



ROHDE & SCHWARZ

Manual

**POWER REFLECTION METER
NAP**

392.4017.02

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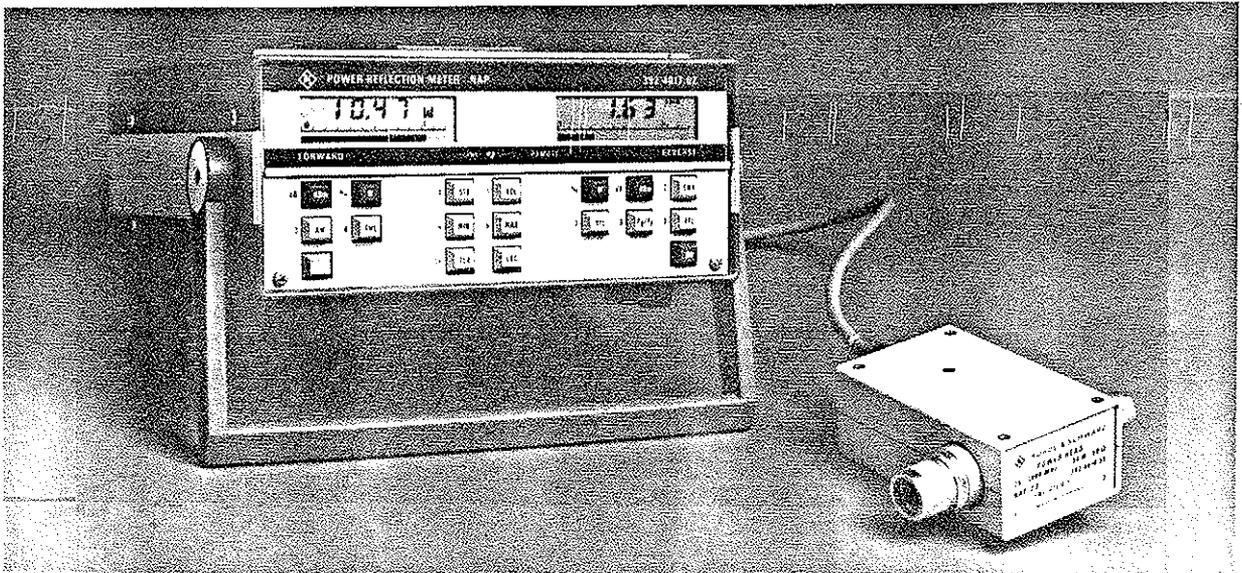
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ROHDE & SCHWARZ

POWER REFLECTION METER NAP

25 to 1000 MHz.

20 mW to 1100 W



- * Wide, continuous frequency range
- * Separate power heads simplify measurements at test points difficult to reach
- * Two displays for simultaneous indication of the incident and the reflected measurement function in analog and digital form
- * Measurement direction of power head arbitrary
- * High intelligence permits direct readout in W or dBm, SWR reflection factor, transmission and return loss
- * Clearly arranged analog display
- * 4 exchangeable power heads (4 power ranges)
- * Basic model: battery operation
Option: operation from storage battery or AC supply, remote control via IEC bus
- * Special functions for self-test and service

Use

The Power Reflection Meter NAP is a handy meter for measuring power and transmission characteristics of radio sets and systems. It is provided with a high internal intelligence and able to directly indicate even complex measurement functions. Simple operation makes it particularly suitable for use in service and production, but also in development and quality control.

The instrument consists of the NAP display section and one Power Head NAP-Z3 to Z6, which is connected to the meter via a cable. Four power heads with different power ranges are available:

NAP-Z3	(20 mW to 35 W)
NAP-Z4	(50 mW to 110 W)
NAP-Z5	(0.2 to 350 W)
NAP-Z6	(0.5 to 1100 W)

The wide power range and the continuous frequency range of each power head (25 to 1000 MHz) permit measurements to be made on radiotelephone systems in all important radio bands, VHF transmitters and air-traffic control systems.

Operation

The power head connected between transmitter and test item (e.g. radio set and antenna) measures the incident and reflected power and the microprocessor in the display section calculates all other measurement functions from these measured power parameters. Conversion tables, nomograms and calibration to 100% for determining the transmission characteristics are no longer required.

The following functions can be measured direct with NAP and power head and the results are indicated simultaneously in an analog and digital form.

- * Incident and reflected power in W or dBm
- * Standing-wave ratio SWR
- * Reflection coefficient in %
- * Transmission and return loss in dB
- * Reflected-to-incident power ratio in %
- * Modulation depth in % at AM
- * Relative measurements (deviation of incident and reflected power in % or dB from specified reference values)
- * Display of minimum or maximum values of one measurement series for each measurement function.

Simple operation and clear display make the NAP an easy-to-use measuring instrument of high accuracy:

- * Selection of almost all measurement functions by pressing one key only.
- * Measured parameters are indicated on a 3 1/2 digit display and simultaneously on a bar meter with accurate scaling.
- * Independent from the measurement direction in the power head, incident power functions are always indicated on the left display, reflected power functions on the right display either with the respective unit (e.g. W) or with a brief designation (e.g. SWR).
- * Temperature-compensated rms rectifiers measure the true rms power; consequently also amplitude modulation, harmonics up to 1000 MHz and the real power of several simultaneously applied signals are displayed.
- * RF-shielded design permits error-free measurements also in the vicinity of antennas and transmitters.
- * The extremely low transmission loss of the power heads permits monitoring of transmitter systems and measurements under normal operating conditions without falsifying the transmission characteristics between transmitter and load.

Special functions such as range presetting or holding the automatically set ranges, display of battery voltage, consideration of zero offset etc. facilitate special measurement tasks. Service functions simplify adjustment and checking of the instrument. When the instrument is switched on, a self-test program is started which checks the main functions of the display section and, if required, indicates errors in the display.

Power supply

The NAP is a battery-operated unit designed for mobile use independent from AC supply. The basic model is equipped with 6 single cells (LR 20 to DIN or IEC). With an operation of 8 hours per day, the dry Alkali-Mn batteries have a lifetime of more than 500 hours of operation.

Instead of the single cells, option NAP-B4 may be fitted. It comprises a power supply section for AC supply operation and rechargeable NiCd batteries. Consequently operation is possible either from AC supply or from storage batteries. This option also includes an IEC-bus interface for remote control.

In the case of operation from batteries or storage batteries, the instrument is switched off automatically if no measurement is made for about 1/2 hour. This prevents rapid discharge of the batteries, if the operator fails to switch off the instrument.

IEC-bus interface

If option NAP-B4 has been fitted, measurement and special functions may be set via IEC bus and the pertaining measured values are transferred in the same way. This makes the NAP fully suitable for use in automatic test systems.

Simple setting commands facilitate program writing: They permit selection of various formats for data output, precise definition of starting conditions for measurements, service request with detailed status information.

Analog outputs

One analog output is provided at the rear for the forward and one for the reflected power channel. Here DC voltages proportional to the indicated measured parameters are generated. With the aid of these voltages, the measured value for each function may be recorded on a plotter in the form of a curve. Long-term monitoring of transmitter systems, e.g. for quality control, burn-in tests, troubleshooting etc., is possible without any problems.

Display section NAP

Measurement ranges	1/10/100% of max. power range of each power head; automatic or manual selection
Connector for power head	15-pole, to DIN 41652
Display functions	Incident/reflected power in W or dBm, standing-wave ratio SWR, reflection coefficient in %, transmission and return loss in dB, incidental and reflected power ratio in %, modulation depth at AM in %, relative measurements in % or dB, min./max. values
Indication of measured values	on 3 1/2-digit display analog on bar with 56 scale divisions
Measurement speed	digital display: 2.5 measurements/s analog indication: battery operation: 2.5 measurements/s AC supply operation: 12.5 measurements/s
Analog outputs	for incident and reflected power channels four 4-mm sockets 1 mV/1 digit of display Internal impedance: 2.2 k Ω Error: < ± 20 mV, referred to displayed value
<u>Remote control</u>	
(with option NAP-B4 and AC supply operation)	
Interface	IEC bus (IEC 625-1 / IEEE 448)
Interface functions	SH1, AH1, T6, L4, SR1, RL1, DC1, DT1
Connector	24-pole Amphenol

General data

Nominal temperature range	-10 to +55°C
Storage temperature range	-40 to +70°C
Ambient conditions	Class 1 acc. to IEC 359 (with extended nominal temperature range)
RF leakage	The requirements to VDE 0871 and MIL STD 461A, method CE 03 and RE 02, regarding conducted and radiated interferences, are complied with. Limits for RF suppression to VDE 0875 grade K are met.
Electromagnetic compatibility	20 V/m min.
Power supply	Basic model: dry cells with option NAP-B4: storage batteries or AC supply
Batteries	6 single cells, 1.5 V (LR20) lifetime > 500 h (dry Alkali-Mn cells, 8 h/day)
Storage batteries	5 NiCd round cells, 1.2 V (GSZ 1.8 DIN 40766) duty cycle about 150 h
AC supply	100 to 120 V/220 to 240 V ±10% 47 to 63 Hz, 14 VA
Dimensions (W x H x D)	
Display section	240 mm x 113 mm x 217 mm
Power Head	125 mm x 105 mm x 45 mm
Weight	
Display section	3.5 kg
Power Head	0.6 kg

Ordering information

Order designation		Order No.
Power Reflection Meter	NAP	392.4017.02
AC supply/IEC bus option	NAP-B4	392.5913.02
Power Head	NAP-Z3	392.6610.55
Power Head	NAP-Z4	392.6910.55
Power Head	NAP-Z5	392.7116.55
Power Head	NAP-Z6	392.7316.54

Accessories supplied

Power cable (for option NAP-B4)

Manual

Addendum to manual of
POWER REFLECTION METER
NAP

392.4017.02

The following amendments or supplements are necessary:

Pages 2.6/2.20/2.23/4.2/5.5/5.7

The lowest permissible battery voltage is 5.7 V. Below 5.8 V the analog display begins to flash.

Page 2.8

After switching on, the software code digits are presented in the right-hand display.

Page 2.15

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. 1 shows the relationship between the modulation depth and the maximum power up to which the RF rectifier will not be overloaded.

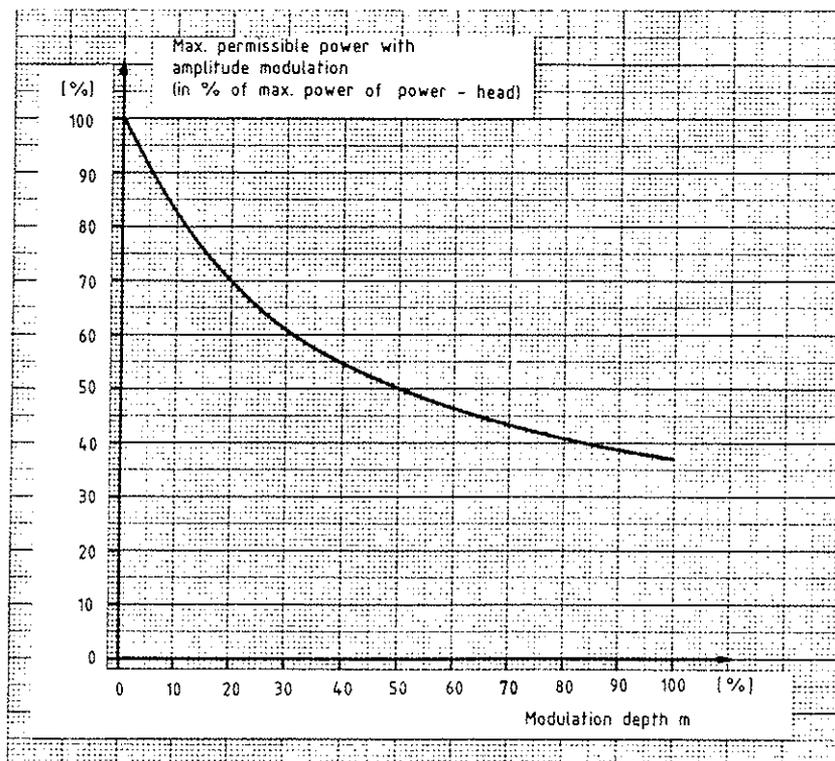


Fig. 1 Overload limits with amplitude modulation

Page 2.20

The scaling of the analog displays can be maintained with special function 31. When this special function is stored, every subsequent result of a measurement function is presented in the analog display with the same scale as that set when the measurement function was first entered until the function is entered again. This special function can be used, for instance, in adjustments where the automatic range selection of the analog display is not desired.

Page 2.22

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 right-hand display.

Page 2.44

The automatic zero measurement can cause the output of the measured value to be delayed by 640 ms every 3.3 min approximately.

Page 5.20

When the self-test facility discovers a hardware fault, 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".

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**

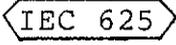
Ref. No.	Labelling	Function
<u>1</u>	SHIFT	Key for entry of shift function while another key is pressed.
<u>2</u>	FORWARD	Display to indicate the incident measurement functions.
<u>3</u>	LINE	LED to indicate AC power ON (only if option B4 is fitted).
<u>4</u>	REMOTE	LED to indicate the remote control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

¹⁾ Only applies if power head is used.

Ref. No.	Labelling	Direct function	SHIFT function
<u>9</u>	W %	Reflected power in W	Reflected-power deviat. in % } ¹⁾ Reflected-power deviat. in dB } ¹⁾
	dBm dB	Reflected power in dBm	
	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"
<u>10</u>	LOC .	Switching from remote control to manual control in IEC-bus operation.	Input of decimal point.
<u>11</u>	CLR SF	Clearing of error messages, wrong key or decimal inputs.	Call or storage of special functions.
<u>12</u>	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"
<u>13</u>	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"
<u>14</u>	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 ¹⁾	Decimal input "4"

¹⁾ Only applies if power head is used.

2.1.2 Rear View

Ref. No.	Labelling	Function
<u>15</u>	POWER HEAD	Connector for power head (50-way trapezoidal connector to DIN 41652)
<u>16</u>		Connector for IEC-bus interface (24-way Amphenol connector of Series 57)
<u>17</u>	47...63 Hz	Power receptacle
<u>18</u>	220...240 V T 0,1 B 100...120 V T 0,2 B	Fuse panel
<u>19</u>	F1	Fuse holder
<u>20</u>	DC \pm 2 V F  R	Analog output for forward (F) power and reflected (R) power.
<u>21</u>		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 1000 MHz
	Male connector	Female connector	
UHF	017.7384.00	017.5217.00	0.15 kW
BNC	017.7832.00	017.5730.00	0.3 kW
N	017.7532.00	017.5398.00	0.79 kW
4.1/9.5	017.9106.00	017.8516.00	1.75 kW
Dezifix B	018.2486.00		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 SF40.

In case the battery voltage drops too much during operation, the analog displays (scale and bar) 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 SF60 has been entered. The voltage indicated in the right-hand display must not exceed 5.4 V.

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 150 hours.

The NAP is designed for line voltages of 100 to 120 V $\pm 10\%$, 220 to 240 V $\pm 10\%$ 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 18 on the rear side of the NAP. For this purpose, the appropriate power fuse must be inserted into the fuse holder 19:

Line voltage	Fuse
100 to 120 V	T 0.2 B DIN 41571
220 to 240 V	T 0.1 B DIN 41571

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. After a period of about 10 hours the accumulators are fully recharged. 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. Operation is only possible if the power head has been connected before switching on.

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

- A software code digit in the right display for about 0.5 s.
- For about 6 s, the maximum nominal power of the power head in the left display, the IEC-device address in the right display.

Examples:

A rectangular digital display with a black border. The text 'MAX' is in the top left corner. The number '35' is in the center, and 'W' is in the bottom right corner.

Nominal power of
power head:
35 W

A rectangular digital display with a black border. The text 'A25' is centered in the display.

Device address in AC
power operation: 25

A rectangular digital display with a black border. The text 'MAX' is in the top left corner. The number '110' is in the center, and 'W' is in the bottom right corner.

Nominal power of
power head:
110 W

A rectangular digital display with a black border. The text 'A - -' is centered in the display.

Device turned on via
battery or accumulator

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 and both displays blink. In this case, switch off the unit and connect the power head. When switching on again, the unit is only ready for operation after 100 s. The time that passes until the measurement start is indicated on the left display.

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.

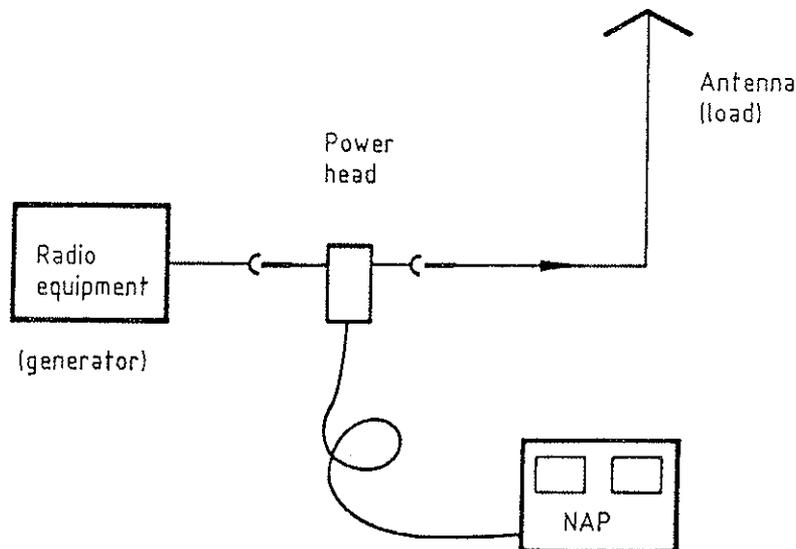


Fig. 2-3 Basic test setup with NAP and power head

This effect is negligible if the length of the additional line is less than 0.1λ . This is the case up to a limit frequency of 220 MHz if the electrical length of the Power Heads NAP-23 to Z6 is 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 radio-telephony 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.

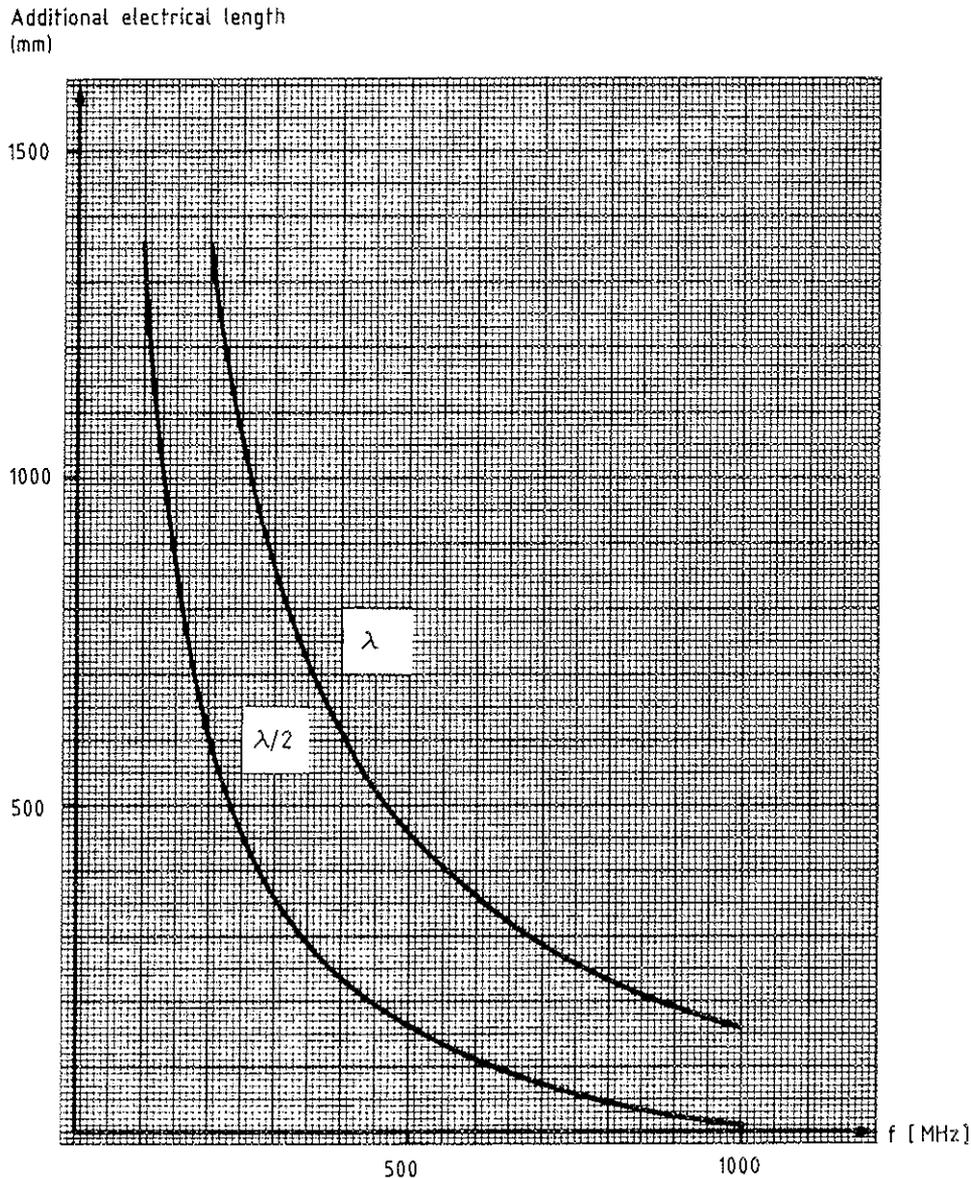


Fig. 2-4 Complementing length of directional coupler to $\lambda/2$ or λ
(for Power Heads NAP-Z3 to Z6)

2.3 Operation

With the aid of the NAP display section and one of the Power Heads NAP-Z3 to Z6 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.

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
Measurement range 1	0.35 W	1.1 W	3.5 W	11 W
Measurement range 2	3.5 W	11 W	35 W	110 W
Measurement range 3	35 W	110 W	350 W	1100 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 $3\frac{1}{2}$ 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.

