ROHDE & SCHWARZ
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Manual

SIGNAL GENERATOR SMDU

RADIOTELEPHONE MODEL 249.3011.06
249.3011.09

RADIOTELEPHONE and
AIR-NAVIGATION MODEL 249.3011.07

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2. Preparation for Use and Operating Instructions

The values mentioned in this section are not guaranteed; only the specifications given in 1.3 are binding.

2.1 Legend for Fig. 2-1

The reference numbers 4 to 9 refer to the control elements of the Synchronizer SMDU-B1, which can be incorporated subsequently.

Ref.No.	Engraving	Function
1	392-525 784-1050 286-395 572-790 196-290 510-580 118-198 85-119 63.5-88 49-64.5 0.14-50	Pushbuttons for selecting the frequency range. The red engraving of the upper three ranges (510 to 1050) is applicable if the 1.05-GHz Frequency Range Extension SMDU-B3 or the 1.05-GHz Frequency Doubler SMDU-B5 is incorporated and button 2 depressed.
2		Button for frequency doubling. Pressing this button doubles the upper three frequency ranges if the 1.05-GHz Frequency Range Extension SMDU-B3 or the 1.05-GHz Frequency Doubler SMDU-B5 is incorporated. Then the red engravings apply.
3		Digital frequency readout. Operating mode and frequency range are selected by means of buttons 11 . Internal RF or AF or external frequencies applied to sockets 45 , 46 , 47 can be measured. Button 10 permits the resolution to be multiplied by ten.
4	SYNCHRON	Button for cutting in synchronization (no synchronization possible, when pushbutton 11 EXT. 20 - 525 MHz is depressed). With synchronization on, lamp 5 lights up. The state of synchronization is indicated on meter 6 .
5		Pilot lamp lighting up with synchronization mode.
6	CONTROL VOLT.	Meter for indicating the state of synchronization.
7	CH. SPACING 12.5/20/25/50/100/ 150 kHz	Switch for selecting the spacing of the locked frequencies for synchronization. With synchronization mode (button 4 and one of buttons 11, except for EXT. 20 - 525 MHz, pressed) and when turning the fine-tuning control 50, the signal generator frequency varies according to the selected spacing of the locked frequencies.

Ref.No.	Engraving	Function
8	FINE TUNING	Button for cutting in fine tuning. Fine tuning of the synchronized signal generator frequency is made with rotary switch 9 .
9	FREQ. FINE	Twin coaxial rotary control for tuning of the synchronized signal-generator frequency; button 8 must be depressed. Outer knob: 1 rotation = about 10% of selected frequency spacing Inner knob: 1 rotation = about 0.1% of selected frequency spacing
10	RESOL. x10	Button for multiplying the resolution of frequency readout 3 by ten.
11	0.5 - 1 GHz 20 - 525 MHz } EXT. 15 Hz - 30 MHz RF AF } INT.	Buttons for selecting the operating mode and the frequency range of frequency readout 3 . Internal (INT.) or external (EXT.) frequencies can be measured, external signals being fed into sockets 45 , 46 or 47 . Frequencies from 525 MHz to 1 GHz can be measured only if the 1-GHz Frequency Meter SMDU-B4 is incorporated.
12	MOD. INT. AM EXT.	Buttons for cutting in the amplitude modulation and for selecting internal or external AM. With external AM, the signal is fed into socket 51 . With button 23 AM depressed, meter 15 indicates the modulation depth (adjusted with 35).
13	PREEMPH. 6 dB/OKT.	Buttons for cutting in a preemphasis of 6 dB/octave with FM.
14	MOD. INT. FM EXT.	Buttons for cutting in the frequency modulation and for selecting internal or external FM. With external FM, the signal is fed into socket 52 . With button 23 FM depressed, the frequency deviation is indicated on meter 15 (adjustment with 17).
15		Meter for indicating the modulation depth, the frequency deviation, the phase deviation, the voltage at modulation-generator output 41 , the voltage at AF voltmeter input 44 , the distortion or the SINAD ratio. The type of indication is selected by means of buttons 23 , the range of indication with switch 22 . Type and range of indication are displayed on 16 .
16		Illuminated display of type of indication selected with buttons 23 (kHz, rad, %, mV) and of indicating range selected with 22 .

Ref.No.	Engraving	Function
17	10 100 kHz	Push-pull rotary knob for adjusting a frequency deviation up to 10 kHz (in) or up to 100 kHz (out). The frequency modulation is selected with 14 . If button 23 FM is depressed, the frequency deviation is indicated on meter 15 . The button permits adjustment of the phase deviation if 13 is pressed.
18	MOD. GENERATOR FIXED VAR.	Button for selecting the fixed frequencies set with 19 (released) or the ranges set with 19 (pressed) and tunable with 21 .
19	6 10-30 3 3-10 2.7 1-3 1 0.3-1 0.4 0.1-0.3 0.3 0.03-0.1 kHz kHz	Buttons for selecting the fixed frequencies (left column) or the frequency ranges (right column) of the modulation generator depending on the position of button 18 . Fine tuning of the modulation frequency is made with 21 , the frequency being indicated on 20 or 3 .
20	FREQ.	Scale for indicating the frequency of the internal modulation generator if 18 is pressed. The frequency range is selected with 19 , fine tuning of the frequency is made with 21 . With button AF INT. 11 pressed, the digital frequency readout 3 indicates the accurate modulation frequency if one of buttons MOD. 12 or 14 is pressed.
21		Rotary knob for adjusting the frequency of the modulation generator if 13 is pressed. The frequency range is selected with buttons 19 and the frequency read on 20 . With button AF INT. 11 pressed, the frequency of the modulation generator is indicated on the digital readout 3 . The modulation generator is operative only if at least one of buttons MOD. 12 or 14 is pressed.
22	RANGE AUTO STOP MAN.	Range selector for meter 15 . In the upper position the indicating range is selected automatically, in mid-position the momentary range is preserved and each time when setting the switch to the lower position switchover to the next range is effected. The indicating range is displayed on 16 .

Ref.No.	Engraving	Function
23	INDICATION FM φM 6 dB/OKT. AM MOD. GEN. AF VOLTM.	Buttons for selecting the type of indication of meter 15 . The measuring unit (kHz, rad, %, mV) is displayed on 16 .
24	DEV. METER ON	Button for switching in the deviation meter. The mode is selected by means of 27 , 28 . The deviation is indicated on 15 with button FM 23 pressed. If the test signal present at 46 or 47 is unmodulated, the spurious deviation is indicated.
25	- +	Button for indicating the negative or the positive deviation.
26		LED indicating that the deviation meter is ready for operation. It lights up only if the frequency of the RF signal present at 46 or 47 is within the operating range (or pulling range with Duplex AFC) of the deviation meter and its level is sufficient.
27	RELAIS ON f_{up} OFF f_{low}	Switch (3 positions) for selecting the relay mode. Up: Upper band (f_{up}) Centre: Relay operation off Down: Lower band (f_{low}) Relay mode OFF is indicated by the LED.
28	SIMPLEX DUPLEX-AFC	Button for selecting the simplex or duplex mode in the case of deviation measurements.
29	ZERO I	Rotary knob for compensation of the deviation amplitude in relay operation.
30	CCITT FILTER	Button for switching in the CCITT filter. This filter is switched in only if one of buttons FM 23 or φM 23 together with 24 or if button AF VOLTM. 23 is pressed.
31	DIST. 1 kHz	Button for switching in the distortion meter. The distortion meter is switched in only if one of buttons FM 23 or φM 23 together with 24 or if button AF VOLTM. 23 is pressed. Meter 15 indicates the distortion, % appears on readout 16 . If no signal is present, LED UNCAL. lights up on 15 . The CCITT filter 30 can be connected for distortion measurements.
32	ZERO II	Rotary knob for compensation of the deviation phase in relay operation.

Ref.No.	Engraving	Function
33	SINAD	Button for connecting the SINAD ratio meter. The notes given under 31 also apply. The SINAD values 6/12/20 dB are marked by LEDs on meter 15 . They light up if the corresponding range is selected.
34	LEVEL 0.5 V 5 V	Push-pull rotary knob for adjusting the output voltage of the modulation generator at socket 41 . When pushing the knob, output voltages down to 0.5 V and when pulling it, levels up to 5 V can be adjusted.With button 23 MOD.GEN. depressed, the adjusted voltage is indicated on meter 15.The modulation generator is only operative if at least one of the buttons MOD. 12 or 14 is depressed.
35	%	Rotary knob for adjusting the modulation depth. The amplitude modulation is selected with buttons 12 . With button 23 AM depressed, the modulation depth is indicated on meter 15 .
36		Crank-type knob for adjusting the RF output voltage.
37		Fine scale of the RF output attenuator; graduated in 0.1-dB steps for adjusting and reading small level differences.
38	○ ⊓ ⊥ |	Power switch; pressed ≙ on.
39	RF 50 Ω	Output socket for RF voltage (adaptable). The output level can be read on scale 43 .
40	RF OFF	Illuminated button for cutting off the RF voltage. The output impedance of output 39 is not affected. Due to the incorporated Overload Protection SMDU-B2, this button lights if an external voltage is fed into output 39 .
41	MOD. GEN. ≈ 50 Ω	Output socket of modulation generator. The amplitude of the output voltage is adjusted with 34 and indicated on meter 15 if button 23 MOD. GEN. is depressed. The modulation generator is only operative if one of the buttons 12 or 14 MOD. is depressed.

Ref.No.	Engraving	Function
42	MOD. AF	AF output socket for meter amplifier. The signal type can be selected with 23 and the amplitude adjusted in 10-dB steps by means of 22 . CCITT weighting is possible with the aid of button 30 . With buttons FM 23 and 24 pressed, the demodulated signal from the deviation meter is available. When measuring the distortion, only the harmonics spectrum is available.
43	U_A EMK 6 dB dBm 50 Ω dBV	Scale for indicating the level at RF output 39 . The level is adjusted with 36 . The dBm and dBV scales are calibrated in 2-dB steps. Smaller steps can be adjusted with the attenuator fine scale 37 . Above 1 V_{EMF} the mark for E_{out} into 50 Ω on the cursor of the attenuator applies. Note: the attenuator is calibrated in V_{EMF}, the mark for E_{out} into 50 Ω may have an additional error of ±1 dB.
44	AF VOLTMETER 15 Hz - 150 kHz > 100 kΩ	Input socket for the AF voltmeter. If button 23 AF VOLTM. is depressed, the external signal voltage is indicated on meter 15 . When button 31 is pressed, the distortion is indicated. With button 33 pressed, the SINAD ratio can be read.
45	EXT. FREQ. METER 15 Hz - 30 MHz U_E > 10 mV > 10 kΩ 40 pF MAX. 3 V	Input socket of frequency meter for external signals from 15 Hz to 30 MHz. The frequency of the signal applied is indicated on digital readout 3 if button 11 EXT. 15 Hz - 30 MHz is depressed. Signals with an amplitude between 10 mV and 3 V can be measured. Voltages up to 10 V (also DC voltage) do not damage the frequency meter.
46	EXT. FREQ. + DEV. METER 20 - 525 MHz U_E > 10 mV ≈ 50 Ω MAX. 3 V	Input socket of frequency and deviation meter for external signals from 20 to 525 MHz. The frequency of the signal applied is indicated on 3 if button 11 EXT. 20 - 525 MHz is depressed. The deviation is indicated on 15 if buttons 24 and FM 23 are pressed. Signals with an amplitude between 10 mV and 3 V can be measured. If the minimum voltage is < 10 mV, the input is cut off; zero is indicated on 3 and 26 goes out. Voltages up to 10 V, also DC, do not damage the test input.

Ref.No.	Engraving	Function
47	EXT. FREQ. + DEV. METER 0.5 - 1 GHz $U_E > 30$ mV ≈ 50 Ω Max. 1 V	Input socket of frequency and deviation meter for external signals from 0.5 to 1 GHz. For this measurement the 1-GHz Frequency Meter SMDU-B4 must be incorporated. With button 11 EXT. 0.5 - 1 GHz depressed, the frequency of the signal is displayed on 3 . The deviation indication is the same as under 46 if button 2 (frequency doubling) is pressed. Signals with an amplitude between 30 mV and 1 V can be measured. Voltages up to 3 V, also DC, do not damage the test input.
48	MHz	Analog frequency drum dial. The eight individual scales are selected with buttons 1 . Each selector button is arranged on the same level as its scale. The red engraving of the upper three ranges (510 to 1050) is applicable if the 1.05-GHz Frequency Range Extension SMDU-B3 or the 1.05-GHz Frequency Doubler SMDU-B5 is incorporated and button 2 depressed.
49		Rotary knob for coarse tuning of the signal generator frequency. Fine tuning is made with 50 . The adjusted frequency can be read on scale 48 and after depressing button 11 RF INT. also on digital readout 3 .
50		Rotary knob for fine tuning of the signal generator frequency. See also under 49 .
51	EXTERN. MODULATION AM ≈ 15 mV/% ≈ 600 Ω	Input socket for external AM signals. Button 12 AM EXT. must be depressed. The modulation depth can be selected with 35 and, after depressing button 23 AM and selecting the indicating range with 22 , read on meter 15 .
52	EXTERN MODULATION FM ≈ 5 $V_s/\Delta f_{MAX}$ MAX. 10 V_s	Input socket for external FM signals. Button 14 FM EXT. must be depressed. The frequency deviation can be selected with 17 and, after depressing button 23 FM and selecting the indicating range with 22 , read on meter 15 . Phase modulation is obtained with button 13 pressed.

Ref.No.	Engraving	Function
53	AC ≈ 600 Ω DC ≈ 2 kΩ	Switch for selecting the coupling of signals at FM input 52 . With DC coupling the input impedance at 52 is approx. 2 kΩ, with AC coupling approx. 600 Ω.
54	AC SUPPLY ADAPTER	AC-voltage output for connecting accessory units (e.g. AM Unit SMDU-Z1). The voltage at this output is cut in via the power switch of the SMDU.
55		Output socket of internal 10-MHz crystal oscillator. See also 56 .
56	REF. FREQ. 10 MHz ⊓⊔⊓⊔ 5 V	Input socket of counter control; connected via cable with the output of the internal 10-MHz crystal oscillator. After removing the cable, an external 10-MHz time base with TTL output level can be connected.
57	DEMOD. OUTPUT	The demodulated signal of the SMDU is available at connections 1 and 2 (chassis), e.g. for measuring the AM distortion. In the case of version 249.3011.07, connection of a VOR-ILS Unit 214.3115.. is possible.
58	BEAT FREQ. ONLY W. OPT. DEV. METER	Output of beat frequency meter in deviation meter. The output signal is independent of the position of buttons 23 , 24 , 28 .
59	⊥	Chassis socket
60	RF OUTPUT II	Output socket for the RF voltage derived before the amplitude modulator. A signal of > 20 mV is available for measuring the frequency, deviation etc. The level is independent of the setting of the output attenuator 36 . With the 1.05-GHz Frequency Range Extension SMDU-B3 or the 1.05-GHz Frequency Doubler SMDU-B5 built in and an output frequency > 525 MHz, the non-doubled frequency is available at this output.
61	BCD OUTPUTS/ RECORDER	Output socket for recording the test results. From the frequency meter the frequency is available in BCD code; from meter 15 the indication voltage is available; 1 V ≙ full deflection. In addition, the internal operating voltages are taken to this output (see Fig. 2-2). By connecting points 49 and 50, the resolution of the digital frequency meter is increased by the factor of 10.

Ref.No.	Engraving	Function
62	115 V T 1,6 D 125 V 220 V T 0,8 B 235 V	Voltage selector with power fuse, and spare fuses on the inside of the cover plate.
63	AC SUPPLY	AC-supply receptacle.

2.2 Preparation for Use (For operating controls see Fig. 2-1)

2.2.1 Adjusting to the Local AC-supply Voltage and Switching On

The SMDU complies with the safety regulations according to VDE 0411 Class I. Class I requires insulation of the circuits carrying AC supply during operation. In addition, all exposed conducting elements that are likely to be immediately alive in the case of a failure, must properly and permanently be connected with each other and with the non-fused earthed conductor. The power plug should therefore be inserted only into an earthing-contact type socket. Do not interrupt the non-fused earthed conductor when using extension lines. Connect the terminal, if any, permanently to a non-fused earthed conductor.

The SMDU is factory-adjusted for operation from 220 V AC supply. By changing the position of the voltage selector 62 the set can also be operated from 115, 125 or 235 V. For this purpose unscrew the fuse from 62 and remove the cover plate. Turn the cover plate until its marker line points to the desired AC-supply voltage and put it on again. Screw in the fuse required for the selected AC-supply voltage:

T 1.6 D for 115 or 125 V
T 0.8 B for 220 or 235 V

Connection to the AC supply is made via socket 63 and the power cable supplied. Variations of the AC-supply voltage up to ±10% of the ratings do not affect the performance of the set as specified in section 1.3. With heavier fluctuations, a transformer or AC-voltage stabilizer should be connected ahead of the signal generator.

The set is switched on with button 38 . When the set is switched on and the power fuse is intact, the digital display 3 lights up.

2.2.2 Adjusting the Zero of the Meter

If the SMDU is switched off, the pointer of meter 15 must be at scale zero. Correct, if necessary, with the recessed screw below the meter. Before checking or adjusting the zero, wait a few minutes after the set has been switched off in order to avoid incompletely discharged capacitors causing a residual deflection. The electrical zero is identical with the mechanical zero. Meter 6 (only with incorporated Synchronizer SMDU-B1) serves as indicator, its zero (centre) cannot be corrected.

2.3 Operating Instructions (For operating controls see Fig. 2-1)

2.3.1 RF Oscillator

2.3.1.1 Adjusting the Frequency

Select the desired frequency with the corresponding button 1 . The frequency range is indicated beside the button and the associated frequency scale is arranged on the same level. The red engravings are applicable if the 1.05-GHz Frequency Range Extension SMDU-B3 or the 1.05-GHz Frequency Doubler SMDU-B5 is incorporated and button 2 depressed.
Coarse adjustment of the frequency is made with tuning knob 49 and fine adjustment with the outer tuning ring 50 . For highly accurate setting use the internal frequency meter. Depress button 11 RF INT. and read the signal generator frequency on display 3 , in the frequency range 0.14 to 50 MHz with a resolution of 10 Hz, in all other ranges up to 787 MHz with a resolution of 100 Hz. After depressing button 10 , the accuracy of indication is increased by the factor of 10 so that up to 50 MHz an accuracy to within 1 Hz and up to 787 MHz to within 10 Hz can be achieved. In the uppermost frequency range from 787 to 1050 MHz the resolution is 1 kHz and 100 Hz respectively. Since the resolution of the oscillator vernier drive is limited, a frequency below 50 MHz can only be set to within 1 Hz with the Synchronizer SMDU-B1 built in.

2.3.1.2 Synchronizing the Frequency
(only with built-in Synchronizer SMDU-B1)

The Synchronizer permits the frequency to be set with high accuracy and kept stable. The synchronization is cut in with button 4 (if button 11 EXT. 20 - 525 MHz is pressed, synchronization is not possible). Pilot lamp 5 lights up with synchronization mode. The frequency can now be set to integral multiples of the spacing of the locked frequencies selected with switch 7 . When rotating knob 50 , the frequency varies by the amount of the selected spacing as soon as the hold range of the synchronization is exceeded. On meter 6 can be observed how quickly and exactly when, the changeover point is reached.

For adjusting any frequency in between, depress 8 and tune the frequency with double knob 9 . When rotating the outer knob 9 ten times, the frequency is varied by about the spacing selected with 7 , whereas ten rotations of the inner knob 9 yield a frequency tuning of about 1% of the spacing. A frequency change by the amount of the selected spacing can be started from any frequency adjusted with the fine-tuning control. The frequency jump may however deviate up to 1% from the selected spacing. Rotary knob 9 permits this deviation to be corrected.

2.3.1.3 Adjusting the Output Voltage

The RF output voltage can be adjusted with crank-type knob 36 , read on scale 43 and derived at socket 39 . Scale 43 is made up of three differently calibrated scales. The upper scale is calibrated in V_{EMF} and reads twice the voltage into a 50-Ω load. The lower scales are calibrated in dBm (referred to 1 mW into 50 Ω) and dBV (referred to 1 V_{EMF}).

Small level differences below -10 dB can be adjusted with the fine scale 37 of the attenuator knob. The fine scale is calibrated in 0.1-dB steps and in 0.2-V steps. One rotation of the fine scale (10 dB) may cause an error of ±0.8 dB, i.e. the EMF, dBm or dBV calibration of scale 43 may differ from the fine scale by this amount. On the cursor of scale 43 a shorter line is engraved at 6 dB left from the long line, which permits reading of the output voltage into 50 Ω. Since the scale is calibrated in V_{EMF}, dBm and dBV, the line for E_{out} into 50 Ω may have an additional error of about ±1 dB due to the linearity error of the output attenuator.

The VSWR is < 4 for maximum output voltage and < 1.2 with attenuator settings > 10 dB (for Dezifix A output). Although the error resulting from this VSWR is compensated for by the calibration of the output attenuator, a smaller VSWR is desirable in certain precision measurements and in cases where the SMDU must constitute a reflection-free termination for the load. In this case the interconnection of a 10-dB UHF Attenuator DPF 100.1814.50 equipped with Dezifix A connectors is recommended for reducing the reflection coefficient to about 5 to 3%, depending on the output attenuator setting.

2.3.1.4 Connecting a Load

The RF output 39 of the SMDU is fitted with an N connector, therefore a cable with an N connector is required for connecting a load. Care should be taken that the N connectors are not damaged by knocks and jolts. The contact surfaces of the connectors should always be kept clean; this makes for better contact and reduces the reflection coefficient. If an optimum RF connection and minimum reflection coefficient are not essential, the other end of the cable can be adapted to the input connection of the test item. Should it not be possible to connect test items with N connectors, the RF output of the SMDU can be adapted for use with other connector systems, as described in section 2.3.1.8.

In order to protect the RF output, the SMDU radiotelephone model is equipped with the Overload Protection SMDU-B2. This overload protection separates the connection between output socket 39 and the output attenuator in case of overloading. If the output attenuator is set to maximum (right-hand stop), a DC voltage of 20 V does not cause damage and with output voltages below 0.1 V up to 250 V DC may be applied. Its response time is approx. 1 ms and the response is indicated by pilot lamp 40.

2.3.1.5 Voltage at the Load

If the input impedance of the test item is complex and does not exactly agree with the source impedance of the signal generator, the voltage $\underline{E}$ at the load can be calculated from the open-circuit voltage EMF adjusted on the signal generator and the complex input impedance $\underline{Z}_l$ of the load:

$$\underline{E} = \text{EMF}\ \frac{\underline{Z}_l}{\underline{Z}_l + Z_s}$$

This formula applies provided that the characteristic impedance of the cable connecting the load is equal to the signal-generator output impedance (50 Ω) and with attenuator settings < 0 dBm. It is advisable to select the load impedance equal to the source impedance of the signal generator. Then the voltage at the load is half the EMF adjusted and indicated on the signal generator (also with levels > 0 dBm), the output impedance of the signal generator being 50 Ω. The cable impedance, contact resistances and other discontinuities are negligible. The conversion factors for the voltage and the level at the load for different load resistances are given in the following Table.

R_l [Ω]	k	a_k [dB]
50	0.5	6
60	0.545	5.3
75	0.6	4.4
150	0.75	2.5
240	0.828	1.6
600	0.92	0.7

R_l = input resistance of load

E_l = voltage at the load

a_l = level at the load

EMF = EMF adjusted on the signal generator

a = level adjusted on the signal generator

k = conversion factor

a_k = dB value to be subtracted with different load resistances

Voltage at the load E_l = EMF x k

Level in dB at the load a_l = a - a_k

2.3.1.6 Power Consumption of the Load

The lower scale 43 of the output attenuator indicates the power delivered by the SMDU to an ideal load in dB below 1 mW into 50 Ω (dBm). Slight mismatch of the load to the voltage source has very little influence on the power consumed. The power drop caused by a characteristic impedance differing from that of the signal generator output is almost negligible. As can be seen in Fig. 2-3, a mismatch of Z_l/Z_s = 1/3 results in a power drop of about 2.5 dB and Z_l/Z_s = 2/1 produces a power drop of 1 dB.

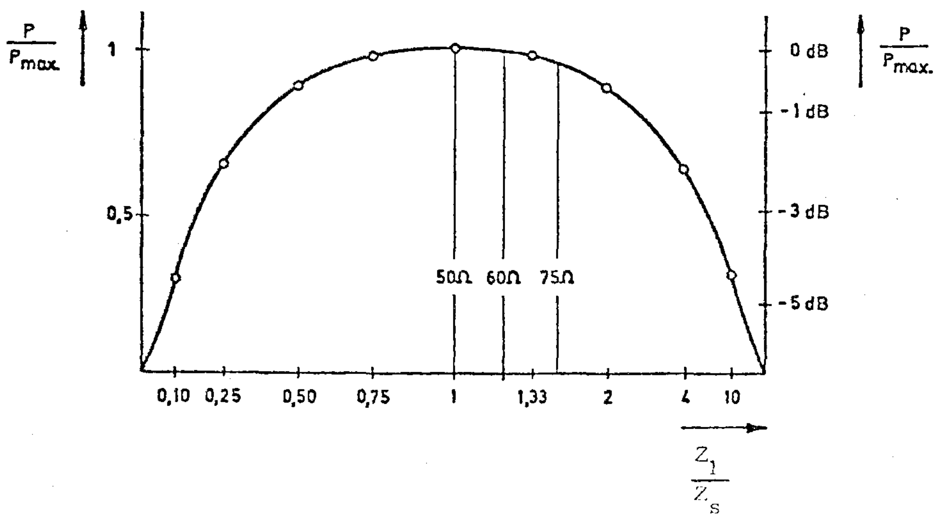
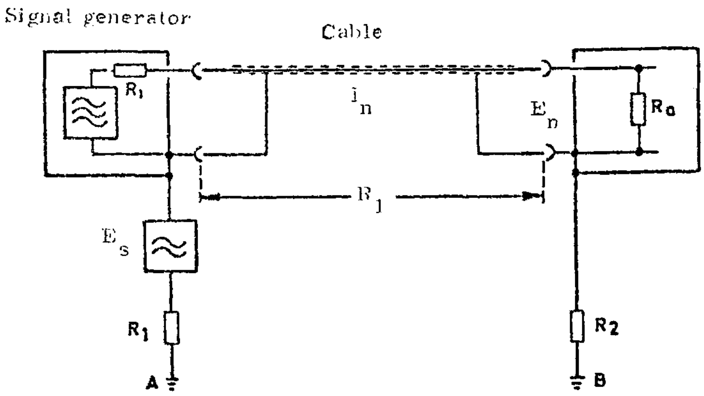


Fig. 2-3 Real power with mismatch

2.3.1.7 Adjusting Extremely Small Output Voltages

The high-quality output attenuator and good shielding of the SMDU permit accurate setting of extremely small output voltages. Whether these small voltages arrive at the input of the test item or whether they are invalidated by superimposed noise voltages depends on the test item and the connecting cables used. In general, noise voltages can be prevented by good shielding of the test item, use of short connections (avoid cables, if possible) and AC supply from twin wall sockets. Noise voltages may develop as follows:

Two types of noise voltage are distinguished by their sources: noise voltages developing from hum pickup and noise voltages caused by inductive leakage. Fig. 2-4 illustrates the development of a noise voltage. The noise voltage E_n is effective at the load input if the noise current I_n on the outer conductor of the cable with resistance R_c causes the voltage drop $E_n = I_n \times R_c$. The noise voltage source E_s is somewhere in the noise voltage loop formed by R_1, R_c and R_2.



$$E_n = I_n \times R_c = E_s \frac{R_c}{R_1 + R_c + R_2}$$

Fig. 2-4 Equivalent circuit diagram of a noise voltage source

The equation given in Fig. 2-4 shows that the noise voltage at the load decreases with decreasing noise voltage source E_s and resistance R_c and with increasing earth wire resistances R_1 and R_2. Since R_1 and R_2 must be kept small for reasons of safety, the impedance R_c must be minimized. The impedance R_c depends not only on the cable sheath and the contact resistances of the outer conductor, but also on the shielding of the input stage of the test item. The shielding and connection to the outer conductor of the connecting cable should be short and of low impedance.

The noise voltage source E_s may exist between the earthing points A and B if the neutral conductor of the AC supply is at the same time used as a non-fused earthed conductor. If signal generator and test item are earthed at different points of the AC supply, the voltage drop between A and B (Fig. 2-4) may also be caused by the power consumption of a third load. This will result in noise voltages of a frequency of 50 Hz and its harmonics. The noise source can be avoided by minimizing the distance between points A and B (twin socket). Noise voltages can be induced in the hum-pickup loop R_1, R_c, R_2 by inductive leakage of power transformers or poorly shielded RF voltage sources. These noise voltages can be prevented by making the pickup loop as short as possible by suitable wiring.

2.3.1.8 Adapting the RF Output to other Connector Systems

Output 39 of the SMDU can readily be adapted to suit other connector systems. Output 39 is provided with an adaptable Dezifix A base. Simply unscrew the end pieces of the outer and inner conductor of the N socket and replace them by the corresponding parts of the desired connector. The following screw-in assemblies are available for the adaptable Dezifix A base:

Desired connector on the equipment (50 Ω)	Order number
DEZIFIX A	400.1517.00
PRECIFIX A	400.1017.00
General Radio 900	017.9758.00
BNC plug	017.7910.00
BNC socket	017.5923.00
C plug	063.3013.00
C socket	017.5617.00
N plug	017.7690.00
N socket	017.5481.00
UHF plug	017.7449.00
UHF socket	017.5323.00
4.1/9.5 plug	017.9212.00
4.1/9.5 socket	017.8651.00
1.8/5.6 plug (DIN 47226)	435.0017.00
1/3 plug Schnapp	424.8486.00
1/3 socket Schnapp	424.8557.00
TNC plug	420.2525.00
TNC socket	420.2554.00
General Radio 874	420.2790.00
1.3/4 plug	420.2690.00
1.3/4 socket	420.2625.00

Attention is drawn to the fact that the conversion of the N connector into another system, with the exception of Dezifix A and Precifix A, affects the reflection coefficient of the output and possibly the RF leakage.

2.3.2 Modulation Generator

2.3.2.1 Setting the Frequency

Fixed frequencies: Release button 18 . Buttons 19 permit one of the six fixed frequencies of the modulation generator to be selected. The frequency values are given to the left of the pushbuttons.

Variable frequencies: Press button 18 . The desired frequency range is selected with buttons 19 ; the ranges are given to the right of column 19 . The frequency is adjusted by means of rotary knob 21 within the selected range and read on scale 20 . The digital frequency meter 3 permits the frequency of the modulation generator to be adjusted and read accurately to within 1 Hz if buttons 11 AF INT. and 10 RESOL. are depressed.

The built-in modulation generator is only operative if one of the buttons MOD. 12 or 14 is depressed.

2.3.2.2 Adjusting the Output Voltage

The modulation generator signal can also be used for external purposes. The output voltage can be adjusted with knob 34 and derived at socket 41 . Knob 34 is of push-pull type. When pulling it, an output voltage up to 5 V can be adjusted, when pushing it, a maximum voltage of 0.5 V is adjustable. The voltage can be read on meter 15 if button 23 MOD. GEN. is depressed. The indicating range of meter 15 can be selected with switch 22 . In position AUTO of the switch, the indicating range is selected automatically so that the pointer of meter 15 is always between 1/3 f.s.d. and f.s.d. In mid-position STOP the momentary range is preserved, and each time when setting the switch to the lower position MAN. (momentary position), switchover to the next range is effected. The selected indicating range (10, 30, 100, 300, 1000, 3000, 10,000) and the measuring unit (mV) are indicated on the illuminated display 16 above meter 15 .

Note that the modulation generator is only operative if one of the buttons MOD. 12 or 14 is depressed.

2.3.3 Modulation

2.3.3.1 Frequency Modulation

The frequency modulation is cut in with the upper button MOD. 14 . With the lower button 14 internal or external frequency modulation can be selected. With internal FM, the signal of the built-in modulation generator is used for frequency modulation, the modulation frequency being selected according to section 2.3.2.1. When selecting FM EXT., the SMDU can be frequency-modulated with external signals between 0 and 100 kHz applied to input FM 52 . For maximum deviation, a voltage of about 5 V_p into 600 Ω is required. The voltage must not exceed 10 V_p since otherwise the input may be damaged. Frequency modulation with external signals permit DC or AC coupling, selectable with switch 53 . With DC coupling the source impedance is approx. 2 kΩ, with AC coupling approx. 600 Ω at a bandwidth of 30 Hz to 100 kHz.

The frequency deviation range is selected with switch 17 and fine adjustment made by turning rotary knob 17 . After depressing button 23 FM, the frequency deviation can be read on meter 15 . With switch 22 in upper position AUTO, the indicating range of the meter is automatically selected so that the pointer of the meter is always in the most favourable range between 30 and 100% of f.s.d. In mid-position STOP the presently selected range is stopped and when setting the switch to the lower position MAN. (momentary position), switchover to the next range is effected. The indicating range (0.1, 0.3, 1, 3, 10, 30, 100) and the associated measuring unit (kHz) are indicated on the illuminated display 16 above meter 15 . The rms value is measured in the two lower ranges (0.1 and 0.3 kHz) and the peak value indicated in the remaining ranges. Thus the value indicated in ranges 0.1 and 0.3 kHz is smaller by a factor of 1.4.

To disable the frequency modulation, button MOD. 14 is released. AM and FM are possible simultaneously (see 2.3.3.3).
In the synchronized mode, a modulation index of 1500 should not be exceeded at a 150-kHz spacing of the locking points. Minimum modulation frequency: 100 Hz.

2.3.3.2 Phase Modulation

Button 13 permits a preemphasis to be cut in if FM has been selected before in accordance with section 2.3.3.1. According to FTZ recommendations, the preemphasis is 6 dB/octave in the modulation frequency range 300 Hz to 3 kHz, level adjustments being referred to 1 kHz. For the adjustments and indication of phase modulation, the notes given under 2.3.3.1 also apply.

After pressing button φM 23 , the phase deviation can be read on meter 15 . The indication ranges 0.1, 0.3, 1, 3, 10, 30, 100 rad are available. When measuring make sure that the deviation adjusted with 17 is not exceeded (check by selecting the frequency modulation mode).
Phase and amplitude modulation are possible simultaneously (see section 2.3.3.3).

2.3.3.3 Amplitude Modulation

Amplitude modulation is cut in with the upper button 12 MOD. With the lower button 12 internal or external amplitude modulation can be selected. With internal AM, the signal of the built-in modulation generator is used for amplitude modulation, the desired modulation frequency being selected according to section 2.3.2.1. When selecting AM EXT., the SMDU can be amplitude-modulated with external signals applied to input 51 AM. For a modulation depth of 100%, a voltage of about 1.5 V into 600 Ω is required. The voltage must not exceed 10 V since otherwise the input may be damaged.

The modulation depth is adjusted with rotary knob 35 . After depressing button 23 AM, the modulation depth can be read on meter 15 . With switch 22 in upper position AUTO, the indicating range of the meter is automatically selected so that the pointer of the meter is always between 1/3 f.s.d. and f.s.d. In mid-position STOP the presently selected range is preserved and each time when setting the switch to the lower position MAN. (momentary position), switchover to the next range is effected. The indicating range (1, 3, 10, 30, 100) and the associated measuring unit (%) are indicated on the illuminated display 16 above meter 15 .

When releasing button 12 MOD., the amplitude modulation is cut off. Simultaneous amplitude and frequency modulation are of course also possible (see sections 2.3.3.1, 2.3.3.2).

2.3.4 Frequency Measurements

The digital frequency meter of the SMDU can also be used for external signals, for which three inputs are provided on the front panel:

Socket 45 for signals between 15 Hz and 30 MHz,
Socket 46 for signals between 20 MHz and 525 MHz,
Socket 47 for signals between 0.5 GHz and 1 GHz.

Signals between 0.5 and 1 GHz can only be measured if the 1-GHz Frequency Meter SMDU-B4 is incorporated in the SMDU. After depressing one of buttons 11 EXT., the frequency applied to the input is indicated on the digital display 3 . The resolution is 10 Hz when measuring at socket 45 (15 Hz to 30 MHz) and 100 Hz in the other frequency ranges. When depressing button 10 RESOL. x 10, the resolution is increased to 1 Hz or 10 Hz due to the extended measuring time. By connecting the contacts 49 and 50 on the rear multipoint connector 61 , the measuring time of the frequency meter can additionally be increased by the factor 10 so that a resolution of 0.1 Hz or 1 Hz is achieved (the decimal point is not shifted).

Signals with voltages between 10 mV and 3 V (30 mV to 1 V in the range 0.5 to 1 GHz) are accurately indicated.

In position AF INT. of button 11 , the counter indicates the frequency of the signal which is processed in the modulation unit.

