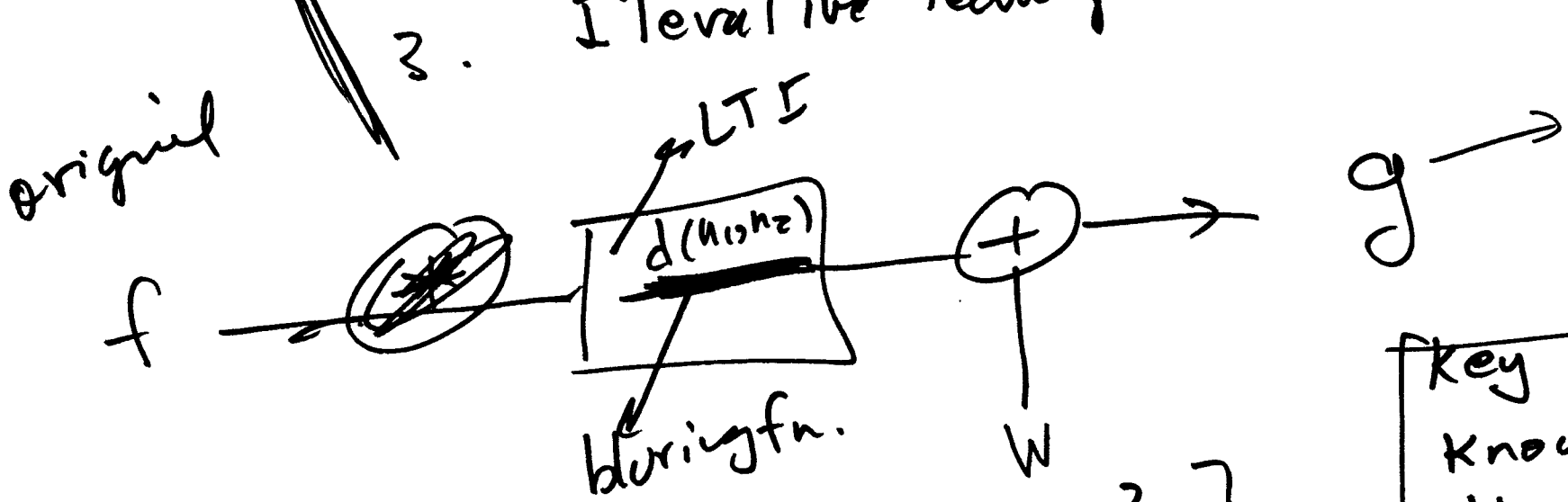
Image Restoration.

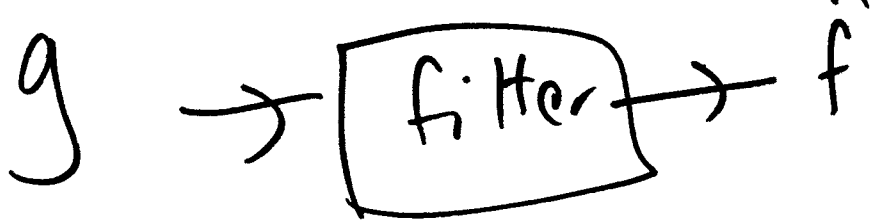
4-23-03

3 methods:

1 - Inverse filter
2 - least square filters → weiner filter, constrained least square.
3. ITerative techniqu.



$$E\left[(f-\hat{f})^2\right]$$

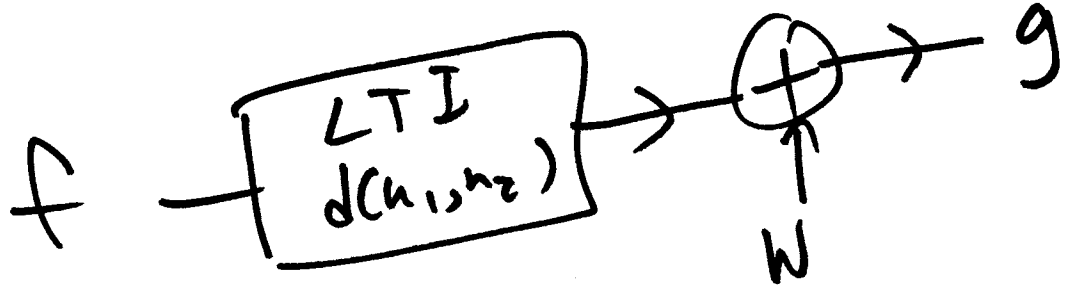


Key assumption:
Know d(n1,n2) blur function.

