Audio Coding Standards: Overview and Basic Principles

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History of MPEG Standards [1]

- MPEG-1 coding of synchronized video and audio at a total rate of 1.5 MBPS finalized in 1992
- MPEG-2 coding of s synchronized video and audio at a total rate of 10 MBPS finalized in 1994
- MPEG-4 finalized in 1998

MPEG-1 Audio [1]

- Originally intended for the coded representation of high quality audio for storage media and decoding high quality audio
- Later tested under ITU-R and recommended for some broadcasting applications
- Standardization of the bitstream and decoder only, but not the encoder

MPEG-2 Audio [1]

- Initial goal was to define the multichannel extension to MPEG-1, designated MPEG-2 BC (backwards compatible), and to
- Define lower sampling rates than MPEG-1, 16 kHz, 22.5 kHz, and 24 kHz
- Later MPEG-2 NBC or MPEG-2 AAC
- Also, MPEG-2 LSF and MPEG-2.5

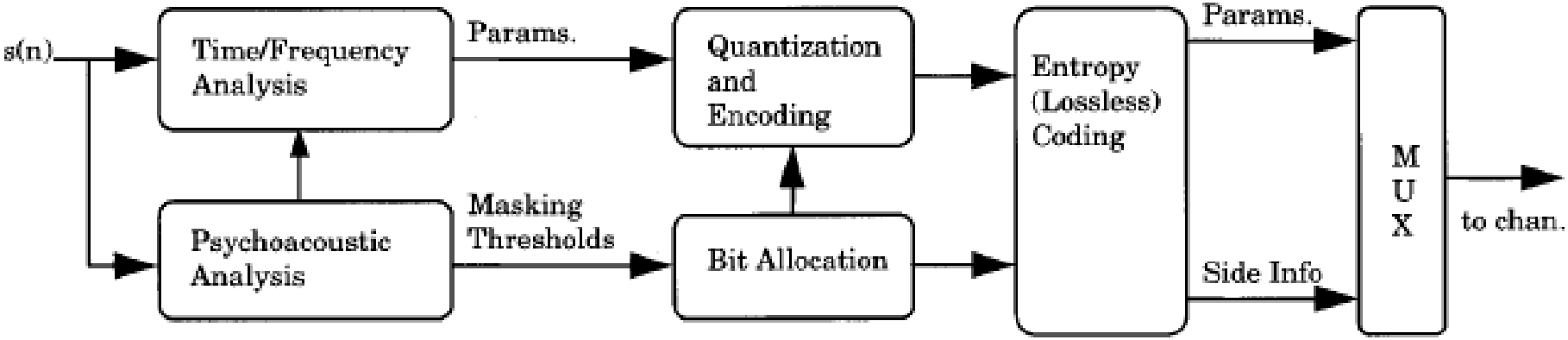
Other Audio Coding Standards

- Dolby AC-3
- DVD-Audio

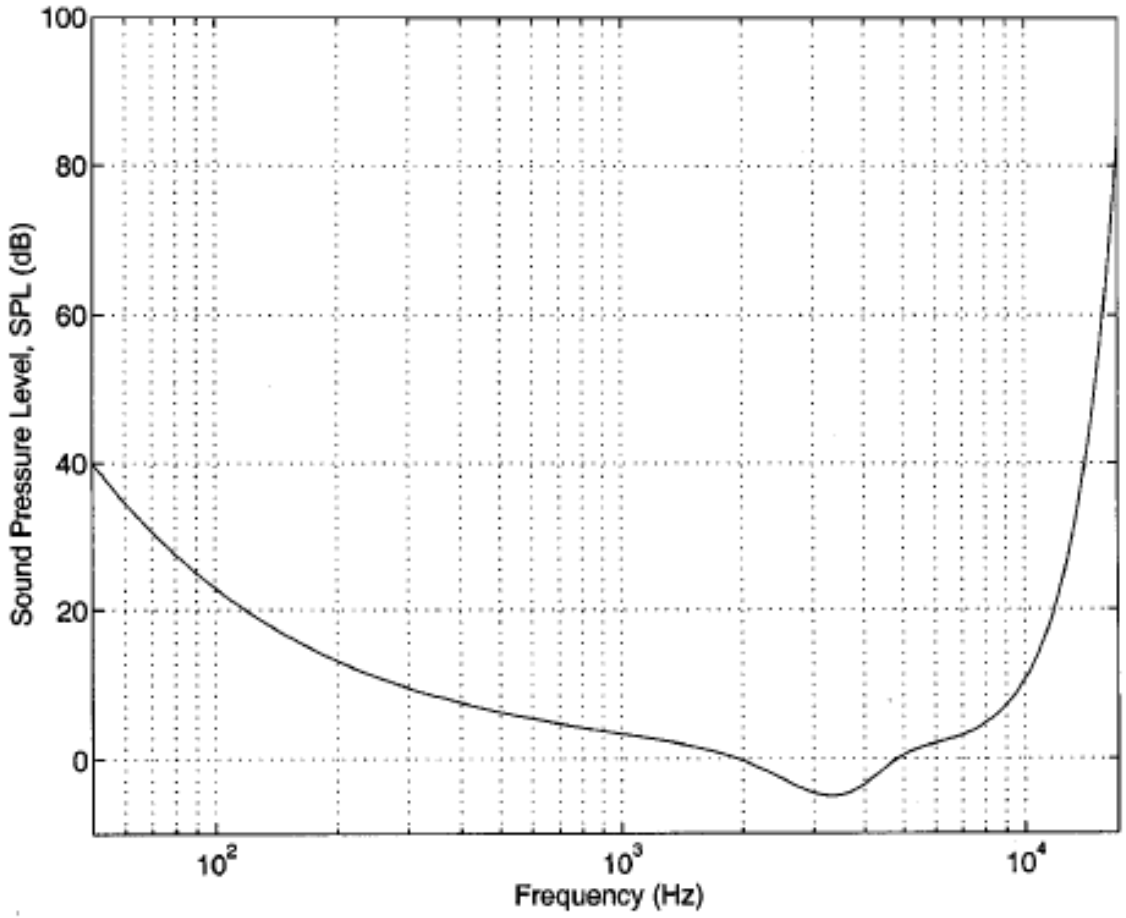
Audio Coding Standards and Applications [2]

