Gradient Lobe Shapes
Imaging Gradients

Oct 31, 05

Review: Simple Gradient Lobes

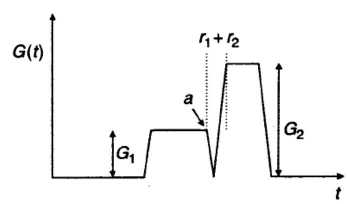
1. Trapezoidal and triangular lobes

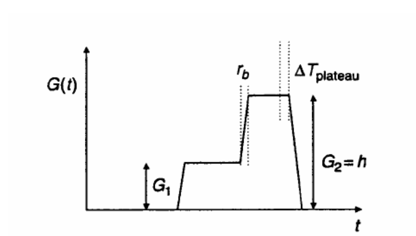
2. Sinusoidal lobes

Bridged Gradient Lobes

- Trapezoidal and triangular lobes are the most efficient lobes to generate a predetermined gradient area.
- When gradient lobe with a specified amplitude is adjacent to another lobe of the same polarity the most efficient gradient lobe shape is the bridged gradient lobe.

Bridged Gradient Lobes (cont'd)





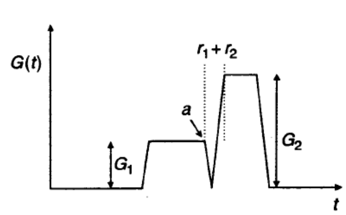
Handbook of MR pulse sequences

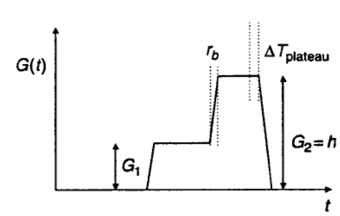
Advantages of the Bridged Gradient Lobes

- Time savings
  - $r_b < r_1 + r_2$
- Less acoustic noise
- Reduced eddy currents
- Less gradient heating

Mathematical Description

- Assume $G_2 > G_1 > 0$ then,
  - $r_1 + r_2 = (G_1 + G_2)/S_R$ but
  - $r_b = (G_2 - G_1)/S_R$



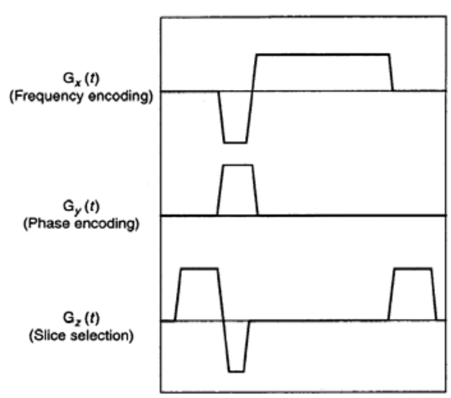


Gradients for Oblique Acquisitions

- Oblique acquisition is achieved by digitally modifying the gradient waveforms that are sent to the gradient amplifiers.

Cartesian acquisitions

- Frequency encoding, phase encoding and slice selection denoted by logical axes. (*x, y, z*)



Physical axes

- X, Y, Z: cartesian coordinate system that is fixed to the magnet and rotated with respect to the logical axes
- Isocenter: gradients produce zero magnetic field and generally it lies in the center of the magnet

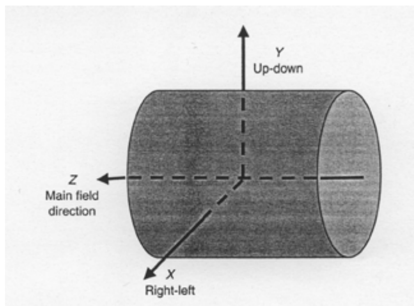


Image orientation standards

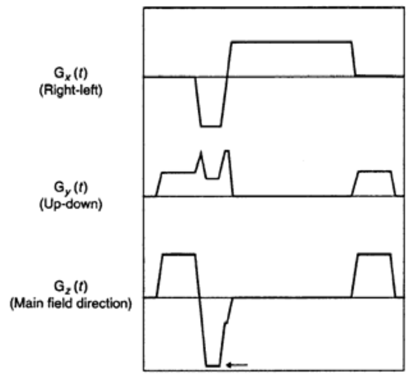
Conventional Image Orientations[a]

