Magnetic Resonance Imaging
History

Nuclear magnetic resonance was first described by Isidor Rabi in 1938 - Columbia University, New York City, (Nobel Prize Nobel Prize in Physics 1944)

1946 - Edward Mills and Felix Bloch Purcell refined the technique for use on liquids and solids, (Nobel Prize in Physics in 1952)
History

1977 - First human scan was made

2003 - Paul C. Lauterbur and Sir Peter Mansfield received the Nobel Prize in Medicine for their discoveries concerning magnetic resonance imaging
Theory

Measures the nuclear magnetization alignment of hydrogen atoms under a powerful magnetic field.

http://www.magnet.fsu.edu/education/tutorials/magnetacademy/mri/fullarticle.html
Theory

https://www.youtube.com/watch?v=1OrPCNVSA4o
Theory

https://www.youtube.com/watch?NR=1&v=pGcZvSG805Y&feature=fvwp
Theory

• Superimpose a linear field gradient on the static field

• When hydrogen atoms are excited with a really strong magnet, they all line up

• When they are then hit with a radio wave, they are knocked down and scattered

• While they are getting back in line again, each atom sends out very distinct signals
Theory
Theory

The stronger the magnetic field, the higher the resonance frequency.
Theory
Permanent Magnets

Magnetic field of 21.1 Tesla

- Soft Iron Yoke
- Fringing Field
- Air Gap for Patient
- Soft Iron Shims
- Permanent Magnet
Static Magnets Coils

The patient distorts the magnetic field when put into the scanner and so an active shim correction must be made before scanning.

The diameter of the coils is 1.3 m, and the total length of wire is about 65 km.
Static Magnets Coils

The main magnet coils and the superconducting shim coils are maintained at liquid helium temperature (4.2 K) and carry 200 A to produce the 1.5-T magnetic field.

A constant current flow indefinitely so long as the temperature of the coils is maintained below the superconducting transition temperature.
Static Magnets Coils

Cross-section of a Typical Superconducting Magnet
Gradient Magnets

The gradient magnets change the direction of the permanent magnet in order to scan the section of interest. Three coils are used allowing a 3D scanning. (similar effect as in the Cathode ray tube of old TVs)
Gradient Magnets
Gradient Magnets
RF Coils

The RF coil is used to both perturb and receive MR signal

Transverse plane and approximately on the order of 10 T
RF Coils

Figure 2-9: (A) Head Coil - Quadrature transmit and receive. (B) Peripheral Vascular Phased Array Coil. (C) Phased Array Coil. (D) Breast Array Coil. (E) General Purpose Coil. (F) Knee Coil.
MRI Machine Components

The main components of an MRI system are the superconducting magnet, the gradient system, the RF system and the computer system.
MRI Machine Components
Timing Signals

- Timing Signals
- $k_y$ readout
- phase encode
- Slice Selection
- RF
- $G_z$
- Phase Encode
- $G_y$
- Dephase
- $G_x$
- Readout
- A/D
Timing Signals

Spin Echo Pulse Sequence

TR

TE

2

TE

FID

Echo

TE – thermal equilibrium (100 ms)
Characteristics

Advantages

• Appears safe - Does not use ionizing radiation
• Measure tissues using their physical and biochemical properties (Neurological, musculoskeletal, cardiovascular, and oncological-cancer)
Characteristics

Limitations

• Patients experience claustrophobia
• RF heating: body temperature rise < 1°C
• Higher levels - Nerve stimulation
• Movement artefacts may result
• Slow scanning time
• Patients with pacemakers cannot be studied
Block Diagram

Product Availability and Design Disclaimer - The system block diagram depicted above and the devices recommended are designed in this manner as a reference. Please contact your local TI sales office or distributor for system design specifics and product availability.
Block Diagram
Safety
Safety

Be sure to tell the technologist if you have any of the following:

- A pacemaker or artificial valve in your heart.
- Metal pins, plates, rods, screws or nails anywhere in your body.
- Wire sutures or surgical staples.
- An intrauterine device (IUD) or diaphragm.
- An insulin pump.
- An aneurysm clip.
- A joint replacement.
- An ear implant.
- A stent, filter or coil in any blood vessel.
- Any type of prosthesis, including a penile implant or artificial eye.
- Permanent (tattooed) makeup, such as eyeliner or lip coloring.