Phase Characteristics of FIR Filters

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Symmetric FIR Filters Special! Have Desirable Phase & Delay

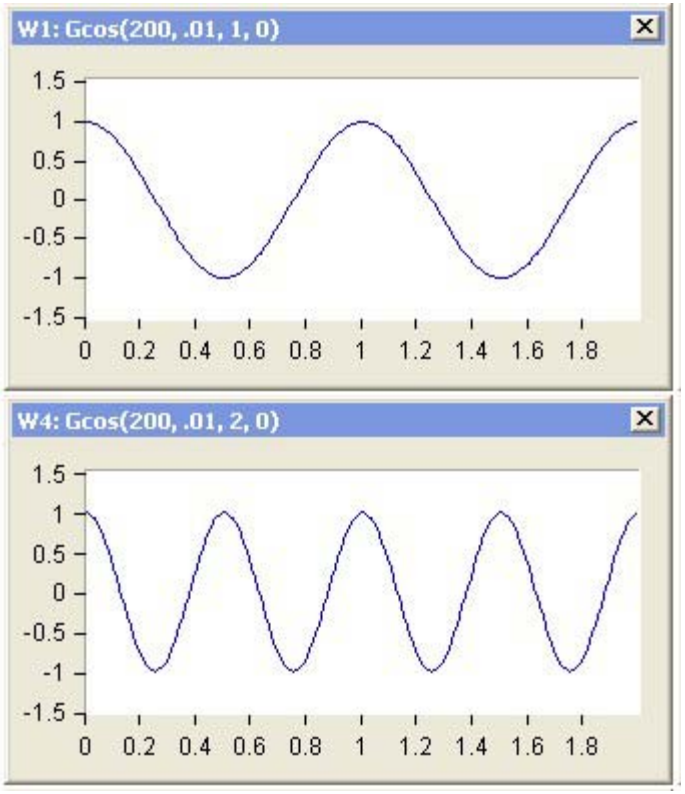
- Symmetric: $B_0 = B_{M-1}, B_1 = B_{M-2} \cdots$
- Anti-symmetric: $B_0 = -B_{M-1}, B_1 = -B_{M-2} \cdots$
- Provides constant delay for any frequency.
- Useful when filters are included in timing applications, for example. Filter delay is same, irrespective of signal input.

Group Delay Used To Quantify Phase Changes

- Phase of filter given by <H(F).
- Group Delay defined as: $\frac{1}{2\pi}\frac{-d\{<H(F)\}}{dF}$
- A constant group delay implies:
  - Linear phase variation
  - Constant delay, for any frequency
  - No dispersion. Hence no change in overall signal shape due to non-linear phase shifts.

Dispersion Alters Signal Shape

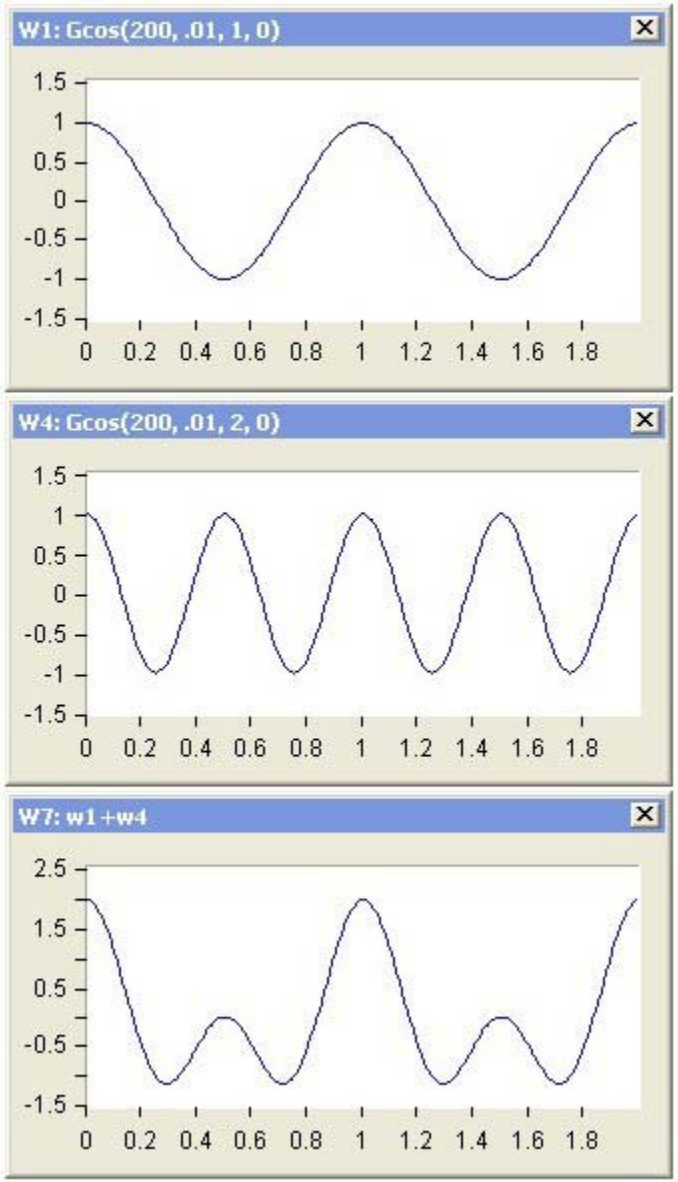
- Consider two sinusoids.
- f1=1, f2=2.
- Imagine where peak of sum occurs…?



