ROHDE&SCHWARZ

Manual

VECTOR ANALYZER ZPV

291.4012.93

Printed in West Germany

R 39382 - 1

Table of Contents

1. Data Sheet
Uses
Characteristics
Specifications
Equipment Supplied
Recommended Extras

2. Preparation for Use and Operating Instructions 5
2.1 Legend for Figure 2-1 5
2.2 Preparation for Use 9
2.2.1 Exchanging the Plug-in 9
2.2.2 Adjusting to the Local AC Supply 9
2.2.3 Setting up 9
2.2.4 Switching on 9
2.3 Operating Instructions 10
2.3.1 General 10
2.3.1.1 Basic Settings 10
2.3.1.2 Changing the Mode of Operation 10
2.3.1.3 Electronic Locking of Pushbuttons 10
2.3.2 Vector Measurement 11
2.3.2.1 Voltage Measurement in Channel A 11
2.3.2.2 Voltage Measurement in Channel B 11
2.3.2.3 Measurement of the Voltage Ratio of Channel B to Channel A 11
2.3.3 Parameter Measurement 12
2.3.3.1 Reflection Factor Measurement 12
2.3.3.2 Impedance Measurement 13
2.3.3.3 Admittance Measurement 13
2.3.3.4 Transmission Measurement 13
2.3.4 Group Delay Measurement 14
2.3.4.1 Single Measurement 14
2.3.4.2 Continuous Measurement 15
2.3.4.3 Measurement of Group Delay Difference 15.1
2.3.5 Indication of Reference Value 15.1
2.3.6 Stabilization of Test Results 15.1
2.3.7 Disconnecting the Autoranging Facilities 16

2.3.7.1 Disconnecting the Amplitude Autoranging Facility 16
2.3.7.2 Disconnecting the Frequency Autoranging Facility 16
2.3.8 Quasi-analog Indication 16
2.3.9 Analog Voltage Inputs/Outputs 16
2.3.9.1 IF Outputs IF/1 V.. 16
2.3.9.2 SWEEP/1 V Outputs 17
2.3.9.3 REC./1 V Outputs 17
2.3.9.4 ΔF CONTR. Output 17
2.3.9.5 DC Input ADC/10 V 17
2.4 Remote Control 18
2.4.1 General 18
2.4.2 Switchover to Local, Remote or Combined Operation 18
2.4.3 Setting the Device Address 18
2.4.4 Setting the Last Character 18
2.4.5 Disconnecting the Service Request 19
2.4.6 Programming Commands 19
2.4.7 Internal/External Trigger Operation 19
2.4.8 Data Output 19
2.4.8.1 Output of Lefthand Readout (7) 19
2.4.8.2 Output of Righthand Readout (12) 20
2.4.8.3 Output of Lefthand and Righthand Readouts (7 and 12) ... 20
2.4.8.4 Output of Measurement Range of Channel A 20
2.4.8.5 Output of Measurement Range of Channel B 21
2.4.8.6 Output of Frequency Range of Plug-in 21
2.4.8.7 Output of DC Voltage at ADC Input 21
2.4.8.8 Output of Device Status Word 21
2.4.8.9 Output of Status Byte with Serial Polling 22
2.4.8.10 Output of Test Frequency with Tuner ZPV-E1 22
2.4.9 Programming Examples for Desktop Calculators PPC and TEK 4051/52 22
2.4.9.1 Programming of Device Setting 22
2.4.9.2.1 Programming of Frequency Range 22
2.4.9.2.2 Programming of Frequency Setting with ZPV-E1 23
2.4.9.3 Reading out a Complete Test Result 23
2.4.9.4 Transfer of Device Status Word 24
2.4.9.5 Service Request (SRQ) when using the ZPV + TEK 4051/52 25
2.4.9.6 Increasing the Test Rate in Programmed Operation 25
2.4.9.7 Input and Output of Reference Value for Relative Measurements 26
2.4.9.8 Phase Offset 26

2.5	Measurement of Crystal Equivalent Circuit Parameters ...	27
2.5.1	General ...	27
2.5.2	Manual Measurement ...	28
2.5.2.1	Vector Measurement ...	28
2.5.2.2	S-parameter- and Z-measurement ...	28
2.5.3	Automatic Measurement ...	29
2.5.4	Control Amplifier ...	30
2.5.4.1	Hints for the Adjustment of the Potentiometers P1 and P2 ...	31
3.	**Maintenance and Repair** ...	32
3.1	Required Measuring Equipment and Accessories ...	32
3.2	Checking the Rated Specifications...	33
3.2.1	Indication Error of Magnitude Range ...	33
3.2.2	Crosstalk Attenuation ...	34
3.2.3	Error of Phase Indication ...	34
3.2.4	Narrowband Sweeping ...	35
3.2.5	Basic Setting for Switching on AC Supply ...	36
3.2.6	Control of Analog Section ...	36
3.2.7	Operating and Indicating Elements ...	36
3.2.8	Calculator Routines ...	37
4.	**Circuit Description** ...	38
4.1	Analog Section ...	38
4.1.1	Amplitude Measurement ...	38
4.1.2	Phase Measurement ...	41
4.1.3	Narrowband Sweeping ...	44
4.1.4	Power Supply ...	46
4.2	Digital Section ...	47
4.2.1	Computer Board Y21 ...	48
4.2.2	Front Panel Y1 ...	50
4.2.3	D/A Converter Y32 ...	52
4.2.4	IEC Interface ...	52
5.	**Repair Instructions** ...	55
5.1	Required Measuring Equipment and Accessories ...	55
5.2	Adjustments ...	56
5.2.1	Power Supply ...	56

5.2.2	IF-Section, Amplitude Measurement Branch	57
5.2.3	Phase Measurement Branch	58
5.2.3.1	Phase Indication	59
5.2.4	Narrowband Sweeping	60
5.2.5	Digital Filter	61
5.3	Trouble Shooting in the Digital Section	62
5.3.1	General	62
5.3.2	Signature Analysis	63
5.3.2.1	Checking the ROM Content and the Address and Data Busses	64
5.3.2.1.1	Purpose	64
5.3.2.1.2	Preparation	64
5.3.2.1.3	Checking the Total ROM Content	65
5.3.2.1.4	Trouble-shooting in the ROM Range	65
5.3.2.2	Checking the Entire Digital Section	65
5.3.2.2.1	Purpose	65
5.3.2.2.2	Preparation	65
5.3.2.2.3	Trouble-shooting in the Digital Section	66

<u>Parts Lists</u>

<u>Circuit Diagrams</u>

<u>Components Plans</u>

2. Preparation for Use and Operating Instructions

2.1 Legend for Figure 2-1

No.	Engraving	Function
1		Plug-in for ZPV
2	LOCAL COMB. REMOVE	Slide switch for selecting the local, remote or combined local plus remote control mode.
3	AMPL. STOP AUTORANGING	Pushbutton for switching on and off the amplitude autoranging facility.
4	AMPL. STOP AUTORANGING	Status indication of amplitude autoranging facility; lights up if amplitude autoranging is switched off.
5	FREQ. STOP AUTORANGING	Pushbutton for switching on and off the frequency autoranging facility.
6	FREQ. STOP AUTORANGING	Status indication of frequency autoranging facility; lights up if frequency autoranging is switched off.
7		Digital readout for one component of the test result.
8		Quasi-analog tendency indication for one component of the test result by an LED line.
9	LEVEL REF. STORE	Pushbutton for storing the voltage reference value.
10	PARAM. CAL.	Pushbutton for storing a voltage and phase reference value for vector measurements and when calibrating the test setup for parameter measurements.
11	φ, τ REF. STORE	Pushbutton for storing a phase or group-delay reference value (depending on the mode selected).
12		Digital readout for one component of the test result.
13		Quasi-analog tendency indication for one component of the test result by an LED line.
14	r, φ	Status indication of polar coordinate display; lights up if this mode is selected.

No.	Engraving	Function
15	r, φ	Pushbutton for selecting polar coordinate display.
16	X, Y	Status indication of Cartesian coordinate display; lights up if this mode is selected.
17	X, Y	Pushbutton for selecting Cartesian coordinate display.
18	○ □ ⊥ I	Power switch
19	RECALL REF.	On/off button for displaying the reference values in readouts 7 and 12; lights up in the ON state.
20	FILTER	On/off button for stabilizing the test results with the aid of an electronic filter; lights up if the filter is switched in.
21	LIN.	Luminous button for selecting linear display of test results.
22	LIN./REF. (VSWR)	Luminous button for selecting linear display in relation to a reference value (also VSWR in conjunction with 32).
23	LOG.	Luminous button for selecting logarithmic display of test results.
24	LOG. REF.	Luminous button for selecting logarithmic display in relation to a reference value.
25	B	Luminous button for selecting voltage measurement in channel B and measurement of the phase angle between channel A and channel B.
26	A	Luminous button for selecting voltage measurement in channel A and measurement of the phase angle between channel A and channel B.
27	B/A	Luminous button for selecting ratio measurement of voltage in channel B referred to voltage in channel A plus measurement of phase angle between channel A and channel B.
28	Y	Luminous button for selecting admittance measurement.

No.	Engraving	Function
29	50 Ω ○ 75 Ω ☼	Luminous button for entering the characteristic impedance of the test system: On = 75 Ω Out = 50 Ω
30	Z	Luminous button for selecting impedance measurement.
31	DIR. COUPL.	Luminous button for entering information on test setup used: On = test setup with directional coupler or VSWR bridge Out = test setup without directional coupler or VSWR bridge
32	S11, S22	Luminous button for selecting measurement of s parameters s_{11} or s_{22} (reflection factors).
33	S21, S12	Luminous button for selecting measurement of s parameters s_{21} or s_{12} (transmission factors).
34	τ	Luminous button for selecting group delay measurement.
35	CAL.	Luminous button for selecting frequency deviation adjustment for automatic group delay measurement; lights up during the adjustment procedure.
36	$\Delta\tau$	Luminous button for selecting measurement of group delay deviation from a reference group delay value.
37	SET f_o + 40 kHz	Luminous button for entering the frequency deviation of 40 kHz.
38	AUTO XTAL	Luminous button for selecting automatic group delay measurement with generator deviation control. Selection of crystal measurement.
39	SET f_o + 4 kHz	Luminous button for entering the frequency deviation of 4 kHz.
40	SET f_o HIGH Z	Luminous button for entering the test start in the case of manual two-point and high-impedance Z measurements.

No.	Engraving	Function
41	SET $f_o + 0.4$ kHz	Luminous button for entering the frequency deviation of 0.4 kHz.
42	⏚ 47 - 420 Hz	AC supply connector
43	220 V T 0.8 B 235 V 115 V T 1.6 B 125 V	Voltage selector plus fuse holder.
44		Air filter of blower.
45	A IF/1 V	IF output of channel A.
46	B IF/1 V	IF output of channel B.
47	r SWEEP/1 V	Recorder output for the magnitude with narrowband sweeping.
48	φ SWEEP/1 V	Recorder output for the phase with narrowband sweeping.
49	r, X REC./1 V	Recorder output for the magnitude or real component.
50	φ, Y REC./1 V	Recorder output for the phase or imaginary component.
51	CONTR. ΔF	Recorder output for deviation control in the case of automatic group delay measurement.
52	ADC/10 V	DC voltage test input. (see 2.3.9.5)
53	IEC BUS	IEC bus connector (24 poles, Amphenol).

2.2 Preparation for Use

2.2.1 Exchanging the Plug-in

After unlocking the plug-in (1), it can be withdrawn and exchanged; the new plug-in should be locked again. During this procedure the ZPV must be switched off.

2.2.2 Adjusting to the Local AC Supply

The instrument is factory-set for an AC supply voltage of 220 V, the frequency range covering 47 to 420 Hz. By changing the position of the voltage selector 43, the ZPV can be operated also from a 115, 125 or 235 V supply. To this effect the fuse in 43 is unscrewed and the cover of the voltage selector withdrawn. Then the cover is reinserted such that the mark points to the desired AC supply voltage and the corresponding fuse is screwed in:

T 1, 6 B for 115 or 125 V
T 0, 8 B for 220 or 235 V.

The AC supply is connected to 42 using the supplied power cord. The instrument performance is not affected by AC supply fluctuations of ±10% from nominal. In the case of greater variations, a transformer or a voltage regulator should be connected ahead of the ZPV.

2.2.3 Setting up

The ambient temperature should not exceed 45°C; for this reason, direct insolation is to be avoided. To permit easy reading of the test results, a tilt stand can be swung out on the bottom of the instrument. The ZPV is fully isolated from the AC supply and provided with safety earthing. Chassis connection to the test item is made via the plug-in. If required, an additional ground connection can be established at the lefthand, lower screw fixing the front panel.

2.2.4 Switching on

To switch the ZPV on, button 18 is pressed; the instrument is ready for operation after about 1 s. When the ZPV is switched on, the buttons and the readout should light up.

2.3 Operating Instructions

2.3.1 General

2.3.1.1 Basic Settings

After switching the ZPV on, the voltage measurement mode in channel A is automatically set. The output of the test result magnitude and phase is linear (mV). The amplitude and frequency autoranging facilities are connected and filter 20 is switched off.

The position of the mode selector 2 is important; see 2.3.1.3.

2.3.1.2 Changing the Mode of Operation

When changing the mode of operation (vector, parameter, group-delay measurement), automatic switchover to the physical unit (linear or logarithmic, absolute or relative) previously stored in this mode is performed if meaningful. Changing the unit does not make sense when switching over from button

25 to 26; 28 to 30; 32 to 33.

The information on the test setup entered with 29 and 31 is applicable for buttons 28, 30, 32 and 33.

The states selected with 3, 5, 15, 17, 19 and 20 are not stored and are therefore maintained irrespective of any change of the mode operation.

2.3.1.3 Electronic Locking of Pushbuttons

In position REMOTE of switch 2 all pushbuttons are electronically locked, only remote control being possible.

Depending on the mode of operation, some modes of indication do not make sense or are not realized for the remaining positions of switch 2. These specific modes cannot be selected due to electronic locking of the pushbuttons. However, the modes of operation as such can be switched in (25, 26, 27, 28, 30, 32, 33, 34, and 36).

2.3.2 Vector Measurement

2.3.2.1 Voltage Measurement in Channel A

By pressing button A 26, the voltage in channel A and the phase angle between channels A and B, referred to channel A, are measured. The phase is measured as absolute phase (21 or 23 pressed) or relative to a reference value (22 or 24 pressed) and indicated in degrees. The following voltage indication modes can be selected:

a) absolute linear indication in mV by pressing button LIN. 21

b) linear indication referred to a reference value by pressing button LIN.REF. 22

c) absolute logarithmic indication in dBm by pressing button LOG. 23

d) logarithmic indication in dB referred to a reference value by pressing button LOG./REF. 24.

The voltage reference is the measured value at which button LEVEL REF. STORE 9 is pressed. The phase reference is the measured value at which button φ, τ REF. STORE 11 is pressed.

For the basic setting the voltage reference is 1 mV and the phase reference 0°.

2.3.2.2 Voltage Measurement in Channel B

By pressing button B 25, the voltage in channel B and the phase angle between channels A and B, referred to channel A, are measured. The phase is measured as absolute phase (21 or 23 pressed) or relative to a reference value (22 or 24 pressed) and indicated in degrees. For voltage indication and voltage and phase reference values the same applies as under channel A (see 2.3.2.1).

2.3.2.3 Measurement of the Voltage Ratio of Channel B to Channel A

By pressing button B/A 27 the voltages in channel A and in channel B and the phase angle between channels A and B, referred to channel A, are measured. The phase is measured as absolute phase (21 or 23 pressed) or relative to a reference value (22 or 24 pressed) and indicated in degrees.

The following modes of indication can be selected for the ratio of the voltages:

a) absolute linear ratio, dimensionless, by pressing button LIN. 21

b) linear ratio, relative to a reference ratio, dimensionless, by pressing button LIN./REF. 22.

c) absolute logarithmic ratio in dB by pressing button LOG. 3

d) logarithmic ratio in dB, relative to a reference ratio, by pressing button LOG./REF. 24.