The following table shows in which mode, frequency range and range of analog indication the counter functions properly:

Mode	Range of analog indication 1)	Frequency range of frequency meter
AF voltmeter	$\geq$ 10 mV	30 Hz to 30 kHz
Mod. generator	$\geq$ 10 mV	30 Hz to 30 kHz
AM	$\geq$ 1%	30 Hz to 30 kHz
FM and φM	$\geq$ 1 kHz dev.	30 Hz to 30 kHz
Deviation meter	$\geq$ 1 kHz dev.	300 Hz to 15 kHz
Distortion meter	--	no frequency indication

1) Proper functioning of the counter below 1/3 fsd of meter 15 cannot be guaranteed.

When not in use, switch off the internal modulation generator in order to avoid crosstalk on the counter.

At the rear socket 61 the counter content is available in BCD code with TTL level. In addition, the internal operating voltages can be measured at this socket. Table 2-1 (Appendix) shows the contact wiring.

2.3.5 AF Voltmeter

The SMDU radiotelephone model can be used as an AF voltmeter for external signals applied to socket 44 . With button 23 AF VOLTM. depressed, the AF voltage in the frequency range 15 Hz to 150 kHz is indicated on meter 15 . The indicating range of meter 15 is selected with switch 22 . With switch 22 in the upper position AUTO, the indicating range is automatically selected so that the pointer of the meter is always in the most favourable range between 30 and 100% of f.s.d. In mid-position STOP the presently selected range can be held and each time when setting the switch to the lower position MAN. (momentary position), switchover to the next range is effected. The indicating range (10, 30, 100, 300, 1000, 3000, 10,000) and the associated measuring unit (mV) are indicated on the illuminated display 16 above meter 15 .

The voltage at socket 44 must not exceed 30 V since otherwise the input will be damaged.

2.3.6 Deviation Measurements

Two inputs are provided on the front panel for application of the test signal in the case of deviation measurements:

Socket 46 for signals up to 525 MHz
Socket 47 for signals between 0.5 GHz and 1 GHz.

These sockets are also the inputs of the frequency meter. Deviation measurements on signals between 0.5 and 1 GHz are possible only if the 1-GHz Frequency Meter SMDU-B4 is built in. If also the 1.05-GHz Frequency Range Extension SMDU-B3 or the 1.05-GHz Frequency Doubler SMDU-B5 is built in, deviation measurement in this range does not differ from that in the range up to 525 MHz. If only the 1-GHz Frequency Meter SMDU-B4 is incorporated, deviation measurements in the range 0.5 to 1.05 GHz are also possible. For this application the SMDU has to be set to half the frequency value at which the measurement is to be taken. Moreover, in the simplex mode (section 2.3.6.1) and duplex mode (section 2.3.6.2), operation is slightly different.

The indication of the frequency deviation is switched in with button FM 23 , positive or negative deviation being selected with button 25 . For measuring the phase deviation, press button φM 23 ; in this way, a deemphasis of 6 dB/octave is connected.

Switchover from spurious FM (rms weighting) to wanted FM (peak weighting) measurement is automatic. The spurious FM is measured in the two lower ranges (100 Hz and 300 Hz), the wanted FM is indicated in the remaining ranges (1 kHz to 100 kHz). The indication range of meter 15 is selected with switch 22 . In position AUTO of switch 22 , the range is automatically selected. The range (0.1, 0.3, 1, 3, 10, 30, 100) and the associated unit (kHz or rad) are displayed on 16 above meter 15 . The switchover from rms to peak-responding indication is automatic when changing over from the 300-Hz to the 1-kHz range.

Since the wanted FM is measured as peak value, it is necessary that for the determination of the S/N ratio either the indicated peak value is converted into an rms value ($\frac{\text{indicated value}}{\sqrt{2}}$) or the S/N ratio calculated with peak value is reduced by 3 dB.

Deviation measurements are possible in the simplex, duplex AFC and relay modes (see sections 2.3.6.1 and 2.3.6.2).

2.3.6.1 Simplex Mode

Press the corresponding button FREQ. METER EXT. 11 and read the frequency of the test item on 3 . Press button RF INT. 11 and adjust the SMDU for the same frequency. Press button 28 : the oscillator of the SMDU is now automatically varied by 200 kHz (corresponding to the IF of the deviation meter) and "add 200 kHz" lights up on digital readout 3 . Next switch in the deviation meter using button 24 and FREQ. METER EXT. by means of button 11 . LED 26 lights up indicating that the deviation meter is ready for operation. In the case of unmodulated test items, meter 15 indicates the spurious FM, in the case of modulated devices the wanted FM.

If the 1-GHz Frequency Meter SMDU-B4 is incorporated together with the 1.05-GHz Frequency Range Extension SMDU-B3 or the 1.05-GHz Frequency Doubler SMDU-B5, the deviation in simplex mode for range 0.5 to 1.05 GHz can be determined as described above. If, however, only the 1-GHz Frequency Meter is built in, the automatically adjusted frequency offset of 200 kHz must be reduced to 100 kHz.

2.3.6.2 Duplex AFC Mode

With button 28 released, the deviation meter uses automatic frequency control, the maximum pull-in range being 6.5 MHz. Set the SMDU frequency on the analog scale to a value 4.2 to 10.7 MHz lower than the test item frequency:

$$f_{SMDU} = f_{test\ item} \ (\pm) \ \underset{\text{pull-in range}}{(4.2 \text{ to } 10.7 \text{ MHz})}$$

In the case of a positive frequency offset ($f_{SMDU} > f_{test\ item}$), note that positive and negative deviation indication are interchanged. If the frequency of the test item is 4.2 to 10.7 MHz, switch off the oscillator by turning the tuning control beyond the selected range.

Press button 24 . LED 26 lights up indicating that the deviation meter is ready for operation. The LED is on if the carrier frequency is within the pull-in range or if the deviation meter has tuned to a harmonic of the test signal. In the latter case, meter 15 may indicate an increased spurious FM or wanted deviation. Tuning of the deviation meter to a harmonic can be avoided by checking the frequency against counter 3 .

An increased spurious FM may occur at the pull-in range limits. This can be avoided by tuning the SMDU oscillator accordingly.

If the test item is not modulated, meter 15 indicates the spurious FM; if the device under test is modulated, the wanted frequency deviation is indicated.

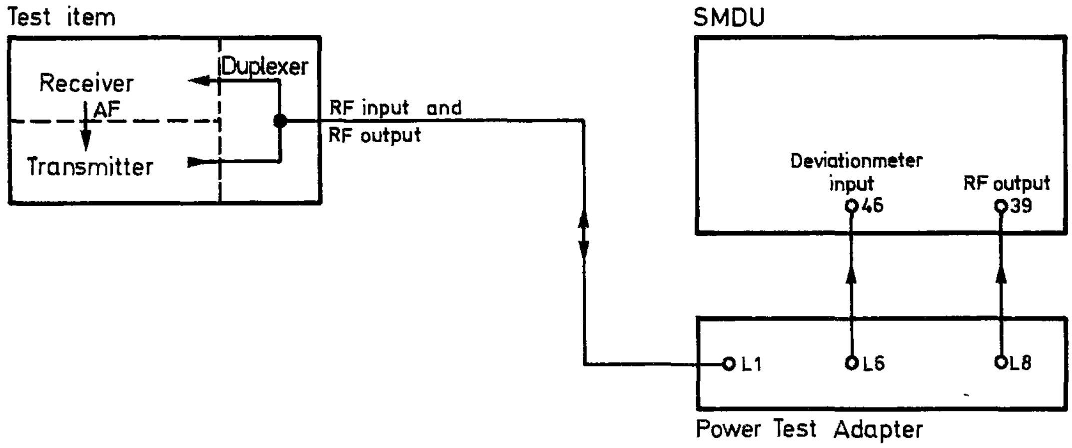
The same principle applies for measurements in the 0.5 to 1.05 GHz range, if the 1-GHz Frequency Meter SMDU-B4 and the 1.05-GHz Frequency Range Extension SMDU-B3 or the 1.05-GHz Frequency Doubler SMDU-B5 are incorporated. If only the SMDU-B4 is incorporated, set the SMDU frequency not to a value 4.2 to 10.7 MHz lower than the test item frequency, but reduce it instead by 2.1 to 5.3 MHz with respect to the test item frequency.

The duplex mode is particularly suitable for checking multichannel RT equipment since it is not necessary to tune the individual channels within the pull-in range.

2.3.6.3 Relay Mode

In conjunction with the Power Test Adapter SMDU-Z2 or the AM Unit SMDU-Z1, the SMDU permits measurements in the so-called "relay mode". Press button L 3 (Fig. 1-6) of the Power Test Adapter or the AM Unit for transmitter receiver measurements. The transmitter and receiver of the RT operate in separate frequency bands, the transmitter being modulated with the demodulated AF signal of the receiver.

Test setup



Measurement procedure:

a) Tune the RF oscillator of the SMDU to the receiver frequency and adjust for standard modulation, e.g. 2.4 kHz deviation, 1 kHz modulation frequency (see section 2.3.3.1).

b) Adjust the RT equipment in the simplex mode to the transmitter frequency.

c) Select the duplex mode for the deviation meter (section 2.3.6.2) and set switch 27 to "relay mode". Set switch 27 to "f_{up}" if in relay operation the transmitter frequency of the RT exceeds the receiver frequency, or to "f_{low}" if the transmitter frequency falls below the receiver frequency. Relay mode ON is indicated by the LED.

d) Switch in the RT transmitter (unmodulated) and adjust the deviation indication on 15 for minimum (< 20 Hz if the CCITT filter is used) by alternately turning potentiometers 29 and 32 .

e) Select the relay mode on the RT equipment; the test setup is ready for operation.

The following parameters can be measured:
Receiver SINAD ratio, receiver distortion, squelch response and hysteresis, transmitter frequency, transmitter deviation at the corresponding deviation of the receiver input signal, transmitter distortion.

When changing the carrier or modulation frequency, the test setup has to be adjusted again.

2.3.6.4 Indicating the Frequency of the Demodulated Signal

After pressing button AF INT. 11 , the frequency of the signal processed in the modulation unit is indicated on digital readout 3 .

Select the signal to be indicated on meter 15 and digital readout 3 with buttons FM, φM, AM, MOD. GEN. and AF VOLTM.

In the case of distortion measurements, the harmonics spectrum from the distortion meter is applied to the counter.

Proper functioning of the counter in the most sensitive indication range and below 1/3 fsd of meter 15 cannot be guaranteed.

2.3.6.5 AF Output of Deviation Meter

The demodulated and amplified AF signal derived from the deviation meter is available at socket 42 . The voltage is proportional to the pointer deflection of meter 15 , at fsd it is 1 V_{rms} or 1 V_p.

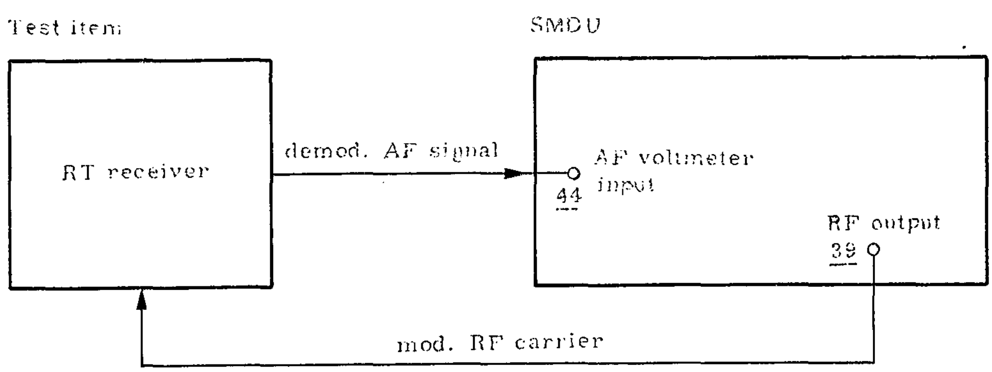
The AF indication voltage is also available in the modes AM, MOD. GEN. and AF VOLTM. In this way, the meter amplifier, which can be adjusted automatically or manually with 22 in steps of 10 dB, can be used as a variable attenuator or as an amplifier.

When measuring the deviation (24 pressed) and the AF level (AF VOLTM. 23 pressed), the output voltage can be weighted by connecting the CCITT filter (with 30) and the 1-kHz bandstop filter of the distortion meter (with 31).

2.3.7 Distortion Measurement

The distortion can be measured at the modulation frequency of 1 kHz. If the AF generator frequency is not adjusted to 1 kHz ±1%, measuring errors occur.

Test setup



Measuring the AF distortion

Apply the modulated carrier (f_{mod} = 1 kHz) to the RT receiver. Apply the demodulated AF receiver output signal to input 44 of the SMDU. Press buttons AF VOLTM. 23 and 31 . Meter 15 indicates the distortion in %. If the AF input level is not within the regulation range of the level control (< 50 mV), LED "uncal." on 15 lights up and the distortion meter is disabled. Level variations in the case of levels > 50 mV are regulated.

Measuring the modulation distortion

Modulate the RF with f_{mod} = 1 kHz. Connect the deviation meter with 24 , select the mode with 28 or 29 and press button 31 . Meter 15 indicates the modulation distortion; LED "uncal." lights up if the deviation is less than about 700 Hz. Variations of deviations > 700 Hz are regulated.

2.3.8 SINAD Ratio Measurement

The receiver S/N ratio referred to 1 kHz (SINAD ratio) can be measured after pressing button 33 . For this measurement, the modulation frequency should be set accurately to 1 kHz, otherwise measuring errors will occur.

Connect the RT receiver in accordance with section 2.3.7. Press buttons AF VOLTM. 23 and 33 . Meter 15 indicates the S/N ratio in %. The measurement ranges can be selected automatically or manually by means of 22 . LEDs indicate the selected range:

- The 6-dB LED lights up if the 100% range is selected.
- The 12-dB LED lights up if the 30% range is selected.
- The 20-dB LED lights up if the 10% range is selected.

The accurate SINAD ratio is obtained when the pointer is at the red marking corresponding to the lit LED, i.e.:

- The pointer deflection of 50% (in the 100% range) corresponds to the SINAD ratio of 6 dB.
- The pointer deflection of 25% (in the 30% range) corresponds to the SINAD ratio of 12 dB.
- The pointer deflection of 10% (in the 10% range) corresponds to the SINAD ratio of 20 dB.

LED "uncal." lights up if the input-voltage value is below the regulation range of the level control.

Note: When using an external AF generator for distortion or SINAD ratio measurements, disconnect the internal modulation generator.

2.3.9 CCITT Filter

The CCITT filter is connected by means of button 30 . It is effective in the modes "deviation meter" (24 pressed) and "AF voltmeter" (AF VOLTM. 23 pressed). For deviation measurements button FM 23 or φM 23 should also be depressed. Distortion and SINAD ratio measurements can also be weighted in accordance with CCITT.

With the CCITT filter switched in, the meter indication 15 and the signal present at AF output 42 are weighted.

2.3.10 Beat Frequency Meter

Connect the test item to frequency input 46 or 47 . Connect headphones to the beat frequency output 58 on the rear panel and adjust the SMDU frequency to nominal. The beat frequency can be heard. Next the adjustment to zero beat is made.

2.3.11 DEMOD. OUTPUT (on SMDU 249.3011.07 only)

A VOR-ILS Unit 214.3115 can be connected to DEMOD. OUTPUT 57 and powered via socket 54 . Output 57 is wired as follows:

Contact	Occupation
1	Output for demodulated AF signal
2 and 3	Chassis
4	RF OFF
5	+15 V

When shorting contacts 4 and 5, the RF carrier is suppressed. The same effect is obtained when button 40 is pressed.

3. Maintenance

The values mentioned in this section are not guaranteed; only the specifications given in the data sheet are binding.

3.1 Required Measuring Instruments

Pos. No.	○ Equipment, required specifications ● Recommended R&S instrument	Type	Order No.	Use
1	○ RF millivoltmeter ● RF-DC Millivoltmeter with 50-Ω Insertion Unit 50 µV - 1050 V (DC), 0.5 mV - 10.5 V (RF)	 URV -	 216.3612.02 243.9418.54	3.2.1.2 3.2.9 3.2.4.3
2	○ Power meter, 50 Ω ● Microwave Power Meter with 50-Ω Probe 0.1 - 330 mW, 0 - 15 GHz	 NRS -	 100.2433.92 100.2440.50	3.2.1.2
3	○ Psophometer with CCITT or CCIR weighting ● Psophometer with CCITT weighting ● Psophometer with CCIR weighting	 UPGS UPGR	 248.0019.02 248.1915.02	3.2.1.7 3.2.7.4
4	○ Field-strength meter 0.14 - 50/350 - 500 MHz ● Field Strength Meter 0.1 - 30 MHz ● VHF-UHF Test Receiver with Plug-ins 160 - 470 MHz 460 - 900 MHz	 HFH ESU - -	 100.1014.02 100.1143.02 100.1195.02 100.1208.02	3.2.1
5	○ Modulation meter e.g. AFM 2 of Radiometer			3.2.7 3.2.11
6	○ Frequency analyzer 0.14 - 1000 MHz ● Analyskop and UHF Tuner 6 kHz - 1400 MHz	 EZF EZFU	 100.8831.52 210.0011.03	3.2.1.4

Pos. No.	○ Equipment, required specifications ● Recommended R&S instrument	Type	Order No.	Use
7	○ Distortion meter ● Direct-Reading Distortion Meter 0.2 - 30% at 40 Hz/1/5/15 kHz ● Wave Analyzer 5 Hz - 60 kHz	FTZ FAT 1	100.6100.02 100.8683...	3.2.7.3 3.2.7.7 3.2.13 3.2.5.2
8	○ Stereocoder			3.2.7.10
9	○ Stereodecoder			3.2.7.10
10	○ Frequency counter for 10 MHz 9-digit display			3.2.4.1 3.2.1.1 3.2.4.2
11	○ Decade signal generator ● Decade RF Signal Generator 0 - 50 MHz	SMDW	103.9968...	3.2.8.4
12	○ Mixer, frequency range of SMDU			3.2.8.4
13	○ XY Recorder ● XY Recorder	ZSK 2	247.4010...	3.2.8.4
14	○ RF power signal generator ● Power Signal Generator 25 - 1000 MHz, 2 W into 50 Ω	SMLU	200.1009...	3.2.9 3.2.4.3
15	○ AF voltmeter ● Millivoltmeter	UVN		3.2.5.3 3.2.5.4 3.2.6
16	○ Precision AF generator ● Precision LF Generator	SSN		3.2.10
17	○ Digital voltmeter			3.2.10

3.2 Checking the Specifications

3.2.1 RF Output

3.2.1.1 Frequency Measurement

Measurement: The frequency should be checked at both ends and at the centre of each frequency range with the incorporated frequency meter. When pressing button 11 RF INT., the result appears on the digital readout 3 . Check the frequency meter beforehand according to section 3.2.4.2. When using an external frequency counter, connect it to RF output 39 .

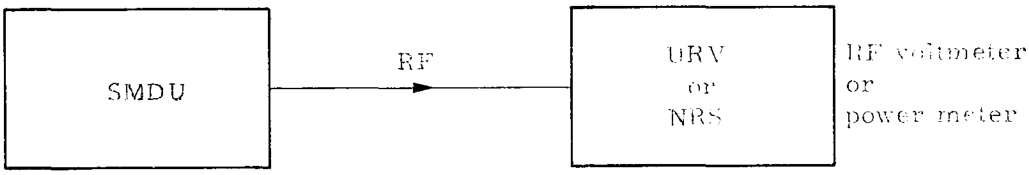
Permissible deviation of the analog from the digital frequency indication of the SMDU:

0.14 - 50 MHz .... approx. ±(5% + 300 kHz)
50 - 1050MHz .... approx. ±1%

Adjust the oscillator concerned according to section 5.3.5.

3.2.1.2 Checking the Output Voltage or Output Power

Test setup

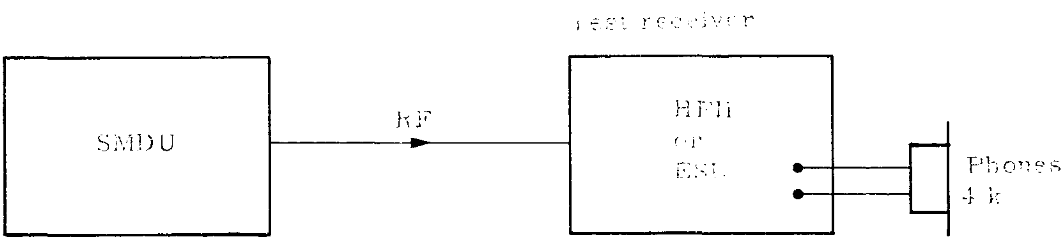


Measurement: Set the SMDU output attenuator to 0 dBm. Measure the output voltage or output power in the frequency range 0.14 to 525 MHz (1050 MHz); permissible error < ±1 dB (±2 dB). In the lowest frequency range the ALC is switched over at about 400 kHz or 440 kHz and at about 8 MHz (see section 4.3.8); the output voltage varies thereby within the error limits. The attenuation calibration can be checked according to section 5.3.6.10.

Adjust with R12 in the control amplifier Y38; see section 5.3.6.1.

3.2.1.3 Measurement of Non-harmonic Spurious Signals

Test setup



Measurement: Measure the spurious-signal suppression in the following ranges:

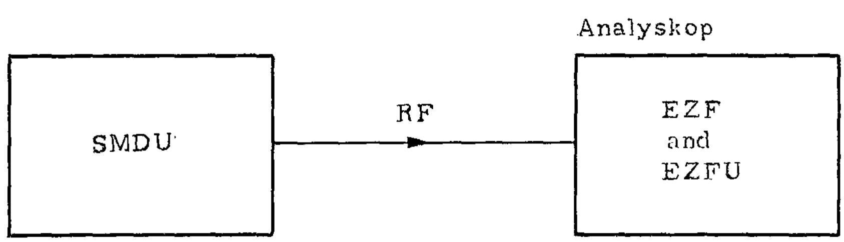
Frequency range	Spurious-signal suppression
0.14 to 50 MHz	> 90 dB
392 to 525 MHz	> 90 dB
520 to 1050 MHz (with SMDU-B3)	> 70 dB
520 to 1050 MHz (with SMDU-B5)	> 20 dB

Adjustment: In the range 0.14 to 50 MHz, no adjustment is possible.

Use R3 in doubler Y26 to adjust in the range 392 to 525 MHz and R13 in doubler Y301 for range 520 to 1050 MHz.

3.2.1.4 Measurement of Harmonics

Test setup



Measurement: Set the SMDU output attenuator to 1 V EMF and measure the harmonics ratio with the Analyskop EZF (plus UHF Tuner EZFU).

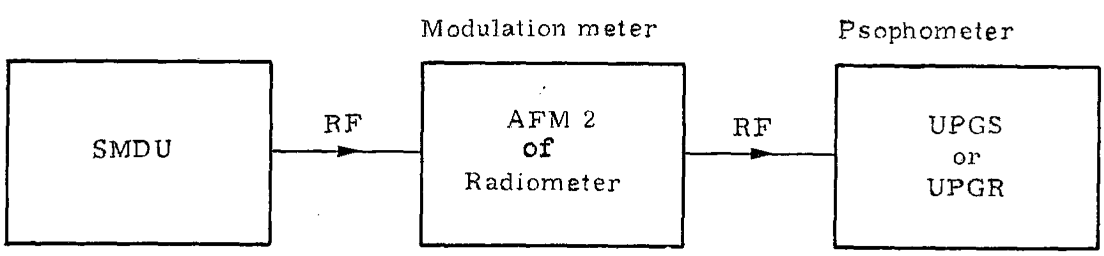
Nominal value:

in range 0.14 to 50 MHz .... > 26 dB
in range 49 to 525 MHz .... > 35 dB
in range 520 to 1050 MHz (with SMDU-B3) .... > 26 dB (typ. > 30 dB)
in range 520 to 1050 MHz (with SMDU-B5) .... > 20 dB

Adjustment: No adjustment is possible. For fault location see section 5.2.3.

3.2.1.5 Measurement of Residual FM

Test setup



Measurement: Residual FM should be measured at least at one frequency (centre frequency) of each range. Set the SMDU output voltage to 100 mV and release AM MOD. button 12 . Tune the modulation meter. Set 1 kHz freq. dev. with 1 kHz modulation frequency on the SMDU. Measure the voltage at the AF output of the modulation meter with Psophometer UPGS (weighting in line with CCITT) or UPGR (weighting in line with CCIR). The psophometer indication corresponds to 1 kHz deviation. Switch the frequency modulation of the SMDU off and measure the level drop at the psophometer. It is a measure of residual FM; for example, a level drop of 30 dB corresponds to a residual FM of 30 Hz.

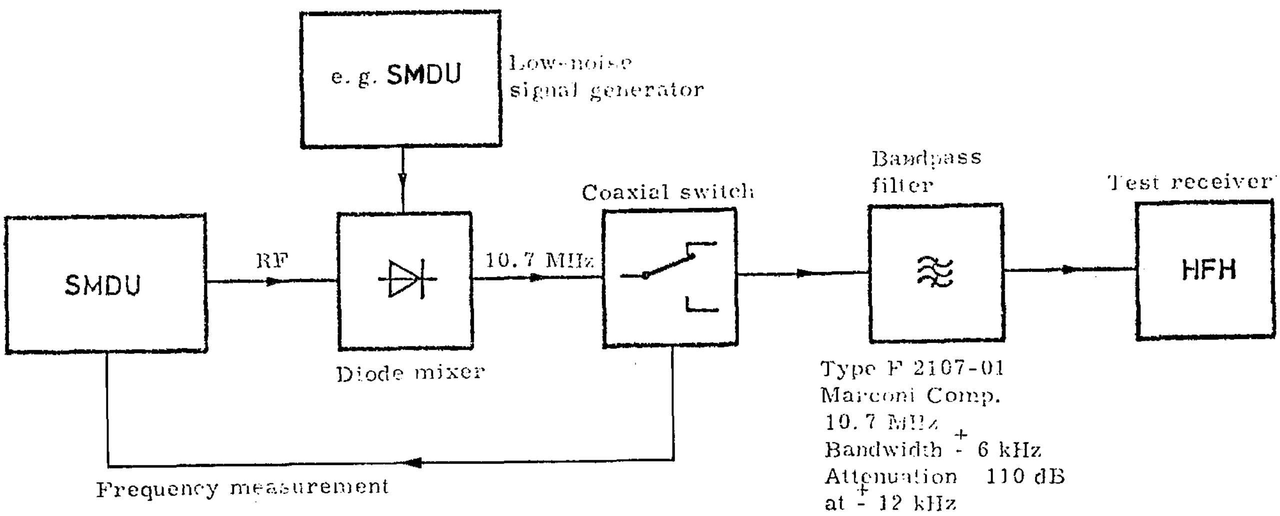
Permissible residual FM:

Bandwidth:	0.3 - 3 kHz (CCITT)	20 Hz - 15 kHz (CCIR)
0.14 - 400 MHz	< 7 Hz	< 20 Hz (typ. 10 Hz)
400 - 800MHz	< 10 Hz	< 40 Hz (typ. 20 Hz)
800 - 1050 MHz	< 15 Hz	< 60 Hz (typ. 30 Hz)

Adjustment: No adjustment possible.

3.2.1.6 Measurement of Noise Voltage

Test setup



Measurement: Adjust the required frequency and an output voltage of about 300 mV on the SMDU with unmodulated operation. Set the FM range switch to 10 kHz or 100 kHz. Adjust the output voltage of the low-noise signal generator to about 1.5 V and its frequency to 10.7 MHz from the SMDU frequency. The 10.7-MHz frequency can be measured via the 15 Hz to 30 MHz input of the SMDU by changing the position of the coaxial switch.

The 10.7-MHz signal is conveyed via the bandpass filter to the test receiver. Tune the test receiver to 10.7 MHz with ±4 kHz bandwidth and determine the signal level. Change the SMDU frequency by 20 kHz (resulting mixer product 10.72 MHz or 10.68 MHz) and determine the level drop at the test receiver.

Calculation of S/N ratio referred to 1 Hz measuring bandwidth:

Measured difference between signal level and noise level	100 dB
Conversion factor with bandwidth ±4 kHz (corresponding to 10 log 8000)	39 dB
S/N ratio referred to 1 Hz bandwidth	139 dB

The same method can be used to determine the S/N ratio at 100 kHz or 500 kHz from the carrier.

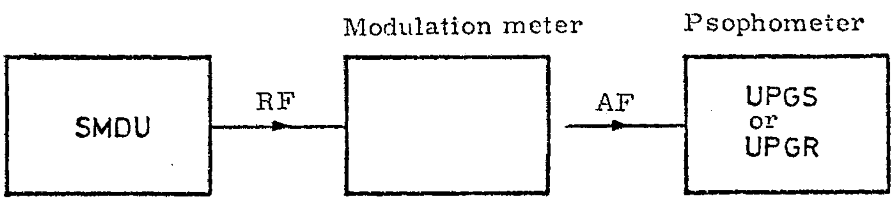
Permissible S/N ratio:

Distance from carrier:	20 kHz	500 kHz
0.14 - 50 MHz	> 125 dB	> 130 dB
50 - 400 MHz	> 135 dB	> 145 dB
400 - 525 MHz	> 130 dB	> 140 dB
525 - 1050 MHz	> 125 dB	> 135 dB

Adjustment: No adjustment possible.

3.2.1.7 Measurement of Residual AM

Test setup



Residual AM down > 75 dB with
CCIR weighting (20 Hz - 15 kHz)

Measurement: Two different methods can be used for measuring the residual AM.

a) Set the SMDU output voltage to at least 100 mV and release FM MOD. button 14 . Make the measurement at several frequencies, tuning the modulation meter each time to the test frequency. Adjust 50% AM with 1 kHz modulation frequency on the SMDU. Measure the AF voltage with the Psophometer UPGS (CCITT weighting) or UPGR (CCIR weighting). Switch the amplitude modulation off and determine the level drop of the AF voltage relative to AM operation. 6 dB must be added to this level difference to refer the residual AM to 100% modulation.

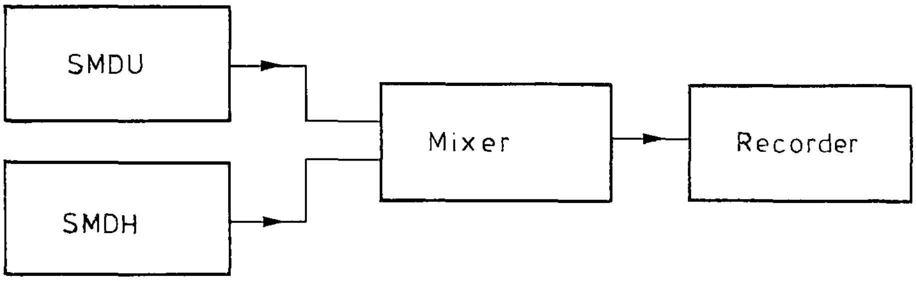
b) Connect the psophometer to the demodulation output 57. Set the output voltage, the modulation depth and the modulation frequency as under a) and carry out the measurements as explained above.

Permissible residual AM:
CCITT weighting (0.3 - 3 kHz) .... down > 80 dB
CCIR weighting (20 Hz - 15 kHz) .... down > 72 dB

Adjustment: No adjustment possible.

3.2.1.8 Checking the Frequency Stability

Test setup



Decade signal generator

Test conditions: The measurement should be made in a room held at constant temperature. Before the measurement the SMDU should be stored in this room long enough to attain the ambient temperature.

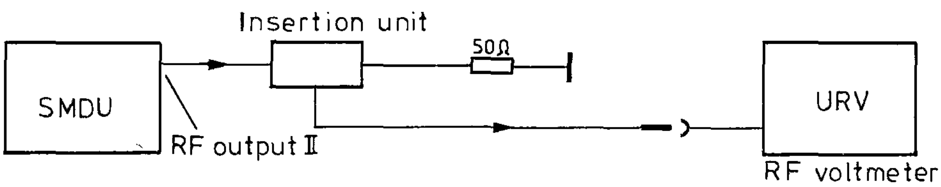
Measurement: In the Mixer, the SMDU output signal is mixed with the stable frequency derived from the decade signal generator. The recorder plots the difference.

Permissible frequency drift (see data sheet)

Adjustment: No adjustment possible.

3.2.2 Voltage Measurement at RF Output II

Test setup



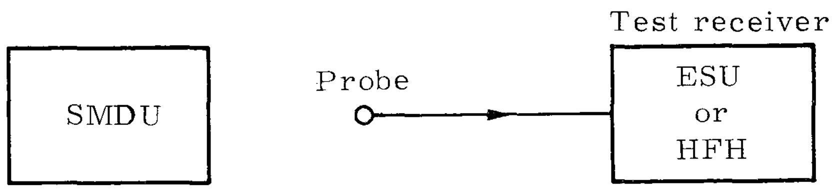
Measurement: The SMDU operates without modulation. The rms output voltage should be > 20 mV for frequencies below 8 MHz and > 50 mV for frequencies above 8 MHz.

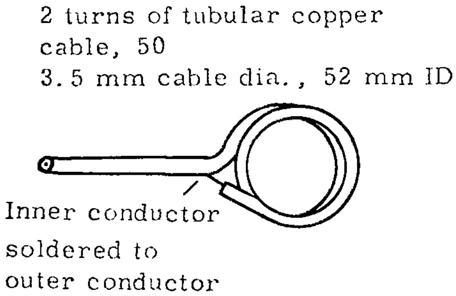
Adjustment: See sections 5.3.6.5 and 5.3.6.6.

Note: In the range 520 to 1050 MHz, half the output frequency is available at RF output II.

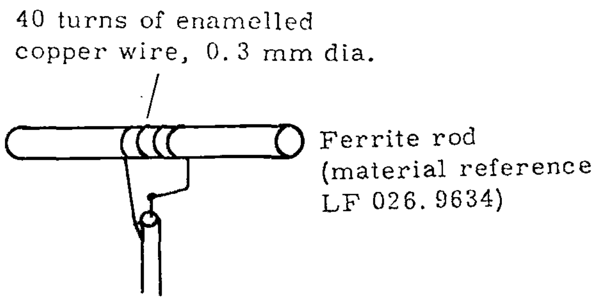
3.2.3 Measurement of RF Leakage

Test setup





Probe for 150 MHz and 470 MHz



Probe for 0.2 MHz

Measurement: Set the SMDU frequency successively to 0.2 MHz, 150 MHz, 470 MHz and 1000 MHz (with SMDU-B3 or B5). Set the RF attenuator of the SMDU fully clockwise, hold the probe near the RF output, tune the test receiver to the test frequency and calibrate. Set the RF attenuator of the SMDU fully counter-clockwise and search the environment of the SMDU with the probe at a distance of 5 cm to find the maximum indication of the test receiver.

Permissible voltages:

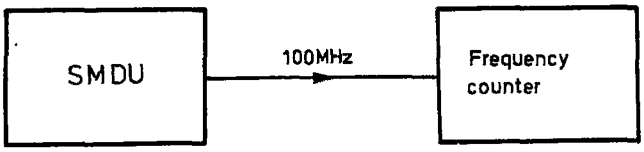
0.2 MHz .... < 2 µV
150 MHz .... < 2 µV
470 MHz .... < 2 µV
1000 MHz .... < 2 µV

Adjustment: No adjustment possible.

3.2.4 Frequency Meter

3.2.4.1 Checking the Timebase

Test setup



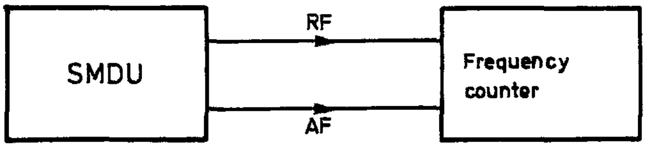
Measurement: Connect a frequency counter to the RF output of the SMDU. Set the frequency to 100.000 000 MHz (synchronized) and measure.

A deviation of 5 Hz is permissible.

Adjustment: See section 5.3.3.1; for fault location see section 5.2.5.

3.2.4.2 Checking the Accuracy of the Frequency Meter

Test setup



Measurement: Adjust the RF and AF output voltages of the SMDU to values higher than 100 mV. Switch the frequency modulation off and internal amplitude modulation on. Depress the button RESOL. x 10 to increase the resolution of the SMDU frequency meter by a factor of 10. Allow about 15 minutes for warming up before making the measurement. Depress the button RF INT. and measure in the frequency range 0.14 to 50 MHz and in any of the other ranges. Check the highest frequency of the modulation generator with the button AF INT. depressed.

