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Measuring Instruments
and Systems Division

Manual

POWER REFLECTION METER
NAP

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2 Preparation for Use and Operating Instructions

(Refer to Figs 2-1 and 2-2 in the appendix)

The values given in this section are not guaranteed values. Only the values given in the data sheet are binding.

All underlined figures refer to the operating controls of the front and rear views.

2.1 Explanation of the Front and Rear Views

2.1.1 Front View

Ref. No.	Labelling	Function
1	SHIFT	Key for entry of shift function while another key is pressed.
2	FORWARD	Display to indicate the incident measurement functions.
3	LINE	LED to indicate AC power ON (only if option B4 is fitted).
4	REMOTE	LED to indicate the remote control status in IEC-bus operation (only if option B4 is fitted).
5	REVERSE	Display to indicate the reflected measurement functions, IEC address and special functions.
6	ON	Key to switch the instrument on and off.
7	1	RF input for measuring channel 1.
8	2	RF input for measuring channel 2.

Ref. No.	Labelling		Direct function	SHIFT function
9	W	%	Reflected power in W	Reflected-power deviat. in %
	dBm	dB	Reflected power in dBm	Reflected-power deviat. in dB
	SWR	2	Standing-wave ratio	Decimal input "2"
	RTL	7	Return loss in dB	Decimal input "7"
	P_R/P_F	8	Incident-to-reflected power ratio in %	Decimal input "8"
	RFL	·	Reflection coefficient in %	Decimal input "9"
10	LOC	.	Switching from remote control to manual control in IEC-bus operation	Input of decimal point.
11	CLR	SF	Clearing of error messages, wrong key or decimal inputs.	Call or storage of special functions.
12	MIN	5	Start of minimum-value display of the last measurement function selected.	Decimal input "5"
	MAX	6	Start of maximum-value display of the last measurement function selected.	Decimal input "6"
13	STO	0	Termination of reference-value input or decimal input.	Decimal input "0"
	RCL	1	Output of reference-value or stored special function.	Decimal input "1"
14	dBm	dB	Incident power in dBm	Incident-power deviation in dB
	W	%	Incident power in W	Incident-power deviation in %
	AM	3	Amplitude modulation in %	Decimal input "3"
	TML	4	Transmission loss in dB	Decimal input "4"
15	PEP	CF	Switchover between peak-value and average-value measurement [1])	Entry and check of calibration factors

[1]) Only applies if power head permitting switchover between peak-value and average-value measurement is used.

2.1.2 Rear View

Ref. No.	Labelling	Function
16	POWER HEAD	Connector for power head (50-way trapezoidal connector to DIN 41652)
17	IEC 625	Connector for IEC-bus interface (24-way Amphenol connector of Series 57)
18	47...63 Hz	Power receptacle
19	220 V...240 V T 100 100 V...120 V T 200	Fuse panel
20	F1	Fuse holder
21	DC ± 2 V F R	Analog output for forward (F) power and reflected (R) power.
22		Cable clamp for pull relief of power-head cable

2.2 Preparation for Use

2.2.1 Setting up the Power Meter

The NAP may be operated in any position. For ease of operation and to facilitate reading the displays, it is best to tilt the instrument slightly. For this purpose, press the two ends of the carrying handle together near the pivot, adjust the handle to the desired position and release it to let it lock in place.

Like all liquid crystal displays, the displays of the NAP have a preferred visual line where an optimum contrast of the display is ensured. In the case of the NAP this optimum contrast is in a diagonal direction from above.

Two bars at the top of the NAP are provided to fix the power head when the whole unit is to be transported. For shipping purposes, however, the power head should be packed separately.

2.2.2 Rackmounting the Power Meter

The NAP can be mounted in 19" racks when using Adapter ZZA-12 (see "Recommended Extras"). For this purpose, the two covers are replaced by special covers, the carrying handle and the two side strips are removed and a dummy section is screwed to the left-hand or right-hand side of the NAP.

In the rack the NAP should be placed such that it is exposed to minimum heat, thus reducing faults caused by thermal voltages.

2.2.3 Adapting the RF Connectors

The power heads of the NAP are fitted with precision Dezifix B or N connectors, depending on the maximum power. Rohde & Schwarz supplies screw-in assemblies for adaptation to other connector systems. The most common ones are:

Type	Order number		Power-handling capacity at SWR 1.0	
	Male connector	Female connector	100 MHz	1000 MHz
N	017.7532.00	017.5398.00	2 kW	0.6 kW
BNC	017.7832.00	017.5730.00	1.5 kW	0.4 kW
4.1/9.5	017.9106.00	017.8516.00	2 kW	0.8 kW
Dezifix B	018.2486.00		2.5 kW	1.3 kW

Always order two sets of screw-in assemblies.

Replace the outer and inner conductors of the connector by the screw-in assembly (screw inner conductor not too tight). A special wrench (order No. FG 019.1877) is available for unscrewing the N or Dezifix B outer conductor.

Generally, adaptation is only advisable if always or chiefly the same RF connector system is used. However, if measurements are to be made with different connector systems, it is preferable to use RF adapters. Adapters available from Rohde & Schwarz are listed in data sheet 902.100.

The VSWR and directivity specified in this data sheet apply if the power head is fitted with Dezifix B or N connectors. When using other connector systems, the VSWR increases according to the inherent reflection of these systems, while the directivity may slightly decrease.

2.2.4 Power Supply

2.2.4.1 Battery Operation

The basic model of the NAP is equipped with six single cells of 1.5 V/R20. Each battery set has a lifetime of about 500 hours.

To prevent discharging of the batteries when the operator fails to switch the NAP off, it turns off automatically if for half an hour neither an entry is made nor a change of the measured value requires changing of the scale in at least one of the displays. If such automatic turn-off is not desired, it can be inhibited by entering the special function 40.

In case the battery voltage drops too much during operation, the analog displays begin to flash. From this moment the power meter will still be operating for about 10 minutes; it then switches off automatically. The method of exchanging the batteries is described in section 3.4.2.

The battery voltage can be checked after the special function 60 has been entered. The voltage is indicated in the right-hand display. Below 5.8 V, the analog display begins to flash; if the voltage drops below 5.7 V, the NAP turns off automatically.

2.2.4.2 Operation with AC Power/IEC-bus Option NAP-B4

If the NAP is fitted with the option NAP-B4, it may be operated with AC power or the built-in nickel-cadmium accumulators.

When the NAP is not connected to the power line, power is automatically supplied from the accumulators, which means that the instrument operates as described in the preceding section "Battery Operation". With the accumulators fully charged the duty cycle is about 100 hours.

The NAP is designed for line voltages of 100 to 120 V ±10%, 220 to 240 V ±10% and frequencies of 47 to 63 Hz. The instrument is factory-adjusted for a line voltage of 220 to 240 V. It can be switched to another line voltage via the fuse panel 19 on the rear side of the NAP. For this purpose, the appropriate power fuse must be inserted into the fuse holder 20:

Line voltage	Fuse
100 to 120 V	T 200 DIN 41662
220 to 240 V	T 100 DIN 41662

Spare fuses are supplied with the instrument.

Connect the NAP to the power outlet via the cable supplied. Since the power meter meets the regulations of VDE 0411 Safety Class I, connect it only to an outlet with earthing contact.

The LED 3 (LINE) is lit when the AC power is turned on. Automatic turn-off as is the case in battery or accumulator operation does not occur and the indication of the battery voltage via the special function is inhibited.

The accumulators are always recharged when the NAP is connected to the power line, even if the instrument is switched off. Discharged accumulators are completely recharged again after approx. 16 hours. If then the instrument is not immediately used for measurements, it is recommended that the AC power be turned off.

2.2.4.3 Mounting the Option NAP-B4

Remove the two panels, disconnect the cable to the battery box on the digital/analog PC board and remove the cover from the battery box. Loosen two screws on the rear panel and two on the battery box on the front side and take off the battery box.

Unscrew the two threaded bolts on the IEC-bus connector of the option and insert the option instead of the battery box; run the flat cable between the front panel and the PC board. Screw the option to the NAP by means of four screws (two screws on the rear panel, two on the front side of the option board). Screw the two rear bolts to the IEC-bus connector.

Connect the two sockets of the flat cable to the PC board and make sure that the narrow socket allows the cable to be run to the centre of the instrument.

Screw the cover on again.

Prior to putting the NAP into service, check for correct line voltage. When changing to 110 V, replace the power fuse.

2.2.5 Switching On

Switch the NAP on with key 6.

The switch-on procedure starts an initialization program during which the power head is detected and the following readings are available:

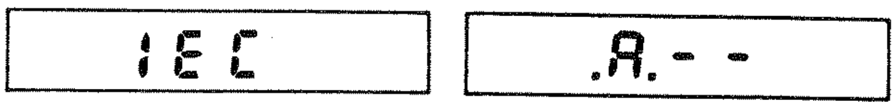
→ For about 1 s, a software code digit in the right display.

→ For about 1 s, "IEC" in the left display,
the IEC device address in the right display.

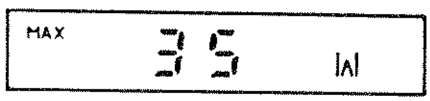
→ For about 7 s, the maximum nominal power of the power head in the left display.

Examples:

Device address in AC power operation: 25



Device turned on via battery or accumulator



Nominal power of power head: 35 W

Now the NAP automatically begins to measure with basic settings (power measurements in W, autoranging).

Note: During the self-test executed after switching on of the unit the most essential functions of the display section are checked. In case of errors, corresponding messages are read out (see 5.4). If the unit is switched on when the power head is not connected, the error message "Er.9"appears on the left display. It is maintained until the power head is connected. The initialization begins. If the unit cannot be switched on in AC supply operation, this may be due to defective accumulators (see section 5.4.3).

The error message "Er.6" indicates that neither a reference value nor a calibration factor or an IEC address is stored. This is the case e.g. after changing the battery or the accumulator.

2.2.6 Connecting the Power Head to the Signal Generator or the Load

Connect the signal generator to one terminal, the load to the other terminal of the power head. Since the two measuring channels are alike, either terminal can be used as input or output (Fig. 2-3).

Irrespective of the measuring direction, the incident power (from the signal generator to the load) is always indicated on the left display, while the reflected power (reflected by the load) always appears on the right display. The reflected power is always lower than or at the most equal to the incident power.

2.2.7 Influence of the RF Line Length of the Power Head

If the input impedance of the load differs from the characteristic impedance, the power head connected ahead of the load causes a change in load impedance, particularly at higher frequencies, since the RF line of the power head transforms the load impedance. Thus, when using signal generators with a load-dependent power output, such as is the case when the source impedance differs from the characteristic impedance, the signal generator delivers a slightly different power if the NAP power head is connected between the generator and the load than if these are directly connected.

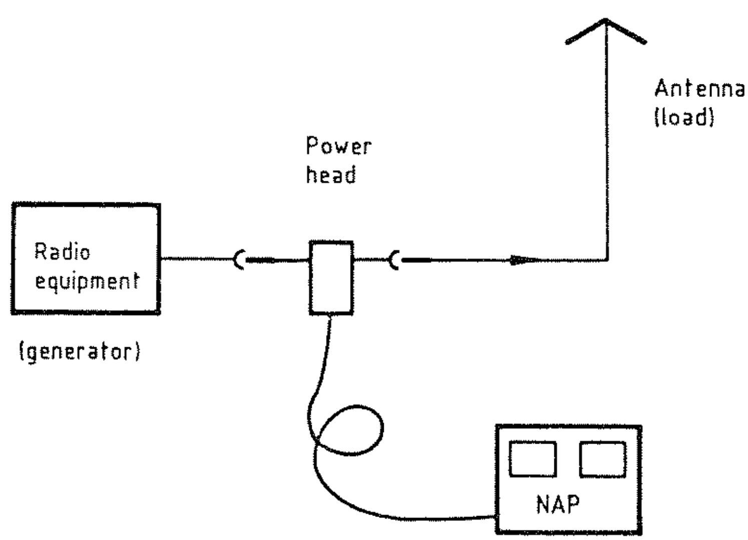


Fig. 2-3 Basic test setup with NAP and power head

This effect is negligible if the length of the additional line is less than 0.1 λ. This is the case for the Power Head NAP-Z7 and NAP-Z8 in the entire frequency range (up to 80 MHz), for the Power Heads NAP-Z3 to Z6 and Z9 up to a limit frequency of 220 MHz (electrical length of power heads: 140 mm).

If the power output is affected above this limit frequency, the electrical length of the power head can be complemented with an additional line section so that the overall electrical length of the line between the signal generator and the load equals $\lambda/2$ or is a multiple thereof. A $\lambda/2$ line does not cause a transformation.

The required electrical length l of the additional line is shown in Fig. 2-4. For measurements over a wide frequency range a line of variable length can be used. When measuring in a single radiotelephony band, however, it is sufficient to adjust the length of the line according to the centre frequency of the band, e.g. to 186 mm in the 70-cm band.

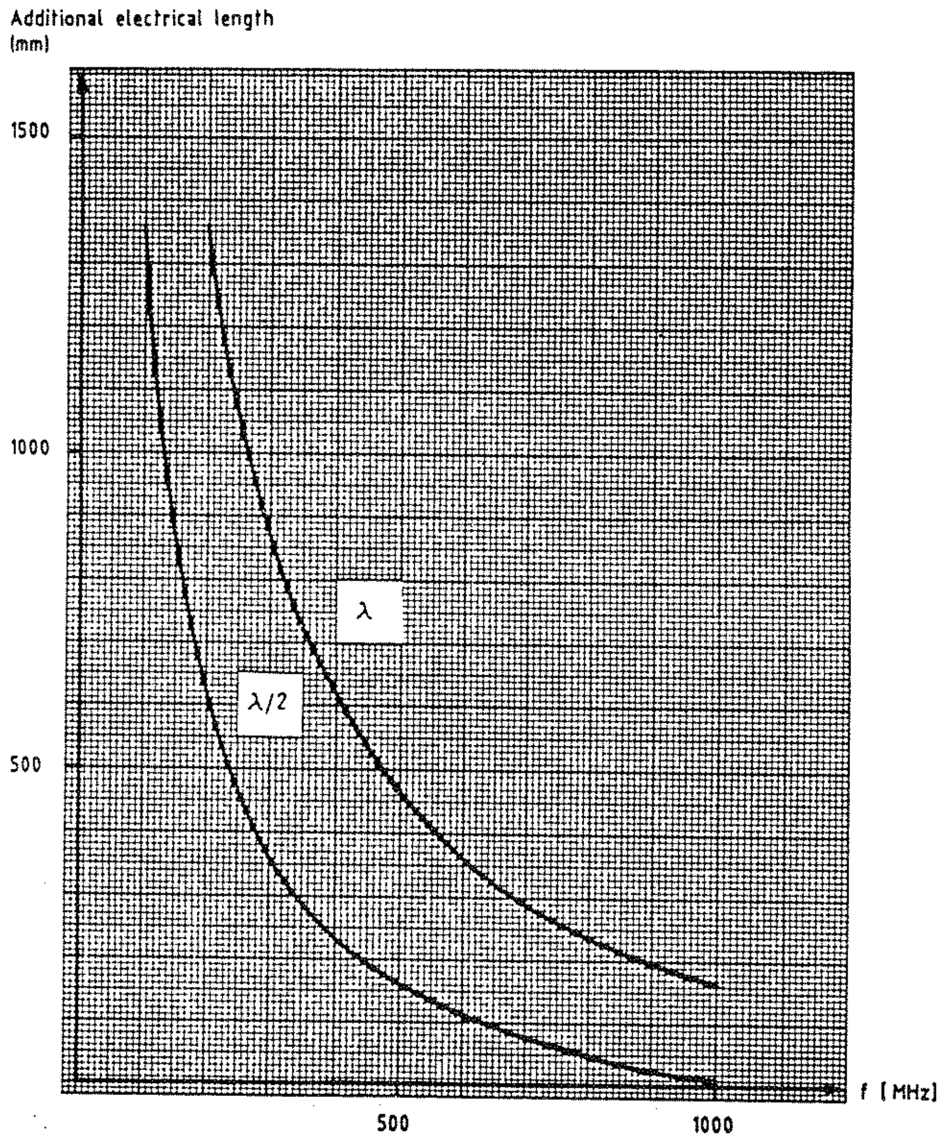


Fig. 2-4 Complementing length of directional coupler to $\lambda/2$ or λ (for Power Heads NAP-Z3 to Z6 and Z9)

2.3 Operation

With the aid of the NAP display section and one of the Power Heads NAP-Z3 to Z9 the following functions can be measured:

- Incident power in W or dBm
  (power flowing from the signal generator to the load)
- Reflected power in W or dBm
  (power reflected by the load)
- Transmission loss in dB
- Modulation depth in % for sinewave amplitude modulation
- Standing-wave ratio SWR
- Return loss in dB
- Reflected-to-incident power ratio in %
- Reflection coefficient in %
- Deviation of the incident and reflected power in % or dB from specified reference values
- The minimum or maximum value of every measurement function, observed during a measurement series, can be displayed.
- Moreover, the carrier peak power of modulated signals can be measured when using Power Heads NAP-Z7/Z8.

With the test setup shown in Fig. 2-3 the incident power and the reflected power of the NAP are measured in two separate channels. All the other measurement functions are calculated from these two power values by the built-in microprocessor.

Each of the two measuring channels contains an analog amplifier with three measurement ranges which are divided up according to the power head used:

	NAP-Z3	NAP-Z4	NAP-Z5	NAP-Z6	NAP-Z7	NAP-Z8	NAP-Z9
Measurement range 0	0.35 W	1.1 W	3.5 W	11 W	1.95 W	19.5 W	11 mW
Measurement range 1	3.5 W	11 W	35 W	110 W	19.5 W	195 W	0.11 W
Measurement range 2	35 W	110 W	350 W	1100 W	195 W	1950 W	1.1 W

The measurement range that corresponds to the power applied is generally selected by autoranging, however it can also be preselected by the entry of a special function (see section 2.3.10).

The incident measurement functions selected with keys 14 are indicated on display 2, while the reflected measurement functions (keys 9) appear on display 5 and that - as already mentioned in section 2.2.6 - irrespective of the directions in which the incident and reflected powers flow through the power head. The measured value is displayed in $3^1/_2$ digits together with one of the units W, dBm, dB and %, unless it is a non-dimensional quantity.

If the measurement function cannot be recognized from the unit (e.g. W or dBm), the short designation of the measurement function is indicated in the right upper section of the display. In addition, both displays have an analog section with a calibrated scale and a bar below the digital section. This analog display represents any change of measured value more clearly than does the digital display, particularly if adjustments are to be made. Further special displays will be explained in detail in the following sections.

Two different functions can be entered via the front-panel keys. When pressing one of the keys, the function marked with black letters is entered (direct function). The second function is entered while pressing the SHIFT key (blue marking beside the keys). The SHIFT key must always be pressed first and held down while pressing the other key.

2.3.1 Measuring the Power

Entry: W or dBm

Keys 14: incident power
Keys 9: reflected power

Display: W or dBm

For conversion from W to dBm, the following applies:

$$P_{dBm} = 10 \times \lg(1000 \times P_W)$$

$$P_W = 10^{\left(\frac{P_{dBm}}{10} - 3\right)}$$

If the input impedance of the load differs from the characteristic impedance, only part of the incident power (P_{inc}) produced by the signal generator is handled by the load, the other part is reflected and flows back to the signal generator (P_{refl}). Incident power and reflected power are measured by the NAP and displayed. The active power P handled by the load can be obtained from

$$P_{inc} - P_{refl}$$

A very small part of the incident and reflected power is coupled out in the power head for indication. The result is a transmission loss that is so low that it can be neglected. The power heads are calibrated according to the power output.

2.3.2 Measuring Relative Power Variations

It is possible to measure relative power deviations (in % or dB) from a reference value (in W or dBm).

The reference value may be a measured value or a decimal value entered for this purpose. When a power head is used, a reference value can be stored for both the incident power and the reflected power. The stored value can be checked by means of the RECALL function and is retained even if the instrument is switched off; it is only cleared when a new reference value is entered.

Measuring the relative power variation or checking the reference value by the RECALL function is also possible with the unit (W, dBm or %, dB) that has not been used for the reference value. The NAP automatically performs the corresponding conversion.

a) Storing the reference value:

Entry:	← SHIFT →	
[W] or [dBm]	[Decimal input]	[STO]
Keys 14: incident power Keys 9: reflected power	Reference value = decimal input Maximum of 4 keys + decimal point	Keyboard 13

Without decimal input:
reference value = measured value

Display: [REF W] or [REF dBm]

If the STO key is pressed immediately after pressing the W or dBm key, the instantaneous measured value is stored as a reference value. But it is also possible to store a freely selected reference value by entering a decimal value between the two entries via the keyboard. While pressing the SHIFT key the decimal value is input with digits and point according to the decimal notation. At the same time, the input data appears on the display after the key "W" or "dBm" has been pressed. The number of digits that can be entered is determined by the number of digits that can be displayed. An incorrect decimal input can be cleared and reentered with the CLR key (permissible reference values >0 W, <63 dBm and <1996 W).

b) Measuring the relative power variation:

Entry: SHIFT % [W] or SHIFT dB [dBm]

Keys 14: incident power
Keys 9: reflected power

Display: [Δ %] or [dB Δ]

c) Checking the reference value:

Entry: [W] or [dBm] [RCL]

Keys 14: incident power
Keys 9: reflected power

Keyboard 13

Display: [REF W] or [REF dBm]

2.3.3 Measuring the Transmission Loss

Entry: TML

Display: TML dB

The transmission loss is the value by which the power-handling capacity of a load is reduced due to mismatch referred to the power with matched characteristic impedance.

