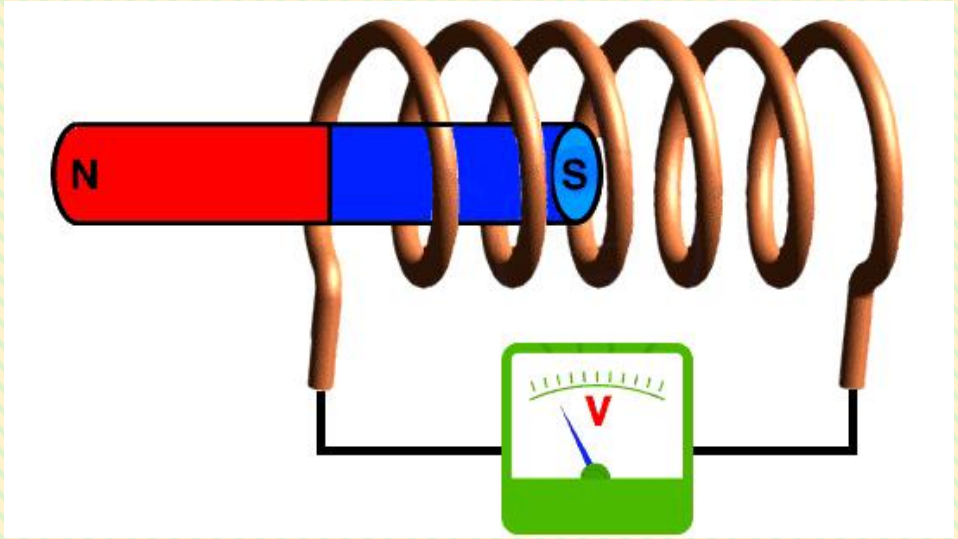
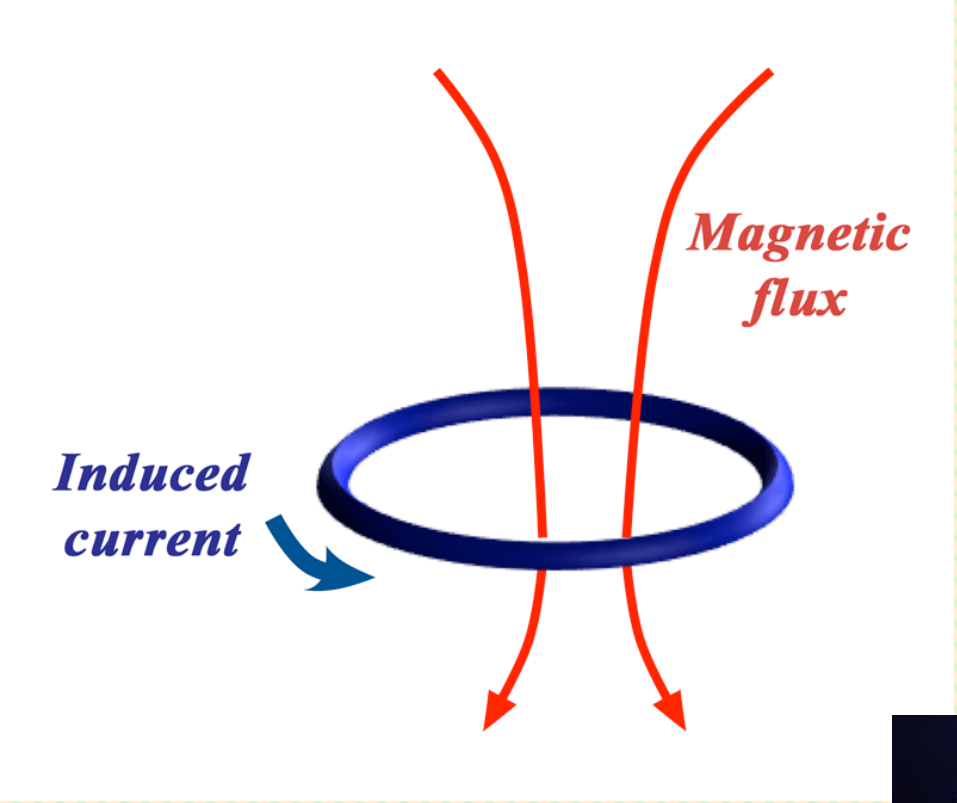
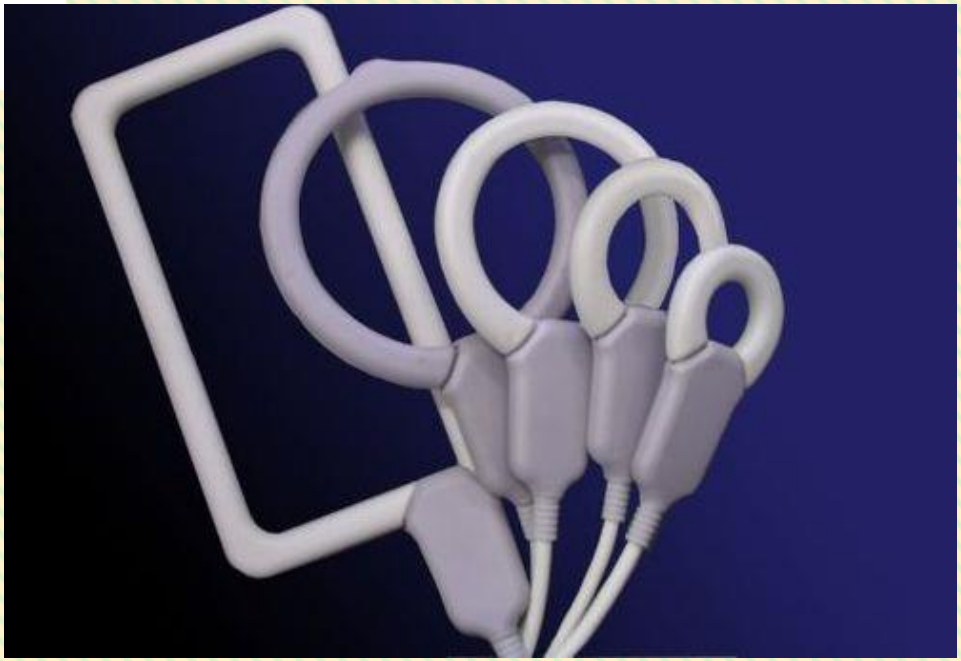
Lecture 4
RF system