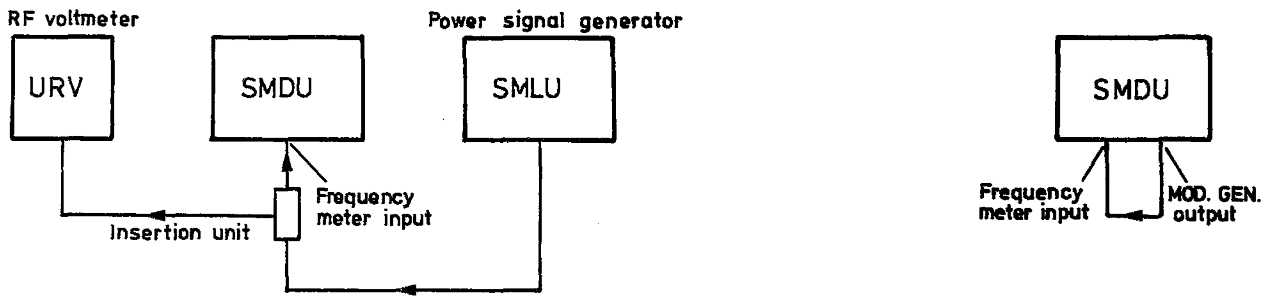
Permissible deviation of the SMDU frequency indication from the frequency counter readout:

AF INT. .... ±1 Hz
RF INT. 0.14 - 50 MHz .... ±1 Hz
50 - 800 MHz .... ±10 Hz
800 - 1050 MHz .... ±100 Hz

Adjustment: The built-in digital frequency display can be corrected by adjusting the time base (see section 5.2.5). If the frequency indication deviates only in the range 0.14 to 50 MHz (e.g. unsteady indication) it is necessary to check the mixer oscillator (see section 5.3.3).

3.2.4.3 Sensitivity Check in the Range 10 Hz - 30 MHz

Test setups



Measurement: First check the accuracy of the frequency meter according to section 3.2.4.2.

One of the MOD. buttons must be pressed so that the modulation generator is on. Checks above 150 kHz are made with the test setup shown above to the left, those below 150 kHz with the setup to the right. Increase the RF or AF voltage at the frequency meter input until the frequency indication becomes steady. When the test voltage is further increased up to 3 V, the frequency indication must not change.

Nominal sensitivity .... ≤ 10 mV

Adjustment: No adjustment possible.

3.2.4.4 Sensitivity Check in the Range 20 - 525 MHz

Test setup as in section 3.2.4.3, left-hand diagram.

Measurement: First check the frequency meter accuracy according to section 3.2.4.2.

Adjust the voltage at the frequency meter input to about 1 mV and increase until the automatic cutoff responds and the frequency is indicated. The indication must be steady. Measure at several frequencies, in particular at 20 MHz and 525 MHz. When the input voltage is increased to 3 V, the frequency indication must not change.

Nominal sensitivity .... $\leqq$ 10 mV

Adjustment: No adjustment is possible for the input voltage requirement. The threshold of the automatic cutoff can be adjusted with R52 in the divider Y72; see section 5.3.4.2.

3.2.4.5 Sensitivity Check in the Range 525 - 1050 MHz

Test setup as in section 3.2.4.3, left-hand diagram.

Measurement: First check the frequency meter accuracy according to section 3.2.4.2.

Adjust the voltage at the frequency meter input to about 10 mV and increase until the automatic cutoff responds and the frequency is indicated. The indication must be steady. Measure at several frequencies, in particular at 525 MHz and 1000 MHz (with the 1.05-GHz Frequency Range Extension SMDU-B3 or the 1.05-GHz Frequency Doubler SMDU-B5). When the input voltage is increased to 1 V, the frequency indication must not change.

Nominal sensitivity .... $\leqq$ 30 mV

Adjustment: The sensitivity can be adjusted using R14 in the 1-GHz Frequency Meter SMDU-B4. See section 5.3.10.2.

3.2.5 Modulation Generator

3.2.5.1 Frequency Measurement

Release button 18 (FIXED) and select successively the different fixed frequencies with 19 . Select with button 11 AF INT. the digital frequency readout and adjust with 34 for an output voltage > 10 mV. The frequency read on the digital readout should differ not more than ±1.5% from the adjusted fixed frequency.

Press button 18 (VAR.) and select the frequency ranges with 19 . Set the following frequencies for the different ranges on scale 20 :

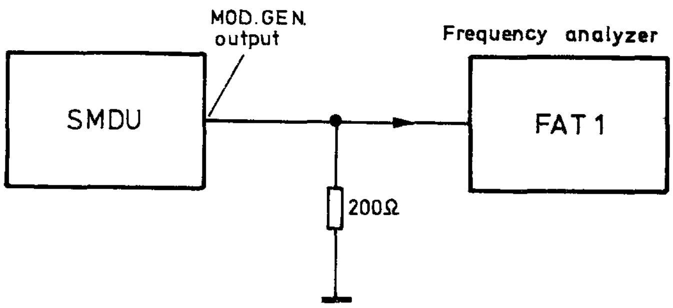
Range	kHz	10-30	3-10	1-3	0.3-1	0.1-0.3	0.03-0.1
Frequency	kHz	20	6	2	0.6	0.2	0.06

The frequency displayed on the digital readout may differ by ±10% from the indication on scale 20 .

Adjustment: See section 5.3.7.1.

3.2.5.2 Distortion Measurement

Test setup



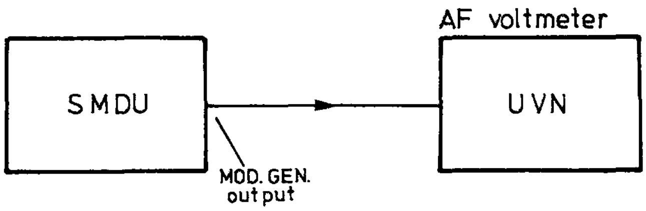
Measurement: Make the measurement with an output voltage of 5 V_{rms} into 200 Ω.

Set several frequencies in accordance with section 3.2.5.1. At all fixed frequencies and at the variable frequencies in the range 0.03 to 10 kHz, the distortion should be < 0.5%.

Adjustment is not possible.

3.2.5.3 Output Voltage Measurement

Test setup



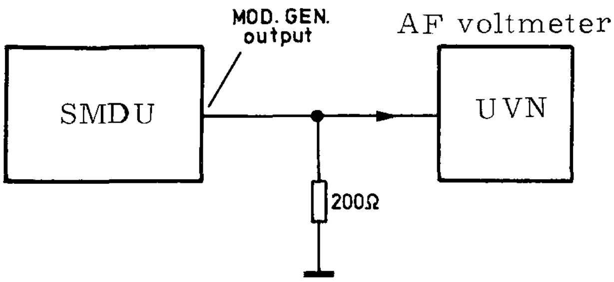
Measurement: Depress the MOD. GENERATOR button 18 and adjust the output voltage to 1000 mV with a modulation generator frequency of 1 kHz. The indications of the panel meter and of the UVN must be equal;
permissible deviation .... < ±(2% of rdg +1.5% of f.s.d.)

When the LEVEL knob 34 is pulled, it must be possible to adjust the output voltage up to 5 V_{rms}. When the knob is pressed, the output voltage must be adjustable up to 500 mV_{rms}.

Adjust with R45 in the modulation generator Y84; see section 5.3.7.1.

3.2.5.4 Measuring the Frequency Response of the Output Voltage

Test setup



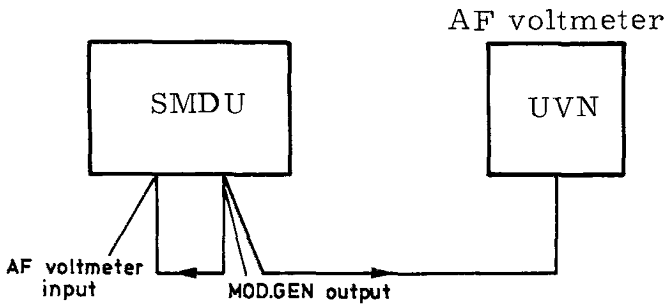
Measurement: Make the measurement with an output voltage of 1000 mV into a load of 200 Ω.
Successively select the different fixed frequencies.
Permissible variation of output voltage .... < 1%

In the VAR. mode, tune the frequency through the different ranges. Permissible variation of output voltage in range 10 to 30 kHz .... < 10%
in the remaining ranges .... < 5%

Adjustment is not possible.

3.2.6 Checking the AF Voltmeter

Test setup



Measurement: Depress the AF VOLTM. button 23 on the SMDU. Feed an AF voltage of constant level (e.g. 1 V) to the AF VOLTMETER input 44 of the SMDU and vary the frequency in the range 15 Hz to 150 kHz.

Permissible deviation of the level indication on the SMDU from that on the UVN:

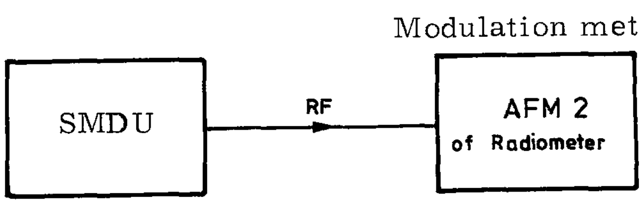
15 Hz - 30 kHz .... < ±(3% of rdg + 1.5% of fsd)

30 kHz - 150 kHz .... -3 dB

3.2.7 Modulation

3.2.7.1 Checking the Modulation Depth Indication

Test setup



Measurement: Set the SMDU to a frequency above 450 kHz and a level below 1 V EMF. Modulate the carrier signal 80% with an internal modulation frequency of 1 kHz. The error of the modulation depth indication on the SMDU must be .... < ±(4% of rdg +1.5% of f.s.d.)

Adjust with R2 in Y41; see section 5.3.6.12. Adjustment of the modulation unit may also be necessary; see section 5.3.7.3.

3.2.7.2 Checking the External Amplitude Modulation

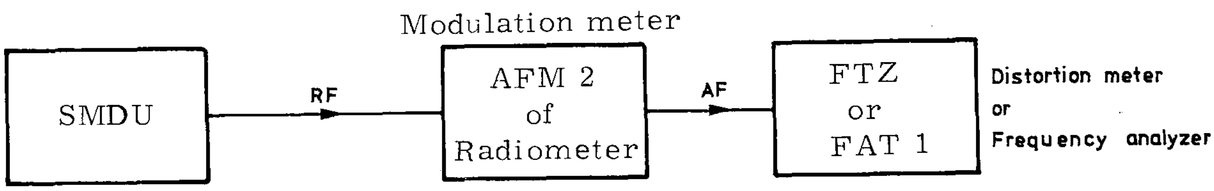
Test setup see section 3.2.7.1. Select AM EXT. on the modulation unit and apply an AF signal of 1 kHz to the AM socket.

Measurement: The voltage required for external modulation should be about 15 mV/%. For the indication error see 3.2.7.1.

Adjustment is possible with R87 in the modulation unit; see section 5.3.7.2.

3.2.7.3 Measurement of Modulation Distortion with AM

Test setup



Measurement: Adjust for 80% modulation with a modulation frequency of 1 kHz. Attenuator position < 1 V EMF.

Permissible modulation distortion at 0.4 to 400 MHz .... < 1.5%
400 to 525 MHz .... < 3%

Adjustment: See section 5.3.6.6.

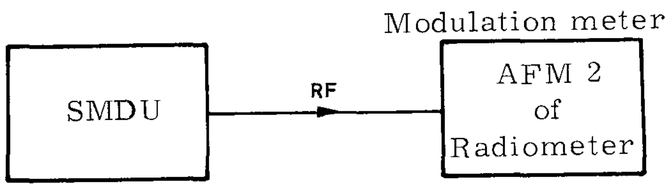
3.2.7.4 Measurement of Spurious AM with Frequency Modulation

Select a frequency > 1 MHz on the SMDU and modulate with 1 kHz and 100 kHz frequency deviation. Switch the SMDU to AM indication, measurement range 3% and read the spurious AM. The value of 1% AM should not be exceeded.

Adjustment is not possible. For the adjustment without AM see section 5.3.6.6.

3.2.7.5 Checking the Frequency Deviation Indication

Test setup



Measurement: Adjust the output voltage of the SMDU to at least 100 mV. Make measurements at both ends and at the centre of each frequency range, the modulation meter being tuned to the test frequency in each case. Modulate the SMDU with 1 kHz modulation frequency and 100 kHz frequency deviation. The true deviation can be read on the modulation meter.

Permissible difference of SMDU indication and
indication of modulation meter .... < ±(5% of rdg +1.5% of f.s.d.)

Adjustment: If the difference is uniform in all frequency ranges, the FM indication can be adjusted according to section 5.3.7.3. When a difference exists in a single frequency range proceed according to section 5.3.5.

3.2.7.6 Checking the External Frequency Modulation

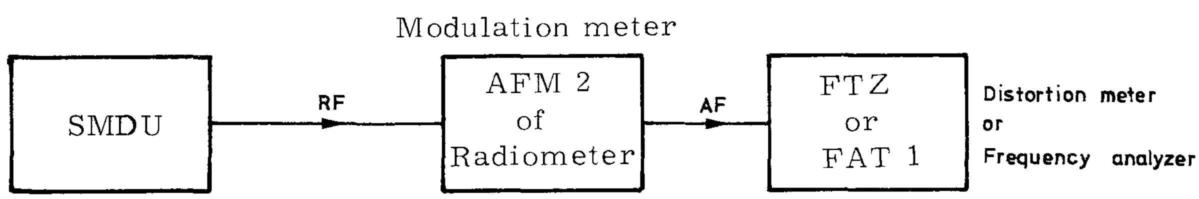
Test setup see section 3.2.7.5. Select FM EXT. on the modulation unit and apply an AF signal of 1 kHz to the FM socket.

Measurement: Proceed as described in section 3.2.7.5 except that the SMDU is operated with external frequency modulation. The voltage required for external FM should be about 5 V_p for 100 kHz frequency deviation. Indication error as in section 3.2.7.5.

Adjustment see section 3.2.7.5.

3.2.7.7 Measurement of Modulation Distortion with FM

Test setup



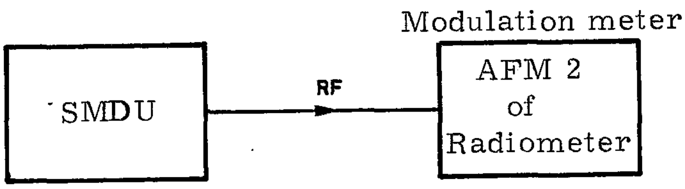
Measurement: Adjust the SMDU output voltage to at least 100 mV. Make measurements at both ends and at the centre of each frequency range. For measurements in the carrier frequency ranges 5 to 15 MHz and 86 to 110 MHz, the distortion of the modulation generator must be < 0.05% (model SMDU 249.3011.09). It is therefore advisable to modulate the SMDU in these ranges with an external AF generator.

Tune the modulation meter to the test frequency. Modulate the SMDU with 100 kHz frequency deviation and 1 kHz modulation frequency. Tune the distortion meter to the modulation frequency and read the distortion.

Permissible modulation distortion .... < 1%
For model .09 in the carrier frequency ranges
5 to 15 MHz and 86 to 110 MHz .... <0.2%

3.2.7.8 Measurement of Incidental FM with Amplitude Modulation

Test setup



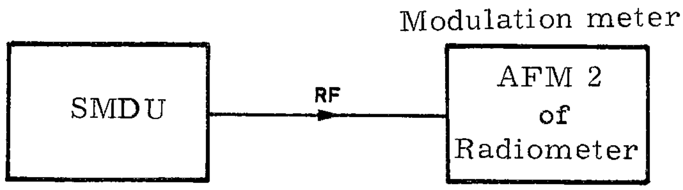
Measurement: Adjust the SMDU output voltage to at least 100 mV. Measure at several frequencies, tuning the modulation meter each time to the test frequency. Modulate the SMDU 30% with 10 kHz modulation frequency. Switch the modulation meter to FM measurement and read the incidental FM. Accurate reading on the modulation meter is not possible with carrier frequencies below 20 MHz. Therefore an AF voltmeter must be connected to the AF output of the modulation meter. For calibration modulate the SMDU with 1 kHz deviation and 1 kHz modulation frequency. The drop of the indication on the modulation meter or AF voltmeter relative to the calibrated indication amounts to the incidental FM being measured.

Permissible incidental FM:
Carrier frequency 0.14 - 20 MHz .... < 200 Hz
20 - 110 MHz .... < 1000 Hz
110 - 525 MHz .... < 2000 Hz

Adjustment: No adjustment possible.

3.2.7.9 Checking the Preemphasis

Test setup



Measurement: Modulate the SMDU with a frequency of 1 kHz. Adjust the SMDU meter for 1 kHz deviation. Permissible difference of meter indication and indication on modulation meter .... $\leq \pm 1\%$.

Connect the preemphasis and check the meter indication at the following modulation frequencies:

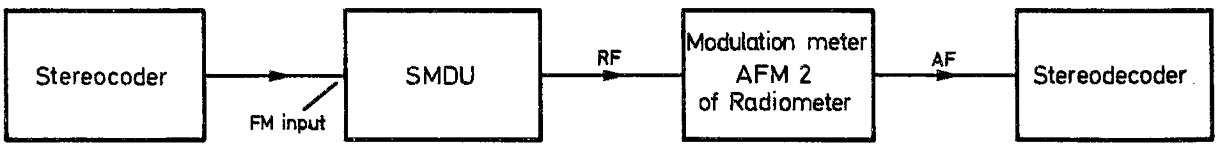
Modulation frequency	Deviation indication	Permissible error
0.4 kHz	0.4 kHz	+2%
1.0 kHz	1.0 kHz	+2%
2.7 kHz	2.7 kHz	+2%
3.0 kHz	3.0 kHz	+2%
6.0 kHz	6.0 kHz	-3%

Adjustment is not possible.

3.2.7.10 Measurement of Crosstalk Attenuation with Stereo Modulation

(only for SMDU model 249.3011.09)

Test setup



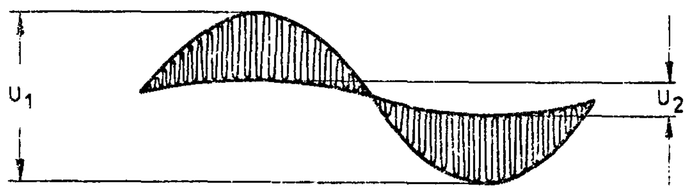
Measurement: Two different methods can be used for measuring the crosstalk attenuation.

a) Adjust the SMDU for a frequency in the VHF band (86 to 108 MHz) with an output voltage of at least 100 mV. Modulate the SMDU with a frequency deviation of 40 kHz from the stereocoder. Tune the modulation meter to the test frequency. The signals for the left and right channels can be measured with the stereodecoder. The difference between the two signals gives the crosstalk attenuation when one channel is operated without modulation.

b) Since the distortions causing crosstalk are produced in the AF path, the crosstalk attenuation can also be measured with an oscilloscope at ST101 of the range-switch board 215.1019 (K101 must remain connected). From a stereocoder a multiplex signal without pilot tone is fed into the external FM input. To measure crosstalk attenuations > 20 dB with sufficient accuracy, an oscilloscope with good overdrive capacity is required so that the picture can be enlarged accordingly.

From V_1 and V_2 (see diagram) one calculates

$$\text{crosstalk attenuation} = 20 \times \log \frac{V_1}{V_2}$$



Permissible values of crosstalk attenuation:

Modulation frequency	50 Hz	> 40 dB
	1 kHz	> 46 dB
	15 kHz	> 46 dB

<u>Adjustment</u>: No adjustment possible.

3.2.8 Synchronization

The following checks are only to be made when the Synchronizer SMDU-B1 is incorporated.

3.2.8.1 Checking the Synchronization

<u>Measurement:</u> The signal generator must synchronize in all frequency ranges. The CONTROL VOLT. meter on the front panel serves for checking. The pointer of the meter must be at rest and the digital frequency display must read an integral multiple of the selected frequency spacing of the locking points.

On variation of the tuning knob 49 (Fig. 2-1), the meter indication must change and at about f.s.d. the frequency must change by an amount correspond ing to the selected spacing.

Adjustment: See section 5.3.8.1; for fault location see section 5.2.7.

3.2.8.2 Checking the Fine Tuning

The signal generator must synchronize in all frequency ranges; check as described in section 3.2.8.1. A frequency variation by at least ±0.55 x spacing of the locking points must be possible by means of the FREQ. FINE knobs. The inner knob must provide a variation of at least 10 Hz.

Measure the frequency stability as described in section 3.2.4.2. After a warmup time of 15 min and with a measuring time of 10 min, the following values must be obtained (depending on spacing of locking points):

Signal generator freq.	0.14 - 200 MHz	$\leq$ 100 Hz
	200 - 525 MHz	$\leq 5\times10^{-7}$

Measure the spurious FM according to section 3.2.1.5. It is not allowed to exceed the following values:

Spacing of locking points:		12.5 kHz	150 kHz
Signal generator freq.	0.14 - 64 MHz	< 10 Hz	< 30 Hz
	64 - 525 MHz	< 20 Hz	< 40 Hz
	525 - 1050 MHz	< 40 Hz	< 80 Hz

Adjustment: See section 5.3.8.2; for fault location see section 5.2.7.

3.2.8.3 Measurement of Frequency Stability

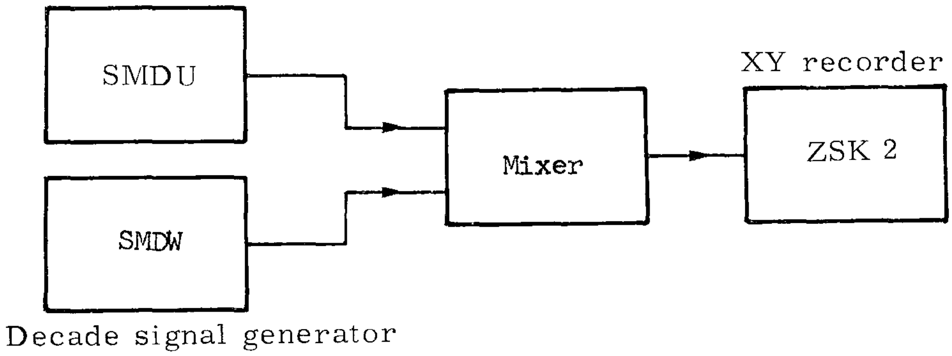
Measurement: The frequency stability of the RF output signal can be determined by means of an accurate frequency meter or by phase comparison with a standard frequency. After a warmup period of 15 min, the departure of a locked frequency for a measurement time of 10 min must be < $(5\times10^{-8}+10\text{ Hz})$.

For checking of the timebase see section 3.2.4.1.

Adjustment: See section 5.3.3.1.

5.2.8.4 Measurement of Spurious FM with Synchronization

Test setup



Measurement: The SMDU output signal is mixed with the highly stable frequency of the decade signal generator in the mixer. The XY recorder plots the difference frequency.

Typical spurious FM with 12.5 kHz locking-point spacing, with fine tuning:

140 kHz - 50 MHz .... 15 Hz

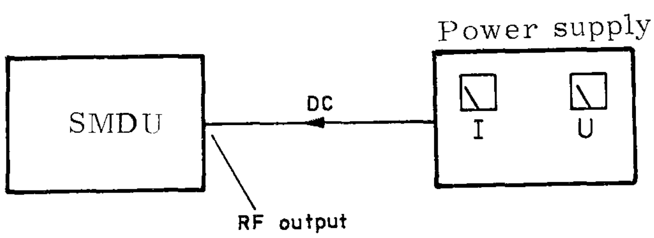
50 MHz - 525 MHz .... 10 Hz

525 MHz - 1050 MHz .... 20 Hz

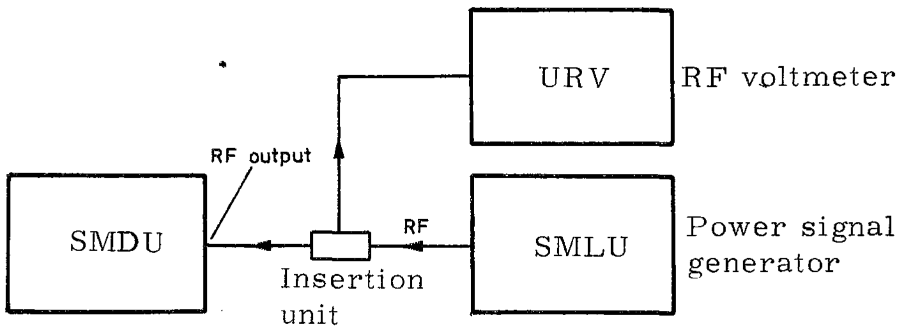
Adjustment: No adjustment possible; for fault location see section 5.2.7.

5.2.9 Checking the Overload Protection (SMDU-B2

Test setup for DC check



Test setup for RF check



Measurement: Turn the attenuator knob on the SMDU to left stop; the oscillator must remain connected. Feed a DC voltage to the RF output and increase until the button beside the RF output lights up. The button must light also when the voltage polarity is reversed. When the button is lit, the current supplied by the power supply must go to 0 since the RF output is cut off.

Feed an RF signal from the power signal generator with different frequencies to the RF output and increase until the button lights.

Nominal response threshold:

DC voltage .... ≥ 0.5 V

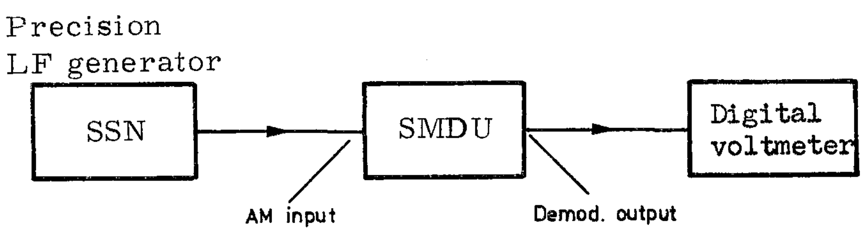
RF voltage .... 4.5 to 6.5 V

Adjustment: The response threshold can be adjusted with R5 in the Overload Protection SMDU-B2.

3.2.10 Checking the Output Voltage for the VOR-ILS Adapter

(only for SMDU Model 249.3011.07)

Test setup



Measurement: Modulate the SMDU 40.0% with modulation frequencies of 90 Hz and 150 Hz; attenuator of SMDU in position 100 mV. The modulation voltages of the 90-Hz and 150-Hz signals must be identical (difference < 0.005%). Connect the digital voltmeter to contacts 1 and 2 (chassis) of the DEMOD. OUTPUT 57 socket.

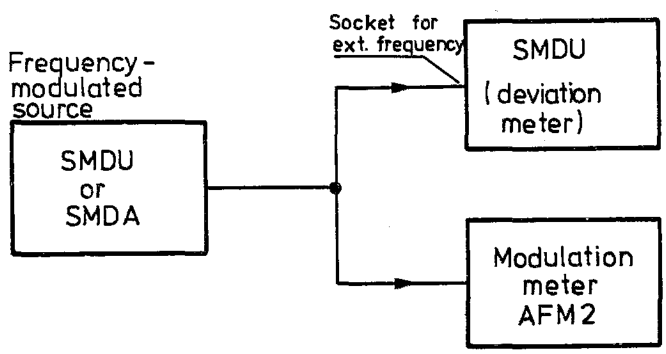
Measure at 115 MHz and 330 MHz; the following voltages must be obtained:

	Nominal	Permissible deviation
DC voltage	0 V	±20 mV
DC voltage with RF OFF 40 depressed	-3.50 V	±5 mV
AC voltage	990 mV	±1 mV
AC voltage difference between 90-Hz and 150-Hz signals		±0.5 mV

Adjustment see section 5.3.6.12.

3.2.11 Checking the Deviation Meter

Test setup



a) Checking the Simplex Mode

Adjust the source to about 150 MHz and frequency-modulate it. Set the SMDU deviation meter to the SIMPLEX mode and compare the SMDU indication with the indication of the modulation meter. Check the AF frequency response for 3 kHz, 10 kHz and 50 kHz deviation:

Modulation frequency	Permissible error of indication
100 Hz	$\pm$(1.5% of rdg +1.5% of f.s.d.)
1 kHz	$\pm$(1.5% of rdg +1.5% of f.s.d.)
6 kHz	$\pm$(1.5% of rdg +1.5% of f.s.d.)
15 kHz	$\pm$3 x (1.5% of rdg +1.5% of f.s.d.)
20 kHz	3 dB

Disconnect the modulation and use the CCITT filter for weighting the residual FM which should be < 5 Hz.

b) Checking the Duplex AFC Mode

Select the DUPLEX AFC mode.

Checking the pull-in range: Tune the SMDU oscillator over a range offset by 4.2 to 10.5 MHz from the test frequency. LED 26 should not go out within this range. If necessary, adjust the LED response threshold with R64 in subassembly Y83.

Check the AF frequency response as described under a) in accordance with the following table:

Modulation frequency	Permissible error of indication
50 Hz	$\pm$3 x (1.5% of rdg +1.5% of f.s.d.)
200 Hz	$\pm$(1.5% of rdg +1.5% of f.s.d.)
1 kHz	$\pm$(1.5% of rdg +1.5% of f.s.d.)
6 kHz	$\pm$(1.5% of rdg +1.5% of f.s.d.)
15 kHz	$\pm$3 x (1.5% of rdg +1.5% of f.s.d.)

With CCITT weighting the residual FM should be < 10 Hz.

c) Checking the Relay Mode

Set the oscillator of the SMDU, which is used as the deviation meter, to a frequency which is 4.2 to 10.5 MHz lower than the test frequency. Switch the deviation meter to the DUPLEX mode. Modulate the test frequency with 1 kHz and 3 kHz deviation. Switch over to the relay mode "f_{up}" and adjust the deviation indication for minimum. With CCITT weighting, the residual deflection should be < 15 Hz.

d) Checking the Indication of Phase Deviation

In phase deviation measurements, the demodulated AF signal is weighted by a deemphasis filter of -6 dB/octave. Set the SMDU to indication of the phase deviation and select the DUPLEX mode. Modulate the test frequency with 1 kHz and adjust the indication of phase deviation to 1 rad. Vary the modulation frequency:

Modulation frequency kHz	Phase deviation rad	Additional error of indication %
0.25	4	±3
0.5	2	±2
1	1	±2
2	0.5	±3
4	0.25	±4

3.2.12 Checking the CCITT Filter

Apply an 800-Hz signal of about 1 V_{rms} to the AF voltmeter input and press buttons AF VOLTM. and CCITT FILTER. Adjust the voltage such that the meter indicates 0 dB.

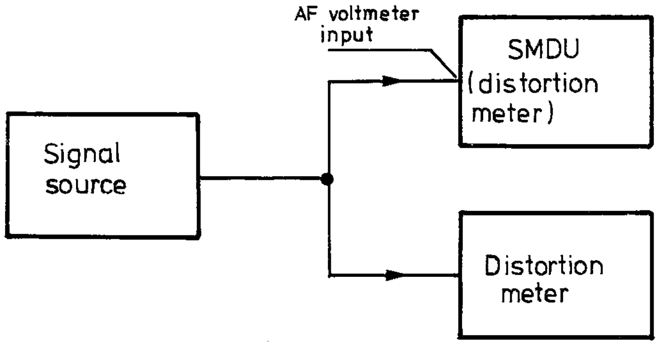
Vary the frequency of the AF signal:

Frequency	Attenuation (indication) dB	Tolerance dB
100 Hz	-40.1	±2
300 Hz	-10.6	±2
400 Hz	-6.3	±1
800 Hz	0	0
1 kHz	+1	±1
2 kHz	-3	±1
3 kHz	-5.6	±1
4 kHz	-15	±2
5 kHz	-36	±3

The adjustment is made at 800 Hz with R65 in Y83; see section 5.3.7.3.

3.2.13 Checking the Distortion and SINAD Ratio Meters

Test setup



Measuring the inherent distortion

Apply a low-distortion (< 0.1%) 1-kHz signal to the AF voltmeter input. Measure the voltage with the AF voltmeter of the SMDU and adjust the signal to 50 mV_{rms}.

Switch over to distortion measurement. The SMDU meter indicates the inherent distortion which should be < 0.3%. When increasing the voltage of the AF signal, this value should no more than double. With voltages of < 50 mV, LED "uncal." lights up.

Checking the distortion indication

Adjust the frequency of the AF signal to 3 kHz. The indicated distortion should be 90 to 110%.

For accurate checking of the distortion indication, apply a limited 1-kHz signal (processed for instance by a diode, with cathode connected to earth). Compare the SMDU indication with that of the distortion meter. The permissible indication error of the SMDU is .... ±(10% of rdg +1.5% of fsd + inherent distortion)

Checking the SINAD ratio meter

For checking the SINAD ratio meter, superimpose a noise signal onto the applied 1-kHz signal. Adjust the SINAD ratios 6 dB, 12 dB and 20 dB by varying the noise component.

Permissible error of indication .... ±(10% of rdg +1.5% of fsd + inherent noise)

Adjustment: Use R28 and R91 in the 1-kHz bandstop filter and attenuator Y82I (250.2644); see section 5.3.7.4.

4. Detailed Description

4.1 Oscillator Y1

See overall circuit diagram 249.4518 S

The output coupling lines of the six range oscillators are combined on the coupling board 249.5243. The switching diodes Gl 1 to Gl 9 make sure that only the oscillator in operation is connected to the output cable K112, the output line of this oscillator being at a negative voltage whereas those of the other oscillators carry positive voltage.

The FM modulation voltage is applied simultaneously to the FM inputs of the six oscillators via the FM filter 249.5295. The filter prevents RF voltages from leaking through cable K101. The cutoff frequency of the filter is about 4 MHz. Diode Gl 10 compensates for temperature-dependent capacitance variations of the FM diodes by affecting the DC voltage across R10 according to temperature.

4.1.1 Oscillators Y11 (49 - 64.5 MHz) and Y12 (63.5 - 88 MHz)

See circuit diagrams 249.4630 S and 249.4724 S

The oscillators are of similar configuration and differ only in the values of the frequency-determining components.

The resonant circuit consists of the inductance L1 (adjustment of lower frequency limit), trimmer capacitor C5/C6 (adjustment of upper frequency limit), and tuning capacitor C8/C12. The temperature coefficient and capacitance of the series capacitors C5 and C8 compensate for the temperature drift of the oscillator. The oscillator transistor T1 is a FET of high output impedance whose drain is connected to a tap of L1 to provide minimum damping of the resonant circuit. Feedback to the source is made via another tap and L4/C3. The source voltage is applied via R5 and L5. R1 permits the gate voltage and thus the optimum transistor current to be adjusted.

The inductances L3 and L4 consist of two ferrite beads slid on two contacts of L1. They prevent oscillations at high frequencies when the range oscillator is cut off by the switching diode Gl 1.

The varactors Gl 2 and Gl 3, which are connected to the tuning capacitor C12 via the series capacitors C9 and C10, are used for frequency modulation. The series capacitors straighten the capacitance characteristic of the diodes, keeping FM distortion at a minimum. To maintain adequate voltage sensitivity in spite of this fact, two varactors are used. The bias voltage is applied via L9. It can be adjusted in the range switch Y10 for minimum FM distortion. The trimmer capacitors C10 and C11 are used to adjust for tracking of the frequency deviation, C10 being more effective at the low end and C11 at the high end of the range.

The RF voltage is brought out at the low end of the coil L1. L2 and C14 suppress harmonics. The oscillator switching voltage, which is capable of shorting the oscillator feedback by means of the switching diode Gl 1, is moreover applied to the oscillator output coupling 249.5243 via the RF coupling line.

4.1.2 Oscillator Y13 (85 - 119 MHz)

See circuit diagram 249.4799 S

The basic function is the same as that described in section 4.1.1. The only difference lies in the configuration of the varactors Gl 2 and Gl 3. Gl 3 alone provides a relatively low FM distortion together with good voltage sensitivity. However, throughout the oscillator range the distortion does not remain as low as required. For example, when distortion is adjusted to a minimum at the lower range end, it increases towards the upper end, assuming a value which is no longer acceptable. This effect is counteracted by diode Gl 2. Since the series capacitor C9 has a very low capacitance, Gl 2 is effective only when the tuning capacitor C12 is fully out of mesh, so that it influences the frequency deviation at the upper range end. The bias of Gl 2 is adjustable by varying the switching voltage.

4.1.3 Oscillator Y14 (118 - 198 MHz)

See circuit diagram 249.4860 S

The function is the same as that described in section 4.1.1.

4.1.4 Oscillator Y15 (196 - 290 MHz)

See circuit diagram 249.4930 S

The basic function is the same as that described in section 4.1.1. The series capacitance C7 ‖ C81 ‖ C82 of the variable capacitor C12 is used for the adjustment of the lower limit frequency. Coil L1 can be slightly varied to permit accurate adjustment of the frequency of 240 MHz (beginning of the mixing range). One varactor is sufficient for frequency modulation since the maximum deviation is equal in all frequency ranges so that only a small capacitance variation is required at high frequencies. If the series capacitor C10 is optimally adjusted, the required voltage sensitivity is also obtainable with one diode.

