Lesson 10: K space, Spatial encoding

Aims

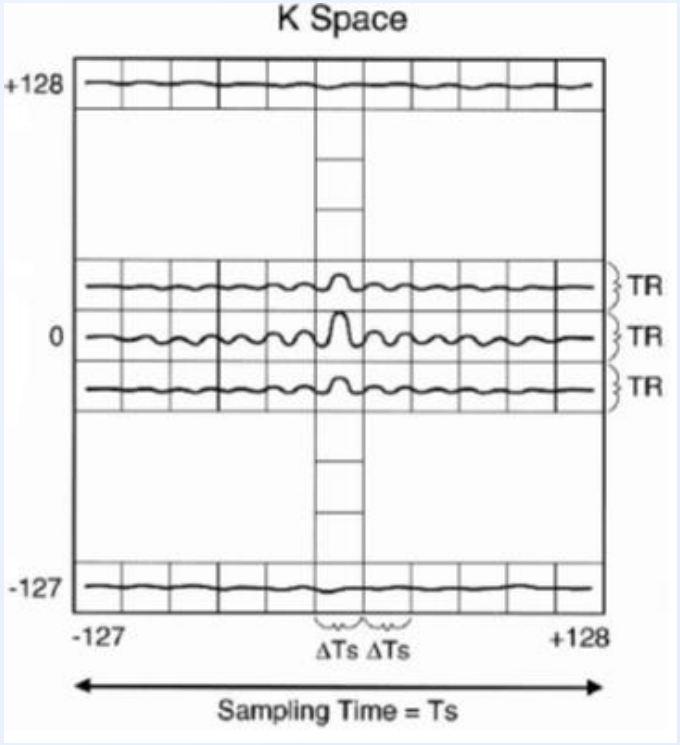
- Learning the following topics about K space and spatial encoding:
- K space
- Phase encoding
- Frequency encoding

K space

- k-space, can be thought of as a digitized version of the data space.
- Each line in it representing a sampled version of the received signal (the echo).
- The Fourier transform of k-space is the desired image.

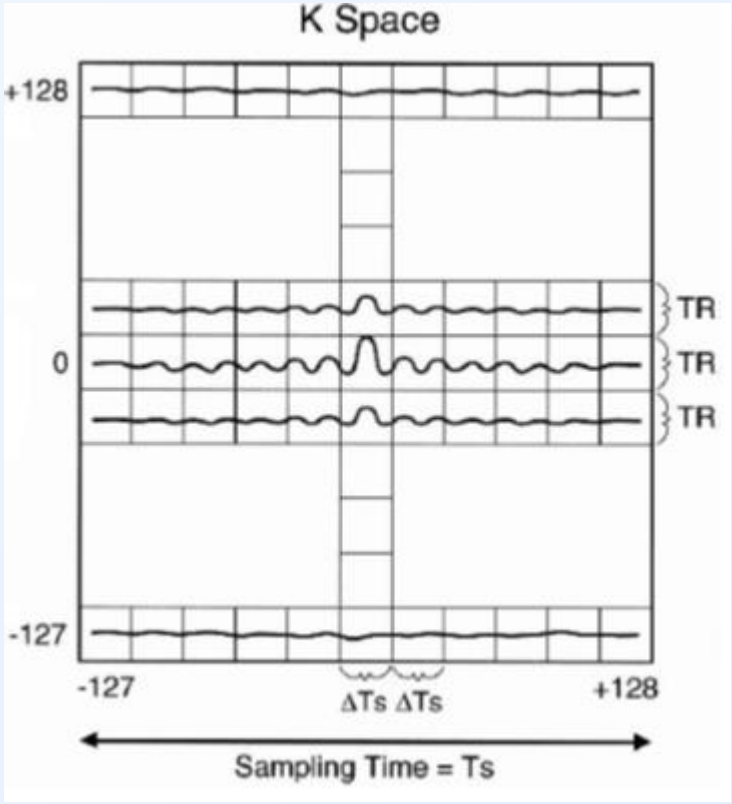
K space

- In the data space, the coordinates are in time.
- Horizontal scale is on the order of the sampling interval (sampling time)
- The vertical scale is on the order of TR



