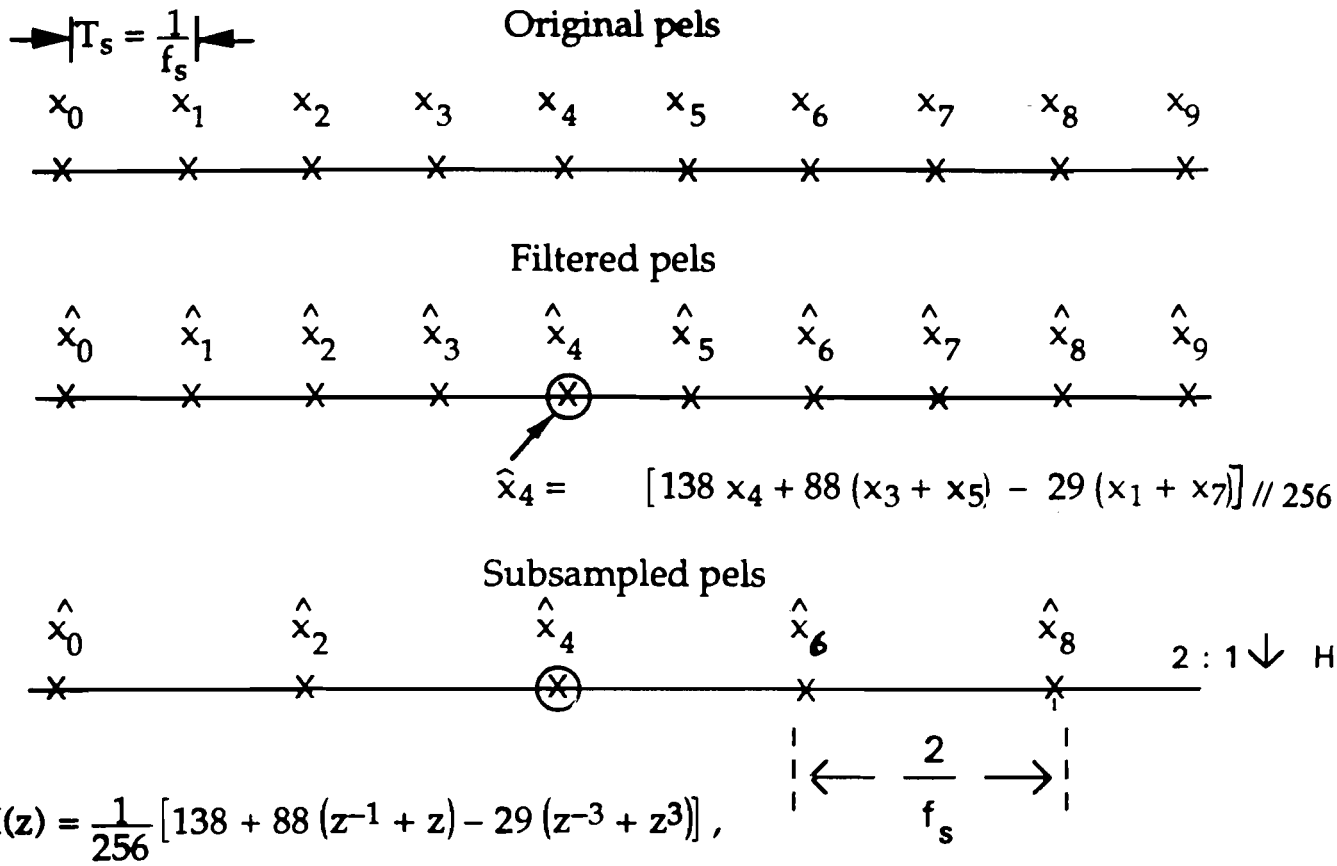


$$H(z) = \frac{1}{256}\left[138 + 88\left(z^{-1} + z\right) - 29\left(z^{-3} + z^{3}\right)\right],$$

$$H\left(e^{j\omega T_s}\right) = \frac{1}{128}\left[69 + 88\cos\omega T_s - 29\cos 3\omega T_s\right] = \text{frequency response}$$

