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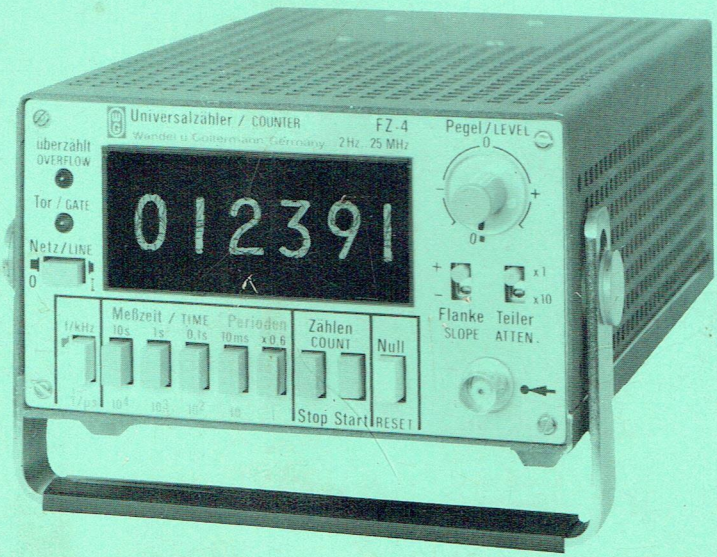
Description and
Operating Manual



25 MHz Universal Counter

FZ-4

UNIVERSAL COUNTER FZ-4

Description and Operating
Instructions 497 C...

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Subject to change without notice

Wandel u. Goltermann · Reutlingen/Germany

CONTENTS

INTRODUCTION

This handy universal counter with the designation FZ-4 is supplied with 6 digit read-out. The self-contained buffer stage provides a flicker-free display of the measured result and thus to a large extent permits low-fatigue, reliable reading. The various measurement functions can be set by push button and give a wide field of application.

The decimal point is shifted automatically so that the frequency is displayed over the whole measuring range in kHz and the period always in µs. At high frequencies frequency measurement has higher resolution and at low frequencies this is the case with period measurements. Trigger error during period measurement is reduced by averaging over $10 \ldots 10^4$ cycles.

The input (1 MΩ ‖ 60 pF) incorporates a divider stage switchable from 1 : 1 to 1 : 10 so that it can be loaded with peak values up to 250 V. The input sensitivity is up to 5 MHz at 50 mV, up to 15 MHz at 75 mV and up to 25 MHz at 150 mV.

The trigger level is continuously adjustable according to switch position of the input divider between ± 1 V and ± 10 V; with the rotary knob engaged it is close to zero-axis crossing. Triggering itself can be switched from positive to negative trigger edge.

Apart from frequency and period measurement continuous counting can be carried out with this instrument such as occurs during fixed quantity measurement (e. g. flow, power, unit quantities, etc.). When measuring occurrences per minute (e. g. revolutions per minute, etc.) the conversion factor (x 0.6) is fed in by push button. The display reproduces according to measuring time selected a decadic part of the occurrences per minute to be measured.

All functions listed above can be set on the front panel and also remote controlled via contact boards on the back of the instrument. In addition other functions can be performed by means of these rear connections, such as for example the input of a more accurate frequency as substitute for the internal standard frequency, measurement of frequency or pulse ratios, measurement of pulse duration or time intervals, summation of individual results, stop watch operation and output of periodic time signals.

Connections on the back also permit data output to a recording unit, that is to say parallel in BCD code 8-4-2-1 in negative logic. With a special adapter connection to the digital output complies with the Wandel und Goltermann Works standard for instruments with recording output. It is thus possible to connect the printers customary in the ANDIMAT 3 system direct.

Cables are available which have BNC connectors at both ends. It is possible to convert the instrument for fitment in 19" racks with suitable fitting components.

Unless otherwise stated the values are valid for the rated operating AC line voltage and temperature immediately after switching on.

1.1. MANUAL AND REMOTE CONTROLLED OPERATING MODES, ranges and error limits

1.1.1. FREQUENCY MEASUREMENT, measurement input

Measurement range	2 Hz to 25 MHz
Measurement time, selectable manually	10 s, 1 s, 0.1 s, 10 ms
also programmable externally	1 ms, 100 µs, 10 µs
Error limits	± 1 digit ± Q [1]
Read-out	in kHz with decimal point

1.1.2. PERIOD MEASUREMENT, measurement input

Frequency range	2 Hz to 250 kHz
Measurement time	1 cycle
Error limits	± 1 digit ± Q [1] ± T [2]
Interval of counting pulses	1 µs
Read-out	in µs with decimal point

1.1.3. MULTIPLE PERIOD MEASUREMENT, measurement input

Frequency range	2 Hz to 15 MHz
Measurement time	10, 10^2, 10^3, 10^4 cycles
Error limits	± 1 digit ± Q [1] ± T [2] /number of cycles
Interval of counting pulses	1 µs
Read-out	in µs with decimal point

1.1.4. MEASUREMENT OF OCCURRENCES PER MINUTE, measurement input

Measurement range	10 to 10^9 occurrences per minute
Measurement time	0.6 s, 6 s
Error limit	± 1 digit ± Q [1]
Read-out	in 100 occurrences per min.; 10 occurrences per min.

1.1.5. CONTINUOUS COUNTING, measurement input, (read-out memory switched off)

Counting range	1 to 999 999
Counting frequency	0 to 25 . 10^6 pulses/s
Error limits	± 1 digit
Totalizing and attenuation	remote-controllable
Start and stop	manual and remote-controllable

1.1.6. TEST

The internal standard frequency is connected to the counting input. It is possible to test frequency measurement, measurement of occurrences per minute and period measurement.

---

1) Q = Error of standard frequency used

2) T = Error caused by inaccuracy of the trigger threshold (± 0.5 mV refer to the input). The resultant measurement error depends on the slope of the voltage rise at the trigger point, i. e. in the case of sinusoidal measurement voltage the error reduces with rising frequency and amplitude.

1.2. EXCLUSIVELY REMOTE-CONTROLLABLE OPERATING MODES, ranges and error limits

1.2.1. FREQUENCY RATIO MEASUREMENT, measurement input and "Ext. oscillator" input

Frequency ranges f_x (measurement input)	2 Hz to 25 MHz
f_n ("Ext. oscillator" input)	100 Hz to 5 MHz
Error limits	± 1 digit ± T 2)

1.2.2. PULSE DURATION MEASUREMENT, TIME INTERVAL MEASUREMENT, measurement input or "Start/Stop" inputs

Measurement time when using the 1 MHz frequency (1 µs resolution)	10^{-2} s to 2 s
when using the 1 kHz frequency (1 ms resolution)	10^{-3} s to 2000 s
Error limits measurement input	± 1 digit ± Q [1] ± T 2)
"Start/stop" input	± 1 digit ± Q [1]

1.3. MEASUREMENT INPUT (Front panel)

	BNC jack No. 31-221
Cable plug	BNC No. RT 51-111
Frequency range	2 Hz to 25 MHz
Input sensitivity with sinusoidal voltage U_{eff} to 5 MHz	≦ 50 mV
to 15 MHz	≦ 75 mV
to 25 MHz	≦ 150 mV

Input sensitivity with pulse shape voltage U_{ss} and pulse width ≧ 20 ns

Trigger level 0 (preset)	3.5 V; trigger level at optimum setting · 200 mV
Trigger edge, switchable	positive or negative
Input attenuater	"x 1" = 1 : 1 · "x 10" = 1 : 10

Input voltage U = ÷ U_s	max. 150 V	max. 250 V
U_{eff} from 2 Hz to 500 Hz	max. 50 V	max. 250 V
upto 25 MHz	max. 20 V	max. 200 V
Input resistance	1 MΩ ‖ 60 pF	1 MΩ ‖ 35 pF
with over modulation	> approx. 3 V: 500 kΩ ‖ 2200 pF	> approx. 30 V: 1 MΩ ‖ 100 pF

Trigger level continuosly adjustable · approx. + 1 V to - 1 V · · · approx. + 10 V to - 10 V

1.4. CONTACT BOARD A (back panel)

Remote control	Contact board 2 x 22 pole
Multi-point connector for above	F 0532 Part No. 2422 044 42252 (Valvo)

1.4.1. "EXT. OSCILLATOR" INPUT, contact D

Frequency range	100 Hz to 5 MHz
Minimum pulse amplitude U_{ss}	0.7 V } any position between
Maximum pulse amplitude U_{ss}	5.0 V } -5 V and +5 V
Input impedance	2 kΩ

1.4.2. "EXT. COUNTER FREQUENCY" INPUT, contact B; signal level see 1.6.

Frequency range	0 to 15 MHz
Edge steepness	< 1 µs

1.4.3. TIME BASE OUTPUTS

Operation with internal standard frequency	1 MHz, 100, 10, 1 kHz
with additional programming	100, 10, 1, 0.1 Hz
Operation with external standard frequency	f/10, $f/10^2$, $f/10^3$
with additional programming	$f/10^4$, $f/10^5$, $f/10^6$, $f/10^7$

---

1) Q = Errof of standard frequency used

2) T = Error caused by inaccuracy of the trigger threshold (± 0.5 mV refer to the input). The resultant measurement error depends on the slope of the voltage rise at the trigger point, i.e. in the case of sinusoidal measurement voltage the error reduces with rising frequency and amplitude.

1.5. CONTACT BOARD B (back panel)

Digital output	Contact board 2 x 22 pole
Multi-point connector for above	F 053 Part No. 2422 044 42252 (Valvo)

1.5.1. DATA OUTPUT, signal level see 1.6

Code	BCD 8-4-2-1
7 digits, "over range" signal and decimal points	parallel on 32 conductors
Digit content $10^0 \ldots 10^5$	0...9
10^6 (over range)	0...7

1.5.2. RECORDING INSTRUMENT CONTROL; signal level see 1.6.

Recording instrument trigger, negative (0-1-0) pulse	typical 250 µs
Recording instrument inhibit	1-signal whilst gate open
Counter inhibit (from recording unit)	by 1-signal

1.5.3. PERIODIC TIME SIGNALS

Pulse interval	1 or $2 \cdot 10^{-6} \ldots 10^{6}$ s 1 or $2 \cdot 10^{-7} \ldots 10^{4}$ min

1.6. SIGNAL LEVEL, negative 5 V logic (TTL)

Inputs low (1-signal)	0 to + 0.8 V
high (0-signal)	+ 2.0 V to + 5.5 V
Outputs low (1-signal)	0 to + 0.4 V
high (0-signal) at 50 µA load	+ 2.4 V to + 5.25 V
Pulse duration	> 30 ns

1.7. INTERNAL STANDARD FREQUENCY

Frequency at + 23 °C and 60 min after switch-on	1 MHz ± 1 Hz
Long term instability	per year $\pm 2 \cdot 10^{-6}$; per week $\pm 3 \cdot 10^{-7}$
Temperature dependence in rated temperature range related to + 23 °C	$\pm 10 \cdot 10^{-6}$
Average temperature dependence in rated temperature range per °C	$\pm 5 \cdot 10^{-7}$
Voltage dependency in rated line voltage range	$\pm 1 \cdot 10^{-6}$

1.8. READ-OUT

Result display	max. 1999999 with point
Read-out storage	remote controlled switch-off
Storage capacity	max. 7999999
Read-out time with automatic reset	until next measurement completed
with remote control	optionally extendible
Over range read-out with over range = 1	"over range" lamp is on
with over range ≧ 2	"over range" lamp flickers
Gate-open time	Gate lamp remains on as long as gate is open

1.9. GENERAL DATA

Line voltage (selectable by soldering) rated value, BN 597/2	110 V, 220 V
BN 597/3	120 V, 240 V
Rated service ranges, BN 597/2	99 V to 121 V, 198 V to 242 V
BN 597/3	106 V to 130 V, 213 V to 261 V
Line frequency, rated service range	45 Hz to 66 Hz
Power consumption	approx. 25 W
Ambient temperature, rated service range for operation	+ 5 °C to + 40 °C
for storage	- 40 °C to + 70 °C
Dimensions w x h x d in mm	142 x 80 x 220
Weight	approx. 2 kg

1.10. PART NUMBERS

6 digits, 110, 220 V	BN 597/2
6 digits, 120, 240 V	BN 597/3

1.11. ACCESSORIES

19" installation kit for 1 FZ-4 unit	BN 597/50
for 2 FZ-4 unit	BN 597/51
Adapter for remote control (with 50 pole amphenol jack)	BN 597/52
Adapter for data output (with 50 pole amphenol jack; connection complies with the W. u. G. Works Standard for measuring instruments with recording output)	BN 597/53
Programme card (with 2 HF inputs BNC)	BN 597/54
Connecting cable (HF plugs BNC on both ends) 50 Ω, 1 m long	K 76
or 75 Ω, 1 m long	K 80

Subject to modification without notice

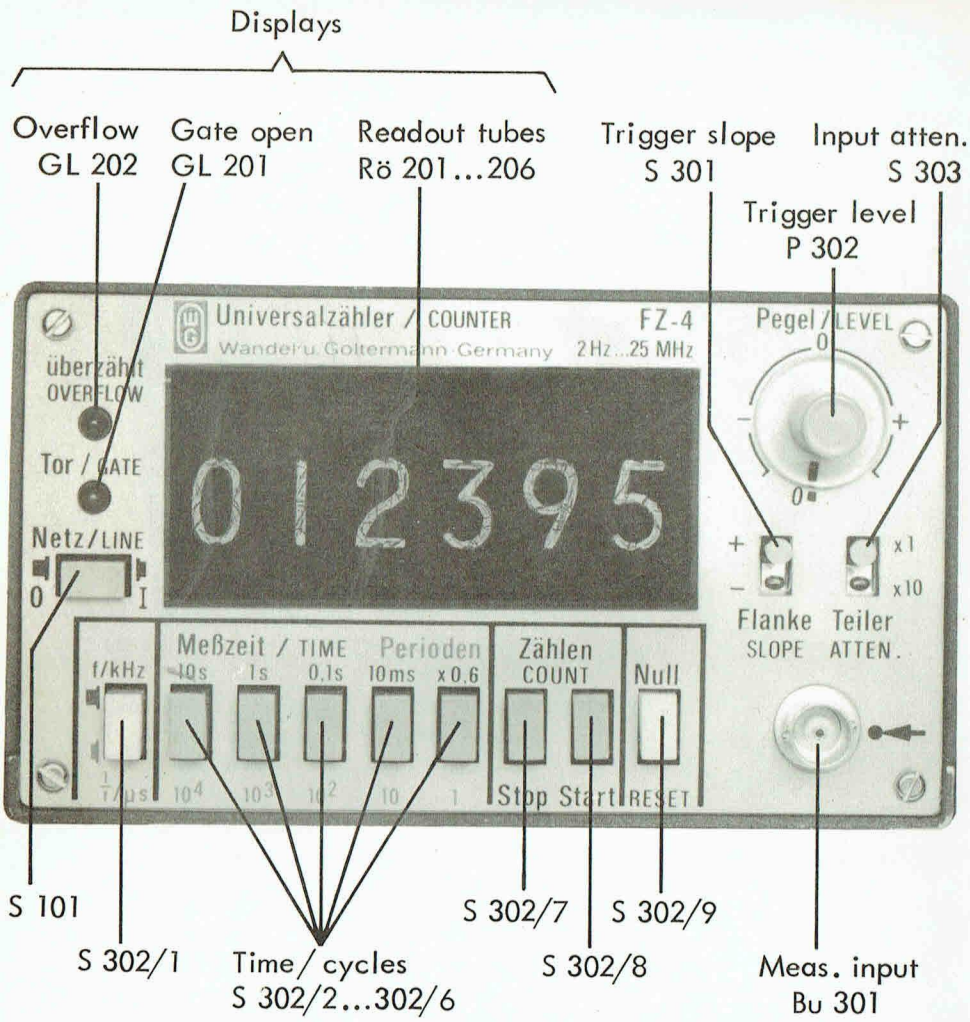

Fig. 2-1 Universal Counter FZ-4, front view

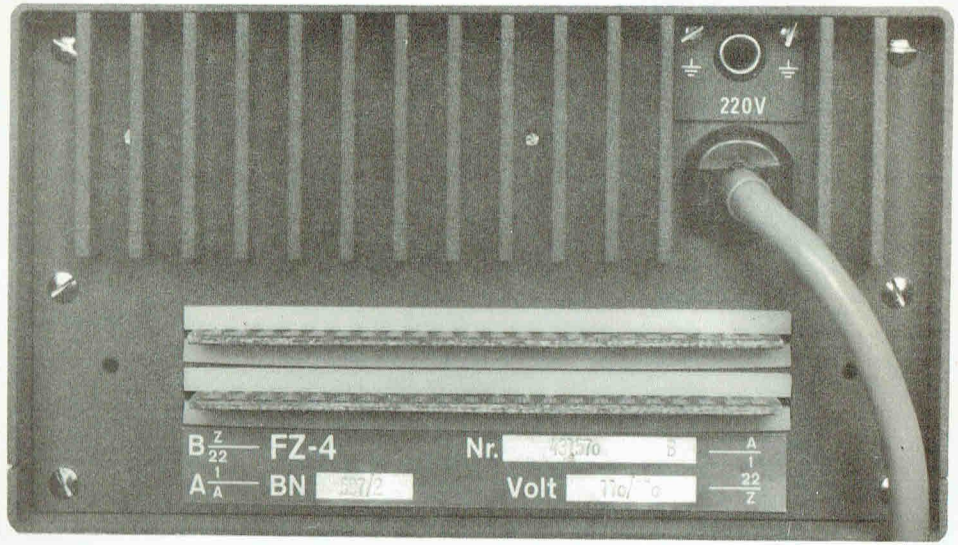

Fig. 2-2 Universal Counter FZ-4, rear view

2. OPERATION

2.1. Installing the Unit

The Universal Counter FZ-4 should be operated at ambient temperatures between +5 °C and +40 °C. Suitable ventilation should be ensured inside the meter structures, above all in the case of rack installation so that the supply air to the instrument does not exceed this temperature range. To ensure cooling by natural air circulation the instrument should be operated in standard position (front panel inclined up to 30° from the vertical), the ventilation openings in base, cover and side panels should be kept free.

All operating and display devices as well as the measurement input are located on the front panel. The connections for line, remote control and printer are on the back of the unit. See Figs. 2-1 and 2-2 together with the section below.

2.2. Connecting the Unit

2.2.1. Line connection

In accordance with Order specification the counter is supplied either for 220/110 V or for 240/120 V line voltage. Re-soldering from 220 V to 110 V and vice-versa for one model and from 240 V to 120 V and vice-versa for the other model is described in section 5.2.

Connection to line is by means of the line cable permanently connected to the unit. In accordance with protection class I as per VDE 0411 the non-fused earth conductor of the cable is connected to the case so that the latter is at earth potential when the unit is connected.

2.2.2. Measurement Input

The measurement input on the front panel takes the form of a BNC jack. Details of the input and permissible input values can be found in the Technical Data. An additional earthing jack is provided on the back of the unit.

2.2.3. Control Inputs and Outputs, Digital Output

On the back of the unit are located the 2 x 22 pole, gold plated contact boards A and B. Adapters are available for both output which provide for connection to 50 pole Amphenol jacks. (For jack connection of contact boards see 4.3.).

2.2.3.1. Control inputs and outputs

At contact board A are located all inputs and outputs for remote control as described in section 3.1.

2.2.3.2. Digital output with negative logic (recording instrument output)

Connection of a recording instrument is at contact board B. When using the above mentioned adapter connection of the Amphenol jack complies with the Wandel u. Goltermann Works Standard for measuring instruments with recording output. The data is parallel, BCD coded with negative logic, that is to say there are 7 digits with the 6 digit counter, whereby the 7th digit (which only appears in readout on over range) still provides the numbers 0...7.

In addition an "over range" signal is available for example for ribbon changeover or for recording a special symbol and signals for the individual decimal points. Thus it is possible either to represent the decimal point itself or to record the appropriate measuring range coded. If the decimal point leads are incorporated in the printer cable, the latter should be a maximum of 0.5 m long, otherwise a length of up to 2.5 m is permissible.

The following printers supplied by Messrs. Kienzle [1] can be connected direct to the digital output of the FZ-4 (when using the adapter with a standard printer cable):

Tape printer D 44 E n-W (Table unit)
Tape printer D 44 G n-w (rack slide-in unit)
Spring balance printer D 44 SW n-w

Recording units with different logic and/or different code and interrogation system require an interface for connection to the FZ-4.

Section 3.3. gives information on the signals for recording unit control.

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1) Messrs. Kienzle Apparate GmbH. 722 Villingen-Schwenningen

2.3. Operation

2.3.1. Controls

The controls for manual operation of the universal counter are located on the front panel, they are illustrated in Fig. 2-1 and described below.

"Line" key (S 101)

The unit is switched on and off by means of the "Line" key. It is ready for use immediately. Reset of the storage is combined with switch-on.

"Reset" key (S 302/9)

All storages are reset when this key is operated. A continuous measurement is interrupted.

"Trigger slope" slide switch (S 301)

According to the position of the "Trigger slope" switch the counter responds to the positive or negative slopes of the signal at the measuring input.

"Input attenuater" slide switch (S 303)

According to the amplitude of the input signal the attenuater switch should be set to "x 1" or "x 10". In the "x 10" position the values given in the Technical Data under input A for input sensitivity and adjustable trigger level range are increased by 10.

"Trigger level" adjuster (P 302)

The trigger level potentiometer has at its left-hand end a position of engagement in which triggering takes place near the zero-axis crossing (approx. 50 mV). If the potentiometer is disengaged it can be continuously adjusted between left and right-hand stop, that is to say on attenuater setting "x 1" adjustment of the trigger level from approx. - 1 V to + 1 V and in the "x 10" setting from approx. - 10 V to + 10 V.

2.3.2. Digital read-out and display lights

The digital read out has 6 digits. The numerical value of the read-out (without taking into account the decimal point) corresponds to the number of pulses entering the counting decade during the measurement time. Whether and in what position the decimal point appears depends on the operating mode and measurement time. The measured frequency is basically displayed in "kHz", the period in "µs".

The measurement result is read-in after completion of the counting operation, display remains readable until conclusion of the subsequent measurement.

If more than 999 999 pulses pass into the counting decades, the highest digit of the result will be outside the range of the digital read-out. Single over range will cause the "over range" light (GL 202) to burn continuously, in the case of two or more over ranges it will flicker (except in the case of continuous counting). In the "frequency measurement" operating mode, except for 10 ms measurement time, read-out of this digit can thus be indicated as 0.1 or "over range".

The "gate open" light (GL 201) burns during the gate-open time, that is to say during the measurement time of the counter.

2.3.3. Manual Operating mode selection

The following operating modes can be selected with the keys on the front:

Frequency measurement	Occurrences per minute
Period measurement	Continuous counting
	Test

In view of the low measurement error and the shorter measurement time frequency measurement is recommended at high frequencies and period measurement at low frequencies (see also Fig. 3-26 and 3-27).
A conversion table period $\rightleftharpoons$ frequency is given in the appendix.

For some operating modes several keys habe to be depressed; mutual releasing keys can be engaged by depressing at exactly the same time.

2.3.3.1. Frequency measurement "f/kHz"

If of the operating mode keys only 1 of the measurement time keys S 302/2...5 is depressed, the unit measures the frequency of the signal at the measuring input during the selected measurement time with constant repetition.

For this purpose the input circuit derives pulses from the measurement voltage which pass to the counting decades during the measurement time and are counted there. The measurement time (gate-open time) is derived from the internal standard frequency of 1 MHz by decadic frequency division. The resultant gate control pulses with decadically stepped intervals of 10 ms ... 10 s are evaluated so that the 1st pulse opens the gate and the subsequent one closes it again. At the end of each measurement process the counter result is transferred from the counting decades to the storage and displayed. It remains legible until the end of the subsequent measurement. The selected measurement time determines the position of the point so that display is always in "kHz". During counting the connection between storage and counting decades is broken so that the actual counting process is not visible in the display.

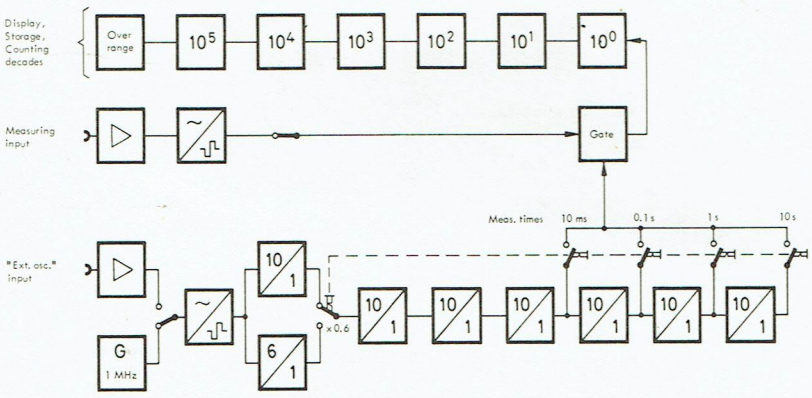


Fig. 2-3 Universal Counter FZ-4 in "Frequency measurement" operating mode

2.3.3.2. Period measurement "$\frac{1}{f}$ / µs"

To determine the period of a signal at the measuring input depress key S 302/1. In addition the required number of cycles should be selected with one of the keys S 302/2 ... 6.

The number of cycles for gate control is derived in this operating mode from the signal to be measured by connecting the measuring input to the divider chain. This provides gate opening times over 1...10^4 cycles of the signal to be measured. Whilst the gate is open the 1 MHz standard frequency pulses pass to the counting decades. Each pulse corresponds to a time unit of 1 µs. The selected number of cycles determines the position of the point so that display always indicates the duration of a cycle. (Change of scale see 3.1.2.1.).

If it is desired to measure the period of frequencies >250 kHz, the single cycle measurement should be averaged at least over 10 cycles and >5 MHz at least over 100 cycles (see also section 3.3.5.).

As in the case of frequency measurement the result is read-in at the end of each measuring operation and remains legible until the end of the subsequent measurement.

