# Moving Target Indicators

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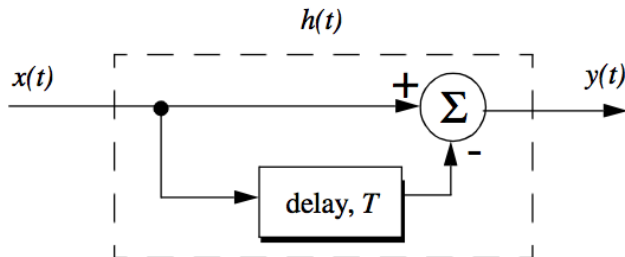April 25, 2014

# Single Delay Line Cancelers



Figure : Single delay line canceler

Source: Bassem R. Mahafza. *Radar Systems Analysis and Design Using MATLAB®*. Chapman & Hall/CRC, 2000.

# Single Delay Line Cancelers

$$h(t) = \delta(t) - \delta(t - T)$$
$$H(\omega) = 1 - e^{-j\omega T}$$
$$|H(\omega)|^2 = H(\omega)H^*(\omega)$$
$$= (1 - e^{-j\omega T})(1 - e^{j\omega T})$$
$$= 2(1 - cos\omega T)$$
$$= 4(sin(\omega T/2))^2$$

Source: Bassem R. Mahafza. *Radar Systems Analysis and Design Using MATLAB®*. Chapman & Hall/CRC, 2000.
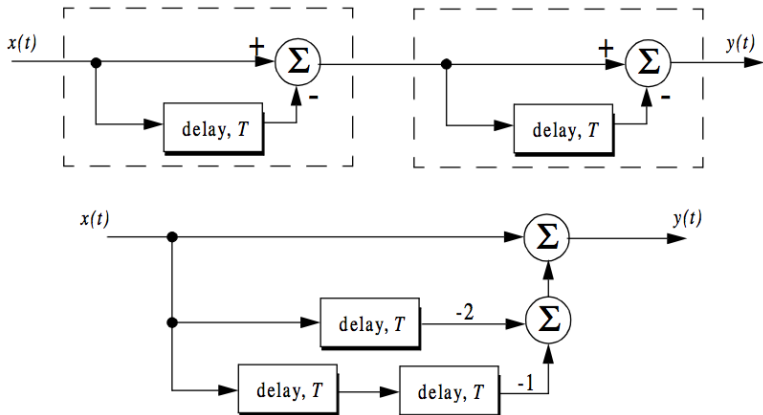
# Double Delay Line Cancelers



Figure : Two configurations for a double delay line canceler

Source: Bassem R. Mahafza. *Radar Systems Analysis and Design Using MATLAB®*. Chapman & Hall/CRC, 2000.

# Double Delay Line Cancelers
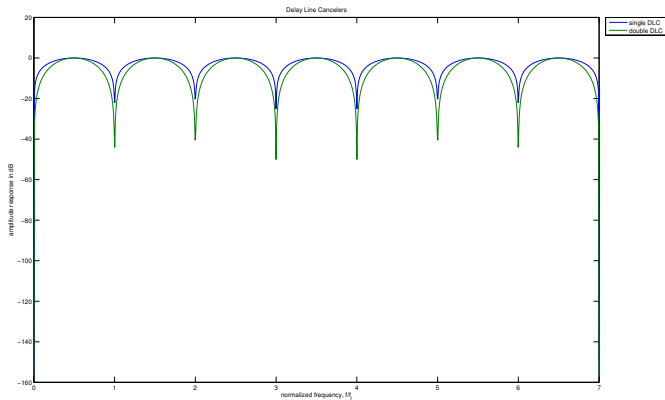
$$h(t) = \delta(t) - 2\delta(t - T) + \delta(t - 2T)$$