[-29 / 0 / 88 / 138 / 88 / 0 / -29] // 256

↓ 2 : 1 DECIMATION FILTER

$f_s = 13.5$ *MHZ* *for* Y

$f_s = 6.75$ *MHZ* *for* C_R, C_B

↓2:1 Chrominance

1	3	3	1	//8

$$\hat{x}_4 = [138\, x_4 + 88(x_3 + x_5) - 29(x_1 + x_7)] \;//\; 256$$

$$\hat{x}_4 = [3(x_4 + x_5) + (x_3 + x_6)] // 8$$

CCIR 601 FORMAT TO SOURCE INPUT FORMAT (SIF)

(PPS : pictures/second)

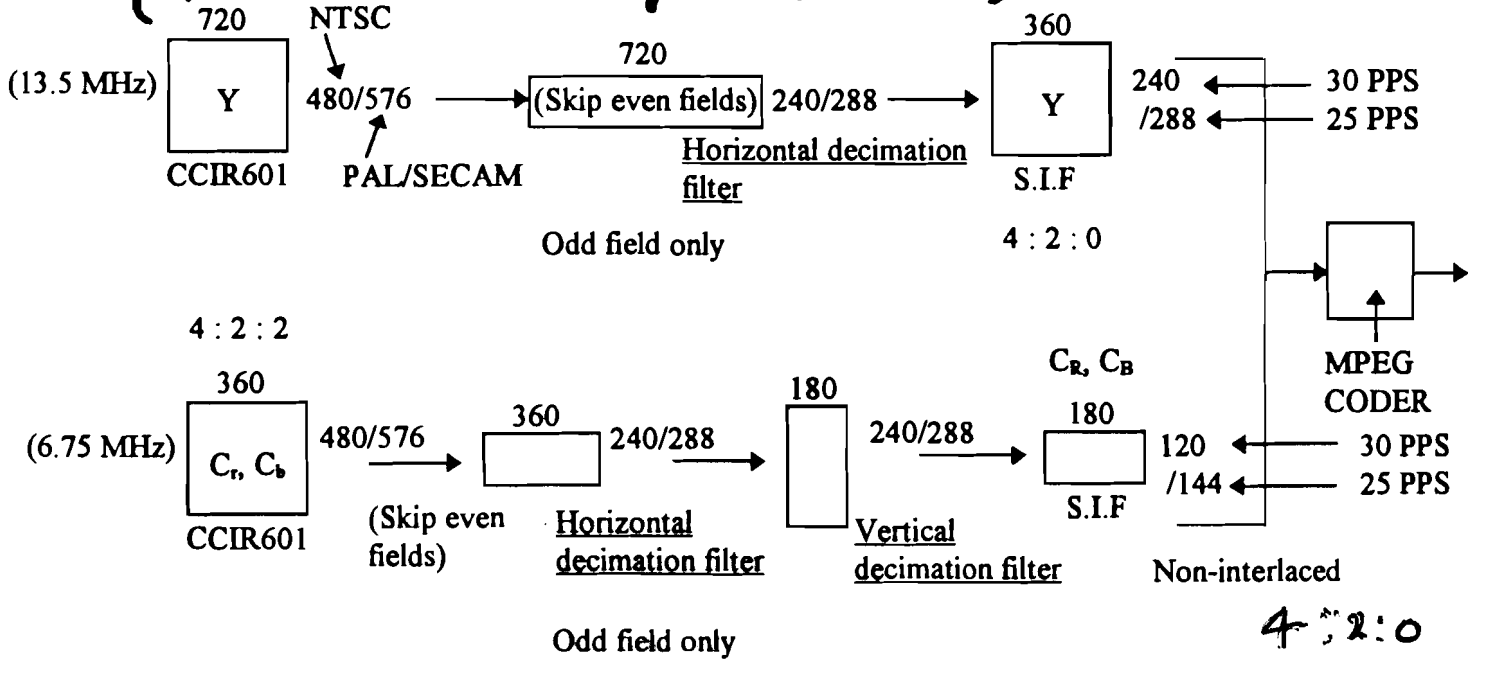


Figure 3.2 Conversion of the CCIR601 format into the S.I.F

(H & V) 2:1 ↓ Decimation

EXAMPLE

CCIR-601	- 29	0	88	138	88	0	-29	// 256

$\omega T_s = 2\pi f / f_s$
$2\pi f T_s = \omega / f_s$

LUMINANCE

f_s = sampling rate = $1/T_s$, T_s = Sampling interval

