Problem

Generate an oscillating circuit of undamped electromagnetic oscillation by feedback via a transistor amplifier stage.

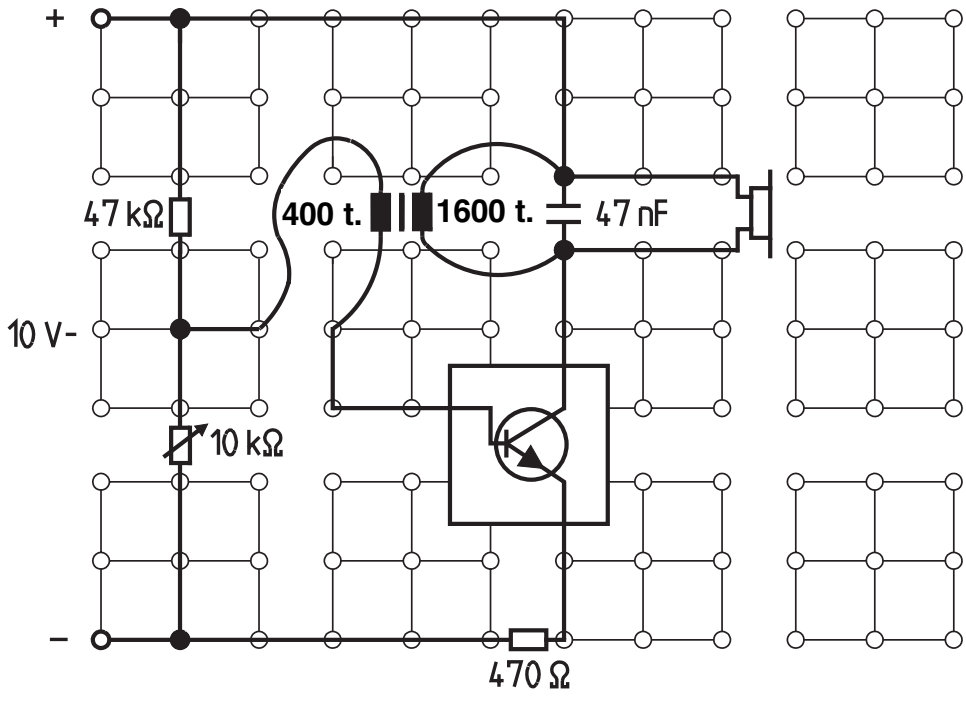
Equipment

Plug-in board	06033.00	1
Resistor, 470 Ω	39104.15	1
Resistor, 47 kΩ	39104.38	1
Adjustable resistor 10 kΩ	39108.03	1
Capacitor, 47 nF	39105.17	2
Electrolytic capacitor, 47 μF, bipolar	39105.45	1
Transistor BC337	39127.20	1
Headphones, 2 kΩ, 4-mm plug	06811.00	1
Coil, 400 turns	07829.01	1
Coil, 1600 turns	07830.01	1
U-core	07832.00	1
Yoke	07833.00	1
Wire building block	39120.00	4
Connecting cables, 10 cm, red	07359.01	1
Connecting cables, 10 cm, blue	07359.04	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

— Place both coils on the U-core. Lay yoke over U-core.
— Set up experiment as shown in Fig. 1.
— Switch on power supply unit and set direct voltage to 10 V.
— Vary adjustable resistor and listen to whether there is a tone in the headphones. Set adjustable resistor to the point where you can just hear a tone. If you do not hear any tone, switch around the connections of the coil and try again.
— Lift yoke up off of U-core. Vary distance between yoke and U-core and listen to whether you can hear a tone. Note observation (Table 1, line 1).
— Remove yoke from U-core. Slide 1600-turn coil back and forth on U-core. Observe pitch of tone. Note observation.
— Slowly lift 400-turn coil up off of U-core and listen for a tone. Note observations.
— Connect second 47 nF capacitor in parallel to the other 47 nF capacitor. Observe change in the pitch of tone. Note observation.
— Switch around the connections to one coil. Vary adjustable resistor and note observation. Reconnect connections to original positions.
— Switch power supply unit off. Replace 470 Ω resistor with wire building block and use the 47 μF capacitor for the oscillation circuit. Put yoke on the U-core.
— Switch power supply unit back on. Lift yoke up off of U-core slightly and note observation.
— Switch off power supply unit.

