Condition Monitoring of Industrial Fans

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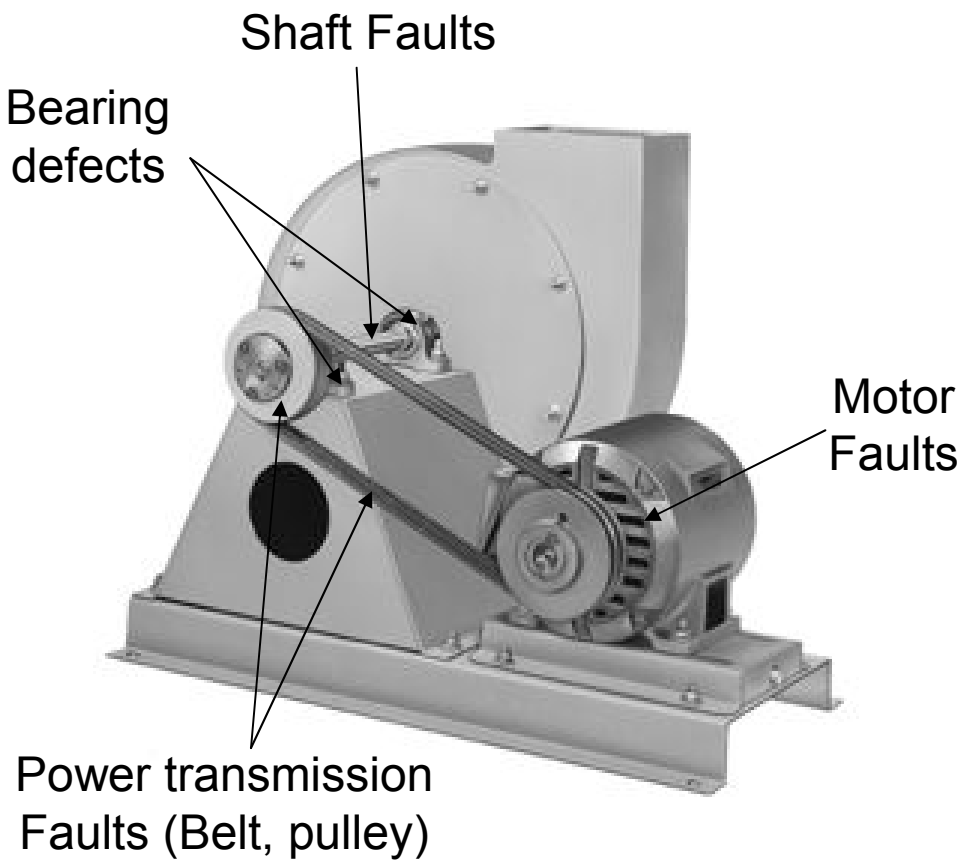
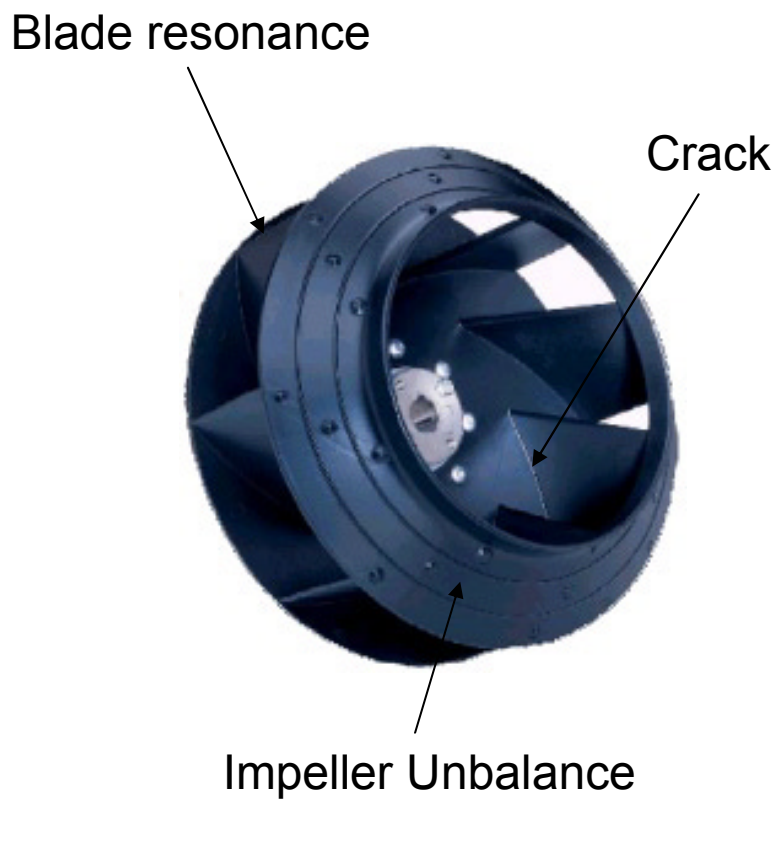
Outline