Algorithm	Sample Rates (kHz)	Channels	Bit Rates (kbps)	Applications	References
APT-X100	44.1	1	176.4	Cinema	[19]
ATRAC	44.1	2	256/ch	MiniDisc	[365]
Lucent PAC	44.1	1 - 5.1	128/stereo	DBA: 128/160 kbps	[306]
Dolby AC-2	44.1	2	256/ch	DBA	[313]
Dolby AC-3	44.1	1 - 5.1	32 – 384	Cinema, HDTV	[315]
MPEG-1, LI-III	32, 44.1, 48	1, 2	32 – 448	"MP3": LIII DBA: LII@256 kbps DBS: LII@224 kbps DCC: LI@384 kbps	[17]
MPEG-2/BC-LSF	32, 44.1, 48, 16, 22, 24	1 - 5.1	32 – 640	Cinema	[18]
MPEG-2/AAC		1 – 96	8 – 64 /ch	Internet/www, e.g., LiquidAudio™, atob™ audio	[112]
MPEG-4		1 -	200 bps – 64 kbps/ch	General	[222]

Generic Audio Coding Method [2]



Absolute Threshold of Hearing in Quiet [2]



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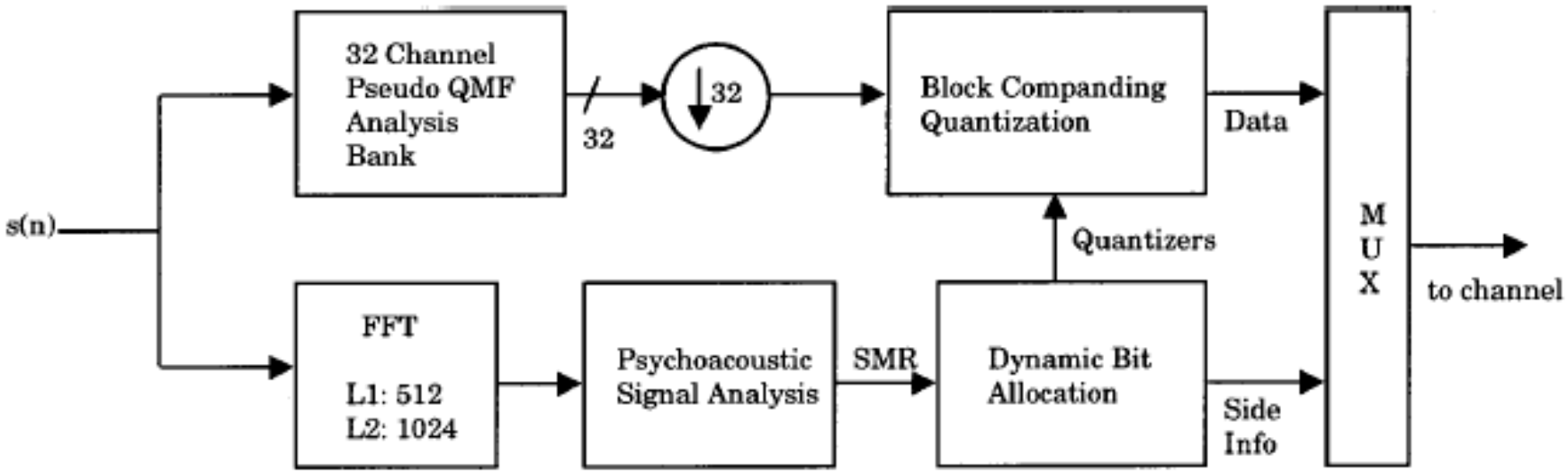
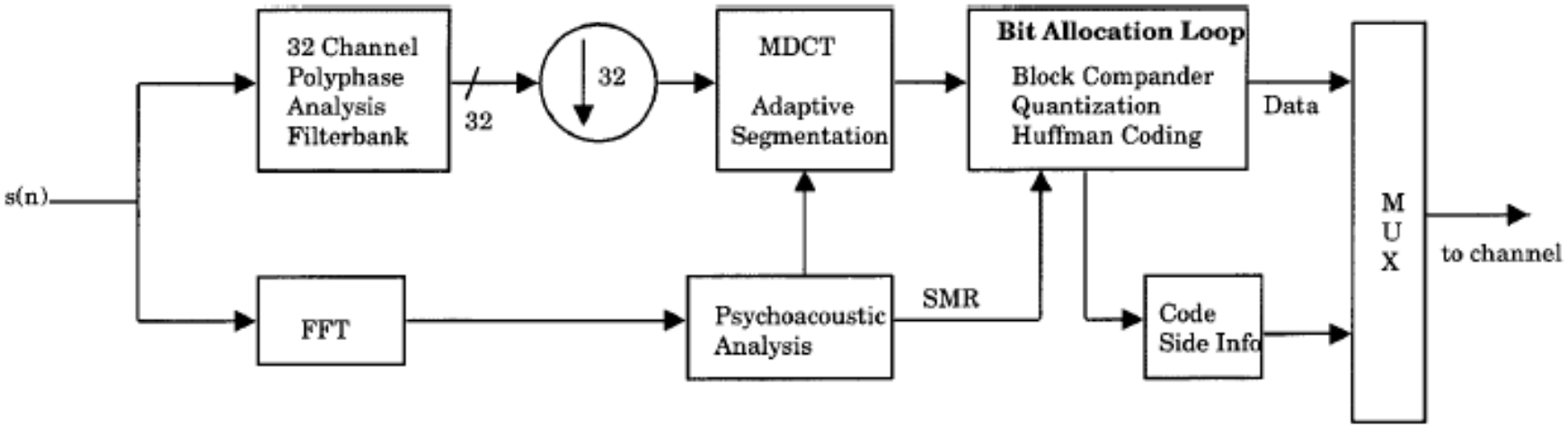
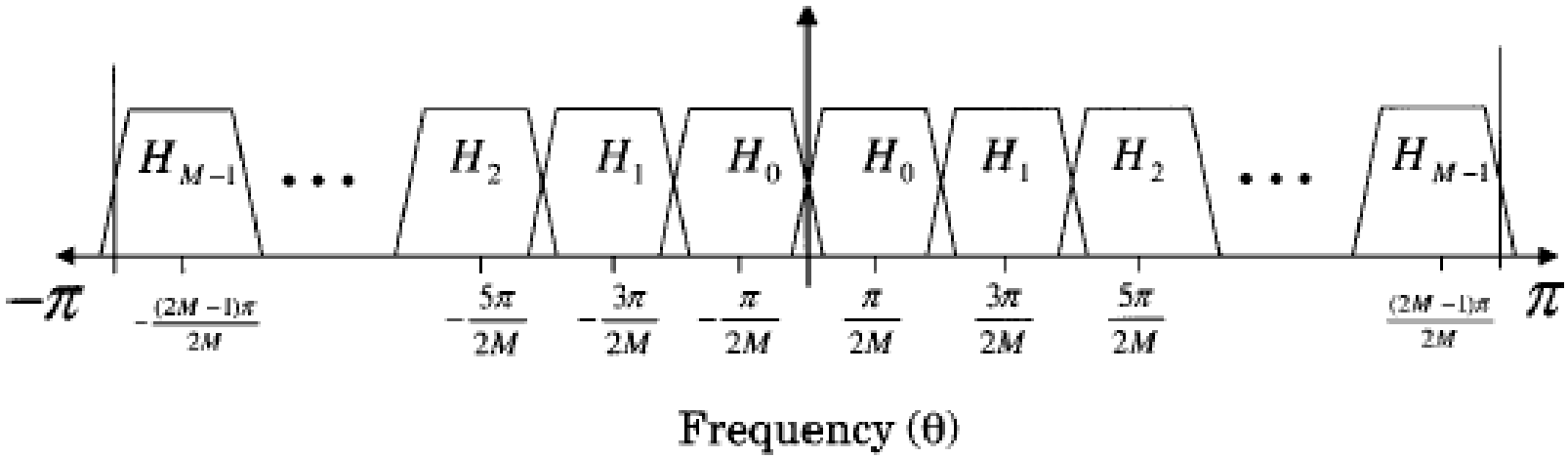
MPEG-1 Layer I/II Encoder [2]