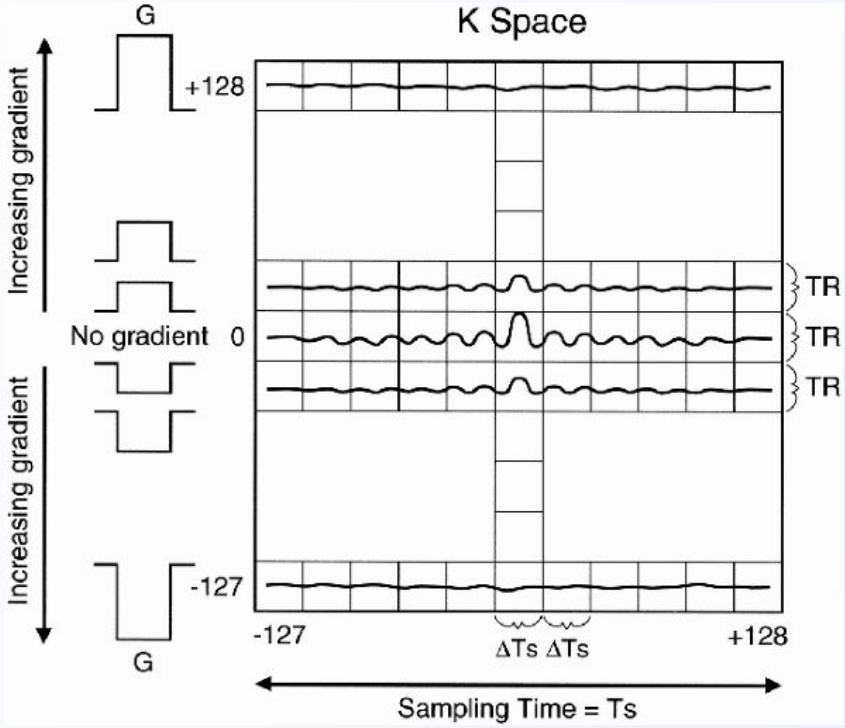
K space

- Each TR is obtained using a different phase-encoding step in the y axis.



