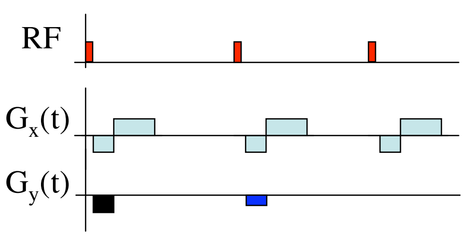
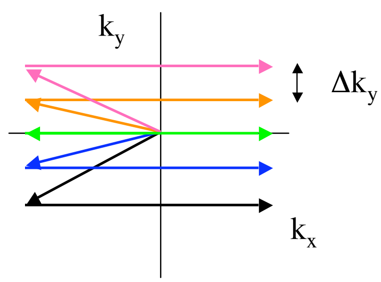
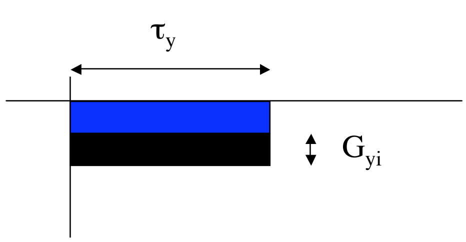
Bioengineering 280A
Principles of Biomedical Imaging

Fall Quarter 2006
MRI Lecture 3a

Sampling in k_y



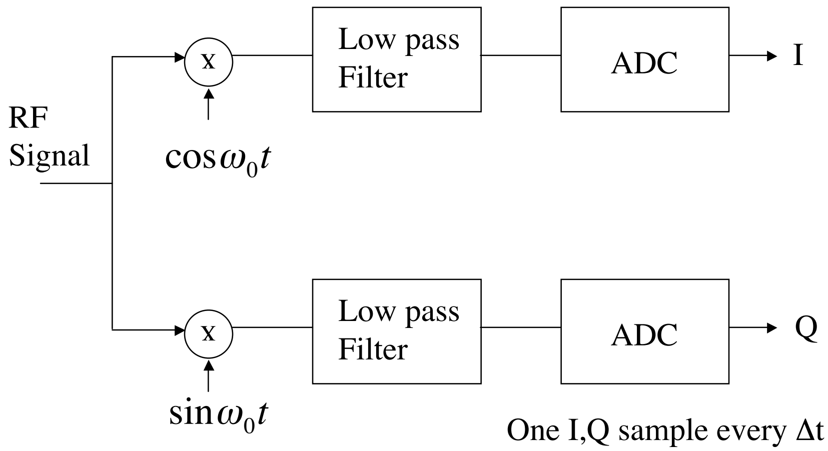




$$\Delta k_y = \frac{\gamma}{2\pi} G_{yi} \tau_y$$

$$FOV_y = \frac{1}{\Delta k_y}$$

Sampling in k_x

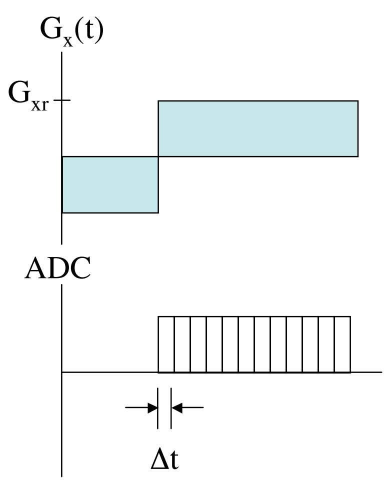


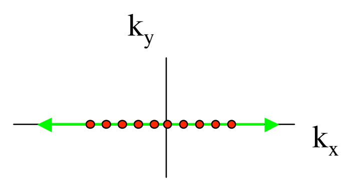
One I,Q sample every Δt

M= I+jQ

Note: In practice, there are number of ways of implementing this processing.