The transmission loss in dB can be computed from the incident and reflected power (in W) as follows:

$$a_{TML} = 10 \times \lg\left(\frac{P_{inc}}{P_{inc} - P_{refl}}\right)$$

Values of 0 dB correspond to the matched characteristic impedance, while very high values mean a total reflection (short circuit or open circuit).

2.3.4 Measuring the Modulation Depth

Entry: AM

Display: AM %

The sideband frequencies that occur during amplitude modulation cause an increase of the transmitter power. The modulation depth can be computed from the power ratio between the modulated and the unmodulated signal. A sinusoidal modulation, a constant carrier mean value during the modulation and an rms value measurement of the power, as is possible with the Power Heads NAP-Z3 to Z9, are required to ensure a correct measurement.

When pressing the AM key, the power present at this moment is stored as an AM reference value (power of unmodulated carrier). This means that the transmitter must still be unmodulated during this procedure; "0 %" appears on the display. The modulation depth is displayed after switching in the modulation. It is computed from:

$$m = 100 \times \sqrt{2 \times \left(\frac{P_{mod}}{P_{unmod}} - 1\right)}$$

As the modulation depth is calculated from the increase of the average-value power, the operating mode PEP (peak power measurement) must be switched off (section 2.3.17) when using Power Heads NAP-Z7/Z8. Otherwise, the NAP automatically switches on the AVG mode (average-value measurement) by pressing the AM key.

The rms transmitter power increases when amplitude modulation is applied. With a modulation depth m = 100%, this increase is 50%. The peak carrier power, on the other hand, increases fourfold. This can lead to the RF rectifier being overloaded, and thus to an increased error in modulation depth measurements. Fig. 2-5 shows the relationship between the modulation depth and the maximum power up to which the RF rectifier will not be overloaded.

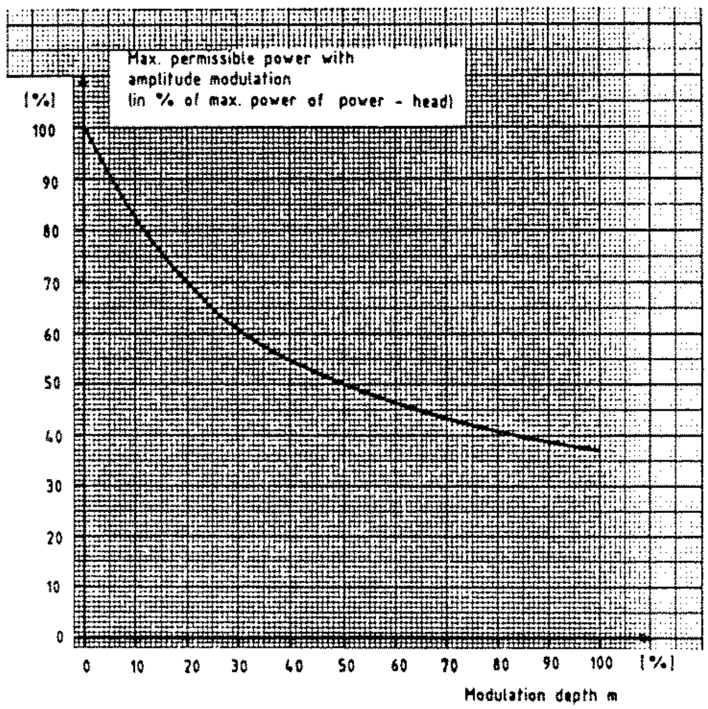


Fig. 2-5 Overload limits with amplitude modulation

2.3.5 Measuring the Standing-wave Ratio (SWR)

Entry: | SWR |

Display: | SWR |

The standing-wave ratio SWR (also called voltage standing-wave ratio VSWR) is a widely used measuring unit for the deviation of the input impedance from the characteristic impedance. It can be computed from the incident and reflected power by means of the following equation:

$$SWR = \frac{1 + \sqrt{P_{refl}/P_{inc}}}{1 - \sqrt{P_{refl}/P_{inc}}}$$

where SWR = 1 means matched characteristic impedance; very high SWR values indicate a total reflection.

2.3.6 Measuring the Return Loss

Entry: | RTL |

Display: | RTL dB |

The return loss is the ratio between the reflected voltage wave, which is caused by the mismatch of the load, and the incident voltage wave. It can be computed from the incident and reflected power by the following equation and is expressed in dB:

$$a_{RTL} = 10 \times \lg\left(\frac{P_{inc}}{P_{refl}}\right)$$

If the result is 0 dB, the incident power is equal to the reflected power. This means a total reflection. Very high values correspond to a matched characteristic impedance.

2.3.7 Measuring the Reflected/Incident Power Ratio

Entry: P_R/P_F

Display: R / F %

With this measurement function, the reflected-to-incident power ratio is displayed in per cent.

$$P_R/P_F = 100 \times \frac{P_{refl}}{P_{inc}}$$

2.3.8 Measuring the Reflection Coefficient

Entry: RFL

Display: RFL %

The reflection coefficient, too, is a measuring unit for the departure of the input impedance from the characteristic impedance. The physical definition for the reflection coefficient is:

$$r = \frac{R_E - Z}{R_E + Z}$$

The reflection coefficient p (in %) can be calculated from the reflected and the incident power (in W):

$$p = 100 \times \sqrt{P_{refl}/P_{inc}}$$

A reflection coefficient of 0% corresponds to a matched characteristic impedance, while a value of 100% means a total reflection.

2.3.9 Determining the Minimum or Maximum Value

Entry: [MIN] or [MAX]

Display: [MIN] or [MAX]

The NAP is able to display the minimum and maximum values of every measurement function selected with key 9, 14 or 15 during a measurement sequence.

Each time a measurement function is entered via key 9, 14 or 15, the storage of the minimum and maximum values begins for this measurement function. After pressing the MIN or MAX key, all the minimum or maximum values so far determined are displayed.

If the same key is pressed again, the current measured values reappear on the display. By repeated actuation of the MIN or MAX key the minimum value, maximum value or current measured value is displayed in any sequence; the storage of minimum and maximum values, however, is not interrupted.

When a measurement function is entered via key 9, 14 or 15, the display of minimum or maximum value is superseded by the display of the current measured values. Now a new minimum/maximum storage begins for the measurement function entered. For the measurement function indicated on the other display, however, storage is continued.

Note: When pressing the AM key (see section 2.3.4), the instantaneous measured value is used as a reference power of the unmodulated carrier; the value displayed is 0%. Thus the minimum value displayed in AM measurements is always Ø.

Overshoot of the display may occur with Power Heads NAP-Z7/Z8 in the PEP mode (peak power measurement, see section 2.3.17), if the input power changes suddenly. For this reason, the maximum value determined by the NAP may be too high.

2.3.10 Special Functions

The special functions permit device settings to adapt the NAP to special measurement tasks. However, since these special functions are not required very often, no extra keys are provided for them. Therefore, the settings have to be made via decimal inputs.

Setting special functions:

Entry: SF [CLR] [Z1] [Z2] [STO]
(SHIFT over CLR, Z1, Z2)

Z1, Z2: decimal digits of the special functions to be set. As long as special functions are stored, the reading on the right-hand display (bottom right) is "S". Special functions that are only temporarily effective (S41/60) are not displayed in this way.

Displaying stored special functions:

Entry: SF [CLR] [RCL]
(SHIFT over CLR)

After this entry, the special-function number, e.g.: .S.20

appears on the right display, provided special functions are stored.

Repeated actuation of the RCL key causes the stored functions to be displayed sequentially. If no special functions are stored, the following reading is obtained.

.S.- -

The following special functions can be set:

SØ Clears all stored special functions except for S43.

S1 Clears special functions S1Ø to S3Ø. Autoranging

Preselection of measurement ranges:

	Incident power range	Reflected power range
S1Ø	1	Ø
S11	1	1
S2Ø	2	Ø
S21	2	1
S22	2	2

S3Ø The incident and reflected power ranges set at the time of this entry are retained (hold ranges).

S31 Maintains the scaling of the analog displays if automatic selection of the scaling is undesirable. For each subsequent input of a measurement function, the result is displayed with the appropriate scaling, and the scaling maintained again.

S32 Prepares the fixed-decimal-point display. With this special function stored, every entry of a measurement function will result in a fixed-decimal-point display.

S33 Fast analog display in battery operation. The lifetime of the battery is thereby reduced to about its half.

S4Ø Inhibits the automatic turn-off of the instrument in battery operation. An automatic turn-off only occurs if the minimum battery voltage is not attained (see section 2.2.4.1).

S41 Calls up the zero measurement prematurely. The next zero measurement is performed 10 minutes after this entry. The special function 41 can be used to ensure the output of the measured value for 10 minutes without interruption by a zero measurement (e.g. with remote control).

S43 Corrects the zero offset occurring in the power head during temporary variations of the ambient temperature.

S6Ø Displays the battery voltage in volts on the right-hand display.
Example:

U 5.9

Minimum value: 5.7 V
(Display only possible in battery operation.)

Further special functions, which are only required for service purposes, are described in section 5.2.

Instructions for use:

The special functions 1Ø to 3Ø permit the measurement ranges to be selected by the user. Fixed setting of the measurement range prevents the most sensitive measurement range from being automatically selected every time the measuring power is temporarily removed. Since the incident power is always indicated on the left display and the reflected power on the right display, the allocation of the measuring channels and the displays is not fixed but rather depends on the direction in which the power passes through the power head. For setting of the measurement ranges selected with special functions 1Ø to 3Ø, the NAP will first have to determine this allocation by measuring the incident and reflected powers. To differentiate between the two powers, the following conditions must be fulfilled:

+ incident power >0.3% of max. power of power head
+ VSWR <10 (i.e. $P_{refl.}/P_{inc.}$ <0.67)

If the two conditions are not fulfilled at the time of entry of special functions 1Ø to 3Ø (i.e. no power available or total reflection), the autoranging mode will remain active for the time being and the selected measurement ranges will be stored. As soon as the above requirements for allocation are met, the selected ranges will automatically be set by the NAP.

In case of a subsequent change of the direction of measurement it is advisable to operate the NAP in the autoranging mode for a short time (special function 1) to allow for the new allocation to be determined.

Normally the digital display of the measured value is with a floating decimal point. The change of position of the decimal point during a measurement series causes a change of sensitivity at the corresponding analog output. This can be avoided by means of the **special function 32** which yields a fixed-decimal-point representation whenever a measurement function is entered. If the set number range of the scale is exceeded, the fault signal "Er.3" is issued. When the measurement function is entered again, the decimal point is fixed in the new position.

Special function 41 initiates the zero offset measurement of the measuring amplifier, which is normally performed automatically every 3.3 minutes. For data transfer via IEC bus, this function ensures undisturbed measurement output for a period of 10 minutes, since no zero offset measurements will take place during this time.

The **special function 43** is designed to correct a zero offset which may occur in the power head while the ambient temperature changes on account of thermal voltages, and which cannot be corrected with a periodic zero measurement of the display section. Since the zero offset changes during thermal equalization, this special function is only efficient for a period of 10 minutes from the entry. After this period the offset is ignored by the instrument. In cases where the temperature variation lasts longer, the special function should be entered several times.

The execution time for special functions 41 and 43 is dependent on the value of the measured power that was applied before the special function was called up; it is between 5 and 15 s. No power should be applied to the power head when special function 43 is entered otherwise the power to be measured will be incorrectly registered as an offset.

Both special functions cause a new calibration of the analog output.

The execution of these special functions is ended as soon as the originally set measurement function is presented in the righthand display.

On removing the power head with the display unit switched on, all special functions are erased.

2.3.11 Analog Output

An analog output (21) for each the incident power and the reflected power is provided on the rear panel. A recorder (e.g. R&S Model ZSKT) can be connected to this output, thus permitting the measured values to be represented as a curve.

The output voltage (in mV) at the analog outputs is equal to the number displayed, the decimal point not being taken into consideration. For example, if the reading is 12.34, the voltage is 1234 mV. If the numeric representation has a negative sign, the voltage is also negative. Thus the maximum output voltage is ±1.999 V.

Since the numeric representation is generally a floating-decimal-point representation, the decimal point may be shifted in the course of a measurement series, thus also changing the reading of the analog value. With the aid of the special function 32, however, the decimal points in both displays can be fixed in their momentary position.

Each of the two outputs has an impedance of 2200 Ω; the load should have an impedance exceeding 200 kΩ.

The open-circuit voltage of the analog outputs has a maximum error of ±20 mV referred to the display value. This error may increase as a result of temperature variations. Such increase, however, can be cancelled by recalibrating the analog output with special function 41 or 43.

2.3.12 Measurement speed

The digital display of the measured value occurs every 400 ms. The same applies to the analog display when the NAP is battery-operated, whereas in AC power operation the interval is 80 ms. However, when entering the special function 33, the analog display is set every 80 ms also in battery operation. As a result of this, current consumption doubles, causing the batteries to discharge more quickly.

2.3.13 Error Messages

The NAP is able to detect a great number of error conditions and to display them in coded form. Table 2-1 shows all possible error messages, the operating errors causing the error messages and the measures to be taken to restore faultless operation.

Note: The error messages OFL as opposed to OFL^{MAX} is only delivered if the measurement range Ø or 1 has been fixed by means of a special function. With this setting the instrument is unable to detect an excessive power of the power head. Therefore, these error messages may signify an overload of the power head, which must be immediately eliminated.

A flashing analog display does not mean that the NAP is in a faulty condition but indicates that the voltage of the batteries or accumulators has dropped so that a service lifetime of only 10 to 30 minutes remains. If the voltage falls below 5.7 V, the instrument turns off automatically.

Table 2-1 Error Messages

Display	Operating error	Clearing of error message
- -	Measured value undefined (AM <0 %, TML, SWR, RTL, P_R/P_F or RFL without measuring power). Calling of IEC address in battery operation.	Change measurement conditions
OFL	Overrange	Reduce measuring power
OFL MAX	Maximum power of power head exceeded.	
Er.1	Inadmissible entry. Entry of special functions that are not available. Incorrect code entered via IEC-bus. Entry of IEC-bus address >30. Entry of IEC-bus address in battery operation.	CLR or new entry
Er.2	Overflow	Change measurement conditions
Er.3	Overflow (Only with special function 32.)	Change measurement conditions or new entry of measurement function
Er.4	Inadmissible reference value. (0 W, >63 dBm)	CLR new entry
Er.P	Special function 43 cannot be executed, because power is present on test probe.	Do not apply power

Display	Operating error	Clearing of Error message
LOC	Data request via IEC bus in the local state. For the output of test data, set NAP to REMOTE.	Set unit as a listener
Analog display flashes	Batteries or accumulators almost discharged. Remaining service lifetime about 10 to 30 min.	Change batteries or recharge accumulators
Er.U	Batteries or accumulators discharged. Unit will automatically switch off after 3 sec. Indication Er.U. in AC supply operation (see section 5.4.3)	
noAcc	AC power operation only possible with accumulators inserted.	Insert nickel-cadmium accumulators (see section 3).
Er.5 … Er.9	Hardware error (see section 5.4)	

2.3.14 Measurement Error

The power measurement error specified in the data sheet for power heads only applies to a match-terminated characteristic impedance irrespective of the directivity. The effect of the directivity on the measurement error of the NAP in case of mismatch shall be explained in the following.

An accurately matched characteristic impedance of the power head does not cause reflected power. However, a very low value may nevertheless be indicated. This low value of reflected power occurs in the power head and is the result of a finitely high directivity. In this case, this is the ratio between incident power and reflected power.

The only finitely high directivity causes an additional match-dependent measurement error. This is applicable to all directional power meters, regardless of whether they use a coaxial directional coupler or an L/C directional coupler or whether they are designed as a VSWR bridge.

For the incident and reflected power displayed on the NAP with power head the following equations apply, taking into account power measurement error and directivity:

Displayed incident power:

$$P_F = P_{inc} \times \left(1 \pm E_P\right) \times \left(1 \pm \frac{r}{D}\right)^2 \qquad [1]$$

Displayed reflected power:

$$P_R = P_{inc} \times \left(1 \pm E_P\right) \times \left(r \pm \frac{1}{D}\right)^2 \qquad [2]$$

Error of incident power:

$$E_F = \left(1 \pm E_P\right) \times \left(1 \pm \frac{r}{D}\right)^2 - 1$$

Error of reflected power:

$$E_R = \left(1 \pm E_P\right) \times \left(1 \pm \frac{1}{r \times D}\right)^2 - 1$$

P_{inc} : incident power coming from the power head
r : reflection coefficient of the load
E_P : power measurement error

$$D = 10^{\left(\frac{\text{directivity}}{20}\right)}$$

(For directivity and error of power measurement, see data sheet.)

As already mentioned, all measurement functions are calculated from the incident and the reflected power. With the aid of equations [1] and [2] the maximum possible measurement errors for these functions can be determined.

In practice, however, these maximum errors will occur very rarely, i.e. only if all individual errors add up in a most unfavourable way. Since directivity and reflection coefficient are complex AC quantities, the error becomes a maximum error only if the phases of directivity and reflection coefficient are equal or opposite.

Effect of ambient temperature

The temperature response of the display specified in the data sheet only applies if all components of the power meter have the same temperature.

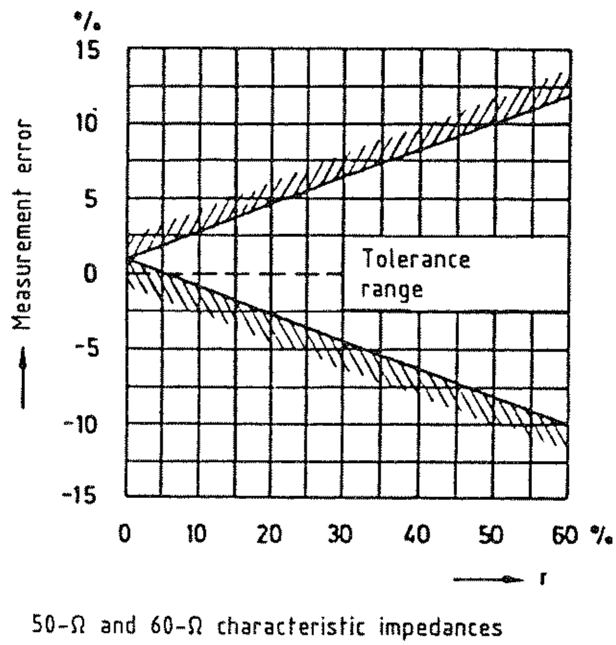
When the temperature changes, a temporary zero offset may cause a small measurement error in the most sensitive range. This offset can be corrected by means of the special function 43 (see section 2.3.10).

Different characteristic impedances of power head and device under test

If the system to be measured has a characteristic impedance that differs from that of the power head, the incident- and reflected-power values change while the active power delivered by the signal generator remains constant. The difference between the incident and the reflected power displayed is always the active power that has in fact been transmitted.

The incident power changes slightly as long as the mismatch of the load is low. The measurement error of the incident power remains within the tolerance limits shown in Fig. 2-6. The values apply to the Power Heads NAP-Z7/Z8 in the useful frequency range, NAP-Z3 to Z6 and Z9 up to 220 MHz. If the electrical length of the power head is complemented to λ or n x $\lambda/2$ by means of a line, the values are also valid for higher frequencies.

The measurement functions SWR, RFL, TML, RTL and P_R/P_F exhibit incorrect values, since the measurement of the reflected power is wrong due to the use of a power head with departing characteristic impedance.



The reflection coefficient r of the load is related to the characteristic impedance of the system.

Fig. 2-6 Measurement errors of the incident power with different characteristic impedances of power head and item under test.

Peak power measurement (PEP)

The tolerances for this operating mode stated in the specifications apply to a 2-tone beat signal (Fig. 2-6.1). It can be generated by the 2-tone modulation of an SSB signal generator.

It is, of course, possible to determine the peak power of an RF carrier modulated by other than a 2 tone beat signal. Irrespective of the shape of the envelope, the following conditions must be met:

1. $P_{PEP} - P_{AVG}$ > 0.25 W (NAP-Z7)
   > 2.5 W (NAP-Z8)

2. Pulse width (at 85% of the envelope amplitude) >25 µs

3. Period of envelope signal < 15 ms

If condition 1 cannot be met, e.g. for unmodulated carrier or for low reflected power, the PEP display is always too high, i.e. there is an offset of up to 0.1 W for the NAP-Z7 or up to 1 W for the NAP-Z8. Thus, **reflection measurements (VSWR, return loss etc.) for low reflected power (< 0.5 W for NAP-Z7, < 5 W for NAP-Z8) are to be carried out in the average-value measurement mode!** In the PEP mode, the display noise in the most sensitive measuring range is somewhat higher than in the AVG mode.