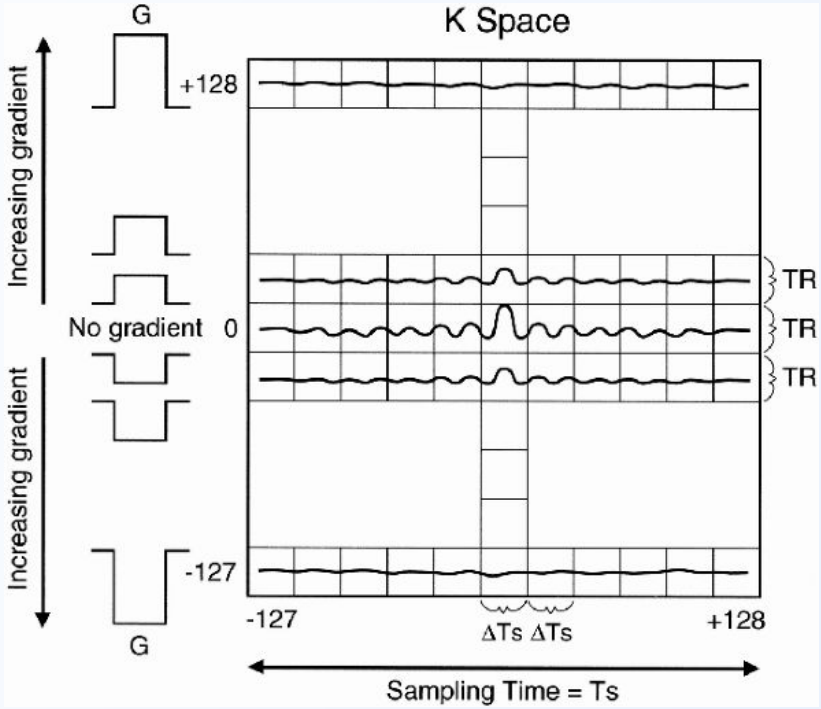
Phase encoding

Phase encoding steps



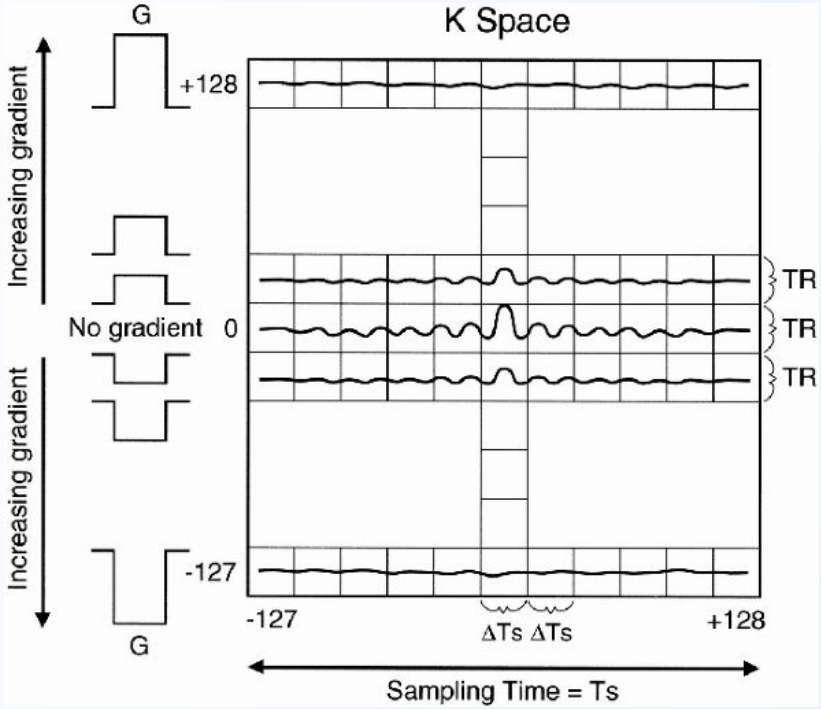
- We have 256 phase-encoding steps.
- We keep the zero-step (i.e., no phase encoding) in the middle of k-space, so we go from -127 phase encode to +128 phase encode (bottom to top).
- We also have 256 frequencies.

Phase encoding y axis and gradients



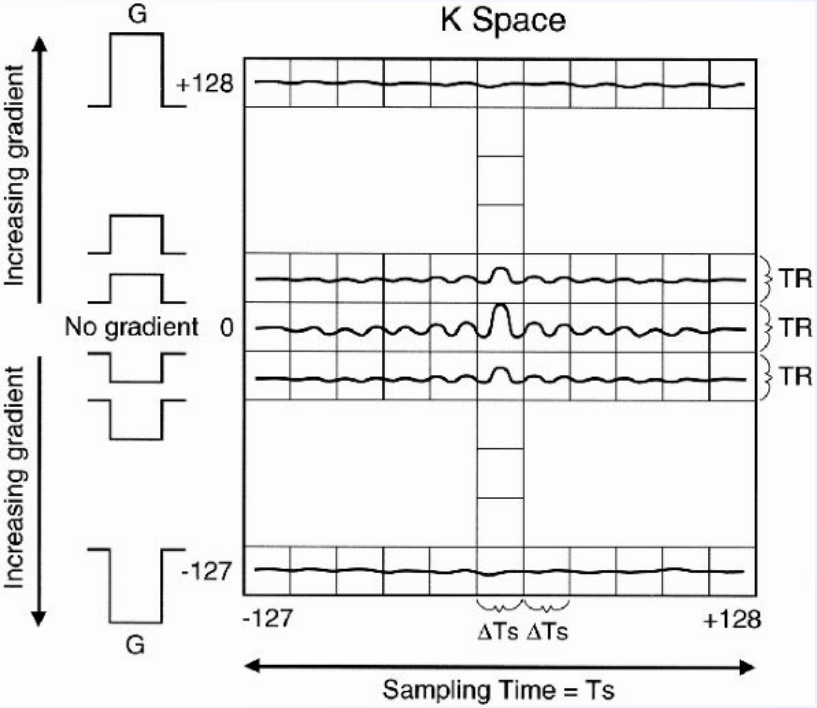
- The **y axis** is the phase-encoding direction.
- In the center, we put the signal acquired with no phase-encoding gradient.
- As one advances on the **y axis**, each set has signal acquired with an increasing phase-encoding gradient.