$$|H(\omega)|^2 = |H_1(\omega)|^2 |H_1(\omega)|^2$$

$$where \ |H_1(\omega)|^2 = 4(sin(\omega T/2))^2$$

$$|H(\omega)|^2 = 16 \left( sin \left( \omega \frac{T}{2} \right) \right)^4$$

Source: Bassem R. Mahafza. *Radar Systems Analysis and Design Using MATLAB*®. Chapman & Hall/CRC, 2000.
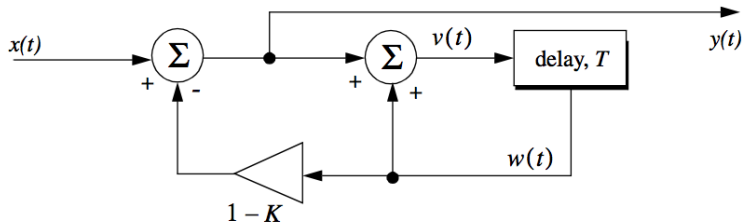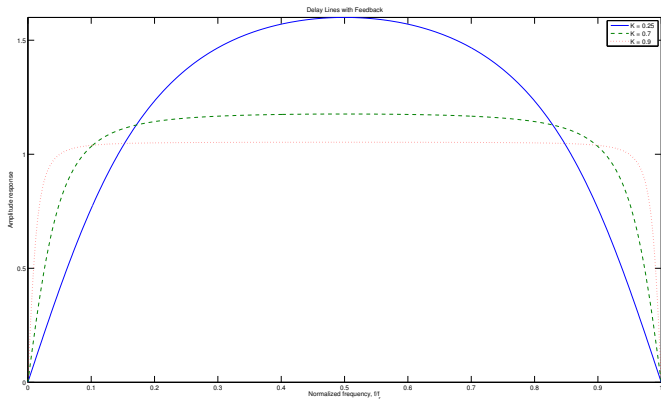
# Delay Line Cancelers



Delay Line Cancelers

# Delay Lines with Feedback



Figure : MTI recursive filter

# Delay Lines with Feedback

$$H(z) = \frac{1 - z^{-1}}{1 - Kz^{-1}}$$

$$|H(z)|^2 = \frac{(1 - z^{-1})(1 - z)}{(1 - Kz^{-1})(1 - Kz)}$$

$$= \frac{2 - (z + z^{-1})}{(1 + K^2) - K(z + z^{-1})}$$

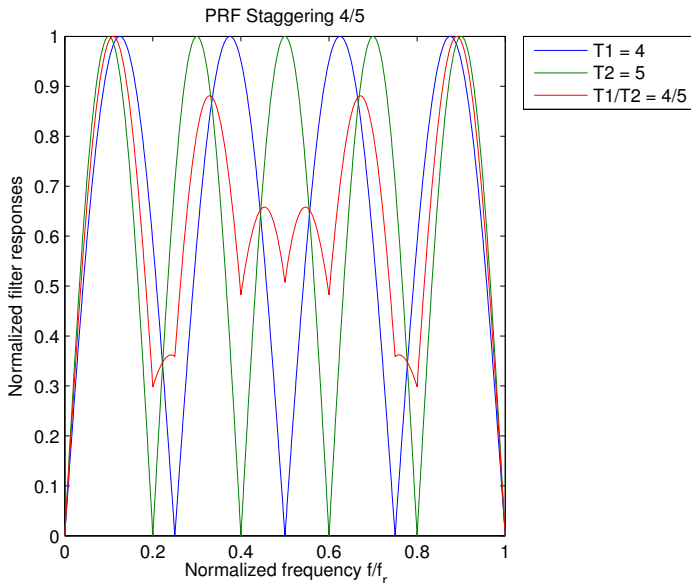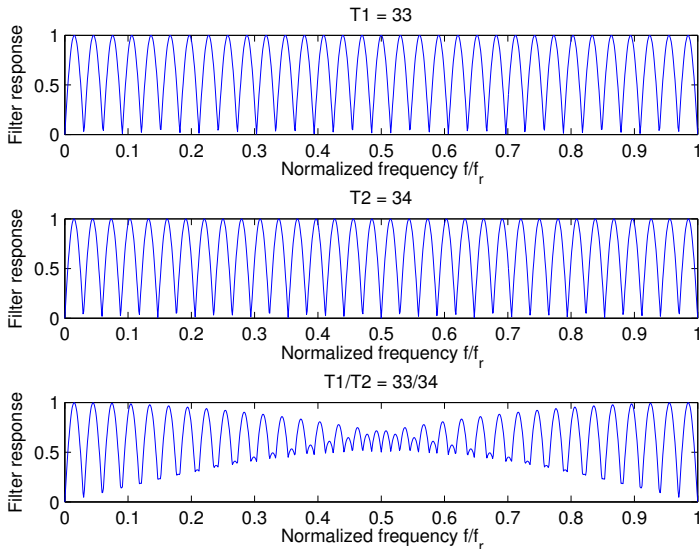$$\left|H(e^{j\omega T})\right|^2 = \frac{2(1 - cos\omega T)}{(1 + K^2) - 2Kcos(\omega T)}$$