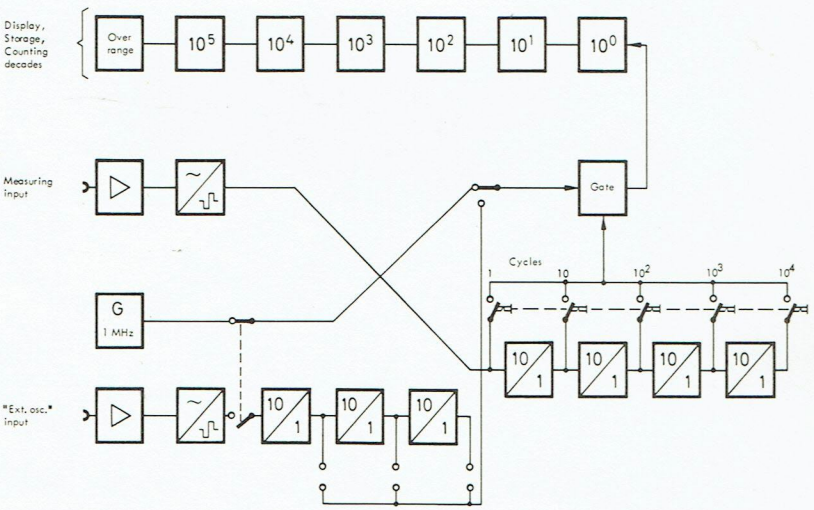


Fig. 2-4 Universal Counter FZ-4 in "Period measurement" operating mode

2.3.3.3. Measurement of occurrences per minute (rpm, etc.).

If in the "frequency measurement" operating mode the key S 302/6 marked "x 0.6" is depressed at the same time as the measurement time key this will produce the measurement times multiplied by 0.6. The table below gives details of the relationship of measurement time keys, measurement time and magnitude of read-out:

Measurement time keys depressed		Measurement time	Read-out
10 s	x 0.6	6 s	x 10/min
1 s		0.6 s	x 100/min
0.1 s		0.06 s	x 1000/min
10 ms		0.006 s	x 10000/min

2.3.3.4. Continuous counting

This simple counter operation is controlled by the "Start" and "Stop" keys. Operating the start key opens the gate. The trigger pulses of the input circuit pass to the counting decades and as with this operating mode, storage and counting decades are constantly connected to one another, via the storage to the read-out. That is to say the counting process can be observed in the read-out. Only when the stop key is depressed and thus the gate is closed are the counting decades separated from the storage and reset. The result remains in the storage and is displayed until renewed tripping takes place by means of the start key or operating the reset key return the storage and display to zero.

2.3.3.5. Test

It is possible to check the function of the counter in the operating modes "frequency" and "period measurement" as well as "occurrences per min". It is not possible thus to check the internal standard frequency, as during the test it is applied at the measurement input and also controls the gate. To carry the test out the keys necessary to select the functions and the stop key must be depressed simultaneously. The FZ-4 then constantly carries out measurements in the operating mode set and produces the following read-out:

Measurement time key depressed		Frequency measurement	Occurrences per min. Measuring	Period
Measuring time	Number of cycles	f/kHz	x 0.6	1/f/µs
10 ms	10	01000.0	006000	00001.0
0.1 s	100	1000.00	060000	0001.00
1 s	1000	⊗ 000.000	600000	001.000
10 s	10000	⊗ 00.0000	⊗ 000000	01.0000

⊗ "over range" light burns continuously; ⊗ "over range" light flickers

During period measurement the still measurable frequency during 1 cycle remains at 250 kHz, so that at 1 MHz there is no utilizable read-out.

2.3.4. Standard Frequency

The universal counter FZ-4 operates at an internal, quartz controlled standard frequency of 1 MHz. It can be switched off when an external standard frequency is passed to the counter. At the same frequency value the front panel labelling remains valid, if this is not the case the measurement times must be multiplied by the factor $\frac{int \cdot f_n}{ext \cdot f_n}$. As regards accuracy it is only necessary to insert the figures of external standard frequency in the Technical Data.

2.3.4.1. Outputs of internal standard frequency

The internal standard frequency of 1 MHz is available at contact 16 of contact board A even when an external standard frequency is fed in.
During operation with internal standard frequency the derived frequencies of 100 kHz, 10 kHz and 1 kHz are available at contact 18, 19 and V of the same contact board. If in addition contacts 2 and 14 of contact board A are connected together, the divided frequencies 100, 10, 1 and 0.1 Hz are then present at outputs 7, 9, 8 and A. (See also Fig. 3-1).

2.3.4.2. Inputs and outputs for external standard frequency

An external standard frequency can be fed to the unit via contact D of contact board A. For this purpose contact 20 must remain connected to contact 14 of the same board. The divided frequencies $f_n/10$, $f_n/100$ and $f_n/1000$ are then available at contact 18, 19 and V. If in addition contacts 2 and 14 of contact board A are connected together, the divided frequencies $f_n/10^4$, $f_n/10^5$, $f_n/10^6$ and $f_n/10^7$ are then available at outputs 7, 9, 8 and A (see also Fig. 3-1).

2.3.5. Sequence of operation

Below is given a simple schedule for sequence of operation:

Depress Line key,

Engage trigger level at left-hand stop,

Set input attenuater to "x 10",

Apply measurement signal to measuring input and depress required measurement time key(s)

If no display takes place
or if it is not positive:

set input attenuater to "x 1".

If the "over range" light comes on, a shorter measurement time or a smaller number of cycles should be selected until the read-out displays even the highest digits of the result.

The FZ-4 unit operates with TTL circuits. Accordingly one should only apply signals to the inputs at the rear which supplies for the signal levels given in 1.6.; in the case of input "external oscillator" see 1.4.1.

In the following sections it will be shown how the control jack (contact board A) should be connected for remote control of the unit. A cable no longer than approximately 1 m can either be connected direct via the appropriate multi-point connector or via adapter BN 597/52 (with 50pole Amphenol plug) to contact board A.

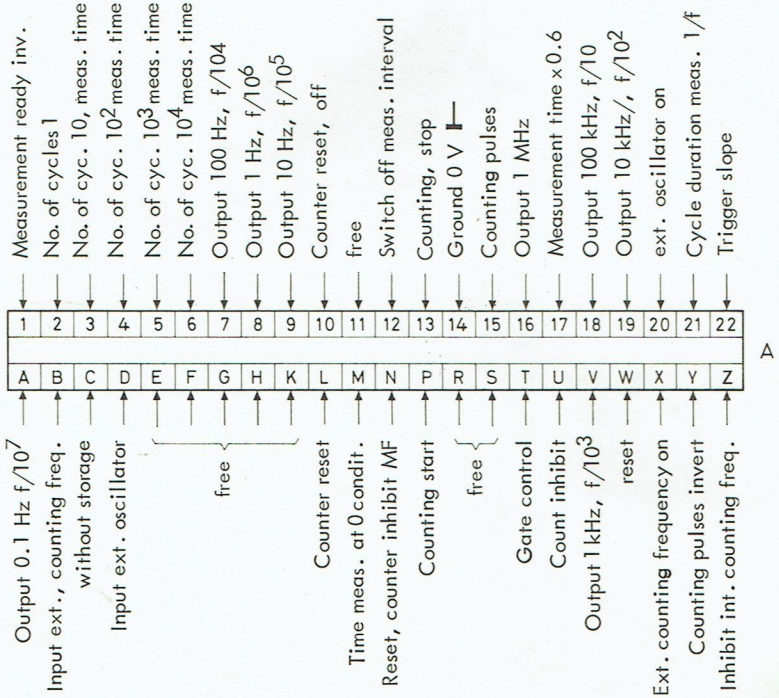


Fig. 3-1 Connection to contact board A (bottom board at the back)

A further possibility for controlling the unit is offered by programming board BN 597/54. All connections indicated in the programming examples below by a figure in ca circle can be made on the programming board by using a short circuit plug for this number as shown in Fig. 3-2. To keep short circuit plugs not required in a safe place, they are plugged in at 2 jack points at right-angles to the direction of programming which are visibly connected by a circuit track (e. g. 1-2, 3-4 ...).

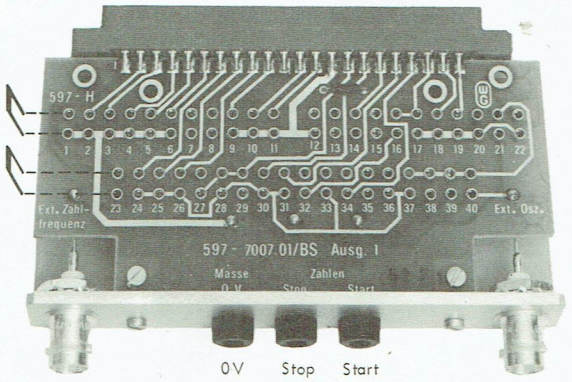


Fig. 3-2 Programming board BN 597/54, plan view

In addition the inputs "external oscillator" and "external counting frequency" are lead out to BNC jacks on this board. The programming board can be screwed on to the unit back panel in plugged-in condition by means of 2 metal brackets (see Fig. 3-2/1). This also applies to the other adapters.

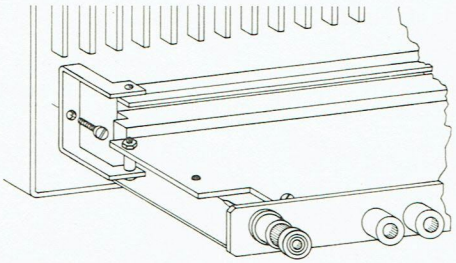


Fig. 3-2/1 Attachment to the back of the unit.

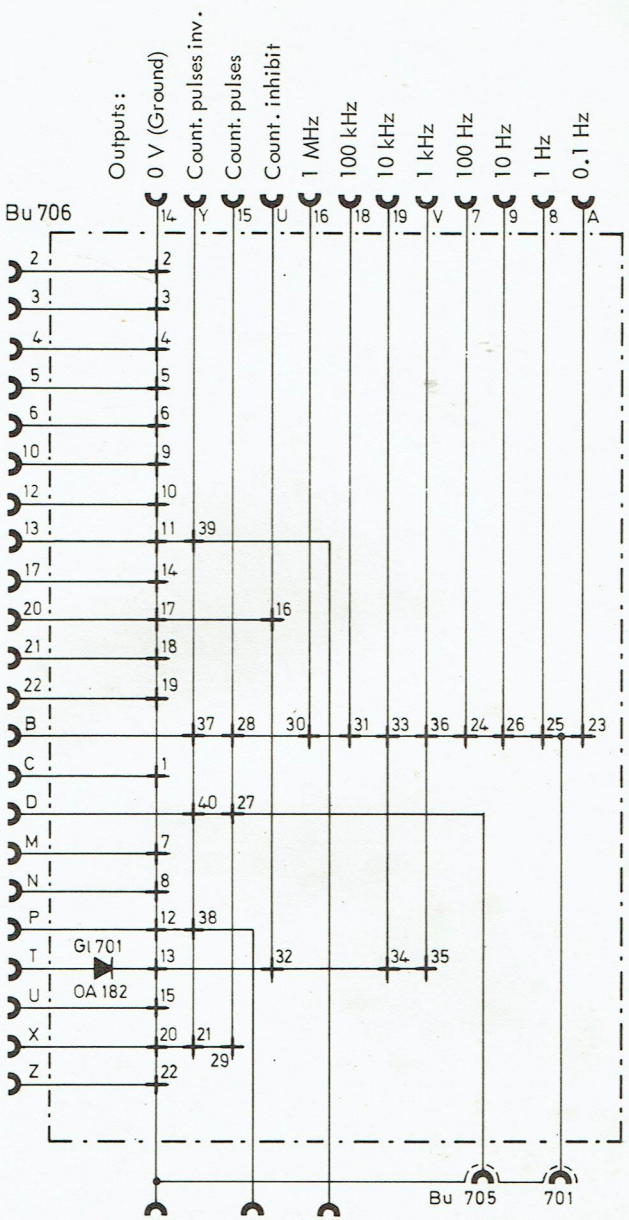


Fig. 3-3
Arrangement on the programming board BN 597/54

3.1. Remote control

With the exception of the trigger level and the input divider, it is possible to remote control all functions of the unit selectable on the front panel. On the front only the line key should be depressed and the slope switch set to "-".

Selection of a function or operating mode is effected by connecting the corresponding contacts on the contact board A to 0 V (ground), that is to say contact 14 of the same board. For example contact 22 should be connected to 14 (19), in order to switch the trigger slope to "+" and W to 14 in order to reset. (Signal duration see 4.3.).

3.1.1. Frequency measurement "f/kHz", occurrences per min.

According to the required measurement time make the necessary connection. The connection 14/17 is only necessary for the measurement of occurrences per min. (see 2.3.3.3.).

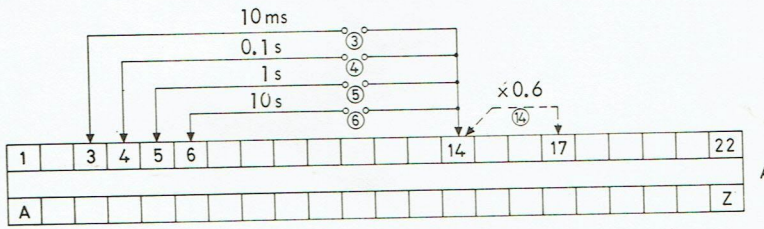
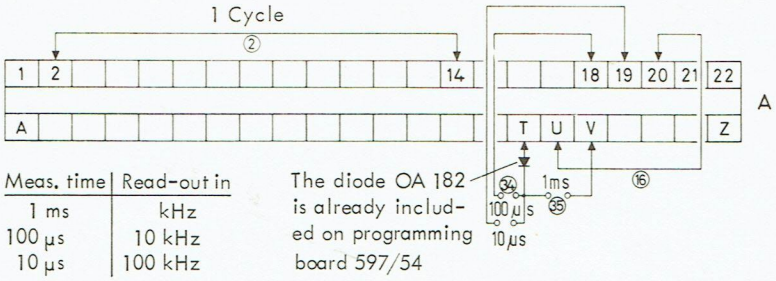


Fig. 3-4

3.1.1.1. Frequency measurement at shorter measurement times

If with the 6 digit counter at frequency measurements = 10 MHz the highest digit should appear in the digital display instead of in the "over range" display, or if the digits of the lowest positions are inaccurate (no stationary read-out), then the measurement time can be shortened to 1 ms or if necessary also to 100 µs or 10 µs.



Meas. time	Read-out in
1 ms	kHz
100 µs	10 kHz
10 µs	100 kHz

The diode OA 182 is already included on programming board 597/54

Fig. 3-5

As a result of connecting the output of the divided standard frequency to the "gate control" input its pulses alternately flip the gate flip-flop to operative and rest position. The gate itself is only opened however when simultaneously one of the measurement times or cycle numbers is selected. Cycle No. 1 is particularly suitable because as a result no additional pulses pass to the gate flip-flop. Lock-out of the counter between two consecutive measurements is obtained with the signal "counter inhibit" by its preventing entry of the internal standard frequency into the time base divider via the input "external oscillator on".

3.1.1.2. Frequency measurement with longer measurement times

Longer measurement times can be obtained by input of an external, that is to say lower standard frequency than the internal one.

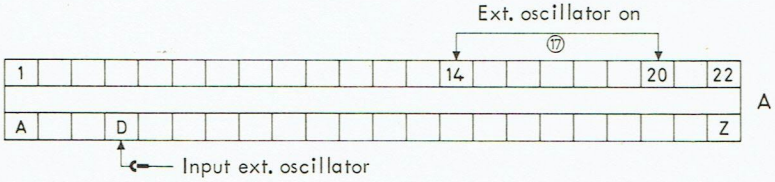


Fig. 3-6

In order to obtain the true measurement time the selected measurement time should be multiplied by the frequency ratio $\frac{\text{internal standard frequency 1 MHz}}{\text{Frequency of ext. oscillator in MHz}}$, the result by the reciprocal ratio so that it is available in kHz.

3.1.2. Period measurement "$\frac{1}{f}$ / µs"

The appropriate connection should be made according to the required period number.

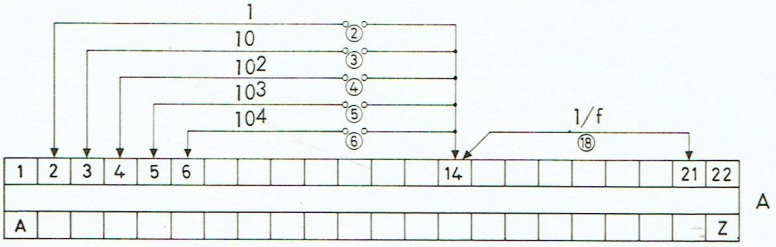


Fig. 3-7

3.1.2.1. Single cycle measurement with modified resolution

In the case of single cycle measurement without additional programming, the internal standard frequency of 1 MHz is entered. Thus in the case of the 6 digit counter the maximum read-out is 999 999 µs, the corresponding frequency approx. 1 Hz. In the case of pulse shaped voltage it is possible to measure up to approximately 0 Hz. In order not to "over range" at frequencies of 1 Hz and above all in order to eliminate the last, usually uncertain digits from the read-out, it is necessary to enter at a lower counting frequency. This can take place with a frequency derived from the 1 MHz frequency by connecting either the 100 kHz, the 10 kHz or the 1 kHz output to the "external counting frequency" input. With 2 further connections this input will be released and the internal counting frequency switched off. Fig. 3-8 illustrates this additional programming and gives the modified unit of measure of the read-out.

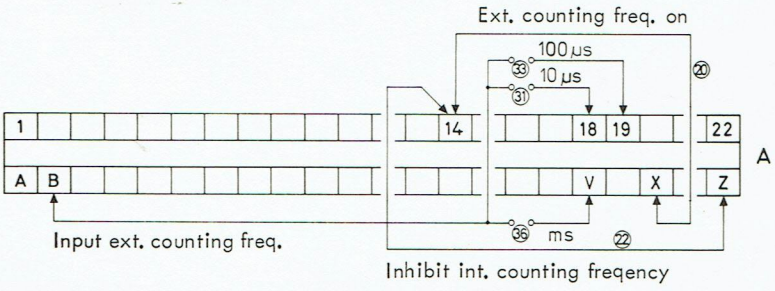


Fig. 3-8

3.1.3. Continuous counting

The method of operation is identical to that described under 2.3.3.4. Manual operation is replaced by the following connection of the remote control inputs.

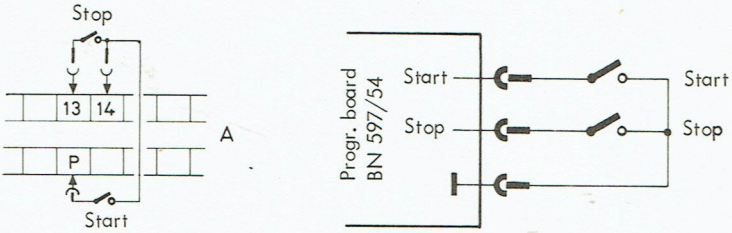


Fig. 3-9

3.1.4. Frequency ratio measurement, Pulse ratio measurement

The Universal Counter FZ-4 can determine the ratios fx : f_n or f_n : f_x from two frequencies passed to it as unknown frequency f_x and as known frequency f_n. This method of measurement is advisable if for example in a test department there is a large number of oscillators to be balanced to a certain frequency. Using the "frequency measurement" operating mode every digit of the result read-out must be checked, which easily leads to reading errors.

Ratio measurement makes it possible to connect an oscillator of the required frequency, e. g. 261.94 kHz to the "external oscillator input and to connect the oscillator to be balanced to the measuring input.

If in "frequency measurement"operating mode the measurement type key "0.1 s" is depressed, or correspondingly programmed, then the actual measurement time will embrace 10^5 cycles of the external standard frequency instead of the internal 1 MHz frequency. When the osicllator to be checked is balanced, 10^5 cycles must also fall in the measurement time (f_x : f_n = 1 : 1). This will give the read-out 1 000.00. This result can be read-off simply and without errors.

3.1.4.1. Ratio f_x : f_n

This ratio is displayed by the counter when a measurement time is selected using the "frequency measurement" operating mode and the input is cleared for the external oscillator.

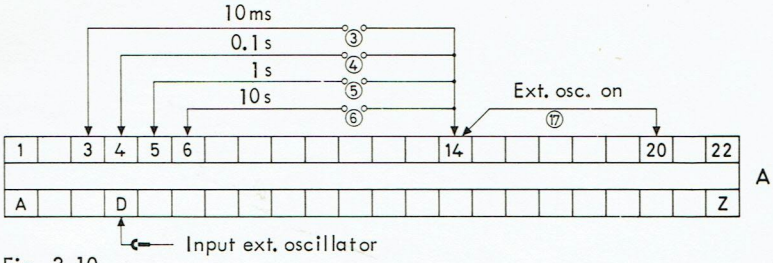


Fig. 3-10

The table below gives information on the "read-out filling" frequency ratio for the individual "measurement times".

Measurement time selected	$f_x : f_n$	Read-out ($\hat{=} 1000\frac{f_x}{f_n}$)	$f_{x\,max}$ [1]
10 s	1 : 100	10.0000	50 kHz
1 s	1 : 10	100.000	500 kHz
0.1 s	1 : 1	1000.00	5 MHz
10 ms	10 : 1	10000.0	25 MHz

3.1.4.2. Ratio fn : fx

If period measurement is selected instead of frequency measurement, the ratio $f_n : f_x$ will be displayed. In this case the following connection should be carried out. The cycle number and period measurement can either be programmed in accordance with Fig. 3-7 or selected on the front panel.

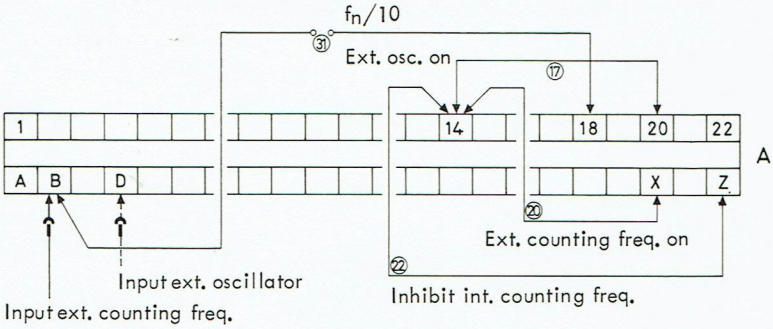


Fig. 3-11

1) This frequency limit for f_x results because a maximum of 5 MHz is permissible for f_n at the "external oscillator" input.

If - as mentioned at the beginning, the external reference frequency f_n is present at the "external oscillator" input, it should be noted that it will pass into the counter as fn/10 in accordance with the programming. The correspondence of selected cycle number to the "read-out filling" frequency ratio $f_n : f_x$ should be taken from the table below.

Selected cycle No.	$f_n : f_x$ at $f_n/10$	Read-out $\hat{=} 10\frac{f_n}{f_x}$	f_x max 1)
10^4	$10^2 : 1$	10.0000	50 kHz
10^3	$10^3 : 1$	100.000	5 kHz
10^2	$10^4 : 1$	1000.00	500 Hz
10	$10^5 : 1$	10000.0	50 Hz
1	$10^6 : 1$	100000	5 Hz

Basically the maximum permissible frequencies for the various inputs should be noted as stated in the Technical data.

3.1.5. Pulse duration measurement

The FZ-4 unit measures the duration of the high or low condition of individual pulses or of pulse sequences with decadically stepped resolution between 1 µs and 10 s. Measurement is repeated as long as the condition to be measured is present at the input. In the case of chattering contacts it should be noted that the counter only starts to measure after the end of the chatter, as with each chatter pulse it closes the gate and is reset. As the result is only stored in the measurement interval, the programming described under 3.1.5.1. is only suitable, however, if the interval between 2 measurement operations is adequate for reading (approx. >1 s). During the gate opening time the storage function is switched off and the counting process is visible in the read-out. If the measurement interval, i. e. the time for a reading, is too short (approx. <1 s), it is advisable to use the programming described under 3.1.5.2. It is suitable for measurement of the high or low condition of rapid pulse sequences or for half cycle measurement.

1) This frequency limit for f_x results because a maximum of 5 MHz is permissible for f_n at the "external oscillator" input.

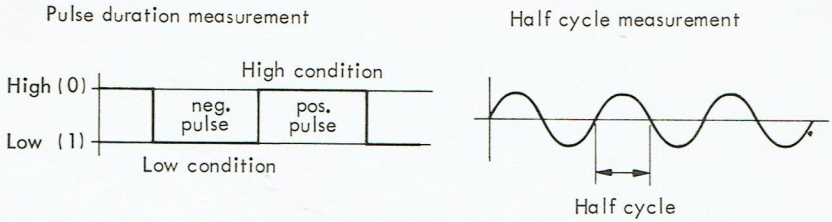


Fig. 3-12

3.1.5.1. Measurement interval >1 s

If the pulse to be measured complies with the data given under 1.6., it can be applied to the "count start" input. The "count stop" input is connected to chassis. With this programming the FZ-4 measures the duration of the low condition of a pulse. The high condition is measured when the "time measurement during 0 condition" input is connected to chassis.

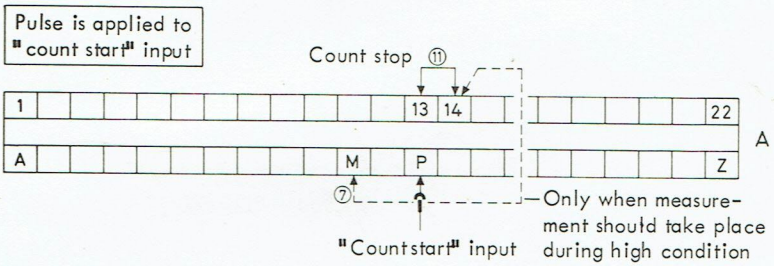


Fig. 3-13

If the pulse to be measured does not comply with the data given under 1.6., it must be applied to the measuring input. It will then be inverted at the "counting pulses inverted output", but available at the correct level and is applied to the "count start" input. The high condition is measured without connection M-14.

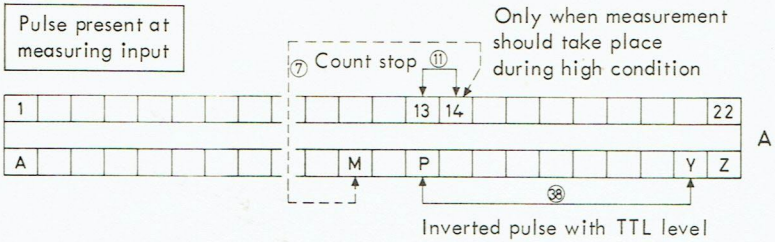


Fig. 3-14

The required resolution should be programmed as follows:

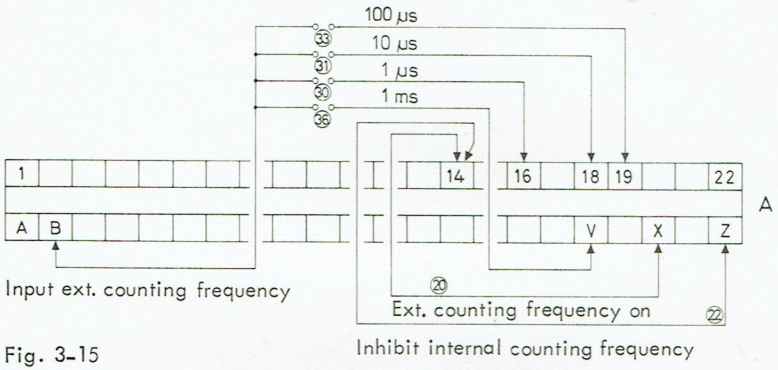


Fig. 3-15

The programming in accordance with Fig. 3-15 is balid for 1 µs to 1 ms, thats shown in Fig. 3-16 for 10 ms to 10 s.