Dispersion Alters Signal Shape

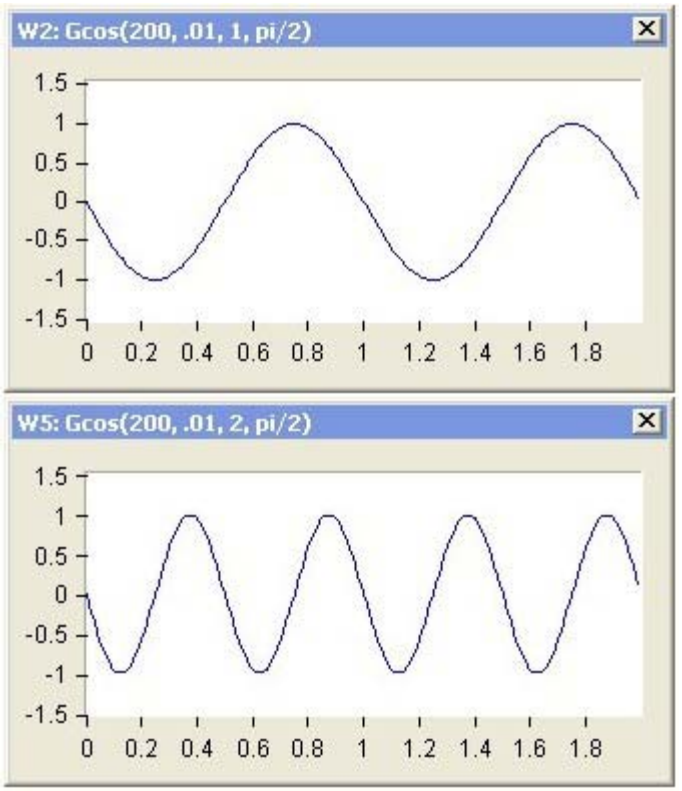
- Consider two cosines.
- f1=1, f2=2.
- Imagine where peak of sum occurs…?

- Where peaks of cos()'s align.



