Hardware

- **Coil Overlook**
- **Coil in MRI system**
- **TEM Coil**

Coil Overlook

Part1

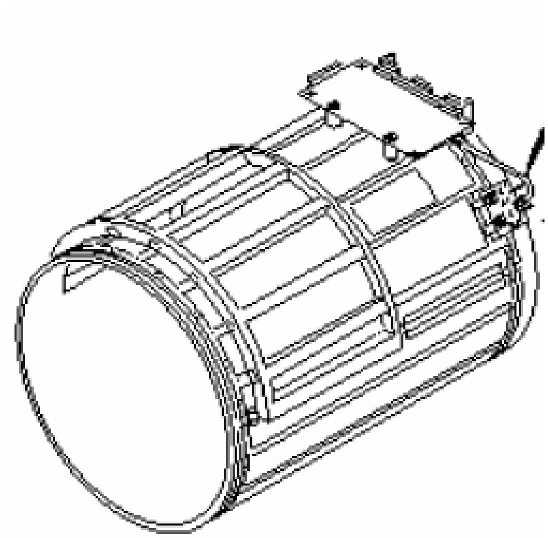
Transmit and Receive

- Head coil T/R
- Body coil T/R
- Surface coil and multi-coil R

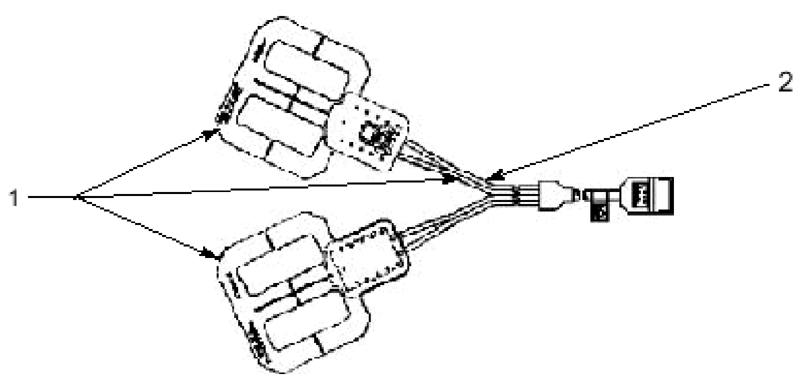
New uses of coils

- Surface coil and multi-coil T/R
- Siemens whole body scan

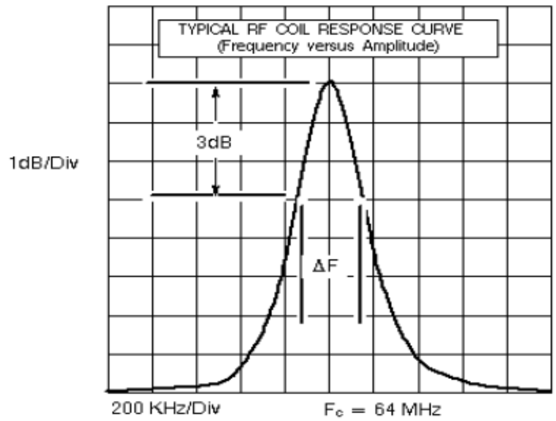
QUAD HEAD COIL



Cardiac COIL



The quality factor (Q) is typically a measure of the bandwidth of an RF coil.



$$Q = \frac{(F_c)}{(\Delta F)}$$

RF COIL QUALTITY FACTOR

Tuning and Matching

- Coils should be matched to 50 ohms in order to maximize power delivery to the preamplifier load even though modern preamplifiers have input impedance close to 3 ohms real for the following reasons:
- – test equipment (network analyzers) are designed to measure accurately at this impedance.
- – 50 ohm coaxial cable is standard and matching the transmission line to the impedance at one end reduces reflection losses in the cable
- – the preamplifier is noise matched (has minimum noise figure) when the source is 50 ohms

Coil IN MRI System

Part2

The body acts like a capacitor.

