Problem

Try to amplify the small alternating voltages induced by alternating magnetic fields of the power supply unit in a coil so that they can be detected on headphones.

Equipment

Plug-in board	06033.00	1
On/off switch	39139.00	1
Resistor, 47 kΩ	39104.38	1
Adjustable resistor 10 kΩ	39108.03	1
Capacitor, 47 nF	39105.17	1
Electrolytic capacitor, 47 μF, bipolar	39105.45	1
Silicone diode 1N4007	39106.02	1
Transistor BC337	39127.20	1
Headphones, 2 kΩ, 4-mm plug	06811.00	1
Coil, 1600 turns	07830.01	1
Yoke	07833.00	1
Wire building block	39120.00	5
Connecting cables, 25 cm, red	07360.01	1
Connecting cables, 25 cm, blue	07360.04	1
Connecting cables, 50 cm, red	07361.01	2
Connecting cables, 50 cm, blue	07361.04	2
Multi-range meter	07028.01	1
Power supply, 0...12 V-, 6 V~, 12 V~	13505.93	1

Set-Up and Procedure

First Experiment

— First, connect headphones directly with the coil. Slide I-core into the coil. Switch on power supply unit.

— Move coil (with iron core) close to the power supply unit. Listen to whether a humming sound can be heard in the headphones.

— Switch power supply unit off and note observation under (1).

— Set up experiment as shown in Fig. 1. Switch multi-range meter to measurement range of 10 V-. Switch on power supply unit and set direct voltage to 12 V-.

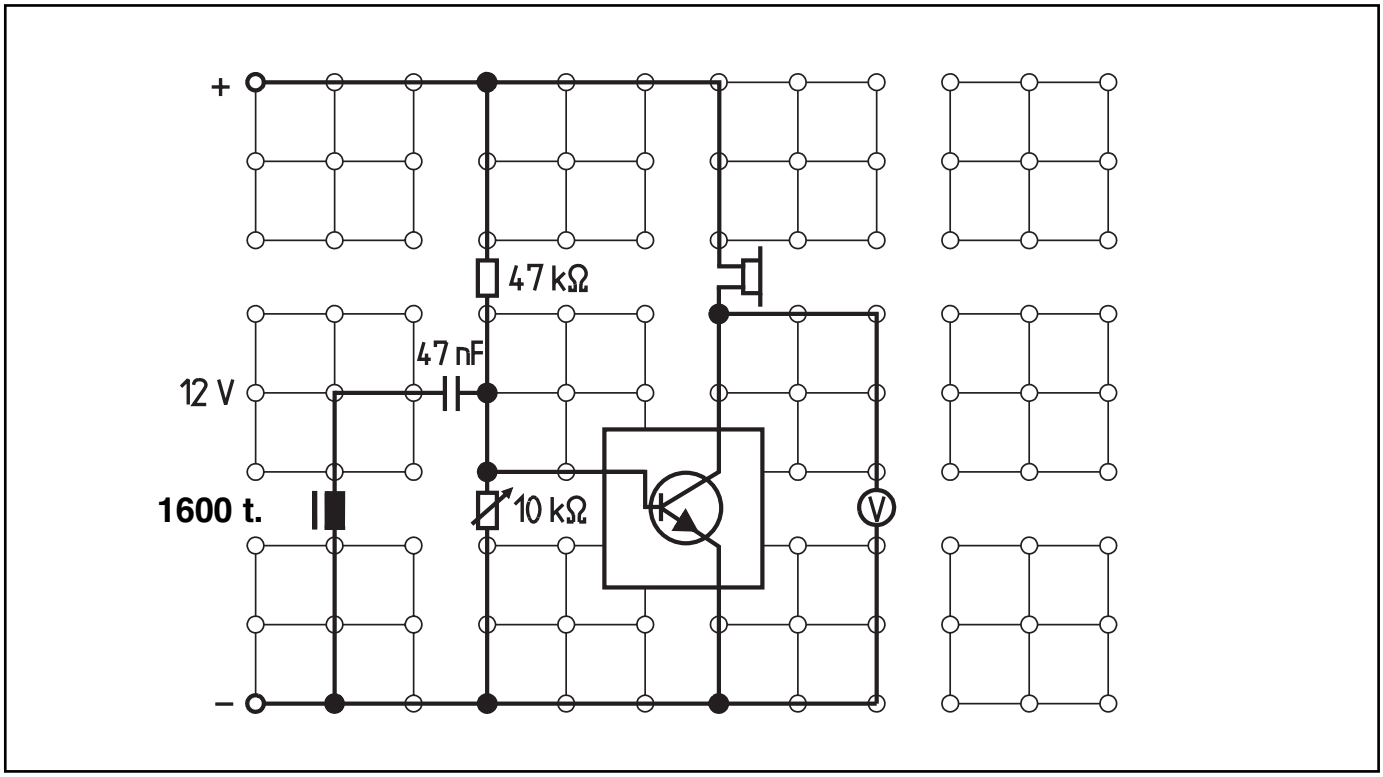
— Set the collector-emitter voltage displayed on the meter to about 5 volts with the adjustable 10 kΩ resistor.

