

Instruction Book

NOISE GENERATOR

Type SUF

BN 4150

Note: Always quote the Type and Order Number (BN) in addition to the Serial Number (Fnr.) of the set when asking for technical information and, in particular, when ordering repair parts.

Edition R 6123/1158



1. Specifications

Frequency range of noise spectrum	30 cps to 6 mc	
3 ranges selectable by switch	30 cps to 6 mc	★)
	30 cps to 600 kc	
	30 cps to 20 kc	
Frequency response of the spectrum between 30 cps and 6 mc	less than $\pm 10\%$	
Source impedance	approx. 75 Ω	
Output socket	13-mm socket	
Output voltage	1 v rms max. into 75 Ω in each frequency range	
Output voltage variation	continuous, 1 : 10	
Output attenuation	1 : 10^{-5} in 10 steps	
Attenuator accuracy	$\pm 5\% \pm 0.5 \mu\text{v}$	
Minimum output voltage	1 μv	
Output voltage indication	by meter calibrated in rms volts into 75 Ω	
Accuracy of indication	$\pm 5\%$ of f.s.d.	
Noise power related to 1 cps bandwidth at an output of 1 v rms in the range		
30 cps to 6 mc	approx. $2.2 \cdot 10^{-9}$ w/cps	
30 cps to 600 kc	approx. $22 \cdot 10^{-9}$ w/cps	
30 cps to 20 kc	approx. $660 \cdot 10^{-9}$ w/cps	
Overdrive limit of the amplifier sections	approx. 5 v	
Power supply	115/125/220/235 v 40 to 60 cps 140 va	
Permissible supply voltage fluctuations	$\pm 10\%$	
Valves	2 x E 88 CC 1 x ECH 81 1 x EF 804 s 3 x EL 34 4 x E 180 F 1 x 85 A 2 1 x RL 210	
Fuses	1-amp fuse for 220/235 v or 2-amp fuse for 115/125 v 2-amp fuse 0.5-amp fuse	

★) On request, the instrument can be equipped with filters of other cut-off frequencies lower than 6 mc.

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Dimensions 570 x 234 x 378 mm
(22 1/2" x 9 1/4" x 15")
(R&S Standard Cabinet 56)

Weight approx. 25 kg (55 lb)

2. Theory of the Measurement with White Noise

2.1 Some Characteristics of Noise Voltages

White noise is caused by very small irregular variations of electric currents. Being a random phenomenon, the characteristics of noise can be described only by probability calculus, which shows that a noise voltage spectrum extends from zero frequency to infinity. In practice it is impossible to generate a noise spectrum of continuous energy distribution over all frequencies but in theory, too, a limit is set at very high frequencies since there is no infinitely fine energy quantization. Noise can be produced only over part of the spectrum, covering, however, a very large frequency range. Relatively slow fluctuations and steep rises in amplitude are suppressed by the limitations imposed on the spectrum. However, this is of minor practical importance since frequencies below the audible range are of little interest and extremely high peak values, which go along with a steep rise of amplitude, occur with negligible probability.

2.1.1 Amplitude Distribution in Time

If the noise voltage is free from correlated components then it is possible to predict how often a given amplitude will occur. The probability that within the period of observation a given amplitude related to the rms value is exceeded is expressed by the formula

$$p(u) = 1 - \Phi\left(\frac{u}{\sqrt{2} E_{\text{rms}}}\right) \quad (1)$$

where

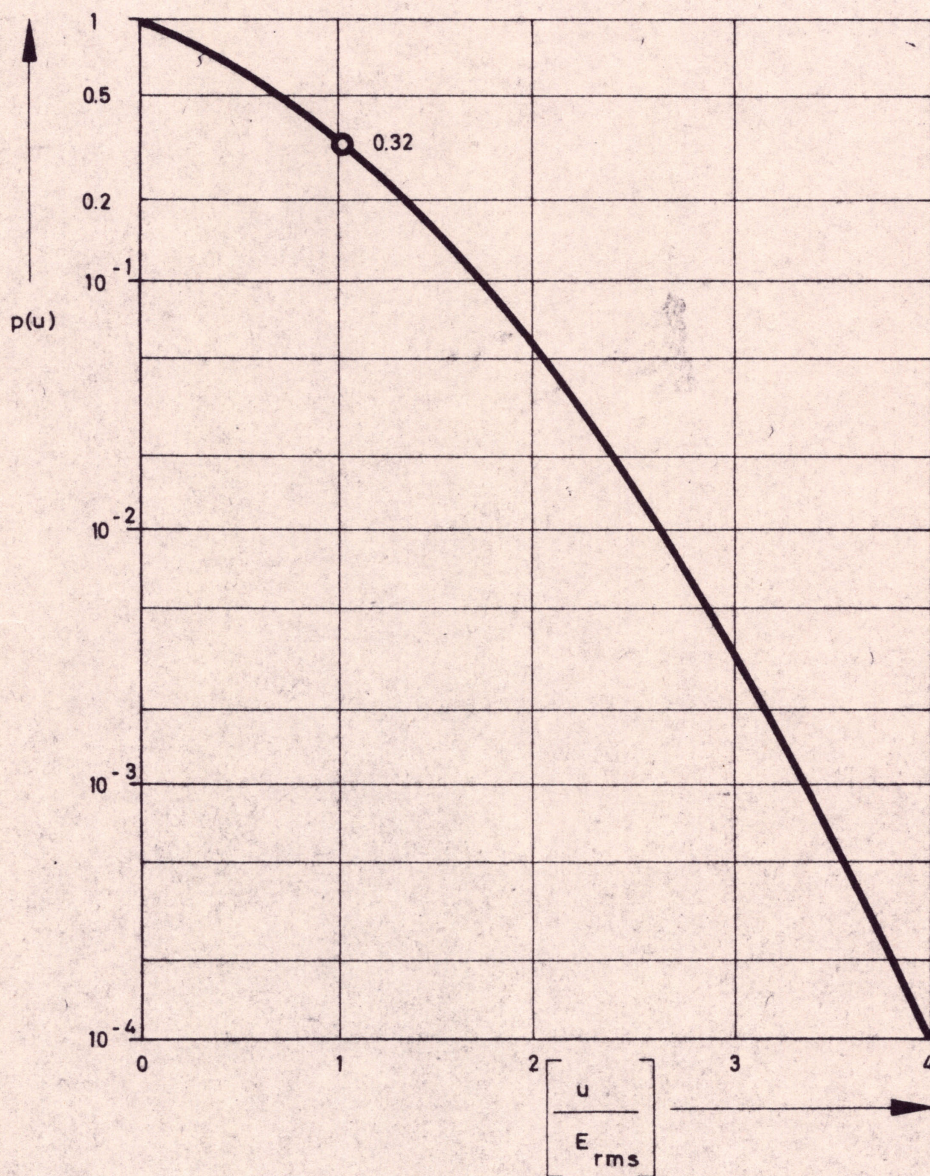
- $p(u)$ = probability of the relative amplitude E/E_{rms} being exceeded
- Φ = Gauss error integral
- u = peak value of threshold amplitude
- E_{rms} = rms value of noise amplitude over a long period of time

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The curve shows the probability $p(u)$ of the noise voltage exceeding the value u .

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The probability is shown in the curve. The number of times a given threshold value is exceeded within a second is given for a rectangularly limited noise spectrum by the formula

$$N = \frac{1}{2\pi} \sqrt{\omega_o^2 + \frac{\Delta\omega^2}{12}} \cdot e^{-\frac{u^2}{2E_{rms}^2}} \quad (2)$$

where

N = number of times per second the threshold value related to the rms value averaged over a long period of time is exceeded

ω_1 = lower cut-off frequency

ω_2 = upper cut-off frequency

$\omega_o = \frac{1}{2}(\omega_1 + \omega_2)$

$\Delta\omega = \omega_2 - \omega_1$

u = peak value of threshold amplitude

E_{rms} = rms value of amplitude over a long period of time

2.1.2 Energy Content, Power Level, and RMS Voltage

The energy content of white noise is of constant average value and uniformly distributed over all frequencies produced. Consequently the power level and rms voltage have constant values when measured over a long period of time.