- Different loads with different compositions (water versus muscle versus fat) have different loading characteristics. Larger loads of the same composition have more of an effect than smaller ones.
- This capacitance shift the frequency down

Two equations

- Quality factor (Q)

$$Q = \frac{\omega L}{R_{coil}}$$

- Resonance frequency *f*

$$C = \frac{1}{(2\pi f_{res})^2 L}$$

Another question:

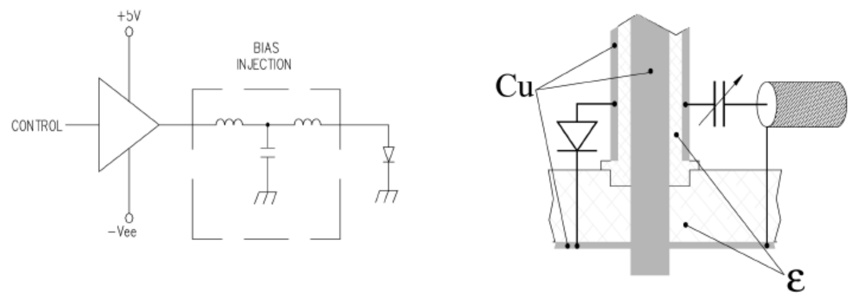
- In field we find out:
- Sometimes SMALL load make the resonant frequency out of bandwidth of RF coil. At another way LARGE load can not get it. Why?

Auto-tune system function

- electronically optimizes the tuning of the disposable coil on a per-coil and per-patient basis by sweeping an electronically controlled reactance through a range of values
- locking in the value which provides the optimum response at the nominal X MHz MRI system frequency.

Auto-tune system function (continue)

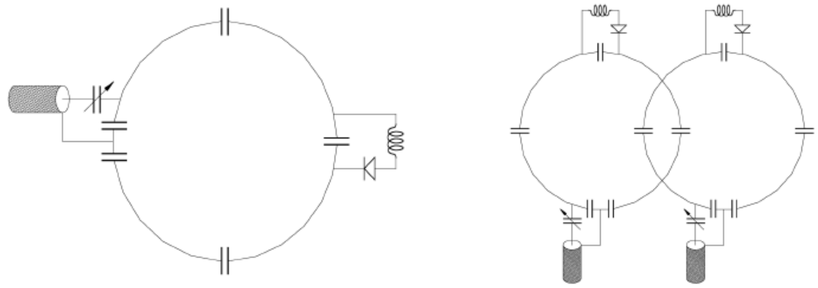
- to provide effective decoupling of the disposable coil from the RF excitation field during transmitting period
- includes a matching network to transform the nominal coil impedance to 50 ohms,



Body TEM Coil Detuning Circuit

Detuning Circuit

- When current is biased on, the diode shorts the outer conductor of the coaxial line element to the grounded cavity wall of the coil. When the diode is voltage-biased off, the connection is reopened with high impedance to restore the operational configuration of the tuned TEM coil.

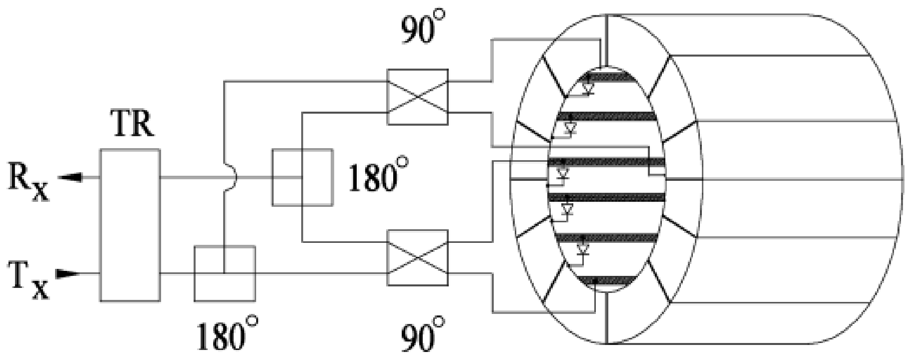


Surface Coil Detuning Circuit

Quadrature Coil

- Quadrature design is important for a receive coil. The quadrature effect will increase the level of signal while at the same time decrease the noise level.
- This improves the SNR for a quadrature type coil over a linear one by a factor of ?.

The actively detuned TEM volume coil is shown. The coil is capable of operating in transmit and/or receive modes, and is actively de-tunable for operation with independent receiver coils. Included in the four-port drive circuit are a pair of 180° splitter/combiners, a pair of 90° hybrids, and a T/R switch.