How about if we don't know d(n1,n2)?

When $d(n_1, n_2)$ = blurring fn is unknown

$\Longrightarrow$ Blind deconvolution.



① Estimate parameters of the blur fn.

Know what kind of Blur
- Atmosphere
- out of focus
- motion.

Approach: look @ F.T. of g.

zeros of $G(w_1, w_2)$ tell you about parameters of blur function
- R in out of focus cam
- L, ϕ, motion blur.

- Can also look @ cepstrum.

spectrum.

~~cep~~ · spectrum of $G(\omega_1, \omega_2)$

cepstrum of $g = \hat{g}(n_1, n_2) = \cancel{F^{-1}\{\log|G(\omega_1,\omega_2)|\}}$

$$= F^{-1}\{\log|G(\omega_1, \omega_2)|\}$$

$$\begin{tikzcd} X \arrow[r] & \otimes \arrow[r] \arrow[d] & xy. \\ & y & \end{tikzcd}$$

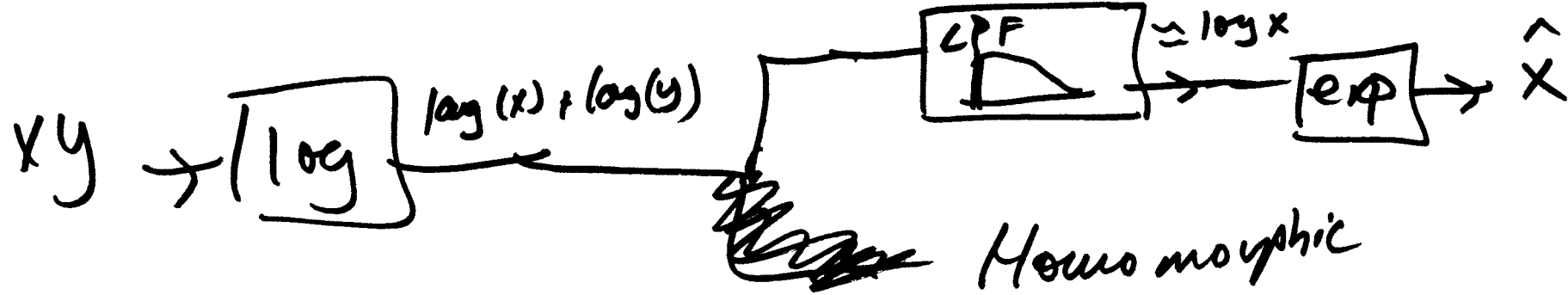
multiplicative noise

$$\log(xy) = \log(x) + \cancel{\log(y)}$$

apply LTI

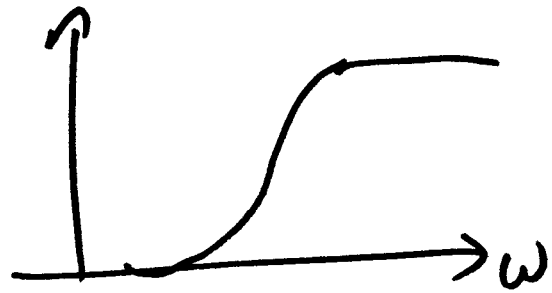
$= \log(x)$

homop $\rightarrow x$

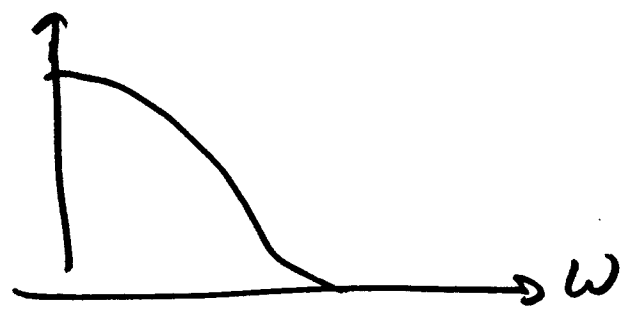


Homomorphic filtering.