Sampling in k_x



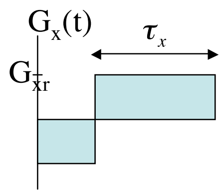


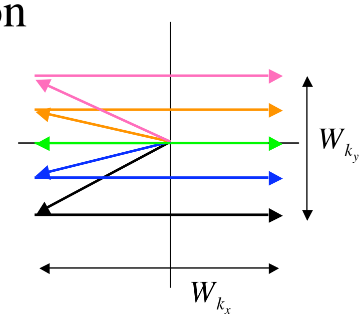
$$\Delta k_x = \frac{\gamma}{2\pi} G_{xr} \Delta t$$

$$FOV_x = \frac{1}{\Delta k_x}$$

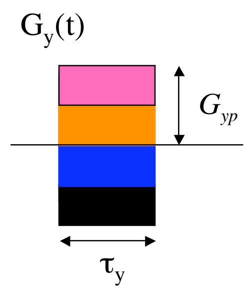
Resolution

$$\delta_x = \frac{1}{W_{k_x}} = \frac{1}{2k_{x,\max}} = \frac{1}{\frac{\gamma}{2\pi}G_{xr}\tau_x}$$





$$\delta_y = \frac{1}{W_{k_y}} = \frac{1}{2k_{y,\max}} = \frac{1}{\frac{\gamma}{2\pi}2G_{yp}\tau_y}$$



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Example

Goal:

$$FOV_x = FOV_y = 25.6 \text{ cm}$$

$$\delta_x = \delta_y = 0.1 \text{ cm}$$

Readout Gradient:

$$FOV_x = \frac{1}{\frac{\gamma}{2\pi}G_{xr}\Delta t}$$

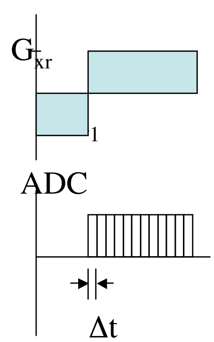
Pick $\Delta t = 32\ \mu\text{sec}$

$$G_{xr} = \frac{1}{FOV_x \frac{\gamma}{2\pi}\Delta t} = \frac{1}{(25.6cm)(42.57\times10^{6}T^{-1}s^{-1})(32\times10^{-6}s)}$$

$$= 2.8675 \times 10^{-5}\text{T/cm}$$

$$= .28675 \text{ G/cm}$$

1 Gauss = 1×10^{-4} Tesla



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Example

Readout Gradient :

$$\delta_x = \frac{1}{\frac{\gamma}{2\pi} G_{xr} \tau_x}$$

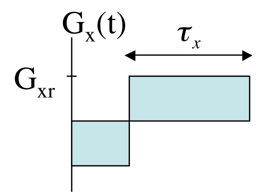
$$\tau_x = \frac{1}{\delta_x \frac{\gamma}{2\pi} G_{xr}} = \frac{1}{(0.1cm)(4257\ G^{-1}s^{-1})(0.28675\ \text{G/cm})}$$

$$= 8.192\ \text{ms}$$

$$= N_{\text{read}} \Delta t$$

where

$$N_{\text{read}} = \frac{FOV_x}{\delta_x} = 256$$



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Example

Phase - Encode Gradient :

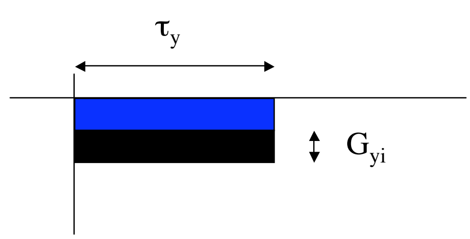
$$FOV_y = \frac{1}{\frac{\gamma}{2\pi} G_{yi} \tau_y}$$

Pick $\tau_y = 4.096\ m\text{sec}$

$$G_{yi} = \frac{1}{FOV_y \frac{\gamma}{2\pi} \tau_y} = \frac{1}{(25.6cm)(42.57 \times 10^6 T^{-1}s^{-1})(4.096 \times 10^{-3} s)}$$

$$= 2.2402 \times 10^{-7}\ \text{T/cm}$$

$$= .00224\ \text{G/cm}$$



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Example

Phase - Encode Gradient :

$$\delta_y = \frac{1}{\frac{\gamma}{2\pi} 2 G_{yp} \tau_y}$$

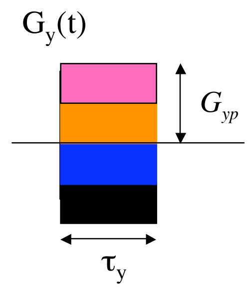
$$G_{yp} = \frac{1}{\delta_y 2 \frac{\gamma}{2\pi} \tau_y} = \frac{1}{(0.1cm)(4257\ G^{-1}s^{-1})(4.096 \times 10^{-3}\ s)}$$