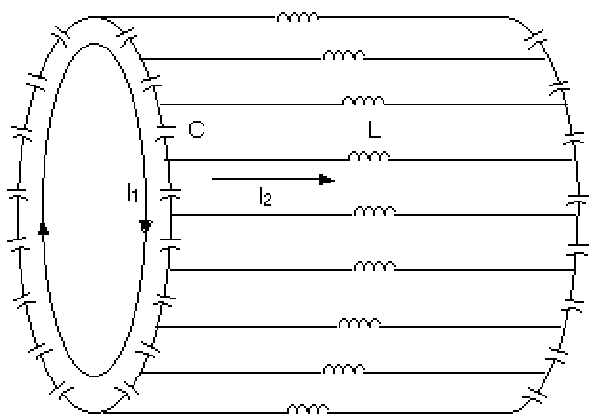
Quadrature Function

- This design is based on the fact that destructive fields (ones that do not help the MR process) will cancel each other, leaving only the X and Y components that produce a rotating RF field inside of the coil.
- SNR?

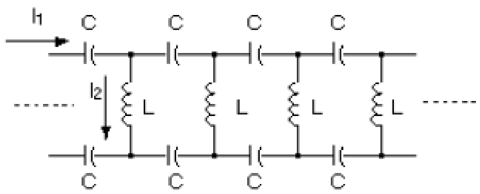
Tem Coil

Part3

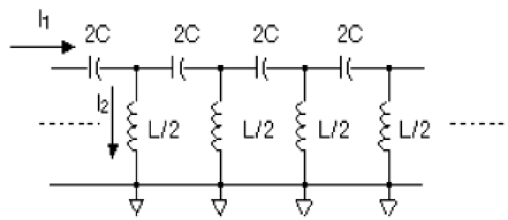
Birdcage coil



In the Body Coil this resonant frequency is a function of both the chip capacitors placed at the end rings and the length (or inductance) of the birdcage.



NORMAL HIGH PASS LADDER NETWORK
ILLUSTRATION 2-1



FOLDED HIGH PASS LADDER NETWORK
ILLUSTRATION 2-2

The first descriptions of TEM resonator structures appeared in patents:

- Ro¨schmann P. High-frequency coil system for a magnetic resonance imaging apparatus. US Patent 4746866, 1988.
- Bridges JF. Cavity resonator with improved magnetic field uniformity for high frequency operation and reduced dielectric heating in NMR imaging devices. US Patent 4751464, 1988.

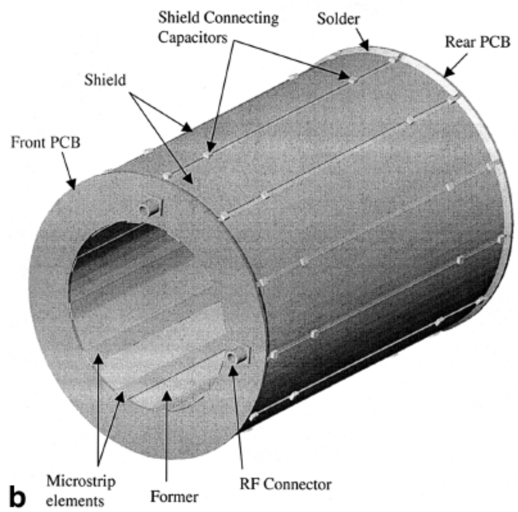
Two definitions help to describe and clarify the integral cavity component of the TEM coil circuit, and to differentiate it from the shield often used with the birdcage coil design.

- A cavity is a metallic enclosure inside which resonant fields may be excited.
- a shield is a metallic covering placed around or between electric circuits to suppress the effects of undesired signals

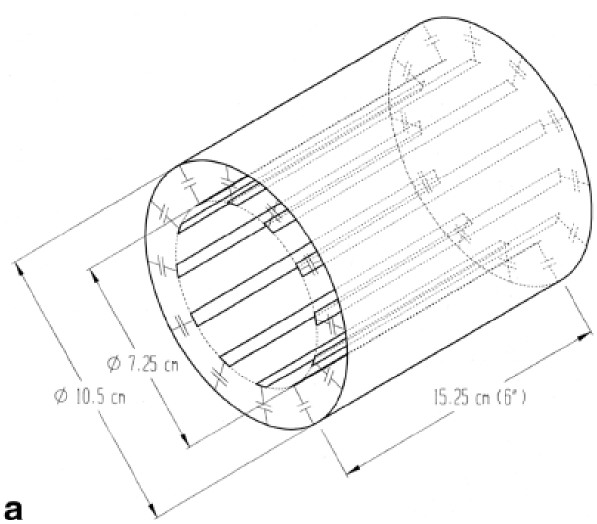
The definition of TEM Coil

- Further, a cavity resonator is a space which is normally bounded by an electrically conducting surface and in which oscillating electromagnetic energy is stored; the resonant frequency is determined by the geometry of the enclosure. The TEM coil by definition, is a cavity resonator.