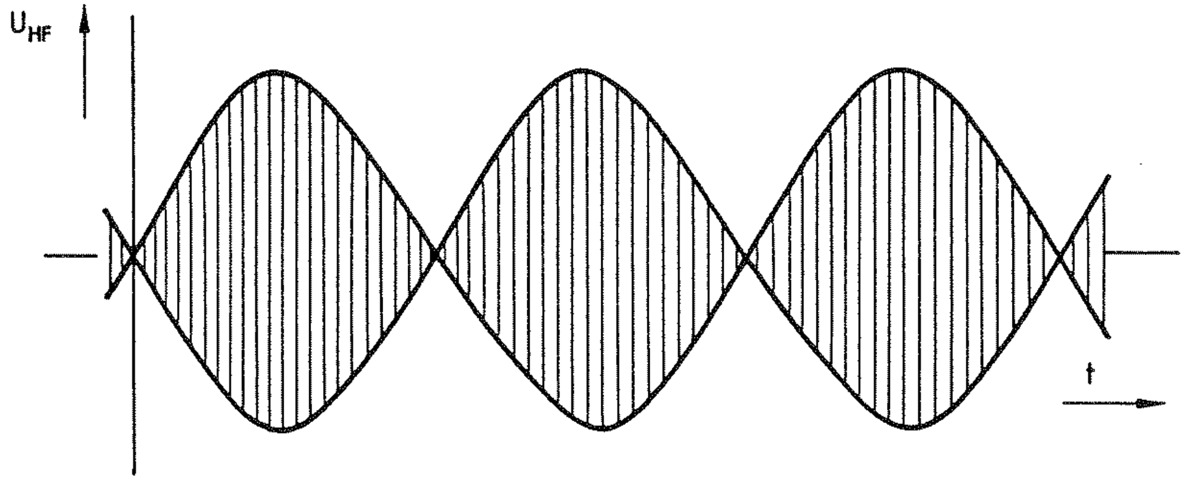


Fig. 2-6.1 2-tone beat signal

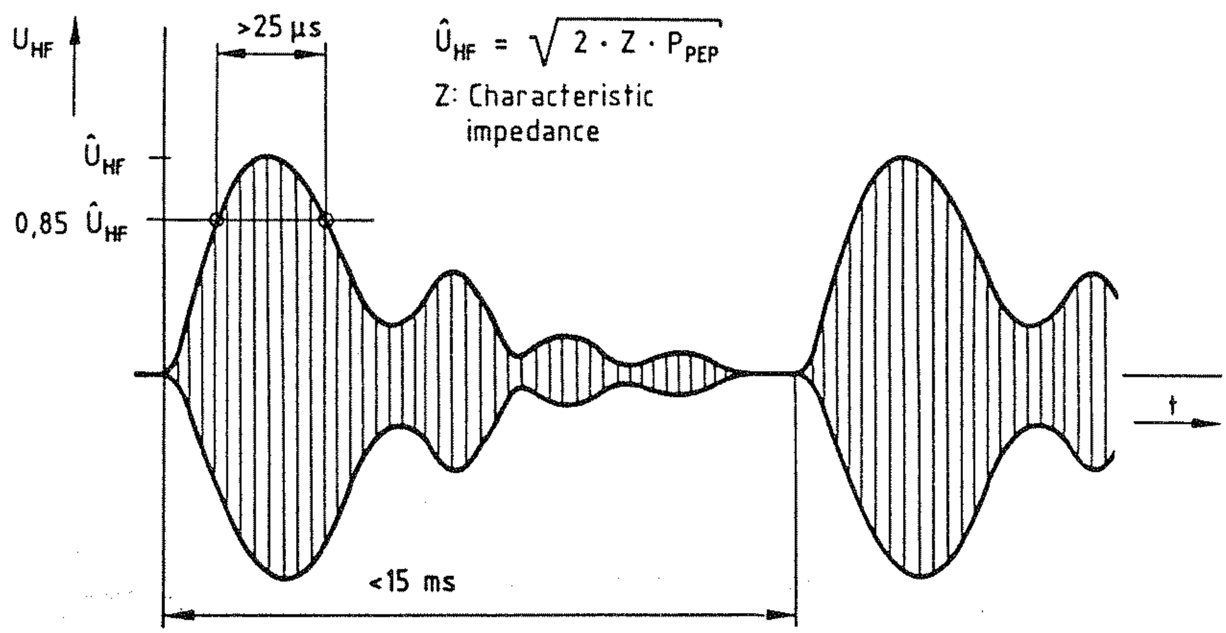


Fig. 2-6.2 PEP measurement on an AM modulated RF carrier

a) VSWR measurements

Matching is made in the following two ways:

- Matching the input impedance of a load to the characteristic impedance of a transmission system.
- Matching the input impedance of a load to the output impedance of a signal generator or mutual matching so that the load utilizes maximum power (conjugate complex matching).

Matching according to the first method is necessary in cases where the ratings of RF systems are only adhered to if the characteristic impedance is matched. The matching characteristic of the load must be adjusted for minimum reflection coefficient or minimum VSWR. Signal generators having a resistive impedance are suitable for this purpose. Then observe the NAP display and adjust for minimum value.

When matching antennas to radio equipment, also adjust for minimum P_{refl}/P_{inc} ratio. In the case of narrowband units, this adjustment can be made by shortening the antenna length, whereas wideband units require an appropriate adjustment of the matching circuit.

The transmission of maximum power, e.g. between two amplifier stages, is the second requirement that can be met by matching. In this case, the impedance must be matched to the maximum difference between P_{inc} and P_{refl}, i.e. to the maximum active power P.

b) **Measuring the power transmission**

The test setup in Fig. 2-7 includes two NAPs with power heads for measurements on amplifier stages. The one NAP permits the matching procedure between the amplifier input and the signal generator to be observed, the other NAP the matching of the amplifier output to the load. With the aid of this arragement the mutual influence of the circuits while changing the input and output matching characteristics can be detected.

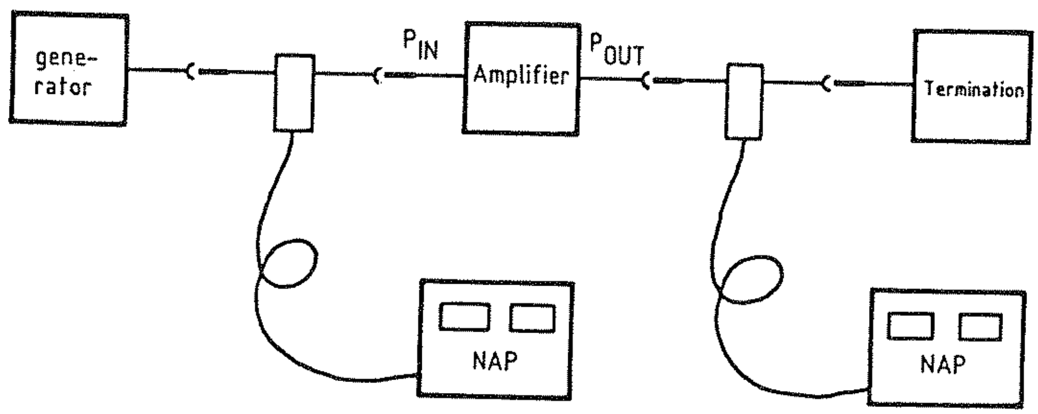


Fig. 2-7 Measurement of VSWR between signal generator and load.

The gain of the amplifier stage is obtained by

$$V = 10 \lg \frac{P_{out}}{P_{in}}$$

where input power (P_{in}) and output power (P_{out}) are active powers, hence the difference between P_{inc} and P_{refl}.

c) **Output power measurement**

In conjunction with a termination that can be loaded up to the maximum power to be measured, the NAP can also be used as an output power meter.

The termination is connected to the one RF terminal of the power head, the RF power to be measured is applied to the other terminal. In the output power measurement, too, the power delivered by the power head and applied to the termination is indicated. The power produced by the signal generator is higher by the magnitude of the (low) transmission loss.

For frequency and deviation measurements, attenuators of sufficient power-handling capacity can be used instead of the termination. A frequency counter or a deviation meter can be connected to the output of the attenuator.

2.3.16 Analog Display

The NAP analog display replaces conventional pointer indication. Depending on the measured value and function, different scales are used to obtain the best possible resolution. As in the case of pointer indicators, different multiplication factors are to be observed for different measurement ranges. The relationship between measured value and indication for different scale resolutions is shown in the table below.

Measured function	Scaling	Measured value
W	0 to 1 0 to 3	Analog indication x 0.1/1/10/100/1000
dBm	0 to 10	Analog indication + 0/10/20/30/40/50/60dBm
Δ%	-1 to +1	Analog indication x 10/100
ΔdB	-1 to +1 -10 to +10	Absolute analog indication
AM	0 to 1	Analog indication x 100
TML	0 to 1 0 to 3 0 to 10	Absolute analog indication
SWR	1 to 3 1 to 10	Absolute analog indication
RTL	0 to 10	Analog indication + 0/10/20/30/40 dB
$P_{refl.}/P_{inc.}$	0 to 1 0 to 3	Analog indication x 10/100 Analog indication x 10
RFL	0 to 1 0 to 3	Analog indication x 10/100 Analog indication x 10

2.3.17 Measurement of the Carrier Peak Power

It is possible to determine either the average power (AVG) or the peak envelope power (PEP) by means of the power heads. In both cases, the r.m.s. value of the RF signal is measured.

The average-value measurement mode is set by switching on the NAP. Switchover between the average-value and the peak-value measurement is effected by means of key 15 (PEP). In case of peak-value measurement, the indication PEP appears in the two top left-hand displays. The set operating mode applies always to the incident and reflected power channel. If the PEP key is pressed and one of the Power Heads NAP-Z3 to Z6 connected, the error signal Er.1 appears in the right-hand display to indicate that in this case, no peak-value measurement is possible.

Note: If the carrier power is very low or the carrier very weak or unmodulated, the peak power indicated is always slightly too high, i.e. up to 0.1 W for NAP-Z7 or 1 W for NAP-Z8. This may lead to a somewhat higher measurement error (section 2.3.14) particularly when determining the reflected power and the derived factors (reflection coefficient etc.)

2.3.18 Taking into Account Calibration Factors

In order to increase the measurement accuracy, calibration factors can be entered. They are indicated for the power heads NAP-Z7 and -Z8 in an individual calibration report for individual fixed frequencies and constitute the ratio in percent of displayed power to actually measured power.

After switching on the NAP, calibration factors of 100 % each are assumed for the display of incident and reflected power.

a) Entry of calibration factors

Key entry : CF [PEP] [decimal entry] [STO]
(SHIFT spans from PEP to the end of decimal entry)

Decimal entry: Calibration factor in % for the direction of measurement indicated in the left-hand display.
Permissible values: 50.0 to 199.9

The first entry refers to the direction of measurement 1-2 (power flow from RF connector 1 to RF connector 2).

1 second after this entry has been terminated, the calibration factor for the direction of measurement 2-1 is indicated. By entering the decimal value and STO, a new calibration factor can now be entered for this direction of measurement.

By pressing the CLR key, the previously set measurement functions are called up again. The calibration factors entered remain stored after the NAP has been switched off.

b) Switchover of calibration factors

The function "Select Factor" enables easy switching between the stored calibration factors (generally ≠ 100%) and calibration factors = 100%.

|←— SHIFT —→|

Key entry: CF [PEP] SF [CLR]

c) Checking of effective calibration factors
The calibration factors that are effective for the calculation and output of measured values can be checked as follows:

SHIFT

Key entry: CF [PEP] [RCL]

The left-hand display indicates the direction of measurement, the right-hand display indicates the permissible calibration factor. Repeated pressing of the RCL key causes the calibration factor for the other direction of measurement to be displayed.

By pressing the CLR key, the measurement functions set before are called up again.

2.4 IEC-bus Control

When fitted with the option NAP-B4 and operated with AC power, the NAP may be remote-controlled via the IEC bus for transmitting setting data and measured values.

Socket 17 is located on the rear panel; the pin assignment can be seen from Fig. 2-8.

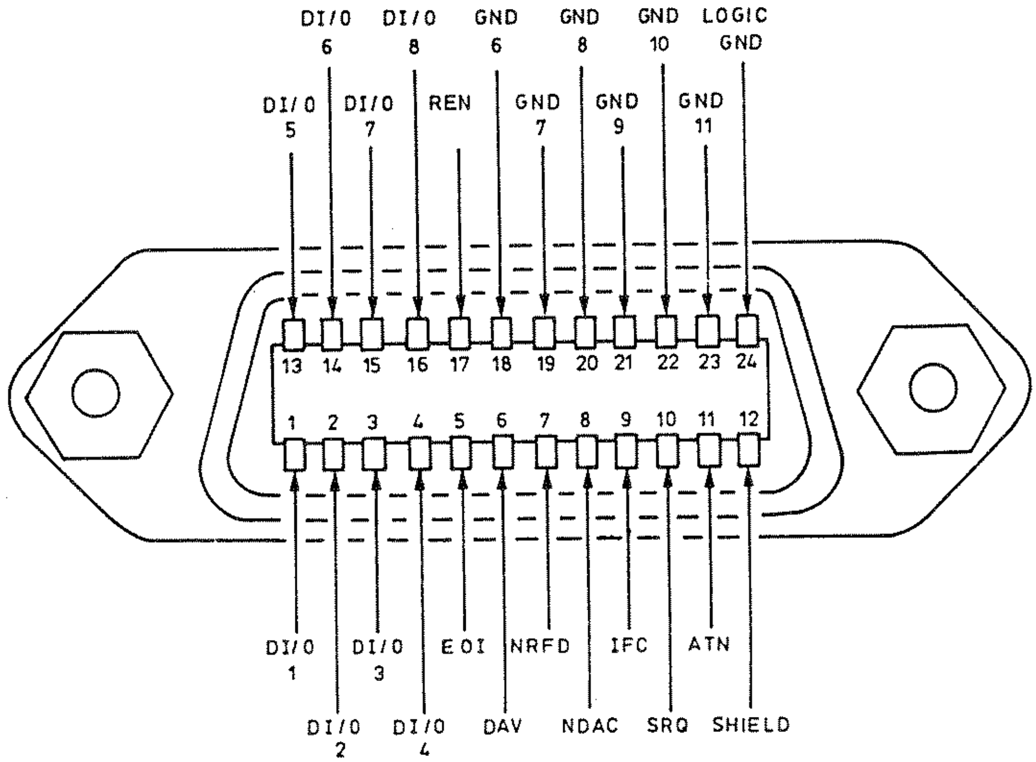


Fig. 2-8 Pin assignment of socket 17.

Data transfer, the configuration of the control, handshake and data lines as well as timing meet the DIN IEC 625 regulations. The characters of the ASCII code used for data transfer are listed in table 2-3.

According to the standard, IEC-bus devices may be fitted with different interface functions. Those of the NAP are stated in the following table:

SH1	Source handshake, complete capability
AH1	Acceptor handshake, complete capability
T6	Talker Capability of answering to a serial poll, unaddressing if MLA
L4	Listener, unaddressing if MTA
SR1	Service request, complete capability
RL1	Remote/local, complete capability
DC1	Device clear, complete capability
DT1	Device trigger, complete capability

2.5 Setting the Device Address

If several devices are connected to the IEC bus, an address has to be assigned to each of them in order to enable data transfer between any one of the devices and the controller.

In the NAP the device address is stored in a non-volatile memory. The address is indicated on the right display when the NAP is powered on. It can be checked or varied by entering a special function.

After input of the sequence

SF [CLR] • [LOC] [RCL]   (SHIFT held from CLR to LOC)

the selected address appears on the right display.
Example:

.A.2 3

If the instrument is not connected to the power line or if it is not fitted with the NAP-B4 option, two lines appear instead of the digits indicating that remote control is not possible in this state.

If a new function is entered via keys 9 after the above input (e.g. SWR), a value corresponding to this function appears on the right display; the stored device address does not change.

The following input is required to store a new device address:

SF [CLR] • [LOC] [Z1] [Z2] [STO]   (SHIFT held from CLR to Z2)

Z1 and Z2 are the decimal inputs Ø to 9 of the new device address. Valid values are ØØ to 3Ø. One-digit addresses can be entered with a leading zero or with one digit.

With inputs Z1Z2>30 the error display "Er.1" appears. If then the STO key is pressed, the invalid address is not accepted but the previously stored address is maintained.

Storage of a device address is only possible when the NAP is connected to the power line, otherwise the error message "Er.1" is displayed if the storage of an address is attempted.

2.6 Remote-control Commands and Output of Measured Values

Before the NAP is able to transfer measured values to the controller, programming instructions have to be sent to the NAP to allow setting of the desired measurement function and determination of the data format of the measured values, the start conditions of the measurement and the end-of-data characters.

2.6.1 Device-specific Setting Instructions

a) Measurement functions

Ref. No.	Instruction code	Measurement function	
1	LWF	Power in W	Incident-power channel
2	LMF	Power in dBm	
3	MAM	Amplitude modulation in %	
4	TML	Transmission loss in dB	
5	RWF	Relative power change in %	
6	RMF	Relative power change in dB	
7	LWR	Power in W	Reflected-power channel
8	LMR	Power dBm	
9	SWR	Standing-wave ratio	
10	RTL	Return loss in dB	
11	ALR	Reflected/incident power ratio in %	
12	RFL	Reflection coefficient in %	
13	RWF	Relative power change in %	
14	RMR	Relative power change in dB	
15	PEP	Peak-value measurement 1)	Incident-power and reflected-power channels
16	AVG	Average-value measurement	

The instructions 1 to 12 determine the measurement function for the incident- and reflected-power channels. The physical definitions of the measurement functions are given in section 2.3.

Note to Ref. No. 3:

The modulation depth is calculated from the transmitter power with modulation and the transmitter power without modulation as a reference value. This reference value is fixed by the first data output in the incident-power channel after having set the function "amplitude modulation". During this procedure the transmitter must be unmodulated; the first data output has the value 0%. This reference value is used for all further data outputs until the instruction code MAM is sent (see also section 2.3.4).

1) Only applies if power head permitting switchover between peak-value and average-value measurement is used.

b) Control of data output and start of measurement

Ref. No.	Instruction code	Function
17	DF	Data output only for incident-power channel
18	DR	Data output only for reflected-power channel
19	DT	Data output for both channels
20	NØ	Data output with header
21	N1	Data output without header
22	X1	Start of a single measurement
23	X2	Start of a measurement on data request
24	X3	Continuous measurements
25	XØ	Reset instruction for X2/X3
26	X4	Storage of reference values for the relative measurement functions

The instructions 17 to 19 enable the user to decide whether the measurement data shall be output for only one channel or for both channels at the end of measurement.

The data output can be set so that it only contains numerical data (instruction N1) or in addition has an alphanumeric header (instruction NØ), which indicates the measurement function and the validity of the data. Coding of the header is described in section 2.6.3.

Instructions 22 to 26 determine the moment at which the NAP is to start a measurement according to the set function. When the instruction X1 is received, a measurement is started immediately. After the elapse of the transient of both amplifiers, the measured values are available for output to the controller. The output causes the simultaneous display of the measured values.

Instruction X2 itself does not trigger a measurement but sets the NAP such that the read data instructions of the controller initiate the measurement. When the transient is over, the measured values are output to the controller and displayed.

The instruction X3 starts continuous measurements. The measured values are output when the controller sends a request, i.e. without waiting for the end of the amplifier transient.

When using the setting combination DT, X2 (data output for both channels and measurement start on data request), it must be taken into consideration that the first and then only every other read data instruction starts a new measurement, since in this case two measured values have to be transferred within each measurement. The first output always contains the measured values of the incident-power channel, the second output those of the reflected-power channel. The instruction XØ causes an abortion of X2 or X3 without setting a new measurement start.

Upon reception of instruction X4, the measured powers applied then are stored as reference value in the channel in which a relative measurement function is set (Ref. No. 5, 6, 13 or 14). X4 deletes the previous measurement start setting. A subsequent continuous measurement or a subsequent measurement start on data request requires the trigger command X3 or X2 to be issued before.

c) Special functions

Instruction code	Function	
SØ	Clear all special functions (except S43)	
S1	Clear special functions 10 to 30. Autoranging	
	Preselect measurement ranges:	
	Incident power range	Reflected power range
S1Ø	1	0
S11	1	1
S2Ø	2	0
S21	2	1
S22	2	2
S3Ø	The measurement ranges set during this entry remain fixed.	
S32	After storage of this special function, an entry of a measurement function causes a fixed decimal-point setting in the associated measuring channel.	
S41	Premature zero measurement	
S43	Zero offset correction	

The figures of the special functions via the IEC bus are identical with those of the special functions stated in section 2.3.10. The same section also contains a detailed description of the special functions. Further special functions, which are only provided for service purposes, are dealt with in section 5.2.

d) Delimiters and end characters for data output and instruction input

Instruction code	End characters sent by the NAP	
WØ	NL	(New line, ASCII 10)
W1	CR	(Carriage return, ASCII 13)
W2	ETX	(ASCII 3)
W3	CR + NL	
W4	EOI	(End or identify)
W5	NL + EOI	
W6	CR + EOI	
W7	ETX + EOI	
W8	CR + NL + EOI	

With instructions or data consisting of several characters, the talker has to send an end character enabling the listener to recognize the end of the message. The NAP is able to send any end character specified in the standard (or common combinations of end characters) at the end of the data output. The desired setting can be made with the instruction codes WØ to W8.

When receiving instructions, the NAP accepts each end character whatever it is so that a setting to a certain end character for reception is not necessary.

The NAP can also receive several instructions within a string.A delimiter (decimal point, ASCII 44 or space, ASCII 32) has to be sent between the individual instructions, and an end character after the last instruction.

Any number of delimiters can be sent one after another; the NAP will accept them as a single delimiter.

e) Service request

Instruction code	Function
Q0	Service request disabled
Q1	Service request enabled

Setting the SRQ line enables the NAP to send a service request to the controller. This is only expedient if the end of a message or an error is to be disclosed to the controller. If the controller performs a serial poll after having received a service request, it is able to determine the device status by evaluating the status byte sent by the NAP.