2.2 Effective Noise Bandwidth

If P is the power of a noise spectrum of bandwidth Δf then the power per 1 cps bandwidth is $A = \frac{P}{\Delta f}$. (3)

If the pass band of Δf_F is cut out of a rectangular noise spectrum Δf by a filter of ideally steep slopes, the power within this narrowed-down frequency range is

$$P_F = P \frac{\Delta f_F}{\Delta f} \quad (4)$$

The rms voltage is then

$$E_{Frms} = E_{rms} \sqrt{\frac{\Delta f_F}{\Delta f}} \quad (5)$$

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Equation (4) shows that the noise power in a subrange of the noise spectrum is proportional to the ratio of the bandwidths. According to Eq. (5), the voltage in the subrange is therefore proportional to the square root of the bandwidth ratio.

Since the filters used in practice do not provide rectangular selectivity the limits of the pass band must be laid down by agreement. Thus the "effective noise bandwidth" of a filter is defined as the bandwidth of an equivalent filter of rectangular response curve cutting out the same noise power as does the actual filter having, for example, a bell-shaped curve.

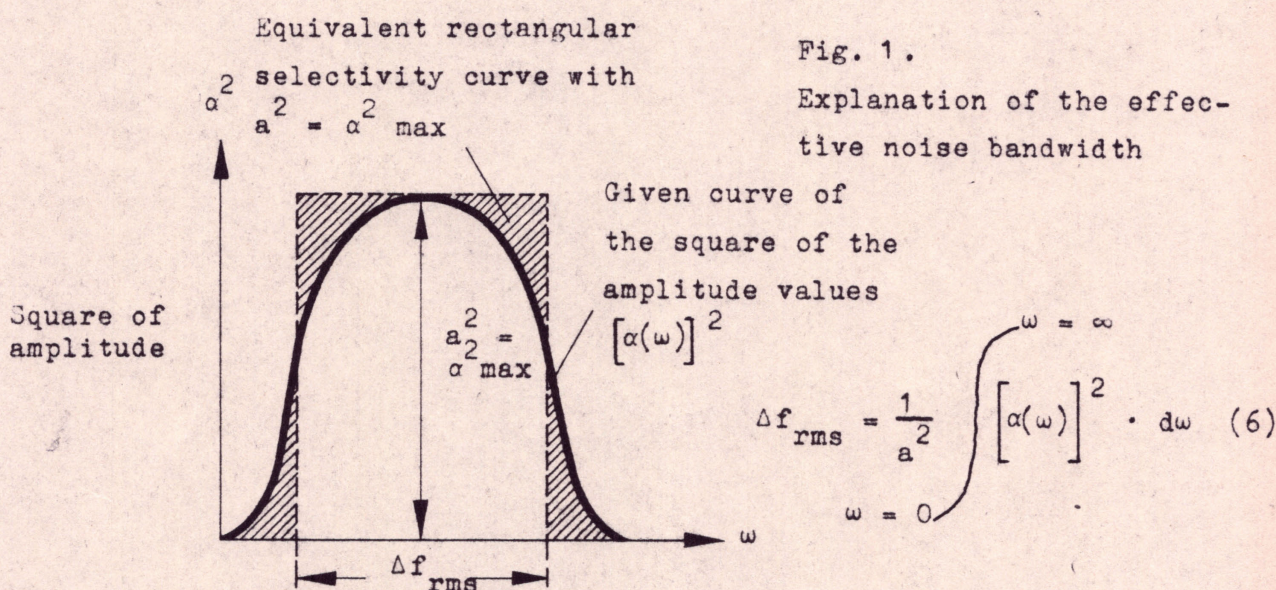


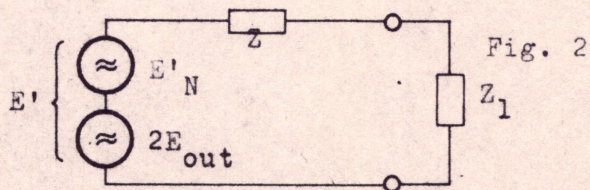
Fig. 1. Explanation of the effective noise bandwidth

2.3 Thermal Noise of a Resistor between the Noise Source and Load

The noise power input to the load cannot be reduced beyond a certain limit by a matched attenuator pad of balanced impedance inserted between the noise source and the output, since a resistor at room temperature produces $4 \cdot 10^{-21}$ w/cps into the load. This fact must be taken into account when very high attenuation is involved since then the power output of the noise source may be of the same order as the thermal noise of the resistor.

If the output voltage is measured at the voltage source ahead of the attenuator, then the open-circuit voltage of the generator may be assumed to be double the output indication with match termination and may be

taken as the equivalent open-circuit voltage of the generator plus attenuator. Thus a simple equivalent circuit is obtained, taking account of the thermal noise of the attenuator.



$$E'_N = \sqrt{4 \cdot kT \cdot Z \cdot \Delta f} \quad (7)$$

The equivalent circuit comprises two voltage sources, the one having an e.m.f. equal to the open-circuit voltage $2 E_{out}$ of the generator plus attenuator, the other having the noise e.m.f. E'_N of the ohmic attenuator at room temperature. The output impedance Z of the attenuator is taken for source impedance. Z_L is the load impedance assumed free from noise.

Taking account of thermal noise the total open-circuit voltage of the generator is

$$E' = \sqrt{(2 E_{out})^2 + 4 kT \cdot Z \cdot \Delta f} \quad [v \text{ rms}] \quad (8)$$

where

$$k = \text{Boltzmann's constant} = 1.38 \cdot 10^{23} \text{ [ws/}^\circ\text{K]}$$

$$T = \text{absolute temperature [}^\circ\text{K]}$$

$$Z = \text{output impedance of attenuator representing the generator source impedance } [\Omega]$$

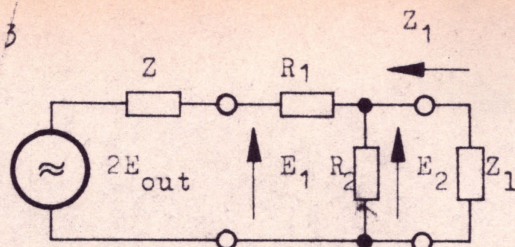
$$\Delta f = \text{frequency range of noise spectrum of the generator [cps]}$$

It is necessary to check in every individual case whether thermal noise need be considered. In most cases the open-circuit voltage of generator plus attenuator can be assumed to be $2 E_{out}$.

2.4 Resistive Matching Networks

When the input impedance of the load differs from the source impedance of the noise source matching can be accomplished by insertion of a suitable four-terminal network. The simplest form of matching network is an attenuator pad of an input impedance matching the generator source impedance and output impedance matching the magnitude of the load impedance.