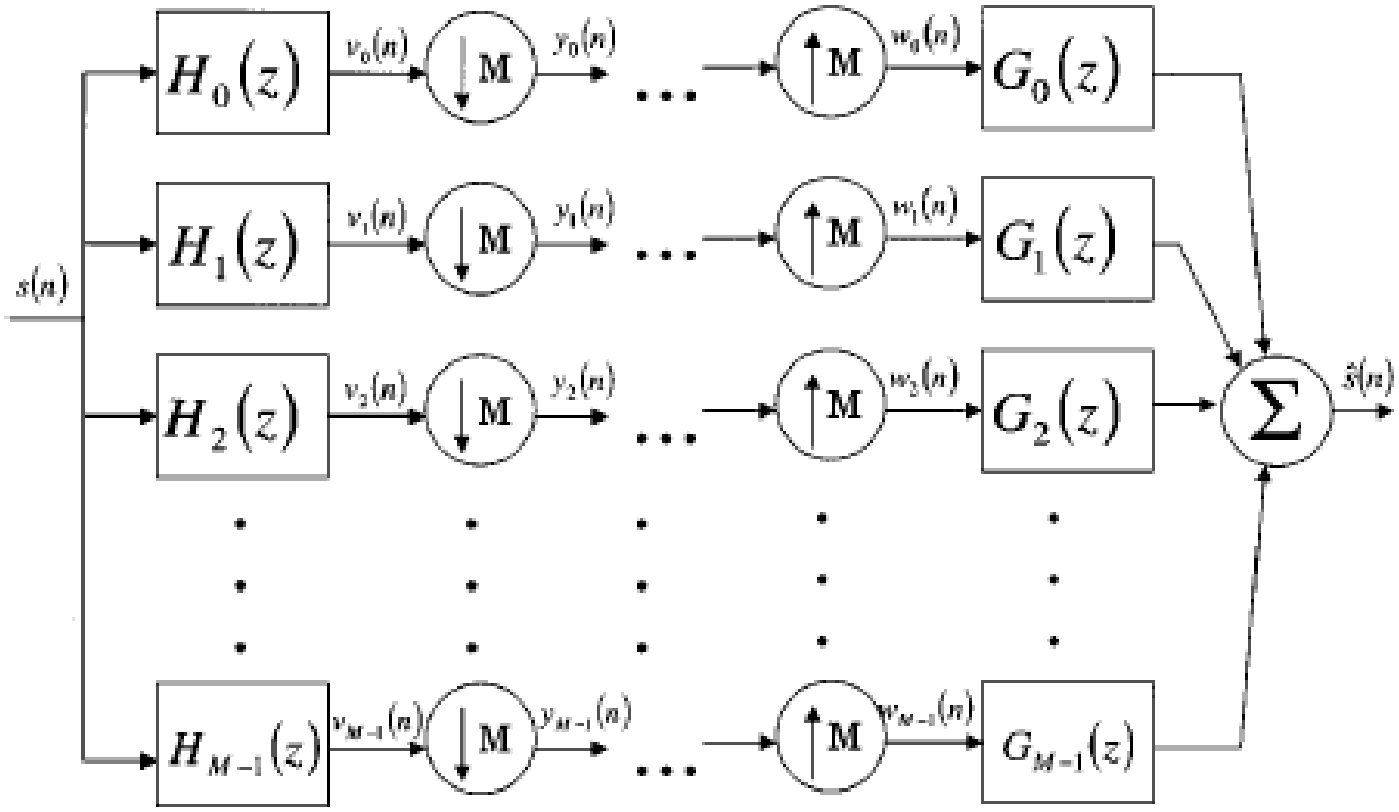
MPEG-1 Layer III Encoder [2]



Magnitude Response—Uniform Filter Bank [2]



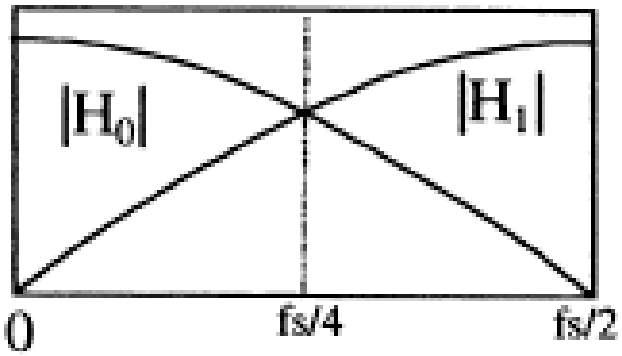
Uniform M-Band Maximally Decimated Analysis Synthesis Filter Bank [2]



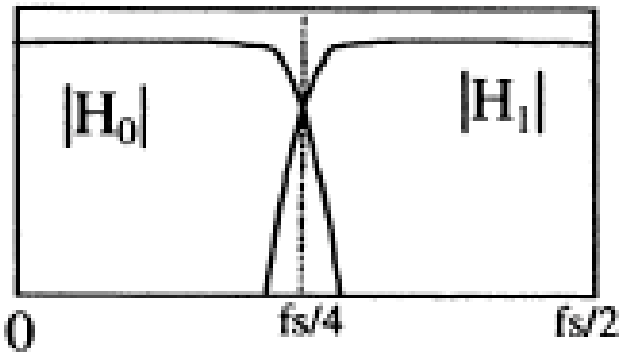
Two-Channel Filter Banks

- QMF Solutions
- Haar Example
- Conjugate Quadrature Filter (CQF) Solutions

Haar QMF and Longer Approximations to the QMF Perfect Reconstruction Condition [1]



