

Investigating the current and voltage on a *Lecher* line with a loop dipole

Objects of the experiments

- Detecting the reflection-free propagation of a current and voltage wave on the Lecher line terminated with the loop dipole.
- Determining the current and the voltage maxima at the loop dipole.

Principles

When a high-frequency electromagnetic field is transmitted onto a *Lecher* line, a voltage wave

$$U = U_0 \cdot \sin(\omega t - kx),$$

$$\omega = 2\pi\nu, \quad k = \frac{2\pi}{\lambda}$$

propagates in the direction x of the wires. The frequency ν and the wavelength λ of this wave agree with those of the transmitted field. The voltage between the wires is associated with a charge distribution along the wires. The displacement of these charges leads to a current in the wires which propagates as a wave.

At the end of the Lecher line, the waves are reflected if the two ends of the wires are open or short-circuited. The incoming and the reflected wave then interfere to form a standing wave. If, however, the ends of the wires are connected by an ohmic resistor which is equal to the characteristic wave impedance of the Lecher line, then no reflection occurs and no standing waves arise. The same is true when the loop dipole terminates the Lecher line. The current and voltage maxima can then be found at the loop dipole.

The reflection-free propagation along the Lecher line is proven in the experiment by successively sliding a probe with lamp and an induction loop with lamp along the Lecher line at a fixed distance. Both lamps shine continuously; that is, there are no pronounced voltage or current maxima on the Lecher line. On the loop dipole, however, a standing wave arises, the total width of which is about half the wavelength. The current maximum of this standing wave is located in the middle of the dipole. At each end of the dipole a voltage maximum can be detected.

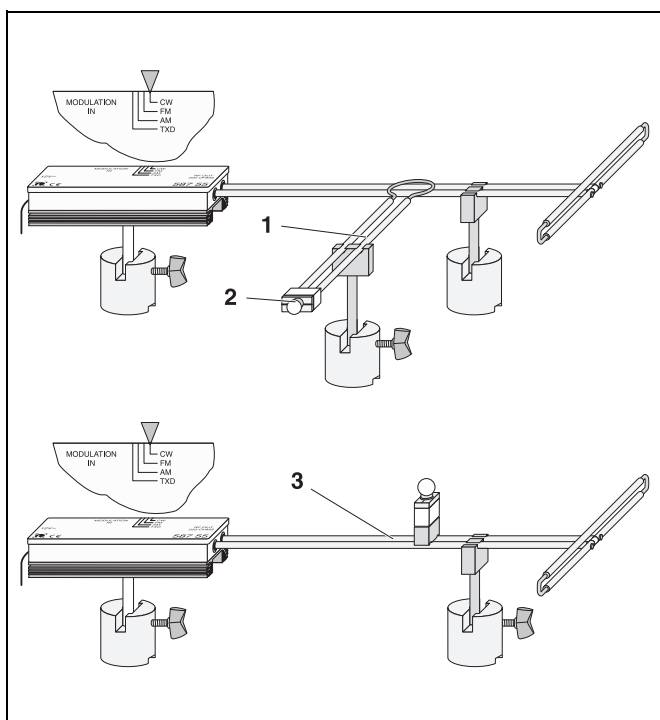


Fig. 1 Experimental setup for the determination of the current (above) and the voltage (below) maxima on a Lecher line with a loop dipole

Apparatus

| | |
|--|---------|
| 1 UHF transmitter | 587 55 |
| 1 plug-in unit 230 V/12 V | 562 791 |
| 1 Lecher system with accessories | 587 56 |
| 1 steel tape measure, 2 m | 311 77 |
| 3 saddle bases | 300 11 |

Setup

The experimental setup is illustrated in Fig. 1.

- Clamp the UHF transmitter in the saddle base and choose operating mode CW.
- Plug the sections of the Lecher line together, slide on a holder with rod from one end and clamp it in a base.
- Plug the 4-mm plugs of the Lecher line into the antenna output of the UHF transmitter.
- Align the UHF transmitter and the Lecher line in height so that the Lecher line is horizontal.
- Slide a holder with rod on the coupling loop from one end, and clamp it in a saddle base.
- Make an induction loop by putting the lamp socket E10 together with the lamp (2) on the coupling loop (1).
- Align the induction loop in height so that the curved end is just somewhat higher than the Lecher line.
- Have the loop dipole ready.

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.

Carrying out the experiment**a) Current maxima:**

- Switch on the UHF transmitter by plugging in the plug-in unit.

Without loop dipole:

- Slide the induction loop along the Lecher line, and find a position where the lamp lights up as brightly as possible.
- Optimize the brightness by shifting the induction loop perpendicularly to the Lecher line and, if necessary, by carefully reducing its distance from the Lecher line without touching the Lecher line.

With the loop dipole plugged in:

- Slide the induction loop along the Lecher line and look for brightness maxima and minima of the lamp.
- Next move the induction loop above the loop dipole and look for brightness maxima (see Fig. 2 left).

b) Voltage maxima:

- Assemble the plastic adapter (3) and the lamp socket E10 with lamp (2) and place it on the Lecher line as a probe.

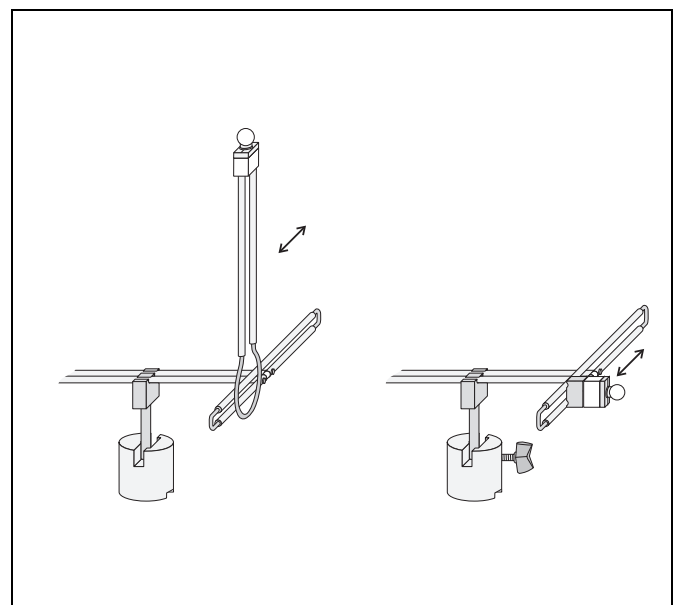
Without loop dipole:

- Slide the probe along the Lecher line and find a position where the lamp lights up as brightly as possible.

With the loop dipole plugged in:

- Look for brightness maxima and minima of the lamp using the probe.
- Next move the probe above the loop dipole, and look for brightness maxima (see Fig. 2 right).

Fig. 2 Determination of the current (left) and the voltage (right) maxima at the loop dipole



Measuring example**a) Current maxima:**

| | |
|----------------------|------------------------------------|
| Lecher line: | no pronounced current antinodes |
| loop dipole, middle: | current antinode |

b) Voltage antinodes:

| | |
|--|------------------------------------|
| Lecher line: | no pronounced voltage antinodes |
| loop dipole, left end (at 3 cm distance from the end): | voltage antinode |
| loop dipole, right end (at 3 cm distance from the end): | voltage antinode |

Evaluation and results

Decimeter waves propagate approximately reflection-free along the Lecher line when the end of the line is terminated by the loop dipole.

A standing wave arises on the loop dipole, the total length of which is about half the wavelength. A current maximum is found in the middle of the dipole and a voltage maximum at a small distance from each end.