Coding of status byte:

Device status	Status byte	Decimal value	Display
Measurement terminated	0101 0000	80	Measured value
Underrange	0101 0001	81	Measured value
Zero measurement termin.	0101 1010	90	S41/S43
Overrange	0110 0000	96	OFL
Syntax error	0110 0001	97	Er.1
Output in local	0110 0010	98	LOC
Output without measuring start	0110 0011	99	old measured value
Overflow of readout	0110 0100	100	Er.2/.3
Measured value undefined	0110 0101	101	--
Illegal cal. value	0110 0110	102	Er.4
No zero measurement since power applied to power head	0111 0011	115	Er.P
Power head reconnected	1100 0000	192	Initialization
Hardware error	1110 0000	224	Er.5...Er.9

If X2 has been set for measurement start, service requests containing status values 80, 81, 96, 100 and 101 will not be sent. The same applies for X3 if the controller input is sent prior to the termination of the next measurement.

When a service request is used for marking the termination of a zero measurement called up by special functions 41 or 43, the controller output containing the setting instructions S41/S43 must not contain any further instructions. These would be carried out by the NAP only upon termination of the zero measurement and the IEC bus would be blocked during the entire period, a result which is contrary to the purpose intended when sending the service request.

f) Entry of calibration factors

Instruction code	Function
C12 datum	Entry of calibration factors for direction of measurement 1→2
C21 datum	Entry of calibration factors for direction of measurement 2→1

datum: 50.0 to 199.9 (calibration factor in %)

(For more details refer to section 2.3.18)

g) Basic device setting

Instruction code	Function
C1	Basic setting of the NAP

The instruction code C1 provides for the basic setting of the NAP, such as is the case when the NAP fitted with a power head is turned on.

→ Power measurement in W in the incident-power and reflected-power channels (LWF, LWR).

→ Data output for both channels (DT).

→ Data output with header (NØ).

→ Measurement start on data request from the controller (X2).

→ Autoranging in both channels.

→ End character for data output: CR + NL (W3).

→ Service request disabled (QØ).

→ Power head identification

→ Average-value measurement if suitable power head is connected

→ All special functions off (except S43)

→ Calibration factors for both directions of measurement = 100 %

2.6.2 Group of Addressed and Universal Instructions

a) Local/remote

If the NAP is addressed as a listener by the controller, it changes to the remote control mode in accordance with the standard and remains in this state even after data transfer has been terminated. Except for the LOC key (10) all front-panel controls are inhibited, the status is indicated by the LED REMOTE (4).

Local control is again enabled as soon as the controller sends the addressed GTL (go to local) instruction. The REMOTE indicator goes out.

The NAP also resumes the local state when the LOC key is pressed. This key, however, may be inhibited by the universal instruction LLO (local lockout) from the controller.

Changing the mode from local to remote or vice versa does not change the other device settings.

When the NAP is addressed as a talker, no change of status takes place. Hence, if the device is in the local mode, this status is retained even after a data output.

b) Device clear

If the controller sends the universal instruction DCL (device clear) or the addressed instruction SDC (selected device clear), the NAP resumes its basic setting. The basic setting is also activated when the NAP is powered on or when the device-specific instruction C1 is issued. The corresponding device settings are described in section 2.6.1 f).

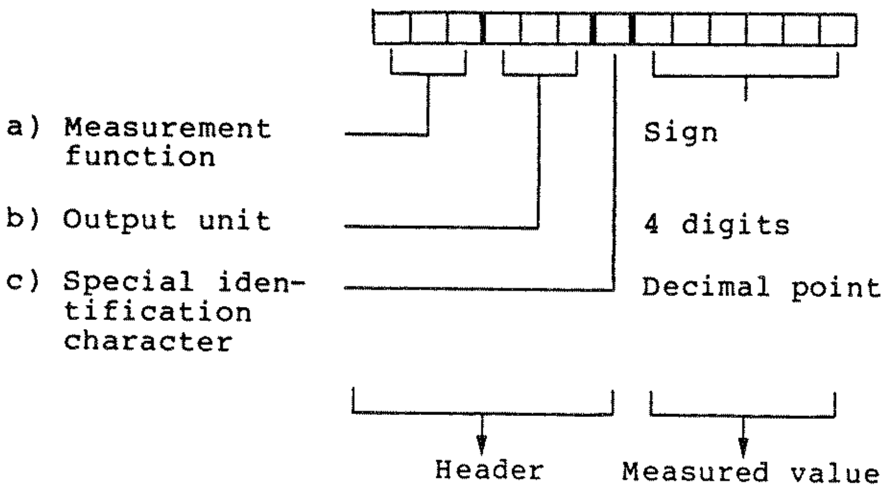
c) Device trigger

On receiving the addressed instruction GET (group execute trigger), the NAP starts immediately a measurement at the selected setting. This trigger instruction corresponds to the device-specific instruction X1.

2.6.3 Data Output

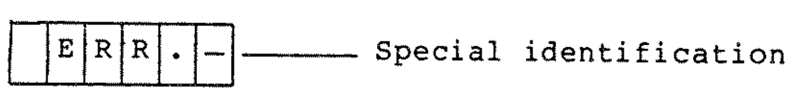
Data request by the controller (controller input command) enables the NAP to send the measured values. When setting is made with the instruction NØ, the measured values are preceded by an alphanumeric header which contains the measurement function, the unit of the electrical quantity and a special identification character. The NAP sends valid data only in the remote state, which is indicated by the LED 4 (REMOTE). For this reason, the NAP must be addressed as a listener (e.g. by the transfer of a setting instruction) prior to the first data output.

Header and measured value are sent in the following format:



The measured value is output with floating decimal point but without exponent.

After the NAP has been addressed as a talker, it sends data to the controller in any case - even if a fault condition is present - to prevent blocking of the IEC-bus communication. In this case, the error source is indicated by the special identification character of the header and the following is displayed instead of the measured value:



The tables below show the coding of the header. A blank space (ASCII 32) is identified by a line (-).

a) **Coding of measurement function**

Code	Measurement function
PF_	Power in incident channel
AM_	Amplitude modulation
PR_	Power in reflected channel
TML	Transmission loss
SWR	Standing-wave ratio
RTL	Return loss
RFL	Reflection coefficient
R/F	Reflected-to-incident power ratio

b) **Coding of output unit**

Code	Output unit
_W_	W
DBM	dBm
_%_	%
_DB	dB
___	without dimension (for SWR)

c) **Coding of special identification character**

Code	Meaning	Data output
R	Unit not in remote state	No
E	Hardware error	No
T	Controller input without start of measurement	No
H	Overrange	No
U	Measured value undefined (AM <0%, TML, SWR, RTL, P_R/P_F, RFL without measuring power or overrange in other channel)	No
O	Overflow of readout	No
V	Illegal reference value (P <-50 dBm)	No
L	Underrange, reduced measurement accuracy	Yes
P	Peak-value measurement [1])	Yes
-	Valid measured value	Yes

The special identification characters in the table are arranged according to their priority. R has the highest priority, P the lowest.

2.6.4 Measurement Times in IEC-bus Operation

With the setting X1 or X2 (start of a single measurement or measurement start on data request) the new measured value cannot be read out immediately after triggering but only after a specific period for rectifiers and amplifiers to settle. For the various power heads, this period is:

NAP-Z3 to Z6 and Z9 : 0.4 s
NAP-Z7/Z8 (AVG) : 0.5 s
NAP-Z7/Z8 (PEP) : 1.5 s

With the setting X3 (consecutive measurement), data output occurs every 80 ms. Within this period, however, the transient of the amplifiers is not yet completed.

With all settings, the output is delayed by 160 ms or 320 ms if the range has to be changed once or twice between two measurements. The automatic zero measurement, too, may cause a delay of the output by approx. 0.8 to 1 s about every three minutes. However, premature calling-up of the output is possible by means of the special function 41. In this case, the next zero measurement is only executed after ten minutes.

Process controllers fitted with a time control (e.g. R&S type PUC) should be set for a maximum output time of 16 s. In the case of the PUC this setting can be made with the instruction IECTIME255.

[1]) Only with power heads permitting switchover between peak-value and average-value measurement

2.6.5 Programming Examples

Programming of the R&S Process Controller PUC for measurements with the NAP via the IEC bus may be seen from the following three examples:

Example 1 shows the basic programming.

Example 2 shows how the measured data is checked for validity and converted into numerical values for mathematical processing.

Example 3 explains the use of the service request (SRQ) of the NAP. After the NAP starting the measurement (in line 300), the controller can continue the main program while the NAP is executing the measurement. Only when the NAP signals the end of the measurement by a service request, the main program is interrupted by a jump to the SRQ sub-program for the read-in of the measured data. After this procedure the main program is continued. In time-critical programs the controller can thus utilize the 400-ms measurement time of the NAP.

The device address is 25 in all three examples.

Example 1

```
100 REM INIT
110 IECTIME 255
120 IECTERM 13
130 IECDEV
140 IECDEV NAP=25
150 IECOUT NAP,"LWF,LWR,DT,N0,X2,W1,Q0"
 :
 :
 :
200 FOR N=1 TO 20
210 IECIN NAP,PV$
220 IECIN NAP,PR$
230 PRINT PV$;PR$
240 NEXT
```

Lines 110–150: Initialization of NAP and PUC

Lines 200–240: Measurement with the NAP

- → Measurement of incident and reflected power in W
- → Data output without header for both channels
- → Start of measurement by input command
- → End character CR, service request disabled

Example 2

```
100 REM INIT                                   ┐
110 IECTIME 255                                │ Initialization
120 IECTERM 13                                 ├ of NAP and PUC
130 IECDEV                                     │
140 IECDEV NAP=25                              │
150 IECOUT NAP,"LMF,SWR,DT,N1,W1,QØ"           ┘
 :
 :
 :
200 FOR N=1 TO 2Ø                              ┐
210 IECOUT NAP,"X1"                            │
220 IECIN NAP,V$                               │
230 IF LEFT$(V$,2)=" E" THEN PRINT V$,:GOTO26Ø │
240 V=VAL(V$)                                  │ Measurement
250 PRINT V,                                   ├ with the NAP
260 IECIN NAP,R$                               │
270 IF LEFT$(R$,2)=" E" THEN PRINT R$:GOTO3ØØ  │
280 R=VAL(R$)                                  │
290 PRINT R                                    │
300 NEXT                                       ┘
```

→ Measurement of incident power in dBm and VSWR

→ Data output without header for both channels

→ End character CR, service request disabled

→ Start of measurement in line 21Ø

→ Check for invalid measurement in lines 23Ø and 27Ø

→ Numeric conversion in lines 24Ø and 28Ø

Example 3

```
100 REM ------------------------------INIT
110 IECTIME 255
120 IECTERM 13
130 IECDEV
140 IECDEV NAP=25
150 IECOUT NAP,"LMF,SWR,N1,DT,W1,Q1,X0"
160 IECSRQ GOTO1000
 :
 :
 :
```

Initialization of NAP and PUC

```
200 REM -------------------- MAIN PROGRAM
210 IECOUT NAP,"X1"
 :
 :
300 A=10
 :
 :
 :
400 GOTO300
410 STOP
 :
 :
 :
```

Main program

```
1000 REM ---------- SUBROUTINE SERIAL POLL
1010 IECSPL NAP,S%
1020 IF S%AND64 THEN 2000
1030 REM --------- SERIAL POLL OTHER UNITS
 :
 :
 :
2000 REM --------- MEASURED VALUES FROM NAP
2010 IECIN NAP,A$:IECIN NAP,B$
2020 V=VAL(A$):R=VAL(B$)
2030 PRINT F,R
2040 IECOUT NAP,"X1"
2050 IECRETSRQ
```

Serial Poll and data transfer

- → Measurement of incident power in dBm and VSWR
- → Data output without header for both channels
- → End character CR, service request enabled
- → Start of measurement in line 210
- → Line 300: check whether SRQ was sent
- → If SRQ, jump to sub-program from line 1000
- → If SRQ from NAP, jump to line 2000
- → Line 2010: readout of measured values
- → Line 2040: start of next measurement
- → Line 2050: jump from SRQ sub-program back to main program

2.6.6 Table 2-2 Setting Instructions

Instruction code	Function	
LWF	Power in W	Incident-power channel
LMF	Power in dBm	Incident-power channel
MAM	Amplitude modulation in %	Incident-power channel
TML	Transmission loss in dB	Incident-power channel
RWF	Relative power change in %	
RMF	Relative power change in dB	
LWR	Power in W	Reflected-power channel
LMR	Power in dBm	Reflected-power channel
SWR	Standing-wave ratio	Reflected-power channel
RTL	Return loss in dB	Reflected-power channel
ALR	Reflected-to-incident power ratio Power in %	Reflected-power channel
RFL	Reflection coefficient in %	Reflected-power channel
RWF	Relative power change in %	
RMR	Relative power change in dB	
PEP	Peak-value measurement	[1]) In both channels
AVG	Average-value measurement	[1]) In both channels
DF	Data output for incident-power channel	
DR	Data output for reflected-power channel	
DT	Data output for both channels	
NØ	Data output with header	
N1	Data output without header	
X1	Start of a single measurement	
X2	Start of a measurement on data request	
X3	Consecutive measurement	
X4	Start of a single measurement and storage of the measured values as reference values	
XØ	Reset for X2/X3	

[1]) Only applies if power head permitting switchover between peak-value and average-value measurement is used.

Instruction code	Function	
SØ	Clear all special functions	
S1	Clear special functions 1Ø to 3Ø	
	Preselect measurement ranges:	
	Indicent power range	Reflected power range
S1Ø	1	Ø
S11	1	1
S2Ø	2	Ø
S21	2	1
S22	2	2
S3Ø	Hold range	
S32	Prepare fixed decimal point display	
S41	Premature zero measurement	
S43	Zero offset correction (See special functions for checking stated in Section 5.2.)	
WØ	End character NL (ASCII 10)	
W1	CR (ASCII 13)	
W2	ETX (ASCII 3)	
W3	CR + NL	
W4	EOI (end or identify)	
W5	NL + EOI	
W6	CR + EOI	
W7	ETX + EOI	
W8	CR + NL + EOI	
QØ	Service request disabled	
Q1	Service request enabled	
C12 datum	Entry of calibration factor for direction of measurement 1→2	
C21 datum	Entry of calibration factor for direction of measurement 2→1 datum: 50.0 to 199.9 (calibration factor in %)	
C1	Basic setting	

(SENT AND RECEIVED WITH ATN=1)

b_7 b_6 b_5 →					0 0 0	MSG (1)	0 0 1	MSG	0 1 0	MSG	0 1 1	MSG	1 0 0	MSG	1 0 1	MSG	1 1 0	MSG	1 1 1	MSG
b_4	b_3	b_2	b_1	ROW ↓ / COLUMN →	0		1		2		3		4		5		6		7	
0	0	0	0	0	NUL		DLE		SP	MLA ASSIGNED TO DEVICE	0	MLA ASSIGNED TO DEVICE	@	MTA ASSIGNED TO DEVICE	P	MTA ASSIGNED TO DEVICE	`	MEANING DEFINED BY PCG CODE	p	MEANING DEFINED BY PCG CODE
0	0	0	1	1	SOH	GTL	DC1	LLO	!		1		A		Q		a		q	
0	0	1	0	2	STX		DC2		"		2		B		R		b		r	
0	0	1	1	3	ETX		DC3		#		3		C		S		c		s	
0	1	0	0	4	EOT	SDC	DC4	DCL	$		4		D		T		d		t	
0	1	0	1	5	ENQ	PPC (3)	NAK	PPU	%		5		E		U		e		u	
0	1	1	0	6	ACK		SYN		&		6		F		V		f		v	
0	1	1	1	7	BEL		ETB		'		7		G		W		g		w	
1	0	0	0	8	BS	GET	CAN	SPE	(		8		H		X		h		x	
1	0	0	1	9	HT	TCT	EM	SPD	)		9		I		Y		i		y	
1	0	1	0	10	LF		SUB		*		:		J		Z		j		z	
1	0	1	1	11	VT		ESC		+		;		K		[		k		{	
1	1	0	0	12	FF		FS		,		<		L		\		l		|	
1	1	0	1	13	CR		GS		-		=		M		]		m		}	
1	1	1	0	14	SO		RS		.		>		N		^		n		~	
1	1	1	1	15	SI		US		/		?	UNL	O		_		o		DEL	

Columns 0–1: ADDRESSED COMMAND GROUP (ACG) (column 0 MSG), UNIVERSAL COMMAND GROUP (UCG) (column 1 MSG); columns 2–3: LISTEN ADDRESS GROUP (LAG); columns 4–5: TALK ADDRESS GROUP (TAG); columns 2 through 5: (4). Together: PRIMARY COMMAND GROUP (PCG).

Columns 6–7: SECONDARY COMMAND GROUP (SCG)

NOTES: (1) MSG = INTERFACE MESSAGE
(2) b_1 = DIO1...b_7 = DIO7
(3) REQUIRES SECONDARY COMMAND
(4) DENSE SUBSET (COLUMN 2 THROUGH 5)

3 Maintenance

3.1 Required Measuring Equipment and Accessories

Ref. No.	o Equipment, Specifications ● Recommended R&S unit	Type	Order No.	See section
1	o DC Voltmeter Input impedance > 10 MΩ Measurement error < 0.01 % ● Digital Multimeter	 UDS5	 349.1510.02	5.2.1 5.2.4 5.2.6 5.2.8 5.3.1.3 5.3.2.4
2	o Oscilloscope with probe 10:1; 0 to 500 kHz; 0.1 V/cm ● Oscilloscope	 BOL	 374.2000.02	5.2.2 5.2.3 5.2.4 5.3.3.1
3	o Power signal generator f = approx. 120 MHz for NAP-Z3 to Z6 0.4 (0.2) to 80 MHz for NAP-Z7 (Z8) P depending on probe: NAP-Z3: P > 30 W Z4: P > 100 W Z5: P > 300 W Z6: P >1000 W Z7: P > 200 W Z8: P >2000 W Checking the PEP function (NAP-Z7/Z8): Generator must have modulation capability as shown in Fig. 2-61. Beat frequency 0.03 to 10 kHz.			3.2 5.2.10 5.2.11 5.2.12 5.3.2.1 5.3.2.2 5.3.2.3 5.3.3 3.2.2 5.2.13
4	o Termination 0 to 1000 MHz; 50 Ω ● Termination	 RNA	 272.4510.50	5.2.10 5.2.13
5	o Power meter 0 to 330 mW; 0...1000 MHz; Z = 50 Ω ● Microwave Power Meter	 NRS	 100.2433.92	3.2 5.2.11 5.2.12 5.3.2.1 5.3.2.2 5.3.2.3 5.3.3

Ref. No.	o Equipment, Specifications ● Recommended R&S unit	Type	Order No.	See section
6	o Sweep assembly for reflection measurements 25 to 1000 MHz, 50 Ω Directivity > 46 dB			5.2.14
7	o Signal generator P >1 W; 25 to 1000 MHz ● Power Signal Generator	 SMLU	 200.1009.02	5.3.7.3 5.2.11 5.2.14
8	o DC ammeter I >0.5 A ● Digital Multimeter	 UDS5	 349.1510.02	5.2.9
9	o High power attenuators, depending on power head: Z3: 20 dB; 30 W Z4: 30 dB; 100 W Z5: 30 dB; 300 W Z6: 40 dB; 1000 W Z7: 30 dB; 200 W Z8: 40 dB; 2000 W			3.2 5.2.10 5.2.11 5.2.12 5.2.13 5.3.2.1 5.3.2.2 5.3.2.3 5.3.3
10	o DC source ● Power Supply	 NGT20	 117.7133.02	5.2.8
11	o Adapter (Fig. 3-2)			5.2.7
12	o Separating plate (Fig. 3-3)			5.2.9
13	o Precision termination 0 to 1000 MHz; 50 Ω VSWR < 1.005			5.2.14

3.2 Checking the Rated Specifications

The test setup is shown in Fig. 3-1.

Required measuring instruments: Power signal generator
High-power attenuators
Microwave power meter

Make sure that the power head, attenuators and power meter have the same characteristic impedance and are interconnected without the use of cables as these lead to measurement errors due to cable loss and reflection.

After switching on, wait at least 1 minute before checking the rated specifications. If necessary, wait until temperature variations in the power head or display section have completely levelled out.

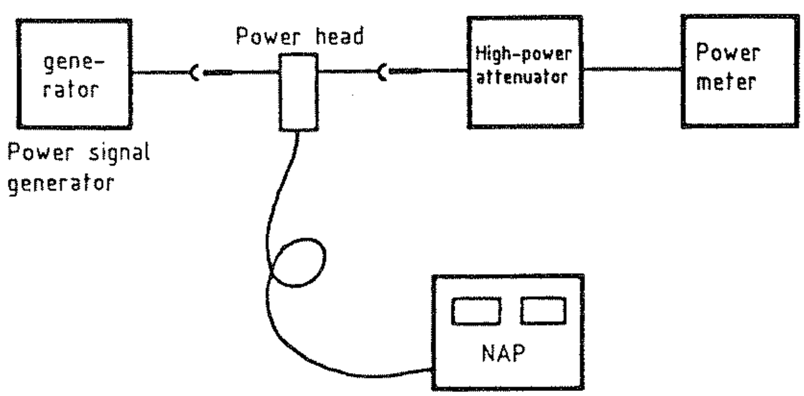


Fig. 3-1 Test setup 1 for checking the characteristics of the NAP and for adjustment

3.2.1 Checking the Power Indication

Check the indication in both directions using an unmodulated RF signal at the power values stated in the Performance Test Report (item 3).

The limit values given in the report are calculated using the specifications of the data sheet; they are valid for NAP-Z3 to Z6 in the frequency range 25 to 1000 MHz, for NAP-Z7/Z8 in the range 1.5 to 30 MHz (PEP function is switched off).