The reference value is the voltage ratio at which button LEVEL REF. STORE 9 is pressed. The phase reference is the measured value at which button φ, τ REF. STORE 11 is pressed.

For defining reference ratio and reference phase at the same time press button PARAM. CAL. 10.

For the basic setting the reference ratio is 1/1 and the phase reference 0°.

2.3.3 Parameter Measurement

2.3.3.1 Reflection Factor Measurement (s_{11}, s_{22}, a_r, VSWR)

By pressing button S11, S22 32, the voltages in channel A and in channel B and the phase angle between channels A and B, referred to channel A, are measured. Depending on the plug-in used and the test setup, the button DIR. COUPL. 31 should be pressed (see also manual of the corresponding plug-in).

Depending on the connection of the test item, the result is, in linear display (LIN. 21 pressed), either the input reflection factor s_{11} or the output reflection factor s_{22}. The magnitude and phase (r, φ 15 pressed) or the real and imaginary components (X, Y 17 pressed) of these reflection factors can also be output.

If logarithmic display is selected by pressing button LOG. 23, the output is the reflection attenuation a_r of the test item in dB and the phase angle associated with the reflection factor. When pressing button LIN./REF. 22, the VSWR of the test item and the phase angle associated with the reflection factor are output.

For calibrating the test setup with directional couplers and VSWR bridges, a shortcircuit has to be established in the test plane and button PARAM. CAL. 10 pressed. In all other cases the test output should be match-terminated and button PARAM. CAL. 10 pressed.

2.3.3.2 Impedance Measurement

By pressing button Z 30, the voltages in channel A and in channel B and the phase angle between channels A and B, referred to channel A, are measured. Depending on the plug-in used and on the test setup, button DIR. COUPL. 31 and button 50 Ω/75 Ω 29 must be pressed.
Depending on the connection of the test item, the result is - in linear display (LIN. 21 pressed) - either the input or the output impedance in Ω. High impedances can also be measured when one of the Tuners ZPV-E1, ZPV-E2 or ZPV-E3 and an adequate test setup are used. For this measurement, press buttons Z 30 and SET f_o HIGH Z 40. (See also manual for Tuner ZPV-E1, 10 Hz to 50 MHz.)
Pressing r, φ 15 displays the magnitude and phase and pressing X, Y 17, the real and imaginary components of the test result.
By pressing button LIN./REF. 22, the impedance is normalized to the reference value of 50 Ω or 75 Ω selected with button 29.
Calibration as described under section 2.3.3.1.

2.3.3.3 Admittance Measurement

By pressing button Y 28, the voltages in channel A and in channel B and the phase angle between channels A and B, referred to channel A, are measured. Depending on the plug-in used and on the test setup, button DIR. COUPL. 31 and button 50 Ω/75 Ω 29 should be pressed.
Depending on the connection of the test item, the result is - in linear display (LIN. 21 pressed) - either the input or the output admittance in
Also low admittances can be measured when one of the Tuners ZPV-E1, ZPV-E2 or ZPV-E3 and an adequate test setup are used. For this measurement, press buttons Y 28 and SET f_o HIGH Z 40. (See also manual for Tuner ZPV-E1, 10 Hz to 50 MHz.)
Pressing button r, φ 15 displays the magnitude and phase and pressing button X, Y 17 displays the real and imaginary components of the test result. By pressing button LIN./REF. 22, the admittance is normalized to the reference value of 1/50 Ω or 1/75 Ω selected with button 29.

Calibration as described under section 2.3.3.1.

2.3.3.4 Transmission Measurement (s_{21}, s_{12}, a_{21}, a_{12})

By pressing button S21, S12 33, the voltages in channel A and in channel B and the phase angle between channels A and B, referred to channel A, are measured. Depending on the plug-in used and on the test setup, button DIR. COUPL. 31 should be pressed.

Depending on the connection of the test item, the result is - in linear display (LIN. 21 pressed) either the forward transmission factor s_{21} or the backward transmission factor s_{12}.

Pressing button r, φ 15 displays the magnitude and phase and pressing button X, Y 17 the real and imaginary components of these factors.

When selecting logarithmic display with button LOG. 23, the output is the forward or backward transmission factor in dB together with the phase angle associated with the forward or backward transmission factor.

For calibrating the test setup, connect the equipment without the test item and press button PARAM. CAL. 10.

2.3.4 Group Delay Measurement

In the modes A, B or B/A (25, 26 or 27 pressed) the group delay can be measured instead of the phase.

2.3.4.1 Single Measurement

Pressing button τ 34 conditions the group delay measurement. For performing individual measurements, buttons SET f_o 40, SET f_o + 0.4 kHz 41, SET f_o + 4 kHz 39 and SET f_o + 40 kHz 37 are operated.

The test method is based on two individual phase measurements which are made at two very closely spaced frequencies. The phase difference $\Delta\varphi$ is obtained and, using the frequency difference Δf, the group delay τ is calculated from $\tau = \Delta\varphi/2\pi\Delta f$. The three different Δf values corresponding to buttons 37, 39 and 41 permit three measurement ranges to be selected:

40 kHz:	0.001 to 9.999 µs
4 kHz:	0.01 to 99.99 µs
0.4 kHz:	0.1 to 999.9 µs

The test procedure is as follows:

a) Set the signal generator to the desired test frequency.

b) Press button SET f_o 40.

c) Depending on the expected test result, increase the signal generator frequency by 40 kHz, 4 kHz or 0.4 kHz.

d) Press button SET f_o + 40 kHz 37, SET f_o + 4 kHz 39 or SET f_o + 0.4 kHz 41 in accordance with the frequency increase.

e) The test result is indicated on readout 12; for a new measurement, start with a).

Since the accuracy of the frequency increase directly influences the test result, the signal generator should be checked, if required, using a frequency counter.

Due to the built-in frequency counter, group-delay measurements are possible at any frequency deviation when Tuner ZPV-E1 is used.

The generator frequency can be increased or decreased as required (step c), see above.

For step d), press button AUTO XTAL 38. (See also manual for Tuner ZPV-E1, 10 Hz to 50 MHz).

2.3.4.2 Continuous Measurement

Pressing button τ 34 conditions the group delay measurement.
Select continuous measurement by first pressing one of buttons SET f_o +0.4 kHz 41, SET f_o +4 kHz 39, SET f_o +40 kHz 37 and then AUTO XTAL 38. (With ZPV-E2 and ZPV-E3 button AUTO XTAL 38 may be pressed immediately after button τ 34.)

For automatic continuous measurements, the output CONTR. ΔF 51 of the ZPV is connected to the FM-DC input of a generator. As with individual measurements, the phases of two very closely spaced frequencies are measured and the group delay is calculated from the phase and the frequency differences.

However, the generator frequency is automatically varied with the aid of the ZPV. This facilitates operation considerably. The frequency variation of 0.4 kHz, 4 kHz or 40 kHz is determined by pressing buttons SET f_o + 0.4 kHz 41, SET f_o + 4 kHz 39 or SET f_o + 40 kHz 37. The Δf setting also fixes the corresponding measurement range (see 2.3.4.1).

After connecting the ZPV to the signal generator, the Δf voltage should be matched by calibrating the slope of the generator modulation characteristic. To this effect, the test item is replaced by the supplied calibrating cable and button CAL. 35 is pressed. The ZPV performs the calibration automatically, extinguishing button 35 upon termination.

The linearity and frequency independence of the generator modulation characteristic are essential for the accuracy of the test results. The modulation sensitivity of the generator should always be in the range 1 V/10 kHz to 2.5 V/10 kHz.

2.3.4.3 Measurement of Group Delay Difference

Pressing button $\Delta\tau$ 36 conditions the measurement of the group delay difference relative to a reference delay both for the single and the continuous modes. Sections 2.3.4.1 and 2.3.4.2 apply accordingly.

The reference group delay is the value at which button φ, τ REF. STORE 11 is pressed.

For the basic setting, the reference delay is 0 µs.

2.3.5 Indication of Reference Value

Pressing button RECALL REF. 19 interrupts the test cycle and causes the corresponding reference value to be displayed. When button 19 is lit, this mode is switched on. Another push of button 19 makes go out, the test cycle is continued and the test results appear in the readout.

2.3.6 Stabilization of Test Results

By pressing button FILTER 20 an electronic filter is connected for stabilizing the test results. This adaptive filter proves especially useful for low-level and noisy signals. Another push of button 20 disables the filter and the luminous button is extinguished.

2.3.7 Disconnecting the Autoranging Facilities

2.3.7.1 Disconnecting the Amplitude Autoranging Facility

For the vector measurement modes in channel A and channel B it may be necessary to disconnect the amplitude autoranging facility of the amplifier, which uses 10-dB steps. To this effect, button AMPL. STOP AUTORANGING 3 is pressed and the status indication 4 lights up. Another push of button 3 causes the luminous indication 4 to be extinguished and amplitude autoranging is connected again. In all other operating modes the amplitude autoranging facility of the amplifier cannot be switched off. Button 3 then only affects the recorder outputs REC/1 V.

2.3.7.2 Disconnecting the Frequency Autoranging Facility

If only one frequency range of the tuner is used, the frequency autoranging facility can be disconnected to increase the measuring rate and the corresponding range can be set by hand. To this effect button FREQ. STOP AUTORANGING 5 is pressed and the status indication 6 lights up. After pushing button 5 once again, the luminous indication 6 goes out and frequency autoranging is connected again.

2.3.8 Quasi-analog Indication

The quasi-analog luminous spot indication 8 is associated with the digital readout 7 and the quasi-analog luminous spot indication 13 with the digital readout 12. Although these linear luminous spot indicators feature no absolute accuracy, they facilitate the recognition of a tendency towards a maximum or a minimum value and thus prove particularly useful for alignment work. In order to increase the system speed these indications can be switched off by computer command.

2.3.9 Analog Voltage Inputs/Outputs

2.3.9.1 IF Outputs IF/1 V

The IF voltages of channels A and B are available at the two BNC sockets A 45 and B 46 on the rear panel. The IF is 20 kHz. The level and phase shifts of the IF outputs correspond to those of the RF input signals in channels A and B.

2.3.9.2 SWEEP/1 V Outputs

During sweep operation, which can be set for instance on the plug-in ZPV-E2 or ZPV-E3, a voltage corresponding to the amplitude of channel A or B or to the ratio of channel B/channel A is available at BNC socket r SWEEP/1 V 47 on the rear panel in modes A, B or B/A. The voltage present at BNC socket SWEEP/1 V 48 corresponds to the phase angle between channels A and B. These voltages are produced in a purely analog way. The amplitude and frequency autoranging facilities are disabled.

When measuring the ratio B/A the voltage in channel A must be between 35 mV and 350 mV. This is monitored by the microprocessor and any error is indicated on the display.

2.3.9.3 REC./1 V Outputs

At the rear BNC socket r, X 49 an analog voltage corresponding to the digital readout 7 is available. The analog voltage present at BNC socket φ , Y 50 is associated with digital readout 12. To increase the speed of the system, these recorder outputs can be switched off by a computer command. They are also not enabled during sweep operation since in this case outputs 47 and 48 are available (see also 2.3.9.2).

The relationship between display modes and recorder outputs can be seen in table 2-12.

2.3.9.4 ΔF CONTR. Output

For automatic group delay measurement BNC socket CONTR. ΔF 51 is connected to the FM-DC input of a generator to control the deviation frequency (see also 2.3.4.2).

2.3.9.5 DC Input ADC/10 V

From serial number 879 268 onwards, the internal A/D converter is used for checking the tuning voltage of group delay measurements with the aid of the Basic Software ZPV-K10 (internal wiring). If the external input is required, a BNC socket is mounted again on the rear panel and cable K58 is connected between the socket and the A/D converter. In addition, the 20-kΩ resistance between pins 3 and 9 of B16 on the D/A converter pcb 291.5119 must be removed.

2.4 Remote Control

2.4.1 General

The ZPV is equipped with a remote-control connector in accordance with DIN - IEC 66.22 (IEEE 488); this is the 24-pole programming connector 53 on the rear panel (for contact allocation see table 2-2). The characteristics realized according to this standard are SH1, AH1, T6, TE6, L4, SR1, DC1, DT1, RLØ, PPØ, CØ (see table 2-4).

Only ASCII characters meeting the latest recommendations are used (see table 2-3). When connecting the ZPV into an IEC bus system it is not necessary to be familiar with the functioning of the interface. It is sufficient to know the programming commands and the data output formats which are explained below.

2.4.2 Switchover to Local, Remote or Combined Operation

The front-panel switch 2 permits manual operation (LOCAL), remote control (REMOTE) and a combined local plus remote mode (COMB.) which is especially useful for producing test routines.

These three functions cannot be programmed.

2.4.3 Setting the Device Address

The talker and the listener addresses are set together in accordance with table 2-5 using switch S1 on the IEC-bus Option ZPV-B1. The factory-set address of the talker is Z and that of the listener : (corresponding to device address 26 when using the TEK 4051). The address status is indicated on the readout, either LI (listener) or TA (talker) lighting up.

2.4.4 Setting the Delimiter

Switch S2.1 to S2.4 on the IEC-bus Option ZPV-B1 permits setting of the delimiter furnished by the ZPV at the end of a data transfer (see table 2-6). This character is factory-set to CR.

2.4.5 Disconnecting the Service Request

Switch S2.6 on the IEC-bus Option ZPV-B1 permits the service request capability (SRQ) of the ZPV to be disconnected (S2.6 ON) or connected (S2.6 OFF).

2.4.6 Programming Commands

Programming of the ZPV corresponds to manual operation. Each pushbutton of the front panel can be remote-controlled by applying a combination of two ASCII characters. Figure 2-8 shows the association of the different programming commands with the ZPV front-panel controls. The on/off buttons are disabled by a letter and a 0 and enabled by the same letter and a 1.

Example:

I0 means "filter off"; I1 means "filter on".

In addition to the button functions, the amplitude ranges of the amplifier and the frequency subranges of the plug-in can be programmed in accordance with table 2-10.

Thus programming simply consists of a sequence of ASCII characters corresponding to the order of buttons pushed.

Table 2-9 gives an alphabetical list of all control characters accepted.

2.4.7 Internal/External Trigger Operation

ZPV measurements can be triggered both internally and externally. Internal triggering is selected by the programming command combination TI and external triggering by TE. When switching on, the instrument is set to internal triggering.

With external triggering, the output command combination LR or LX or the secondary talker addresses a, b or c initiate a test procedure whose result is available for outputting at the end of the test.

2.4.8 Data Output

2.4.8.1 Output of Lefthand Readout (7)

The output command combination LX or the secondary talker address a conditions the output of the measured component of the lefthand readout 7 in accordance with the following format example:

SP±1234E±01CR+)

The format is made up as follows: one space (SP), one polarity sign of the mantissa (±), four digits of the mantissa, one exponent symbol (E), one polarity sign of the exponent (±), two digits of the exponent and one delimiter (CR). The associated unit is either a basic physical unit (V, Ω, 1/Ω, degree) or, with ratios, 1/1, dB.

2.4.8.2 Output of the Righthand Readout (12)

The output command combination RX or the secondary talker address b conditions the output of the measured component of the righthand readout 12 in accordance with the following format example:

SP±1234E±01CR+)

For the format and physical unit see 2.4.8.1.

2.4.8.3 Output of Lefthand and Righthand Readouts (7 and 12)

The output command combination LR or the secondary talker address c conditions the output of the two measured components of the lefthand (7) and righthand (12) readouts. The output consists of the information furnished in accordance with 2.4.8.1 and 2.4.8.2 separated by a comma. See the following format example:

SP±1234E±01,SP±1234E±01CR.

For the format and physical unit see 2.4.8.1.

2.4.8.4 Output of Measurement Range of Channel A

The output command combination RA or the secondary talker address e conditions the output of the measurement range of channel A. The output consists of two digits plus one delimiter.