Dispersion Alters Signal Shape

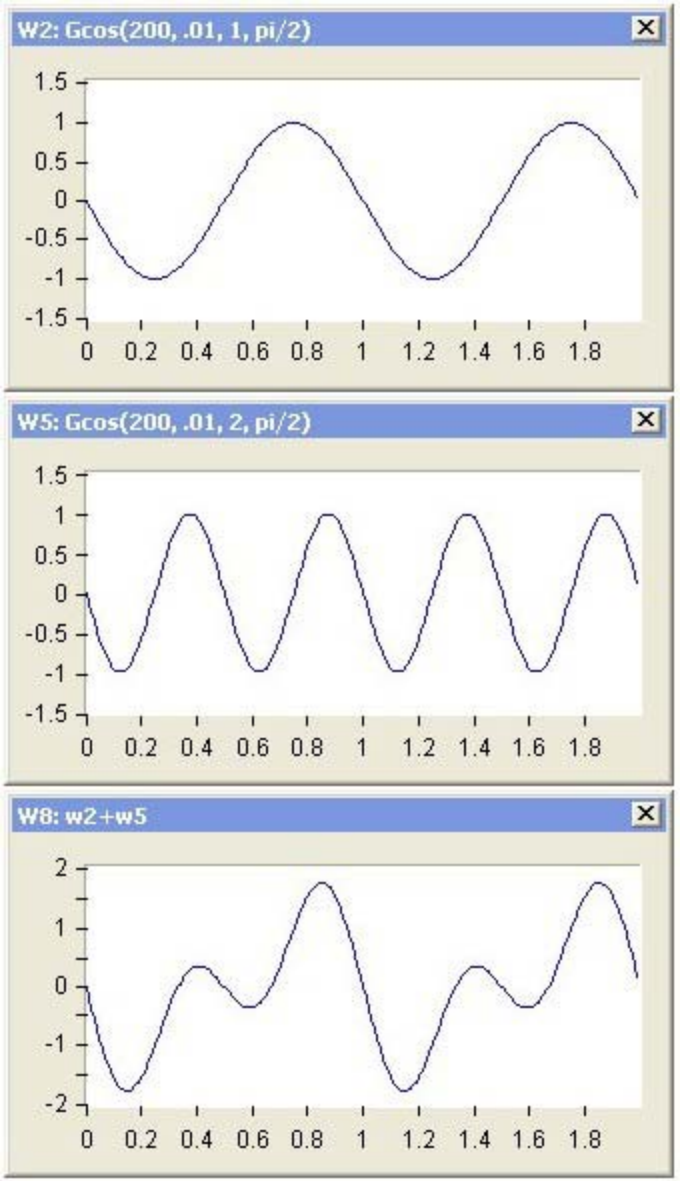
- *Consider effect of phase shift on signal shape…*
- Each cos() is shifted by pi/2.
- Does shape of sum change for shifted versions?
- Is peak altered?



Dispersion Alters Signal Shape

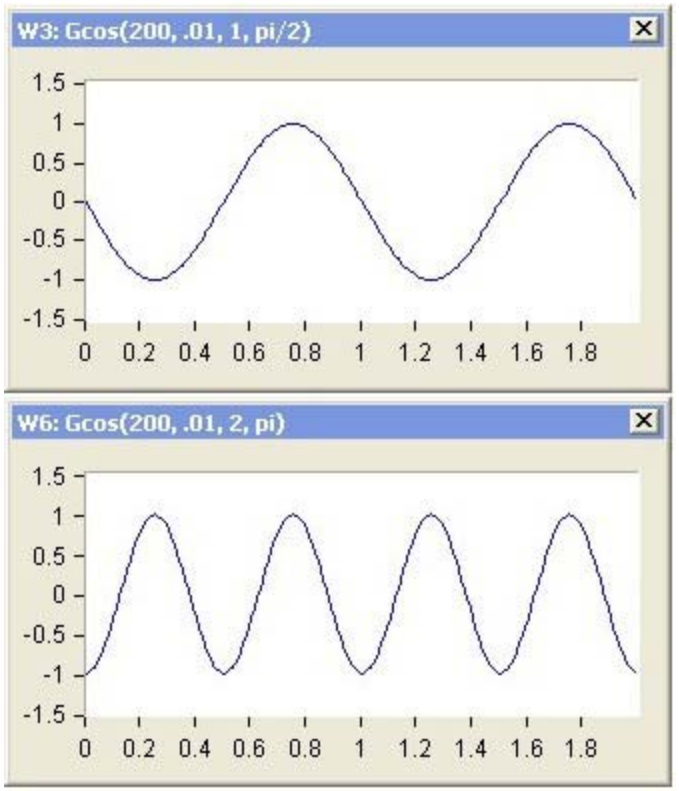
- *Consider effect of phase shift on signal shape…*
- Each cos() is shifted by pi/2.
- Does shape of sum change for shifted versions?
- Is peak altered?

- Yes!



Dispersion Alters Signal Shape

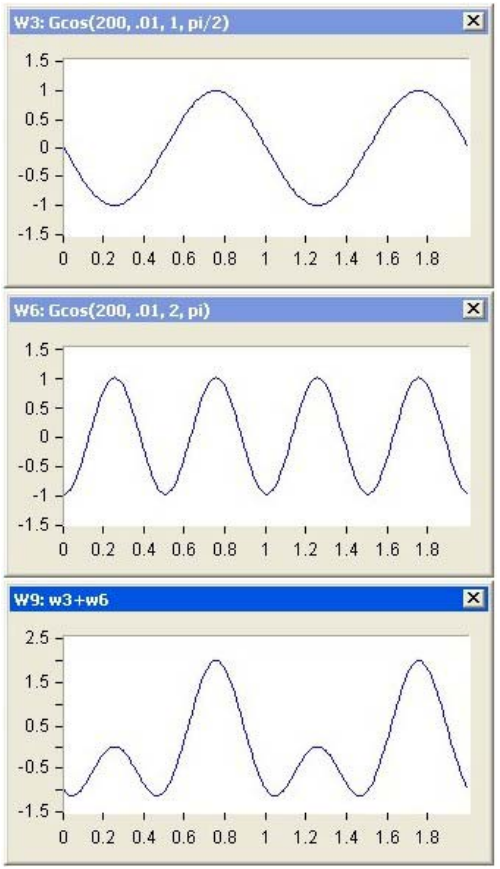
- *Consider a linear phase shift*
- Each cos() is shifted in proportion to frequency.
- Does shape of sum change for shifted versions?



