Radiation characteristic and polarization of decimeter waves

Objects of the experiments

- Studying the radiation characteristic of a dipole antenna.
- Studying the polarization of the radiated decimeter waves and determining the direction of their polarization.
- Studying the action of an antenna rod as a reflector or a director.

Principles

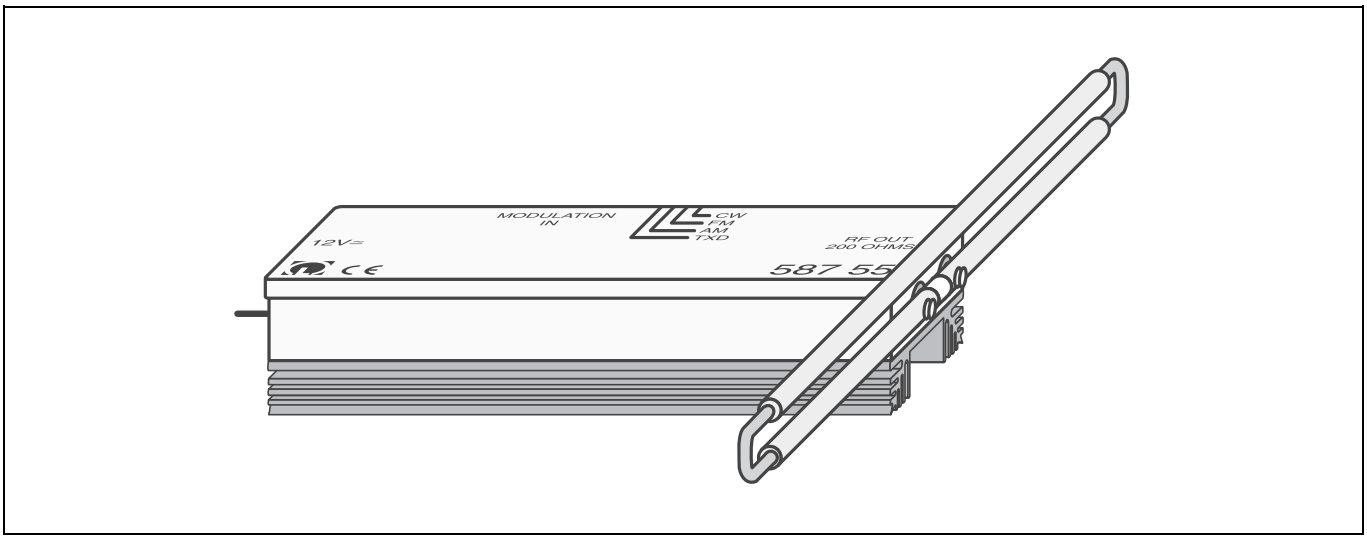
In a straight conductor, electromagnetic oscillations can be excited similarly as in an oscillatory circuit. Such an oscillator radiates electromagnetic waves; the radiated intensity being highest when the length of the conductor is equal to half the wavelength (this is a so-called $\lambda/2$-dipole). Experiments related to this phenomenon are particularly successful at wavelengths in the decimeter range.

The radiated waves can be detected by means of a second straight conductor aligned parallel to the transmitter and also having the length $\lambda/2$. The alternating electric field of the radiation induces an alternating current in the antenna, and the decimeter waves can be detected by supplying a lamp with the voltage associated with this current. In order to measure the received field strength, the voltage can – after passing a high-frequency rectifier – also be fed to a measuring instrument. Dipoles used in practice are slightly shorter than $\lambda/2$ because, in the case of finite diameters, there is a contracting factor for the overall length and a larger band width due to a flattening of the resonance curve of the antenna.

