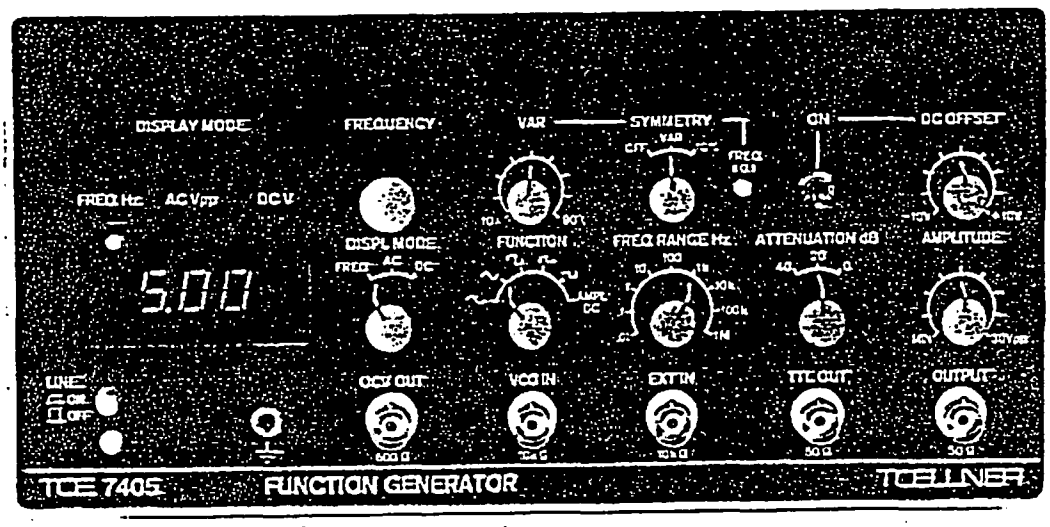
INSTRUCTION MANUAL
Function Generator

TOE 7405



Contents

1 General Information

1.1 Introduction

Today, function generators represent the most interesting and most versatile group of instruments in the field of low-frequency measuring equipment. In addition to a wide frequency-range the waveform of the output signal can be selected out of different voltage vs. time-functions. By this it is possible to examine electrical systems not only with sinusoidal test signals. The TOE 7405 function-generator can be used for all ranges of application in up-to-date electronics.

The signal frequency, the amplitude, and the d-c voltage of the output signal are indicated by a digital display.

A special feature of this instrument is the 'amplifier'-mode in which it performs as a wideband-amplifier with a frequency-range from d-c up to approx. 10 MHz.

1.2 Block diagram

The triangular and rectangular signals generated by the relaxation-oscillator are led, after being amplified separately, to the FUNCTION-switch. The sinusoidal signal is derived from the triangular by means of a resistor-diode-network (sine-shaper) and, after amplification, led to the FUNCTION-switch. In the wideband-amplifier-mode (AMPL) the buffered input signal is passed on by the FUNCTION-switch.

The signal which is selected by the FUNCTION-switch is applied to the AMPLITUDE-potentiometer with a setting-range of more than 30 dB. Then it is fed into the output-amplifier where, if desired, a d-c offset voltage can be added. The amplifiers output signal is, via a step-attenuator, which provides for a total attenuation of up to 40 dB by increments of 20 dB, connected to the OUTPUT-connector.

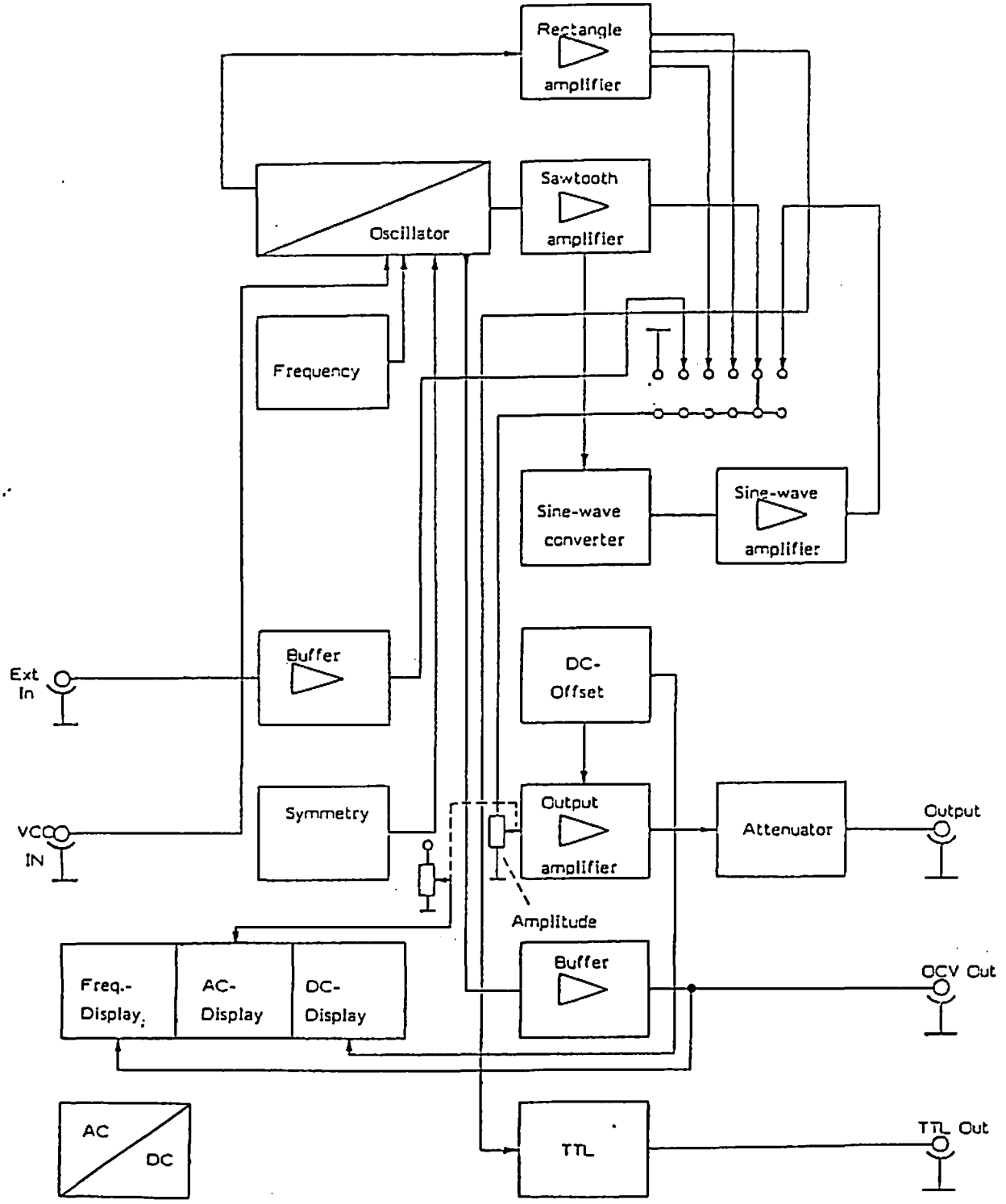
The oscillator-frequency is voltage controlled. The frequency increases with the control-voltage going positive. The control-voltage is provided by the FREQUENCY-potentiometer. Alternatively, the genera-

tor-frequency can be governed by an external control-voltage fed into the VCO IN-connector. The voltage which controls the oscillator-frequency can be monitored at the buffered output OCV OUT. If variable symmetry is selected the oscillator-frequency is reduced by one decade; this condition is indicated by a LED.

A rectangular signal for driving TTL-circuits is available at connector TTL OUT.

The output signal parameters frequency, amplitude, and d-c voltage are, selectable by switch DISPL. MODE, displayed by a digital readout.

BLOCK DIAGRAM



1.3 Technical Data

Signal functions and operational modes

Functions:	Sine, triangle, rectangle, pcs. pulse, neg. pulse, variable symmetry
Operational modes:	Free-running oscillator, external frequency control, amplifier mode, bipolar d-c voltage source

Frequency

Range:	50 µHz ... 5 MHz, divided into nine decadic subranges
Error:	2 % of full range value, 5 % of full range value in subranges x .01 Hz, x .1 Hz, x 1 Hz, x 1 MHz
Stability:	10^{-3}/K up to 500 kHz, 3×10^{-3}/K up to 5 MHz, (after 30 min warm-up)
	5×10^{-3} within 8 h (after 30 min warm-up)
Display resolution:	4 digits

Signal output

Signal amplitude:	10 mV (peak-peak) ... 30 V (peak-peak), 5 mV (peak-peak) ... 15 V (peak-peak) in pulse mode
Display resolution:	3 digits
Error:	± 5 % of full range value at 1 kHz for sinusoidal and triangular signals

Frequency response:	+ 10 %, - 15 % in the x 1 MHz range for sinusoidal and triangular signals
Output impedance:	50 Ohm The output is no-load- and short-circuit-proof

D-c offset and d-c voltage source

Voltage range:	- 10 V ... 0 V ... + 10 V
Display resolution:	3 digits
Error:	5 % of full range value