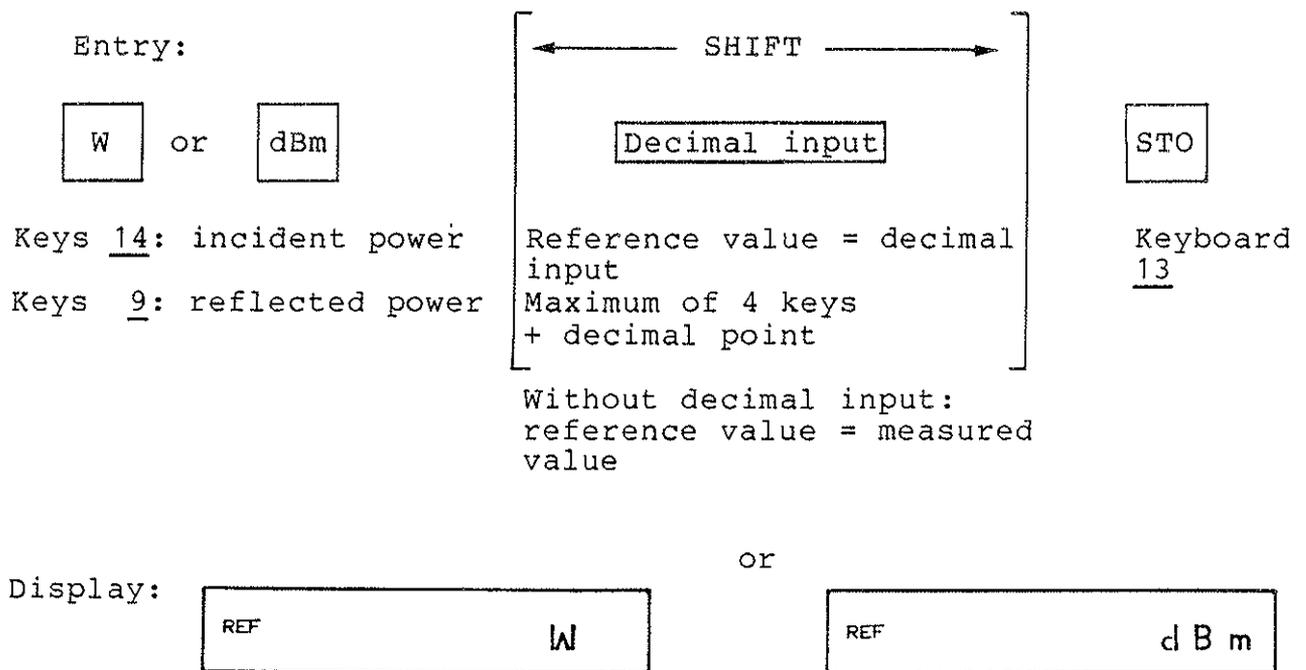
2.3.2 Measuring Relative Power Variations

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:



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 Z6, 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:

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

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 RatioEntry: Display:

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

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

2.3.8 Measuring the Reflection CoefficientEntry: Display:

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):

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

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 keys 9 or 14 during a measurement sequence.

Each time a measurement function is entered via keys 9 or 14, 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.

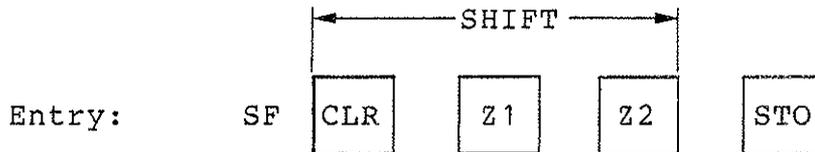
If the same key is pressed again, the current measured values reappear on the display. By repeated actuation of the MIN or MAX key the minimum value, maximum value or current measured value is displayed in any sequence; the storage of minimum and maximum values, however, is not interrupted.

When a measurement function is entered via keys 9 or 14, 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.

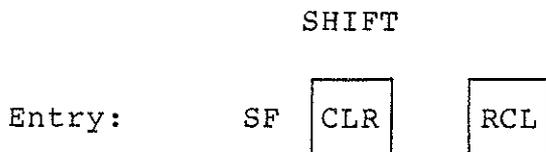
Note: When pressing the AM key (see section 2.3.4), the instantaneous measured value is used as a reference power of the unmodulated carrier; the value displayed is 0%. Thus the minimum value displayed in AM measurements is always 0.

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.

Storing special functions:

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 (SF41/60) are not displayed in this way.

Calling up stored special functions:

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

.5.23

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.

.5. - -

The following special functions can be set:

- SF0 Clears all stored special functions and the letter "S" on the right-hand display.
- SF11 Range 1 } Switch on in measuring
 SF12 Range 2 } channel 1.
 SF13 Range 3 }
- SF21 Range 1 } Switch on in measuring Only applies if
 SF22 Range 2 } channel 2. power heads are
 SF23 Range 3 } used.
- SF30 The ranges set in measuring channels 1 and 2 at the time of this entry are retained (hold ranges).
- SF32 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.
- SF33 Fast analog display in battery operation. The lifetime of the battery is thereby reduced by the factor ≈ 5 .
- SF40 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).
- SF41 Calls up the zero measurement prematurely. The next zero measurement is performed 10 minutes after this entry. (This ensures the output of the measured value for 10 minutes without interruption by a zero measurement when calling via a device-specific IEC-bus command.)
- SF43 Corrects the zero offset occurring in the power head during temporary variations of the ambient temperature.
- SF60 Displays the battery voltage in volts on the right-hand display.
 Example:

05.9

Minimum value: 5.4 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 SF11 to SF30 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. With the aid of the markings 1 and 2 provided for the RF connectors on the type plate of the power head this allocation can be determined. The relation can be seen from Fig. 2-5.

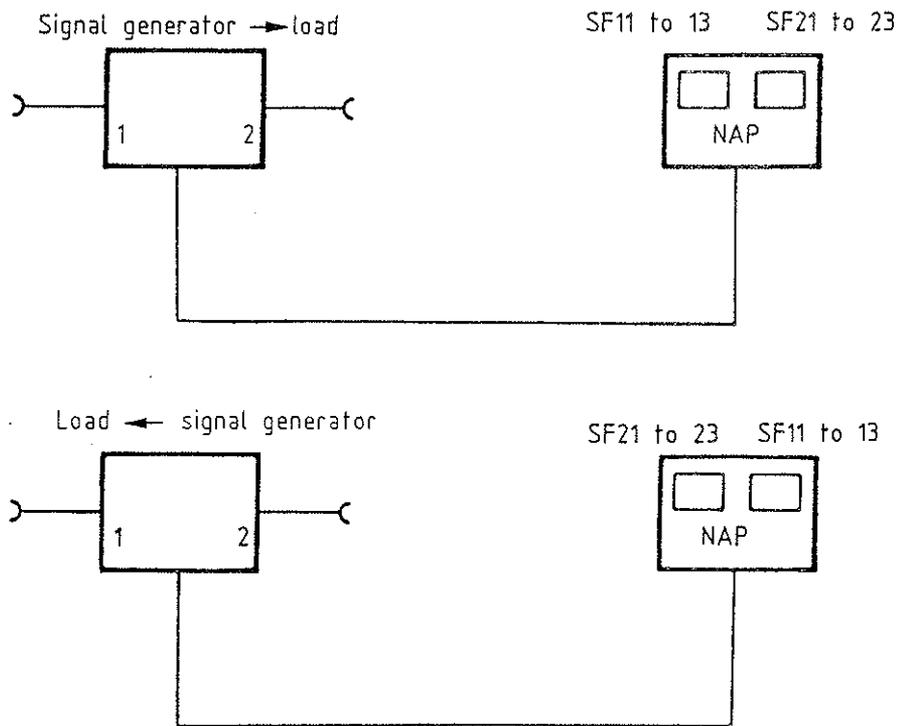


Fig. 2-5 Allocation of direction of measurement and measuring channels.

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.

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. When the special function 43 is entered, power must not be applied to the power head for 4 seconds, in order to prevent that the applied power is inadvertently identified as an offset.

2.3.11 Analog Output

An analog output (20) for each the incident power and the reflected power is provided on the rear panel. A recorder (e.g. R&S Type 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 SF32, 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 k Ω .

The open-circuit voltage of the analog outputs has a maximum error of ± 20 mV referred to the display value.

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. The result is an increase in current consumption that is five times higher and causes 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 OFL1, OFL2 and OFL3 are only delivered if the measurement range 1 or 2 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 (scale and bar) 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 5.4 V, the instrument turns off automatically. Further error messages may be triggered by the self-test. They are described in section 5.4.

Table 2-1 Error Messages

Display	Operating error	Clearing of error message
- -	Measured value undefined (AM <0 %, TML, SWR, RFL, P _R /P _F or RFL without measuring power). Calling of IEC address in battery operation.	Change measurement conditions 
OFL 1 OFL 2 OFL 3 OFL MAX	Overrange in measuring channel 1. Overrange in measuring channel 2. Overrange in channels 1 and 2. Maximum power of power head exceeded.	Reduce measuring power
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.	 or new entry
Er.2	Overflow	Change measurement conditions
Er.3	Overflow (Only with special function SF32.)	Change measurement conditions or new entry of measurement function
Er.4	Inadmissible reference value. (0 W, >63 dBm)	 new entry
Er.P	Special function 43 cannot be executed, because power is present on test probe.	 new entry

Display	Operating error	Clearing of Error message
L O C	Data output via IEC bus in the local state. For the output of test data, set NAP to REMOTE.	<div style="border: 1px solid black; padding: 2px; display: inline-block;">CLR</div> or new entry
Analog display flashes	Batteries or accumulators almost discharged. Remaining service lifetime about 10 to 30 min.	Change batteries or recharge accumulators
no Acc	AC power operation without accumulators.	Insert nickel-cadmium accumulators (see section 3).

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:

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

Displayed reflected power:

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

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 produced by the signal generator

r : reflection coefficient of the load

E_P : power measurement error

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

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.

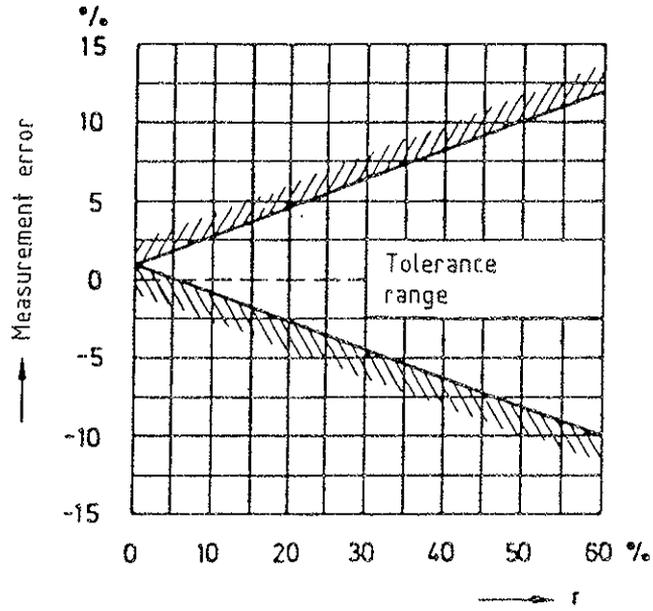
When the temperature changes, a temporary zero offset may cause a small measurement error in the most sensitive range. This offset can be corrected by means of the special function 43 (see section 2.3.10).

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-Z3 to Z6 up to 220 MHz. If the electrical length of the power head is complemented to λ or $n \times \lambda/2$ by means of a line, the values are also valid for higher frequencies.

The measurement functions VSWR, reflection coefficient, 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.



50- Ω and 60- Ω characteristic impedances

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.

2.3.15 Examples of Measurements

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 arrangement the mutual influence of the circuits while changing the input and output matching characteristics can be detected.

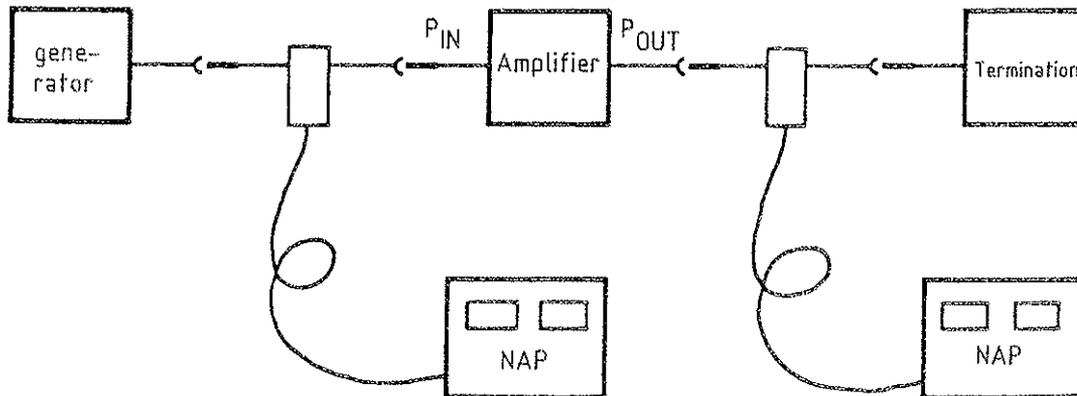


Fig. 2-7 Measurement of VSWR between signal generator and load.

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.

2.4 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 16 is located on the rear panel; the pin assignment can be seen from Fig. 2-8.

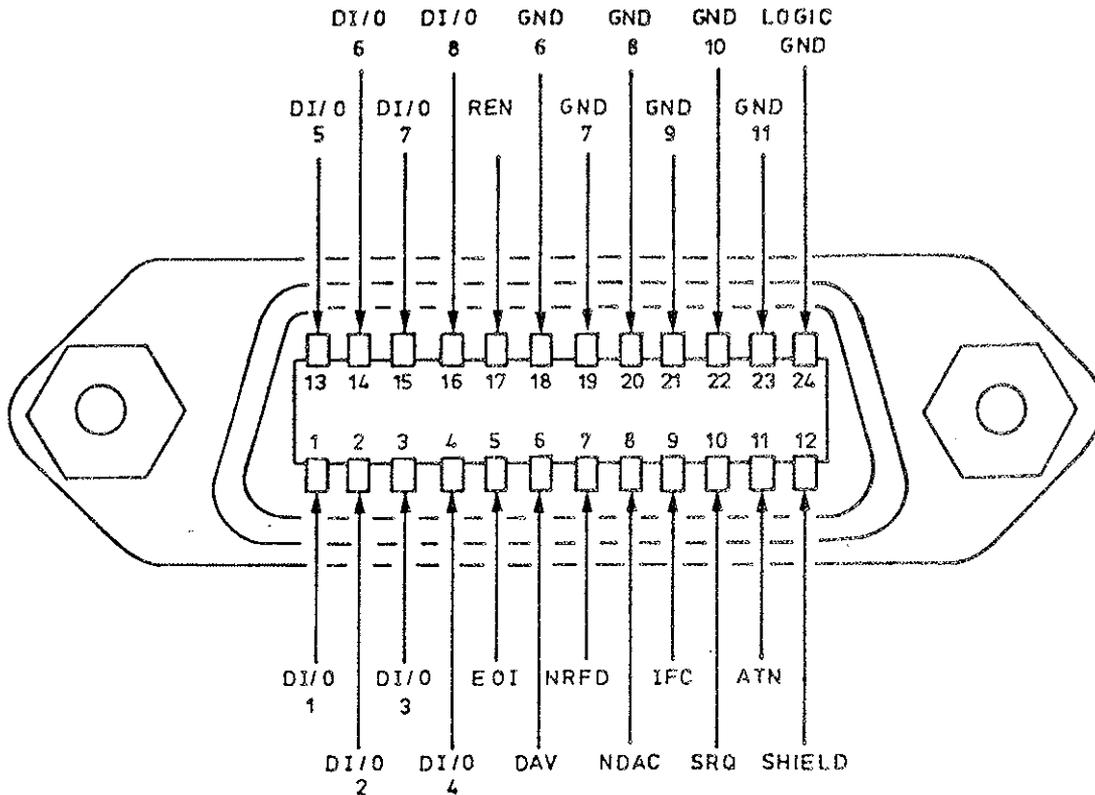


Fig. 2-8 Pin assignment of socket 16.

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:

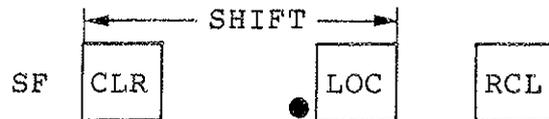
SH1	Source handshake, complete capability
AH1	Acceptor handshake, complete capability
T6	Talker Capability of answering to a serial poll, unaddressing if MLA
L4	Listener, unaddressing if MTA
SR1	Service request, complete capability
RL1	Remote/local, complete capability
DC1	Device clear, complete capability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



the selected address appears on the right display.

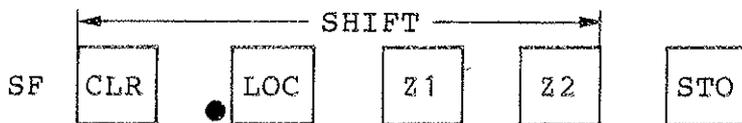
Example:

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:



Z1 and Z2 are the decimal inputs 0 to 9 of the new device address. Valid values are 00 to 30. 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. An incorrect decimal entry can be corrected by pressing the CLR key and repeating the decimal value.

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 ¹⁾	
5	LWR	Power in W	Reflected-power channel 1)
6	LMR	Power dBm	
7	SWR	Standing-wave ratio	
8	RTL	Return loss in dB	
9	ALR	Reflected/incident power ratio in %	
10	RFL	Reflection coefficient in %	

The instructions 1 to 10 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.

1) Only applies if power head is used.

b) Control of data output and start of measurement

Ref. No.	Instruction code	Function
11	DF	Data output only for incident-power channel
12	DR	Data output only for reflected-power channel
13	DT	Data output for both channels
14	NØ	Data output with header
15	N1	Data output without header
16	X1	Start of a single measurement
17	X2	Start of a measurement on data request
18	X3	Continuous measurements
19	XØ	Reset instruction for X2/X3

1)

The instructions 11 to 13 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 16 to 19 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.

¹⁾ Only applies if power head is used.

The instruction X3 starts consecutive 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 X0 causes an abortion of X2 or X3 without setting a new measurement start.

c) Special functions

Instruction code	Measurement function	
S0	Clear all special functions	
S11	Set measurement range 1	Measuring channel 1
S12	Set measurement range 2	
S13	Set measurement range 3	
S21	Set measurement range 1	Measuring channel 2 1)
S22	Set measurement range 2	
S23	Set measurement range 3	
S30	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.

1) Only applies if power head is used.

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

Instruc- tion code	End characters sent by the NAP
W0	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 W0 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 decimal point (ASCII 44) has to be sent as a delimiter between the individual instructions, and an end character after the last instruction.

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 Underrange	0101 0000	80	Measured value
	0101 0001	81	Measured value
Overrange Syntax error Output in local Output without measuring start Overflow of readout Measured value undefined	0110 0000	96	OFL1/2/3/max
	0110 0001	97	Er1
	0110 0010	98	LOC
	0110 0011	99	old measured value
	0110 0100	100	Er2/3
	0110 0101	101	--
Hardware error	1110 0000	224	Er5...Er9

f) 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).

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 (for output of measured values), 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).

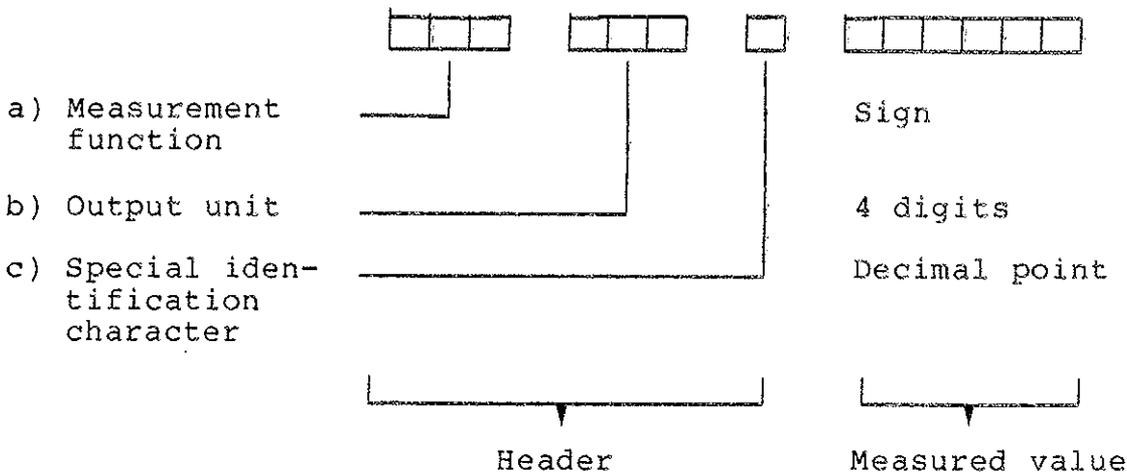
c) Device trigger

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

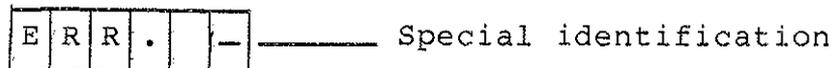
Data request by the controller (controller input command) enables the NAP to send the measured values. When setting is made with the instruction NØ, the measured values are preceded by an alphanumeric header which contains the measurement function, the unit of the electrical quantity and a special identification 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

1)

b) Coding of output unit

Code	Output unit
-W-	W
DBM	dBm
-%-	%
-DB	dB
---	without dimension (for SWR) ¹⁾

¹⁾ Only applies if power head is used.

c) Coding of special identification character

Code	Significance	Data output
-	Valid measured value	Yes
L	Underrange, reduced measurement accuracy	
E	Hardware error	No
H	Overrange	
R	Device not in remote state	
T	Controller input without measurement start	
O	Overflow of readout	
U	Measured value undefined (AM < 0 %, TML, SWR, RTL, P _R /P _F , RFL without measuring power)	

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) measured values can be output every 400 ms. This is the transient period of the amplifiers to settle to the new measured value.

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 400 ms or 800 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 400 ms about every three minutes. However, premature calling-up of the output is possible by means of the special function SF41. 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) must be set for a maximum output time of 1.2 s. In the case of the PUC this setting can be made with the instruction IECTIME20.