Typical features of a dipole antenna are the angular distribution and the polarization of the radiated waves. The radiated intensity is zero along the axis of the antenna and has its maximum perpendicular to the axis. Moreover, the waves are linearly polarized, the electric field oscillating in the direction of the antenna axis. These phenomena are studied in the experiment by means of a UHF transmitter with a loop dipole at the frequency $\nu = 433.92$ MHz. Besides the radiation characteristic and the polarization, you will study the influence that an additional rod antenna acting as a director or as a reflector has on the electric field.

Setup

Notes:
The radiation characteristic of the UHF transmitter is influenced by the surroundings, particularly by metal objects and by the position of the experimenter.
The connection leads between the receiver dipole and the voltmeter too may influence the measurement depending on their alignment.



Apparatus

1 UHF transmitter		587 55
1 plug-in unit 230 V AC / 12 V AC		562 791
1 multimeter MA1H		531 51
2 saddle bases		300 11
2 connection leads, 200 cm	for example	501 38

The experimental setup is illustrated in Fig. 1.

– Clamp the UHF transmitter in the saddle base and connect the loop dipole to the antenna output of the UHF transmitter.
– Clamp the mounting rod for receiver dipoles in a saddle base and screw the receiver dipole with lamp on.
– Choose operating mode CW and put the UHF transmitter into operation by plugging in the plug-in unit.

Carrying out the experiment

a) qualitative studies by means of the receiver dipole with lamp:

– Place the receiver dipole with lamp at a distance of about 0.5 m from the UHF transmitter and align it parallel to the loop dipole so that the lamp lights up.
– Turn the receiver dipole with respect to the connecting axis between both dipoles and observe the brightness of the lamp.
– Lift the receiver dipole above the loop dipole, then move it to the side of the loop dipole. In both positions turn it around the connecting axis and observe the brightness of the lamp.

Safety notes

Experiment setups using the UHF transmitter may not always conform to the limit values of class A (group 2 of the standard EN 55011). The device can interfere with other equipment in the experiment room of the educational facility. Also, radio interference can occur up to a distance of several hundred meters. It is the responsibility of the user to take all precautions to ensure that equipment installed outside of the experiment room can continue to function properly.

- See the information contained in the Instruction Sheet of your UHF transmitter.
- Do not operate the transmitter longer than is required to conduct the experiment; when the experiment is concluded, shut down the device immediately by switching off the plug-in supply unit.

b) quantitative studies by means of the receiver dipole with diode:

– Screw the receiver dipole with diode onto the mounting rod: connect the voltmeter (measuring range 5 V-) with twisted connection leads, and place it as far as possible from the radiation field of the UHF transmitter.
– Place the receiver dipole with diode at a distance of about 1 m from the UHF transmitter, and align it parallel to the loop dipole so that the voltmeter displays maximum deflection.
– Repeat the studies of part a, read the voltages from the voltmeter and record them.

c) Study of the influence of an additional antenna rod as a reflector or as a director.

– Place the receiver dipole with diode at a distance of about 5 m from the UHF transmitter, and align it parallel to the loop dipole so that the voltmeter displays maximum deflection (see Fig. 2).
– Hold the middle of the antenna rod, move it as a reflector towards the receiver dipole with diode from behind, and look for the maxima and minima of the displayed voltage.
– Move the antenna rod as a director above and below the connecting axis towards the receiver dipole with diode from the front, and look for the maxima and minima of the displayed voltage.

Measuring example

Radiation characteristic and polarization:

Table 1: Signal of the receiver dipoles as a function of the direction of radiation and the polarization with respect to the alignment of the loop dipole (cf. Fig. 3)

dir. of radiation	Polarization	pos.	lamp	$\frac{U}{V}$
perpendicular	parallel	1a	bright	2
perpendicular	perpendicular	1b	dark	0.5
perpendicular	parallel	2a	bright	2
perpendicular	perpendicular	2b	dark	0.5
parallel	perpendicular	3a	dark	0.5
parallel	perpendicular	3b	dark	0.5

Antenna rod as reflector or director.

distance: 5 m

without antenna rod: U = 0.44 V
with reflector: U = 0.58 V
with director: U = 0.50 V

Evaluation and results

The intensity radiated by the UHF transmitter with a loop dipole has its maximum perpendicularly to the dipole axis and its minimum parallel to the dipole axis. The emitted waves are linearly polarized the electric field vector being aligned parallel to the dipole axis.

