	
¼ Pel Motion Compensation	X	X	X	
Variable Block Size (16x16 to 4x4)	X	X	X	
CAVLC/UVLC	X	X	X	
Error Resilience Tools – Flexible MB Order, ASO, Red. Slices	X		X	
SP/SI Slices			X	
B Slice		X	X	
Interlaced Coding		X	X	
CABAC		X		
Data Partitioning			X	

H.264 Profiles

- **Baseline Profile (BP)**: Primarily for lower-cost applications with limited computing resources, this profile is used widely in videoconferencing and mobile applications.
- **Main Profile (MP)**: Originally intended as the mainstream consumer profile for broadcast and storage applications, the importance of this profile faded when the High profile was developed for those applications.
- **Extended Profile (XP)**: Intended as the streaming video profile, this profile has relatively high compression capability and some extra tricks for robustness to data losses and server stream switching.
- **High Profile (HiP)**: The primary profile for broadcast and disc storage applications, particularly for high-definition television applications (this is the profile adopted into HD DVD and Blu-ray Disc, for example).
- **High 10 Profile (Hi10P)**: Going beyond today's mainstream consumer product capabilities, this profile builds on top of the High Profile—adding support for up to 10 bits per sample of decoded picture precision.
- **High 4:2:2 Profile (Hi422P)**: Primarily targeting professional applications that use interlaced video, this profile builds on top of the High 10 Profile—adding support for the 4:2:2 chroma sub sampling format while using up to 10 bits per sample of decoded picture precision.
- **High 4:4:4 Predictive Profile (Hi444PP)**: This profile builds on top of the High 4:2:2 Profile—supporting up to 4:4:4 chroma sampling, up to 14 bits per sample, and additionally supporting efficient lossless region coding and the coding of each picture as three separate color planes.
- **High 10 Intra Profile**: The High 10 Profile constrained to all-Intra use.
- **High 4:2:2 Intra Profile**: The High 4:2:2 Profile constrained to all-Intra use.
- **High 4:4:4 Intra Profile**: The High 4:4:4 Profile constrained to all-Intra use.
- **CAVLC 4:4:4 Intra Profile**: The High 4:4:4 Profile constrained to all-Intra use and to CAVLC entropy coding (i.e., not supporting CABAC).

Level number	Max macroblocks per second	Max frame size (macroblocks)	Max video bit rate (VCL) for Baseline, Extended and Main Profiles	Max video bit rate (VCL) for High Profile	Max video bit rate (VCL) for High 10 Profile	Max video bit rate (VCL) for High 4:2:2 and High 4:4:4 Predictive Profiles	Examples for high resolution @ frame rate (max stored frames) in Level
1	1485	99	64 kbit/s	80 kbit/s	192 kbit/s	256 kbit/s	128x96@30.9 (8) 176x144@15.0 (4)
2	11880	396	2 Mbit/s	2.5 Mbit/s	6 Mbit/s	8 Mbit/s	320x240@36.0 (7) 352x288@30.0 (6)
2.1	19800	792	4 Mbit/s	5 Mbit/s	12 Mbit/s	16 Mbit/s	352x480@30.0 (7) 352x576@25.0 (6)
2.2	20250	1620	4 Mbit/s	5 Mbit/s	12 Mbit/s	16 Mbit/s	352x480@30.7(10) 352x576@25.6 (7) 720x480@15.0 (6) 720x576@12.5 (5)
3	40500	1620	10 Mbit/s	12.5 Mbit/s	30 Mbit/s	40 Mbit/s	352x480@61.4 (12) 352x576@51.1 (10) 720x480@30.0 (6) 720x576@25.0 (5)
3.1	108000	3600	14 Mbit/s	17.5 Mbit/s	42 Mbit/s	56 Mbit/s	720x480@80.0 (13) 720x576@66.7 (11) 1280x720@30.0 (5)
3.2	216000	5120	20 Mbit/s	25 Mbit/s	60 Mbit/s	80 Mbit/s	1280x720@60.0 (5) 1280x1024@42.2 (4)
4	245760	8192	20 Mbit/s	25 Mbit/s	60 Mbit/s	80 Mbit/s	1280x720@68.3 (9) 1920x1088@30.1 (4) 2048x1024@30.0 (4)
4.1	245760	8192	50 Mbit/s	62.5 Mbit/s	150 Mbit/s	200 Mbit/s	1280x720@68.3 (9) 1920x1088@30.1 (4) 2048x1024@30.0 (4)

