Moving Target Indicator

Chakradhar Thallapaka (09007046)
Swrangsar Basumatary (09d07040)

Department of Electrical Engineering
IIT Bombay, Powai

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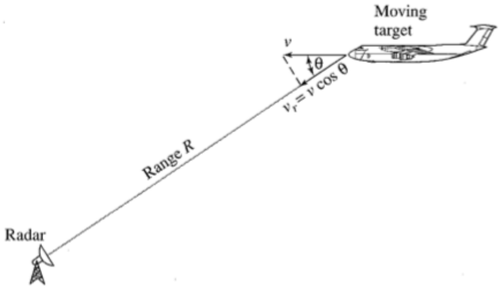
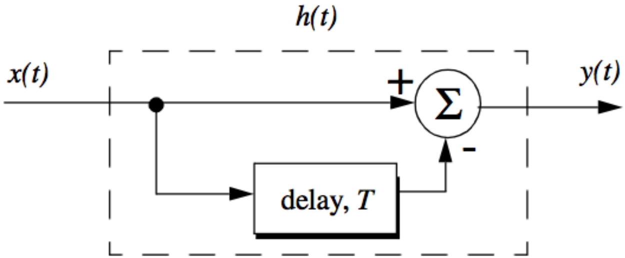
Moving Target Indicator

- mode of operation of radar
- makes use of doppler effect



Source: Merrill I. Skolnik. *Introduction to Radar Systems*. McGraw-Hill, 2001.

Single Delay Line Canceler



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

Single Delay Line Canceler

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

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

Double Delay Line Canceler

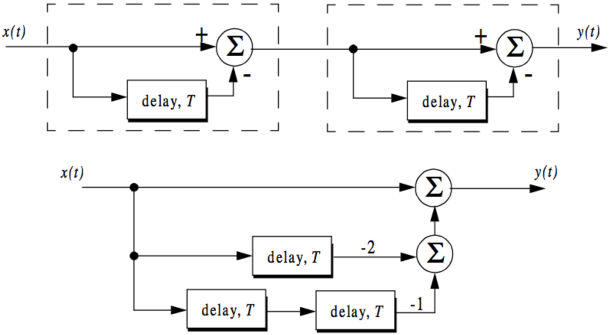


Figure : Two configurations for a double delay line canceler

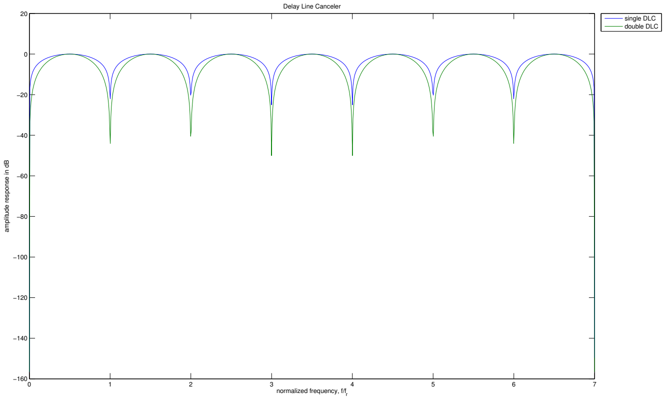
Source: Bassem R. Mahafza. *Radar Systems Analysis and Design Using MATLAB®*. Chapman & Hall/CRC, 2000.

Double Delay Line Canceler

$$
\begin{aligned}
h(t) &= \delta(t) - 2\delta(t-T) + \delta(t-2T) \\
|H(\omega)|^2 &= |H_1(\omega)|^2 |H_1(\omega)|^2 \\
& \quad where\ |H_1(\omega)|^2 = 4(sin(\omega T/2))^2 \\
|H(\omega)|^2 &= 16\left(sin\left(\omega \frac{T}{2}\right)\right)^4
\end{aligned}
$$

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

Delay Line Canceler



Delay Lines with Feedback

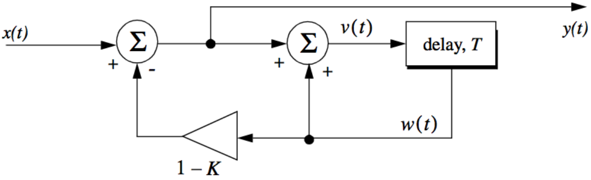


Figure : MTI recursive filter

Here, K is the gain factor.
Source: Bassem R. Mahafza. *Radar Systems Analysis and Design Using MATLAB®*. Chapman & Hall/CRC, 2000.