Output attenuators

Setting range:	30 dB continuously (with potentiometer AMPLITUDE), plus 20 dB or 40 dB (with switch ATTENUATION dB)
Frequency response:	For sinusoidal and triangular signals: .3 dB; .5 dB for frequencies > 1 MHz

Output signal specifications

at max. output voltage into a 50 Ohm load

Sinusoidal signal	
Harmonic distortions:	< .5 % up to 50 kHz, < 5 % up to 5 MHz
Triangular signal	
Linearity error:	< 1 % up to 100 kHz
Symmetry error:	< 1 % up to 100 kHz
Rectangular signals	
Transition time:	< 25 ns
Overshoot:	< 5 %
Pulse signals:	Same as for rectangular signals
Variable symmetry:	Continuously adjustable within 10 % ... 90 % (with potentiometer VAR), or, alternatively, a fixed setting of 10 % (with switch SYMMETRY)
	When variable symmetry is selected, the signal frequency is reduced by one decade; this condition is indicated by LED FREQ. x 0.1

Amplifier mode

Gain:	Approx. 17 dB for d-c ... approx. 10 MHz

Harmonic distortions:	< .1 % up to 100 kHz
Input resistance:	10 kOhm

Other signal inputs and outputs

Synchronizing signal out:	TTL-compatible
Source resistance:	50 Ohm
Connector:	TTL OUT
Modulation signal in:	Approx. 4 V for a frequency variation ratio of 1000 : 1
Input resistance:	10 kOhm
Connector:	VCO IN
Control voltage out:	Approx. 4 V at a frequency variation ratio of 1 : 1000
Source resistance:	600 Ohm
Connector:	OCV OUT
Amplifier input	
Max. input voltage:	± 40 V
Input resistance:	10 kOhm
Connector:	EXT IN

Display

Layout:	3 1/2 digit, 7-segment, LED type
Modes:	Frequency, AC (p-p) voltage, DC voltage, selectable with switch DISPL MODE, the selected display mode is indicated by 1 out of 3 LEDs in the top line of the read-out.

General data

Protection class:	1, protective earth, acc. to IEC 348.
Mains voltage:	115/230 V, ± 10 %
Mains frequency:	48 ... 60 Hz
Power consumption:	30 VA
Operating temperature range:	0 ... + 50 °C
Dimensions:	255 x 135 x 280 mm, (w x h x h)
Weight:	Approx. 3.5 kg
Cabinet:	Aluminium

1.4 Accessories

1 Mains cord
1 Instruction manual

Options:
1.5 m Coaxial cable with 2 BNC-connectors
50 Ohm feed-through termination resistor
Adapter BNC/4 mm-socket
Adapter BNC/4 mm plug
60 dB attenuator

2 Directions for use

2.1 Putting into service

The function generator TOE 7405 has been designed and tested according to IEC Publication 348 (VDE 0411 respectively) and has been supplied insafe condition. It complies with Safety Class 1, (protective earth conductor).

The instruction manual contains informations and warnings which shall be followed by the user to ensure safe operation and to retain the instrument in safe condition.

Before switching on the generator, make sure that it is set to the voltage of the local public power supply.

The mains plug shall only be inserted into a mains outlet with a protective earth contact. The protective action shall not be negated by the use of an extension cable without protective earth conductor. (In some countries the operation of Safety Class 1 equipment is permitted in particular locations without protective earth connection).

WARNING!

Any interruption of the protective conductor inside or outside the instrument or disconnection of the protective earth terminal is likely

to make the device dangerous. Intentional interruption is prohibited!

2.2 Operation

Mains switch After the device is connected to mains supply and push-button switch LINE is depressed the generator is ready for use.

Function Selection of the output signal shape, the amplifier- and d-c source mode is accomplished by the FUNCTION-switch. In amplifier-mode (AMPL DC) the device can be used as a wide-band amplifier for d-c up to approx. 10 MHz. Amplifier input terminal is connector EXT IN.

When no signal is applied to the EXT IN connector and the DC OFFSET switch is set to its ON position a d-c voltage which can be adjusted continuously within a range of - 10 V ... + 10 V with potentiometer DC OFFSET is available at the OUTPUT connector. The value of the output voltage is displayed when switch DISPL MODE is set to DC.

Amplitude The maximum signal output voltage is 30 V (peak-peak) at no load and 15 V (peak-peak) into a 50 Ohm load. The continuous adjustment of the output signal amplitude is done by potentiometer AMPLITUDE over a range of more than 30 dB.

Attenuator Additional signal attenuation is provided in two steps of 20 dB each and can be selected by switch ATTENUATION dB.

D-c offset By switch DC OFFSET in ON position the DC Offset-potentiometer is activated which allows to continuously adjust the d-c offset voltage from - 10 ... + 10 V. The value of the offset voltage is displayed when switch DISPL MODE is set to DC.

Var. symmetry A variation of the symmetry (vs. time) of the output

signal shape is possible. When switch VAR SYMMETRY is set to the VAR-position the signal symmetry can be adjusted continuously within a 10 % ... 90 % range by potentiometer VAR SYMMETRY. When the switch is set to the 10 %-position a fixed ratio of 10 % is selected. In the variable symmetry mode the signal frequency is reduced by one decade; this condition is indicated by light emitting diode FREQ x 0.1 being turned on.

Frequency — The desired frequency sub-range is selected by switch FREQ RANGE Hz. Continuous adjustment of the output signal frequency within the decadic sub-ranges is carried out with 10-turn potentiometer FREQUENCY. The frequency value is displayed when switch DISPL MODE is set to FREQ.

Display — The displayed parameter is selected with switch DISPL MODE to either output signal frequency, a-c signal amplitude, or d-c offset voltage. The selected parameter is indicated by one of three LEDs being turned on in the top line of the display.

The value of the a-c amplitude is displayed as peak-peak voltage for unloaded signal output. The d-c offset voltage also valid for unloaded output. The voltage at the loaded output terminal must be individually evaluated from the displayed e.m.f. value, the source resistance of 50 Ohm, and the apllied load-resistance.

The displayed value of the signal frequency is not evaluated by a frequency-counter but by a voltmeter circuit which measures the control voltage of the oscillator. This method provides for instant read-out of extremely low frequency values.

Input and output connectors

OUTPUT — Signal output. The source resistance is 50 Ohm. The output is no-load- and short-circuit-proof.

TTL OUT — Signal output for driving TTL circuits. Signal potetentials are TTL-compatible, duty cycle corresponds with the the duty cycle selected for the generator output signal.

EXT IN — In the amplifier mode the input signal is connected to this terminal.

VCO IN — Input for an external frequency control voltage. An alteration of the input voltage by 4 V will cause the output frequency to change by a ratio of 100C : 1. Depending on the setting of the frequency potentiometer the control voltage must amount to a value between - 4 V and + 4 V. If the frequency potentiometer is set to the full scale value of the sub-range selected only a control voltage of 0 V ... - 4 V will produce a variation of the output signal frequency.

OCV OUT — This output carries the voltage which controls the oscillator frequency. The source impedance is 600 Ohm.

2.3 Description of circuit

Oscillator

The oscillator, consisting of function groups T 13 through T 40, generates symmetrical as well as asymmetrical triangular and rectangular voltages. Frequency range switches S 2a and S 2b connect the time-determinating RC-networks to the oscillator circuit, mainly via the operational amplifiers IC 1, 2, and 3. The relaxation-oscillator mainly consists of switched current sources, a comparator, and an integrator which will, when appropriately interconnected, simultaneously generate a rectangular and a triangular oscillation. Selection of one out of different capacitors in the integrator determines the frequency sub-range. By 10-turn potentiometer R 124 any frequency value within the selected sub-range can be adjusted. An external control of the oscillator frequency is possible by feeding a control voltage into the VCO input.

Amplifier for triangular signal

The triangular signal is coupled out via the complementary emitter-followers T 27 through T 30. By this the signal is supplied with a low source-resistance into the final amplifier via switch S 6b and to the sine-shaper via resistors R 135 and R 136.

Sine-shaper and voltage booster

The triangular signal is fed into the sine-shaper, which consists mainly of three diode-quartets D 7 through D 18, via resistor R 135. The sinusoidal signal is coupled out via L 1 and R 153. Since the output voltage is only approx. 600 mV (peak-peak) it must be amplified up to the nominal input voltage of the final amplifier. This is realized by a voltage booster, the circuit design of which is entirely symmetric and which includes T 41 through T 48 plus peripheral components. Its output voltage is approx. 4.5 V(peak-peak).

Rectangular and pulse signal

The rectangular and pulse signals are generated by T 1 through T 12 and are coupled out with low source resistance. The output voltage is adjusted by potentiometers R 13 and R 16.

Final stage and attenuator

The final stage is an amplifier of entirely symmetric design of circuitry and complementary active components T 49 through T 58. Its input voltage is adjusted with the AMPLITUDE potentiometer R 183 which covers a range of more than 30 dB. The constant gain of the amplifier provides for good transmission characteristics even when the input signal amplitude is readjusted. The following step-attenuator is provided with input- and output-impedances of 50 Ohm in both stages. By this not only a constant load at the amplifiers output but also a well defined output impedance of the device is secured.

Power supply unit

The d-c power for the entire circuitry is supplied by voltage regulators IC 4 through IC 8 and zener-diode D 31. Transformer T 1 provides separation from mains potential and voltage conversion.

