Attenuators

Calibrating the attenuator, measuring relative microwave power

Definition and properties

Attenuators are among the linear, reciprocal components of electrical lines (four-pole). They are frequently realized like reflection-free waveguide terminals in the form of dissipating resistances. As such the operating principle comprises the transformation of RF power into thermal energy. With the exception of a few high-load attenuators reciprocity always exists. Only in the former is the input designed to take more power than the output, which is why any interchanging of the gates is not permitted. A distinction is drawn between fixed attenuators and variable attenuators. Variable attenuators can be adjusted mechanically or manufactured with electronically controllable line components. The electronic attenuators are designed using, for example, PIN diodes. The PIN diode is used here as an electrically controllable resistance for microwaves. For that reason a PIN diode attenuator has variously high transmission and reflection coefficients depending on the control voltage. The function of the PIN diode is explained in greater detail in Experiment Ex1 “Principle of the PIN modulator” in MTS 7.4.5, for that reason we will only focus here on passive attenuating elements. Fig. 4.1 presents 2 conventional principles for the assembly of mechanically tuneable attenuators.

The basic idea involves inserting an absorbing medium into the waveguide. The rectangular waveguide depicted in Fig. 4.1 guides the fundamental mode (TE_{10}). You can either insert a vane attenuator into the waveguide through a middle slot along the waveguide's longitudinal side, or slide the attenuator vane into the field from the side. The latter possibility is implemented in the attenuator 737 09. The shift movement of the attenuator vane is performed backlash-free using a micrometer screw. In order to attain low insertion loss the vane is inserted in such a manner that the absorbing layer lies against the waveguide wall (E = 0) for a shift of x = 0 mm. Because of scarfing the reflection coefficient caused by the vane is kept as small as possible. The attenuating vane itself can consist of coated fiber glass, mica or plastics like mylar or Kapton. Nickle-chrome or tantalum alloys are deposited as layered coatings in vacuum metallization processes. These metal layers have inherent absorbtion properties (as opposed to reflecting ones) as long as their layer thicknesses are smaller than the penetrating depth δ of the electrical field at the desired operating wavelengths. Resistance film cards are manufactured with varying resistance per square unit (surface resistance). Standard values lie between 50 and 377 Ω/square (Square means that the resistance is the same for any random square surface and is given a specific value. Thus the resistance is dependent on the geometry, not on the surface area). The surface resistance in an attenuator in conjunction with the field distribution of the mode in question (often TE_{10}) determines the attenuation characteristic as a function of the shift x. Fig. 4.2 contains a cross-section through the adjustable attenuator 737 09.

The calibration of the attenuator is performed in the experiment using the power scale of the SWR meter. The microwave power is con-

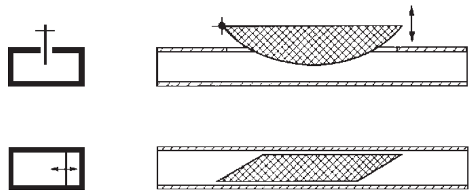


Fig. 4.1: On the principle of attenuation by means of insertion with an attenuating vane

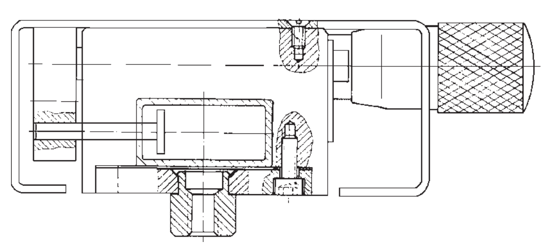


Fig. 4.2: Cross-section through the attenuator 737 09

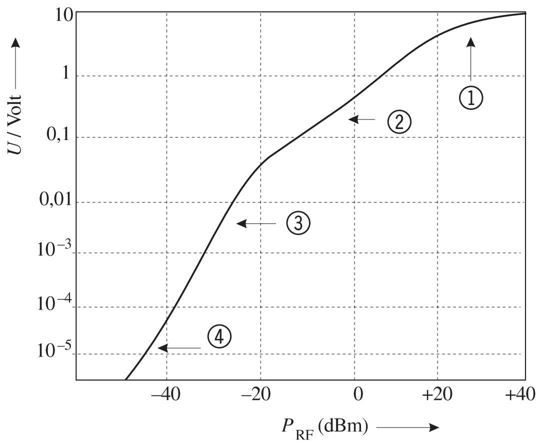


Fig. 4.3: Detector output voltage as a function of the microwave power
① Saturation range
② Linear range
③ Quadratic range
④ Noise

verted into a LF signal with the coax detector. As long as the coax detector is operated in the range of square-law characteristic there is a proportional relationship between its output signal and the incidenting microwave power. A correct reading of the dB scale is only possible under these conditions. Generally speaking when it comes to detectors, low power levels are the precondition for the square law characteristic range. Fig. 4.3 shows the principle characteristic curve of the output signal versus the microwave power.