Image Plane	Apparent Location of the Viewer	Top of Image	Right Side of Image
Axial and axial-like oblique	Patient's feet	Patient's front	Patient's left
Sagittal and sagittal-like oblique	Patient's left	Patient's head	Patient's back
Coronal and coronal-like oblique	Patient's front	Patient's head	Patient's left

[a] These conventions are usually followed regardless of the patient positioning.

Oblique acquisitions

- The three logical waveforms are digitally mixed in ratios determined by angulations



Rotation Mathematics

- A 3 x 3 orthogonal rotation matrix achieves the physical gradient waveforms

$$\begin{bmatrix} G_X(t) \\ G_Y(t) \\ G_Z(t) \end{bmatrix} = \Re \begin{bmatrix} G_x(t) \\ G_y(t) \\ G_z(t) \end{bmatrix}$$

$$\Re\Re^T = I$$

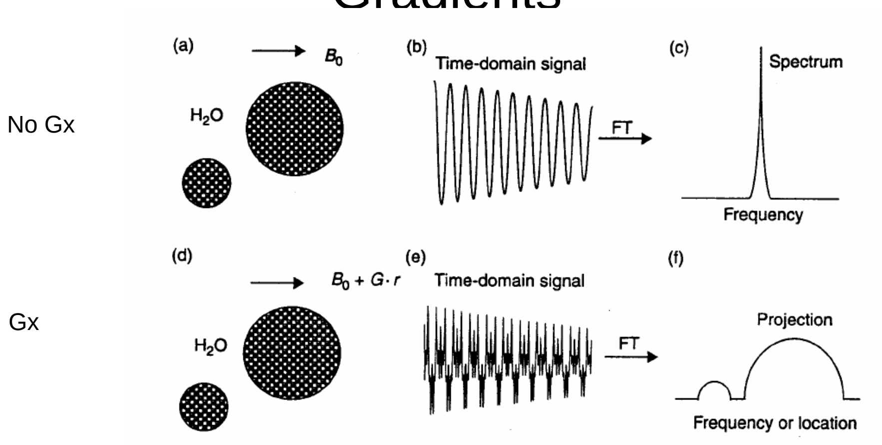
Imaging Gradients

1. Frequency-Encoding Gradients
2. Phase-Encoding Gradients
3. Slice Selection Gradients

Frequency-Encoding Gradients

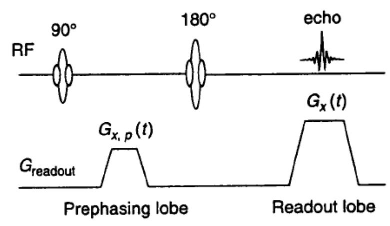
- The gradient spatially encodes NMR signals by assigning a unique Larmor frequency to each spin isochromat at a distinct spatial location along the gradient direction.
- Time domain NMR signals will consist of a range frequencies corresponding to different locations
- The polarity of the gradient can be either positive or negative

Qualitative description of X-Gradients



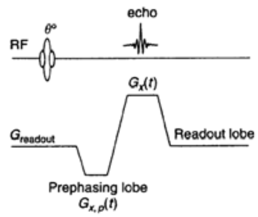
Content of the Frequency-Encoding gradients

- Two major lobes
  - Prephasing gradient lobe (dephasing)
  - Readout gradient lobe
- In an RF Spin echo pulse sequence , the lobes are separated by an RF refocusing pulse.



Qualitative (cont'd)

- In a gradient-echo pulse sequence, both lobes can be combined



- The purpose of the prephasing lobe is to prepare is to prepare the transverse magnetization so that an echo signal can be created at a later time

Quantitative Description of Frequency-Encoding Gradients