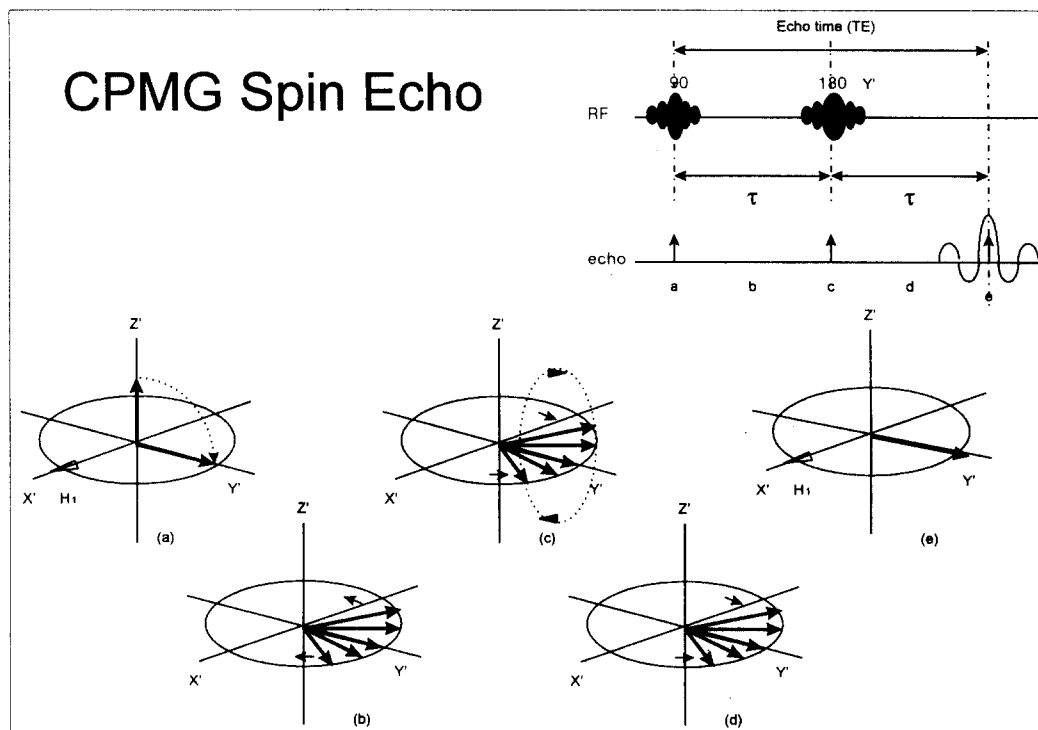
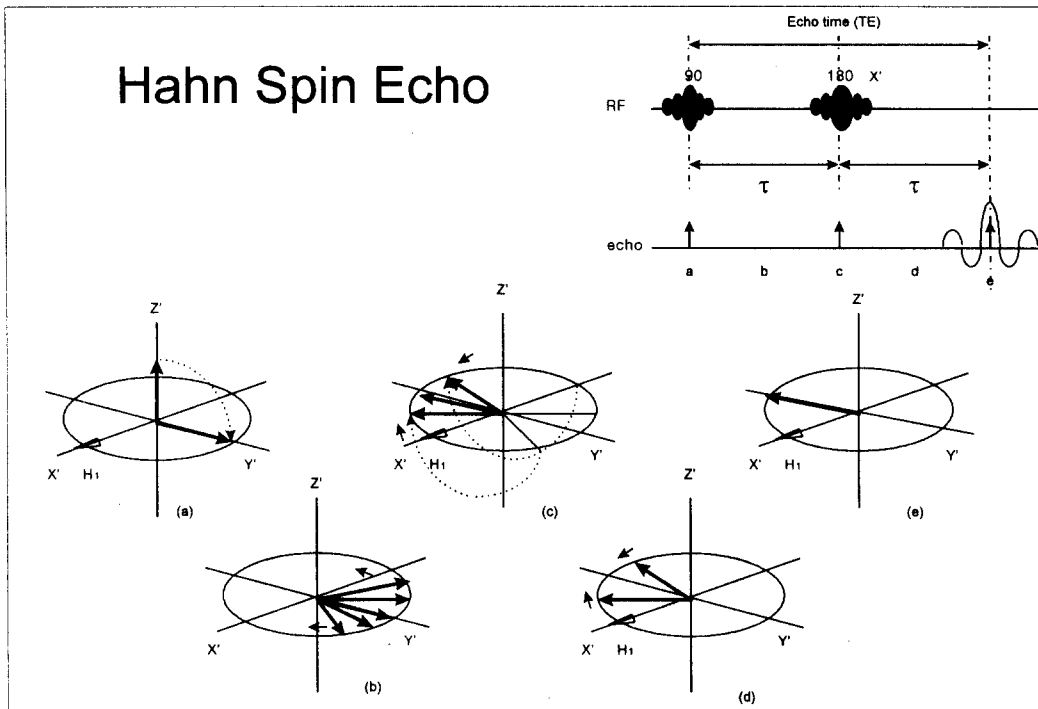