- Fault Categorization
- Unbalance
- Shaft Faults
- Bearing Defects
- Resonance
- Conclusions and Future Work

Fault Categorization



www.nyb.com/frames/products_fr.htm



www.continentalfan.com/tek.htm

Unbalance sources – Tolerable level

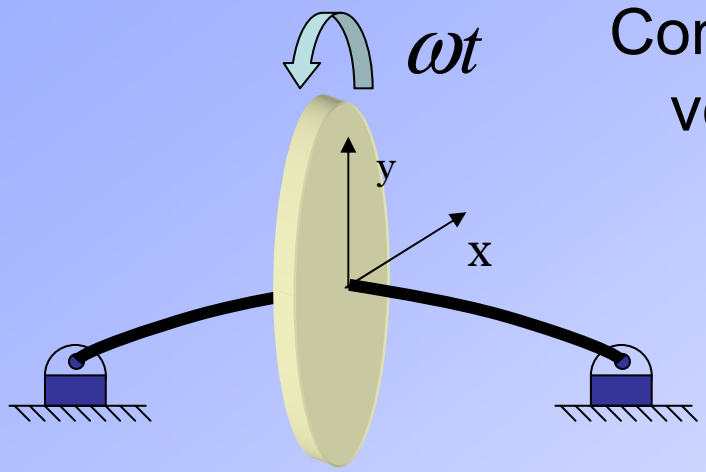
- Impeller fabrication
- Loose hub, bolt, balance weight
- Material deposition inside airfoil blades
- Temperature variation
- Deformation
- Broken blades
- Corrosion
- Particle adherence

ANSI/AMCA standard 204-96

"Balance Quality and Vibration Levels for Fans"

The acceptable vibration level of the Fan for different applications (Residential, HVAC, Industrial, Transportation, Petrochemical, Computer Chip Mfg.)