— Move and rotate coil with iron core back and forth close to the power supply unit. Listen for a humming noise in the headphone. Note results under (2).

Second Experiment

— Add the additional components to the experiment set-up as shown in Fig. 2. Move coil around near power supply unit as before and observe the deflection of the pointer on the meter. Search for the location on the power supply unit where the strongest alternating magnetic field (the strongest electrosmog) is detected. Note observation and measurement under (3).

Fig. 1



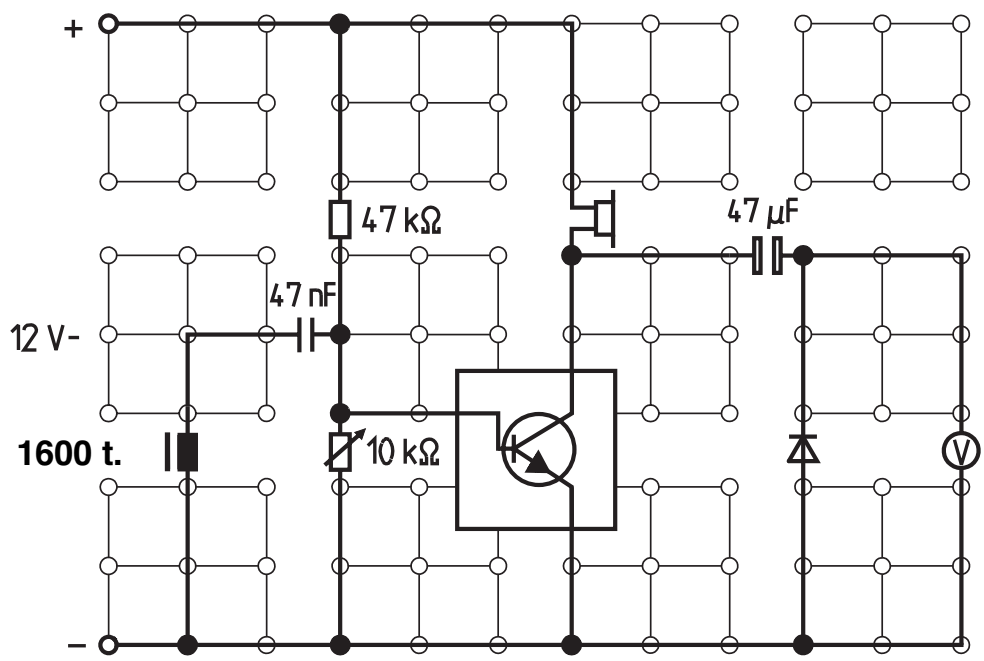
Observations and Measurement Results

(1)

(2)

(3)

Fig. 2



Evaluation

1. Why is there a humming noise in the headphones when the coil is moved close to the power supply unit?

2. What purpose does the voltage divider consisting of the 47 kΩ resistor and the 10 kΩ adjustable resistor serve?

3. What effect does the induced alternating voltage transmitted to the base of the transistor via the capacitor have?

4. Why is the inductance coil connected to the base terminal of the transistor via a capacitor?

5. Describe how a detection device for magnetic electrosmog could be constructed in principle.

(How can electrosmog be delected?)