# Delay Lines with Feedback



Source: Bassem R. Mahafza. *Radar Systems Analysis and Design Using MATLAB*®. Chapman & Hall/CRC, 2000.

# PRF Staggering 4/5
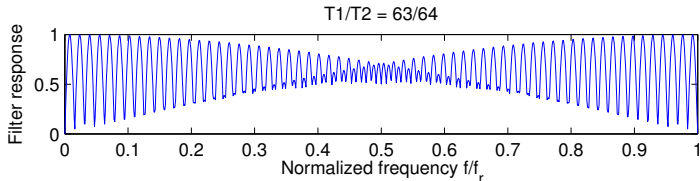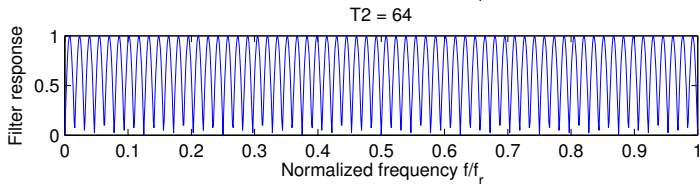


PRF Staggering 4/5

# PRF Staggering 33/34



Source: Bassem R. Mahafza. *Radar Systems Analysis and Design Using MATLAB®*. Chapman & Hall/CRC, 2000.

# PRF Staggering 63/64
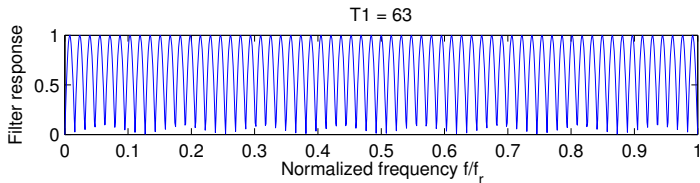
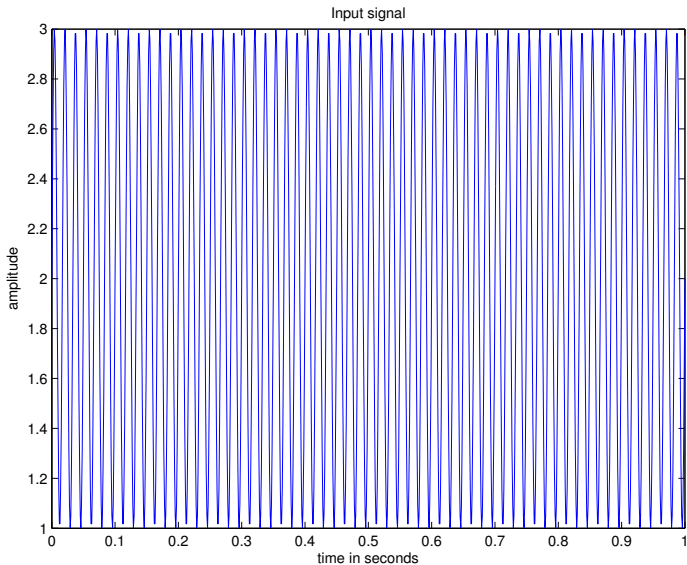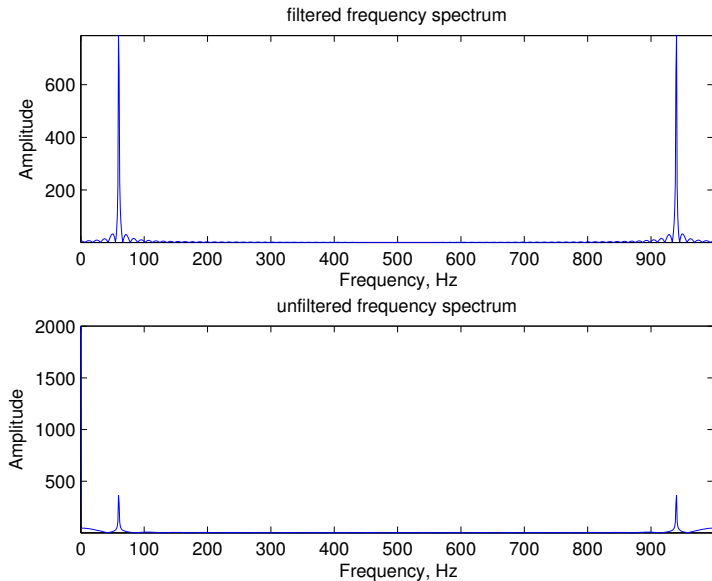# First staggered blind speed