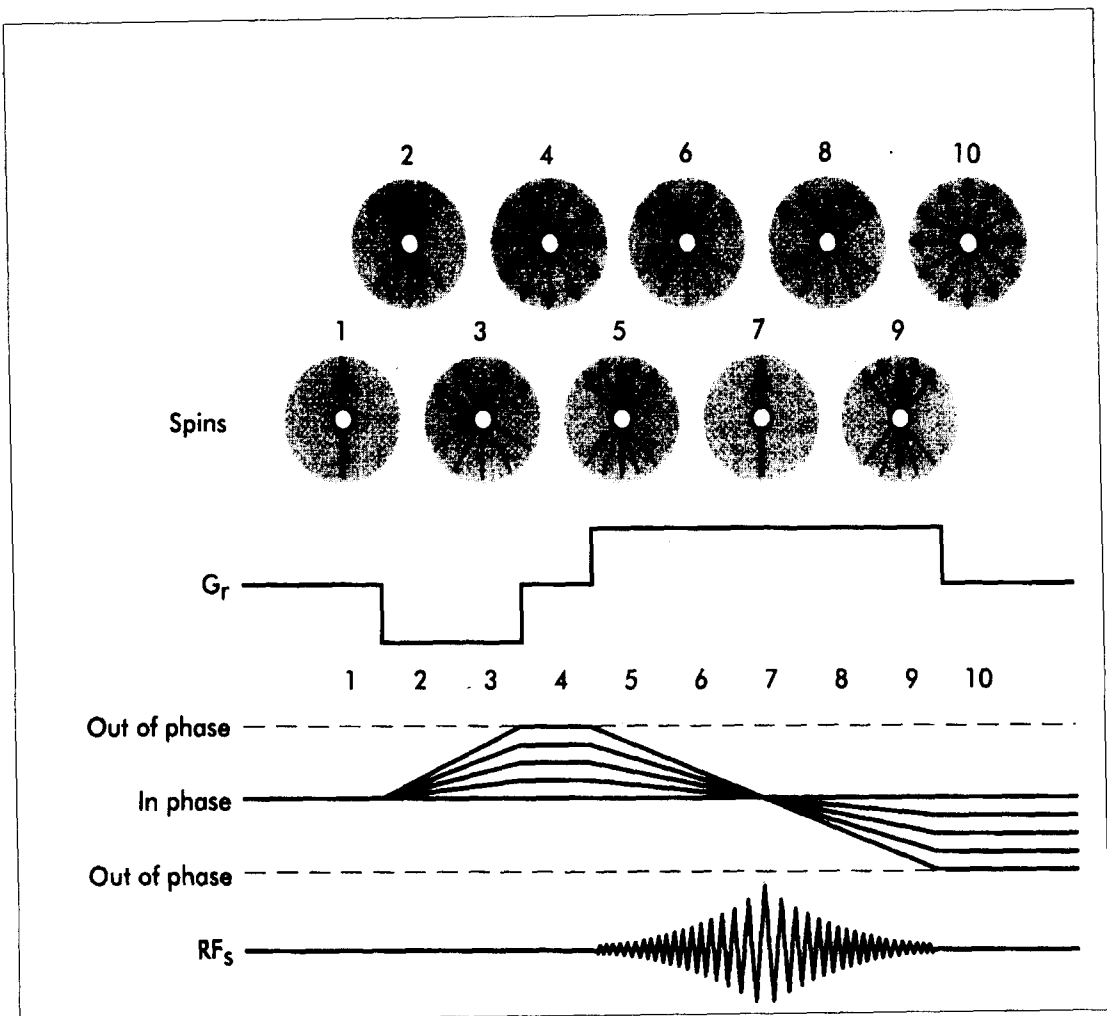
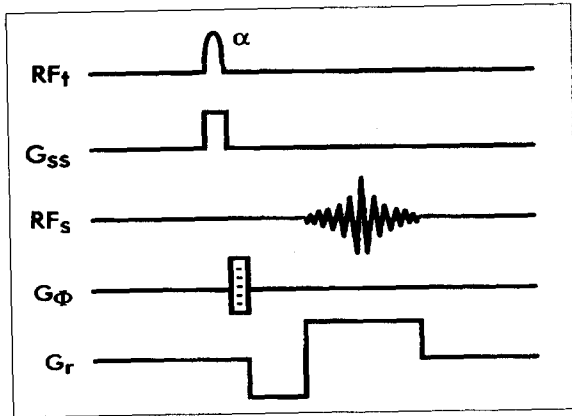
Pulse Sequences : Spin Echo vs. Gradient Echo

