ELECTRONIC MEASURING INSTRUMENTS

FFV Mätteknik AB

MULTI FREQUENCY TEST EQUIPMENT
ZTEK 75302

ELMI A/S

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HARDWARE MANUAL

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CONTENTS

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1. INTRODUCTION

The object of this manual is to describe, in detail, the hardware of the Multi Frequency Test Equipment ZTEK 75302.

The description concentrates on:

* Function
* Diagram
* List of components
* Location of components

The last sections give a brief description of trouble-shooting and adjustment procedures.

For specifications and operation, see the 'Operator's Manual'

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2. GENERAL DESCRIPTION

The instrument comprises two features:

GENERATOR TEST enabling measurement of frequency and level of a generator (tone sender).

RECEIVER TEST providing functional test and reaction time measurement of a single receiver or a pair of receivers (tone receivers).

The GENERATOR TEST unit comprises a balanced input selector and an accurate frequency and level measuring circuit. The measurable input signals cover the range of the multi frequency signalling tone generators.

The RECEIVER TEST unit comprises an accurate programmable two-tone generator and a function and time measuring circuit. The two-tone generator provides a pulsed or continuous signal output, which is fed into the tone receivers of the system being tested. The response of the receivers is recorded by the measuring unit, which returns the result as a functional test, an interruption test, or an operation time or release time measurement.

The RESULT is presented on the RESULT display, which includes a real-time display of the receiver test input. If activated, the printer returns the result together with the parameters.

The PARAMETERS, which are needed to enable the test procedure, are loaded into the MFTE by means of the keyboard. Each test requires a different number of parameters. The MFTE indicates the appropriate parameters by flashing the parameter display or keys, thus optimizing the parameter input sequence.

The test procedure is externally programmable through the IEC-Bus interface.

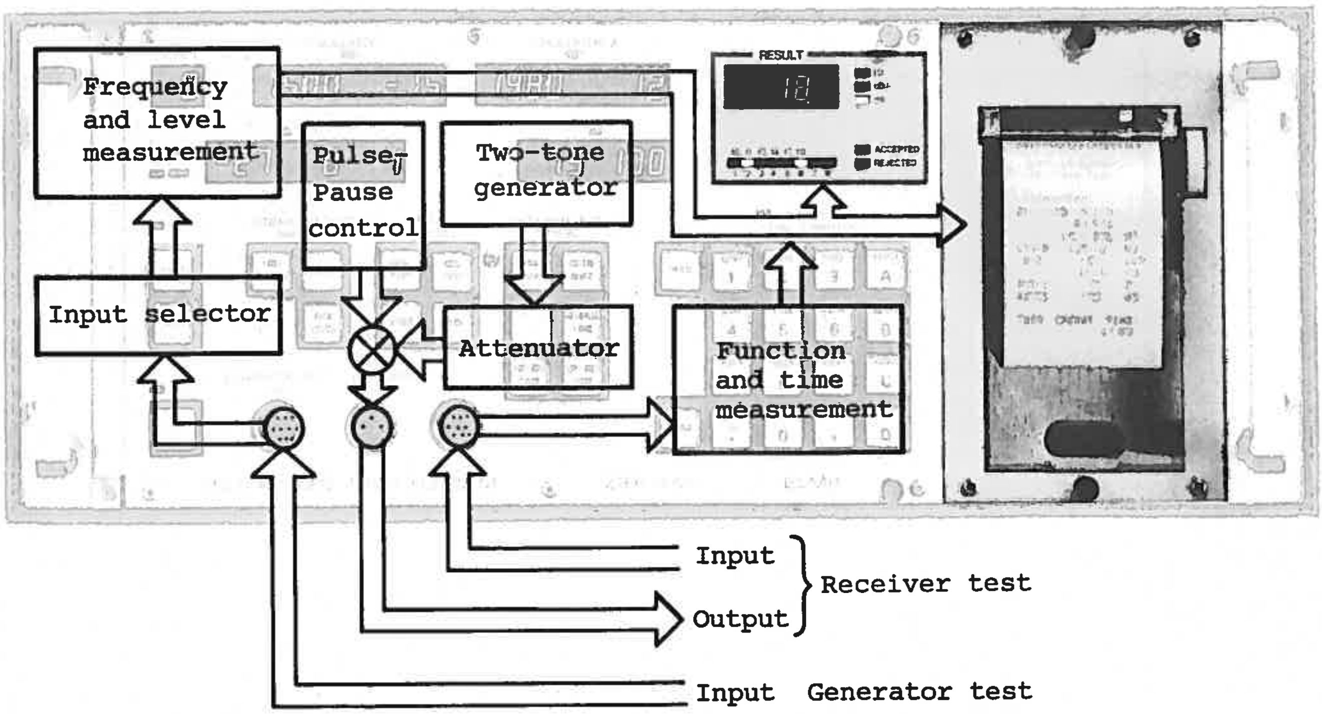

Fig. 2.1 Functional Block Diagram.

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The MFTE is based on INTEL's 8085 microprocessor, which controls all functions of the instrument, and comprises the following functional blocks:

* Microprocessor
* Program and Data Storage
* Receiver Test
* Generator Test
* IEC-Bus Interface
* Display and Keyboard
* Printer
* Power Supply

See the block diagram, fig. 2.2.

The <u>microprocessor</u> controls the exchange of data with another block by means of:

* data bus
* address bus and
* control bus

The control bus consists of control lines and selection lines.

CONTROL LINE	TO	SIGNIFICATION
RESET	Receiver Test, IEC-Bus, Display and Keyboard, Printer	Resetting of internal functions.
CLK	Display and Keyboard	Microprocessor clock for synchronization of functions.
ALE	Program and Data Storage,	Data on data bus to be interpreted as address byte A_7-$A_\emptyset$.
$\overline{RD}$	Receiver Test, IEC-Bus,	Unit addressed allowed to provide the bus with data.
$\overline{WR}$	Display and Keyboard,	Unit addressed allowed to read data from the bus.
A13	Printer	Address bit No. 13.
$\overline{RAM\emptyset}$	Data Storage	Selects data storage (1 k RAM).
$\overline{RAM1}$	Receiver Test, Printer	Selects input of Receiver Test Input and output of data for the printer.
$\overline{OSC1/\emptyset}$, $\overline{OSC1/1}$	Receiver Test	Selects output of frequency for oscillator 1.
$\overline{OSC2/\emptyset}$, $\overline{OSC2/1}$	Receiver Test	Selects output of frequency for oscillator 2.
$\overline{ATT1}$	Receiver Test	Selects output of attenuation for oscillator 1.

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CONTROL LINE	TO	SIGNIFICATION
$\overline{ATT2}$	Receiver Test	Selects output of attenuation for oscillator 2.
BURST	Receiver Test	Sets pulse/pause function.
$\overline{GENIN}$	Generator Test	Selects output for Generator Test Input Selector.
$\overline{MEASHI}$ $\overline{MEASLO/Ø}$ $\overline{MEASLO/1}$	Generator Test	Selects input of frequency or level measured.
$\overline{IECADR}$ $\overline{IECBUS}$	IEC-Bus	Selects input and output of data for IEC-Bus Interface.
$\overline{CS1}$ $\overline{CS2}$ $\overline{CS3}$	Display and Keyboard	Selects input and output of data for Display and Keyboard.
$\overline{PRENAB}$	Printer	Causes printing to start.
RESET IN	Microprocessor	Forces the microprocessor to resume its starting position.
INTTIM	Microprocessor	Timing signal for controlling duration of tone bursts.
INTBUS	Microprocessor	IEC-Bus Interface has data for microprocessor.
INTKEY	Microprocessor	A key has been activated.

The program and data storage contains:

14 k bytes program storage (PROM) and
1 k bytes data storage (RAM).

The receiver test contains 1) a two-tone generator with attenuators and an output amplifier and 2) Test Inputs from the tone receivers.

The two-tone generator forms digitally two tones, whose frequencies are set by the microprocessor. The two digital tones are converted into independent analog signals, which are attenuated by a value set by the microprocessor. The two analog tones are added in the output amplifier. An auxiliary signal may be added too. The two tones (and the auxiliary signal) are turned on/off by the microprocessor, whereby two-tone bursts are sent.

Test Inputs are through-inputs to the microprocessor, which is the measuring unit.

All time relations are controlled by the microprocessor by means of a 4 kHz clock, which gives an accuracy of measurement of 1/4 ms.

The generator test contains circuits for measuring the frequency and level of the tone selected by the input selector circuit. The further processing of the results of measurement is effected by the microprocessor.

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The display and keyboard unit consists of 1) control and driving circuits for controlling outputs to displays and LEDs and 2) a control circuit for controlling the input of a pressed key. Inputs and outputs are interpreted by the microprocessor.

The printer contains, besides the mechanical printer, a control circuit for printing. Exchange of data and time relations are controlled by the microprocessor.

The power supply contains conventional circuits for generating +15 V, -15 V and -30 V. +5 V is generated by a Switch-Mode Power Supply.

The block diagram (fig. 2.2) shows how the functional blocks described above are related to each other. The physical location on printed circuit boards is indicated by means of capital letters in the bottom left-hand corner of each block.

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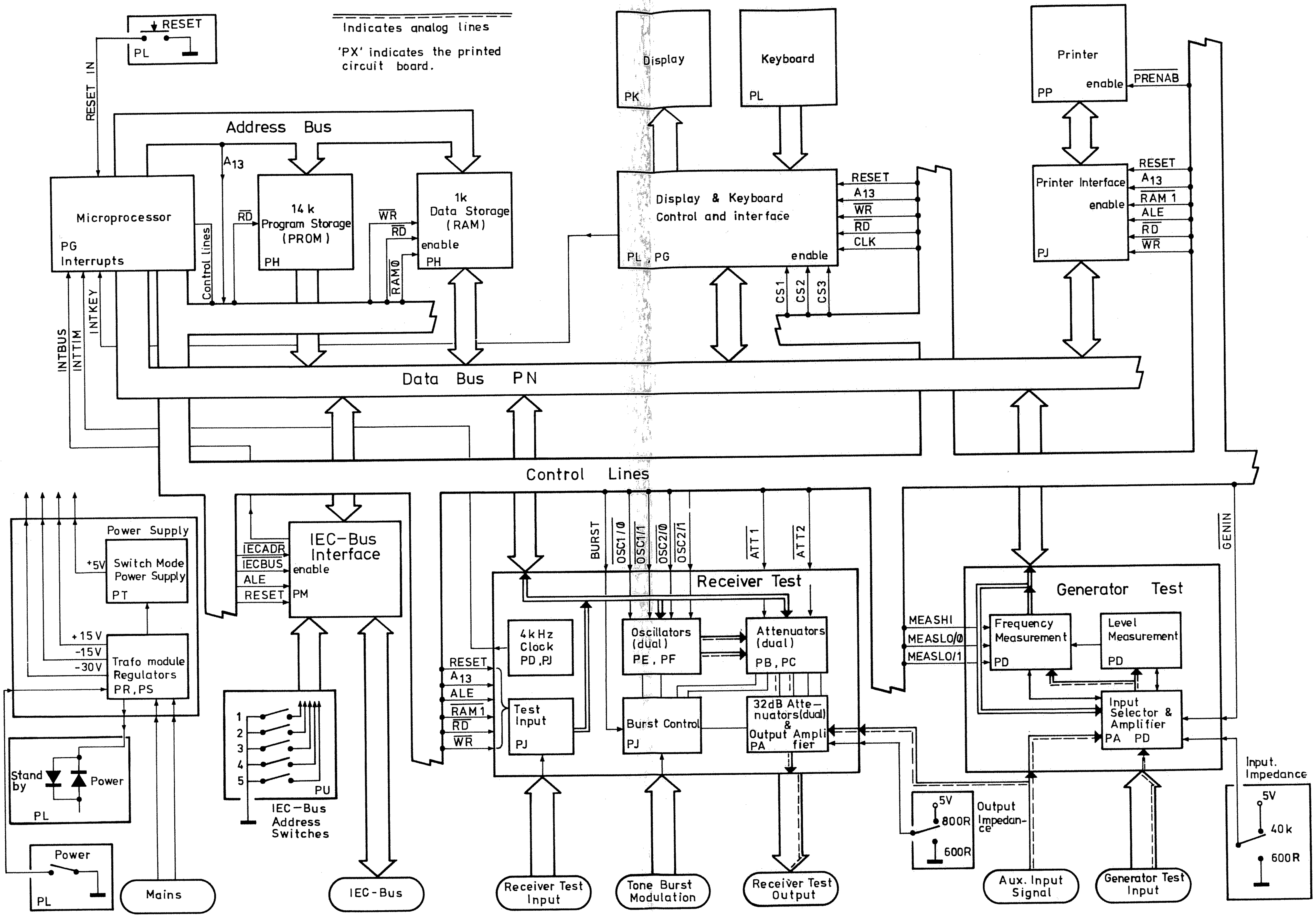

Fig. 2.2 Block Diagram

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3. DETAILED DESCRIPTION

The following pages describe, in detail, how the functional blocks work.

The description is based on the division into printed circuit boards. Consequently, the description of each board may include parts from several functional blocks.

3.1 PRINTED CIRCUIT BOARD PA:

Generator Test Input/ Receiver Test Output

The board PA comprises two parts: the Generator Test Input and the Receiver Test Output.

The generator test input consists of an input selector which passes on one of six balanced input signals, or the auxiliary signal, to the balanced input transformer. After being transformed, the signal is low-pass filtered and passed on from the board PA to the measuring circuit on the board PD.

The data latches IC4 and IC5 contain information on the generator test. The three least important data bits - D_0, D_1 and D_2 - select the input wanted by means of the decoder IC6, the relay drivers IC7 and the relays RE1-RE7. During switch-on of power, the circuit R9, C3, D2 ensures that the decoder is disabled, until the right data has been written out.

The data bits D_3, D_4 and D_5 are control signals for the measurement and are passed on direct to the board PD. The connection of the 600Ω relay RE8 is controlled by the data bit D_6, depending on the position of the rear-panel switch 40 kΩ / 600Ω. If the switch is at 0 V (the 600Ω position), D_6 = 1 will cause a 604Ω resistance (R2) to be connected parallel across the transformer, thus creating an input impedance of 600Ω. The microprocessor uses this process, when selecting the right input for the following two purposes:

1) In the case of auxiliary input measurements, the input is already terminated by 600Ω. RE8 must, therefore, be disconnected during

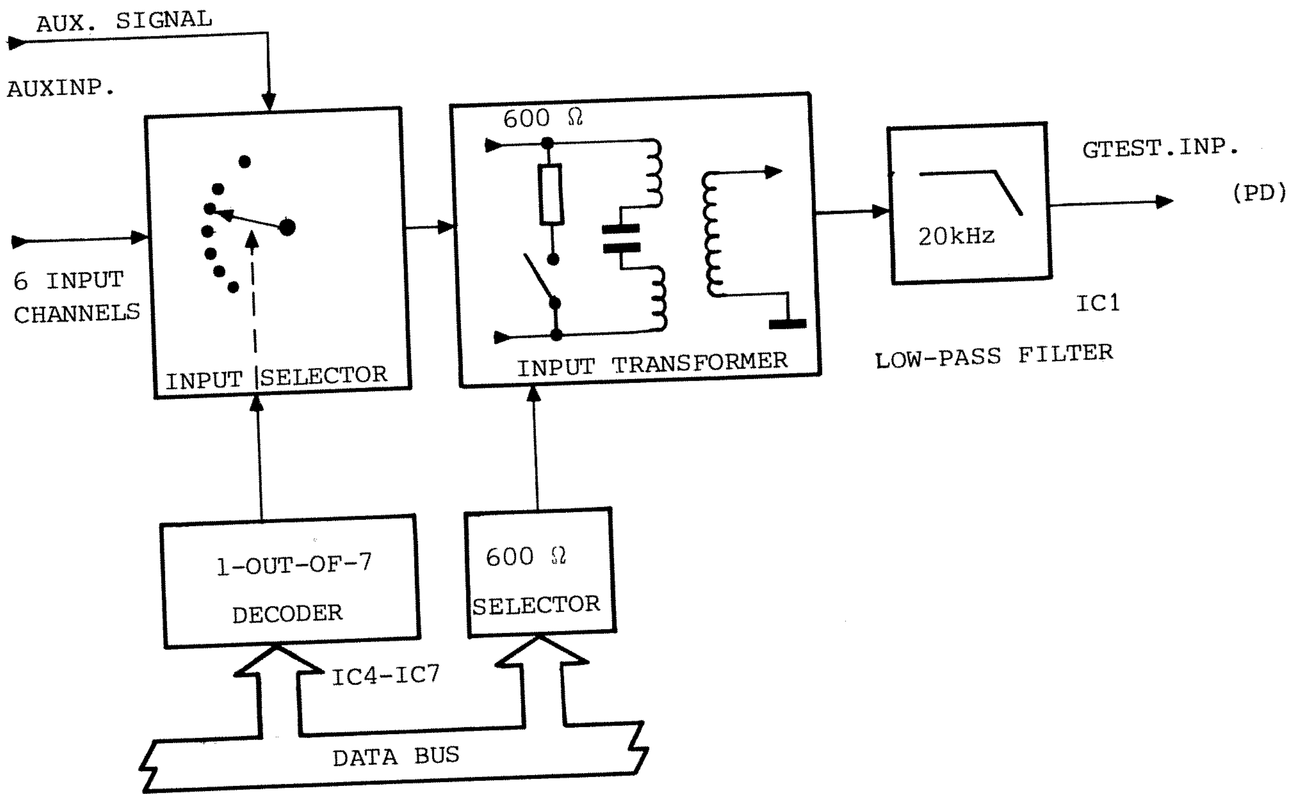

Fig. 3.1 Block diagram of Generator Test Input.

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measurements, irrespective of the position of the switch.

2) When changing over from one input relay to another, there is a risk of causing damage to the relay contacts, if RE8 is connected at the same time as ringing voltage (11o V_{rms}, 25 Hz) is applied to an input. The microprocessor, therefore, ensures that RE8 is disconnected during the change-over.

The input wires to the balanced transformer contain two resistors, R30 and R31, which attenuate the unintended oscillations (approx. 10 Hz) which may occur when TR1, C2 is connected to a generator with low impedance and DC offset.

R4 ensures a uniform input impedance in the frequency area 200-6000 Hz, whereas differences of performance of the transformer may be adjusted by means of the adjusting resistors RX1 or RX2.

IC1 functions as a low - pass filter with an upper cut-off frequency of approx. 20 kHz and is input-protected by D3 and D4.

The receiver test output receives two analog tones from the attenuators PB and PC. Depending on the value of the attenuation, both tones may be attenuated by 32 dB before being added in the output amplifier. An auxiliary signal from the rear panel may be added to the tones. From the output amplifier, the signal is sent to the line via the balanced output transformer.

The 32 dB attenuators are controlled by the relays RE9 and RE10. The auxiliary signal is controlled by the electronic switch IC3, which ensures that the input impedance of the signal is correct, no matter whether the signal is sent to the output amplifier or not.

IC2 functions as a summation amplifier, which sends the signal to the current amplifier T3. The amplification at this stage is set by the potentiometer P3. T2 is a constant-current source (approx. 60 mA) for T3, which is protected against overvoltages from the transformer by means of D9.