The reception of the decimeter waves with a receiver dipole can be improved by means of additional antenna rods, which are arranged either as reflectors behind the receiver or as directors in front of the receiver.

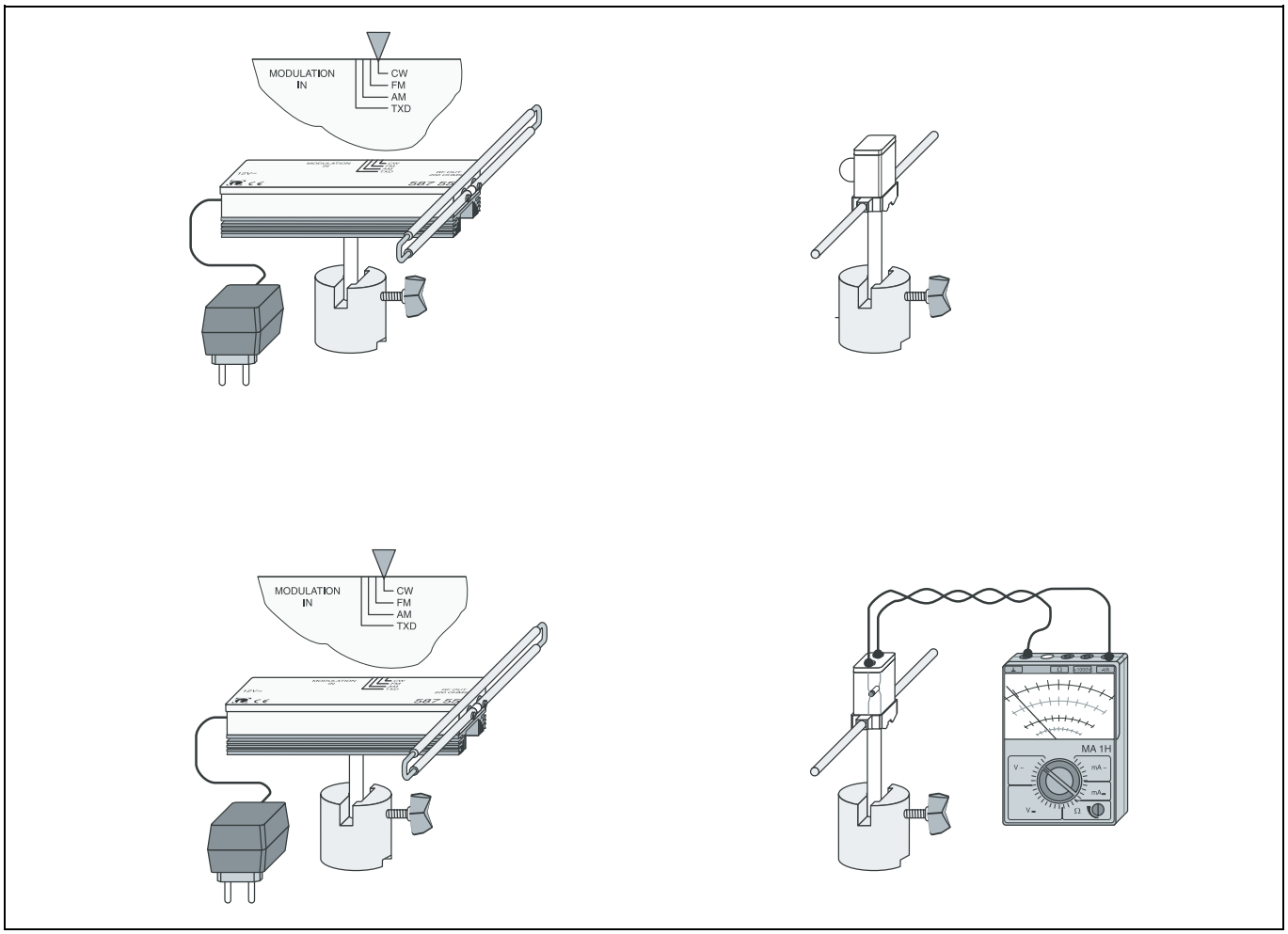


Fig. 1 Setup for the study of the radiation characteristic and the polarization by means of the receiver dipole with lamp (above) or the receiver dipole with diode