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 20
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="; PV$, "PR="; PR$
240 NEXT

```

} Initialization
of NAP and PUC

} 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 20
120 IECTERM 13
130 IECDEV
140 IECDEV NAP=25
150 IECOUT NAP,"LMF,SWR,DT,N1,X2,W1,Q0"
:
:
:
200 FOR N=1 TO 20
210 IECOUT NAP,"X1"
220 IECIN NAP,V$
230 IF LEFT$(V$,1)="E" THEN PRINT V$,:GOTO250
240 V=VAL(V$)
250 IECIN NAP,R$
260 IF LEFT$(R$,1)="E" THEN PRINT R$:GOTO280
270 R=VAL(R$)
280 PRINT V,R
290 NEXT

```

} Initialization
of NAP and PUC

} Measurement
with the NAP

- 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 210
- Check for invalid measurement in lines 230 and 260
- Numeric conversion in lines 240 and 270

Example 3

```

100 REM INIT
110 IECTIME 20
120 IECTERM 13
130 IECDEV
140 IECDEV NAP=25
150 IECOUT NAP,"LWF,DF,N1,W1,Q1"
160 IECSRQ GOTO900
:
:
:
200 REM MAIN PROGRAM
:
:
300 IECOUT NAP,"X1"
:
:
800 END
:
:
:
900 REM SERIAL POLL
910 IECSPL NAP,S%
920 IF S%AND64 THEN 940
930 IECRETSRQ
940 IF S%AND32 THEN PRINT"ERROR":GOTO930
950 IECIN NAP,P$
960 P=VAL(P$)
970 GOTO930

```

Initialization of NAP und PUC

Main program

Serial poll and data transfer

- Measurement of incident power in dBm
- Data output without header for incident-power channel only
- End character CR, service request enabled
- Start of measurement in line 300
- If SRQ, jump to sub-program from line 900
- If SRQ from NAP, jump to line 940
- Check for measurement error in line 940

2.6.6 Table 2-2 Setting Instructions

Instruction code	Measurement function
LWF LMF MAM TML	Power in W Power in dBm Amplitude modulation in % ₁) Transmission loss in dB } Incident-power channel
LWR LMR SWR RTL ALR RFL	Power in W Power in dBm Standing-wave ratio Return loss in dB Reflected-to-incident power ratio Power in % Reflection coefficient in % } Reflected-power channel ₁)
DF DR DT	Data output for incident-power channel Data output for reflected-power channel Data output for both channels } ₁)
N0 N1	Data output with header Data output without header
X1 X2 X3 X0	Start of a single measurement Start of a measurement on data request Consecutive measurement Reset for X2/X3
S0 S11 S12 S13 S21 S22 S23 S30 S32 S41 S43	Clear all special functions Set measurement range 1 Set measurement range 2 Set measurement range 3 Set measurement range 1 Set measurement range 2 Set measurement range 3 Hold range Prepare fixed decimal point display Premature zero measurement Zero offset correction (See special functions for checking stated in Section 5.2.) } Measuring channel 1 } Measuring channel 2
W0 W1 W2 W3 W4 W5 W6 W7 W8	End character NL (ASCII 10) CR (ASCII 13) ETX (ASCII 3) CR + NL EOI (end or identify) NL + EOI CR + EOI ETX + EOI CR + NL + EOI
Q0 Q1	Service request disabled Service request enabled
C1	Basic setting

¹) Only applies if power head is used

3 Maintenance3.1 Required Measuring Equipment and Accessories

Ref. No.	o Equipment, Specifications ● Recommended R&S unit	Type	Order No.	See section
1	o DC Voltmeter V >10 V; R _{in} >100 k Ω /V ● Digital Multimeter	UDS5	349.1510.02	5.2.1
2	o Oscilloscope with probe 10:1; 0 to 500 kHz; 0.1 V/cm ● Oscilloscope	Se- ries 5100	Tektronix	5.2.2
3	o Power signal generator f = approx. 300 MHz; P depending on probe: NAP-Z3: P > 30 W Z4: P > 100 W Z5: P > 300 W Z6: P >1000 W			3.2 and 5.2.10
4	o Termination 0 to 1000 MHz; 50 Ω ● Termination	RMC	100.2940.50	5.2.10
5	o Power meter 0 to 330 mW; 0...1000 MHz; Z = 50 Ω ● Microwave Power Meter	NRS	100.2433.92	3.2 and 5.2.12

Ref. No.	○ Equipment, Specifications ● Recommended R&S unit	Type	Order No.	See section
6	○ Reflection meter Z = 50 Ω; 30...1000 MHz			5.2.13
7	○ Signal generator P > 1 W; 25 to 1000 MHz ● Power Signal Generator	SMLU	200.1009.02	3.2.2 and 5.3.6
8	○ DC ammeter I > 0.5 A ● Digital Multimeter	UDS5	349.1510.02	5.2.9
9	○ High-power attenuators 10 dB; 100 W 20 dB; 30 W 40 dB; 1000 W			3.2 and 5.2.10
10	○ DC source ● Power Supply	NGT20	117.7133.02	5.2.8
11	○ Adapter (Fig. 3-2)			5.2.7
12	○ Separating plate (Fig. 3-3)			5.2.9

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.

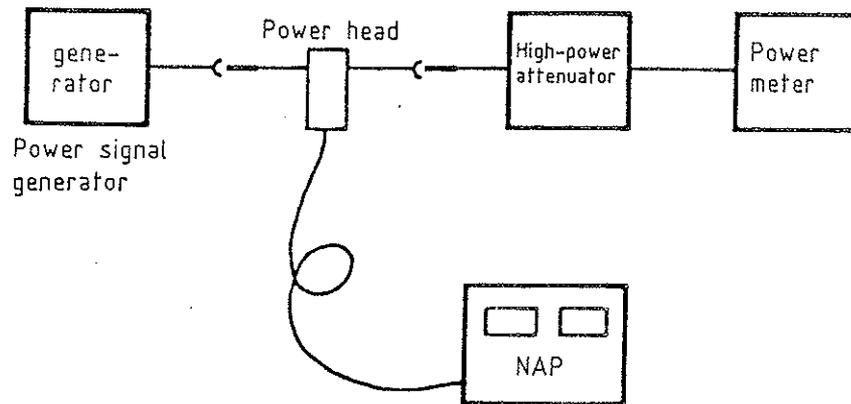


Fig. 3-1 Test setup 1 for checking the characteristics of the NAP and for adjustment

3.2.1 Checking the Power Indication

Check the indication in both directions. The measured power should read as follows:

100%	} of maximum power in power head
50%	
30%	
8.5%	

The measured value depends on the power head used:

NAP-Z3: 34.8 W, NAP-Z4: 110 W, NAP-Z5: 348 W and NAP-Z6: 1100 W.
 The calibration refers to the output power of the power head. Set the NAP to autoranging while checking.
 The permissible error limits are specified in the data sheet.

3.2.2 Checking the Frequency Response

Check the frequency response at a constant power in both directions. If attenuators are used between the NAP and the power meter, their frequency response has to be taken into account.

The permissible error limits are $\pm 3\%$ referred to the measured value at 300 MHz.

3.2.3 Checking the Directivity

Check the directivity as described in 5.2.10 (directivity of power head).

3.2.4 Checking the Performance of Displays and Keyboard

Enter the special function SF70 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
PR/PF	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.