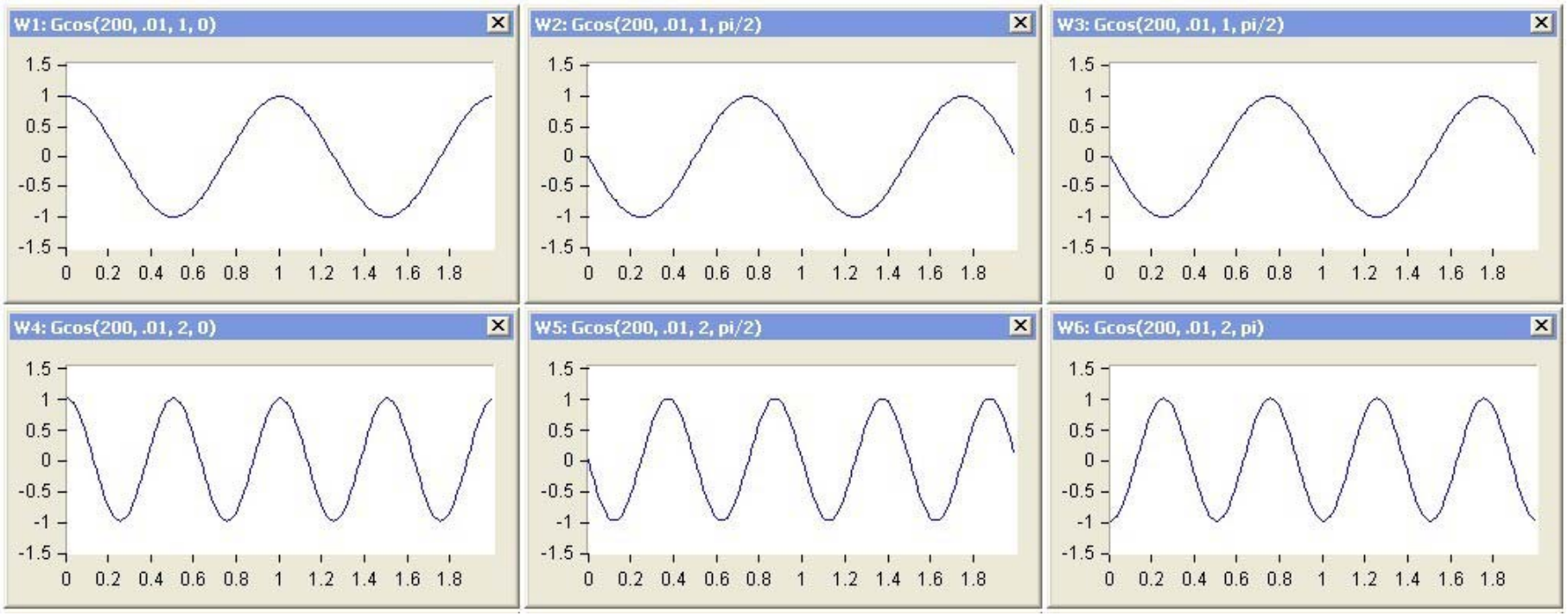
Dispersion Alters Signal Shape

- *Consider a linear phase shift*
- Each cos() is shifted in proportion to frequency.
- Does shape of sum change for shifted versions?

- No! **A linear phase shift results in a pure delay!**



Dispersion Alters Signal Shape (*Try adding wave shapes*!)



Constant Group Delay is Useful

- A constant group delay implies:
  - Linear phase variation
- Constant delay, for any frequency.
  - Useful when filters are included in timing applications, for example. Filter delay is same, irrespective of signal input.
- No dispersion, so no change in overall signal shape.
  - Useful when trying to recognize wave shape, or find peak of a wave shape (for example) in time domain.