광운대학교 전기공학과 안창범

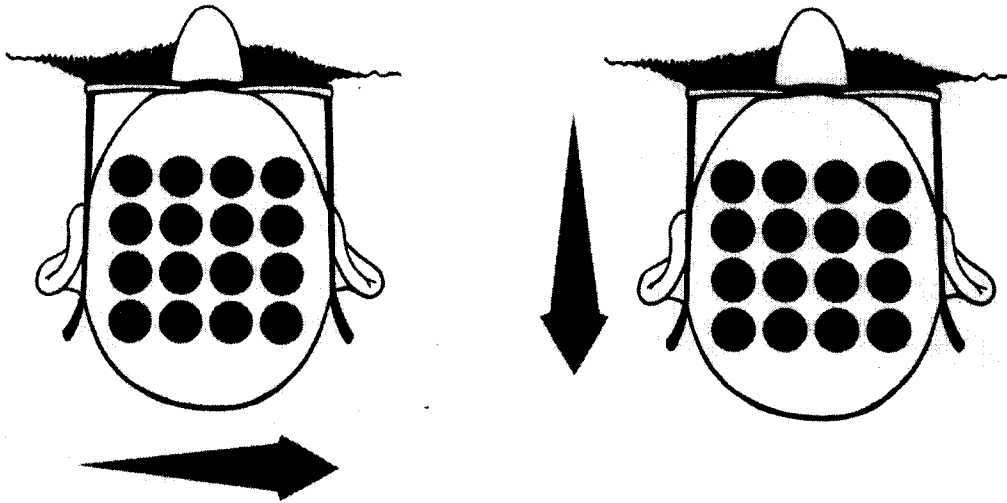
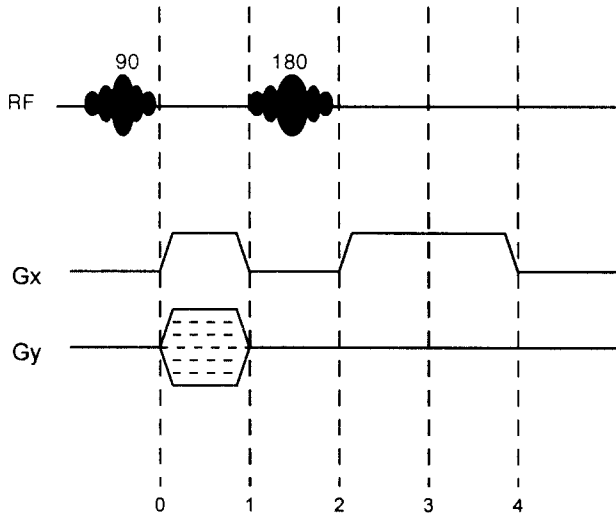
◆ Spin echo formation



◆ Gradient echo formation



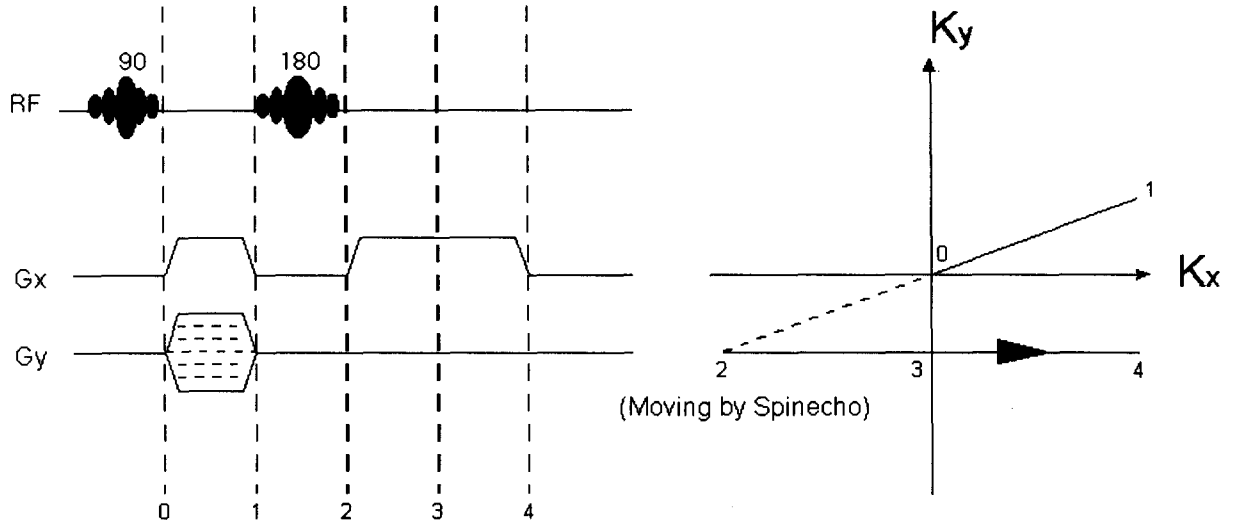
◆ Frequency (readout) & Phase encoding gradients