Example: 08CR

The two figures indicate the range No., which is explained in table 2-10.

+) SP and CR are the ASCII characters for space and carriage return (see table 2-3).

2.4.8.5 Output of Measurement Range of Channel B

The output command combination RB or the secondary talker address f conditions the output of the measurement range of channel B. The output consists of two digits plus one delimiter.

Example: 01CR

The two figures indicate the range No., which is explained in table 2-10.

2.4.8.6 Output of Frequency Range of Plug-in

The output command combination RF or the secondary talker address g conditions the output of the frequency range of the plug-in. The output consists of two digits plus one delimiter.

Example: 12CR

The two figures indicate the range Nos, which may have a different meaning depending on the plug-in used. For plug-ins ZPV-E1, ZPV-E2 and ZPV-E3, they are explained in table 2-11.

2.4.8.7 Output of DC Voltage at ADC Input (see 2.3.9.5)

The output command combination AD or the secondary talker address h triggers the A/D conversion of the DC voltage applied to ADC input 52 and conditions the digital output; the data format is in accordance with 2.4.8.1.

Example: SP+1234E-03CR.

The unit is V, the input voltage range covers 0 to +10 V. The measurement is performed only in one range, therefore the exponent -03 is fixed.

2.4.8.8 Output of Device Status Word

The output command combination DS or the secondary talker address d conditions the output of the device status word. The output consists of ten ASCII characters plus one delimiter.

Example: 83B58X1A87CR

This device status word contains the overall device status in coded form. It can be read in by the controller at any time and applied to the device later together with the corresponding listener command TS. Thus the controller is able to "learn", for instance, the device status set by hand.

2.4.8.9 Output of Status Byte with Serial Polling

Due to the service request capability SR1, the device is able at any time to transfer a status byte, for instance during serial polling. This is conditioned by the universal command SPE. A single byte without delimiter is output. The meaning of each bit of the status byte is explained in table 2-7.

At the end of the transfer, the controller should send the universal command SPD.

2.4.8.10 Output of Test Frequency with Tuner ZPV-E1

The frequency of the signal at the SYNC input of Tuner ZPV-E1 is output with the output command combination FV or with the secondary talker address j.

The format is the same as with the righthand and lefthand readout (2.4.8.1); the unit is Hz.

2.4.9 Programming Examples for Desktop Calculators PPC and TEK 4051/52

2.4.9.1 Programming of Device Setting

Problem: The ZPV is to be set to B/A, LIN. and the filter is to be connected.

Solution:

a) The ZPV is factory-set to the listener address: This corresponds to device address 26 with TEK 4051/52 (see table 2-5).

b) Fig. 2-8 shows the association of the programming commands with the individual pushbuttons, button B/A corresponding to command BA, button LIN. to LI and button "filter on" to I1.

c) Thus the solution reads:

```
IECOUT 26, "BALII1"    (PPC)
PRINT @ 26: "BALII1"   (TEK 4051/52)
```

2.4.9.2.1 Programming of Frequency Range (ZPV-E2 or ZPV-E3)

Problem: Plug-in ZPV-E2 is to be set to the range 30 to 60 MHz.

Solution:

a) Same as under 2.4.9.1

b) The command characters - FR - for frequency range programming are found in table 2-9 and the frequency range number for plug-in ZPV-E2 from table 2-11 - 08 - is added. This yields the setting combination FR08.

c) Thus the solution reads:
IECOUT26, "FR08" (PPC)
PRINT@26: "FR08" (TEK 4051/52)

Problem: The correct frequency range is to be adjusted on plug-in unit ZPV-E2 or ZPV-E3 by entering a frequency of 750.5 MHz.

Solution:

a) Same as under 2.4.9.1

b) The command characters - HZ - for frequency programming are found in table 2-9 and the five-digit frequency value 07505 (unit 0.1 MHz) is added. Leading zeros may be replaced by SP, the decimal point may be set at any position.

c) Thus the solution reads:
IECOUT26, "HZ07505" (PPC)
PRINT@26 "HZ07505" (TEK 4051/52)

2.4.9.2.2 Programming of Frequency Setting with ZPV-E1

The test frequency can be directly communicated to the Tuner ZPV-E1 when frequencies < 25 kHz are concerned. No signal is then required at the SYNC input. For this application, frequency autoranging must be disabled with control character Q1.

The output format is "HZ␣␣␣␣␣.␣", the unit 0.1 Hz. Transmitting of a decimal point is possible, but not necessary.

Example: IECOUT26, "TEQ1" (PPC)
IECOUT26, "HZØ1234.5"
IECOUT26, "TI"

sets the ZPV-E1 to the frequency 1.2345 kHz. (See manual for Tuner ZPV-E1)

2.4.9.3 Reading out a Complete Test Result

Problem: A complete test result consisting of the two components of the lefthand and righthand ZPV panel indication is to be read out.

Solution:

a) The ZPV is factory-set to the talker address Z. This corresponds to the device address 26 with TEK 4051/52 (see table 2-5).

b) Section 2.4.8.3 explains the two possibilities of outputting both panel readouts. Either the command combination LR or the secondary talker address c is used, the latter becoming secondary address 3 with TEK 4051/52 (see table 2-5).

c) The test result can be read in as an ASCII string (e.g. A$) and is available in this form for further processing.

d) Thus the following two solutions are possible:

1)	IECOUT 26, "LR"		PRINT @ 26: "LR"	
	IECIN 26, A$	(PPC)	INPUT @ 26: A$	(TEK 4051/52)
2)	IECIN 26; 3, A$		INPUT @ 26, 3: A$	

2.4.9.4 Transfer of Device Status Word

Problem: The ZPV is completely set by hand in the combined mode; this device setting is to be transferred to the TEK 4051/52, stored and output at a later date.

Solution:

a) As to listener and talker addresses see 2.4.9.1 and 2.4.9.3.

b) Section 2.4.8.8 explains the two possibilities of reading in the device status word. Either the command combination DS or the secondary talker address d is used, the latter becoming secondary address 4 with TEK 4051/52 (see table 2-5).

c) The status word can be read in as an ASCII string (e.g. S$).

d) Thus the following two possibilities of reading in exist:

1)	IECOUT 26, "DS"		PRINT @ 26: "DS"	
	IECIN 26, S$	(PPC)	INPUT @ 26: S$	(TEK 4051/52)
2)	IECIN 26; 4, S$		INPUT @ 26,4: S$	

Later output is caused by the command

IECOUT 26, "TS"		PRINT @ 26: "TS"	
IECOUT 26, S$	(PPC)	PRINT @ 26: S$	(TEK 4051/52)

2.4.9.5 Service Request (SRQ) when using the ZPV + TEK 4051/52

The ZPV can send an SRQ message if, for example, it is not in sync, the measurement range is exceeded, etc. To this end,

1) set switch S2.6 on the IEC interface board to OFF (cf. 2.4.5).
2) use the TEK to set the ZPV for external trigger operation ("TE") and to initiate a test cycle ("LR" or secondary address). Cf. 2.4.9.3.

Example: (TEK 4051/52)

100 ON SRQ THEN 2ØØ	
110 PRINT @ 26: "TE"	External trigger operation
120 PRINT @ 26, 3: X1, X2	Initiate test cycle; output results
130 PRINT @ 26: "TI"	Internal trigger operation
140 END	
:	
200 POLL A, B; 26	Serial poll
210 PRINT A, B	Printout of device list number (A), and status byte (B)
220 REM SRQ REMOVE FAULT	e.g., by altering test level
230 RETURN	

NOTE: Relationship between status byte (B) after a SRQ, and the readout on the ZPV (cf. Table 2-7).

ZPV readout	Status byte (B) 4051/4052
A??	96
A>>	80
B>>	72
B<<	68
A<<	66 (ZPV-E1 only)

2.4.9.6 Increasing the Test Rate in Programmed Operation

The test rate of the ZPV can be increased by the commands

GØ	Tendency indication off
KØ	Recorder output off
SH	Fast test rate

Switchover to normal operation is achieved by the commands

G1 Tendency indication on

K1 Recorder output on

SL Normal test rate

Example: Switching the ZPV over to fast test rate:
IECOUT 26, "GØKØSH" (PPC)
PRINT @ 26: "GØKØSH" (TEK 4051/52)

2.4.9.7 Input and Output of Reference Value for Relative Measurements

The reference value for the test result can be output from the ZPV in coded form (10 ASCII characters) and reentered in the ZPV.

Example:

Reference value output

IECOUT 26, "SR"	(PPC)	Preparation of reference value output
PRINT @ 26: "SR"	(TEK 4051/52)	
IECIN 26, A$	(PPC)	Output of reference value and storage in A$
INPUT @ 26: A$	(TEK 4051/52)	

or with a single command using secondary address 9:
IECIN 26; 9, A$ (PPC)
INPUT @ 26,9: A$ (TEK 4051/52)

Reentry of reference value in the ZPV

IECOUT 26, "TR" IECOUT 26, A$	(PPC)	PRINT @ 26: "TR" PRINT @ 26: A$	(TEK 4051/52)

2.4.9.8 Phase Offset

In external trigger operation ("TE") it is possible to enter a phase value into the ZPV prior to the measurement, which is subtracted from the measured phase in the measurement. The phase offset holds only for one measurement command.

The phase offset is programmed by "POXXXX" with the value of XXXX ranging from 000.0 degrees to 360.0 degrees. The decimal point does not have to be used.

Example: (PPC)

IECOUT 26, "TEBA"	External triggering, mode B/A
IECOUT 26, "PO18ØØ"	Phase offset 180 degrees
IECIN 26;2, P	Result on lefthand readout (phase value P) P = measured phase - phase offset
IECIN 26;2, P	Result on lefthand readout (phase value P) P = measured phase since phase offset holds only for one measurement after "POXXXX" has been entered.

2.5 Measurement of Crystal Equivalent Circuit Parameters

2.5.1 General

The Vector Analyzer ZPV in conjunction with a frequency counter, an FM-DC signal generator, a control amplifier and a crystal adapter (π-network in accordance with IEC 444 or DIN 45 105) permits measurement of crystal equivalent circuit parameters.

The ZPV supplies a phase-proportional DC voltage which after amplification in the control amplifier pulls the signal generator to the series-resonance frequency of the crystal. The resonant frequency can be read off on the frequency counter.

If the keys Z and AUTO/XTRL are pressed the ZPV determines the resonant impedance of the crystal from the attenuation at resonance which is read out directly on the lefthand display.

Use of a desktop calculator with IEC-bus interface, such as Process Controller PPC, in the test assembly permits also the dynamic inductance L_1 and the dynamic capacitance C_1 to be determined.

To this end, the ZPV is programmed for a phase offset φ_o', i.e. the control loop locks at $\pm\varphi_o$. From the two frequencies at which the phase of the crystal is $\pm_o$ and the resonant impedance, L_1 and C_1 are calculated by means of the desktop calculator.

To select the mode "measurement of crystal equivalent circuit parameters" press the button AUTO . Modes τ and $\Delta\tau$ must be switched off.

The following combinations can be selected:

A	AUTO	LIN/REF	Measurement of voltage in channel A relative to a reference value
B	AUTO	LIN/REF	Measurement of voltage in channel B relative to a reference value
B/A	AUTO	LIN/REF	Measurement of voltage ratio B/A relative to a reference value
Z	AUTO		Measurement of resonant impedance
Y	AUTO		Measurement of resonant admittance
S21, S12			Same as with B/A AUTO LIN/REF

The phase measurement range is limited to about $\pm 120^\circ$ in these modes since only values between $\pm 90^\circ$ are required for measuring crystal equivalent circuit parameters.

2.5.2 Manual Measurement

2.5.2.1 Vector Measurement

Calibration

- Select B/A LIN/REF AUTO on the ZPV.
- Press the button r, φ on the ZPV.
- Adjust the nominal crystal frequency on the signal generator and select the test level.
- Press the button STOP AUTORANGING FREQ on the ZPV. The lamp lights up.
- Connect a shorting link into the π network in place of the crystal and press button LEVEL REF STORE . The lefthand display reads out 1.00.
- Connect a resistor into the π network, the resistance of which corresponds to about the resonant impedance of the crystal to be expected.
- Press the button φ, τ REF STORE on the ZPV. The righthand display reads out 0°.

Measurement

- Connect the crystal into the π network.
- Now the control loop pulls the crystal to the exact resonant frequency. The righthand display of the ZPV reads out 0°.
- The resonant frequency of the crystal can be read off on the frequency counter.
- The resonant impedance is given by the formula

$$Z_r = \left(\frac{1}{B/A} - 1 \right) \times 25 \qquad [\Omega]$$

where B/A is the attenuation read out on the lefthand display.

2.5.2.2 S-parameter and Z-measurement

The calibration and measurement procedures are basically the same as for the vector measurement (section 2.1). For calibration, the S21,S12 AUTO mode must however be used. The S21,S12 AUTO mode corresponds to the B/A AUTO LIN/REF. mode.

If the Z AUTO or Y AUTO mode is selected, the ZPV calculates the resonant impedance or admittance in accordance with the above formula and reads it out on the left-hand display.

2.5.3 Automatic Measurement

Program-controlled measurement is based on the same principle as manual measurement.

The controller sets the required button combinations via the IEC bus, stores the measured data and calculates from them the equivalent circuit parameters.

In automatic operation, a phase offset can be entered into the ZPV, say, for example, $\pm 45^\circ$, which causes the control loop to pull the signal generator to the frequency at which the phase of the crystal is not 0° but, for example, $\pm 45^\circ$. With the given resonant impedance Z_r, the controller can calculate the dynamic inductance L_1, the capacitance C_1 and the Q from the two 45° frequencies in accordance with the following formulae:

$$L_1 = \frac{(Z_r + 25\ \Omega) \cdot \tan\varphi}{2\pi\ (f_{+\varphi} - f_{-\varphi})}$$

$$C_1 = \frac{1}{4\pi^2 \cdot fr^2 \cdot L_1}$$

$$Q = \frac{2\pi \cdot fr \cdot C_1}{Z_r}$$

where f_r = resonant frequency

$f_{+\varphi}$ = frequency with positive phase offset

$f_{-\varphi}$ = frequency with negative phase offset

φ = phase offset (e.g. 45°)

Z_r = resonant impedance.

The IEC-bus instruction for programming a phase offset with the PPC reads

IECOUT@26: "PO....".

The decimal points stand for a figure each. For a 45^{o} phase offset, for example, program

```
IECOUT   26 , "PO045Ø"
```

and for -45^{o}

```
IECOUT   26 , "PO315Ø".
```

2.5.4 Control Amplifier

Fig. 2-13 is an example of a simple control amplifier circuit. C_x, R_x, R_y, together with the deviation of the FM-DC signal generator, determine here the gain and the time constant of the control loop. In the case of high-Q crystals, the loop gain and the time constant should preferably be switch-selectable.

The control amplifier is driven from the signals obtained at the ZPV outputs CONTR. ΔF and SWEEP φ . The output voltage of the internal phase meter is available at the SWEEP φ output.

Scale: 0^{o} corresponds to 0 V
-180^{o} corresponds to approx. -0.5 V
$+180^{o}$ corresponds to approx. +0.5 V.

In addition, a reference voltage is available at the CONTR. ΔF output. This reference voltage is proportional to the reference value stored in the ZPV by means of the button φ , τ REF STORE .

Scale: 0^{o} corresponds to 5 V
-179.9^{o} corresponds to 0 V
$+179.9^{o}$ corresponds to 10 V.

If the two signals are taken to an amplifier which matches the scales to one another and subtracts the signals from one another, a voltage is obtained at its output corresponding to the phase readout in either the B/A LIN/REF AUTO or S21,S12 AUTO mode.

If a phase offset is programmed via an IEC bus instruction, the reference voltage at the CONTR. ΔF output changes accordingly, e.g. it falls by 1.25 V if an offset of 45^{o} is programmed.