3.2.5 Checking the IEC-bus Interface

This test is best 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,NØ,Q1"
                    130 IECSRQ GOTO200
                    140 IECOUT4,"X1"
                    150 A=10
                    160 GOTO140
                    200 REM SERIAL POLL
                    210 IECSPL4,S%
                    220 PRINTS%
                    230 IECIN4,P$
                    240 PRINTP$
                    250 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
NØ: _____ // _____ with header
Q1: Enable Service Request
```

The process controller calls up an individual measurement via "X1" and stores the device settings and the current measured value in S% or P\$ after the NAP has issued the Service Request.

3.3 Performance Test Report

Power Reflection Meter NAP
Order No. 392.4017.02

Commission No.
Serial No.

Power Head NAP-Z...

Commission No.
Serial No.

Item	Test	Measure acc. to section	Minimum value	True value		Maximum value	Unit	Confirmation
				1→2	2→1			
1	Performance test Displays and Keyboard	3.2.4	-			-	-	
2	Performance test Option NAP-B4	3.2.5	-			-	-	
3	Power indication at 23 ±2°C	3.2.1						
	NAP-Z3		34.8	32.71		36.89	W	35.2
			17.4	16.36		18.44	W	
			10.4	9.78		11.02	W	
			3.0	2.82		3.18	W	
	NAP-Z4		110	103.4		116.6	W	
			55.0	51.7		58.3	W	
			33.0	31.0		35.0	W	
			9.4	8.84		9.96	W	
	NAP-Z5		348	327.1		368.9	W	
			174	163.6		184.4	W	
			104	97.8		110.2	W	
			30	28.2		31.8	W	
	NAP-Z6		1100	1034		1166	W	
			550	517		583	W	
			330	310		350	W	
	94	88.4		99.6	W			

Item	Test	Measure acc. to section	Mini- mum value	True value		Maxi- mum value	Unit	Con- firma- tion
				1+2	2+1			
4	Directivity 25 MHz 30 to 1000 MHz	5.2.10	26 30			- -	dB dB	
5	Reflection	5.2.13	-			1.5	%	

3.4 Regular Maintenance

3.4.1 Electrical Maintenance

3.4.2 Replacing the Batteries

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.

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

Attention: To prevent damage, an NAP fitted with the Option NAP-B4 may only be operated with AC power if the accumulators are incorporated.

3.4.3 Checking the Digital/Analog Conversion Range

Enter the special function SF80 from the keyboard and measure the voltage at check point P4. The resulting value should be +2.200 V. Then enter SF81 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 $\pm 0.1\%$). If this is not the case, correct as described in section ~~5.3.3~~.

p. 5.19

3.4.4 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. The same applies to the accumulators of Option NAP-B4.

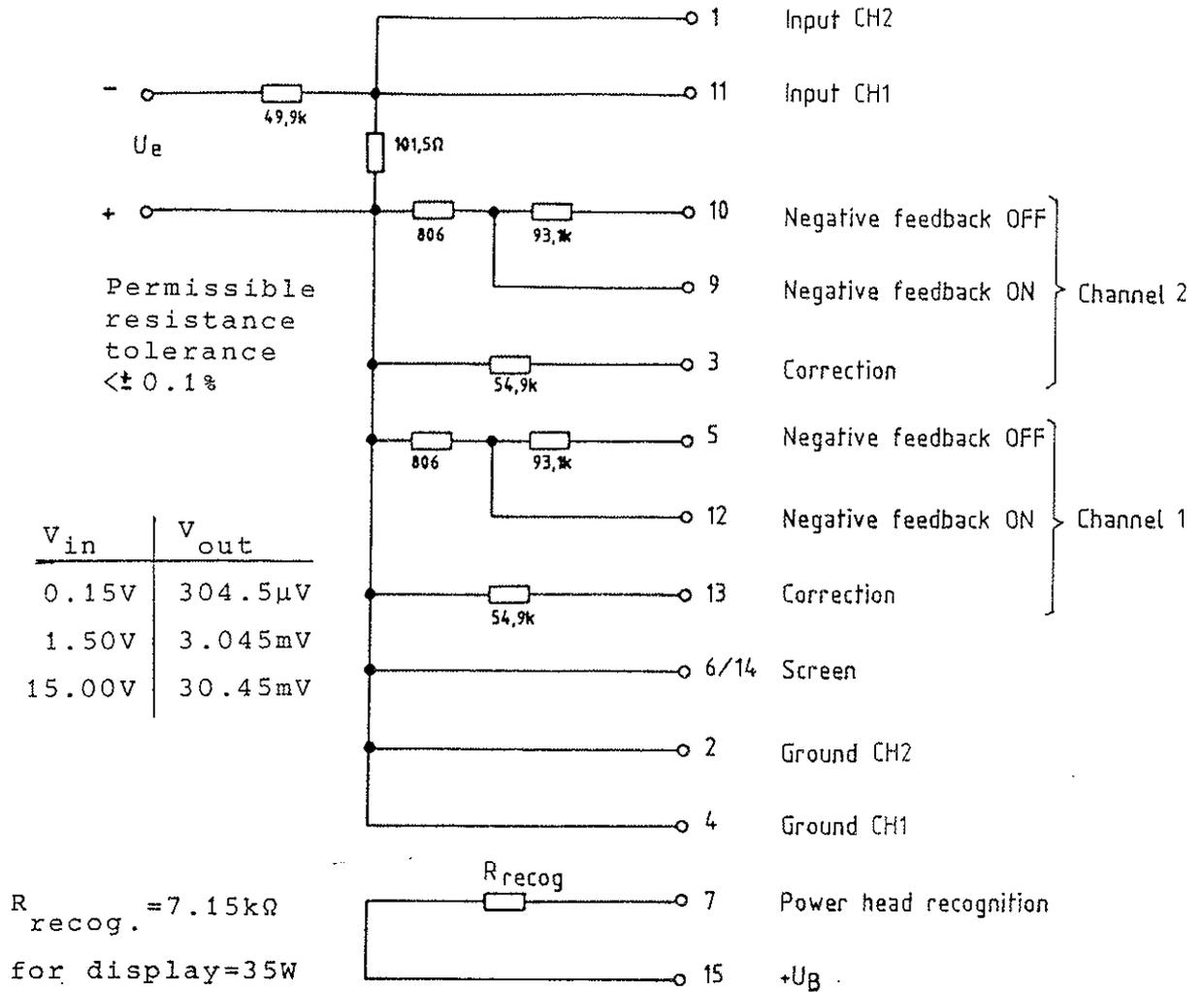


Fig. 3-2 DC adapter

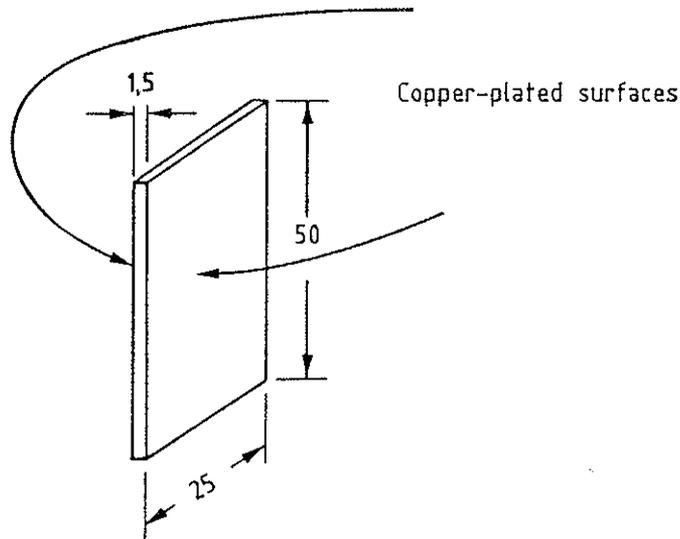


Fig. 3-3 Isolating plate for measurement of charging current

4 Servicing of Complete NAP4.1 Performance Test4.1.1 Hardware

The NAP consists of the following subassemblies:

→ Digital/analog section	392.4517.02
→ Display section	392.4217.02
→ Battery section 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 -3.34 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.

The analog section further comprises a multivibrator for the chopper amplifiers, circuits for generating and stabilizing a negative operating voltage of -6.5 V, and a data-bus expander that drives the multiplexer, sets the measurement ranges, switches between offset and signal measurement and identifies the power head. All inputs and outputs of the analog section are taken via lead-through filters.

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 timer I is continuously reset via the signal OPT = high, while 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, 27128) with 16-kbyte capacity. 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. 5.4 to 9 V) so as to obtain a constant output voltage of about 5.2 V.

To keep the NAP operating as long as possible with only one set of monocells (6 in all), the regulator has been designed such that it permits a low voltage drop between input and output (ΔV) and nevertheless levels out the load variations (approx. 0.2 to 0.3 V in the NAP).

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 to about one half; the possibility of recharging, however, 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 with a capacity of 16 kbyte (27128). 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.

- Initialization of displays
- Initialization of keyboard circuit
- Display of version number (software state) for approx. 0.5 s
- RAM test
- Power head identification
- Display of maximum permissible power of power head (left display)
- Display of IEC address
 - Battery operation: "A--"
 - AC power operation: selected address
 - In AC power operation, also initialization of IEC interface
- Calibration of analog output
- Measurement of supply voltage
- Measurement of zero offset in the three amplifier ranges for both channels

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 continuously 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 permanently 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:
$$P = \frac{W - W_0}{K} \times 10^{(R-1)}$$

P = power in W
 W = "measured" bit pattern
 W₀ = bit pattern from offset measurement
 K = identifier for power head
 R = selected range

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.

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 main part of the digital/analog board is fixed with two snap-action locks. When these locks are released, the entire sandwich plate can be folded forward (the power head must be disconnected beforehand). 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).

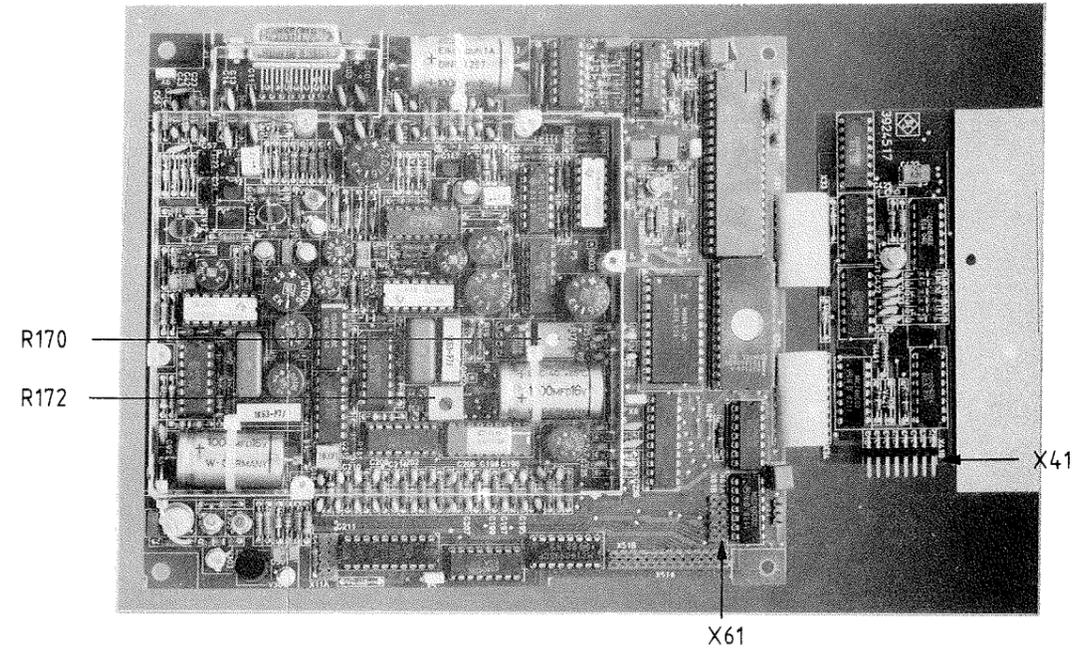


Bild 4-2 D/A-Platte
Fig. 4-2 D/A board

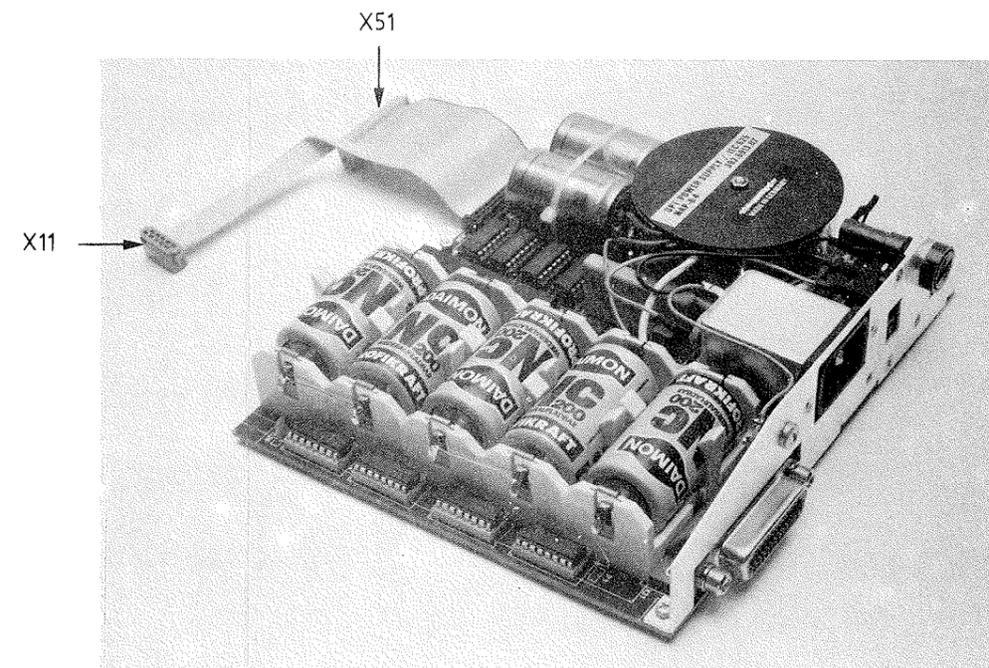


Bild 4-3 Option NAP-B4
Fig. 4-3 Option NAP-B4

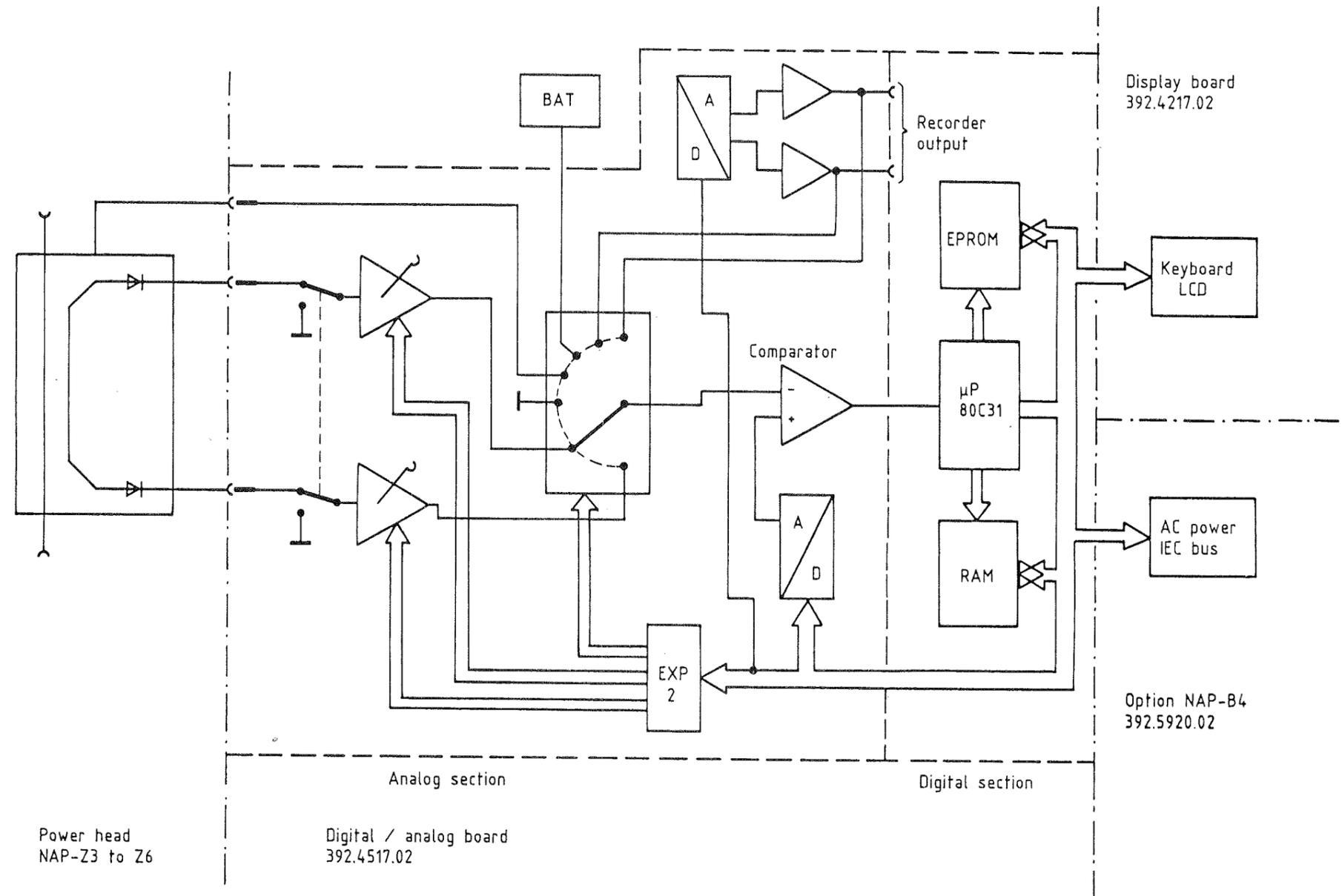


Fig. 4-1 Block diagram of NAP

5 Servicing of Subassemblies and Option

5.1 Circuit Description

5.1.1 Power Head

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 directional 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.

5.1.2 Analog Amplifier

See circuit diagram 392.4517.01

The DC voltage obtained in the power head is so low (between 10 μ V 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.