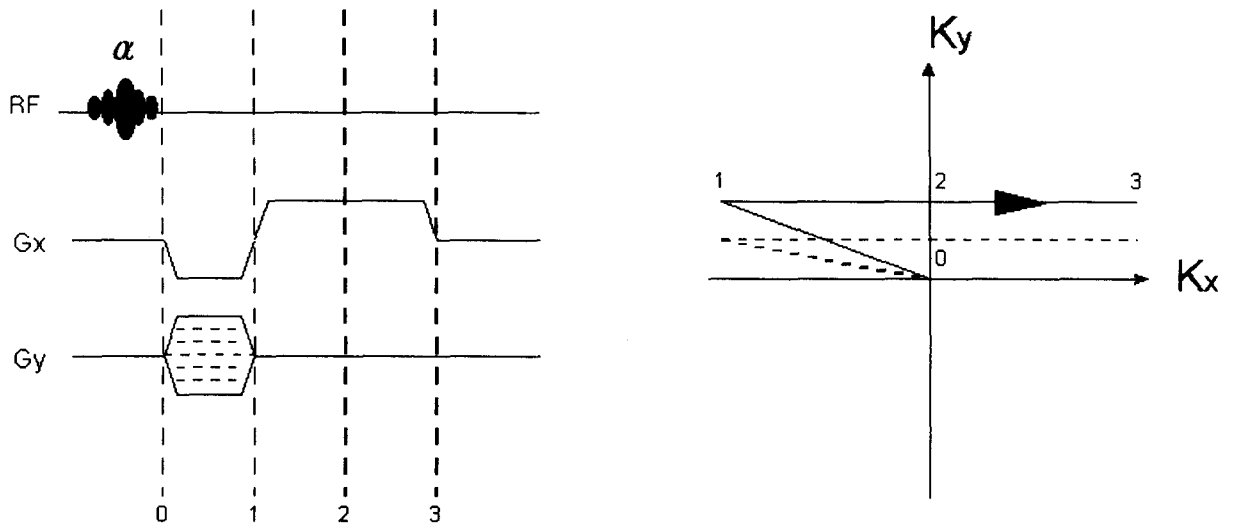
◆ Gradients and k-space diagram

$$k_x(t) = \gamma \int_0^t G_x(t') dt'$$

$$k_y(t) = \gamma \int_0^t G_y(t') dt'$$



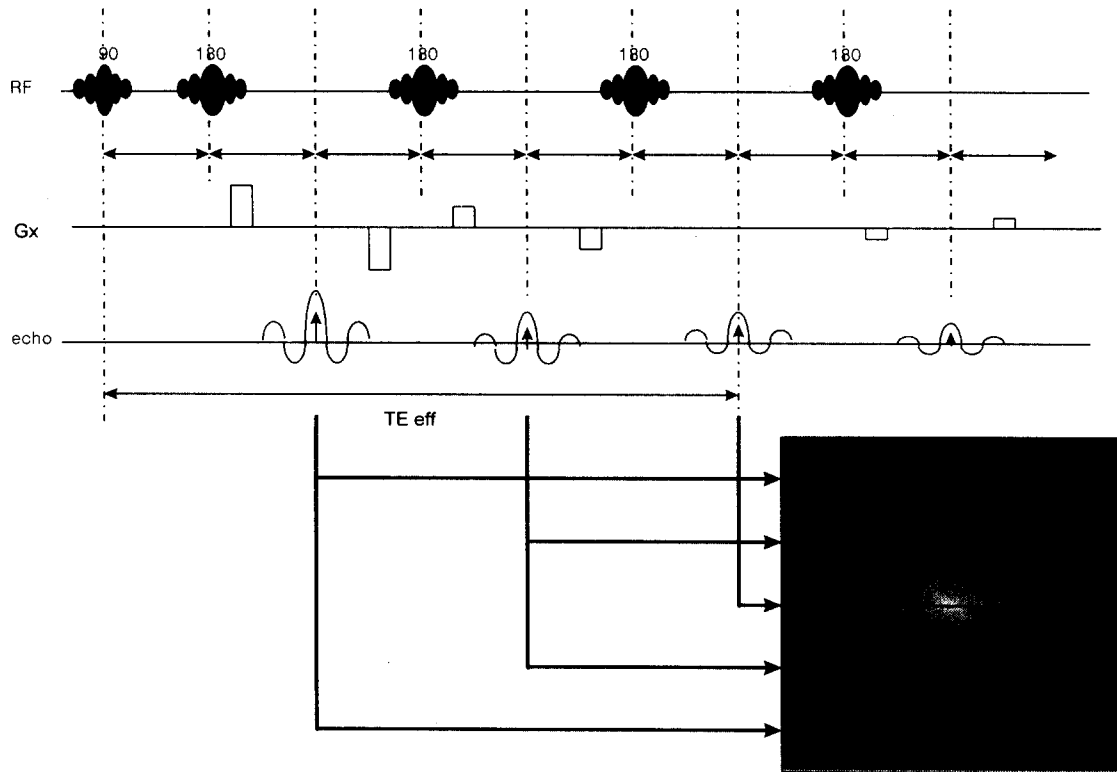
Spin echo sequence

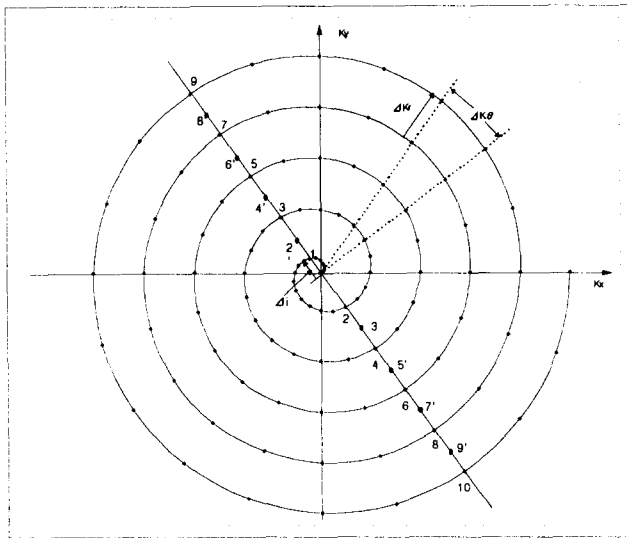