Required equipment

1 Basic unit	737 021
1 Gunn oscillator	737 01
1 Fixed attenuator	737 095
1 Variable attenuator	737 09
1 Transition waveguide/coax	737 035
1 Coax detector	737 03
1 Set of thumb screws (4 each)	737 399

Additionally required equipment

2 Stand bases	301 21
2 Supports for waveguide components	737 15
1 Stand rod 0.25 m	301 26
2 Coaxial cable with BNC/BNC plugs, 2 m	501 022

Recommended

1 PIN modulator	737 05
1 Isolator	737 06

Experiment procedure

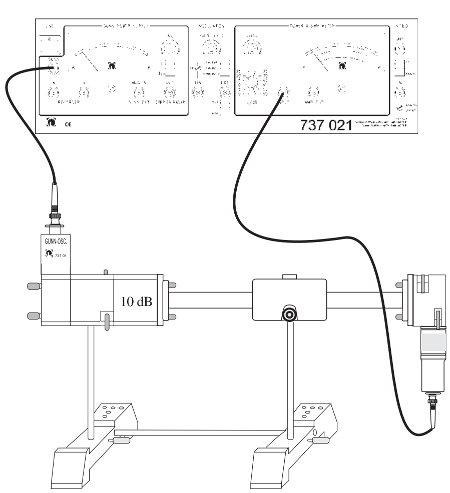
Note:
When using the PIN modulator and isolator complete the experiment setup as specified in Fig. 0.5 (Preface).

1. *Calibration of the attenuator*

– Experiment setup as specified in Fig. 4.4

Note:
The fixed attenuator is required to attenuate the microwave signal present at the coax detector by approx. 10 dB. This is how the detector is supposed to be operated in its square-law characteristics range.

– Connect the coax detector to the SWR receiver “INPUT”.
Modulate the microwave signal (generally performed by means of direct modulation of the Gunn oscillator). Set the variable attenuator to x = 0.00 mm. Calibrate the display ***a*** of the homodyne SWR meter to



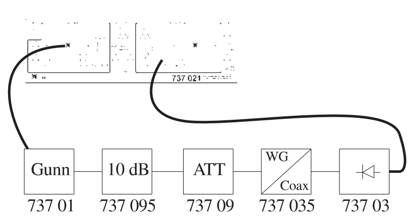


Fig. 4.4: Experiment setup

0 dB using the gain selection switch V/dB and the ZERO control knob. Do not make further changes to the ZERO control knob in the course of the experiment.
First check the validity of the square law (the detector operates in the linear range). Now increase the attenuation to 3 dB by turning the micrometer screw (set *x* to value specified on the attenuator). The display ***a*** of the power meter should now lie in the range from –2.5 dB to –3.5 dB. You will hardly be able to reach the ideal value of –3 dB due to the unavoidably large dispersion of the detector's microwave diode.

– Reset the attenuator to *x* = 0.00 mm. Now set the attenuation to the values specified in the table. Enter the measured values ***x*** into Table 4.1 and plot the dependency |*a (x)*| in a graph.

Questions

1. Which other components can be used to reduce the microwave power to avoid overloading the detector?

Table 4.1: Calibration of the attenuator

a / dB	x / mm
0	0.00
–1	
–2	
–3	
–4	
–5	
–6	
–7	
–8	
–9	
–10	
–12	
–14	
–16	
–18	
–20	

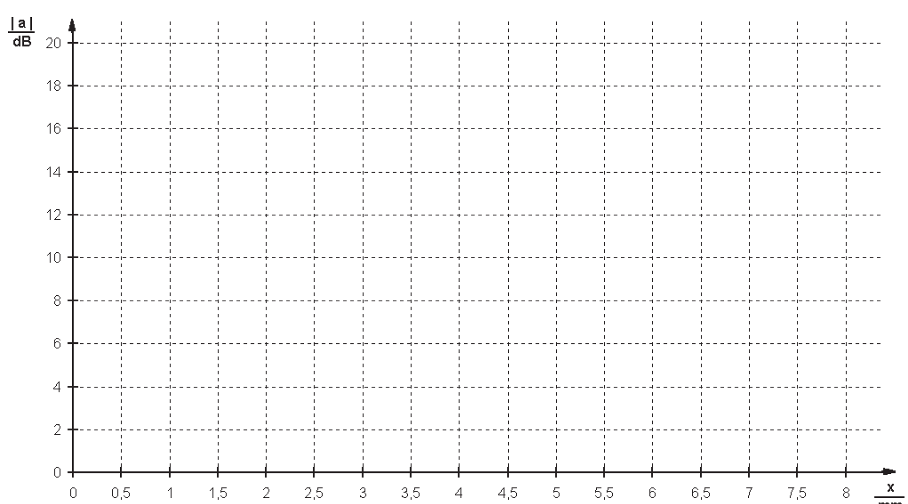


Diagram 4.1: Plot of the values from Table 4.1