2.5.4.1 Hints for the Adjustment of the Potentiometers P1 and P2

Using a controller.

The adjustment is best made during operation, i.e. when measuring on a crystal.

If the control amplifier is not correctly adjusted, the control loop locks not exactly at 0° but, for example, at 1.3°.

Adjustment

- Adjust the potentiometer P2 (Fig. 1) so that the control loop locks exactly at 0°.
- Program a phase offset of 45°. The control loop will now lock not exactly at 45° but, for example, at 46°.
- Adjust P1 for 45°.
- Program a phase offset of 0° and adjust P2 again for 0°.
- Repeat this alternate adjustment until the control loop locks exactly at both 45° and 0°.

Without a controller

If no computer is available, proceed as follows:

- Switch the ZPV off and back on again.
- Select the B/Y LIN/REF AUTO mode.
- Shortcircuit the SWEEP φ input of the control amplifier.
- Connect the CONTR ΔF input of the control amplifier to the CONTR ΔF output of the ZPV.
- The voltage at this output is now 5.0 V.
- Vary P2 until the voltage at the output of the control amplifier is 0 V.
- Remove the shortcircuit at the SWEEP φ input and connect the input to the SWEEP φ output of the ZPV.
- Produce a phase shift of about 45° (watch the display on the ZPV), for example, by interconnecting the Group-delay cable 292.4000.00 (accessory supplied with the ZPV) at a frequency of about 2.5 MHz.
- Press the button STOP AUTORANGING FREQ. ; the associated lamp lights up.
- Adjust the output voltage of the control amplifier to 0 V by means of P1.

3. Maintenance and Repair

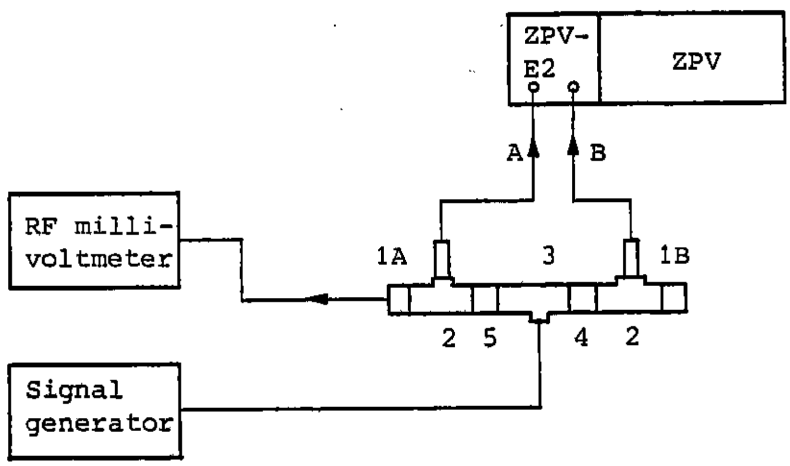
3.1 Required Measuring Equipment and Accessories

Item	○ Designation, required specifications ● Recommended R&S instrument	Type	Order No.	Use see section
1	○ Signal generator, 1 MHz, 2 V/50 Ω ● Signal generator, 10 Hz to 140 MHz	SMK	348.0010.03	3.2.1 to 3.2.4
2	○ Attenuator set 0 to 100 dB/50 Ω ● Programmable Attenuator	DPVP	214.8017.52	3.2.1 3.2.3
3	○ RF millivoltmeter 10 kHz to 10 MHz; error <1% ● RMS Voltmeter	URE	342.1214.02	3.2.1
4	○ 20-kHz signal generator with two output signals whose phase shift (-180° to +180°) is adjustable with an error of <±0.1°			3.2.3
5	○ Digital voltmeter ● Digital multimeter	UDL4	346.7800.02	3.2.4
6	○ 50-Ω termination ● Precision termination	RNA	272.4510.50	3.2.1 to 3.2.4
7	● Insertion adapter	ZPV-Z1	292.2713.50	3.2.1 to 3.2.4
8	● Feed unit	ZPV-Z2	292.2913.50	3.2.1 to 3.2.4
9	● Tuner 0.1 to 1000 MHz	ZPV-E2	292.0010.02	3.2.1 to 3.2.8
10	○ Attenuator 40 dB; 50 Ω (N) ● Attenuator (2x20 dB/50 Ω)	DNF	272.4310.50	3.2.1

3.2 Checking the Rated Specifications

3.2.1 Indication Error of Magnitude Range

Test setup



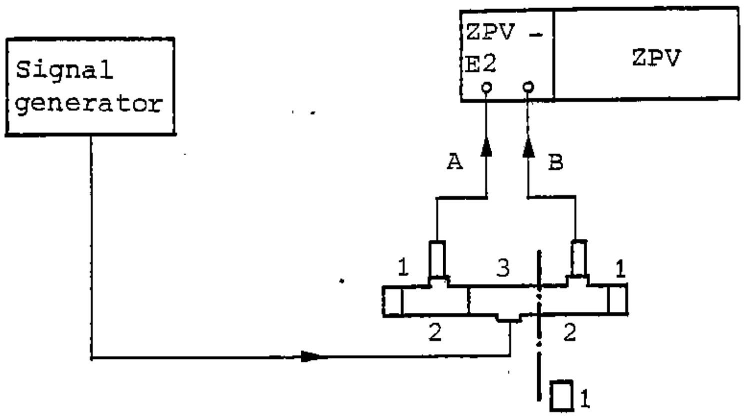
1A, 1B = 50-Ω termination
2 = insertion adapter UPV-Z1
3 = feed unit ZPV-Z2
4 = attenuator set
5 = attenuator 40 dB; 50 Ω

Select on the ZPV-E2 the frequency range 1-2 MHz and on the ZPV the operating mode A, LIN. Connect instead of the termination 1A the probe of the RF millivoltmeter (50 Ω). Adjust for an attenuation of 0 dB on the attenuator set. Set the generator frequency to 1 MHz and the level according to the RF millivoltmeter to 80 mV. The value indicated on the ZPV must not differ more than stated in the Specifications. Exchange the probes of the ZPV, select the operating mode B, LIN. and determine the deviation in the same way as in channel A.

Re-establish the initial test setup. Connect the insertion adapter A via the attenuator 5; adjust for 2 V, 50 Ω on the signal generator and 20 dB on the attenuator set. Select the operating mode B, LOG.-REF. and store the reference value in the ZPV (button LEVEL REF. STORE). Vary the attenuation of the attenuator set between 0 dB and 90 dB in 10-dB steps. The indicated values must not differ from the rating (n x 10 dB) more than stated in the Specifications (taking into account the calibration curve of the attenuator set).

3.2.2 Crosstalk Attenuation

Test setup



1 = 50-Ω termination

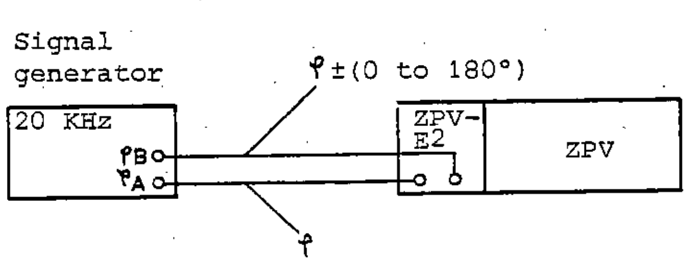
2 = insertion adapter ZPV-Z1

3 = feed unit ZPV-Z2

Select on the ZPV-E2 the frequency range 1-2 MHz and on the ZPV the operating mode B/A, LOG.-REF. Set the generator frequency to 1 MHz and the output level to 2 V/50 Ω (corresponding to 1 V at the ZPV). Store the magnitude by pressing the button LEVEL REF. STORE. The indicated magnitude should now be 0 dB. Disconnect the insertion adapter with the probe B and connect the feed unit with a termination (50 Ω). If required, terminate also the insertion adapter B. The indicated magnitude corresponds to the crosstalk signal in channel B, referred to the amplitude of the signal in channel A. The crosstalk attenuation is then equal to the absolute value of the magnitude indication and must not be smaller than stated in the Specifications.

3.2.3 Error of Phase Indication

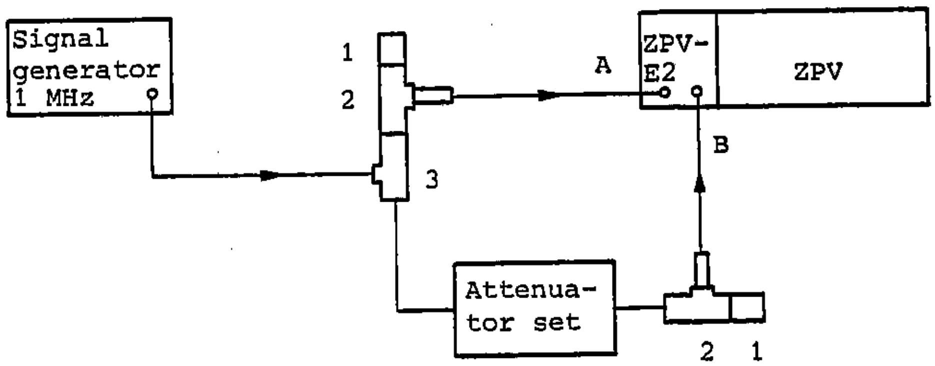
Test setup



Adjust the phase on the generator to 0° and store it on the ZPV. The indication should be 0°. Check the linearity in the entire range of indication from +180° to -180°.

Level dependence of phase indication

Test setup



1 = 50-Ω termination

2 = insertion adapter ZPV-Z1

3 = feed unit ZPV-Z2

Select on the ZPV-E2 the frequency range 1-2 MHz, set the transmitter frequency to 1 MHz and the level to ca. 1 V. Adjust 0 dB on the attenuator set and store the phase on the ZPV. The indication should be 0°. Increase the attenuation of the attenuator set in steps up to 90 dB. Taking into account the crosstalk attenuation and the variation of the electrical length of the attenuator set, the variation of the phase must not exceed the specified values.

3.2.4 Narrowband Sweeping

Test setup see 3.2.1

Set the signal generator to 1.5 MHz and vary the output level so, that the ZPV indicates 130 mV. Select on the ZPV-E2 the frequency range 1-2 MHz and switch on SWEEP. The output voltage at socket r 47 should be 730 mV ±30% (operating mode B/A). Reduce the output level of the signal generator to 40 mV (equivalent to an indication of 20 mV at the ZPV). The output voltage at socket r 47 must now be 300 mV ±30%.

The function of button 3 AMPL. STOP AUTORANGING is checked in that the ZPV signals that the minimum voltage in channel A is not reached when the signal-generator level is reduced even more.

Independent of the operating mode (A, B, B/A) the voltage +0.5 V ($+180^{\circ}$) to -0.5 V (-180°) proportional to the phase must be output at socket φ 48. In the other operating modes (SWEEP, OFF) the sockets are disconnected ($Z_{out} \rightarrow \infty$)

3.2.5 Basic Setting for Switching on AC Supply

Immediately after switching on the ZPV (button 18), the following instrument functions must be effective:

Operating mode vector measurement in channel A (A 26 lights),
dimension linear (LIN. 21 lights),
polar coordinates (r, φ 14 lights),
frequency and amplitude autoranging (4 and 6 do not light).

The readout panels 7 and 12 indicate the dimensions mV and angular degrees (φ BA).

3.2.6 Control of Analog Section

When performing the checks according to sections 3.2.1 to 3.2.4, the control of the analog section by the microcomputer is checked at the same time.

3.2.7 Operating and Indicating Elements

The instrument features 7 operating modes. In anyone mode, only a limited number of pushbuttons can be actuated, the other buttons being inhibited. The possibilities for the individual operating modes are shown below. Checking can be made by hand (switch 2 set to LOCAL or COMB.) or, if the IEC-bus option ZPV-B1 is incorporated, by means of the desktop calculator (switch 2 set to COMB. or REMOTE). The dimensions as selected by means of the respective buttons must be indicated on the display panels 7 and 12.

a) Vector measurements in channel A (button 26, control character CA)

Function	Button	Control character
Dimension linear, absolute	21	LI
Dimension linear, relative	22	ZY
Dimension logarithmic, absolute	23	DB
Dimension logarithmic, relative	24	DR
Input of reference voltage	9	LS
Input of reference phase, group delay	11	PS
Reference value indication	19	C1/CØ
Filter	20	I1/IØ
Crystal measurement	38	A1/AØ
Amplitude autoranging	3	M1/MØ
Frequency autoranging	5	Q1/QØ
Group-delay measurements	34 to 41	see Fig. 2-8

b) Vector measurements in channel B (button 25, control character CB) see a)

c) Vector measurements, ratio B/A (button 27, control character BA) see a)

d) s-parameters S11, S22 (button 32, control character S1)

Function	Button	Control character
Dimension linear, absolute	21	LI
Dimension linear, relative	22	ŻY
Dimension logarithmic, absolute	23	DB
Reference input	10	PC
Directional coupler	31	R1/RØ
System impedance 50 Ω/75 Ω	29	05/07
Polar coordinates	15	RP
Cartesian coordinates	17	XY
Filter	20	I1/IØ
Amplitude autoranging	3	M1/MØ
Frequency autoranging	5	Q1/QØ

e) s-parameters S21, S12 (button 33, control character S2) same as d), but without button 22.

f) Input impedance Z (button 30, control character Z1) same as d), but without button 23.

g) Input admittance (button 28, control character Y1) same as d), but without button 23.

The status selected in a particular operating mode remains stored when switching over to another operating mode and is restored when the original operating mode is selected again (see also section 2.3.1.2).

3.2.8 Calculator Routines

The calculator routines of the s-parameter measurement option ZPV-B2 and the group-delay measurement option ZPV-B3 are best checked with the aid of suitable test setups and some defined test items (e.g. short circuit, open circuit, termination, cable of known electrical length).

4. Circuit Description

4.1 Analog Section

The Vector Analyzer ZPV, in conjunction with the RF section, permits the measurement of the magnitude and the phase of two applied voltages in a wide frequency range. The instrument has two independent test inputs, to which the measured values can be applied and further processed. The measured values are evaluated at the fixed intermediate frequency of 20 kHz. This design features a high measuring sensitivity and phase measurement accuracy, but places exacting requirements on the frequency conversion with respect to linearity and delay in the entire frequency range. In order to meet these requirements, the ZPV is designed as an instrument with exchangeable RF sections (plug-ins).

The interface between the basic unit and the plug-in contains in addition to the necessary connections for the power supply and control of the plug-in also two independent IF inputs. This interface has also a connection for supplying the digital filter with the reference signal.

4.1.1 Amplitude Measurement

The IF signal of reference channel A is taken from the input (ST42.A4) directly to the PC board Y35, selectivity filter A, (see circuit diagram) 291.5319 S), where the signal, converted to the IF with correct phase and amplitude, is derived via the buffer stage R2-C2 and made available for monitoring purposes at the socket IF A on the rear panel.

In order to reduce the crosstalk between the reference channel A and the test channel B, the input of channel A is referred to the ground terminal of the IF input (ST42.A4). After filtering in the switch-selectable bandpass filter L1-C1 and buffering (B1) the signal is available at connector ST1.17a/b for phase and amplitude measurement.

The amplitude indication Y34 (see circuit diagram 291.5160 S) is a programmable AF millivoltmeter. The input can be electronically switched to reference channel A or test channel B. The necessary crosstalk attenuation of ca. 130 dB is obtained by the arrangement of the switching transistors T1 to T3 and T4 to

T6 and by suitable choice of levels (Fig. 4-3). Both input circuits are equipped with complementary transistors and can thus be controlled at a common point from the level converter B7.

The sensitivity is ca. 1 mV for full-scale deflection of 7.9 V and can be switch-selected in 10-dB steps up to 1 V for full-scale deflection. The two attenuator stages of 20 dB and 30 dB are designed as passive attenuator pads and are switched by T8 for 20 dB and T9 and T10 for 30 dB. A 10-dB switchover is already effected in the first amplifier stage B1 by T7. The necessary switching signal is processed by the level converter B7. The amplifier stages B1, B2, B3 are designed such that with automatic range selection by the microprocessor no dead times and delays occur. The coding of the TTL control signals for the channel and range selection can be taken from Table 4-4.