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

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
0	0	0	0	13	Output K1
0	0	1	1	14	Output K2
0	1	0	2	15	Power head identification
0	1	1	3	12	$U_{BATT} \approx 1.2 \text{ V}$
1	0	0	4	1	Free
1	0	1	5	5	Analog output K1
1	1	0	6	2	Analog output K2
1	1	1	7	4	Ground of analog output

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 5.3.3.

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.

5.1.6 Battery Test

When the NAP is operated without AC power, the battery is checked at intervals of about 3.3 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 5.7 V, both the scale and the bar start blinking. Below a value of 5.4 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 5.4 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 μ A). This voltage is applied to the base of the left transistor of the dual transistor V302 (TD101), while the right transistor receives the stepped-down output voltage.

The dual transistor 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 $\overline{\text{TAUS}}$ 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 200 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	7C00 to 7FFF
D501	LSB bus latch	BC00 to BFFF
D481	MSB bus latch	DC00 to DFFF
	Keyboard	EC00 to EFFF
	IEC-bus option	F400 to F7FF
D471	Expander 1	F800 to FBFF
D1,D2	LCD driver	FC00 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	$\overline{\text{INT0}}$	AC power/IEC-bus option
13	$\overline{\text{INT1}}$	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		Description
	High (hexadecimal)	Low (hexadecimal)	
GAUS	F801	F800	NAP switched off if display does not change for 30 minutes or if VBAT < 5.4 V
REM	F803	F802	Signal für REMOTE LED
$\overline{\text{IEA}}$	F805	F804	IEC interrupt enable
$\overline{\text{CS}}$ analog output	F807	F806	Chip select Analog output DAC
$\overline{\text{CS}}$ expander 2	F809	F808	Chip select expander 2

Setting data for expander 2 (D221)

Setting	Bus latch data (LSB) (decimal)
Range III Range II } K1 Range I } K1	8/11 9/10 8/10
Range III Range II } K2 Range I } K2	12/15 13/14 12/14
Amplifier to ground	6
Amplifier to input	7
Analog output	1 / 3 / 5
Ground K1	1 / 2 / 5
Ground K2	0 / 3 / 5
BATT	1 / 3 / 4
Power head	0 / 3 / 4
Ground potential K1	0 / 2 / 4
Ground potential K2	1 / 2 / 4

Settings on multiplexer D161

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

In battery operation, the processor and the EPROM are only operating as long as required for the measurement of the input signal and for the conversions. When the processor has completed its task, it issues the $\overline{T_{ON}}$ signal starting the timer I (D331). After a delay (R334/C334), this timer removes the operating voltage from EPROM D351 for about 400 ms, while the microprocessor D341 goes to the power-down mode by setting a register.

When the pause is terminated, the EPROM receives again voltage and the processor is restarted with a short reset signal. After interrogation of the RNS (reset after stop) signal, the microprocessor continues the program with a new measurement (see Fig. 5-4).

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 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} .

5.1.11 LCD Drive

The two LCDs H₁/H₂ are driven by the two drivers D₁ and D₂ generating all the signals necessary for operation. The circuits perform a 4-signal multiplexing function and, therefore, are able to drive $4 \times 32 = 128$ segments.

The drivers are connected to the processor, which transfers the data serially to them via the busy, SI (Serial Input) and 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 200 mA.

Note: To keep the dissipated power of the series transistor V306 within permissible limits, the accumulators limiting the charging circuit to a maximum of 7.4 V must always be incorporated when the NAP is AC powered.

5.1.13 IEC-bus Interface

The IEC-bus interface consists of the IC D25 (8291) and the line drivers D26 to D29 (3448). 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 sub-program 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:

-
- SF 70 All LCDs are on, in AC operation also the REMOTE LED for approx. 1 s.
- SF 80 Set all logic inputs of the DAC to 0.
→ $V_{P4} = +2.200 \text{ V}$
- SF 81 Set all logic inputs of the DAC to 1. → $V_{P4} = -3.942 \text{ V}$
- SF 90 Generate $V_{\text{out}} = 0 \text{ V}$ at the analog output.
- SF 91 Generate $V_{\text{out}} = -2000 \text{ mV}$ at the analog output.
- SF 92 Generate $V_{\text{out}} = +2000 \text{ mV}$ at the analog output.

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

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 ($\pm 2.5\%$)
P10: -6.5 V ($\pm 3\%$)

Check the $+V_{\text{op}}$ 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 $T = 7.4 \text{ ms}$ ($\hat{=} 135 \text{ Hz}$).

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 μ s (\pm 75 Hz). In case of deviation, this value must be corrected as described in 5.3.1.

5.2.4 D/A Converter

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

Check as described in 3.3.2. If the conversion range is offset, adjust it as described in 5.3.3. In normal measurement, an oscillogram as shown in Fig. 5-2 can be seen on the oscilloscope.

5.2.5 Battery Voltage

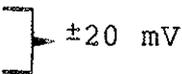
The battery voltage can be checked by means of the NAP itself without needing any other measuring instrument. For this purpose, call the special function SF60 via the keyboard and observe the battery voltage on the display. In AC power operation, however, this special function is disabled.

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
SF90	0 V
SF91	-2000 mV
SF92	+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 k Ω	:	110 W
11.3 k Ω	:	350 W
13.3 k Ω	:	1100 W

5.2.8 Sensitivity of Display Section

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

The resistive voltage divider in the adapter is so dimensioned that a value of 1.5 V (corresponding to 3.48 W in range 2 on both displays) must be applied.

To make sure that range 2 is selected (and not the lower limit of range 3 due to a hysteresis), it is recommended that the special functions SF12 and SF22 be called prior to applying the voltage via the keyboard. These functions will set the correct range.