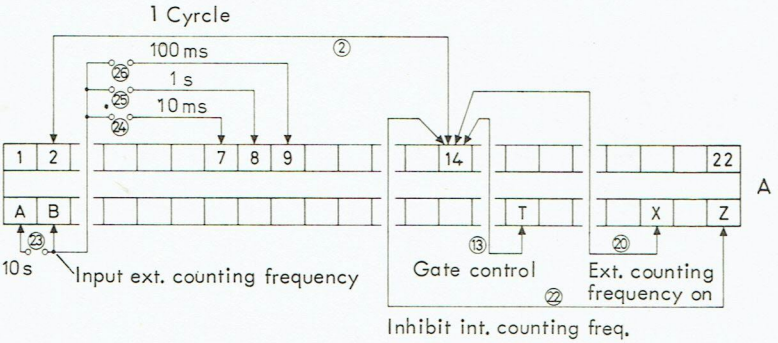


Fig. 3-16

3.1.5.2. Measurement interval <1 s, rapid pulse sequences, half cycle measurement

These measurements are carried out using the "period measurement" operating mode. By selecting the corresponding cycle number (manual or programmed) totalizing and averaging is carried out by means of 1, 10, 100, 1000 or 10000 pulse widths or half cycles.

The inherent system error of ± 1 counting unit can theoretically occur during every measurement and can accummulate; in practice this is not the case, so that the relative error is less as a result of the averaging.

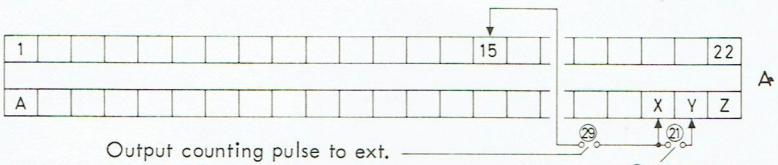


Fig. 3-17

The signal is present at the measuring input. The cycle number selected determines the gate opening time. During the unmeasured pulse widths for half waves the standard frequency should not however be entered in the counter. This is achieved by connecting X-15 or X-Y. The read-out is with decimal point and takes place when programming in accordance with Fig. 3-17 in µs. Resolution can however, be modified as shown in Fig. 3-15, whereby however connection X - 14, (20), is omitted. The result remains stored during the measuring process.

3.1.6. Time interval measurement

By this means it is possible to measure the time interval between 2 pulses. These can be received either on 2 separate leads (see 3.1.6.1.), or on one common lead (see 3.1.6.2.).

3.1.6.1. Start/stop signals on separate leads

The programming makes it possible for both positive and negative pulses to trigger the start/stop functions, that is to say always at the leading edge. The lead on which the "count start" signal is received should be connected to contact P. If it is a positive pulse, M should additionally be connected to 14.

If the "count stop" signal is a negative pulse, the lead is connected direct to contact 13. Otherwise the lead is passed to the measuring input and passes the inverted signal from the "counting pulses inverted" output to contact 13.

As the signals are processed statically, the starting pulse must have disappeared before appearance of the stop pulse. This also applies in reversed sequence.

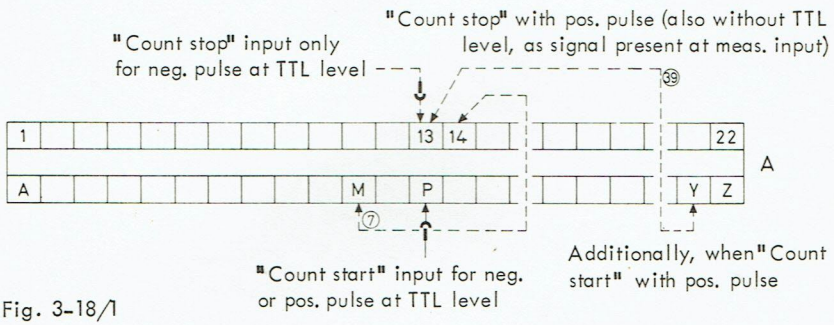


Fig. 3-18/1

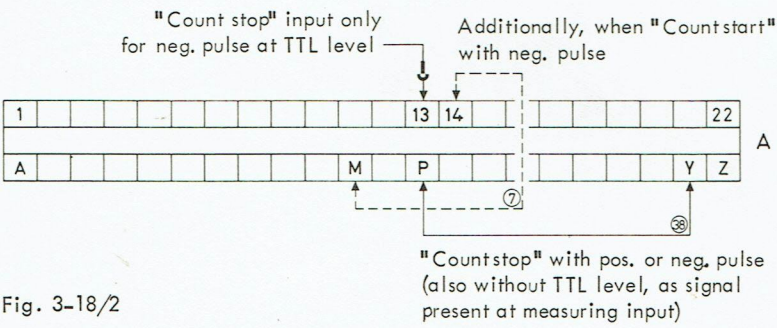


Fig. 3-18/2

For programming of resolution (1 µs - 10 s) see 3.1.5.1., Fig. 3-15 and Fig. 3-16.

3.1.6.2. Start/stop signals on common lead

The lead is connected to the measuring input and period measurement together with cycle number 1 selected (manual or remote control). If with slope switch on "+" both the start and also the stop signal is a negative pulse, the time is measured from leading edge to leading edge, if both are positive pulses, the trailing edges will be used to determine the time. If the slope switch is on "-" in the case of negative pulses the the trailing edges and in the case of positive pulses the leading edges will be used. The read-out will be in µs. A different resolution (decadically stepped from 1 µs to 1 ms) is obtainable using the programming shown in Fig. 3-15.

3.1.7. Pulse Counting during externally determined time

If pulses are to be counted within the duration of a control pulse, that is to say either during the high or during the low condition, section

3.1.7.1. will be applicable.

If the counting gate is controlled by 2 consecutive pulses, see under

3.1.7.2., if the two pulses are received on separate leads and under

3.1.7.3., if a common lead is being used.

Section 3.1.7.4. gives information on attenuation of the pulses to be counted up to 10^7 per counted pulse.

3.1.7.1. Pulse counting within a pulse duration

		Counting pulses have required signal level (see 1.6.)	
		Yes	No
Control pulse has required signal level (see 1.6.)	Yes	Connect counting pulses to contact B of contact board A and X and Z to 14, see also Fig. 3-13	Counting pulses at measuring input, see also Fig. 3-13
	No	Connect counting pulses to contact B of contact board A and X and Z to 14, see also Fig. 3-14	———

3.1.7.2. Pulse counting during a time interval between two consecutive pulses on separate leads

The pulses to be counted are passed to the measuring input where it is not required for inversion of the stop pulse, or to contact B of contact board A. Then they must comply with the data given under 1.6.; in addition contacts X and Z should be connected to 14.

Programming is carried out so that the leading edges of the control pulses trigger the start/stop functions. Section 3.1.6.1. describes the relationships, Fig. 3-18 shows the programming of the control pulses.

3.1.7.3. Pulse counting during a time interval between 2 consecutive pulses on a common lead

The lead on which the controlling pulses are received is connected to the measurement input and period measurement as well as cycle No. 1 selected (manual or remote control). The pulses to be counted must be present at the "ext. counting frequency" input.

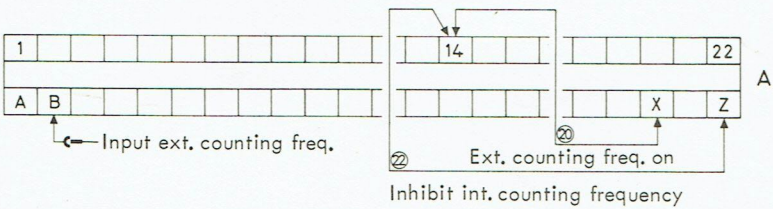


Fig. 3-19

3.1.7.4. Attenuation of the pulses to be counted

In order to attenuate the pulses to be counted they should be fed in to the unit via the "ext. oscillator" input. According to the required attenuation one of the 2 following programmes should be set. For programming in accordance with 3.1.7.3. it is only possible to attenuate up to 10^3 in accordance with Fig. 3-20.

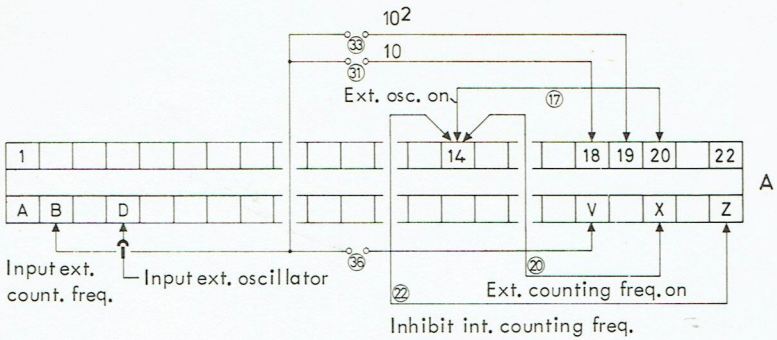


Fig. 3-20 Attenuation $10 \ldots 10^3$

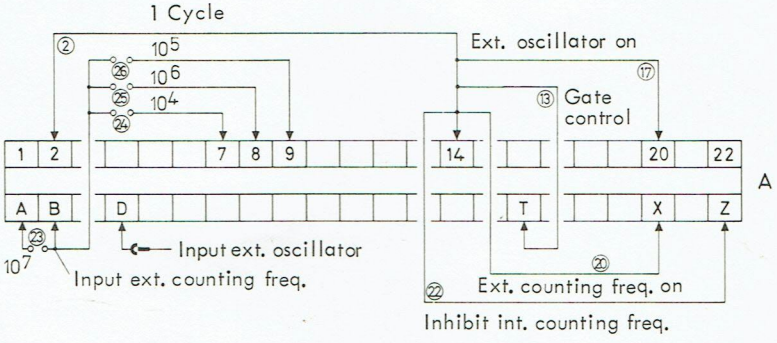


Fig. 3-21 Attenuation $10^4 \ldots 10^7$

3.1.8. Totalizing individual results

In order to totalize a number of consecutive counting operations in the counter it is only necessary to cancel the counter reset by connection of 10 to 14 on contact board A (⑨ on programming board BN 597/54). The connection should however be removed before the last measurement to be added, as otherwise a further result will be recorded.

Automatic operation is obtained if one communicates the beginning of the 1st measuring period to a counter module and generates the 1-signal "counter reset of" at its output via a flip-flop. The signal must be present at contact 10 of contact board A. At the

beginning of the last measuring period the counter module will flip the flip-flop back.

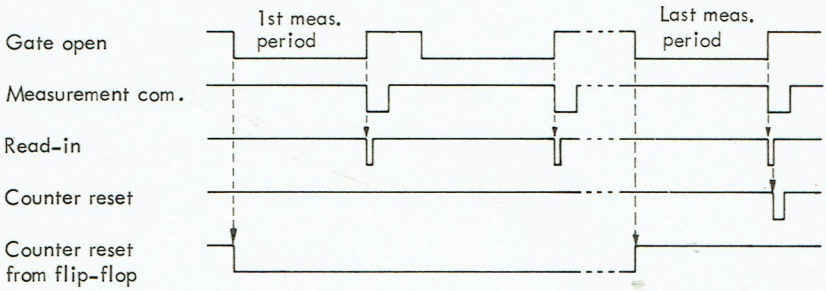


Fig. 3-22

A connected recording instrument which should only record the final result can be inhibited by connecting 21 to 1 on contact strip B.

3.1.9. Sampling rate

As soon as an operating mode, frequency or period measurement is selected on the FZ-4, the counter will carry out continuous measurements. The sampling rate is composed of the measuring period (gate opening time) and the measurement interval and at the same time represents the period during which the result is being stored. The measuring interval is - independent of the measuring time - of varying length. In the case of frequency measurement and 10 ms measuring period it will last 10 ms, from 0.1 s to 10 s it will in each case last 100 ms. In the case of period measurement the measuring time is determined by the duration of the cycle to be measured and the cycle number selected. The interval is at least 250 µs long in the case of 1 and 10 cycles, as from cycle No. 100 it corresponds to the time for 100 cycles. It is now possible to extend or shorten the interval between the individual measuring times and thus the sampling rate as well as the storage time of the read-out. The sampling rate is extended if after commencement of the "measurement complete" signal (inverted signal to contact 1 of board A) a 1-signal at contact U [1)] of board A inhibits the counter. As soon as the signal is removed the standard measurement interval takes place and subsequently the next measurement takes place.

1) Only wired-or-suitable integrated circuits may be connected to the "counter inhibit" input.

If contacts 12 and 14 of contact board A are connected to one another (10 on programming board 597/54), the measurement interval is reduced to minimum. In the case of frequency measurement the interval is a maximum of 1 ms, in the case of period measurement a maximum of 1 cycle, at least however 250 µs. When cycle number 1 is selected no reduction can be obtained.

3.1.10. Triggering single measurement

If instead of constantly carrying out consecutive measurements the counter is only required to carry out one single measurement, the "counter inhibit" input (contact U on board A) is wired for a 1-signal. As soon as this signal is switched off the time base divider chain is released. According to operating mode the gate is opened either with the next 0-1-slope reaching the divider chain or after elapse of the measurement interval of max. 100 ms ("measurement interval off" see 3.1.9.). After closing the gate the counter is inhibited internally for 250 µs and during this inhibition time the external 1-signal "counter inhibit" should be switched on again.

3.1.11. Switching read-out storage

In the case of all functions selected from the front panel except "count" the result is only stored and displayed after completion of measurement. If contact C is connected to 14 (contact board A), the counting process is visible in the display during the gate opening time. At the end of measurement the storage will in any case be reset so that the final result is not available. If instead of this connection one connects contact C of contact board A and contact B or contact board B, the counting operation is visible in the display and the final result is stored.

3.1.12. Digital clock

With the programming shown in Fig. 3-23 the pulses of the internal quartz oscillator can be fed in to the counter directly or after attenuation. Thus one has a digital clock which displays the periods of time in ms, s or fractions of a minute. Connection of P to 14 sets the clock in motion, disconnection stops it, without resetting either during closing or during opening.

As a result of this feature and the sufficiently large counting range of 10^6 time units the FZ-4 is also suitable for use as a running time meter in research set-ups.

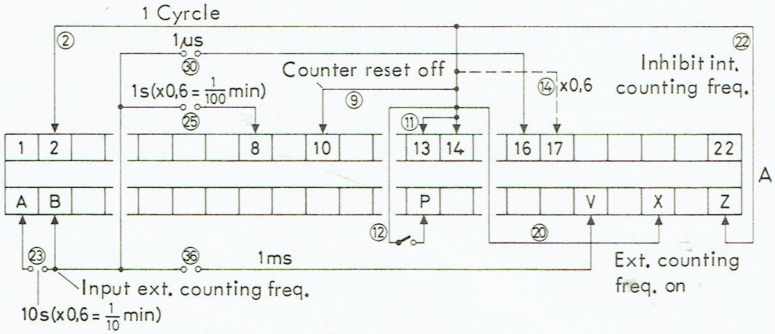


Bild 3-23

3.1.13. Periodic time signals

As a result of programming in accordance with Fig. 3-23 the storage is switched off when connection P-14 (12) is closed, so that every change in the counter content appears at the digital output (contact board B). Thus the counter provides periodic time signals which can be used for signal emission or for triggering external measuring operations. It should be noted that the pulse duty factor is 1 : 1 or 1 : 4 and that the duration of the signals increases with increasing time interval.

Time signals 1 or 2 . 10^x at contact board B Output...

Exponent "x" with connection to contact board A of contact ... - contact ..., (...) = corresponding connection on programming board

$1 \cdot 10^x$	$2 \cdot 10^x$	B - 16 (30) µs	B - V (36) ms	B - 8 (25) s	B - 8 (25) min 2)	B - A (23) s	B - A (23) min 2)
1)	19	0	0	0	- 2	1	- 1
16	S	1	1	1	- 1	2	0
N	M	2	2	2	0	3	1
J	12	3	3	3	1	4	2
15	11	4	4	4	2	5	3
8	4	5	5	5	3	6	4

1) The time signal $1 \cdot 10^0$ us is obtained at output 16 from contact board A
2) Here it is additionally necessary to connect 17/14 (= x 0.6) on contact board A

3.1.14. Use as calibration spectrum generator

Present at contact board A are the oscillator frequency 1 MHz together with the frequencies derived therefrom of 100 kHz, 10 kHz and 1 kHz (contacts 16, 18, 19 and V). With a simple auxiliary electronic unit (1 x SN 7400 N) it is possible to generate calibration lines at an interval of 1 MHz, 100 kHz, 10 kHz and 1 kHz. (The auxiliary electronic unit is necessary as the signals are available at a pulse duty factor of 1 : 4 in the case of which the even and odd harmonics and those of lower and higher order occur at widely differing amplitudes).

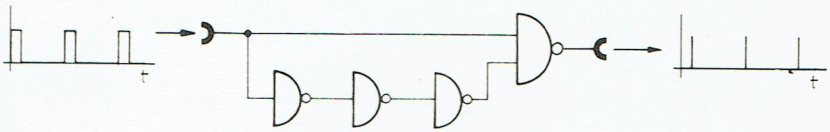


Fig. 3-24 (e. g. SN 7400 N)

The pulses are passed to the circuit as shown in Fig. 3-24. As a result of the transit time of a signal through the 3 series connected gates when a 0-signal is applied a 1-0-1-pulse appears at the output, its duration being typically 40 ns and its rise time being several ns. This pulse contains harmonics extending far into the VHF range with sufficient amplitude.

3.2. Recorder control

Control of connected recorders is effected by means of the inputs and outputs "meas. complete" (contact Y), "counter inhibit" (contact Z) and "gate open" (contact B) on contact board B. Further details can be taken from the jack connections and transfer data under 4.2.

The signal "gate open" which is present during measurement inhibits the recorder. On disappearance of this signal the signal "measurement complete" appears for 250 µs, its leading edge triggering the recorder.

Even before this signal has disappeared the recorder must supply a 1-signal to the "counter inhibit" input until it can be triggered again.

When the signal has disappeared the counter starts fresh measurement (for information on measrement interval and switch off see 3.1.9. sampling range).
If the recording time is shorter than the measuring time, the recorder can take over the measurement result displayed whilst the counter carries out fresh measurement and need not pass any signal to the counter inhibit. This overlapping operation leads to more rapid sampling rates.

3.3. Sources of measuring error

As a result of the characteristics of the instrument and the principle of measurement measuring errors can occur whose limits are stated in the technical data. The causes and steps for preventing or reducing errors are summarized here.

3.3.1. Inherent system error: ± 1 digit

This error can occur in the last digit of the read-out with all measurement modes except "counting". Its cause can be seen in Fig. 3-25 in the example of frequency measurement. According to commencement of measurement either 3 or 4 positive signals occur during the same measurement time.

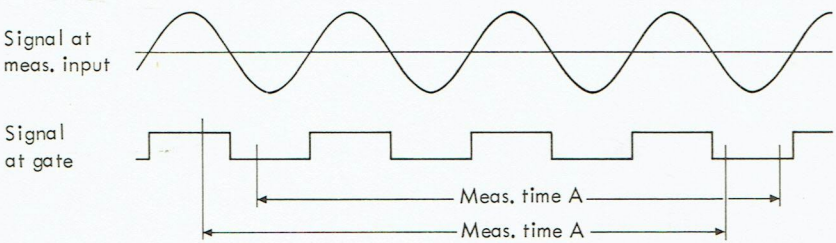


Fig. 3-25

The same thing occurs during period measurement. The inherent system error of ± 1 digit is dependent on the measurement time or cycle number selected. Related to the measurement result the relative error obtained is smaller the longer the measurement time or the period number selected is.

This relationship is also illustated in Fig. 3-26.

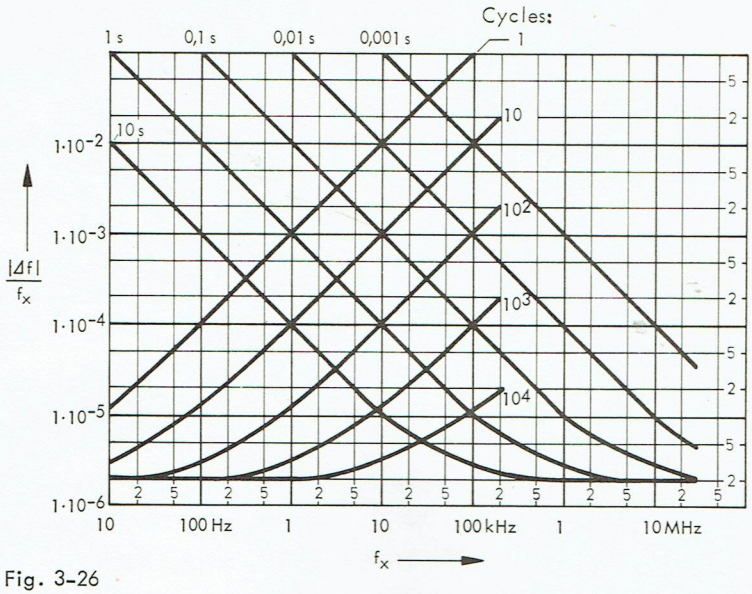


Fig. 3-26

In Fig. 3-26 the standard frequency error already described under 3.3.2. has already been taken into account, but not the trigger threshold error (in this connection see 3.3.3.).

3.3.2. Standard frequency error

Basically the error of internal or external standard frequency enters into the result of all measurement modes with the exception of "counting". The momentary standard frequency error consists of a number of individual components, that is to say of the frequency error on supply, the long term error and the temperature dependence. The error limits of the internal standard frequency are listed in the Technical data under 1.7. Short-term fluctuations of the internal standard frequency do not occur in the case of constant ambient temperature. An error of $2 \cdot 10^{-6}$ has been taken into account in Figs. 3-26 and 3-27.

3.3.3. Trigger threshold error

This error Δt, which related to the measurement input is $U_F = \pm 0.5$ mV, is only to be taken into account in the case of period measurement. It depends on the steepness of the voltage rise at the trigger point, i. e. in the case of sinusoidal voltage and engaged trigger level adjuster the error is reduced with increasing frequency and measurement signal amplitude.

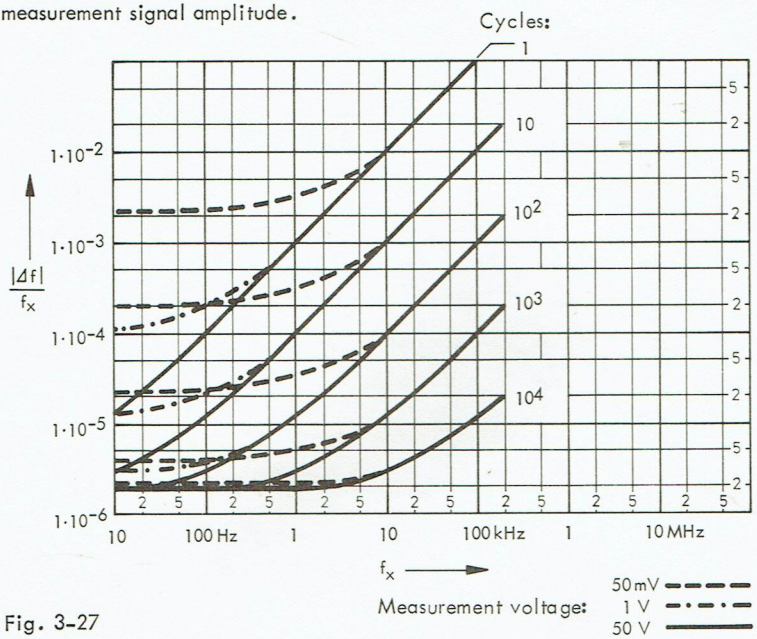


Fig. 3-27

The following is applicabel to the slope at zero axis crossing:

$$S = 2\pi f \cdot \sqrt{2} \cdot U_{eff}$$

Thus we obtain for the trigger threshold error:

$$\Delta t = \frac{U_F}{S \cdot n} \rightarrow \frac{\Delta t}{\mu s} \approx \pm \frac{60}{\frac{f}{kHz} \cdot \frac{U_{eff}}{mV} \cdot n}$$

The total error in the case of period measurement shown in Fig. 3-27 consists of the inherent system error of ± 1 digit, the internal standard frequency error (here $2 \cdot 10^{-6}$) and the double time error of 1 trigger point (double time error as the temporal trigger point shift becomes effective at beginning and end of a measurement).

Example: sinusoidal measurement voltage f = 1 kHz, U_{eff} = 50 mV

Number of cycles measured n = 1

Measuring error: $\frac{\Delta t}{\mu s} \approx \pm \frac{60}{1 \cdot 50 \cdot 1} = \pm 1.2$

In this case where trigger level shift has not been taken into account, the result may deviate additionally by ± 2 digits.

3.3.4. Measuring errors resulting from disturbing voltages

The FZ-4 universal counter uses an input circuit with hysteresis. That is to say the condition at the output of this input circuit only changes when a rising voltage at the input reaches a certain positive threshold or when a decreasing voltage at the input reaches a certain negative threshold. Thus the permissible disturbing voltage level is limited in order to prevent erroneous counting. As the FZ-4 is AC coupled the trigger points are at the arithmetical mean of the input voltage. In the case of symmetrical signals therefore that is also symmetrically between 2 peak values whilst the position of the trigger points in the case of asymmetrical signals shifts in positive or negative direction.

3.3.4.1. Disturbing voltage at higher frequency than the useful voltage

A condition for correct counting is: the voltage shift of the desired signal during 1 cycle of the spurious signal must be greater than the total amplitude of oscillation of the spurious signal.

Expressed as a formula:

$$\frac{d\,U_{Use}}{d_t} \cdot \frac{1}{f_{Spurious}} > U_{Spur\,pp}$$

In the case of a sinusoidal signal the following will thus apply:

$$2\,\pi\,U_{Use}\,\frac{f_{Use}}{f_{Spur.}} > U_{Spur\,pp}$$

Thus for example a 100 kHz disturbing voltage with 50 mV effective value will lead to additional counting pulses even if it is super imposed on a 100-fold useful voltage at 100 Hz. If the input attenuater is switched to "x 10" the example is applicable to a disturbing voltage with a 500 mV effective value.