- ***Faraday's Law of Induction*** *is a fundamental principle in MRI for both transmitting and receiving signals.*



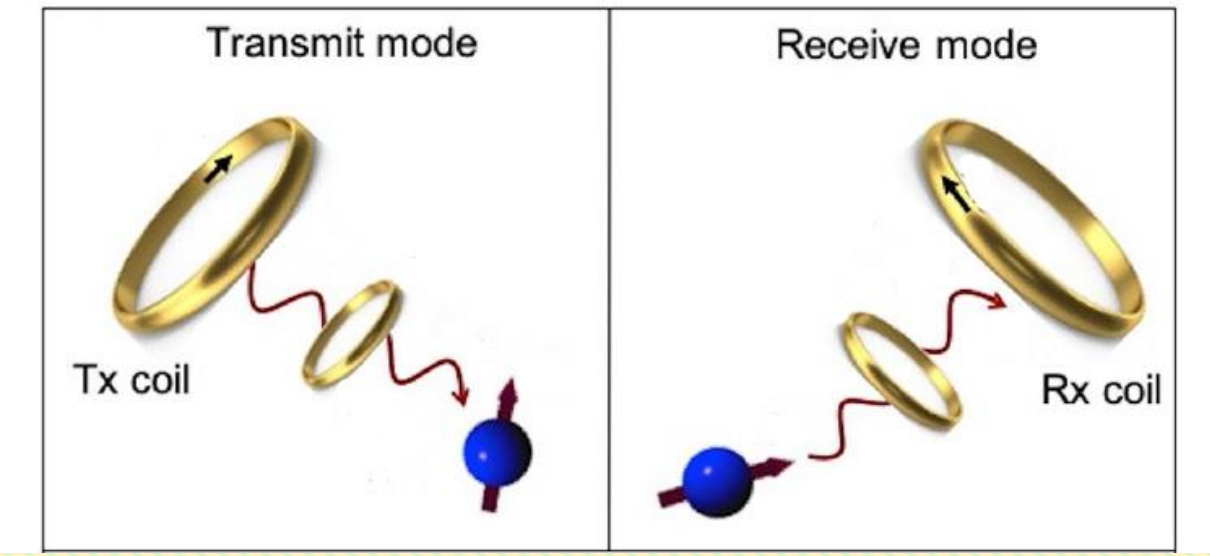
- *Faraday's Law states that a change in magnetic flux through a closed loop generates an electric voltage in the loop. This voltage is proportional to the rate of change of the magnetic flux, leading to an induced current in the conductor.*