$$= 0.2868\ \text{G/cm}$$

$$= \frac{N_p}{2} G_{yi}$$

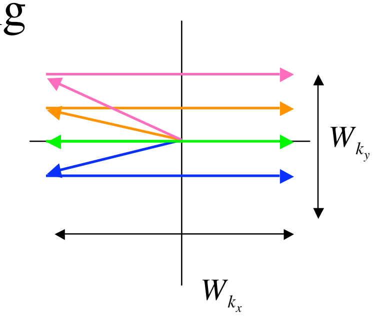
where

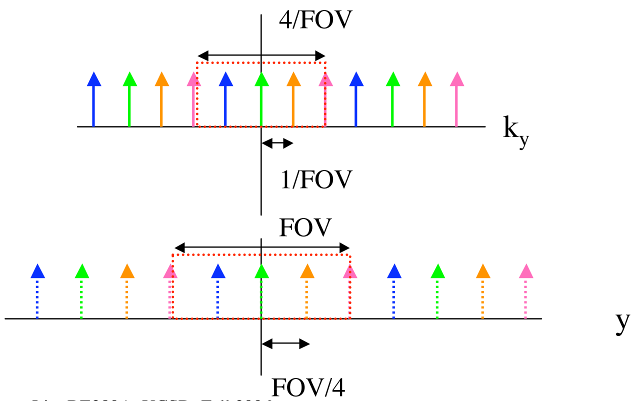
$$N_p = \frac{FOV_y}{\delta_y} = 256$$



Sampling

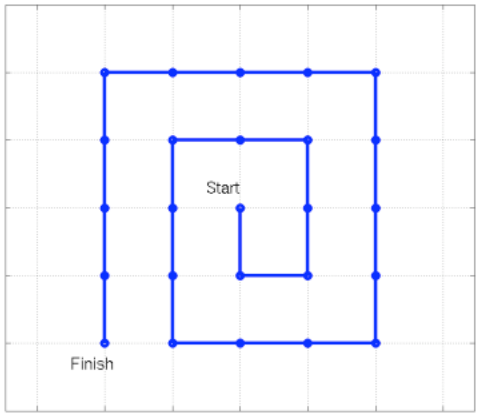
In practice, an even number (typically power of 2) sample is usually taken in each direction to take advantage of the Fast Fourier Transform (FFT) for reconstruction.





Example

Consider the k-space trajectory shown below. ADC samples are acquired at the points shown with $\Delta t = 10\ \mu\text{sec}$. The desired FOV (both x and y) is 10 cm and the desired resolution (both x and y) is 2.5 cm. Draw the gradient waveforms required to achieve the k-space trajectory. Label the waveform with the gradient amplitudes required to achieve the desired FOV and resolution. Also, make sure to label the time axis correctly.



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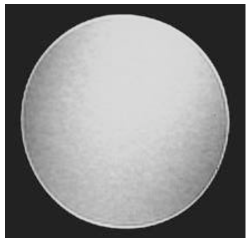
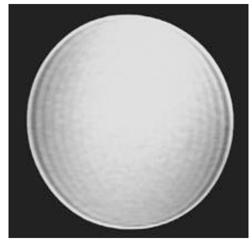
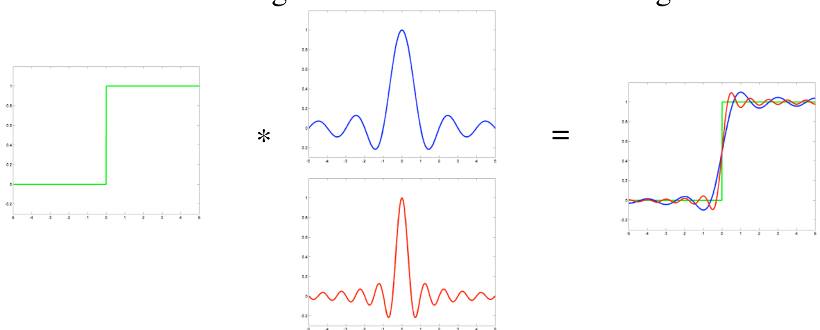
Gibbs Artifact