Fig. 1



Observations

Table 1

Changes made	Observations
Increase distance between U-core and yoke	
Slide 1600-turn coil around on core	
Slide 400-turn coil around on core	
Increase capacity of oscillation circuit capacitor	
Switch around coil connections	
Use 47 μF capacitor for oscillation circuit	

Evaluation

1. What is the relationship between the pitch and frequency of the tone?

2. The oscillation switch used in this experiment is composed of three sections with three different functions; the oscillation circuit, the feedback, and the amplifying. List the components belonging to each one of these sections/functions.

3. Why does the frequency of the tone change when you move the yoke or the coil on the core?

4. Why do the oscillations cease when the 400-turn coil is removed from the iron core?

5. Why is there no undamped oscillation when the connections are switched around on one of the coils?

6. What are some possible applications for an oscillation circuit?

(How can undamped electromagnetic oscillation be produced?)

The Meissner oscillating circuit used in this experiment should demonstrate the principle of deattenuation of an oscillating circuit via feedback. A system consisting of an amplifier and a feedback circuit can be caused to oscillate at a specific frequency if amplification is at least large enough to compensate the loss in amplitude in the feedback circuit and the feedback voltage at the desired frequency is in-phase with the amplified voltage. This set of requisites, known as Barkhausen's Precondition for Self-Excitation, can be fulfilled by the circuit in this experiment. The feedback factor, i.e. the ratio of the number of turns on the oscillation coil to the number on the feedback coil, is 1:4. Therefore, voltage amplification of 4 is sufficient to fulfill the precondition for amplitude.
The precondition for phase is only fulfilled for the intrinsic frequency of the oscillating circuit because there is a phase shift between voltage and current for all other frequencies.

Note on Set-Up and Procedure
The coils must be connected properly so that the feedback voltage is not fed back to the oscillating circuit with an opposing phase.

Observations
Table 1

Changes made	Observations
Increase distance between U-core and yoke	Higher tone
Slide 1600-turn coil around on core	Even higher tone
Slide 400-turn coil around on core	Tone interrupted
Increase capacity of oscillation circuit capacitor	Lower tone
Switch around coil connections	No tone
Use 47 μF capacitor for oscillation circuit	The yoke is attracted to the U-core with minimal frequency

Evaluation
1. The tone sounds higher the higher the frequency of the oscillation is.
2. The oscillating circuit consists of the 1600-turn coil with the iron core and the capacitor connected in parallel. Feedback is produced by the 400-turn coil, coupled inductively with the oscillating circuit coil.
   The transistor with the voltage divider for the base voltage and emitter resistance are responsible for amplification.
3. The less the inductivity of the coil, the higher the intrinsic frequency of an oscillating circuit. An iron core increases the inductivity of a coil. A coil has the greatest inductivity when the iron core is closed and the coil is on the iron core. Therefore, lifting the yoke or removing the coil form the U-core decreases inductivity and increases oscillation frequency.
4. Removing the 400-turn coil from the iron core has no affect on the frequency of the tone, but the oscillations cease because the feedback from the oscillating circuit to the amplifier is too small and voltage amplification is not sufficient to maintain the oscillations.
5. When the connections on one of the coils are switched around, then the voltage is fed back to the oscillating circuit with opposite polarity or phase. Therefore, the damped oscillations formed when the oscillating circuit is switched on are canceled instead of being amplified.
6. It could be used to construct electrical music instruments.

Undamped Electromagnetic Oscillation

(How can undamped electromagnetic oscillation be produced?)

Room for notes