$\log(y)$



$\log x$



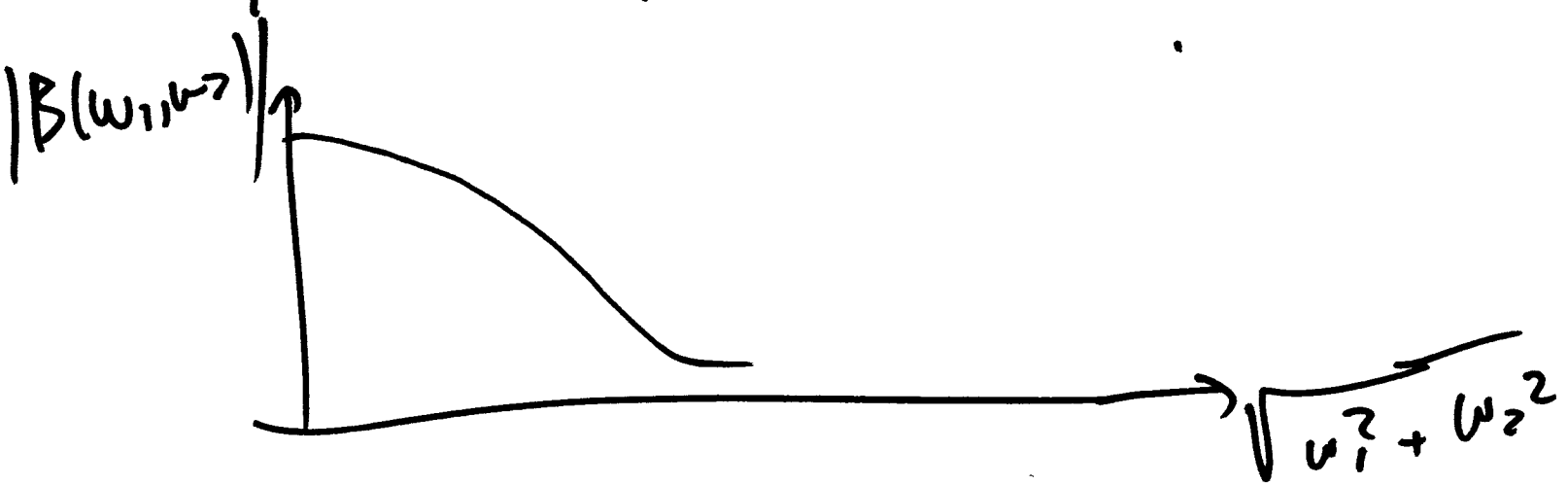
Blind deconvolution where nothing is known about blur fn

$$F(\omega_1,\omega_2) \longrightarrow \boxed{B(\omega_1,\omega_2)} \longrightarrow G(\omega_1,\omega_2)$$

Assumption $|B(\omega_1,\omega_2)|$ is smooth fn.