256x256 image



256x128 image



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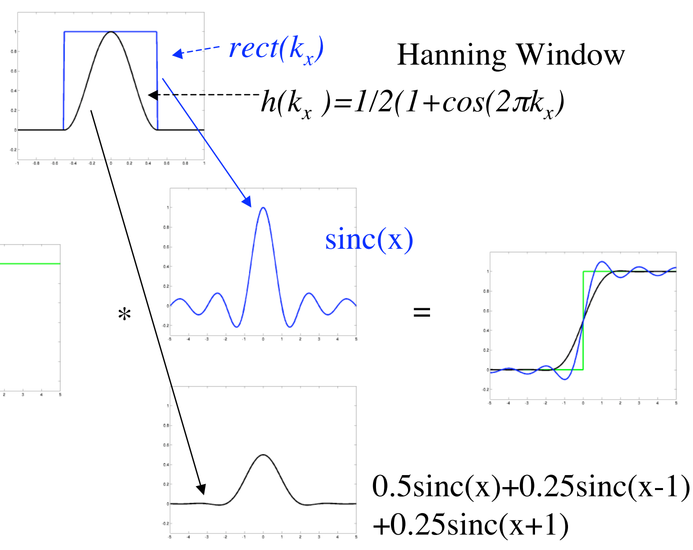
Images from http://www.mritutor.org/mritutor/gibbs.htm

Apodization



Hanning Window

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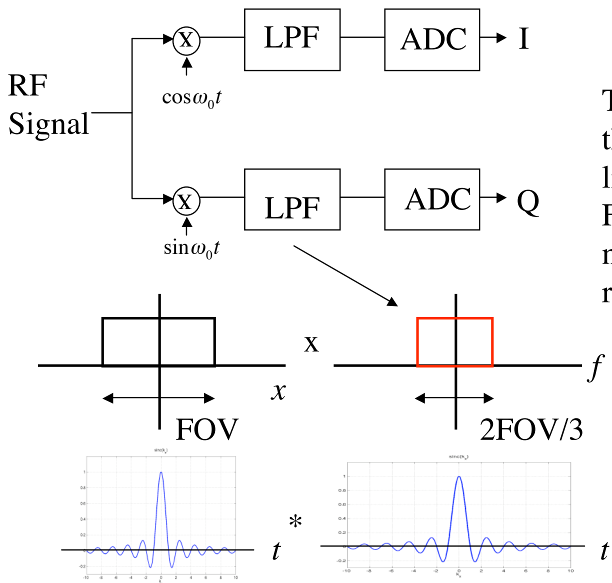
Images from http://www.mritutor.org/mritutor/gibbs.htm

Aliasing and Bandwidth



Temporal filtering in the readout direction limits the readout FOV. So there should never be aliasing in the readout direction.

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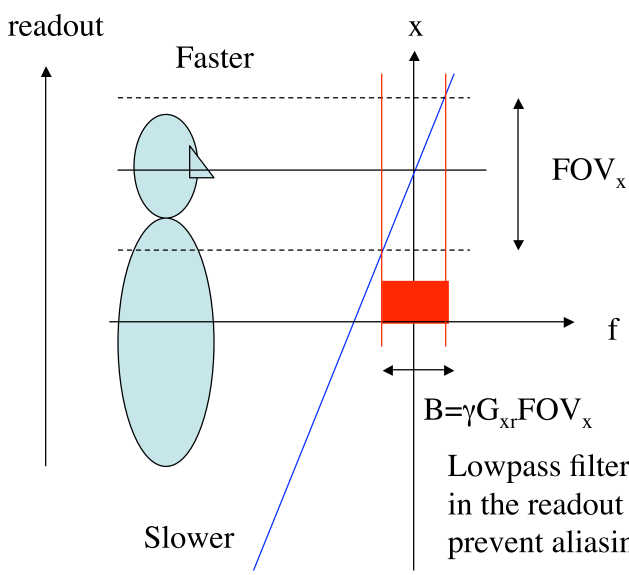
Aliasing and Bandwidth



Lowpass filter
in the readout direction to
prevent aliasing.

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Figure 7-31 Default Axial Directions

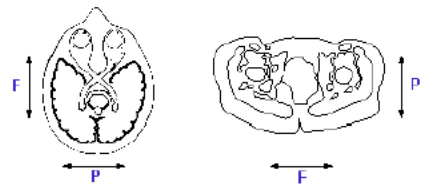
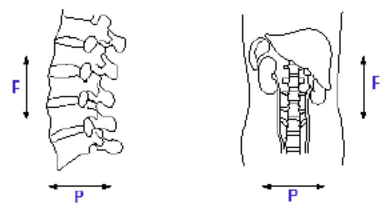


Figure 7-32 Default Sagittal and Coronal Directions



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