Unbalance Detection – Theoretical View



Constant when rotation velocity is constant

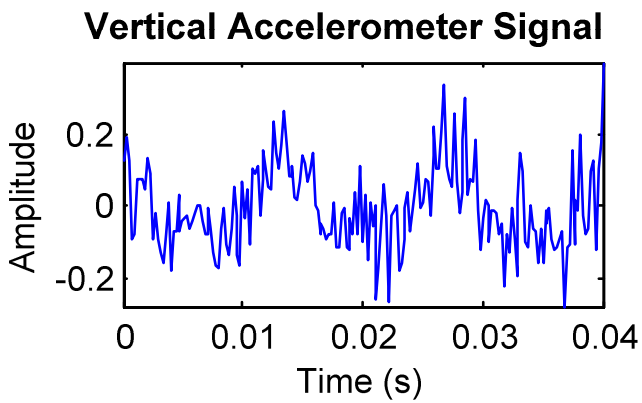
$$F = me\omega^2 \sin \omega t$$

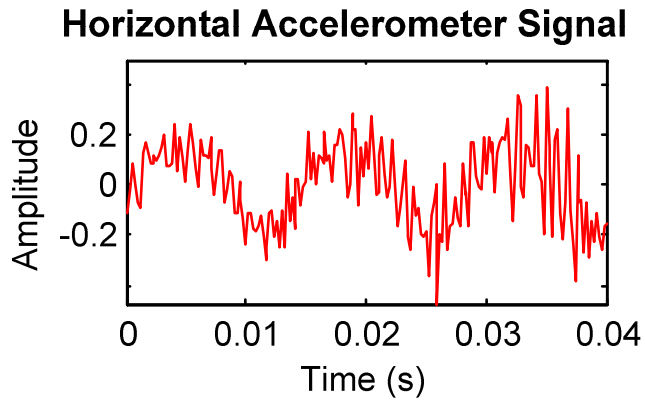
Sinusoidal at the shaft frequency

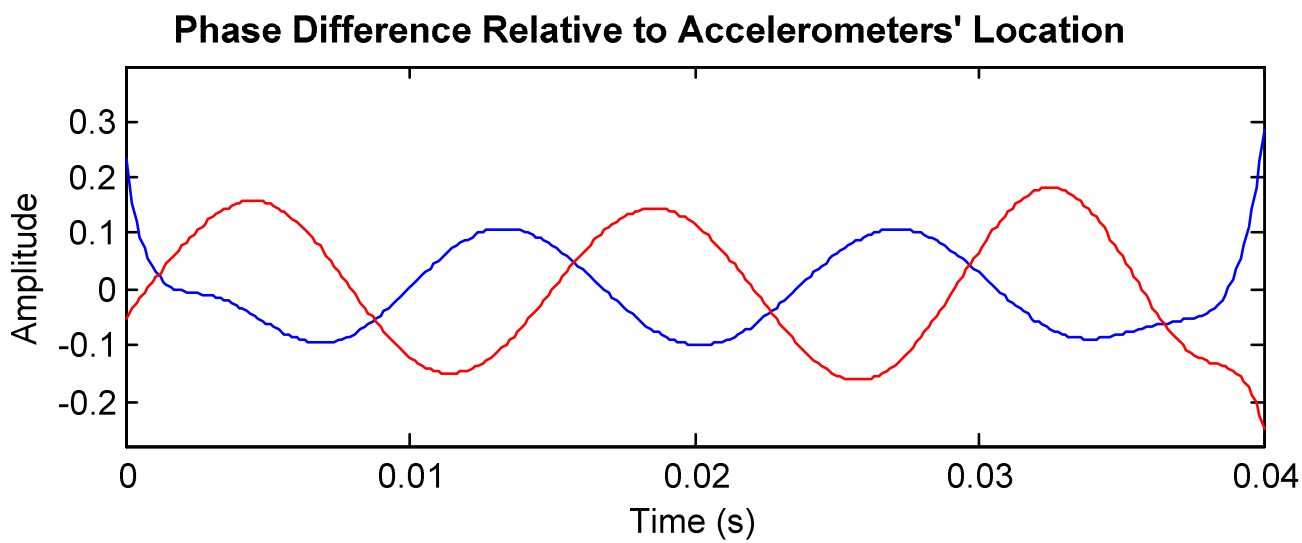
Unbalance force is a rotating vector

Vibration Phase follows the location of detecting point

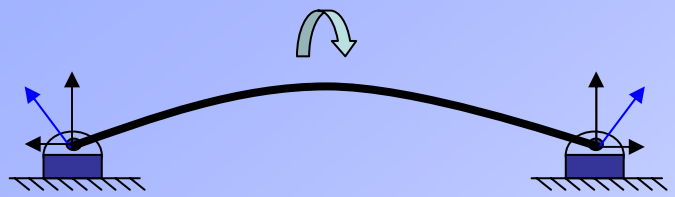
Unbalance Detection – Practical View

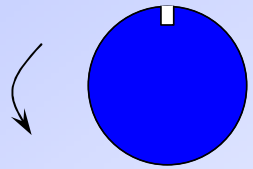






Shaft Faults





Misalignment

- Caused by:
  - Bent shaft
  - Improper seated bearing
  - Shaft center offset
- How to detect:
  - 150º - 200º phase shift at the ends
  - High second harmonic