Fig. 3



Noise source Matching network Load $|Z_1| = Z_1 < Z$
of the 1st type

Fig. 3a

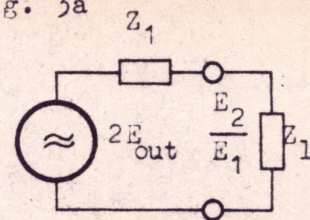
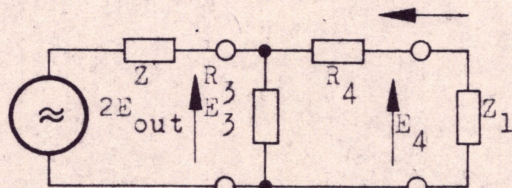
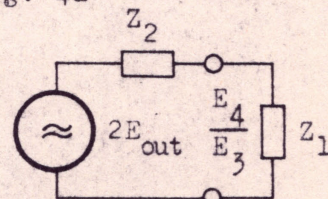


Fig. 4



Noise source Matching network Load $|Z_1| = Z_2 > Z$
of the 2nd type

Fig. 4a



In Figs. 3 and 4 are

- Z = source impedance of generator and input impedance of attenuator pad
- Z_1 and Z_2 = output impedance of attenuator pad = $|Z_1|$
- E_{out} = generator output voltage reading obtained with termination in Z
- $E_1; E_3$ = input voltage of attenuator pad with match termination $|Z_1| = Z_1$ or Z_2 , resp.
- $E_2; E_4$ = output voltage of attenuator pad with match termination $|Z_1| = Z_1$ or Z_2 , resp.
- $R_1; R_2; R_3; R_4$ = resistors of attenuator pad
- Z_1 = load impedance

The matching network of the 1st type provides matching of the generator source impedance to a lower load impedance and is designed according to the formulae

$$R_2 = Z_1 \sqrt{\frac{Z}{Z - Z_1}} \quad (9)$$

$$R_1 = Z - \frac{R_2 \cdot Z_1}{R_2 + Z_1} \quad (10)$$

then

$$\frac{E_2}{E_1} = 1 - \frac{R_1}{Z} \quad (11)$$

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The matching network of the 2nd type provides matching of the generator source impedance to a higher load impedance. The design formulae are

$$R_3 = Z \sqrt{\frac{Z_2}{Z_2 - Z}} \quad (12)$$

$$R_4 = Z_2 - \frac{R_3 \cdot Z}{R_3 + Z} \quad (13)$$

then

$$\frac{E_4}{E_3} = \frac{Z_2}{R_4 + Z_2} \quad (14)$$

The voltage across the load, the active power consumed and the available power can be determined in accordance with the simplified equivalent circuits shown in Figs. 3a and 4a.

Thermal noise in the resistive source impedance can be considered, if necessary, according to Figs. 3a and 4a and section 2.3.

2.5 Noise Voltage and Absolute Sensitivity

The absolute sensitivity of amplifiers and receivers can be determined in terms of kT_0 . A given generator output voltage for noise doubling is converted into kT_0 units by the formula

$$n = \frac{E_{out}^2}{Z \cdot \Delta f} \cdot \frac{1}{4 \cdot 10^{-21}} \quad [kT_0] \quad (15)$$

In contrast, the voltage corresponding to a given absolute sensitivity for a given frequency range of the noise spectrum is

$$E_{out} = \sqrt{n \cdot Z \cdot \Delta f \cdot 4 \cdot 10^{-21}} \quad [v \text{ rms}] \quad (16)$$

where

- n = noise figure in terms of kT_0
- E_{out} = generator output voltage with the load matched to the generator source impedance
- Z = generator source impedance
- Δf = frequency bandwidth of noise spectrum

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According to the definition of absolute sensitivity of receivers the self-noise of the generator source impedance need not be considered separately in absolute-sensitivity measurement since this impedance may be regarded as equivalent to the radiation resistance of the aerial which also produces thermal noise power.

2.6 References

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- K. Pöschl: Mathematische Methoden in der Hochfrequenztechnik
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Frequenz 1955, Vol. 9, No. 8 and No. 12

3. Uses of the Noise Generator SUF

Considerable noise power output which can be widely reduced by a built-in attenuator, and several frequency ranges make the Noise Generator Type SUF suitable for noise measurements of various kinds.

A few examples of many possible applications will be quoted. To measure non-linear distortion in amplifiers and transmission systems a noise spectrum from which a narrow frequency band is cut out by a band-rejection filter is applied to the item under test. Then the noise voltage present after the item under test in the gap is measured with a selective

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receiver or via a band-pass filter and gives a measure of non-linearity. In contrast with distortion measurements, this method covers not only harmonics but also all products generated by intermodulation within this range and is particularly suitable to determine crosstalk in carrier-frequency circuits and in transmission of carrier-frequency signals over radio links, the noise spectrum here being used to modulate the transmitter.

In the field of acoustics many measuring techniques use a noise spectrum, in contrast with the usual method using a single-tone signal. In frequency-response and distortion measurements with a single-frequency signal generator the signal-generator frequency is continuously varied, the receiver and indicating voltmeter being broadband; when the noise generator is used a selective tunable voltmeter or analyzer is necessary for indication. This method has the advantage that it covers also beat effects due to non-linearities in the transmission system, transients in the loudspeaker, etc., since the noise is more closely related to natural noises and sounds than is a sinusoidal tone. On the other hand, resonances, echoes, etc. will be less pronounced.

In television engineering the noise generator is used for frequency-response measurements, investigation of the disturbance observed on the television screen because of a given signal-to-noise ratio, and for similar purposes. Similar investigations with noise can be made in the field of radar.

The Noise Generator Type SUF also caters for noise figure measurements on receivers at frequencies up to 6 mc, as do sets containing a noise diode. Using the built-in attenuator the output voltage is to be adjusted to suit the kT value under measurement, according to formulae (15) and (16).

Another application of the instrument is experimental study of general statistical phenomena, e.g. correlation, and model tests.

4. Description

A pentode (Rö1; E 180 F) produces a continuous noise spectrum. The grid-cathode path of this valve is shorted for radio frequency. The valve is followed by a three-stage VHF amplifier (Rö2, Rö3, Rö4;

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3 x E 180 F) whose bandwidth is about 12 mc at a centre frequency of ≈ 60 mc. The amplified noise spectrum is frequency-changed to the band 30 cps to 6 mc by an oscillator (R65; ECH 81) in the mixer section of R65 (ECH 81). The oscillator operates on the centre of the pass band of the VHF amplifier.

Low-pass filters limit the frequency band, adapting the frequency range of the noise spectrum to the various applications. Three exchangeable filters are provided in the instrument and can be selected with a switch (S3). Suitable design of the filters ensures constant output of the SUF in spite of different frequency ranges.

A three-stage amplifier (R68, R67, 2 x E 88 CC and R66, EL 34) with cathode follower output amplifies the noise voltage again in the range 30 cps to 6 mc. Continuously variable gain caters for output voltage control. A switch serves to cut off the anode voltage of the amplifier stages and thus the noise voltage output of the generator.

The voltage is rectified at the cathode of the power amplifier valve (R66) by a germanium diode and the rectified current is applied to a meter calibrated in effective noise voltage.

The noise voltage output of the generator passes from the cathode of the power amplifier valve R66 via an electrolytic capacitor to an attenuator switch.

The attenuator switch provides for attenuation of the noise voltage by the factor 10^{-5} in steps of 10 db. The cable K2 connects to the 75- Ω output of the instrument.

The gain control in the a-f broadband amplifier permits further reduction of output voltage in the ratio 1 : 10, giving a minimum output voltage of 1 μ v in the frequency ranges of 30 cps to 20 kc and 30 cps to 600 kc of the noise spectrum. In the range 30 cps to 6 mc the minimum output voltage setting of 1 μ v is lower than the noise voltage generated by the resistors of the attenuator at room temperature (see 2.3). The resistor noise voltage in the range 30 cps to 6 mc is 1.34 μ v when the noise generator is switched off and terminated by 75 Ω .