The output transformer TR2 has two inputs: one for an output impedance of

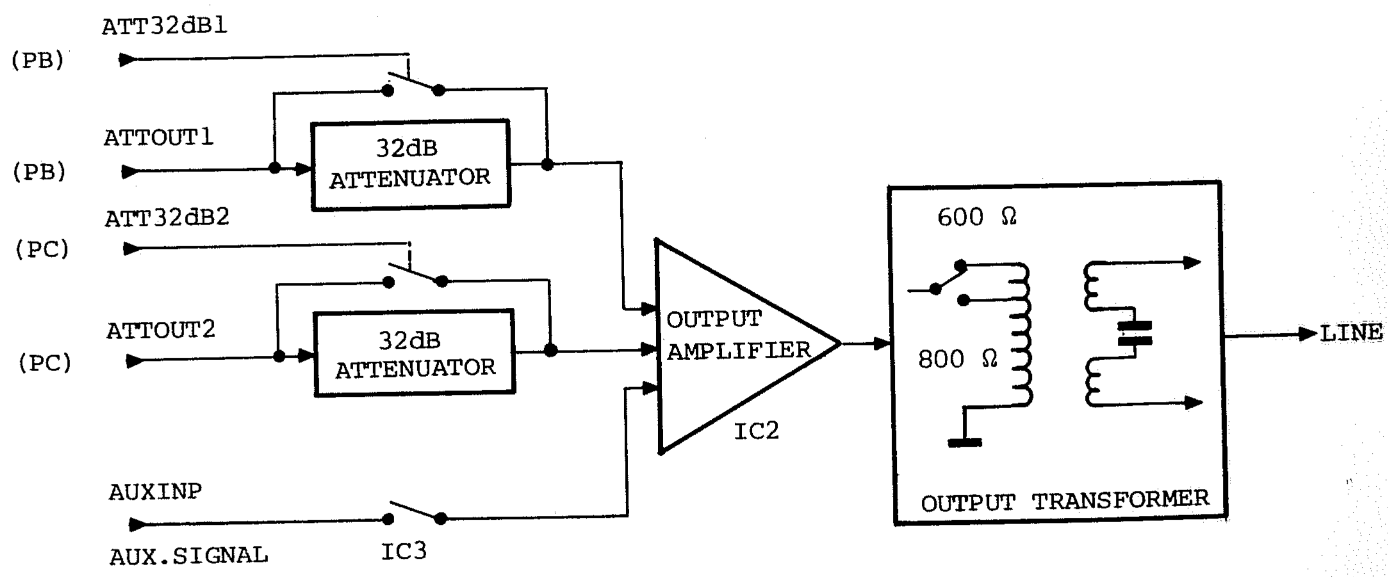

Fig. 3.2 Block diagram of output amplifier.

600Ω and another for an output impedance of 800Ω. The input to be used is selected by the relays RE11 and RE12. The value of the output impedances are determined by R27, P1 (600Ω) and R28, P2 (800Ω), whereas the relation between the two output voltages is determined by RX3.

The dependence of the copper windings of the transformer on the temperature is compensated for by the NTC resistor R32.

3.2 PRINTED CIRCUIT BOARDS PB, PC:

Filter and Attenuator

The MFTE has two filter and attenuator boards, one for each tone. The tone is received from the digital oscillator as negative half-waves in the form of quantized current, which is converted into quantized voltage, Every second half-wave is converted into a positive half-wave (controlled by the signal SIGN), whereupon the quantized sine

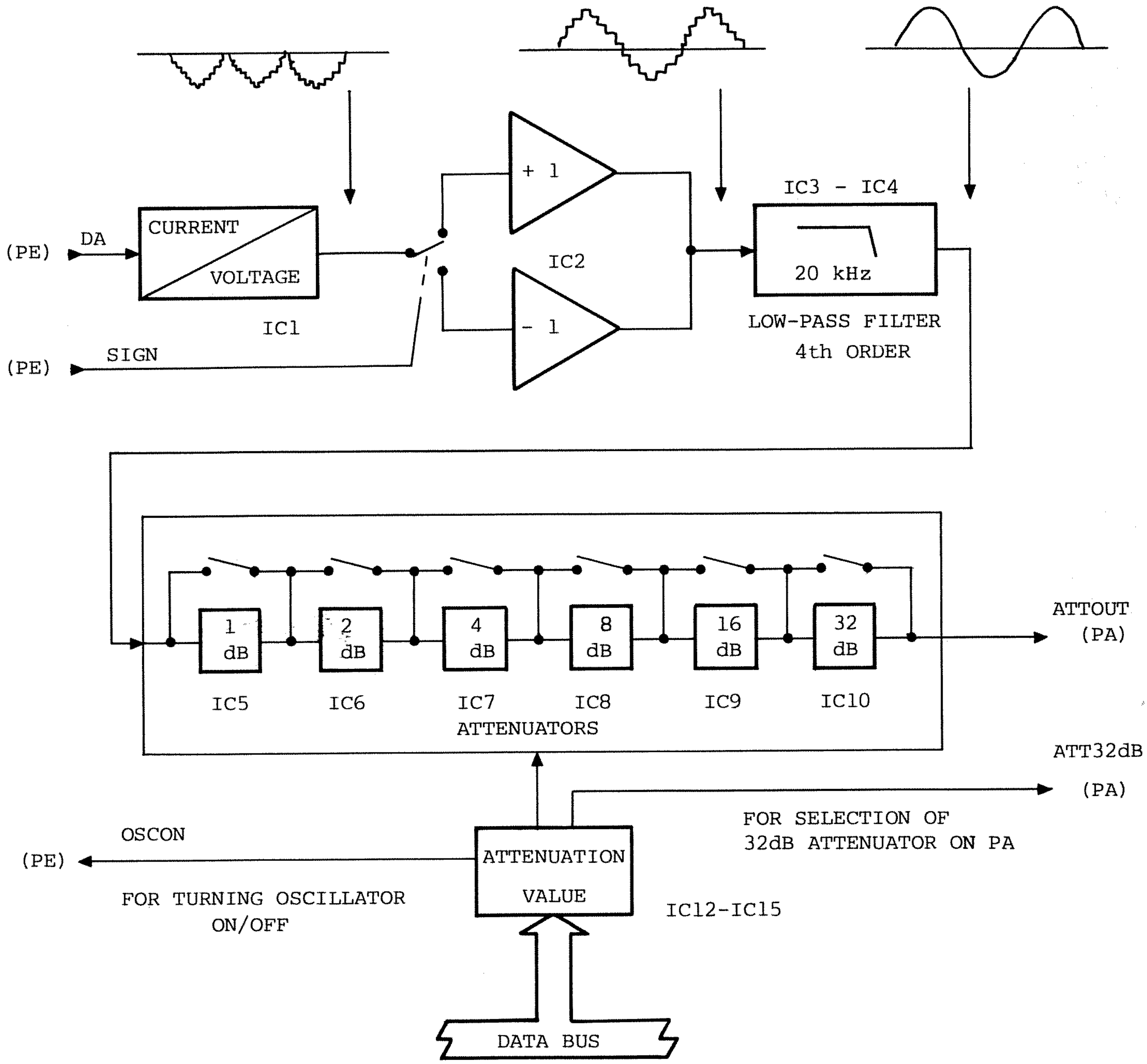

Fig. 3.3 Block diagram of filters and attenuators.

tone is sent through two 2nd order Butterworth low-pass filters connected in series, which remove the sample frequency. Depending on the attenuation value set by the microprocessor, the sine tone is attenuated by the attenuators (note that the last 32 dB attenuator is located on the board PA).

IC1 and R1 form the current-to-voltage converter, where C1 removes the spikes which may occur in connection with the quantization of the tone by the D/A-converter.

By means of the switch T2, IC2 forms an amplifier capable of amplifying by +1 (T2 is open) or $-1 = -R3/R2$ (T2 is closed). The DC-offset of IC1 and IC2 can be adjusted by means of P1 so as to minimize the jump between positive and negative half-waves.

IC3 and IC4 both form a 2nd order Butterworth low-pass filter with a cut-off frequency of 20.5 kHz ($=\sqrt{2}/2\pi R9C2$), which means that the sample frequency (65.5 kHz) is attenuated by 40 dB. The attenuation of the highest possible tone frequency (4095 Hz), however, is only 0.0001 dB the attenuation of 256 Hz.

The attenuators are constructed as voltage dividers which may be connected by means of relays. Note that the 64 dB attenuator is formed by two 32 dB attenuators, one of which is located on the board PA. This is to avoid the introduction of noise in connection with large attenuations.

3.3 PRINTED CIRCUIT BOARD PD:

Generator Test

The generator test board measures the level or frequency of the analog signal from the board PA.

This function is divided into two parts as follows:

1) an analog part where the level of an analog signal is converted into a frequency, and

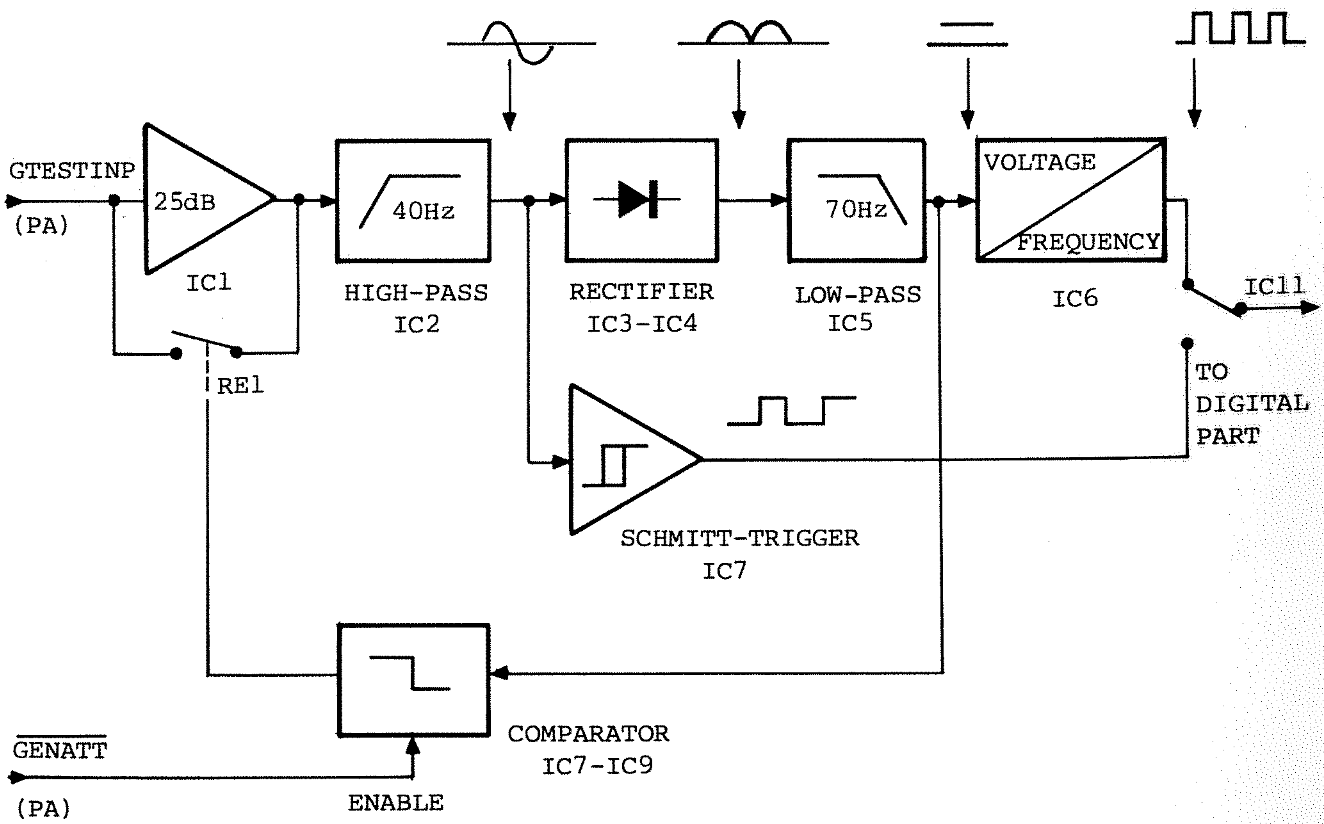

Fig. 3.4 Block diagram of analog part.

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2) a digital part consisting of a period-measuring unit.

The object of the analog part is to convert the level and frequency of the analog signal into square-wave signals with frequencies proportional to the level and frequency just mentioned.

The analog signal is sent through an amplifier which is set at 0 dB or 25 dB, depending on the level of the analog signal. After being high-pass filtered, the signal is sent to a rectifier and a Schmitt-trigger. The latter converts the analog signal into square-waves with the same frequency as the signal. A low-pass filter smoothes the positive half-waves from the rectifier so as to produce a DC-voltage.

Passing through a voltage-to-frequency converter, the DC-voltage is converted into square-waves with a frequency proportional to the level of the analog signal.

IC2 is a 2nd order high-pass filter with a cut-off frequency of 40 Hz ($=\sqrt{2}/2\pi R9C3$), the purpose of which is to cut off the DC from IC1 and at the same time prevent low-frequency oscillations from the input transformer from getting any further.

IC7/1 is a comparator, which functions as a Schmitt-trigger for the analog signal. Its output is a square-wave signal with the same frequency as the input signal. The Germanium diode D4 prevents the input voltage from falling below -0.3 V.

IC4 and IC3 together function as a full-wave rectifier. In the case of negative half-waves, IC3 will force (by means of D2) the IC4 +input to earth, and IC4 will function as an inverting amplifier, thus causing the IC4 output to appear with positive half-waves. In the case of positive half-waves, the IC3 output will follow the signal at the IC4 +input, and D2 will block the current. In this case, IC4 functions as a non-inverting amplifier, and the positive half-waves are passed direct through IC4. D1 ensures that the differential voltage between +input and -input does not exceed 0.6 V (the highest permissible differential voltage is 7 V).

IC5 is a 2nd order low-pass filter with a cut-off frequency of 70 Hz ($=1/2\pi R17C5$), which smoothes the positive half-waves to a DC-level with a maximum ripple of 2% at 200 Hz. The final smoothing occurs in R21, C7 where the ripple is max. 0.1% at 200 Hz. The 2nd order filter has a double pole at 70 Hz, which ensures minimum ringing when a signal is applied. Thereby the amplification control IC7, IC9 is prevented from oscillating.

The cut-off frequency was chosen at the value (70 Hz) giving the shortest possible signal delay (30 ms).

IC6 is a precision voltage-to-frequency converter, which gives a frequency proportional to the input level. The amplification of this stage is regulated by means of P3.

The amplification control IC7, IC9 consists of a comparator and a flip-flop.

The comparator controls the amplification of the IC1 input signal, thus ensuring that the level of the IC5 output signal will be 0-25 dB. The flip-flop IC9 remembers the position of IC7. By means of the disable signal $\overline{\text{GENATT}}$, the flip-flop is prevented from changing position during a measurement. IC7/4 indicates whether the input signal is too low for measurement (<-25 dBu).

The digital part consists of a period-measuring unit, which measures the time it takes for the square-wave signal produced in the analog part to traverse 64 periods. The further calculation of the correct level or frequency is made by the microprocessor.

A measurement starts by the signal START CONV. clearing the start/stop flip-flop IC14/2, the overflow flip-flop IC14/1, the 8 bits counter IC12-13

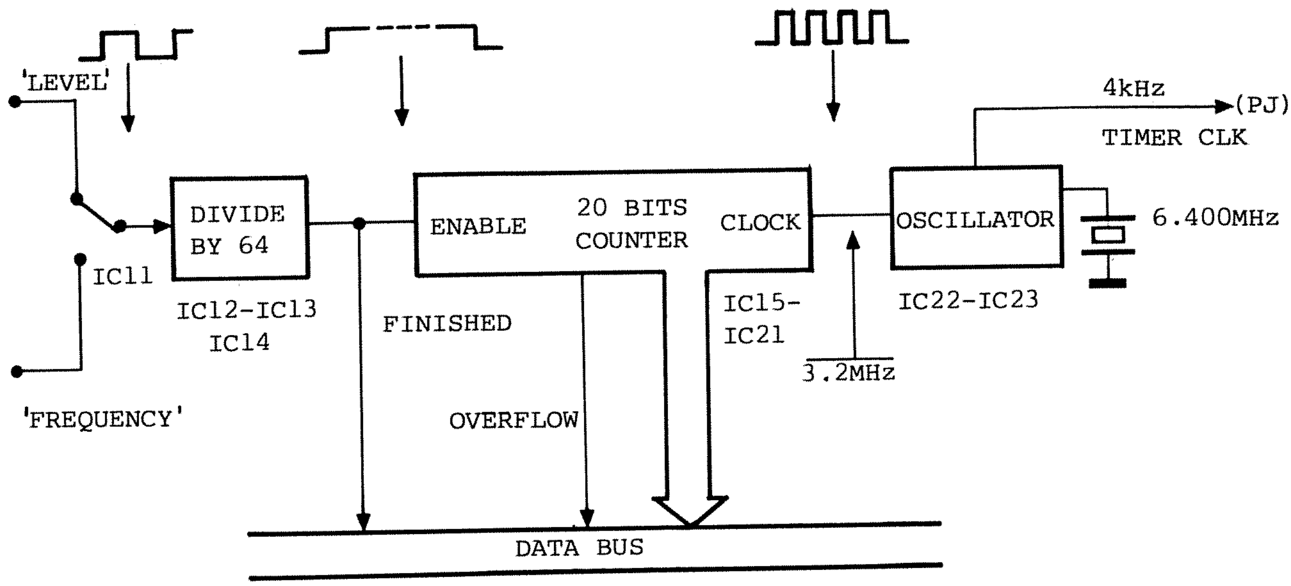

Fig. 3.5 Block diagram of digital part.

and the 20 bits counter IC15-17. When START CONV. disappears, the first pulse from IC11 will load IC12,13 with the number 64, and the 20 bits counter will be enabled. The counter IC12,13 will count up to 128, whereupon the start/stop flip-flop IC14/2 is set at 1 thus disabling the 20 bits counter. The latter will then have counted the number of 3.2 MHz clock pulses during 64 periods of the input signal.

The overflow flip-flop IC14/1 will signal, if the frequency of the input signal is too low.

3.4 Printed Circuit Boards PE, PF

Oscillators (dual)

The boards PE and PF form a two-tone digital frequency synthesizer, both tones being generated as independent digital waveforms.

Principle

Within a read-only-memory (ROM) the equivalent of 2^{16} words are stored, corresponding to equispaced samples of a sine wave taken over exactly one

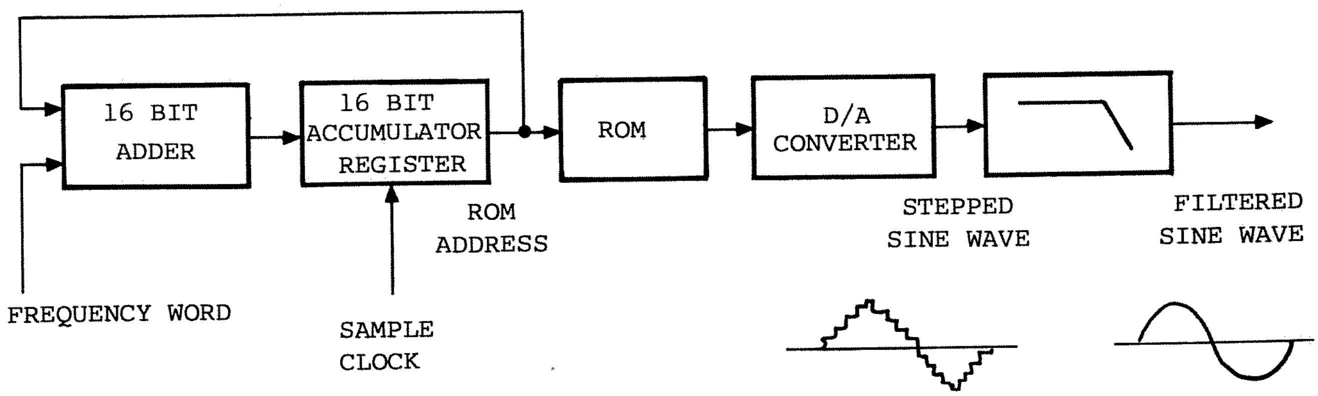

Fig. 3.6 Block diagram of oscillator principle.

waveform cycle. The ROM is addressed by an accumulator whose 16-bit contents at any instant correspond to a sine wave angle. On each clock pulse, the accumulator is incremented by an amount propotional to the desired output frequency. This is accomplished by adding the increment to the previous word and storing the result.