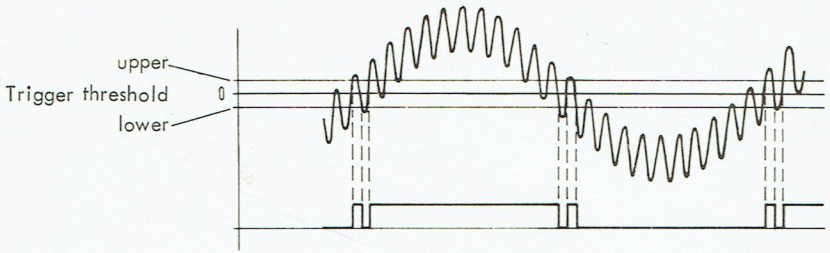


Fig. 3-28

Such high frequency disturbing voltages can be kept from the counter by interposing a low pass filter.

3.3.4.2. Disturbing voltage of lower frequency than the useful voltage

As long as the peak-to-peak value of the desired signal is at least 50 mV greater than the total amplitude of oscillation of the spurious signal, the spurious signal will only cause temporal shift of the zero-axis crossings. The resultant error is negligible in the case of frequency measurement and in the case of period measurement can be kept low if a large cycle number is selected. If the difference is < 50 mV, the two trigger thresholds will at times not be crossed and read-out will be too low.

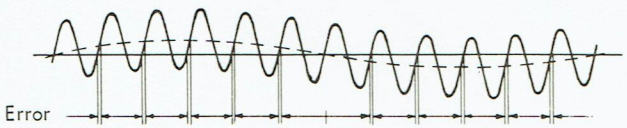


Fig. 3-29

An effort must be made to reduce this disturbing voltage component, for example by means of short connecting wires, grounding, etc.

3.3.5. Frequency limit with period measurement

When measuring the period of a high-frequency signal over 1 or 10 cycles the limits of the still measurable frequencies will be as follows

for 1 cycle	approx. 250 kHz
and for 10 cycles	approx. 5 MHz

If the frequency at the input exceeds the values stated with the number of cycles in question, the counter will display a constant value independent of the frequency. If the frequency is increased further, the read-out will be zero until the counter finally totalizes. In such cases it is also advisable in the interests of improved resolution to switch over to higher frequency numbers or to frequency measurement.

4. FUNCTION AND CHARACTERISTICS

4.1. Description of function with reference to Block Circuit Diagram

Appended to this description is the block circuit diagram with signal sequence diagram which is based on the following principles. The method of function is explained with the aid of an example of frequency measurement.

4.1.1. Sequence of operations of frequency measurement

As long as no measuring time key is depressed, the "counter inhibit" signal prevents infeed of time marker pulses into the 4th stage of the time base divider chain. As soon as a measuring time key is depressed-here in the example "100 ms" - the reset mono-flop flips and maintains the counter inhibit for a further 30 ms. This corresponds to the maximum chatter time of the measuring time keys. In addition reset takes place: the still inhibited part of the time base divider chain, the counting decades, the storage which is open during the flipping time of the reset mono-flop, together with the gate and the start/stop flip-flop. When the reset mono-flop flips back the counter inhibit is removed and the 1 kHz time marker pulses pass into the now open part of the time base divider chain. In addition the trailing edge of the reset signal after elapse of a delay sets the last 2 decades of the time base divider chain to the number "9". Thus the measurement interval which is otherwise equal to the measurement time is limited to a maximum of 100 ms (see also 3.1.9.). In the case of the measurement time of 100 ms selected in the example here it is therefore just 100 ms until the 1st pulse at the 10 Hz output of the gate flip-flop flips into operative position. As the gate opens, the gate light comes on and the counting pulses pass to the counting decades. After a further 100 ms the 2nd pulse appears at the 10 Hz output and flips the gate flip-flop back to rest position. The gate closes and the gate light extinguishes. At the same time the read-in and the measurement complete mono-flops now flip.

With the signal "read-in" the storage now takes over the contents of the counting decades and the result appears in the read-out. The counting decades are reset immediately after read-in. At the same time the signal "counter inhibit" appears for 250 µs and sets the last 2 decades of the time base divider chain back to 9. The

2 decades in front are still at zero as since the 2nd 10 Hz pulse through the counter inhibit no further 1 kHz time marker pulse has been able to pass into the divider chain. However as soon as the counter inhibit is removed the 1 kHz time marker pulses pass into the time base again.

When the measurement interval has elapsed a new measurement commences at the end of which the new measurement result is read-in. This supersedes the result of the previous measurement in the display.

If during these repetitve measurements a different measuring time key is depressed the new cycle begins as described above with flip-ping of the reset mono-flop.

4.1.2. Sequence of operation of period measurement

The essential difference from frequency measurement lies in the fact that the 1 MHz pulses of the internal standard frequency are present at the counter whilst the signal at the measurement input controls the gate. As in the case of this operating mode as well the last 2 decades of the time base divider chain are set to 9, the maximum measurement interval is limited in the case of high cycle numbers to 100 cycles. Reduction of the measurement interval to 1 cycle or 250 µs is described in section 3.1.9.

4.2. Explanation of important Guarantee Data

4.2.1. Characteristics of the measurement input with sinusoidal voltage

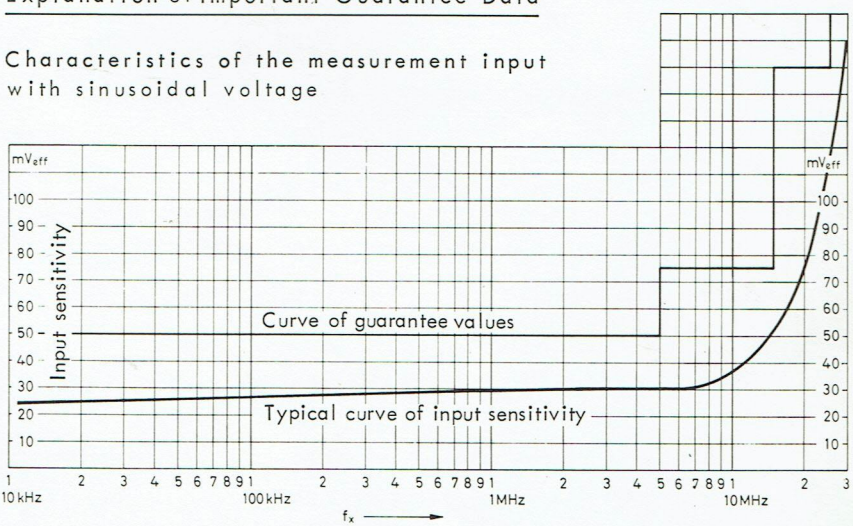


Fig. 4-1 Input characteristics with sinusoidal voltage (trigger level engaged)

The curve shows the typical input sensitivity of the FZ-4 in comparison with the guarantee values stated in the Technical Data.

4.2.2. Characteristics of the measurement input with pulse-shaped voltage

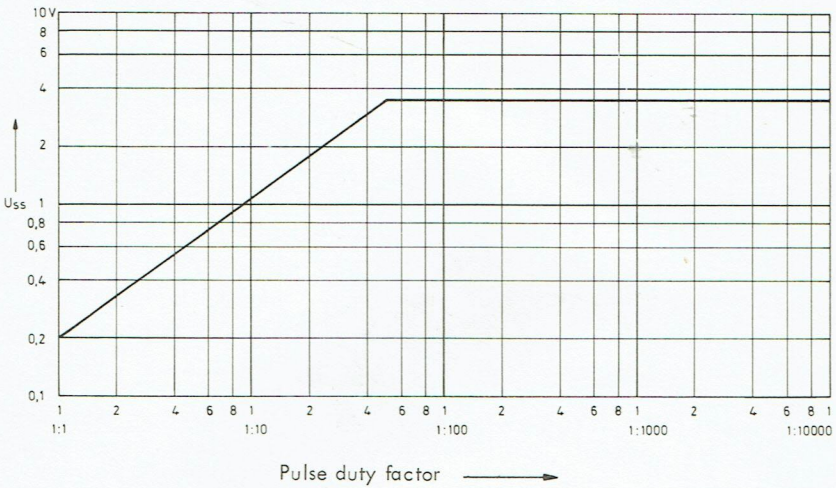
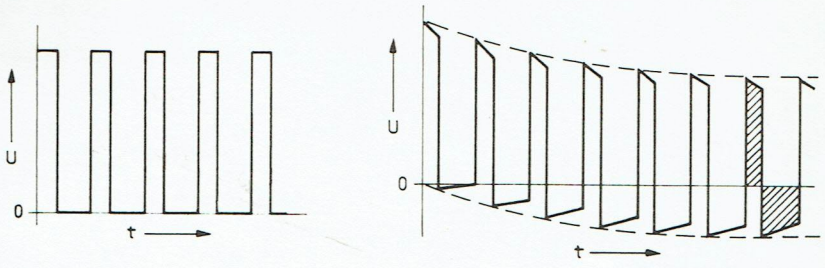


Fig. 4-2 Input characteristics with pulse-shaped voltage

If the input amplitude of a signal present at the measurement input amounts to at least the value corresponding to the pulse duty factor indicated by the curve in Fig. 4-2, with trigger level adjuster set the trigger thresholds will be such that exact counting is possible. If the pulse duty factor is not constant the necessary pulse height will be determined by the most unfavourable factor.

Shift of the trigger level is necessary if the pulse amplitude does not reach the values required by Fig. 4-2. That is to say the adjuster must be set to the range 0 to -1 V in the case of high-low ratios >1 : 1 and in the range 0 to + 1 V in the case of high-low ratios <1 : 1. Thus for example a pulse amplitude of 200 mV will be sufficient for correct counting independent of the pulse duty factor if in the 1st instance the trigger level is set to approx. -50 mV and in the 2nd case to approx. +50 mV.



Signal at meas. input

Signal after high-pass filter

Fig. 4-3 Warm-up effect

As the measuring frequency is coupled in via a capacitor which with the input resistor forms a high-pass filter, a warm-up effect results on application of DC voltage charged signals as shown in Fig. 4-3, equivalent to displacement of the pulse base line until no further DC voltage component is present. This process lasts approximately 1 s and is unimportant in the case of continuous measurement. If on the other hand the FZ-4 carries out single measurements where the signal must be newly applied before each measurement, this period between application and triggering must be taken into account.

This delay can be avoided with the exception of period measurement if the signal maintains the signal level in accordance with 1.6. by applying it to the "external counting frequency " input instead of to the measurement input.

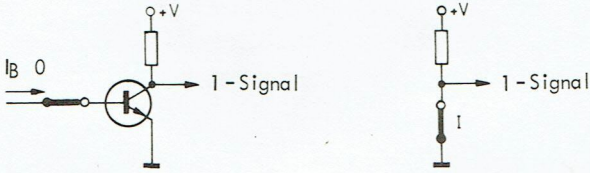
4.3. Transfer Data

4.3.1. Definition

The following definitions apply to the "negative logic" used in the FZ-4:

0-signal high — Positive potential, blocks transistor or open contact

1-signal low — Almost zero potential (0 to approx. + 0.8 V), conductive transistor or closed contact

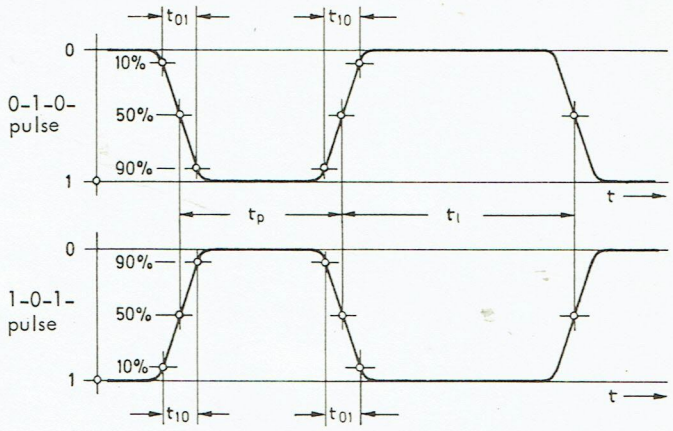


By the designations "0" and "1" or 0-signal and 1-signal are meant the signals "logic 0" and "logic 1". ("0" and 0-signal should not be confused with the voltage of 0 V).

1-0-transition	Transition from 1- to 0-signal. This does not involve the edge time but crossing a certain threshold
0-1-transition	Transition from 0- to 1-signal. Otherwiese as for 1- 0-transition.
1/0-edge	Jump from 1- to 0-signal, that is to say to a more positive potential. In this case a certain edge time must be maintained.
0/1-edge	Jump from 0- to 1-signal, that is to say to a more negative potenial. In this case a certain edge time must be maintained.
1-0-1-pulse	Positive pulse with definite duration (e.g. + 0.5 V / + 5 V / + 0.5 V).
0-1-0-pulse	Negative pulse with definite duration (e.g. +5 V / +0.5 V / + 5 V).

Pulse times

The pulse times defined below apply to both negative and positive pulses.



Definitions:

1/0-rise time t_{10}: The period between the 2 moments in which the instantaneous value of the pulse during transition from 1 to 0 assumes first of all 10% and then 90% of the pulse amplitude.

0/1-decay time t_{01}: The period between the 2 moments in which the instantaneous value of the pulse during transition from 0 to 1 assumes first of all 90% and then 10% of the pulse amplitude.

Pulse duration t_p: The period between the 2 moments in which the instantaneous value in the case of the positive pulse on the 1/0 edge and the 0/1 edge has reached 50% of the pulse amplitude and in the case of the negative pulse on the 0/1 edge and 1/0 edge 50% of the pulse amplitude.

Pulse interval t_l: In the case of the positive pulse the period from the moment at which the instantaneous value on the 0-1-edge of the pulse has reached 50% of the pulse amplitude up to the moment at which the instantaneous value on the 1/0 edge of the following pulse has reached 50% of the pulse amplitude.
The corresponding relationship applies to the negative pulse.

All signal designations are selected so that the determinative active state is obtained by a 1-signal in "negative logic". Exceptions are indicated by the addition of "inv." (inverted) [1].

1) In circuit diagrams "inv." can be replaced by a line over the corresponding signal (e. g. "triggered" corresponds to "triggered inv.").

TRANSFER DATA CONTACT BOARD A

Signal designation E ≙ Input Signal A ≙ Output duration	Connection	Input current in units 1.6 mA	Max. load	Signal Description
Measurement complete inv. A 250 µs	A/1		10	The signal disappears for 250 µs after completion of a measurement, where no "inhibit measurement complete" is programmed.
Period number 1 E and A	A/2	2.5	When selected by key: 10 In the case of remote selection dependent on the triggering stage	The signal is present as long as key S 302/6 is depressed. In the case of remote control (key not depressed a signal must be present at least until appearance of the signal "counter inhibit". If it is present any longer, measurement will continue.
Cycle number 10 Measurement time 10 ms E and A	A/3 B/W	3.5 + load at B/W		The signal is present as long as key S 302/5 is depressed. For remote control see cycle number 1.
Cycle number 10^2 Measurement time 0.1 s E and A	A/4 B/V	3.5 + load at B/V		The signal is present as long as key S 302/4 is depressed. For remote control see cycle number 1.
Cycle number 10^3 Measurement time 1 S E and A	A/5 B/U	3.5 + load at B/U		The signal is present as long as key S 302/3 is depressed. For remote control see cycle number 1.
Cycle number 10^4 Measurement time 10 s E and A	A/6 B/T	3.5 + load at B/T		The signal is present as long as key S 302/2 is depressed. For remote control see cycle number 1.
Output 100 Hz; $f/10^4$ A 2 ms	A/Z	-	10	The signal does not appear periodically during freq. or period measurement as the time base divider is inhibited after each measurement during the counter inhibit signal and pre-set. If key S 302/5 is depressed, the gate is opened with the trailing edge of the 1st signal and closed again with the trailing edge of the 2nd signal. A periodic signal is obtained when a 1-signal is applied to connection A/2 (cycle number 1).
Output 1 Hz; $f/10^6$ A 200 ms	A/8	-	10	If key S 302/3 is depressed the gate is opened with the trailing edge of the 1st signal and closed again with the trailing edge of the 2nd. See also output 100 Hz.
Output 10 Hz; $f/10^5$ A 20 ms	A/9	-	10	If key S 302/4 is depressed the gate is opened with the trailing edge of the 1st signal and closed again with the trailing edge of the 2nd. See also output 100 Hz.
Counter reset off E	A/10	1.5	-	If the signal is available curing the signal "measurement complete", the counter will not be reset and the pulses of the next measurement will be cummulatively added. (See also 3.1.8.).
Switch off measurement interval E	A/12	1.5	-	If a 1-signal is present during the counter inhibit signal, the last 4 decades of the time base divider are set to "9". (See also 3.1.9.).

Signal designation E ≙ Input A ≙ Output Signal duration	Connection	Input current in units 1.6 mA	Max. load	Signal Description
Count stop E and A	A/13	2.5	see A/2	The signal is present as long as key S 302/7 is depressed. In the case of continuous counting the gate can be closed by a 1-signal
Counting pulses A	A/15	-	10	At this output are available the frequencies or pulses present ar the measuring input with the levels required for triggering integrated TTL circuits.
Output 1 MHz A 1 µs	A/16	-	10	Here the quartz oscillator frequency is available. Pulse duty factor 1 : 1
Measurement time x 0.6 E and A	A/17	5.5 + load at B/X	see A/2	The signal is present as long as key S 302/6 is depressed. For remote control see cycle number 1.
Output 100 kHz; f/10 A 2 µs	A/18	-	10	Pulse duty factor 1 : 4
Output 10 kHz, f/100 A 20 µs	A/19	-	10	Pulse duty factor 1 : 4
Ext. oscillator on E	A/20	2.5	-	If a 1-signal is present, the external oscillator frequency will be fed into the divider chain of the time base instead of the inernal standard frequency (A/D).
Period measurement E and A	A/21	5.5	10	The signal is present as long as key S 302/1 is depressed. For remote control see cycle number 1.
Trigger slope + E and A	A/22	3.5	see A/2	The signal is present as long as the trigger slope slide switch is at "+". In the case of remote control (slide switch at -) the signal must be present during the whole measurement time.
Output 0.1 Hz/f/10^7 A 2 s	A/A	-	10	If key S 302/2 is depressed the gate will be opened with the trailing edge of the 1st signal and closed again with the trailing edge of the 2nd signal. See also output 100 Hz.
Input external counting frequency E	A/B	1.5	-	Max. counting frequency 15 MHz; the pulses pass to the gate when the input "external counting frequency on" is connected to chassis (A/X).
Without storage E	A/C	1.5	-	If a 1-signal is applied to this input, read-in of the pulses can be followed on the read-out (see also 3.1.11.).
Input ext. oscillator E	A/D			See Technical Data 1.4.1.
Counter reset A	A/L	-	10	A signal appears a) during reset of counter via the reset lead, b) in the case of selection of a measureme time by key pressure for approx. 30 ms, c) in the case of remote selection of a measurement time for approx. 20 µs, d) After reading in a result for approx. 15 µs.

TRANSFER DATA CONTACT BOARD A

Signal designation E ≙ Input Signal A ≙ Output duration	Connection	Input current in units 1.6 mA	Max. load in units 1.6 mA	Signal Description
Time measurement during 0-status E	A/M	2.5	-	If this input is connected to chasis, in the case of suitable programming (see 3.1.5. and 3.1.6.) the duration of a negative pulse or the pulse interval between 2 positive will be measured.
Reset counter inhibit - MF E	A/N	2.5	-	A 1-signal prevents pre-setting of the time base divider chain. One then obtains: measurement invertal = measurement time, but at least 0.1 s.
Count start E and A	A/P	2.5	see A/2	The signal is present as long as key S 302/8 is depressed. The gate can be opened for continuous measurement by a 1-signal.
Gate control E and A	A/T	4	6	Independent of the measurement time selected the pulses are available with which the gate flip-flop is flipped into operative position and rest position (during frequency or period measurements). Flipping of the gate flip-flop is prevented by a 1-signal at this input (triggering only with wired-or-compatible integrated circuits.)
Counter inhibit E and A	A/U B/Z	5 + load at B/Z	Internal stage 5	1-signal appears: as long as no measurement time selected; during reset signal, after each measurement for 300 µs. A 1-signal at the input extends the interval between 2 measurements, i. e. the read-out or recording time. The signal must be applied between beginning and end of the signal "measurement complete".
Output 1 kHz; f/1000 A 200 µs	A/V	-	10	Pulse duty factor 1 : 4
Reset E and A	A/W	2.5	7	A signal appears a) as long as key S 302/9 is depressed, b) on selection of a measurement time by key pressure for approx. 30 ms, c) in the case of remote selection of a measurement time for approx 20 µs. A 1-signal on this lead will reset counter, storage, start-stop flip-flop and gate flip-flop (triggering only with wired-or-compatible integrated circuits).
Ext. counting frequency on E	A/X	1.5	-	If a 1-signal is present at this and simultaneously at the input "inhibit internal counting frequency", the pulses present at the input "ext. counting frequency" pass to the gate.
Counting pulses inverted A	A/Y	-	9	At this output are available the frequencies or pulses present at the measuring input with the levels necessary for triggering of integrated circuits.
Inhibit int. counting frequency E	A/Z	2.5	-	A 1-signal at this input cuts off measuring input and internal standard frequency from the gate. If a 1-signal is simultaneously present at A/X, input "ext. counting frequency" is connected to the gate.

Signal designation E ≙ Input A ≙ Output Signal duration	Connection	Input current in units 1.6 mA	Max. load	Signal Description
BCD Outputs A	See jack connection	-	10 each	The signals are present approx. 0.5 us after completion of measurement and are available until the end of a further measurement.
Counter outputs $2^3 \times 10^3$ $2^3 \times 10^4$	B/2 B/3	- -	(9) (9)	Direct output of counter before storage. Permissible lead length 10 cm.
+5 V	B/20	-	(100)	
Inhibit measurement complete E	B/21	2.5	-	If during the flipping time of the measurement complete mono flip-flop a 1-signal is present, no signal appears at the output "measurement complete" and "measurement complete inverted".
Gate open A	B/B	-	10	During the gate open time a 1-signal is present. It can be used for inhibiting a connected recorder (see also 3.2.).
"over range" lamp A	B/C	-	10	A signal appears as soon as the 1st digit of the result extends past the read-out range, that is to say continuous signal as long as only a 1, a cycled signal, if ≧ 2 is over range.
"over range" A	B/D	-	10	A signal appears if more than 1 is "over range". Can for example be used for ribbon reversal or recording of a special symbol.
Decimal point 4 E and A	B/T A/6	3.5 + load at A/6	In the case of selected by key: 10 In the case of remote selection dependent on triggering stage	The signal is present as long as key S 302/2 is depressed or a 1-signal is present at A/6.
Decimal point 3 E and A	B/U A/5	3.5 + load at A/5		The signal is present as long as key S 302/3 is depressed or a 1-signal is present at A/5.
Decimal point 2 E and A	B/V A/4	3.5 + load at A/4		The signal is present as long as key 302/4 is depressed or a 1-signal is present at A/4.
Decimal point 1 E and A	B/W A/3	3.5 + load at A/3		The signal is present as long as key 302/5 is depressed or a 1-signal is present at A/3.
Inhibit decimal point E and A	B/X A/17	5.5 + load at A/17		The signal is present as long as key 302/6 is depressed or a 1-signal is present at A/17.
Measurement complete A 250 µs	B/Y	-	9	The signal appears for 250 µs after completion of measurement, if no "measurement complete" inhibit is programmed. It can be used for triggering a recorder (see also 3.2.).
Counter inhibit E and A	B/Z A/U	5 + load at A/U	Internal stage 5	During the recording time the counter can be inhibited by means of this input. If the recording time is longer than the measuring time, inhibition must take place, that is to say counter inhibit before disappearance of the internal signal (see A/U and 3.2.) (Triggering only by wired-or compatible integrated circuits).

5. MAINTENANCE AND MISCELLANEOUS

▶ Withdraw power plug before opening the unit ! ◀

5.1. Mechanical Construction

The universal counter is made up of 3 printed circuits, the time base board, the counter and display board and the "powerpack and oscillator" board.

The inputs and outputs of the time base board are lead out to form contact board A on the back panel, the inputs and outputs of the counter and display board to form contact board B.

The "powerpack and oscillator" board is accessible after removing the top cover of the FZ-4. For this purpose it is necessary to undo the 4 top screws on the front panel, on the back panel the top and centre screws and on the cover itself the 4 screws which connect the cover to the transformer.

5.1.1. Fitment in 19" racks

To fit a counter in a 19" rack it is necessary to remove the handle after detaching the unit cover and in its place to screw on the 2 brackets contained in the 19" installation kit. Fig. 5-1 shows how the FZ-4 should be inserted in the opening of the 19" front panel.

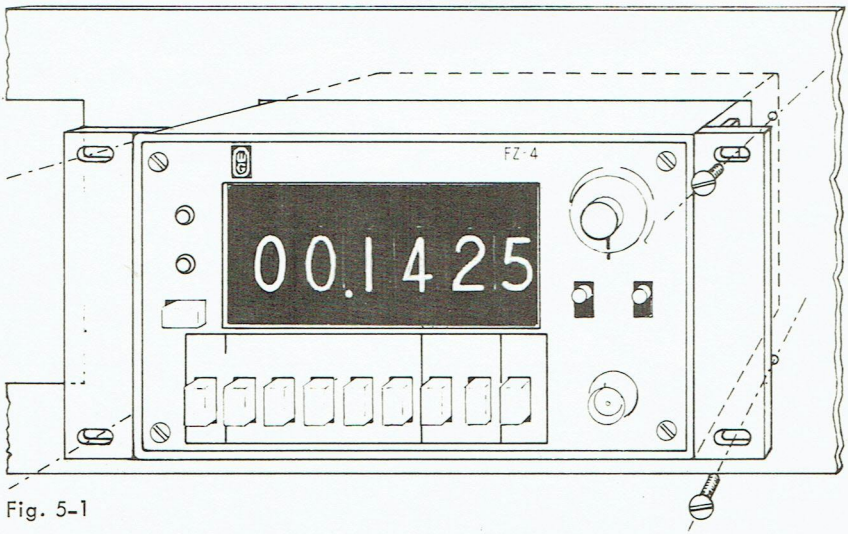


Fig. 5-1

5.2. Line voltage changeover

As regards line voltage the FZ-4 units are supplied in 2 versions each of which is designed for 2 line voltages in the ratio of 2 : 1. In order to changeover from 1 voltage to the other, the bridges on the "powerpack and oscillator" board must be resoldered (for this purpose see Circuit Diagram and equipment drawing of this board in appendix). The fuse is the same for both voltages. The board is accesible after removing the cover.