TTL output

A rectangular signal which is drawn from the main oscillator and which is buffered and matched to required d-c potential by transistor T 59

is fed via R 247 into one of three NAND-gates of IC 9. Via R 250 a TTL-compatible signal is led to the TTL OUT connector.

EXT IN

Any signal applied to connector EXT IN is buffered by transistors T 74 through T 77 is available at point k with a very low source resistance. When AMPL/DC mode is selected, this signal is applied to the AMPLITUDE potentiometer R 183 and then fed into the final amplifier. After being amplified by a gain which is adjusted with potentiometer R 183 AMPLITUDE and by the setting of the step-attenuator ATTENUATOR it is available at the signal output connector OUTPUT.

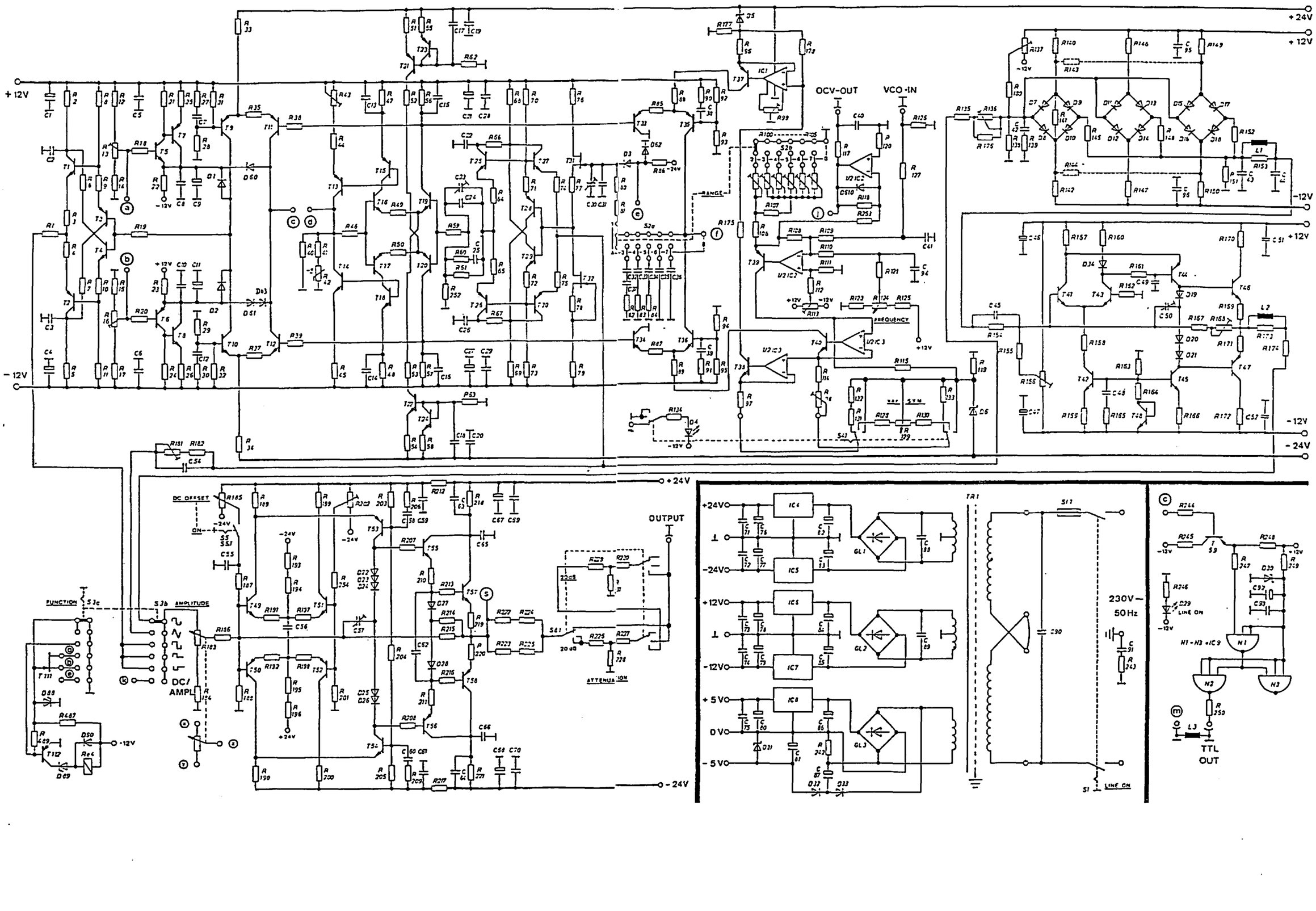
Display

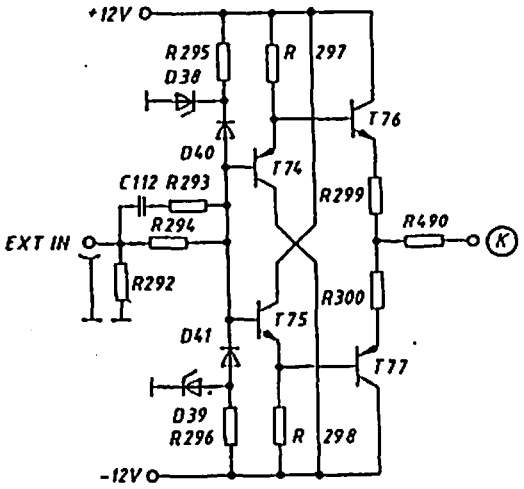
The oscillator frequency is measured indirectly by monitoring the voltage which controls the oscillator. The control voltage is adapted as required with resistors R 471 through R 473 and then applied to the input of the analog-digital converter. When the d-c offset is measured the neccessary phase shift and adaption is accomplished with one half of the dual operational amplifier IC 38 and resistors R 481 through R 486. When a-c amplitude is measured a simulation of the final amplifiers input must be established with R 474 through 480, Re 4, R 488, and the second half of operational amplifier IC 38. The signal amplitude is monitored at the wiper-position of the second section of the tandem potentiometer AMPLITUDE. In the positive- and negative-pulse-mode voltage adaption is accomplished with resistors R 480 and R 488. Via switch S 9, DISPL MODE, the analogue value of the quantity to be measured is applied to the input of the analog-digital converter. The other segments of switch S 9 control the indicating LEDs for FREQ, AC, and DC and, together with Re 3, the blanking of the display for frequency and a-c amplitude in the operational mode AMPL/DC. Switch S 8, ATTENUATION dB, provides for the step-attenuation of the output signal and the respective positioning of the decimal point in the numeric display.