The output of the ROM is applied to a digital-to-analog converter, generating a sampled-and-held stepped sine wave as the accumulator steps the ROM through the indicated addresses. Because the stepping frequency is many times higher than the sine wave frequency, low-pass filtering easily removes the steps to give a clean sine wave.

Clearly, the output frequency is proportional to the speed with which the addressing advances through the sample table stored in the ROM. Higher frequencies thus have fewer samples per cycle. To simplify the filtering, the clock rate was made high enough (65.536 Hz) to generate about 16 samples per cycle at the highest output frequency (4.095 Hz). The clock rate is exactly the number of stored samples (2^{16}) so the lowest output frequency would be 1 Hz and all other frequencies are multiples of 1 Hz. The low end of the instrument's range, however, is restricted to 256 Hz.

In practice, storage of 65.536 (2^{16}) sine wave samples is economically impractical. An immediate four-fold reduction is achieved by storing samples for one quadrant only, and reusing the data appropriately to derive the other quadrants.

A further reduction of significant proportions is achieved by use of the relationship (valid for small B):

$$\sin(A+B) = \sin A + \cos A \sin B$$

Relatively few values of A are used to give coarse angular resolution and small values of B can increment the angles between values of A. The ROM stores 64 magnitude values of sinA equispaced throughout a quadrant which, of course, also gives 64 magnitude values for cosA. Then the ROM has 64 values for sinB magnitude but since negative values of B can be used, these only have to have a range sufficient to interpolate half-way between the values for A. Sign information is supplied by the accumulator register.

Thus, the real-time calculation of each sample value from reduced sine function information enables a ROM of only 64x12 bits to be used.

The principle of calculation is shown in fig. 3.8. Bit 15 (sign) indicates whether the value calculated is positive or negative.

Bit 14 indicates whether cosine or sine of the angle should be calculated, the sines of the quadrants being related as follows:

$$\sin(\pi/2+X) = \cos X \text{ and}$$
$$\sin(\pi + X) = -\sin X$$

Bit 7 indicates whether angle B should be added or subtracted.

(Note that the ROM contains sinA and sinB. CosA and cos(A+B) are found by complementing the address bits of A and B).

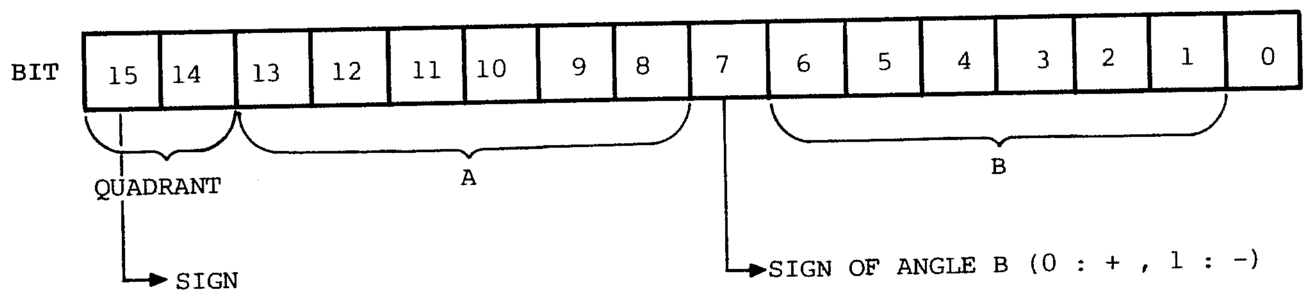

Fig. 3.7 Accumulator Register.

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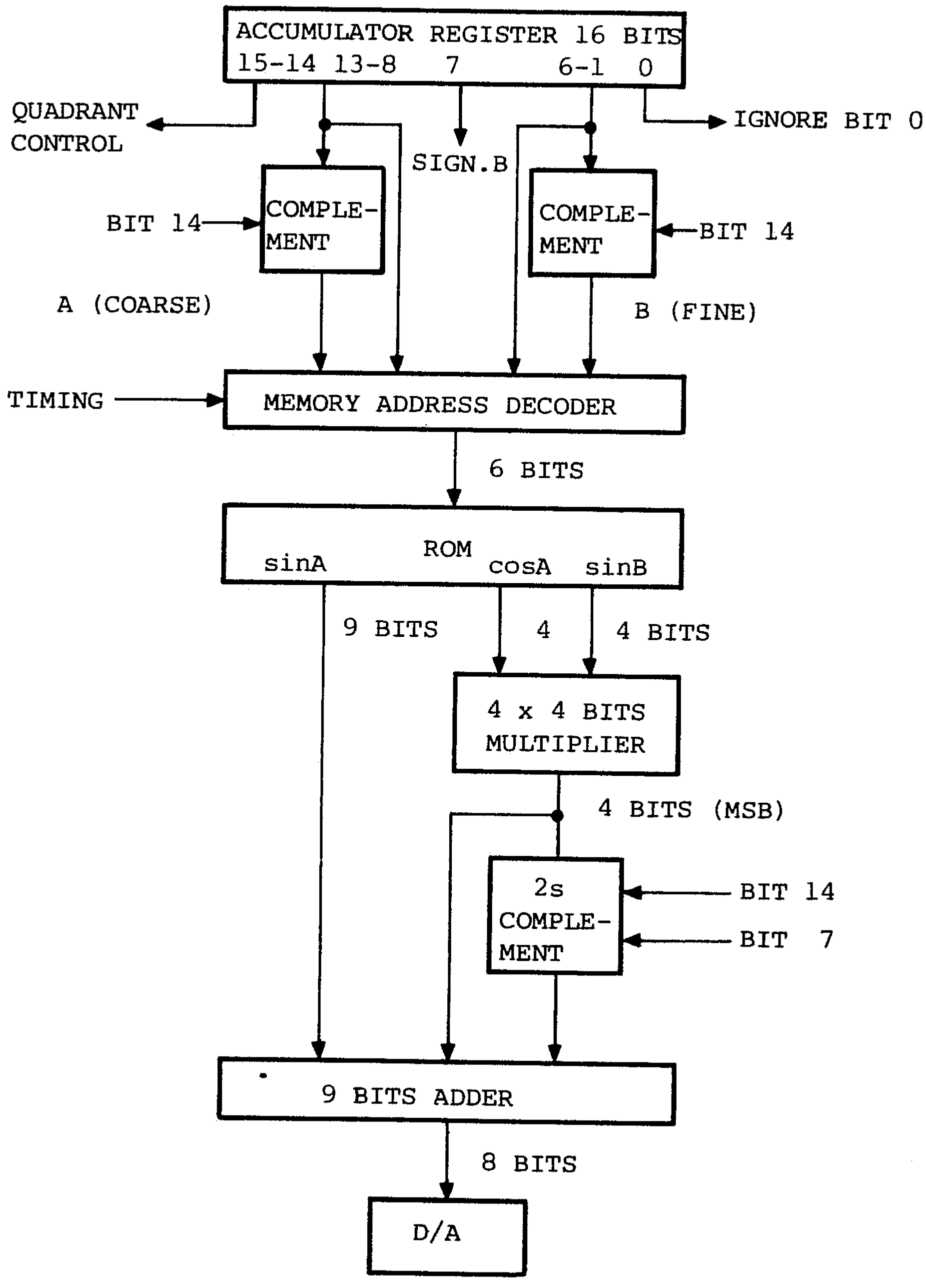

Fig. 3.8 Block diagram showing the principle of calculation of sinA+cosA sinB .

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Hardware

The boards PE and PF contain two digital frequency synthesizers, which, however, use the same calculating circuit. Calculations are controlled by time signals. Interim and final results are stored in registers.

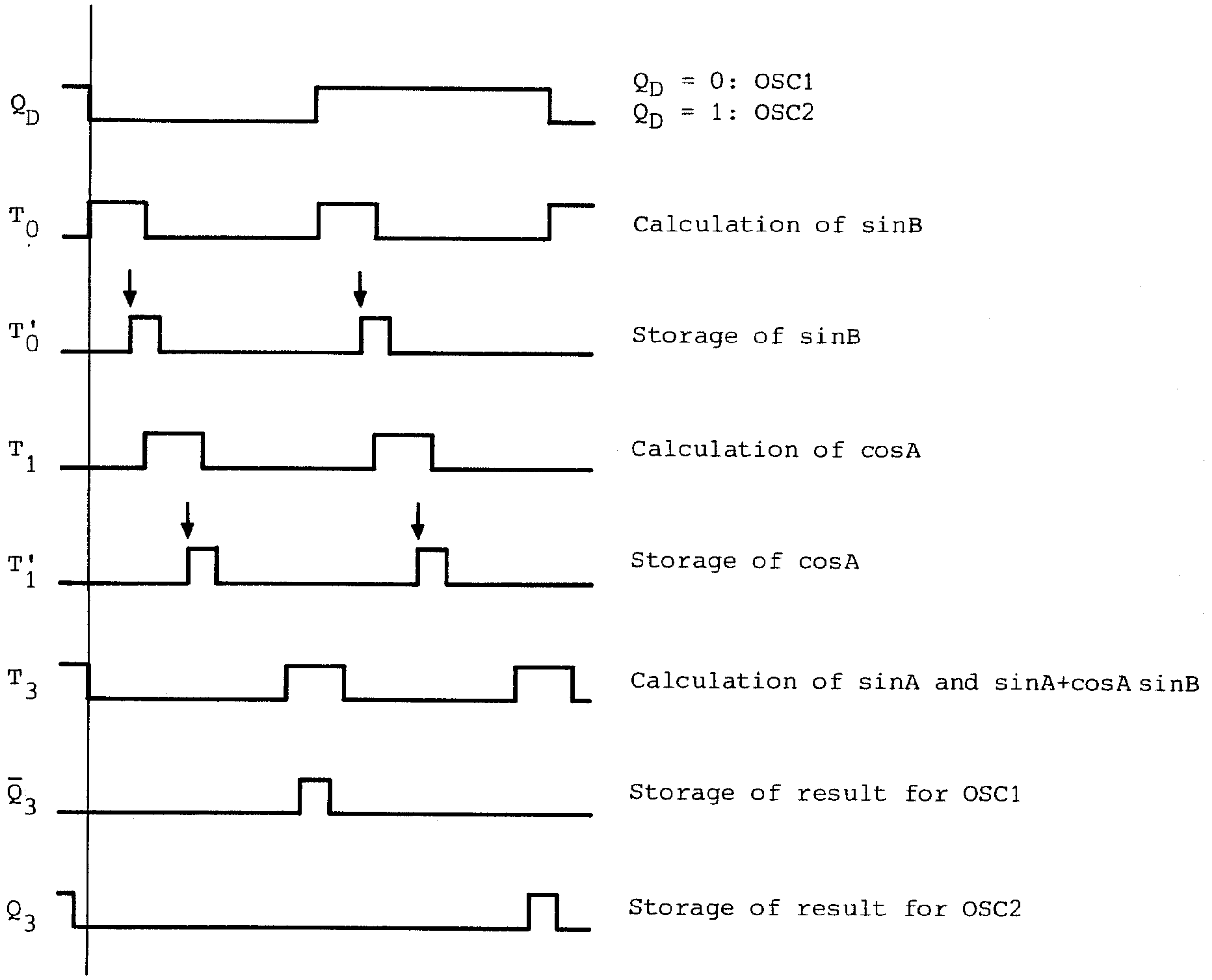

Fig. 3.9 Time diagram for calculation of sinA+cosA sinB .

The board PF contains registers for the two oscillator frequency words, the 16 bits adder, the accumulator register and the memory address decoder.

The frequency words of the two oscillators are written into IC1-6 from the data bus. IC1-6 include output disabling features, and data on the A-bus can thus be controlled by means of Q_D and $\bar{Q}_D$. When $Q_D = 0$, the frequency word of OSC1 will be on the A-bus. Data are written into IC7-IC14 from the output of the 16 bits adder, when sine of the accumulator register word (= adder output) has been calculated, i.e. the input takes place at the end of the period $Q_D/\bar{Q}_D$ (by means of the signal $Q_3/\bar{Q}_3$). IC7-14, too, include output disabling features whereby data on the B-bus are controlled. The address bits for the ROM are decoded in the complement/no complement circuit IC19-22, and addition/subtraction of cosA sinB is indicated as follows (I16):

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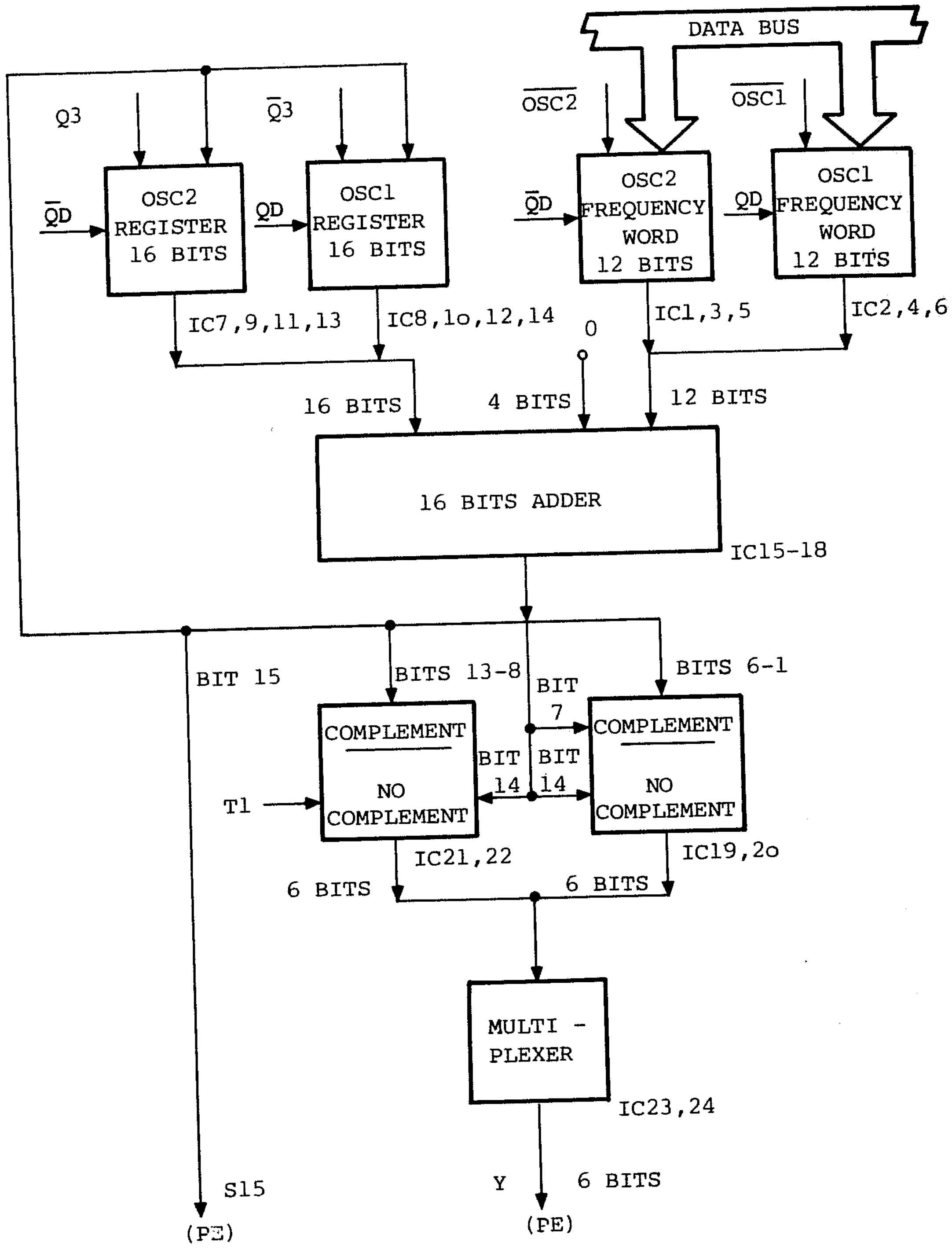

Fig. 3.10 Block diagram of board PF.

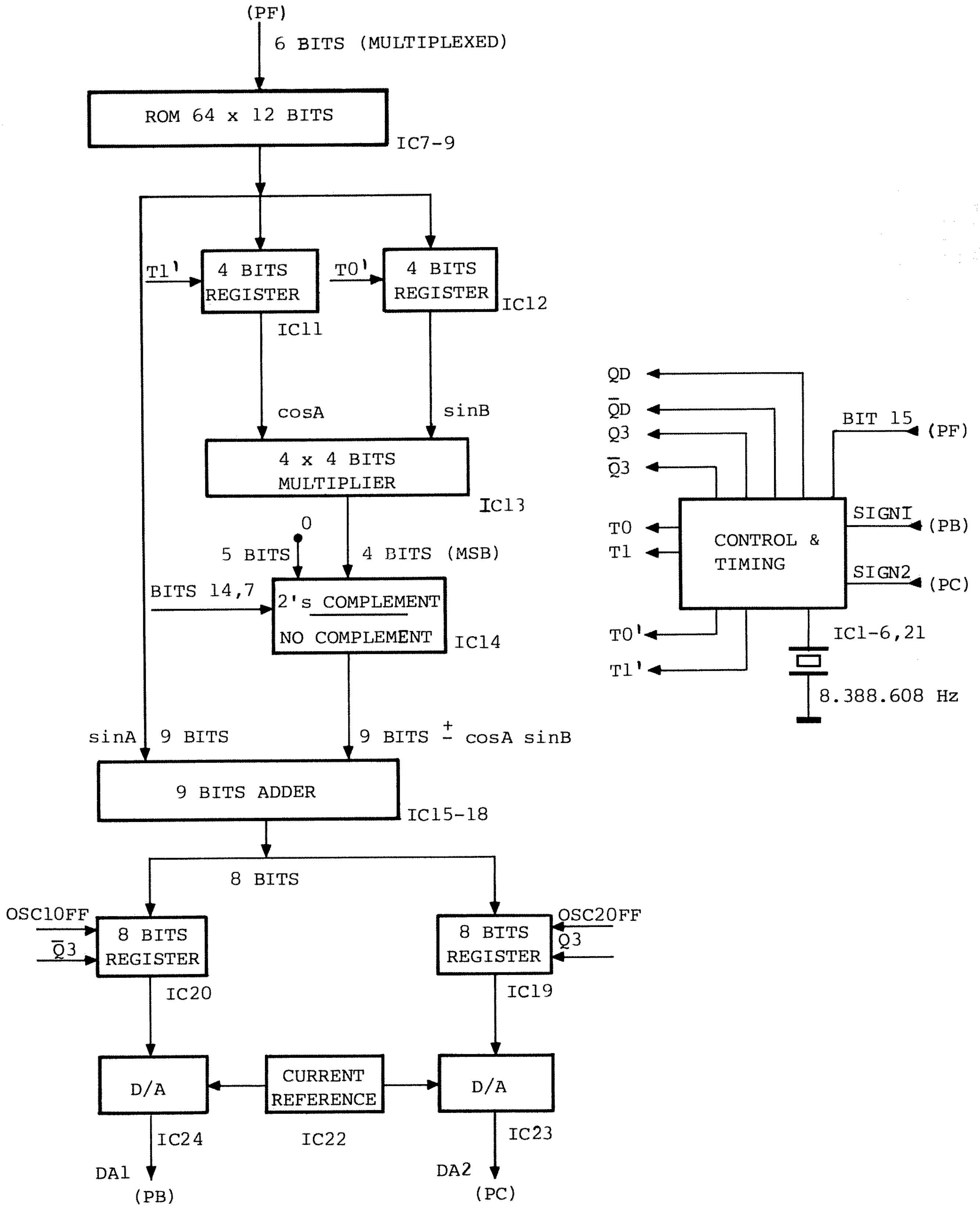

Fig. 3.11 Block diagram of board PE.