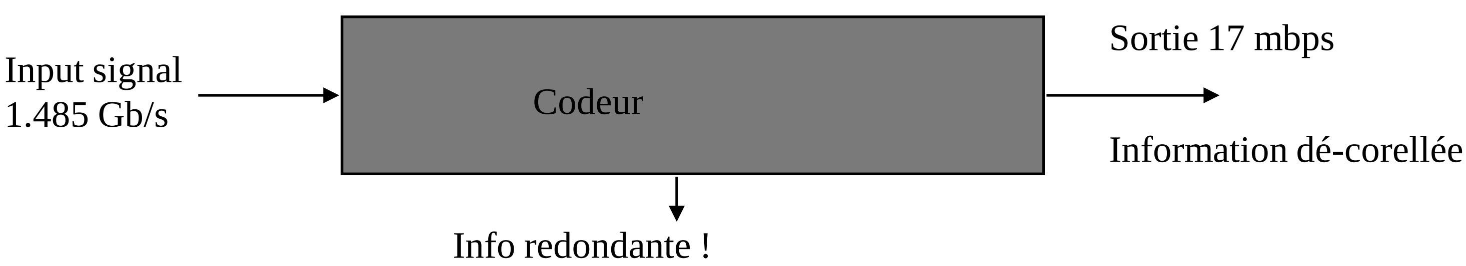
HD coding efficiency



COMPRESSION D'IMAGES

MPEG-2 MP HL (Main Profile High Level)

La compression video est basée sur une analyse perceptuelle qui identifie des éléments redondants que le codeur retirera pour les ré-insérer au niveau du décodeur



2012 VIDEO COMPRESSION STATUS

10 years after the finalization of H.264/AVC, encoders are still improving

New generation of encoders launched this year achieves :

- An excellent HD1080i quality, close to source quality, at 15Mb/s in 4:2:2 10 bits for contribution,
- 15% bitrate gain for broadcast and an additional 15% gain is targeted by end 2013
  - **7 Full HD1080i** programs in **DVB-S** (34Mb/s) or **9** programs in **DVB-S2** (46Mb/s) by end 2013

- ***1ST VERSION OF HEVC STANDARD NEARLY FINALIZED.***

  Now is coming the “encoder makers know-how” time !

  One goal : to make the best use of the toolbox

HEVC PERFORMANCE ANALYSIS

Initial goal achieved :

- Same subjective quality with half the bitrate for HEVC model (Main profile) vs H.264/AVC model
- Best gains on higher resolutions and on low activity contents (sometimes more than 50%)