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The power supply comprises a valve circuit for electronic stabilization of the HT voltage, consisting of a neon stabilizer (Rö12; 85 A 2), control valve (Rö11; EF 804 s), and two paralleled regulating valves (Rö9, Rö10; 2 x EL 34). A positive d-c voltage is tapped via a voltage divider from the stabilized HT voltage, for the grid bias of the amplifier valves E 180 F. The relatively high cathode resistances of these valves and the positive d-c voltage give negative d-c feedback compensating for fluctuations in gain due to heating and for a decrease in gain due to valve aging.

The power supply also generates a d-c heater voltage for the mixer valve Rö5 and the two preamplifiers Rö8 and Rö7.

The method used in the Noise Generator Type SUF, i.e. generation and amplification of the noise voltage in the VHF range, followed by frequency conversion and further amplification, prevents the amplitudes of the noise spectrum from increasing due to the flicker effect at frequencies below 10^4 cps. The noise input to the a-f broadband amplifier is so high that its ratio to the self noise of the valves (flicker effect) is high enough and the amplitude distribution in the range 30 cps to 6 mc can be kept constant within $\pm 10\%$. The amplifier design provides for correct transmission of peak noise voltages of 5 times the rms value. Since the noise spectrum exhibits Gaussian amplitude distribution the probability of peak voltages higher than 5 times the rms value is given for less than 0.01 % of the time and the alteration of the spectrum by overdriving effects is negligible.

5. Operating Instructions

5.1 Connection to the A-C Supply

The SUF leaves our factory adjusted for 220 v a-c supply voltage. To adjust it for operation from 115, 125, or 235 v, remove the screws at the four corners of the front panel, withdraw the chassis from its cabinet and insert a fuse into the clips marked to correspond with the local supply voltage. The fuse strip is at the transformer at the right-hand side of the instrument. The 1-amp fuse provided for 220 v is suitable also for 235 v.

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For operation from the other supply voltages insert instead a 2 A (2 amps) DIN 41571 fuse. Put the chassis back into the cabinet.

Connect the instrument to the a-c mains via a three-wire lead with a three-contact safety plug. If this mains lead is plugged into a three-contact mains socket the instrument is earthed for operation.

The on-off switch is in the lower right-hand corner of the front panel. The neon lamp over the switch is the mains voltage indicator.

5.2 Setting the Mechanical Zero

When the instrument is switched off the pointer of the meter should be at the mechanical zero, i.e. the mark "0" of the scale. Correction is possible by means of the preset control provided below the dial.

5.3 Setting the Frequency Range of Noise Voltage

A switch provided at the left below the meter serves to select the three frequency ranges engraved on the front panel. In each switch position the maximum output of the SUF is 1 v rms into 75 Ω .

5.4 Setting the Output Voltage

5.4.1 Continuous Setting of Output Voltage

A knob at the left below the meter provides for continuous output voltage variation in the ratio of 10 : 1. The values of full-scale deflection are indicated at the attenuator switch.

5.4.2 Stepwise Adjustment

A resistive attenuator switchable in 10-db steps provides for adjustment of the output voltage over a wide range. The bar-type knob at the right of the meter serves to set the full-scale value.

5.4.3 Switching off the Noise Voltage

A switch provided at the right of the continuous output voltage control serves to turn off the noise voltage of the generator. It should be borne in mind that, according to what has been said under 2.3, the thermal noise voltage of the resistors adds to the output voltage at very low outputs ($< 10 \mu\text{v}$) in the frequency range 30 cps to 6 mc and that ,



with the generator switched off, a thermal noise voltage of $1.34 \mu\text{V}$ into 75Ω is generated in the range of 30 cps to 6 mc and cannot be switched off.

5.5 Output Voltage Indication

The output voltage is measured with a germanium diode ahead of the output attenuator. The meter is calibrated from 0.1 to 1 and from 0.3 to 3.16 in rms values into 75Ω corresponding with the 10-db steps of the attenuator switch. The magnitude of the output voltage and the scale to be used are found by means of the full-scale values engraved at the attenuator switch. The output voltage indication is correct only if the generator is terminated with 75Ω .

5.6 Connection of the Load to the SUF

Connect the load to the SUF with a coaxial connector (FS 413) of 13 mm outer diameter. For correct measurement the SUF must be terminated with 75Ω . In the case of a load impedance other than this, match termination can be accomplished by matching networks.

The use of simple resistive attenuators has been described under 2.4.

6. Maintenance

The SUF does not require any particular maintenance other than replacement of valves after a long service life.

6.1 Replacement of Valves

The twelve valves of the instrument may be replaced without affecting its performance.

Remove the four screws at the corners of the front panel and withdraw the chassis from its cabinet. Replace defective valves by the same type as given in the table of replaceable parts.

6.2 Replacement of the Fuses

The mains input of the SUF is protected by two fuses, the one located

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on the fuse strip at the transformer and the other at the rear of the instrument at the right over the terminal strip. Beside it is the fuse for the electronically stabilized HT voltage. After removal of the chassis from the cabinet the fuses can be replaced by the same type as listed in the table of replaceable parts.

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7. Table of Replaceable Parts

(Reference numbers according to circuit diagram)

Ref. No.	Designation	Ratings	R&S Stock No.
C1	Capacitor, feed-through, ceramic	5000 μ f/500 v	CFR 1/5000/500
C2	Capacitor, feed-through, ceramic	5000 μ f/500 v	CFR 1/5000/500
C3	Capacitor, feed-through, ceramic	5000 μ f/500 v	CFR 1/5000/500
C4	Capacitor, feed-through, ceramic	5000 μ f/500 v	CFR 1/5000/500
C5	Capacitor, feed-through, ceramic	5000 μ f/500 v	CFR 1/5000/500
C6	Capacitor, feed-through, ceramic	5000 μ f/500 v	CFR 1/5000/500
C7	Capacitor, feed-through, ceramic	5000 μ f/500 v	CFR 1/5000/500
C8	Capacitor, feed-through, ceramic	5000 μ f/500 v	CFR 1/5000/500
C9	Capacitor, feed-through, ceramic	5000 μ f/500 v	CFR 1/5000/500
C10	Capacitor, feed-through, ceramic	5000 μ f/500 v	CFR 1/5000/500
C11	Capacitor, feed-through, ceramic	5000 μ f/500 v	CFR 1/5000/500
C12	Capacitor, feed-through, ceramic	5000 μ f/500 v	CFR 1/5000/500
C13	Capacitor, feed-through, ceramic	5000 μ f/500 v	CFR 1/5000/500
C14	Capacitor, feed-through, ceramic	5000 μ f/500 v	CFR 1/5000/500
C15	Capacitor, ceramic	1000 μ f	CCG 94/1000
C16	Capacitor, ceramic	1000 μ f	CCG 94/1000
C17	Capacitor, ceramic	150 μ f	CCG 91/150
C18	Capacitor, ceramic	1000 μ f	CCG 94/1000
C19	Capacitor, feed-through, ceramic	5000 μ f/500 v	CFR 1/5000/500
C20	Capacitor, ceramic	3 μ f 0.5 μ f	CCG 41/3 CCG 11/0,5 parallel
C21	Capacitor, ceramic	1000 μ f	CCG 94/1000
C22	Capacitor, ceramic	1000 μ f	CCG 94/1000
C23	Capacitor, ceramic	150 μ f	CCG 91/150