For Y, f_s = 13.5 Mhz

Table 3.2 Decimation filter

CHROMINANCE

1	3	3	1	// 8

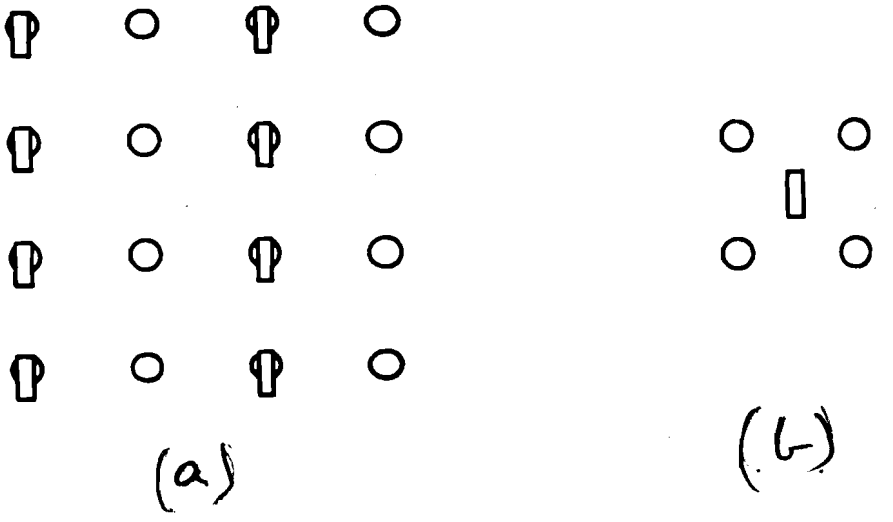
Notation

(//) = INTEGER DIVISION WITH ROUNDING TO THE NEAREST INTEGER AWAY FROM ZERO

F. M. Wang and D. Anastassiou, " High quality coding of even fields based on the odd fields of interlaced video sequences", IEEE Trans. Circuits & Systems, vol. 38, pp. 140-142, Jan. 1991.

I. Chen and G. E. Ford, " An FIR image interpolation filter design based on properties of human vision", ICIP 94, pp. III 581-585, Austin TX, Nov. 1994.

IEEE

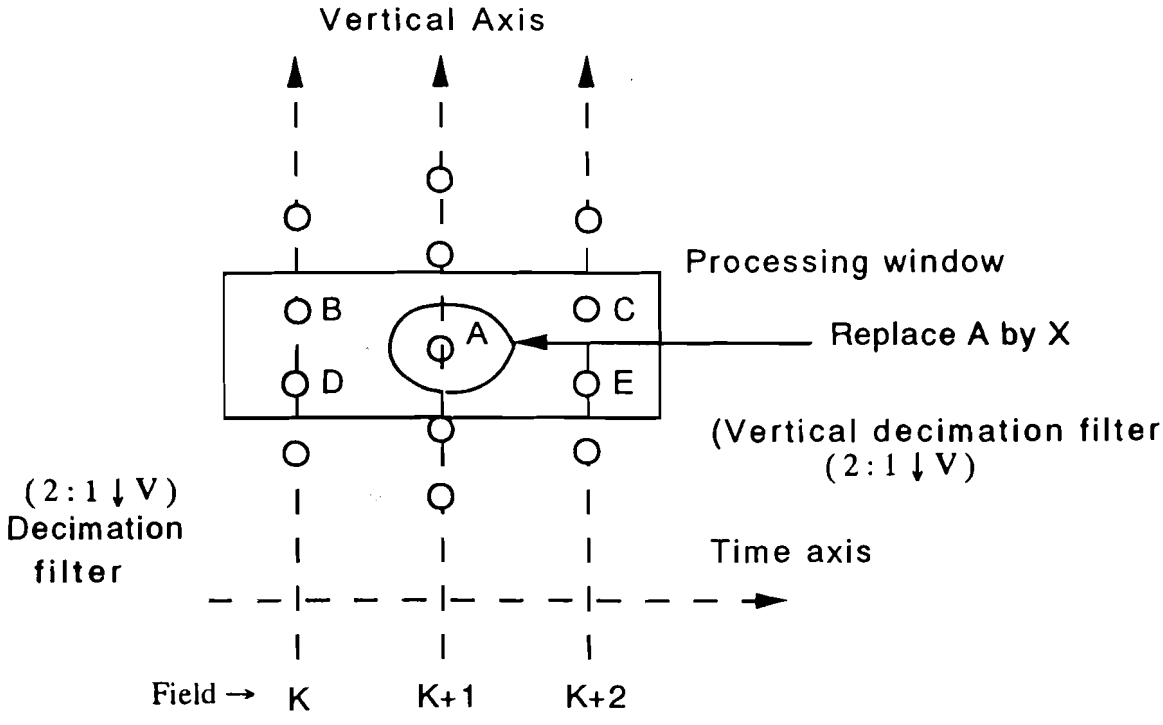


(a) Sampling pattern for 4:2:2 (CCIR 601)