Note: The incident-power indication applies always to the **output power** of the power head.
Set NAP to automatic range selection for the check!

3.2.2 Checking the Peak Power Measurement (NAP-Z7/Z8)

Modulate RF signal in the frequency range 1.5 to 80 MHz as shown in Fig. 2-6.1 (section 2.3.14, peak power measurement), beat frequency 0.3 to 3 kHz.

Measure average power (AVG) of the signal and store reference value for the incident-power channel. Switch over to peak power measurement (PEP) and determine percental deviation of indication from stored average value.

Check adherence to the limit values for the peak powers stated in the Performance Test Report. Carry out the check for both directions.

Note: Check test signal using a spectrum analyzer when the limit values are exceeded. Suppress intermodulation products and a possible carrier by at least 50 dB with respect to the two useful signals.

3.2.3 Checking the Directivity

Check the directivity as described in 5.2.10 (directivity of power head). Frequencies and limit values as stated in the Performance Test Report.

3.2.4 Checking the Reflection

Carry out check as described in section 5.2.12 (reflection). Frequencies and limit values as stated in the Performance Test Report.

3.2.5 Checking the Performance of Displays and Keyboard

Enter the special function 70 via the keyboard. Now all LCD segments must be visible. In AC power operation, the REMOTE LED must light up additionally for about 1 second.

The easiest way to check the keyboard is to press the keys in the following sequence and to observe the response of the NAP on the displays.

The keys can only be tested when the power head is connected.

Incident-power channel (left display)	
Key	**Display**
dBm	dBm
W	W
AM	AM and %
TML	TML and dB
SHIFT and dBm	Δ and dB
SHIFT and W	Δ and %

Reflected-power channel (right display)	
Key	**Display**
W	W
dBm	dBm
SWR	SWR
RTL	RTL and dB
P_R/P_F	R/F and %
RFL	RFL and %
SHIFT and dBm	Δ and dB
SHIFT and W	Δ and %

Centre keys	
Key	**Display**
W	"W" *)
SHIFT and RCL	"1"
SHIFT and STO	"10"
SHIFT and LOC	"10."
SHIFT and MIN	"10.5"
SHIFT and MAX	"10.56"
CLR	Digital display cleared

*) The subsequent indication refers to the channel for which the W key has been pressed.

Test: PEP key

Indication Er.1 in the right-hand display (for Power Head NAP-Z3 to Z6)

Indication PEP in both displays (for Power Head NAP-Z7/Z8)

3.2.6 Checking the IEC-bus Interface

This test is best be performed by sending some special commands from a process controller to the NAP and then checking the response of the instrument.

Prior to this test, initialize the NAP (turn it off and immediately on again).

Programming example:

```
100 IECTIME20
110 IECOUT4,"LMF,LMR"
120 IECOUT4,"DT,N0,Q1"
130 IECSRQ GOTO200
140 IECOUT4,"X1"
150 A=10
160 GOTO150
200 REM SERIAL POLL
210 IECSPL4,S%
220 PRINTS%
230 IECIN4,P$:IECIN4,R$
240 PRINTP$,R$
250 IECOUT4,"X1"
260 IECRETSRQ
```

Explanations:

Line 110: In the above example, "4" has been used as IEC address. The following setting instructions are sent from the process controller (e.g. PUC) to the NAP:

LMF, LMR: Display in dBm in both channels
DT: Data output on both channels
N0: Data output with header
Q1: Enable Service Request

The process controller starts an individual measurement via "X1" and stores the device status in S% and the measured values in P$ and R$ after the NAP has issued the Service Request. The next measurement is started by the instruction in line 250.

3.3 Performance Test Report NAP, NAP-Z3 to Z6

R & S

Power Reflection Meter NAP
Order No. 392.4017.02

Serial No. ....

Power Head NAP-Z...

Serial No. ....

Amendment 1

Date ....

Name ....

Item	Test		Measure acc. to section	Minimum value	True value 1→2	True value 2→1	Maximum value	Unit	Confirmation
1	Performance test Displays and Keyboard		3.2.4	-			-	-	
2	Performance test Option NAP-B4		3.2.5	-			-	-	
3	Power indication at 20 to 25° C		3.2.1						
	NAP-Z3	30.0		28.2			31.8	W	
		17.4		16.36			18.44	W	
		10.4		9.78			11.02	W	
		3.0		2.82			3.18	W	
	NAP-Z4	100.0		94.0			106.0	W	
		55.0		51.7			58.3	W	
		33.0		31.0			35.0	W	
		9.4		8.84			9.96	W	
	NAP-Z5	300		282			318	W	
		174		163.6			184.4	W	
		104		97.8			110.2	W	
		30		28.2			31.8	W	
	NAP-Z6	1000		940			1060	W	
		550		517			583	W	
		330		310			350	W	
		94		88.4			99.6	W	
4	Directing		5.2.10						
		25 MHz		26			-	dB	
		30 to 1000 MHZ		30			-	dB	
5	Reflection 25 to 1000 MHz		5.2.13	-			1.5	%	

R & S

Power Reflection Meter NAP
Order No. 392.4017.02

Serial No. ....

Power Head NAP-Z7
Order No. 350.8214.02

Serial No. ....

Amendment Ø

Date ....

Name ....

Item	Test	Measure acc. to section	Minimum value	True value 1→2	True value 2→1	Maximum value	Unit	Confirmation
1	Performance test Displays and keyboard	3.2.4	-			-	-	
2	Performance test Option NAP-B4	3.2.5	-			-	-	
3	Power indication at 20 to 25° C 1.5 to 30 MHz 185 100 50 15	3.2.1	 173.9 94.0 47.0 14.10			 196.1 106.0 53.0 15.90	 W W W W	
4	Peak Power Measurement at 20 to 25° C 1.5 to 80 MHz PEP: 15 W 3 W 0.5 W	3.2.2	 95.0 90.8 64.8			 105.0 109.2 135.2	 % % %	
5	Directivity 0.4 MHz 1.5 MHz 30 MHz 50 MHz 80 MHz	5.2.10	 23 35 35 30 20			 - - - - -	 dB dB dB dB dB	
6	Reflection 30 MHz 80 MHz	5.2.12	 - -			 1.0 1.5	 % %	

3.3 Performance Test Report NAP, NAP-Z8

R & S

Power Reflection Meter NAP
Order No. 392.4017.02

Serial No. ....

Power Head NAP-Z8
Order No. 350.4619.02

Serial No. ....

Amendment Ø

Date ....

Name ....

Item	Test	Measure acc. to section	Minimum value	True value 1→2	True value 2→1	Maximum value	Unit	Confirmation
1	Performance test Displays and keyboard	3.2.4	-			-	-	
2	Performance test Option NAP-B4	3.2.5	-			-	-	
3	Power indication at 20 to 25° C 1.5 to 30 MHz 1850 1000 500 150	3.2.1	 1739 940 470 141.0			 1961 1060 530 159.0	 W W W W	
4	Peak Power Measurement at 20 to 25° C 1.5 to 80 MHz PEP: 15 W 30 W 5 W	3.2.2	 95.0 90.8 64.8			 105.0 109.0 135.2	 % % %	
5	Directivity 0.2 MHz 0.4 MHz 1.5 MHz 30 MHz 50 MHz 80 MHz	5.2.10	 25 30 35 35 30 20			 - - - - - -	 dB dB dB dB dB dB	
6	Reflection 30 MHz 80 MHz	5.2.13	 - -			 1.0 1.5	 % %	

3.4 Regular Maintenance

3.4.1 Electrical Maintenance

3.4.1.1 Replacing the Batteries or Accumulators

If the battery voltage is too low, remove the upper cover of the case (4 Phillips screws) and the screening plate below this cover (also 4 Phillips screws) and replace the batteries by six mono-cells 1.5 V/IEC-R20 (round cells R20 DIN 40866). Use leak-proof batteries only.

The service life of the rechargeable NiCd round cells of the NAP-B4 option depends on the operating conditions. The most favourable conditions are those with the cells fully charged and the unit not in use disconnected from the AC supply (see section 2.2.4.2). If the service life of accumulator operation specified in the data sheet is considerably lower after the cells have been completely charged, insert five new NiCd round cells of 1.2 V (GSZ 1.8 DIN 40766). The exchange is carried out in the same way as the replacement of the battery.

After checking the battery voltage (see section 5.2.5), screw the screening plate on again and close the case.

If equipped with the NAP-B4 option, charge all accumulators every two to three months when the unit is not in use (connect unit approx. 16 hours to AC power supply).

3.4.1.2 Checking the Digital/Analog Conversion Range

Enter the special function 8Ø from the keyboard and measure the voltage at check point P4. The resulting value should be +2.200 V. Then enter S81 and make sure that the voltage at P4 is -3.942 V.

The difference between the two voltage settings must be 6.142 V (with an accuracy of ±0.1%). If this is not the case, correct as described in section 5.3.1.3.

3.4.2 Mechanical Maintenance

The NAP does not require any mechanical maintenance.

3.5 Storage

Should the NAP be shelved for a long period, it is recommended that the batteries be removed as described in 3.4.2, in order to avoid damage due to leaking cells.

If the option is incorporated in the unit, the accumulators of this option, too, should be removed in order to avoid leakage or overdischarging.

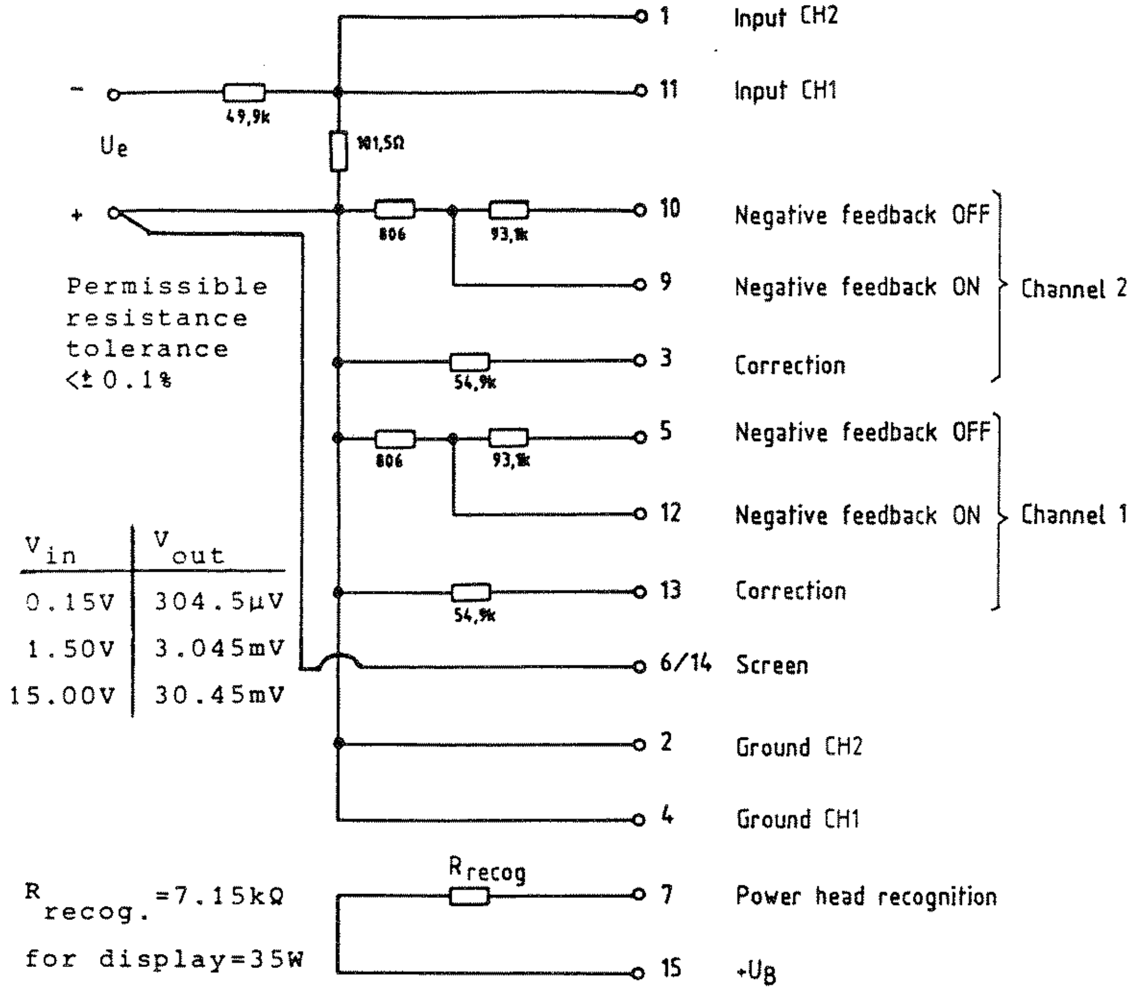


Fig. 3-2 DC adapter

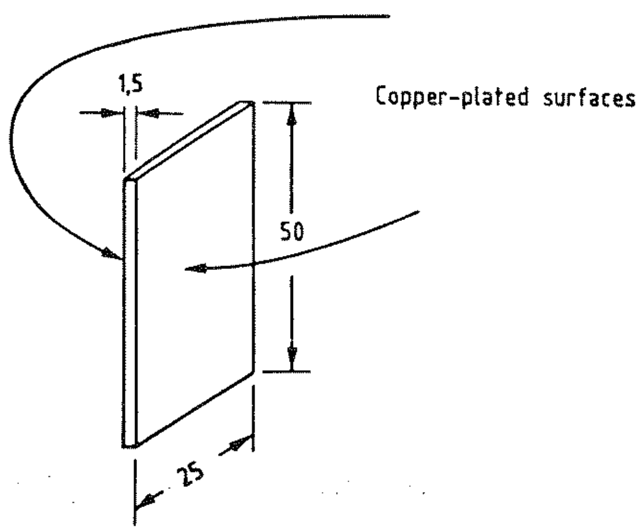


Fig. 3-3 Isolating plate for measurement of charging current

4 Servicing of Complete NAP

4.1 Performance Test

4.1.1 Hardware

The NAP consists of the following subassemblies:

- → Digital/analog section 392.4517.02
- → Display section 392.4217.02
- → Battery section 392.4881 or AC Power/IEC-bus Option 392.5913.02

With the exception of the battery section, all circuits are mounted on printed-circuit boards (see block diagram 4-1).

Analog section

The analog circuit is located in the screened area of the digital/analog board. It contains two chopper amplifiers (one for incident-power display and the other for reflected-power display) which amplify the input signal of the order of some µV to 25 mV to a maximum output voltage of -3.9 V in each of the three measurement ranges. Both signals pass through an active filter with Bessel function, which suppresses noise voltages above 5 Hz.

The filters are followed by a processor-controlled multiplexer that switches the signals of the two channels alternately to the inverting input of a comparator. The other input is driven by a 12-bit digital/analog converter. The output signal is high or low, depending on whether the test signal is greater or smaller than the reference level and is taken via lead-through filters to the microprocessor.

The digital/analog conversion routine scans all twelve bits, which can be 0 or 1, depending on the level of the test signal, and thus generates a bit pattern that corresponds to the test signal plus amplifier offset. The processor now generates a bit pattern from the zero offset (measured beforehand) and the range setting data; this pattern corresponds to the measured quantity.

The bit pattern thus obtained is used to display the measured value and to drive a further digital/analog converter whose analog output delivers an analog voltage corresponding to the value displayed in mV and being available at the rear telephone jack for recording purposes.

Digital section

The digital section surrounds the screened area of the digital/ analog board. The associated keyboard circuit is located on the cover (second part of the digital/analog board).

The NAP is electronically switched on and off (univibrator D461 I/II, flip-flop D421, ON key at the contacts 7B/8B of connector X41).

When the instrument is switched on, the signal $\overline{\text{TAUS}}$ becomes low and thus causes the control section to switch in. At the same time, GEIN goes to high and after a delay (via R321, C321) the reset signal RES becomes low.

The processor interrogates the $\overline{\text{OPT}}$ signal. In battery operation ($\overline{\text{OPT}}$ = high), the processor (D341) and the EPROM (D351) are turned off for about 400 ms after every computing cycle. Completion of the timer I interval initiates the turn-on of the equipment and the start of timer II which generates a reset pulse of about 1 ms for microprocessor start.

The processor interrogates the RNS (reset after stop) signal to determine whether the reset function has been performed after turn-on of the instrument (initialization required) or after the stop interval (program continuation). The RNS signal is low after turn-on and high after stop.

The stop interval can be aborted via the $\overline{\text{TAST}}$ signal on pressing the key (timer I reset).

When the NAP is AC powered, the processor and the EPROM remain turned on. When the NAP is battery-operated, it turns off automatically via GAUS = high after about 30 minutes, provided the display has not changed during this period.

The instructions the processor requires to perform its tasks are obtained from an external EPROM (D351). Like the RAM 5516 this EPROM is addressed via a latched bus.It receives the addresses over the upper six lines directly from the processor via port 2.

Some circuit components are permanently powered (V_{RAM}) even if they are turned off. One of them is the RAM (D391) including the IEC address and the complete circuit for the electronic switching on and off of the NAP (D461, D421).

The non-screened section of the digital/analog board also contains the circuit generating the RAM voltage (V_{RAM}) and a regulator stabilizing the input voltage (approx. 5.7 to 9 V) so as to obtain a constant output voltage of about 5.2 V.

In addition the circuit used to generate the RAM voltage (V_{RAM}) and a control component designed to generate a constant output voltage of approx. 5.2 V from the available input voltage (approx. 5.7 to 9 V) are located in the screened area of the digital/analog board.

In order to be able to operate the unit as long as possible with a set of 6 cells, the control section was designed such that the required voltage drop between the input and output for correct control of the load variations may be as low as possible.

Display

The display board contains the keyboard, the LCDs and the drivers. It is connected to the digital/analog board via a multipoint connector. The drivers (D1 and D2) are connected to the microprocessor which writes the required data and instructions serially into the LCD drivers.

Two potentiometers serve for setting the multiplex frequency (flickerless display) and the contrast of the display. A temperature control circuit keeps the adjusted contrast constant over a wide temperature range.

The processor decodes the keyboard by means of a key identification routine using the ICs D441 and D451. This routine is called up via a keyboard interrupt.

The display board receives via the connector the control signals for the LINE and REMOTE LEDs. The LINE LED lights when the NAP is AC powered, the REMOTE LED lights additionally during remote control.

AC Power/IEC-bus Option NAP-B4

If the NAP-B4 Option (392.5913.02) is incorporated instead of the battery pack of the basic model, the NAP can be operated with AC power or via the buffered accumulators of the option which make the NAP a portable instrument. Since the accumulators reveal a lower capacity (approx. 2 Ah) than the single cells, the time of operation is reduced; the possibility of recharging, however, more than compensates this disadvantage.

If the NAP is connected to an AC outlet by means of the power cable (392.5942) supplied, the built-in accumulators are continuously recharged even if the instrument is switched off.

When AC powered, the NAP can also be remote-controlled via the incorporated IEC-bus interface. This interface has its own 5-V power supply and permits the NAP to be used in a system test assembly that is controlled by a central computer. In this case, it is not only possible to send a request for measurement data from the NAP and to read them out but also to remote control the NAP.

4.1.2 Software

The complete program is contained in an EPROM. A brief description of the most important program parts is given in the following.

Power on

After the operating voltage has built up and the processor started by a reset pulse, the program execution begins with the initialization routine.

→ Measuring amplifier to ground, setting of measurement range 2

→ Initialization of displays

→ Initialization of keyboard circuit

→ Display of software code digit for approx. 1 s

→ RAM test

→ Display of IEC address

→ Power head identification

→ Initialization of IEC interface

→ Display of maximum permissible power of power head

→ Calibration of analog output

→ Measurement of supply voltage

→ Measurement of zero offset in the three amplifier ranges for both channels

During the individual initialization phases, the self-test is performed step by step.

On completion of the initialization, the NAP is ready for measurement.

Setting the analog hardware

Settings are made either by key depression, IEC bus or by the program itself (autoranging). The setting data of the analog section are transferred via a latched bus (D481 and D501) and the lead-through filters.

Both the key depression and the IEC-bus command trigger an interrupt on the microprocessor. This interrupt takes the program to the subroutine that identifies the type of interrupt and contains the setting instructions.

Measurement procedure

In manual or IEC-bus operation, the NAP measures in the selected range. As long as the hold-range function is not selected, the correct measurement range is always selected and the amplifiers are protected against overloading. The test results are displayed in digits or by a scaled bar in a quasi-analog display.

When being used for triggered measurements, the NAP aborts the free-running measurement on receiving the instruction to start measurement and begins a new measurement procedure.

The digital value obtained during measurement cannot be displayed or output via the IEC bus immediately but must be corrected by the amplifier offset, the selected range and a constant factor that depends on the power head used.

Corresponding formula: $P = \frac{W - W_O}{K} \times 10^{(R-1)}$

P	=	power in W
W	=	"measured" bit pattern
W_O	=	bit pattern from offset measurement
K	=	scaling factor for power head
R	=	selected range (Ø,1,2)

The amplifier offsets are determined about every 3.3 minutes, thus compensating for temperature-dependent drift of the amplifier by means of an appropriate software.

4.2 Mechanical Construction

4.2.1 Power Head

NAP-Z3 to Z6

The power head is accommodated in an aluminium diecast case that contains three cavities enclosed by two U-shaped covers.

The first cavity includes the directional coupler. One of the two coupling plates can be shifted for setting the maximum directivity. The second cavity incorporates the RF rectifier and a PC board on which the negative feedback circuit of the chopper amplifiers and the temperature control circuit are mounted. The third cavity accommodates the cable fittings.