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Ref. No.	Designation	Ratings	R&S Stock No.
C24	Capacitor, ceramic	1000 μf	CCG 94/1000
C25	Capacitor, ceramic	3 μf 0.5 μf	CCG 41/3 CCG 11/0,5 parallel
C26	Capacitor, ceramic	1000 μf	CCG 94/1000
C27	Capacitor, feed-through, ceramic	5000 $\mu\text{f}/500 \text{ v}$	CFR 1/5000/500
C28	Capacitor, ceramic	1000 μf	CCG 94/1000
C29	Capacitor, ceramic	1000 μf	CCG 94/1000
C30	Capacitor, ceramic	150 μf	CCG 91/150
C31	Capacitor, ceramic	3 μf 0.5 μf	CCG 41/3 CCG 11/0,5
C32	Capacitor, feed-through, ceramic	5000 $\mu\text{f}/500 \text{ v}$	CFR 1/5000/500
C33	Capacitor, ceramic	1000 μf	CCG 94/1000
C34	Capacitor, ceramic	1000 μf	CCG 94/1000
C35	Capacitor, ceramic	1000 μf	CCG 94/1000
C36	Capacitor, ceramic	150 μf	CCG 91/150
C37	Capacitor, ceramic	3 μf 1 μf	CCG 41/3 CCG 41/1
C38	Capacitor, ceramic	5 μf	CCG 68/5
C39	Capacitor, ceramic	1000 μf	CCG 94/1000
C40	Capacitor, MP	2 $\mu\text{f}/160 \text{ v}$	CMR 2/160/2
C41	Capacitor, ceramic	5 μf	CCG 68/5
C42	Capacitor, ceramic	4 μf	CCG 11/4
C43	Capacitor, electrolytic	32 $\mu\text{f}/350 \text{ v}$	CED 32/350
C44	Capacitor, electrolytic	10 $\mu\text{f}/70 \text{ v}$	CED 3/10/70
C45	Trimmer, tubular, ceramic	0.5 to 3 μf	CV 7202
C46	Capacitor, electrolytic	200 $\mu\text{f}/100 \text{ v}$	CED 100/100 CED 100/100 parallel
C47	Capacitor, MP	1 $\mu\text{f}/250 \text{ v}$	CMR 1/250/2
C48 C49	Capacitor, MP	16 $\mu\text{f}/350 \text{ v}$	CMR 8+8/350

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Ref. No.	Designation	Ratings	R&S Stock No.
C50	Capacitor, ceramic	1000 μf	CCG 94/1000
C51	Capacitor, paper	25,000 $\mu\text{f}/250\text{ v}$	CPK 25 000/250
C52	Capacitor, paper	25,000 $\mu\text{f}/250\text{ v}$	CPK 25 000/250
C53	Capacitor, electrolytic	1000 $\mu\text{f}/35\text{ v}$	CEG 21/1000/35
C54	Capacitor, paper	25,000 $\mu\text{f}/250\text{ v}$	CPK 25 000/250
C55	Capacitor, paper	10,000 $\mu\text{f}/250\text{ v}$	CPK 10 000/250
C57 C58	Capacitor, MP	16 $\mu\text{f}/350\text{ v}$	CMR 8 + 8/350
C59	Capacitor, paper	10,000 $\mu\text{f}/250\text{ v}$	CPK 10 000/250
C60	Capacitor, electrolytic	500 $\mu\text{f}/35\text{ v}$	CEG 21/500/35
C61	Capacitor, MP	16 $\mu\text{f}/500\text{ v}$	CMR 8 + 8/500
C62	Capacitor, MP	4 $\mu\text{f}/500\text{ v}$	CMR 4/500 parallel
C63	Capacitor, MP	4 $\mu\text{f}/500\text{ v}$	CMR 4/500
C64	Capacitor, electrolytic	2500 $\mu\text{f}/12\text{ v}$	CEG 6/2500/12
C65	Capacitor, MP	0.1 $\mu\text{f}/500\text{ v}$	CMR 0,1/500
C66	Capacitor, paper	100,000 $\mu\text{f}/630\text{ v}$	CPK 100 000/630
C67	Capacitor, ceramic	150 μf 150 μf 22 μf	CCH 68/150 CCH 68/150 CCH 68/22 parallel
C68	Capacitor, ceramic	3 x 180 μf 22 μf	3 x CCH 68/180 CCH 68/22 parallel
C69	Capacitor, ceramic	150 μf 150 μf 22 μf	CCH 68/150 CCH 68/150 CCH 68/22 parallel
C70	Capacitor, ceramic	22 μf	CCH 68/22
C71	Capacitor, ceramic	82 μf	CCH 68/22
C72	Capacitor, ceramic	22 μf	CCH 68/22
C73	Capacitor, ceramic	Adjusted value	
C74	Capacitor, ceramic	33 μf	CCH 31/33
C75	Capacitor, ceramic	adjusted value	
C76	Capacitor, feed-through, ceramic	5000 $\mu\text{f}/500\text{ v}$	CFR 1/5000/500

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Ref. No.	Designation	Ratings	R&S Stock No.
C77	Capacitor, MP	4 μ f/350 v	CMR 4/350
C78	Capacitor, ceramic	1000 μ f	CCG 94/1000
C79	Capacitor, feed-through, ceramic	5000 μ f/500 v	CFR 1/5000/500
C80	Capacitor, MP	4 μ f/500 v	CMR 4/500
C81	Capacitor, electrolytic	1000 μ f/35 v	CEG 21/1000/35
C82	Capacitor, ceramic	22 μ f	CCG 68/22
C83	Capacitor, paper	25,000 μ f/250 v	CPK 25 000/250
C84	Capacitor, electrolytic	1000 μ f/35 v	CEG 21/1000/35
C 85	Capacitor, feed-through, ceramic	5000 μ f/500 v	CFR 1/5000/500
G11	Rectifier		GNV 19/250/120 M
G12	Rectifier		GNB 11/30/1000 B
G13	Diode, crystal		GK/GD 6 E
I1	Meter	20 μ amps	INS 30401/20 μ A
K1	Cable 35 cm		LK 127/3
K2	Cable 20 cm		LK 127/3
L1	Coil		BV 105 730
L2	Coil		BV 105 730
L3	Coil		BV 105 730
L4	Coil		BV 105 730
L5	Coil		BV 105 731
L6	Coil		BV 105 731
L7	Coil		BV 105 731
L8	Coil		BV 105 732
L9	Coil		BV 105 733
L10	Coil		BV 103 316

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Ref. No.	Designation	Ratings	R&S Stock No.
L11	Coil		BV 103 316
L12	Coil		BV 103 316
L14	Coil		BV 103 308
L15	Coil		BV 103 308
L16	Coil		BV 103 309
L17	Coil		BV 103 309
L18	Coil		BV 103 310
L19	Coil		BV 103 310
L20	Choke		BV 105 734
L21	Choke		BV 104 712
L23	Choke		BV 104 713
L25	Choke		DB 75/2
L26	Choke		BV 30 791
R1	Resistor, depos. carbon	100 k Ω /0.1 w	WF 100 k/0,1
R2	Resistor, depos. carbon	1.6 k Ω /0.1 w	WF 1,6 k/0,1
R3	Resistor, depos. carbon	1.6 k Ω /0.1 w	WF 1,6 k/0,1
R4	Resistor, depos. carbon	1.6 k Ω /0.1 w	WF 1,6 k/0,1
R5	Resistor, depos. carbon	630 Ω /0.5 w	WFO 630/0,5
R6	Resistor, depos. carbon	10 k Ω /0.5 w	WFO 10 k/0,5
R7	Resistor, depos. carbon	1 k Ω /0.5 w	WFO 1 k/0,5
R8	Resistor, depos. carbon	1.25 k Ω /0.05 w	WF 1,25 k/0,05
R9	Resistor, depos. carbon	630 Ω /0.5 w	WFO 630/0,5
R10	Resistor, depos. carbon	10 k Ω /0.5 w	WFO 10 k/0,5
R11	Resistor, depos. carbon	1 k Ω /0.5 w	WFO 1 k/0,5
R12	Resistor, depos. carbon	1.6 k Ω /0.1 w	WF 1,6 k/0,1
R13	Resistor, depos. carbon	630 Ω /0.5 w	WFO 630/0,5
R14	Resistor, depos. carbon	10 k Ω /0.5 w	WFO 10 k/0,5