$$G(\omega_1,\omega_2) = F(\omega_1,\omega_2)\, B(\omega_1,\omega_2)$$

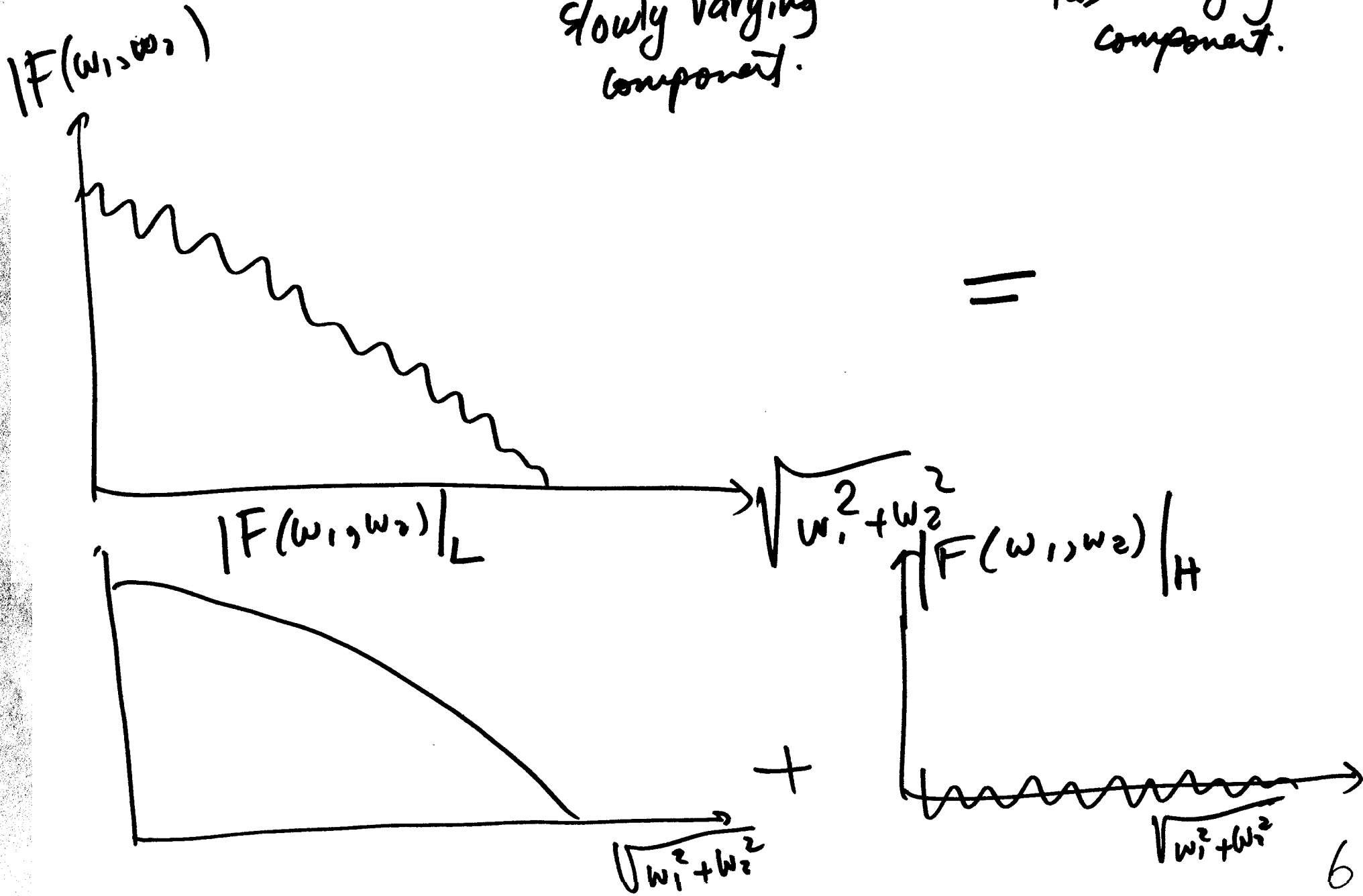
$$|G(\omega_1,\omega_2)| = |F(\omega_1,\omega_2)|\,|B(\omega_1,\omega_2)|$$