Haar Filters

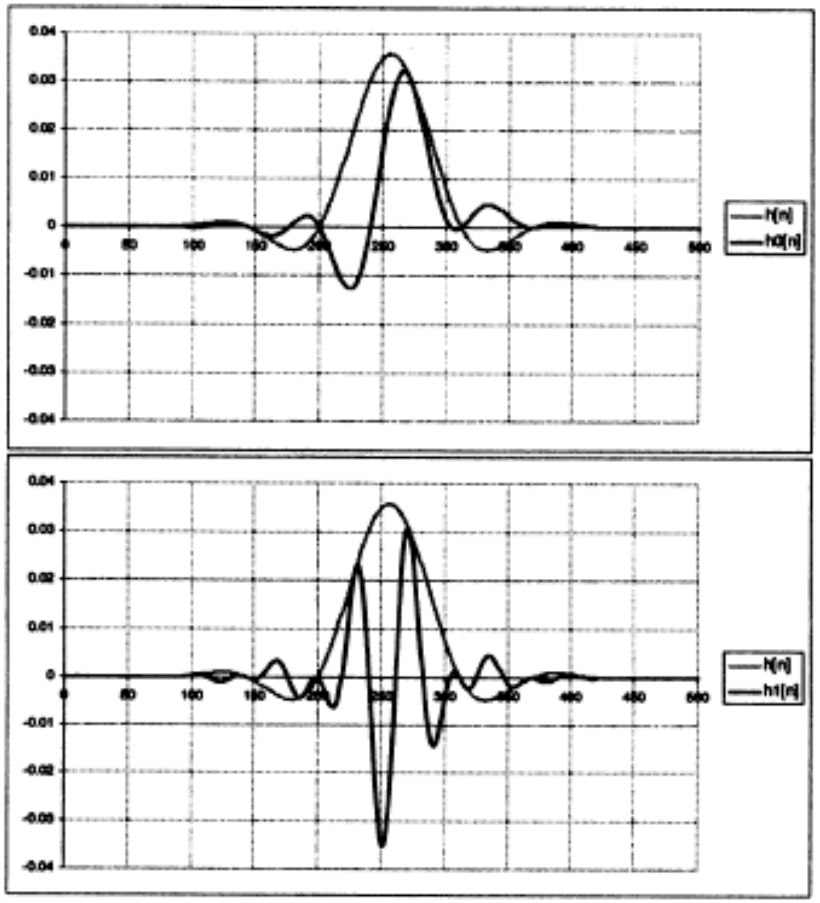


QMF

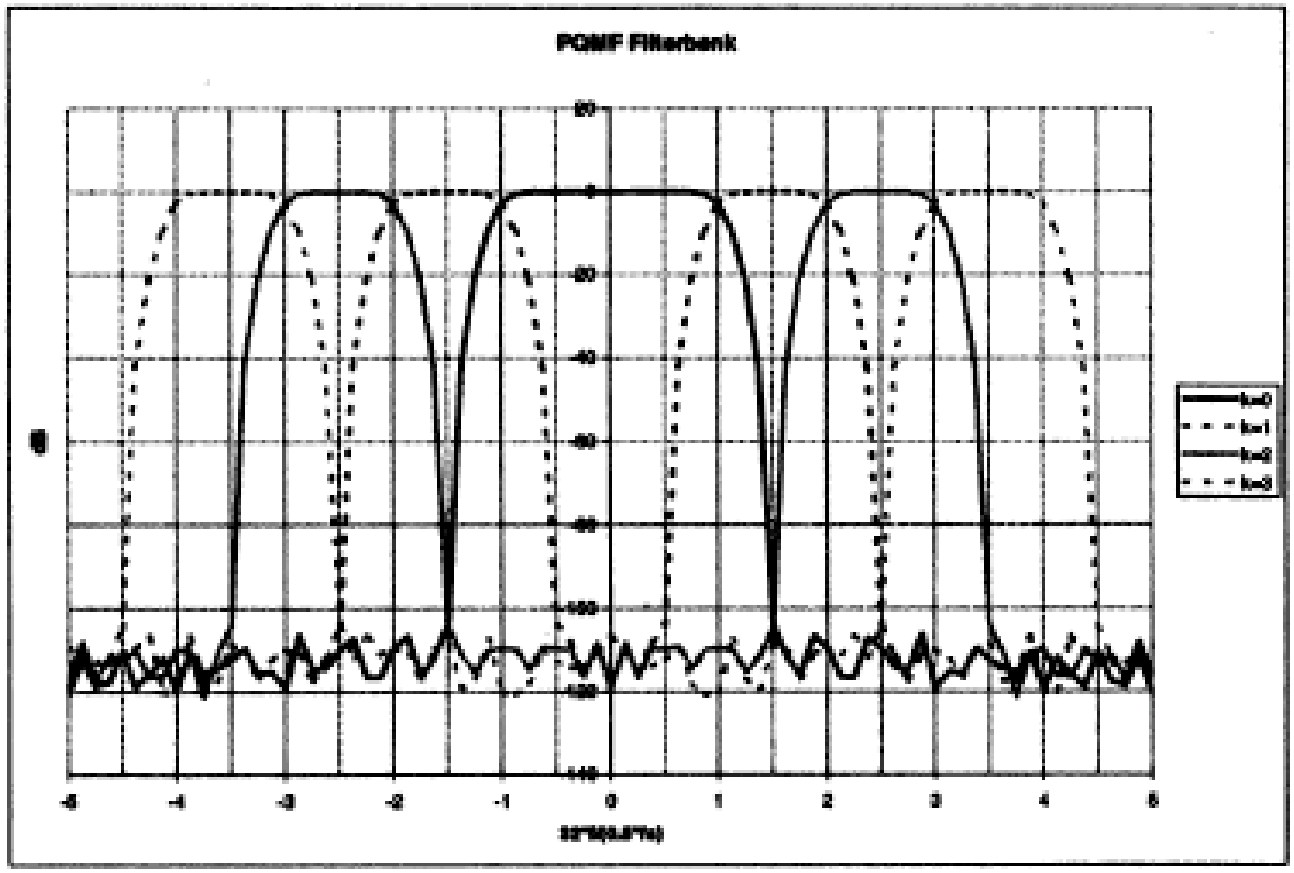
Idealized Critical Band Filter Bank [2]