Fig. 2 Employment of an additional antenna rod as a reflector or as a director

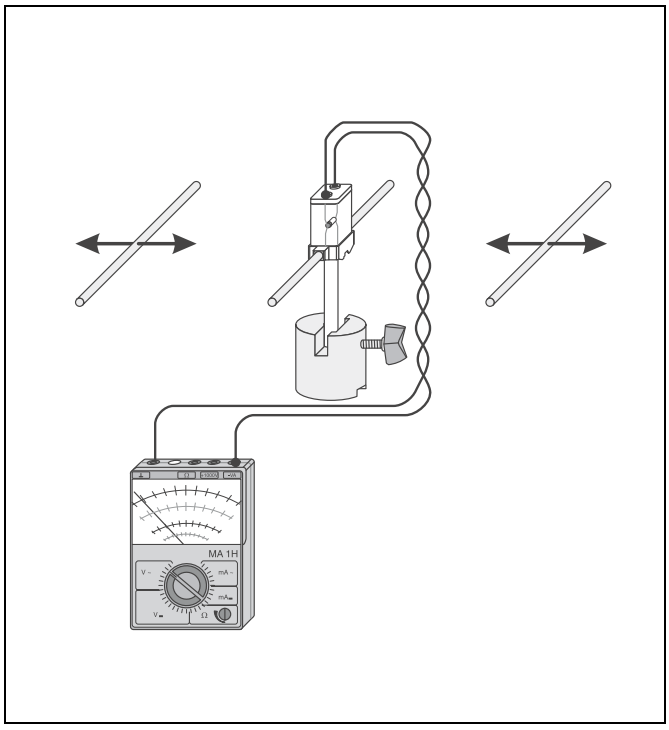
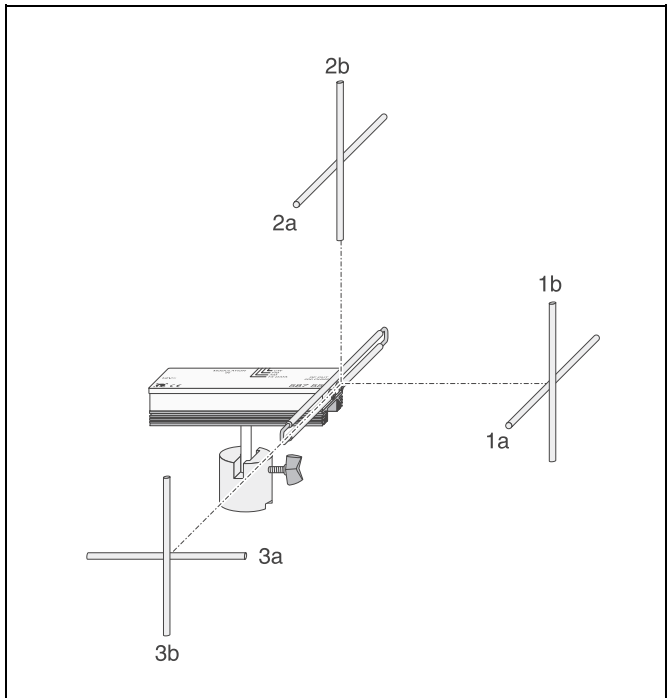


Fig. 3 Positions of the receiver dipoles for the study of the radiation characteristic and the polarization of the waves



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