Maximum and minimum gradients



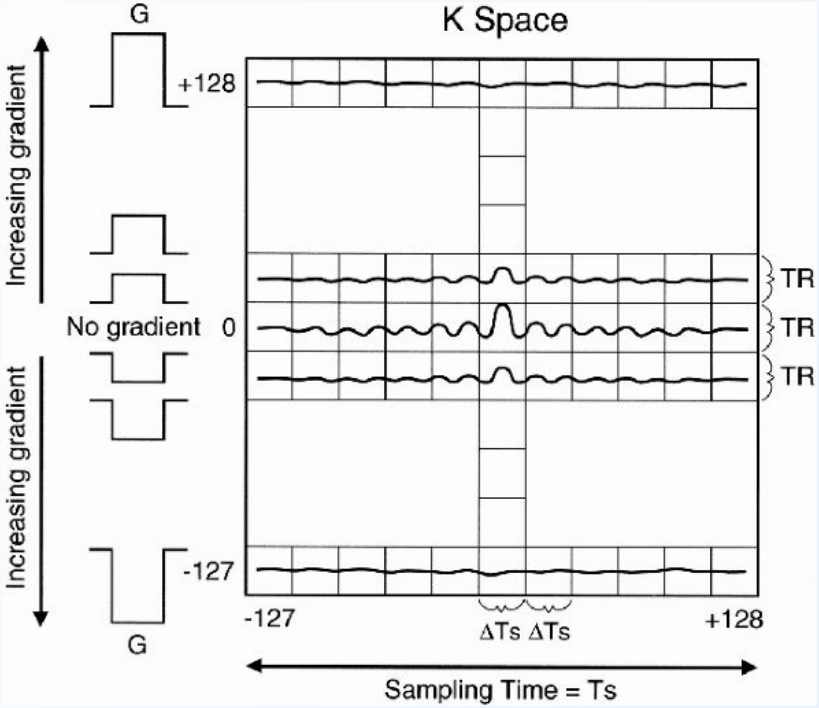
- Maximum gradient at +128 phase-encode step.
- As one goes down from zero gradient in the y axis, each step has signal acquired with an increasing phase-encoding gradient in the opposite direction with maximum gradient at -127 phase-encoding step.

Phase encoding gradient and dephasing



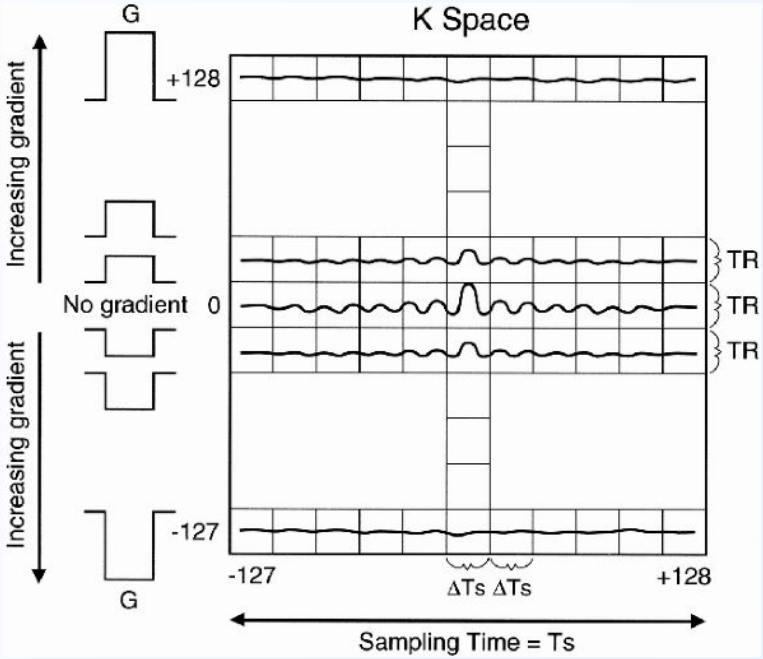
- Role of the phase-encoding gradient:
- It causes **dephasing** of the signal.