4.1.5 Oscillator Y16 (286 - 395 MHz)

See circuit diagram 249.5008 S

The basic function is the same as described in section 4.1.1. Since the resonant-circuit coil L1 is not adjustable, the series capacitance C7 || C81 || C82 of the variable capacitor C12 is varied for adjustment of the lower limit frequency. One varactor is sufficient for frequency modulation since the maximum deviation is equal in all frequency ranges so that only a small capacitance variation is required at high frequencies. If the series capacitor C10 is optimally adjusted, the required voltage sensitivity is also obtainable with one diode.

4.2 Mixer Oscillator Y6

See overall circuit diagram 249.6810 S

The frequencies of the range 0.14 to 50 MHz are produced in the mixer oscillator. Phase locking of the 240-MHz mixer with the 10-MHz crystal frequency affords high stability. The crystal signal is also used as the reference signal for the counter Y7 and the Synchronizer SMDU-B1.

4.2.1 240-MHz Oscillator Y61

See circuit diagram 249.6956 S

The oscillator consists of transistor T1 and the tank circuit L1, C1, C3, C4. C1 is used for coarse and L1 for fine adjustment of the resonant frequency. The tuning voltage for the varactor Gl 1 at contact 3 is also adjusted with L1 to its nominal value.

The oscillator is followed by a two-stage amplifier which boosts the signal to the output voltage of 1.5 V and prevents reaction on the oscillator from the subsequent subassemblies. Since a symmetrical signal is required for the 240-MHz divider and mixer Y62, the balun TR1 is provided at the synchronizing output of the oscillator.

4.2.2 240-MHz Divider and Mixer Y62

See circuit diagram 249.7017 S

The 240-MHz divider and mixer synchronizes the 240-MHz signal from the oscillator Y61 with the 10-MHz frequency from the signal oscillator Y63 according to the principle of harmonic-phase synchronization.

240-MHz divider

The 240-MHz signal is reduced to 30 MHz by 2 : 1 and 4 : 1 divisions with the ECL flip-flops B1 and B2. The 30-MHz ECL signal is transformed into a TTL signal in the two-stage amplifier T1 and T2 and then divided down to 2.5 MHz with B3 and B4.

10-MHz switch

The 10-MHz signal from the crystal oscillator Y63 is transformed into a TTL signal by T3 and T4. From T4 the signal is conveyed via cable K61 to BU61 at the rear of the instrument (see circuit diagram 249.6810 S). The external cable K1 feeds the signal back to the circuit board via BU62 and K62. When cable K1 is removed, an external 10-MHz reference signal at TTL level can be applied to BU62. In this way it is possible, for example, to obtain higher counter and frequency stability with synchronization. For use in the counter Y7, the 10-MHz signal is conveyed to ST62 via B5 IV.

Mixer and AFC amplifier

The 10-MHz signal is divided to 5 MHz in B5 IV and applied, via B5 III, to gate B5 II which functions as a mixer and phase discriminator; after being divided to 2.5 MHz, the 240-MHz signal is applied, via B5 I, to the same gate, B5 II. The mixer product is conveyed through a lowpass filter to the AFC amplifier B6 and is used to tune the 240-MHz oscillator Y61 after suppression of noise by another lowpass filter.

4.2.3 10-MHz Crystal Oscillator Y63

See circuit diagram 249.7081 S

The crystal oscillator consists of crystal Q1, transistor T8 and tank circuit TR1, C7, C8, C9. C8 provides temperature compensation for the transformer TR1. C4 is used to adjust the accurate frequency. Transistor T5 functions as an impedance transformer.

The oscillator transistor and the crystal are accommodated in an oven to ensure a stable temperature. Thermistor R11 is the temperature-sensing element and transistor T7 the heating element. The nominal temperature is fixed by the value of R2. The differential amplifier T1, T2 together with T4 forms the control amplifier. R9, Gl 1 and T4 provide current limiting for the heating transistor T7.

4.3 Amplifier Y2

See overall circuit diagram 249.7846 S/249.7830 S (for models 249.3011.06/.07)

4.3.1 Buffer Amplifier Y21

See circuit diagram 249.9426 S

The buffer amplifier Y21 has been provided in order to isolate the output of oscillator Y1 from the subsequent stages of the amplifier chain and thus to avoid shifting of the oscillator frequency. Low noise figure, in particular of T1, low input and output reflection with a flat frequency response and good harmonic suppression are ensured by suitable configuration of the input and of the emitters of T1, T2 and T3.

The buffer stage T21, T22 feeds the RF signal to the counter Y7 via R30, R31, R32; the high output/input isolation of this stage ensures good decoupling of the counter.

The three-stage amplifier is followed by the PIN diodes Gl 1, Gl 2, Gl 3 in π connection. Independently of the attenuation of the PIN diode circuit, its input impedance should remain constant. The reference voltage at Gl 4 and Gl 5 together with R17 ensures that the reflection coefficient remains $< 20\%$ with an attenuation > 2 dB of the PIN diode circuit.

Transistor T4 interrupts the control voltage if the RF voltage is suppressed with the aid of button <u>30</u> or via a VOR-ILS Unit. This prevents the attenuation of the control circuit from being reduced to a minimum.

4.3.2 Mixer Y22

See circuit diagram 249.8265 S

A 9-section Chebyshev lowpass filter suppresses the harmonics of the input signal. The filter is followed by the actual mixer, which is designed as an IC ring mixer.

4.3.3 Lowpass Filter Y23

See circuit diagram 249.8336 S

The 8-section Chebyshev lowpass filter has a cutoff frequency of 5o MHz; it provides a spurious-frequency suppression > 90 dB. The filter is followed by amplifier T1 with negative voltage feedback; it affords a gain of about 10 dB. The attenuator R13 to R15 provides matching to the modulator Y28.

4.3.4 Diode Switch Y24

See circuit diagram 249.8365 S

In the diode switch the oscillator signal is applied to one of three signal paths, which are decoupled from one another. A particularly high stopband attenuation is required for the direct path comprising diodes Gl 1 to Gl 6, in view of a high suppression of spurious signals. The attenuation in the direct path is > 110 dB for frequencies < 50 MHz and from 185 to 270 MHz. A lower stopband attenuation is sufficient in the mixer path Gl 8 to Gl 11 and in the doubler path Gl 13 to Gl 16.

4.3.5 Lowpass Filter Y25

See circuit diagram 249.8413 S

Transistor T1 boosts the RF signal in the range 196 to 262.5 MHz by about 10 dB. The five-section Chebyshev lowpass filter with a cutoff frequency of 270 MHz suppresses harmonics and transforms to the 25-Ω input impedance of the doubler Y26.

4.3.6 Doubler Y26

See circuit diagram 249.8465 S

The doubler operates on the principle of full-wave rectification. Diodes Gl 2 I and GL 2 II are driven in phase opposition via a Guinella transformer. The halfwaves of the RF signal are equally damped by two more diodes, Gl 1 I and Gl 1 II, so that the odd harmonics of the RF signal are heavily attenuated in the doubler thanks to the symmetrical configuration.

The symmetry adjustment is made with R3 by varying the bias current of the diodes.

The doubler has an output impedance of 100 Ω. It is followed by the amplifier T1, which is terminated by the matching section R12 to R14.

4.3.7 Bandpass Filter Y27

See circuit diagram 249.8513 S

The seven-section bandpass filter is in hybrid technology, the four parallel circuits being of stripline design and the three coupling circuits consisting of discrete components. The passband is 392 to 525 MHz.

The required stopband attenuation of > 70 dB at frequencies < 262.5 MHz and > 60 dB at frequencies > 588 MHz is ensured.

4.3.8 Modulator Y28

See circuit diagram 249.9403 S

The RF signal at the modulator input is applied to three signal paths:

- The output amplifier T1 conveys the signal to the counter and to the RF output II at the rear of the set.
- The demodulator diode Gl 1 and the integrator B1 drive the PIN diode circuit in the final stage Y30, providing level control at the modulator input (see section 4.5.2).
- The signal is amplitude-modulated with transistors T3 and T4.

The two modulation transistors T3 and T4 operate on the principle of current distribution. They are driven in phase opposition by the differential amplifier B2 II/III. When T4 is cut off, the RF signal is taken to chassis via T3, R24, C16; when T4 conducts, the signal is applied to the amplifiers T5 and T6, which operate with negative voltage feedback.

Switching criteria f $\gtrless$ 8 MHz and f $\gtrless$ 400 kHz

Both criteria of the signal generator frequency must be provided with hysteresis. The hysteresis for the $\gtrless$ 8 MHz criterion is given by the mechanical construction of switch S17 on the oscillator drum, that for f $\gtrless$ 400 kHz is produced in the discriminator of the first decade Y73 with switching points at 400 kHz and 440 kHz.

The frequency information is signalled to the modulator by a change of polarity at the soldered points 3 and 13. Together with the amplitude-modulated RF signal the unwanted AF signal is present at the collector of the modulation transistor T4. It is largely suppressed by C24 and the lowpass filter L5 to L7; the latter is switched over for f $\gtrless$ 8 MHz and f $\gtrless$ 400 kHz. Depending on the frequency criteria, the charging time constant of the demodulator Y41 is also switched over. To maintain the stability of the inverse-modulation circuit, the cutoff frequency of the lowpass filter C39, C40 is changed correspondingly by the switching diodes Gl 9, Gl 10. For signal generator frequencies < 400 kHz the capacitance values C13 and C14 at the bases of the modulation transistors T3 and T4 must be increased. This is achieved by the parallel connection of C22 and C23.

Switching criterion AM/FM, unmodulated

A switching voltage of +15 V is present at soldered point 4 with amplitude modulation, -15 V in all other cases. The lowest RF level in the whole amplifier Y2 is present at the collector of the modulation transistor T4. It is about 6 dB below the level at the modulator input. The wideband noise can therefore be reduced by about 5 dB if the RF level at the collector of T4 is increased. The level increase can, however, be made only in unmodulated operation, otherwise T4 would be overdriven. Even so T4, via R55, is only 90% conductive so that any residual AM can be levelled out via the negative modulation feedback (see section 4.5.3).

4.3.9 Final Stage Y30

See circuit diagram 249.8865 S

At frequencies above 8 MHz the highpass filter C6, L5, C22 opens the signal path through the PIN diode circuit Gl 3 to Gl 5. This circuit is driven by B1 in the modulator Y28 (see section 4.5.2). Frequencies below 8 MHz are conveyed via L6 and thermistor R5 to the RF final amplifier.

The driver transistor T1 and final stage transistor T2 operate with negative voltage feedback, providing a flat frequency response and low input and output reflection.

4.3.10 Filter Y31 and Output Filter Y32, Y33

See circuit diagrams 249.8694 S, 249.8720 S, 249.8813 S

The final stage Y30 is followed by the switchable filter Y31 and the output filters Y32 and Y33. One lowpass filter is switched in via the switching diodes in filter Y31, the other signal paths being cut off. Apart from the 525-MHz path the lowpass filters are Cauer circuits. To minimize distortions produced by the switching diodes at frequencies below 1 MHz, a bias current of about 100 mA, fed in with high impedance via T1, flows through the diodes of the 86-MHz path. Frequencies above 300 MHz are filtered in the subsequent lowpass filters Y32 and Y33.

The filters Y31, Y32, Y33 on the one hand ensure minimum RF distortion of the output signal and on the other hand reduce the error of the demodulator Y41, which acts as the sensing element for the amplitude control and the inverse-modulation circuit. This gives a considerable improvement of the frequency response of the output signal and of AM distortion.

4.3.11 AF Filters Y35, Y37, Y39, Y40

See circuit diagrams 249.8613 S, 249.8913 S

The AF filters Y35/Y37 and Y39/Y40 from 9-section Cauer lowpass filters which provide RF shielding for the amplifier Y3. The cutoff frequency is at 100 kHz.

4.3.12 Control Amplifier Y38

See circuit diagram 249.8765 S

The control amplifier processes the control voltage from the demodulator Y41. The characteristic of the rectifier diode in the demodulator is linearized to a large extent by a bias current flowing through R2 and by the amplitude filter R7, Gl 1. The operational amplifier B1 and the emitter follower T1 amplify the demodulated AM signal without distortion and convey it to three signal paths: via R20 the signal passes to the modulator Y28 where the inverse modulation is achieved; via R22 the signal is used for the indication of modulation depth and via Y41 it is passed on to the VOR-ILS socket. The DC component is separated by the integrator B2, which has a high loop gain, and applied via R24 to the PIN diode circuit in the buffer amplifier Y21 where the amplitude control is performed.

4.3.13 Rectified-voltage Compensation Y41

See circuit diagram 249.9161 S/249.9184 S (for versions 249.3011.06/07)

Potentiometer R2 is used to adjust the modulation depth. The rectified voltage is available for checking at socket BU12.1 DEMOD. OUTPUT (see fault location instructions, section 5.2).

Version 249.3011.07 only: With RF OFF, adjust the DC voltage at socket BU12.1 DEMOD. OUTPUT for VOR-ILS units to -3.5 V using R8. With the RF carrier cut in, adjust to 0 mV using R12 in the control amplifier Y38.

4.4 RF Attenuator Y4

See circuit diagram 249.3711 S

The RF attenuator Y4 has an exponential attenuation characteristic. It consists of potentiometer R41 whose resistive layer is earthed at its broad sides via metallized pasted strips. The wiper is moved by a spindle-guided carriage to which the pointers for level reading are fixed. The input and output impedances are 50 Ω in the positions < 0 dBm.

4.4.1 Demodulator Y41

See circuit diagram 249.3711 S

The demodulator is located in the attenuator Y4 close to the feed point of the attenuator layer. It comprises two antiparallel-connected hot-carrier diodes for the rectification of the output signal. Due to this symmetrical design, the even harmonics of the RF signal which are caused by the non-linear characteristic of the rectifier diode compensate to a large extent. The charging time constant of the rectifier circuit is changed twice in the range 0.14 to 50 MHz by adding capacitances. The switchover points are at 400/440 kHz and about 8 MHz. This makes for an error of the regulated output level of < 3%.

The rectifier diode, being the sensing element, has a decisive effect on the error of amplitude control and modulation feedback, and thus on AM distortion. Its temperature dependence is compensated for by a second diode which is located on the same ceramic substrate. The diodes have opposite effects on the operating point of the operational amplifier B1 in the control amplifier Y38. The rectifier diode characteristic is linearized within the control amplifier; see section 4.3.12.

4.5 Control Circuits

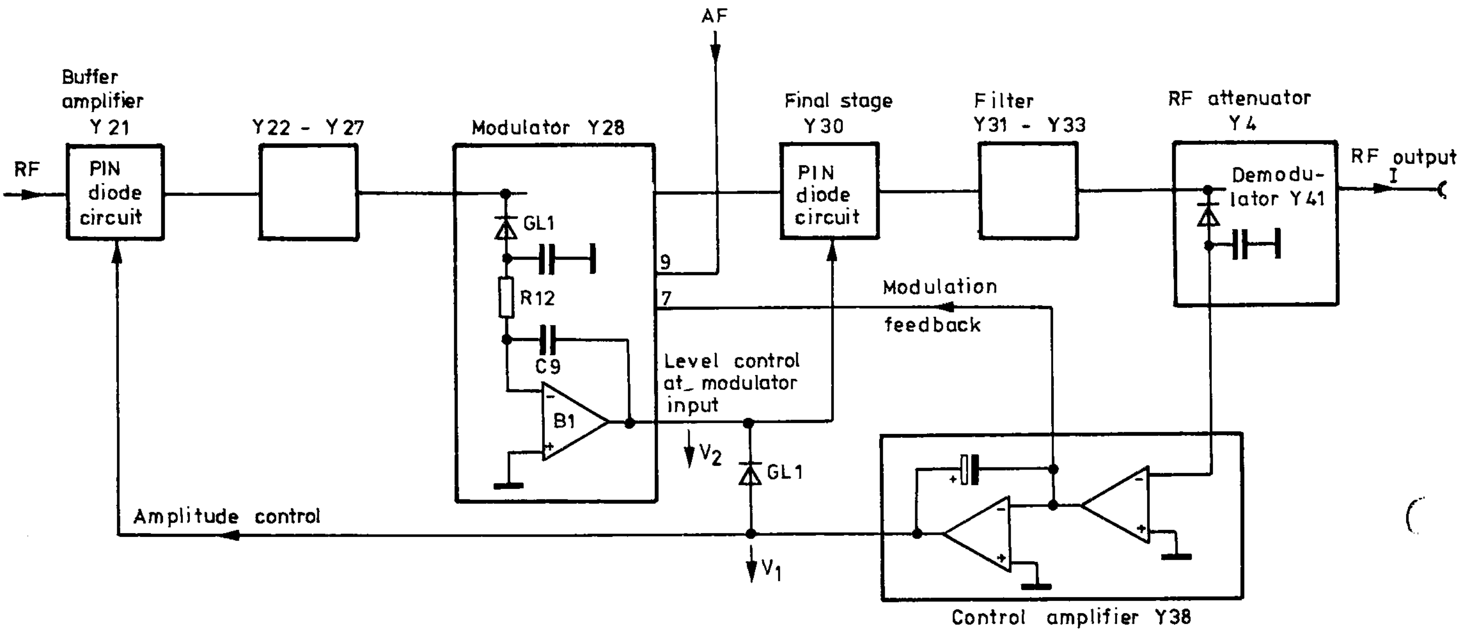


Fig. 4-1 Control circuits of amplifier Y2

4.5.1 Amplitude Control

The amplitude control is the primary control circuit covering the whole amplifier Y2 (Fig. 4-1). The demodulator Y41 (sensing element) is followed by the control amplifier Y38 (reference point); the PIN diode circuit in the buffer amplifier Y21 is the positioning element. The amplitude control circuit ensures a constant frequency-independent voltage at the input of the RF attenuator Y4.

4.5.2 Level Control at the Modulator Input

The secondary control circuit governs the level control at the modulator input. It includes the modulator Y28 and the PIN diode circuit (positioning element) of the final stage Y30 (Fig. 4-1).

The demodulator diode Gl 1, the integrator B1 in the modulator Y28 and the PIN diode circuit Gl 3, Gl 4, Gl 5 plus thermistor R5 in the final stage Y30 make sure that the RF level at the modulator input remains constant. To avoid disturbance of the amplitude control, which has priority, the level control at the modulator input is not effective until the amplitude control has reached steady state. This is performed by

- diode Gl 1 on the distributor board 249.8188
- adequate time constant of the integrator B1 realized by R15 and C9 in the modulator Y28.

As long as the difference $V_1 - V_2$ of the two control voltages is greater than the threshold voltage of Gl 1, the PIN diode circuit of the final stage Y30 remains conductive. Only when $V_1 - V_2 \leq 0.5$ V, the level control at the modulator input becomes effective.

4.5.3 Modulation Feedback

The third control circuit improves the AM characteristics of the amplifier Y2 by negative modulation feedback. This control circuit comprises the RF signal path from the modulator Y28 to the demodulator Y41 and is closed via the control amplifier Y38 (monitoring element); Fig. 4-1. The AF signal is applied via the 100-kHz lowpass filters Y35 and Y37 and added in the operational amplifier B3 of the modulator Y28. Via the emitter follower B2 V and C37 the AF signal is applied to the differential amplifier B2 II, B2 III and passed on with opposite phases to the bases of the modulation transistors T3 and T4.

Capacitor C37 is shunted by two antiparallel diodes. The charging and discharging time constants are thereby reduced for higher amplitudes, accelerating the transients of the control circuit.

4.6 Range Switch Y10

See circuit diagram 250.1019 S

The frequency-range-dependent functions of the signal generator are controlled through the range switch:

Counter, synchronizer and 1.05-GHz frequency range extension (if incorporated), oscillator ranges, FM sensitivity, reactance diode bias, diode switch and output filter in amplifier Y2.

The range switch circuit board also comprises the FM amplifier and the supply voltage regulators for the oscillator (-18 V) and for the FM amplifier (+60 V).

4.6.1 Control of Counter, Synchronizer and 1.05-GHz Frequency Range Extension or 1.05-GHz Frequency Doubler

See circuit diagram 250.1019 S

The row of pushbuttons S101 provides the control signals for the counter Y7:

- control signals for decimal-point control and 0.1 s/1 s gate-time control (ST114.7 and .19)
- via gates BI, BII, BIII and transistor T1, depending on the logic level of button RF INT. which is signalled via ST114.9: control signals for the 0.2/2 s gate-time control with internal frequency measurement 392 to 525 MHz or with external frequency measurement 0.5 to 1 GHz (ST114.17), and for the 0.04/0.4 s gate-time control with internal frequency measurement 784 to 1050 MHz (ST114.20).

When a Synchronizer SMDU-B1 is incorporated, the pushbuttons control

- the program divider via ST114.10 and .14
- the input divider in the fine tuning circuit Y201 via ST114.2, .3 and .13.

When the 1.05-GHz Frequency Range Extension SMDU-B3 is incorporated, the frequency ranges 510 to 1050 MHz and the associated filters are switched via ST114.4, .5, .6 and .10. The signal which puts the frequency range extension into operation simultaneously controls, via T2 and ST113.6, a field-effect transistor in the modulation unit so that the indication of frequency deviation is doubled.

When the 1.05-GHz Frequency Doubler SMDU-B5 is incorporated, the same functions are switched except for the filters, which are not included in this version.

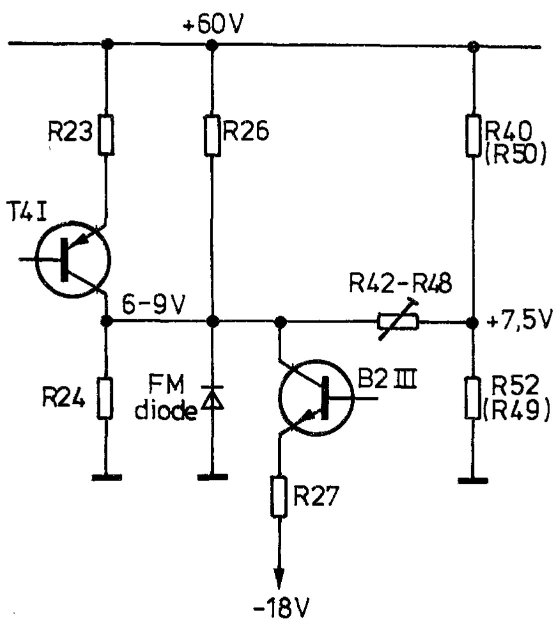
4.6.2 FM Amplifier

See circuit diagram 250.1019 S

The FM amplifier consists of the two stages B2 II and T4 I. The first stage has unity voltage gain; its base voltage of 0 V is produced by the transistor B2 I and can be adjusted with R14 and R17. Since both transistors B2 are comprised in a transistor array they are always at the same temperature. The temperature-dependent base current of B2 II is controlled by B2 I in such a way that the base voltage of B2 II does not change in case of temperature variations. This temperature compensation prevents the signal generator frequency from varying with different frequency deviation.

The lowpass filter C1, L2 in the emitter circuit of transistor B2 II causes the voltage at the collector of B2 II to lead with reference to the base voltage so that the delay of the FM filter which lies between the FM amplifier and the FM diodes (see circuit diagram 249.4518 S) is compensated for. The second amplifier stage T4 I normally has a voltage gain of about 5 : 1 to keep the amplifier noise low. In position 1000 kHz of the FM switch in the modulation unit, relay RS1 is connected to +5 V and the gain switched over to unity. Transistors T4 II, B2 IV are arranged symmetrically to B2 II, T4 I and thus simulate the temperature drift of the emitter voltage of T4 I, to prevent the FM diode voltage from changing when relay RS1 switches. The emitter voltage of T4 I is equal to that of T4 II which is adjustable with R98.

The gain of the amplifier stage T4 I is determined by the ratio of emitter resistance to collector resistance. R23 is the emitter resistor in the frequency deviation ranges 10/100 kHz and R23 ‖ R25 is that for position 1000 kHz of the FM switch. Diode Gl 14 serves for temperature compensation of the base-emitter voltages of B2 II and T4 I. The effective collector resistance is composed of R24, R26, R10 on the FM filter circuit 249.5295 and, depending on the frequency range, R42 to R48 as well as R40 and R52 or R49 and R50. The gain is adjustable individually for each frequency range during the frequency deviation adjustment. The selected potentiometer (R42 to R48) is connected in a DC bridge (see diagram) so that the DC voltage



at the collector of T4 I and thus the bias of the FM diode are not varied too much when the gain is adjusted. To obtain minimum FM distortion, the operating FM diode is used at its optimum operating point. For this purpose the FM control voltage at the collector of B2 III can be varied in its DC level without the AC amplitude being affected. This is performed through the operational amplifier B3 and transistor B2 III whose collector current of B2 III depends on the output voltage of B3, which can be adjusted with the potentiometers R53 to R58 depending on the frequency range.

When the Synchronizer SMDU-B1 is incorporated, its tuning voltage is applied via R41 to the amplifier B3; at the output of B3 the sum of the signals for diode bias and for synchronization is thus available. The temperature-dependent base-emitter voltage variation of B2 V appears inverted at the output of B3, compensating the temperature drift of the base-emitter voltage of B2 III since the two transistors are located in the same array.

The lowpass filter L1, C4 at the emitter of B2 III causes a heavy drop in gain at frequencies above 1 kHz. Noise voltages resulting from the control voltage from the Synchronizer SMDU-B1, amplifier B3 and transistor B2 III are largely suppressed.

4.6.3 -18-V and +60-V Regulators

See circuit diagram 250.1019 S

The highly stable and noise-free supply voltage of -18 V required for the RF oscillators and the FM amplifier is taken from a stabilizing circuit. The reference voltage is produced by the temperature-compensated ($< 1 \times 10^{-5}/{}^{\circ}C$) Zener diode Gl 16. The noise voltage of the diode is filtered by the RC section R62, C8. The operational amplifier B4 I controls the series transistor T5. The voltage is adjusted with R64. The negative supply voltage of the operational amplifier is stabilized with Gl 17.

The +60-V voltage required for the FM amplifier is derived from the stabilized -18-V source. The voltage ratio is determined by resistors R69, R72. The operational amplifier B4 II and transistor T12 are the control amplifiers, T6 is the series transistor.

4.6.4 Oscillator Switchover

See circuit diagram 250.1019 S

Contacts 1, 2, 3 of the pushbuttons S101 control the switching voltages for the individual oscillator ranges. Buttons 8, 7 and 5 switch the oscillator ranges 49 to 64.5 MHz, 63.5 to 88 MHz and 118 to 198 MHz directly. The limit switches of ranges 85 to 119 MHz and 286 to 395 MHz are used to switch the oscillators off in the conversion range (lowest range) at frequencies < 0.14 MHz and in the doubled range (highest range) at frequencies > 525 MHz. To this end, transistor T7 or T8 is rendered conductive when button 2 or 9 is depressed so that the control voltage at ST111.1 for the oscillator range 196 to 290 MHz now depends on the position of the limit switch S13 or S16 (see circuit diagram 249.4518 S). If S13 or S16 has switched off, a voltage of +15 V is at ST111.4 or ST111.5. This voltage is conveyed via Gl 22 or Gl 21 and T8 or T7 to ST111.1 and switches the oscillator range 196 to 290 MHz off. If the limit switch S13 or S16 is in the ON position, the control input of the oscillator range concerned is connected via R88 to -15 V. To switch the range 85 to 119 MHz or 286 to 395 MHz on, a negative voltage is applied via R85 or R83 to the control input of the range concerned; for switching off, a positive voltage from the limit switch S13 or S16 is used via diode Gl 23 or Gl 24. The switching voltage of the frequency range 85 to 119 MHz is adjustable with R80 since it is also used as bias voltage for a varactor of this range.

4.6.5 Diode Switch Control

See circuit diagram 250.1019 S

Contacts 4, 5 and 6 of pushbuttons S101 control the diode switch Y24 which selects the mixer Y22, the direct signal path or the doubler Y26. The mixer is switched directly via button 9 (0.14 to 50 MHz) and the doubler via button 2 (392 to 525 MHz), whereas the direct path is supplied with positive voltage via buttons 3 to 8 and ST113.3; resistors R89 and R90 cut the transistor T9 off at the same time. If none of buttons 3 to 8 is depressed, T9 conducts and connects -15 V to ST113.3.

By applying -15 V to ST113.14 it is possible to cut off the diode switch in all three signal paths so that the RF voltage is off. This is done either via the RF OFF button 40 on the front panel or by shorting the contacts 4 and 5 of the DEMOD. OUTPUT socket on the rear panel (e.g. by connecting the VOR-ILS Unit), thereby driving the switching transistors T1 and T2 in the rectified-voltage compensation subassembly Y41.

4.6.6 Output Filter Control

See circuit diagram 250.1019 S

The contacts 7, 8, 9 of the pushbuttons S101 deliver the voltages for the switching diodes which are used to select the individual lowpass sections of the filter Y31. The frequencies of the ranges 0.14 to 50 MHz, 49 to 64.5 MHz and 63.5 to 86 MHz pass through the same filter. The buttons 9, 8 and 7 which are associated with these ranges are therefore connected via diodes and via ST113.5 to a common control line. At the same time transistor T11 is cut off by these diodes. If none of buttons 7, 8 or 9 is depressed, the diodes are cut off and T11 becomes conductive via R93 so that ST113.5 is at -15 V. The common filter branch for the ranges 386 to 395 MHz and 392 to 525 MHz is controlled in the same way by means of diode logic and transistor T10.

4.7 Counter Y7

See overall circuit diagram 294.9021 S

4.7.1 Counter Input Y71

See circuit diagram 294.9580 S

The counter input unit includes the amplifiers for external signals from 15 Hz to 30 MHz, internal RF signals from 0.14 to 525 MHz, internal AF signals from 15 Hz to 150 kHz, the associated Schmitt trigger and a preamplifier for external signals from 20 to 525 MHz.

The amplifier branch for external signals in the range 15 Hz to 30 MHz is in operation if -15 V is applied to contact 2, the amplifier T7 for internal signals in the range 0.14 to 50 MHz then being automatically cut off. The amplifier branch consists of the diode limiter Gl 1 to Gl 4 which protects the input against overvoltage, the FET amplifier T1 with L1 increasing the gain in the upper frequency range, the diode limiter Gl 22, Gl 23 suppressing amplitude modulation, the emitter follower T2 for impedance transformation and the amplifier stage T3. The collector voltage of T3 is held constant at 0.6 V by the control amplifier Bl I. The reference voltage for the control is derived at Gl 21. The collector voltage of T3 determines the switching state of the Schmitt trigger T4, T5. The output level at contact 8 must be low if no input signal is present, to ensure that the frequency meter reads 0 in the least significant digit.

Signals below 100 kHz are rectified in diode Gl 9 via the RC network R23, C5 and applied to diode Gl 6 via control amplifier Bl II. Thus RF interference is suppressed in the case of signals below 100 kHz.

Internal signal-generator frequencies from 0.14 to 525 MHz are conveyed via ST75 and contact 3 to the input of the buffer amplifier T10. The amplified signal is applied via a resistance network and contact 11 to the RF output II and via contact 12 to the deviation-meter connector ST172. The voltage for the frequency measurement of the internal signals 0.14 to 50 MHz is tapped at the collector of T10 via R41. The lowpass filter L3, C17, L4, C18 ensures that only frequencies below 50 MHz are passed on to the amplifier T7. T7 operates when +5 V is present at contact 2 and at the same time -15 V is at contact 10. Thus transistor T1 and diodes GL7 and G19 are cut off simultaneously so that the paths EXT. 15 Hz - 30 MHz and AF INT. are off. The signal amplified by T7 is applied to the Schmitt trigger T4, T5 via Gl 11, the impedance transformer T2 and amplifier T3.

Internal AF signals from the modulation generator are applied via the lead-through D76 and contact 9 to the diode switch Gl 11, Gl 19. If +5 V is present at contact 10, then Gl 19 conducts. The signal is directly applied to the base of T2 and via T3 to the Schmitt trigger T4, T5.

External signals from 20 to 525 MHz are conveyed via ST72 and contact 4 to the preamplifier T11. The diodes Gl 16, Gl 17 limit the input signal and protect T11 against excessive voltages. The amplified signal is applied via contact 15 to the divider Y72.

4.7.2 Divider Y72

See circuit diagram 294.9515 S

The divider board includes an amplifier for external signals in the range 20 to 525 MHz, a diode switch for switchover from internal to external signals and a 10 : 1 divider which is followed by an amplifier for matching to TTL level.

The external signals of 20 to 525 MHz coming from the preamplifier of the counter control Y71 are applied via contact 1 to the two-stage amplifier T1, T2 and passed on from its output via C13 to the diode switch. The signal is also applied via contact 5 to the deviation-meter connector ST171.

The diode switch Gl 1 to Gl 11 permits selection of RF INT. or EXT. 20 - 525 MHz. The selected signal is applied to the limiter transistor T5, which provides the correct input level for the divider B1.

A special circuit prevents a wrong indication of the frequency meter in case the input level of the divider is too low or too high.
before the 10:1 divider B1 is rectified with Gl 17, filtered with C37 and applied via B2 I to the operational amplifier B2 II. Transistor T6 is thereby cut off if the level falls short of the required minimum at the input of B1. If the incoming signal is amplitude-modulated, an AF is produced at C37 with a DC component which is derived from the negative half-

wave of the RF voltage. Since B2 I plus Gl 19 and C39 represents a peak-responding rectifier, a DC voltage corresponding to the RF voltage in the modulation valley appears at C38. The correct threshold (minimum level) for switching off is thus maintained with amplitude-modulated signals. If the input level is such that a positive voltage is obtained at output 7 of B2 II, the PIN diode Gl 16 of the counter input circuit 294.9580 is reverse-biased. Causing the input voltage of T11 to be reduced.

The output signal of the 10 : 1 divider B1 wich ECL level is boosted to TTL level by the transistors T6, T7 and passed on via contact 8 to the counter control Y73 and via contact 9 and ST77 to the Synchronizer SMDU B1.

4.7.3 First Decade Y73

See circuit diagram 294.9621 S

The first decade consists of the 50-MHz counter B1 and the associated store B10.

The counter is driven via AND gates B2I to III and transistor T1. The gates permit switchover to the different counter channels. The count pulse reaches the outputs 2, 3 and 11 of B2 via flip-flop B5II.

The same board accommodates the 100 : 1 divider for the reference frequency (B3) and the 400-kHz frequency discriminator which produces a voltage for time-constant switchover in the modulator Y28 and the demodulator Y41.

The signals arriving via C1 from the counter input Y71 are pretreated in lowpass filter L1-C2 and amplified to TTL levels in comparator B4. Flipflop B5I provides frequency division and produces a 1 : 1 squarewave. This squarewave voltage is approximated to a sinewave by lowpass filter L2-C4 and taken to rectifier GL3 via the RC lowpass filter R3-C6 and to rectifier GL4 via the RC highpass filter C5-R7. The cutoff frequencies of these two filters are such that the rectified voltages are equal at about 400 kHz. If the frequency departs from this value, amplifier B6 connected as a Schmitt trigger is switched. R10 permits accurate setting of the switching point.

4.7.4 Counter with Indication Y74

See circuit diagram 294.9650

This board accommodates the counter control, decades 2 to 7 with the associated stores, decoders and indicating elements as well as the decoder and indication of the first decade.

The counter control circuit serves the purpose of supplying the digital counter with the necessary pulses. This includes, above all, a count timing pulse of accurate duration and short rise time. Different selectable counting times ranging from 0.04 s to 10 s are required. Therefore a timing pulse control is provided which permits the required counting time to be set. In addition to the count timing pulse, the counter control circuit must supply the transfer pulse which causes the binary information available at the counter output to be transferred to the display store. It also delivers a counter reset pulse which erases the counter content prior to the beginning of a new count period.

The crystal-controlled 10-MHz reference frequency is divided by B3 (first decade), B13, B17 and B18 to the frequency corresponding to the desired counting time. The dividers B14, B13II and B17I are switched in or bypassed with NAND gates, according to the desired counting time by the timing pulse control. Counting times of 0.04/0.4/4/0.2/2/20/0.1/1/10 s are thus obtainable.

The circuit is here described for a counting time of 1 s. Gate B15III and B15IV are inhibited, B15II is enabled so that divider B14 is bypassed. The presence of an L signal at BU2.10 inhibits gate B16I and enables B13II to count. With a counting time of 1 s, a frequency of 10 kHz is thus available at the output of B16II.

Divider B17I can be switched in additionally by an L signal at BU4.9. All time events are thereby extended by a factor of 10 so that the tenfold counting time is obtained.

The frequency is divided down to 1 Hz by B17II, B18I and B18II. The 2 : 1 divider B5II provides the counting time of 1 s for the count gate B2. During the counting period, H level is present at the $\overline{Q}$ output of flip-flop B9II; the count gate is enabled. The Q output of B9II is consequently at L level and resets the flip-flops B9I, B19I and B19II via their clear inputs, so that their $\overline{Q}$ outputs change to L state.