(b) Sampling pattern for MPEG (SIF)

Circles represent luminance; Boxes represent Chrominance

Figure 2-D.8 Conversion of CCIR 601 to SIF



$$X_{lin} = (1/2)\,A + (1/8)\,(B+C+D+E)$$

This is not part of MPEG standard. MC PIC Proposal for MPEG coding standard from BELLCORE.

$$X = \begin{cases} X_{lin} & \text{if } |X_{lin} - A| < T1 \quad \text{(i)} \\ \dfrac{(T2 - |X_{lin} - A|)}{(T2 - T1)}\, X_{lin} + \dfrac{(|X_{lin} - A| - T1)}{(T2 - T1)}\, A & \text{if } T1 < |X_{lin} - A| < T2 \quad \text{(ii)} \\ A & \text{if } |X_{lin} - A| > T2 \quad \text{(iii)} \end{cases}$$

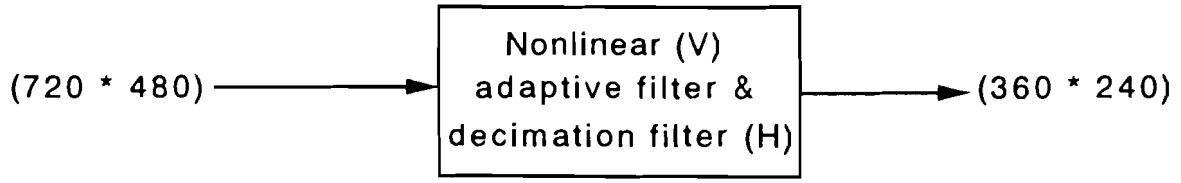
Instead of dropping every other field in the original image (going from CCIR 601 to SIF), an adaptive nonlinear filter is applied for implementing 2:1 vertical decimation. a 2-D diamond shaped lowpass filter is applied along vertical and temporal domains to reduce the aliasing and noise. After extensive simulation $T_1 = 30$ and $T_2 = 70$ are chosen.