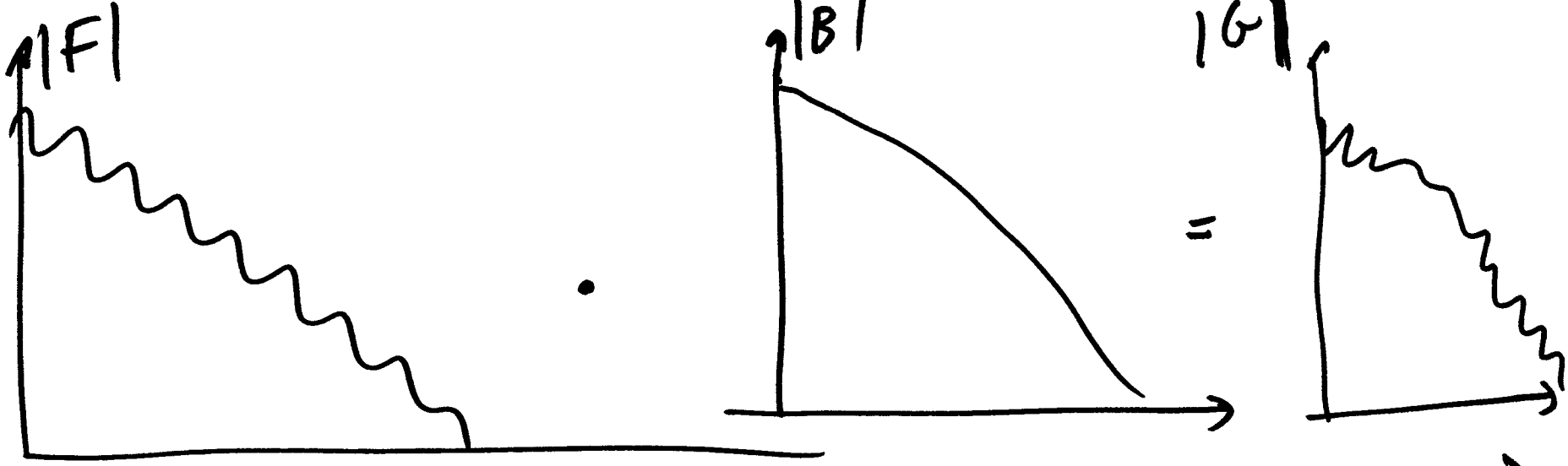


$$|F(\omega_1,\omega_2)| = |F(\omega_1,\omega_2)|_L + |F(\omega_1,\omega_2)|_H$$

slowly varying component.

fast varying component.



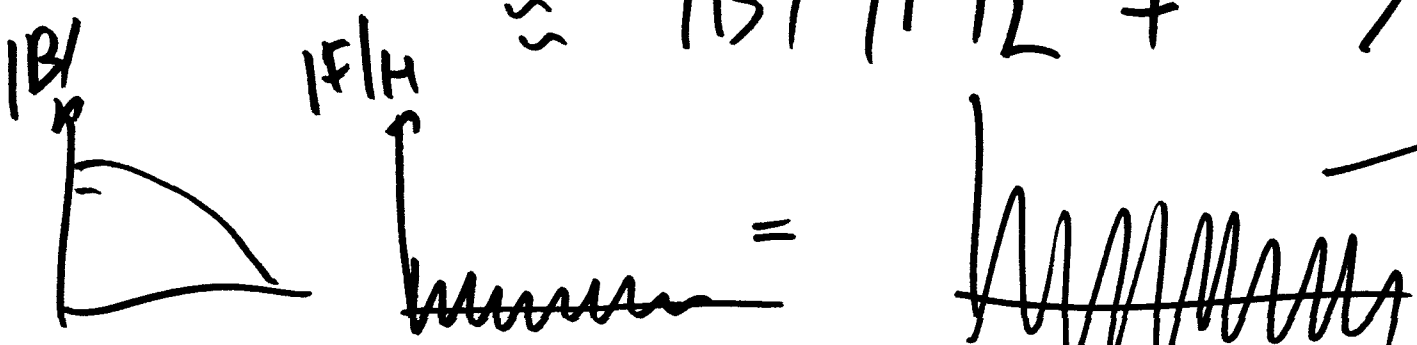


$$|G(\omega_1,\omega_2)| = |B(\omega_1,\omega_2)| \left(|F(\omega_1,\omega_2)|_L + |F(\omega_1,\omega_2)|_H \right)$$