$$\frac{n_1}{T_1} = \frac{n_2}{T_2} = ... = \frac{n_N}{T_N}$$

$$v_{blind} = \frac{n_1 + n_2 + ... + n_N}{N} v_{blind1}$$

Source: Bassem R. Mahafza. *Radar Systems Analysis and Design Using MATLAB®*. Chapman & Hall/CRC, 2000.

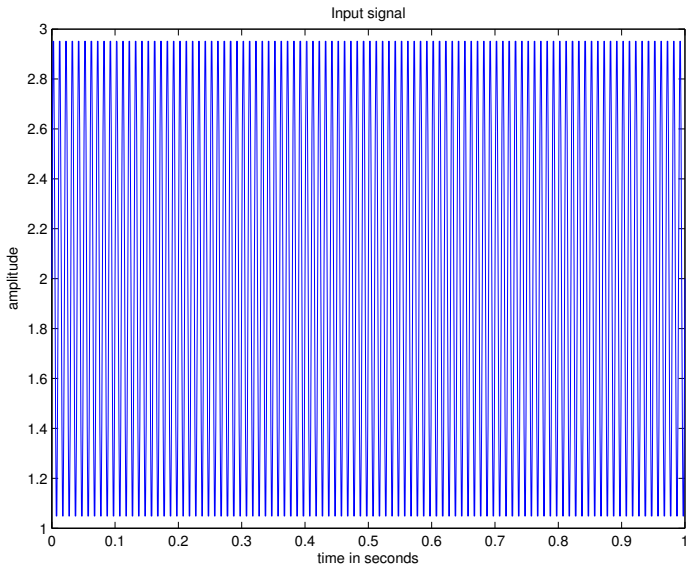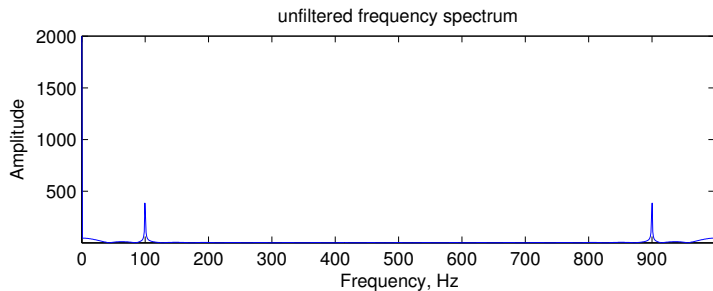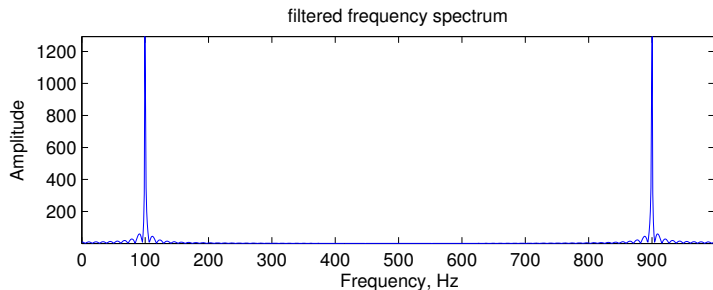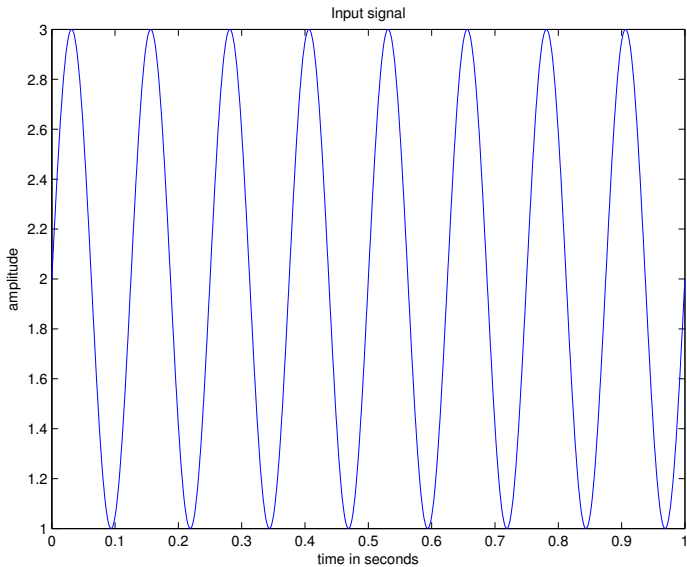# 60Hz input