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:	$I_{ch} \approx 200 \text{ mA}$
NAP switched on:	charging current decreased by the current drain of NAP.

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)

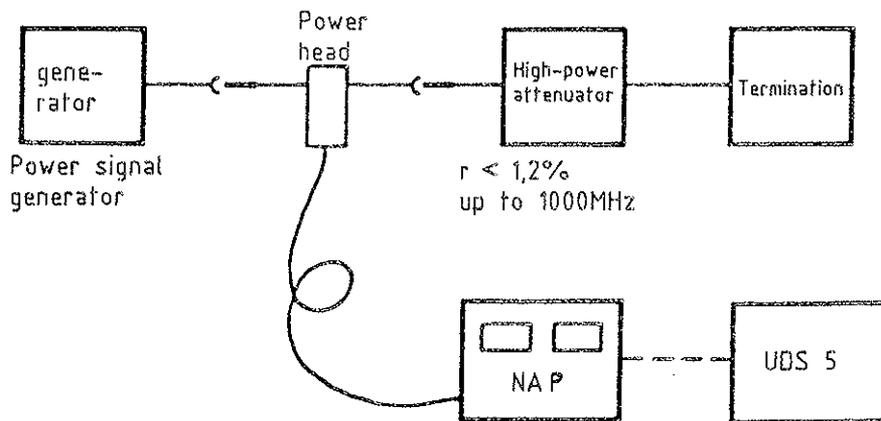


Fig. 5-1 Test setup 2 for checking the NAP characteristics

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.

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

The measurement should preferably be made at the test frequencies 25, 30, 300, 525 and 1000 MHz in both directions of the power head.

The measured values are as specified in the data sheet.

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 SF43 (without power of power head).
- b) Apply measuring power.
- c) Check for distinct change of the display in the reflected-power channel. If no change has occurred, increase the incident power.
- d) Depress the RTL key.
- e) 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: $P_F > 6 \text{ W}$
 NAP-Z4: $P_F > 20 \text{ W}$
 NAP-Z5: $P_F > 60 \text{ W}$
 NAP-Z6: $P_F > 200 \text{ W}$

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

Check the frequency response as described in 3.2.2.

5.2.12 Linearity of Displayed Values of Power Head

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

Check the linearity in both measurement directions but only in the highest measurement range.

Measurement powers: 0.3 and 0.5 of maximum power of power head
Indication error: < $\pm 2\%$ of measured value

If the permissible error is exceeded, adjust according to 5.3.5.

5.2.13 Reflection

Measuring instruments: Power signal generator
Reflection meter
Termination
(Ref. Nos. 7, 6 and 4 in section 3.1)

Measure in both directions of the power head.

Measured values according to data sheet.

5.3 Adjusting the NAP and NAP-Z3 to Z6

Settings on the power head (see sections 5.3.4 to 5.3.6) should only be made with the special function SF43, thus avoiding errors due to offset caused by thermal loading.

5.3.1 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 μ s ($\hat{=}$ 75 kHz) with potentiometer R1.

5.3.2 Adjusting the Display Contrast

Auxiliary equipment: Power supply
Adapter
(Ref. Nos. 10 and 11 in section 3.1)

The DC voltage applied via the adapter should cause a power indication that contains at least the digit "2". 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.

5.3.3 Adjusting the D/A Converter

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

Calling the special function SF80 via the keyboard sets the D/A converter to zero. Adjust for a voltage of +2.200 V with R170 at check point P4. Then call the special function SF81 and adjust for -3.942 V by means of R172.

Since the potentiometer settings influence one another, it is advisable to adjust the voltage difference of 6.142 V without taking into account the offset. Then adjust the offset.

Since the accuracy of the NAP is directly dependent on the voltage-difference setting, the setting must be repeated several times to achieve an accuracy of 6.142 V \pm 0.1%.

5.3.4 Adjusting the Power Head Sensitivity

Measuring instruments: NAP of increased accuracy
Power signal generator
High-power attenuator
Thermal power meter
(Ref. Nos. 7, 9 and 5 in section 3.1)

Test setup: shown in Fig. 3-1

The frequency should be about 300 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 S12 and S22).

5.3.5 Linearization of Indication

Measuring instruments: same as listed in 5.3.4

Test setup: shown in Fig. 3-1

The indication can be linearized in range 3 (= 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.

Check with 0.3 and 0.5 of the maximum power of the power head. The input powers should be as follows:

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

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.

5.3.6 Adjusting the Frequency Response

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

Test setup: see Fig. 3-1

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 only 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 300 MHz).

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 (9,15)
Er.6	Incorrect values in external RAM	After battery change: D391, D401 VRAM
Er.7	Zero of D/A converter shifted	D191, N171 (7), Adjustment acc. to section 5.3.3
Er.8	Zeros of measuring amplifiers shifted	Measuring amplifiers for channels 1 and 2
Er.9	Measurement with D/A converter not possible	Power head not connected. Cable faulty.

Both displays are blinking

5.4.1 Power Head

Error	Source of error
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.

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.

5.4.2 Connecting Cable W1

Error	Source of error
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 sideways 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
Channel K1	Voltmeter	P2	+1.4 V at $V_{in} = 0$ V
Channel K2	Voltmeter	P1	+1.4 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.

5.5 Electrical Repair

5.5.1 Mounting the Connecting Cable W1

- 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.

5.5.2 Display Section

Owing to the intelligence of the NAP most of the components can be replaced without requiring new adjustments. Varied voltage values (e.g. offset) are processed by the processor and, therefore, need not be corrected.

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

<u>To be replaced</u>	<u>Adjustment acc. to section</u>
D191	5.3.3
V301	5.3.3
D2	5.3.1
V11	5.3.2

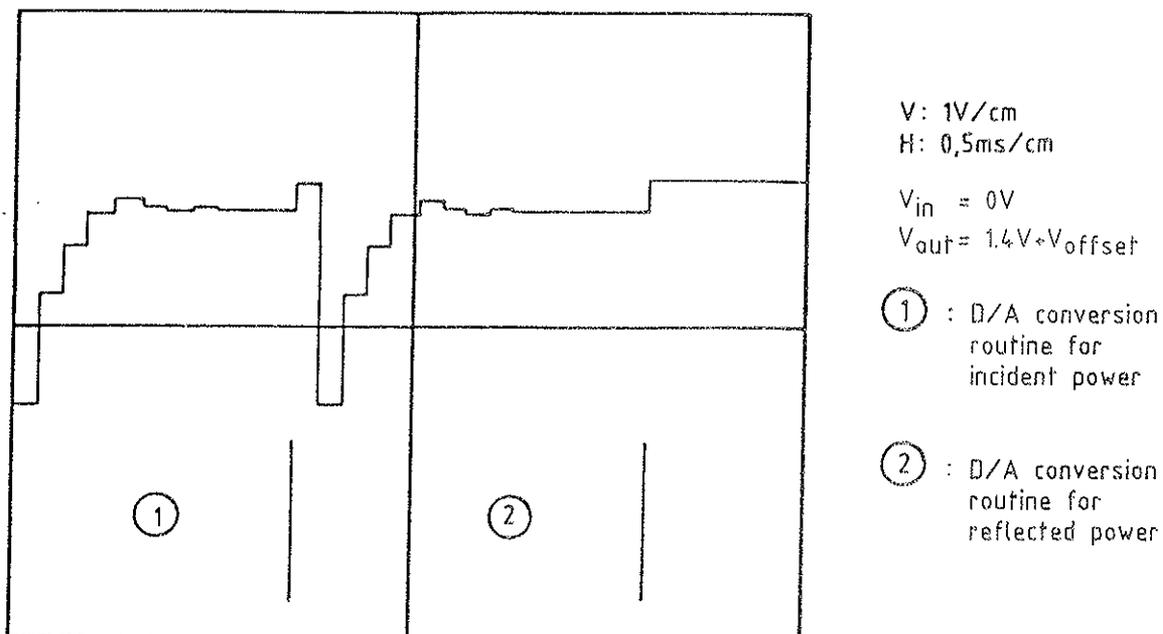
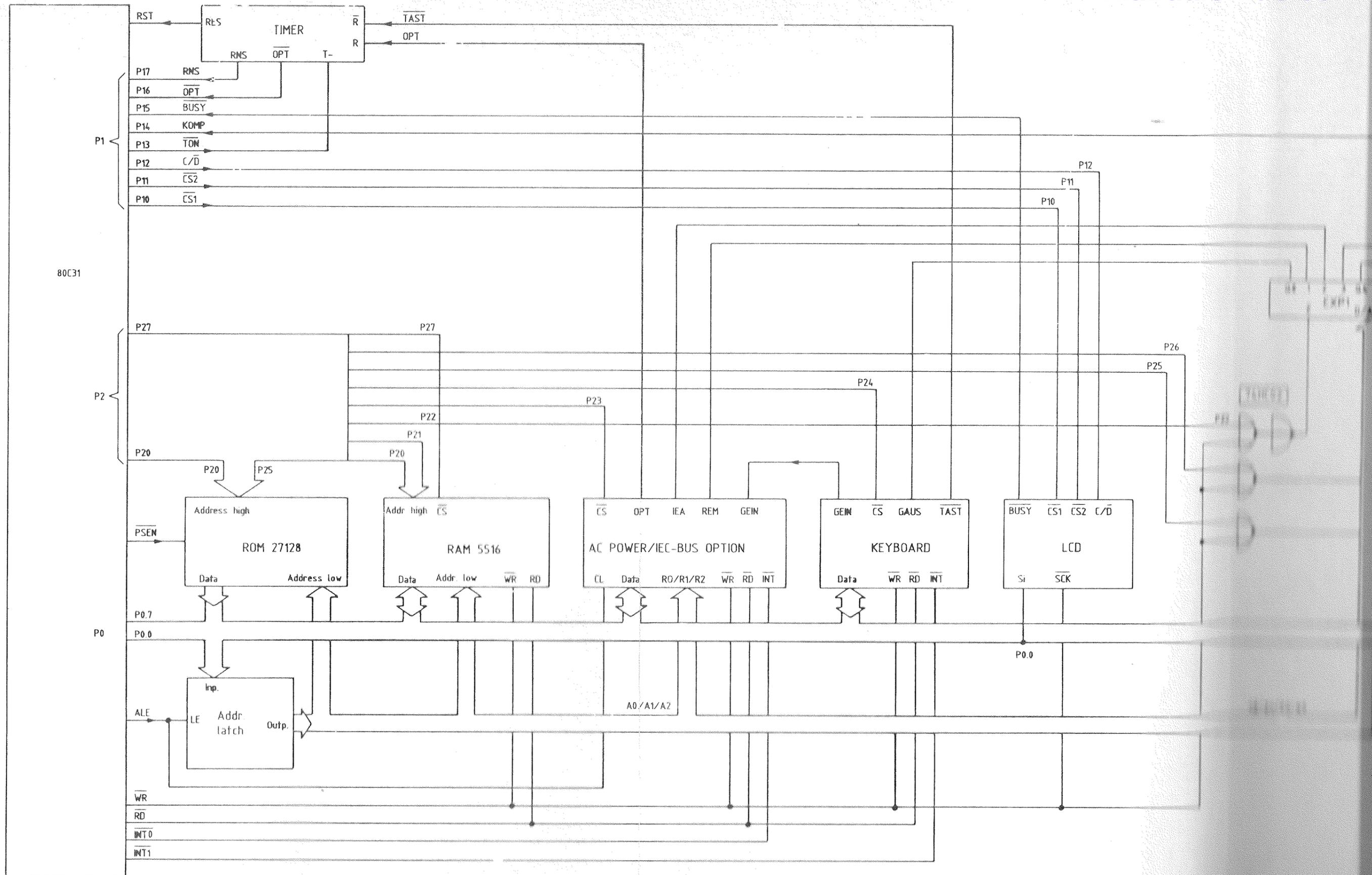
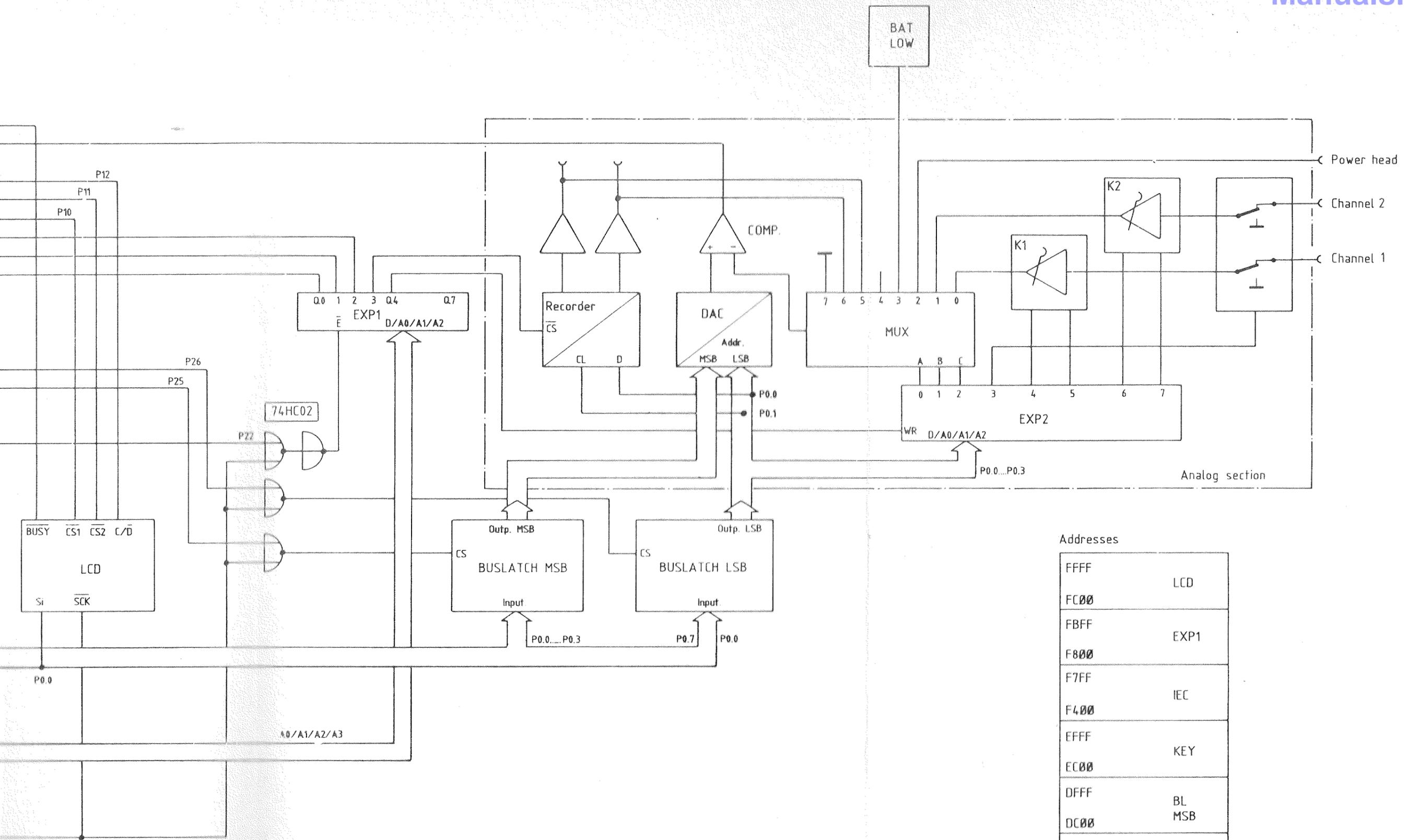


Fig. 5-2 Oscillogram of D/A conversion routine





Addresses

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

Fig.5-3 Address lines and Address ranges

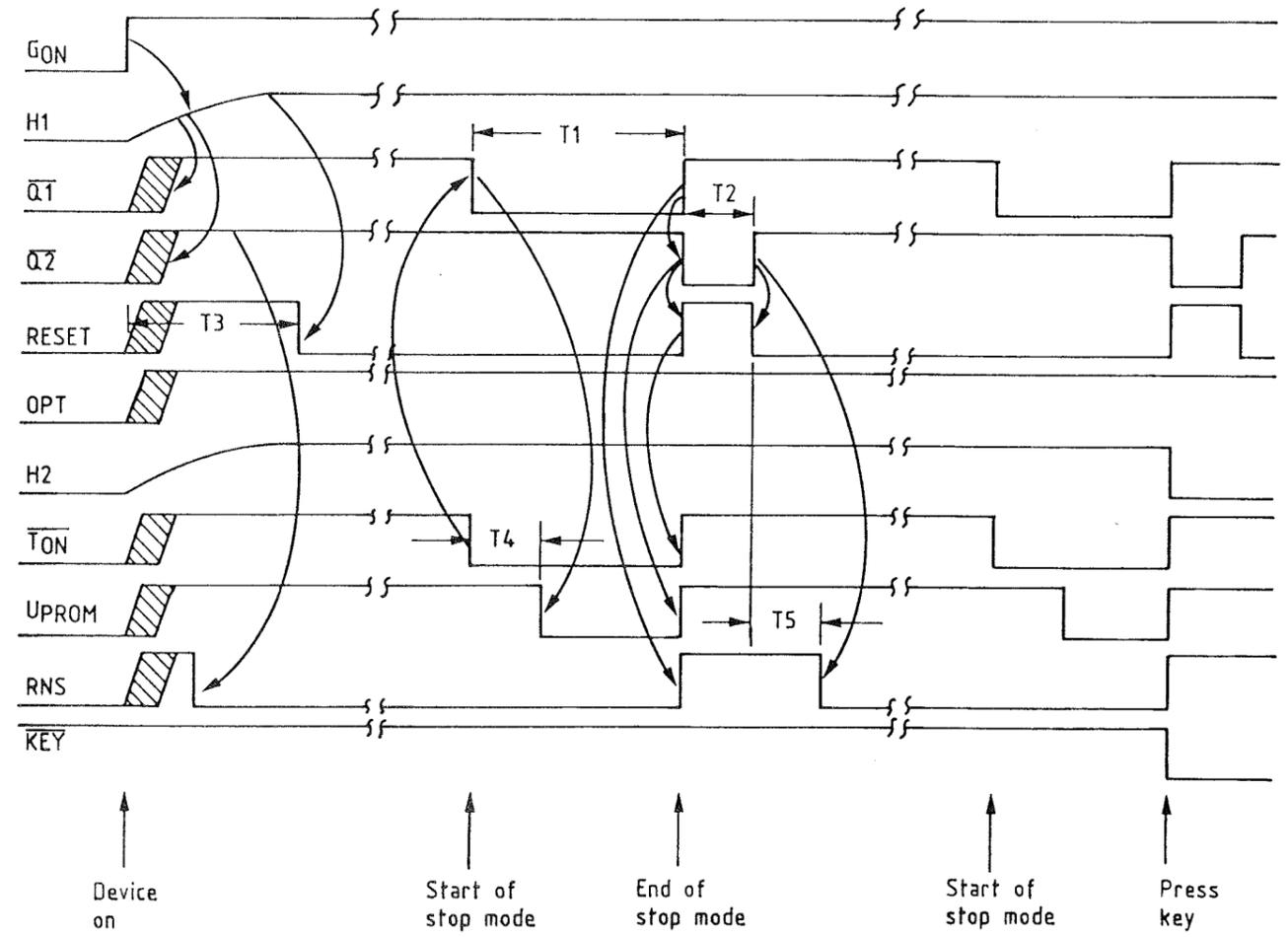
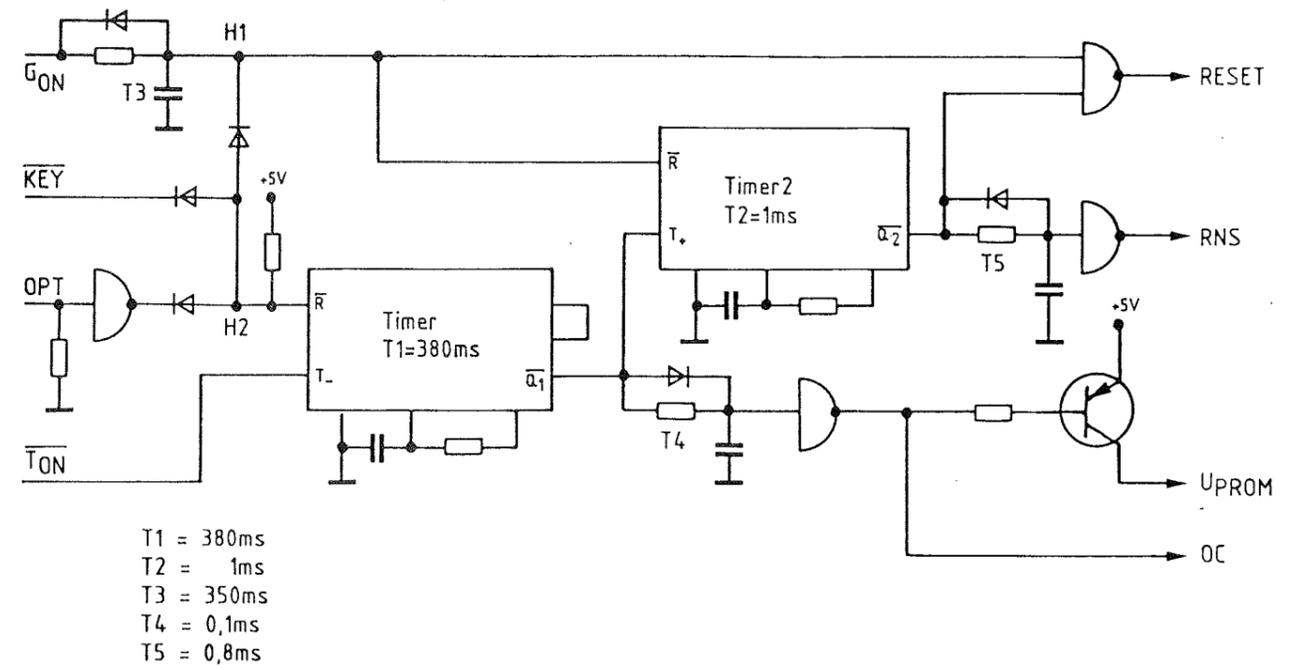


Fig.5-4 Pulse diagrams and delay times in processor operation



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Bilder

Figures

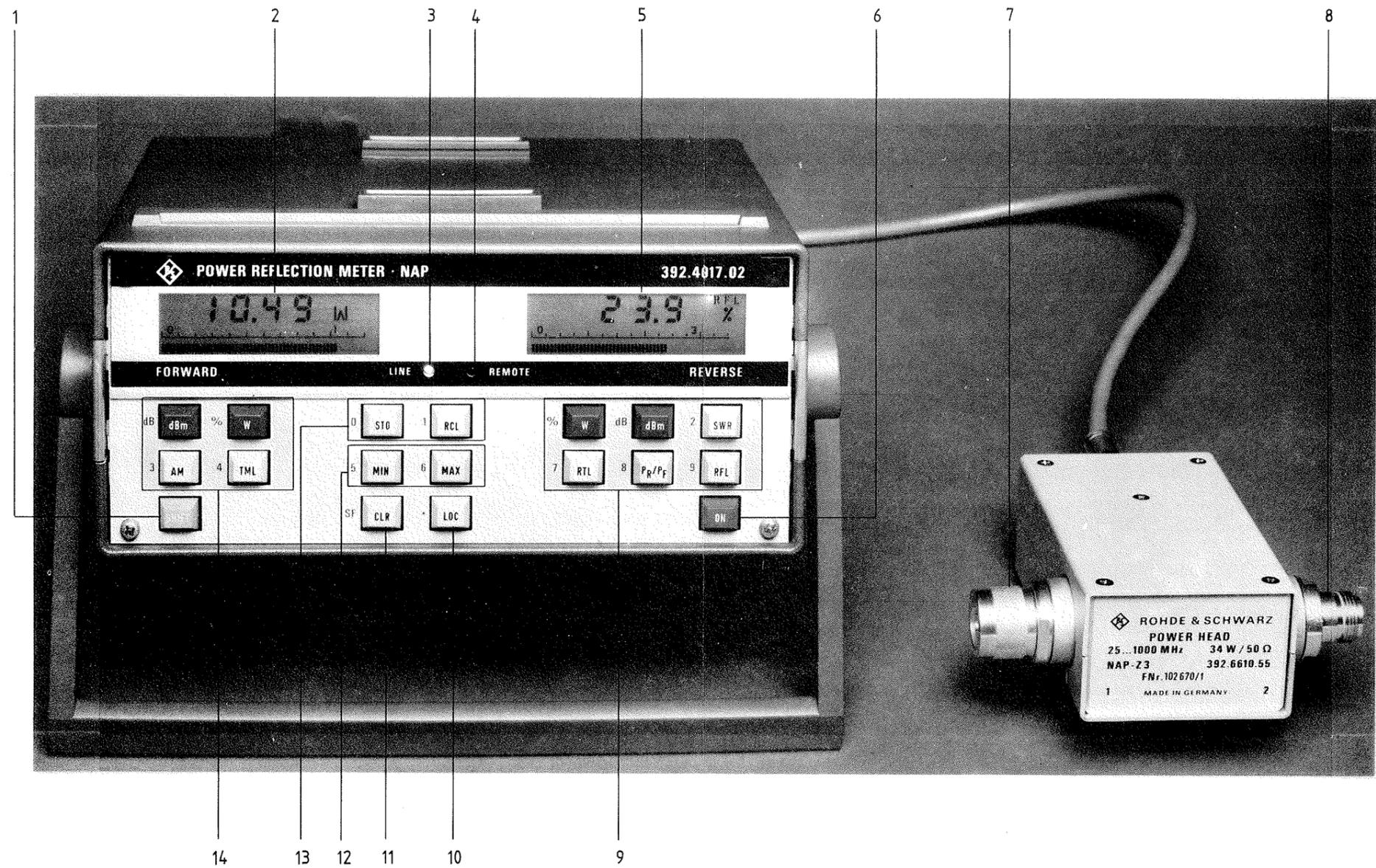


Bild 2-1 Frontansicht NAP und Durchgangsleistungsmeßkopf
 Fig. 2-1 Front view NAP and Power Head

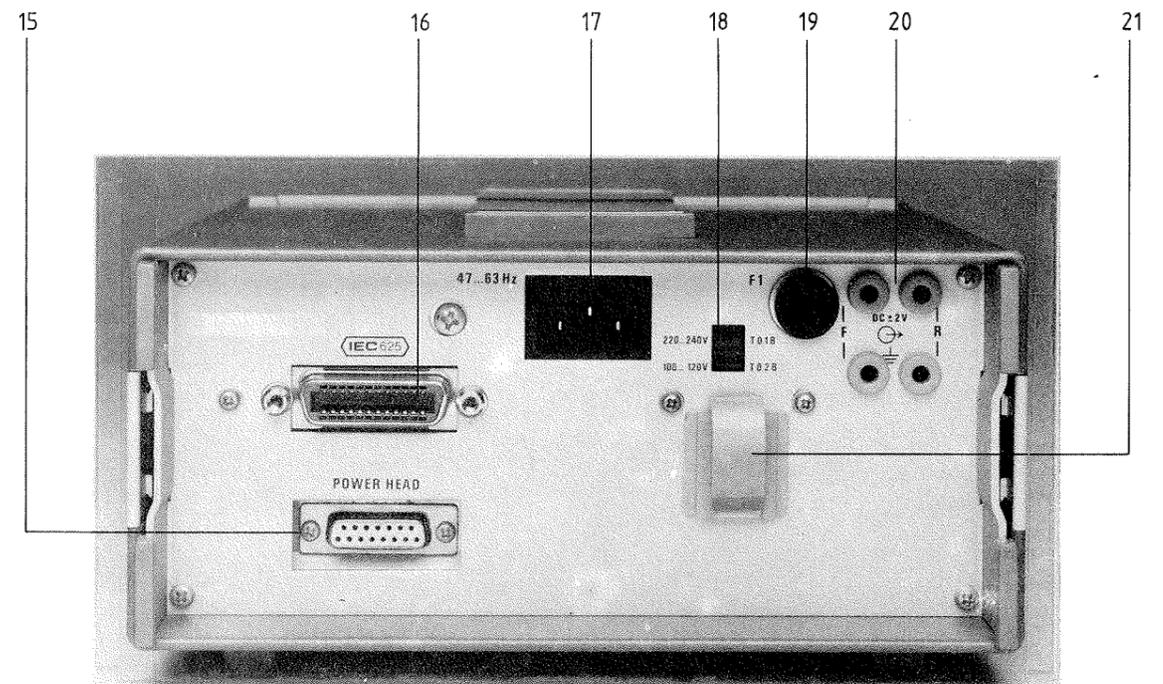


Bild 2-2 Rückansicht NAP
Fig. 2-2 Rear view NAP