Crack

- Caused by:
  - Fatigue
  - Non-homogenous material
  - Machining defect
- How to detect:
  - First harmonic
  - Phase analysis

Bearing Fault Detection Methods

- Ratio of Peak vibration to RMS (Tandon)
- Probability density and Kurtosis (Dyer)
- Shock pulse method
- Analysis of characteristic frequencies
- Power cepstrum (Collacott)
- Envelope detection
- Wavelet transform (Zhengjia)

Analysis of Characteristic Frequencies

- Defect on outer race
- Defect on inner race
- Ball defect
- Train defect

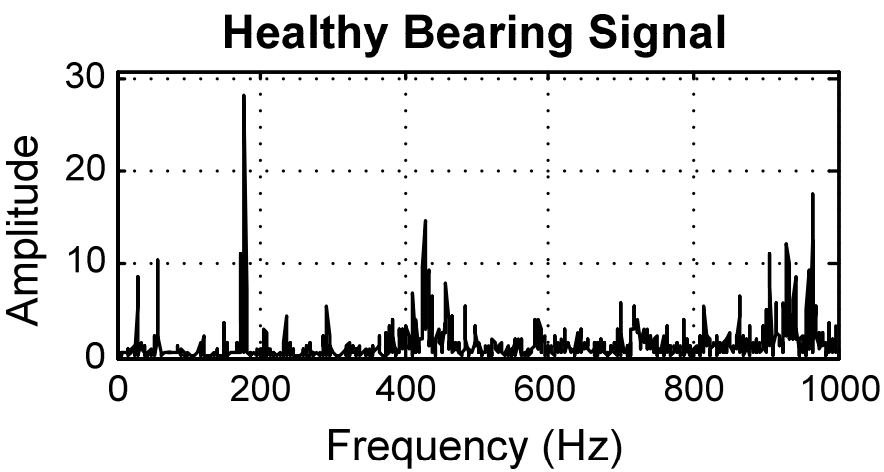