Magnetic
flux
Induced
current



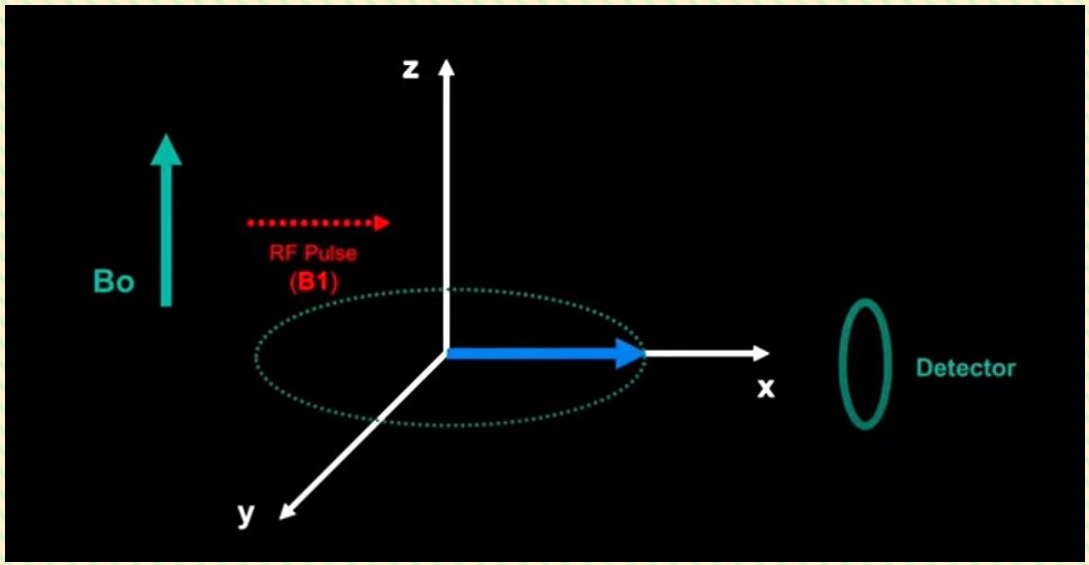
What is a Coil?

RF (Radiofrequency) Coils are essential components of MRI machines. They are used to transmit RF pulses to the patient's body and receive the resulting MRI signals. These coils play a key role in generating and detecting the electromagnetic signals needed to create detailed images of internal organs.



- ***Transmission RFt :***

During transmission, RF coils generate a time-varying magnetic field that excites the hydrogen protons in the body. This excitation changes the magnetic field, which induces an electric current in the surrounding tissues based on Faraday's Induction. When used as transmitters, RF-coils generate an oscillating/rotating magnetic field (denoted B1) that is perpendicular to the static main magnetic field (Bo).