This experiment serves as an introduction to the application of transistors for amplifying alternating voltage.
The stray field produced by the transformer of the power supply unit induces a small alternating voltage in the coil. It is so minimal that it can not be sufficiently detected directly with the headphones. To attain the necessary voltage amplification, the alternating voltage is superimposed on a base voltage produced by a voltage divider. This alternating voltage controls the collector current periodically around the average value set by the bias voltage. The fluctuations in the collector current produce voltage fluctuations in the headphones, evidenced by a humming noise.
This experiment also serves as an introduction to the much discussed electrosmog issue. It proves that electrical devices produce magnetic fields in their surroundings when in operation.

Notes on Set-Up and Procedure
Direct acoustic detection of the magnetic stray field in the vicinity of the power supply unit requires a low level of noise in the experiment room.
The most intense magnetic field can be detected at the front panel of the power supply unit, above the jacks for alternating voltage.
The experiment set-up in Fig. 1 presents no special difficulties. Setting the collector voltage to exactly half the value of the operating voltage is not particularly critical; the set value may deviate by 1 or 2 volts.
The coupling capacitor at the amplifier input prevents a short-circuit of the base voltage (produced by the voltage divider) due to the low-impedance coil resistance and transmits the alternating voltage induced in the coil to the base terminal of the transistor.
The circuit in Fig. 2 enables an objective semi-quantitative analysis of the strength of the magnetic field. The capacitor at the collector terminal only transmits the amplified alternating voltage to the meter. The diode rectifies this alternating voltage, thus allowing the use of the sensitive direct voltage range of the multi-range meter.

Observations and Measurement Results
(1) A weak humming noise can be heard close to the power supply unit. The humming noise is loudest at the front panel.
(2) When the coil is connected to the transistor, a loud humming noise can be heard in the headphones when coil is moved close to the power supply unit. The volume depends on how close the coil is to the power supply unit and the direction of the coil axis in relation to the power supply unit.
(3) The pointer on the meter deflects the most when the coil is directly next to the transformer in the left side of the power supply unit and when the iron core is parallel to the side panel of the power supply unit. It indicates a voltage of about 0.5 V.

Evaluation
1. The transformer in the power supply unit produces an alternating magnetic field in its surrounding, too, because an alternating current is flowing through it. Induction causes a minimal alternating voltage in the coil which excites the electromagnets in the headphones causing mechanical vibrations in the membrane. These vibrations produce a tone with the same frequency of the alternating current.
2. The voltage divider produces a base bias for the transistor. The base voltage is necessary for determining the operating point.
3. The alternating voltage transmitted to the base of the transistor via the capacitor causes the base voltage to fluctuate around the value set by the voltage divider. As a result of the amplification from the transistor, the collector current and, therefore, also collector voltage fluctuate more than the base current and the base voltage.
4. Due to its high direct current resistance, the capacitor prevents the base bias produced by the voltage divider from short-circuiting due to the low resistance of the coil. The transmission of the alternating voltage induced in the coil, however, is not obstructed thanks to the low impedance of the capacitor.
5. A detection device for magnetic electrosmog could be constructed similarly to the set-up used in this experiment. It would consist of an inductance coil, an amplifier, and a meter for indicating the intensity of electromagnetic induction.

Notes
The students can determine the intensity of the magnetic field quantitatively with the second experiment (suggested supplementary experiment). To do this, a coil excited by an alternating current should be used to produce an alternating magnetic field. The intensity of this field can be calculated and calibrated with the meter in the experiment set-up.

(How can electrosmog be delected?)

Room for notes