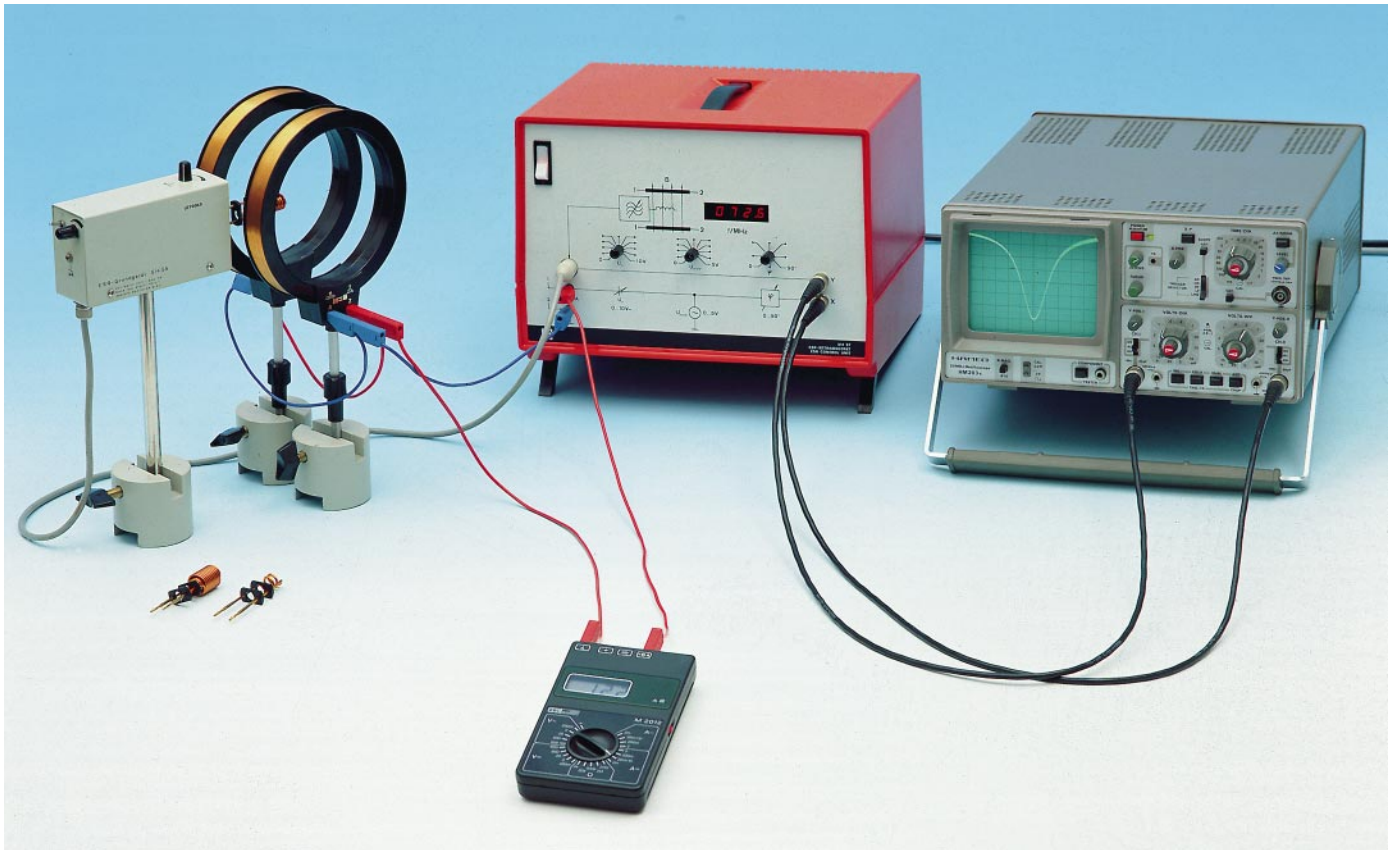
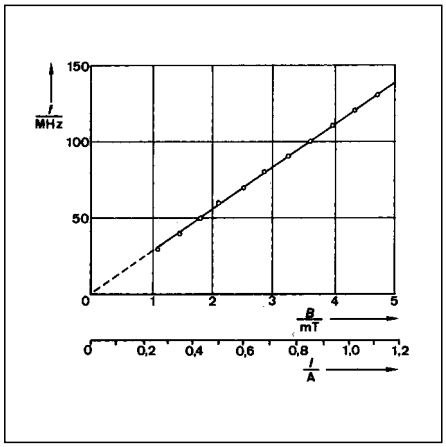
Electron Spin Resonance

The equipment for this topic set provides the basis for the investigations of the microphysical quantities of the electron. With the resonance method used, the difference in energy between two spins can be measured directly. For this a paramagnetic substance (e.g. DPPH = diphenyl-pikryl-hydrazyl) is placed between a pair of Helmholtz coils (constant field with 50 Hz modulation) and an r.f. coil (frequency range 15 to 150 MHz). The r.f. coil is part of a high quality parallel resonance circuit. In the resonant case the sample absorbs r.f.energy, thus changing the AC resistance (damping) of the oscillatory circuit. By triggering the two-channel oscilloscope with the modulation signal of the magnetic field it is possible to simultaneously display the curves for field modulation and ESR absorption (see fig. below).