Non Linear Filter for Preprocessing

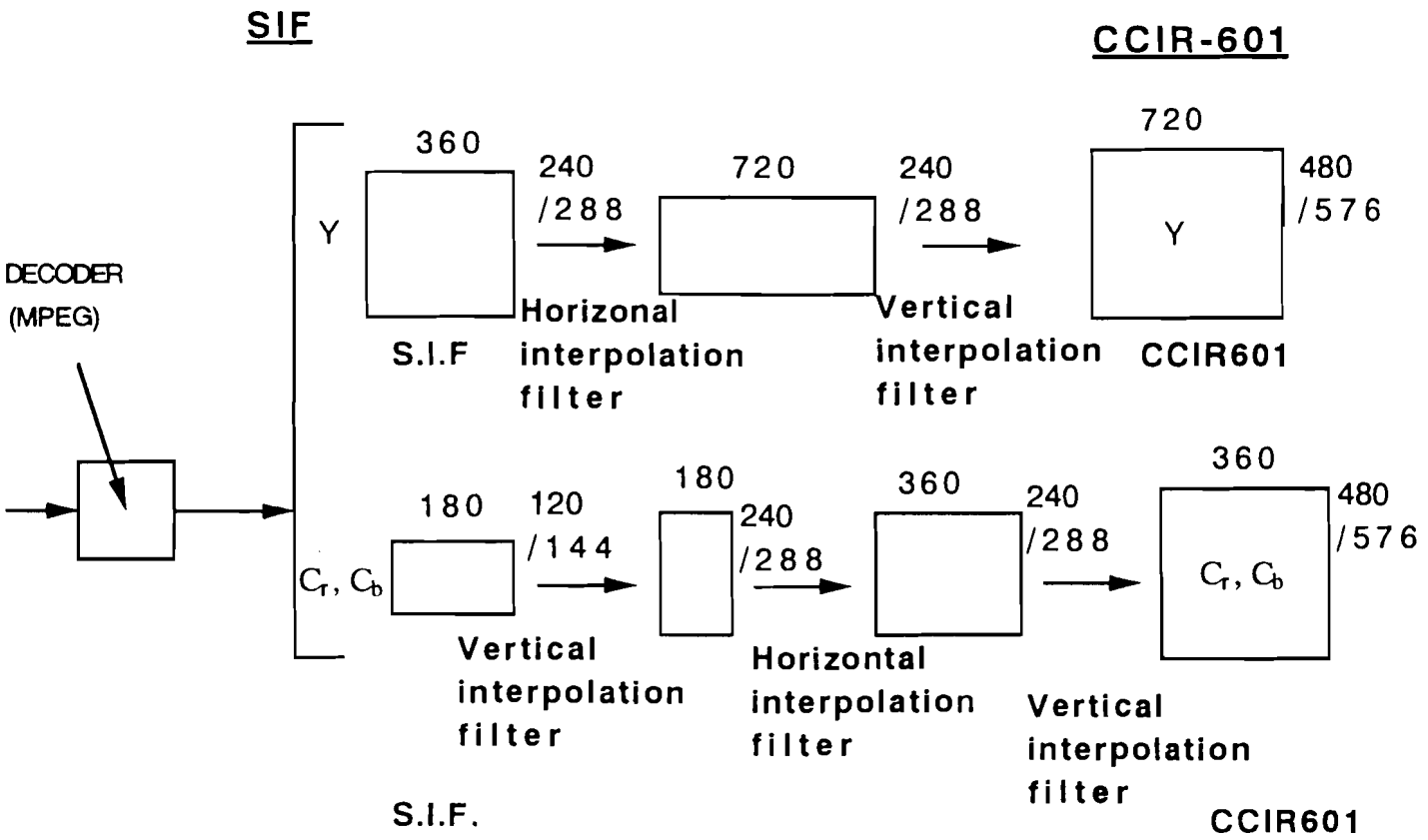
(i) Reduces aliasing effect and noise

(ii) Smooth transition region and reduces visibility of false contours.

(iii) Retains image sharpness (Vertical subsampling and Horizontal subsampling)



Source Input Format to CCIR 601 Format



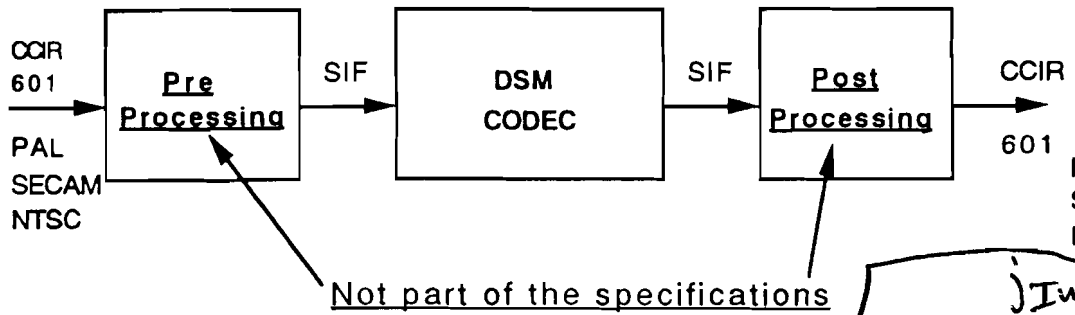
Conversion of S.I.F. into CCIR601 format

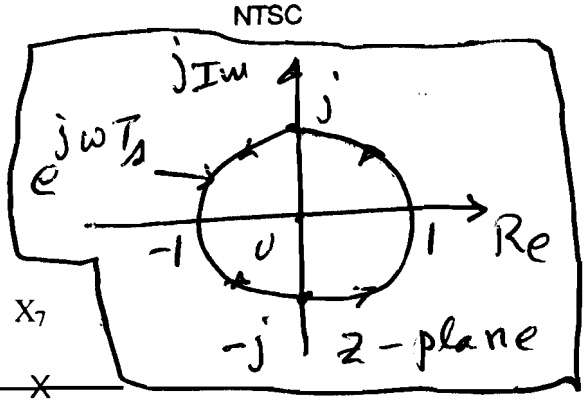
(H & V) 1:2 ↑ Interpolation

-12	0	140	256	140	0	-12	//256

Table 2.3 Interpolation Filter

1:2 (Horizontal) ↑ (Same for Y & C_r, C_b)