Gradient echo sequence

S. Ljunggren, *J. Magn. Reson.* vol. 54, pp.338-343, 1983.

Fast spin echo sequence



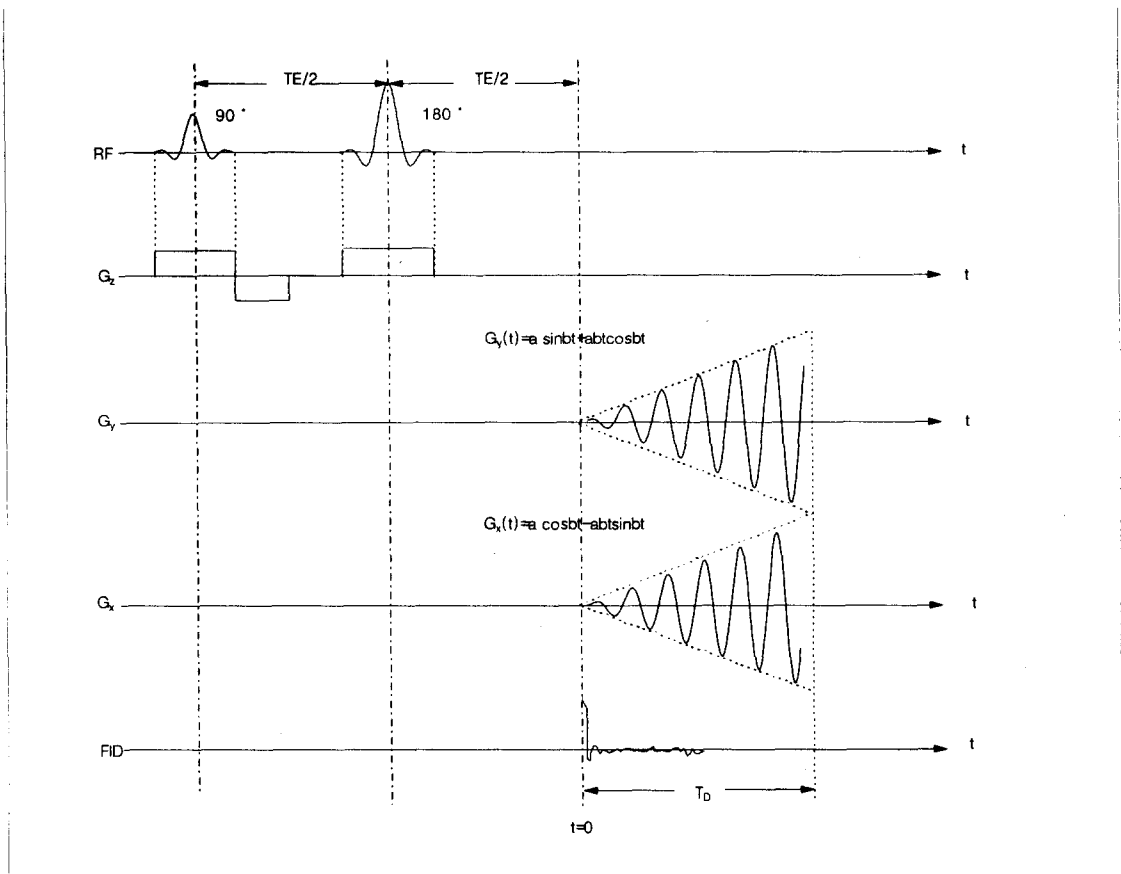


$$k_x(t) = \gamma a t \cos bt$$

$$k_y(t) = \gamma a t \sin bt$$

$$G_x(t) = \frac{1}{\gamma} \frac{d k_x(t)}{dt} = a \cos bt - abt \sin bt$$