The thin-film terminating resistors of the coupling line, the capacitors C_1 and C_4 for frequency response equalization, and the slides for frequency response adjustment are mounted on both sides of the case.

The capacitors C_1 and C_4 are made of thin silver-coated mica sheets. These are slightly bent to equalize thermal expansion. To maintain the bow produced by mechanical prestress, the two fixing screws of the terminating resistors must not be loosened.

The division into cavities (plus the screening plates below the covers of the NAP-Z5 and NAP-Z6) make the power head extremely pickup-proof against radio interference and RF voltages that may be present on the cable.

NAP-Z7/Z8

The Power Heads NAP-Z7 and NAP-Z8 are, to a large extent, of identical design; all adjustment and test points are accessible after removing the two U-shaped covers. Two thin screening plates which are pressed against the housing all round by means of a spring mat ensure RF pick-up-proof closure.

The power heads can be divided into four subassemblies: directional coupler, rectifier/multiplexer, negative feedback divider/temperature control circuit and peak value meter.

The current transformer Z1 of the directional coupler and the two coupler capacitances designed as coaxial capacitors are accommodated in the coupling cavity closed at the front by means of a separate cover. The directional coupler board 350.4860.12 (.02) with the potentiometer R 14 (directivity) is screwed to the rear of the cavity.

Between the two screening strips, the rectifier board 350.4719.12 (.02) comprises the rectifiers V100 (V200) with the adjustment elements X105 (X205) and R105 (R205) (linearity) as well as the multiplexer D100 (D200) with the control component D300. The negative feedback divider with the temperature control circuit as well as the potentiometer R116 (R216) (power head sensitivity) are accommodated outside the inner cavity at the cable entry.

The peak value meters for the two channels are located separately on a plug-in board 350.4819.02 each. The potentiometer R406 for the linearity are accessible from above.

4.2.2 Display Section

The NAP is accommodated in a case especially designed for compact R&S units and thus provides easy servicing. All printed-circuit boards are readily accessible.

Digital/analog board

This board becomes accessible when removing the lower cover from the cabinet (4 Phillips screws). The particular feature of this PC board is its sandwich design. The two plates are interconnected by two flat cables. The upper plate performs two tasks:

a) It carries part of the digital circuit.

b) The remaining part provides the upper screening cover of the analog section.

After unscrewing the five Phillips screws the upper plate can be swung aside, thus giving access to the complete components side, also to that of the analog circuit.

The entire digital/analog board can be folded forward after unscrewing two screws at the rear edge of the board and one screw at the rear panel with the power head being disconnected. Thus, the printed sides of the digital/analog board and of the Option NAP-B4, if fitted, are accessible.

Display board

To remove the upper and lower covers, unscrew the four Phillips screws and disconnect the multi-point connectors X41 and X61 after having taken off the upper screening plate below the upper cover: see Fig. 4-2). Unscrew the four Phillips screws from the two side walls and remove the display board, including the front plate, to make the printed side accessible. During this process, the cover of the LCDs and the mask with the inscriptions for the special functions of the keys are loosened as well.

The components side will be accessible after screwing off six further Phillips screws and removing the front sheet from the display board.

AC power/IEC-bus option (NAP-B4)

The components side of the option board becomes accessible when screwing off the four Phillips screws and removing the upper cover plus the upper screening sheet metal (4 Phillips screws).

This board contains:

- 5 rechargeable NiCd accumulators
- Charger
- The complete IEC-bus circuit with its own stabilized power supply.
- The instrument power supply with power transformer, rectifier, charging electrolytic capacitor, fuse and voltage selector.

As already mentioned, the printed side can be made accessible when the digital/analog board is swung out.

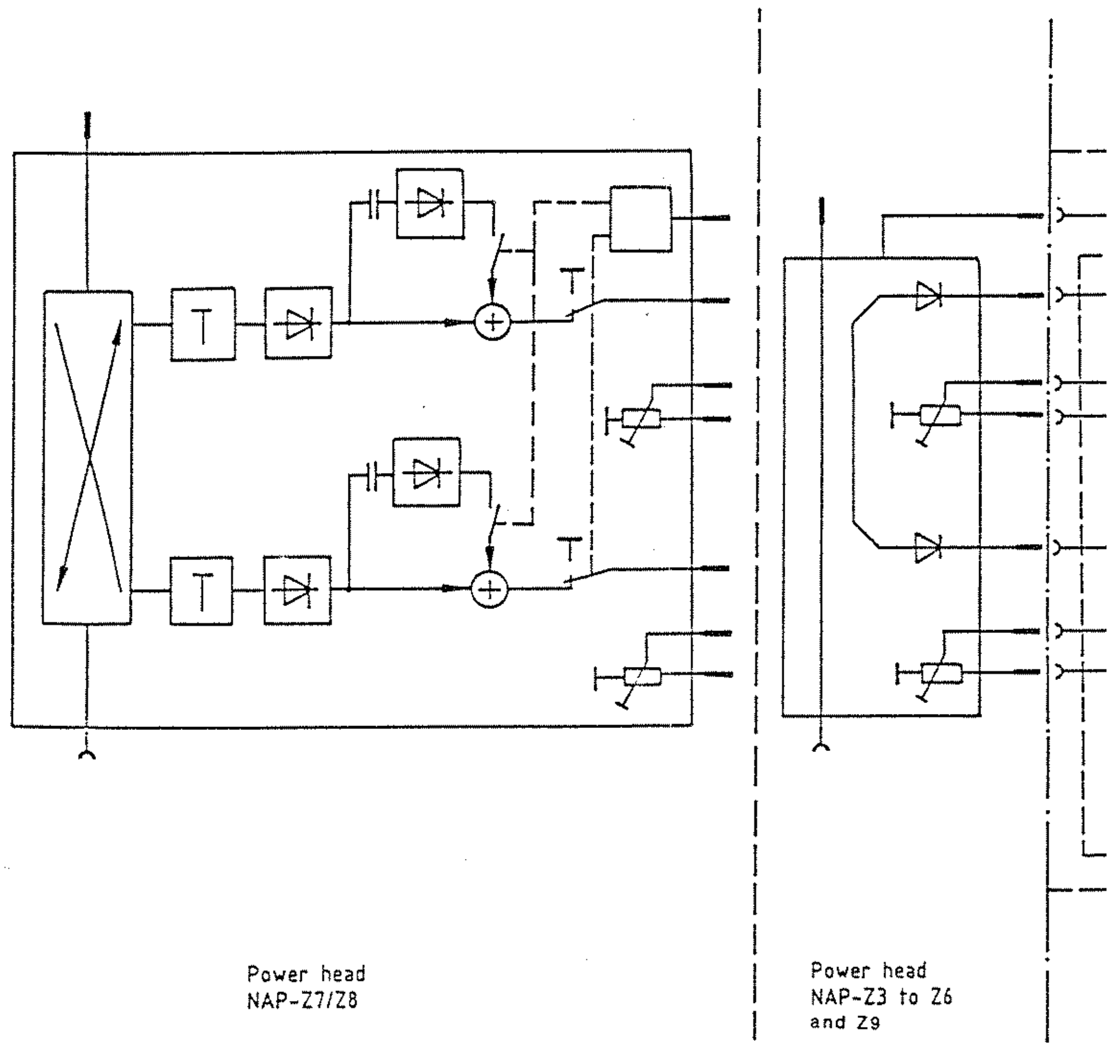
The voltage selector and the fuse holder are located on the rear side of the NAP and thus accessible without opening the instrument.

The option board is connected to the digital/analog board by means of a multi-point connector (X11 and X51, spliced; see Fig. 4-3).

Battery section

In its basic version, the NAP is equipped with a battery section which is accessible after removing the top cover (4 Phillips screws) and the top screening sheet (4 Phillips screws). It is equipped with 6 commercial single cells incorporated in a battery holder.

The battery section is connected to the digital/analog board by means of a multi-wire cable (connector X11).



Power head
NAP-Z7/Z8
Power head
NAP-Z3 to Z6
and Z9

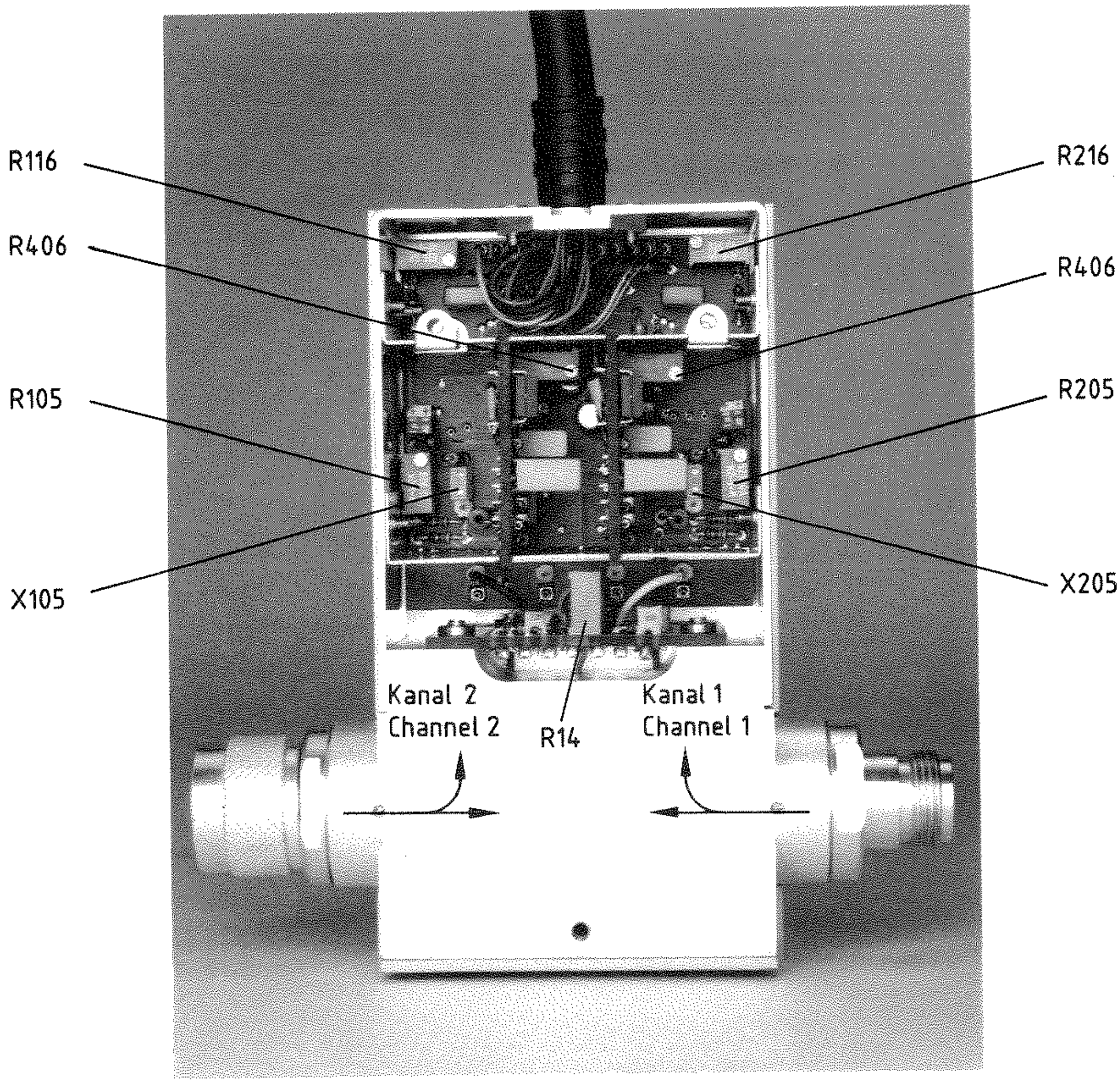


Bild 4–3a Lage der Abgleichelemente NAP–Z7/–Z8

Fig. 4–3a Location of adjusting devices NAP–Z7/–Z8

5.1 Circuit Description

5.1.1 Power Head

NAP-Z3 to Z6 (see circuit diagram 392.6610)

In the power head, the RF energy passes through a symmetrical directional coupler that serves for the measurement of the incident and the reflected power. The direction coupler derives parts of the incident and the reflected power via R1-C1 (R2-C4). The combinations R1-C1 and R2-C4 constitute the matched terminations for the directional coupler and at the same time compensate for the coupling voltage that increases with the frequency according to a sinewave function.

RF rectification is accomplished by the diodes V1 (V2) and the associated charging capacitors C2 (C3).

The coupling attenuation in the directional coupler and the voltage division of the frequency-response compensation are such that the RF rectifier diodes are only driven in the square-law portion of their characteristic.

NAP-Z7/Z8 (see circuit diagram 350.8214 and 350.4619)

The power heads comprise a directional coupler of discrete components delivering two voltages at its two outputs X5 and X6; these voltages are proportional to the incident and reflected power. The coupling attenuation is approx. 40 dB. The coupled RF voltages are matched to the rectifiers V100 (V200) via the voltage dividers R100/R101/R102 (R200/R201/R202) (rms rectification in the square-law portion of their characteristic). The transfer characteristic is linearized by means of appropriate resistive loading of the rectifier output voltages (R105, R205), these voltages being proportional to the powers to be measured.

For peak-power measurement, the peak value of the AC component of the detector output voltage is generated which, following amplification by N400, is subsequently added to the DC component (average value of power) via the dividers R107/R106 (R207/R206).

The peak-power measurement as well as the offset detection for the amplifiers can be switched on via the multiplexer D100 (D200). To this end, the power head outputs X300.11 (X300.2) are grounded via R108 (R208). The offset detection for the Power Heads NAP-Z3 to Z6 is carried out in the basic unit NAP. The setting of the multiplexer D100 (D200) is carried out via the counter D300 which can be counted up by means of short pulses (150 µs) at X300.8 and reset by means of a long pulse (35 ms) (see also section 5.1.5, Identification of Power Head).

Analog Amplifier

(See circuit diagram 392.4517 sheet 1)

The DC voltage obtained in the power head is so low (between 10 µV and 25 mV) that a chopped amplifier is required for further amplification.

The input signal passes through a switch made up of the FETs V16 and V17 (V106 and V107) before it arrives at the amplifier. This switch permits a zero offset measurement of the total analog amplifier even if measurement power is applied. For this purpose, the power head output is to be disconnected from the amplifier input which is connected to ground via R12 (R102).

A series-parallel chopper including the transistors V21 and V22 (V111 and V112) represents the amplifier input where the DC voltage obtained in the power head is chopped into a rectangular AC voltage (f = 135 Hz) and taken to the preamplifier via C31 (C121).This preamplifier boosts the chopped DC voltage by approximately 54 dB. The signal is then passed on to the synchronous detector D101 and C41 (C131).

The transistors of the series-parallel chopper are driven together with the synchronous detector by the rectangular generator D71 so that the transistors V21 (V111) and V22 (V112) are conducting alternately. When V21 (V111) conducts, pin 15 is connected to pin 1 of D101, while with V22 (V112) conducting pin 15 is connected to pin 2 of D101. The synchronous detector acts on the charging capacitor C41 (C131) via a series resistor R41 (R131). C41 (C131) and R41 (R131) also operate as an RC low-pass filter with a low cutoff frequency.

The feedback circuit of the two choppers is provided in the power head. In this circuit, the gain is adjusted as a function of the diode characteristic and slight variations of the diode voltage as a function of temperature are compensated for.

The synchronous detector delivers again a DC voltage. The range amplifier is connected to the output of the stage following the detector. In this amplifier, the signal is amplified by 0.75, 20.75 or 40.75 dB, depending on its magnitude. The analog switch D51 (D141) selecting the measurement range is controlled by the processor via the expander D221. In the highest measurement range (= lowest gain), the adjustment can be additionally corrected by means of the potentiometers R6 (16) in the power head, thus compensating for linearity deviations of the rectifier diodes (applies only to NAP-Z3 to Z6).

After the range amplifier, the amplified input signal arrives at an active Bessel filter that suppresses all unwanted signals on the DF voltage, the cutoff frequency being approximately 5 Hz. This filter has a gain of about 1.73 dB and displaces the output voltage range by approximately 1.4 V (V_{in} = 0 mV, V_{out} = 1.4 V) so that the conversion range of the digital/analog converter (D191) can better be utilized. The output of the filter is also the output of the complete analog amplifier and is connected to one of the inputs of the following multiplexer (D161).

5.1.3 Multiplexer (D161)

The multiplexer allows the following signals to be switched to the inverting input of the comparator.

- → Output signal K1 of measuring amplifier
- → Output signal K2 of measuring amplifier
- → Voltage for identification of power head
- → Attenuated battery voltage for BATT LOW identification
- → Signal of analog output (incident power)
- → Signal of analog output (reflected power)
- → Ground

The inputs of multiplexer D161 (CD4051) are addressed by the expander D221 (CD4099) and switched through to the output (pin 3 of CD4051).

Addressing of multiplexer inputs

9	10	11	Multiplexer pins		
C	B	A	Input	Pin	Description
Ø	Ø	Ø	Ø	13	Output K1
Ø	Ø	1	1	14	Output K2
Ø	1	Ø	2	15	Power head identification
Ø	1	1	3	12	V_{BATT}
1	Ø	Ø	4	1	Free
1	Ø	1	5	5	Analog output, incident power
1	1	Ø	6	2	Analog output, reflected power
1	1	1	7	4	Ground

5.1.4 Analog/Digital Converter

The analog/digital converter converts the analog test signal into a bit pattern that can be handled by the processor. The heart of this subassembly is the 12-bit digital/analog converter AD7531 (D191).

The conversion routine is as follows (see also Fig. 5-2):

A certain signal level is available at the inverting input of the comparator N181 (LP311). For the sake of simplicity it is assumed that this level is constant. The microprocessor now sets the most significant bit (high) and all other bits (low). Depending on its resolution (1 bit (LSB) = 1.5 mV), the DAC now converts these bits into an analog voltage which is passed on to the non-inverting input of the comparator. If the test signal is greater than that of the DAC, the output of LP311 is low, otherwise it is high. In the first case, the most significant bit remains set and the processor sets the second-order bit (high). The corresponding output level is again compared with the test signal and applies a high or a low signal to the output of the LP311.

Assuming that the output level of the DAC is higher than the test signal, then the processor resets the second-order bit to low and sets the third-order bit instead. After checking of all twelve bits, a bit pattern corresponding to the measured voltage is available for the microprocessor.

At the same time, the DAC receives via the combination R191-C191 a reference voltage stepped down corresponding to the instructions from the processor and then made available as an analog signal for the comparator N181. A portion of the negative voltage is applied via the resistors R170 and R171 to the operational amplifier (N171I) at the output of the DAC. This amplifier causes an offset which is adjusted, together with the gain of this stage, as described in 5.3.1.3

5.1.5 Identification of Power Head

Since different types of power heads can be used with the NAP, it is the task of the microprocessor to identify the type currently connected. For this purpose, every power head is fitted with an identification resistor which acts, together with R4 in the NAP, as voltage divider between the negative and the positive supply voltages. With the aid of the D/A conversion routine the processor now measures the voltage at check point P3 (multiplexer output), after having addressed the corresponding input via expander D221, and thus recognizes the power head used. The transistor V94 is disabled during this measurement.

When operating with the Power Heads NAP-Z7/Z8, the "MK identification" (X1.7) is also used for the transfer of serial setting data which trigger switchover between peak-value and average-value measurement as well as between measurement and offset detection. To this end, control pulses switch transistor V94 on and off (see also section 5.1.1, Power Head NAP-Z7/Z8).

5.1.6 Battery Test

When the NAP is operated without AC power, the battery is checked at intervals of about 3.3 minutes (when S41 or S43 are called up, a battery test is performed after 10 minutes). The purpose of this battery test is to determine the charge state, i.e. the voltage at the cells. This is of particular importance if measurements are to be made over long periods of time without the possibility of connecting up AC power, for example in outdoor measurements.

Thus, after each zero offset measurement, the program executes a routine for measuring the battery voltage. During this process, the corresponding input of the multiplexer D161 is switched to the output (P3) and the D/A conversion routine is called up.

If the battery voltage is less than 5.8 V, the scaled bar begins to flash. Below a value of 5.7 V, the NAP turns off automatically.

5.1.7 Analog Outputs

The NAP has two analog outputs (incident and reflected power) for documenting the measured values. The subassembly for the analog outputs consists of the four-stage D/A converter D231 (144111), every stage being fitted with an operational amplifier N171 (III and IV). The microprocessor loads the D231 serially with a bit pattern corresponding to the current measured value. The D231 converts this bit pattern into an analog DC voltage. The output voltages of the subsequent operational amplifiers correspond to the values appearing in the LCDs (mV) without taking into account the decimal point. An offset also permitting the output of the negative voltage values is set via the resistors R241 and R242.

5.1.8 Generation of Operating Voltages

5.1.8.1 Regulator for $+V_{OP}$

This circuit is to regulate the input voltage, which may be between 5.7 V and 9 V (with the batteries fully charged), to a constant output voltage of approximately +5.2 V.

The diode V301 (ICL 8069) is used as a reference element that delivers a highly stable voltage of 1.23 V and requires a very low operating current (50 µA). This voltage is applied to the base of the left transistor of the dual transistor V302, while the right transistor receives the stepped-down output voltage. The dual transistor configured as a differential amplifier compares the two voltages and controls the transistors V303 and V304 used as control amplifiers. These provide the correct output voltage by controlling the base voltage of the series transistor V306.

The regulator is switched in and out by the GEIN signal. Transistor V304 is cut off by a high level on the $\overline{TAUS}$ LINE and the regulator no longer delivers an output voltage (see 5.1.10).

