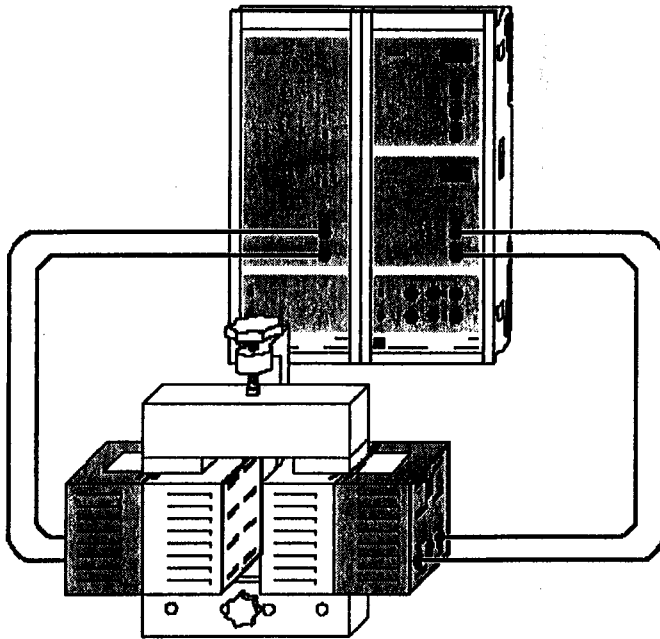
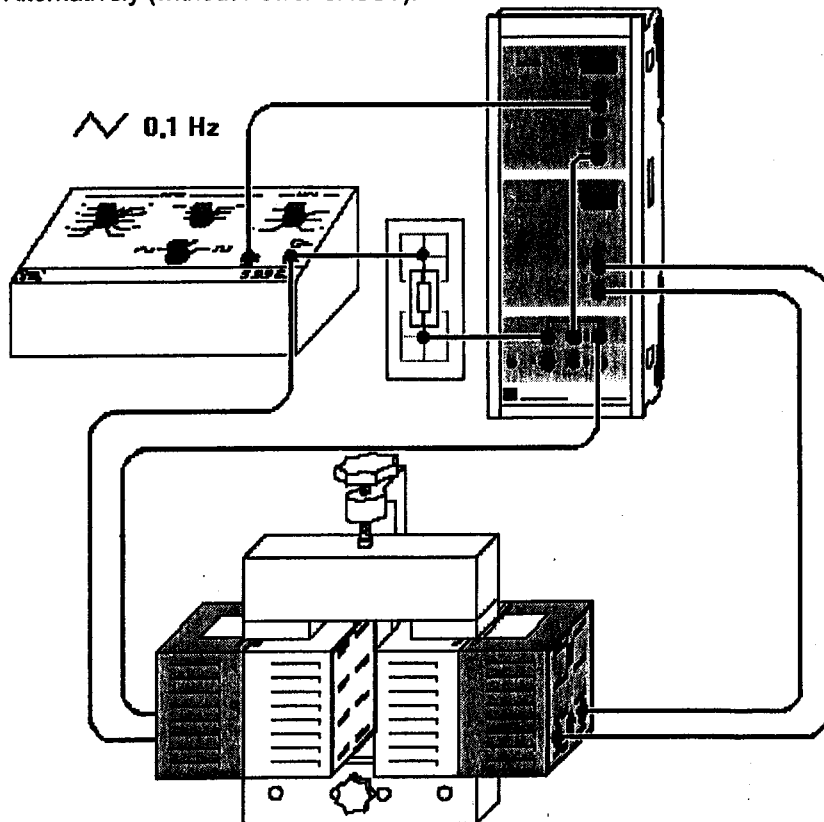


Hysteresis of a transformer core



Alternatively (without Power-CASSY):



- Load example (with Power-CASSY)
- Load example (without Power-CASSY)



Experiment description

In a transformer core (ferromagnet) the magnetic field

$$H = N1/L \cdot I$$

is proportional to the coil current I and the effective turns density $N1/L$ of the primary coil. However, the generated magnetic flux density or magnetic induction

$$B = \mu_r \cdot \mu_0 \cdot H \quad (\text{where } \mu_0 = 4\pi \cdot 10^{-7} \text{ Vs/Am})$$

is not proportional to H . Rather, it reaches a saturation value B_s as the magnetic field H increases. The relative permeability μ_r of the ferromagnet depends on the magnetic field strength H , and also on the previous magnetic treatment of the ferromagnet. In a demagnetized ferromagnet, the magnetic field strength is $B = 0 \text{ T}$ at $H = 0 \text{ A/m}$. Normally however, a ferromagnet still retains a residual magnetic flux density B not equal to 0 T when $H = 0 \text{ A/m}$ (remanence).