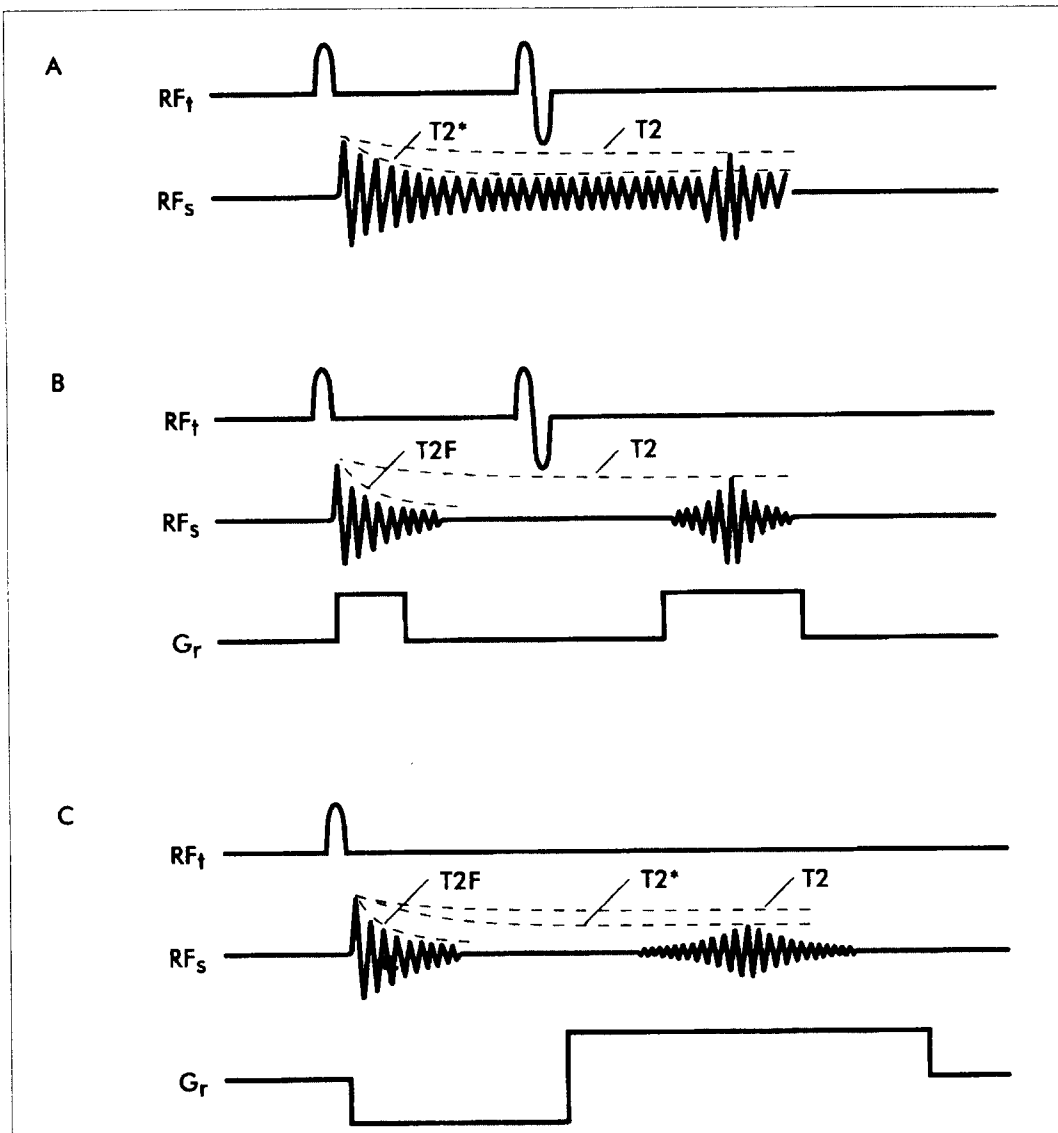
$$G_y(t) = \frac{1}{\gamma} \frac{d k_y(t)}{dt} = a \sin bt + abt \cos bt$$



Spiral scan echo planar imaging

C.B. Ahn, J.H. Kim, and Z.H. Cho, *IEEE Trans. Med. Imag.*, vol. 5, pp.1-6, 1986.