After changing over please use the plate printed on both sides fitted on the back to prevent the unit being connected to incorrect line voltage (See also Fig. 2-2).

5.3. Changing the fuse

The fuse (1.6 A slow-blow) is located on the "powerpack and oscillator" board and can be changed after removing the cover.

5.4. Calibration of the internal standard frequency oscillator

The unit should not be opened for calibration and must be at operating temperature.

A calibrating frequency of sufficiently high accuracy is applied to the measuring input and frequency measurement adjusted at 10 s measurement time. The error limits for this operating mode are given in the Technical data as ± 1 digit ± Q. As the inherent system error of 1 digit at 10 s measurement time corresponds to 1/10 Hz, the remaining error of the internal standard frequency Q is only slightly affected in the case of adjustment to approx. ± 1 Hz (in the read-out ± 10). For calibration of the oscillator the trimmer capacitor C 112 which is on the "powerpack and oscillator" board directly next to the display tubes should be turned with an adjusting pin of insulating plastic. This is carried out from above through one of the ventilation holes in the unit cover.

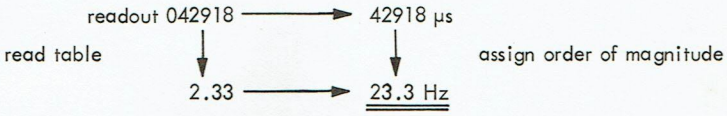
Appendix

Explanation for the conversion table 1/f → f

Since measurements of periods at lower frequencies have better possibilities of resolution, the accompanying table simplifies conversion of a period into the corresponding frequency. Two examples illustrate the use and point out the requirements for applying the tables.

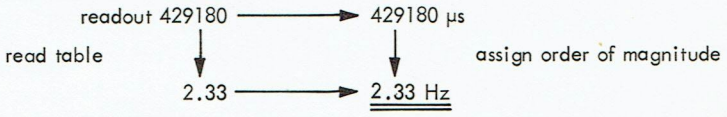
Example 1: With unchanged resolution (1 µs), the tables are valid for a range of 10.0 Hz to 99.9 Hz (the sixth digit of the readout is displayed as 0).

Counting example: measurement of period; 1 period, resolution 1 µs.



Example 2: In the range 1.00 Hz to 9.99 Hz, only the five highest digits can be read in the tables, the 1's position must be interpolated.

Counting example: measurement of period; 1 period, resolution 1 µs.



Equally efficient use can be made of the tables also for frequencies to be converted to the corresponding periods.

n	0	1	2	3	4	5	6	7	8	9
1,0	100000	99010	98039	97087	96154	95238	94340	93458	92593	91743
1,1	90909	90090	89286	88496	87719	86957	86207	85470	84746	84034
1,2	83333	82645	81967	81301	80645	80000	79365	78740	78125	77519
1,3	76923	76336	75758	75188	74627	74074	73529	72993	72464	71942
1,4	71429	70922	70423	69930	69444	68966	68493	68027	67568	67114
1,5	66667	66225	65789	65359	64935	64516	64103	63694	63291	62893
1,6	62500	62112	61728	61350	60976	60606	60241	59880	59524	59172
1,7	58824	58480	58140	57803	57471	57143	56818	56497	56180	55866
1,8	55556	55249	54945	54645	54348	54054	53763	53476	53191	52910
1,9	52632	52356	52083	51813	51546	51282	51020	50761	50505	50251
2,0	50000	49751	49505	49261	49020	48780	48544	48309	48077	47847
2,1	47619	47393	47170	46948	46729	46512	46296	46083	45872	45662
2,2	45455	45249	45045	44843	44643	44444	44248	44053	43860	43668
2,3	43478	43290	43103	42918	42735	42553	42373	42194	42017	41841
2,4	41667	41494	41322	41152	40984	40816	40650	40486	40323	40161
2,5	40000	39841	39683	39526	39370	39216	39063	38911	38760	38610
2,6	38462	38314	38168	38023	37879	37736	37594	37453	37313	37175
2,7	37037	36900	36765	36630	36496	36364	36232	36101	35971	35842
2,8	35714	35587	35461	35336	35211	35088	34965	34843	34722	24602
2,9	34483	34364	34247	34130	34014	33898	33784	33670	33577	33445
3,0	33333	33223	33113	33003	32895	32787	32680	32573	32468	32362
3,1	32258	32154	32051	31949	31847	31746	31646	31546	31447	31348
3,2	31250	31153	31056	30960	30864	30769	30675	30581	30488	30395
3,3	30303	30211	30120	30030	29940	29851	29762	29674	29586	29499
3,4	29412	29326	29240	29155	29070	28986	28902	28818	28736	28653
3,5	28571	28490	28409	28329	28249	28169	28090	28011	27933	27855
3,6	27778	27701	27624	27548	27473	27397	27322	27248	27174	27100
3,7	27027	26954	26882	26810	26738	26667	26596	26525	26455	26385
3,8	26316	26247	26178	26110	26042	25974	25907	25840	25773	25707
3,9	25641	25575	25510	25445	25381	25316	25253	25189	25126	25063
4,0	25000	24938	24876	24814	24752	24691	24631	24570	24510	24450
4,1	24390	24331	24272	24213	24155	24096	24038	23981	23923	23866
4,2	23810	23753	23697	23641	23585	23529	23474	23419	23364	23310
4,3	23256	23202	23148	23095	23041	22989	22936	22883	22831	22779
4,4	22727	22676	22624	22573	22523	22472	22422	22371	22321	22272
4,5	22222	22173	22124	22075	22026	21978	21930	21882	21834	21786
4,6	21739	21692	21645	21598	21552	21505	21459	21413	21368	21322
4,7	21277	21231	21186	21142	21097	21053	21008	20964	20921	20877
4,8	20833	20790	20747	20704	20661	20619	20576	20534	20492	20450
4,9	20408	20367	20325	20284	20243	20202	20161	20121	20080	20040
5,0	20000	19960	19920	19881	19841	19802	19763	19724	19685	19646
5,1	19608	19569	19531	19493	19455	19417	19380	19342	19305	19268
5,2	19231	19194	19157	19120	19084	19048	19011	18975	18939	18904
5,3	18868	18832	18797	18762	18727	18692	18657	18622	18587	18553
5,4	18519	18484	18450	18416	18382	18349	18315	18282	18248	18215

n	0	1	2	3	4	5	6	7	8	9
5,5	18182	18149	18116	18083	18051	18018	17986	17953	17921	17889
5,6	17857	17825	17794	17762	17730	17699	17668	17637	17606	17575
5,7	17544	17513	17483	17452	17422	17391	17361	17331	17301	17271
5,8	17241	17212	17182	17153	17123	17094	17065	17036	17007	16978
5,9	16949	16920	16892	16863	16835	16807	16779	16750	16722	16694
6,0	16667	16639	16611	16584	16556	16529	16502	16474	16447	16420
6,1	16393	16367	16340	16313	16287	16260	16234	16207	16181	16155
6,2	16129	16103	16077	16051	16026	16000	15974	15949	15924	15898
6,3	15873	15848	15823	15798	15773	15748	15723	15699	15674	15649
6,4	15625	15601	15576	15552	15528	15504	15480	15456	15432	15408
6,5	15385	15361	15337	15314	15291	15267	15244	15221	15198	15175
6,6	15152	15129	15106	15083	15060	15038	15015	14993	14970	14948
6,7	14925	14903	14881	14859	14837	14815	14793	14771	14749	14728
6,8	14706	14684	14663	14641	14620	14599	14577	14556	14535	14514
6,9	14493	14472	14451	14430	14409	14388	14368	14347	14327	14306
7,0	14286	14265	14245	14225	14205	14184	14164	14144	14124	14104
7,1	14085	14065	14045	14025	14006	13986	13966	13947	13928	13908
7,2	13889	13870	13850	13831	13812	13793	13774	13755	13736	13717
7,3	13699	13680	13661	13643	13624	13605	13587	13569	13550	13532
7,4	13514	13495	13477	13459	13441	13423	13405	13387	13369	13351
7,5	13333	13316	13298	13280	13263	13245	13228	13210	13193	13175
7,6	13158	13141	13123	13106	13089	13072	13055	13038	13021	13004
7,7	12987	12970	12953	12937	12920	12903	12887	12870	12853	12837
7,8	12821	12804	12788	12771	12755	12739	12723	12706	12690	12674
7,9	12658	12642	12626	12610	12594	12579	12563	12547	12531	12516
8,0	12500	12484	12469	12453	12438	12422	12407	12392	12376	12361
8,1	12346	12330	12315	12300	12285	12270	12255	12240	12225	12210
8,2	12195	12180	12165	12151	12136	12121	12107	12092	12077	12063
8,3	12048	12034	12019	12005	11990	11976	11962	11947	11933	11919
8,4	11905	11891	11876	11862	11848	11834	11820	11806	11792	11779
8,5	11765	11751	11737	11723	11710	11696	11682	11669	11655	11641
8,6	11628	11614	11601	11587	11574	11561	11547	11534	11521	11507
8,7	11494	11481	11468	11455	11442	11429	11416	11403	11390	11377
8,8	11364	11351	11338	11325	11312	11299	11287	11274	11261	11249
8,9	11236	11223	11211	11198	11186	11173	11161	11148	11136	11123
9,0	11111	11099	11086	11074	11062	11050	11038	11025	11013	11001
9,1	10989	10977	10965	10953	10941	10929	10917	10995	10893	10881
9,2	10870	10858	10846	10834	10823	10811	10799	10787	10776	10764
9,3	10753	10741	10730	10718	10707	10695	10684	10672	10661	10650
9,4	10638	10627	10616	10604	10593	10582	10571	10560	10549	10537
9,5	10526	10515	10504	10493	10482	10471	10460	10449	10438	10428
9,6	10417	10406	10395	10384	10373	10363	10352	10341	10331	10320
9,7	10309	10299	10288	10277	10267	10256	10246	10235	10225	10215
9,8	10204	10194	10183	10173	10163	10152	10142	10132	10121	10111
9,9	10101	10091	10081	10070	10060	10050	10040	10030	10020	10010

Explanations for tests

With the precise questions – in the routes of the fault tracing plan – it is possible to locate the source of a fault. The rectangular blocks contain the type of fault, or else information is given for removing the fault. Test 1, Test 2, and Test 3 check the digital portion of the Counter. They are linked together; that is, the proper sequence of always starting with Test 1 and continuing on until either the cause of the fault is located or the block "Undertake Test..." leads to the succeeding test. However, if the fault is located within the test plan at hand, then it is not necessary to continue on to any more Test. But, the same Test should be followed through once more to verify that the fault really had been located.

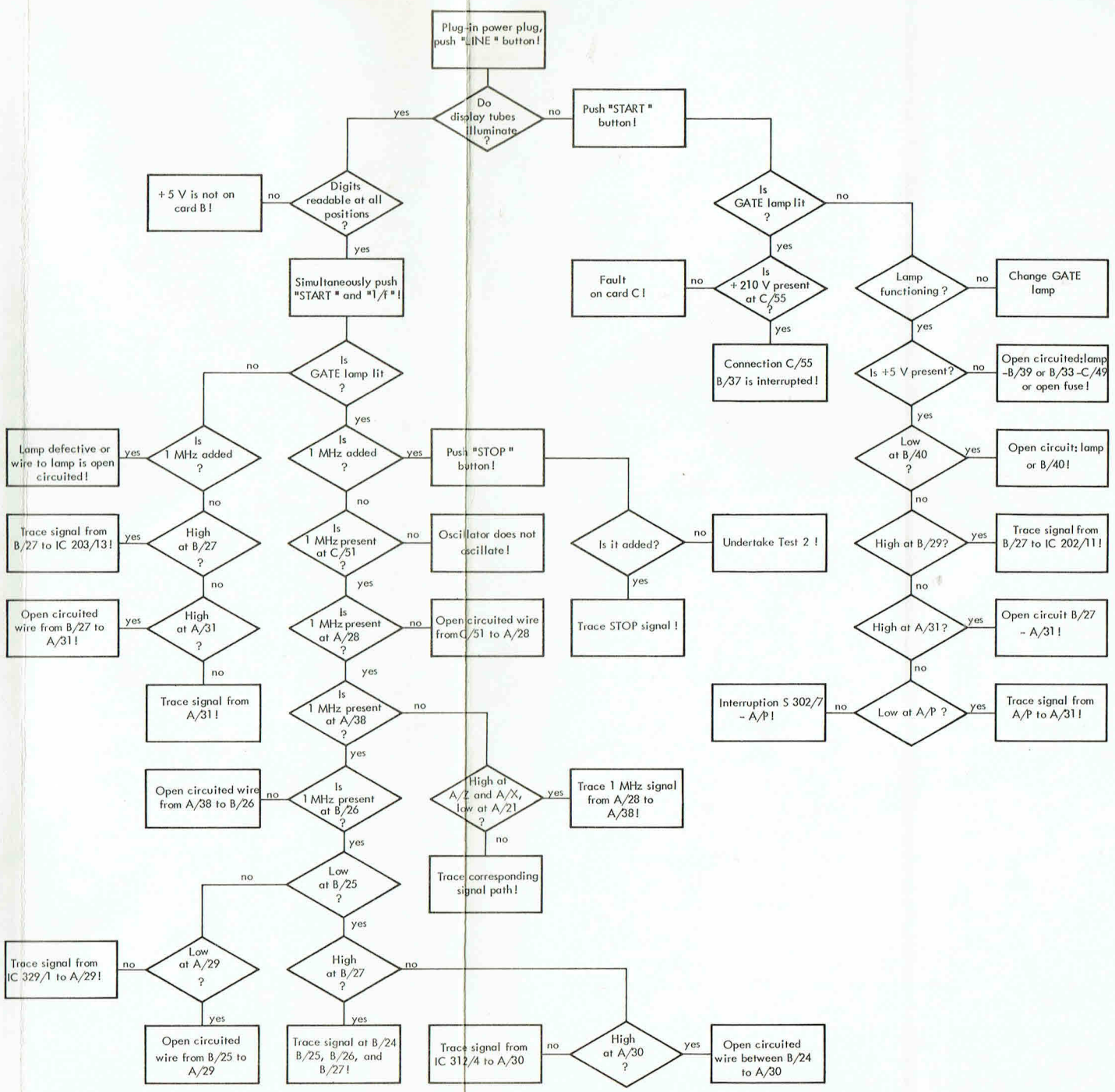
Test 4 checks the analog portion of the counter (input A = measurement input). It is independent of Tests 1 through 3. Also, of course, it is valuable to run through the test once more after the trouble is located.

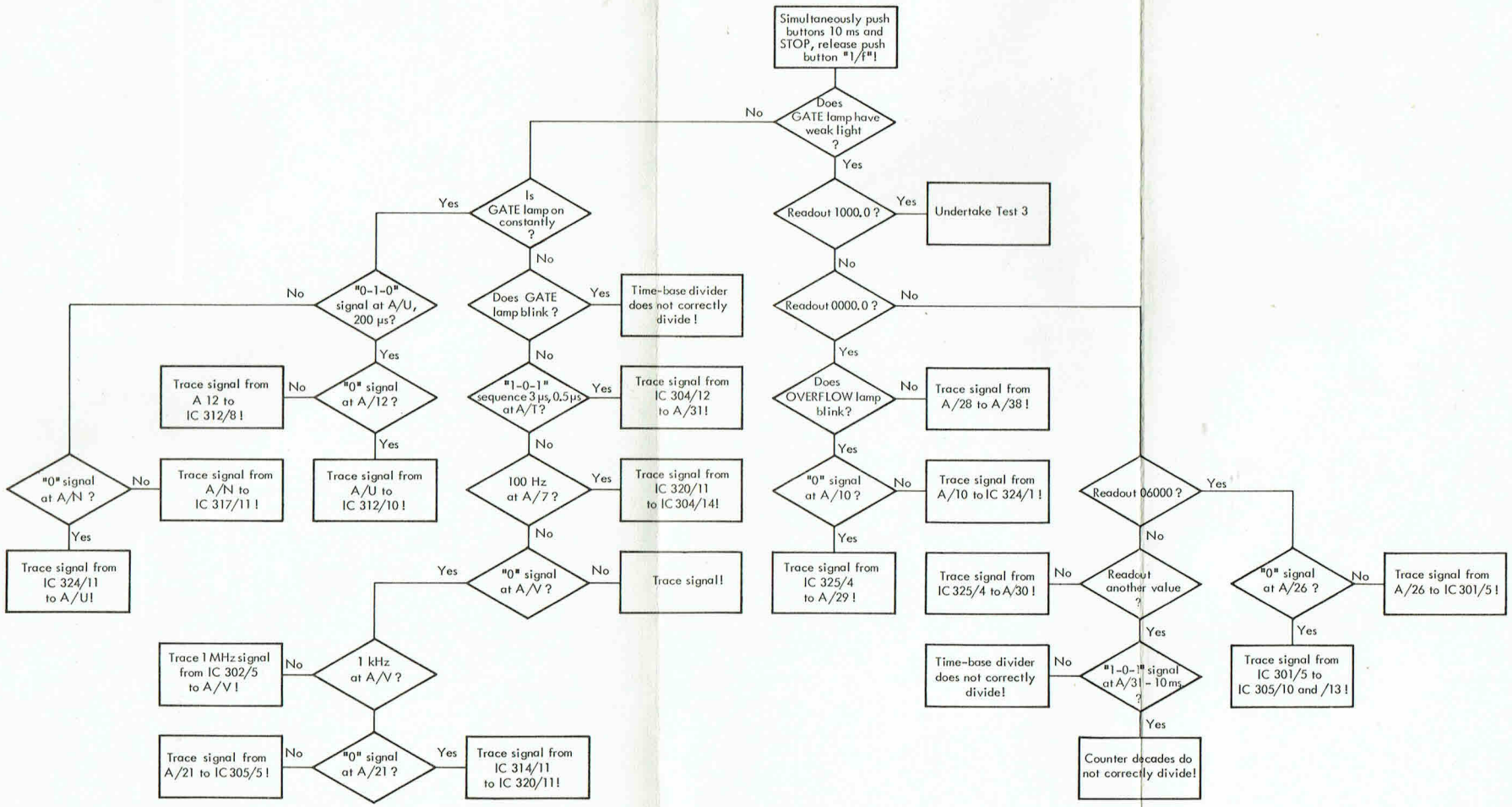
As auxiliary materials, it is necessary to have:

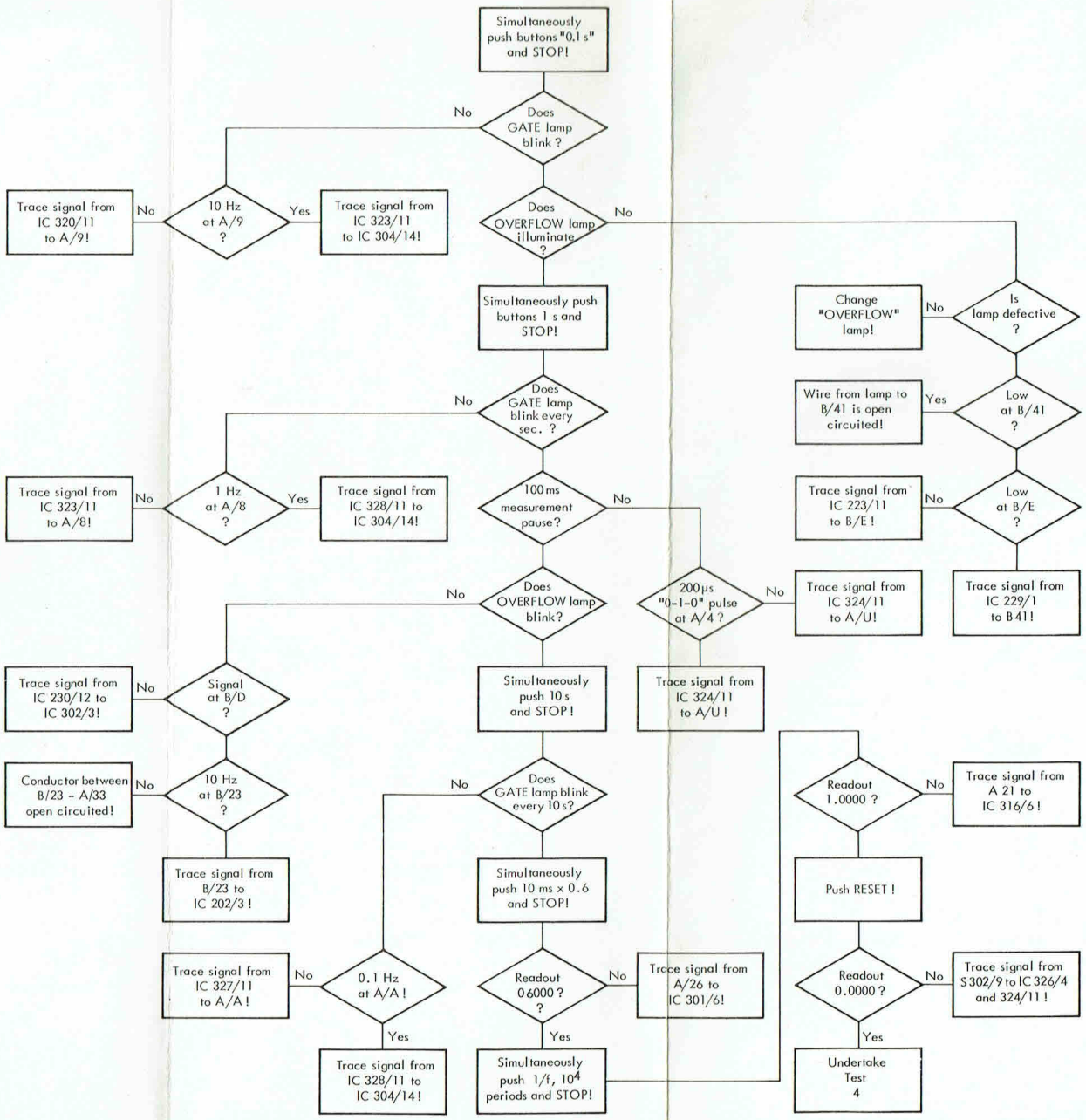
1 Oscillograph; e.g. OS-2 from Wandel u. Goltermann

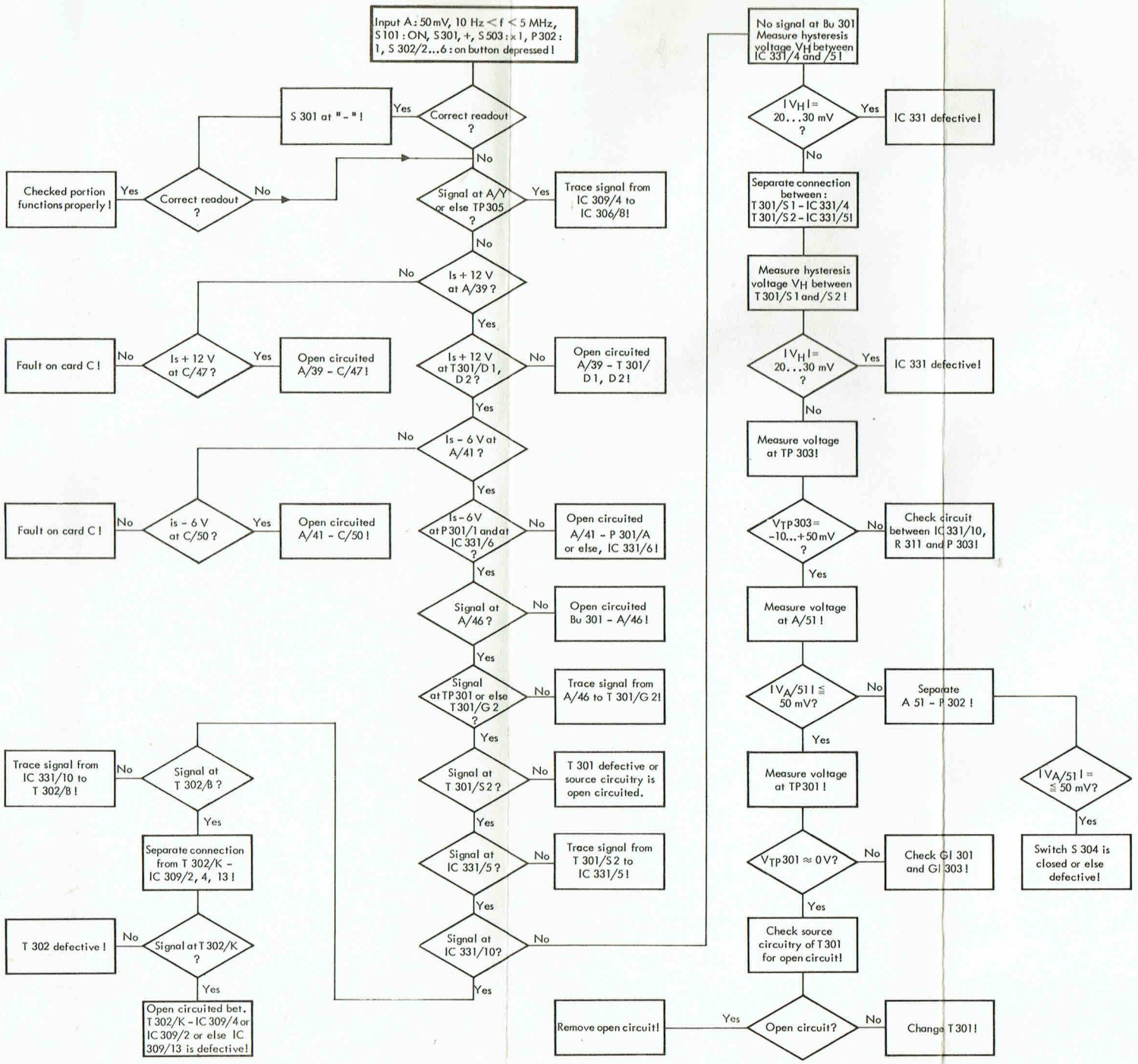
1 D.C. volt meter

Logical signals (0 or 1 signal in the Test 1 through 3) can be traced easily and properly with the Digital Probe TKL-5 from Wandel u. Goltermann.