The 20-kHz IF signal from the output of B3 is applied to the full-wave rectifier B4, B5. The current of the negative halfwave is directly fed into B5. The positive halfwave is also fed into B5, but inverted by B4 and derived with double current. The main advantage of this rectifier is its good linearity and high slew rate. The other amplifier stages B6, used as active lowpass filters, provide for suppression of the spurious products of the rectification, permitting at the same time short transient response times. The DC offset can be adjusted with R32. R33 is intended for calibration of the amplitude. The analog signal is then routed via the electronic switch T1 and T2 in the selectivity filter A (Y35, circuit diagram 291.5319 S) together with the ground reference potential in order to avoid measuring errors. It is then applied to the D/A converter Y33.

The test signal of channel B is similarly processed as in the reference channel A in order to avoid any delay differences. The input signal of ST42.A1 is applied to the preamplifier B (Y24, circuit diagram 291.5219 S) and derived via the buffer stage R3-C1 for monitoring purposes. The signal is available at the socket IF B on the rear panel. The transistors T1, T2, T3, T4 form together with T11 and T12 in the digital filter (Y23, circuit diagram 291.5260 S) an electronic switch which is required for buffering the amplifier T11 to T16. Driving is made via T6 to T8.

T2 and T3 are through-connected for the voltage measuring ranges 0.3 mV to 1 mV; T1 and T4 remain inhibited. The signal is taken via the emitter follower T5 to the electronic switch T12 (Y23) and applied to the bandpass filter L1-C20 in the digital filter. The necessary isolation between the phase measuring branch and the amplitude measuring branch is provided by B4, which is used as impedance transformer and to whose output both measuring branches are connected. The amplifier B1, which is used as intermediate link and is switchable via B2, in the preamplifier B (Y24) provides for sufficient isolation of the amplitude measuring branch in the measuring ranges < 1 mV. R40 (Y24) is provided for compensating the tolerances between the two channels.

In the measurement ranges 100 µV and 30 µV the digital filter is cut in. The IF signal is now taken via the circuit C3-L1 and T1 and applied to the amplifier T11 to T16 (preamplifier Y24). At the same time T4 becomes conductive and T2 and T3 are inhibited in order to ensure sufficient isolation between the two branches. The output signal of the amplifier T11 to T16 is taken to the digital filter Y23. The operating principle of the digital filter is shown in Fig. 4-6. The input signal is applied via R and S to the storage capacitances C1 to C4. The switching frequency is identical with the frequency of the input signal. In this way the mean value of the applied voltage during a quarter period is formed at each capacitance. The fundamental wave is then derived again with the aid of the subsequent bandpass filter. The limit frequency f_T of the filter circuit and hence also the bandwidth of the digital filter with $B = 2 \times f_T$ are determined by the time constant $R \times C$.

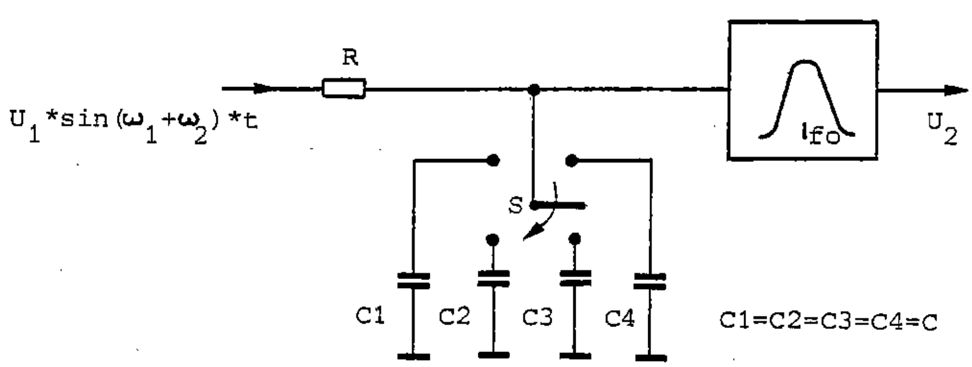


Fig. 4-6 Functional diagram of digital filter Y23

The switchover circuit is made up of T6 to T9 and a suitable drive (T1 to T5, B1, B2, B3). The transistors T3 and T4 form a multivibrator whose frequency is regulated by T2 to 160 kHz. This frequency is divided in B1 down to 20 kHz and the phase compared with the reference signal (T1). The voltage proportional to the phase deviation is filtered out at C1 and serves as control signal for the multivibrator T3, T4.

By logic operations, four successive pulses are generated which drive the switching transistors T6 to T9 (testpoints 9 to 12 and associated oscillograms in circuit diagram 291.5260 S).

A compensation network (R15, R16, C7, C12) is provided in order to suppress the crosstalk of the reference signal. The arrangement of the compensation network permits the generation of a voltage vector which has the same amplitude but opposite phase. The staircase signal from the digital filter is routed via the buffer stage T10 and T11 to the bandpass filter L1-C20, where the fundamental wave of the test signal is derived again. R24 permits exact calibration of the two measurement ranges 30 µV and 100 µV.

4.1.2 Phase Measurement

The phase meter consists of two identical channels, which convert the analog signal with variable amplitude and without phase distortion into a TTL signal. The phase information is then converted into an analog signal.
The amplitude of the test signal in each channel is kept constant by an AGC amplifier (Fig. 4-7).

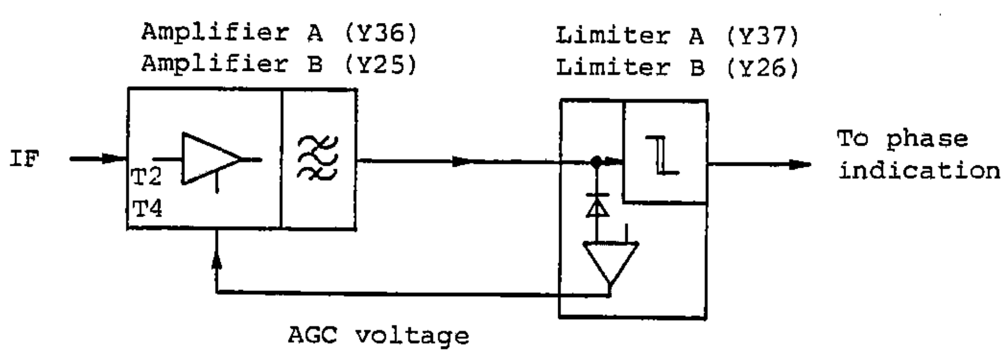


Fig. 4-7 Block diagram of phase meter

The test signal amplified by T2 and T4 and filtered out in the bandpass filter L1-C9 (see circuit diagram 291.5360 S and 291.5460 S) is further amplified in the limiter A (B) by T1 and T2 (see circuit diagram 291.5419 S and 291.5519 S). The symmetrical signal is then rectified (GL1 to GL4) and filtered. The actual voltage value is compared with the rated value at the non-inverting input of B2. The resulting deviation is linearized by T3, processed by B2 and taken back to the amplifier A (B). An attenuator pad (R3, T1) ensures a dynamic range of the amplifier of 100 dB. The amplitude of the IF signal of amplifier A (B) is thus constant and free from harmonics within the dynamic range. Phase distortions due to shifting of the zero-axis crossing are thus largely eliminated. The subsequent comparator B1 in the limiter A (B) converts the sinewave input signal into a TTL signal for the phase indicator Y27.

The phase indicator (see circuit diagram 291.5060 S) consists in principle of a phase meter with subsequent lowpass filter, a phase reset circuit and a calibration circuit, which permits calibration of the phase meter without an external standard.

The phase meter is equipped with the flipflop B5, which is set by the signal in channel A and reset by the signal in channel B. The mark-to-space ratio of the output pulses and hence also the mean value of the voltage with constant pulse amplitude is then proportional to the phase difference between the voltages in the reference and test channels. The constant amplitude of 6 V of the pulses is ensured by the switching transistors T1 and T2 and the use of the constant reference voltage of the D/A converter. The active low-pass filter B7, B8 derives then the mean value of the output voltage from the phase meter.

The phase of the two voltages in the channels A and B is additionally evaluated with the gate B4. For the automatic phase resetting the symmetrical characteristic of the phase meter is used by an exclusive OR gate (Fig. 4-8). With a phase difference of more than $\pm 100^{\circ}$ the switching threshold of the Schmitt trigger B6 is reached and the logic state of the storage flipflop B5 is changed. B4 inverts the reference signal, this corresponding to a phase offset of $\pm 180^{\circ}$.

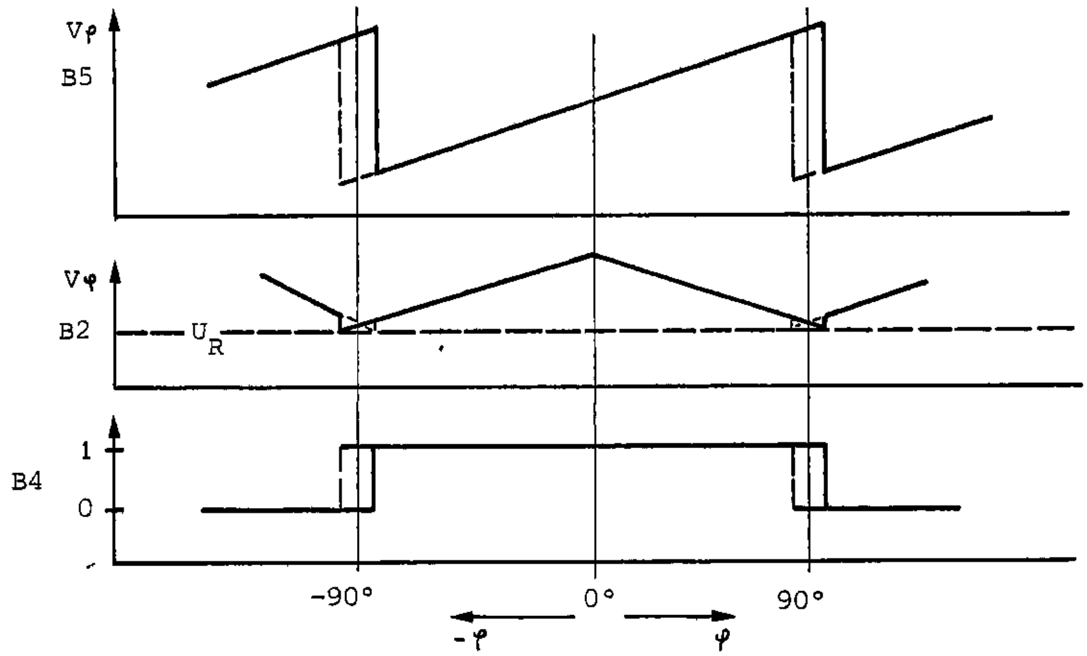


Fig. 4-8   Switching conditions of automatic phase resetting

The phase offset is then taken into in account in the built-in calculator when the phase value is output. In this way the otherwise negatively-sloped characteristic of the phase meter at a phase difference of $\pm 180^{\circ}$ and hence also the measuring inaccuracy is eliminated. In order to ensure proper functioning of the phase resetting and also for switchover from narrowband sweeping, the multivibrator T5, T6 delivers, if required, the missing reset pulses until the phase-proportional voltage at the input of the Schmitt trigger B6 reaches again the proper values.

The phase indicator Y27 permits in addition self-calibration of the phase meter, taking into account the error of the 180° phase offset. For this purpose the input B of the phase meter is supplied with the signal of channel A delayed by = 12.5 µs (Fig. 4-9). This delay corresponds to a phase shift of $\pm 90^{\circ}$, the polarity being dependent on the logic level at ST1.31b. As can be seen from Fig. 4-8, this phase shift is within the hysteresis of the phase resetting. Due to the forced switchover at ST1.17a it is then possible to cut in or out the 180° phase offset.

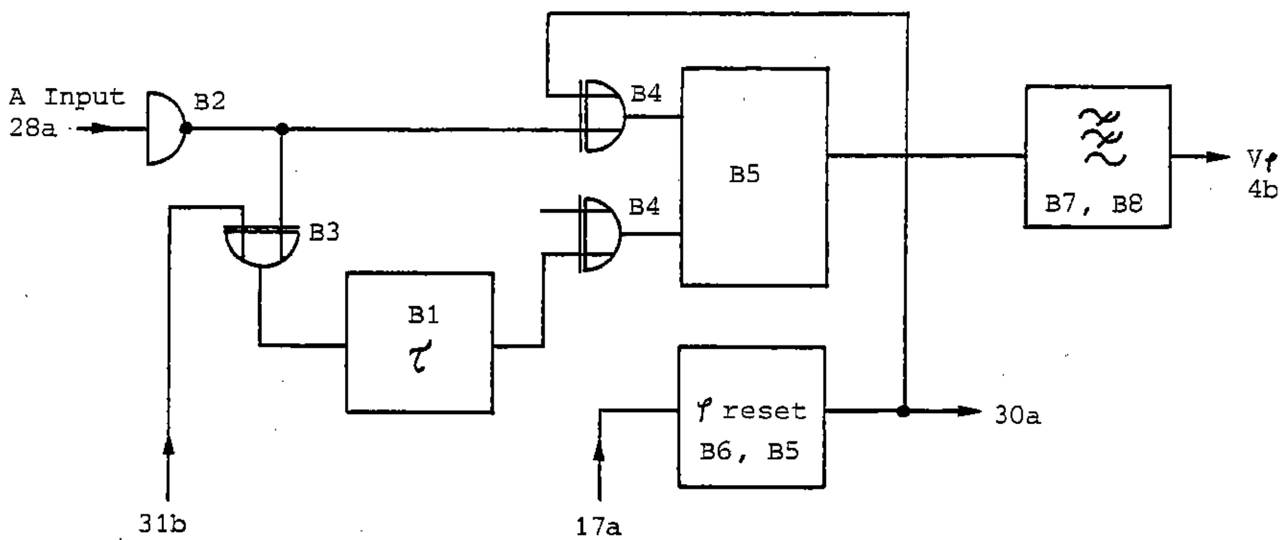


Fig. 4-9 Block diagram of self-calibration

The exact phase measure M and the phase offset O are determined from the four phase values and the corresponding analog voltages as follows:

$$M = \frac{|V_1 - V_2| + |V_3 - V_4|}{360} \quad \frac{V}{\text{degree}}$$

$$O = \frac{|V_1 - V_2|}{M} \text{ degree}$$

where

$$V_1 = \varphi_1$$

$$V_2 = \varphi_2 = \varphi_1 - O$$

$$V_3 = \varphi_3 = -\varphi_1 - O$$

$$V_4 = -\varphi_1$$

4.1.3 Narrowband Sweeping

In some cases a continuous display of the measured values, at least in a small frequency range, would be desirable, as is for instance required by crystal manufacturers or for measurement of narrowband filters. Such displays on the screen of an oscilloscope or in conjunction with an XY recorder are permitted by the operating mode SWEEP of the ZPV. A sweep rate of up to 300 MHz/s is possible with a sweep width corresponding to the holding range of the frequency synchronization.

Contrary to the other operating modes of the ZPV, in which the analog test values are digitized by the computer and output, the built-in computer monitors in the narrowband sweep mode the level in reference channel A. In this way accurate measurement without any additional adjustments is also possible in the SWEEP mode.

First condition for an accurate measurement is a constant signal at the input of the test item. In order to avoid exacting requirements on the signal generator used, the level at the input of the test item is measured in reference channel A and the value measured in channel B is corrected accordingly; the ratio of the two voltages is then formed.