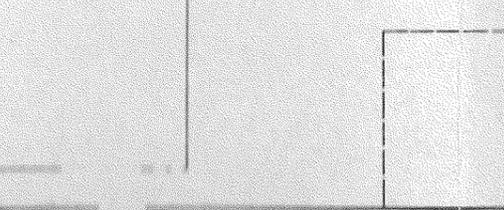
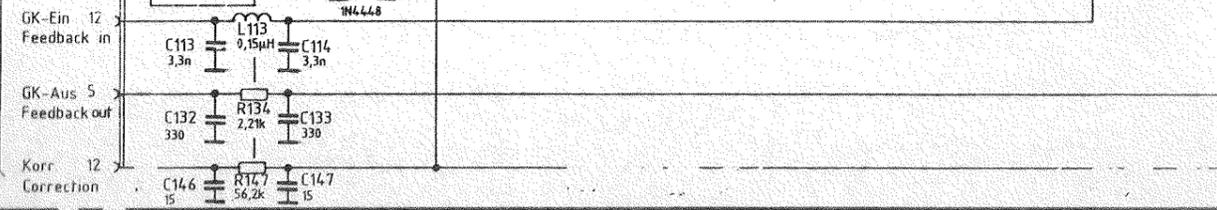
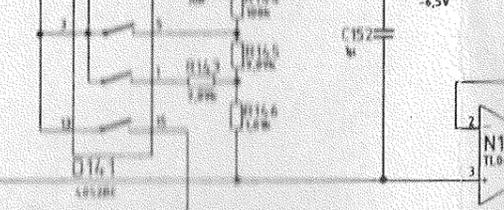
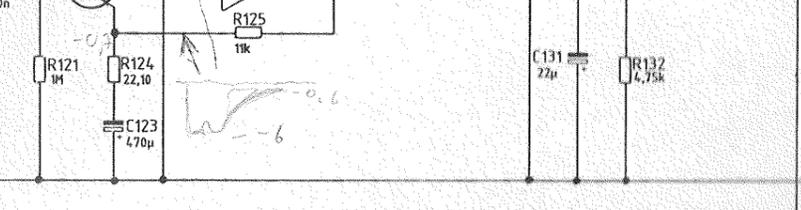
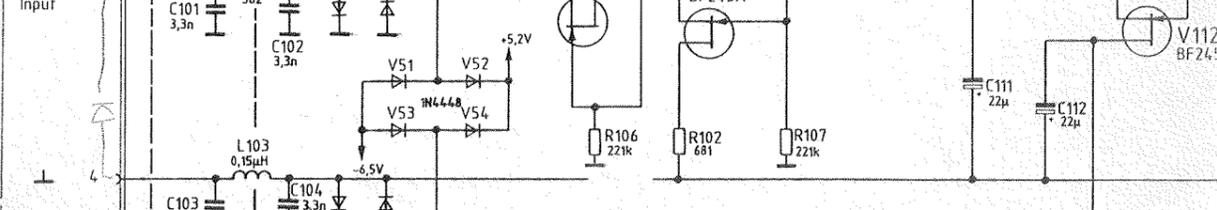
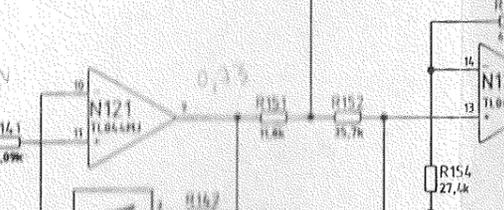
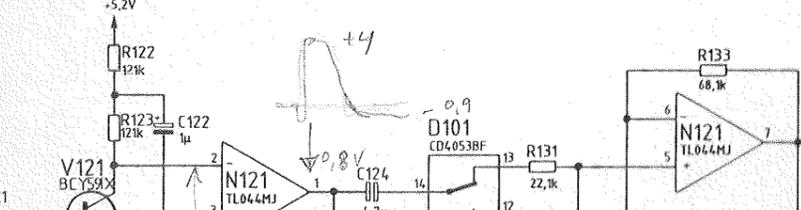
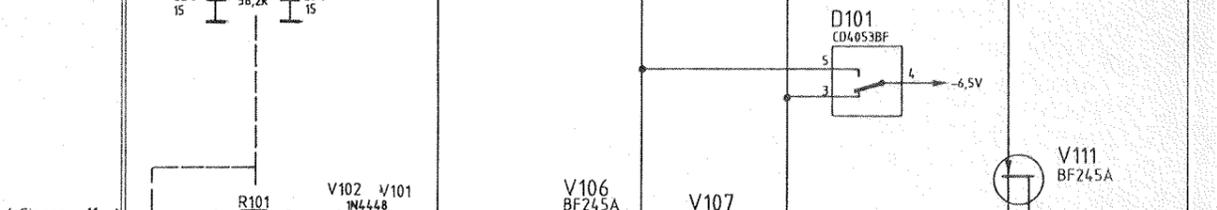
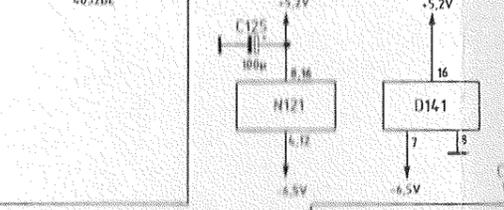
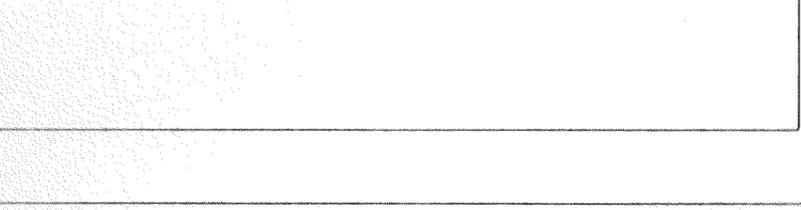
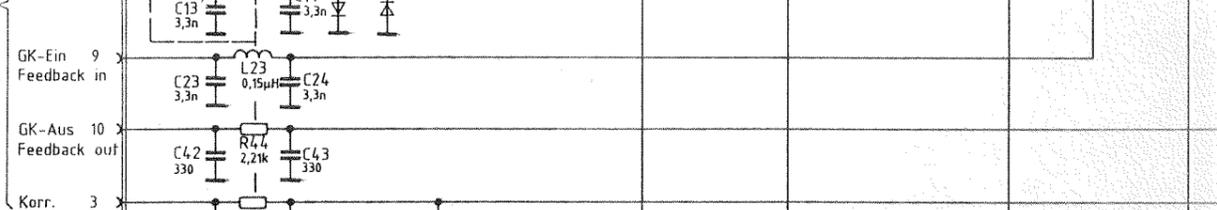
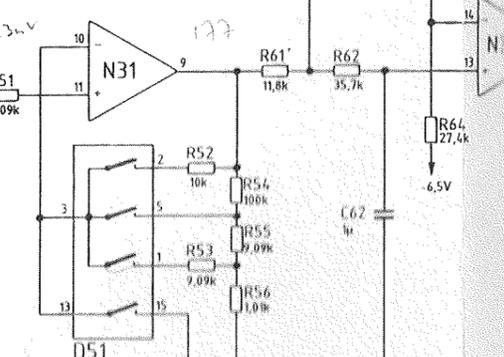
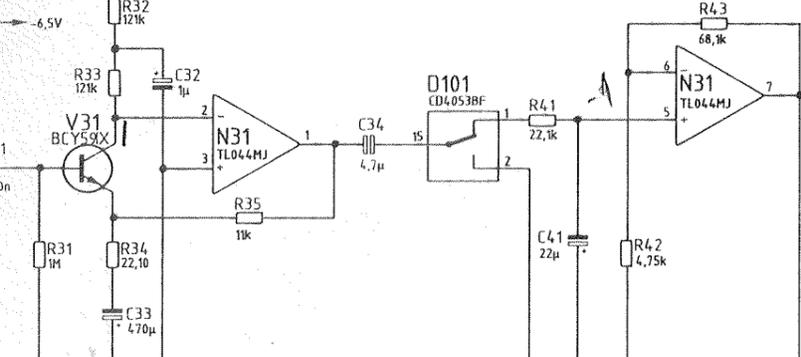
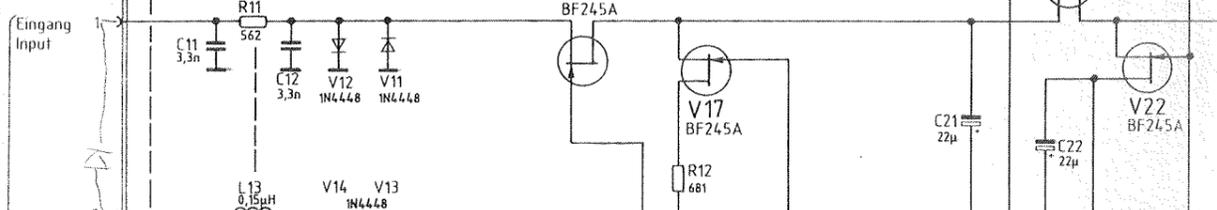
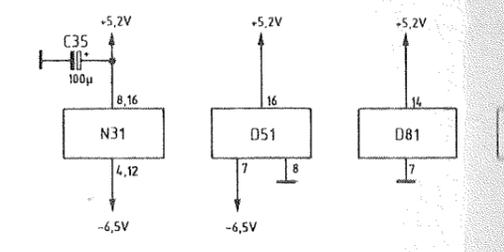
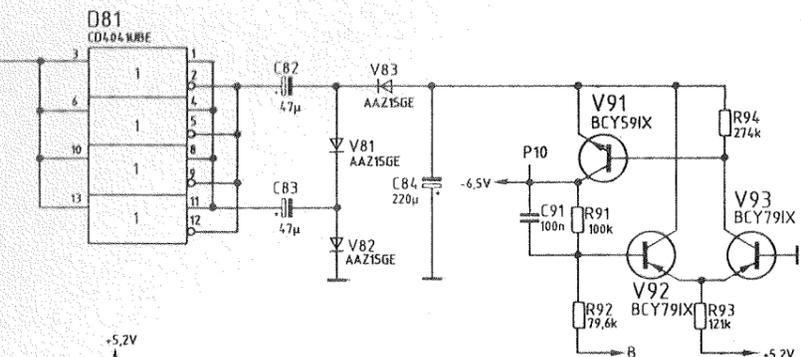
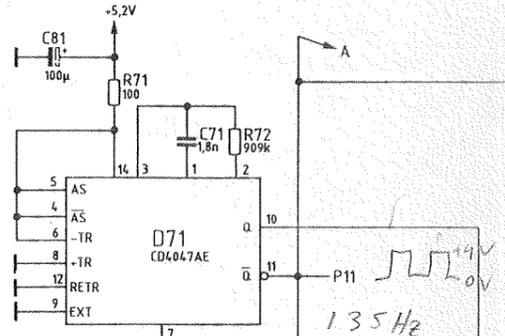
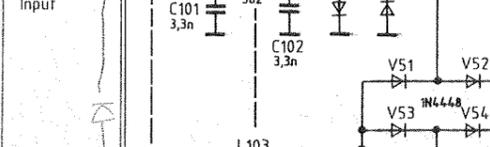
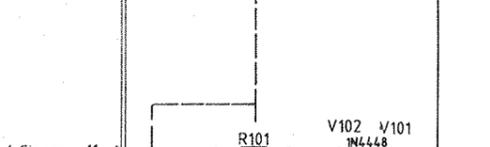
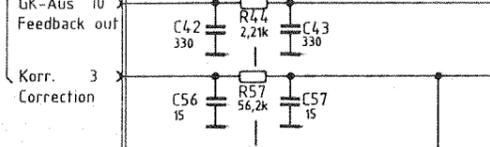
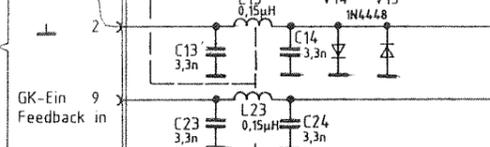
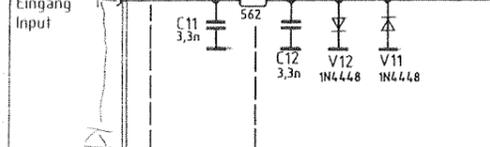
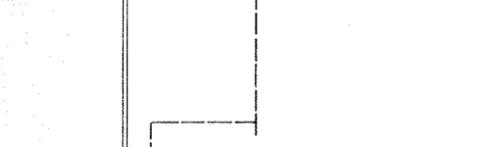
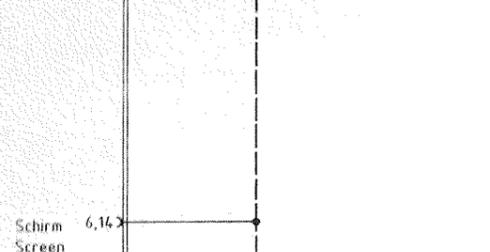
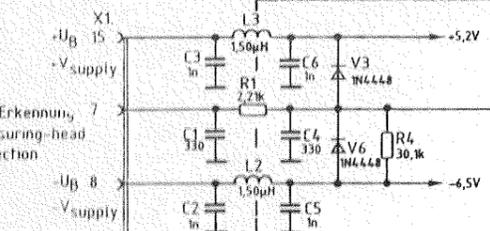


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Stromläufe
Bestückungspläne
Circuit diagrams
Components plans

Meßkopfschluß
Measuring-head connector



Rücklauf Reflected

Vorlauf Incident

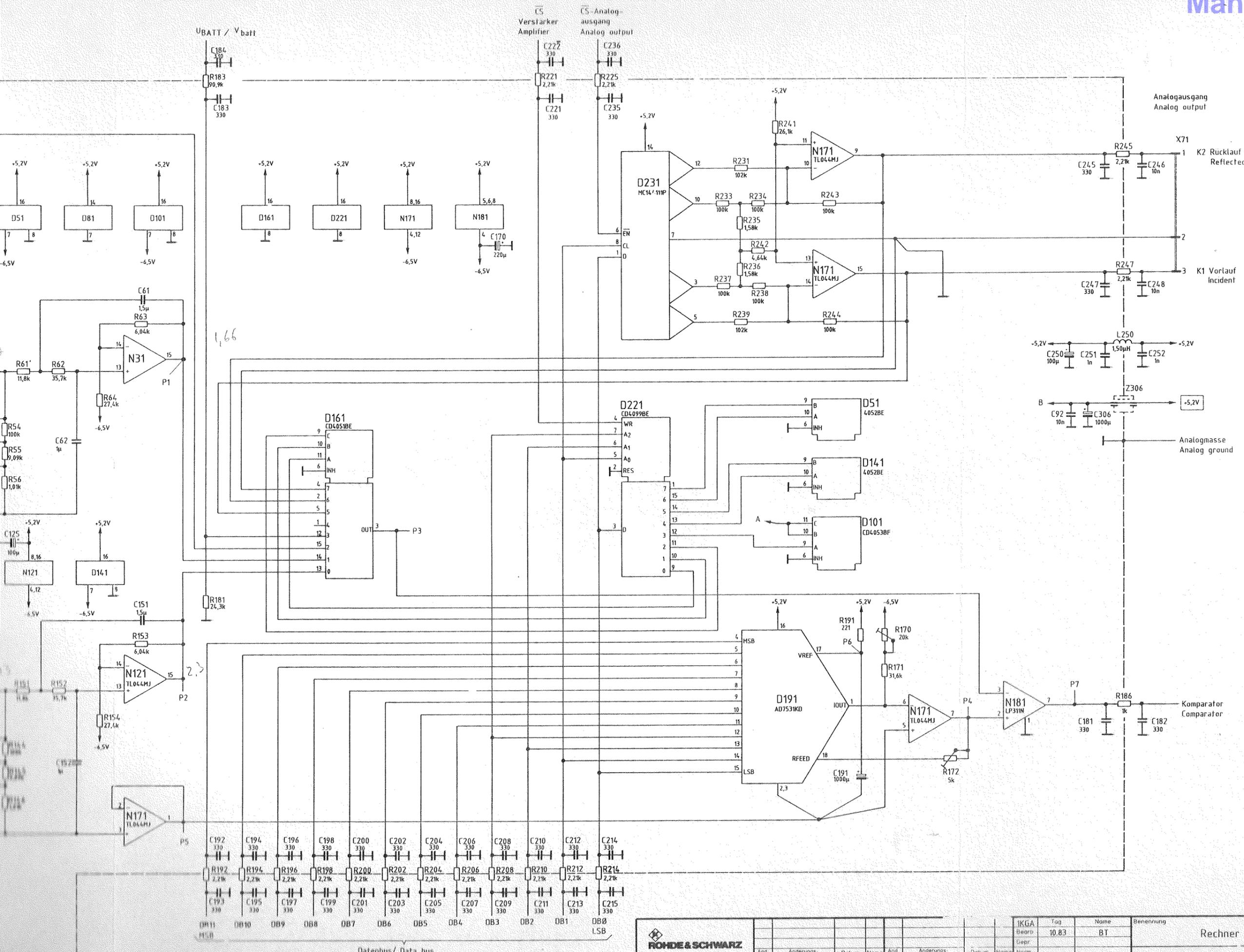
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0.8 V

-0.6

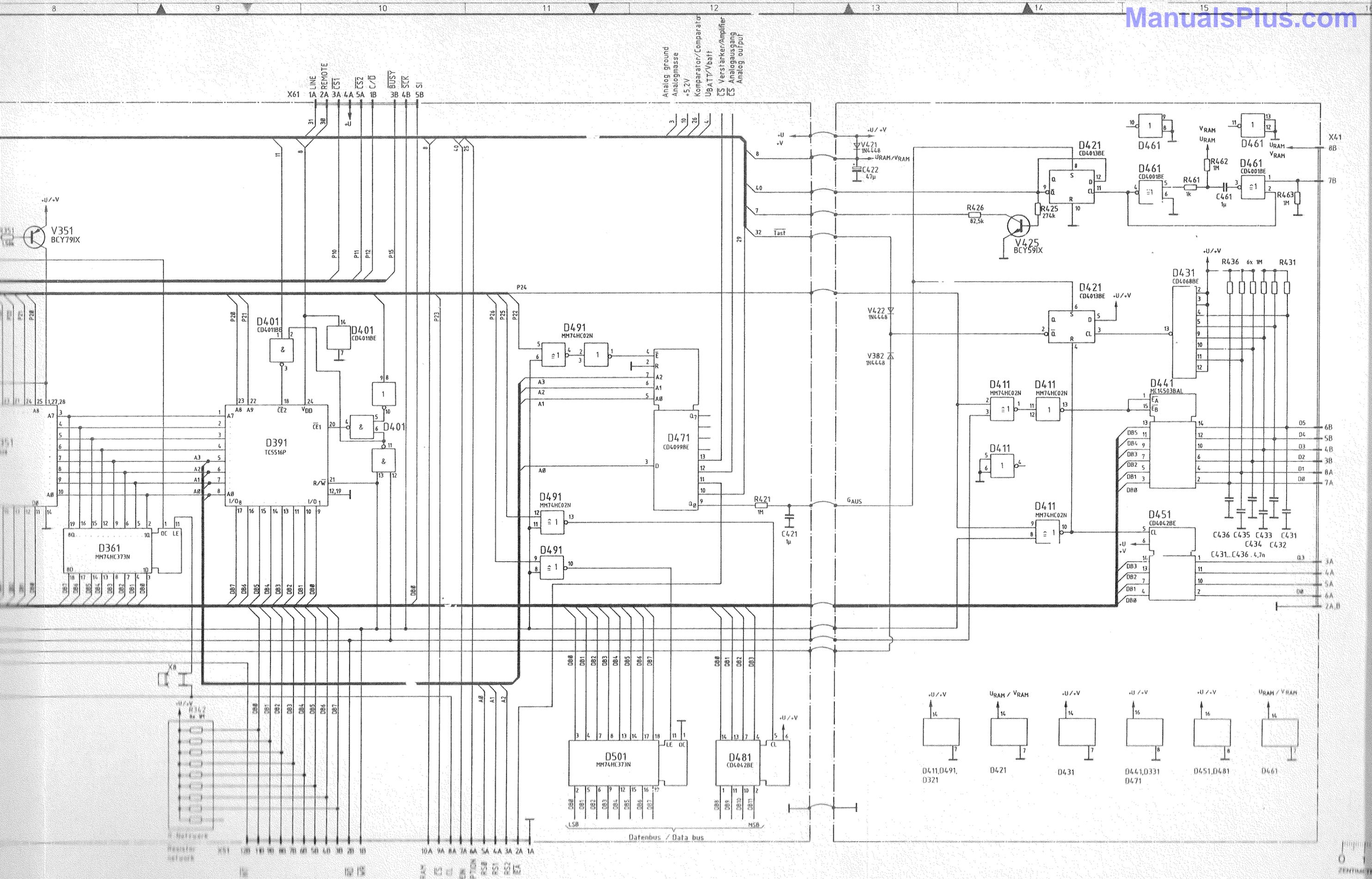
0.23 V

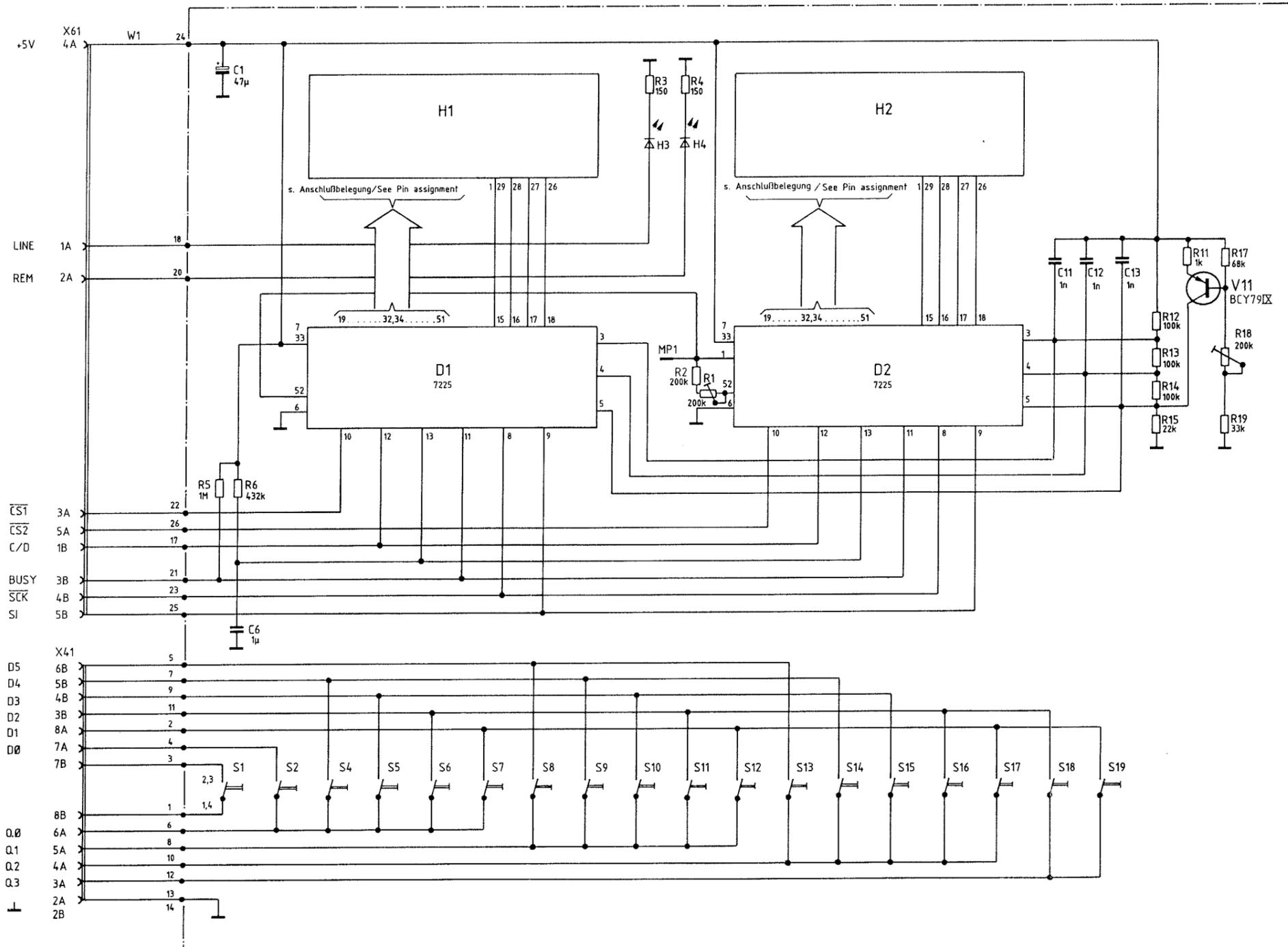
0.33



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And. Zugl. Änderungs-Mitteilung Datum Name And. Zugl. Änderungs-Mitteilung Datum Name Norm.	zu Gerät NAP	reg. i. V. 1974/017	

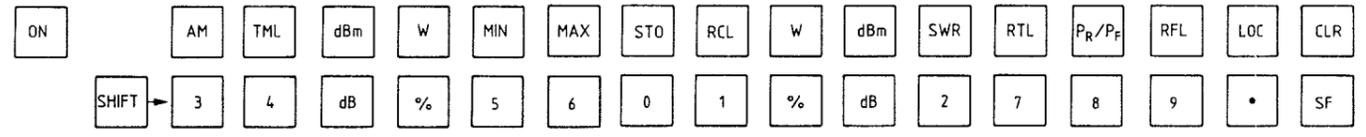
Einbaustelle für Druckerausgang durch diese Zone möglichst nur Leitungen führen





Anschlußbelegung / Pin assignment

Display H1, H2	Treiber Driver D1, D2	Display H1, H2	Treiber Driver D1, D2
2	28	30	51
4	27	31	50
5	26	32	49
6	25	33	48
7	24	35	47
9	23	36	46
11	22	39	45
13	21	40	44
15	20	42	43
17	19	43	42
18	29	46	41
19	30	47	40
20	31	49	39
21	32	50	38
22	34		
23	35		
24	36		
25	37		



Name	
Datum	
And. Nr.	
Name	
Datum	
And. Nr.	

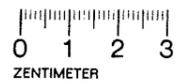
Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

ROHDE & SCHWARZ MÜNCHEN

Name	
Datum	
And. Nr.	
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And. Nr.	

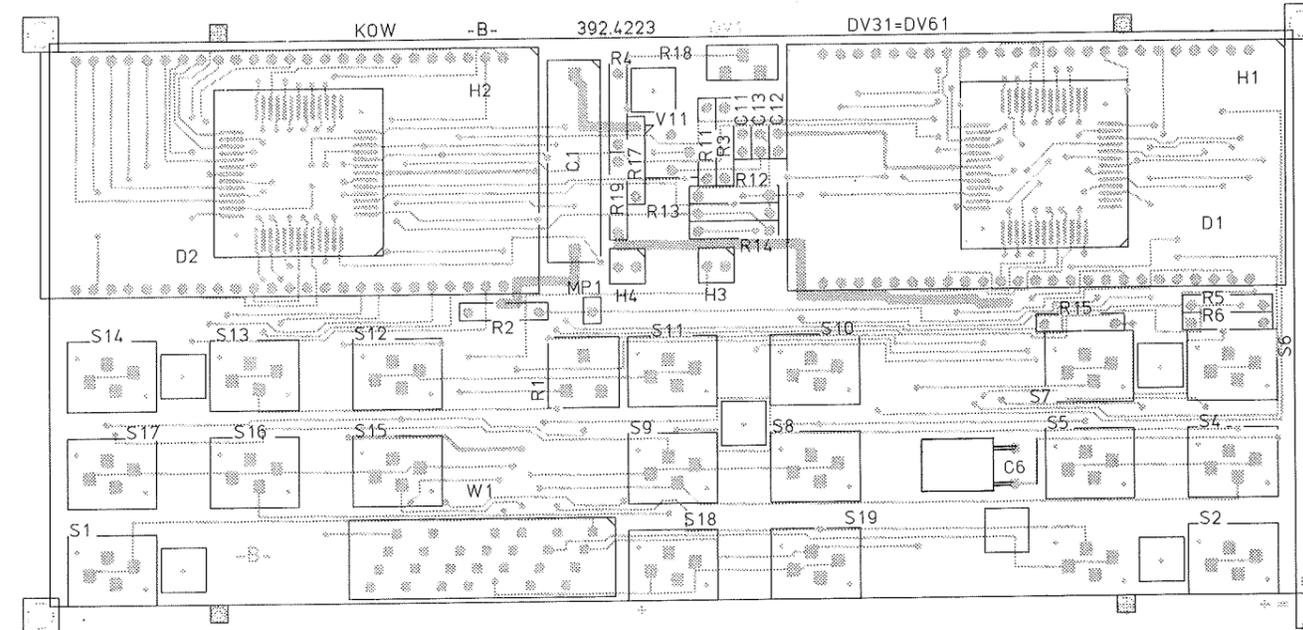
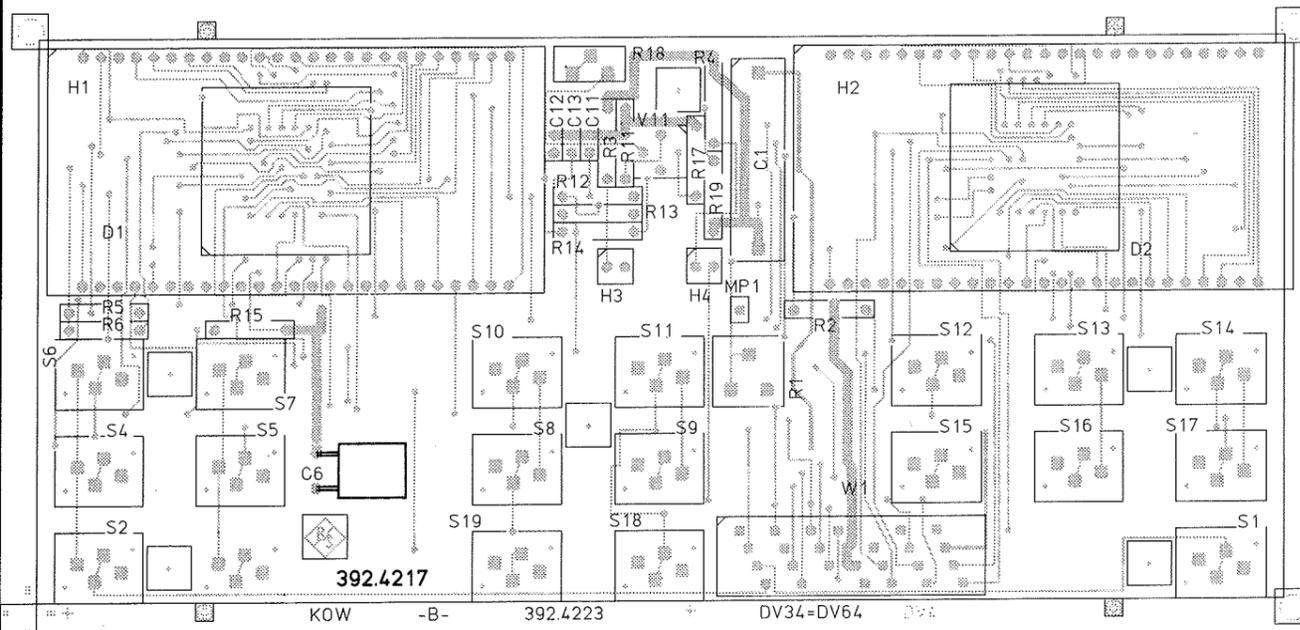
Stromlauf zu
 Tastatur-Anzeige / Keyboard-Display

Zeichn. Nr. 392.4217 S
 392.4017 V 392.4223



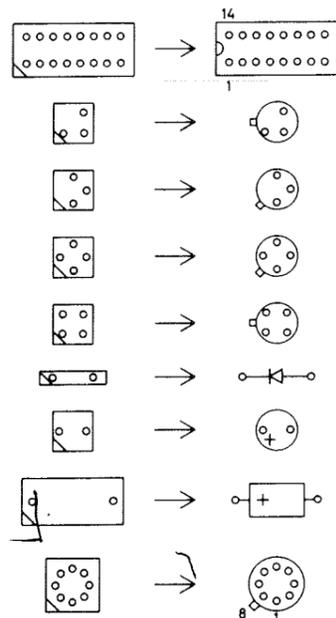
Ansicht und Leitungsführung Bauteilseite
View of tracks on component side

Ansicht und Leitungsführung Lötseite
View of tracks on solder side



Für diese Unterlage behalten wir uns alle Rechte vor

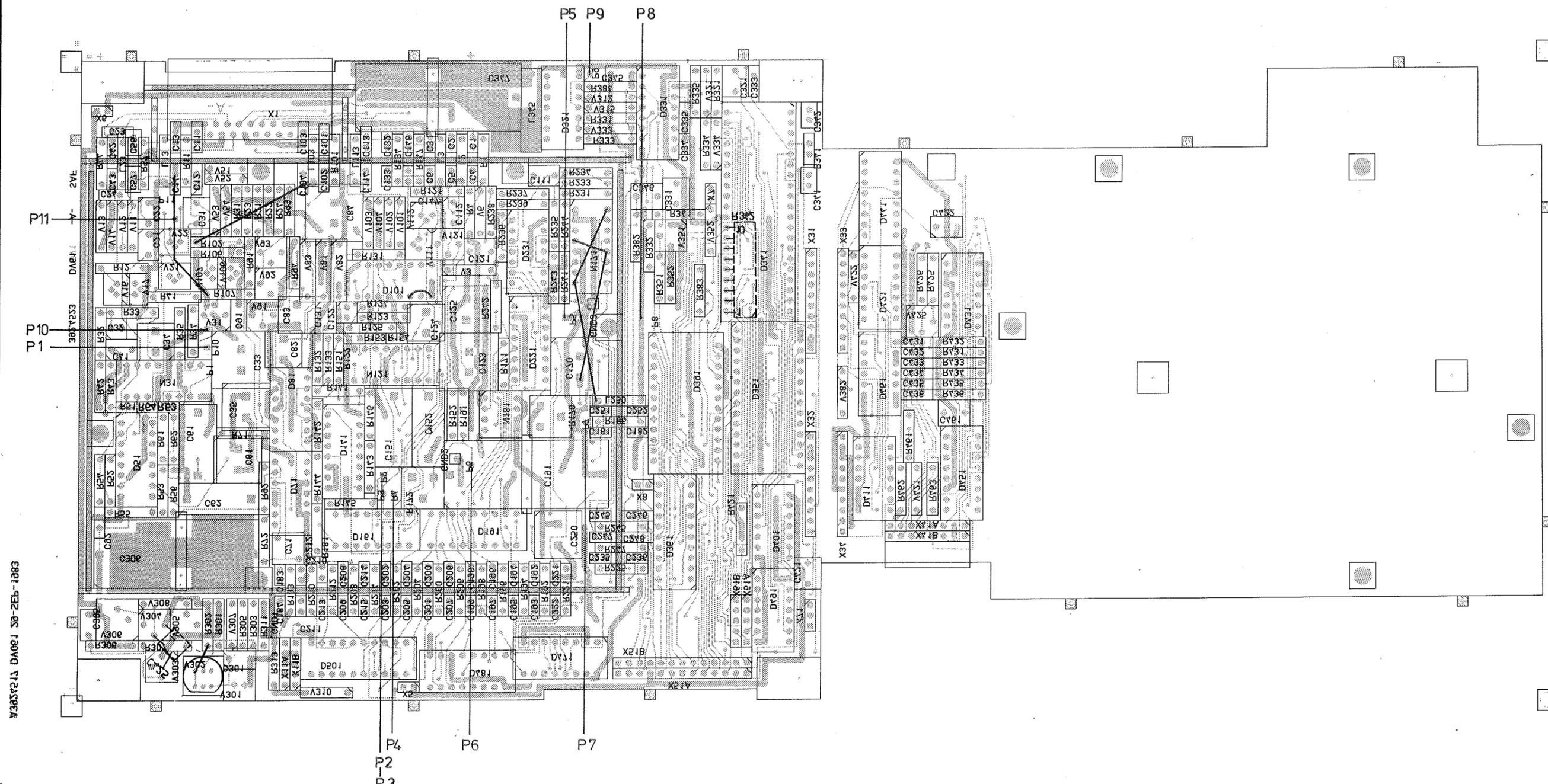
Symbolschlüssel



Achtung! MOS-Bauteile
Caution. MOS components

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						1 KGA Tag Name		Benennung	
						Bearb. 5.83 IB		TASTATUR - ANZEIGE	
						Gepr.		Keyboard-Display	
						Norm		Z	
								Zeichn.-Nr.	
								392.4217	
								Blatt-Nr.	
								2	
								v Bl.	
Änd. Zust.		Änderungs-Mitteilung		Tag		Name		reg. i. V. 392.4017V	
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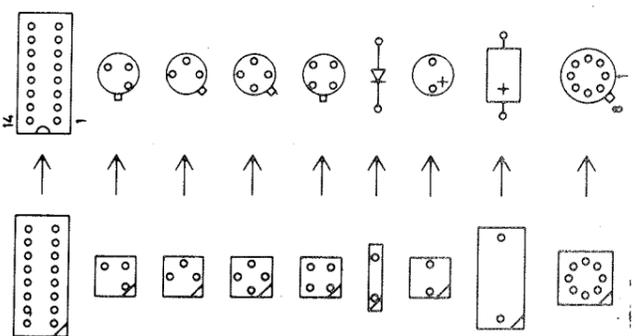
Ansicht und Leitungsführung Lötseite
View of tracks on solder side



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W305213 DA001 30-2EB-1983

Symbol/schlüssel

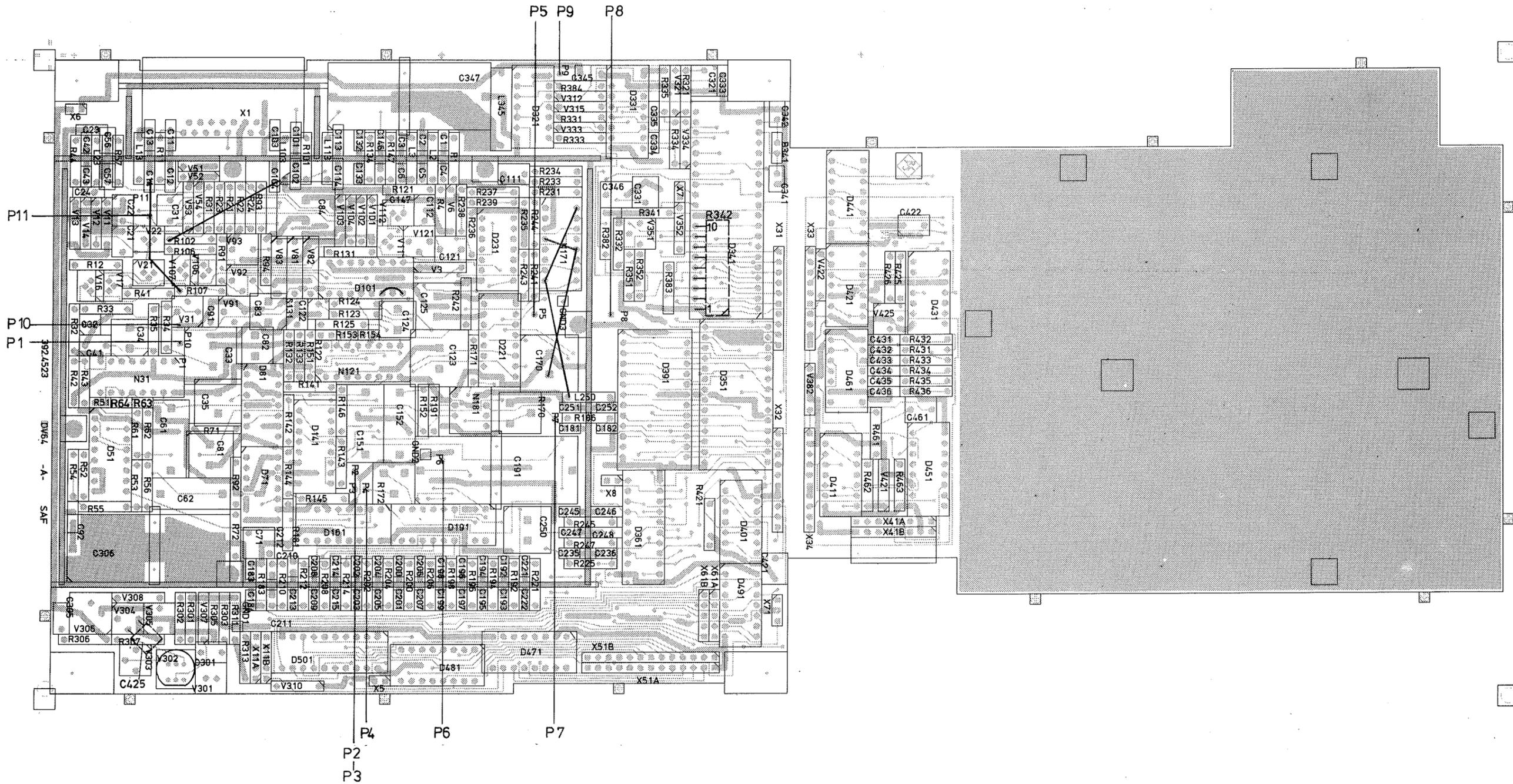


A	30505	11.83	BT	Maße ohne Toleranzangabe	Maßstab 1:1	Halbzeug, Werkstoff	Benennung	Z
B	31622	2.84	BT					
				1KGA	Tag	Name	Rechner	
				Bearb.	9.83	BT		
				Gepr.				
				Norm			Zeichn.-Nr.	Blatt-Nr.
							392.4517	3
							reg. i. V. 392.4017V	erste Z. 392.4017
Änd. Zust.	Änderungs-Mitteilung	Tag	Name			zu Gerät	NAP	

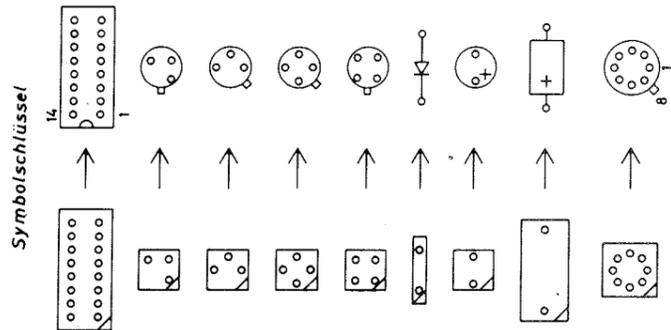
ISO...projektion Methode E

Ansicht und Leitungsführung Bauteilseite
View of tracks on component side

A3924517 DV064 29-SEP-1983



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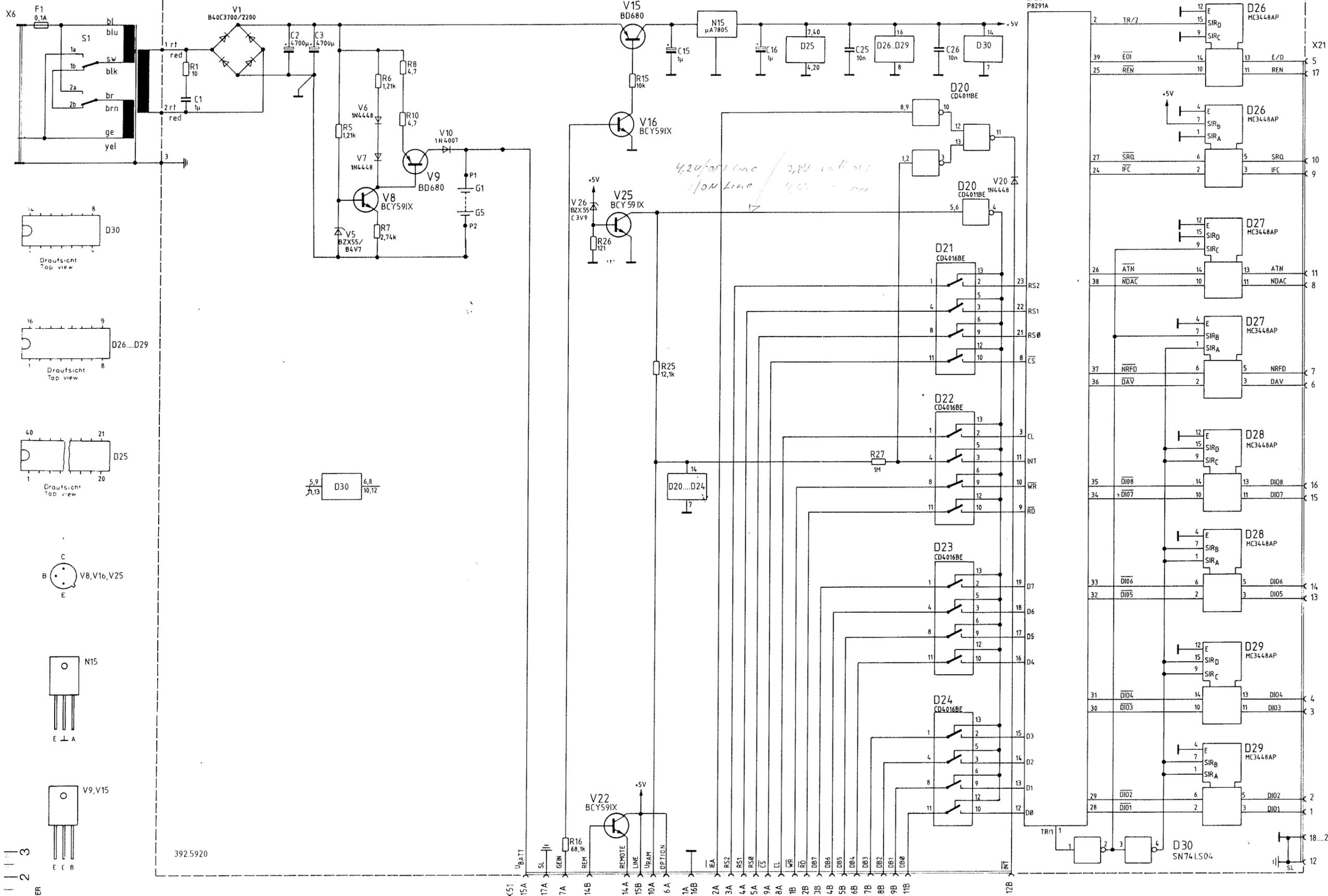
A	30505	11.83	BT	Maße ohne Toleranzangabe	Maßstab 1:1	Halbzeug, Werkstoff	Benennung	Z
B	31622	2.84	BT					
				1KGA	Tag	Name	Rechner	Blatt-Nr. 2
				Bearb.	9.83	BT		
				Gepr.				
				Norm				
						Zeichn.-Nr.		v. Bl.
						392.4517		
And. Zust.	Änderungs-Mitteilung	Tag	Name	zu Gerät		reg. i. V. 392.4017 V		erste Z. 392.4017

Name	
Datum	
Änd. Nr.	
Name	
Datum	
Änd. Nr.	

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ROHDE & SCHWARZ MÜNCHEN

Zeichn.-Nr.	392.5920 S
1/1 GA	
Datum	6.83
Name	bt
Änd. Nr.	
Datum	10.83
Name	bt
Änd. Nr.	
Datum	11.83
Name	bt
Änd. Nr.	

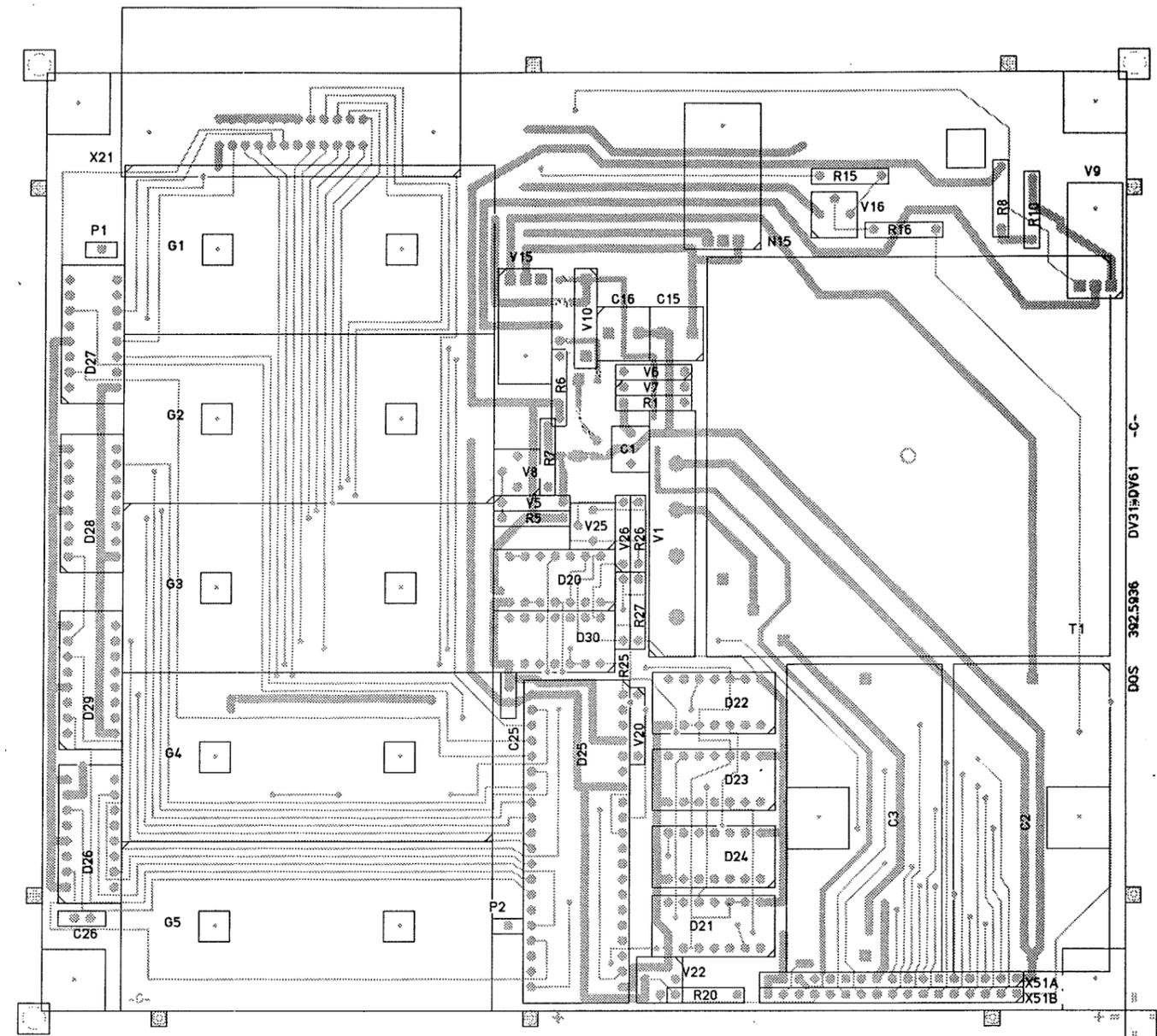
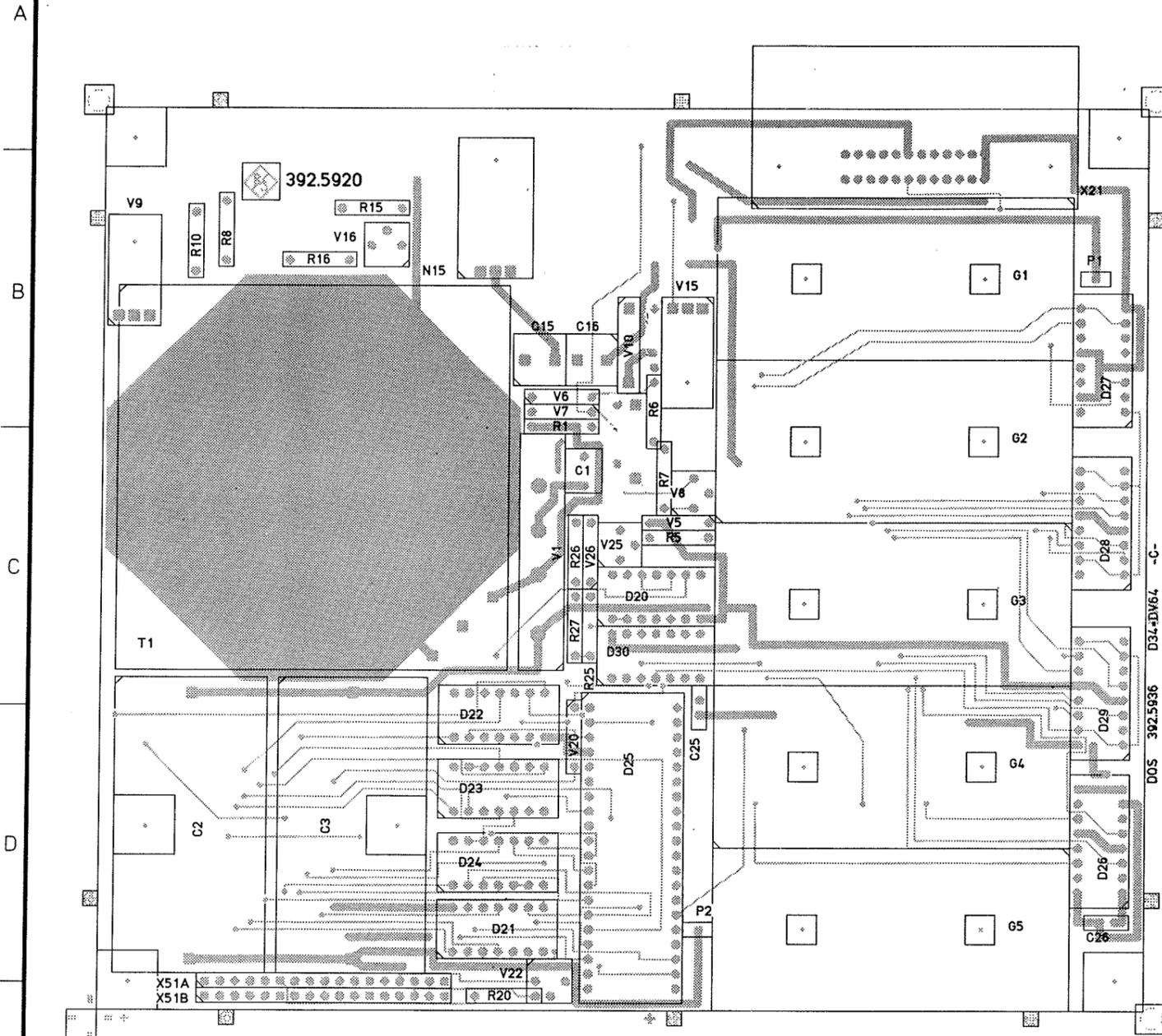


Stromlauf zu NAP-B4
 Netzteil und IEC-Bus / Power supply and IEC-Bus

Zeichn. Nr.	392.5913 S
Z	392.5913
	392.5913 V

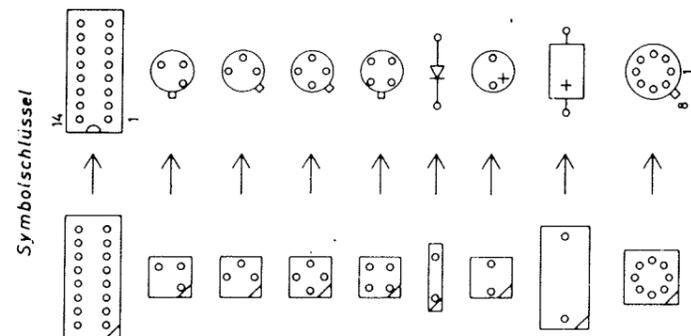
Ansicht und Leitungsführung Bauteilseite
View of tracks on component side

Ansicht und Leitungsführung Lötseite
View of tracks on solder side



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Achtung! MOS - Bauteile
Caution. MOS components



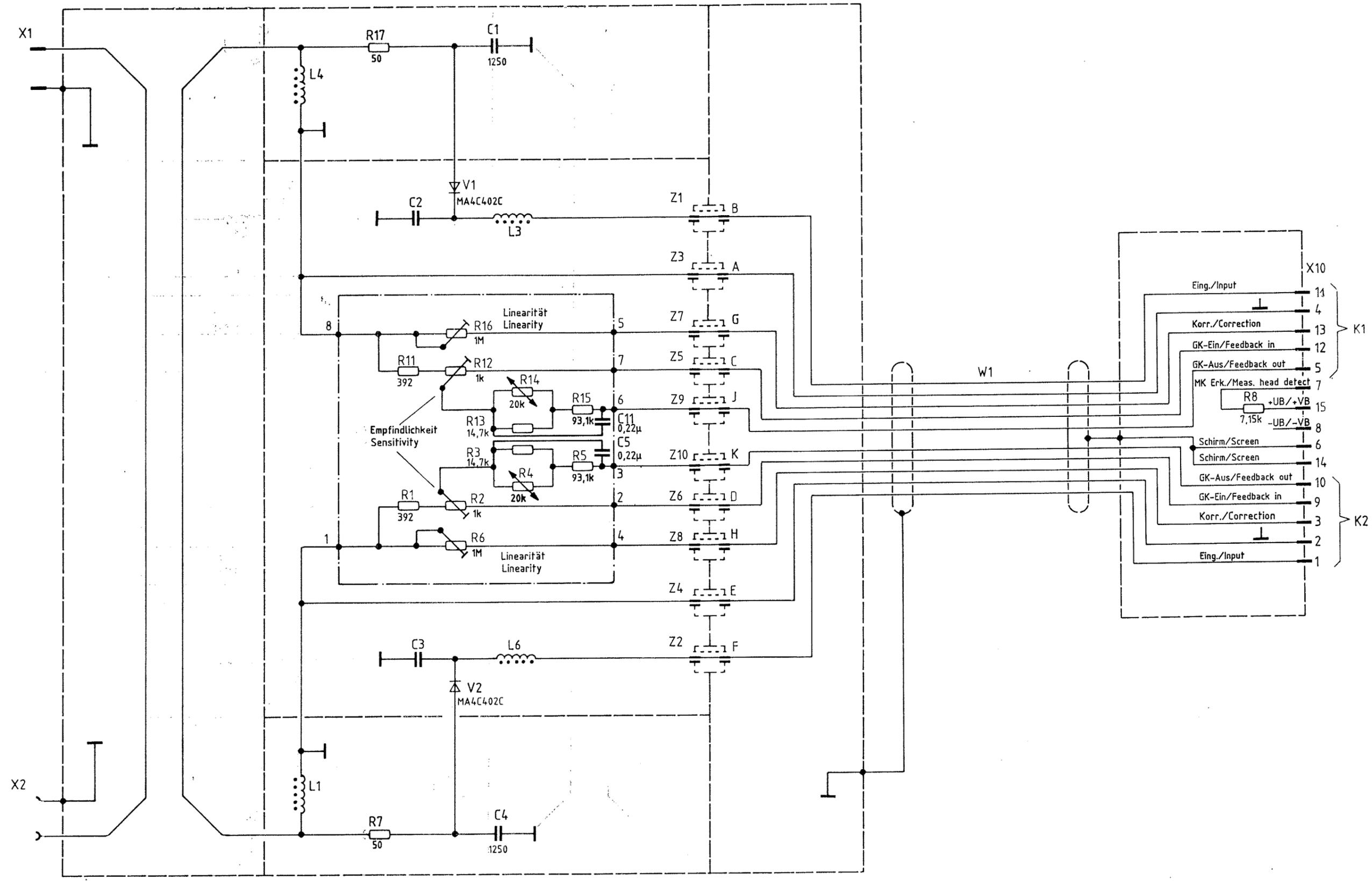
C		7.83	BT	Maße ohne Toleranzangabe	Maßstab 1:1	
E	30793	11.83	BT		Halbzeug, Werkstoff	
				1KGA	Tag	Name
				Bearb	7.83	BT
				Gepr		
				Norm		
				ROHDE & SCHWARZ		Zeichn-Nr
				zu Gerät NAP - B4		392.5920
And Zust	Anderungs-Mitteilung	Tag	Name	reg i V	392.5913 V	erste Z 392.5913
						Blatt-Nr 2 v Bl

And. Nr.	And. Mäng. Nr.
And. Zust.	And. Mäng. Nr.
Name	Name
Datum	Datum
Name	Name
um	um
Name	Name

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ROHDE & SCHWARZ MÜNCHEN

1KGA	10.83	BT
geprüft	30984	BT
normiert	30984	BT
geprüft	10.83	BT
normiert	11.83	BT



Stromlauf zu
 NAP-Z3 Meßkopf/ Measuring head

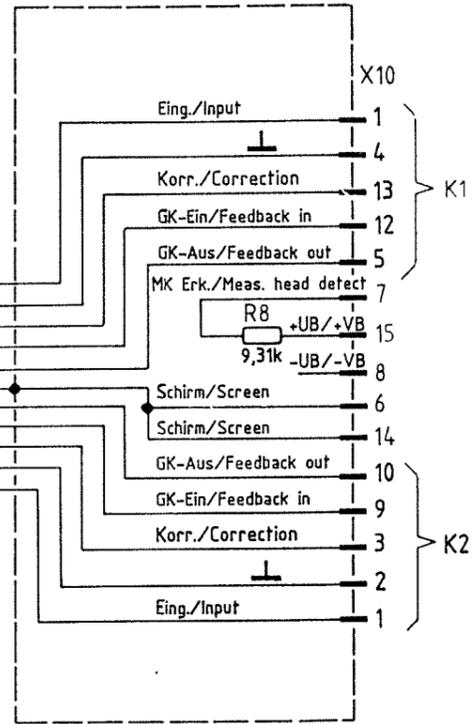
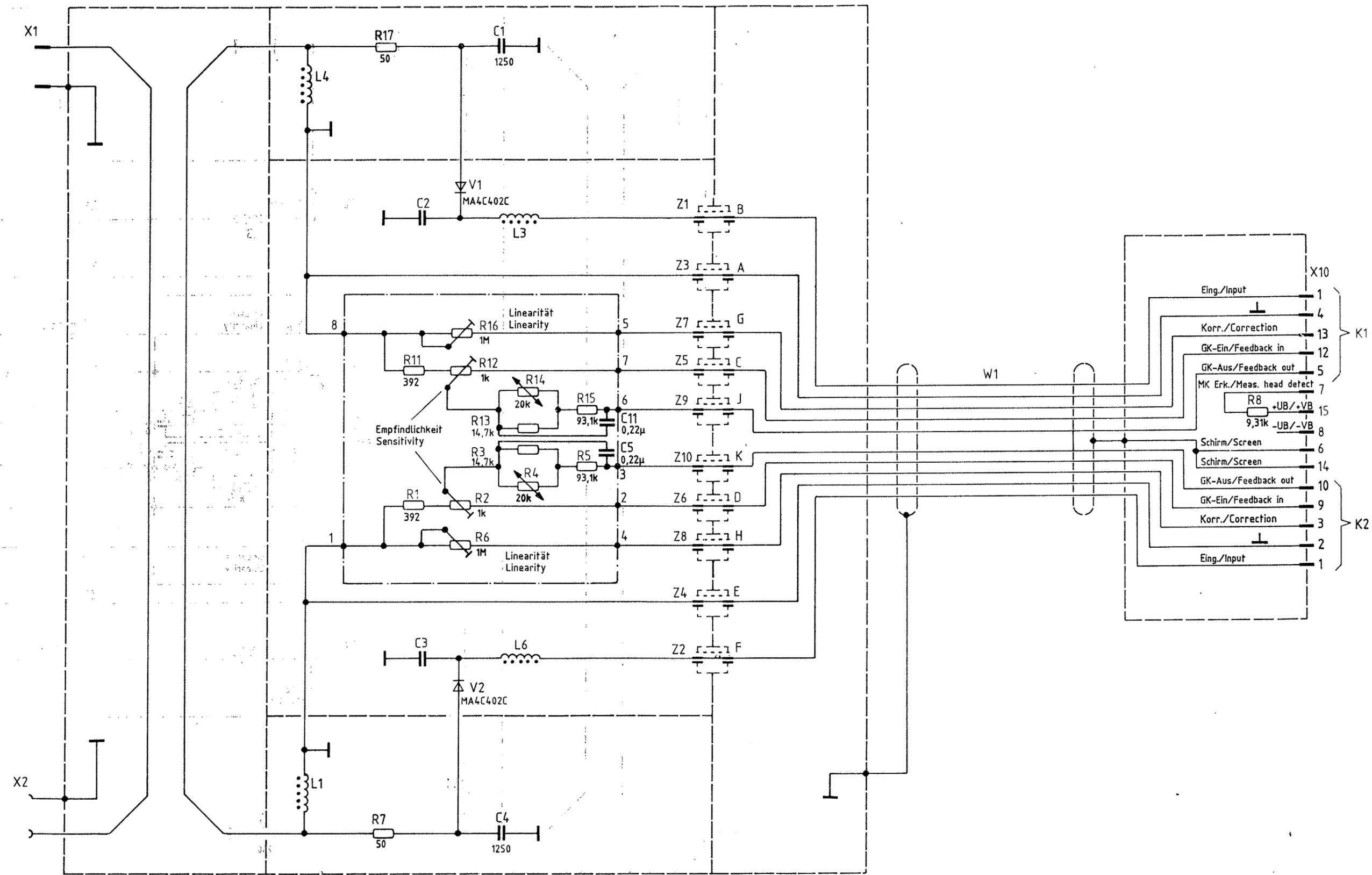
Zeichn. Nr.	392.6610 S
reg. Nr.	392.6610 V erste Z

Name	
Datum	
And. Nr.	
And. Zust.	
Name	
Datum	
And. Nr.	
And. Zust.	

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ROHDE & SCHWARZ MÜNCHEN

IKGA			
Bestell-Nr.	30985	Datum	10.83
Bestell-Nr.	30985	Datum	11.83
Name	gu		BT
Name	bt		BT
Datum	9.83		
geprüft			
normiert			



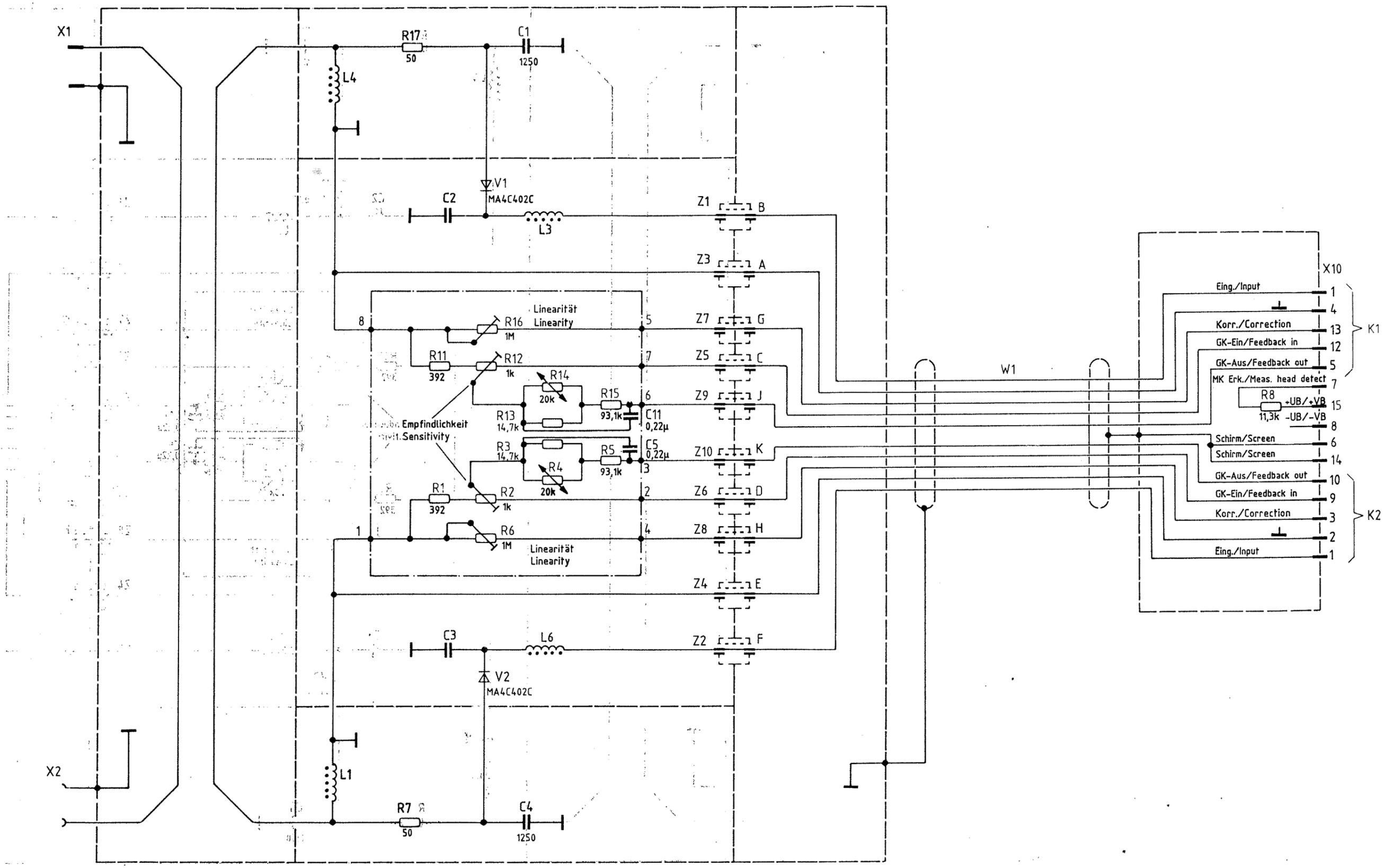