Simultaneously push buttons 10 ms and STOP, release push button "1/f"!
Does GATE lamp have weak light ?
No
Yes
Readout 1000.0 ?
Yes
Undertake Test 3
No
Readout 0000.0 ?
No
Yes
Does OVERFLOW lamp blink?
No
Trace signal from A/28 to A/38 !
Yes
"0" signal at A/10 ?
No
Trace signal from A/10 to IC 324/1 !
Yes
Trace signal from IC 325/4 to A/29 !
Readout 06000 ?
Yes
No
Readout another value ?
No
Trace signal from IC 325/4 to A/30 !
Yes
"1-0-1" signal at A/31 - 10 ms ?
No
Time-base divider does not correctly divide!
Yes
Counter decades do not correctly divide!
"0" signal at A/26 ?
No
Trace signal from A/26 to IC 301/5 !
Yes
Trace signal from IC 301/5 to IC 305/10 and /13 !
Is GATE lamp on constantly ?
Yes
No
Does GATE lamp blink ?
Yes
Time-base divider does not correctly divide !
No
"1-0-1" sequence 3 µs, 0.5 µs at A/T?
Yes
Trace signal from IC 304/12 to A/31!
No
100 Hz at A/7 ?
Yes
Trace signal from IC 320/11 to IC 304/14!
No
"0" signal at A/V ?
No
Trace signal!
Yes
1 kHz at A/V ?
No
Trace 1 MHz signal from IC 302/5 to A/V !
"0" signal at A/21 ?
No
Trace signal from A/21 to IC 305/5 !
Yes
Trace signal from IC 314/11 to IC 320/11!
"0-1-0" signal at A/U, 200 µs?
No
"0" signal at A/N ?
No
Trace signal from A/N to IC 317/11 !
Yes
Trace signal from IC 324/11 to A/U!
Yes
"0" signal at A/12 ?
No
Trace signal from A 12 to IC 312/8 !
Yes
Trace signal from A/U to IC 312/10 !


Simultaneously push buttons "0.1 s" and STOP!
Does GATE lamp blink ?
No
Does OVERFLOW lamp illuminate ?
No
10 Hz at A/9 ?
No
Yes
Trace signal from IC 320/11 to A/9!
Trace signal from IC 323/11 to IC 304/14!
Simultaneously push buttons 1 s and STOP!
Change "OVERFLOW" lamp!
No
Is lamp defective ?
Wire from lamp to B/41 is open circuited!
Yes
Low at B/41 ?
Does GATE lamp blink every sec. ?
No
1 Hz at A/8 ?
No
Yes
Trace signal from IC 323/11 to A/8!
Trace signal from IC 328/11 to IC 304/14!
100 ms measurement pause?
No
Trace signal from IC 223/11 to B/E !
No
Low at B/E ?
Trace signal from IC 229/1 to B41!
Does OVERFLOW lamp blink?
No
200 µs "0-1-0" pulse at A/4 ?
No
Trace signal from IC 324/11 to A/U!
Signal at B/D ?
No
Trace signal from IC 230/12 to IC 302/3!
Simultaneously push 10 s and STOP!
Trace signal from IC 324/11 to A/U !
Conductor between B/23 - A/33 open circuited!
No
10 Hz at B/23 ?
Does GATE lamp blink every 10 s?
No
Readout 1.0000 ?
No
Trace signal from A 21 to IC 316/6 !
Trace signal from B/23 to IC 202/3 !
Simultaneously push 10 ms x 0.6 and STOP!
Push RESET !
Trace signal from IC 327/11 to A/A !
No
0.1 Hz at A/A !
Readout 0.6000 ? ?
No
Trace signal from A/26 to IC 301/6!
Readout 0.0000 ?
No
Trace signal from S302/9 to IC 326/4 and 324/11 !
Yes
Trace signal from IC 328/11 to IC 304/14!
Yes
Simultaneously push 1/f, 10^4 periods and STOP!
Yes
Undertake Test 4


Input A: 50 mV, 10 Hz < f < 5 MHz, S 101: ON, S 301, +, S 503: x 1, P 302: 1, S 302/2...6: on button depressed!
Correct readout ?
Yes
S 301 at "-"!
No
Signal at A/Y or else TP 305 ?
Yes
Trace signal from IC 309/4 to IC 306/8!
No
Correct readout ?
Yes
No
Checked portion functions properly!
Is + 12 V at A/39 ?
No
Yes
Is + 12 V at C/47 ?
No
Yes
Fault on card C!
Open circuited A/39 - C/47!
Is + 12 V at T 301/D 1, D 2 ?
No
Open circuited A/39 - T 301/ D 1, D 2!
Yes
Is - 6 V at A/41 ?
No
Yes
is - 6 V at C/50 ?
No
Yes
Fault on card C!
Open circuited A/41 - C/50!
Is - 6 V at P 301/1 and at IC 331/6 ?
No
Open circuited A/41 - P 301/A or else, IC 331/6!
Yes
Signal at A/46 ?
No
Open circuited Bu 301 - A/46!
Yes
Signal at TP 301 or else T 301/G 2 ?
No
Trace signal from A/46 to T 301/G 2!
Yes
Signal at T 301/S 2 ?
No
T 301 defective or source circuitry is open circuited.
Yes
Signal at IC 331/5 ?
No
Trace signal from T 301/S 2 to IC 331/5!
Yes
Signal at IC 331/10?
No
Yes
Trace signal from IC 331/10 to T 302/B!
No
Signal at T 302/B ?
Yes
Separate connection from T 302/K - IC 309/2, 4, 13!
T 302 defective!
No
Signal at T 302/K ?
Yes
Open circuited bet. T 302/K - IC 309/4 or IC 309/2 or else IC 309/13 is defective!
No signal at Bu 301 Measure hysteresis voltage V_H between IC 331/4 and /5!
$|V_H|$ = 20...30 mV ?
Yes
IC 331 defective!
No
Separate connection between: T 301/S 1 - IC 331/4 T 301/S 2 - IC 331/5!
Measure hysteresis voltage V_H between T 301/S 1 and /S 2!
$|V_H|$ = 20...30 mV ?
Yes
IC 331 defective!
No
Measure voltage at TP 303!
V_{TP} 303 = -10...+ 50 mV ?
No
Check circuit between IC 331/10, R 311 and P 303!
Yes
Measure voltage at A/51!
$|V_{A/51}| \leq$ 50 mV?
No
Separate A 51 - P 302!
Yes
$|V_{A/51}| \leq$ 50 mV?
Yes
Switch S 304 is closed or else defective!
Measure voltage at TP 301!
V_{TP} 301 ≈ 0 V?
No
Check Gl 301 and Gl 303!
Yes
Check source circuitry of T 301 for open circuit!
Open circuit?
Yes
No
Change T 301!
Remove open circuit!

Sollten die Werte bestimmter Bauelemente in den Stromlaufplänen und Schaltteillisten differieren, so sind stets die Angaben in den Schaltteillisten als verbindlich anzusehen.

If the values of individual parts lists in the circuit diagrams and parts lists should differ from another, those values given in the parts lists are valid.

Bei der Bestellung von Ersatzteilen sind folgende Angaben notwendig:
Bestellnummer, Gerätenummer und Positionsnummer des Bauelements, z. B.

BN 597/0 Nr. 442102 G1 101

When ordering spare parts the following information should be given:
Order number, serial number of the instrument and position number of the part, e.g.

BN 597/0 Nr. 442102 G1 101

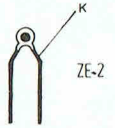
Belastbarkeit der Widerstände
(Power rating of resistors)

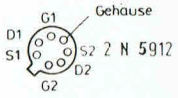
Anstelle der Belastbarkeit von Widerständen ist in den Schaltteillisten die genormte Größenbezeichnung nach DIN 44050 und folgende angegeben. Die Angabe der Belastbarkeit in den Stromlaufplänen entfällt.

In the parts lists instead of the power rating of resistors, the standard size designations according to DIN 44050 are given. In the circuit diagram, symbol denoting power rating is no more given.

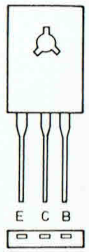
Elektrodenkennzeichnung
(Electrode designation)

Dioden und Thyristoren
(Diodes and thyristors)





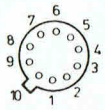
Transistoren (Transistors)

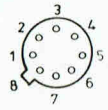


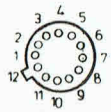
Auf Lötseite gesehen
Looking at soldering terminals

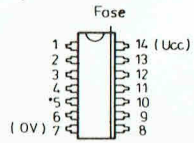
Integrierte Schaltungen (IC's)

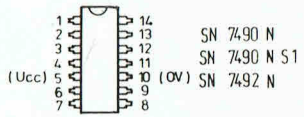
Auf Lötseite gesehen
Looking at soldering terminals



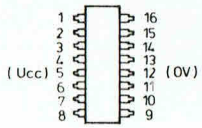


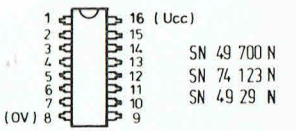


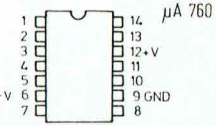




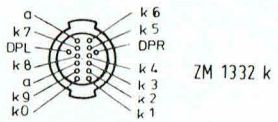
Draufsicht
Top view







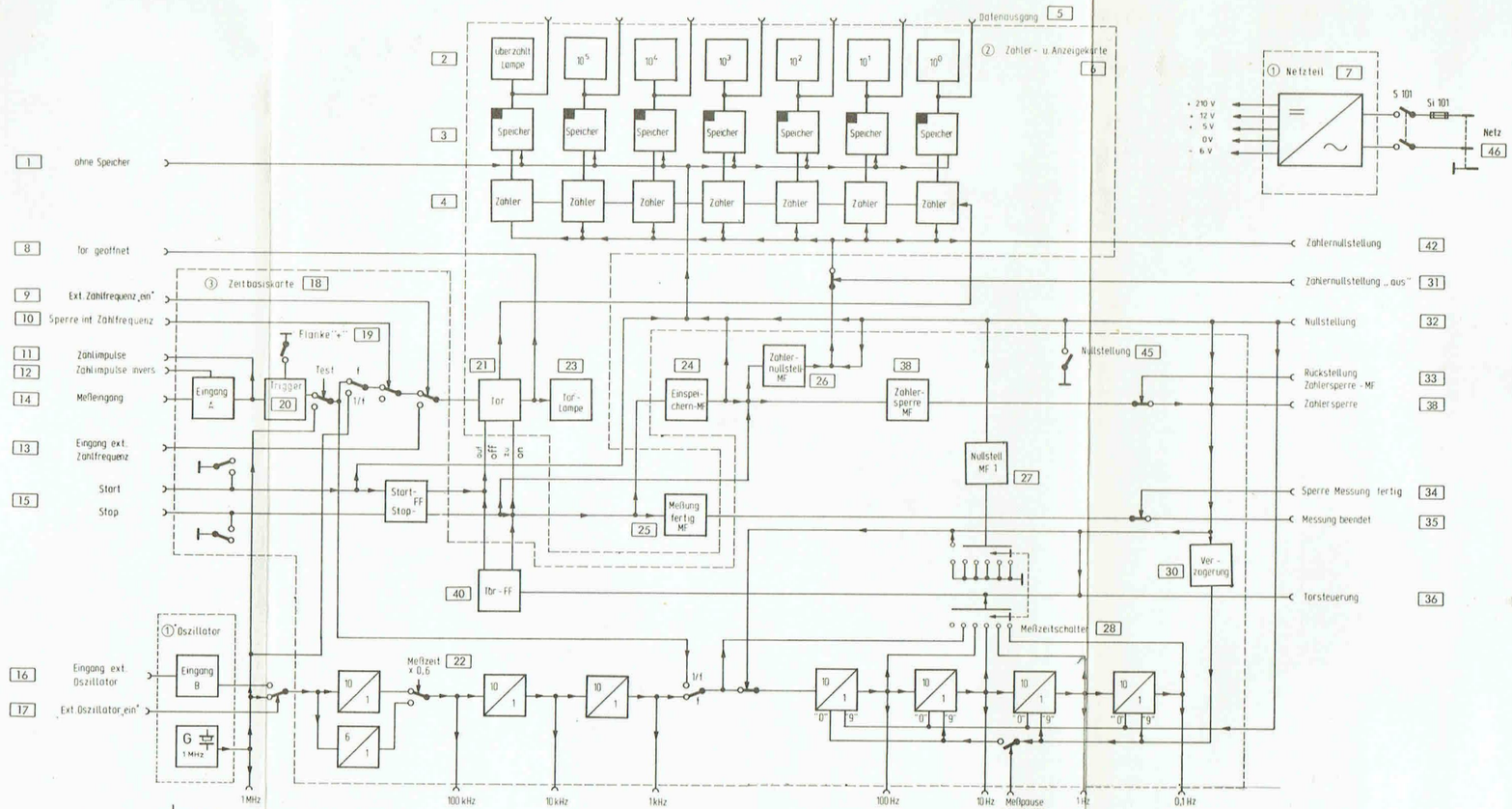
Anzeigeröhren (Indicator tubes)



Auf Lötseite gesehen
Looking at soldering terminals

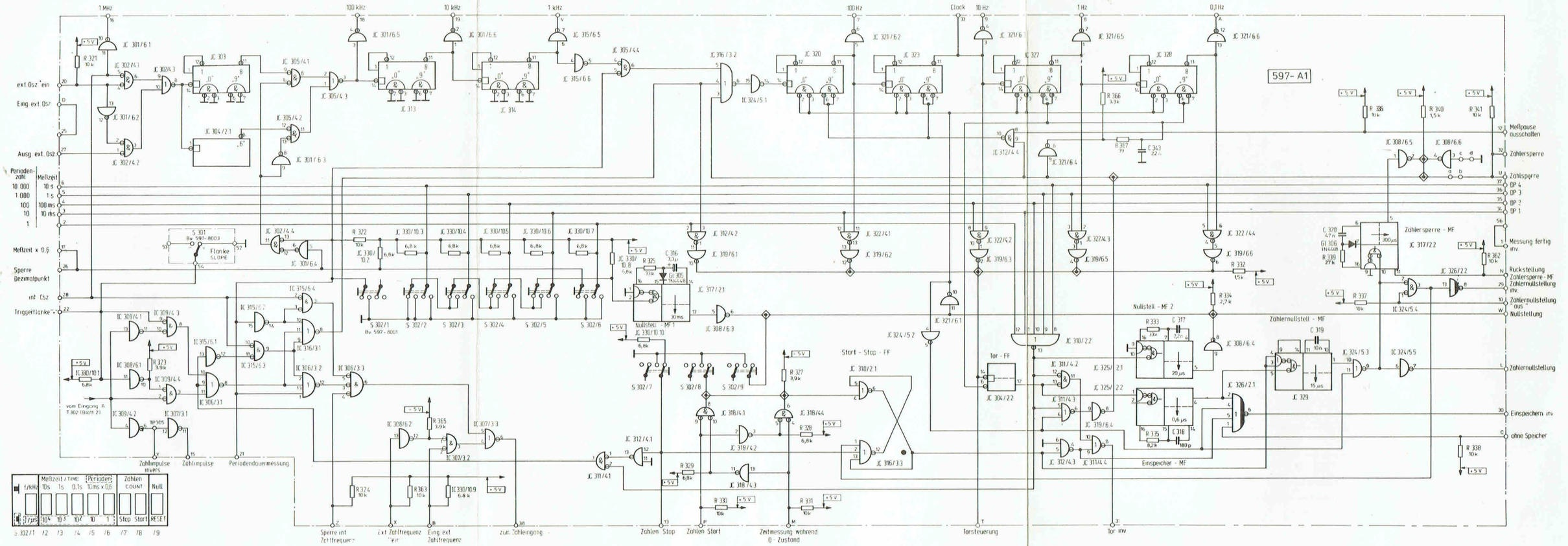
Vocabulary

1	without storage
2	overflow lamp
3	storage
4	counter
5	data output
6	counter and readout card
7	power supply
8	gate open
9	ext. count. freq. "ON"
10	inhibit int. counter freq.
11	count pulse
12	count pulse inverted
13	input ext. count freq.
14	input
15	start/stop
16	input ext. oscillator
17	ext. oscillator "ON"
18	time-base card
19	slope "+"
20	trigger
21	gate
22	meas. time
23	gate lamp
24	buffer store monostable
25	measurement ended monostable
26	counter reset monostable
27	reset monostable 1
28	measurement time switch
29	measurement pause off
30	delay
31	counter reset "OFF"
32	reset
33	inhibit counter monostable
34	inhibit measurement complete
35	measurement ended
36	control for gate
37	measurement time sample
38	counter inhibit
39	clock pulse
40	gate flip-flop
41	store
42	counter reset
43	counting ended monostable
44	signal sequence plan for a freq. measurement
45	zero setting
46	mains



Signalfolgediagramm für eine f-Messung 44

Blockschaltplan FZ-4
Block diagram BN 597

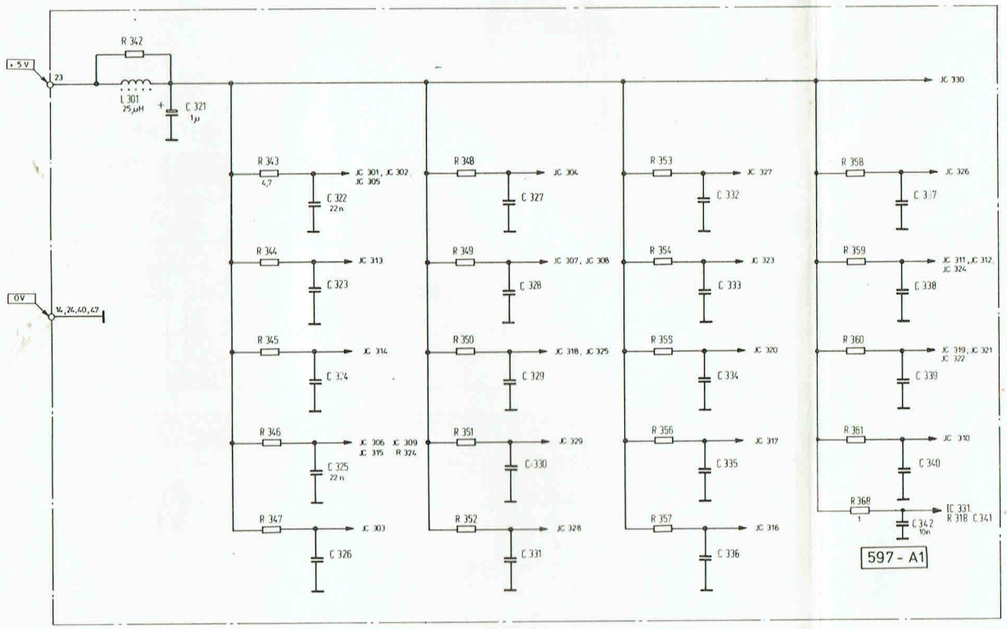


Vokabular / Vocabulary

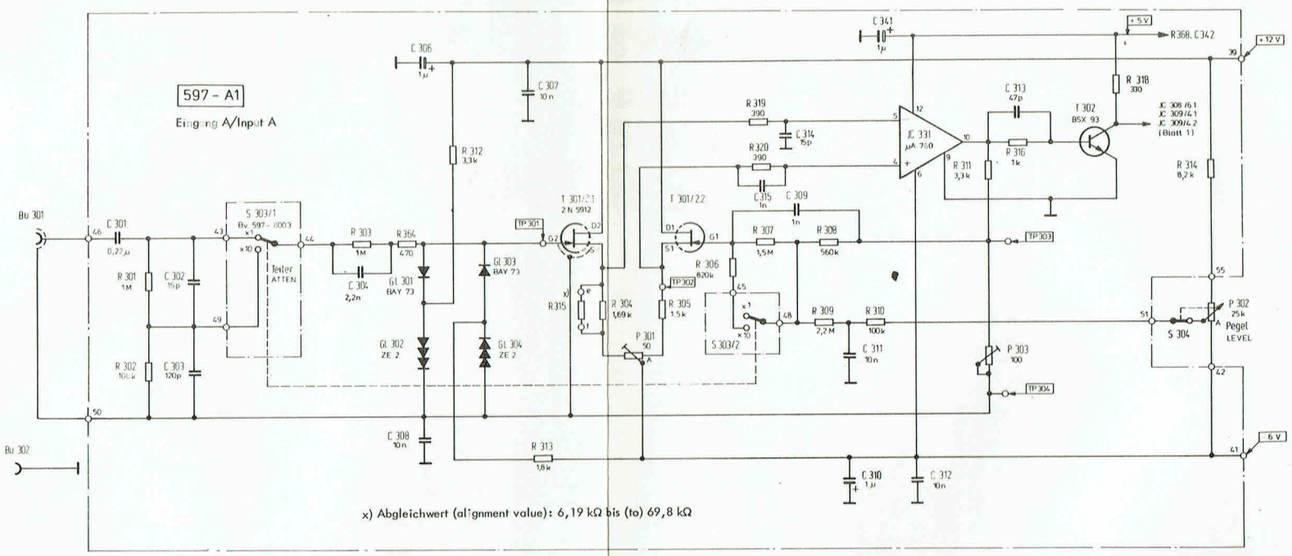
Ext. Osz. "ein"	ext. oscillator "on"	Periodendauermessung	interval – continuous measuring	Einspeicher – MF	store – MF
Eing. ext. Osz.	input ext. oscillator	ext. Zählfrequenz "ein"	ext. count frequency "on"	Meßpause	measurement pause
Ausg. ext. Osz.	output ext. oscillator	Eing. ext. Zählfrequenz	input ext. count frequency	ausschalten	switched out
Periodenzahl	interval count	zum Zähleingang	to count input	Zählersperre	counter inhibit
Meßzeit	measuring time	Zählen Stop/Start	count stop/start	Zählsperre	count inhibit
Sperre	inhibit	Nullstell – MF	zero set – MF	Messung fertig inv.	measurement finished inv.
Dezimalpunkt	decimal point	Zeitmessung während	time measuring interval	Rückstellung	re-set
Triggerflanke	trigger pulse edge	0-Zustand	"0"-condition	Zählernullstellung	counter zero set
int. Osz.	int. oscillator	Torsteuerung	gate control	Einspeichern inv.	store inv.
vom Eingang A	from input A	Tor inv.	gate inv.	ohne Speicher	without store
Zählimpulse inv.	count pulse inv.	Zählernullstell – MF	counter zero set – MF		

Fortsetzung/continued

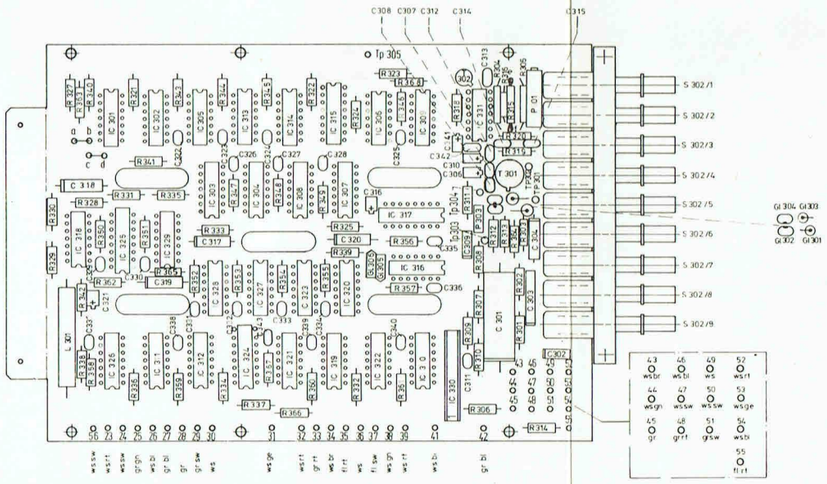
Zeitbasiskarte FZ-4
Time base card BN 597 (3) A



R 344 bis (to) R 361: 1 Ω
C 323 bis (to) C 340: 10 nF (außer C 325) (except for C 325)

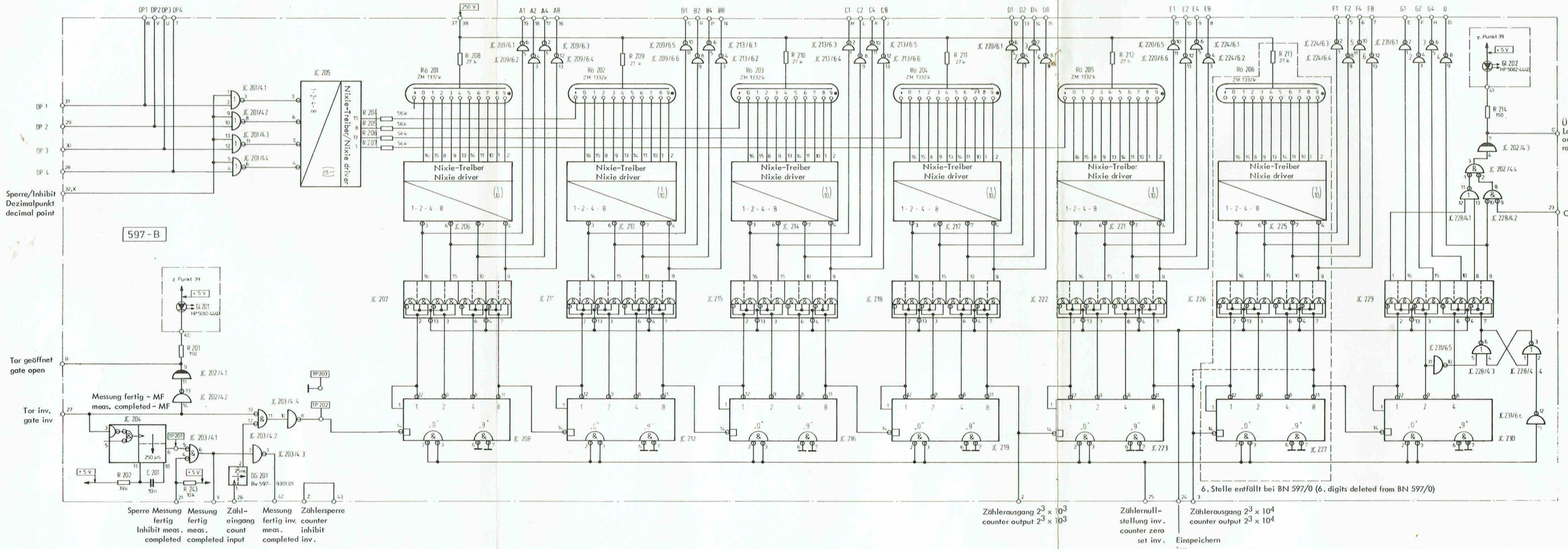


x) Abgleichwert (alignment value): 6,19 kΩ bis (to) 69,8 kΩ



Fortsetzung/continued

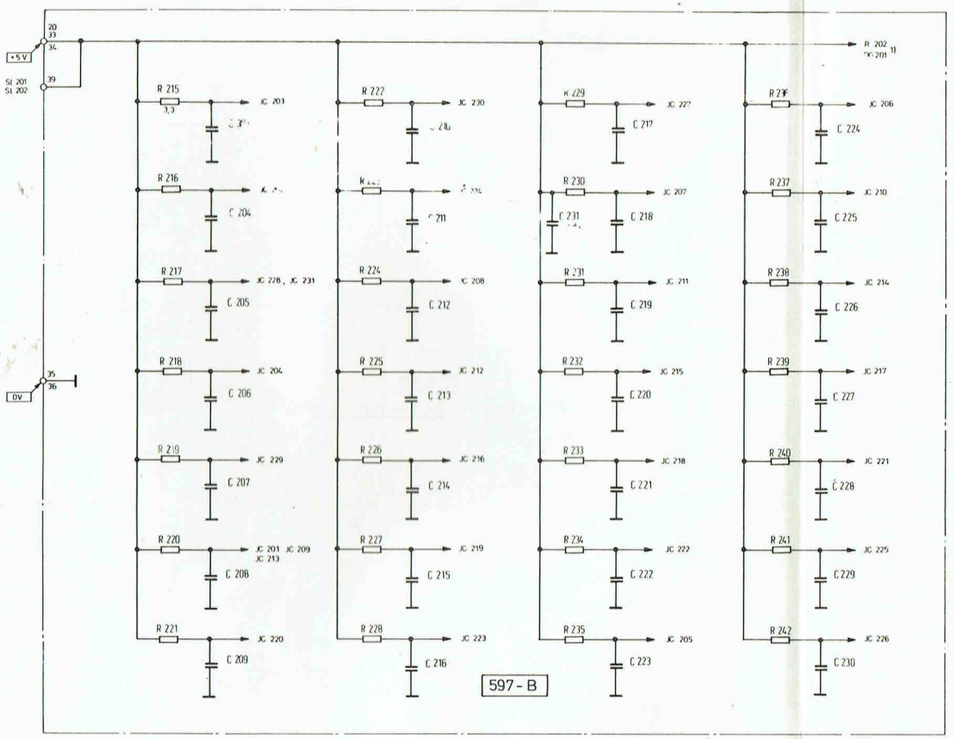
Zeitbasiskarte FZ-4
Time base card BN 597 ③ **A**