$$f(f_r, N, d_b, d_p, \beta)$$

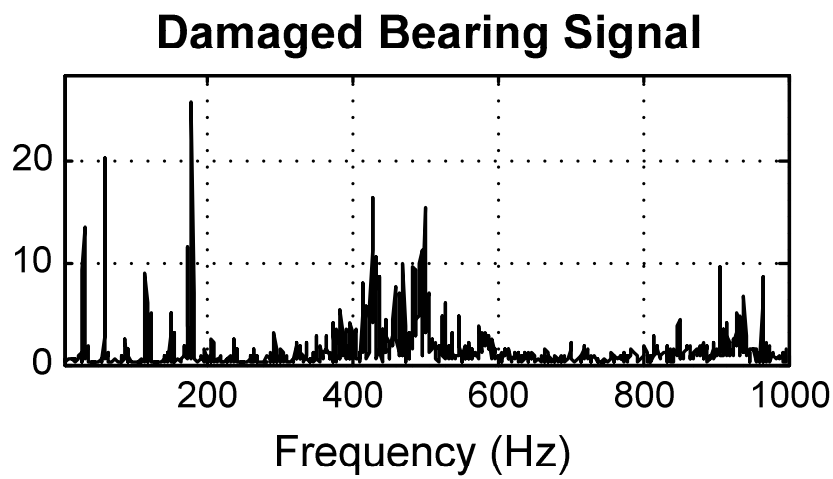
f_r: Rotational frequency

d_b, d_p : Ball, Pitch diameter

N: Number of Balls

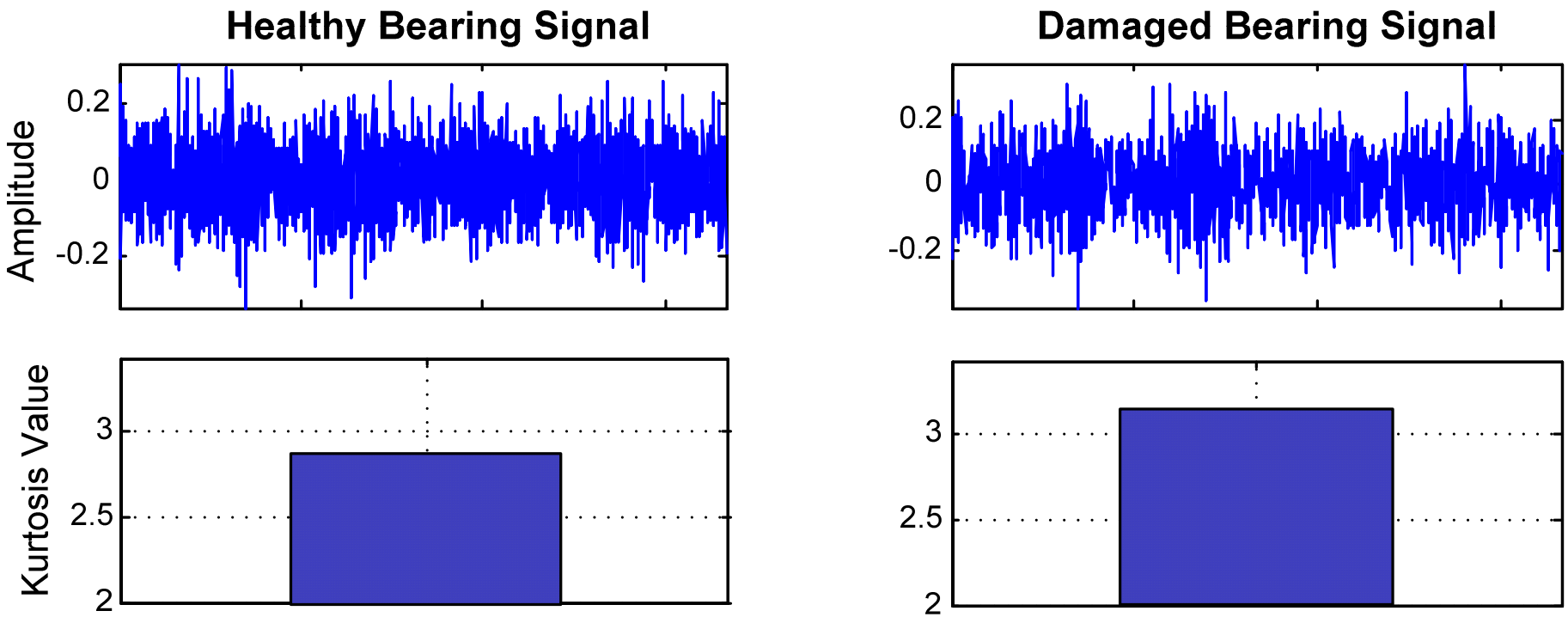
β: Contact angle





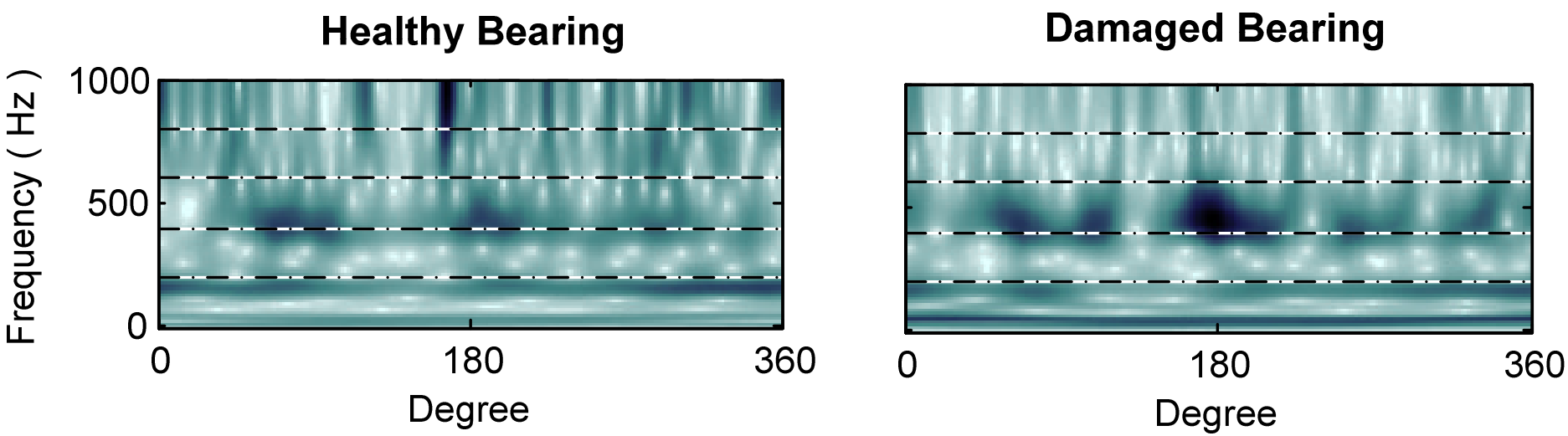
Kurtosis

- The forth statistical moment of signal normalized with fourth power of standard deviation
- Damaged bearing β>3



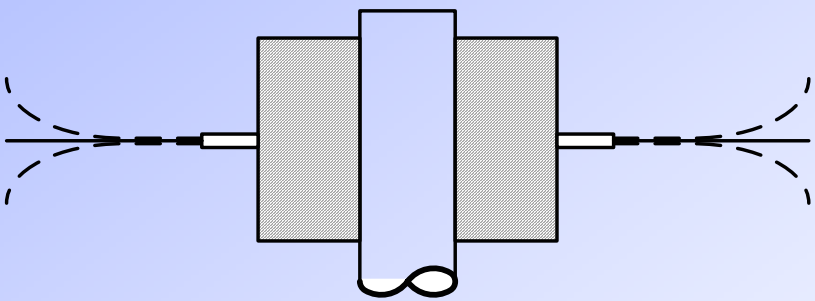
Wavelet Transforms

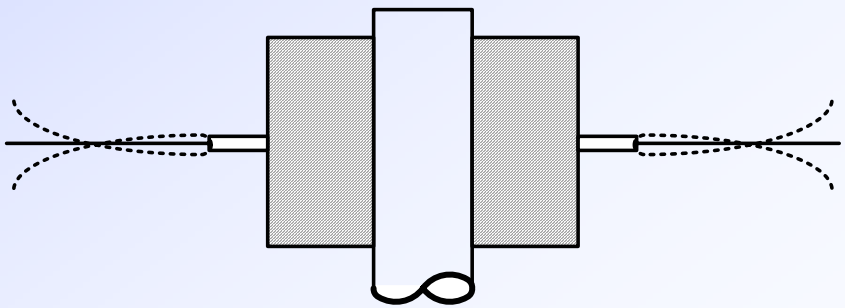
- A time-frequency domain transform base on Morlet wavelet
- High sensitivity to early stage defects



Blade Resonance

- Usually Occurs within one of first three harmonics of the shaft frequency
- Extensively depends on rotation speed
- Phase is not constant





Conclusion and Future work

- Imbalance, Shaft fault, bearing defect, and blade resonance are common sources of fault in fans and can be detected through vibration analysis
- Studying the effect of pressure and fluid damping on the level of vibration
- Introducing a decision making algorithm for diagnosing industrial fans

Thank You

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