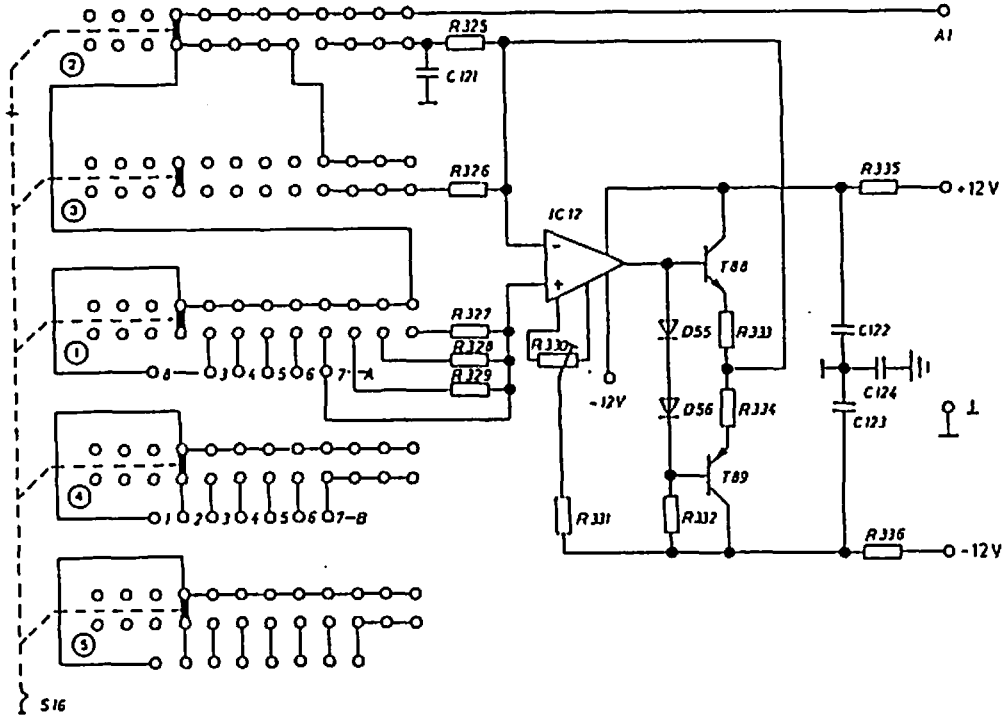
Extension of the frequency range

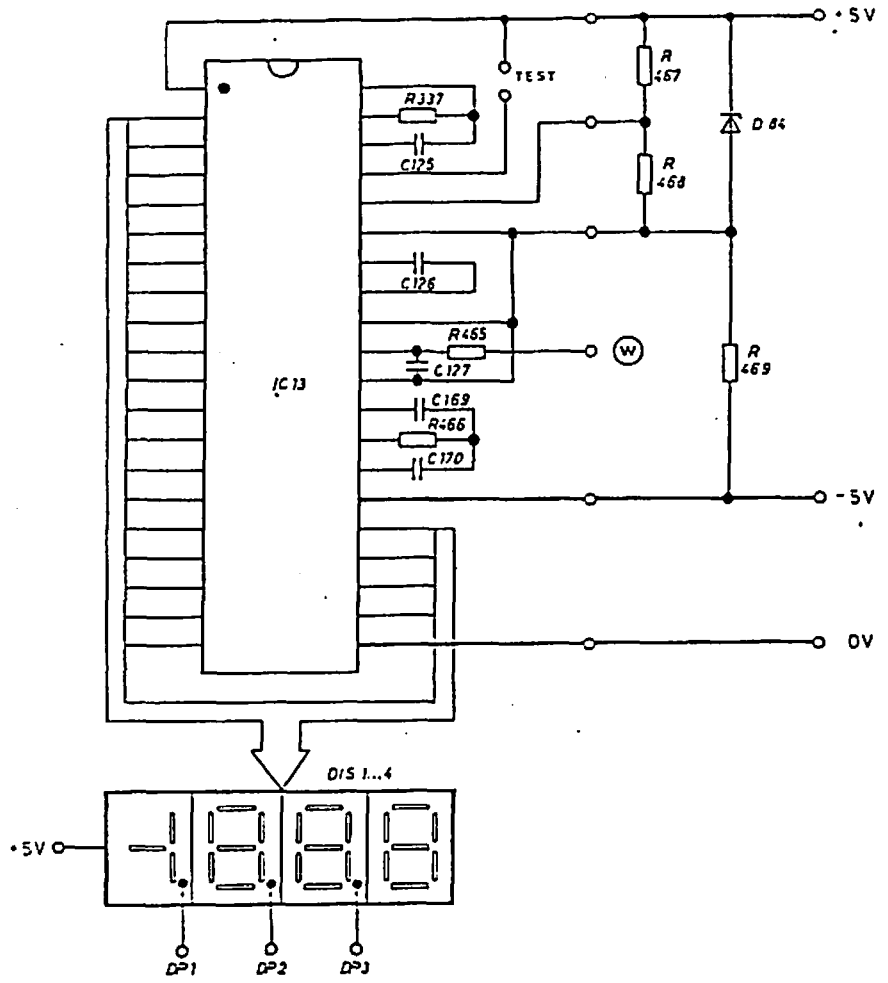
This part of the circuitry extends the basic range of the oscillator in direction to lower frequencies. IC 12, S 16, T 88, and T 89 are the important components of this special circuit. Time-symmetry at the lower end of the requency range is adjusted with R 330.

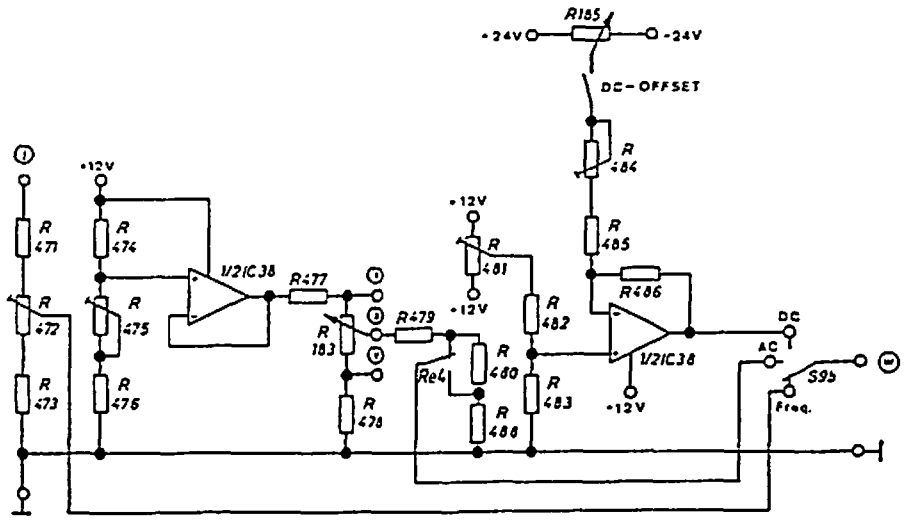
2.4 Circuit diagram

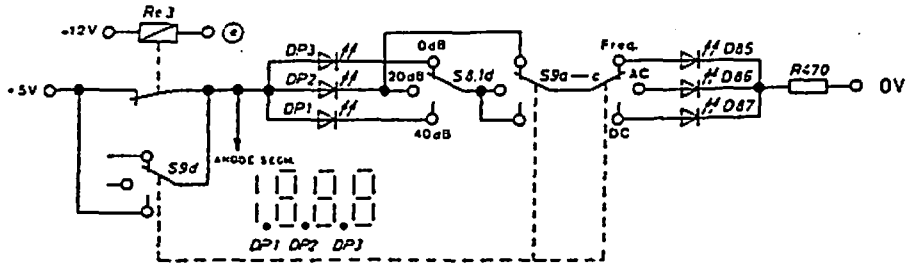



+12V
R295
D38
R 297
T76
D40
T74
C112 R293
R299
R294
R490
K
EXT IN
R292
R300
T75
D41
T77
D39
R296
R 298
-12V


R325
A1
C 121
R326
R335
+12V
IC17
T88
R327
R328
R329
R330
D55
R333
C122
C124
C123
-12V
D56
R334
T89
R331
R332
R336
-12V
S16


+5V
TEST
R 467
D 84
R337
C125
R 468
C126
R465
C127
IC 13
R 469
C169
R466
C170
-5V
0V
DIS 1...4
+5V
DP1
DP2
DP3


R185
+24V
-24V
DC-OFFSET
R 484
R 485
R486
+12V
R 481
+12V
R 482
1/2IC38
DC
AC
S9b
Freq.
R 480
R 483
Re4
+12V
R 486
R 471
R 474
1/2IC38
R477
R 472
R 475
R 183
R479
R 473
R 476
R 478


Re3
+12V
+5V
DP3
DP2
DP1
0dB
20dB
40dB
S8.1d
S9a—c
Freq.
AC
DC
D85
D86
D87
R470
0V
S9d
ANODE SEGM.
DP1 DP2 DP3

2.5 Parts List

R 1 = 46 R 4
R 2 = 150 R
R 3 = 22 R 1
R 4 = 22 R 1
R 5 = 150 R
R 6 = 121 R
R 7 = 121 R
R 8 = 1 K 47
R 9 = 12 R 1
R 10 = 12 R 1
R 11 = 1 K 47
R 12 = 12 K 1
R 13 = Trimmer
R 14 = 2 K 21
R 15 = 2 K 21
R 16 = Trimmer
R 17 = 12 K 1
R 18 = 464 R
R 19 = 1 K
R 20 = 464 R
R 21 = 221 R
R 22 = 1 K
R 23 = 1 K
R 24 = 221 R
R 25 = 22 R 1
R 26 = 22 R 1
R 27 = 22 1 R
R 28 = 8 K 25
R 29 = 8 K 25
R 30 = 221 R
R 31 = 1 K
R 32 = 1 K
R 33 = 1 K 21
R 34 = 1 K 21
R 35 = 46 R 4
R 36 = 221 R
R 37 = 46 R 4
R 38 = 82 R 5
R 39 = 82 R 5
R 40 = 221 R
R 41 = 4 K 75
R 42 = NTC

R 43 = Trimmer
R 44 = 392 R
R 45 = 453 R
R 46 = 82 R 5
R 47 = 274 R
R 48 = 274 R
R 49 = 10 R
R 50 = 10 R
R 51 = 1 K
R 52 = 464 R
R 53 = 464 R
R 54 = 1 K
R 55 = 8 K 25
R 56 = 150 R
R 57 = 150 R
R 58 = 8 K 25
R 59 = 46 R 4
R 60 = 1 K 47
R 61 = 619 R
R 62 = 7 K 32
R 63 = 7 K 32
R 64 = 5 R 62
R 65 = 5 R 62
R 66 = 221 R
R 67 = 221 R
R 68 = 121 R
R 69 = 121 R
R 70 = 2 K 21
R 71 = 5 R 62
R 72 = 5 R 62
R 73 = 2 K 21
R 74 = 5 R 62
R 75 = 5 R 62
R 76 = 121 R
R 77 = 150 R
R 78 = 150 R
R 79 = 332 R
R 80 = 3 R 16
R 81 = 121 R
R 82 = 22 R 1
R 83 = 5 R 62
R 84 = 3 R 16