$$|G| = |B|\,|F|_L + |B|\,|F|_H$$

$$S\{|G|\} = S\{|B|\,|F|_L\} + S\{|B|\,|F|_H\}$$

$$\approx |B|\,|F|_L + \emptyset$$



smoothing applied to this results in $\emptyset$

$$S\{|G|\} \simeq |B|\,|F_0|_L$$

$$\boxed{|B| \simeq \frac{S\{|G|\}}{|F|_L}}$$

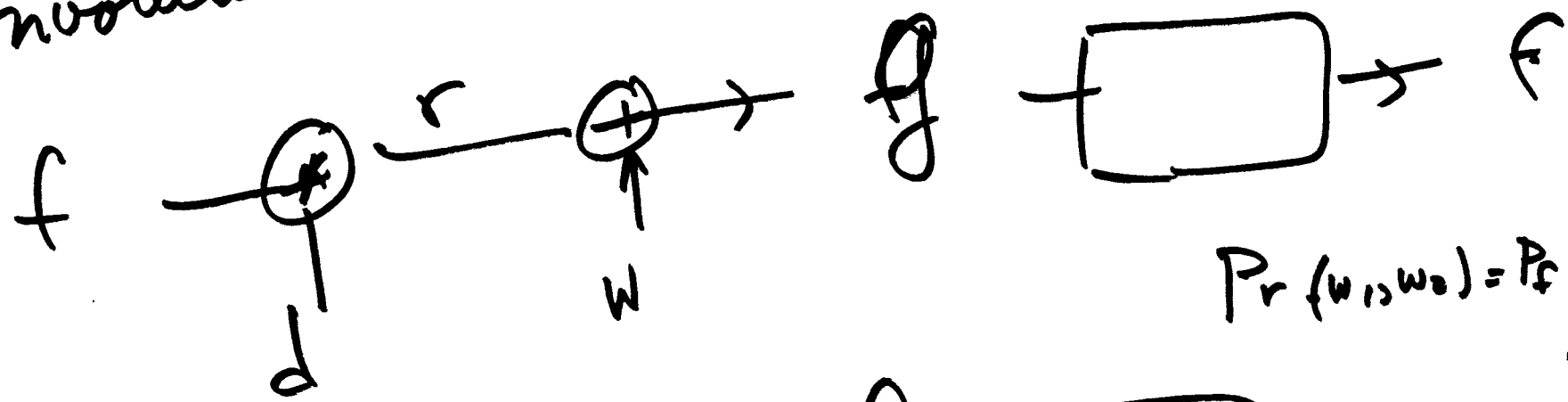
Ensemble of images $|F'|_L$ = average over.