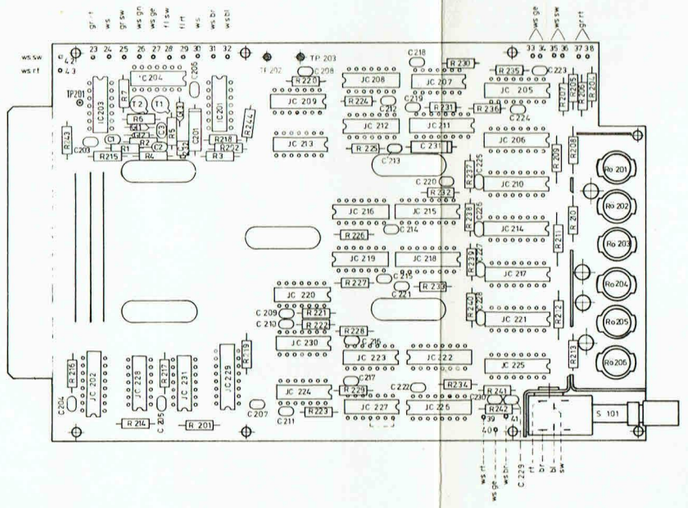


Fortsetzung/continued

Zähler und Anzeigekarte
Counter and indicator card

FZ-4
BN 597 (2) **B**

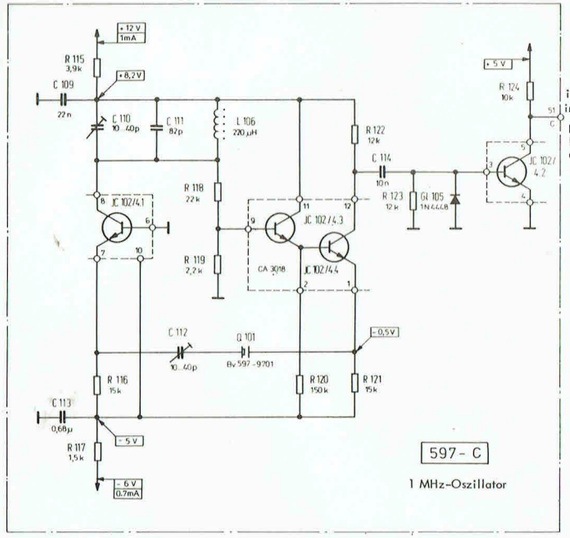




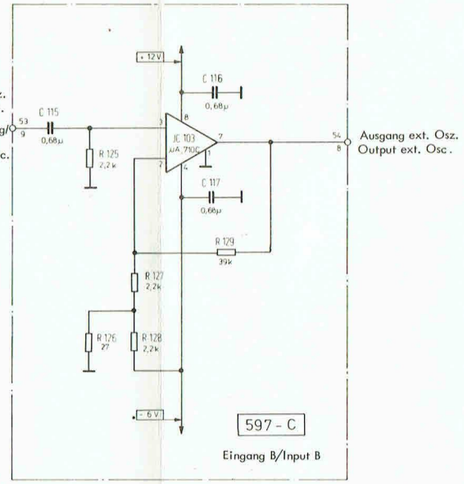
Alle nicht bezeichneten Widerstände · 1 Ω
All resistors not otherwise designated are : 1 Ω

Alle Kondensatoren (28 Stück) : 10 nF
All capacitors (28 pieces) : 10 nF

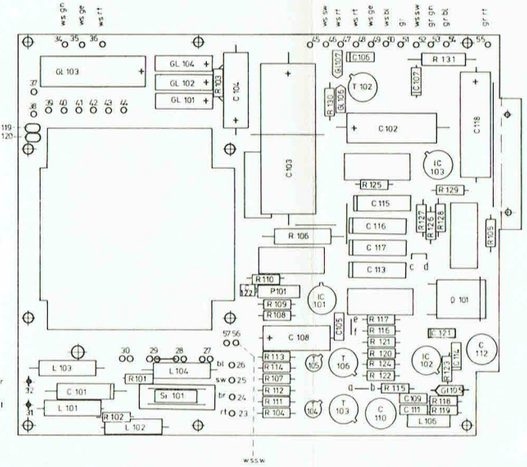
Fortsetzung/continued

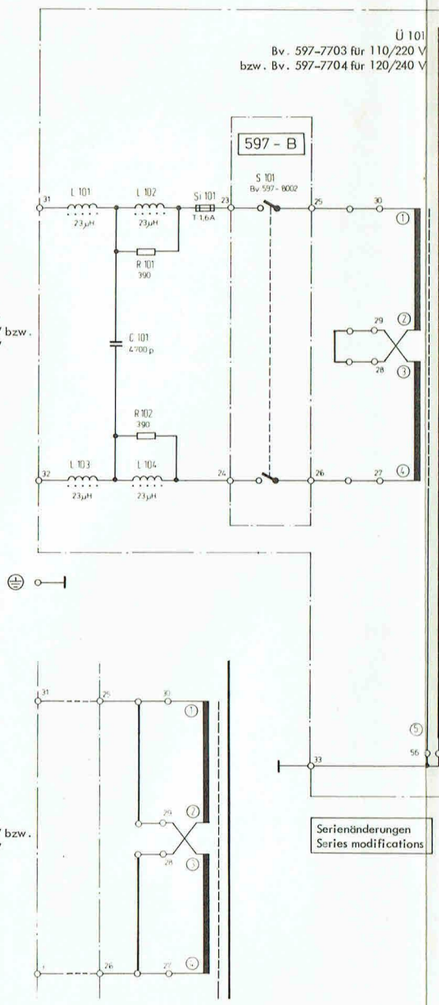


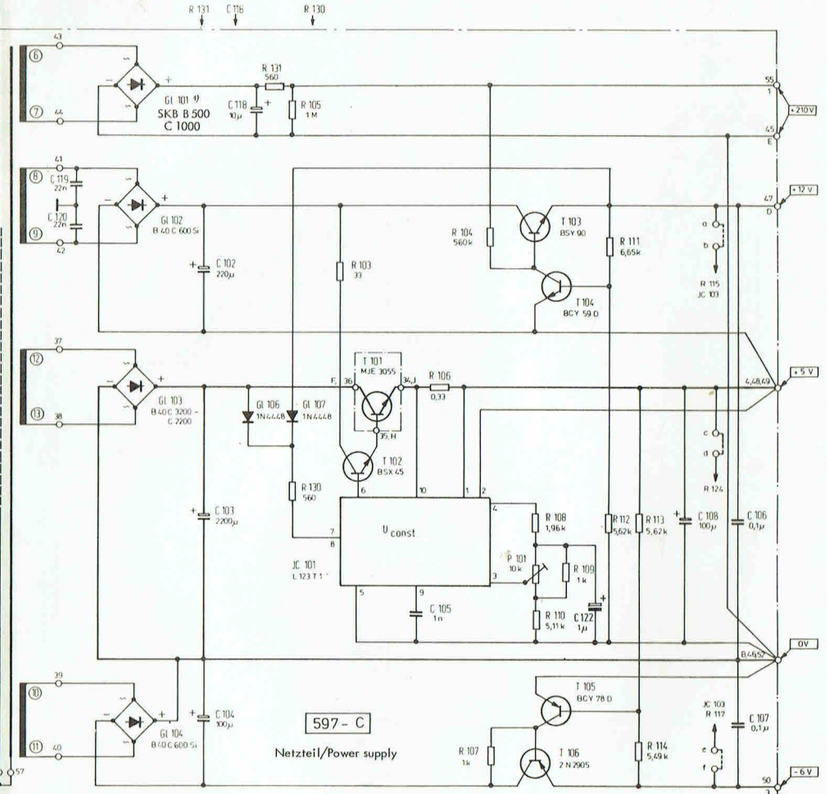
int. Osz.
int. Osc.
Eingang/Input
ext. Osc.



Ausgang ext. Osz.
Output ext. Osc.





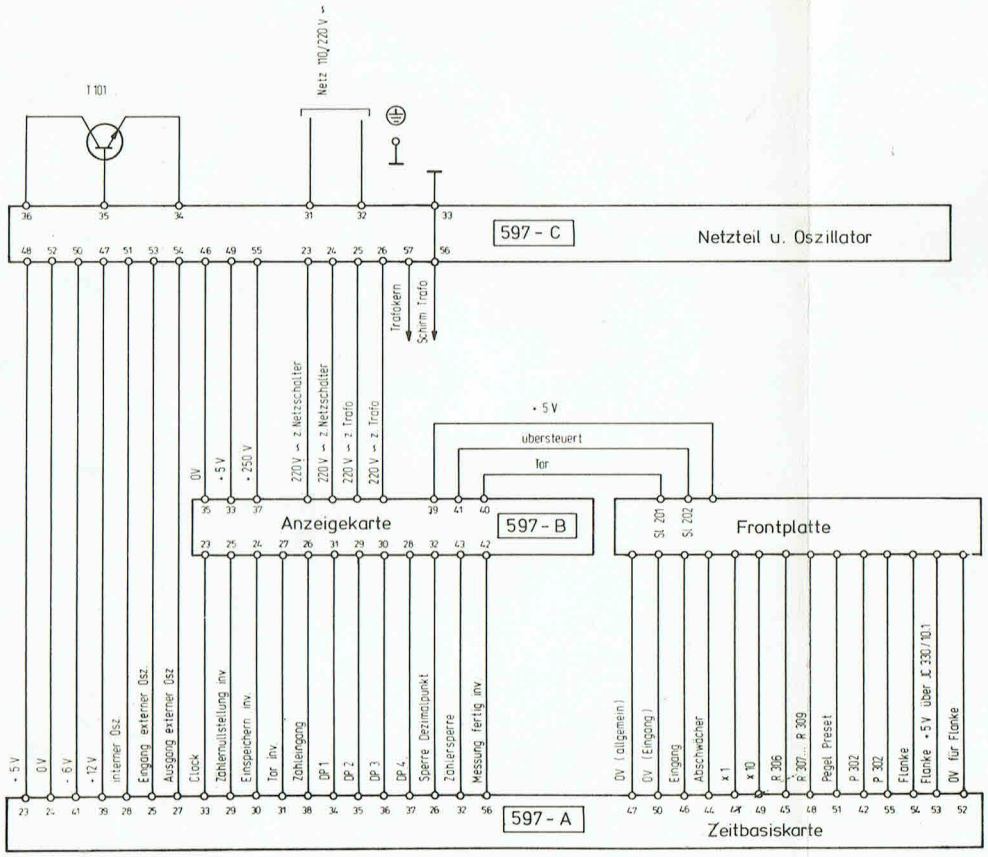


Serienänderungen
Series modifications

Serie C: 1) B 250 C 600 Si

Netzteil und Oszillator
Power supply and oscillator

FZ-4
BN 597 (1) **C**



Verdrahtungsplan

Anzeigekarte (597-B)

	Zählersperre	Messung fertig	Sperre Dezimalpunkt	Dezimalpunkt 1	Dezimalpunkt 2	Dezimalpunkt 3	Dezimalpunkt 4	Zehnerstelle (10^1)				Hunderterstelle (10^2)				Tausenderstelle (10^3)				Zehntausenderstelle (10^4)				Hunderttausenderstelle (10^5)				Millionenstelle (10^6) bei 6-Stellen	Überzähl (>2)	Überzähl - Lampe	Tor geöffnet
	Z	Y	X	W	V	U	T	S	R	P	N	M	L	K	J	H	F	E	D	C	B	A								
	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1								
	Sperre Messung fertig	5 V	A1	A2	A4	A8	B8	B4	B2	B1	D1	E8	E4	E2	E1	F8	F4	F2	F1	Zählerausgang $2^3 \times 10^4$	Zählerausgang $2^3 \times 10^3$	0V Masse								
	Einerstelle (10^0)																													

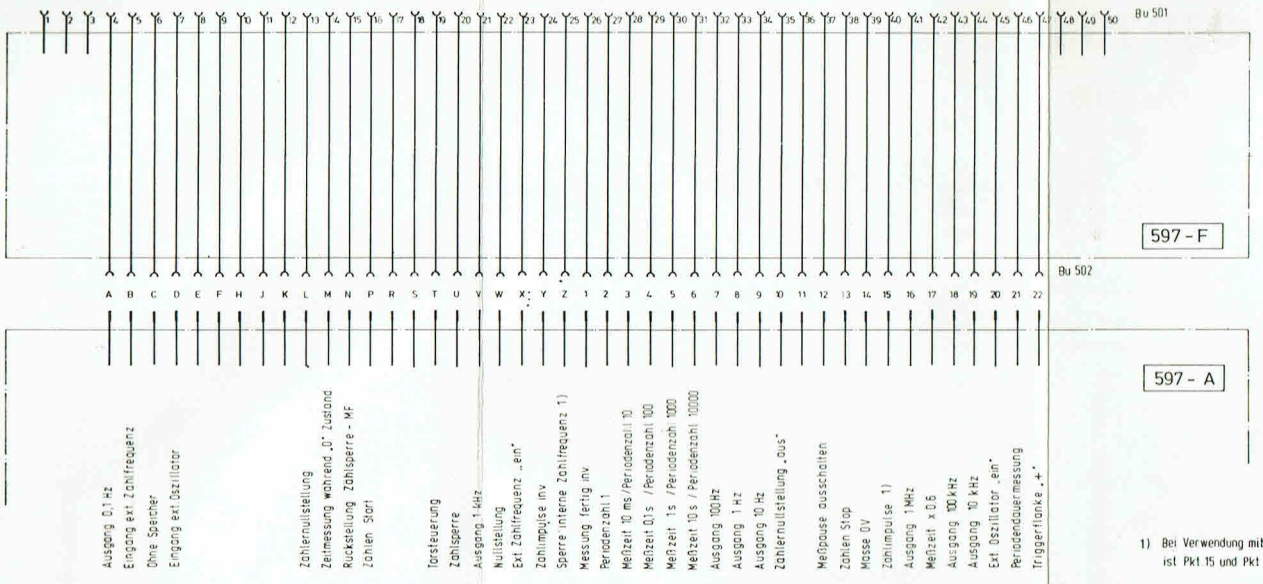
Zeitbasiskarte (597-A)

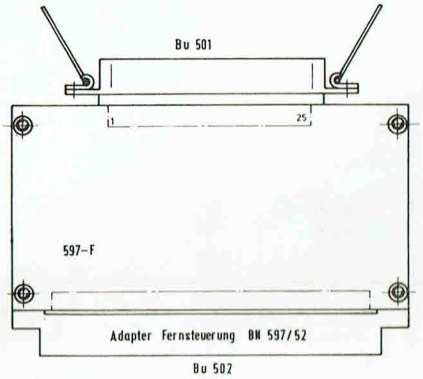
	Messung fertig invers	Periodenzahl 1	Periodenzahl 10	Periodenzahl 100	Periodenzahl 1000	Periodenzahl 10.000	Ausgang 100 Hz	Ausgang 1 Hz	Ausgang 10 Hz	Zählernullstellung "aus"	Meßpause ausschalten	Zählen Stop	Masse 0V	Zählimpulse	Ausgang 1 MHz	Meßzeit x 0,6	Ausgang 100 kHz	Ausgang 10 kHz	Ext. Oszillator "ein"	Periodendauermessung	Triggerflanke "+"
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	A	B	C	D	E	F	H	J	K	L	M	N	P	R	S	T	U	V	W	X	Y	Z
	Ausgang 0,1 Hz	Eingang ext. Zählfrequenz	ohne Speicher	Eingang ext. Oszillator						Zählernullstellung, Zeitmessung während 0-Zustand	Rücksetzung Zählersperre - ME	Zählen Start				Torsteuerung	Zählsperre	Ausgang 1 kHz	Nullstellung	Ext. Zählfrequenz "ein"	Zählimpulse inv.	Sperre interne Zählfrequenz

Kontaktbelegung (Ansicht auf die Rückwand)

Verdrahtungsplan und Kontaktbelegung
Wiring scheme and contact arrangement

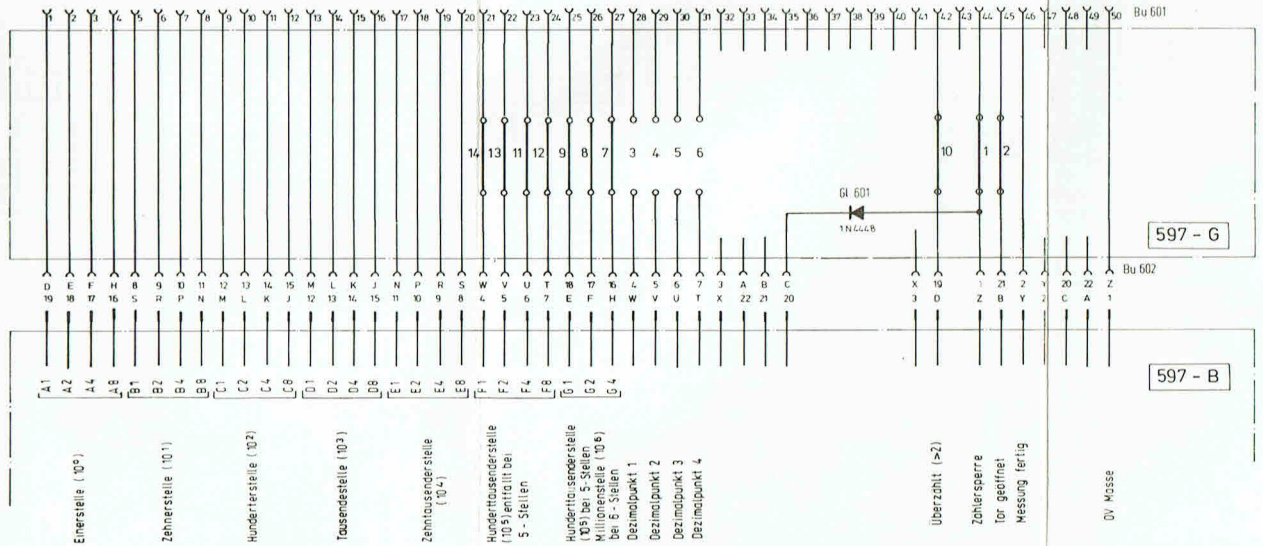
FZ-4
BN 597 (4)

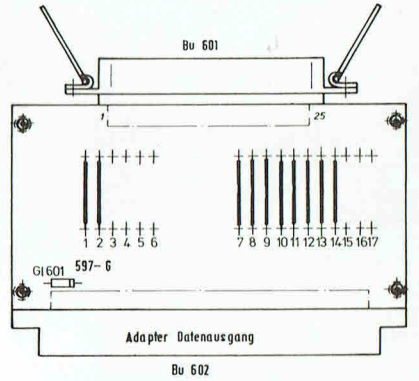




1) Bei Verwendung mit FZ-4/BN 597 aus der Serie A ist Pkt 15 und Pkt Z von 597-A nicht belegt

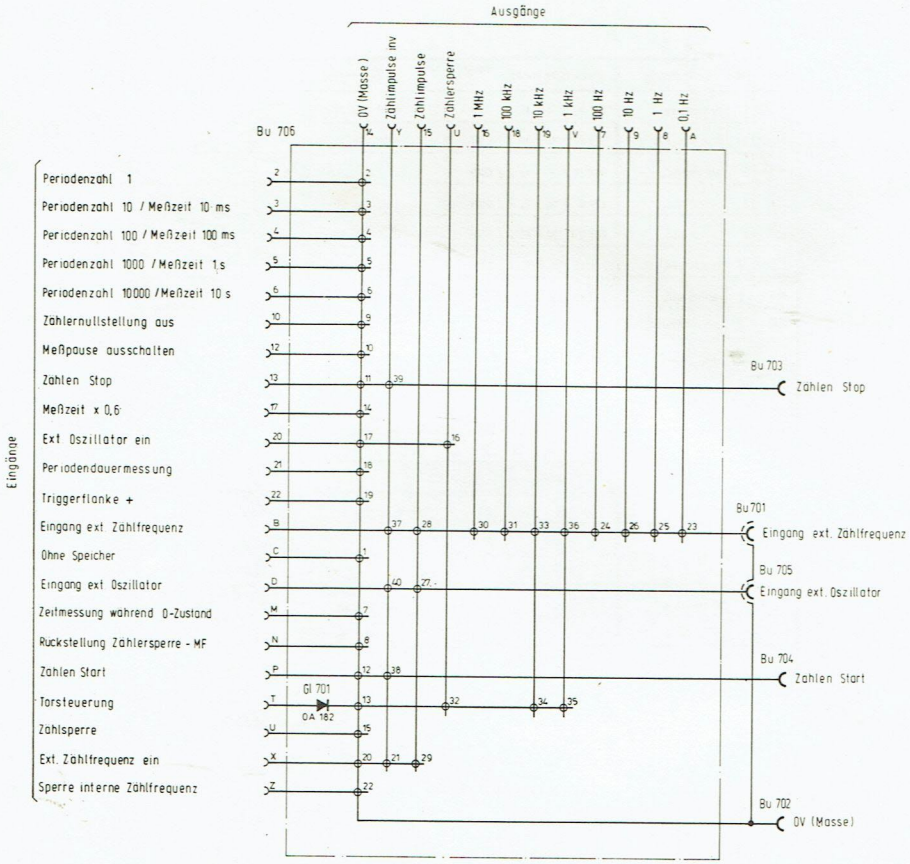
Adapter Fernsteuerung FZ-4 F
Adaptor, remote control BN 597 (5)

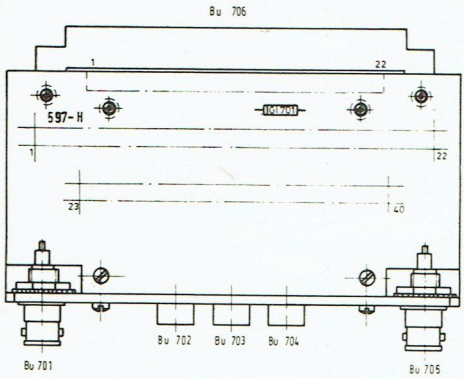




Drahtbrücke 7,8,9,11,12,13,14 nur bei Verwendung mit BN 597/2 u. /3 dafür entfallen die Brücken 15,16,17
Drahtbrücke 3,4,5,6 zur Dezimalpunkt-Meßbereichsregistrierung.
Drahtbrücke 1 entfällt bei überlappendem Betrieb
Drahtbrücke 10 entfällt, wenn keine Farbbandumschaltung bei überzahl Signal erwünscht
Drahtbrücke 2 entfällt, wenn Druck auch am Drucker selbst ausgelöst werden soll.