Delay Lines with Feedback

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

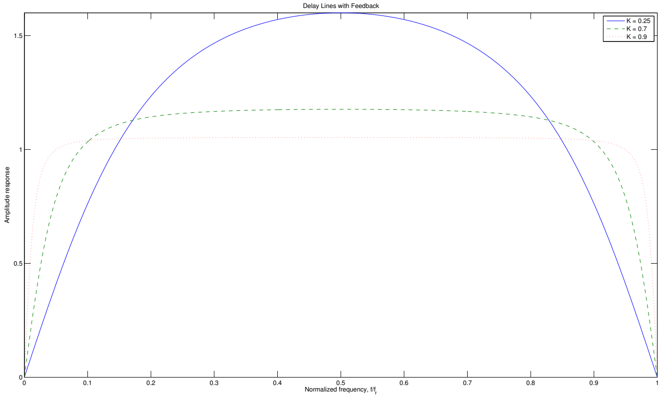
$$|H(z)|^2 = \frac{(1 - z^{-1})(1 - z)}{(1 - Kz^{-1})(1 - Kz)}$$

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

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

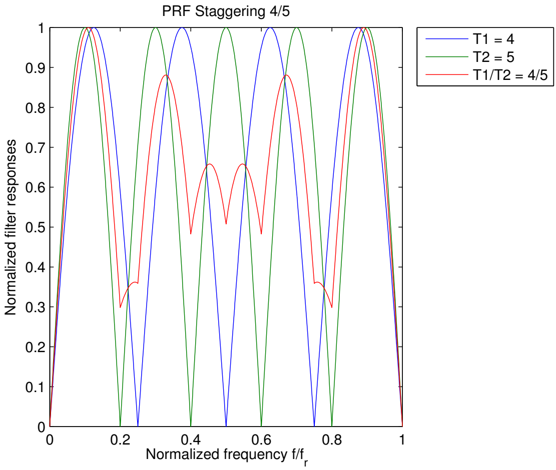
Source: Bassem R. Mahafza. *Radar Systems Analysis and Design Using MATLAB®*. Chapman & Hall/CRC, 2000.

Delay Lines with Feedback



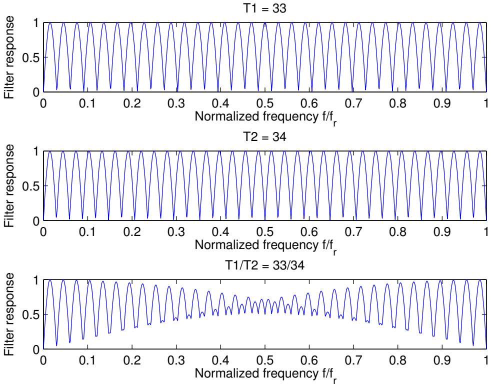
Source: Bassem R. Mahafza. *Radar Systems Analysis and Design Using MATLAB®*. Chapman & Hall/CRC, 2000.

PRF Staggering 4/5



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

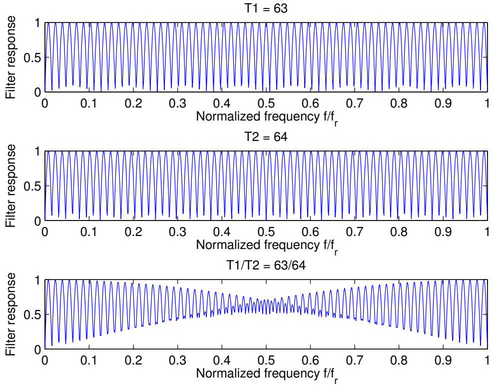
PRF Staggering 33/34



Note: The dips in the upper two plots all touch y=0 axis in reality. But since this is a digital plot with just 1000 samples from t=0 to t=1, some of them did not get sampled.

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

PRF Staggering 63/64



Note: The dips in the upper two plots all touch y=0 axis in reality. But since this is a digital plot with just 1000 samples from t=0 to t=1, some of them did not get sampled.