Band No.	Center Freq. (Hz)	Bandwidth (Hz)	Band No.	Center Freq. (Hz)	Bandwidth (Hz)	Band No.	Center Freq. (Hz)	Bandwidth (Hz)
1	50	-100	10	1175	1080-1270	19	4800	4400-5300
2	150	100-200	11	1370	1270-1480	20	5800	5300-6400
3	250	200-300	12	1600	1480-1720	21	7000	6400-7700
4	350	300-400	13	1850	1720-2000	22	8500	7700-9500
5	450	400-510	14	2150	2000-2320	23	10,500	9500-12000
6	570	510-630	15	2500	2320-2700	24	13,500	12000-15500
7	700	630-770	16	2900	2700-3150	25	19,500	15500-
8	840	770-920	17	3400	3150-3700			
9	1000	920-1080	18	4000	3700-4400			

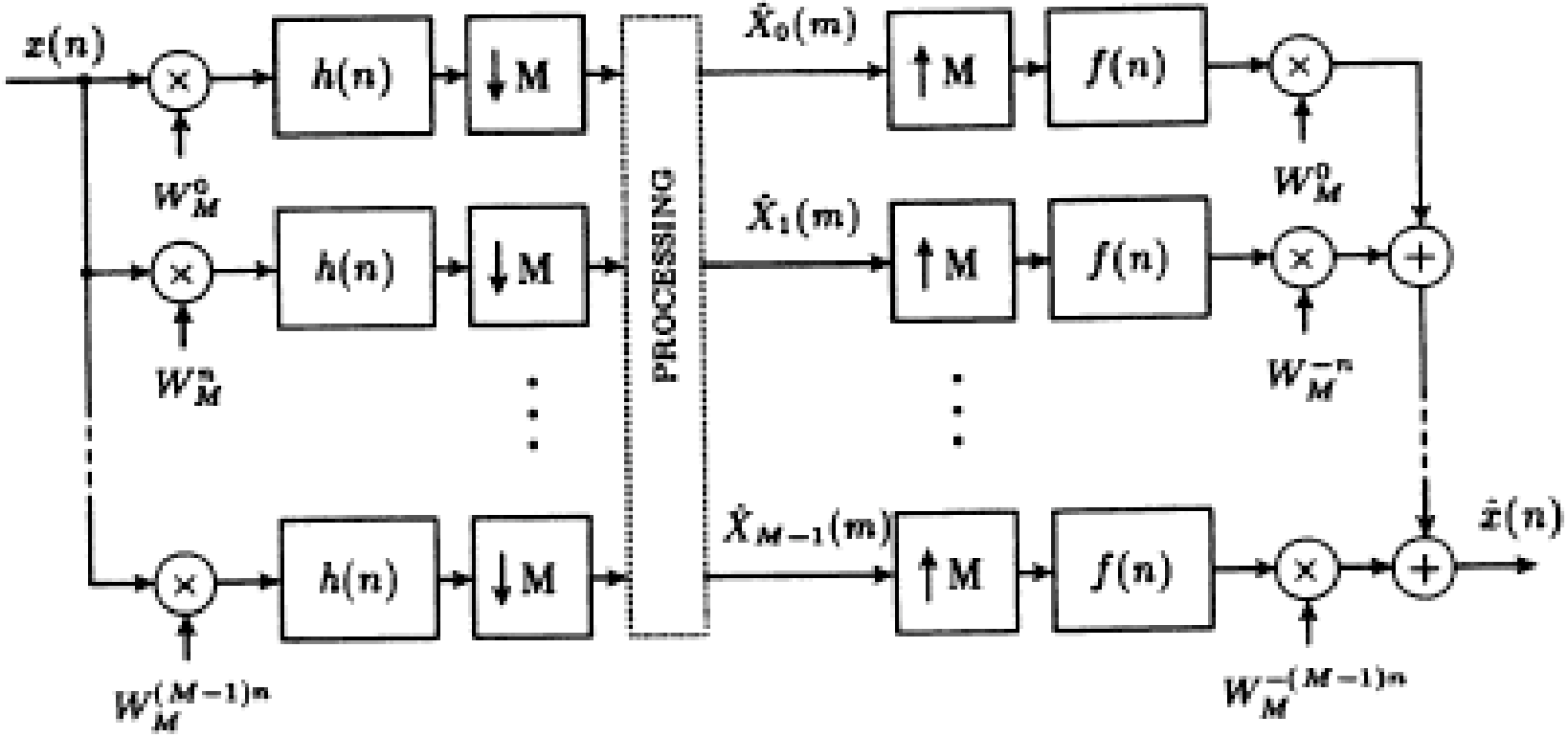
Prototype and Example Impulse Responses [1]