Complement of bits 13-8:

b_{14} \ T_1	0	1
0	0	C
1	C	0

T_1 = 1: Calculation of cosA

T_1 = 0: Calculation of sinA

C = Complement

0 = No complement

Complement of bits 6-1 and cosA sinB (= subtraction order):

bits 6-1

b_{14} \ b_7	0	1
0	C	0
1	C	0

I16

b_{14} \ b_7	0	1
0	C	0
1	0	C

The address bits 6-1 (during period T_0) or 13-8 (outside period T_0) are selected by the multiplexers IC23-24.

The board PE contains the circuit for calculation of sinA+cosA sinB, registers and D/A-converters.

The sine ROM consists of 64x12 bits organized as 64x9 bits sinA and 64x3 bits sinB. Each ROM (IC7, 8 and 9) consists of 32x8 bits distributed as indicated in fig. 3.12.

The angle is selected by 6 bits from the memory address decoder, and the rightangle values are put out by means of IC3 and IC10. IC11 is the register for cosA, and IC12 the register for sinB. The four most significant bits of cosA sinB are taken from the 4x4 bits multiplier IC13. Depending on I16, the result is complemented in IC14. IC16 (4 bits adder) will increase the result by the least significant bit of cosA sinB and add the least significant bit of sinA. The result is then added to or subtracted from the 8 bits sinA in IC17 and IC18. The final result is stored in IC19 (OSC2) or IC20 (OSC1) and is D/A-converted in IC23 and IC24 respectively.

The D/A-converters are supplied with reference current from IC22. The maximum values can be adjusted bu means of P1 and P2. The tones can be turned off by means of the signals OSC1OFF and OSC2OFF respectively.

The frequency accuracy is set by the crystal oscillator, and control and timing signals are generated by IC1-6. The sine half-wave sign is written into IC21.

3.5 PRINTED CIRCUIT BOARDS PG, PH:

Microprocessor System

The complete microprocessor system comprises the microprocessor board PG and the memory board PH.

The Board PG consists of a microprocessor, buffers for data and control lines, address latches, decoding circuits for memory and input/output selection, and a display and keyboard control.

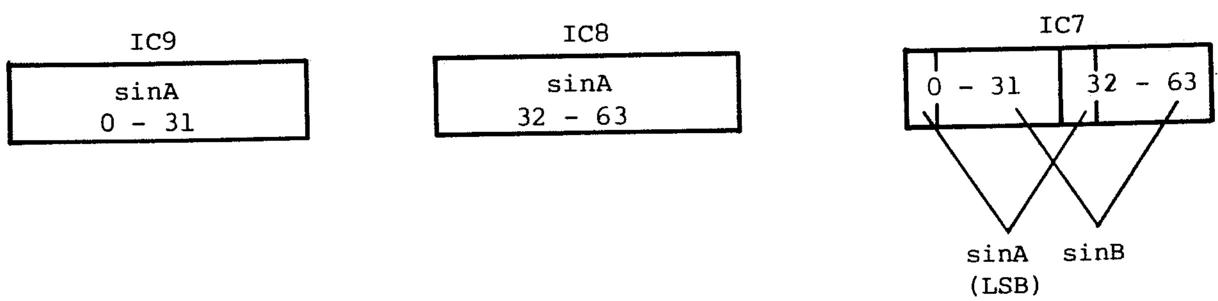

Fig. 3.12 Organization of sinA and sinB in three 32x8 bits ROMs.

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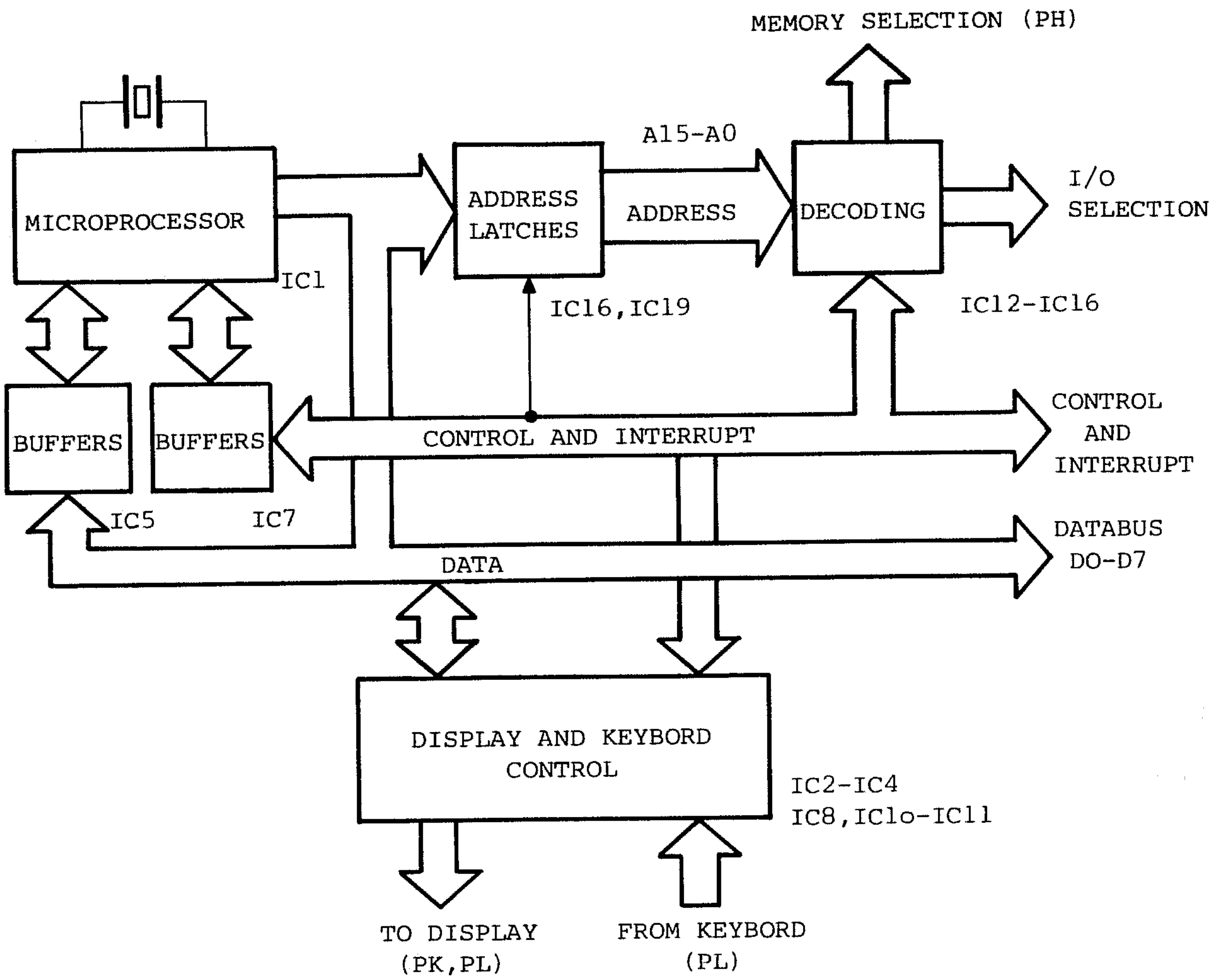

Fig. 3.13 Block diagram of board PG.

The microprocessor IC1 has control and interrupt lines, whose functions are described in section 2. The five control lines CLK, RESET OUT, ALE, $\overline{RD}$, and $\overline{WR}$ are buffered by the driver circuit IC7.

The data bus AD_0-AD_7 is buffered by the bidirectional bus driver IC5, whose direction is controlled by the signal $\overline{RD}$. At the beginning of the machine cycle of the microprocessor, the data bus will contain the 8 least significant address bits A_0 - A_7 (ALE being active). A_0 - A_7 are stored in the data latch IC6, which means that IC6 and IC9 will have 16 address bits at their outputs. The decoding takes place in IC12-IC16 according to the following memory map I/O principle: input or output is interpreted as a memory address. The microprocessor can address up to 64 k bytes. The memory map therefore looks as follows:

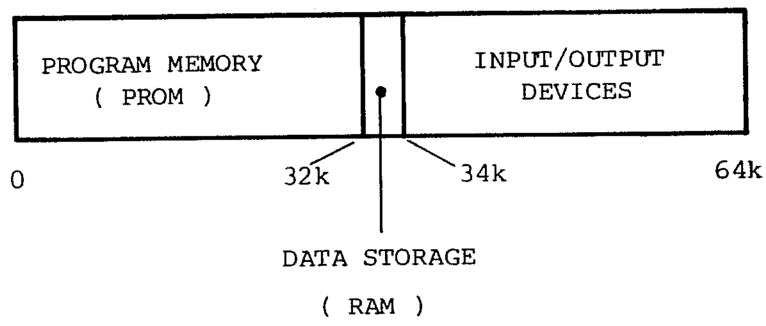

Fig. 3.14 Memory map.

The memory addresses used are as follows:

ADDRESS	NAME
0000H - 3FFFH	Program Memory (16k)
8000H - 87FFH	Data Storage (2k)
	$\overline{\text{RAMØ}}$, $\overline{\text{RAM1}}$
8800H	$\overline{\text{OSC1/Ø}}$
8801H	$\overline{\text{OSC1/1}}$
8802H	$\overline{\text{OSC2/Ø}}$
8803H	$\overline{\text{OSC2/1}}$
8804H	$\overline{\text{GENIN}}$
8805H	$\overline{\text{MEASLO/Ø}}$
8806H	$\overline{\text{MEASLO/1}}$
8807H	$\overline{\text{MEASHI}}$
8C00H	$\overline{\text{ATT1}}$
8C08H	$\overline{\text{ATT2}}$
8C10H	$\overline{\text{IECADR}}$
8C18H	$\overline{\text{IECBUS}}$
8C28H	$\overline{\text{PRENAB}}$
9000H	DIS1D (8279,#1)
9400H	DIS2D (8279,#2)
9800H	DIS3D (8279,#3)

Fig. 3.15 Memory Addresses.

The internal registers of the 8279-circuits are addressed by means of A_{13} in combination with one of the address lines DIS1D, DIS2D or DIS3D.

The Input/Output selection signals from IC13 and IC14 are of the same duration as $\overline{\text{RD}}$ in the case of read-in from inputs. In the case of write-out to outputs, their duration is half a CLK-period shorter than $\overline{\text{WR}}$. This is so in order that data hold time may be long enough for data to be written into the CMOS-circuits. The signal dutation is controlled by IC15 and IC16.

The 8279-circuit is a programmable keyboard and display I/O interface device. The keyboard part provides a scanned interface to a 64 contact key matrix. The display part provides a scanned display interface to a 16x8 bits matrix.

The 8279-circuit reads the keyboard by scanning the RL-lines for ground level, the latter indicating contact making. The address of the active key (0-63) is stored in an internal RAM, which is accessable to the microprocessor. At the same time, an interrupt signal (INTKEY) is sent to the microprocessor. The 8279-circuit automatically checks for contact debouncing and 2-key rollover.

Output to the display is controlled by the scanning lines RS. The 8279-circuit has an internal 16x8 bits RAM, which can be updated by the microprocessor. Data are written out from the RAM to the A- and B-lines, 8 bits at a time, the scanning ratio thus being 1:16. After each write-out, the data are blanked, and $\overline{\text{BD}}$ changes to a low state usable for blanking of displays.

Input from the keyboard is read by IC2 (8279,#1), the keys having the following internal addresses:

Internal address	Key function
0	Rec. Test Auto
1	Function
2	Interruption
3	Hold
4	1
5	2

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Internal address	Key function
6	3
7	A
8	Run
9	Operation Time
10	Release Time
12	4
13	5
14	6
15	B
16	STEP
17	OP. + REL. TIME
18	OP. - REL. TIME
20	7
21	8
22	9
23	C
24	AUX. Level
25	Frequency
27	Load
28	*
29	O
30	#
31	D
32	Gen. Test Auto
33	Level
41	Print

Fig. 3.16 Internal key addresses.

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IC2 contains information for 32 displays in the form of 4 bits BCD. For each scan, two figures are read out, one on the A-lines and one on the B-lines. The displays are addressed as follows:

Scan counter	A	B
0	Deviation OSC2(1)	Freq. series (1)
1	Deviation OSC2(0)	Freq. series (0)
2	LEDS abs./rel.	Oscillator 1 (3)
3	Level (2)	Oscillator 1 (2)
4	Level (1)	Oscillator 1 (1)
5	Level (0)	Oscillator 1 (0)
6	Ind. level 1 (1)	Deviation OSC1 (3)
7	Ind. level 1 (0)	Deviation OSC1 (2)
8	Ind. level 2 (1)	Deviation OSC1 (1)
9	Ind. level 2 (0)	Deviation OSC1 (0)
10	Pulse (2)	Oscillator 2 (3)
11	Pulse (1)	Oscillator 2 (2)
12	Pulse (0)	Oscillator 2 (1)
13	Pause (2)	Oscillator 2 (0)
14	Pause (1)	Deviation OSC2 (3)
15	Pause (0)	Deviation OSC2 (2)

Fig. 3.17 Display addresses in IC2.

IC3 (8279,#2) contains information for result displays, result LEDs, decimal points of displays (whether to flash or not) and LEDs (whether to flash or not), which are addressed as follows:

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	A				B				
Scan counter	3	2	1	0	3	2	1	0	
0					Result (4)				
1					Result (3)				
2					Result (2)				
3					Result (1)				
4					Result (0)				
5	Hz	dBu	ms				ACC.	REJ.	result LEDs
6	8	7	6	5	4	3	2	1	result LEDs
7	Re-mote	Gen. no.	Rec. comb.						result LEDs
8	Flash information for keyboard LEDs:								
		AB	=	1	:	LOAD			
			=	2	:	Gen. Test			
			=	3	:	Rec. Test			
9			=	4	:	STEP/RUN			
10			=	5	:	PRINT			
11			=	6	:	Gen. no.			
			=	7	:	Rec. Comb.			
12	Flash information for decimal points:								
		AB	=	1	:	Frequency series			
			=	2	:	Oscillator 1			
			=	3	:	Level			
			=	4	:	Ind. level 1			
			=	5	:	Ind. level 2			
13		AB	=	1	:	Oscillator 2			
			=	2	:	Deviation OSC1			
			=	3	:	Deviation OSC2			

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The board contains data registers for the printer. The registers consist of 7 data bits for the printing head and 4 control lines.

The pulse/pause ratio of the Receiver Test Output signal is controlled by the signals MODOSC from the rear panel, OSCON from the filter boards PB/PC and BURST from the microprocessor.

The Input Detectors IC8-IC15 are window comparators which are activated by means of the reference voltage $V+_{REF}$ and $V-_{REF}$, if the input voltage is between -1.6 V and 1.6 V. In the case of open input, the pull-up resistor connected to +5 V will pull the input out of the active area. The comparators are protected at the input by resistors and a Zener diode. The value of the latter was chosen so as to achieve as little leakage current as possible. The 16 detected input signals are encoded by the priority encoder IC1/IC4, which, by means of IC2, shows a binary figure 0-15. Out of 16 inputs which may be active, the figure indicates the active one with the highest number.

The multiplexer IC3/IC5 chooses to show either the binary figure from the priority encoder or the real picture of inputs 1-8. The multiplexer is controlled by the signal REC (1-OF-16) from the rear panel.

IC7 (8155) contains three programmable input/output ports, a programmable timer and 1/4 k RAM. IC7 is controlled by the microprocessor. Port A is used as input port for the 8 bits Receiver Test Input signal from the multiplexer IC3/IC5. Port B is used as output port for data to the printer and Port C as input port for data from the printer. Some inputs and outputs are protected against overvoltages from the printer by means of diodes. This version of the instrument does not use the 8155-timer. As, however, this timer has a 4 kHz input signal, it may be activated. By means of strapping, the timer's output signal $\overline{\text{TIMER OUT}}$ may be admitted to INTTIM.

The tones OSC1 and OSC2 and the AUX. SIGNAL are set independently ON/OFF by the Tone Burst Control IC6. The inputs MODOSC1, MODOSC2 and MODAUX from the rear panel are protected by means of PTC-resistors and diodes and will witstand voltages of up to 125 Vrms.

3.7 PRINTED CIRCUIT BOARDS PK, PL

Display and Keyboard

The display board PK, the keyboard board PL and the interface circuits 8279 on the board PG together form a complete control and interface system for the display and keyboard.

The board PK contains displays, result LEDs and cathode drivers for displays and LEDs.

The method of writing out data to displays and result LEDs is decribed in section 3.5 under Printed Circuit Board PG. The scan counters from 8279, #1 and #2 are decoded on the board PL into 1-out-of-16 signals which drive the common cathodes of the displays.

A- and B-data are decoded on the board PL into 7-segment signals, which, together with decoded scanning signals, give information to each individual display.

The decoded scanning signal and the A- and B-data are decoded in the NAND-circuits. The information is passed on to the result LEDs.

IC1-IC6 are cathode drivers capable of yielding up to 1.5 A, which is the maximum amount of current that can be pulled through two displays (each consisting of seven segments and one decimal point) during the presence of a scan value. The diodes D1 and D2 (LEDs for ABSOLUTE and RELATIVE LEVEL) are selected by means of segment-decoding too.

IC43-IC52 select and drive the result LEDs by means of the cathode driver IC6 and data from the A- and B-data buses.

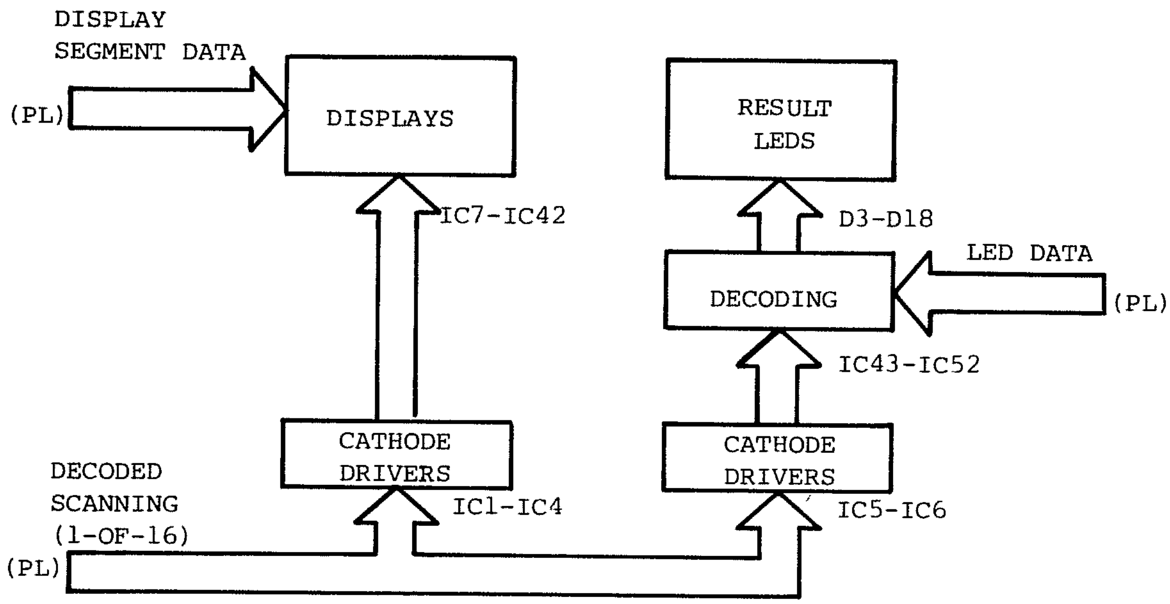

Fig. 3.22 Block diagram of board PK.