The micro-strip TEM resonator: (**b**) physical layout



The micro-strip TEM resonator: (**a**) schematic



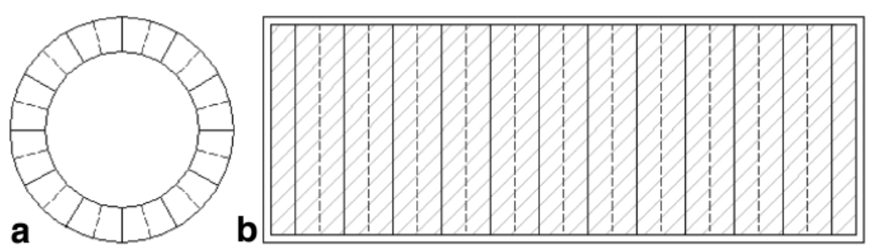
Both the birdcage shield and the TEM cavity must be segmented or slotted to sufficiently break up switched gradient-induced eddy currents.

the Birdcage Coil

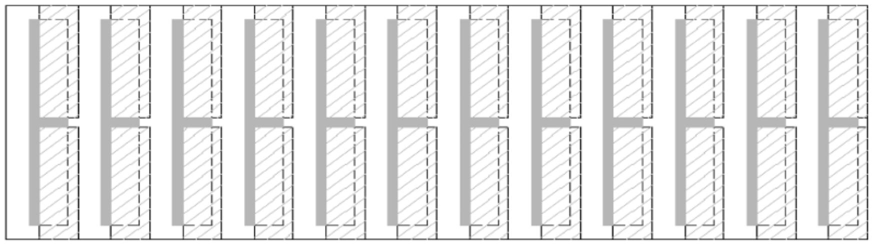
- Viewing the birdcage with its end rings as a closed-ladder network of loops, the optimal birdcage shield is segmented in thumbprint patterns so as to not interrupt looping RF current patterns induced on the shield by the cage currents

TEM resonator

- The significant current return path from the line elements in the TEM resonator is on the cavity wall, in the *z* direction. The TEM cavity must be segmented in the *z* direction, from the front (head entry side), to the back wall of the cavity. Any *x* or *y* component in the TEM cavity segmentation pattern interrupts or adds inductance to the return path circuit. A thumbprint design for the TEM cavity would therefore be suboptimal.



Shown are the (**a**) open front wall, (**b**) cylindrical outside wall,



The inside wall of the cavity comprised 24 capacitive line elements or rungs coaxial with the outside wall of the cavity. These elements may be coaxial, strip line, or double-sided, as shown. The parallel inside and outside walls form the coaxial or TEM cavity.

Advantages of TEM volume coils

- The inductances of the elements comprising birdcage coils increase with the coils' overall sizes, unreasonably low value capacitors are required to resonate the large body birdcage coils.
- Size scaling of TEM coils, on the other hand, is much easier, since the area of the elements comprising a TEM coil can be controlled by adjusting the distance between the coil's legs and its shield.
- Additional advantages of the TEM coils include absence of the end ring currents and better sensitivity.

Etched Connection

- Connected slots were etched in the front, back, and cylindrical outside walls of the TEM cavity. The slots were etched on two sides of a double-sided 5-μ-thick copper film deposited on a 12-μ-thick polyimide substrate. The slots on one side were overlapped by lands on the other side. The capacitive bridging thereby achieved between the segments provides low impedance to the RF currents and high impedance to the gradient-induced eddy currents between segments, improving the RF conduction efficiency and shielding qualities of the cavity.

References

- Vaughan JT, Hetherington HP, Harrison JG, Otu JO, Pan JW, Pohost GM. High frequency volume coils for clinical NMR imaging and spectroscopy. Magn Reson Med 1994;32:206–218.
- Vaughan JT. An improved volume coil for high field MRI. In: Proceedings of the 7th Annual Meeting of ISMRM, Philadelphia, 1999. p 167.
- Bridges JF. Cavity resonator with improved magnetic field uniformity for high frequency operation and reduced dielectric heating in NMR imaging devices. US Patent 4751464, 1988.
- Ibrahim TS, Lee R, Baertlein BA, Kangarlu A, Robitaille PML. Modeling the TEM resonator in the presence of a human head for high field MRI. In: Proceedings of the 8th Annual Meeting of ISMRM, Denver, 2000.
- Avdievich NI, Krymov VN, Hetherington HP. Modified perturbation method for transverse electromagnetic (TEM) coil tuning and evaluation. Magn Reson Med 2003;50:13–18.