Stromlauf zu
NAP-Z4 Meßkopf/ Measuring head

Zeichn. Nr. **392.6910 S**
 reg. v. **392.6910 V** erste Z

IKGA	Name	gu	bt
9.83	Datum	9.83	11.83
A	30986	10.83	BT
B	30986	11.83	BT

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ROHDE & SCHWARZ MÜNCHEN

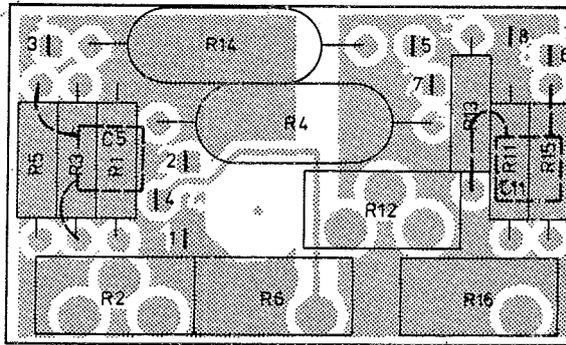


Stromlauf zu
NAP-Z5 Meßkopf / Measuring head

Zeichn. Nr. **392.7116 S**
 reg. IV **392.7116 V** erste Z

Ansicht und Leitungsführung Bauteilseite
View of tracks on component side

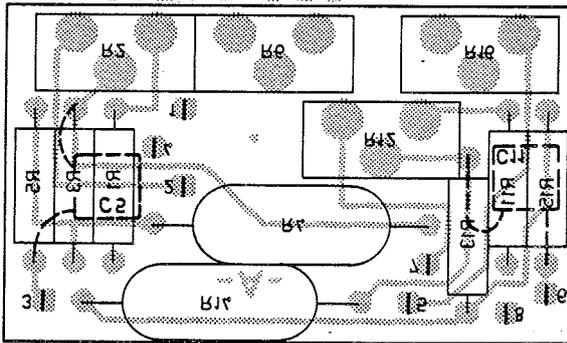
MX6-46,99/Y6-32,39



= 392-6678DV4

Ansicht und Leitungsführung Lötseite
View of tracks on solder side

= 392-6678DV4



392-6678DV4

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A	30984	11.83	BT	Maße ohne Toleranzangabe	Maßstab 2 : 1	Halbzeug, Werkstoff
				1KGA	Tag	Name
				Bearb.	3.83	BT
				Gepr.		
				Norm		
					Benennung	Meßkopfplatte
					Zeichn.-Nr.	392.6661
						Blatt-Nr. 2
And Zust	Anderungs-Mitteilung	Tag	Name	zu Gerät NAP - Z3		v. BI
				reg. i. V.	erste Z	

2.3 Operation

With the aid of the NAP display section and one of the Power Heads NAP-Z3 to Z6 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.

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
Measurement range 1	0.35 W	1.1 W	3.5 W	11 W
Measurement range 2	3.5 W	11 W	35 W	110 W
Measurement range 3	35 W	110 W	350 W	1100 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 3¹/₂ 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.

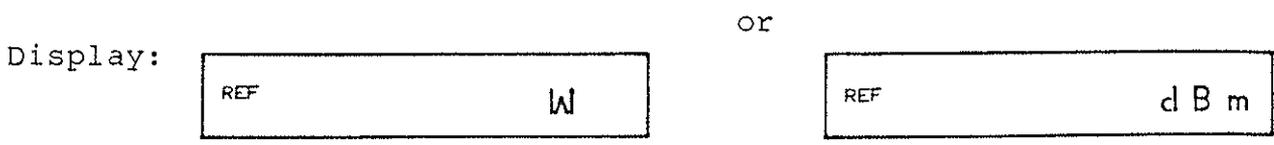
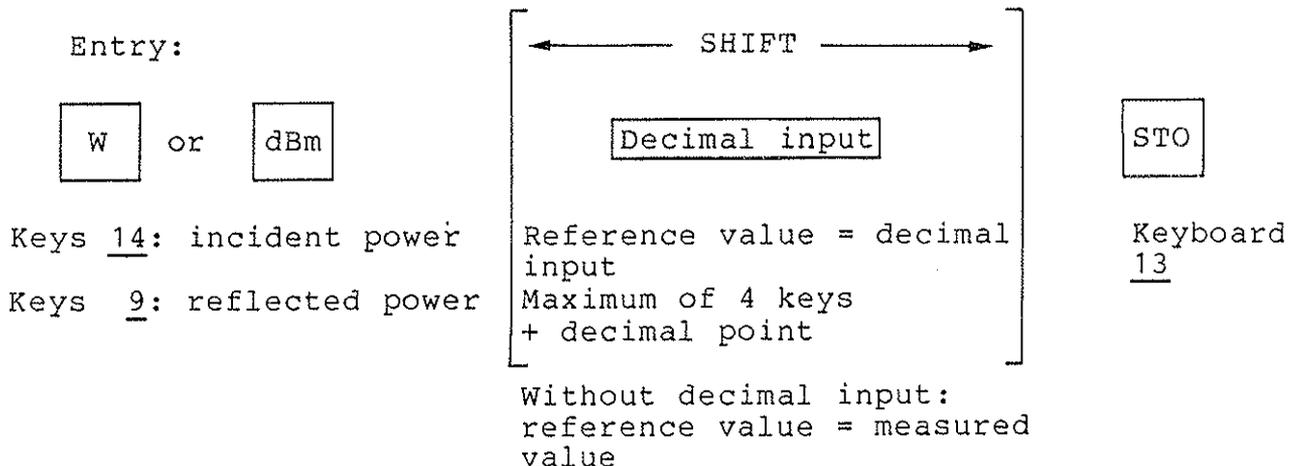
2.3.2 Measuring Relative Power Variations

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:



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, <1999 W and <63 dBm).

b) Measuring the relative power variation:

Entry: SHIFT SHIFT
 % W or dB dBm
 Keys 14: incident power
 Keys 9: reflected power

Display: or
% dB^Δ

c) Checking the reference value:

Entry: W or dBm RCL
 Keys 14: incident power Keyboard 13
 Keys 9: reflected power

Display: or
REF W 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:

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

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 Z6, 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:

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

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 keys 9 or 14 during a measurement sequence.

Each time a measurement function is entered via keys 9 or 14, 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.

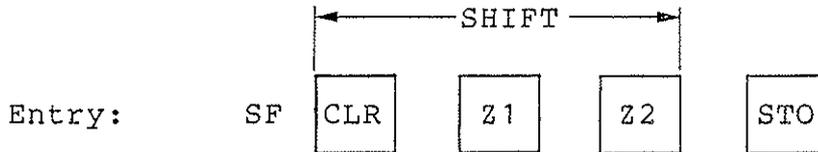
When a measurement function is entered via keys 9 or 14, the display of minimum or maximum value is superseded by the display of the current measured values. Now a new minimum/maximum storage begins for the measurement function entered. For the measurement function indicated on the other display, however, 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 0.

2.3.10 Special Functions

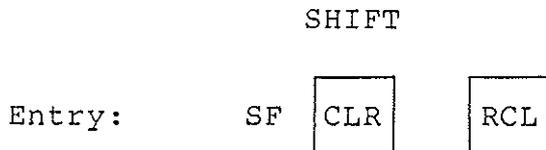
The special functions permit device settings to adapt the NAP to special measurement tasks. However, since these special functions are not required very often, no extra keys are provided for them. Therefore, the settings have to be made via decimal inputs.

Storing special functions:



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 (SF41/60) are not displayed in this way.

Calling up stored special functions:



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

.5.23

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.

.5. - -

The following special functions can be set:

- SF0 Clears all stored special functions and the letter "S" on the right-hand display.
- SF11 Range 1 } Switch on in measuring
 SF12 Range 2 } channel 1.
 SF13 Range 3 }
- SF21 Range 1 } Switch on in measuring Only applies if
 SF22 Range 2 } channel 2. power heads are
 SF23 Range 3 } used.
- SF30 The ranges set in measuring channels 1 and 2 at the time of this entry are retained (hold ranges).
- SF32 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.
- SF33 Fast analog display in battery operation. The lifetime of the battery is thereby reduced by the factor ≈ 5 .
- SF40 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).
- SF41 Calls up the zero measurement prematurely. The next zero measurement is performed 10 minutes after this entry. (This ensures the output of the measured value for 10 minutes without interruption by a zero measurement when calling via a device-specific IEC-bus command.)
- SF43 Corrects the zero offset occurring in the power head during temporary variations of the ambient temperature.
- SF60 Displays the battery voltage in volts on the right-hand display.
 Example:

U 5.9

Minimum value: 5.4 V
 (Display only possible in battery operation.)

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

An alle R & S-VERTRETUNGEN
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41 29- 2973München, den
MunichBlatt
Page
17Betrifft
Subject.**Important sales information!**
=====

Because of delivery problems of the firm of Intel, some of the NAP display sections must be equipped with another μ P. Since this entails a higher power consumption, the data-sheet specifications are modified as stated below:

- a) Operating time from storage batteries about 10 h.
Because of the higher current drain, instruments including a HMOS processor are only supplied together with option NAP-B4 (AC supply/ IEC-bus).
- b) During operation from storage batteries, only rapid analog display is possible (12.5 changes/s).

There are no restrictions in the case of operation from AC supply. As soon as the CMOS microprocessor 80C31 is available again, the characteristics stated in the data sheet can on customer's request be fully restored without further modifications being required by simply exchanging the microprocessor. (For exchanging the μ P, switch off the NAP and remove one storage battery).

This special model (with HMOS processor) will only be supplied as demo unit

In the case of urgent requirements of customers, this special version may also be supplied as a batch-produced unit after due consultation with you and the customer.

Basically, orders will only be carried out by supplying units equipped with the CMOS μ P 80C31.