Thus, it is common to represent the magnetic induction B in the form of a hysteresis curve as a function of the rising and falling field strength H . The hysteresis curve differs from the magnetization curve, which begins at the origin of the coordinate system and can only be measured for completely demagnetized material ($H = 0 \text{ A/m}$, $B = 0 \text{ T}$).

In this example H and B are not measured directly; rather, the quantities proportional to these, i.e. the primary current $I = L/N1 \cdot H$ and magnetic flux $\Phi = N2 \cdot A \cdot B$ through the secondary coil are used ($N2$: number of turns of secondary coil; A cross-section of ferromagnet). The magnetic flux Φ is calculated as the integral of the voltage U induced in the secondary coil.

Equipment list

1	Power-CASSY	524 011
1	Sensor-CASSY	524 010
1	CASSY Lab	524 200
1	U-core with yoke	562 11
1	Clamping device	562 12
2	Coils with 500 turns	562 14
4	Connecting leads, 100 cm, black	500 444
1	PC with Windows 95/98/NT	

Alternatively (without Power-CASSY)

1	Sensor-CASSY	524 010
1	CASSY Lab	524 200
1	U-core with yoke	562 11
1	Clamping device	562 12
2	Coils with 500 turns	562 14
1	Function generator S12	522 62
1	Transformer, 12 V AC	562 73
1	STE resistor 1 Ω , 2 W	577 19
1	Socket board section	576 71
1	Connecting lead, 50 cm, black	500 424
7	Connecting leads, 100 cm, black	500 444
1	PC with Windows 95/98/NT	

Experiment setup (see drawing)

Power-CASSY supplies the current for the primary coil of the transformer. The magnetic flux Φ is calculated from the induction voltage U of the secondary coil, which is measured at Sensor-CASSY input B.

Alternatively, you can perform the experiment without Power-CASSY, using the function generator S12. This apparatus must be set to sawtooth signal, frequency around 0.1 Hz and amplitude about 2 V. Recording of the magnetization curve is triggered at $I = 0 \text{ A}$. To hit this point exactly, the current is shunted past the transformer by the relay and flows through a 1 Ω resistor prior to recording of the curve.

Carrying out the experiment

- Load settings (with Power-CASSY)
- Load settings (without Power-CASSY)
- Correct the offset if necessary: open Settings UB, select **Correct**, set the first target value 0 V and click on **Correct Offset**.
- Demagnetize the transformer core, e.g. by striking the end face of the yoke against the end faces of the U-core several times.
- Start the measurement with F9.
- Stop the measurement with F9 after one period of the hysteresis curve or at $\Phi = 0$ Vs (in this case the core does not have to be demagnetized again).
- If the hysteresis curve lies in the second and fourth quadrants, reverse the connections on one of the two coils.
- If the display instrument UB is overdriven during measurement (display flashes), extend the measuring range in Settings UB.

Evaluation

As the area of a hysteresis loop B(H)

$$\int B \cdot dH = \frac{E}{V}$$

just corresponds to the energy loss in remagnetization per volume V of the demagnetized material, the enclosed area in the diagram $\Phi(I)$

$$\begin{aligned} \int \Phi \cdot dI &= \int N_2 AB \cdot \frac{L}{N_1} \cdot dH \\ &= \frac{N_2}{N_1} V \int B \cdot dH = \frac{N_2}{N_1} E \end{aligned}$$

gives us precisely the energy loss E of the remagnetization for $N_1=N_2$.

In the diagram, you can calculate this energy loss using "peak integration" of a hysteresis loop.