The signal in reference channel A is further amplified in B1 on the PC board selectivity filter A (see circuit diagram 291.5319 S) and subsequently rectified by the operational rectifier B3. After filtering in the active lowpass filter B6 the measured DC voltage of the reference channel is applied to the multiplier B5. The measurement range of reference channel A is thus fixed to 0.05 to 0.5 V. At the same time, the voltage is taken via T2 to the computer. If the reference level leaves the particular range, a corresponding signal is delivered via the computer. The Zener diode GL3 ensures proper functioning of the instrument in the other operating modes.

The test signal of channel B is processed and measured like in the other operating modes of the ZPV (see section 4.1.1). With narrowband swept-frequency operation, the analog signal is applied via ST1.11a to the multiplier B5. The voltage ratio between channels A and B is formed and as analog voltage brought out via the switching transistor T4 at the socket r SWEEP on the rear panel of the set. Since the measurement range B can be switch-selected in 10-dB steps, swept-frequency measurements are possible in the entire dynamic range with a reference level of 0.03 to 0.3 V. The reference value 1 lies within the measurement range B = 0.1 to 0.3.

In addition to the possibility of forming the ratio B/A, a swept display of the values measured in channel B or A is also possible by switching off the voltage measurement in channel A by T3. The reference voltage REF. 1 routed via ST1.7a is used as reference potential. Switchover of the function is effected via the level converter B4 by applying a logic 1 to ST1.1b.

B4 also processes the signal required for switching the phase indicator Y27 (see circuit diagram 291.5060 S). When selecting the SWEEP mode, the phase is automatically output in analog form at the socket φ SWEEP on the rear panel. The phase-proportional voltage is processed without phase resetting as used in point-for-point measurements. The phase resetting is disabled by applying the logic level 0 to B5.1 via R11. The amplitude of the phase-proportional voltage is reduced in B6 to ±0.5 V for full-scale deflection (±180°) and taken via the switching transistor T3 and R41 to the socket φ SWEEP. The output impedance is fixed at 100 Ω by R41.

4.1.4 Power Supply

The power supply Y2 (see circuit diagram 291.6015 S) is a self-contained module which is accommodated on the rear panel of the basic unit ZPV. Since the rear panel can be removed, measuring and checking the power supply is easy. The power supply is connected with the basic unit by means of two flat cables which are plugged into the motherboard and are part of the power supply. The power supply contains six supply units, which supply the ZPV basic unit and the plug-in with ±5 V, +12 V, ±15 V, ±20 V and +120 V.

The supply units for ±20 V and +12 V are of conventional design with fixed voltage regulators B1, B2, B3. R14 and R17 provide for exact setting of +20 V and -20 V. All three units have an internal current limiting and thermal overload protection and are therefore short-circuit-proof. Due to their low current load, the supply voltages of ±15 V are derived from ±20 V via the Zener diodes GL6 and GL9.

The +120-V unit is intended for the supply of the pulse generator in the tuner plug-in. The +20-V supply is used as reference voltage source. The amplifier T2, T3 is supplied from the -20-V unit. The overload protection of the series regulator T1 is ensured by the current limiting R2, GL2, GL3 and an additional fuse SI2.

The +5-V supply is a separate subassembly. The arrangement of the series regulator T4 permits driving into the saturation region of the collector-emitter voltage, thus ensuring less leakage power in the regulator. The -5-V supply with the fixed voltage regulator is used as reference voltage source. The deviation of the actual value from the rated value is amplified in B4 and via T5 applied to T4.

The voltage at R29, which is proportional to the current load, is compensated by the bias voltage at R27. In case of overload the sum of the voltages at R29 and at R27 becomes < 0. As a result the amplifier B4 takes over the driving via GL18 and adjusts for a smaller value of the output voltage. Thus the bias voltage at R27 becomes smaller and also the maximum short-circuit current, which means a foldback current characteristics (Fig. 4-10).

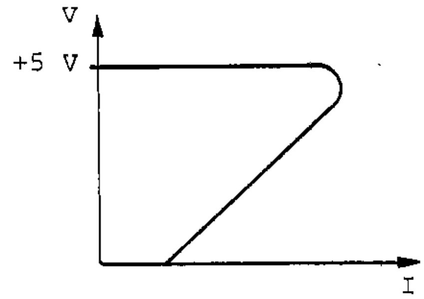


Fig. 4-10 Current characteristic of the +5-V supply

In order to keep the source impedance of the power supply small, separate sensor lines for measuring the +5-V voltage and the ground potential are brought out at BU15.11 and .1. The resistors R30 and R11 provide for a defined potential on the sensor lines for the case that the power supply should not be properly connected. The diodes GL17, GL21, GL7 and GL8 provide for a protection against overvoltage at the outputs of the power supply.

In addition to the analog and digital subassemblies of the ZPV the power supply also supplies the three-phase generator M01 of the blower. The power supply is designed for all usual AC supply voltages, which can be selected by means of the voltage selector on the rear panel of the ZPV. AC supply frequencies between 47 Hz and 420 Hz are permissible. A filter incorporated in the power cable provides for suppression of mains noise.

4.2 Digital Section

As can be seen from Fig. 4-1 in the appendix, the analog section of the ZPV is controlled by the digital section. The block diagram shows the internal structure of the digital section. The individual blocks represent the PC boards or subassemblies. The connecting lines within the digital section represent address bus, data bus and control lines.

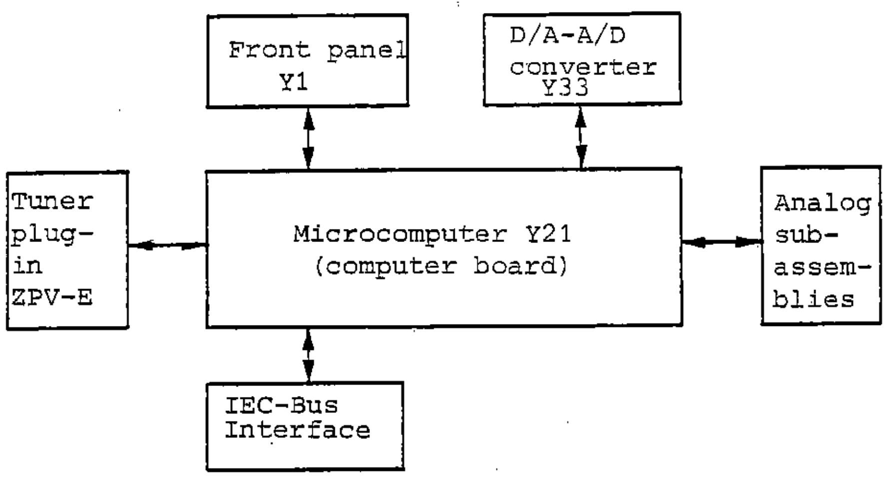


Fig. 4-11 Block diagram of digital section

The main part of the digital section is the PC board carrying the microcomputer. The front panel with pushbuttons and readouts serves for operation of the set and indication of the test results. The IEC-bus interface board enables remote control according to IEC standards. On the D/A converter board both digital values are converted into analog values (analog voltage outputs, tendency indication control) and analog values into digital values (test voltages). The connection between computer board and plug-in provides for the information about the synchronizing state and the possibility of automatic frequency range selection. The connection to the analog section of the basic unit is required for channel selection, automatic amplitude range selection, phase calibration, etc.

4.2.1 Computer Board Y21

See circuit diagram 291.4812 S

The microcomputer proper of the ZPV is accommodated on this PC board. The block diagram below shows the simplified design.

The heart of the microcomputer is the microprocessor, which mainly consists of the two-phase clock pulse generator B1, the central processing unit B3, the bus control module B6 and the address buffers B4 and B5 The program commands and fixed information required for the microprocessor are available in ROMs B11 to B14. The decoder B10 in conjunction with the gates B7 and B2 serves for selecting the individual ROMs. The ROM capacity is 4 kbytes.

Variable data and return addresses are stored by the microcomputer in the RAMs B16 and B17. The inverter B2 and gate B15 provide for the selection of these RAMs. The available RAM capacity is 1 kbyte.

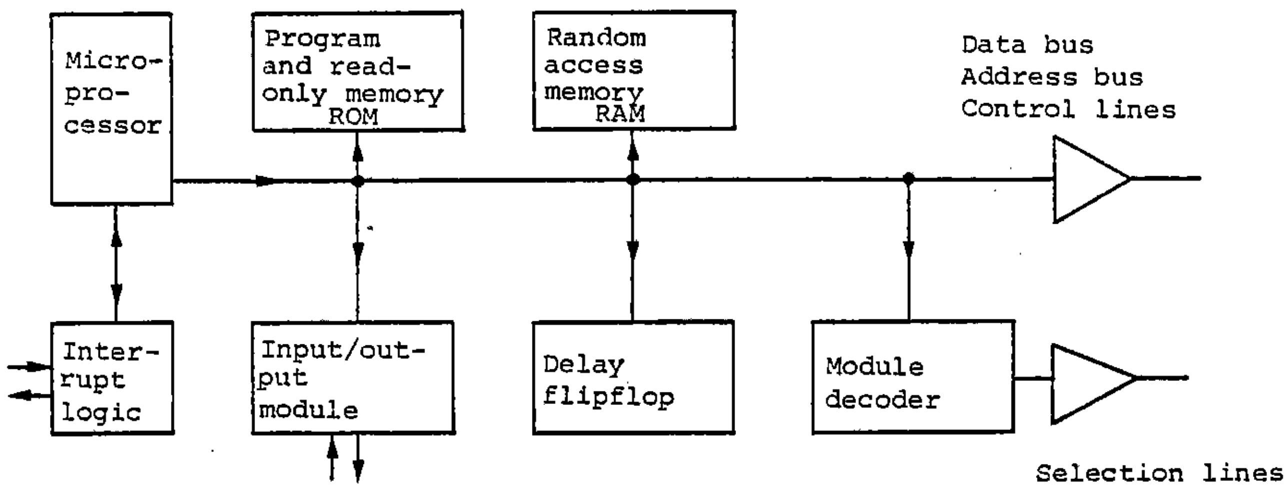


Fig. 4-12 Block diagram of computer board

An interrupt logic combines the three interrupt requests: keyboard interrupt, LACS and TACS (B7, B8, B9). Only one interrupt level is used (interrupt 7). The keyboard interrupt signal is emitted by the keyboard as soon as one button is pressed and sets the flipflop B9, whose output addresses the central processing unit and interrupts via B7 and B8 the keyboard clock signal, thus stabilizing the status. After processing of the interrupt the flipflop is reset and hence free for new interrupts.

The signals LACS and TACS come from the IEC interface board and mean a listener or a talker interrupt. The flipflop B9 is set and the central processing unit is addressed by the timing of signal SP15 and B7. A listener interrupt is stabilized by DAC via B8. After recognition of the cause of interrupt the flipflop is reset again and is free for a new interrupt.

The input/output module B23 is mainly used for controlling the analog section. In addition, it also controls the two monoflops B24, which are used for generating delays. The input/output module is selected by the input/output

decoder B20, B21, B22 like the other input/output modules on other sub-assemblies.
Parts of the address bus, the data bus and certain control lines are connected with the basic unit via the connector strips.

4.2.2 Front Panel Y1

See circuit diagram 291.4112 S

The front panel consists of the readout panel and the keyboard.
The following block diagram shows the individual functional groups.

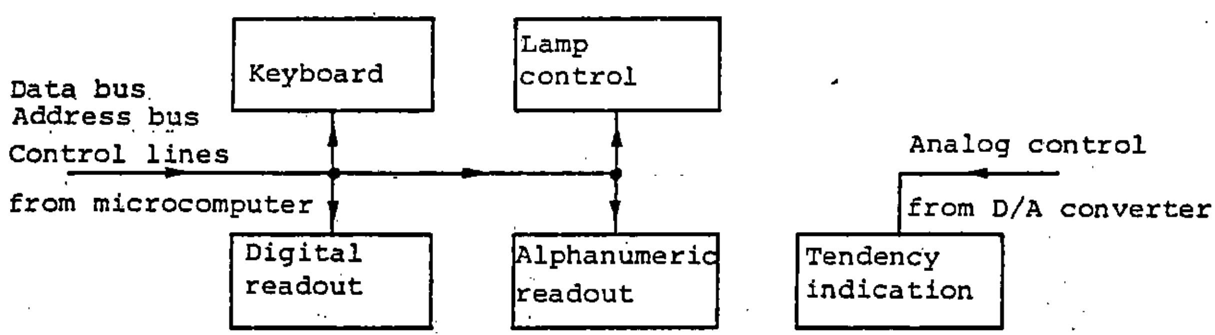


Fig. 4-13 Block diagram of front panel

All functional units, with the exception of the tendency indication, are connected to the address bus, the data bus and the input/output selection lines of the microcomputer. The keyboard operates with independent interrogation of the pushbuttons. The counter B43 is continuously switched by the keyboard clock signal. A level of 0 V is present only at one output line of the decoder B42 which is connected to B43. If a button is depressed, the 0 V-level is switched to one of the inputs of the B44. Consequently the counter disable line goes to +5 V and inhibits via the computer board the keyboard clock signal. After a certain delay, the keyboard interrupt signal appears also and causes an interruption of the current computer program. The microcomputer reads in the gates B33, B34 and determines the depressed button. After releasing the button, the interrogation of the buttons is continued. The counter combination 15, which is not used for the pushbuttons, enables on the computer board an interruption by the IEC bus interface.

The flipflops B31, B41, B45 with the subsequent decoders B40, B50, B51, B52, B53 and the transistor array B46 drive the lamps in the luminous buttons as well as the LEDs GL4 to GL7. The selection for the data transfer to the individual flipflops is made via the decoder B32.

The hexadecimal components B2, B3, B4, B5 provide for the digital readout of the lefthand indication panel and B12, B13, B14, B15 for that of the righthand indication panel. The polarity signs of these digital readouts are produced by the overflow indicators B1 and B11. The sign and the decimal point of the lefthand digital readout are controlled via the flipflop B19, that of the righthand digital readout via the flipflop B21. The flipflop B211 provides for blanking of both digital readouts. The selection for the data transfer to the digital readouts and of the associated flipflops is made by the decoder B9.

The alphanumeric 5-by-7 dot matrices B6, B7, B8 are used for dimension indication of the lefthand readout and B16, B17, B18 for that of the righthand readout. One column of the left and one of the right dimension indication is unblanked simultaneously with the contents of the RAMs B37, B47, B38 and B48. The column counter B54 in conjunction with its clock pulse generator B36 switches the RAM addresses synchronous with the column decoders B39 and B49. This is an automatic process. If the dimension changes, the microcomputer switches via the alpha write enable signal its address bus via the program switch to the address bus of these RAMs and resets at the same time the column counter. The new dimension pattern can be loaded in conjunction with the selection lines alpha output right and alpha output left.

The LED rows B26, B27 and B28, B29 enable quasi-analog display of the lefthand and the righthand readouts. Driving via B20 and B22 is purely analog by the reference voltage and the control voltages tendency left and tendency right from the D/A converter board.

4.2.3 D/A Converter Y32

See circuit diagram 291.5119 S

The D/A converter board serves both for converting digital into analog values and analog into digital values.

The core of this converter is the 12-bit D/A converter B2. It is driven by the microcomputer via the input/output module B1. Via its output amplifier T9, T10 it can quickly charge the capacitors C7 to C12, which are connected via one of the FET switches T3 to T8, to a certain voltage.

These voltages are then available via high-impedance emitter followers for digital output on the rear panel (X, r; Y, φ), for controlling the tendency indication (tendency left, tendency right) and for the deviation control output CONTR. ΔF on the rear panel (deviation control, τ).

The quad comparator B16 affords the comparison of analog voltages. Thus the voltage of the D/A converter can be compared with that of the A/D converter (from the socket ADC on the rear panel), with the voltage A, B (from the amplitude indication), with the voltage φ (from the phase meter) and with the output voltage of B15. By systematic comparison the microprocessor can thus approximate in 12 steps the voltage under observation and determine its digital value.

For increasing the resolution in the phase and group delay measurement the phase voltage at B8 can be compensated by a voltage at B9 and the difference amplified by B15 can be measured.