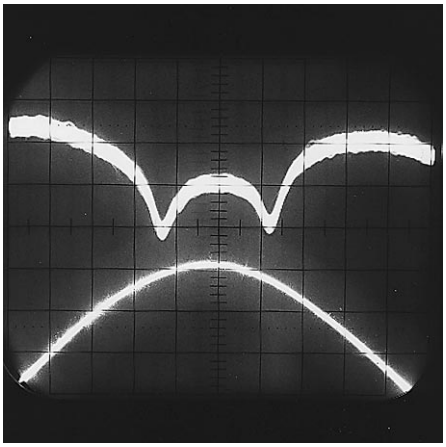
The resonance frequencies *f* at different field strengths *B* are directly indicated on a digital frequency counter, built-in to the ESR unit. From the *f*-*B* graph the gyromagnetic ratio (*g*-factor) can be determined for the particular electron spin system.



Determination of the *g* factor



Resonance frequency *f* as a function of magnetic resonant field strength *B*



Oscilloscope display

Topics

- Resonance absorption of an r.f. tuned circuit
- Electron spin resonance (resonant frequency as a function of magnetic field strength, determination of the *g*-factor)

Equipment list:

1	ESR basic unit	514 55
1	ESR control unit	514 57
1	Pair of Helmholtz coils	555 06
2	Multimeters M 2012	531 56
1	Two-channel oscilloscope	575 211
3	Saddle bases	300 11
1	Insulated stand rod	590 13
2	Screened cables BNC, 4 mm	575 24
3	Conn. leads, 25 cm	501 23
5	Conn. leads, 50 cm	501 28

514 55 ESR basic unit

For experiments on electron spin resonance in conjunction with the ESR control unit (514 57) or the ESR adapter (514 56).

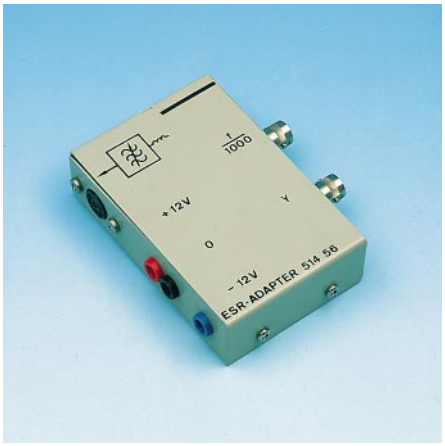
- Power supply: 12 V; 175 mA
- Frequency range of each coil:
  approx. 13 to 30 MHz,
  approx. 30 to 75 MHz,
  approx. 75 to 130 MHz
- Voltage at RF coil:
  approx. 6 V_{pp} (with respect to earth) at 13 MHz and max. amplitude setting
- ESR signal:
  approx. 1 to 6 V (frequency dependent)
- Frequency divider: 1000 : 1
- Frequency response for digital counter: TTL
- Resonance meter current (DC):
  approx. 100 µA
- Frequency range of the passive resonant circuit: 10 to 50 MHz
- Dimensions of the probe head:
  13 cm x 7 cm 4 cm
- Stand length: 18.5 cm
- Weight: approx. 0.7 kg

Scope of delivery:

1 ESR probe head (variable high-frequency transmitter, frequency divider and low-frequency signal amplifier)
3 Plug-in coils for different frequency ranges
1 Measuring cable, for employing the unit as a resonance meter
1 Passive electric resonant circuit for investigating the dependence of the resonant frequency on the magnetic field
1 DPPH-probe (diphenyl-picryl-hydrazyl)

514 57

514 55 on 300 11



514 56

555 06

514 57 ESR control unit

Power supply unit for the RF transmitter of the ESR basic unit (514 55) and the pair of Helmholtz coils (555 06) for experiments on electron spin resonance; integrated high-frequency counter with digital display and phase shifter between the oscilloscope-compatible output voltages, which are proportional to the RF amplitude or the coil current.

- Power supply for magnetic field:
  0 to 10 V DC,
  0 to 5 V AC, continuously adjustable
  Current: max 3 A (no overload protection)
- Adjustable phase difference: 0 to 90°
- Frequency display: 4 decades (MHz)
- Connection:
  115/230 V, 50/60 Hz, via mains cable
- Fuses:
  for 230 V: T 0.8 B
  for 115 V; T 1.6 D
- Dimensions: 30 cm x 21 cm x 23 cm
- Weight: approx. 6.2 kg

514 56 ESR adapter

For connection of the ESR basic unit (514 55) to other power supply units with 4 mm sockets and meters with BNC sockets; required when the ESR control unit (514 57) is not used.
A built-in frequency output allows high frequency measurements with conventional counters (e.g. 575 40 or 575 45).

- Output: 5-pole multiple socket for ESR basic unit
- Signal output: BNC socket
- Frequency output: BNC socket
- Connection: + 1 2 V/0 V/– 12 V, via 4 mm sockets
- Dimensions: 9.5 cm x 7.5 cm x 2.5 cm

Additionally required:

DC power supply
0 to ± 15 V 521 45
Variable extra low voltage
transformer S 521 35
Counter P 575 45
Stopclock 313 07

555 06 Pair of Helmholtz coils

The pair of coils are used to produce a homogeneous magnetic field of variable strength in which the deflection of electrons within tubes 555 07–17 can be shown and investigated, also used with the apparatus for electron spin resonance (514 55). For use with stand (555 05).

- Number of turns per coil: 320
- Max. continuous current: 1.5 A (U = 10 V)
- Max. short-time current: 2 A (U = 15 V)
- Average diameter: 13.5 cm
- Stand rod: 14.5 cm x 8 mm dia.
- Connection two 4-mm sockets on each coil