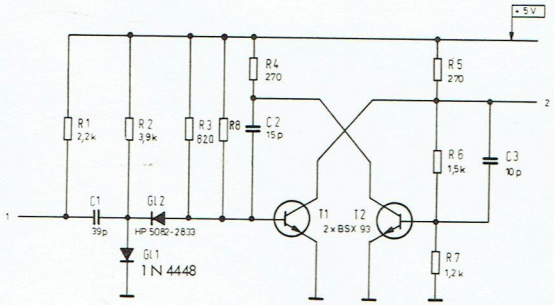
Adapter Datenausgang FZ-4 G
Adaptor, data output BN 597 (6)





Programmierkarte FZ-4
Programming card BN 597 (7) H

Teil	Stck	Bezeichnung	Bestellangaben Elektrische Werte	Benennung	Hersteller, Anmerkgn
R 1	1	Schichtwid.	2,2 kΩ / 5% / K1 2 / 0309	0000 7100 29	
R 2	1	Schichtwid.	3,9 kΩ / 5% / K1 2 / 0309	0000 7100 32	
R 3	1	Schichtwid.	820 Ω / 5% / K1 2 / 0309		
R 4	1	Schichtwid.	270 Ω / 5% / K1 2 / 0309	0000 7100 18	
R 5	1	Schichtwid.	270 Ω / 5% / K1 2 / 0309	0000 7100 18	
R 6	1	Schichtwid.	1,5 kΩ / 5% / K1 2 / 0309	0000 7100 27	
R 7	1	Schichtwid.	1,2 kΩ / 5% / K1 2 / 0309	0000 7100 26	
R 8	1	Schichtwid.	Abgleichwert		
C 1	1	Ker. - Kond.	39 pF/2% / 63 V /N 150 / IB		WN 110 / 2 / 9
C 2	1	Ker. - Kond.	15 pF/2% / 63 V /N 150 / IB		WN 110 / 2 / 9
C 3	1	Ker. - Kond.	10 pF/±0,25 pF/63 V/N 150/ IB		WN 110 / 2 / 9
Gl 1	1	Diode	1 N 4448		
Gl 2	1	Diode	HP 5082 - 2833	0000 7206 10	
Gl 3					
T 1	1	Transistor	BSX 93	0000 7121 28	
T 2	1	Transistor	BSX 93	0000 7121 28	



Monoflop 25 ns FZ-4
DG 201 BN 597-01.01

Teil	Stck	Bezeichnung	Elektrische Werte	Bestellangaben Benennung	Hersteller, Anmerkgn
R 301	1	Schichtwid.	1 MΩ / 5% / K1 2 / 0309	0000 7100 61	
R 302	1	Schichtwid.	100 kΩ / 5% / K1 2 / 0309	0000 7100 49	
R 303	1	Schichtwid.	1 MΩ / 5% / K1 2 / 0309	0000 7100 61	
R 304	1	Schichtwid.	1,69 kΩ / 1% / K1 0,5 / 0414	0000 7220 67	
R 305	1	Schichtwid.	1,5 kΩ / 1% / K1 0,5 / 0414	0000 7177 37	
R 306	1	Schichtwid.	820 kΩ / 5% / K1 2 / 0309	0000 7100 60	
R 307	1	Schichtwid.	1,5 MΩ / 5% / K1 2 / 0309	0000 7100 63	
R 308	1	Schichtwid.	560 kΩ / 5% / K1 2 / 0309	0000 7100 58	
R 309	1	Schichtwid.	2,2 MΩ / 5% / K1 2 / 0309	0000 7100 64	
R 310	1	Schichtwid.	100 kΩ / 5% / K1 2 / 0309	0000 7100 49	
R 311	1	Schichtwid.	3,3 kΩ / 5% / K1 2 / 0309	0000 7100 31	
R 312	1	Schichtwid.	3,3 kΩ / 5% / K1 2 / 0309	0000 7100 31	
R 313	1	Schichtwid.	1,8 kΩ / 5% / K1 2 / 0309	0000 7100 28	
R 314	1	Schichtwid.	8,2 kΩ / 5% / K1 2 / 0309	0000 7100 36	
R 315	1	Schichtwid.	Abgleichwert 1% / K1 0,5 / 0309		WN 18 / 1 / 3
R 316... R 318	1	Schichtwid.	kΩ / 5% / K1 2 / 0309	0000 7100 25	
R 319	1	Schichtwid.	390 Ω / 5% / K1 2 / 0309		
R 320	1	Schichtwid.	390 Ω / 5% / K1 2 / 0309		
R 321	1	Schichtwid.	10 kΩ / 5% / K1 2 / 0309	0000 7100 37	
R 322	1	Schichtwid.	10 kΩ / 5% / K1 2 / 0309	0000 7100 37	
R 323	1	Schichtwid.	3,9 kΩ / 5% / K1 2 / 0309	0000 7100 32	
R 324	1	Schichtwid.	10 kΩ / 5% / K1 2 / 0309	0000 7100 37	
R 325	1	Schichtwid.	33 kΩ / 5% / K1 2 / 0309	0000 7100 43	
R 327	1	Schichtwid.	3,9 kΩ / 5% / K1 2 / 0309	0000 7100 32	
R 328	1	Schichtwid.	6,8 kΩ / 5% / K1 2 / 0309	0000 7100 35	
R 329	1	Schichtwid.	6,8 kΩ / 5% / K1 2 / 0309	0000 7100 35	
R 330	1	Schichtwid.	10 kΩ / 5% / K1 2 / 0309	0000 7100 37	
R 331	1	Schichtwid.	10 kΩ / 5% / K1 2 / 0309	0000 7100 37	
R 332	1	Schichtwid.	1,5 kΩ / 5% / K1 2 / 0309	0000 7100 27	
R 333	1	Schichtwid.	33 kΩ / 5% / K1 2 / 0309	0000 7100 43	
R 334	1	Schichtwid.	2,7 kΩ / 5% / K1 2 / 0309	0000 7100 30	
R 335	1	Schichtwid.	8,2 kΩ / 5% / K1 2 / 0309	0000 7100 36	
R 336... R 338	1	Schichtwid.	10 kΩ / 5% / K1 2 / 0309	0000 7100 37	
R 339	1	Schichtwid.	22 kΩ / 5% / K1 2 / 0309	0000 7100 41	
R 340	1	Schichtwid.	1,5 kΩ / 5% / K1 2 / 0309	0000 7100 27	
R 341	1	Schichtwid.	10 kΩ / 5% / K1 2 / 0309	0000 7100 37	
R 342	1	Schichtwid.	5,1 Ω / 5% / K1 2 / 0309	0000 7133 79	
R 343	1	Schichtwid.	4,7 Ω / 5% / K1 2 / 0309	0000 7163 68	
R 344... R 361	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7139 79	

Teil	Stck	Bezeichnung	Elektrische Werte	Bestellangaben Benennung	Hersteller, Anmerkgn
R 362	1	Schichtwid.	10 kΩ / 5% / K1 2 / 0309	0000 7100 37	
R 363	1	Schichtwid.	10 kΩ / 5% / K1 2 / 0309	0000 7100 37	
R 364	1	Schichtwid.	470 Ω / 5% / K1 2 / 0309		
R 365	1	Schichtwid.	3,9 kΩ / 5% / K1 2 / 0309		
P 301	1	Spindelwid.	50 Ω	0000 7137 38	WN 17 / 4 / 4
P 302	1	Schichtdrehwid.	25 kΩ / lin. / 0,15 W	0000 7220 34	66 W o.JC Best.Nr.124 l = 17 mm, p = 6 mm
P 303	1	Schichtdrehwid.	100 Ω / lin. / 0,5	0000 7104 35	2 WN 17 / 2 / 8
C 301	1	Kf. - Kond.	0,22 µF / 20 % / 250 V ~	0000 7223 35	MKC 1353 - 422 / 2
C 302	1	Ker. - Kond.	15 pF / 5% / N 150	0000 7106 64	WN 110 / 2 / 3
C 303	1	Ker. - Kond.	120 pF / 2% / N 150	0000 7106 75	WN 110 / 2 / 3
C 304	1	Kf. - Kond.	2,2 nF / 2% / 160 V	0000 7107 29	WN 110 / 3 / 1
C 305					
C 306	1	Elko	1 µF / 20 % / 35 V -	0000 7109 78	WN 110 / 5 / 61
C 307	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EOPU / 0,4
C 308	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EOPU / 0,4
C 309	1	Ker. - Kond.	1 nF/+ 50 - 20% / K 4000	0000 7106 81	WN 110 / 2 / 3
C 310	1	Elko	1 µF / 20 % / 35 V-	0000 7109 78	WN 110 / 5 / 61
C 311	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/K 10000	0000 7219 48	EOPU / 0,4
C 312	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/K 10000	0000 7219 48	EOPU / 0,4
C 313	1	Ker. - Kond.	22 pF / 2% / N 150	0000 7106 66	WN 110 / 2 / 3
C 314	1	Ker. - Kond.	15 pF / 2% / 63 V/N 150 / 18	0000 7207 63	EOPU / 0,4
C 315	1	Ker. - Kond.	1 nF / 10 % / 63 V/ K 2000	0000 7222 45	EOPU / 0,4
C 316	1	Elko	3,3 µF / 20 % / 16 V	0000 7109 62	WN 110 / 5 / 61
C 317	1	Kf. - Kond.	2,2 nF / 20 % / 160 V	0000 7129 35	WN 110 / 3 / 2
C 318	1	Kf. - Kond.	180 pF / 2 % / 160 V	0000 7107 18	WN 110 / 3 / 1
C 319	1	Kf. - Kond.	10 nF / 10 % / 160 V	0000 7149 72	WN 110 / 3 / 2
C 320	1	Kf. - Kond.	47 nF / 10 % / 100 V	0000 7140 66	WN 110 / 3 / 2
C 321	1	Elko	1 µF / 20 % / 35 V	0000 7109 78	WN 110 / 5 / 61
C 322	1	Ker. - Kond.	22 nF/+ 100-20% / 40 V/K 10000	0000 7220 13	EOPU / 0,4
C 323	1	Ker. - Kond.	10 nF/+ 100-20% / 40 V/K 10000	0000 7219 48	EOPU / 0,4
C 324	1	Ker. - Kond.	10 nF/+ 100-20% / 40 V/K 10000	0000 7219 48	EOPU / 0,4
C 325	1	Ker. - Kond.	22 nF/+ 100-20% / 40 V/K 10000	0000 7220 13	EOPU / 0,4
C 326, C 340	1	Ker. - Kond.	10 nF /+ 100-20% /40 V/K 10000	0000 7219 48	EOPU / 0,4
G 301	1	Diode	BAY 73	0000 7126 63	
Gl 302	1	Z - Diode	ZE 2	0000 7126 51	
Gl 303	1	Diode	BAY 73	0000 7126 63	

Teil	Stck	Bezeichnung	Elektrische Werte	Bestellangaben Benennung	Hersteller, Anmerkgn
Gl 304	1	Z - Diode	ZE 2	0000 7126 51	
Gl 305	1	Diode	1 N 4448	0000 7122 76	
Gl 306	1	Diode	1 N 4448	0000 7122 76	
Gl 307					
T 301	1	Transistor	2 N 5912	0000 7220 38	
T 302	1	Transistor	BSX 93	0000 7121 28	
JC 301	1	JC	SN 7404 N	0000 7162 55	
JC 302	1	JC	SN 7400 N	0000 7127 01	
JC 303	1	JC	SN 7490 N	0000 7127 15	
JC 304	1	JC	SN 7492 N	0000 7162 79	
JC 305	1	JC	SN 7400 N	0000 7127 01	
JC 306	1	JC	SN 4929 N	0000 7163 12	
JC 307	1	JC	SN 7400 N	0000 7127 01	
JC 308	1	JC	SN 7405 N	0000 7162 56	
JC 309	1	JC	SN 7410 N	0000 7127 04	
JC 310	1	JC	SN 4931 N	0000 7163 13	
JC 311	1	JC	SN 7400 N	0000 7127 01	
JC 312	1	JC	SN 7402 N	0000 7127 03	
JC 313/ JC 314	1	JC	SN 7490 N	0000 7127 15	
JC 315	1	JC	SN 7404 N	0000 7162 55	
JC 316	1	JC	SN 7410 N	0000 7127 04	
JC 317	1	JC	SN 74 123 N	0000 7218 97	
JC 318	1	JC	SN 7403 N	0000 7127 29	
JC 319	1	JC	SN 7405 N	0000 7162 56	
JC 320	1	JC	SN 7490 N	0000 7127 15	
JC 321	1	JC	SN 7404 N	0000 7162 55	
JC 322	1	JC	SN 7402 N	0000 7127 03	
JC 323	1	JC	SN 7490 N	0000 7127 15	
JC 324	1	JC	SN 7400 N	0000 7127 01	
JC 325	1	JC	SN 74 123 N	0000 7218 97	
JC 326	1	JC	SN 7440 N	0000 7127 07	
JC 327/ JC 328	1	JC	SN 7490 N	0000 7127 15	
JC 329	1	JC	SN 74 121 N	0000 7150 13	
JC 330	1	Modul	10 x 1,8 kΩ	Bv. 500 - 9301	
JC 331	1	JC	µA 710 C	0000 7163 41	
L 301	1	Spule	25 µH / 3 A	0000 7140 34	B 8[illegible] 501 - [illegible] - [illegible] 24

Teil	Stck	Bezeichnung	Bestellangaben Elektrische Werte	Benennung	Hersteller, Anmerkgn
R 201	1	Schichtwid.	150 Ω / 5% / K1 2 / 0309		
R 202	1	Schichtwid.	39 kΩ / 5% / K1 2 / 0309	0000 7100 44	
R 204	1	Schichtwid.	56 kΩ / 5% / K1 2 / 0309	0000 7100 46	
R 205	1	Schichtwid.	56 kΩ / 5% / K1 2 / 0309	0000 7100 46	
R 206	1	Schichtwid.	56 kΩ / 5% / K1 2 / 0309	0000 7100 46	
R 207	1	Schichtwid.	56 kΩ / 5% / K1 2 / 0309	0000 7100 46	
R 208	1	Schichtwid.	27 kΩ / 5% / K1 2 / 0414	0000 7101 10	
R 209	1	Schichtwid.	27 kΩ / 5% / K1 2 / 0414	0000 7101 10	
R 210	1	Schichtwid.	27 kΩ / 5% / K1 2 / 0414	0000 7101 10	
R 211	1	Schichtwid.	27 kΩ / 5% / K1 2 / 0414	0000 7101 10	
R 212	1	Schichtwid.	27 kΩ / 5% / K1 2 / 0414	0000 7101 10	
R 213	1	Schichtwid.	27 kΩ / 5% / K1 2 / 0414	0000 7101 10	
R 214	1	Schichtwid.	150 Ω / 5% / K1 2 / 0309		
R 215	1	Schichtwid.	3,3 Ω / 5% / K1 2 / 0309	0000 7129 76	
R 216	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 217	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 218	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 219	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 220	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 221	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 222	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 223	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 224	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 225	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 226	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 227	1	Schichtwid	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 228	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 229	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 230	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 231	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 232	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 233	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 234	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 235	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 236	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 237	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 238	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 239	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 240	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	

Teil	Stck	Bezeichnung	Bestellangaben Elektrische Werte	Benennung	Hersteller, Anmerkgn
R 241	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 242	1	Schichtwid.	1 Ω / 5% / K1 2 / 0309	0000 7129 79	
R 243	1	Schichtwid.	10 kΩ / 5% / K1 2 / 0309	0000 7100 37	
R 244	1	Schichtwid.	5,6 Ω / 5% / K1 2 / 0309		WN 18 / 3 / 1
C 201	1	Kf. - Kond.	10nF / 10 % / 100 V	0000 7129 34	WN 110 / 2 / 2
C 203	1	Ker. - Kond.	10 nF/+ 100-20% /40 V /K 10000	0000 7219 48	EDPU / 0_4
C 204	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 205	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 206	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 207	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 208	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 209	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 210	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 211	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 212	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 213	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 214	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 215	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 216	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000		WN 110 / 2 / 10
C 217	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000		WN 110 / 2 / 10
C 218	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 219	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 220	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 221	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 222	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 223	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 224	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 225	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 226	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 227	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 228	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000	0000 7219 48	EDPU / 0_4
C 229	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000		WN 110 / 2 / 10
C 230	1	Ker. - Kond.	10 nF/+ 100-20% /40 V/ K 10000		WN 110 / 2 / 10
C 231	1	Kf.- Kond.	0,8 µF / 20 % / 100 V	0000 7225 56	MKI 1813-468 / 0
C 232	1	Elko	1 µF / 20 % / 35 V		WN 110 / 5 / 61
Ub 201	1	UG		Bv. 597 - 9301.01	

Teil	Stck	Bezeichnung	Bestellangaben Elektrische Werte	Benennung	Hersteller, Anmerkgn
JC 201	1	JC	SN 7400 N	0000 7127 01	
JC 202	1	JC	SN 49 00 N	0000 7163 16	
JC 203		JC	SN 7400 N	0000 7127 01	
JC 204	1	JC	SN 74 141 N	0000 7150 13	
JC 205	1	JC	SN 74 141 N	0000 7208 12	
JC 206	1	JC	SN 74 141 N	0000 7208 12	
JC 207	1	JC	SN 7475 N	0000 7127 13	
JC 208	1	JC	SN 7490 N	0000 7127 15	
JC 209	1	JC	SN 7404 N	0000 7162 55	
JC 210	1	JC	SN 74 141 N	0000 7208 12	
JC 211	1	JC	SN 7475 N	0000 7127 13	
JC 212	1	JC	SN 7490 N	0000 7127 15	
JC 213	1	JC	SN 7404 N	0000 7162 55	
JC 214	1	JC	SN 74 141 N	0000 7208 12	
JC 215	1	JC	SN 7475 N	0000 7127 13	
JC 216	1	JC	SN 7490 N	0000 7127 15	
JC 217	1	JC	SN 74 141 N	0000 7208 12	
JC 218	1	JC	SN 7475 N	0000 7127 13	
JC 219	1	JC	SN 7490 N	0000 7127 15	
JC 220	1	JC	SN 7404 N	0000 7162 55	
JC 221	1	JC	SN 74 141 N	0000 7208 12	
JC 222	1	JC	SN 7475 N	0000 7127 13	
JC 223	1	JC	SN 7490 N	0000 7127 15	
JC 224	1	JC	SN 7404 N	0000 7162 55	
JC 225	1	JC	SN 74 141 N	0000 7208 12	
JC 226	1	JC	SN 7475 N	0000 7127 13	
JC 227	1	JC	SN 7490 N	0000 7127 15	
JC 228	1	JC	SN 7400 N	0000 7127 01	
JC 229	1	JC	SN 7475 N	0000 7127 13	
JC 230	1	JC	SN 7490 N	0000 7127 15	
JC 231	1	JC	SN 7404 N	0000 7162 55	
Ro 201	1	Röhre	ZM 1332 k	0000 7220 58	Siemens
Ro 202	1	Röhre	ZM 1332 k	0000 7220 58	Siemens
Ro 203	1	Röhre	ZM 1332 k	0000 7220 58	Siemens
Ro 204	1	Röhre	ZM 1332 k	0000 7220 58	Siemens
Ro 205	1	Röhre	ZM 1332 k	0000 7220 58	Siemens
Ro 206	1	Röhre	ZM 1332 k	0000 7220 58	Siemens
Gl 201/ Gl 202	je1	Diode		HP 5082 - 4440	Hewlett - Packard
	je1	Fassung		HP 5082 - 4409	

Teil	Stck	Bezeichnung	Bestellangaben Elektrische Werte	Benennung	Hersteller, Anmerkgn
R 101	1	Schichtwid.	390 Ω / 5% / K1 2 / 0309	0000 7100 20	
R 102	1	Schichtwid.	390 Ω / 5% / K1 2 / 0309	0000 7100 20	
R 103	1	Schichtwid.	33 Ω / 5% / K1 2 / 0309	0000 7100 07	
R 104	1	Schichtwid.	560 kΩ / 5% / K1 2 / 0309	0000 7100 58	
R 105	1	Schichtwid.	1 MΩ / 5% / K1 2 / 0309	0000 7100 61	
R 106	1	Drahtwid.	0,33 Ω / 10 %	0000 7220 32	GwD 2
R 107	1	Schichtwid.	1 kΩ / 5% / K1 2 / 0309	0000 7100 25	
R 108	1	Schichtwid.	1,96 kΩ / 1% / K1 0,5 / 0309	0000 7165 96	
R 109	1	Schichtwid.	1 kΩ / 5% / K1 2 / 0309	0000 7100 25	
R 110	1	Schichtwid.	5,11 kΩ / 1% / K1 0,5 / 0309	0000 7166 31	
R 111	1	Schichtwid.	6,65 kΩ / 1% / K1 0,5 / 0309	0000 7166 41	
R 112	1	Schichtwid.	5,62 kΩ / 1% / K1 0,5 / 0309	0000 7166 35	
R 113	1	Schichtwid.	5,62 kΩ / 1% / K1 0,5 / 0309	0000 7166 35	
R 114	1	Schichtwid.	5,49 kΩ / 1% / K1 0,5 / 0309	0000 7166 34	
R 115	1	Schichtwid.	3,9 kΩ / 5% / K1 2 / 0309	0000 7100 32	
R 116	1	Schichtwid.	15 kΩ / 5% / K1 2 / 0309	0000 7100 39	
R 117	1	Schichtwid.	1,5 kΩ / 5% / K1 2 / 0309	0000 7100 27	
R 118	1	Schichtwid.	22 kΩ / 5% / K1 2 / 0309	0000 7100 41	
R 119	1	Schichtwid.	2,2 kΩ / 5% / K1 2 / 0309	0000 7100 29	
R 120	1	Schichtwid.	150 kΩ / 5% / K1 2 / 0309	0000 7100 51	
R 121	1	Schichtwid.	15 kΩ / 5% / K1 2 / 0309	0000 7100 39	
R 122	1	Schichtwid.	12 kΩ / 5% / K1 2 / 0309	0000 7100 38	
R 123	1	Schichtwid.	12 kΩ / 5% / K1 2 / 0309	0000 7100 38	
R 124	1	Schichtwid.	10 kΩ / 5% / K1 2 / 0309	0000 7100 37	
R 125	1	Schichtwid.	2,2 kΩ / 5% / K1 2 / 0309	0000 7100 29	
R 126	1	Schichtwid.	27 Ω / 5% / K1 2 / 0309	0000 7100 06	
R 127	1	Schichtwid.	2,2 kΩ / 5% / K1 2 / 0309	0000 7100 29	
R 128	1	Schichtwid.	2,2 kΩ / 5% / K1 2 / 0309	0000 7100 29	
R 129	1	Schichtwid.	39 kΩ / 5% / K1 2 / 0309	0000 7100 44	
R 130	1	Schichtwid.	560 Ω / 5% / K1 2 / 0309	0000 7100 22	
R 131	1	Schichtwid.	560 Ω / 5% / K1 2 / 0414	0000 7100 90	
P 101	1	Schichtdrehwid.	10 kΩ / lin. / 0,5 W	0000 7104 47	2 WN 17 / 2 / 8

Teil	Stck	Bezeichnung	Bestellangaben Elektrische Werte	Benennung	Hersteller, Anmerkgn
C 101	1	Papierkond.	4700 pF / 20 % / 1000 V	0000 7106 21	WN 110 / 1 / 1
C 102	1	Elko	220 µF /+ 50 - 10% / 25 V	0000 7162 00	WN 110 / 5 / 40
C 103	1	Elko	2200 µF /+ 50 - 10% / 16 V	0000 7159 95	WN 110 / 5 / 40
C 104	1	Elko	100 µF /+ 50 - 10% / 16 V	0000 7130 86	WN 110 / 5 / 40
C 105	1	Ker. - Kond.	1 nF /+ 80 - 20% / R 4000	0000 7106 77	WN 110 / 2 / 3
C 106	1	Kf. - Kond.	0,1 µF / 20 % / 100 V	0000 7107 40	WN 110 / 3 / 7
C 107	1	Kf. - Kond.	0,1 µF / 20 % / 100 V	0000 7107 40	WN 110 / 3 / 7
C 108	1	Elko	100 µF /+ 50 - 10% / 6 V	0000 7108 76	WN 110 / 5 / 40
C 109	1	Ker. - Kond.	22 nF /+ 100-20% / 40 V/ K 10000	0000 7220 13	EOPU / 0,4
C 110	1	Trimmer	10 ... 40 pF / N 750	0000 7109 92	WN 111 / 1 / 2
C 111	1	Ker. - Kond.	82 pF /2% /63 V/ NPO / 1 B	0000 7218 20	EOPU / 0,4
C 112	1	Trimmer	10 ... 40 pF / N 750	0000 7109 92	WN 111 / 1 / 2
C 113	1	Kf. - Kond.	0,68 µF / 20 % / 100 V	0000 7129 10	WN 110 / 3 / 7
C 114	1	Kf. - Kond.	10 nF / 20 % / 630 V	0000 7156 90	WN 110 / 3 / 7
C 115	1	Kf. - Kond.	0,68 µF / 20 % / 100 V	0000 7129 10	WN 110 / 3 / 7
C 116	1	Kf. - Kond.	0,68 µF / 20 % / 100 V	0000 7129 10	WN 110 / 3 / 7
C 117	1	Kf. - Kond.	0,68 µF / 20 % / 100 V	0000 7129 10	WN 110 / 3 / 7
C 118	1	Elko	10 µF /+ 50 - 10% / 350 V	0000 7162 38	WN 110 / 5 / 40
C 119	1	Ker. - Kond.	22 nF /+ 100-20 % / 40 V/K 10 000	0000 7220 13	EOPU / 0,4 1)
C 120	1	Ker. - Kond.	22 nF /+ 100-20 % / 40 V/K 10 000	0000 7220 13	EOPU / 0,4 1)
C 121	1	Ker. - Kond.	4,1 pF / ± 0,5 pF / P 100	0000 7140 96	WN 110 / 2 / 3 1)
Gl 101	1	Gleichrichter	B 250 C 600 Si	0000 7220 36	Nortron
Gl 102	1	Gleichrichter	B 40 C 600 Si	0000 7129 40	
Gl 103	1	Gleichrichter	B 40 C 3200 - C 2200	0000 7129 38	
Gl 104	1	Gleichrichter	B 40 C 600 Si	0000 7129 40	
Gl 105	1	Diode	1 N 4448	0000 7122 76	
Gl 106	1	Diode	1 N 4448	0000 7122 76	
Gl 107	1	Diode	1 N 4448	0000 7122 76	
T 101	1	Transistor	MJE 3055	0000 7217 31	
T 102	1	Transistor	BSX 45 Stromverstärkungsgruppe 16	0000 7225 57	2)
T 103	1	Transistor	BSY 90	0000 7126 12	
T 104	1	Transistor	BCY 59 D	0000 7202 85	
T 105	1	Transistor	BCY 78 D	0000 7207 10	

Teil	Stck	Bezeichnung	Bestellangaben Elektrische Werte	Benennung	Hersteller, Anmerkgn
T 106	1	Transistor	2 N 2905	0000 7123 17	
JC 101	1	JC	L 123 - T 1	0000 7218 62	
JC 102	1	JC	CA 3018	0000 7220 33	
JC 103	1	JC	µA 710 C	0000 7163 41	
Si 101	1	G - Schmelzeinsatz	T 1,6 D	0000 7110 61	WN 115 / 2 / 1
S 101	1	Netzschalter		Bv. 597 - 8002	
L 101	1	Spule	23 µH / 0,5 A	0000 7158 01	B 82 501 - A - C 16
L 102	1	Spule	23 µH / 0,5 A	0000 7158 01	B 82 501 - A - C 16
L 103	1	Spule	23 µH / 0,5 A	0000 7158 01	B 82 501 - A - C 16
L 104	1	Spule	23 µH / 0,5 A	0000 7158 01	B 82 501 - A - C 16
L 106	1	Spule	220 µH / 5 %	0000 7143 89	1537 - 92
Q 101	1	Quarz		Bv. 597 - 9701	
Ü 101	1	Netztrafo		Bv. 597 - 7703	