R 85 = 22 R 1
R 86 = 12 K 1
R 87 = 22 R 1
R 88 = 121 R
R 89 = 121 R
R 90 = 221 R
R 91 = 221 R
R 92 = 1 K
R 93 = 8 K 25
R 94 = 8 K 25
R 95 = 1 K
R 96 = 619 R
R 97 = 619 R
R 98 = 12 K 1
R 99 = Trimmer
R 100 = Trimmer
R 101 = Trimmer
R 102 = Trimmer
R 103 = Trimmer
R 104 = Trimmer
R 105 = Trimmer
R 106 = 562 R
R 107 = 150 R
R 108 = 33 K 2
R 109 = 33 K 2
R 110 = 33 K 2
R 111 = 221 R
R 112 = 33 K 2
R 113 = Trimmer
R 114 = 562 R
R 115 = 562 R
R 116 = Trimmer
R 117 = 619 R
R 118 = 33 K 2
R 119 = 12 K 1
R 120 = 14 K 7
R 121 = 2 K 21
R 122 = Pot
R 123 = 10 R
R 124 = Pot
R 125 = 1 K 47
R 126 = 12 K 1

R 127 = 1 K
R 128 = 619 R
R 129 = Pot
R 130 = 619 R
R 131 = 619 R
R 132 = 10 K
R 133 = 619 R
R 134 = 1 K
R 135 = 150 R
R 136 = Trimmer
R 137 = Trimmer
R 138 = 221 R
R 139 = 33 R 2
R 140 = 13 K
R 141 = 14 K 7
R 142 = 13 K
R 143 = Abgl.
R 144 = Abgl.
R 145 = 150 R
R 146 = 44 K 2
R 147 = 44 K 2
R 148 = 56 R 2
R 149 = 12 K 1
R 150 = 12 K 1
R 151 = 221 R
R 152 = 392 R
R 153 = 2 K 21
R 154 = 453 R
R 155 = 464 R
R 156 = 464 R
R 157 = 46 R 4
R 158 = 46 R 4
R 159 = 1 K 21
R 160 = 1 K 21
R 161 = 46 R 4
R 162 = 46 R 4
R 163 = 150 R
R 164 = 150 R
R 165 = 150 R
R 166 = 33 K 2
R 167 = Trimmer
R 168 = 3 K 48

R 169 = 8 K 25
R 170 = 3 K 48
R 171 = 221 R
R 172 = 221 R
R 173 = 3 K 01
R 174 = Trimmer
R 175 = 46 R 4
R 176 = 46 R 4
R 177 = 46 R 4
R 178 = 46 R 4
R 179 = 46 R 4
R 180 = 33 K 2
R 181 = Trimmer
R 182 = 3 R 16
R 183 = Pot
R 184 = 33 R 2
R 185 = Pot
R 186 = 1 K
R 187 = 16 K 2
R 188 = 1 K
R 189 = 221 R
R 190 = 221 R
R 191 = 22 R 1
R 192 = 22 R 1
R 193 = 1 K 21
R 194 = 1 K 21
R 195 = 1 K 21
R 196 = 1 K 21
R 197 = 22 R 1
R 198 = 22 R 1
R 199 = 33 R 2
R 200 = 33 R 2
R 201 = 221 R
R 202 = Trimmer
R 203 = 1 K 21
R 204 = 14 K 7
R 205 = 1 K 21
R 206 = 221 R
R 207 = 22 R 1
R 208 = 22 R 1
R 209 = 221 R
R 210 = 82 R 5

R 211 = 82 R 5
R 212 = 12 R 1
R 213 = 5 R 62
R 214 = 221 R
R 215 = 7 K 32
R 216 = 5 R 62
R 217 = 12 R 1
R 218 = Drahtw.
R 219 = 5 R 62
R 220 = 5 R 62
R 221 = Drahtw.
R 222 = 49 R 9
R 223 = 49 R 9
R 224 = 49 R 9
R 225 = 49 R 9
R 226 = 41 R 2
R 227 = 41 R 2
R 228 = 10 R
R 229 = 41 R 2
R 230 = 41 R 2
R 231 = 10 R
R 232 = 26 R 1
R 233 = 26 R 1
R 234 = 17 R 4
R 235 = 17 R 4
R 236 = 41 R 2
R 237 = 41 R 2
R 238 = 10 R
R 239 = 46 R 4
R 240 = 46 R 4
R 241 = 3 R 16

R 243 = 12 R 1
R 244 = 2 K 21
R 245 = 221 R
R 246 = 1 K
R 247 = 1 K 47
R 248 = 1 K 21
R 249 = 332 R
R 250 = 49 R 9
R 251 = 49 R 9
R 252 = 619 R

R 253 = 33 K 2
R 254 = 82 K 5
R 255 = 392 R
R 256 = Trimmer
R 257 = 2 K 21
R 258 = 4 K 75
R 259 = 121 R
R 260 = 2 K 21
R 261 = 12 K 1
R 262 = 12 K 1
R 263 = 1 K
R 264 = 1 K
R 265 = 1 K
R 266 = 1 K
R 267 = 150 R
R 268 = 150 R
R 269 = 221 R
R 270 = Pot
R 271 = 2 K 21
R 272 = 2 K 21
R 273 = 121 R
R 274 = 681 R
R 275 = 681 R
R 276 = 46 R 4
R 277 = 1 M 82
R 278 = 12 K 1
R 279 = 274 R
R 280 = Pot
R 281 = 9 K 09
R 282 = 221 R
R 283 = 221 R
R 284 = 1 K
R 285 = 8 K 25
R 286 = 8 K 25
R 287 = 1 K
R 288 = 681 R
R 289 = 2 K 21
R 290 = Trimmer
R 291 = 5 R 62
R 292 = 12 K 1
R 293 = 121 R
R 294 = 1 K

R 295 = 22 K 1
R 296 = 22 K 1
R 297 = 4 K 75
R 298 = 4 K 75
R 299 = 22 R 1
R 300 = 22 R 1
R 301 = 1 K
R 302 = 1 K
R 303 = 1 K
R 304 = 1 K
R 305 = 3 R 16
R 306 = 56 R 2
R 307 = Trimmer
R 308 = Pot
R 309 = Trimmer
R 310 = 1 K
R 311 = 22 R 1
R 312 = 3 K 48
R 313 = 1 K
R 314 = 3 K 48
R 315 = 150 R
R 316 = 1 K
R 317 = 464 R
R 318 = 5 K 62
R 319 = 12 K 1
R 320 = 2 K 21
R 321 = 909 R
R 322 = 3 K 48
R 323 = 22 R 1
R 324 = 22 R 1
R 348 = 221 R
R 349 = 2 K 21
R 350 = 1 K
R 351 = 12 K 1
R 352 = 9 K 09
R 353 = 2 K 21

R 13 = Trimmer lin. 1 K/0,75 W Tol.: 20 %
R 16 = Trimmer lin. 1 K/0,75 W Tol.: 20 %
R 42 = NTC-Widerstand 5 K Tol.: 20 %
R 43 = Trimmer lin. 100 R/0,75 W Tol.: 20 %
R 99 = Trimmer lin. 10 K/0,75 W Tol.: 20 %
R 100 = Trimmer lin. 220 R/0,75 W Tol.: 20 %
R 101 = Trimmer lin. 220 R/0,75 W Tol.: 20 %
R 102 = Trimmer lin. 220 R/0,75 W Tol.: 20 %
R 103 = Trimmer lin. 220 R/0,75 W Tol.: 20 %
R 104 = Trimmer lin. 220 R/0,75 W Tol.: 20 %
R 105 = Trimmer lin. 220 R/0,75 W Tol.: 20 %
R 113 = Trimmer lin. 47 K/0,75 W Tol.: 20 %

R 116 = Trimmer lin. 100 R/0,75 W Tol.: 20 %
R 122 = Potentiometer lin. 4 K 7/2 W Tol.: 10 %
R 124 = Potentiometer lin. 1 K/2 W Tol.: 10 %
R 129 = Potentiometer lin. 10 K/2 W Tol.: 10 %
R 136 = Trimmer lin. 100 R/0,75 W Tol.: 20 %
R 137 = Trimmer lin. 47 K/0,75 W Tol.: 20 %
R 143 =
R 144 =
R 167 = Trimmer lin. 47 K/0,75 W Tol.: 20 %
R 174 = Trimmer lin. 2 K 2/0,75 W Tol.: 20 %
R 181 = Trimmer lin. 100 R/0,75 W Tol.: 20 %
R 183 = Potentiometer lin. 1 K/0,15 W Tol.: 20 %

R 185 = Potentiometer lin. 22 K/0,15 W Tol.: 20 %
R 202 = Trimmer lin. 47 K/0,75 W Tol.: 20 %
R 218 = Drahtwiderstand 22 R/2,5 W Tol.: 5 %
R 221 = Drahtwiderstand 22 R/2,5 W Tol.: 5 %
R 256 = Trimmer lin. 4 K 7/0,15 W Tol.: 20 %
R 270 = Potentiometer lin. 4 K 7/0,15 W Tol.: 20 %
R 280 = Potentiometer lin. 4 K 7/0,15 W Tol.: 20 %
R 290 = Trimmer lin. 220 R/0,75 W Tol.: 20 %
R 307 = Trimmer lin. 1 K/0,75 W Tol.: 20 %
R 308 = Potentiometer lin. 1 K/0,15 W Tol.: 20 %
R 309 = Trimmer lin. 10 K/0,75 W Tol.: 20 %