Together with R305, the transistor V305 provides current limitation which is adjusted to approximately 500 mA due to the value of R305.

5.1.8.2 Regulator for $-V_{OP}$

The negative operating voltage is obtained from the +5.2-V by means of the output signal of the multivibrator D71. This signal is applied to D81 (six-stage buffer), in order to avoid loading D71 and to obtain higher output currents. A voltage-inverting and voltage-doubling circuit delivering about -8 to -9 V is connected to the parallel outputs of D81. This voltage is stabilized to -6.5 V by the regulator consisting of V91, V92 and V93, the +5.2 V being used as a reference voltage (check point P10).

5.1.9 Microprocessor System

The core of this subassembly is a 80C31 CPU with the following addressable ICs (see Fig. 5-3):

Symbol	Description	Address range
D391	5516 RAM	7CØØ to 7FFF
D501	LSB bus latch	BCØØ to BFFF
D481	MSB bus latch	DCØØ to DFFF
	Keyboard	ECØØ to EFFF
	IEC-bus option	F4ØØ to F7FF
D471	Expander 1	F8ØØ to FBFF
D1,D2	LCD driver	FCØØ to FFFF

Except for the LCD driver and the IEC-bus option, all ICs are addressed dynamically, i.e. the chip select is only valid in conjunction with a read or write signal of the processor.

The interrupt inputs of the microprocessor are connected as follows:

Processor pin	Designation	Subassembly
12	$\overline{INTØ}$	AC power/IEC-bus option
13	$\overline{INT1}$	Keyboard

The principal function of the processor is described in 4.1.1 ("Digital Section").

5.1.9.1 Expanders

The bus expanders drive the multiplexer in the analog section and address the various chips statically.

Setting data for expander 1 (D471)

Signal	Address (hexadecimal) High	Address (hexadecimal) Low	Description
GAUS	F8Ø1	F8ØØ	NAP switched off if display does not change for 30 minutes or if V_{BAT} < 5.7 V
REM	F8Ø3	F8Ø2	Signal for REMOTE LED
$\overline{IEA}$	F8Ø5	F8Ø4	IEC interrupt enable
$\overline{CS}$ analog output	F8Ø7	F8Ø6	Chip select Analog output DAC
$\overline{CS}$ amplifier	F8Ø9	F8Ø8	Chip select expander 2
Power head drive	F8ØF	F8ØE	Drive V94

Setting data for expander 2 (D221)

Setting			Bus latch data (LSB) (decimal)	
Range 2		K1	8/11	
Range 1		K1	9/10	
Range 0		K1	8/10	
Range 2		K2	12/15	
Range 1		K2	13/14	
Range 0		K2	12/14	
Amplifier to ground			6	
Amplifier to input			7	
Analog output	Ground		1 / 3 / 5	Settings on multiplexer D161
	Incident power		1 / 2 / 5	Settings on multiplexer D161
	Reflected power		0 / 3 / 5	Settings on multiplexer D161
	BATT		1 / 3 / 4	Settings on multiplexer D161
	Power head		0 / 3 / 4	Settings on multiplexer D161
Measurement potential	K1		0 / 2 / 4	Settings on multiplexer D161
	K2		1 / 2 / 4	Settings on multiplexer D161

5.1.9.2 $\overline{T_{ON}}$ Signal

In order to reduce the current consumption, the processor is switched on no longer than required for measurement of the input signal and calculation and display of the measured values. Subsequently, the processor issues the $\overline{T_{ON}}$ signal, starting the timer I (D331). Then the processor enters the power-down mode.

After the pause of timer I (approx. 380 ms) has elapsed, the processor is restarted by a reset pulse for the next measurement cycle.

5.1.9.3 Keyboard Identification

When a key is depressed, an interrupt ($\overline{INT1}$) is triggered at pin 13 of the microprocessor, thus starting the keyboard routine. The interrogation is executed as follows:

First, all the outputs of D451 (4042) Q_0 to Q_3, are low so that a key depression via D431 (4068) and D421I (4013) triggers the interrupt. Then the processor sets all these outputs to high, except for Q_0, and the lines D_0 to D_5 are interrogated via D441 (4503). If a key associated with the output Q_0 has been depressed, one of the D_0 to D_5 is low and thus identifies the key.If no low signal occurs, the processor sets the output Q_0 to high, Q_1 will be low, Q_2 and Q_3 go to high, and the same interrogation is started again.

The processor identifies the depressed key from the column and line information and is now able to execute the required operations. Since the SHIFT key does not trigger an interrupt, it is to be depressed together with another key, thus calling up the second function of the key. Therefore, the processor also interrogates whether the SHIFT key has been depressed after a keyboard interrupt.

After identification of the key, the microprocessor clears the interrupt by a reset pulse at D421I.

5.1.10 Switching On and Off

As already mentioned in 4.1.1 "Digital Section", the NAP is electronically switched on and off. To this end, the univibrator D461 (4001) delivers a pulse to the clock input of D421II (4013) with a duration fixed by R462/C461. This causes a high level at the $\overline{Q}$ output and renders V425 conductive. R426 is connected to ground and the regulator delivers $+V_{OP}$ = 5.2 V to the output.

To allow the electronic switch-on of the NAP, certain components (D461, D421) must permanently be on. They are supplied with the voltage V_{RAM} which is directly obtained from the battery voltage via the voltage divider R311/R313 and the diode V310. When the NAP is switched on, these components (including RAM D391) are additionally supplied with $+V_{OP}$ via the diode V421, thus unloading the high-impedance voltage V_{RAM}.

After switch-on, the program executes a self-test in which a read-write test of the RAM contents is also performed.

5.1.11 LCD Drive

The two LCDs H_1/H_2 are driven by the two drivers D_1 and D_2 generating all the signals necessary for operation. The circuits perform a 4-signal multiplexing function and, therefore, are able to drive 4 x 32 = 128 segments.

The drivers are connected to the processor, which transfers the data serially to them via the busy, SI (Serial Input) and $\overline{SCK}$ (Serial Clock Input) lines.

To generate the three necessary DC voltage levels, a resistive voltage divider is connected to pins 3, 4 and 5. The transistor circuit switched in parallel has the task to vary the DC voltage levels as a function of temperature, thus compensating for the temperature dependence of the displays. In this way, a constant contrast is achieved over a wide temperature range. The contrast can be varied with the potentiometer R18. R1 is used to vary the frequency of the internal oscillator and to adjust for a flicker-free display.

5.1.12 Power Supply

The NAP supply is an integral part of the NAP-B4 Option. It contains the rectifier for the DC voltage generation, the charging electrolytic capacitor and a charging circuit for the NiCd accumulators. This circuit delivers a constant charging current of approximately 145 mA.

5.1.13 IEC-bus Interface

The IEC-bus interface consists of the IC D25 (8291) and the line drivers D26 and D27. The interface is connected to the processor via the analog switches D21 to D24. These are low-impedance in AC power operation and separate the interface from the processor and the drivers when the NAP is powered from the accumulators.

The interface has its own stabilized power supply. The analog switches are supplied with V_{RAM}, to ensure defined initial states.

The transistors V15 and V16 prevent the IEC-bus interface from remaining under power when the NAP is switched off but plugged to the AC power supply.

The G_{EIN} signal not only causes the regulator to switch on but also the IEC-bus interface while the NAP is AC powered.

5.2 Checking the NAP

Normally, no regular checks and adjustments are required. However, to check a circuit after repair or in case of an error, special test settings can be called up. With these settings either a subprogram is executed or the circuit is brought to a defined state. The response of the circuit can be checked at the associated check points.

The following special functions are available for checking the NAP:

S5Ø Input of allocation "Measuring channel Ø" = incident power for measurements with identical powers in both measuring channels, and preselection of measurement range with special functions 1Ø to 3Ø.

S7Ø All LCDs are on, in AC operation also the REMOTE LED for approx. 1 s.

S8Ø Set all logic inputs of the DAC to Ø. → V_{P4} = +2.200 V

S81 Set all logic inputs of the DAC to 1. → V_{P4} = 3.942 V

S9Ø Generate V_{out} = 0 V at the analog output.

S91 Generate V_{out} = -2000 mV at the analog output.

S92 Generate V_{out} = +2000 mV at the analog output.

These special functions can also be set via the IEC bus by means of the instructions S < number >.

Instruction code "INI" permits re-initialization of the NAP. The instruction has the same effect as switching off the NAP and immediately turning it on again, which also means that the unit is not switched to remote control afterwards.

5.2.1 Operating Voltages

Measuring instrument: DC voltmeter (Ref. No. 1 in section 3.1)

Switch the NAP on and measure the DC voltages at the following check points:

P8 : +5.2 V (±2.5%)
P10: -6.5 V (±3%)

Check the $+V_{Op}$ regulation by removing a battery and replacing it by a link. Permissible voltage variation: < 5 mV.

5.2.2 Chopper Frequency

Measuring instrument: Oscilloscope
(Ref. No. 2 in section 3.1)

Check point P11. The period shall be T = 7.4 ms (≙ 135 Hz).

5.2.3 Oscillator Frequency

Measuring instrument: Oscilloscope
(Ref. No. 2 in section 3.1)

Check point P1 on display board. The period shall be 13.3 µs (≙ 75 Hz). In case of deviation, this value must be corrected as described in 5.3.1.1.

5.2.4 D/A Converter

Measuring instrument: DC voltmeter, oscilloscope
(Ref. Nos. 1 and 2 in section 3.1)

Check as described in 3.4.3. If the conversion range is offset, adjust it as described in 5.3.1.3. In normal measurement, an oscillogram as shown in Fig. 5-2 can be seen on the oscilloscope.

5.2.5 Battery Voltage

The battery voltage can be checked by means of the NAP itself without needing any other measuring instrument. For this purpose, call the special function 6Ø via the keyboard and observe the battery voltage on the display. In AC power operation, however, this special function is disabled.

5.2.6 Analog Outputs

Measuring Instrument: DC voltmeter
(Ref. No. 1 in section 3.1)

Measure the voltage at the two analog outputs.

Call special function	Voltage	
S9Ø	0 V	±20 mV
S91	-2000 mV	±20 mV
S92	+2000 mV	±20 mV

5.2.7 Power Head Identification

Auxiliary equipment: Adapter
(Ref. No. 11 in section 3.1)

Check by connecting the adapter instead of the power head and switching the NAP off and on again. In the course of the initialization, a value of 35 W fixed by the identification resistor in the adapter is to appear in the display for about 6 seconds. The display can be changed by varying the resistor R_K in the adapter as follows:

9.31 kΩ	:	110 W
11.3 kΩ	:	350 W
13.3 kΩ	:	1100 W
23.7 kΩ	:	195 W
28.7 kΩ	:	1950 W

5.2.8 Sensitivity of Display Section

Auxiliary equipment: Power supply, adapter, DC voltmeter
(Ref. Nos. 10, 11 and 1 in section 3.1)

The resistive voltage divider in the adapter is so dimensioned that a value of 1.500 V (corresponding to 3.48 W in range 1 on both displays) must be applied.

To make sure that range 1 is selected (and not the lower limit of range 2 due to a hysteresis), it is recommended that the special functions 5Ø and 11 be called prior to applying the voltage via the keyboard. These functions will set the correct ranges.

5.2.9 Checking the AC Power/IEC-bus Option

The option only operates with AC power. It also checks the LINE LED that must light when the NAP is switched on.

5.2.9.1 Charging Circuit

Measuring instrument: DC ammeter
(Ref. No. 8 in section 3.1)

Auxiliary equipment: Plate coated on both sides
(Ref. No. 12 in section 3.1)

Slide a copper-coated plate between the positive pole of the front accumulator and its holder and measure the charging current with the ammeter.

NAP switched off: $I_{ch} \approx 200$ mA [1])
NAP switched on: charging current decreased by the current drain of the NAP ($\approx$ 20 mA).

[1]) From serial No. 881 054 (option NAP-B4): 138 to 155 mA

5.2.9.2 IEC-bus Interface

Check the interface as described in 3.2.5.

5.2.10 Directivity of Power Head

Measuring instruments: Power signal generator
High-power attenuator
Termination
(Ref. Nos. 3, 9, 4 in section 3.1)

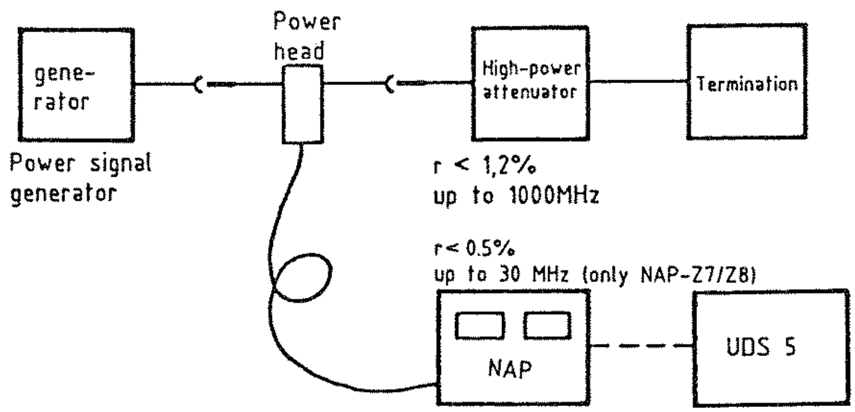


Fig. 5-1 Test setup 2 for checking the NAP characteristics

Measurement:

The directivity is the ratio between the incident power and the reflected power displayed on the NAP, the termination being matched to the characteristic impedance.

$$a = 10 \times \lg \frac{P_F}{P_R}$$

For NAP-Z3 to Z6, the measurement should preferably be made at the test frequencies 25, 30, 300, 525 and 1000 MHz, for NAP-Z7(Z8) at (0.2), 0.4, 1.5, 30, 50 and 80 MHz in both directions of the power head.

The limit values are as specified in the data sheet. (Performance Test Report).

The NAP can be used for the direct measurement of the directivity.

Proceed as follows:

a) Call the correction of the zero offset by means of the special function 43 (without power of power head).

b) NAP-Z7/Z8 only: switch off the function peak-value measurement PEP.

c) Apply measuring power.

d) Check for distinct change of the display in the reflected-power channel. If no change has occurred, increase the incident power.

e) Depress the RTL key.

f) The directivity is indicated in dB in the right display. If the incident power applied is too low, the reflected power will be low as well and, therefore, directivity will appear to be high. The following minimum values of incident power should be observed:

NAP-Z3:	$P_F > 6$ W	NAP-Z7:	$P_F > 40$ W
Z4:	> 20 W	Z8:	> 400 W
Z5:	> 60 W		
Z6:	>200 W		

If high values of power such as these are not available, measure the voltage variations at the check points P_1 and P_2 (e.g. with the UDS 5) and clear the offset with the corresponding key, taking into account the selected range.

5.2.11 Frequency Response of Power Head

Measuring equipment: Power signal generator, High-power attenuator, Microwave power meter (Ref.No. 3,7,9,5 in section 3.1)

The frequency response test must be carried out in both directions at constant power (Fig. 3-1). If attenuators are used between power head and power meter during this test, their frequency dependence must be taken into account.

The following table shows the permissible frequency response of the power heads for indication in W. The reference frequency for NAP-Z3 to Z6 is 120 MHz and for NAP-Z7/Z8, 10 MHz.

Frequency/MHz	25 to 1000
NAP-Z3 to Z6	± 2.5 %

Frequency/MHz	0.2 to 0.4	0.4 to 1.5	1.5 to 30	30 to 50	50 to 80
NAP-Z7	———	-31/+7 %	± 2.5 %	± 7 %	± 20 %
NAP-Z8	-27/+7 %	± 7 %	± 2.5 %	± 7 %	± 20 %

Table 5-1 Permissible frequency response error of power heads

The linearity of the Power Head NAP-Z7/Z8 being frequency-dependent below 1.5 MHz (see section 5.2.12 Indication linearity of Power Head), the frequency response error may depend somewhat on the measurement power in the range mentioned.

5.2.12 Indication Linearity of Power Head

Measuring instruments: Power signal generator
High-power attenuator
Microwave power meter
(Ref. Nos. 3, 5 and 9 in section 3.1)

Check the linearity in both measurement directions but only in the highest measurement range. Select a power value in the medium range as a reference value which can be read out with a high resolution (> 900 digits).

Power referred to the maximum power of power head:

30 % and 50 % for NAP-Z3 to Z6

50 % and 100% for NAP-Z7/Z8

The following table lists the permissible error limits:

Frequency/MHz	25 to 1000
NAP-Z3 to Z6	±2.5 % + 1 digit

Frequency/MHz	0.2 to 0.4	0.4 to 1.5	1.5 to 80
NAP-Z7	———	-1.7/+7.7 %	± 1.7 %
NAP-Z8	-1.7/+10.7 %	-1.7/+3.7 %	± 1.7 %

Table 5-2 Permissible linearity error of power heads

If the indicated limits are exceeded, adjust according to 5.3.2.2.

5.2.13 Peak-Value Measurement (PEP) using NAP-Z7/Z8

Measuring instruments: Power signal generator, with modulation
High-power attenuator
Termination
(Ref. Nos. 3, 9 and 4 in section 3.1)

The measurements are carried out using a beat signal as shown in Fig. 2-6.1, RF frequency range 1.5 to 80 MHz.

Note: Check test signal by means of a spectrum analyzer. Suppress intermodulation products and carrier present by at least 50 dB with respect to the two useful signals.

If this condition cannot be met, the composition of the spectrum should be maintained when changing the beat frequency and signal level.

5.2.13.1 Modulation Frequency

Set RF peak power of approx. 15 W for NAP-Z7, 150 W for NAP-Z8. Determine the ratio of the peak power (PEP) to the average power (AVG) measured with NAP for the frequency ranges indicated in Table 5-3. Check these quotients at 1 kHz beat frequency for adherence to the tolerances (Table 5-3).

Beat frequency/kHz	0.03 to 0.3	0.3 to 3	3 to 10
PEP frequency response error	± 6 %	± 1 %	± 6 %

Table 5-3 Modulation frequency response of PEP indication

5.2.13.2 Indication Linearity

Set the RF peak power to values given in Table 5-4, beat frequency 1 kHz. Determine quotient of the peak power (PEP) to the average power (AVG) measured with NAP as well as the relative deviation of this ratio from the value at 15 W (NAP-Z7) or 150 W (NAP-Z8). The tolerances given in Table 5-4 must be adhered to.

Note: The indications apply to the average PEP values displayed.

PEP/W	NAP-Z7	0.5	1 *	3	190
	NAP-Z8	5	10 *	30	1900
Linearity error		± 10 %	± 1.5 %	± 2.5 %	± 1 %

* Adjustment point (see section 5.3.3.4)

Table 5-4 Linearity of PEP indication

5.2.14 Reflection

Measuring instruments: Signal generator
Reflection meter
Termination
(Ref. Nos. 7, 6 and 13 in section 3.1)

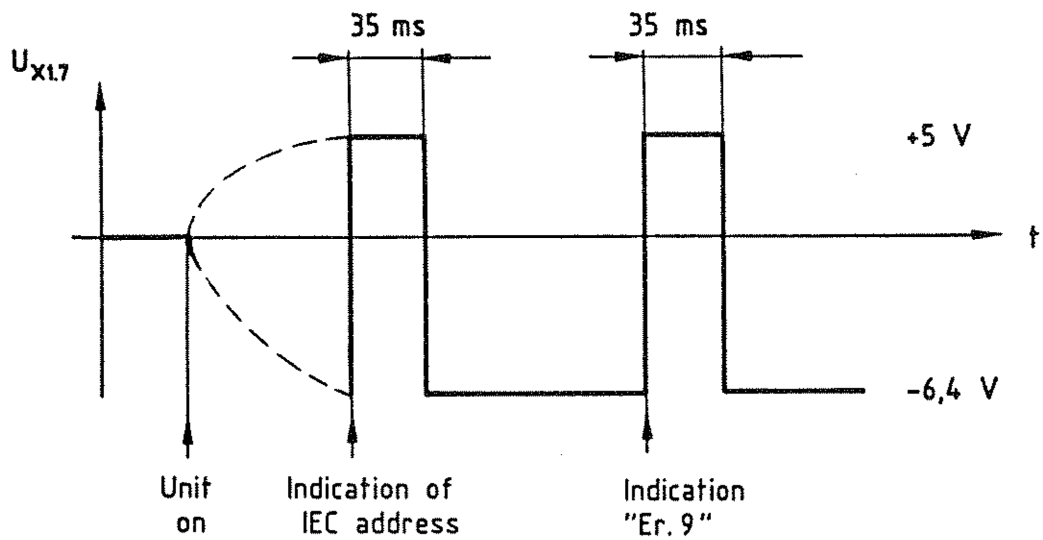
Measure in both directions of the power head.

Measured values according to data sheet (Performance Test Report)

5.2.15 Checking the Power Head Drive

Measuring instruments: Oscilloscope
(Ref. No. 2 in section 3.1)

Switch on NAP without plugged-in power head. Display voltage characteristic at connection X1.7 (power head identification) on oscilloscope.



5.3 Adjusting the NAP and Power Heads

Settings on the power head (see sections 5.3.2 to 5.3.3) should only be made with the special function 43, thus avoiding errors due to offset caused by thermal loading.

5.3.1 Adjusting the NAP

5.3.1.1 Setting the Oscillator Frequency

Measuring instrument: Oscilloscope
(Ref. No. 2 in section 3.1)

Connect the oscilloscope to check point P1 and adjust for a period of 13.3 µs (= 75 kHz) with potentiometer R1.