The count is terminated after 1 s. The $\overline{Q}$ output of flip-flop B9II changes to L level and inhibits the count gate. The inhibition of the flip-flops B9I, B19I and B19II is cancelled at the same time. Since the clock input 5 of flip-flop B19I is driven, for a counting time of 1 s, with the 1-kHz signal from the divider chain B13I and B13II, the Q output of B19I goes to H state. Upon return to L state, the flip-flop B19II changes from L to H, enables the NAND gate B8I and thus produces the store transfer pulse, which is inverted by B8IV and applied to the store of the first decade. By the 4 : 1

division of B19II and B19I, this pulse is delayed by 2 ms relative to the stop pulse for the counter.

After another 2 ms, the $\overline{Q}$ output of B9I changes to L state, supplying the reset pulse for the first decade. At the same time B8I is inhibited and the store transfer pulse terminated. When B9I changes state, its Q output goes to H and thus the divider chain B17II to B18II is preset to 9999 so that the counting interval is shortened. When the flip-flop B9I resets after 4 ms, this presetting is released. Upon the next pulse, the Q output of B9II and B5II changes from L to H, thus enabling the count gate again.

Pulse diagram

Count gate control
B5II, pin 12 (first decade)

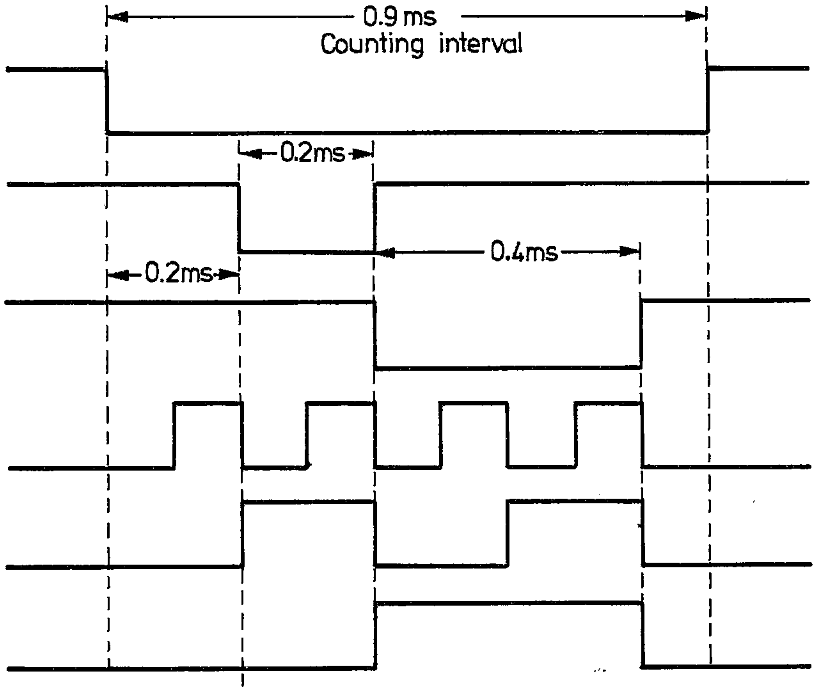
Store transfer pulse
B8IV, pin 11

Counter reset pulse
B9II, pin 8

Q output B19I, pin 9

Q output B19II, pin 12

Q output B9I, pin 9
(presetting of B17II to B18II to 9999)



4.7.5 Counter Switchover Y75

See circuit diagram 294.9867 S

The counter switchover board accommodates the pushbutton switches for selecting the counter mode. Together with the logic signals from the range switch board (ST80.2 to 5), they control, via gates B1III, B1IV, B2III, B2IV, B2II, B2I, B4II, B1II, B4I, the counting time required for the selected mode. The count gates (St2.3 to 2.4) are controlled via gates B3III, B4IV and the decimal point (ST1.1, 2, 3, 15, 16) via B5 and B6. The second deck of pushbutton S71 ensures, via ST6, switchover of the individual channels in the counter input and in the divider.

4.8 Modulation Unit Y8 of Radiotelephone Model

See overall circuit diagram 250.2015 S

4.8.1 Modulation Generator Y84

See circuit diagram 250.2696 S

The modulation generator is an RC generator covering variable frequency ranges from 30 Hz to 30 kHz and six selectable fixed frequencies. The use of metal-film resistors and mica capacitors in the Wien bridge makes this circuitry largely independent of temperature effects.

The frequency-determining bridge paths include the following components: for the six fixed frequencies C21, R11 to R17 and C22, R1 to R7; for the six variable frequency ranges R81, C1 to C10 and R81, C11 to C20.

The twin potentiometer R81 permits variation of the frequency within the individual ranges.

The negative-feedback circuit of the oscillating operational amplifier B1 includes thermistor R25 which ensures a constant amplitude over a wide frequency range and reduces the distortion. The effect of ambient-temperature variations on this thermistor is cancelled by a second thermistor, R27, in the subsequent amplifier stage B2. The generator is operative if FET T1 is inhibited. The required negative gate voltage is applied if one of buttons AM MOD. or FM MOD (in AM/FM switch Y86 I) is pressed. The generator voltage is taken directly (output B2) to the AM/FM switch Y86 for processing of the modulation voltage.

The generator signal is taken to the MOD. GEN. output socket BU6 (on 249.3011 S) via the level control 274.9710 (R84 LEVEL on 250.2015 S) which contains a 1:10 divider and the power output stage B3, B4. With an output impedance of 50 Ω (R43), this stage delivers a signal of max. 5 V_{rms} into a 200-Ω load. After pressing button MOD. GEN., this voltage is indicated on meter J81. After pressing button AF INT., the frequency is indicated on the digital frequency readout 3 .

4.8.2 AM/FM Switch Y86

See circuit diagram 250.2744 S

The modulation voltage for internal and external amplitude and frequency modulation is processed in the AM/FM switch. The modulation generator output voltage is applied to the AM/FM switch in the AM and the FM signal paths. The FM path allows the following modes:

- modulated or unmodulated
- internal or external modulation
- modulation with a preemphasis of 6 dB/octave

In the AM path, internal or external modulation or unmodulated operation can be selected. Simultaneous AM and FM can also be switched on.

4.8.3 AF Processing

See circuit diagrams 250.2644 S (Y82) and 250.2296 S (Y83)

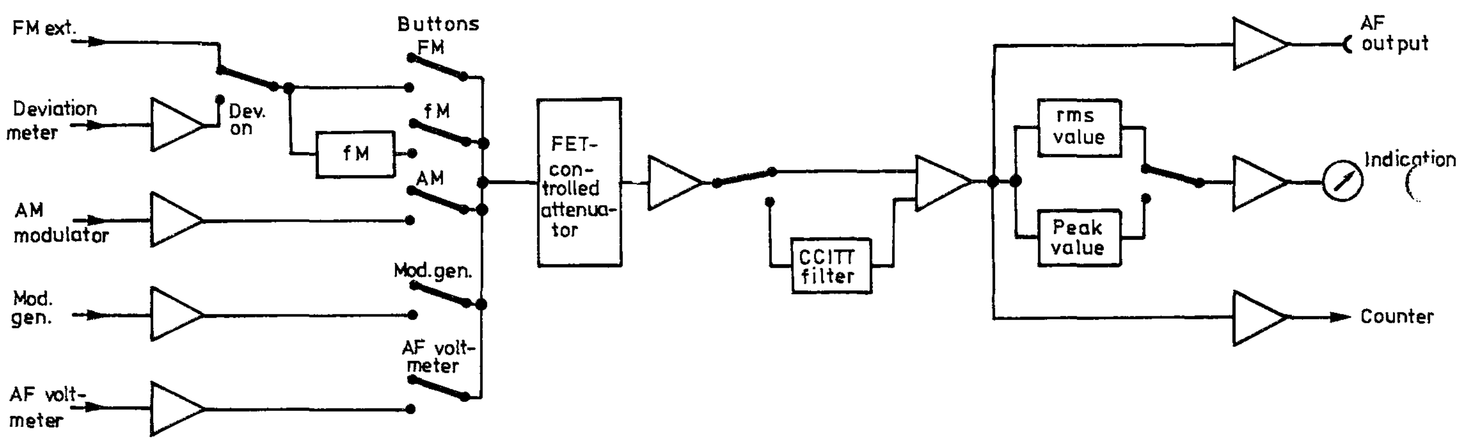


Fig. 4-2 Block diagram of AF processing circuit

All AF signals are amplified in separate stages such that, in the case of full-scale deflection, a voltage of 3 V_{rms} is applied to the attenuator.

Buttons INDICATION S81 take the modulation generator directly to the attenuator whereas the AF voltmeter is connected via an impedance transformer with a 10-dB attenuator (on 249.3011 S). The AM modulator delivers 480 mV for 100% AM; further gain is provided by B3 (see overall circuit diagram 250.2015 S).

The demodulated signal coming from deviation meter Y81 consists of a DC and an AC component. The DC component is used to drive - via comparators B8 (in the rms- and peak-responding meter Y83) - the READY LED which indicates that the deviation meter is ready for operation. Capacitor C2 separates the DC component from the AC component; R12 is the termination of the AF filter in deviation meter 250.3228. The AC component is amplified by B1 (in the 1-kHz bandstop filter and attenuator 250.2644). Switching of the signal between the inverting and the noninverting input of B3 permits selection of negative or positive deviation indication.

To measure the phase deviation, a deemphasis of 6 dB/octave (on 250.2644 S) is connected into the AF path of the deviation meter. B10 I is used as an impedance transformer; the negative-feedback network of B10 II determines the frequency response of the deemphasis.

The weighted voltage for the range $\frac{\Delta f}{f_{mod}} = 2$ is available at the output of B10 II.

Pushbuttons INDICATION permit selection of one of the following modes of indication:

- frequency deviation (FM)
- phase deviation (φM, 6 dB/OKT.)
- modulation depth (AM)
- modulation generator (MOD. GEN.)
- AF voltmeter (AF VOLTM.)

The corresponding signal is taken to the attenuator, a six-stage voltage divider, R73 to R78, which can be switched in 10-dB steps via FETs to reduce the AF signal to the required indication voltage (10 mV for f.s.d.). The FETs are driven via control logic Y85.

Only one FET conducts at a time (U_{gate} = 0 V) and the others are inhibited (U_{gate} < -10 V). The gain of the subsequent B11 can be increased by 10 dB with the aid of FET T12. Thus a total of seven indication ranges can be selected.

The signal is further processed in the rms- and peak-responding meter Y83 (250.2296 S). Here a CCITT filter can be connected for weighting the AF signal. The summing amplifier B1 amplifies the signal applied to the level of 3 V_{rms} (f.s.d.) required for rectification. The impedance transformer B7 delivers the AF signal to socket 42 (MOD. AF) on the front panel.

The signal to be measured is applied either to an rms-responding rectifier (B3) or a peak-responding rectifier (B6) which are connected into circuit by the control logic Y85 via FETs T2 and T4. The two rectifiers are used as follows:

<table>
<tr><th colspan="2">Mode</th><th>rms value</th><th>Peak value</th></tr>
<tr><td colspan="2">FM</td><td></td><td>X</td></tr>
<tr><td colspan="2">φM</td><td></td><td>X</td></tr>
<tr><td colspan="2">AM</td><td></td><td>X</td></tr>
<tr><td colspan="2">Modulation generator</td><td>X</td><td></td></tr>
<tr><td colspan="2">AF voltmeter</td><td>X</td><td></td></tr>
<tr><td rowspan="2">Deviation meter</td><td>Wanted deviation</td><td></td><td>X</td></tr>
<tr><td>Spurious FM</td><td>X</td><td></td></tr>
<tr><td colspan="2">Distortion</td><td>X</td><td></td></tr>
</table>

The rms-responding meter measures the true rms value

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T v^2\, dt}$$

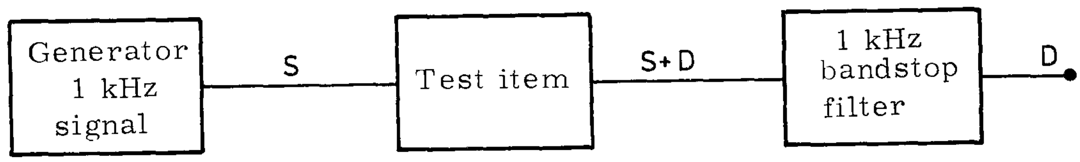
B3 is used for squaring and taking the square root, the integration is performed by R21 and C17. The peak-responding meter comprises the fast operational amplifier B6, diode Gl 4 and C16 which is charged to the positive peak value via Gl 4. Gl 4 is connected into the negative-feedback path of B6 such that the voltage increases with the full open-loop gain of the operational amplifier. To keep the discharging time constant of the peak-responding meter low, C16 is discharged via T1 and R5 if the voltage decreases. Gl 2, R27 and C15 determine the starting point of the discharge (about 40 ms). The discharging time determined by R5 is considerably shorter than the settling time of the moving-coil meter.

The DC voltages are applied to the meter amplifier B5 via FET T2 or T4. The gain of B5 is switched over from 1 to 2 by means of FET T6. The gain of 2 is required only for FM and φM indication using the 1.05-GHz Frequency Extension. The control voltage for FET T6 is cut in via the doubling button (locked if the 1.05-GHz Frequency Extension is not incorporated) and buttons FM and φM 23 via T9.

Diode Gl 11 protects the meter against negative voltages, the voltage limiter B5 II prevents overdriving of the moving-coil meter. Full-scale deflection is obtained at 300 mV, the limiter responds at 350 mV. Any possible permanent overload is thus limited to 17%.

4.8.4 Distortion and SINAD Ratio Meters

4.8.4.1 General Functioning



For distortion measurement, a low-distortion (< 0.5%) 1-kHz signal (S) is applied to the test item input. In addition to the 1-kHz signal (fundamental) the output signal contains the harmonics (D) produced in the test item. A filter separates the 1-kHz signal from this frequency mixture; next the ratio of the rms values of the filter input and output signals is formed. In this way the test-item distortion is obtained.

Distortion: $\dfrac{D}{S+D}$

D: distortion
S: signal, f = 1 kHz

In the case of SINAD ratio measurements, the test-item output signal contains a noise component in addition to the harmonics (the test item being for instance an RT receiver). This noise signal is also evaluated.

SINAD ratio: $\dfrac{S + N + D}{N + D}$

S: signal, f = 1 kHz
N: noise
D: distortion

4.8.4.2 Level Control

See circuit diagram 250.2644 S

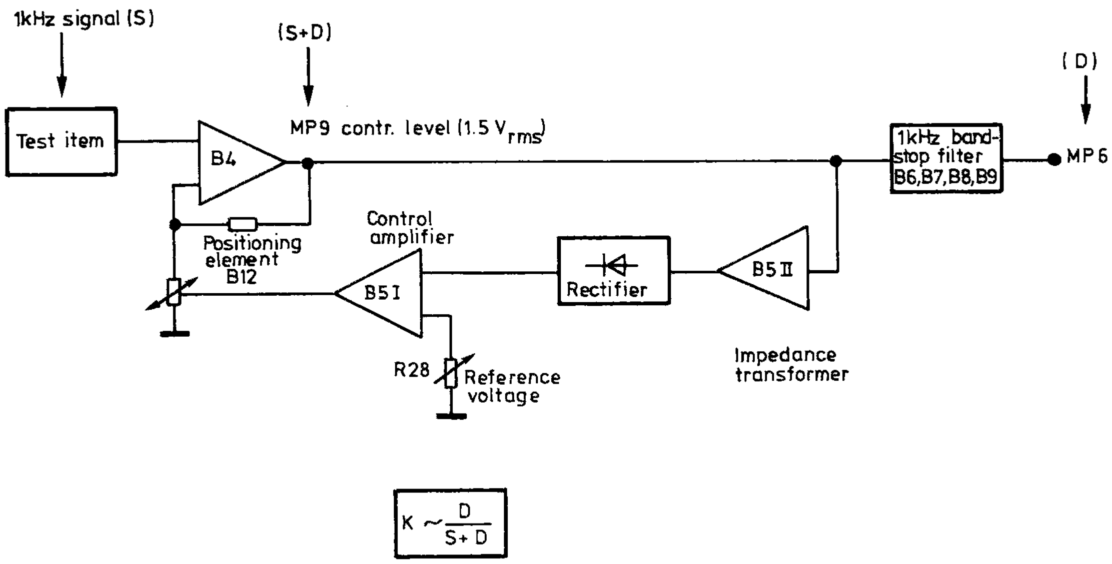


Fig. 4-3 Distortion meter with level control

The level control circuit keeps the AF level at the input of the 1-kHz bandstop filter constant so that the voltage measured by an rms-responding meter at the output of the 1-kHz bandstop filter is directly proportional to the distortion. After appropriate adjustment ($V_1 = V_2 \triangleq 100\%$), the meter indicates the distortion.

The AF signal is applied to amplifier B4 I via voltage divider R22, R23. The resistance of the optocoupler B12, which is connected into the negative-feedback path, and thus the voltage gain of B4 I, is varied as a function of the current injected via R25. The control voltage is obtained via Gl 6, Gl 5 and filter components C5, C6, R31 and R27, then applied to the optocoupler B12 via the control amplifier B5 I. The optocoupler reaches its minimum resistance value (2 kΩ) at about 40 mA. The detector uses combined peak- and average-responding rectification. It is adjusted via R27 and R31 such that, in the case of noisy signals, the maximum deviation of the rectified signal is 11% compared with an rms-responding rectifier.

When the signal at test point MP9 falls short of the permissible level (1.25 V), comparator B4 II switches on LED "uncal." and interrupts the signal path with the aid of T16 (input voltage approx. 50 mV). The level at MP9 is adjusted by varying the reference voltage of the control amplifier with R28. In this way, the indication voltage is adjusted at the same time.

4.8.4.3 1-kHz Bandstop Filter

See circuit diagram 250.2644 S

The 1-kHz bandstop filter consists of three circuits whose resonance frequencies are adjusted in different ways.

The first resonant circuit is constituted by a Wien bridge; here, a symmetry adjustment (R41) is required in addition to the frequency adjustment (R39).

The subsequent series resonant circuits are decoupled via B9 I and B9 II, the resonant-circuit capacitance being constituted by C9 or C11 and the inductance electronically realized by B7 and T2, T3 or B8 and T4, T5 (gyrator circuit). Amplifier B9 II compensates for the transmission loss of the distortion meter; in the case of full-scale deflection (100%) a voltage of 3 V_{rms} is present at test point MP6.

4.8.5 Control Logic Y85

See circuit diagram 274.9861 S

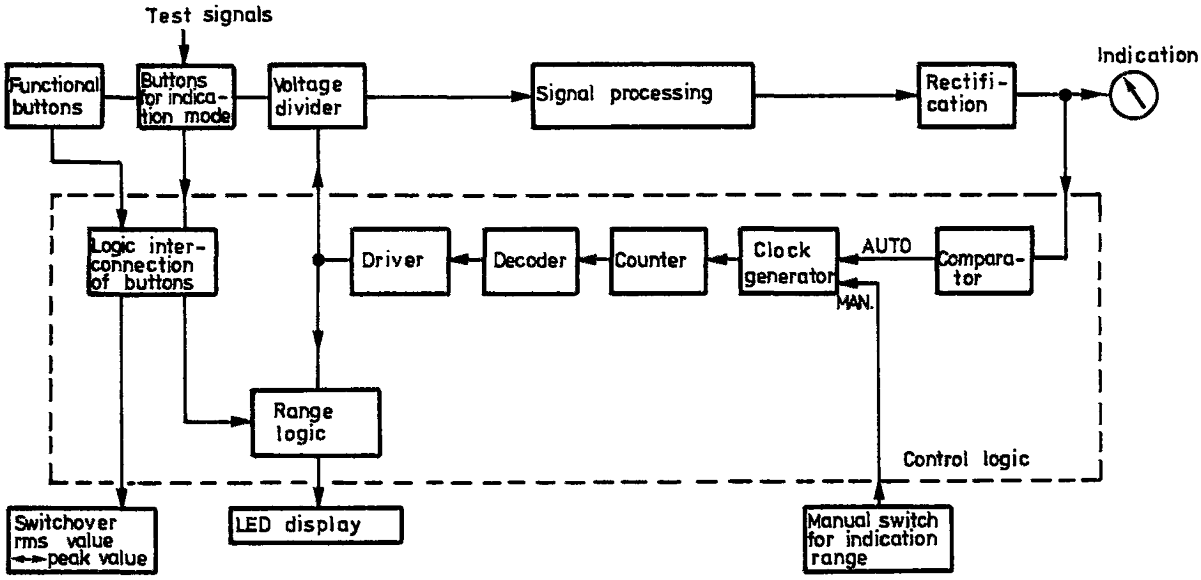


Fig. 4-4 Block diagram of control logic in modulation unit

4.8.5.1 Automatic Operation

The DC signal from the meter amplifier is applied to comparators B1 I, B1 II and B2. B1 I, B1 II switch in the clock generator B4 I via gate B3 if the indication voltage is > 1.05 V or < 0.3 V. The clock frequency, produced by monostable B4 I, is determined by R28 and C20. Monostable B4 II extends the very short clock pulse (30 ns) and feeds it to counter B5. Comparator B2 provides up/down control of B5.

With an indication voltage of > 0.65 V, the count-up mode is operative and with signals of < 0.3 V the count-down mode is switched in.

The signals at the data inputs A, B, C and D (pin 9) determine the initial state of the counter. Low is always applied to inputs A, B and D; depending on the mode of indication, input C receives a high or a low signal. The decimal decoder B6 drives via B9 and B20 the FETs of the attenuator in sub-assembly Y82 I (1-kHz bandstop filter and attenuator). The seven indication ranges for FM, φM, MOD. GEN. and AF VOLTM. require seven counting steps and the five indication ranges for AM and distortion five counting steps. The first two counting steps are suppressed by preprogramming the data inputs. As soon as button AM or the button associated with distortion measurements is pressed, this suppression becomes effective. Decoder B6 delivers the LOAD pulse via B13 IV, B15 IV if the counter switches over into one of the ranges which are to be suppressed.

Mode of indication	Data inputs of counter A B C D
FM/φM/MOD.GEN./AF VOLTM.	0 0 0 0
AM, distortion	0 0 1 0

If no signal is applied, divider B5 is to stop in the most sensitive range. Decoder B6 (pin 1) inhibits the NOR gate B3 II and thus disconnects the clock generator B4 I. If the signal is higher than the maximum indication range would permit, decoder B6 (pin 7) inhibits NOR gate B3 I via inverter B8 and also disconnects the clock generator B4 I.

4.8.5.2 Manual Range Selection

In manual operation, the measurement range must be freely selectable irrespective of the comparator signal level. In the positions STOP and MAN., the RANGE switch disconnects the clock generator B4 I via its input 11 (clear). The count mode of B5 is set to "up" via B12 I (LOW at input 5 DN/UP). When changing the RANGE switch over from STOP to MAN., a pulse is applied via B3 III to monostable B4 II which advances the counter by one range. If the seventh decimal range is reached, the LOAD pulse resets the counter to the programmed initial value. NAND gates B10 eliminate contact bounce.

4.8.5.3 Indication Range Logic

The indication logic interconnects the INDICATION buttons with the functional buttons for deviation, distortion and SINAD-ratio measurement.

This logic controls

- the indication modes mV, %, kHz and rad

- the indication ranges 1 to 100
  0.3 to 100
  10 to 10,000
- automatic switchover from rms to peak value
- the LEDs for 6, 12 and 20 dB SINAD

For the interconnections see table 4-1.

Table 4-1 Logic interconnections

Indication buttons	Range	Indication	Rectifier	Measurement mode
FM	.100 -.300	kHz	rms value	internal modulation
	1 - 100	kHz	peak value	
φM	.100 -.300	rad	rms value	
	1 - 100	rad	peak value	
AM	1 - 100	%	peak value	AM int.
MOD. GEN.	10 - 10 000	mV	rms value	voltage
AF VOLTM.	10 - 10 000	mV	rms value	voltage
Combination of indication and functional buttons				
Button	**Range**	**Indication**	**Rectifier**	**Measurement mode**
FM + deviation	.100 -.300	kHz	rms value	spurious FM
	1 - 100	kHz	peak value	wanted deviation
φM + deviation	.100 -.300	rad	rms value	spurious FM
	1 - 100	rad	peak value	wanted deviation
FM + deviation + distortion φM + deviation + distortion	1 - 100	%	rms value	distortion
AF VOLTM. + distortion	1 - 100	%	rms value	
FM + deviation + SINAD ratio φM + deviation + SINAD ratio	1 - 100 +6 dB SINAD 12 dB SINAD	%	rms value	SINAD ratio; LED "uncal." lights up if level is too low
AF VOLTM. + SINAD	20 dB SINAD	%	rms value	
No button pressed		no indication		

4.8.5.4 Extension of Indication Ranges

The indication range logic can be adjusted to different indication ranges by resoldering T2.

	Wiring	Indication range	Indication mode
a)	no link	10 mV - 10 V	MOD. GEN. and AF VOLTM.
b)	link 1-3	1 mV - 1 V	AF VOLTM.
c)	link 1-2	1 mV - 1 V	MOD. GEN. and AF VOLTM.

For modification b), the gain in the signal path is to be increased by the factor 10. To this effect, the impedance converter 274.8165 has to be modified as follows:

Exchange operational amplifier B1 (LM 310) for LM 318 (BO 252.5240) and remove resistors R9 and R10.

4.8.6 Deviation Meter

See circuit diagram 250.3228 S

4.8.6.1 SIMPLEX Mode

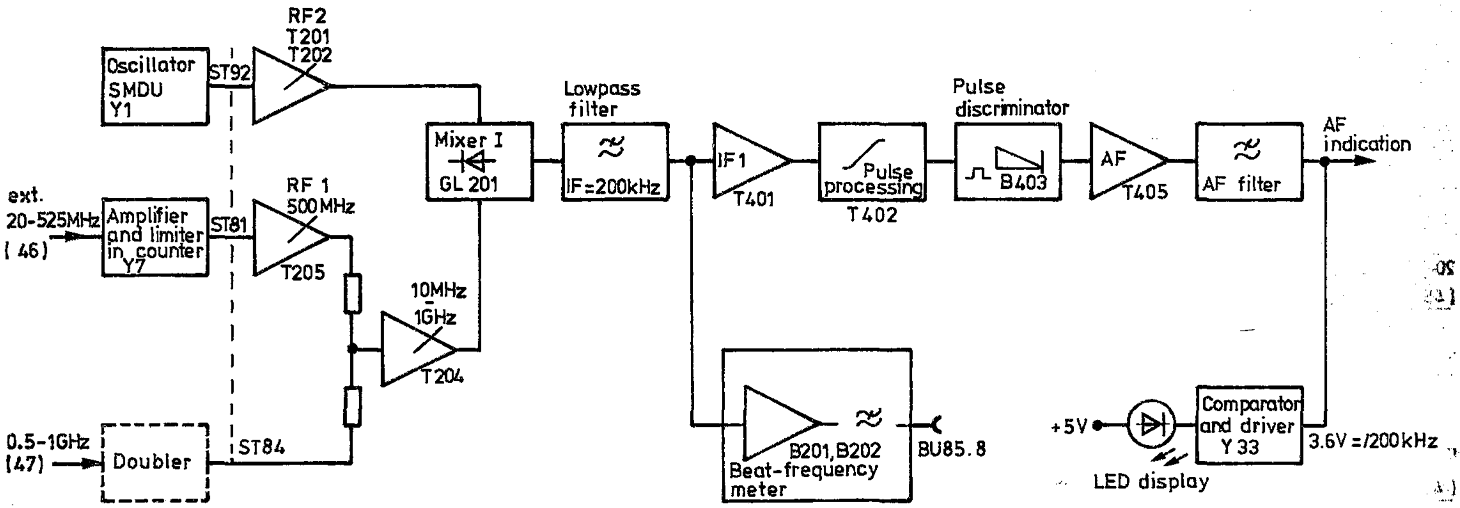


Fig. 4-5 SIMPLEX mode

The RF signal coming from the test item is brought to a constant level of 40 mV_{rms} in a preamplifier and limiter stage Y72 which is included in the counter Y7. This signal is applied to the deviation meter subassembly, i.e. to the buffer amplifier stage T205, from where it is passed on to diode Gl 201. In this diode, the RF signal is mixed with the signal generator frequency which is applied from the oscillator Y1 in the basic unit via ST82 to the RF amplifier. The difference frequency of 200 kHz is taken via a lowpass filter and the gates B101 (enabled) to the IF amplifier T401 and subsequently to the pulse processing stage T402. The produced 200-kHz squarewave signal is applied to pulse discriminator B403. Monostable B403 marks every positive edge of the squarewave with a pulse of constant width so that in case of a frequency variation of the IF signal a squarewave curve with a frequency-dependent mark-to-space ratio is applied to the collector of T405. Impedance transformer T408 matches the AF filter to discriminator B403. The AF filter, which has an upper cutoff frequency of about 20 kHz, forms the DC mean value from the 200-kHz pulses. In the case of modulation, the demodulated AF signal is superimposed on this DC component. The AF signal is applied to the AF processing circuit which is included in the rms- and peak-responding meter Y83. The DC component of the AF signal drives, via two comparators, the LED DEV. METER READY which lights up as soon as a DC voltage of about 0.6 V corresponding to the 200-kHz IF signal is applied to the comparators.

4.8.6.2 DUPLEX Mode

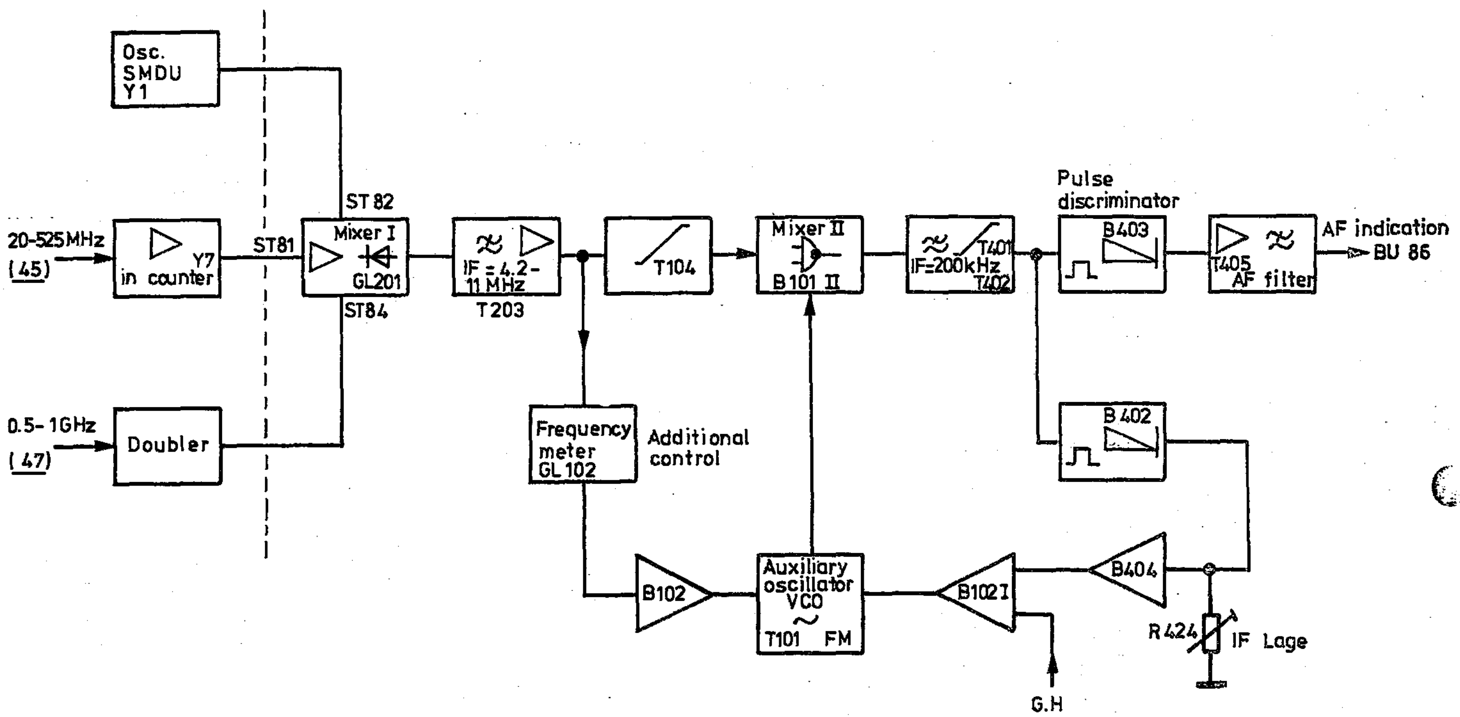


Fig. 4-6 DUPLEX mode

As in the SIMPLEX mode, the RF signal coming from the test item and the signal-generator frequency are mixed in diode Gl 201 in DUPLEX operation. The IF signal (IF = 4.2 to 11 MHz) is applied to mixer B101 after amplification in T203 and limiting in T104. In B101, the signal is mixed with the frequency of the voltage-controlled auxiliary oscillator so that an IF of 200 kHz is obtained.

The frequency of the auxiliary oscillator is controlled such that the difference frequency produced in mixer B101 remains constant (IF = 200 kHz). The control voltage is derived - in pulse discriminator B402 - from the squarewave signal which has been brought to TTL level. A frequency-proportional DC voltage is produced at the integrating capacitor C429. After amplification in the control amplifier B404, this voltage controls varactor Gl 101 of the auxiliary oscillator via the summing amplifier B102 I. In conjunction with series capacitor C108, varactor Gl 101 constitutes the capacitance of the oscillator circuit. The tunable frequency range of the oscillator is ca.4.0 to 10.5 MHz.

Potentiometer R424 permits the reference voltage of the control amplifier B404 and thus the value of the IF (nominal value = 200 kHz) to be adjusted.

The control amplifier functions as an integrator and, in the case of modulation, suppresses the AF demodulated in discriminator B402.

AFC Circuit

The AFC circuit is effective only if the difference frequency between the first IF and the auxiliary oscillator signal is around 200 kHz. Only in this case does the level amplifier B404 receive a DC signal which is within the control range of amplifier B102 I and the auxiliary oscillator can be controlled. After switching on or frequency changeover, a search circuit ensures that the auxiliary oscillator sweeps the search range (4 to 10.5 MHz), the search circuit being the discharge circuit of the integrating capacitor (C431) in the negative-feedback path of control amplifier B404. It responds at an IF of > 210 kHz; in this case comparator B405 switches in FET T406 and C431 discharges. This discharge varies the output voltage of the control amplifier and the auxiliary-oscillator frequency changes. The time constant introduced by R433/C426 and the hysteresis of the comparator ensure that the discharge is not switched off until the oscillator has reached its lowest frequency. Next the control amplifier drives the auxiliary oscillator through the control range until the IF of 200 kHz is reached and the control circuit locks.

If the IF is > 3 MHz, no signal reaches the discriminator via the lowpass filter and the search procedure does not take place. If the capture range is reached, the auxiliary oscillator tunes in directly in the case of continuous frequency variations up to 6.5 MHz without starting the search circuit.

Additional Control of Auxiliary Oscillator

The additional control element (Gl 102) produces a DC voltage which is frequency-proportional to the RF signal and presets the auxiliary oscillator via B102 II and Zener diode Gl 103 such that the pull-in range with respect to the IF signal of mixer I (4.2 to 10.7MHz) is smaller than the harmonic interval. If no RF signal is applied, the oscillator functions at about 7.5 to 7.9 MHz. In this way locking of the control circuit to a harmonic is prevented.

4.8.6.3 Relay Mode

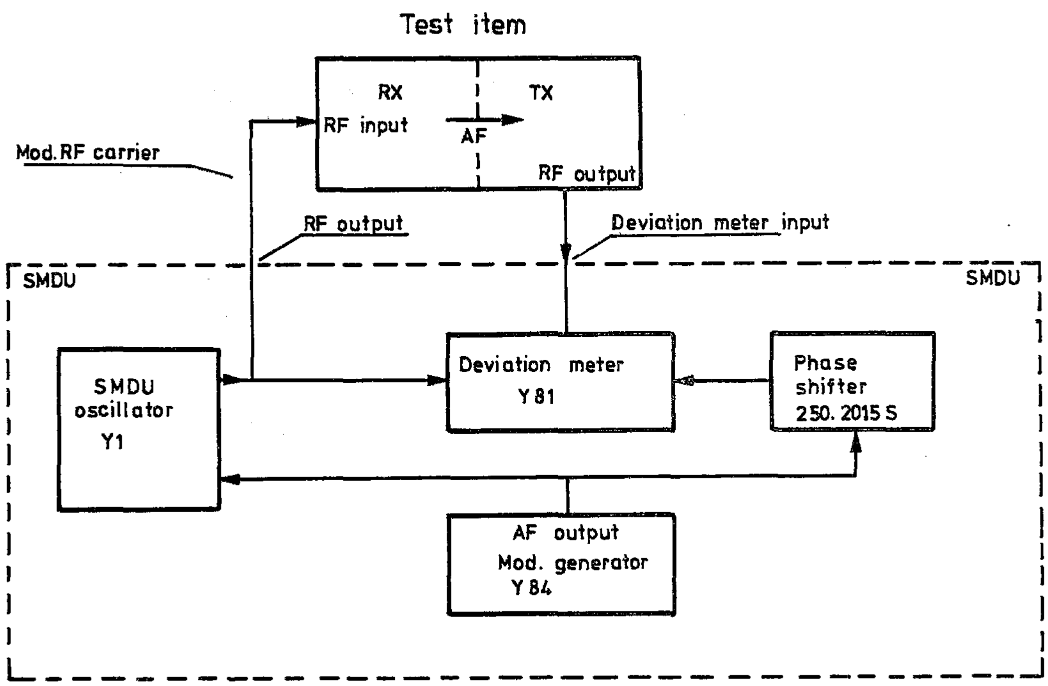


Fig. 4-7 Relay mode

The relay mode permits measurements on transmitting/receiving equipment using only one signal generator. The modulated signal coming from the SMDU oscillator is simultaneously used for application to the receiver and for deviation measurements on the transmitter.

