Spectrometer overview

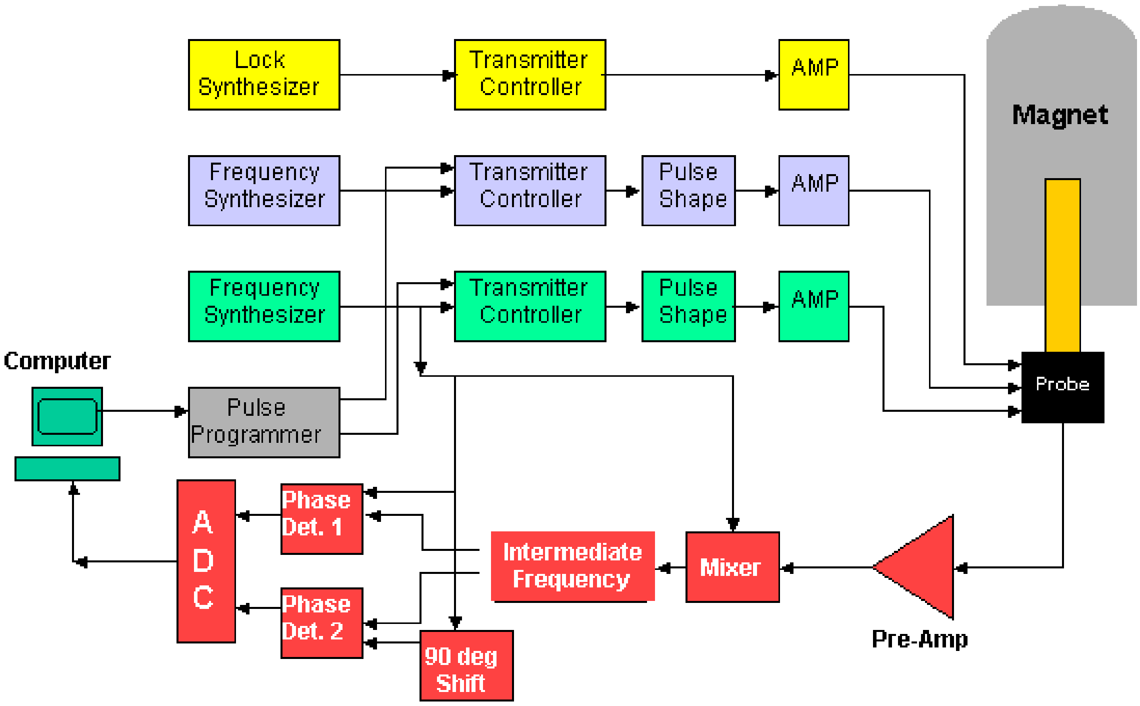

Figure 2.1 Schematic Layout of an NMR Spectrometer

An NMR spectrometer consists of several separate components that are linked together to excite the sample and then receive the NMR signal, these are represented diagrammatically in Figure 2.1. The main parts of the spectrometer are:

1. Magnet

The magnetic field is providing an ultra high filed super-conducting magnet.
WARNING these magnets are extremely powerful, and will easily pull magnetic objects, such as pocket knives, pens, key chains, mp3-players, cell-pones etc out of your grasp. They will wipe credit cards, and destroy watches that use springs in the movement. They will interfere with the operation of pace makers and other automated medical devices.
The magnet is maintained as a super-conductor by the use of liquid Helium. This is surrounded by a vacuum chamber which in turn is surrounded by a dewar of liquid Nitrogen. The central bore of the magnet contains shim coils that are used to adjust the field homogeneity in the vicinity of the sample.

2. Probe

The NMR sample is placed in a probe inside the magnet which is arranged so that the sample sits at the center of the magnetic field. The probe contains a set of coils that are used both to generate the RF pulses and to detect the signal induced by the effects of the pulse on the sample. In addition, the probe contains a heating element for temperature stability and may also have a Gradient Coil for applying Magnetic Field Gradients.

3. Lock Circuit (Yellow)

A stable deuterium frequency is generated by a ***Frequency Synthesizer***. This signal is passed through a ***Transmitter*** which controls the input of the deuterium signal to the probe. The signal is passed through an ***Amplifier*** before going to the probe.The lock circuitry is connected to a feed back loop mechanism. This detects changes in the resonant frequency of the deuterium signal and adjusts the magnetic field to compensate for these changes by changing the current in a solenoid which forms part of the shim system.

4. TRANSMITTER CIRCUIT (GREEN/LAVENDAR)

The frequency for the Observe Channel is generated by a Frequency Synthesizer. The timing of the pulses in the NMR experiment is controlled by the Transmitter under the influence of the Pulse Programmer. The output from the transmitter is fed through an optional Pulse Shape Unit and then amplified before passing into the Probe.

5. DETECTOR CIRCUIT (RED)

The signal detected in the coil at the Observe Frequency is passed through a ***Preamplifier*** to increase the signal. This is then combined with a second frequency generated by the ***Frequency Synthesizer*** in a ***Mixer***. The resulting signal has a frequency of ~10-20 MHz. This ***Intermediate Frequency*** is then amplified and split into two parts which pass into the ***Phase Sensitive Detectors.*** The detectors are 90º out of phase with respect to each other. The detectors also remove the ***Intermediate Frequency*** generated by the ***Frequency Synthesizer***, which results in an output with a frequency range of a few kilohertz. This signal is passed into the ***Analogue to Digital Converter*** which converts the analogue signal into a digital form that can be stored in the computer.

6. DECOUPLER CIRCUIT (PURPLE)

In principle there can be as many decoupler circuits as you can afford. They all have essentially the same design, but it is more usual to pack the first and second decoupler channels with the many features and to use more basic designs for any additional channels. The Decoupler circuit again consists of a very stable ***Frequency Synthesizer*** coupled to a ***Transmitter*** which are controlled by the ***Pulse Programmer***. The input signal passes through a ***Pulse Shaping*** unit before being amplified and sent to the probe. Often the Decoupler signal is passed through a filter to remove any unwanted frequency spikes e.g. Deuterium that may have been introduced along the way.

7. GRADIENT AMPLIFIER (NOT SHOWN)

Most modern NMR spectrometers now include Gradient Amplifiers. These are acoustic amplifiers that can be used to apply a magnetic field gradient across the sample. That means the effective magnetic field in one part of the sample is different from another. These units also come under the control of the pulse programmer.