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Ref. No.	Designation	Ratings	R&S Stock No.
R15	Resistor, depos. carbon	1 k Ω /0.5 w	WFO 1 k/0,5
R16	Resistor, depos. carbon	1.6 k Ω /0.1 w	WF 1,6 k/0,1
R17	Resistor, depos. carbon	630 Ω /0.5 w	WFO 630/0,5
R18	Resistor, depos. carbon	10 k Ω /0.5 w	WFO 10 k/0,5
R19	Resistor, depos. carbon	1 k Ω /0.5 w	WFO 1k/0,5
R20	Resistor, depos. carbon	1.25 k Ω /0.05 w	WF 1,25 k/0,05
R21	Resistor, depos. carbon	16 k Ω /0.5 w	WFO 16 k/0,5
R22	Resistor, depos. carbon	50 k Ω /0.5 w	WFO 50 k/0,5
R23	Resistor, depos. carbon	30 k Ω /0.5 w	WFO 30 k/0,5
R24	Resistor, depos. carbon	27.7 k Ω \pm 1 %/1 w	WF 27,7 k/1/1
R25	Resistor, depos. carbon	16 k Ω /0.5 w	WFO 16 k/0,5
R26	Resistor, depos. carbon	approx. 8.8 k Ω /0.5 w	WF 20 k/0,5 WF 16 k/0,5 parallel
R27	Resistor, depos. carbon	approx. 8.3 k Ω /0.5 w	WF 50 k/0,5 WF 10 k/0,5 parallel
R28	Resistor, depos. carbon	approx. 8 k Ω /0.5 w	WF 40 k/0,5 WF 10 k/0,5 parallel
R29	Resistor, depos. carbon	1 k Ω /0.1 w	WF 1 k/0,1
R30	Resistor, depos. carbon	10 k Ω /0.1 w	WF 10 k/0,1
R31	Resistor, depos. carbon	80 Ω /1 w	WFO 80/1
R32	Resistor, wire-wound	600 Ω /4 w	WD 600/4
R33	Resistor, depos. carbon	approx. 8 k Ω /0.1 w	WF 8 k/0,1
R34	Resistor, depos. carbon	500 k Ω /0.5 w	WFO 500 k/0,5
R35	Resistor, depos. carbon	300 k Ω /0.5 w	WFO 300 k/0,5
R36	Resistor, depos. carbon	1.25 k Ω /0.5 w	WFO 1,25 k/0,5
R37	Resistor, depos. carbon	80 Ω /0.25 w	WF 80/0,25
R38	Resistor, depos. carbon	600 Ω /0.5 w	WFO 600/0,5
R39	Resistor, depos. carbon	50 Ω /0.1 w	WF 50/0,1
R40	Resistor, depos. carbon	50 Ω /0.1 w	WF 50/0,1
R41	Resistor, depos. carbon	approx. 6 k Ω /0.1 w	WF 6 k/0,1

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Ref. No.	Designation	Ratings	R&S Stock No.
R42	Resistor, depos. carbon	1 M Ω /0.1 w	WF 1M/0,1
R43	Resistor, depos. carbon	1 k Ω /0.5 w	WFO 1 k/0,5
R44	Resistor, depos. carbon	40 k Ω /0.25 w	WF 40 k/0,25
R45	Resistor, depos. carbon, variable	500 Ω lin.	WS 9126/500
R46	Resistor, depos. carbon	50 k Ω /0.25 w	WF 50 k/0,25
R47	Resistor, depos. carbon	5 Ω /0.1 w	WF 5/0,1
R48	Resistor, depos. carbon	1 M Ω /0.1 w	WF 1 M/0,1
R49	Resistor, depos. carbon	1 M Ω /0.1 w	WF 1 M/0,1
R50	Resistor, wire-wound	8 Ω /0.5 w	WD 8/0,5
R51	Resistor, wire-wound	8 Ω /0.5 w	WD 8/0,5
R52	Resistor, wire-wound	10 Ω /4 w	WV 4/10
R53	Resistor, depos. carbon	60 k Ω /0.5 w	WFO 60 k/0,5
R54	Resistor, depos. carbon	1 M Ω /0.5 w	WFO 1M/0,5
R55	Resistor, depos. carbon	1 k Ω /0.5 w	WFO 1 k/0,5
R56	Resistor, depos. carbon	2 Ω /0.5 w	WF 2/0,5
R57	Resistor, depos. carbon	50 k Ω /0.5 w 400 k Ω /0.5 w	WFO 50 k/0,5 WFO 400 k/0,5 parallel
R58	Resistor, depos. carbon, variable	10 k Ω lin.	WS 9122 F/10 k
R59	Resistor, depos. carbon	60 k Ω /0.5 w	WFO 60 k/0,5
R60	Resistor, depos. carbon	10 k Ω /0.5 w	WFO 10 k/0,5
R61	Resistor, depos. carbon	60 k Ω /0.5 w	WFO 60 k/0,5
R62	Resistor, depos. carbon	250 k Ω /0.5 w	WFO 250 k/0,5
R63	Resistor, depos. carbon, variable	10 k Ω lin.	WS 9122 F/10 k
R64	Resistor, depos. carbon	30 k Ω /0.5 w	WFO 30 k/0,5
R65	Resistor, depos. carbon	6.1 k Ω ± 1 %/1 w	WF 6,1 k/1/1
R66	Resistor, depos. carbon	6.1 k Ω ± 1 %/1 w	WF 6,1 k/1/1
R67	Resistor, depos. carbon	27.7 k Ω ± 1 %/1 w	WF 27,7 k/1/1

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Ref. No.	Designation	Ratings	R&S Stock No.
R68	Resistor, depos. carbon	1.7 k Ω ± 1 %/1 w	WF 1,7 k/1/1
R69	Resistor, depos. carbon	1.7 k Ω ± 1 %/1 w	WF 1,7 k/1/1
R70	Resistor, depos. carbon	106.55 Ω ± 1 %/0.1 w	WF 106,55/1/0,1
R71	Resistor, depos. carbon	106.55 Ω ± 1 %/0.1 w	WF 106,55/1/0,1
R72	Resistor, depos. carbon	106.55 Ω ± 1 %/0.1 w	WF 106,55/1/0,1
R73	Resistor, depos. carbon	106.55 Ω ± 1 %/0.1 w	WF 106,55/1/0,1
R74	Resistor, depos. carbon	106.55 Ω ± 1 %/0.1 w	WF 106,55/1/0,1
R75	Resistor, depos. carbon	106.55 Ω ± 1 %/0.1 w	WF 106,55/1/0,1
R76	Resistor, depos. carbon	106.55 Ω ± 1 %/0.1 w	WF 106,55/1/0,1
R77	Resistor, depos. carbon	106.55 Ω ± 1 %/0.1 w	WF 106,55/1/0,1
R78	Resistor, depos. carbon	106.55 Ω ± 1 %/0.1 w	WF 106,55/1/0,1
R79	Resistor, depos. carbon	106.55 Ω ± 1 %/0.1 w	WF 106,55/1/0,1
R80	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R81	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R82	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R83	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R84	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R85	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R86	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R87	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R88	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R89	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R90	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R91	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R92	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R93	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R94	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R95	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1