The modulation of the SMDU oscillator which interferes with deviation measurements is cancelled in the deviation meter by an inverse modulation of the auxiliary oscillator. To introduce the inverse modulation, amplitude and phase adjustment is required; to this effect potentiometers ZERO I (29) and ZERO II (32) are used. The phase shifter is constituted by B2, including C1 and R92 (on 275.0022 S). The maximum phase shift is +180° when relay switch 27 is at f_{up} and -180° when f_{low} is selected. The output signal (ST85.3) of the phase shifter is added via the summing input of amplifier B102 I (on 250.3228 S) to the control voltage applied to the auxiliary oscillator and produces the necessary oscillator deviation.

4.9 Power Supply Y9

See circuit diagram 250.2815 S

The power supply section produces four regulated voltages:

a) +5.2 V for the supply of all subassemblies with digital functions (counter Y7, range switch Y10, mixer oscillator Y6, modulation unit Y8, Synchronizer SMDU-B1, 1.05-GHz Frequency Range Extension SMDU-B3 or 1.05-GHz Frequency Doubler SMDU-B5).

b) +15 V for the supply of RF and AF amplifiers, operational amplifiers and diode switches.

c) -15 V for the supply of operational amplifiers and diode switches.

d) +21 V for the supply of the RF final amplifier.

In addition, the power supply provides the following raw voltages:

a) +12 V for the switching of the RF relays in the Overload Protector SMDU-B2, in the 1.05-GHz Frequency Range Extension SMDU-B3 or in the 1.05-GHz Frequency Doubler SMDU-B5 and for the supply of the lamps in the indication Y74.

b) +24 V as high-end voltage for the supply of the RF amplifiers in the 1.05-GHz Frequency Range Extension SMDU-B3 or in the 1.05-GHz Frequency Doubler SMDU-B5.

c) -24 V as high-end voltage for the supply of the oscillator Y1 and the FM amplifier in the range switch Y10 with -18 V.

d) +65 V as high-end voltage for the supply of the FM amplifier in the range switch Y10.

The regulated voltages +5.2 V, +21 V and -15 V are adjustable whereas the +15 V is fixed by the regulators B3 and B4. The regulating circuits for 5.2 V and -15 V include transistors T1 and T3 respectively. The maximum available output current is therefore much higher than that obtainable with the corresponding regulators B1 and B5 alone. Transistor T2 provides current limiting in the 5.2-V regulating circuit.

4.10 Synchronizer SMDU-B1

See overall circuit diagram 249.6340 S

4.10.1 Fine Tuning Y201

See circuit diagram 249.6610 S

The fine tuning board carries the sampling frequency divider, the program divider and the fine tuning oscillator with mixer and frequency discriminator. The program divider and the fine-tuning oscillator are permanently in operation, whereas the sampling frequency divider is switched on only if the SYNCHRON. button on the front panel is depressed. The spacing of the locked frequencies is determined by the sampling frequency divider and the program divider; it equals the sampling frequency multiplied by the division ratio of the program divider.

Program divider

The input signal at contact 10 which is to be synchronized has already been divided:

by 10 in the frequency range 0.14 to 396 MHz
by 20 in the frequency range 392 to 525 MHz
by 40 in the frequency range 510 to 1050 MHz (only with built-in 1.05-GHz Frequency Range Extension SMDU-B3 or 1.05-GHz Frequency Doubler SMDU-B5).

The signal present at contact 10 is divided in the ratio 4 : 1 by B21 I/II. The succeeding two 2:1 dividers B22 I and B22 II can be bypassed. In the frequency range 392 to 525 MHz, the divider B22 II is bypassed by applying H level to ST1.5. In the range 510 to 1050 MHz (only with built-in 1.05-GHz Frequency Range Extension SMDU-B3 or with built-in 1.05-GHz Frequency Doubler SMDU-B5), the divider B22 I is bypassed by applying H level to ST1.7. The other division ratios are determined by the positions of the CH. SPACING switch (S202 I) as follows:

Spacing	H level at	Selected divider	Division ratio	Division ratio of B21 I/II, B22 I/II	Overall div. ratio	Sampling frequency
12.5 kHz	ST1.4	B26 I	5	2x2x2x2 = 16	80	15.625 Hz
20 kHz	ST1.1	B25 I/II, B27 II	2x2x2	16	128	15.625 Hz
25 kHz	ST1.2	B26 I, B27 II	5x2	16	160	15.625 Hz
50 kHz	ST1.3	B26 I/II, B27 II	5x2x2	16	320	15.625 Hz
100 kHz	ST1.10	B26 I/II, B27 II	5x2x2	16	320	31.25 Hz
150 kHz	ST1.11	B26 I, B27 I, B27 II	5x3x2	16	480	31.25 Hz

Sampling frequency divider

In synchronized operation without fine tuning the 10-MHz crystal reference signal is conveyed from contact 1 via B2 IV/I to the frequency divider. With synchronization plus fine tuning the variable frequency of the VFO is used as reference signal and applied to the frequency divider via B2 II/ III/I.

The sampling frequency divider consists of the four 10 : 1 dividers B11 to B14, the 16 : 1 divider B15 and the two 2 : 1 dividers B16 I/II, the first of which, B16 I, can be bypassed by gate B17 for the spacings 100 kHz and 150 kHz of the locking points. With an input frequency of 10 MHz the sampling frequencies at contacts 8 and 9 are as follows:

Sampling frequency 15.625 Hz for spacings of 12.5/20/25/50 kHz

Sampling frequency 31.25 Hz for spacings of 100/150 kHz.

VFO

The voltage-controlled VFO consists of the oscillator transistor T2, tank circuit L2, C16 to C18 and tuning diode Gl 4. The oscillator is followed by the emitter follower T3 and switching transistor T4. The frequency-variable 10-MHz signal is conveyed via gates B2 II and B1 III to the mixer gate B1 II. The reference frequency from the 10-MHz crystal oscillator Y63 is taken from contact 1 via B1 IV to the mixer gate B1 II. The lowpass filter C1, L1, C2 conveys the difference frequency to the switching gate B1 II. The lowpass filter C1, L1, C2 conveys the difference frequency to the switching gate B1 I and to the divider B3 I/II. This divider can be switched into circuit as required via the gates B5 I/II/IV. The difference frequency of B1 I is conveyed

via B5 I, without division, for the frequency ranges 0.14 to 50/196 to 525 MHz,
via B5 II, divided by 2 : 1, for the frequency range 118 to 198 MHz,
via B5 IV, divided by 4 : 1, for the frequency range 49 to 119 MHz

to the discriminators B4 and B6. The monostable B4 is an auxiliary discriminator facilitating capture and the monostable B6 is the main discriminator. The output signal of B6 controls a voltage switch consisting of the differential amplifier B7 I to IV and the constant-current source B7 V, T1, B8. The operational amplifier B10 stabilizes the negative supply voltage. The integrator B9 functions as a lowpass filter and comparator for the adjustment of the required oscillator frequency. The fine-tuning voltage is applied as reference via ST1.8 to pin 3 of the integrator B9. The auxiliary discriminator B4, switching transistor T5 and integrator B18 facilitate capture if the oscillator frequency is too low. The oscillator frequency is then varied in the opposite direction via the diode Gl 3.

4.10.2 Sampler Y202

See circuit diagram 249.6656 S

The TTL signal of the program divider in the fine tuning section Y201 arrives at contact 1 and is transformed into a triangular voltage which is symmetrical about zero. The squarewave-to-triangle converter consists of the switching transistors T1, T4, the current sources T2, T3 and the current regulators B1, B2. The operational amplifier B3 stabilizes the negative supply voltage, diode Gl 9 functioning as the reference element. The combination T5, T6 forms a temperature-compensated impedance transformer.

With L signal at the input, T1 is conducting and C3 is charged with a constant current via T2. The current is regulated by B1 in such a way that the positive peak voltage at test point MP1 is constant and independent of the period of the TTL input signal. H signal at the input cuts T1 off and T4 conducts. C3 is discharged via T3 and then charged in the opposite sense. Current regulation with B2 affords a constant negative peak voltage.

The triangular voltage is isolated by C9 and applied via the emitter follower T7 to the first sampling transistor T9. Resistor R30 permits an offset voltage for the sampling system to be adjusted. The signal at C11 (can be measured at MP2 after the impedance transformer T10) equals the triangular voltage at T6 for the conduction period of T9. When T9 is cut off, C11 stores the instantaneous value of the voltage at the switchover point.

At the same time T11 conducts and C12 assumes the voltage at C11. This voltage is passed on via the emitter follower T12 and contact 4 to the diode filter Y203. When the triangular voltage is in phase with the sampling voltage, a constant voltage exists at Mp2 and at contact 4. If the two signals are out of phase the voltage varies continuously.

4.10.3 Diode Filter Y203

See circuit diagram 249.6691 S

The diode filter consists of the lowpass filter C1, C2, impedance transformer T1 and amplifier B1. The gain of B1 is changed when the spacing of the locking points is switched over, in order to provide constant loop gain. The tuning voltage at contact 2 is applied via ST203.9 and ST114.12 to the FM amplifier in the range switch Y10 (see section 4.6.2).

4.10.4 Control Section Y204

See circuit diagram 249.6691

An additional control to ±13.5 V is required for the supply voltage of the fine tuning oscillator. The voltage is derived from the regulated ±15 V. Since the two regulating circuits are of symmetrical design, only the positive section is described.

The high-end voltage is applied to point 1. T1 is switched on via R1 and R2. In the control amplifier B1, the divided output voltage is compared with the reference signal derived from Gl 1. The control signal from B1/6 drives the base of transistor T1. Transistors T1 and T2 are mounted in sockets to provide additional shortcircuit protection.

4.11 Overload Protector SMDU-B2

See circuit diagram 249.7346 S

The overload protector guards the final stage Y30, control amplifier Y38 and RF attenuator Y4 against RF and DC voltages that may be applied inadvertently to the RF output on the front panel. The connection between the RF attenuator and the RF output is in this case interrupted by means of relay contact rs1. The voltage is rectified by diode Gl 51 following the capacitive voltage divider C51, C52 and applied to the operational amplifier B1. Any DC voltage applied to the RF output is conveyed via Gl 1 or Gl 2 to the operational amplifier, whose output signal drives the reed relay RS1 via gates and via T1 and T2. When the circuit responds the LED on the front panel is lit via B3 III. The monostable B2 delays the resetting action.

4.12 1.05-GHz Frequency Range Extension SMDU-B3

See circuit diagrams 249.9484 S and 249.9549 S

This 1.05-GHz Frequency Range Extension consists of the following four functional groups:

doubler	Y301
bandpass filters	Y302
final stage	Y303
filter control	

In the range 0.14 to 525 MHz the RF signal is taken, via rs2 and rs3, from amplifier Y2 to the RF attenuator Y4.

In the range 510 to 1050 MHz, the RF signal (205 to 525 MHz) is applied, via rs2, to the doubler Y301 where it is filtered, doubled and then amplified (see section 4.12.1).

The RF signal coming from the doubler is taken to four switch-selected band-pass filters Y302 (see specifications 911.2508 K in the Appendix) which suppress the subharmonics 0.5 f and 1.5 f. The bandpass filters are switched by a logic circuit driven from the range selector Y10 and the microswitch on the oscillator Y1 (see section 4.12.2).

Next, the RF signal is amplified in the final stage Y303 (see specifications 912.4604 K), a thin-film power amplifier, and is fed, via rs3, to the RF attenuator Y4.

4.12.1 Doubler

See circuit diagram 249.9549 S

The RF signal which is to be doubled passes through a lowpass filter (249.9619) with the cutoff frequency of 550 MHz and is brought to the correct level with the aid of the attenuator network R8, R9, R10.

The transformer TR11 delivers the RF signal to the doubler diodes Gl 11I, Gl 11II, Gl 12I and Gl 12II. These diodes operate as full-wave rectifiers so that the fundamental and the third harmonic are heavily suppressed. The doubled RF signal is amplified in two transistor stages, T11 and T12. A bias (DC) current passes through the diodes; R13 permits variation of the current distributed to the two diode paths; in this way the RF signal is balanced.

4.12.2 Doubler Control

See circuit diagram 249.9484 S

The four bandpass filters Y302 are selected via diode switches. The voltage required for switching the filters on is -15 V and that for inhibiting them +15 V. The diode switches are controlled with the range buttons via ST303, contacts 12, 13 and 14, and with a microswitch on the oscillator via ST303, contacts 8, 9, 10 and 11. For the logic connections, see table 4-1.

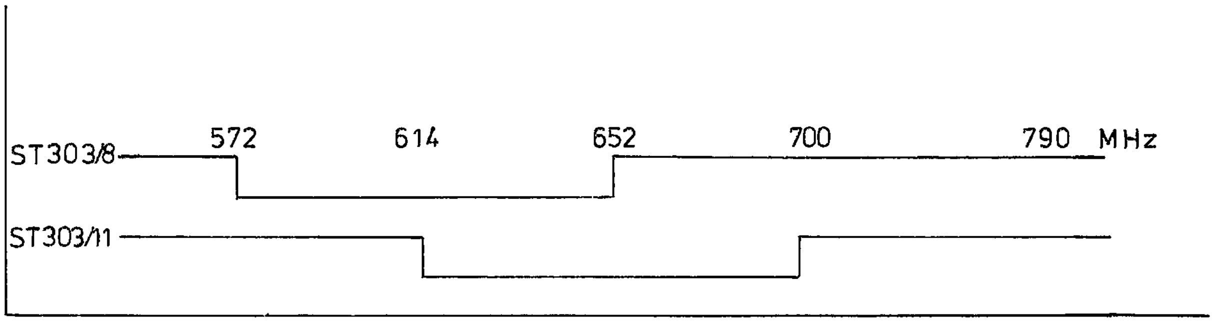
In addition to the switching logic, the voltage regulator B4 for the final stage Y303 and the relay control are located on this circuit board. Transistors T1, T2 and T3 conduct if +5 V is applied from the doubler button to ST303/2. In this way the coaxial switches RS2 and RS3 are set to the doubling mode. At the same time RS1 connects the supply voltages for the bandpass filters.

Table 4-1

Connector ST303	Bandpass filter I	Bandpass filter II	Bandpass filter III		Bandpass filter IV	
Contact	480-580 MHz	572-701 MHz	694-858 MHz		851-1050 MHz	
8	X	0 V/5 V +)	5 V +)	0 V +)	X	Micro-switch (oscil-lator)
9	0 V	0 V	0 V		0 V	
10	X	X	X	X	0 V	
11	X	5 V/0 V +)	5 V +)	0 V +)	X	
12	0 V	0 V	0 V	5 V	+5 V	Buttons
13	0 V	5 V	5 V	0 V	0 V	
14	+5 V	0 V	0 V	0 V	0 V	
		572-790 MHz		784-1050 MHz		

X Any voltage

+) Pulse diagram for contacts 8 and 11



4.13 1.05-GHz Frequency Doubler SMDU-B5

See circuit diagram 249.9549 S

This 1.05-GHz Frequency Doubler consists of the functional groups

doubler Y301
final stage Y303.

In the range 0.14 to 525 MHz, the RF signal is taken, via rs2 and rs3, from amplifier Y2 to the RF attenuator Y4.

In the range 510 to 1050 MHz, the RF signal (205 to 525 MHz) is applied, via rs2, to the doubler Y301 where it is filtered, doubled and then amplified. The doubler functions in the same way as for SMDU-B3 (see section 4.12.1).

The voltage regulator B4 for the output stage Y303 and the relay control are located on board 275.1335. Transistors T2 and T3 conduct if +5 V is applied from the doubler button to ST303/2. Thus the coaxial switches RS2 and RS3 are set to the doubling mode.

4.14 1-GHz Frequency Meter SMDU-B4

See circuit diagram 250.0012 S

The 1-GHz Frequency Meter consists of the following three circuit boards:

PIN diode attenuator	250.0164
amplifier	250.0212
counter	250.0270

4.14.1 PIN-diode Attenuator

The RF signal to be measured arrives at connector ST401 and is attenuated by the PIN-diode network.

If the control voltage at point 3 is about 7 V, diodes Gl 1, Gl 3 and Gl 5 conduct and diodes Gl 2 and Gl 4 are inhibited. The control network has its maximum attenuation. If the voltage at point 3 increases, diodes Gl 2 and Gl 4 start to conduct. Thus the current flowing through R1 and R2 increases, the voltage becomes higher and Gl 1, Gl 3 and Gl 5 start to block. At about 11 V (point 3), minimum attenuation is attained.

4.14.2 Amplifier

The RF signal is first amplified by about 20 dB in the thin-film amplifier B11 (see specifications 910.4620 K) and then taken to the thin-film buffer amplifier B12 (see specifications 912.1305 K) where it is further amplified and then applied to the counter via output A2, point 6. The level of the signal is measured at output A2 and compared with a reference signal, which can be adjusted with R14, in the comparator B10I. The output signal (A2) of B10I drives the PIN-diode attenuator. In this way a constant output signal is obtained at point 6.

If the control signal at the output of B10I exceeds the voltage set with R15 and R16 (input voltage too small), the second comparator, B10II, switches to a positive voltage at its output. The signal is then taken to the counter.
From the buffer amplifier output A1 the RF signal is applied to the deviation meter via connector ST403 and cable K403. The output level is approx. 50 mV.

4.14.3 Counter

The frequency of the input signal is first divided by 4 in B20. This ECL 1-GHz frequency divider requires an operating voltage of 7.4 V. This voltage is regulated in B22 and can be adjusted with R22.

The second ECL divider, B21, divides the frequency by 5 so that a frequency divided by 20 is available at the output of B21. The ECL level is converted into a TTL level using T20 and T21. T22 is the power driver for the 50-MHz signal which is taken to the counter via connector ST402 and cable K402.

When the switching signal at point 7 on the amplifier board 250.0212 changes over to positive voltage, Gl 21 becomes conductive and T20 is switched on. Thus no signal can pass from B21 to the output (point 3). The counter indicates 0.

5. Repair

The values mentioned in this section are not guaranteed; only the specifications given in the data sheet are binding.

5.1 Required Measuring Instruments

Pos.		Equipment, required specification / Recommended R&S instrument	Type	Order No.	Use in section
	○	Equipment, required specification			
	●	Recommended R&S instrument			
1	○	RF millivoltmeter			5.3.5 5.3.7
	●	RF-DC Millivoltmeter with 50-Ω insertion unit 50 µV - 1050 V (DC) 0.5 mV - 10.5 V (RF)	URV	216.3612.02 243.9418.54	
2	○	Power meter, 50 Ω			5.3.6.1
	●	Microwave Power Meter with 50-Ω probe 0.1 - 330 mW, 0 - 15 GHz	NRS	100.2433.92 100.2440.50	
3	○	AF Millivoltmeter 10 Hz - 500 kHz, Range 100 µV			5.3.2 5.3.6.12 5.4 5.3.7
	●	AF Millivoltmeter 10 Hz - 1 MHz 0.1 mV - 300 V	UVN	100.0160.02	
4	○	Digital Voltmeter Resolution 0.1 mV			5.3.1 5.3.2 5.3.3
5	○	DC voltmeter High impedance			5.3.3 5.3.4 5.3.6 5.3.7
	●	Multimeter VOLTAN 10 MΩ ‖ 30 pF	UVV	110.4716.02	
6	○	Frequency counter for 10 MHz and 240 MHz Resolution 0.1 Hz			5.3.3 5.3.7

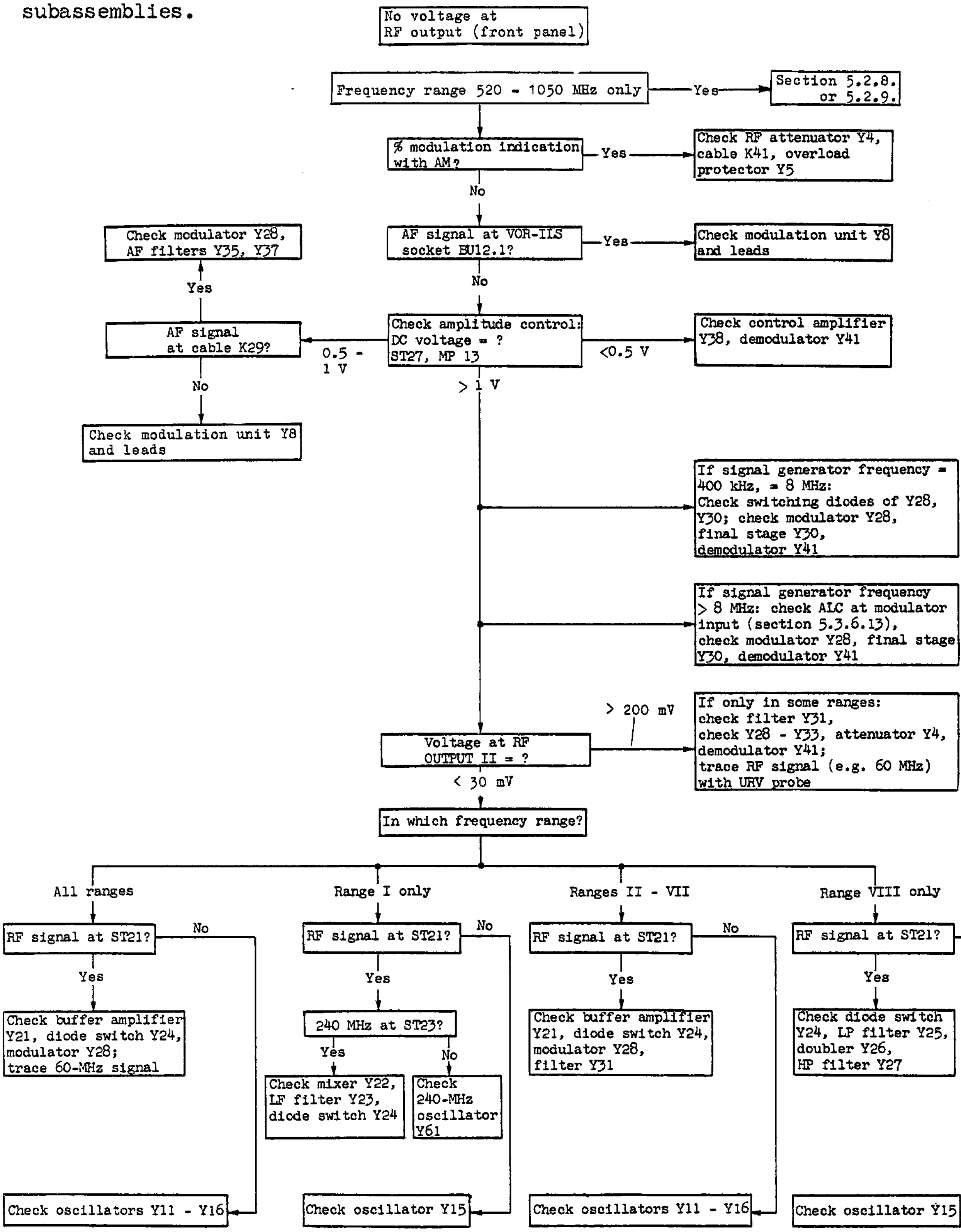
Pos.	○ Equipment, required specification ● Recommended R&S instrument	Type	Order No.	Use in section
7	○ AF/RF Generator 15 Hz - 50 MHz ● Decade RF Signal Generator 0.01 - 500 MHz	 SMDW	 103.9968...	5.3.4 5.3.7
8	○ Oscilloscope 10 µV/cm, e.g. Series 7000 of Tektronix, with plug-in 7A7			5.3.2
9	○ Modulation meter, e.g. AMF 2 of Radiometer			5.3.5 5.4
10	○ Distortion meter ● Direct-reading Distortion Meter 0.2 - 30% at 40 Hz/1/5/15 kHz ● Wave Analyzer 5 Hz - 60 kHz	 FTZ FAT 1	 100.6100.02 100.8683...	5.3.5
11	○ Psophometer with CCITT or CCIR weighting ● Psophometer with CCITT weighting ● Psophometer with CCIR weighting	 UPGS UPGR	 248.0019.02 248.1915.02	5.3.5
12	○ Field-strength meter 0.14 - 50/350 - 500 MHz ● Field-strength Meter 0.1 - 30 MHz ● VHF-UHF Test Receiver with Plug-ins 160 - 470 MHz 460 - 900 MHz	 HFH ESU	 100.1014.02 100.1143.02 100.1195.02 100.1208.02	5.3.6
13	○ Frequency analyzer 0.14 - 1000 MHz ● Analyskop and UHF Tuner 6 kHz - 1400 MHz	 EZF EZFU	 100.8831.52 210.0011.03	5.3.2 5.3.5 5.3.6 5.3.7

Pos.	○ Equipment, required specification ● Recommended R&S instrument	Type	Order No.	Use in section
14	○ Sweep generator assembly 0.1 - 525 MHz ● Polyskop III Display Unit Wideband Sweep Generator, 50 Ω 1 - 300 MHz and 460 - 860 MHz Sweep Oscillator 290 - 470 MHz	SWOB	104.5050.92 215.0010.51 200.7713.02	5.3.4 5.3.6.7
15	○ Sweep impedance meter for the RF range of the SMDU ● Sweep Diagraph 10 - 1000 MHz	ZWD	202.2083.50	5.3.6.8
16	○ RF power signal generator ● Power Signal Generator 25 - 1000 MHz, 2 W into 50 Ω	SMLU	200.1009...	5.3.6.11
17	○ Lowpass filter for the RF range of the SMDU			5.3.6.12

5.2 Fault Location

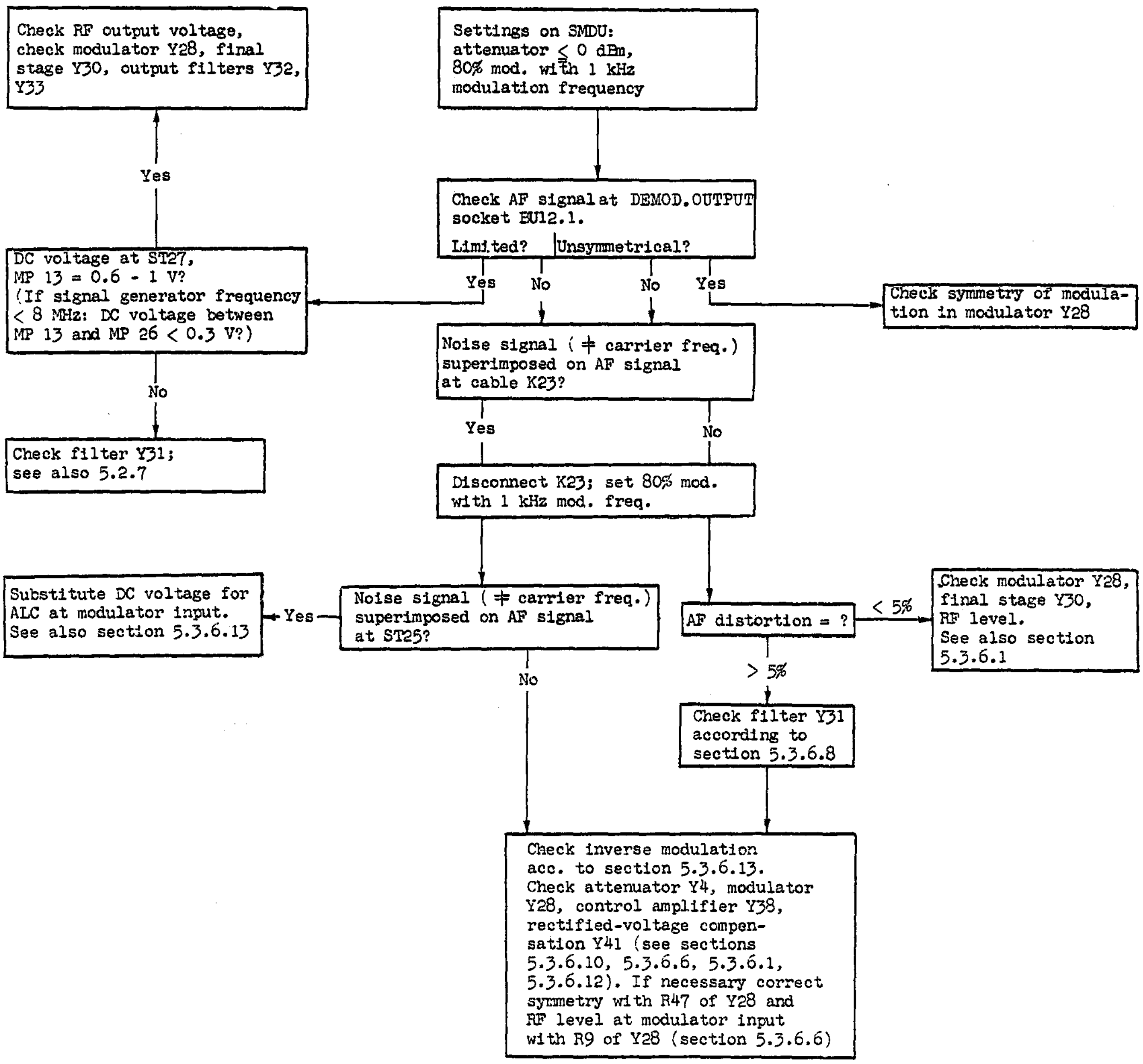
5.2.1 RF Voltage Failure

Note: When changing the range, check the supply and control voltages of the specified subassemblies.



5.2.2 AM Distortion Too High

If a fault occurs only in individual frequency ranges or at the switching thresholds 400 kHz or 8 MHz, check the switching functions. See also the fault-location chart in section 5.2.1.



5.2.3 Harmonic Suppression Inadequate

- Set attenuator of SMDU to < 0 dBm
- Check level at RF output
  - Wrong → Adjust in control amplifier Y38, section 5.3.6.1
  - Right ↓
- Check level of final stage Y30
  - Wrong → Adjust according to section 5.3.6.7
  - Right ↓
- Measure AM distortion
  - Too high → AF distortion too high, proceed acc. to section 5.2.2
  - Right ↓
- Check RF level acc. to level plan (Fig. 5-1)
  - Wrong → Check RF level in modulator Y28 acc. to section 5.3.6.6. Check control circuits acc. to section 5.3.6.13
  - Right ↓
- Check RF distortion in demodulator Y41 acc. to section 5.3.6.11

5.2.4 Non-harmonic Suppression Inadequate

- Measure RF distortion
  - Too high → Proceed acc. to section 5.2.3
  - Right ↓
- Measure AM distortion
  - Too high → Proceed acc. to section 5.2.2
  - Right ↓
- Check amplitude control at MP 13, MP 26, see section 5.3.6.13. Check RF level of subassemblies Y24 to Y28 or Y24, Y22, Y23, Y28

5.2.5 Fault of Timebase

Effect	Fault	Cause
No output voltage at BU61	T3 or T4 in 240-MHz divider and mixer Y62 defective or fault in 10-MHz crystal oscillator Y63	Extraneous voltage at BU61
Frequency error at BU61 (nominal: 10.000 MHz)	Crystal oscillator detuned or fault in thermostat-regulation or crystal defective	
No output voltage at ST61	+15 V at lead-through D61 of 240-MHz oscillator Y61 is missing	Fault in range switch Y10 or in connecting cable
	Oscillator (T1) or amplifier (T2 and T3) or 240-MHz oscillator defective	
Frequency error at ST61 (nominal: 240.0000 MHz)	Wrong adjustment (L1, C1) in 240-MHz oscillator Y61	
	Fault in synchronization loop	Fault in 240-MHz divider and mixer Y62
Output voltage at ST61 too low	Amplifier (T2, T3) of 240-MHz oscillator defective	Extraneous voltage at ST61
Spurious deviation at ST61 too high	Fault in synchronization loop	Fault in 240-MHz divider and mixer Y62

5.2.6 Fault in Modulation Unit

5.2.6.1 Fault of Modulation

See circuit diagram 250.2015 S

No frequency modulation obtainable

Possible cause: Modulation generator does not operate. (Note: The modulation generator is switched on only if the MOD. button 12 or 14 (Fig. 2-1) is depressed).

Depress buttons MOD. and FM INT. 14 and set knob 17 to the righthand stop. Depress button FM 23 and set 22 to AUTO. An AC voltage > 4.25 V must now be present at ST83.9 of the modulation unit (see circuit diagram 250.2015 S).

If the actual voltage differs largely or is not obtainable at all, the fault location procedure may be restricted to the modulation generator (250.2696 S) and the AM/FM switch (250.2744 S). If voltage is present at ST83.9, the cause of error lies in the indication (250.2644 S and 250.2296 S); see 5.2.6.2.

No amplitude modulation obtainable

Depress buttons MOD. and AM INT. 12 and set knob 35 to the righthand stop. Depress button AM 23 and select the indication range 100% with 22 . An rms voltage > 0.6 V must be present at ST83.12 and ≈ 0.5 V at ST83.28.

If there is no voltage at ST83.12, the cause of error lies in the modulation generator (250.2696 S) or in the AM-FM switch (250.2744 S). If only the voltage at ST83.28 is missing, the AM modulator in the amplifier Y2 supplies no AF voltage (see overall circuit diagram 249.7846 S). If voltage is present at ST83.28 but no modulation indication is obtained, the cause of error lies in the indication (250.2644 S and 250.2296 S); see 5.2.6.2.

No frequency indication AF INT., modulation present

If ≈ 0.5 V_{rms} is present at ST83.32, either the cable K171 between ST83.32 and the counter Y7 or the counter is defective (see overall circuit diagram 249.5672 S).

5.2.6.2 Fault of Indication

See circuit diagram 250.2015 S

No measurement possible with the AF voltmeter.

Connect autoranging facility (22 set to AUTO). Apply test voltage of 3 V_{rms} to socket 44 .

1 V_{rms} present at ST83.9 (on 250.2015 S)? — No → Impedance transformer 274.8165, 10-dB attenuator or cable K4 (on 249.3011) defective

Yes

100 mV_{rms} present at MP7 of 1-kHz bandstop filter and attenuator Y82 I (see 250.2644 S)? — No → Fault in attenuator T6 to T11 or amplifier B11 defective

Yes

3 V_{rms} present at MP1 of rms- and peak-responding meter Y83 (see 250.2296 S)? — No → Fault in preamplifier B1

Yes

1 V DC present at MP3 of rms- and peak-responding meter Y83? — No → Fault in rms-responding meter (B3, B4 defective)

Yes

1 V DC present at MP4 of Y83? — No → Fault in meter amplifier (B5, T6, T2 defective)

Yes

Does the meter show 1 V f.s.d.? — No → Fault in current limiter B5II or in control logic Y85.

Yes

Does the luminous readout display 3000 mV? — No → Fault in control logic Y85 (see 274.9861 S)

5.2.6.3 Fault in Deviation Meter

a) Deviation Measurement in Simplex Mode

Connect signal generator to socket EXT. FREQ. + DEV. METER (f = 100 MHz) and select simplex mode in accordance with 2.3.6.1.

	No
200-kHz signal present at output 6 of RF amplifier in deviation meter Y81 (see 250.3228 S)?	Fault in RF amplifier; check mixer Gl 201.
Yes ↓	
200-kHz squarewave signal present at MP9 of discriminator and control circuit (see 250.3228 S)?	Fault in pulse processing circuit (T401, T402, B101).
Yes ↓	
Squarewave signal present at MP13 of discriminator and control circuit (see 250.3228 S)?	Fault in pulse discriminator (B403)
Yes ↓	
AF signal present at AF output BU86.2 of deviation meter Y81 in the case of modulation?	Fault in AF filter 250.2344 or T404, T405 defective
Yes ↓	
Signal present at MP2 of 1-kHz bandstop filter and attenuator (see 250.2015 S)?	Amplifier B1, B3 of 1-kHz bandstop filter and attenuator Y82 I defective
Yes ↓	
Indication defective; fault location according to 5.2.6.2.	

b) <u>Deviation Measurement in Duplex Mode</u>

Prior to fault location in the duplex mode, check the deviation meter in the simplex mode.