L 1 = 4,7 µH

		Tol./%
C 1	= 10 µ/50 V	−10/+50
C 2	= 4 n 7/100 V	10
C 3	= 4 n 7/100 V	10
C 4	= 10 u/50 V	−10/+50
C 5	= 100 n/63 V	−20/+50
C 6	= 100 n/63 V	−20/+50
C 7	= 4 n 7/100 V	10
C 8	= 100 n/63 V	−20/+50
C 9	= 10 µ/50 V	−10/+50
C 10	= 100 n/63 V	−20/+50
C 11	= 10 µ/50 V	−10/+50
C 12	= 4 n 7/100 V	10
C 13	= 56 p/100 V	2
C 14	= 56 p/100 V	2
C 15	= 8 p 2/100 V	0,25
C 16	= 8 p 2/100 V	0,25
C 17	= 4 n 7/100 V	10
C 18	= 4 n 7/100 V	10
C 19	= 100 n/63 V	−20/+50
C 20	= 100 n/63 V	−20/+50

		Tol./%
C 21	= 10 µ/50 V	−10/+50
C 22	= /	/
C 23	= 5-30 p/250 V	/
C 24	= 33 p/160 V	2,5
C 25	= 56 p/100 V	2
C 26	= /	/
C 27	= 10 µ/50 V	−10/+50
C 28	= 100 n/63 V	−20/+50
C 29	= 100 n/63 V	−20/+50
C 30	= 5-30 p/100 V	/
C 31	= 68 p/160 V	2,5
C 32	= 10 n/160 V	5
C 33	= 10 n/160 V	5
C 34	= 100 n/100 V	5
C 35	= 1 µ/100 V	5
C 36	= 10 µ/100 V	5
C 37	= 1 n/160 V	5
C 38	= 4 n 7/100 V	10
C 39	= 4 n 7/100 V	10
C 40	= 4 n 7/100 V	10
C 41	= 4 n 7/100 V	10
C 42	= 56 p/100 V	2
C 43	= 120 p/100 V	2
C 44	= 56 p/100 V	2
C 45	= 2 p 7/100 V	0,25
C 46	= 470 p/100 V	10

		Tol./%
C 47	= 4 n 7/100 V	10
C 48	= 0-6 p/250 V	/
C 49	= 4 n 7/100 V	10
C 50	= 100 n/63 V	−20/+50
C 51	= 4 n 7/100 V	10
C 52	= 4 n 7/100 V	10
C 53	= 100 n/63 V	−20/+50
C 54	=	
C 55	= 4 n 7/100 V	10
C 56	= 470 p/100 V	10
C 57	= 0-6 p/250 V	/
C 58	= 4 n 7/100 V	10
C 59	= 4 n 7/100 V	10
C 60	= 4 n 7/100 V	10
C 61	= 4 n 7/100 V	10
C 62	= 4 n 7/100 V	10
C 63	= 2 p 7/100 V	0,25
C 64	= 2 p 7/100 V	0,25
C 65	= 100 n/63 V	−20/+50
C 66	= 100 n/63 V	−20/+50
C 67	= 10 µ/50 V	−10/+50
C 68	= 10 µ/50 V	−10/+50
C 69	= 100 n/63 V	−20/+50
C 70	= 100 n/63 V	−20/+50

		Tol./%
C 71	= 100 n/63 V	−20/+50
C 72	= 100 n/63 V	−20/+50
C 73	= 100 n/63 V	−20/+50
C 74	= 100 n/63 V	−20/+50
C 76	= 10 µ/50 V	−10/+50
C 77	= 10 µ/50 V	−10/+50
C 78	= 10 µ/50 V	−10/+50
C 79	= 10 µ/50 V	−10/+50
C 82	= 1000 µ/40 V	−10/+50
C 83	= 1000 µ/40 V	−10/+50
C 84	= 1000 µ/40 V	−10/+50
C 85	= 1000 u/40 V	−10/+50
C 88	= 100 n/250 V	−20/+50
C 89	= 100 n/250 V	−20/+50
C 90	= 33 n/1000 V	10
C 91	= 100 n/250 V	−20/+50
C 92	= 10 µ/50 V	−10/+50
C 93	= 100 n/63 V	−20/+50
C 94	= 4 n 7/100 V	10
C 95	= 100 n/63 V	−20/+50
C 96	= 100 n/63 V	−20/+50
C 97	= 10 u/50 V	−10/+50

		Tol./%
C 98	= 10 µ/50 V	−10/+50
C 99	= 10 µ/50 V	−10/+50
C 100	= 10 µ/50 V	−10/+50
C 101	= 100 n/63 V	−20/+50
C 102	= 1 n/100 V	10
C 103	= 100 n/63 V	−20/+50
C 104	= 1 n/160 V	5
C 105	= 10 n/160 V	5
C 106	= 100 n/100 V	5
C 107	= 1 µ/100 V	5
C 108	= 10 u/35 V	20
C 109	= 100 u/10 V	20
C 110	= 4 n 7/100 V	10
C 111	= 4 n 7/100 V	10
C 112	= 470 p/100 V	10
C 113	= 18 p/160 V	2,5
C 114	= 18 p/160 V	2,5
C 115	= 18 p/160 V	2,5
C 116	= 100 n/63 V	−20/+50
C 117	= 18 p/160 V	2,5
C 118	= 18 p/160 V	2,5
C 119	= 100 n/63 V	−20/+50
C 120	= 100 n/63 V	−20/+50
C 130	= 100 n/63 V	−20/+50
C 131	= 10 µ/50 V	−10/+50

T 1 = BF 240
T 2 = BF 440
T 3 = BF 440
T 4 = BF 240
T 5 = BC 237 B
T 6 = BC 307 B
T 7 = BC 307 B
T 8 = BC 237 B
T 9 = BF 440
T 10 = BF 240
T 11 = BF 440
T 12 = BF 240
T 13 = BF 440
T 14 = BF 240
T 15 = BF 440
T 16 = BF 240
T 17 = BF 440
T 18 = BF 240
T 19 = BF 240
T 20 = BF 440
T 21 = BC 307 B
T 22 = BC 237 B
T 23 = BC 307 B
T 24 = BC 237 B
T 25 = BF 240
T 26 = BF 440
T 27 = BF 240
T 28 = BF 440
T 29 = BF 240

T 30 = BF 440
T 31 = BF 245 A
T 32 = BF 245 A
T 33 = BF 440
T 34 = BF 240
T 35 = BF 440
T 36 = BF 240
T 37 = BC 307 B
T 38 = BC 237 B
T 39 = BC 307 B
T 40 = BC 237 B
T 41 = BF 240
T 42 = BF 440
T 43 = BF 240
T 44 = BF 440
T 45 = BF 440
T 46 = BF 240
T 47 = BF 240
T 48 = BF 440
T 49 = BF 240
T 50 = BF 440
T 51 = BF 240
T 52 = BF 440
T 53 = BF 440
T 54 = BF 240
T 55 = BF 240
T 56 = BF 440
T 57 = BD 139
T 58 = BD 140
T 59 = BF 440

T 60 = BC 237 B
T 61 = BC 237 B
T 62 = BC 307 B
T 63 = BC 307 B
T 64 = BC 237 B
T 65 = BC 307 B
T 66 = BC 237 B
T 67 = BF 245 A
T 68 = BF 245 A
T 69 = BC 307 B
T 70 = BC 307 B
T 71 = BC 237 B
T 72 = BC 307 B
T 73 = BC 237 B
T 74 = BC 307 B
T 75 = BC 237 B
T 76 = BC 237 B
T 77 = BC 307 B
T 78 = BF 240
T 79 = BF 240
T 80 = BF 240
T 81 = BF 240
T 82 = BC 237 B
T 83 = BF 240
T 84 = BF 440
T 85 = BF 240
T 86 = BF 240
T 87 = BF 440
T 90 = BC 307 B
T 91 = BC 307 B

alle 1 N 4151 außer:
D 4 = LED 3 mm rot
D 5 = ZPD 5 V 1
D 6 = ZPD 5 V 1
D 29 = LED 5 mm gelb
D 30 = ZPD 5 V 1
D 37 = ZPD 5 V 1
D 38 = ZPD 5 V 1
D 39 = ZPD 5 V 1
D 47 = ZPD 5 V 1

GI 1 = B 80 C 1500/1000
GI 2 = B 80 C 1500/1000

Si 1 = T 0,315/250 B/220 V
T 0,63/250 B/110 V

IC 1 = UA 741 CN
IC 2 = MC 1458 P
IC 3 = MC 1458 P
IC 4 = µA 7824
IC 5 = µA 7924
IC 6 = µA 7812
IC 7 = µA 7912

IC 9 = SN 7410 N
IC 10 = SN 74132 N
IC 11 = SN 7472 N

Re 1 = HE 321 B 1200
Re 2 = HE 321 A 1200

Tr 1 = 30 VA, 110 V/110 V, 24 V/24 V, 15 V/15 V, 8 V

S 1 = Schadow Typ NE 16
S 2 = Seuffer Typ 676
S 3 = Seuffer Typ 676.1
S 4 = Schadow Tastensatz Serie F (Reihe 7700 außer 7702)
S 4.1 = Seuffer Typ 676 (nur bei Typ 7404)
S 5 = Schadow Tastensatz Serie F (Reihe 7700)
S 5.1 = APR Typ 5536 A (Reihe 7400)
S 6 = Schadow Tastensatz Serie F (Reihe 7700)
S 7 = Schadow Tastensatz Serie F (Reihe 7700)
S 8 = Schadow Tastensatz Serie F (Reihe 7700)
S 8.1 = Seuffer Typ 676 (Reihe 7400)
S 9 = Seuffer Typ 676 (Reihe 7700)
S 10 = Schadow Tastensatz Serie F (Reihe 7700)
S 11 = Schadow Tastensatz Serie F (Reihe 7700)
S 12 = Schadow Tastensatz Serie F (Reihe 7700)
S 13 = Schadow Tastensatz Serie F (Reihe 7700)
S 14 = Schadow Tastensatz Serie F (Reihe 7700)