$$\boxed{|B| \simeq \frac{S|G|}{|F'|_L}}$$

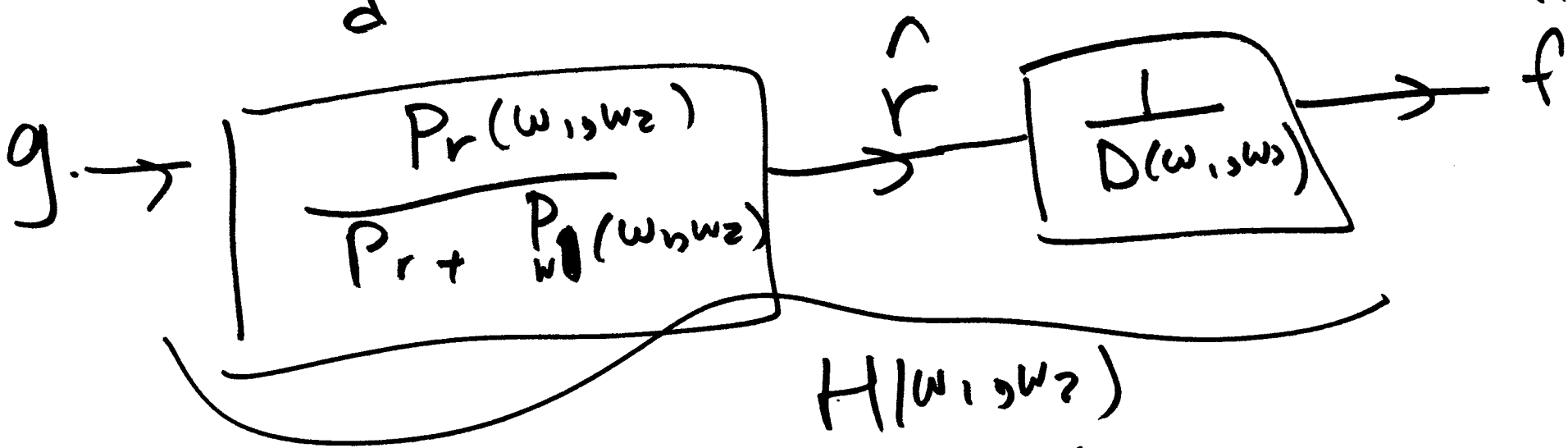
$\angle B(\omega,\omega_y) \simeq 0 \longrightarrow$ zero phase filter.

Reduction of more Than 1 degradation

Convolutional noise + Additive noise



$$P_r(\omega_1,\omega_2) = P_f\,|D(\omega_1)|^2$$



$$H(\omega_1,\omega_2) = \frac{P_f \cdot D^*}{P_f\, D \cdot D^* + P_w}$$

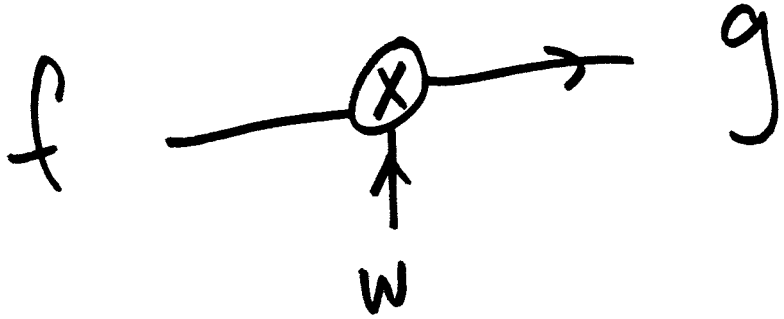
N Degradation

$$f \rightarrow \text{Deg } 1 \rightarrow \text{Deg } 2 \text{ — — . . . .}$$

$$\text{Deg } N \rightarrow g$$

$$g \rightarrow \boxed{\text{Undo Deg } N} \rightarrow \boxed{\text{Undo Deg } N-1} \text{ . . . . .}$$

Reduction of multiplicative noise



$$g(n_1, n_2) = f(n_1, n_2)\, w(n_1, n_2)$$

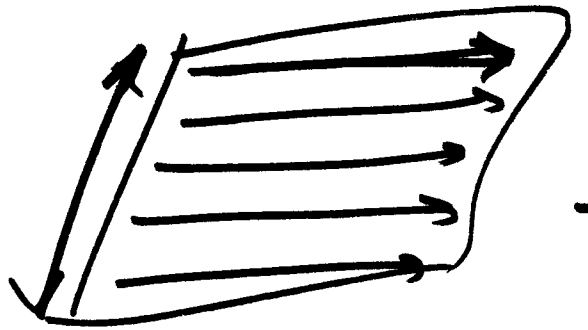
$$\log(g) = \log f + \log w$$

$$g' = f' + w'$$

$\Longrightarrow$ apply any additive noise reduction Technique.

$$g \rightarrow \boxed{\log} \rightarrow \boxed{\text{additive noise red.}} \rightarrow \boxed{\exp} \rightarrow \hat{f}$$

TV Signal:



NTSC

30 frames/sec.

frame → even field
→ odd field.

frame: 500 lines.
each line 500 pixels/line.