The result LEDs are gathered into groups, each group sharing a feeding resistance. This is possible because only one LED at a time of each group can light.

The decimal points of the displays IC7-IC37 may be made to flash by means of data from the board PL. This also applies to the LEDs GEN.NO. and REC.COMB. (D17, D18).

T1 and T2 will cause the decimal point of IC41 of the result display to light when the b- og c-segments light.

The board PL contains the keyboard, key LEDs, decoding for displays, decoding for key and result LEDs and decoding for flashing of key LEDs and decimal points of displays.

The procedures connected with input from the keyboard and output to displays, key LEDs and result LEDs are described in section 3.5 under Printed Circuit Board PG.

The scan counter from 8279, #1 is decoded into 1-out-of-8, which is used in the key matrix to locate the pressed key.

The same scan counter is decoded into 1-out-of-16, which is used on the board PK for selection of displays. The A- and B-buses are decoded by separate 7-segment decoders for the use of displays on the board PK.

The scan counter from 8279, #2 is decoded into 1-out-of-16. The B-bus is decoded by a 7-segment decoder for the use of the five displays of the result display.

The A- and B-buses are transferred to the board PK and decoded for the use of result LEDs.

The eight highest values of the scan counter are used for writing flash information from the A- and B- buses into the registers. The flashing is controlled by a 1 HZ oscillator, which turns off the registers for half the period. During the other half, the oscillator allows the registers to be updated so that the LEDs or decimal points selected will light.

The scan counter from 8279, #3 has already been decoded into 1-out-of-4. The key LEDs may, therefore, be selected directly by the A- and B-buses.

IC19 is a 3-to-8 decoder for the key-

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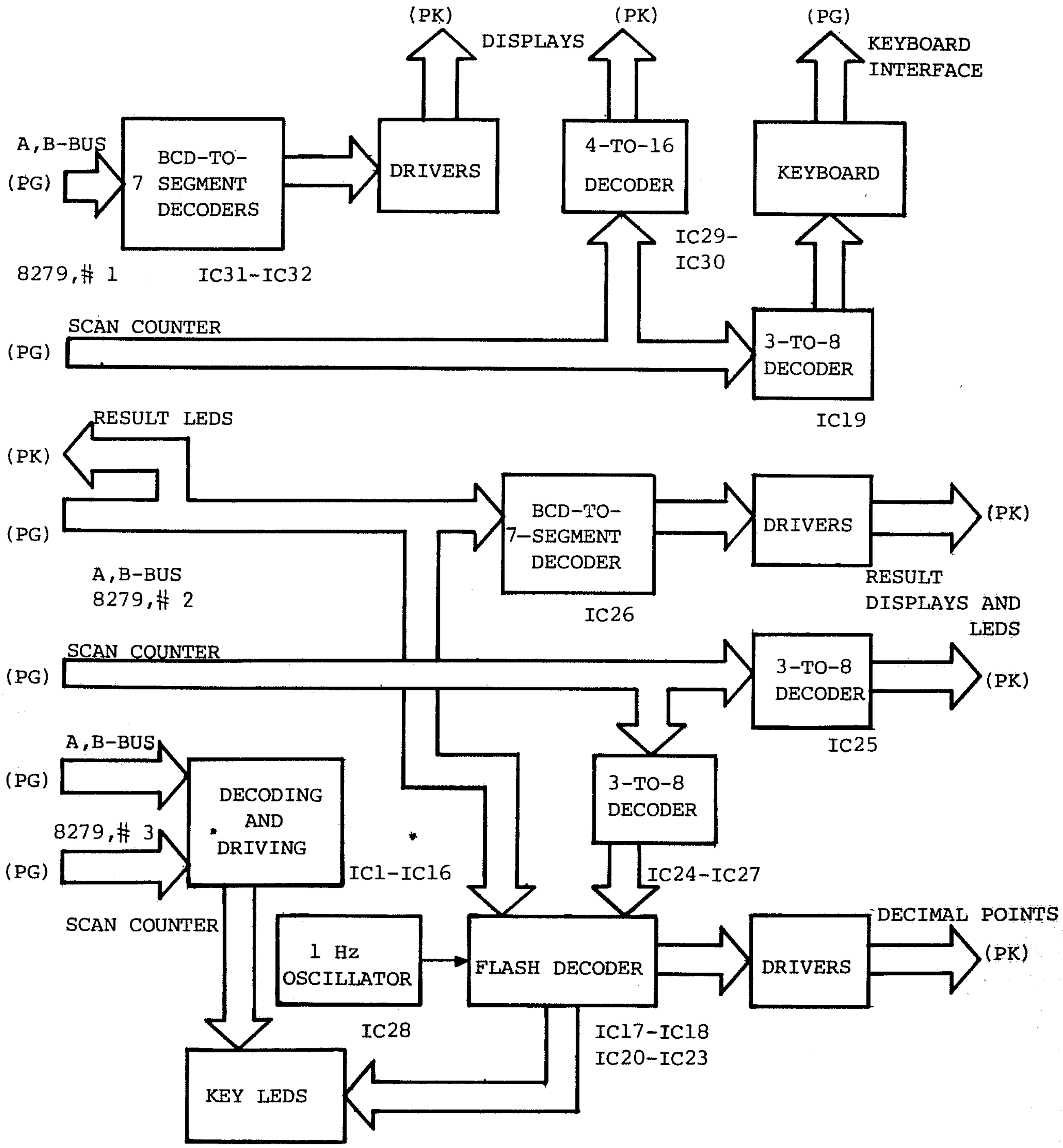

Fig. 3.23 Block diagram of Board PL.

board. The output selected goes low. If a key is pressed, the corresponding RL-line will go low thereby indicating the pressed state to the 8279-interface circuit. The diodes D1-D6 will protect IC19 if two or more keys are pressed at the same time.

IC26, IC31 and IC32 are 7-segment decoders with a constant current output. They drive the display segments by means of the transistors T1-T21 (120 mA/segment).

During change of data on the A- and B-buses, the displays are blanked by means of the $\overline{BD}$-signal at the $\overline{RBO}$-input.

IC29, IC30 and IC25 are 8 bits addressable latches, which are used here as 3-to-8 decoders controlled by scan counters.

IC20, IC21 and IC22 are 8 bits addressable latches too, but are used for decoding of the B-bus. The input is selected by the 3-to-8 decoder IC24. The $\overline{BD}$-pulse is prolonged in IC27 to 220us and is used as trigger pulse for the latches. The flash information is written in by means of addressing on the B-bus.

IC20 provides the key LEDs with flash information, whereas the decimal points of displays receive information from IC21 and IC22.

The decoding and driving of key LEDs are effected in IC1-IC16. The LEDs which can be turned on only one at a time share a feeding resistance.

The board PL also includes the RESET key. The diodes D7-D9 cause the non-active high level on the RESET-line to be rapidly reduced to 0 V when power is turned off.

The POWER key is a 5 V key which can turn on the power supply by means of a small constant-on power circuit.

Note that displays and LEDs have a separate 5 V supply line.

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3.8 PRINTED CIRCUIT BOARDS PM, PU

IEC-Bus Interface

The IEC-Bus interface board PM and the IEC-Bus connector board PU together form a complete interface system between the IEC-Bus and the microprocessor.

IEC-BUS

The IEC-Bus system is defined in detail by the IEC-publication: Standard Interface Systems for Programmable Measuring Apparatus, July, 1974. This standard is very similar to the IEEE-standard 488-1975.

The specification allows three basic functional elements to organize and manage the information interchange among devices:

Listener: a device that can be addressed by an interface message to control its reception of data.

Talker: a device that can be addressed by an interface message to control the transmission of data.

Controller: a device that can address other devices to control their transmission or reception of data and their operating functions.

The bus itself consists of sixteen signal lines in three groups, carrying negative logic signals:

Data bus

Data transfer control bus

Interface management bus

Data Bus

The data bus consists of eight signal lines (DIO1 to DIO8) to carry both interface and device messages. The bus operates in an asynchronous, bidirectional mode. Data is based on the 7-bit ASCII code.

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Data Transfer Control Bus

The three transfer (handshake) lines are used to execute the transfer of each byte of information on the data lines. They allow asynchronous data transfer without timing restrictions being placed on any instrument connected to the bus. The transfer of bytes is accomplished at the speed of the slowest instrument.

NRFD (Not Ready for Data) indicates that all listeners are ready to accept information on the data lines. When NRFD is low, one or more listeners are not ready for data.

NDAC (Not Data Accepted) is high to indicate the acceptance of information on the data lines by all listeners. When NDAC is low, not all listeners have accepted the information.

DAV (Data Valid) indicates the validity of information on the data lines. When DAV is low, the information on the data lines is not valid.

Interface Management Bus

Five lines are provided to control the interface.

ATN (Attention) is driven by the active controller and indicates whether address commands (ATN is low) or data (ATN is high) are being transmitted.

IFC (Interface Clear) is used only by the system controller to initiate the bus by means of the Abort message. When IFC is low, all talkers and listeners are stopped, and control is returned to the system controller.

SRQ (Service Request) is driven low by a device to indicate that it wants the attention of the controller.

EOI (End or Indentify) may be used to indicate the end of an instrument's character sting. When ATN is high, the addressed talker may indicate the end of its data by setting EOI low at the same time that it places the last byte on the data lines.

REN (Remote Enable) is driven by the system controller and is one of the conditions for operating instruments under remote control.

Data Transfer (Handshake)

The transfer of a byte of data is initiated by all listeners, signifying they are ready for data, by setting NRFD high. When the talker recognizes NRFD is high and has placed valid data on the data lines, it sets DAV low. When the listener senses that DAV is low and has finished using the data, it sets NDAC high. Note that the action state, of both NRFD and NDAC is high. Since all instruments on the bus have their corresponding lines connected together, all listeners must be in a high state before those lines go high. This wired AND situation allows a talker to recognize when the slowest listener has accepted a byte of data and is ready for the next byte.

The interface functions and operational sequences are described in detail in the 'Operator's Manual'.

The board PM consists of 1) a dedicated IEC-Bus interface circuit, 2) drivers and receivers for the IEC-Bus lines and 3) interface circuits for the microprocessor.

The dedicated IEC-Bus interface circuit contains hardware interface circuits for the following functions:

- source handshake
- acceptor handshake
- talker
- listener
- service request (serial poll)
- remote/local
- device clear

connections to the microprocessor thus being reduced to 1) two device commands, 2) two two-line data handshakes and 3)

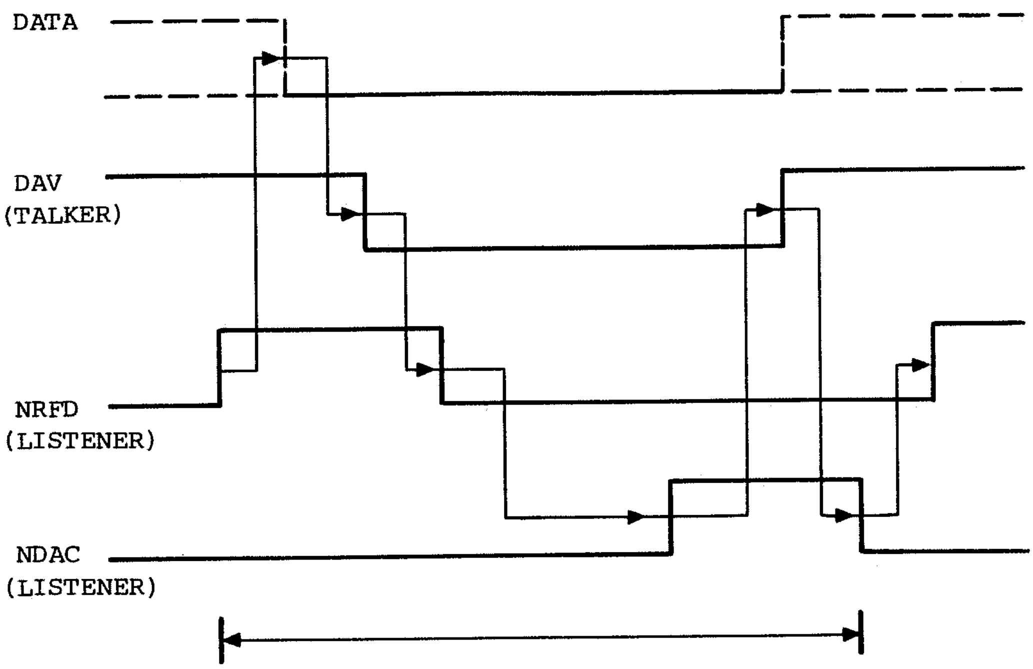

Fig. 3.24 Data transfer.

data inputs and outputs to the transceivers. The two device commands CLEAR and LOCAL, which give interrupt to the microprocessor, are caught in the data latches. By means of the data bus, the two two-line data handshakes are exchanged with the microprocessor, which has direct access to the data lines of the IEC-Bus. The address of the instrument is set by means of switches (rear panel) and read direct by the IEC-Bus interface circuit.

The IEC-Bus interface circuit IC1 (4738) contains inputs and outputs for the five management lines and the three handshaking lines. Only seven out of the eight data lines are necessary as inputs.

By means of the parallel-to-series registeres IC11 and IC12, IC1 can read in information on:

instrument address

request service

The latter may be set by the microprocessor.

The device handshakes are as follows:

dvd (data to device valid) $\overline{\text{rdy}}$ (ready for next byte)	listener
dcd (don't change data) $\overline{\text{nba}}$ (new byte available)	talker

The connection of the device handshakes with the handshake cycles appears from the figures below.

The device handshakes are exchanged with the microprocessor in IC2 and IC5.

The two device commands CLEAR and LOCAL give information about reception of 'Device Clear', 'Placing device in remote' and 'Return device to local'. A change of level at the two outputs CLR and LOC is written into the data latches IC13 and IC14 and may be read by the microprocessor in IC5. At the same time, IC16 gives interrupt to the microprocessor. IC13 and IC14 can be reset by the microprocessor via the decoder IC8.

Data from the IEC-Bus are read in IC6 and IC7, whereas data to the IEC-Bus

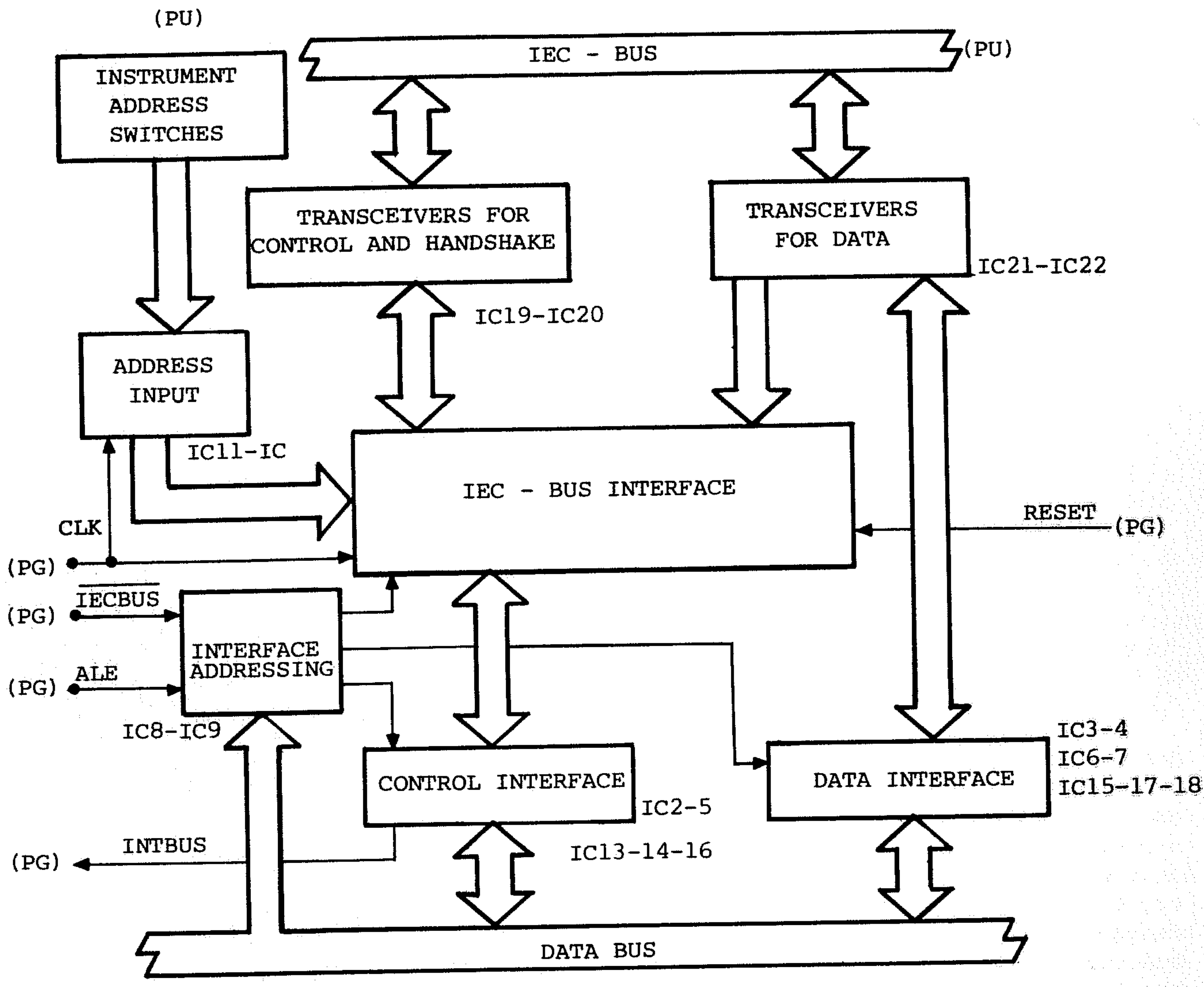

Fig. 3.25 Block diagram of board PM.