5.3.1.2 Adjusting the Display Contrast

Apply a reference value of 222 W to both channels.Adjust the contrast with potentiometer R18 so that the non-driven segments are invisible and the driven segments show maximum saturation.

Check the adjustment with variable angle of view.

5.3.1.3 Adjusting the D/A Converter

Measuring instrument: DC voltmeter
(Ref. No. 1 in section 3.1)

Enter the special function 80 via the keyboard and set the offset voltage to 2.2 V at the test point P4 using R170. Subsequently, enter the special functions 81 and 80 alternatively and set the voltage difference to 6.142 V at P4 using R172.

Since the potentiometer settings influence one another, the two settings must be repeated several times until the indicated voltage values are achieved. Since the indication accuracy of the NAP depends primarily on this, the following tolerances must be adhered to:

Offset voltage: 2.2 V ± 25 mV
Voltage difference: 6.142 V ± 6 mV

5.3.2 Adjusting the Power Heads NAP-Z3 to Z6

5.3.2.1 Adjusting the Power Head Sensitivity

Measuring instruments: NAP of increased accuracy
Power signal generator
High-power attenuator
Thermal power meter
(Ref. Nos. 3, 9 and 5 in section 3.1)

Test setup: shown in Fig. 3-1

The frequency should be about 120 MHz. Adjust in both measurement directions. Adjust the indication on the NAP to the indication on the thermal power meter (taking into account the attenuators) by means of the potentiometers R2 and R12 in the power head. The power applied should be 10% of the maximum power of the power head (enter special functions 11).

5.3.2.2 Linearization of Indication

Measuring instruments: same as listed in 5.3.2.1

Test setup: shown in Fig. 3-1

The indication can be linearized in range 2 (= highest range) with the potentiometers R6 and R16 in the power head. Adjust the NAP indication to that of the thermal power meter, taking into account the attenuators. The input powers should be as follows:

NAP-Z3 : 35 W
NAP-Z4 : 110 W
NAP-Z5 : 350 W
NAP-Z6 : 1100 W

Check with 0.3 and 0.5 of the maximum power of the power head. If the error exceeds the maximum value stated in 5.2.12, adjust the potentiometers so that the offset is the same in both the positive and the negative directions.

5.3.2.3 Adjusting the Frequency Response

Measuring instruments: Signal generator
High-power attenuator
Microwave power meter
(Ref. Nos. 7, 9 and 5 in section 3.1)

Test setup: see Fig. 3-2

Carry out the adjustment by shifting the slide screwed to the terminating resistor as well as the adjustment plate inside the power head.

For shifting the plate, loosen <u>only</u> the nut (SW=4) inside the power head but do not loosen the two screws of the terminating resistor.

Shift the slide and the plate together so that the RF rectifier diode V1 or V2 juts out of the cabinet wall at right angles. A slightly oblique position of the diode is permitted and can be used for fine adjustment of the frequency response by displacing the slide or the plate alone. Prior to each displacement, loosen the stub bolt M1 in the slide to relieve the rectifier diodes from mechanical stress.

Any displacement in the direction of the RF connectors causes a reduced indication in the case of high frequencies. During adjustment, the frequency response can also be measured with the power head covers removed (but with closed directional-coupler compartment). In this case, an additional frequency response decreasing by approximately 2.5% up to 1000 MHz must be taken into consideration. Adjustment and measurement are made with a measurement power in the medium range for both channels.

The permissible frequency response of the power head and the NAP is $< \pm 3\%$ (referred to the measured value at 120 MHz).

5.3.3 Adjusting the Power Heads NAP-Z7/Z8 (Fig. 4-3a)

Since the adjustment of the directivity and the setting of the linearity can influence the power head sensitivity, the adjustment procedures should be carried out in the sequence stated.
Apart from the directivity, different settings must be made for the two channels. Since the display of the NAP does not indicate the incident and reflected channels, the following should be borne in mind:

direction of power flow 1 → 2: incident power in channel 2

direction of power flow 2 → 1: incident power in channel 1

Use NAP with increased accuracy in order to avoid setting errors due to inaccuracies of the basic unit during adjustment of linearity and power head sensitivity.

5.3.3.1 Adjusting the Directivity

The measurement is carried out according to section 5.2.10, frequency 3 to 10 MHz. Adjust directivity to maximum value using R14 on the directional coupler board (> 43 dB).

Note: Adjust only if directivity in the frequency 1.5 to 30 MHz falls considerably short of the limit value of 35 dB. Make sure measurement power is sufficiently high and the connected load has a maximum reflection factor of 0.5 % (drift due to heating to be taken into account).

5.3.3.2 Adjusting the Linearity

The measurement is carried out according to section 5.2.12, frequency 1.5 to 30 MHz. The adjustment is conducted by varying the loading of the detector output voltage using the potentiometers R105 (R205). An increase in load resistance which is shown by an increase in the power indication causes the linearity error to become negative.

The adjustment is carried out correctly, if the linearity error is +0.5 to +1.5 % at 50 % of the maximum power and -0.5 to -1.5 % at 100 % of the maximum power. If the adjustment range of R105 (R205) is not sufficient, it can be extended by reconnecting link X105 (X205).

5.3.3.3 Adjusting the Power Head Sensitivity

Carry out the measurement according to section 3.2.1, frequency 10 MHz, incident power 15 W for NAP-Z7, 150 W for NAP-Z8.

Set incident-power indication of the NAP to the indication on the microwave power meter using the potentiometers R116 (R216) (taking into account the attenuator).

5.3.3.4 Adjusting the PEP Function

Carry out measurement according to section 5.2.13.2, set beat frequency to 1 kHz. Adjust linearity error to 0 ± 1 % (evaluate the average of displayed values) at 1 W PEP (NAP-Z7) or 10 W PEP (NAP-Z8) using R406. Correct adjustment should yield a slightly negative linearity error for 3 (30) W PEP and a somewhat greater positive linearity error for 0.5 (5).

5.3.4 Offset Adjustment of Measuring Amplifier

Measuring instrument: DC voltmeter
(Ref. No. 1 in section 3.1)

Connect any power head, do not apply power. Enter special function 0.
Adjust voltage to +1.45 V ± 0.05 V at the test point P1 using potentiometer R58 and at test point P2 using potentiometer R148.
Carry out adjustment only after power head and NAP have been warmed up.

5.4 Troubleshooting

Errors may occur in the NAP, the power head or the connecting cable. For some errors, there are typical signs which are listed in the table below.

The self-test executed after power on is able to recognize all important errors in the display section. The following error messages thereby appear in the left display:

Error display	Error	Possible source of error
Er.5	Calibration of analog output not possible	D231, N171 III/IV
Er.6	Incorrect values in external RAM	After battery change: D391, D401 V_{RAM}
Er.7 (Both displays are blinking)	Zero of D/A converter shifted	D191, N171 I Adjustment acc. to section 5.3.1.3
Er.8 (Both displays are blinking)	Zeros of measuring amplifiers shifted	Measuring amplifiers for channels 1 and 2 Adjustment according to section 5.3
Er.9 (Both displays are blinking)	Measurement with D/A converter not possible	Power head not connected. Cable faulty.

When the self-test facility discovers hardware faults Er.7 to Er.9, the error message "ERR.E" rather than measured values is output via the IEC bus until the service request function (SRQ) is enabled by instruction code "Q1".

5.4.1 Power Head

All repairs on internal components of the power head should be carried out by the manufacturer, since accurate mechanical adjustments and special technology are required for this purpose.

This is performed by means of special test setups.

NAP-Z3 to Z6

Bad directivity and reduced indication sensitivity.	Coupling lines of directional coupler maladjusted due to excessive mechanical strain or improper adaptation of RF connectors.
Bad directivity and increased indication sensitivity.	Termination R1 (R2) overloaded due to excessive measurement power.

5.4.2 Connecting Cable W1

LCDs indicate continually varying power in the power head (no power applied)	Connecting cable broken
No display of measurement power and visible damage on cable.	Short-circuit in connecting cable

5.4.3 Power Reflection Meter NAP

If an error can neither be located in the power head nor in the connecting cable, continue troubleshooting in the NAP itself. To do this, remove the lower panel with the instrument switched off. The electrical components become accessible after screwing off and swinging sidewards the upper plate of the digital/analog sandwich board. During this procedure, all multipoint connectors remain connected. Switch the NAP on and check successively the following signals.

Test	Measuring instrument	Check point	Signal
Operating voltage $+V_{op}$	Voltmeter	P8	+5.2 V
Operating voltage $-V_{op}$	Voltmeter	P10	-6.5 V
Multivibrator	Oscilloscope	P11	Rectangular voltage 5 V_{pp}
Channel K1	Voltmeter	P2	+1.45 V at V_{in} = 0 V
Channel K2	Voltmeter	P1	+1.45 V at V_{in} = 0 V
V_{Ref}	Voltmeter	P6	+5 V
Comparator	Oscilloscope	P7	Pulse sequence
DAC output	Oscilloscope	P4	Oscillogram Fig. 5-2
Timer	Oscilloscope	P9	Pulses of 1 ms duration in battery operation

If the indicated signal values are not attained, an error has occurred in the associated subassembly. For further troubleshooting, the drive signals specified for the expander and multiplexer can prove to be helpful.

If the Er.U - error is signalled in the AC power mode or if the NAP cannot be switched on from the AC power supply, this may be due to defective accumulators.

Test: Remove top cover and shielding cover. Connect unit to AC power supply. Measure the charging voltage of the five accumulators; it must be at least 1.2 V. If the value falls considerably short of this value after charging for about 1 hour, the accumulator is defective and must be replaced.

5.5 Electrical Repair

5.5.1 Fitting the Connecting Cable

NAP-Z3 to Z6 (W1)

→ Place the power head such that the inscription on the front is not upside down.

→ Remove the top cover from the power head.

→ Slide the new cable through the plastic bush, fix it with a new cable binder and solder the wires to the lead-through filters as shown in drawing No. 392.6610. (This drawing also demonstrates the mounting of the power head connector.)

Attention: To protect the RF rectifier diode from static charges, the soldering iron must be earthed before any soldering is done on the cable.

NAP-Z7/Z8 (W10)

→ Place the power head such that the inscription on the front is not upside down.

→ Remove the top cover of the power head.

→ Slightly slide back cable bush, remove the two fixing screws and pull out cable through the slot in the housing toward the top.

→ Disconnect multiple connector X300.

→ Fit new cable in reverse order.

5.5.2 Display Section

Only when the following components are replaced, new adjustments are to be made:

To be replaced	Adjustment acc. to section
D191	5.3.1.3
V301	5.3.1.3
D1,D2	5.3.1.1
V11	5.3.1.2
N31,N121	5.3.4

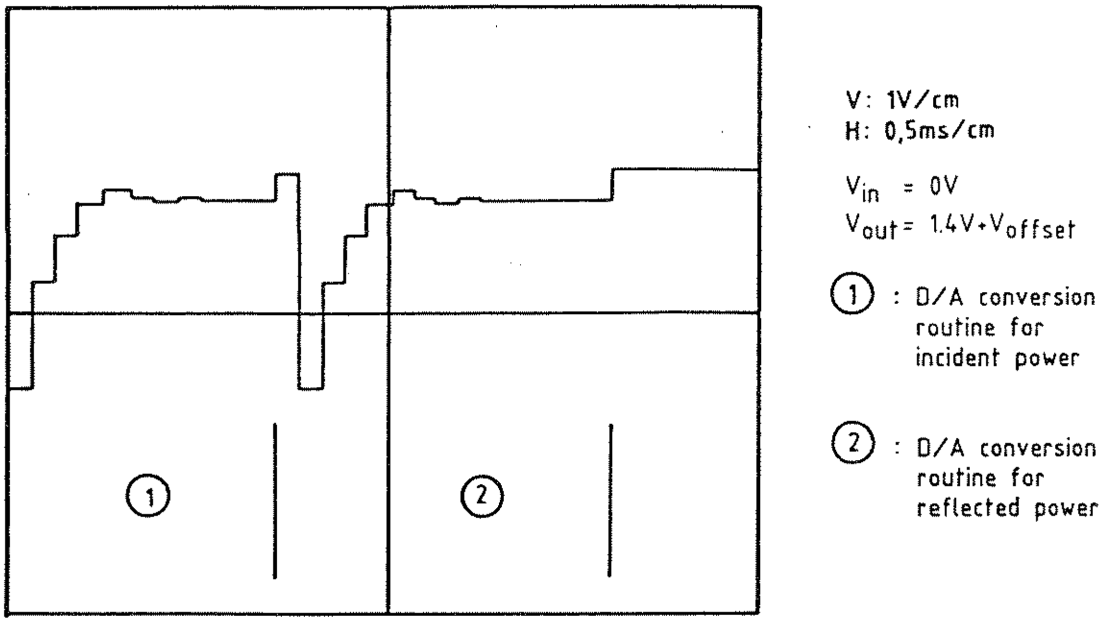
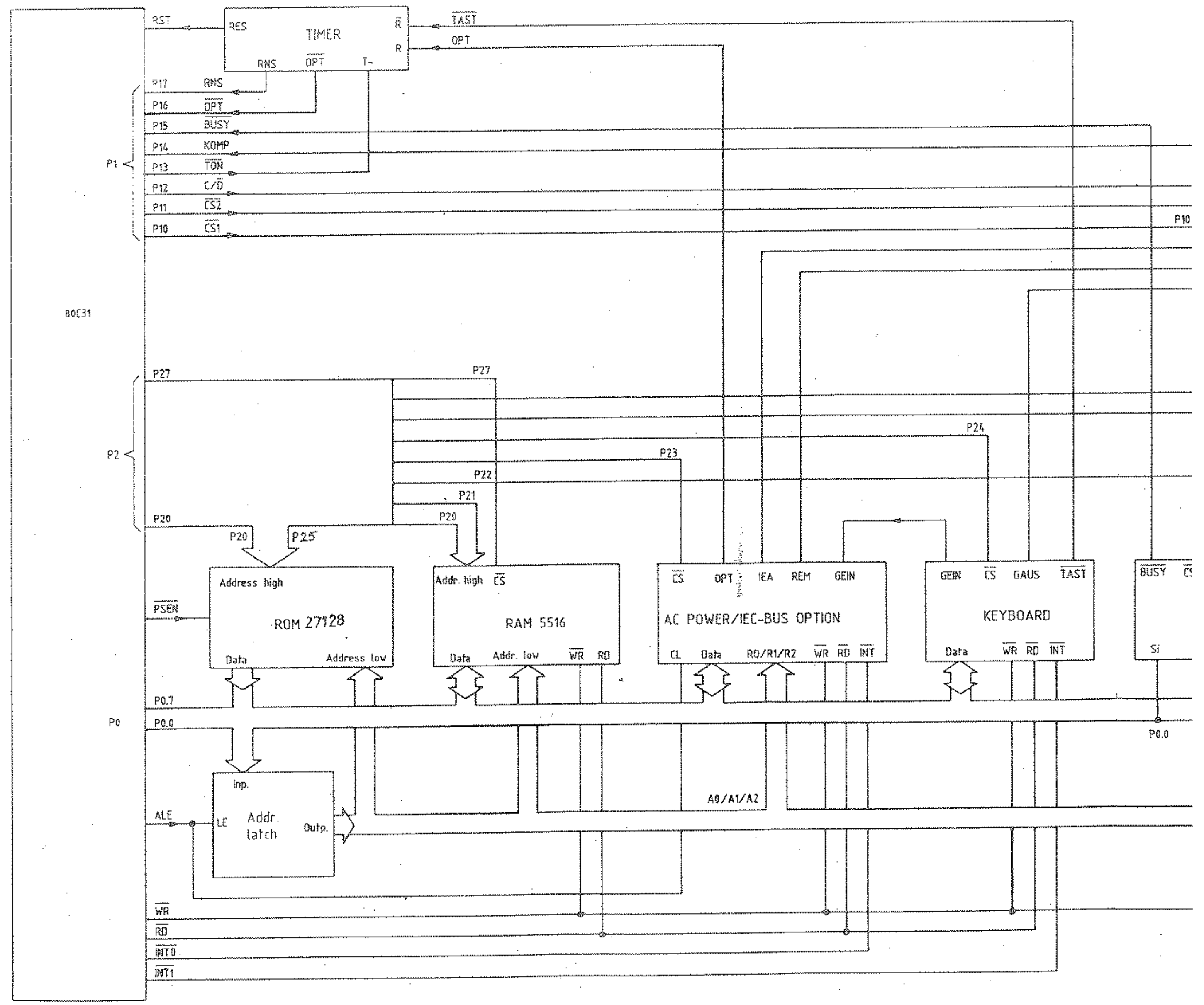


Fig. 5-2 Oscillogram of D/A conversion routine


80C31
TIMER
RES
RNS
OPT
T-
R
TAST
OPT
P1
P17 RNS
P16 OPT
P15 BUSY
P14 KOMP
P13 TON
P12 C/D
P11 CS2
P10 CS1
P10
P2
P27
P20
P25
P21
P22
P23
P24
PSEN
ROM 27128
Address high
Data
Address low
RAM 5516
Addr. high
CS
Data
Addr. low
WR
RD
AC POWER/IEC-BUS OPTION
CS
OPT
IEA
REM
GEIN
CL
Data
RD/R1/R2
WR
RD
INT
KEYBOARD
GEIN
CS
GAUS
TAST
Data
WR
RD
INT
BUSY
CS
Si
P0
P0.7
P0.0
P0.0
Addr. latch
Inp.
LE
Outp.
ALE
A0/A1/A2
WR
RD
INT0
INT1

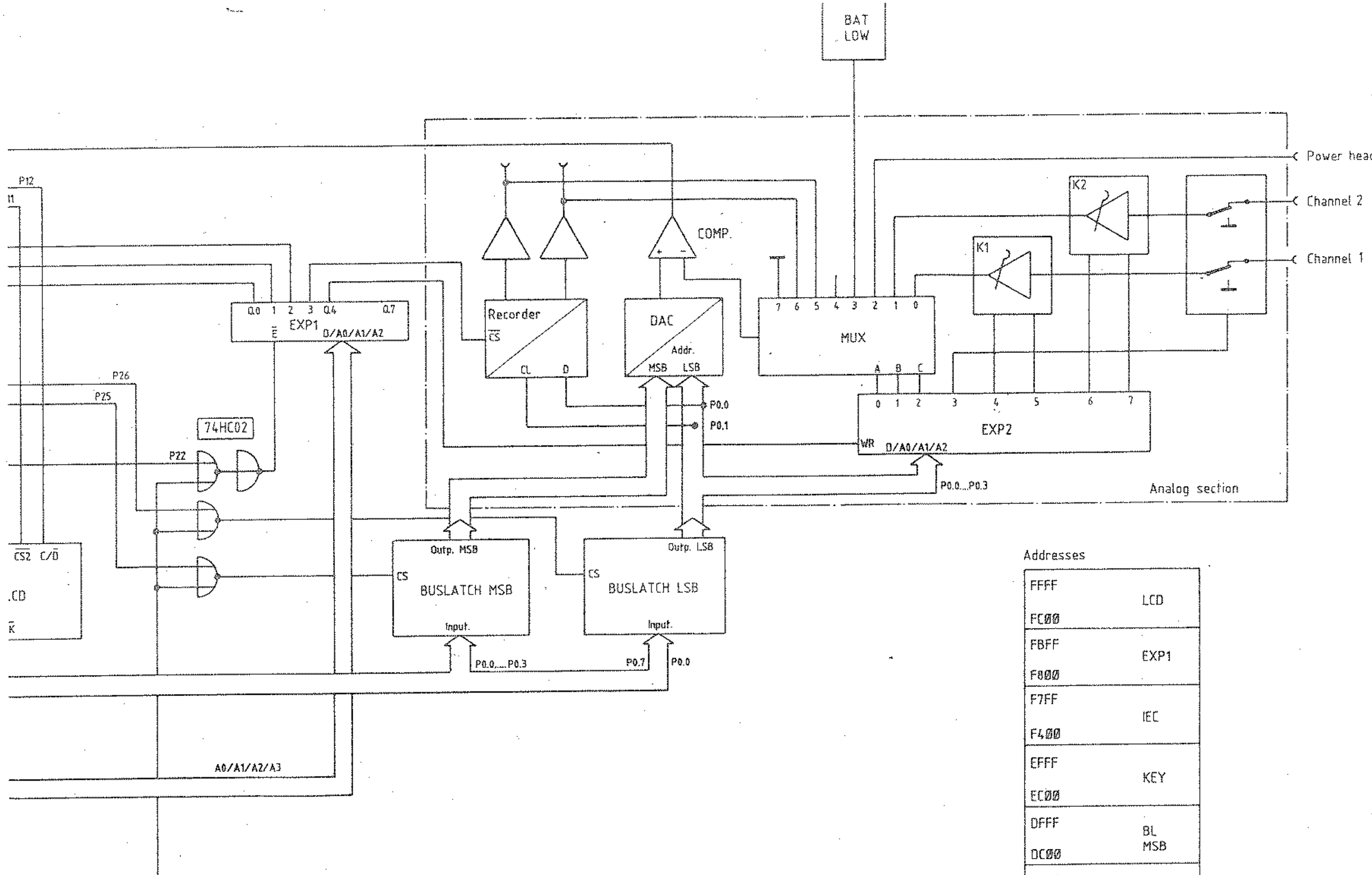


Fig.5-3 Address lines and Address ranges

Addresses

FFFF FC00	LCD
FBFF F800	EXP1
F7FF F400	IEC
EFFF EC00	KEY
DFFF DC00	BL MSB
BFFF BC00	BL LSB
7FFF 7C00	RAM

Fig.5-4 Pulse diagrams and delay times in processor operation