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Ref. No.	Designation	Ratings	R&S Stock No.
R96	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R97	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R98	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R99	Resistor, depos. carbon	144.5 Ω ± 1 %/0.1 w	WF 144,5/1/0,1
R100	Resistor, depos. carbon	1 k Ω /0.5 w	WFO 1 k/0,5
R101	Resistor, depos. carbon	1 k Ω /0.1 w	WF 1 k/0,1
R102	Resistor, depos. carbon	5 k Ω /0.1 w	WF 5 k/0,1
R103	Resistor, depos. carbon	1 k Ω /0.5 w	WF 1 k/0,5
R105	Resistor, depos. carbon	16 k Ω /0.5 w	WFO 16 k/0,5
R106	Resistor, depos. carbon	5 Ω /0.05 w	WF 5/0,05
R107	Resistor, depos. carbon	5 Ω /0.05 w	WF 5/0,05
R108	Resistor, depos. carbon	5 Ω /0.05 w	WF 5/0,05
R109	Resistor, depos. carbon	100 Ω /0.5 w	WFO 100/0,5
R110	Resistor, depos. carbon	4 k Ω /1 w	WF 4 k/1
R111	Resistor, depos. carbon	3 k Ω /1 w	WF 3 k/1
R112	Resistor, depos. carbon	4 k Ω /1 w	WF 4 k/1
R113	Resistor, depos. carbon	3 k Ω /1 w	WF 3 k/1
R114	Resistor, depos. carbon	4 k Ω /1 w	WF 4 k/1
R115	Resistor, depos. carbon	4 k Ω /1 w	WF 4 k/1
R116	Resistor, depos. carbon	4 k Ω /1 w	WF 4 k/1
R117	Resistor, depos. carbon	4 k Ω /1 w	WF 4 k/1
R118	Resistor, depos. carbon	1 M Ω /0.1 w	WF 1 M/0,1
R119	Resistor, depos. carbon	50 Ω /0.1 w	WF 50/0,1
R120	Resistor, depos. carbon	680 Ω /0.5 w	WF 680/0,5
R121	Resistor, depos. carbon	1 k Ω /0.5 w	WFO 1 k/0,5
R122	Resistor, depos. carbon	6 k Ω /0.1 w	WF 6 k/0,1
R123	Resistor, depos. carbon	50 Ω /0.1 w	WF 50/0,1
R124	Resistor, depos. carbon	1 M Ω /0.1 w	WF 1 M/0,1

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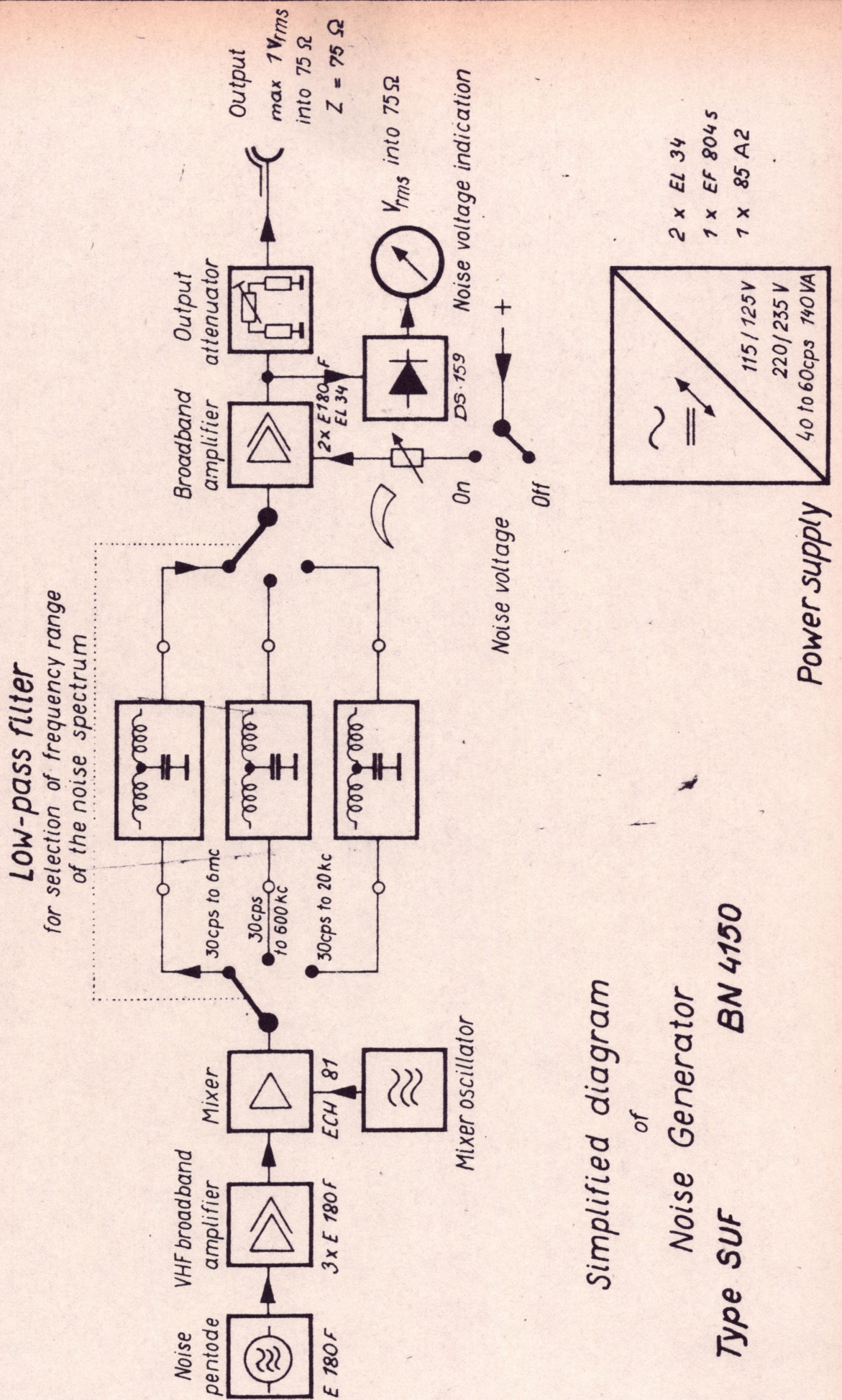
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Ref. No.	Designation	Ratings	R&S Stock No.
R125	Resistor, depos. carbon	80 Ω /0.25 w	WF 80/0,25
R126	Resistor, depos. carbon	600 Ω /0.5 w	WF 600/0,5
Rö1	Pentode		E 180 F
Rö2	Pentode		E 180 F
Rö3	Pentode		E 180 F
Rö4	Pentode		E 180 F
Rö5	Valve		ECH 81
Rö6	Pentode		EL 34
Rö7	Duo-triode		E 88 CC
Rö8	Duo-triode		E 88 CC
Rö9	Pentode		EL 34
Rö10	Pentode		EL 34
Rö11	Pentode		EF 804 s
Rö12	Reference tube		85 A 2
RL1	Lamp, neon, miniature		RL 210
S1	Switch, power		SRK 1
S2	Switch		SR 112/2/32
S3	Switch, wafer		SRW 07220
S4	Switch		SRS 161/32
Tr1	Transformer, power		BV 103 317
Si1	Fuse		2 D DIN 41571
Si2	Fuse		0,3 C DIN 41571
Si3	Fuse		1 C DIN 41571