# Filtered spectrum of 60Hz input



filtered frequency spectrum

unfiltered frequency spectrum

# 100Hz input



Input signal

amplitude vs time in seconds

# Filtered spectrum of 100Hz input



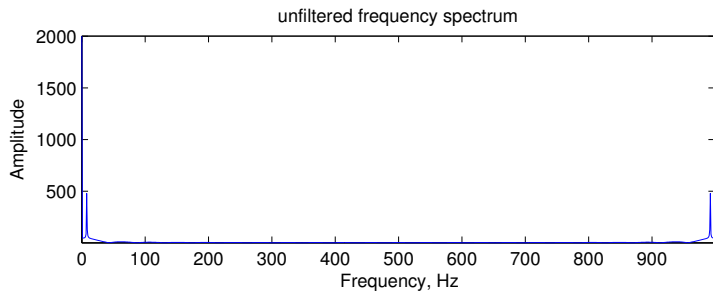filtered frequency spectrum
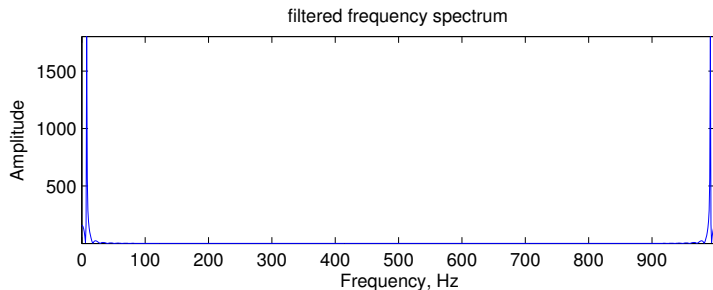
unfiltered frequency spectrum

# 1008Hz input



Aliased because sampling rate is just 1000Hz.

# Filtered spectrum of 1008Hz input

# References

- Merrill I. Skolnik. *Introduction to Radar Systems*. McGraw-Hill, 2001.
- Bassem R. Mahafza. *Radar Systems Analysis and Design Using MATLAB®*. Chapman & Hall/CRC, 2000.

# Thanks