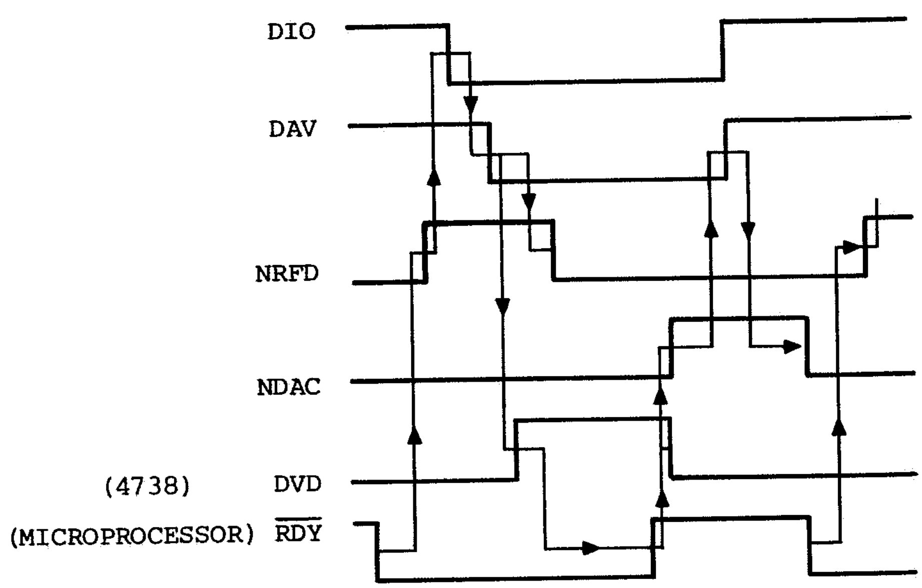

Fig. 3.26 Device handshake (Listener)

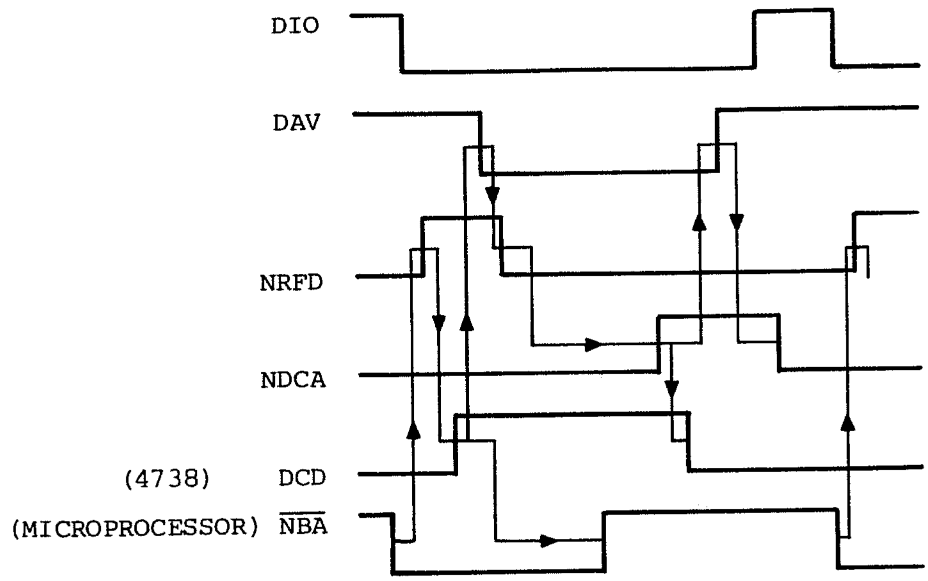

Fig. 3.27 Device handshake (Talker)

are transmitted by IC3 and IC4. Note that the direction of transmission of the data transceivers IC21 and IC22 is controlled by a 4738-output (OTA - talker active) and the ATN-line. The latter may interrupt a transmission asynchronously and get a command through to 4738.

When receiving a service request on the SRQ-line, the controller will execute a serial poll procedure. This causes the 4738-RQS-output to go high thereby indicating that 4738 is in the serial poll mode. If the service request stems from this instrument (in the case of request service, rsv, from the microprocessor), the output SP will be high and set the data output bit 7 (DO7) high via IC17 and IC18. This indicates to the controller that the instrument has sent a service request.

The IEC-Bus lines are terminated according to the IEC-Recommendation.

The Board PU (rear panel) contains 1) the connector for the IEC-Bus and 2) address switches. Note that the ground return of the individual control and status signal lines (pin 18-23) is returned to logic ground, whereas the overall shield of the cable (pin 12) is grounded to chassis.

3.9 PRINTED CIRCUIT BOARD PP

Printer Interface

The printer interface contains timing and driving circuits for controlling the printer.

The printer prints characters constituting 7x5 dot matrix structures. This is effected by means of a 7x1 dot printing head performing horizontal scanning operations. Metallised paper is used for the printing. Besides the printing head, the printer contains a DC-motor, a reed switch for indication of the beginning of a line and a pick-up coil for indication of the printing head's position. The printer has automatic paper feed.

The board PP controls the printer by means of data from the microprocessor. The DC-motor is started by the signal MOTOR. By means of the signal MSTATUS, the microprocessor can read whether the motor is running or not. When the motor has brought the printing head to the beginning of a line, the reed switch will close, thereby indicating on the line PSTATUS that the printing process may begin.

The printing of a dot column begins by the microprocessor writing out dot information to the data latches. At the same time, the pulse width regulator

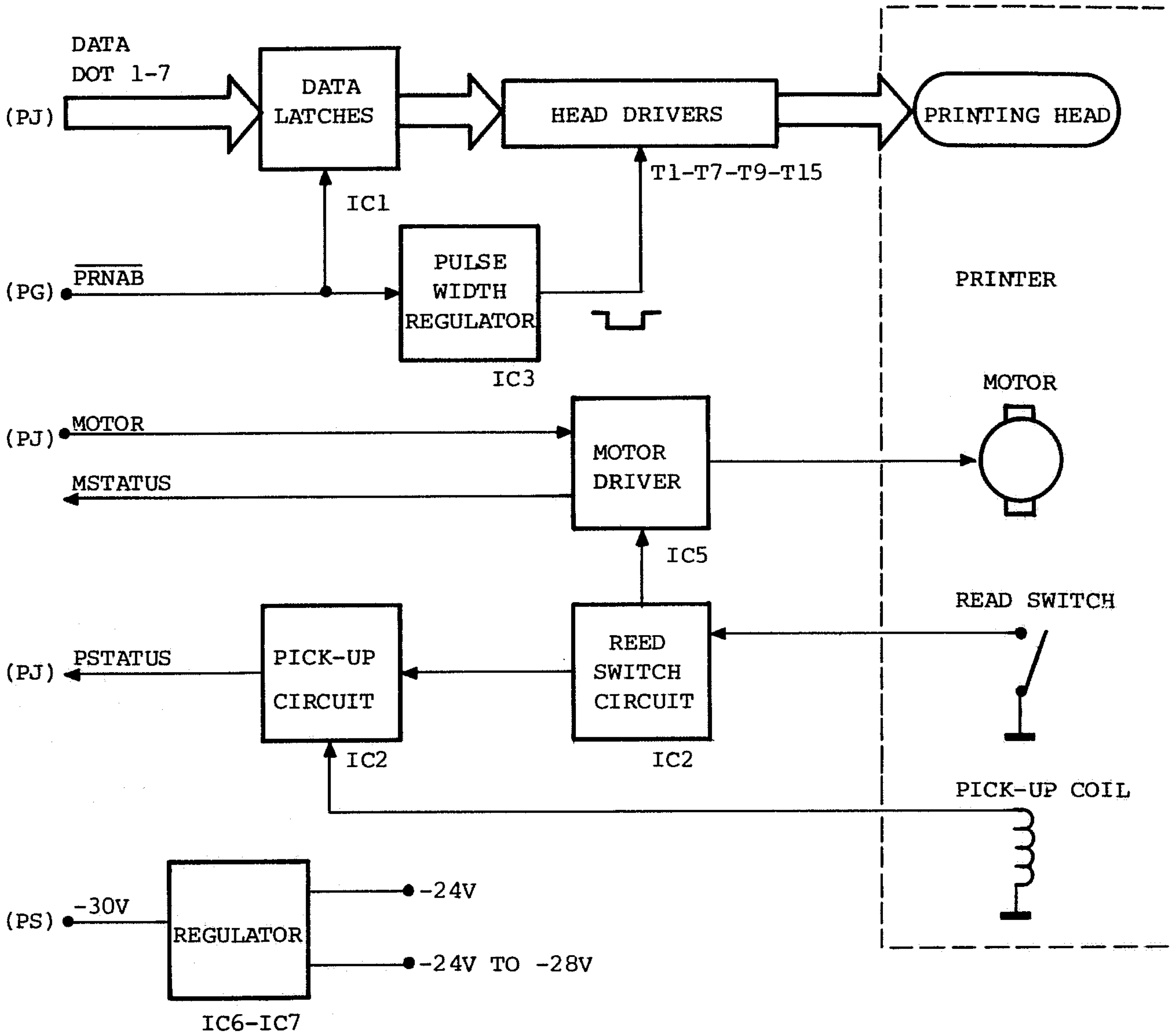

Fig. 3.28 Block diagram of board PP.

sends a 350us signal, thus allowing the printing head 350us to print a dot column. The microprocessor then waits for the pick-up coil to signal (about 350us later) that the next dot column is ready for printing.

One line has 20 characters (each character consists of five dot columns and two space columns).

This board also contains a voltage regulator for the motor (-24 V) and a variable regulator for the printing head (-24 V to -28 V).

The motor is started by means of T19, IC4 and T8. R55 ensures that the motor does not start if the line MOTOR is three-stated. When the reed switch closes, it will keep the motor running by means of IC4 and IC5. The MOTOR signal can thus go off as soon as the reed switch closes.

When power is turned on, T20 will keep the MOTOR signal low to avoid the motor being started unintentionally.

The pulse width regulator is a monostable multivibrator, which is started by the same signal which writes out dot information to the data latches (PRENAB). The pulse width is 350 us.

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The pick-up coil signals every 1.1 ms by means of T18 and IC4. In IC2, the frequency is divided by 2, which means that PSTATUS is a square-wave signal with a 2.2 ms period.

The regulator IC7 supplies the motor with -24 V, whereas the regulator IC6 supplies the printing head with voltage. By adjusting the regulator voltage, the printing intensity may be varied. D2 protects the 5 V supply line against the overvoltage which may occur when the printer module is inserted.

This insertion is indicated to the microprocessor by the terminal PINSERT.

3.10 PRINTED CIRCUIT BOARDS PR, PS, PT

Power Supply

The rectifier board PR, the regulator board PS, the switch-mode power supply board PT and the transformer module together constitute the complete power supply system.

The transformer module is a unit embedding a transformer, a fuse, a switch for 110 V, 127 V, 220 V and 240 V, a mains choke filter and a power socket. Direct contact with the mains voltage is there-

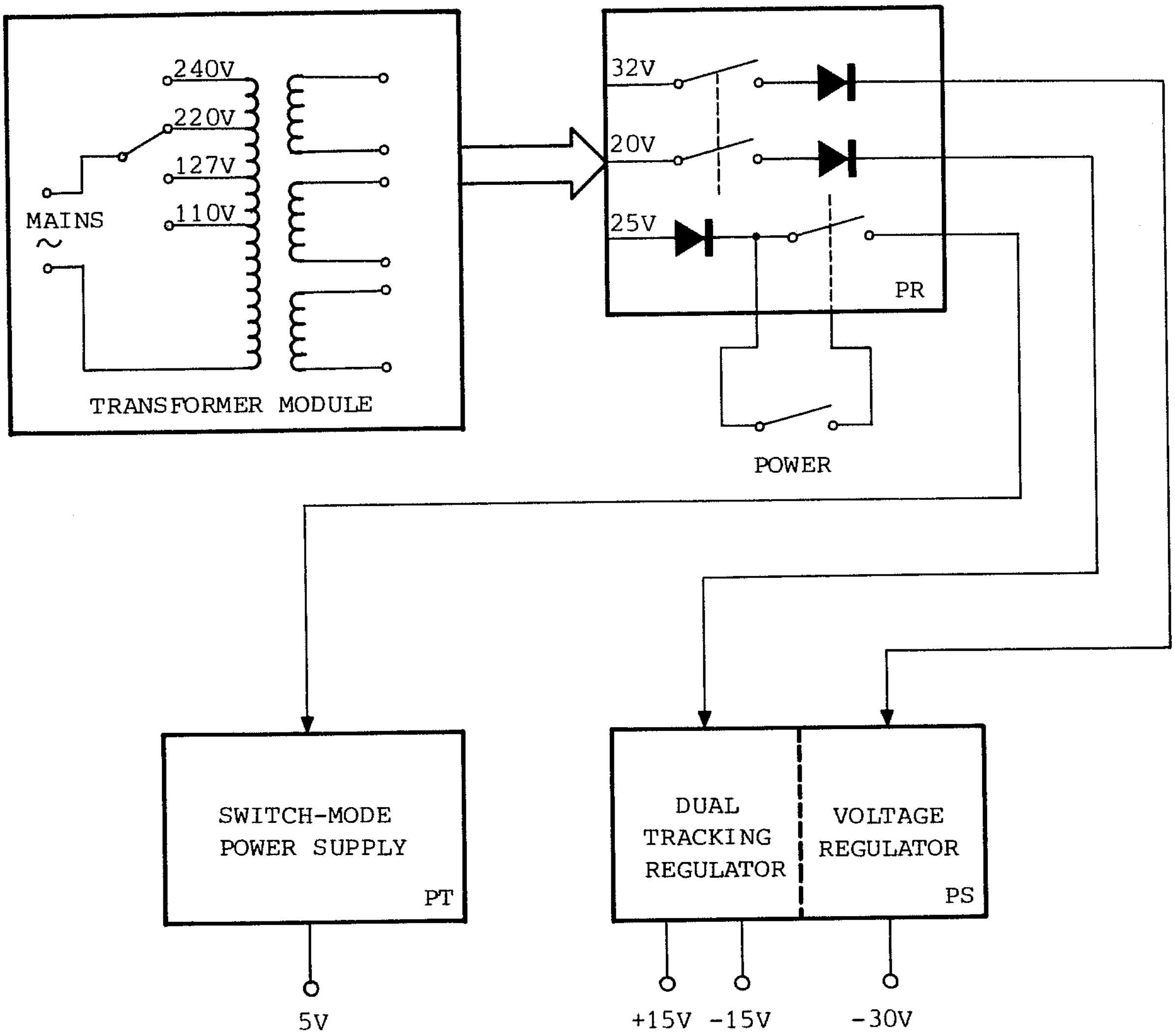

Fig. 3.29 Block diagram of power supply system.

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by avoided. The secondary voltages of the transformer are passed from the module to the board PR. By means of a power key and a relay, the rectified 25 V voltage can control the connection of the secondary voltages to the power supply. This means that there is a constant voltage on the transformer. The consumption of power when the secondary voltages are disconnected is, however, minimal. Voltage on the transformer in the power-off condition is indicated by the LED STAND BY, whereas the power-on condition is indicated by the LED POWER. On the board PS, the voltages -32 V and ±20 V are regulated to -30 V and ±15 V respectively. On the board PT, the voltage 25 V is regulated to 5 V.

The board PR contains 1) a relay for connection of secondary voltages, 2) rectifiers and 3) smoothing capacitors.

Because the relay RE1 is placed on the secondary side of the transformer, therefore breaking high currents, RC-filters are inserted across the secondary windings to protect the contacts of the relay. Two different grounds lead from the transformer: digital ground D.GND (+5, -30 V) and analog ground A.GND (±15 V). They are connected at only one point in the instrument.

The secondary windings are supplied with a fuse for each voltage. The +15 V and -15 V fuses are overdimensioned to 1.25 A (0.3 A would suffice) to keep the fuse resistance down at an acceptable level (0.2 Ω).

The board PS contains voltage regulators for -30 V and ± 15 V.

The -30 V regulator comprises the Zener diode D15 and the transistor configuration T1 and T2. The -30 V voltage contains a ripple voltage, which is filtered by the regulators on the board PP.

In case of short circuit of -30 V to ground, R8 will limit the base current to T1 until the fuse S4 blows.

The bleeder resistor R9 will decrease the -30 V voltage to 0 V when the power supply is turned off.

±15 V regulation is effected by means of IC1, which is a dual tracking regulator. Output currents are increased by means of the booster transistors T3 and T4. Limitation of current to 250 mA is effected by means of the resistors R12 and R13.

The correct output voltages are set by the potentiometer P1.

The board PT contains switch-mode regulation for generation of 5 V, and overvoltage protection to the 5 V output.

The principle of the switch-mode regulation is that the switch T1 will close for so long that the energy taken from the 25 V voltage corresponds exactly to the energy supplied to the 5 V voltage. The length of time during which the switch is closed depends, therefore, on the voltage (5 V) and the current supplied by that voltage. The length of timeis controlled by the switch control IC1. On the other side of the switch T1, the 25 V voltage will appear as a square-wave signal, which is smoothes by the coil L1 and the capacitor C6. When the switch is open, the diode D2 constitutes the return path of the current to L1. If the output voltage exceeds 6.5 V, the overvoltage protection is activated. The switch D1 thereby becomes active and causes the fuse S1 to blow.

IC1 works as a comparator, comparing the output voltage with an internal reference voltage of 5 V. If the output voltage exceeds 5 V, the switch opens. It will close again when the voltage falls under 5 V. To prevent the hysteresis of the comparator from appearing at the 5 V output, it is formed as follows:

In the on-condition of the switch, current flows from the base of T2 into IC1 and out again through R9 and R8 to the 5 V output. IC1 keeps the current through R9 at a constant level until the switch is off-stated, whereby the current of R9 falls to zero. This means that the pin 1 has a square-wave voltage corresponding to the

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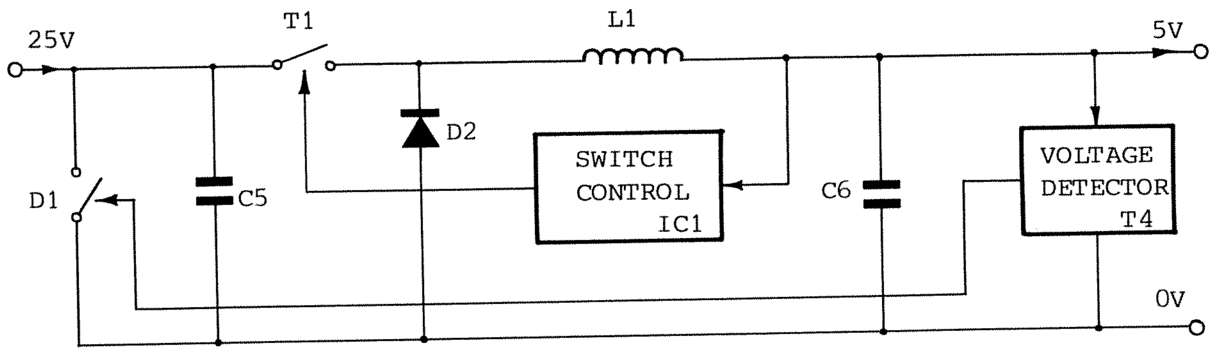


Fig. 3.30 Block diagram of board PT.

square-wave signal of the switch. C2 transfers the square-wave signal to the reference voltage, whereby the hysteresis effect is achieved without the hysteresis being present at the 5 V output.

The output voltage is adjusted to 5 V by means of P1.

The switching frequency is determined by L1, R1, R8 and is approx. 20 kHz.

T3 and R1 function as a current limiter by removing the current for the switch if the output current exceeds approx. 6 A.

The Zener diodes D4 and D5 ensure that the switch-mode regulator does not start before the input voltage exceeds 15 V.

Overvoltage protection is effected by T4 enabling the thyristor D1 to blow the fuse S1.

3.11 PRINTED CIRCUET BOARD PN

Motherboard

The board PN contains the connections between printed circuit boards, connectors for the front and rear terminals and connectors for the printer and power supply.

Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			CARBON FILM RESISTORS type CR25, 0.33W $\pm$5%	
R1	1		100R 2322-211-13101	Philips
R3	1		3K3 13332	"
R4	1		47K 13473	"
R7,8	2		4K7 13472	"
R9	1		100K 13104	"
R20	1		33K 13333	"
R22	1		4R7 13478	"
R23	1		10K 13103	"
R25	1		1K5 13152	"
R29	1		4K7 13472	"
R30,31	2		1K 13102	"
			METAL FILM RESISTORS type MR25, 0.4W $\pm$1%	
R5,6	2		53K6 2322-151-55363	Philips
R13,17	2		5R76 55768	"
R18	1		33K2 53323	"
R19	1		32K4 53243	"
R24	1		54K9 55493	"
R26	1		15R4 51549	"
R27	1		90R9 59099	"
R28	1		95R3 59539	"
			METAL FILM RESISTORS type MR24E, 0,1%	
R10,11, 14,15	4		33K20 2322-160-43323	Philips
R12,16	2		422R0 44221	"
			RESISTOR NETWORK	
IC8	1		220K 4310R-101-224	Bourns
			WIRE WOUND RESISTORS type 280, 2W, 0,5%	
R2,21	2		604R	Diplomatic
			NTC RESISTOR	
R32			15R 2322-642-1159	Philips
			POTENTIOMETERS CERMET	
P1,2	2		10K 3399W-1-103	Bourns
P3	1		5K 3299W-1-502	"
P4	1		2K 3299W-1-202	"

6-3-218 PA Output Amp./Input Selec.
Electrical Parts List I

ELMI A/S
COPENHAGEN DENMARK

Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			METALLIZED POLYESTER CAPACITORS	
C1,6,7	3		6,8 uF 2222-344-21685	Philips
C2,8,9	3		0,47 uF 21474	"
			CERAMIC PLATE CAPACITORS	
C4	1		220 pF 2222-638-52221	Philips
C5	1		100 pF 52101	"
C10-14	5		100 nF B37449-6104-S2	Siemens
			ELECTROLYTE TANTAL, CAPACITORS	
C3	1		4,7 uF, 10V serie 150D	Sprague
C15-17	3		10 uF, 20V serie 150D	"
			INTEGRATED CIRCUITS	
IC1,2	2		CA 3140 S	RCA
IC3	1		LF 13331 D	National
IC4,5	2		CD 4042 BF	RCA
IC6	1		CD 4028 BF	"
IC7	1		ULN 2004 J	Texas
			DIODES, SILICIUM	
D1-7 D9-11	10		1N 4448	Texas
			ZENER DIODE	
D8	1		BZX 79C22, 22V	Philips
			TRANSISTORS	
T1	1		BC 337-40	Siemens
T2,3	2		BDX 86B	"
			TRANSFORMERS	
TR1	1		type o,32 KP. 14.786	J. Schou
TR2	1		type 1,25 KP. 14.731	"
			RELAYS	
RE1-7	7		RA 3031 2051	Electrol
RE8	1		REL 14-A0-1W 5.2P	Erni
RE9-12	4		HE 721 A0 500	Hamlin

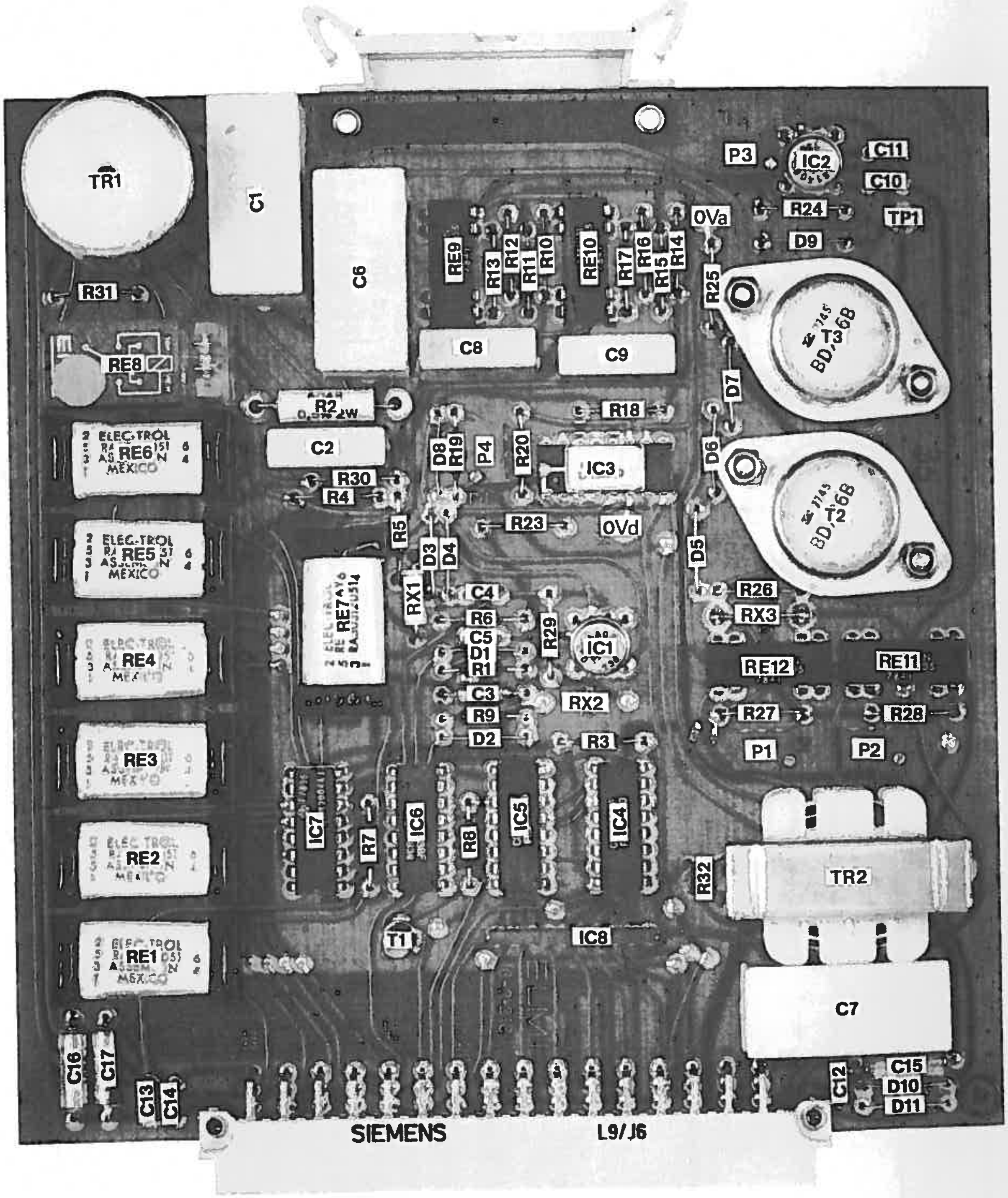
6-3-218 PA Output Amp./Input Selec.
Electrical Parts List II

ELMI A/S COPENHAGEN DENMARK

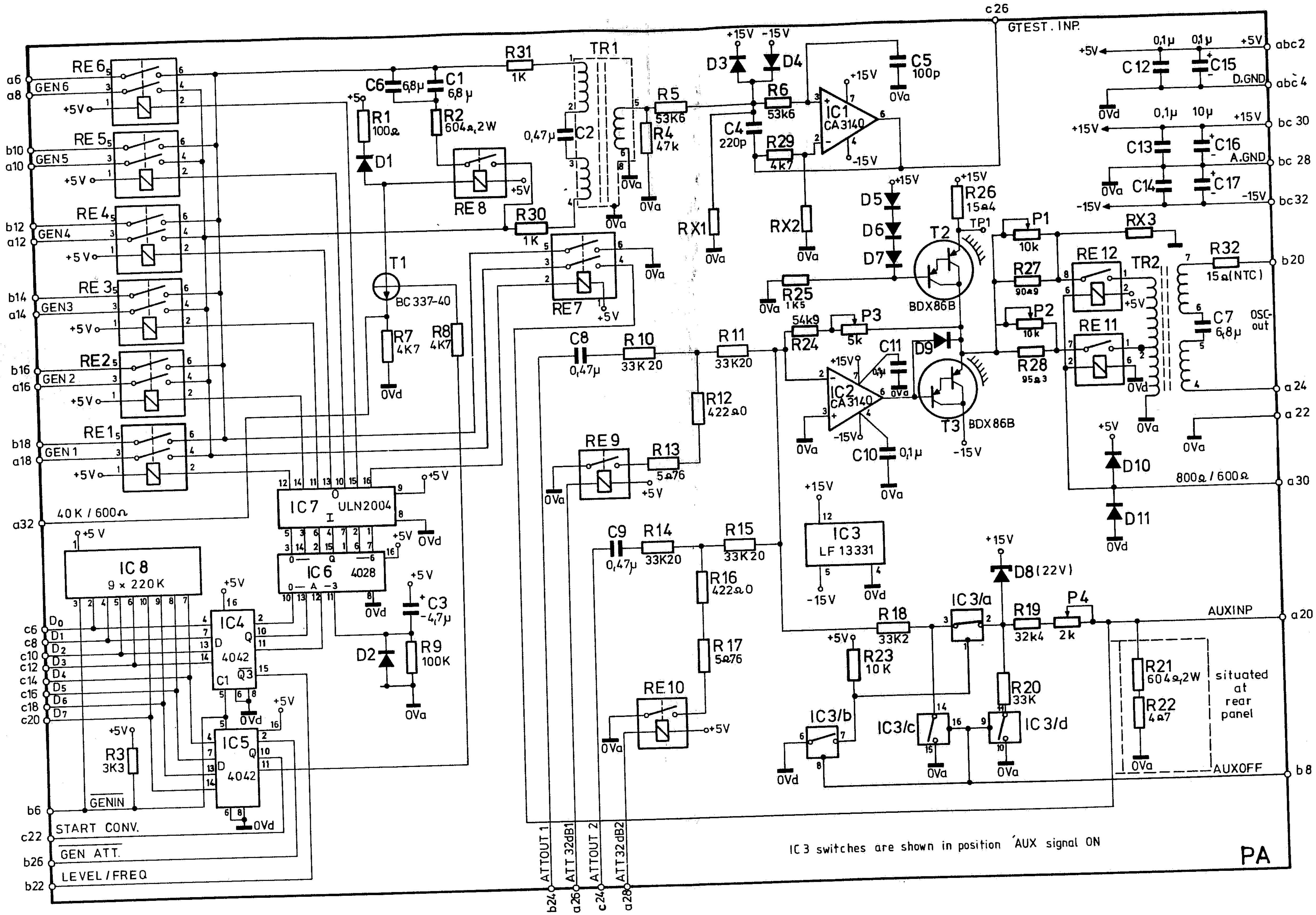
Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			CONNECTOR	
	1		C 42334-A191-A701	Siemens
	1	6-3-218	Printed Circuit Board	Elmi

6-3-218 PA Output Amp./Input Selec.
Electrical Parts List III

ELMI
COPENHAGEN DENMARK

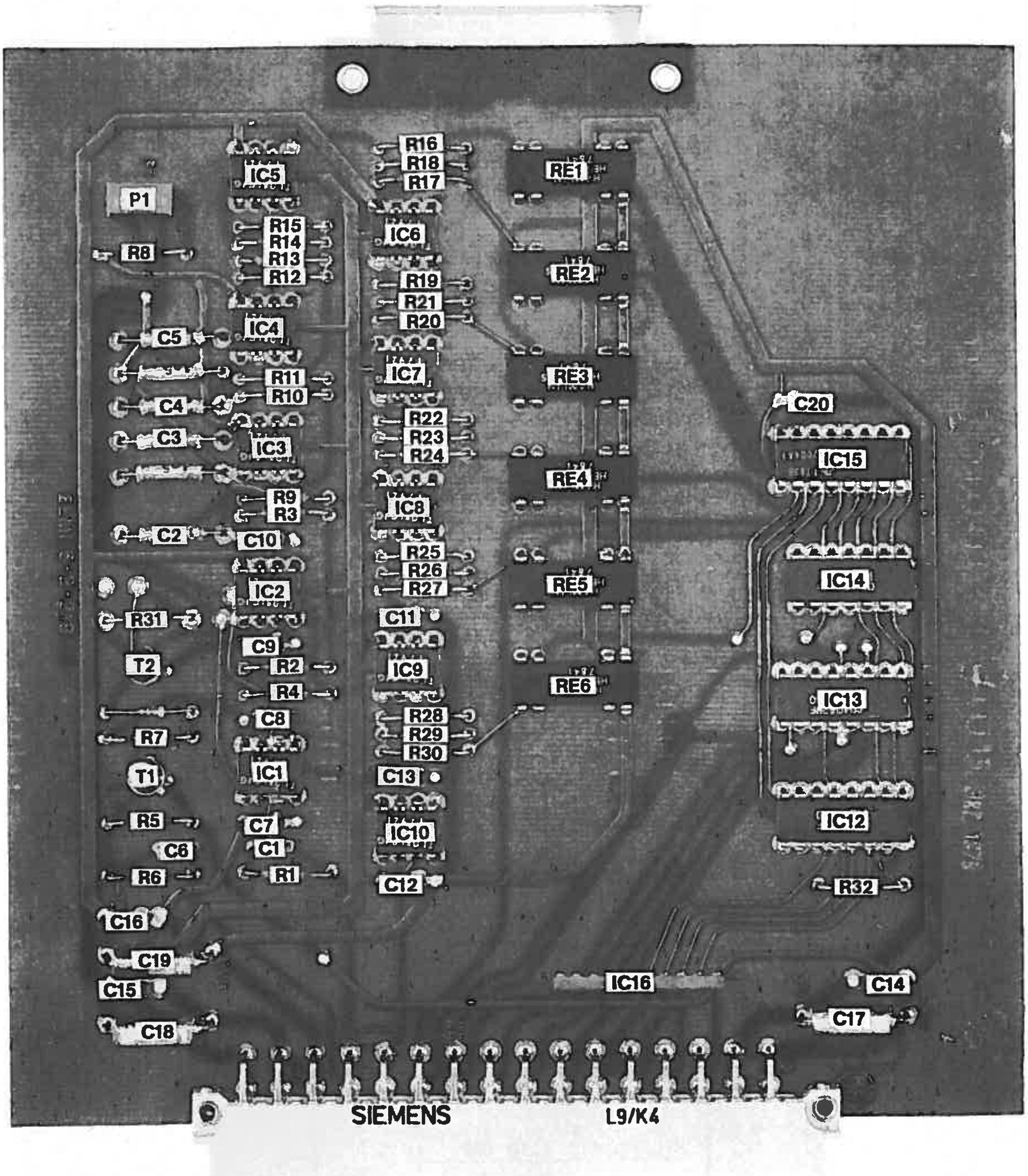


6-3-218 PA Output Amp./Input Selec.
Electrical Parts Location

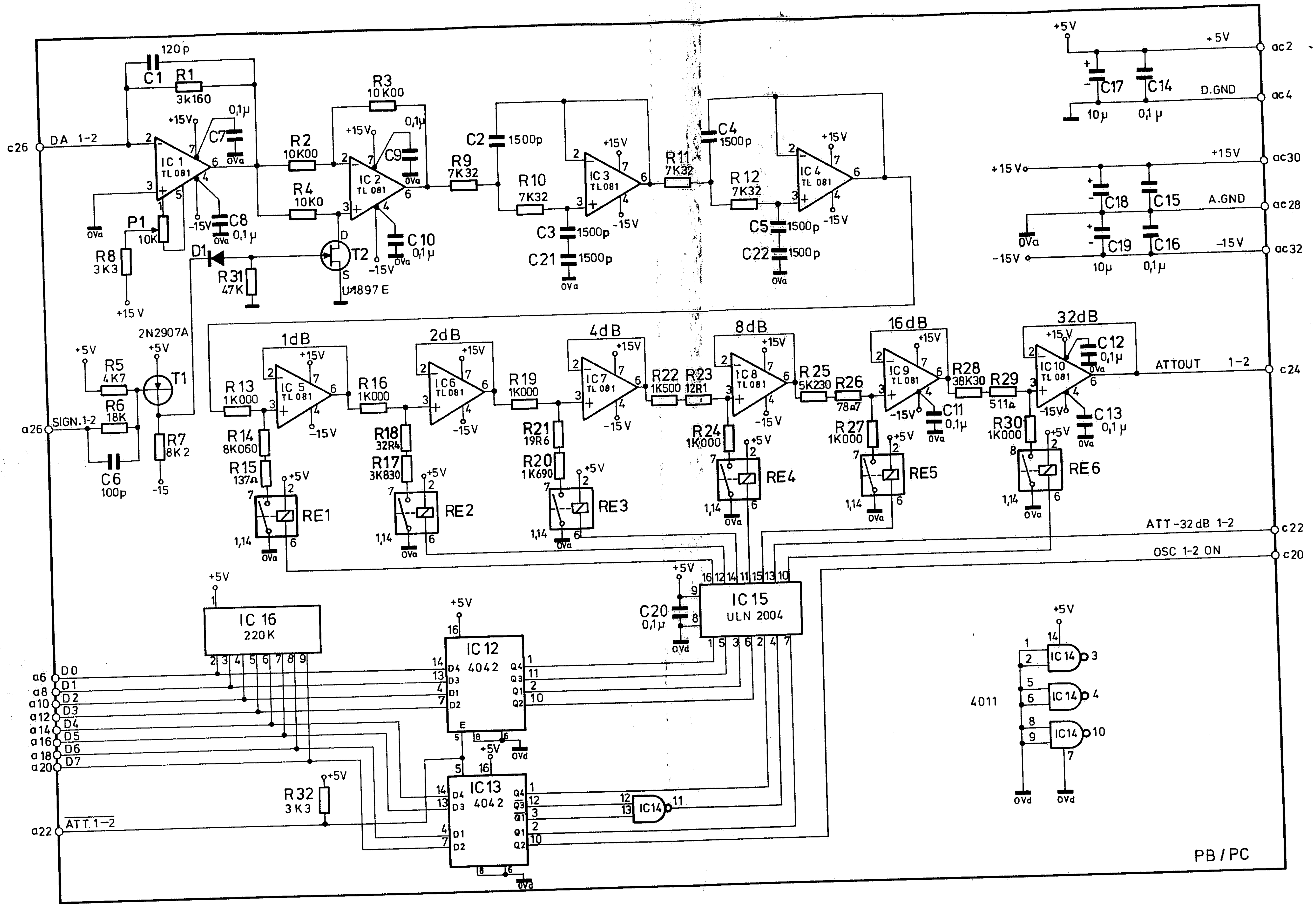


6-3-218 PA Output Amp./Input Selec.
Circuit Diagram

ELMI A/S
COPENHAGEN DENMARK



6-3-219 PB PC Attenuator
Electrical Parts Location



6-3-219 PB PC Attenuator
Circuit Diagram

ZTEK 75302

212-1179

Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			CARBON FILM RESISTORS type CR25 0.33W ±5%	
R1,13 47,49	4		10K 2322-211-13103	Philips
R2	1		100K 13104	"
R10,26 28,29	4		27K 13273	"
R11,15 23,25,38	5		2K2 13222	"
R12,20 24,39	4		4K7 13472	"
R27	1		1M 13105	"
R30	1		15K 13153	"
R35	1		39K 13393	"
R36	1		12K 13123	"
R37,46 48,58	4		1K 13102	"
R50-55 57,61-64	11		3K3 13332	"
R56	1		220K 13224	"
R59,60	2		1K 13102	"
			METAL FILM RESISTORS type MR25 ±1%	
R8	1		28K7 2322-151-52873	Philips
R9	1		56K2 55623	"
R14,16	2		10K0 51003	"
R17,18	2		22K6 52263	"
R21	1		787R 57871	"
R22	1		24K3 52433	"
R32	1		2K87 52862	"
R40	1		8K06 58062	"
R41	1		6K65 56652	"
R42	1		34R8 53489	"
R43	1		274R 52741	"
R44	1		14K7 51473	"
R45	1		316R 53161	"
			METAL FILM RESISTORS type MR 24E 0,1%	
R6	1		10K00 2322-160-41003	Philips
			METAL FILM RESISTORS type MR 34E 0,1%	
R7	1		165K0 2322-163-41654	Philips
			POTENTIOMETER CERMET	
P1-3	3		10K 3299W-1-103	Bourns
			CERAMIC CAPACITORS	
C12	1		100 pF 2222-638-10101	Philips
C13	1		33 pF 10339	"