Signal in the second line



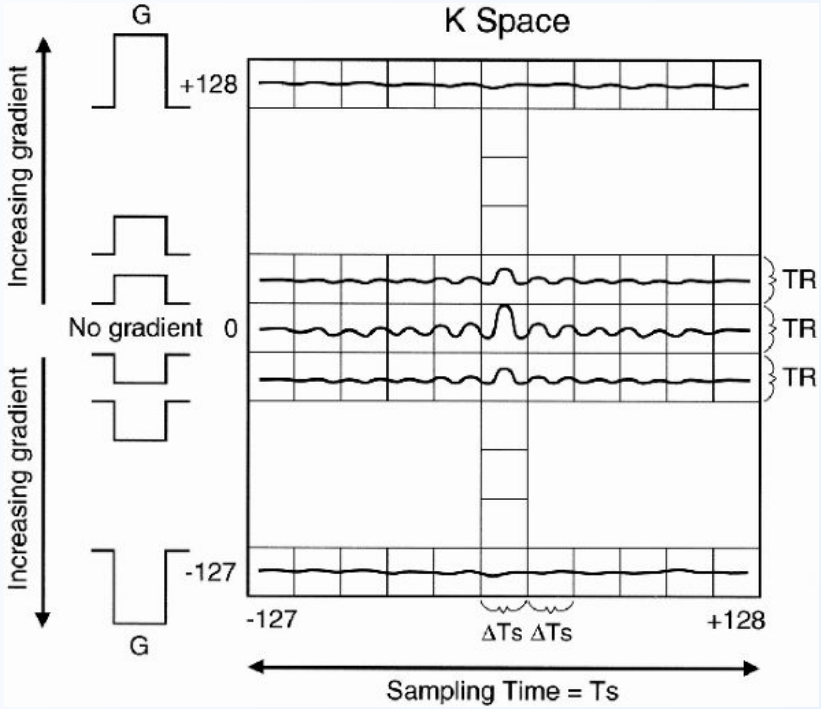
- When we draw this signal into the second line in the data space, we see that it is **similar in shape** to the first signal, but **slightly weaker**.