B17 buffers the two reference voltage outputs REF. 1 for the phase meter and REF. 2 for the tendency indication.

4.2.4 IEC Interface (Option ZPV-B1)

See circuit diagram 292.3632 S

The IEC interface board provides the ZPV with the interface functions SH1, AH1, T6, TE6, L4, SR1, DC1, DT1, RLØ, PPØ, CØ which comply with DIN-IEC 66.22 (IEEE 488). This PC board acts as data coupler between the external data bus DI/01 to DI/08 and the ZPV data bus DB0 to DB7. The IEC interface board performs pure interface functions such as handshake, addressing, unaddressing and last character coding completely independent, i.e. without any involvement of the microcomputer of the ZPV. This is shown in the following block diagram.

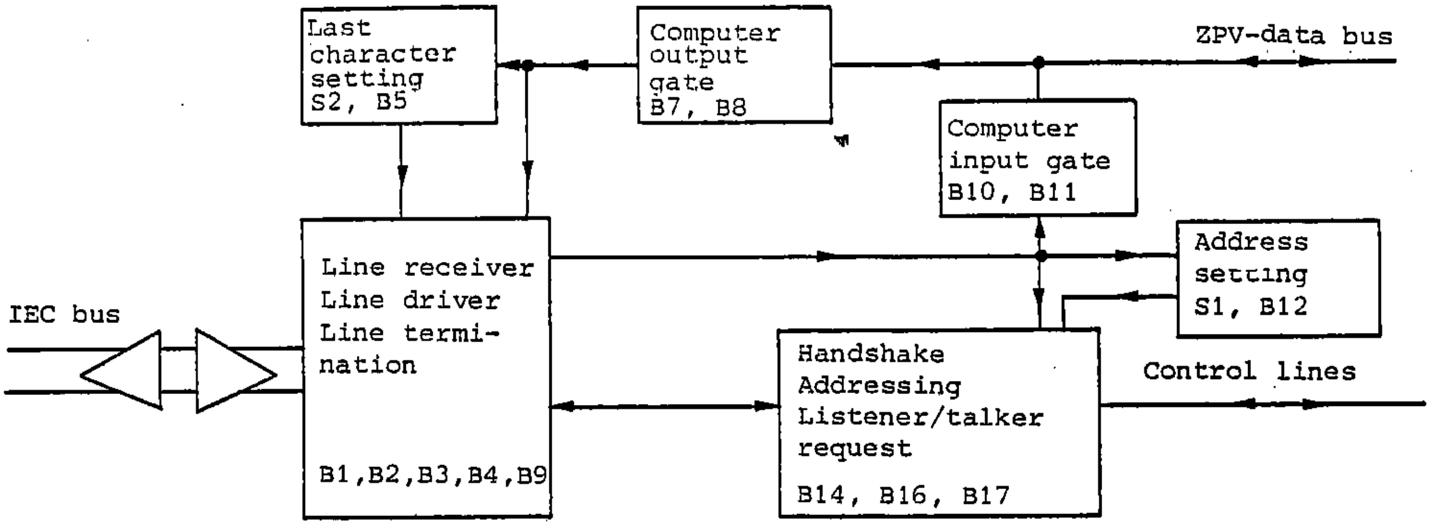


Fig. 4-14 Block diagram IEC-Interface

The lines of the IEC bus aue terminated by the resistor networks R1 to R4, R6, R9 and R10. Depending on the function, either input buffers (B9, B2, B13) or line drivers (B1, B3, B4) are connected to the lines used. A switching network with the field-programmable logic array (FPLA) B14, the memory module B17 and the inverter B16 provides for proper operational sequence of the listener and talker handshake (DAV, NRFD, NDAC, ATN, IFC as well as LADS, TADS, LOCAL and DAC), addressing, unaddressing and interrupt request of the microcomputer of the ZPV. The output 1Q of B17 stores the address status of the listener, whereas output 3Q stores the address status of the talker. The output 2Q of B17 stores the asynchronous IFC signal. This stored IFC signal is read in by the microcomputer (IEC-IN) prior to each data output and is erased again with the data output signal IEC-OUT. The output 4Q stores the active status of the talker, emits via the TACS signal an interupt request to the microcomputer and controls at the same time the bus drivers B3 and B4. Upon an interrupt request by TACS the microcomputer only applies the data byte just to be output to the output modules B7, B8. If the microcomputer is to accept data, addressed commands, universal commands or secondary talker addresses, it will receive an interrupt request via the LACS signal, whereupon it will in turn inhibit the handshake via the DAC signal until such information is accepted by the input modules B10 and B11.

Switch S1 and comparator B12 serve for setting and identifying the device address. The relation between the switch positions and the set device address is shown in Table 2-5.

The switches S2.1 to S2.4, the switching module B5 and the NAND gate B13 serve for setting, output and identification af the last character of a talk process. The relation between the switch positions and the set last character is shown in Table 2-6.

By closing the switch S2.6 the service request (SRQ) to the IEC bus can be disconnected.

5. Repair Instructions

5.1 Required Measuring Equipment and Accessories

Item	○ Designation, required specifications ● Recommended R&S instrument	Type	Order No.
1	○ Signal generator, 18 to 22 kHz, 1 to 2 MHz 1 V/50 Ω ● Signal generator, 10 Hz to 140 MHz	SMK	348.0010.03
2	○ Pulse generator, 20 to 200 Hz, 0 to +5 V		
3	○ Digital voltmeter, 1 mV to 1 V; 0 to >20 kHz, error <0.5% ● Digital multimeter	UDL4	346.7800.02
4	○ Attenuator set, 0 to 80 dB/50 Ω, error <0.02 dB ● Programmable Attenuator	DPVP	214.8017.52
5	○ Oscilloscope, 0 to 10 MHz, vert. 1 mV/cm, hor. 0.5 µs to 20 ms ● Oscilloscope, DC to 30 MHz	BOP	374.0020.02
6	○ 20-kHz generator with two output signals whose phase shift (-180° to +180°) is adjustable with an error of <±0.1°		
7	● Tuner plug-in, 0.1 to 1000 MHz	ZPV-E2	292.0010.02
8	○ Termination 50 Ω		
9	○ Selective millivoltmeter, 10 Hz to 40 kHz ● Test receiver, 9 kHz to 30 MHz	ESH2	303.2020.52
10	○ DC ammeter, 0 to 10 A, error ≤ 2%		
11	○ Load resistors, see section 5.2.1		

5.2 Adjustments

The location of the subassemblies and the adjusting elements is shown in Fig. 5-1.

5.2.1 Power Supply

See circuit diagram 291.6015 S

Set the voltage selector to the local AC supply (220 V). Connect the cables to the motherboard. Connect a load resistor of 270 Ω between ST14.3 (+15 V) and ST15.3 - 8 (ground) and one between ST14.5 (-15 V) and ST15.3 - 8. Load ST14.1 (+20 V) and ST14.8 (-20 V) with 43 Ω and ST14.9 (+120 V) with 8 kΩ referred to ground (ST15.3 - 8).

Adjust the voltage at ST14.1 with R14 in the power supply to +20 V ±0.01 V. Adjust the voltage at ST14.8 with R17 in the power supply to -20 V ±0.01 V. The hum voltage should not exceed 10 mV_{pp}. The voltage at ST14.3 should amount to +15 V ±0.3 V, at ST14.5 -15 V ±0.3 V and at ST14.9 +120 V ±0.5 V. In the case of deviations > ±0.5 V from 120 V, correct by means of R6 or R7. Load the +12-V power supply (ST14.15) with 24 Ω. The voltage should amount to +12 V ±0.6 V. The voltage at ST14.12, loaded with 16 Ω, should amount to +16 V ±2 V. When increasing the loads at the +12-V, +20-V and -20-V outputs, the maximum currents should not exceed 1 A.

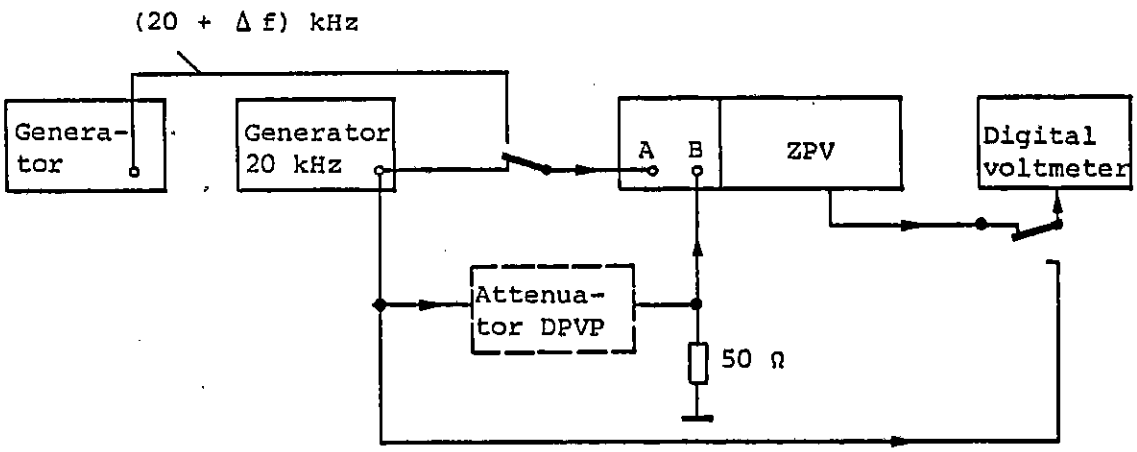
Load the -5-V supply unit (ST15.9) with 11 Ω and the +5-V supply unit (ST15.13 to 16) with 1.1 Ω. The voltage at ST15.9 should amount to -5 V ±0.25 V and at ST15.13 to +5 V ±0.3 V. Increase the load of the +5-V supply, measuring at the same time the maximum current, which should not exceed 7 A. The short-circuit current should not be smaller than 100 mA. Should the current exceed 7 A, check the input offset voltage of the amplifier B4 (for functioning of the current limiting circuit see section 4.1.3). Increase the load of the -5-V supply and measure the maximum current, which should not exceed ca. 0.8 A. Should the +5-V voltage be dependent on the load, check the +5-V sensor line (BU15.11). Should the other supply units be also dependent on the load of the +5-V voltage, check the 0-V sensor line (BU15.1).

Finally check the sense of rotation of the built-in blower M01. The air must be sucked in through the filter on the rear panel and blown into the basic unit ZPV. If necessary, two of the connections on the blower motor must be interchanged. Check the power supply also at the other AC supply voltages with the voltage selector set to the respective positions.

5.2.2 IF Section, Amplitude Measurement Branch

See circuit diagrams: 291.5319 S - selectivity filter A Y35
291.5219 S - preamplifier B Y24
291.5260 S - digital filter Y23
291.5160 S - amplitude indication Y34

Test setup:



Apply the 20-kHz ±5 Hz signal from the signal generator with an amplitude of 100 mV to the IF inputs of the basic unit of the ZPV (BU42.A1/A4). For this adjustment of the basic unit without tuner connect the contacts 4 and 6 of socket BU42 (circuit diagram 291.4012 S) with a 560-Ω resistor to simulate the presence of the tuner for the calculator. Should the digital section of the ZPV be operative, select the operating mode A, LIN. Otherwise make sure that the operating mode A and the voltage measurement range 100 mV are switched on (see Table 4-4); bandwidth = 2 kHz (Table 4-5). Connect the oscilloscope to BU35.17a/b (Y35, selectivity filter A). Adjust with L1 for maximum voltage. Connect the DC voltmeter to BU34.3a (Y34, amplitude indication). Adjust the input signal to 0 V and adjust R32 (Y34) for 0 V at the output (BU34.3a). Set the input voltage to 100 mV and set with R33 (Y34) the output DC voltage to 7.9 V in the measurement range 100 mV. Connect the DC voltmeter to BU35.10a and check the two measured values (0 V and 7.9 V); repeat, if necessary, the adjustment of R33, R32 (7.9 V correspond to an indication of 100). Select mode B, measurement range 100 mV. Adjust with L1 (Y23, digital filter) for maximum voltage. Adjust with R40 (Y24, preamplifier B) for the same sensitivity at 100 mV as in channel A.

Disconnect the signal in channel A. Terminate channel A with 50 Ω. Connect channel B via a terminated attenuator set with the signal generator. Adjust the amplitude from the signal generator, reading from the digital voltmeter. Increase the attenuation of the attenuator set in 10-dB steps, switching over at the same time the amplitude measurement ranges of the ZPV and monitoring the DC voltage at the analog output BU35.10a. The deviations should not be greater than stated in the Specifications. Take into account the calibration curve of the attenuator set.

Adjust the input signal in channel B to 1 V (attenuator set 0 dB), measurement range 1 V. Supply channel A with a signal of ca. 0.5 mV and a frequency displaced by ca. 100 Hz (= Δf) referred to channel B. Select the measuring mode A and the measurement range A = 1 mV. Connect a selective millivoltmeter to the analog output BU35.10a. The superimposed AC voltage with the frequency Δf should not be greater than 16 mV, corresponding to a crosstalk attenuation of 120 dB min.

Exchange the IF inputs. Select the measuring mode B and the measurement range B = 1 mV and measure the crosstalk attenuation as in channel A.

Check finally whether the same signal is present at the IF outputs as at the IF inputs (Z_{out} = 1 kΩ).

5.2.3 Phase Measurement Branch

Test setup as in section 5.2.2

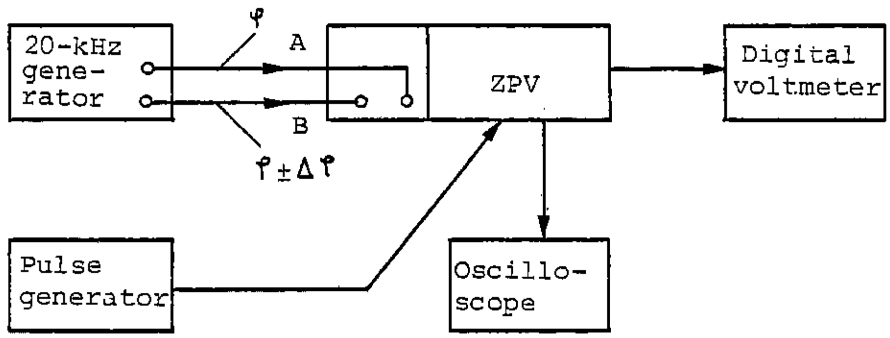
Adjust the level in both channels to approximately 100 mV, measurement range 1 V. Connect the DC voltmeter to BU36.17a/b. Adjust L1 in the amplifier A (Y36) such that the negative DC voltage at BU36.17a/b reaches its minimum. Connect a selective millivoltmeter to BU37.6a/b and adjust L1 in the limiter A (Y37) for optimum suppression of the 40-kHz signal. Adjust the amplifier B (Y25, BU25) and the limiter B (Y26, BU26) in the same way as the amplifier and limiter A. The signal amplitude at the output of the amplifier A (B) should be ca. 1000 mV_{pp} and hardly vary over a dynamic range of 1 V to < 100 µV.

Replace the 20-kHz signal generator by a 20-kHz generator with two output signals which can be shifted in phase. Connect a DC voltmeter to the analog output of the phase indication (BU27.4b). (For this purpose the D/A converter Y33 must be synchronized and the reference voltage of 6.3 V be available at BU27.4.) The DC voltage at BU27.7b should be +5 V ±20 mV for a phase difference of 0°. Minor deviations can be removed by fine adjustment of one of the filters in amplifier A (B).

5.2.3.1 Phase Indication

See circuit diagram 291.5060 S

Test setup:



Remove the computer board Y21. Connect BU27.32a with ground potential (logic level 0). The undelayed signal of channel B is thus disconnected (BU27.26a) and the signal delayed by 12.5 µs by B1 applied to B5.13. Check with the oscilloscope at B5.13 whether the switching circuit functions properly. A variation of the phase position of the input signals must not cause a change of the phase relationships at B4.8 and B4.11. Adjust the time delay in B4 to 12.5 ± 1 µs by suitable selection of the capacitance C4.