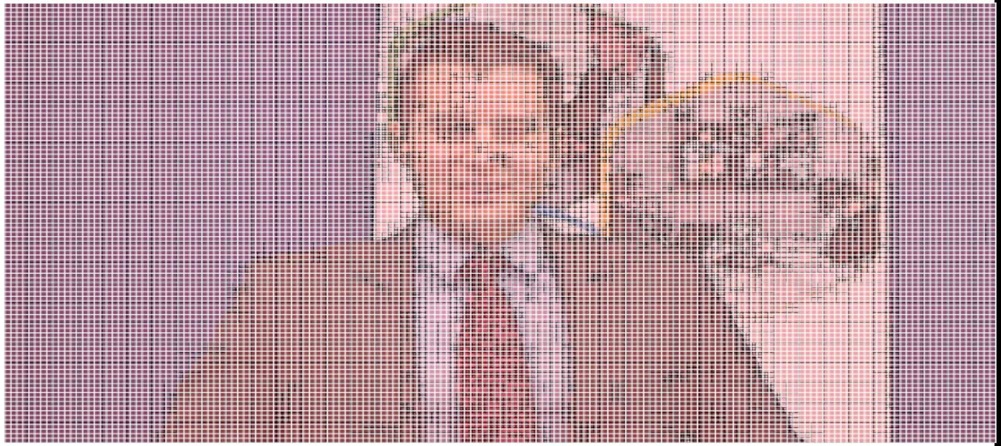
Source type	Resolution	Frame rate	Bitrate saving average *	Bitrate saving min *	Bitrate saving max *
Progressive	3840x2160 (4K)	25	30.6%	22.0% (Ducks)	42.3% (Old town)
	1920x1080	50	29.2%	17% (Parkjoy)	46.3% (Old town)
	1280x720	50	24.7%	14.6% (Parkjoy)	36.6% (Old town)

*** PSNR Bjøntegaard metric**
HM7.0 MP / JM18.3

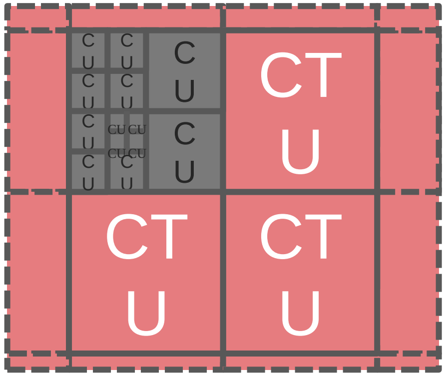
HEVC PERFORMANCE ANALYSIS

Why HEVC is better ?

- Large blocks up to 64x64 pixels



- Better adaptation to the image content,
  no over-partitioning inherent to a regular MB structure



- Advanced motion coding:
  able to capture more redundancy with less signaling data
- Accurate and efficient Intra coding