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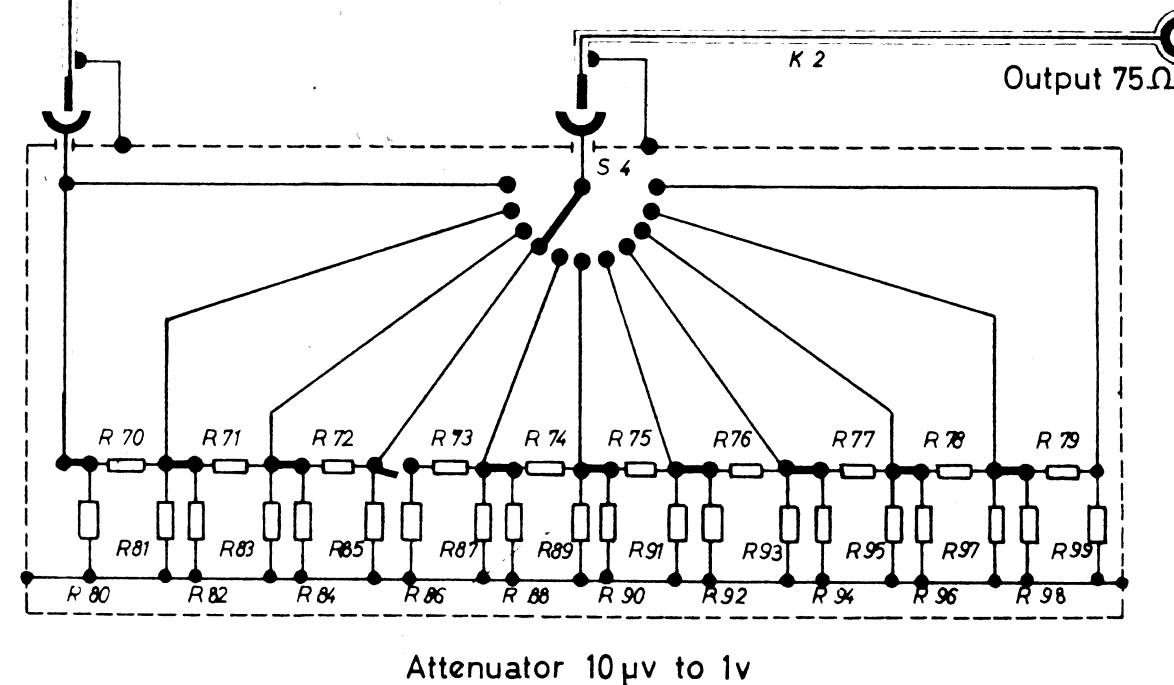
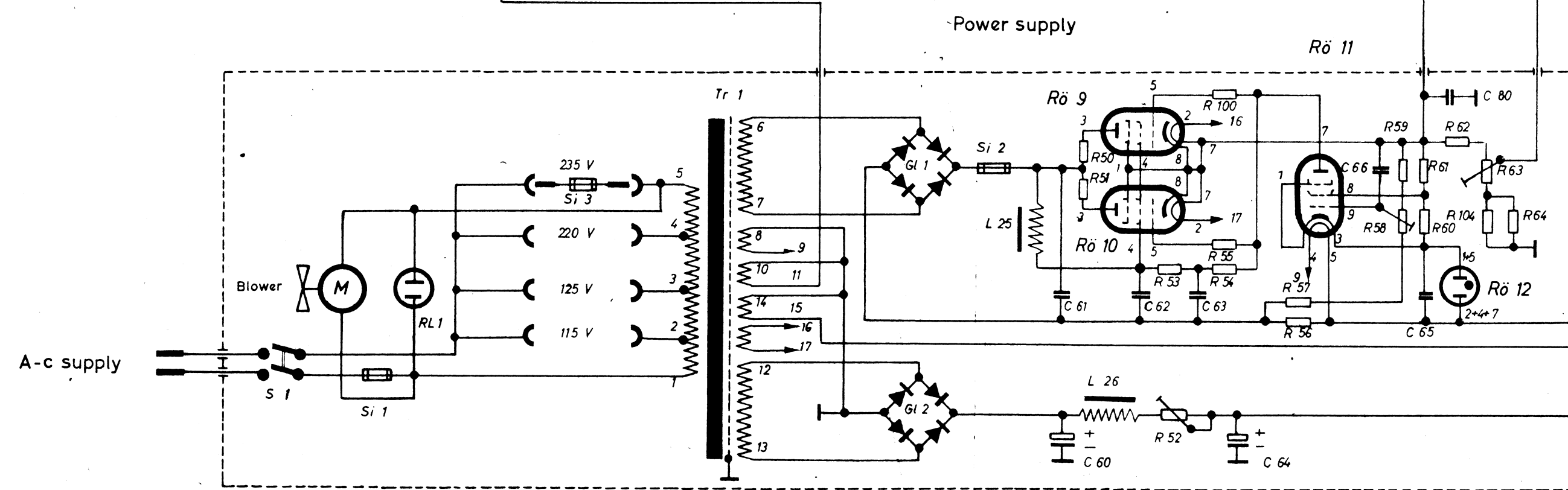
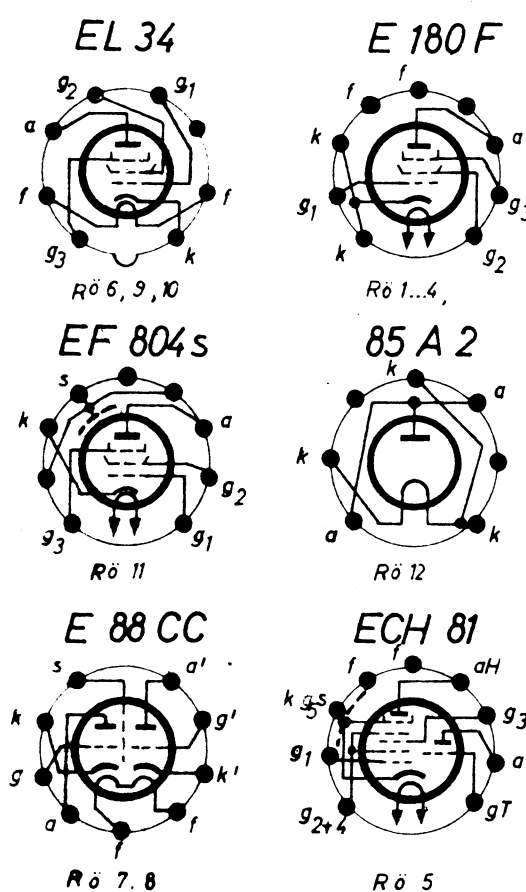
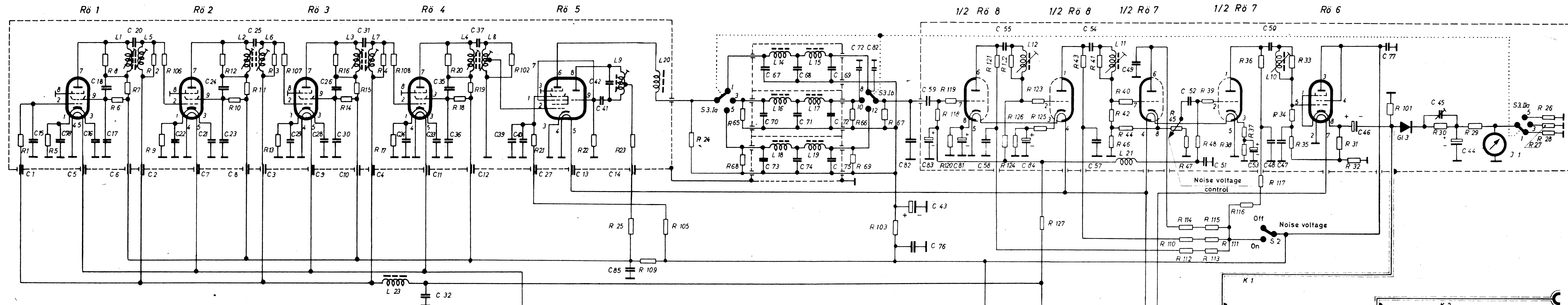


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RF section

Bandpass filter 30 cps to 20 kc
30 cps to 600 kc
30 cps to 6 kc

AF section



gültig ab F Nr. E 345/5/..

Noise Generator Type SUF

Zeichn. Nr.

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