◆ T2 vs. T2* Effects in spin echo and gradient echo imaging

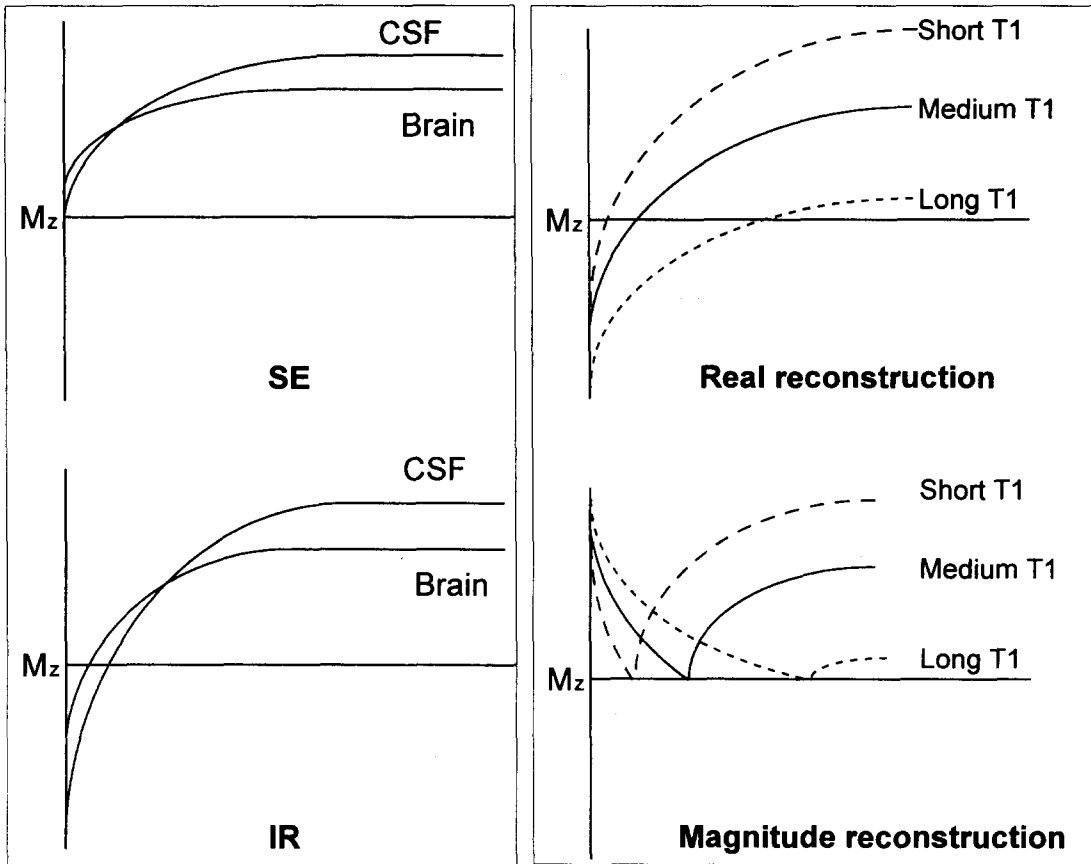


A: Spin echo sequence without gradient field

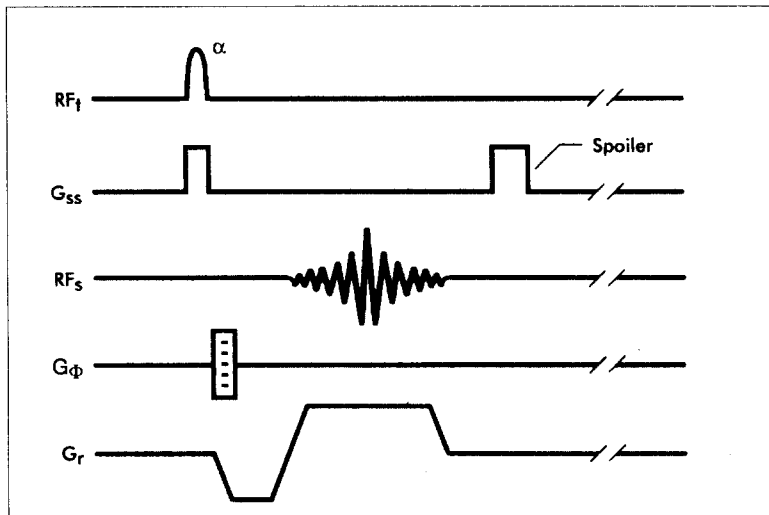
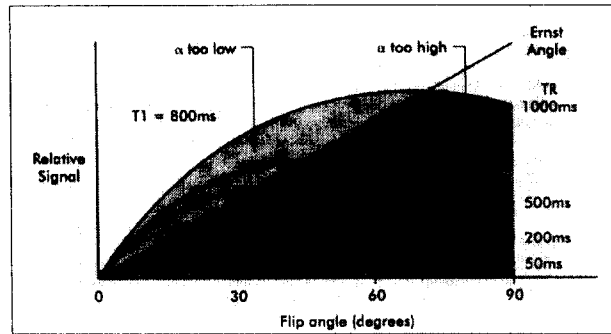
B: Spin echo sequence with gradient field