Components:

- *Frequency Generator: Produces a radio signal at a specific frequency (MHz) matching the nuclear resonance frequency of protons.*
- *Pulse Generator: Shapes the transmission pulses to control their shape, duration, and power.*
- *RF Amplifier: Boosts the RF signal to the required power level to excite the protons.*
- *Transmission Coil: Sends the amplified RF pulses to the patient's body.*

Operations:

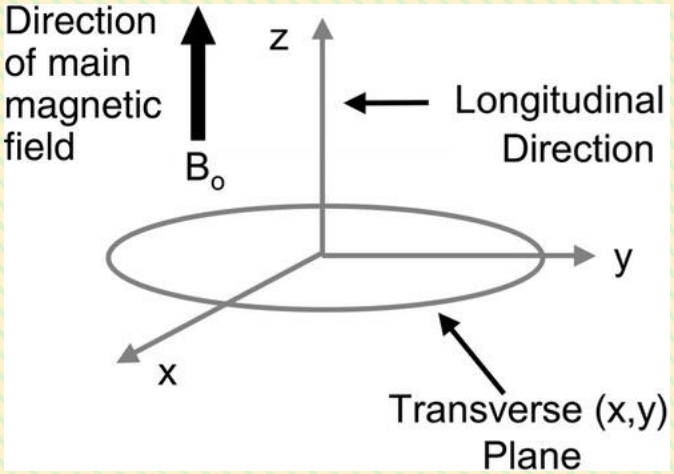
- *Signal Generation: The frequency is set to match the nuclear resonance frequency, and pulses are shaped precisely.*
- *Signal Amplification: The signal is amplified efficiently with precise control over the power.*
- *Transmission: The signal is sent through the transmission coil with uniform distribution.*

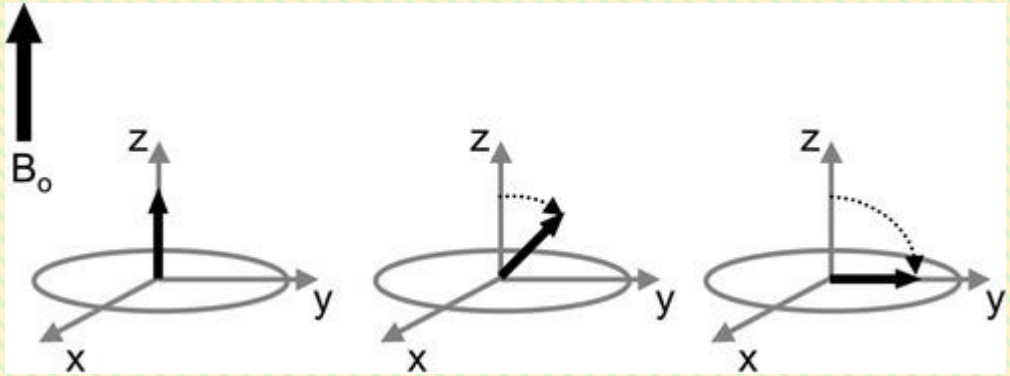
Challenges:

- *Heat: Effective cooling is needed for amplifiers.*
- *Electromagnetic Interference (EMI): EMI must be minimized to avoid interference with other components.*
- *Uniformity: Achieving a uniform RF field requires precise coil design.*

Relationship between RFt and B1:

B1 is a term used to represent the strength of the RF field. In MRI, B1 refers to the magnetic field produced by the RF coil. The B1 field is often visualized as consisting of two vectors rotating in different directions, usually in the transverse plane (Mxy) relative to the main magnetic field B0.





RF Pulses types

RF Pulse Type	Phase	Frequency (Hz)
90° RF Pulse	90°	Matches Larmor frequency (e.g., ~63.87 MHz at 1.5T)
180° RF Pulse	180°	Matches Larmor frequency (e.g., ~63.87 MHz at 1.5T)
Low Flip Angle Pulse	30° - 60°	Matches Larmor frequency (e.g., ~63.87 MHz at 1.5T)
Saturation Pulse	90° or custom	Fat frequency (Water frequency - ~220 Hz at 1.5T)
Inversion RF Pulse	180°	Matches Larmor frequency (e.g., ~63.87 MHz at 1.5T)


THANKS !