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

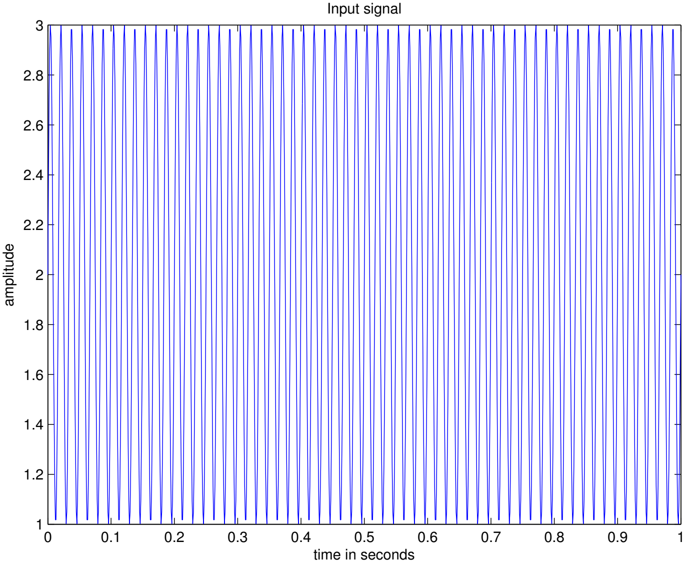
First staggered blind speed

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

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

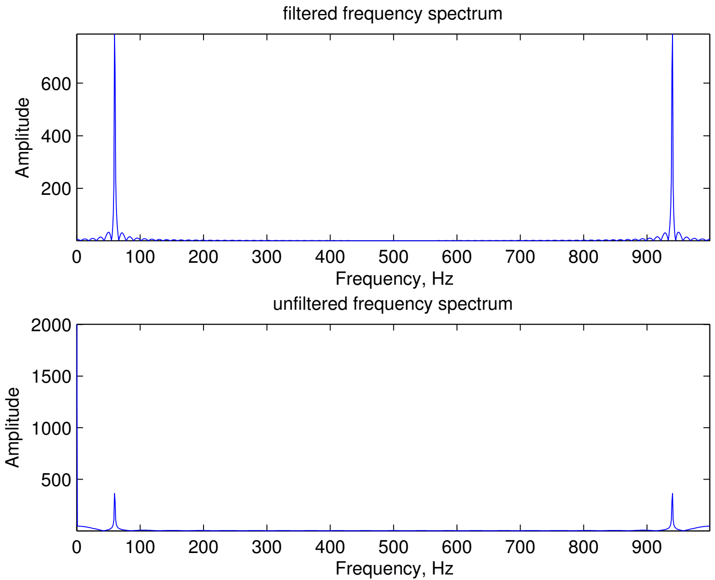
Source: Bassem R. Mahafza. *Radar Systems Analysis and Design Using MATLAB®*. Chapman & Hall/CRC, 2000.

60Hz input

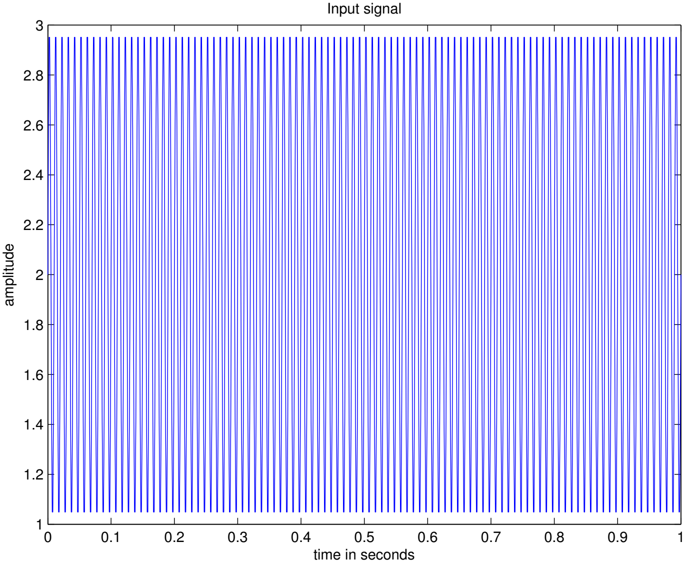


Input signal
amplitude
time in seconds
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