SIF to CCIR-601

Original pels

X_0 X_1 X_2 X_3 X_4 X_5 X_6 X_7

Interpolated pels (1:2 ↑) $(a_0, a_1, a_2, ...)$

EXAMPLE

a_0 a_1 a_2 a_3 a_4 a_5 a_6 a_7 ← Interpolated pels

X_0 0 X_1 0 X_2 0 X_3 0 X_4 0 X_5 0 X_6 0 X_7 0

X_0 X_1 X_2 X_3 X_4 X_5 X_6 X_7 ← original pels

Example: $[-12 \quad 0 \quad 140 \quad 256 \quad 140 \quad 0 \quad -12]$

$$a_3 = \frac{1}{256}[256 + 140(x_3 + x_4) - 12(x_2 + x_5)] \qquad //256$$

$$H(z) = \frac{1}{256}[256 + 140(z^{-1} + z) - 12(z^{-3} + z^3)]$$

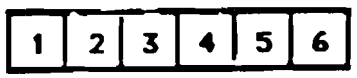
$$H(e^{j\omega T_s}) = [256 + 140(e^{-j\omega T_s} + e^{j\omega T_s}) - 12(e^{-j3\omega T_s} + e^{j3\omega T_s})] \qquad //256$$

$$H(e^{j\omega T_s}) = [128 + 140(\cos\omega T_s) - 12\cos 3\omega T_s] \;//\; 128$$

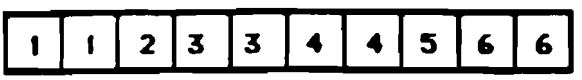
Common decoder for 24/25/30 frames/sec. sources.
(K. Yang, S. Singhal & A. Wong : BELLCORE)

(ISO - JTC - 1/SC2 WG8 MPEG 90/March 1990)

30 Frames/sec



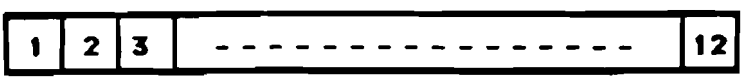
50 Fields/sec



(30 : 50) = (3 : 5)

---

25 frames/sec

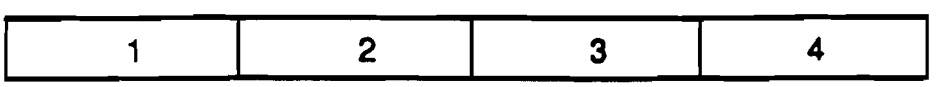


50 Fields/sec

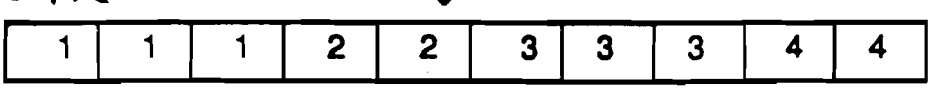
(25 : 50) = (1 : 2)

---

24 Frames/sec



60 Fields/sec

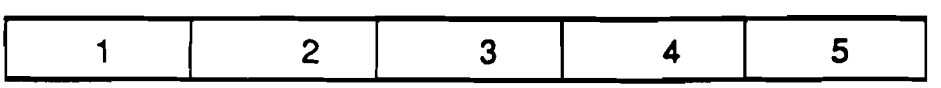


(24 : 60) = (4 : 10)

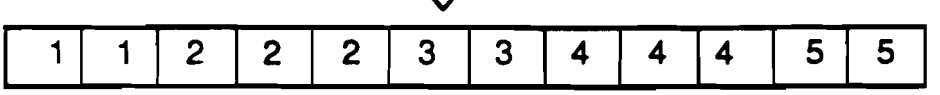
(3 : 2 PULL DOWN)

---

25 Frames/sec



60 Fields/sec



(25 : 60) = (5 : 12)

(24 frames/sec used in Movies)

POSSIBLE FIELD REPEAT PATTERNS (NOT PART OF MPEG)

G. de Haan, P.W.A.C. Biezen and O.A. Ojo, "An evolutionary architecture for motion-compensated 100 Hz television" IEEE Trans CSVT, vol. 5, pp. 207-217, June 1995.