R 242	1 K
R 325	12 R 1
R 326	68 R 1
R 327	68 K 1
R 328	6 K 81
R 329	619 R
R 330	10 K Trimmer lin.
R 331	6 K 81
R 332	4 K 75
R 333	22 R 1
R 334	22 R 1
R 335	22 R 1
R 336	22 R 1
R 465	1 M
R 466	475 K
R 467	44 K 2
R 468	8 K 25
R 469	464 R
R 470	100 K
R 471	16 K 2
R 472	1 K Trimmer lin.
R 473	2 K
R 474	10 K
R 475	1 K Trimmer lin.
R 476	2 K
R 477	46 R 4
R 478	33 R 2
R 479	825 R
R 480	56 R 2
R 481	47 K Trimmer lin.
R 482	274 K
R 483	464 R
R 484	47 K Trimmer lin.
R 485	182 K
R 486	909 R
R 487	17 K 4
R 488	56 R 2
R 489	12 K 1

D 31	ZPD 5 V 1
D 55	1 N 4151
D 56	1 N 4151
D 85	LED 3 mm rot
D 86	LED 3 mm rot
D 87	LED 3 mm rot
D 88	ZPD 8 V 2
D 89	ZPD6 V 2
D 90	1 N 823 A

C 75	100 n/63 V
C 80	10 µ/50 V
C 81	470 µ/16 V
C 86	2200 µ/16 V
C 87	47 µ/25 V
C 121	-
C 122	100 n/63 V
C 123	100 n/63 V
C 124	47 n/250 V
C 132	120 p/100 V
C 133	100 n/250 V
C 134	4 n 7/63 V
C 135	47 n/250 V
C 136	220 n/100 V

T 85	BC 237 B
T 89	BC 307 B
T 111	BF 245 B
T 112	BC 307 B

G1 3	B 80 C 1500/1000

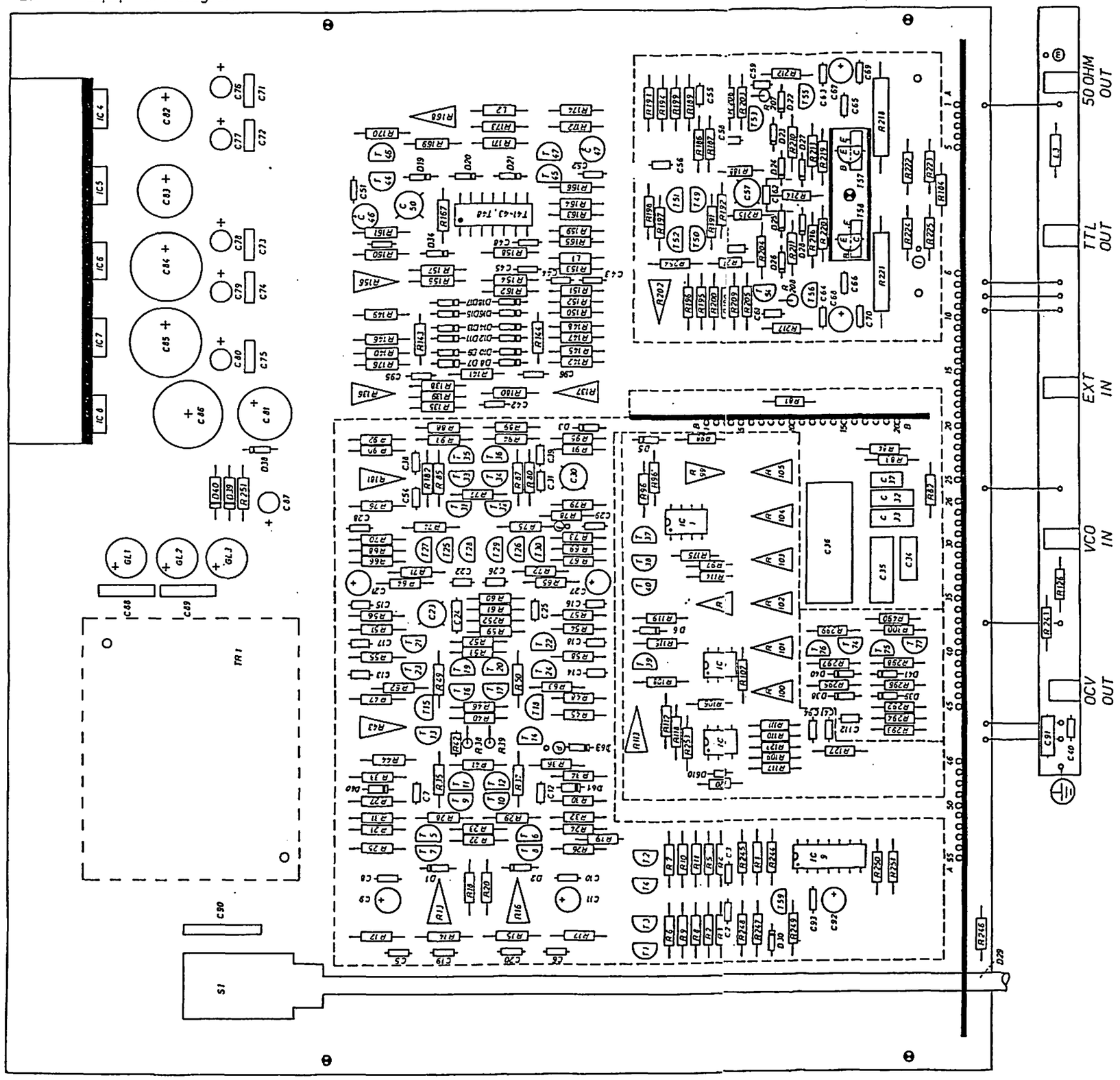
IC 8	µA 7805
IC 12	CA 3140 E
IC 38	MC 1458 P
IC 39	ICL 7107 CPL

Re 3	HE 3321 B 1200
Re 4	HE 3321 C 0500

S 9	Seuffer Typ 676

4 x HD 1105 R

2.6 Equipment diagram



2.7 Maintenance and repair

If the instrument is suspected of being unsafe, measures should be taken to prevent any unintentional operation. This is the case when the device shows physical damage, does not perform to its specifications, or is stressed beyond tolerable limits.

When removing covers or parts by means of tools live parts or terminals could be exposed. Before opening the instrument it must be disconnected from all power sources. Even when power is disconnected parts inside the apparatus (capacitors!) may store a possibly hazardous voltage.

Any repairs must be done by qualified personnel only, being aware of the hazards possibly involved.

It should be ensured that the construction of the apparatus is not altered to the detriment of safety. Leakage paths, air gaps, and insulation layers should not be reduced. Any wires which are galvanically connected to the mains must, before soldering, be fixed to their terminals mechanically (by threading, bending, or that like) so that a faulty solder joint can not cause the wire end to contact any other parts.