Deviation measurement possible in simplex mode?	No →	For fault location proceed as under a)
Yes: Select duplex mode. Signal of about 4 to 11 MHz present at MP1 of oscillator and mixer in deviation meter subassembly (see 250.3228 S)?	No →	Auxiliary oscillator T101 does not function properly.
Yes: TTL signal present at MP2 of oscillator and mixer?	No →	Buffer amplifier T102 or TTL processing circuit T103 defective
Yes: No RF signal applied, SMDU oscillator disconnected. Is the nominal auxiliary-oscillator frequency of 7.5 to 7.9 MHz present at MP2?	No →	Fault in auxiliary-oscillator control circuit (Gl 102 or B102 II defective)
Yes: Set SMDU oscillator frequency to 4.2 MHz and continuously increase to 10.7 MHz? Does the auxiliary-osc. frequency at MP2 change from 4.0 to 10.5 MHz?	No →	Fault in control loop of automatic tuning circuit (pulse discriminator B402 or level amplifier B404 defective)
Yes: Slowly reduce SMDU oscillator frequency from 13 MHz to 10.5 MHz. Does the control circuit respond at 10.5 MHz? Is the auxiliary-oscillator frequency at MP2 10.3 MHz?	No →	Fault in the discharging circuit of the control amplifier B404

5.2.6.4 Fault in Distortion Measurement

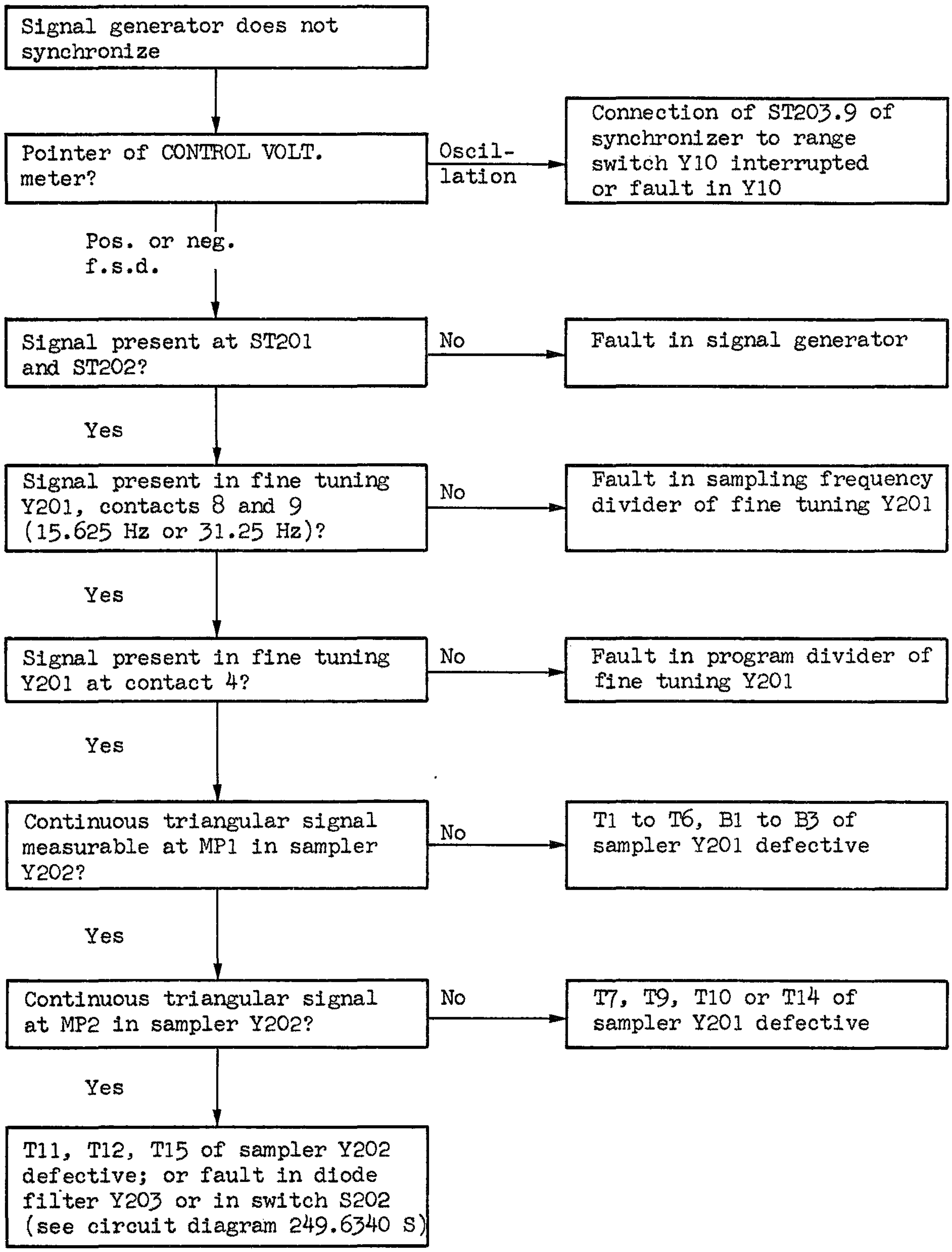
Apply a 1-kHz test signal of 0.5 V_{rms} to the AF voltmeter, socket BU11.a7.

Vary the test signal from 50 mV to 5 V. 1.2 to 1.4 mV_{rms} present at MP9 of 1-kHz bandstop filter and attenuator Y82?	No	Fault in level control (B5, B12, B4)
Yes		
Signal of < 10 mV_{rms} present at MP6 of Y82?	No	Fault in 1-kHz bandstop filter
Yes		
Set frequency of test signal to 2 kHz. 2.7 to 3 V_{rms} present at MP6 of Y82?	No	Fault in 1-kHz bandstop filter or T16 does not switch correctly
Yes		
Does the meter indicate a distortion of 90 to 100%?	No	Fault in indication circuitry or control logic; see section 5.2.6.2

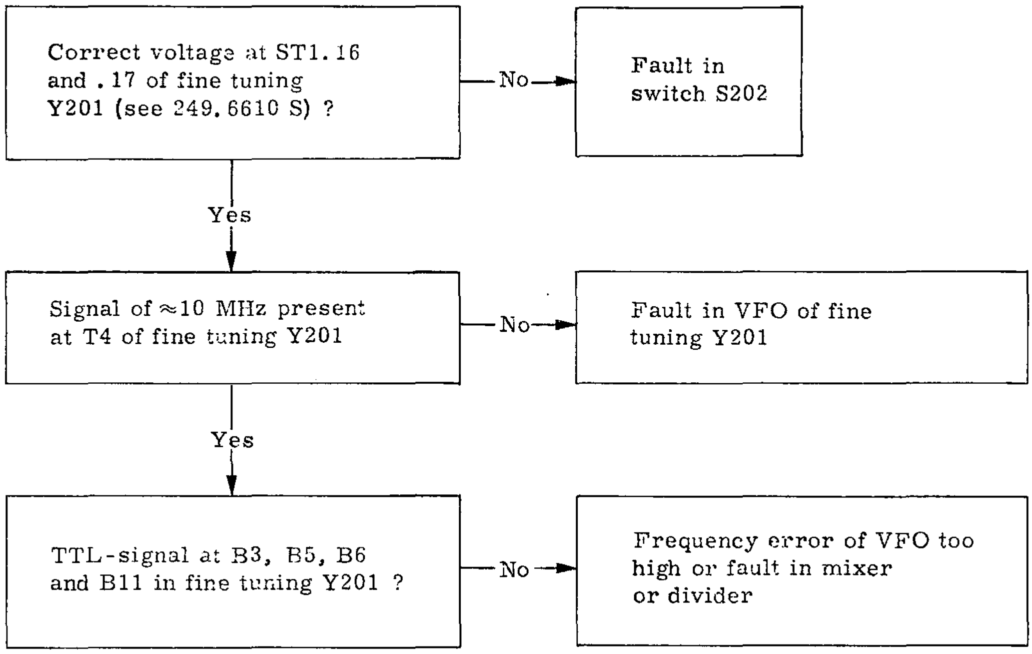
5.2.7 Fault in Synchronizer SMDU-B1

(only with built-in Synchronizer 249.6840)

a) Synchronization without fine tuning (FINE TUNING button released)

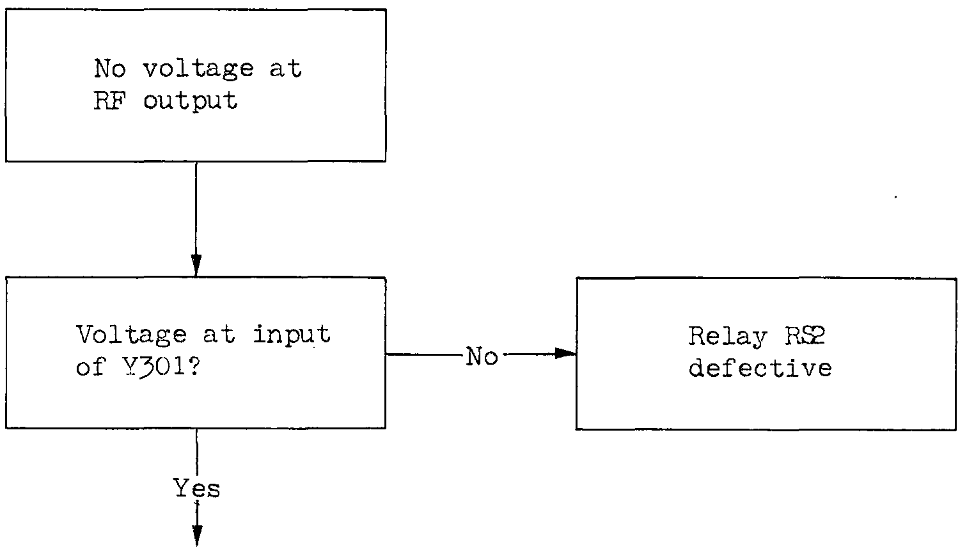


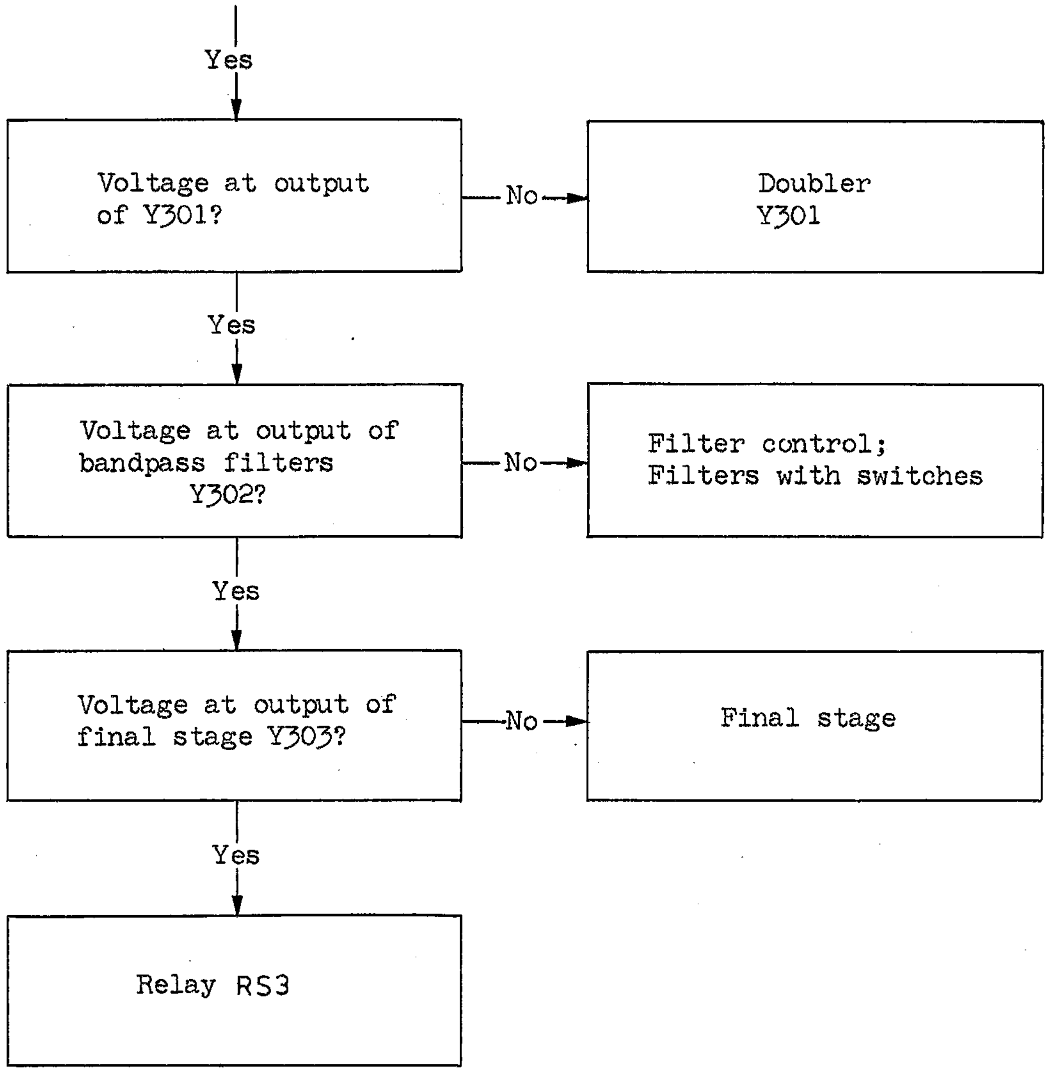
b) Synchronization without fine tuning satisfactory; no synchronization or high spurious FM when fine tuning is switched on (FINE TUNING butto depressed).



5.2.8 Fault in 1.05-GHz Frequency Range Extension SMDU-B3

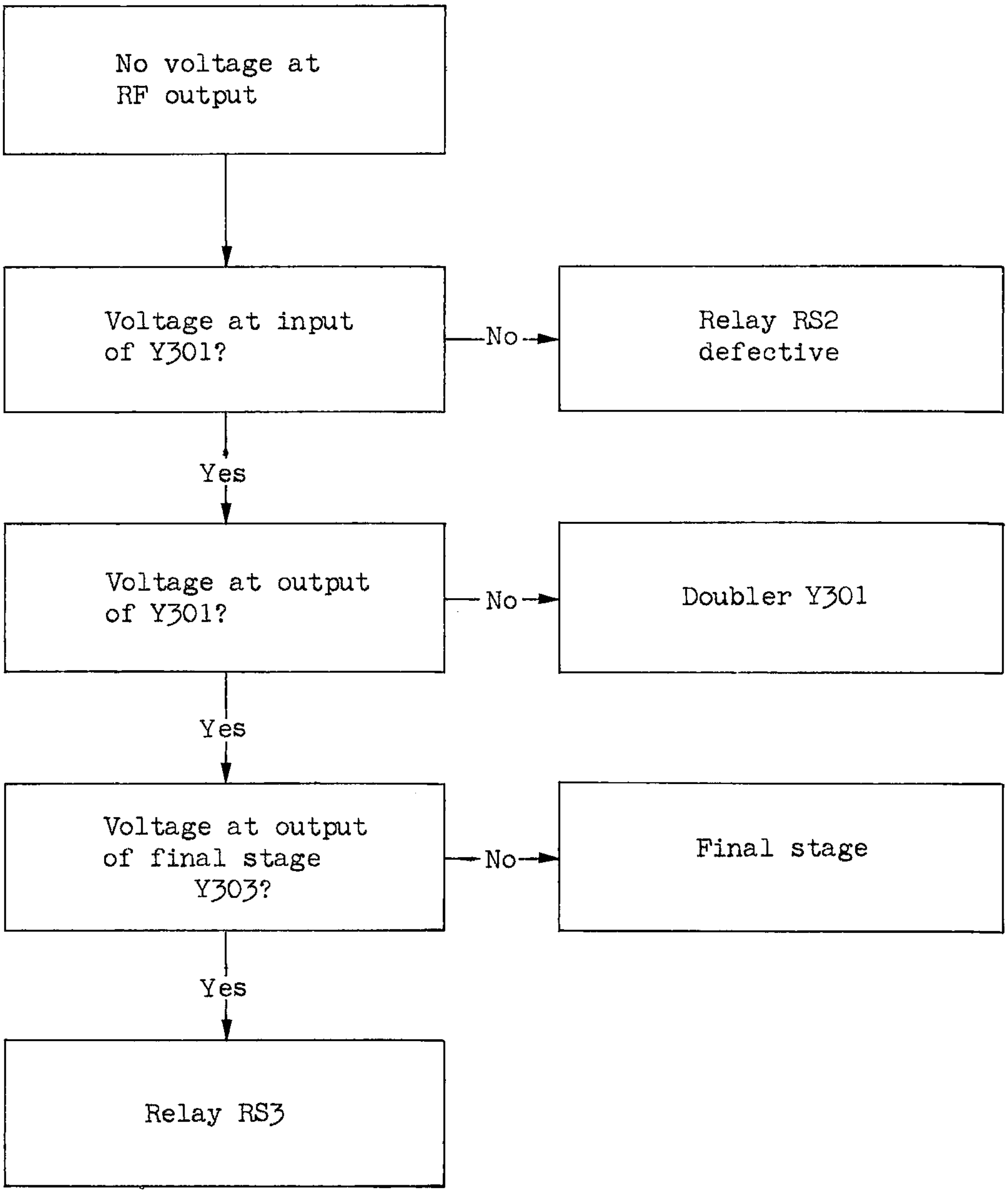
(only with built-in 1.05-GHz Frequency Range Extension 249.9484 ...)




Yes
Voltage at output of Y301?
No
Doubler Y301
Yes
Voltage at output of bandpass filters Y302?
No
Filter control; Filters with switches
Yes
Voltage at output of final stage Y303?
No
Final stage
Yes
Relay RS3

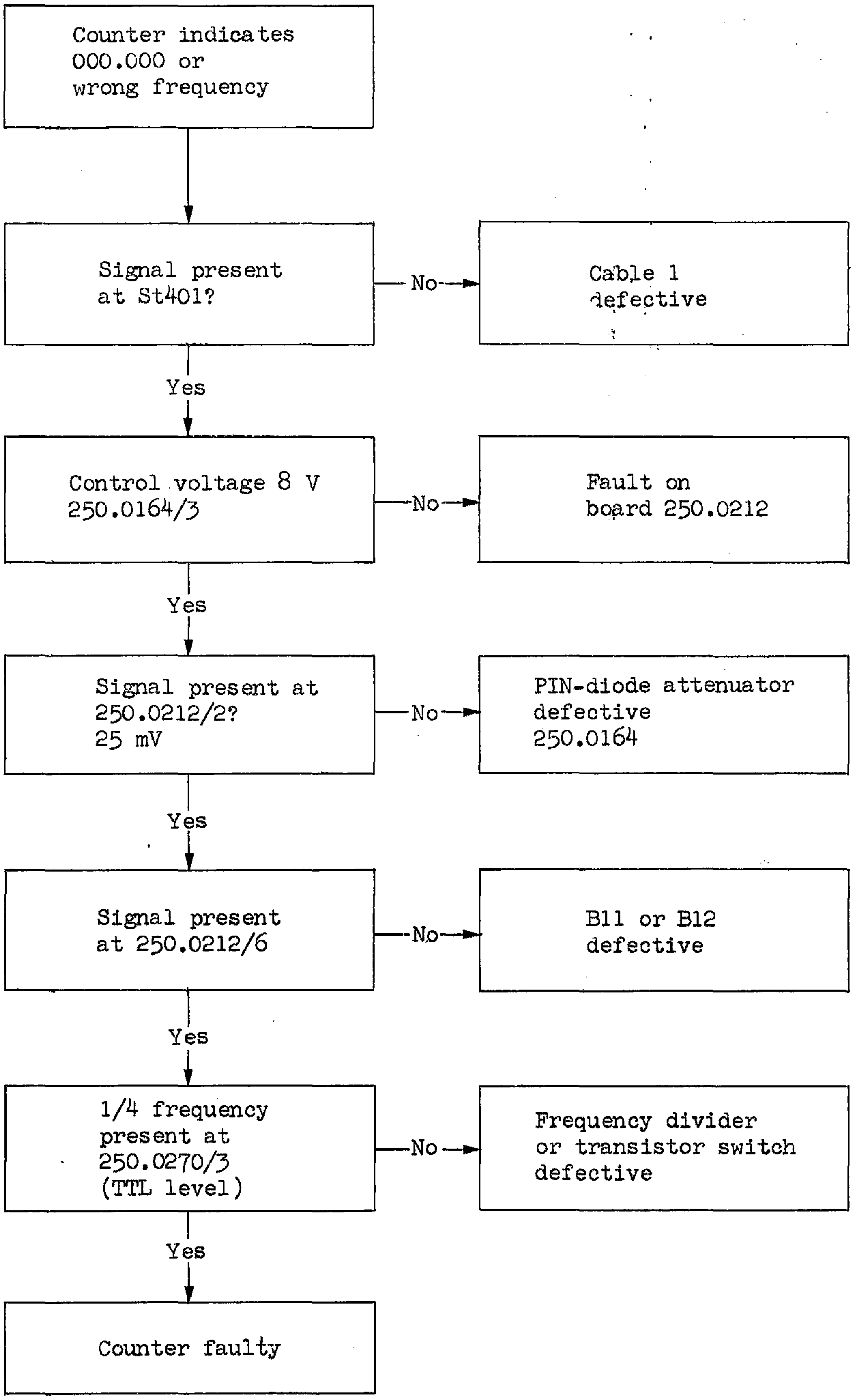
5.2.9 Fault in 1.05-GHz Frequency Doubler SMDU-B5

(only with built-in 1.05-GHz Frequency Doubler 275.1312.02)



5.2.10 Fault in 1-GHz Frequency Meter SMDU-B4

(only with built-in Frequency Meter 250.0012)



5.3 Checking and Adjustment

How to open the subassemblies is described in section 5.4.

The DC voltages specified in the circuit diagrams should be maintained within ±10%.

Checking the RF levels: Unless stated otherwise, the RF inputs and RF outputs of the subassemblies of the SMDU are designed for a characteristic impedance of 50 Ω. A 50-Ω termination should therefore be ensured.

5.3.1 Power Supply Y9

Measure the output voltages and hum voltages according to the values specified in circuit diagram 250.2815 S. Adjust the output voltages with potentiometer R4, R14 or R18 with nominal current.

5.3.2 Range Switch Y10

See circuit diagram 250.1019 S

Prior to making adjustments on the range switch, proceed according to section 5.4.3.

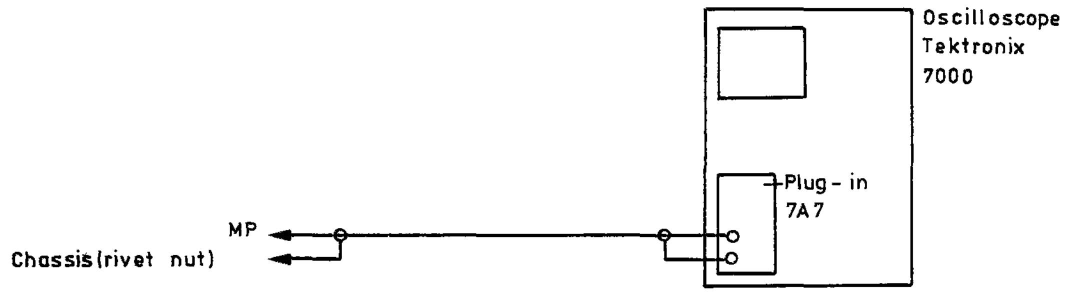
Check the logic levels at connector strips ST111, ST113 and ST114 according to Fig. 5-2.

Adjusting the oscillator operating voltage: Detach cable K101. Connect digital voltmeter to ST111.7 and adjust for -18.00 V ±2 mV using R64.

Checking the supply voltage for the FM control: Connect digital voltmeter to check point MP2 and check voltage; it should be 59.4 to 60.6 V. The voltage cannot be adjusted directly since it is derived from the -18-V oscillator operating voltage.

Measuring spurious voltage superimposed on oscillator voltage and FM operating voltage

Test setup



A spurious voltage of V_{pp} = 20 µV at -18 V and V_{pp} = 40 µV at 60 V with weighting up to 100 kHz is permissible.

Adjusting the input offset voltage of the FM control: Select FM EXT. and maximum deviation on the SMDU front panel. Adjust a voltage of 2.58 to 2.62 V between MP1 and chassis using R14. Connect a digital voltmeter with a resolution of 0.1 mV to the FM input ST113.7/.16 and adjust the voltage to zero using R17.

Adjusting the offset voltage resulting from a switchover of the FM sensitivity:

Connect a digital voltmeter with a resolution of 0.1 mV to the FM output ST101. When the FM sensitivity is switched from 100 kHz to 500 kHz (+5 V at ST113.8), the voltage at the FM output must not change more than 0.1 mV. Adjust with R98 with an FM sensitivity of 500 kHz.

To check the control voltages for the counter and the synchronizer at ST114, for the oscillator ranges at ST111 and for the switchable lowpass filters at ST113, refer to the tables of Fig. 5-2 (Appendix).

Checking the FM amplifier: Select the range 85 to 119 MHz on the front panel of the SMDU. Check the DC voltages against the values specified in the circuit diagram.

Connect an AF generator (10 Hz to 500 kHz, distortion < 0.03%) to the FM input ST113.7/.16 and adjust for a voltage of 3.5 V. The signal may also be fed in via the socket FM EXT. on the front panel if external frequency modulation is selected. Connect an AF voltmeter (0 to 500 kHz, measurement range > 100 μV) to the AF output ST101. Cable K101 leading to the oscillator must remain connected. It should be kept in mind that a DC voltage of about 7 V is present at the output (insert a capacitor if necessary). The AF output voltage must be about 0.8 V. Frequency response between 10 Hz and 150 kHz must be flat within 1%, a deviation of 3 dB being permissible at 500 kHz. The maximum permissible distortion is 0.05% up to 53 kHz and 0.1% at 150 kHz. Noise (weighting 20 Hz to 20 kHz) must not exceed 20 μV_{pp}.

Checking the synchronization input: Connect an AF generator (10 Hz to 10 kHz) to the synchronization input ST114.12/.11 and adjust for a voltage of 0.7 V. Measure the AF voltage at the FM output ST101; it should be about 0.7 V. A frequency response of 1 dB is permissible in the range 0 to 1 kHz, the voltage must drop above 1 kHz and at 10 kHz the attenuation must be 26 dB.

Checking the control input for deviation measurements (model 249.3011.06 only):
Apply -15 V to ST113.9. The oscillator frequency is now reduced by the IF of 200 kHz, i.e. a value of 99.8 MHz instead of 100 MHz is measured.

5.3.3 Mixer Oscillator Y6

See circuit diagram 249.6810 S

5.3.3.1 10-MHz Crystal Oscillator Y63

When the crystal is to be replaced, insert the new crystal and put circuit board 249.7081 back into the cabinet.

Connect a high-impedance DC voltmeter to check point MP. Adjust TR1 for minimum DC voltage at MP, thus adjusting the resonant circuit.

Adjusting the zero-coefficient temperature of the crystal: Connect a frequency meter with a resolution better than 1 in 10^{-8} to socket BU61. Connect an ammeter into the +15-V lead; the oven, when cold, draws about 280 mA. Constant current is established after 5 to 10 minutes. Vary resistor R2 from 100 Ω to 500 Ω in the steps of the E-24 series. Allow 5 minutes after each change of resistor, then read the frequency. The resistor resulting in the lowest frequency is to be soldered in.

Frequency adjustment: Connect a frequency meter to BU61 and adjust to 10 MHz $\pm$0.2 Hz using C4 (and if necessary C5).

5.3.3.2 240-MHz Oscillator Y61

Adjusting the resonant circuit: Select the range 0.14 to 50 MHz on the front panel. Connect a frequency meter to ST61, an oscilloscope to check point MP and a DC voltmeter to contact 3 of the 240-MHz divider and mixer Y62. Adjust the frequency with C1 to about 240 MHz and then with L1 to precisely 240.000 MHz. The oscillogram shown in the circuit diagram 249.7017 S must be obtainable at MP. The control voltage at contact 3 should be 7 V.

5.3.4 Counter Y7

The mechanical work required to open the counter is described in section 5.4.1. The logic levels at ST80 can be checked according to Fig. 5-3.

5.3.4.1 Counter Input Y71

Check the DC voltages by referring to the values specified in circuit diagram 294.9580 S.

Depress button EXT. 15 Hz - 30 MHz on the front panel; the switching voltage at contact 2 changes from +5 V to -15 V. Connect an AF/RF generator (15 Hz to 30 MHz) to the Subminax connector ST73 and apply 10 mV. Check the output voltage at contact 8 with an oscilloscope; when tuning through the whole frequency range, a satisfactory TTL signal must be obtained. Change the input voltage from 10 mV to 3 V. Again a satisfactory TTL signal must exist.

Depress button AF INT.; +5 V must then exist at contact 10. Connect an AF generator (15 Hz to 150 kHz) to the lead-through D76 or to ST80.20 and apply 0.2 V. When tuning through the frequency range, a satisfactory TTL signal must always be obtainable at contact 8.

Depress button RF INT.; +5 V must exist at contact 2 and -15 V at contact 10. Connect an RF generator (0.14 to 50 MHz) to the Subminax connector ST75, apply 50 mV and check the TTL signal at contact 8 again.

To check the buffer amplifier, connect a sweep generator assembly (e.g. SWOB III) between ST75 and ST78 or ST172 and check the gain in the range 0.14 to 525 MHz. The gain should be 0 ±1 dB when measured at ST78 or ST172. The unused output must be terminated with 50 Ω for the measurement.

The swept-frequency check of the preamplifier for external signals in the range 10 to 525 MHz is made together with that of the divider Y72 (see section 5.3.4.2).

5.3.4.2 Divider Y72

Set the potentiometer R52 to the righthand stop and check the DC voltages according to the values specified in circuit diagram 294.9515 S.

Depress button RF INT. on the front panel; the switching voltage at contact 2 goes from -15 V to +8.5 V. Connect an RF generator (49 to 395 MHz) to the Subminax connector ST74 and apply 50 mV. The output voltage at pin 7 of the operational amplifier B2 II must then be > 0 V. The frequency divided 10 : 1 can be checked at ST77. A satisfactory TTL signal must be obtainable in the whole frequency range.

To check the amplifier T1, T2, connect a sweep generator assembly (e.g. SWOB III) between ST72 and ST171 and check the gain in the range 10 to 525 MHz. The gain should be at least 9 dB.

Depress button EXT. 20 - 525 MHz; +15 V must be present at contact 2. Connect an RF generator (20 to 525 MHz) to the Subminax connector ST72. Adjust potentiometer R52 such that T6 is cut off by -13 V at pin 7 of B2 II before the RF voltage is so low that it no longer suffices for satisfactory division in B1. Measure with an oscilloscope at contact 8. Adjust with a frequency of 525 MHz applied. With an input voltage of 10 mV, the automatic switchoff circuit is not allowed to respond in the whole frequency range. A satisfactory TTL signal must be obtainable at contact 8, also when the input voltage is increased to 3 V.

5.3.4.3 First Decade Y73

Check the DC voltages by referring to the values specified in circuit diagram 294.9621 S.

Check the count gate control in accordance with the table in the circuit diagram.

The dividers of the 10-MHz reference frequency (B3I and B3II) should deliver 100 kHz (TTL) at point 1.

For checking the 400-kHz frequency discriminator, apply a signal of about 20 mV at approx. 400 kHz to point 22. When reducing the frequency from 400.0 to 395 kHz, the switching voltage at point 14 should jump from about -13 V to about +13 V. When increasing the frequency, the switching voltage should change from +13 V to -13 V at 425 to 440 kHz.

5.3.4.4 Counter and Indication Y74

Check the DC voltages by referring to the values specified in circuit diagram 294.9650.

Apply the control voltages for counting-time selection to BU29/10/11/12 according to the values specified in the circuit diagram and check the counting times at pin 13 of B9II with an oscilloscope. The transfer and reset pulses can be checked by referring to the pulse diagram in section 4.7.4. The specified times refer to a counting time of 1 s. With other counting times, the pulse times differ correspondingly.

The logic levels at BU3 and BU4 can be checked in accordance with Fig. 5-4 (Appendix).

5.3.4.5 Counter Switchover Y75

Check the logic levels and voltages at ST80 in accordance with Fig. 5-3. The count gate control and the counting time can be checked with the aid of the tables in circuit diagram 294.9876 S.

5.3.5 Oscillator Y1

The checks and adjustments described should be made consecutively for each of the oscillators Y11 to Y16. The oscillator Y1 must be opened according to section 5.4.2 prior to the adjustment.

Adjusting the transistor current: Measure the RF voltage at contact 1 of the oscillator coupling 249.5243 by means of an RF millivoltmeter (e.g. URV) with probe. Adjust the transistor current at the range end with R1 (at oscillator Y1) such that the RF voltage is maximum. Then turn the wiper of R1 to the right until the RF voltage has dropped by 10%.

Checking the RF voltage output: Measure the RF voltage at cable K112 in the whole frequency range by means of an RF millivoltmeter (e.g. URV) with probe. The voltage must be 100 to 200 mV. Correction is possible by changing R1 to R6 on the oscillator coupling 249.5243.

Adjusting the frequency limits: Adjust the lower range end with L1 or C7 and then the upper end with C6. The two adjustments affect one another and should therefore be repeated several times.
In the range 196 to 290 MHz, a frequency of 240 MHz must be accurately adjusted for so that the lower end of range 0.14 to 50 MHz is correct.

Adjusting the frequency deviation: Connect a modulation meter (e.g. AFM 2 of Radiometer) to the RF output. Select FM EXT. on the front panel, set the FM knob for frequency deviation adjustment fully clockwise and apply an external deviation control voltage of $\pm 1.1 V_p$ to the FM socket. Measure the frequency deviation at the lower end of the range and then adjust for the same deviation at the upper end using C11. Repeat the measurement at the lower end and the adjustment at the higher end until the deviation is the same at both ends. Check the frequency limits, and correct if necessary, between the individual adjustments.

Adjust the deviation sensitivity with the appropriate potentiometer in the range switch Y10 (see following table). Measure the frequency deviation at several frequencies within the range; it should be 100 kHz on average.

Oscillator range	49 - 64.5 MHz	63.5 - 88 MHz	85 - 119 MHZ	118 - 198 MHZ	196 - 290 MHZ	286 - 395 MHz	392 - 525 MHz
Potentiometer in range switch Y10	R48	R47	R46	R45	R44	R43	R42

Adjusting the FM distortion: Connect a modulation meter followed by a distortion meter (e.g. FTZ) to the RF output. Modulate the SMDU with a modulation frequency of 1 kHz and 100 kHz deviation. Distortion of the modulation frequency must be < 0.03%; the modulation should therefore be made with an external AF generator. Measure the distortion of the demodulated signal according to the following table and adjust to minimum with the appertaining potentiometer in the range switch Y10.

Oscillator range	49 - 64.5 MHz	63.5 - 88 MHz	85 - 119 MHz	118 - 198 MHz	196 - 290 MHz	286 - 395 MHz
Test frequency	55 MHz	74 MHz	85 MHz	155 MHz	240 MHz	340 MHz
Potentiometer in range switch Y10	R58	R57	R56	R55	R54	R53

Measure the distortion at the lower and at the upper end of the range; it should be < 0.5% (< 0.15% in the ranges 85 to 119/196 to 290 MHz). Correction is possible with C10; this requires, however, a subsequent correction of the frequency deviation.

In the range 85 to 119 MHz, distortion must be measured in addition at 119 MHz and adjusted to minimum with R80 in the range switch Y10. The voltage at the wiper of R80 should be between -10 V and -16 V. Then measure the distortion at several frequencies of the range; it should always be < 0.15%.

Checking harmonic and spurious suppression: Connect an analyzer (e.g. EZF plus EZFU) to the output cable K112 of the oscillator and tune the oscillator through its range. Harmonics must be down > 35 dB in the whole frequency range. Non-harmonic spurious frequencies are not permissible.

Checking the scale precision: Set the frequency at several points of the range according to the analog drum dial and read the accurate value on the counter. The difference must be < 1% (< 5% + 300 kHz in the first range).

Checking the residual FM: Determine the residual FM at least at one frequency (centre) of each range. Set the SMDU output voltage to at least 100 mV. Connect a modulation meter to the RF output and tune. Set a frequency deviation of 1 kHz with a modulation frequency of 1 kHz on the SMDU. Measure the voltage at the AF output of the modulation meter with an AF psophometer (UPGS with CCITT weighting or UPGR with CCIR weighting). The psophometer indication corresponds to 1 kHz deviation. Switch the frequency modulation of the SMDU off and determine the level drop at the psophometer. It is a measure of residual FM, 50 dB level drop, for example, corresponding to a residual deviation of 30 Hz. Correction is not possible.