Signal shape in the second line



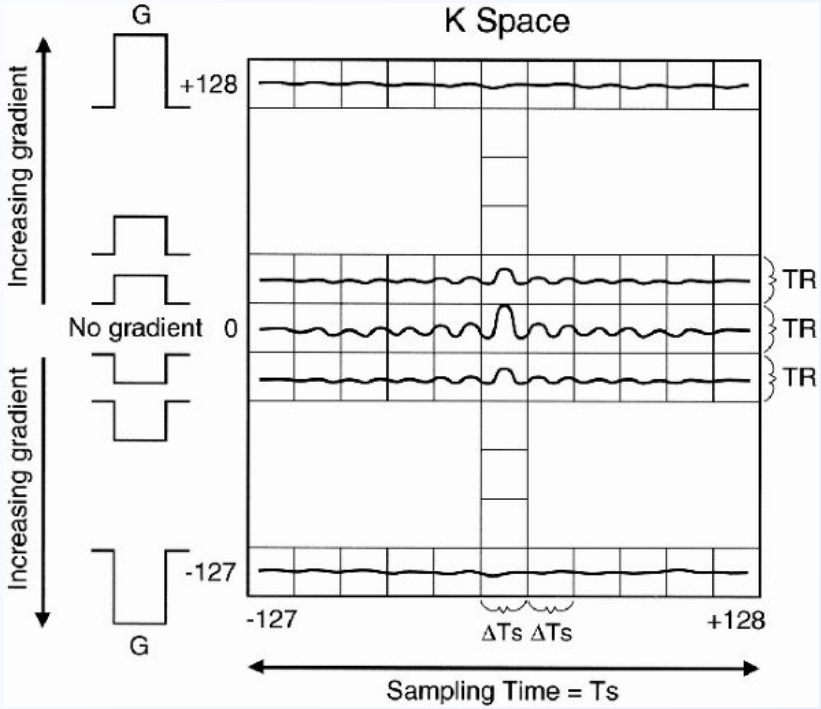
- The signal for the second line of the data space will be **similar in shape** to the first signal because ……..
- both are signals from the **same slice of tissue**, just **obtained at a different time**.

Signal magnitude in the second line



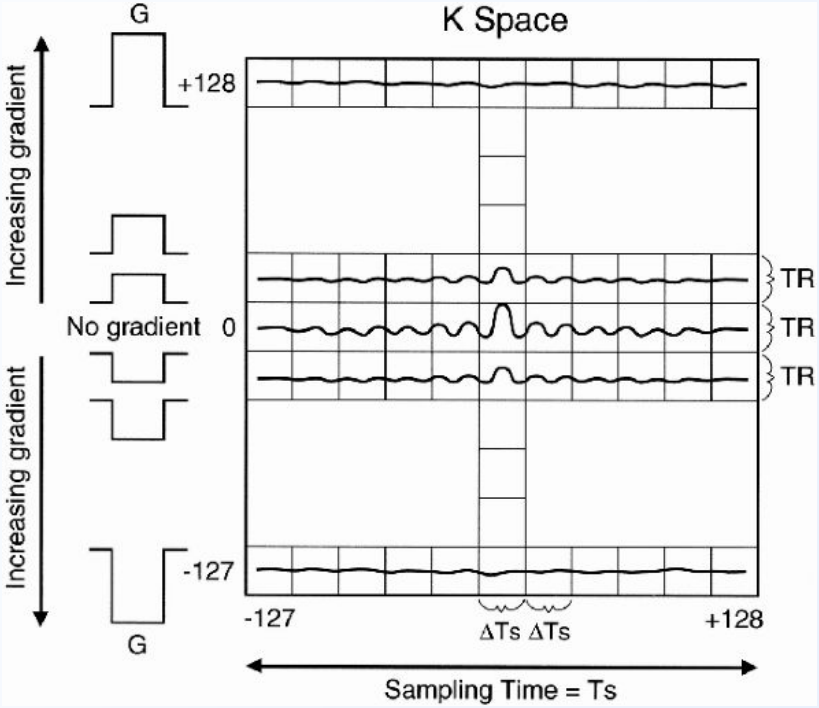
- The second line of the data space will be **smaller in magnitude** than the first signal because ……..
- it undergoes additional dephasing due to the phase-encoding gradient.

Signal in the last line (+128)



- The signal that goes into the last line of the data space (+128) will be almost flat because ……..
- it has undergone maximum dephasing.

Signal in the last line (-127)



- The signal that goes into the line -127 will be almost flat due to maximum dephasing.

Center and periphery of k-space

- The center of k-space contains the maximum signal.
- The periphery of k-space contributes to the fine detail of the image.

Frequency encoding

- We apply a frequency-encoding gradient in the x direction, which allows us to distinguish the columns.

Summary

- K space
- Phase encoding
- Frequency encoding

Reference

- Hashemi RH and Brandy WG. MRI the Basics, Second Edition.