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Manual

VECTOR ANALYZER ZPV

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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	O □ ⏊ |	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	Luminous button for selecting automatic group delay measurement with generator deviation control.
39	SET f_o + 4 kHz	Luminous button for entering the frequency deviation of 4 kHz.
40	SET f_o	Luminous button for entering the test start in the case of manual two-point measurement.

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 0.63 B 235 V 115 V T 1.25 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.
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 1,25 B for 115 or 125 V
T 0,63 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 $\pm 10\%$ 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

(using Option ZPV-B2)

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 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. 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 mS.

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

(using Option ZPV-B3)

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.

2.3.4.2 Continuous Measurement

Pressing button τ 34 conditions the group delay measurement. Button AUTO 38 permits selection of the automatic continuous measurement mode.

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 Outputs

2.3.9.1 IF/1 V Outputs

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).

2.4 Remote Control

(using Option ZPV-B1)

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-E2 and ZPV-E3 they are explained in table 2-11.

2.4.8.7 Output of DC Voltage at ADC Input

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.

2.4.9 Programming Examples for Desktop Calculator TEK 4051

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 (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: PRINT @ 26: "BALII1"

2.4.9.2 Programming of Frequency Range

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 No. for plug-in ZPV-E2 from table 2-11 - 08 - is added. This yields the setting combination FR08.

c) Thus the solution reads: PRINT @ 26: "FR08"

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 can be set at any position.

c) Thus the solution reads: Print @ 26: "HZ 07505"

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 (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 (see table 2-5).

c) The test result can be read in as an ASCII string (e.g. A$\not{0}$) and is available in this form for further processing.

d) Thus the following two solutions are possible:

```
1. PRINT @ 26: "LR"
   INPUT @ 26: AØ
2. INPUT @ 26,3: AØ
```

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, 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 (see table 2-5).

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

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

```
1. PRINT @ 26: "DS"
   INPUT @ 26: SØ
2. INPUT @ 26,4: SØ
```

Later output is caused by the command

```
PRINT @ 26: "TS"
PRINT @ 26: SØ
```

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:

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

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
PRINT@ 26: "GØKØSH"

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

PRINT@ 26: "SR"	Preparation of reference value output
INPUT@ 26: AØ	Output of reference value and storage in AØ

or with a single command using secondary address 9:
INPUT@ 26,9: AØ

Reentry of reference value in the ZPV

PRINT@ 26: "TR"
PRINT@ 26: AØ

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:

PRINT@ 26:	"TEBA"	External triggering, mode B/A
PRINT@ 26:	"PO18ØØ"	Phase offset 180 degrees
INPUT@ 26,2:	P	Result on lefthand readout (phase value P)
		P = measured phase - phase offset

INPUT @ 26,2: P	Result on lefthand readout (phase value P) P = measured phase since phase offset holds only for <u>one</u> 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 (network in accordance with IEC 444 or DIN 45 105) permits measurement of crystal equivalent circuit parameters. For this purpose, the ZPV must be fitted with the Group-delay Option ZPV-B3.

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, in addition, the S-parameter Option ZPV-B2 is fitted, it is possible to determine 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	only possible with Option ZPV-B2
Y	AUTO		Measurement of resonant admittance	only possible with Option ZPV-B2
S21, S12			Same as with B/A AUTO LIN/REF	only possible with Option ZPV-B2

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^o.

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^o.
- 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 Measurement Using the S-parameter Option ZPV-B2

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 reads

PRINT@26: "PO....".

The decimal points stand for a figure each. For a 45° phase offset, for example, program

PRINT @ 26: "P0Ø45Ø"

and for -45°

PRINT @ 26: "P0315Ø".

2.5.4 Control Amplifier

Fig. 1 shows 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 output.

Scale: 0° corresponds to 0 V
-180° corresponds to approx. -0.5 V
$+180^{\circ}$ 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° corresponds to 5 V
-179.9° corresponds to 0 V
$+179.9^{\circ}$ 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° 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.