Permissible residual FM:

Bandwidth:	0.3 - 3 kHz (CCITT)	20 Hz - 15 kHz (CCIR)
0.14 - 400 MHz	< 7 Hz	< 20 Hz (typ. 10 Hz)
400 - 800 MHz	< 10 Hz	< 40 Hz (typ. 20 Hz)
800 - 1050 MHz	< 15 Hz	< 60 Hz (typ. 30 Hz)

5.3.6 Amplifier Y2

Unless stated otherwise, the RF inputs and RF outputs of the amplifier Y2 must be terminated permanently with 50 Ω.

5.3.6.1 Control Amplifier Y38

Checking

Check DC voltages and AF levels against the values specified in circuit diagram 249.8765 S.

Check the equalization of the demodulator characteristic: The DC voltage at R10 must be 1.25 to 1.36 V.

Apply at contact 1 a DC voltage of -0.8 V with a superimposed AF voltage of 0.8 V_{rms} and 5 kHz. Harmonics should be down > 60 dB, if necessary insert a lowpass filter. Measure the harmonic ratio at contact 7 with an analyzer (e.g. Analyskop EZF). Suppression should be

- about 40 to 42 dB for the 1st harmonic
- > 65 dB for the second harmonic
- > 55 dB for higher harmonics.

Adjustment

Adjust the voltage at the RF output on the front panel with R12 so that the RF output delivers 1 mW into 50 Ω with a signal-generator frequency of 60 MHz and attenuator position of 0 dBm. Measure with a microwave power meter (e.g. NRS).

Adjust the DC voltage at the DEMOD. OUTPUT with R26. At 330 MHz and 115 MHz the voltage at BU12.1 (on 249.3011 S) should be 0 $\pm$10 mV.

The two adjustments slightly affect one another and should be repeated if necessary.

5.3.6.2 Buffer Amplifier Y21

Apply 0.5 V DC to contact 2. Check the DC voltages and the RF levels according to circuit diagram 249.8213 S. Measure the RF levels at about 60 MHz and 350 MHz with an RF millivoltmeter (e.g. URV) with probe. Use an RF millivoltmeter (e.g. URV) with probe to check the output level of the buffer stage T21, T22 at contact 5. It should be about 100 to 150 mV if an RF voltage of 100 to 150 mV is applied to the input (contact 1).

To check the PIN-diode circuit, terminate contact 5 with 50 Ω and apply a DC voltage to contact 2. With +1 V DC, the attenuation of the PIN-diode circuit should be about 26 dB, with +0.5 V DC about 10 to 15 dB.

5.3.6.3 Mixer Y22 and Lowpass Filter Y23

Check the DC voltages according to circuit diagram 249.8265 S and 249.8313 S.

Check the gain between mixer input (1) and lowpass filter output (1) by means of an RF millivoltmeter (e.g. URV) with probe. It should be about 0 dB.

5.3.6.4 Doubler Y26

Select the range 392 to 525 MHz and set the signal generator frequency to 392 MHz. Adjust the 196-MHz oscillator signal at the output of the doubler Y26 to a minimum using R3. Measure with a test receiver (e.g. ESU) at the RF output on the front panel; non-harmonic spurious frequencies should be down > 90 dB.

5.3.6.5 Diode Switch Y24

Check the DC voltages by referring to the values specified in circuit diagram 249.8365 S and the RF levels according to Fig. 5-1. To check the attenuation of the diode switch in the off state, connect coaxial cables to contacts 7 and 10. Select the range 392 to 525 MHz for the measurement and cut the oscillator off by turning it out of the oscillation range (engravings of dial drum must disappear).

5.3.6.6 Modulator Y28

Checking

Disconnect cable K23 at contact 7 of the modulator; the negative modulation feedback is then ineffective. If the AF input is disconnected from contact 9 it must be terminated with 2.2 kΩ. Measure the DC voltages by referring to the values specified in circuit diagram 249.8565 S. Check the switching voltages at contacts 3, 4, 13 and the corresponding levels at Gl 3 to Gl 6, Gl 9, Gl 10 and R45.

Measure the frequency response of the modulator between contacts 10 and 12 with a sweep generator assembly (e.g. SWOB III). The gain should be 13 dB ±2 dB in the frequency range 10 to 525 MHz. In the same range the gain of the second-output amplifier between contacts 10 and 1 should be about 0 dB -2 dB.

To measure the distortion with amplitude modulation, connect a demodulator (e.g. of Radiometer) with distortion meter to the RF output. Adjust 80% modulation and 1 kHz modulation frequency. Disconnect cable K23 from contact 7. The RF level at contact 10 should be about 100 mV. AM distortion must be < 3% at 60, 100 and 300 MHz and < 5% at 525 MHz.

Cable K23 is also disconnected when the modulation depth adjustable in operation without AM is checked. Disconnect cable K28 at the input of the AF filter Y37 from the feed-through capacitor C23 and apply via C23 the frequency of 1 kHz from an external AF generator. Operate the SMDU at a frequency above 10 MHz and with the AM off. Connect an oscilloscope to the RF output, vary the level of the AF generator and measure the modulation depth. A modulation depth of about 10% must be obtainable without limiting of the AM.

Adjusting

Adjust the gain between contacts 10 and 12 to maximum (about 19 dB) with R47 and then decrease the gain by 6 dB. Next adjust the AM distortion with R47. For this purpose, modulate the signal-generator frequency of 330 MHz with 85% and a modulation frequency of 1 kHz.

The negative modulation feedback is cut off by disconnecting cable K23. Adjust with R47 for minimum AM distortion at the RF output.

With unmodulated operation, a modulation depth of about 10% should be obtainable without limiting of the AM. Resistor R55 at the base of transistor B2 II is to be selected accordingly.

Adjust R9 so that 100 mV is applied to the modulator input. With a signal generator frequency of 60 MHz, measure the voltage at the RF OUTPUT II and adjust to 90 to 100 mV with R9.

5.3.6.7 Final Stage Y30

Checking

Check the DC voltages by referring to the values specified in circuit diagram 249.8865 S. Check the switching voltage at contact 4 and the associated DC voltages at diodes Gl 1, Gl 2, Gl 6 to Gl 8. To check the PIN diode circuit, proceed according to section 5.3.6.2.

Measure the frequency response of the final stage with a sweep generator assembly (e.g. SWOB III) between contacts 3 and 7. A DC voltage of 1.5 V should lie at contact 1 in the frequency range 15 to 525 MHz. The gain should be 18 dB ±1 dB in this frequency range.

Adjustment

Adjust the collector currents of T1 and T2 with R12 and R21 so that harmonics at the RF output are down > 35 dB for frequencies > 5 MHz and down > 26 dB for frequencies < 5 MHz. 1.5 V should not be exceeded at the emitter of T2.

5.3.6.8 Filter Y31

Check the switching voltages by referring to the values specified in circuit diagram 249.8813 S. Frequency-response measurements with a swept impedance meter (e.g. ZWD) should give passband attenuations < 1 dB and stopband attenuations > 20 dB. Check according to the following table:

Range	1 - 3	4	5	6	7, 8
Passband	< 86 MHz	86 - 130 MHz	120 - 200 MHz	200 - 300 MHz	300 - 525 MHz
Stopband	> 98 MHz	> 170 MHz	> 236 MHz	> 392 MHz	-
Reflection coefficient in passband	< 30%	< 30%	< 30%	< 30%	< 20%

5.3.6.9 Output Filter Y32/Y33

Check the passband characteristic with a swept impedance meter (e.g. ZWD). The attenuation in the passband up to 530 MHz should be < 1 dB. Stopband attenuation above 588 MHz should be > 30 dB. Attenuation poles appear at 588 MHz, 624 MHz, approx. 750 MHz and approx. 1200 MHz.

5.3.6.10 RF Attenuator Y4

See circuit diagram 249.3711 S

Check the input impedance (45 to 60 Ω) at ST41 and the output impedance (42.5 to 57.5 Ω) at BU41 with the attenuator in a position < 0 dBm.

To check the attenuator calibration, connect a test receiver (e.g. HFH) via a precision attenuator set (e.g. DPVP) to the RF output of the SMDU. Measure at 30 MHz. Vary the attenuation in equal steps of opposite direction on the SMDU attenuator and the external attenuator set. Any deviation can be read on the test receiver; it should be < 0.25 dB.

5.3.6.11 Demodulator Y41

The demodulator consists of a thin-film circuit and cannot be repaired. Replacement can be ordered under reference number 910.2904.

For checking unscrew the cover plate, leaving the demodulator in the attenuator.

Measure the rectified voltage at ST42 to determine the frequency response and thereby the different charging time constants. The RF input voltage at ST41 should be 1 V. Set the attenuator to a position < 0 dBm. The maximum possible variation of the rectified voltage in the whole frequency range of the SMDU is ±2%. Also check the switching voltages at ST43:

Frequency at ST41	140 - 400 kHz	0.4 - 8 MHz	> 8 MHz
Voltage at ST43.3 Voltage at ST43.4	+15 V +15 V	-15 V -15 V	-15 V -15 V

Measure the distortion of the demodulated signal at ST42 with an 80% modulated RF signal applied:

Frequency at ST41 mod. = 80%	140 - 400 kHz	0.4 - 8 MHz	> 8 MHz
Modulation frequency	< 5 kHz	< 15 kHz	< 50 kHz
Permissible AF distortion	< 2%	< 2%	< 2%

Measure the RF distortion at the RF output. Set the attenuator to < 0 dBm and apply to ST41 an RF voltage with a level of 1 V and harmonics down > 55 dB (e.g. from SMLU followed by a Lowpass Filter PTU). Measure the harmonic suppression at the RF output with an analyzer (e.g. EZF); it should be > 45 dB.

5.3.6.12 Rectified-voltage Compensation Y41

Radiotelephone Model 249.3011.06

Adjust the AF signal for modulation-depth indication with R2. Contact 7 must either be connected to the modulation unit via K27 or be terminated with 2.2 kΩ. Set the attenuator to a position < 0 dBm and adjust a modulation depth of 80% with 1 kHz modulation frequency. The AF level at contact 7 should be 400 mV_{rms}.

Radiotelephone Model 249.3011.07

Note: Prior to adjusting the AF and the rectified voltage, check the offset adjustment and the adjustment of the RF output voltage in the control amplifier Y38 (see section 5.3.6.1).

The AF signal for modulation-depth indication is adjusted with R2. Contact 7 must either be connected to the modulation unit via K27 or be terminated with 2.2 kΩ. Set the attenuator to a position < 0 dBm and adjust the modulation depth to precisely 40.0% with a modulation frequency of 90 Hz or 150 Hz. The AF level at contact 7 should be 200 mV_{rms}. Adjust the ILS voltage at 115 MHz and 330 MHz for an AF level of 990 mV ±1 mV between contacts 1 and 2 of the DEMOD. OUTPUT using R4.

The rectified voltage is adjusted with R8: Connect a digital voltmeter between contacts 1 and 2 (chassis) of the DEMOD. OUTPUT at the rear. Cut the RF carrier off by connecting contacts 4 and 5 of the DEMOD. OUTPUT and adjust the DC voltage to -3.5 V ±5 mV with R8. Repeat both adjustments if necessary.

5.3.6.13 Checking the Control Loops

See circuit description and diagram in section 4.5

Amplitude control: Close the amplitude control loop through the whole amplifier Y2 including demodulator Y41 and control amplifier Y38. To cut the modulation feedback off, disconnect cable K23 from contact 7 of the modulator Y28. Set a signal-generator frequency below 8 MHz so that the ALC at the modulator input is cut off. Measure the DC voltage at check point ST27.13; the amplitude control has reached steady state at a DC voltage of about +0.6 V.

Level control at modulator input: Check with the negative modulation feedback cut off (cable K23 disconnected). Set a signal-generator frequency above 10 MHz. The DC voltage should be +0.7 to 1 V at ST27.13 and +1.4 V to 1.9 V at ST27.26. The RF level at RF output II should be 90 to 100 mV in the frequency range 90 to 440 MHz and about 50 mV at 525 MHz.

Negative modulation feedback: Interrupt the modulation feedback circuit (disconnect K23 from contact 7 of the modulator) and adjust on the SMDU a level < 0 dBm, the modulation frequency of 1 kHz and a modulation depth of 80%. Close the modulation feedback circuit by reconnecting cable K23. The modulation depth should now be 9 to 10%.

5.3.7 Modulation Unit Y8 of Radiotelephone Model

See circuit diagram 250.2015 S

5.3.7.1 Modulation Generator Y84

See circuit diagram 250.2696 S

Checking the fixed frequencies: Consecutively select the different fixed frequencies and measure using a counter.

Permissible departure from nominal: ±1%

Adjustment: not provided.

Checking the variable frequency ranges: Consecutively select the different frequency ranges; use button FREQ. 21 to adjust the lower and the upper range end and measure with the aid of a counter.

The selected frequency range should at least cover the nominal range; the lower and the upper range limits of the different ranges should overlap.

Adjustment: R10 and R20 permit adjustment of the lower and the upper range limits. The scale is adjusted by turning the disk on the shaft of knob FREQ.

Checking the output voltage: Measure the output voltage at Bu15.a10 or Bu17.b10 (on 250.2015 S). For the fixed frequencies, the nominal level is 4.3 V_{rms} $\pm 2\%$. The voltage at socket MOD. GEN. 41 is measured with a load of 200 Ω. With the LEVEL control turned fully clockwise, the voltage should be at least 5 V_{rms} in the fixed-frequency mode.

Checking the distortion: The distortion is measured at Bu15.a10 or Bu17.b10 under the same conditions as given for the voltage measurement.
Nominal value: $<$ 0.5% for all ranges

5.3.7.2 AM/FM Switch Y86 I

See circuit diagram 250.2744 S

Checking the FM path: Select internal frequency modulation; adjust a modulation frequency of 1 kHz, set the deviation range switch to 100 kHz and turn the FM deviation knob to the righthand stop. Measure the voltage at Bu17.b6; nominal value $\geq$ 4.25 V_{rms}. When switching the deviation range over to 10 kHz, the same voltage ($\pm 1\%$) should be present. The signal should not be limited.

Checking the preemphasis of 6 dB/octave: Connect an AF millivoltmeter to socket Bu17.b6 and adjust for 0.5 V_{rms} with the FM deviation control. Connect the preemphasis and vary the modulation frequency in accordance with the following table.

Frequency	Voltage at Bu17.b6	
0.5 kHz	0.25 V	2%
1 kHz	0.5 V	
2 kHz	1.0 V	
4 kHz	2.0 V	3%

Note: Instead of an AF millivoltmeter at Bu17.b6, the SMDU meter can be used.

Select external frequency modulation and apply an AF signal (1 kHz) to socket EXTERN. MODULATION FM 52 (on the front panel). The signal should appear at socket Bu17.b6.

Checking the AM path: Select internal amplitude modulation and adjust a modulation frequency of 1 kHz. Turn the modulation depth control to the righthand stop.

Measure the voltage at Bu17.b3; nominal value: $\geqq 1.2\ V_{rms}$
The signal should not be limited.

Connect the AM indication (23) and adjust for 100% indication using R87 of 274.9610 (on 250.2015 S).

Select external amplitude modulation and apply an AF signal (1 kHz) to socket EXTERN. MODULATION AM (on the front panel). The signal should appear at Bu17.b3.

Checking the on/off positions of the modulation generator: A signal of -15 V is present at Bu17.a15 if one or both buttons MOD (AM and/or FM) are pressed. If ɒoth buttons are released, the voltage is +15 V.

Checking the AM level control: If button AM MOD. is pressed, +15 V is present at Bu17.b4; with button AM MOD. released, the voltage is -15 V.

5.3.7.3 Meter Section

See circuit diagram 250.2015 S

Checking the AF signal path: see section 5.2.6.2

Adjusting the rms-responding meter (see 250.2296 S):

Connect the AF voltmeter and withdraw the preamplifier B1.

Adjustment	Procedure	Measured value
a) Offset with R19	Take MP1 to chassis	Minimum voltage (< 10 mV) at MP3
b) Symmetry I with R13	Alternately apply +3 V and -3 V DC to MP1	Equal signal at MP3 for positive and negative input: about 1 V
c) Symmetry II with R16	Alternately apply +1 V and -1 V DC to MP1	Equal signal at MP3 for positive and negative input: about 0.3 V
d) Scale error with R23	Apply 3 V_{rms} to MP1	1.000 V DC should be present at MP4

If necessary, repeat the symmetry adjustment several times alternately for symmetry I and II.

Insert the preamplifier B1 and apply 1.000 V_{rms} to socket AF VOLTMETER 44 ; select the 1-V indication range. +1.000 V DC should be present at MP4; if necessary, correct with R23. Adjust the meter for 1 V f.s.d. using R45.

Adjusting the peak-responding meter:

Select AM indication and withdraw the preamplifier B1. Apply an AF signal of 2.12 V_{rms} (= 3 V_p) to MP1. Adjust the DC voltage at MP4 to 1.00 V using R31.

Adjusting the CCITT filter:

The transmission loss of the CCITT filter is 0 dB at 800 Hz. Connect the AF voltmeter and apply an AF signal of 1 V_{rms} and 800 Hz to socket AF VOLTMETER 44 . The meter should indicate 1 V. Switch in the CCITT filter and set the meter to 1 V using R65. The coils of the CCITT filter are preadjusted; no further adjustment is provided.

Adjusting the different modes of indication:

Prior to this adjustment, the rms-responding meter, the peak-responding meter and the AF voltmeter should be adjusted. No particular order has to be followed when adjusting the remaining modes. Press button MOD. GEN. and select f_{mod} = 1 kHz. Use an AF voltmeter to measure the voltage at the different checkpoints.

Adjusting the FM indication:

Adjust for 3.89 V_{rms} (= 5.5 V_p) at output Bu17.b6 (MP4) of the AM/FM switch Y86 II using the FM deviation control. Adjust the meter indication to a deviation of 100 kHz with R4 (on 250.2015 S).

Adjusting the φ M indication:

Same as for adjusting the FM indication. Use R11 (on 250.2015 S) to adjust the meter indication for 100 rad.

Adjusting the AM indication:

Adjust for 400 mV_{rms} at input ST83.28 (on 250.2015 S) using the modulation depth control (35). Adjust the meter indication to 80% with R20 (on 250.2015 S).

Adjusting the MOD. GEN. indication:

Adjust for 1 V_{rms} at the MOD. GEN. output socket (41 on the front panel) using the LEVEL knob 34 . Both meters should indicate 1 V_{rms} (±2%). If this value is not obtained, vary R46 in the modulation generator Y84.

5.3.7.4 Distortion Meter/SINAD Ratio Meter

Checking the distortion meter: see 5.2.6.6

Adjusting the 1-kHz bandstop filter

(see 250.2644 S)

Apply a 1-V_{rms} AF signal to the input AF VOLTMETER; connect the AF voltmeter and the distortion meter. Set the AF to 0.990 kHz and adjust for a voltage minimum at MP6 using R57.

Set the AF to 1.010 kHz and adjust for a voltage minimum at MP6 using R44.

Set the AF to 1.000 kHz and adjust for a voltage minimum at MP4 by varying R41 and R39 alternately. An attenuation of 60 dB should be obtained. If it proves difficult to adjust at MP4, withdraw amplifier B6.

Adjusting the distortion indication and the level control:

Apply an AF signal of 1 V_{rms} and 3 kHz to the input AF VOLTMETER; connect the AF voltmeter and the distortion meter. If LED "uncal." lights up, vary R91 until the LED goes out. Adjust the meter for 100% using R28. The level at MP9 should be 1.6 to 1.7 V_{rms}.

Reduce the input signal to 45 mV_{rms} and 1 kHz. Vary R91 until LED "uncal." lights up (approx. 8.6 V DC at B4II5). Increase the input signal to 50 mV_{rms}, the LED should go out.

No additional adjustment is required for SINAD ratio measurements.

For checking the SINAD ratio meter see 3.2.13.

5.3.7.5 Deviation Meter

Checking the deviation meter: see 5.2.6.3.

Adjusting the IF of the deviation meter and the LED 26 :

Apply a signal of 50 mV_{rms} and 150 MHz to socket EXT. FREQ. + DEV. METER 46 and adjust the SMDU oscillator to about 7 MHz; select the duplex mode on the deviation meter.

Measure the IF at MP9 of the discriminator and control circuit Y81 (squarewave signal). Adjust the IF to 200 kHz using R424 (on 250.3228 S). Next adjust R64 (in the rms- and peak responding meter 250.2296) to make LED READY light. Adjust the potentiometer such that the diode remains on over the entire capture range (4.2 to 10.7 MHz) of the deviation meter.

Adjusting the deviation indication:

Modulate the deviation meter with an external frequency of 1 kHz and 10 kHz deviation. For checking, connect a modulation meter in parallel with the deviation meter input and measure the FM deviation (see 3.2.11). Adjust the deviation indication for 10 kHz deviation using R15 (in the 1-kHz bandstop filter and divider 250.2644).

5.3.7.6 Control Logic

Connect the MOD. GENERATOR and select INDICATION MOD. GEN.

Checking the manual range selection: Select all ranges manually and adjust the level for each range using LEVEL control 34 .

Checking the automatic range selection: Set switch 22 to AUTO and turn the LEVEL control fully clockwise. The range indication should stop in highest range (10,000 mV). Turn the LEVEL control anticlockwise, the range indication should stop in the lowest range (10 mV).

Adjusting the switchover threshold of the meter:
Set switch 22 to AUTO and adjust the meter to 500 mV in the 1000-mV range using the LEVEL control. Reduce the level until the meter switches over to the 300-mV range.

Use R1 (in the control logic 274.9861 S) to adjust this switchover for 300 mV in the 1000-mV range.

Checking the button combinations in accordance with the following tables

Table 5-8

INDICATION buttons					Functional buttons					
1	2	3	4	5	6	7	8			
AF VOLTM.	MOD. GEN.	AM	φM	FM	SINAD	DIST.	DEV. METER	Luminous display	rms value	Peak value
								no indication		
x								mV	x	
x					x			%	x	
x						x		%	x	
x					x	x		%	x	
	x							mV	x	
		x						%		x
			x					rad	1)	x
			x			x	x	%	x	
			x		x		x	%	x	
			x		x	x	x	%	x	
				x				kHz	1)	x
				x		x	x	%	x	
				x	x		x	%	x	
				x	x	x	x	%	x	
Interlocked buttons					Independent buttons					

All combinations of buttons 6 to 8 not shown in the table have the same effect as if none of the buttons were pressed.

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1) rms value in the ranges .1 and .3 kHz
peak value in the range 1 kHz to 100 kHz

Table 5-9

Range	0.1	0.3	1	3	10	30	100	300	1000	3000	10000
%			x	x	x	x	x				
kHz	x	x	x	x	x	x	x				
rad	x	x	x	x	x	x	x				
mV					x	x	x	x	x	x	x

Note: For further logic connections see table 4-1.

Checking the SINAD LEDs

Connect the AF VOLTM. and the SINAD ratio meter; select the different ranges with switch 22 . The LEDs should light up for the following ranges:

6 dB SINAD - 100% range
12 dB SINAD - 30% range
20 dB SINAD - 10% range

5.3.8 Synchronizer SMDU-B1

5.3.8.1 Synchronization without Fine Tuning

Press SYNCHRON button and release FINE TUNING button.

Adjusting the offset voltage for the sampling system:

Adjust R30 in the sampler Y202 so that the holding range of the CONTROL VOLT. meter is equal for positive and negative variation of the signal-generator frequency. Then turn R30 slightly counterclockwise until the holding range for positive variation is 10 to 15% wider than that for negative variation.

Example: Holding range with positive variation: 4.8 div.
Holding range with negative variation: 4.4 div.

Checking: Set a signal-generator frequency of 10.050 MHz, depress button SYNCHRON, release FINE TUNING and set the CH. SPACING switch to 50 kHz. Vary the signal-generator frequency until the pointer of the CONTROL VOLT. meter is close to the left of the centre mark (when the Synchronizer is switched off, the frequency indication is between 10.000 and 10.050 MHz). With the Synchronizer switched on, change the spacing of the locking points from 50 kHz to 100 kHz. The signal generator is not allowed to lock in at 10.050 MHz. Repeat the switchover operation ten times.

5.3.8.2 Synchronization with Fine Tuning

Depress the buttons SYNCHRON and FINE TUNING.

Adjusting the VFO:

Set the upper and the lower button FREQ. FINE fully counterclockwise. Set the CH. SPACING switch to 100 kHz. Connect an oscilloscope to pin 1 of the monostable B6 in the fine tuning circuit Y201. Adjust coil L2 so that the measured curve appears as a steady picture on the oscilloscope and does not change when L2 is slightly varied (coarse adjustment). For fine adjustment measure the DC voltage at pin 6 of B9 and adjust L2 so that the DC voltage minimum is 1.5 V (lower knob FREQ. FINE at lefthand stop, button 49 - 64.5 MHz depressed) and the maximum is 12 V (lower knob FREQ. FINE at righthand stop, button 196 - 290 MHz depressed). Check by turning the lower knob FREQ. FINE clockwise and then again counterclockwise: The curve measured at pin 1 of B6 is not allowed to jump.

Adjusting the temperature effect on the fine tuning circuit: Set a frequency of 100 MHz and a locking-point spacing of 100 kHz. Measure the temperature effect on the synchronized frequency. Compensate with R18. If the frequency falls with temperature, turn R18 counterclockwise; if it increases with temperature, turn R18 clockwise. Turn R18 such that the resulting frequency variation is a multiple of the temperature-dependent drift, e.g. 100 x drift/5 min.

5.3.9 1.05-GHz Frequency Range Extension SMDU-B3 and 1.05-GHz Frequency Doubler SMDU-B5

5.3.9.1 Adjusting the Non-harmonic Suppression

Connect the analyzer to ST305. Set a frequency of 1000 MHz. The suppression of the non-harmonics 0.5 f and 1.5 f is set to maximum using R13. The typical value is 20 dB.

5.3.10 1-GHz Frequency Meter SMDU-B4

5.3.10.1 Adjusting the Operating Voltage for B20

Use R22 to set the operating voltage to +7.4 V $\pm$0.1 V after removing B20. Reinsert B20. If necessary, adjust the voltage with R22.

5.3.10.2 Adjusting the Sensitivity of the Frequency Meter

Apply 500 MHz with 25 mV to input 47 (Fig. 2-1). Press button 11 0.5 - 1 GHz. Adjust R14 such that the counter readout jumps from 500 MHz to zero.

5.4 Removing and Opening the Subassemblies

See Figs. 5-5 to 5-11 of Appendix

5.4.1 Counter Y7

The counter must be opened before adjustments and measurements can be made on this subassembly. This requires the following mechanical work:

Remove the upper cover plate (screws A in Fig. 5-5).

With the Synchronizer SMDU-B1 built-in, remove the front panel insert (remove screws F of Fig. 5-6.3 and connector strip BU1). Remove screws H (Fig. 5-6.1), cables K201 and K202 and connector BU203; then take the Synchronizer case out.

Remove screws J (Fig. 5-6.2) and take the cover plate off.

5.4.2 Oscillator Y1

Before proceeding to adjustments in the oscillator, the following mechanical operations must be made:

Remove the upper and lower cover plates of the instrument (screws A and B in Fig. 5-5).

Remove the lefthand side wall to gain access to the potentiometers on the range switch board 250.1019 (screws C in Fig. 5-5.1).

Remove the Synchronizer front-panel insert (only when Synchronizer 249.6340.02 is incorporated; remove screws F in Fig. 5-6.3 and connector strip BU1 at the lefthand side of the Synchronizer case).

Disconnect cable K11 at the rear of the counter.

Slacken coupling rings of cables K14, K15 and K16 by half a turn.

Loosen the screws fixing the counter (screws G in Fig. 5-6.2) so far that they are pressed upwards by the built-in springs.

Push the counter back as far as possible, lift up the front of the counter and push back again until a stop is felt. The counter can then be swung up (Fig. 5-6.3).

The trimming cover can be removed when the 6 screws L (Fig. 5-7.1) are loosened.

To make repairs on the oscillator, the oscillator cover must be taken off. The 12 screws M (Fig. 5-7.1) must be removed for this purpose.

5.4.3 Range Switch Y10

Before proceeding to adjustments in the range switch, the following mechanical operations must be made:

Remove the upper and lower cover plates of the instrument (screws A and B in Fig. 5-5).

Remove the lefthand side wall (screws C in Fig. 5-5.1).

To remove the range switch board proceed as follows:

Remove connector strips ST111, ST112, ST113 and ST114.

Loosen screws K (Fig. 5-7.2) and remove cable K101. Push the board outward at the rear, then pull it out.

5.4.4 Amplifier Y2

Before any measurements can be made in the amplifier, the following mechanical operations must be made:

Loosen screws B (Fig. 5-5) and remove the lower cover plate.

Remove 24 screws R (Fig. 5- 8.1; 19 of these screws are located along the outer edge of the cover plate) and take the cover plate of the amplifier off.

To remove the amplifier proceed as follows:

Loosen screws B (Fig. 5-8) and remove the lower cover plate.

Remove connector strip BU27 and unscrew the cables K15, K16, K17, K18, K19 and K112 at the amplifier.

Remove screws P (Figs. 5- 7.2 and 5- 7 .3).

Lift the amplifier at the right side and pull upwards to the right (Fig. 5- 8.1).

5.4.5 Mixer Oscillator Y6

To make measurements in the mixer oscillator, remove the screws E (Fig. 5- 8.2) and take the rear panel off.

Remove the screws S (Fig. 5- 8.2) and take the cover plate of the mixer oscillator off.

To remove the mixer oscillator, loosen the screws A and B (Fig. 5-5) and take the upper and lower cover plates off.

Remove the lefthand side wall after loosening the screws C (Fig. 5-5.1).

Remove the connecting cable at the rear panel (REF. FREQ., Fig. 5- 8.2).

Remove connector strip BU63 and unscrew the cables K14 and K17 at the mixer oscillator. Remove the retaining screws Q (Figs. 5-7.1, 5- 7.2 and 5- 8.2) and take the mixer oscillator out.

5.4.6 RF Attenuator Y4

To make measurements in the attenuator and to remove the demodulator Y41 and resistive layer R41 proceed as follows:

Loosen screws B (Fig. 5-5) and remove the lower cover plate.

Remove cables K18 and K19; remove the screws T (Fig. 5- 8.1) and pull the cover plate of the attenuator out at the left side.

To remove the attenuator, loosen screws B (Fig. 5-5) and remove the lower cover plate.

Remove cables K18 and K19. Disconnect cable K41 at the Overload Protector Y5.

Withdraw the Modulation Unit from the instrument in accordance with section 5.4.8.

Unscrew the crank-type knob on the front panel.

Remove screws U (Fig. 5- 7.3) and loosen screws V (Fig. 5- 8.3).

Push the attenuator backwards and pull out by lifting.

5.4.7 Power Supply Y9

To remove the power supply, loosen screws B (Fig. 5-5) and remove the lower cover plate.

Loosen screws E (Fig. 5- 8.2) and remove the rear panel.

Remove the amplifier Y2 according to section 5.4.4.

Remove connector strips BU91 and BU92.

Remove screws W (Fig. 5- 8.2) and remove the power supply at the bottom of the instrument.

5.4.8 Modulation Unit Y8

Remove connector strip BU83 and the cables K20, K30 and K403 (if the 1.05-GHz Frequency Range Extension is incorporated).
Remove the four screws retaining the modulation unit on the front panel and pull the modulation unit out.

Removing the circuit boards

After removing the two mountings Y (Fig. 5- 9.1) withdraw subassemblies Y83 (rms- and peak-responding meter) and Y85 (control logic). Prior to removing Y85, undo the connections ST5, ST6 and ST7.

The subassemblies

- 1-kHz bandstop filter and attenuator Y82
- modulation generator Y84
- AM/FM switch Y86

can be pulled out only after removing the front panel. To this effect proceed as follows:

- Detach all connections between the front panel and the circuit boards.
- Unscrew the knobs on the front panel.
- Remove the screwed connections Z (Figs. 5- 9.1 and 5- 9.2) between the front panel and the motherboard.

Deviation meter Y81 (Fig. 5-10)
Remove the shielding cover of the deviation meter and undo the screws fixing the corresponding circuit board.
Unsolder the connections of the circuit board as well as those leading to the soldering pins and remove the board. When dismantling the RF amplifier 250.2396, undo the screwed connections of the Subminax connectors on the outer side of the RF cable. The board is then withdrawn together with the Subminax connectors.

5.4.9 1.05-GHz Frequency Range Extension SMDU-B3 and 1.05-GHz Frequency Doubler SMDU-B5

To withdraw the Frequency Range Extension, loosen screws A and B (Fig. 5-5.2) and remove the lower and the upper cover plates. Remove the righthand side wall (after loosening screws C; Fig. 5-5.1). Remove connector strip ST303 and unscrew cables K301 and K302 from RS2 and RS3.

Remove the six retaining screws (Fig. 5-11) and withdraw the Frequency Range Extension or the Frequency Doubler.

5.4.9.1 Doubler Y301

To open the subassembly, loosen the six screws of the cover (Fig. 5-11).

5.4.9.2 Bandpass Filters 0.5 - 1 GHz Y302 and Final Stage Y303

(for 1.05-GHz Frequency Range Extension SMDU-B3 only)

These thin-film circuits can be repaired only in the factory.
Opening the subassembly invalidates the guarantee.

5.5 Incorporating Options into the SMDU

5.5.1 Synchronizer SMDU-B1

Loosen screws A (Fig. 5-5) and remove the upper cover plate.

Loosen screws F (Fig. 5-6.3) and take the blank panel off.

Remove the caps of ST76 and ST77 on counter Y7.

Remove screws H (Fig. 5-6.2).

Put the Synchronizer case on the counter case and fix with the screws supplied.

Screw the cable K201 to ST76 (counter) and ST201 (Synchronizer).

Screw the cable K202 to ST77 (counter) and ST202 (Synchronizer).

Insert the Synchronizer front panel and fix with screws F (Fig. 5-6.3).

Plug the connector strip BU203 to the Synchronizer on the left side.

5.5.2 1.05-GHz Frequency Range Extension SMDU-B3 and 1.05-GHz Frequency Doubler SMDU-B5

The 1.05-GHz Frequency Range Extension or the 1.05-GHz Frequency Doubler is incorporated on the righthand side of the SMDU. The units are factory-adjusted and fully operational without any further adjustments.

Incorporating Instructions

a) Loosen screws A and B (Fig. 5-5) and remove the upper and the lower cover plates.

b) Loosen screws D (Fig. 5-5.2) and remove the righthand side wall.

c) Insert the Frequency Range Extension or the Frequency Doubler and fix with six screws. Plug socket Bu303 onto connector ST303.

d) Remove cable K18 between the amplifier Y2/ST26 and RF attenuator Y4/ST41.

   Connect amplifier Y2 (connector ST26) to the Frequency Range Extension or Frequency Doubler (ST301) using cable K301.

Connect RF attenuator Y4 (connector ST41) to the Frequency Range Extension or Frequency Doubler (ST302) using cable K302.

e) Solder wire link BR1 (see drawing No. 250.1019) to switch Y10 (250.1019).

Note: If sidebands are detected with an analyzer at 500 kHz off the carrier, the following step can be useful: Solder a 10 nF capacitor between common point R68-R69-R70-R71 and chassis on Modulator board 249.9403, wich is part of amplifier Y2.

5.5.3 1-GHz Frequency Meter SMDU-B4

The 1-GHz Frequency Meter is fixed on the righthand side of the SMDU to the rear vertical frame section. Fig.5-7.3 shows the position; this is the dark area where two electrolytic capacitors can be seen. The Frequency Meter is factory-adjusted and fully operational without any further adjustments.

Incorporating Instructions

a) Loosen screws A and B (Fig.5-5) and remove the upper and the lower cover plates.
b) Remove the rear cover plate and then the righthand bracket.
c) Unscrew the bracket which is fixed to the Frequency Meter upon delivery and fix it to the rear rail using the nuts and screws included in the delivery.
d) Remove the cap from connector ST403 (located on the 1-GHz Frequency Meter). Insert the Frequency Meter into the slots provided and tighten the screws. Reinsert the cap.
e) Connect cable K1 to connector ST401 and plug socket BU404 onto connector ST404.
f) Connect ST402 to ST7 of subassembly Y7 using cable K402.
g) Remove the locking device at the button FREQ.METER 0.5 - 1 GHz.

5.6. Modification of Synchronizer SMDU-B1

See circuit diagrams 249.6340 S and 275.0168 S

The modification concerns the spacing of the locking points which can be changed from 12.5 kHz to 10 kHz. To this effect, the division ratio of the program divider and the loop gain has to be modified.

a) Modification of division ratio
(circuit diagram 275.0168 S)

Unsolder the cathode of diode GL13 and solder it to the anode of GL6. The new division ratio is 64.

b) Modification of loop gain
(circuit diagram 249.6340 S)

Replace resistor R231 located on the front-panel channel switch by a 8.2-kΩ component.