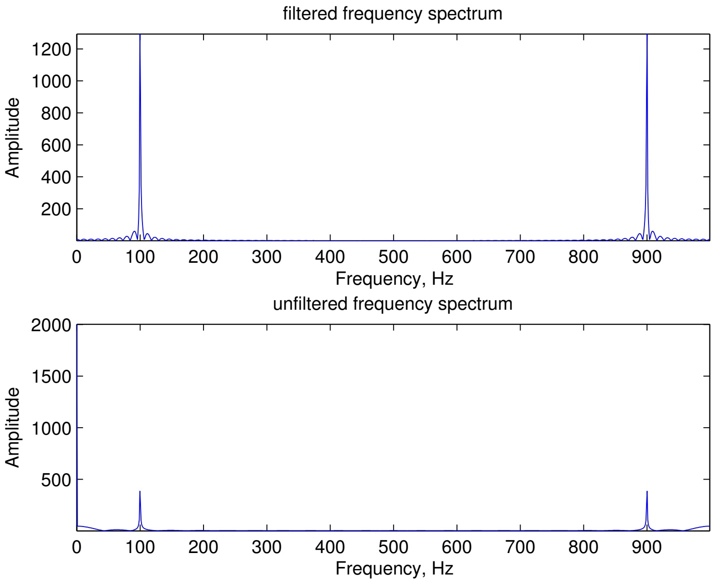
Filtered spectrum of 60Hz input



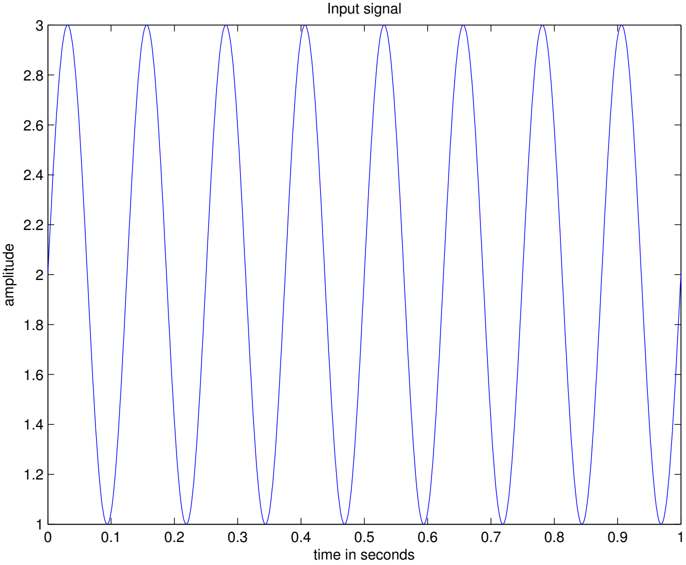
100Hz input


Input signal
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
amplitude
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
time in seconds

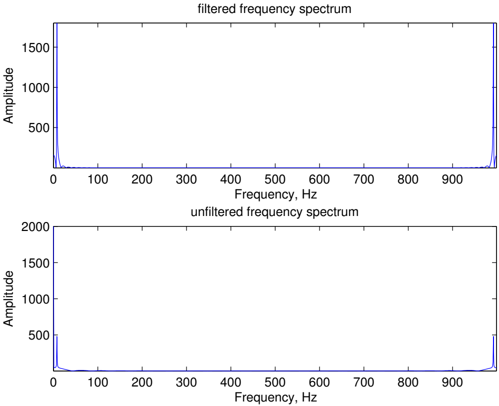
Filtered spectrum of 100Hz input



1008Hz input

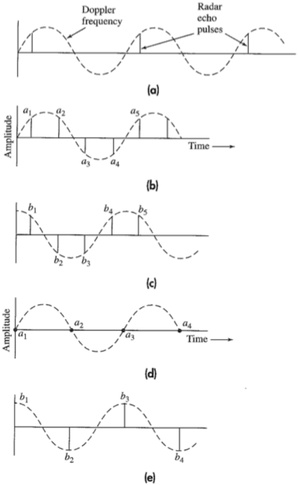


Filtered spectrum of 1008Hz input



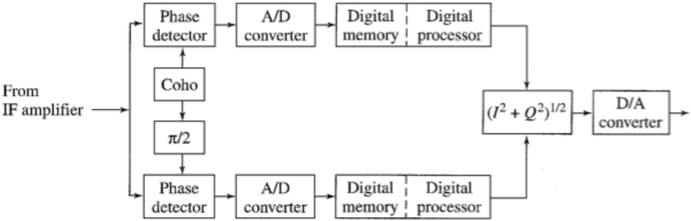
Here we are getting a non-zero filtered output because of aliasing happening due to limited sample rates possible. Ideally we should get a zero output at the frequency in which the blind speed occurs (1008Hz).

Digital MTI (I and Q channels)



Source: Merrill I. Skolnik. *Introduction to Radar Systems*. McGraw-Hill, 2001.

Digital MTI Processor



Source: Merrill I. Skolnik. *Introduction to Radar Systems*. McGraw-Hill, 2001.

Conclusion

- Staggering PRFs is the best way to increase the blind speed.
- Using higher PRFs increases the blind speed, but it reduces the range of the radar too.
- Using staggering ratios like 63/64 gives us an actual first blind speed that is (63+64)/2 or 63.5 times the lowest blind speed among the staggered PRFs.
- Similarly by making the staggering ratio closer to 1 and/or by using more than two staggered PRFs, we can get even higher blind speeds without reducing the range of the radar.

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.
- http://en.wikipedia.org/wiki/Moving_target_indication
- http://www.radartutorial.eu/11.coherent/co13.en.html

Thank You