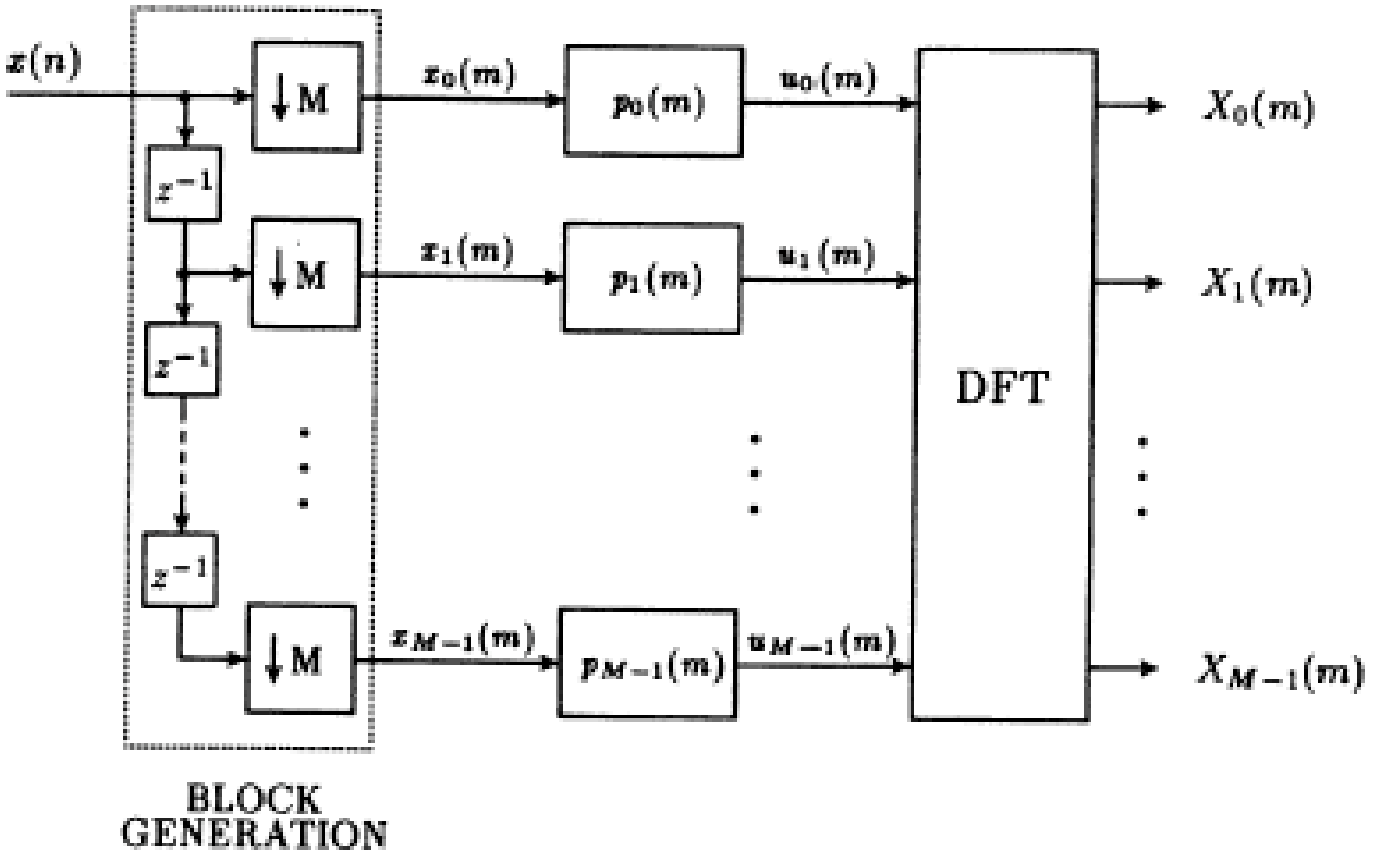
Frequency Response of the MPEG Audio First Four Bands [1]



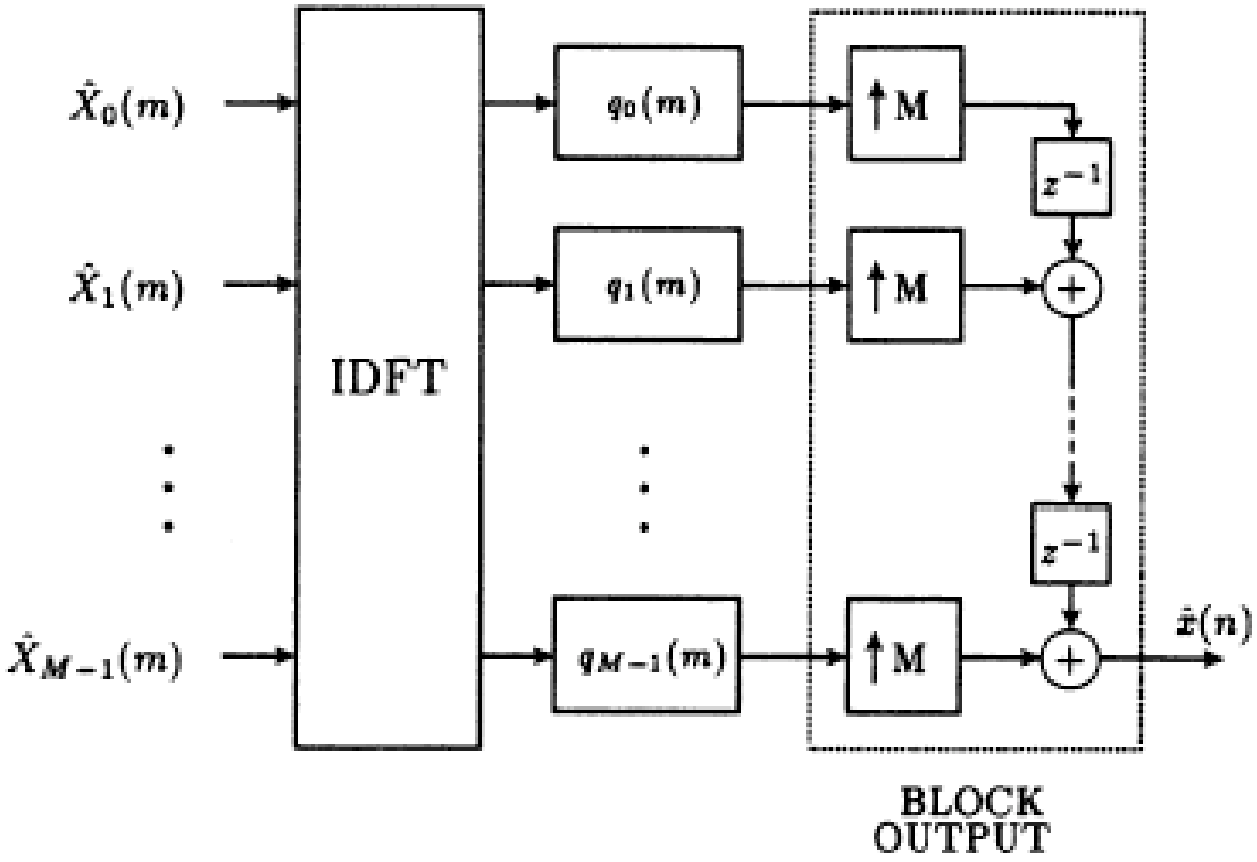
DFT Filter Bank with Complex Modulators [3]