Connect the oscilloscope to BU27.21a. The pulse duty factor should be ca. 4:1. Apply logic 0 to BU27.31b. The pulse duty factor should be switched to ca. 4:3. The voltage at BU27.18b should in both cases amount to ca. +4 V. Connect the oscilloscope to BU27.11b and apply logic 0 to BU42.23. The pulse duty factor of the signal at BU27.11b should be similarly switchable as at BU27.31b. Connect the pulse generator to BU27.17a. Adjust the pulse amplitude to +5 V, the frequency to ca. 100 Hz and a pulse duty factor of 10:9. A squarewave signal with half the pulse frequency should be present at BU27.30a (180° bit).

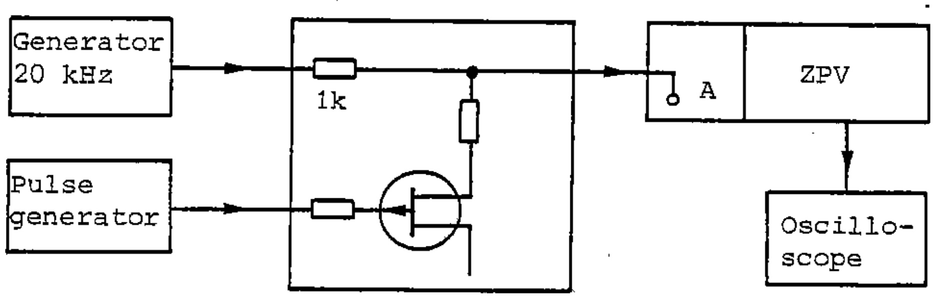
Disconnect BU27.23a from ground and apply logic 0 to BU27.17a. The 180° bit (BU27.30a) must now be periodically set and reset with a frequency of ca. 1 kHz.

Remove all additional connections. Vary the phase of the input signal in the range -180° to 0° to $+180^\circ$. The analog voltage at BU27.4b should accordingly reach, but not exceed, the following values: V > 0 and ≤ 10 V. The dependence of the analog output voltage V_φ and the 180° bit on the phase is shown in Fig. 4-8 (section 4.1.2).

5.2.4 Narrowband Sweeping

See circuit diagrams: 291.5319 S - selectivity filter A Y35
291.5060 S - phase indication Y27

Test setup:



Swept-frequency attenuator

The swept-frequency attenuator is not required with signal generators which permit a periodic variation of the amplitude in a range of ca. 20 dB.

Select the operating mode SWEEP, B/A by applying logic 0 to BU35.2a and BU35.1b. Adjust the amplitude in channel A such that the DC voltage at BU35.14b reaches +4 V, corresponding to about 300 mV at the IF input A.

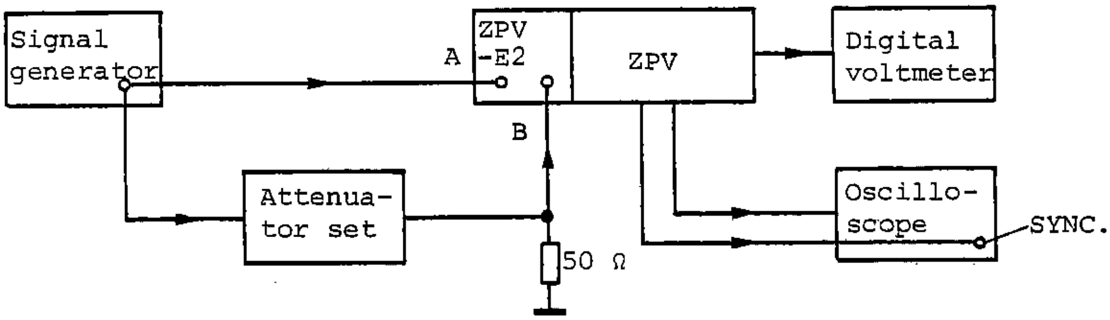
Select the operating mode B and the measurement range B = 1 V (see Table 4-4). Connect the oscilloscope to BU35.14a. Adjust the DC voltage with R41 (Y35) to 0 V. Vary the amplitude of the input signal in the range 0 to -20 dB, referred to the initial setting. Adjust the AC output voltage with R35 for minimum. Select the operating mode A and the measurement range A = 300 mV. The output voltage should be ca. 1 V. Vary the amplitude of channel A in the range 0 to -20 dB and adjust R44 for minimum variation of the output voltage. Repeat the adjustment (R44, R41, R35) if required. At the socket r on the rear panel of the ZPV ca. 20% of the voltage at BU35.14a should be present (Z_{out} = 1 kΩ). The suppression of the variations of the input reference level at socket r is typically -40 dB. Apply logic level 1 to BU35.1b. At BU35.14a and at socket r on the rear panel the swept-frequency representation of the input signal should now be present, without voltage ratio. The measured quantity is determined by the operating mode (A or B). With calculator-controlled ZPV, the B signal must be switched over accordingly for the adjustment.

Feed two 20-kHz signals shifted in phase into channel A and B. The voltage proportional to the phase must be present at T3 (Y27) and at socket on the rear panel with an amplitude of ± 0.5 V/$\pm 180°$.

5.2.5 Digital Filter

See circuit diagram 291.5260 S

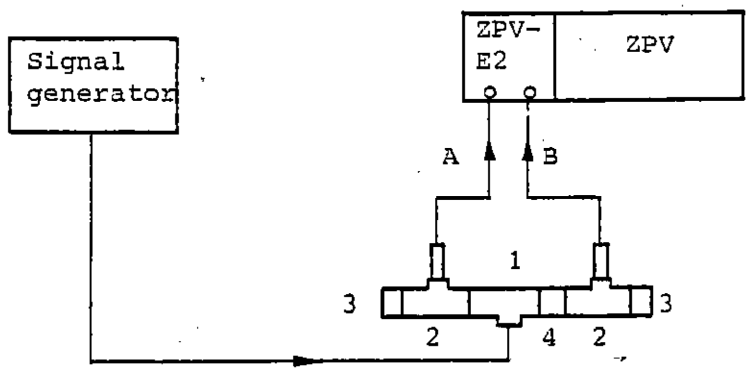
Test setup 1



Connect the oscilloscope to BU23.7b, the SYNC. input to BU23.1a. Select on the ZPV basic unit the local frequency control mode, operating mode B and measurement range B = 100 µV. Select on the ZPV-E2 plug-in the frequency range 600 to 100 MHz. The attenuation of the attenuator set is 60 dB. Adjust the output level of the signal generator to 200 mV and vary the frequency between ca. 19 and 21 kHz. The signal at BU23.7b must be synchronous with that at BU23.1a in a frequency range of at least 20 kHz ±500 Hz. If necessary, correct R2 (digital filter Y23). Set the signal generator frequency to ca. 1 MHz, with a level of 100 mV. Select the frequency range 1 - 2 MHz on the ZPV-E2 plug-in. Adjust with R24 on the digital voltmeter (BU35.10a) the same measured value for the measurement range B = 100 µV with an attenuation of 60 dB and for the measurement range B = 1 mV with an attenuation of 40 dB.

Separate the connection K59-BU24.1a (input of the preamplifier B) and connect the oscilloscope to BU23.31b. Adjust with R15 and R16 (Y23) for minimum crosstalk signal. The lamp UNSYNC. on the ZPV-E2 must not light. Re-establish the connection at BU24.1a and check the calibration of the measurement ranges 30 µV and 100 µV, taking into account the error of the attenuator set. The instrument must comply with the requirements in the Specifications.

Test setup 2



1 = feed unit ZPV-Z2

2 = insertion adapter ZPV-Z1

3 = 50-Ω termination

4 = attenuator 40 dB/50 Ω

Adjust the signal generator frequency in test setup 2 to 1 MHz and the level to ca. 200 mV. Select the frequency range 1 - 2 MHz on the ZPV-E2 plug-in and the measuring mode B/A on the ZPV basic unit. Store the indicated phase (button φ , τ REF. STORE). Adjust the output level from the signal generator according to the magnitude indication of the ZPV to ca. 70 to 80 µV. Adjust L1 in the amplifier B (Y25) such that the phase indication is smaller than $\pm 0.1^{\circ}$.

5.3 Trouble Shooting in the Digital Section

See circuit diagram 291.4812 S - computer board Y21

5.3.1 General

Since the microcomputer is involved in all digital operations of the instrument, trouble shooting appears almost impossible without knowing the complex program flow. The following hints can however be given:

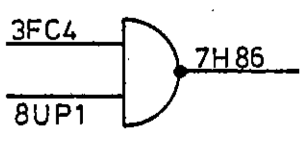
- The functioning of the 2-MHz clock pulse generator on the computer board is an essential condition for the functioning of the microcomputer (check ø1 and ø2 at B1).
- If the central processing unit B3 on the computer board is operative, the SYNC signal appears at B3.18, which consists of one pulse per 4 to 5 clock pulses (check SYNC signal).

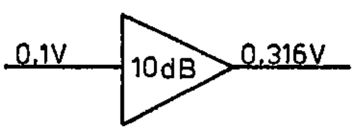
- All information from and to the central processing unit flows via the 8-bit data bus. Short circuits or interruptions of the data lines may lead to a behaviour of the microcomputer which appears completely senseless (check the data bus for short circuits and interruptions).
- From where and to where the information flows is also determined via the 16-bit address bus (not fully utilized). Short circuits and interruptions of the address lines may also lead to a meaningless behaviour of the microcomputer (check the address bus for short circuits and interruptions).
- The control lines of the bus controller B6 generate in conjunction with the address lines in the various selection decoders the write, read, input and output pulses for the individual memory and input/output modules. The absence of these selection pulses may also lead to a meaningless behaviour of the microcomputer (check selection pulses).

5.3.2 Signature Analysis

Signature analysis is a completely new method for trouble-shooting in digital systems.

Detection and analysis of digital signatures in digital systems is comparable to measurement and analysis of analog voltages in analog systems.





When the input signals of a component are correct but not the output signals, the component is either defective, it is too heavily loaded (e.g. shortcircuit) at its output, or the test point is not connected to the output of the component (e.g. interruption). If, for instance, a circuit diagram or corresponding tables with digital signatures are available, errors can be located even at component level.

The ZPV is designed to permit signature analysis. Using, for example, the attractively priced Signature Analyzer HP5004A the technique represents a new tool for rapid and accurate instrument servicing and trouble-shooting.

The tests made on the ZPV can be divided into two phases. In the first phase mainly the ROM content as well as the address and data busses are checked.

The second phase, which is based on the first, serves for checking the entire digital section with the aid of a test program included in the ROM.

5.3.2.1 Checking the ROM Content and the Address and Data Busses

5.3.2.1.1 Purpose

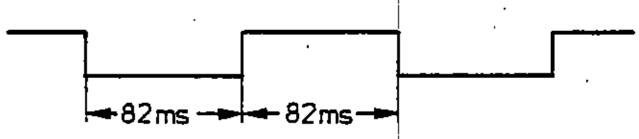
This test is carried out to ensure that
- the microprocessor (B1, B3, B6),
- the address bus drivers (B4, B5),
- the address bus,
- the ROM selection decoder (B10),
- the program memories (B11, B12, B13, B14) as well as
- the data bus

function properly.

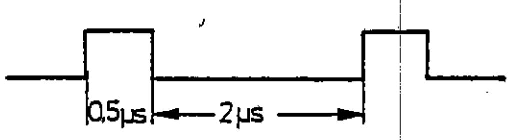
5.3.2.1.2 Preparation

a) Switch off ZPV; fix computer board to extension boards; insert sockets BU4 to BU11 such that contacts 2 and 3 of ST4 to ST11 are connected (links at the bottom); switch on ZPV.

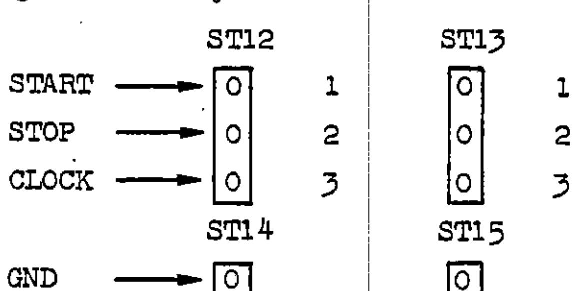
b) Check START/STOP signal 1 at ST12.1 and ST12.2 with an oscilloscope.



c) Check CLOCK signal 1 at ST12.3 with an oscilloscope.



d) Connect signature analyzer to ST12 and ST14



e) Setting of signature analyzer

START:  STOP:  CLOCK: 

5.3.2.1.3 Checking the Total ROM Content

The signatures given in table 5-1 can be measured at ST4.1 to ST11.1 on the computer board. If the measured signatures and those in the table are identical proceed to the second test phase. If this is not the case start error shooting as described under section 5.3.2.1.4.

5.3.2.1.4 Trouble-shooting in the ROM Range

If an error is found in the ROM section (section 5.3.2.1.3) the address lines A0 to A15 and some strobes must be checked according to table 5-2. The signatures of the address lines must first be verified at the CPU (B3 on computer board), then after the address bus drivers (B4 and B5 on the computer board), **Any errors traced (shortcircuits, interruptions, defective components) must be eliminated before the strobes for the individual memory components can be checked. For this trouble-shooting use the remaining signatures of table 5-2.**

Finally the content of each memory component can be checked.
To this end remove all ROMs from the holders on the computer board except for the one to be measured. The signatures produced by each ROM at the data bus can be seen from table 5-3. Thus errors are easily localized (short-circuits, line interruptions or defective components).

Note: Insert each ROM in its proper socket.

5.3.2.2 Checking the Entire Digital Section

5.3.2.2.1 Purpose

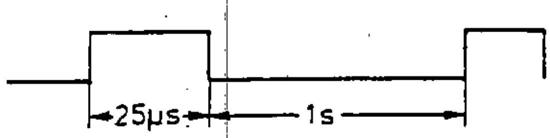
If the ROM content is in order, the digital sections of the total instrument and the RAM components can be checked in a second test phase by using a special test program (provided) in the ROMs.

During this test a certain test pattern is applied periodically to all output gates and RAM positions.

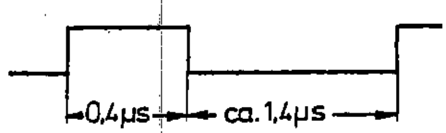
5.3.2.2.2 Preparation

a) Switch off ZPV.
   Connect BU4 to BU11 on the computer board such that contacts 1 and 2 of ST4 to ST11 are connected and connect BU17 on the computer board such that contacts 2 and 3 of ST17 are interconnected. Switch on ZPV.

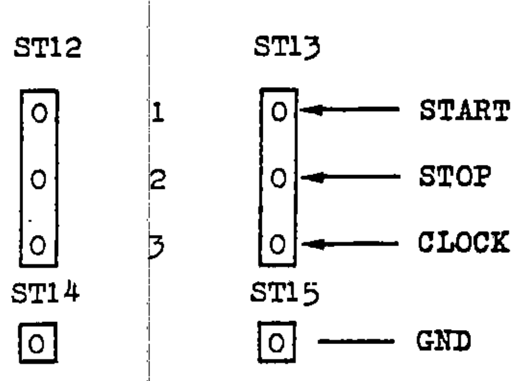
b) Check START/STOP signal 2 at ST13.1 and ST13.2 with an oscilloscope.



c) Check clock signal 2 at ST13.3 with an oscilloscope.



d) Connect signature analyzer to ST13 and ST15.



e) Set signature analyzer to

START: STOP: CLOCK:

5.3.2.2.3 Trouble-shooting in the Digital Section

The running test program causes the indicator lamps to light so that each failure is clearly visible.

If an error occurs, trace back the signal path with the aid of the signatures listed in table 5-4 until the correct signature is measured. The error must then be near this point.