C: Gradient echo sequence

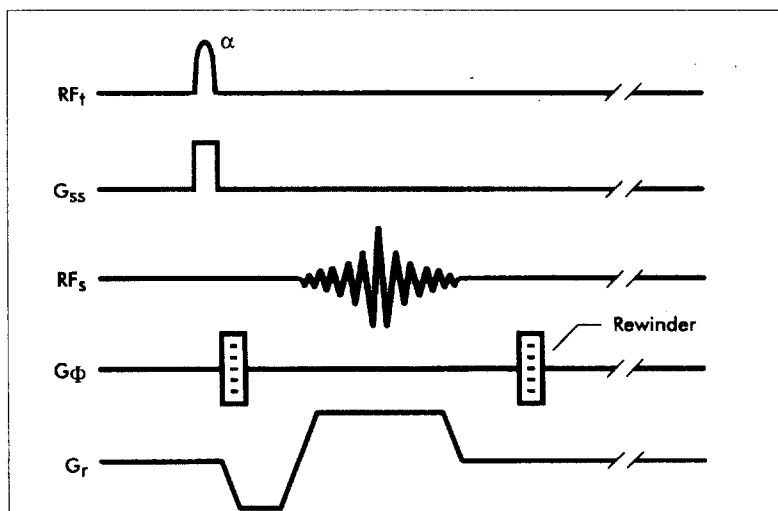
◆ Inversion recovery imaging



◆ FLASH vs. FISP

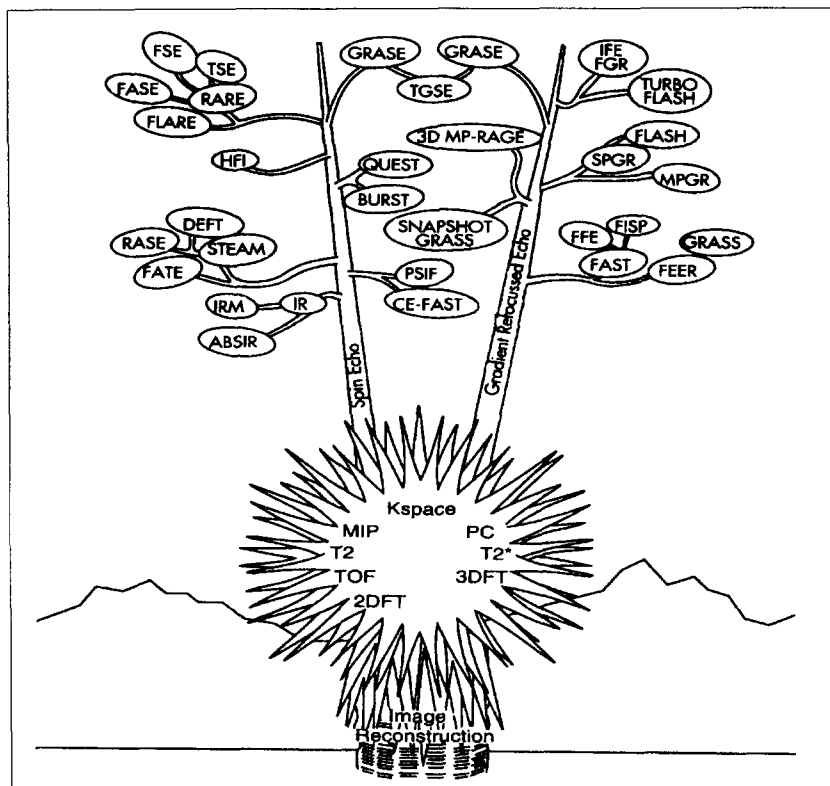


FLASH (Fast low-angle shot)



FISP (Fast imaging with steady state precession)

◆ Variations of Spin echo & Gradient echo imaging methods



Acronyms used in spin echo and gradient echo imaging

CE-FAST	Contrast-enhanced FAST (Picker)
E-SHORT	SS-GRE with SE sampling (Elscent)
FAST	Fourier-acquired steady state (Picker)
FE	Field echo (Otsuka, Picker, Phillips, Toshiba)
FEER	Field even echo by reversal (Picker)
FFE	Fast field echo (Phillips)
FGR	Fast GRASS (GE)
FISP	Fast imaging with steady-state precision (Siemens)
FLASH	Fast low-angle shot (Siemens)
FS	Fast scan (GE)
GFE	Gradient field echo (Hitachi)
GFEC	Gradient field echo compensation (Hitachi)
GRASS	Gradient recalled acquisition in the steady state (GE)
GRECHO	Gradient recalled echo (Resonex)
MPGR	Multiplanar GRASS (GE)
PFI	Partial flip angle (Toshiba)
PSIF	Reversed FISP (Siemens)
RAM-FAST	Rapidly acquired magnetization-prepared FAST (Picker)
RF-FAST	RF-spoiled FAST (Picker)
RS	Rapid Scan (Hitachi)
SMASH	Short minimum angle-shot (Shimadzu)
SPGR	Spoiled GRASS (GE)
SSFP	Steady-state free precession (GE, Shimadzu, Toshiba)
STAGE	Small tip angle GRE (Shimadzu)
TFE	Turbo field echo (Phillips)
TurboFLASH	Turbo version of FLASH (Siemens)
TurboSHORT	Turbo version of SHORT (Elscent)

S.C. Bushong, *Magnetic Resonance Imaging, 2nd ed., Mosby, New York, 1996.*