HEVC PERFORMANCE ANALYSIS

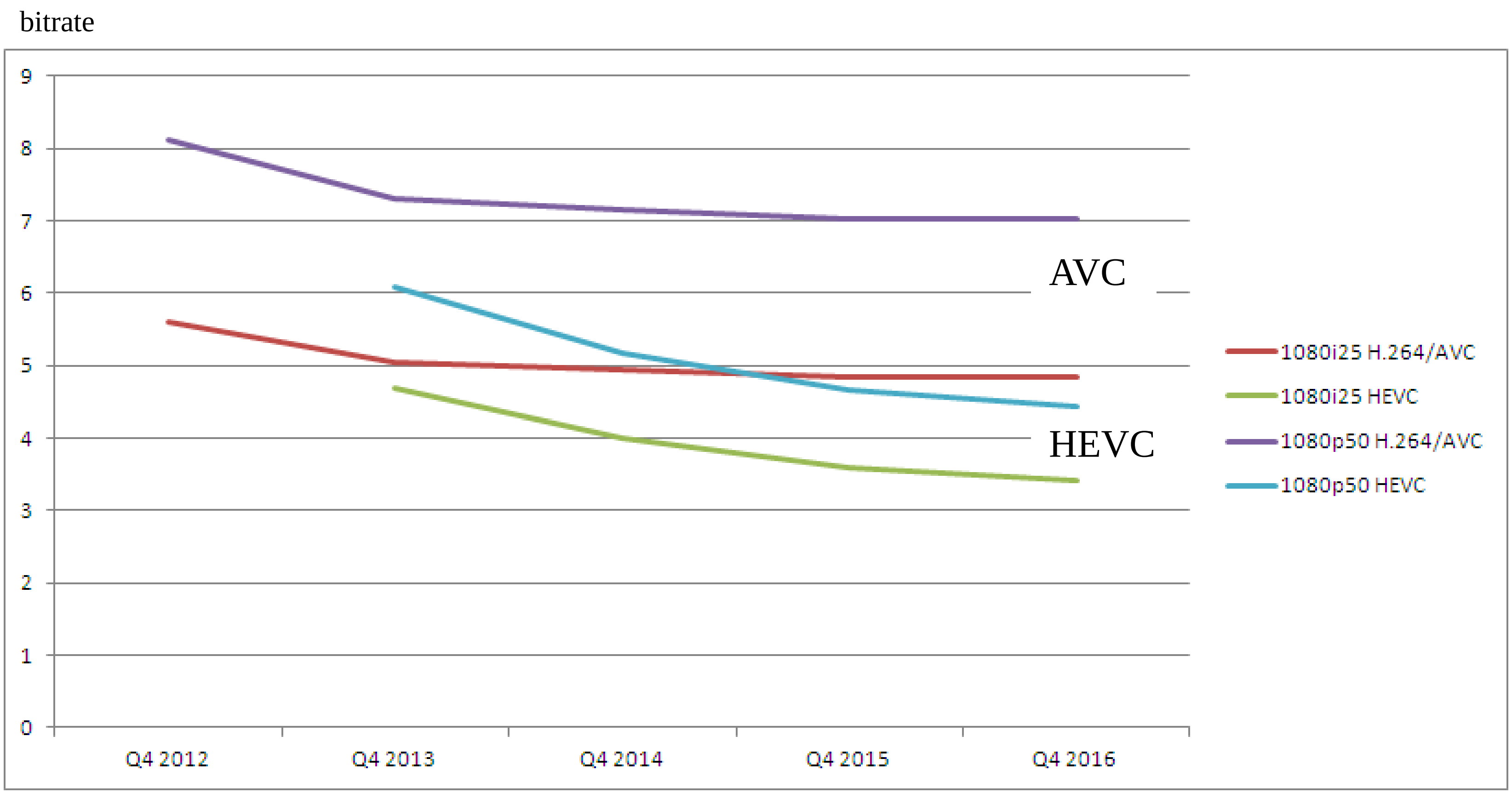
HEVC model computation time

- Far from real-time on a Xeon processor core (range of x1000-3000)

Why HEVC real-time implementation timeline should be faster than in H.264/MPEG4-AVC ?

- Entropy encoder well mastered
- Same High-level encoder architecture (hierarchical GOP structure)
- Parallelism tools included in the standard (Wavefront for entropy coding, Tiles)
- Same packetization layer (NAL)

H.264/AVC – HEVC bitrates evolution plan for DTH



HEVC CURRENT LIMITATIONS

- The “Main profile” only supports 4:2:0 8-bits contents for the time being.
    - Proposal to add a 4:2:0 10 bits profile in the first DIS (useful for 4K content)
    - Professional profiles (4:2:2 / 4:4:4) will be released in 2013
- The « Main profile » brings a limited support to interlaced formats :
    - PAFF (Picture Adaptive Frame Field) is limited at the sequence level with Closed-GOP constraints
    - Field coding is therefore not possible for I pictures when Frame coding is used in the sequence
    - no MBAFF for internal Frame-Field adaptation inside the pictures

OUR VISION OF HEVC DEPLOYMENT

OTT applications : certainly the first user of HEVC in 2013

- Fast renewal of decoding devices
- Real-time SW implementations already demonstrated
- 50% bandwidth savings enables HD on mobile networks

4:2:0 8-bits DSNG & 4:2:2 10-bits Contribution applications

- Will immediately take benefit of lower bandwidth
- No constraint of existing decoder park

IPTV

- Extended HD eligibility
- Need of cheap STBs

DTT

- Legacy issues and display replacement may delay the introduction of HEVC

DTH

- Replacement of existing decoder park, migration scenario TBD

THATS ALL FOLKS

Questions ?

Guy Bouchard

Senior Manager, Broadcast & Signal Transport

New Broadcast technologies

CBC / Radio-Canada

guy_bouchard @ieee.org