$500 \times 500 \times 30 \times 2 \approx$ bits/sec.

~~625~~ 200,000,00

≈ Two hundred Mega bits/sec.

DSL ≈ 600 kb/s ~ 1 mb/s.

cable ≈ 1 mb/s.

2×10^8 bits / s.

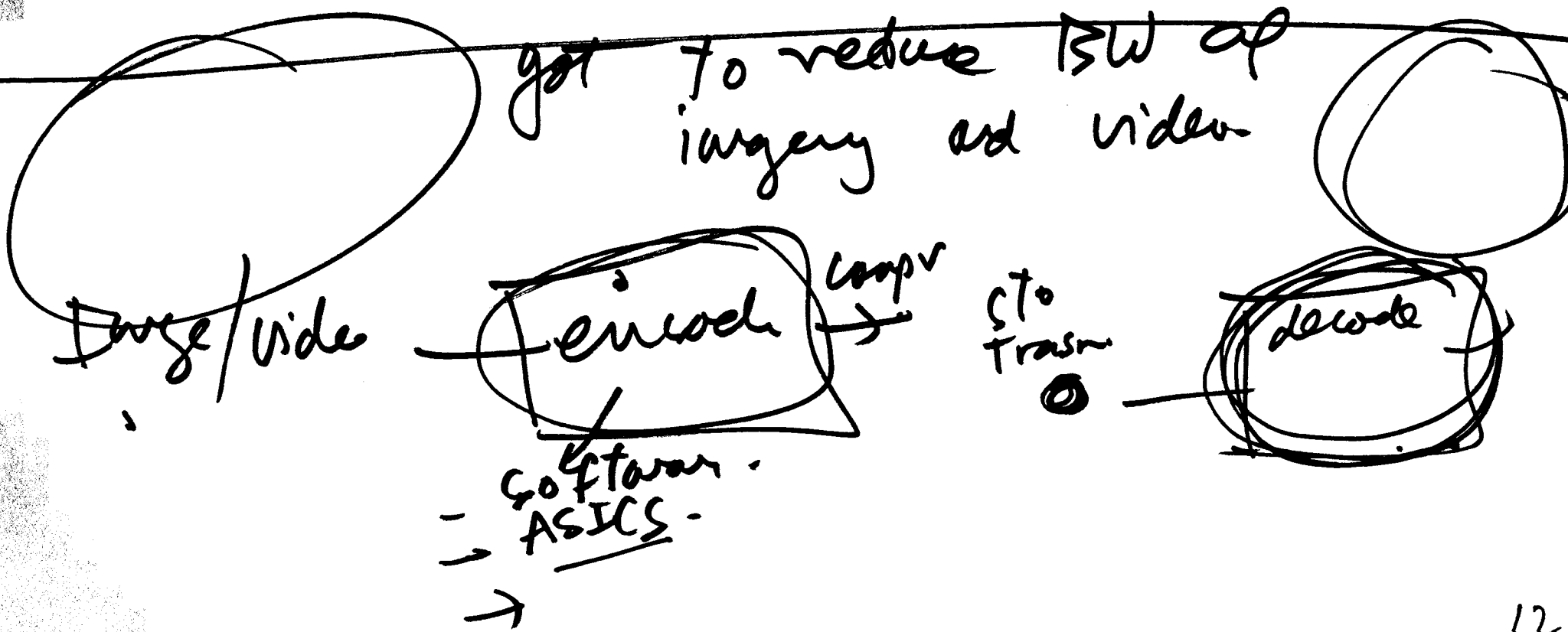
$2 \times 60 \times 60 = 7200 \simeq 10{,}000 \simeq 10^4$

2×10^{12} bits

Giga byte $\simeq 10^{10}$ bits

$\Rightarrow$ 200 GB for 2 hour TV program.

got To reduce BW of imagery and video



live.

non-live

one way vs Two ways

audio / video. Sync.