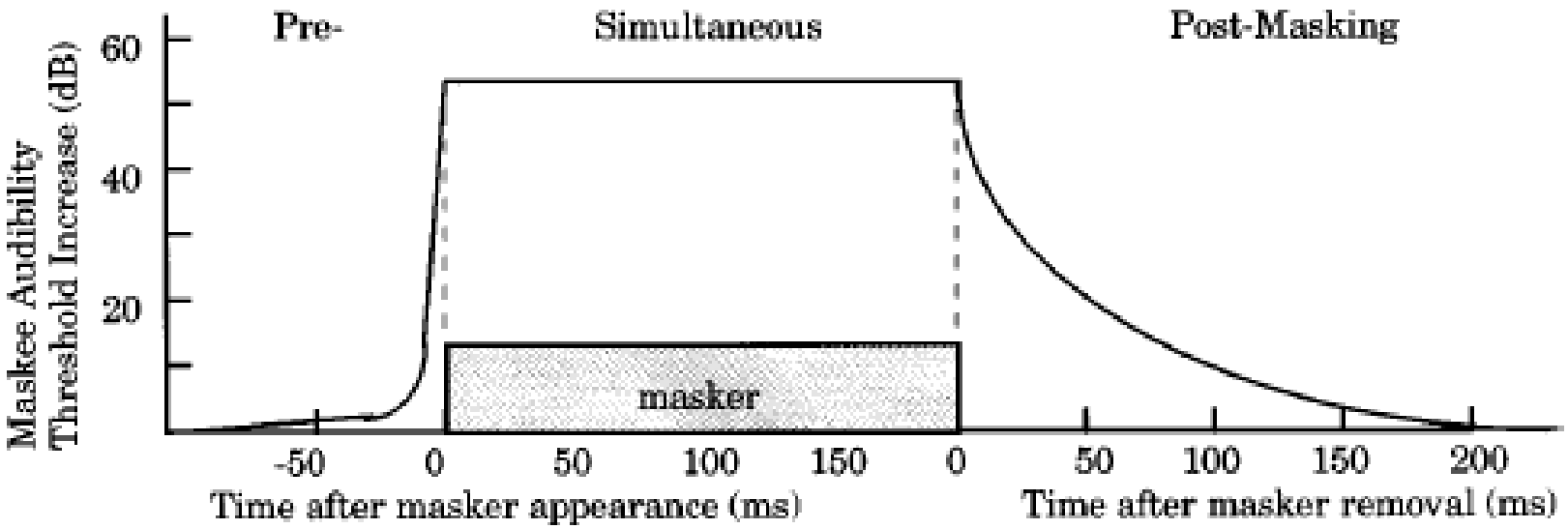
Analysis DFT Filter Bank with Input Blocking [3]



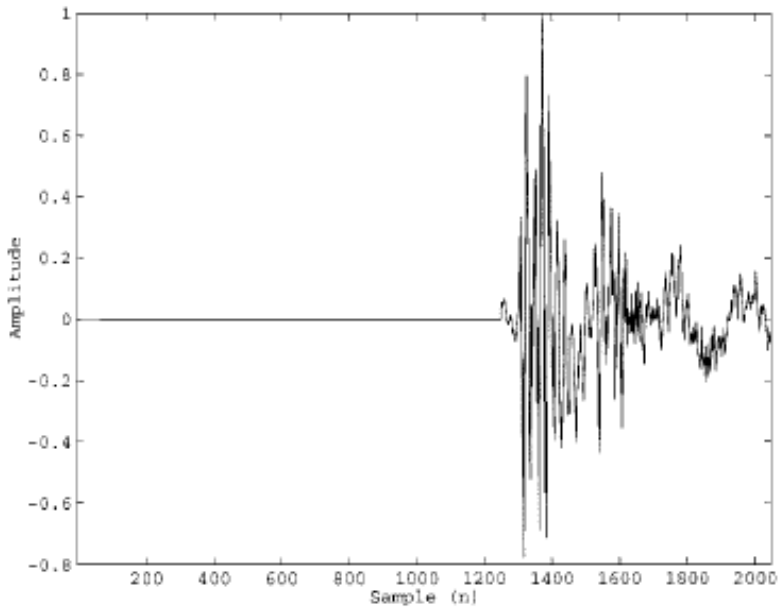
Synthesis DFT Filter Bank with Input Blocking [3]

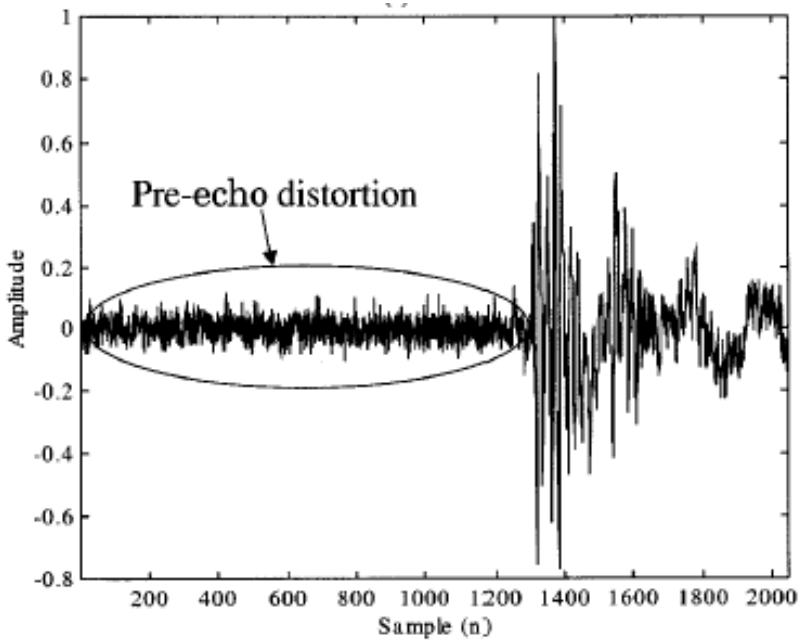


Pre- and Post-Masking Properties [2]