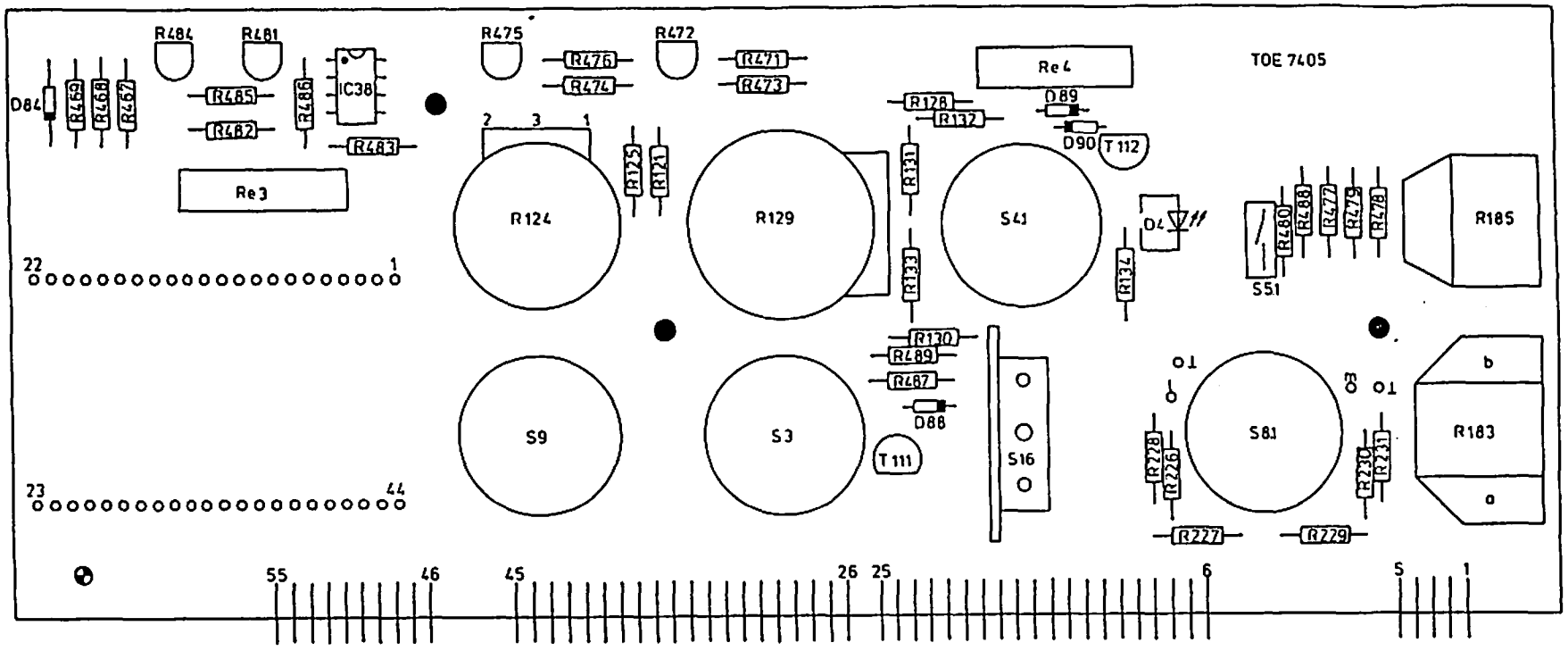
When components have to be replaced original parts should be used. Other parts are only acceptable when the safety measures of the instrument are not impaired. Fuses must be of exactly original specification.

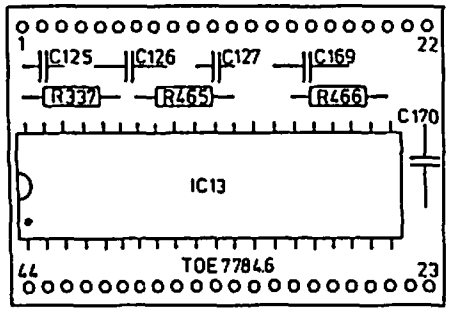
2.8 Adjustment procedure

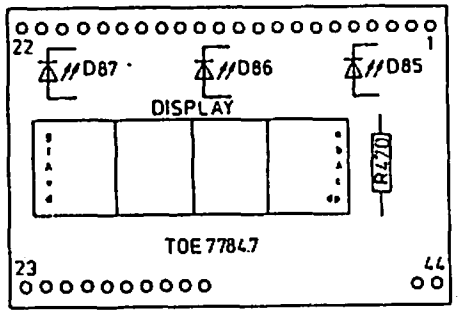
After any repair work or when the instrument fails to perform according to its specifications the function generator must be readjusted according to the following instructions.

Equipment required for the adjustment procedure:

Distortion meter	e.g. HP 339 A
Oscilloscope	e.g. Tektronix 465 B


TOE 7405
R484
R481
R475
R476
R474
R472
R471
R473
IC38
R485
R482
R486
R483
D84
R469
R468
R467
Re3
Re4
R128
R132
D89
D90
T112
R124
R125
R121
R129
R131
R133
S41
D4
R134
S51
R480
R488
R477
R479
R478
R185
R130
R489
R487
D88
S9
S3
T111
S16
S81
R228
R226
R230
R231
R183
b
a
R227
R229
22
1
23
44
55
46
45
26
25
6
5
1


C125
C126
C127
C169
R337
R465
R466
C170
IC13
TOE 7784.6
1
22
44
23


D87
D86
D85
DISPLAY
R470
TOE 7784.7
22
1
23
44

Frequency meter	e.g. HP 5315 A
Digital multimeter	e.g. Keithley 179
Feed-through load resistor	50 Ohm, ≥ 2 W

At maximum amplitude setting the generator can provide approx. 1.2 W of power at its OUTPUT connector. This must be observed when the feed-through load resistor is selected.

The connection between generator output is made with the feed-through load resistor inserted between the generators OUTPUT connector and the cable. Exceptions are stated.

Dismantling of the instrument

Disconnect the device from mains power before opening!

The top-shell and the bottom-shell of the cabinet are removed by detaching four ornamental screws at either side face of the instrument.

Adjustment sequence

1. Switch on the generator, LINE ON.
2. Connect OUTPUT to oscilloscope, insert feed-through resistor between OUTPUT and cable.
3. Check performance of all functions and in all frequency ranges.
4. Turn potentiometer AMPLITUDE fully anti-clockwise to MIN.
5. Switch off d-c offset, DC OFFSET ON toggle switch to down position.
6. Adjust d-c voltage at measuring point S to minimum, 0±20 mV, with R 202, use digital multimeter in 200 mV range.
7. Set potentiometer AMPLITUDE fully clockwise to MAX.
8. Set FUNCTION switch to sine.
9. Set switch DISPL MODE to FREQ, switch FREQ RANGE Hz to 100, and adjust read-out to 50 with potentiometer FREQUENCY.
10. Adjust distortion factor of the output signal to k ≦ .5 % with R 137, R 136, R 43, and R 116. This procedure must be repeated several times as the potentiometers affect each other.
11. Adjust d-c voltage to minimum, 0 ± 20 mV, and, if necessary: With rectangular signal with R 13 and R 16, with sinusoidal signal with R 167, with triangular signal with R 43.

12. Set potentiometer AMPLITUDE fully clockwise to MAX.
13. Set FUNCTION switch to rectangle.
14. Adjust peak-peak amplitude to 15 V ± 5 % into a 50 Ohm load and 30 V at unloaded output with R 13 and R 16. Then check d-c voltage at measuring point S.
15. Set FUNCTION switch to triangle.
16. Adjust peak-peak amplitude to 30 V ± 5 % with R 181 at unloaded output.
17. Set FUNCTION switch to sine.
18. Adjust peak-peak voltage to 30 V ± 5 % at unloaded output with R 174.
19. Readjust distortion factor at a frequency setting of 5 x 100 Hz to k ≦ .5 % with R 99.
20. Set FUNCTION switch to rectangle.
21. Trim signal shape at 1 MHz to optimum with C 57 (transition time ≦ 28 ns).
22. Set FUNCTION switch to triangle.
23. Adjust drop of amplitude at 5 MHz to - .5 dB with C 23.
24. Set frequency to 5 x 1 MHz.
25. Adjust frequency of output signal to 5 MHz - 1 % with R 100 and, if necessary, with C 30.
26. Set frequency to 0.5 x 1 MHz.
27. Adjust frequency of output signal to 500 kHz ± 4 % of limit value with R 113.
28. Set frequency to 5 x 100 kHz.
29. Adjust frequency of output signal to 500 kHz ± 1 % with R 101.
30. Set frequency to 5 x 10 kHz.
31. Adjust frequency of output signal to 50 kHz ± 1 % with R 102.
32. Set frequency to 5 x 1 kHz.
33. Adjust frequency of output signal to 5 kHz ± 1 % with R 103.
34. Set frequency to 5 x 100 Hz.
35. Adjust frequency of output signal to 500 Hz ± 1 % with R 104.
36. Set frequency to 5 x 10 Hz.
37. Adjust frequency of output signal to 50 Hz ± 1 % with R 105.
38. Set frequency reading to 5 with potentiometer FREQUENCY, R 124.
39. Check frequencies in all sub-ranges. Deviations of ± 5 % of full scale values are permissible in sub-ranges x 1 M, x .01, x .1, x 1, and deviations of ± 2 % of full scale values are permissible in all other ranges. If necessary, readjust with R 103. Set switch FREQ RANGE Hz to 10 and potentiometer FREQUENCY fully anti-clock-

wise. Adjust signal symmetry vs. time with R 330.

40. Check signal at TTL OUT. Hi-state voltage must be + 4 V ... + 5 V at the unloaded output.
41. Establish measuring set-up as follows: Switch DC OFFSET to off, switch ATTENUATION to 0 dB, switch FUNCTION to AMPL/DC, and switch DISPL MODE to DC. Adjust read-out value to 0. Set switch DC OFFSET to ON and turn potentiometer DC OFFSET fully clockwise. Connect digital multimeter (range 20 V d-c) to the unloaded output of the unloaded output of the generator. Align reading of the generators display to that of the multimeter.
42. Set FUNCTION switch to rectangle and switch DISPL MODE to AC. Switch off DC OFFSET (toggle in down position) and set switch FREQU RANGE Hz to 100. Turn potentiometers FREQUENCY and AMPLITUDE fully clockwise. Connect digital multimeter (range 20 V a-c) to the unloaded generator output and align the reading of the generators display to exactly twice the value indicated by the digital multimeter with R 475.
43. Connect frequency counter to the TTL OUT connector of the generator and set switch DISPL MODE to FREQ and switch FREQ RANGE Hz to 10 k. Turn potentiometer FREQUENCY fully clockwise. Align the reading of the generators display to that of the frequency counter with R 472.