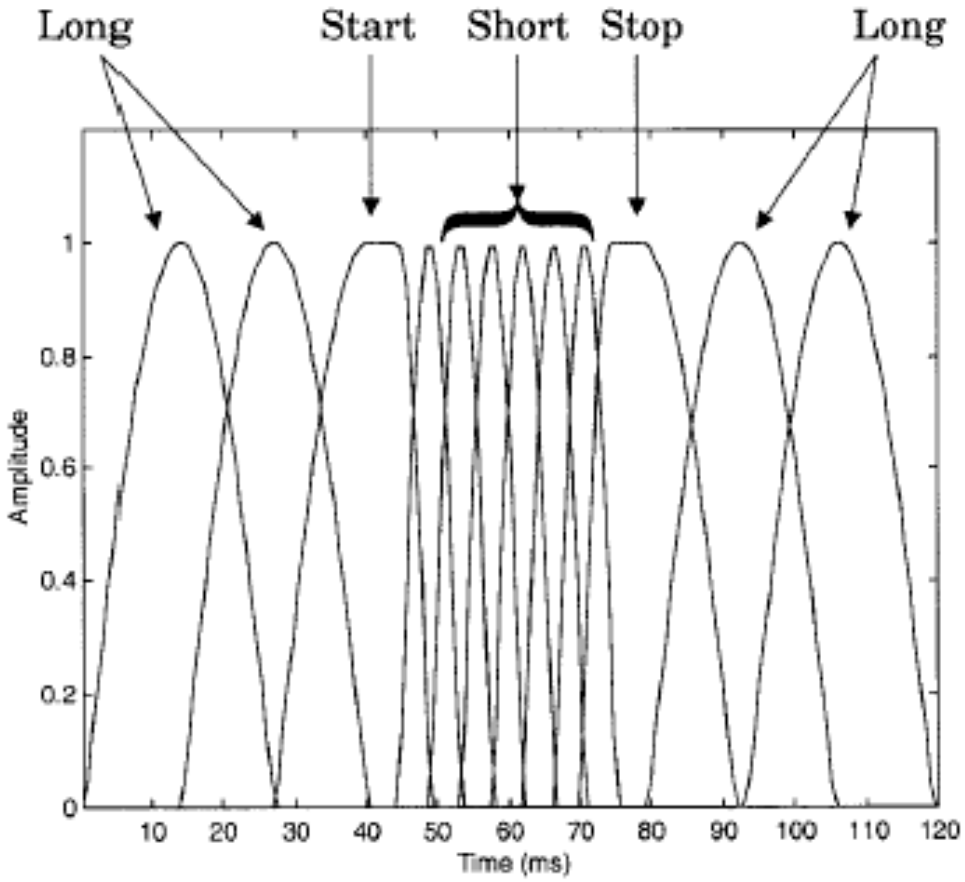


Origin of Pre-Echo Distortion [2]





Example Window Switching for MP3 [2]



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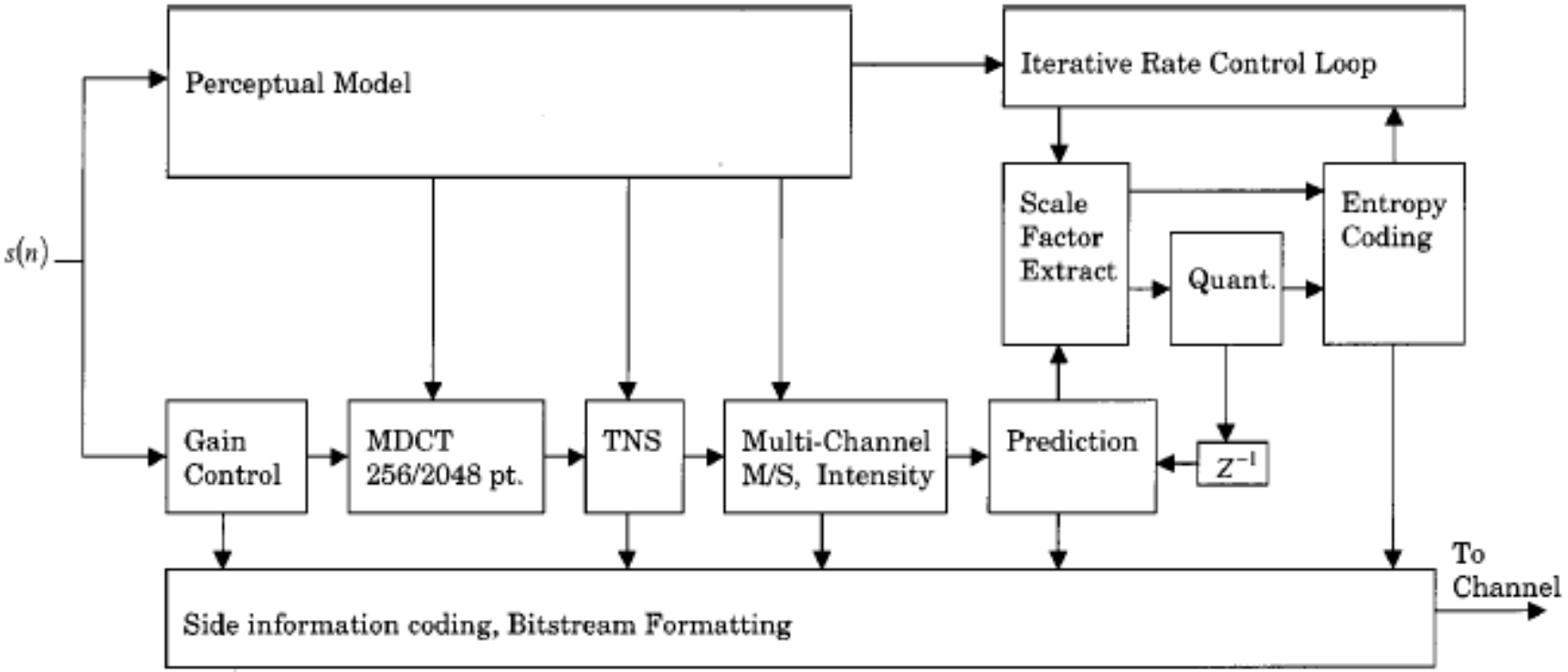
MPEG-2 NBC AAC Encoder [2]



Comparison of Standardized Two Channel Audio Coders [2]

Group	Algorithm	Rate (kbps)	Mean Diff. Grade	Transparent Items	Items Below −1.00
1	AAC	128	-0.47	1	0
	AC-3	192	-0.52	1	1
2	PAC	160	-0.82	1	3
3	PAC	128	-1.03	1	4
	AC-3	160	-1.04	0	4
	AAC	96	-1.15	0	5
	MP-1 L2	192	-1.18	0	5
4	IT IS	192	-1.38	0	6
5	MP-1 L3	128	-1.73	0	6
	MP-1 L2	160	-1.75	0	7
	PAC	96	-1.83	0	6
	IT IS	160	-1.84	0	6
6	AC-3	128	-2.11	0	8
	MP-1 L2	128	-2.14	0	8
	IT IS	128	-2.21	0	7
7	PAC	64	-3.09	0	8
8	IT IS	96	-3.32	0	8

Comparison of Standardized 5.1 Channel Audio Coders [2]

Group	Algorithm	Rate (kbps)	Mean Diff. Grade
1	MP-2 BC	640	-0.51
2	AC-3	448	-0.93
	MP-2 BC	512	-0.99
3	AC-3	384	-1.17
	MP-2 BC	384	-1.73

References

1. M. Bosi and R. E. Goldberg, Introduction to Audio Coding and Standards, Kluwer, 2003.
2. T. Painter and A. Spanias, Perceptual Coding of Digital Audio, Proceedings of the IEEE, Vol. 88, April 2000, pp. 451-512.
3. H. S. Malvar, Signal Processing with Lapped Transforms, Artech House, 1992.