6-3-220 PD Generator Test
Electrical Parts List I

ELMI A/S
COPENHAGEN DENMARK

Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			CERAMIC CAPACITORS	
C21	1		1 nF 2222-630-03102	Philips
C10,11 15-17, 22-28	12		100 nF B37449-6104-S2	Siemens
			PROPYLENE CAPACITORS ±2%	
C3-6	4		100 nF PHE 425 CB 515 G	RIFA
C8	1		15 nF PHE 425 DB 515 G	"
			MICA CONDENSATOR	
C9	1		4700 pF, BF 53.2, 4700/1/250	R. JAHRE
			ELECTROLYTE CAPACITORS TANTAL	
C7,18-20	4		10 uF, 20V type 150D	Sprague
			INTEGRATED CIRCUITS	
IC1,2, 4,5	4		TL 081 CJG	Texas
IC3	1		CA 3140 S	RCA
IC6	1		VFC 32 BM	Burr-Brown
IC7	1		LM 339 J	National
IC9	1		CD 4001 BF	RCA
IC10	1		74 LS 14 J	Texas
IC11	1		74 LS 00 J	"
IC12,13 15	3		74 LS 161 J	"
IC14	1		74 LS 76 J	"
IC16,17	2		CD 4040 BF	RCA
IC18-21	4		MM 80C 97 J	National
IC22	1		74 LS 93 J	Texas
IC23	1		CD 4518 BF	RCA
			DIODES SILICIUM	
D1-3	3		1N4448	Texas
			DIODE GEMANIUM	
D4	1		SFD 129 B	Sescosem
			TRANSISTORS	
T1,2,5	3		2N2222A	Siemens
T3	1		2N2907A	"
T4	1		2N4303	Amelco

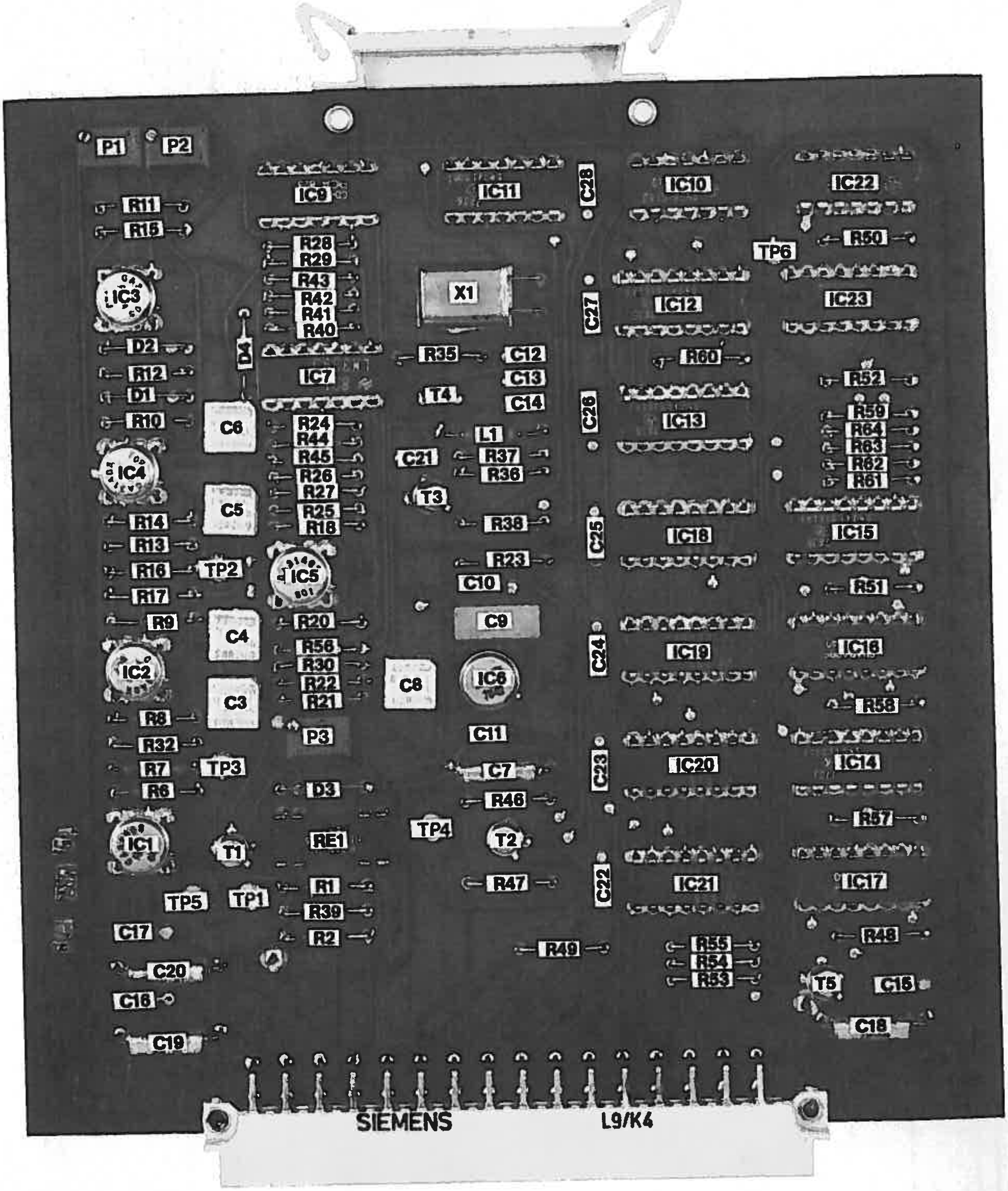
6-3-220 PD Generator Test
Electrical Parts List II

ELMI A/S COPENHAGEN DENMARK

Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			RELAY	
RE1	1		HE 721 AO 500	Hamlin
			CHOKE	
L1	1		10 uH 4322-057-01090	Philips
			X-TAL	
X1	1		6.400 MHz $^{+}$-10 ppM $\pm$ 20 ppM ^{o}C Par.res.	NDK
			CONNECTORS	
	1		C42334 - A191	Siemens
	1	6-3-220	Printed Circuit Board	Elmi

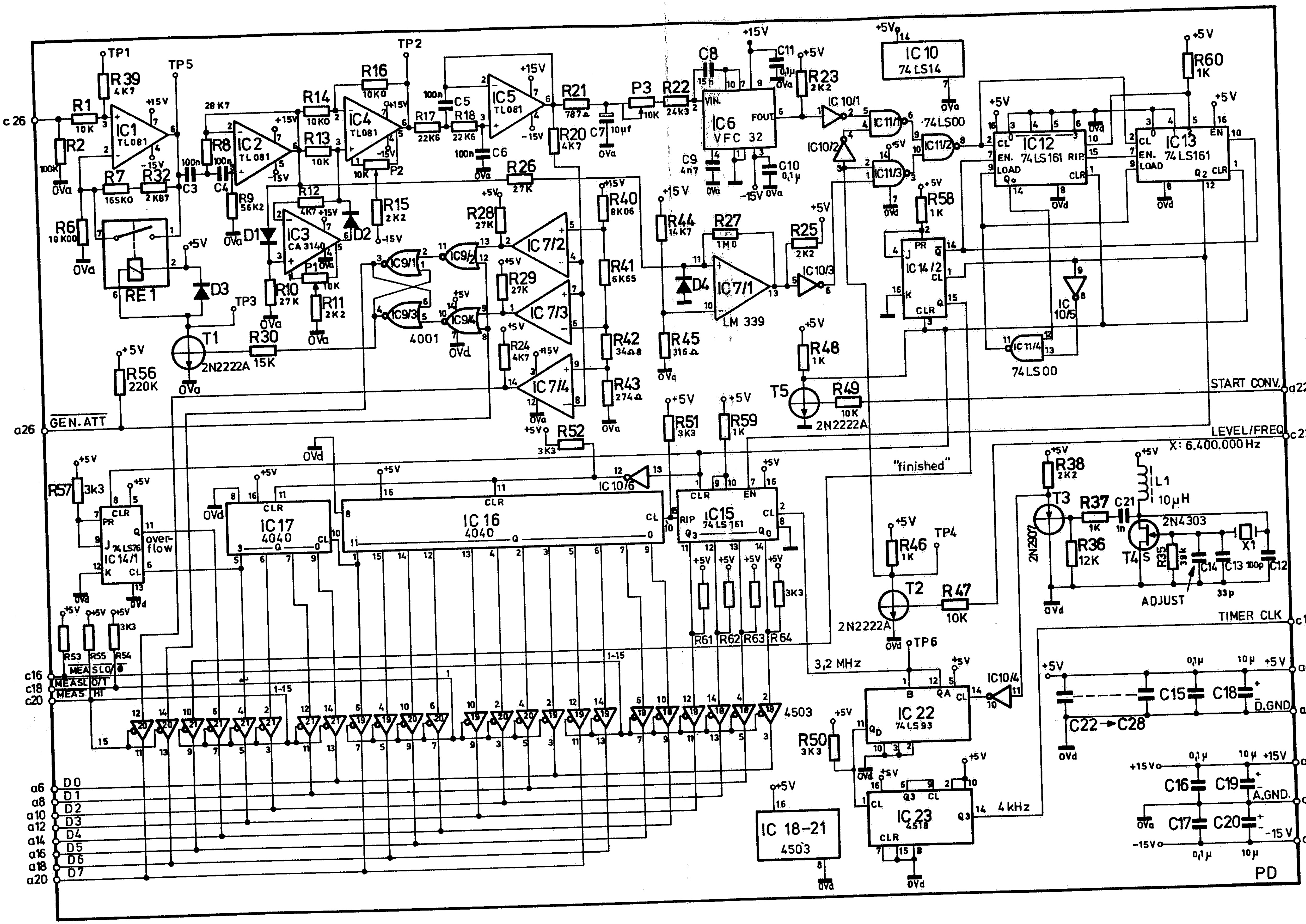
6-3-220 PD Generator Test
Electrical Parts List III

ELMI A/S
COPENHAGEN DENMARK



6-3-220 PD Generator Test
Electrical Parts Location

ELMI COPENHAGEN DENMARK



6-3-220 PD Generator Test
Circuit Diagram

ELMI A/S COPENHAGEN DENMARK

Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			CARBON FILM RESISTORS type CR25 ±5%	
R1	1		2K2 2322-211-13222	Philips
R2	1		1K2 13122	"
R3	1		12K 13123	"
R4	1		39K 13393	"
R5	1		4K7 13472	"
			METAL FILM RESISTORS type MR25 ±1%	
R6-10	5		1K47 2322-151-51472	Philips
R11	1		3K01 53012	"
R12	1		4K02 54022	"
			POTENTIOMETER CERMET	
P1-2	2		2ooR 3299W-1-201	Bourns
			RESISTORS NETWORKS	
IC25-27	3		10K 4310-101-103	Bourns
			CERAMIC CAPACITORS	
C1	1		22 nF 2222-629-03223	Philips
C2,C7	2		100 pF " 638-10101	"
C3	1		22 pF " " 10229	"
C5-6	2		33 pF " " 10339	"
C8-12 C15-22 C24	14		100 nF 837449-6104-S2	Siemens
			ELECTROLYTE CAPACITOR TANTAL	
C13,14 C23,25	4		10 uF 20V, type 150D	Spraque
			INTEGRATED CIRCUITS	
IC1-2	2		74LS 293J	Texas
IC3	1		74LS 04J	"
IC4-5	2		74LS 08J	"
IC6,11, IC12	3		74LS 379J	"
IC7-9	3		74LS 188J	"
IC10	1		74LS 157J	"
IC13	1		74284J	"
IC14-15	2		74LS 86J	"
IC16-18	3		74LS 283J	"
IC19-20	2		74LS 273J	"
IC21	1		74LS 74J	"
IC22	1		72723	"
IC23-24	2		MC 1408L8	Motorola

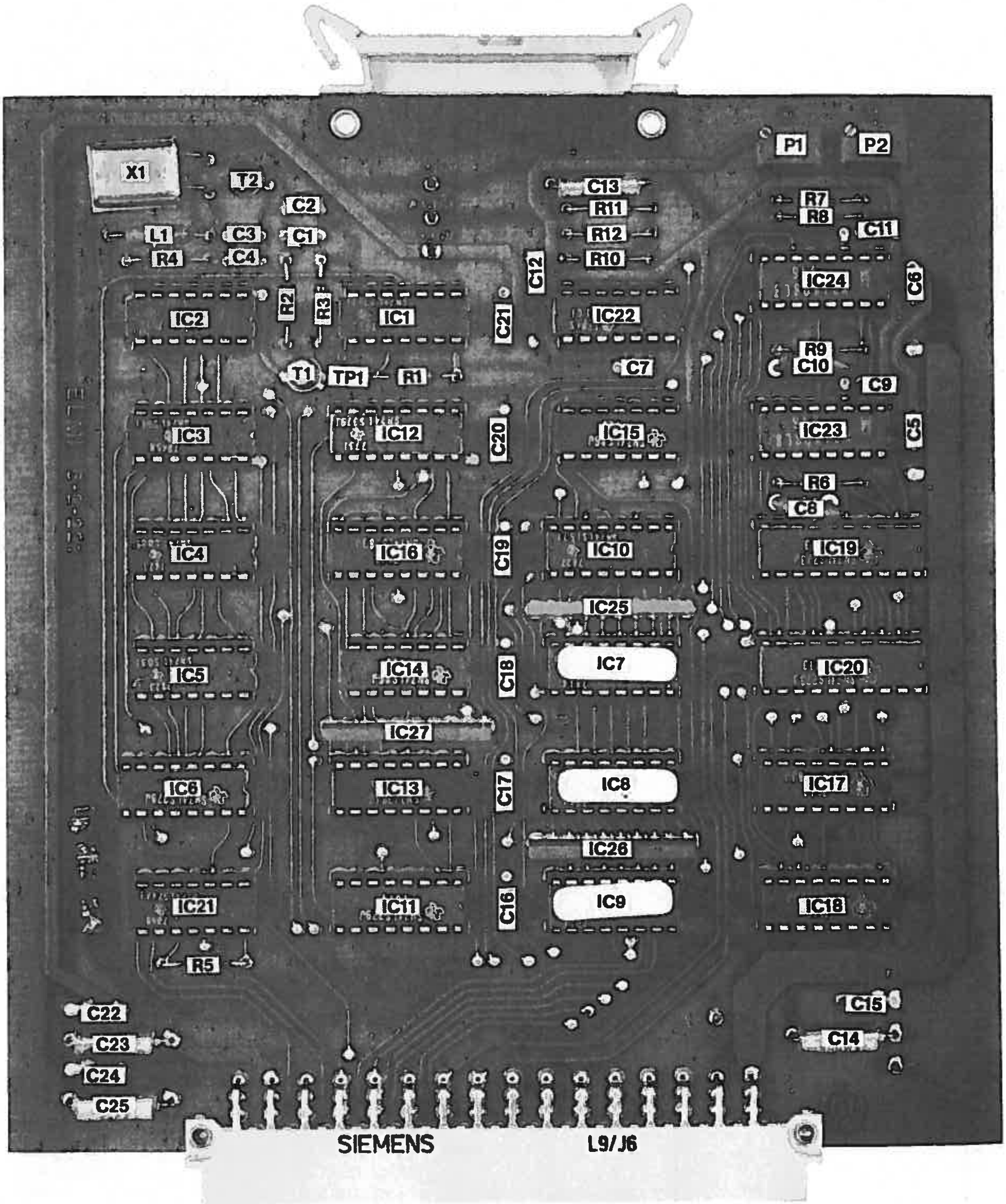
6-3-221 PE Oscillator Part B
Electrical Parts List I

ELMI A/S
COPENHAGEN · DENMARK

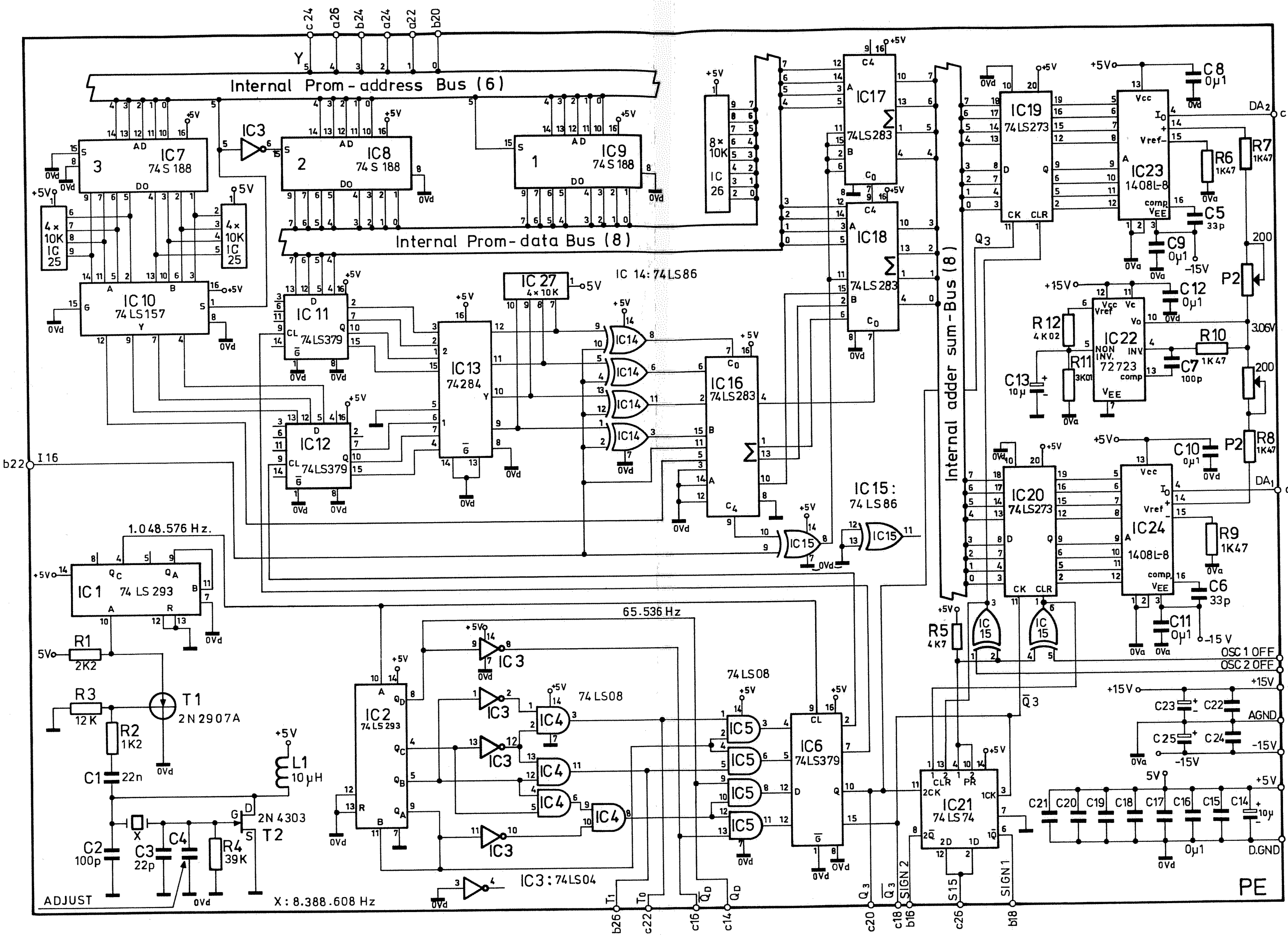
Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			<u>TRANSISTORS</u>	
T1	1		2N2907A	Siemens
T2	1		2N4303	Amelco
			<u>CHOKE</u>	
L1	1		10 uH 4322 -057-01090	Philips
			<u>X-TAL</u>	
	1		8.388608 MHz ±10ppM, ±20ppM ^{0}C Par.res	Dantronik
			<u>CONNECTORS</u>	
	1		C42334-A191-A701	Siemens
	9		14 pins C93-14-02	Texas
	13		16 pins C93-16-02	"
	2		20 pins C93-20-02	"
	1	6-2-221	Printed Circuit Board	Elmi

6-3-221 PE Oscillator Part B
Electrical Parts List II

ELMI A/S
COPENHAGEN DENMARK



6-3-221 PE Oscillator Part B
Electrical Parts Location

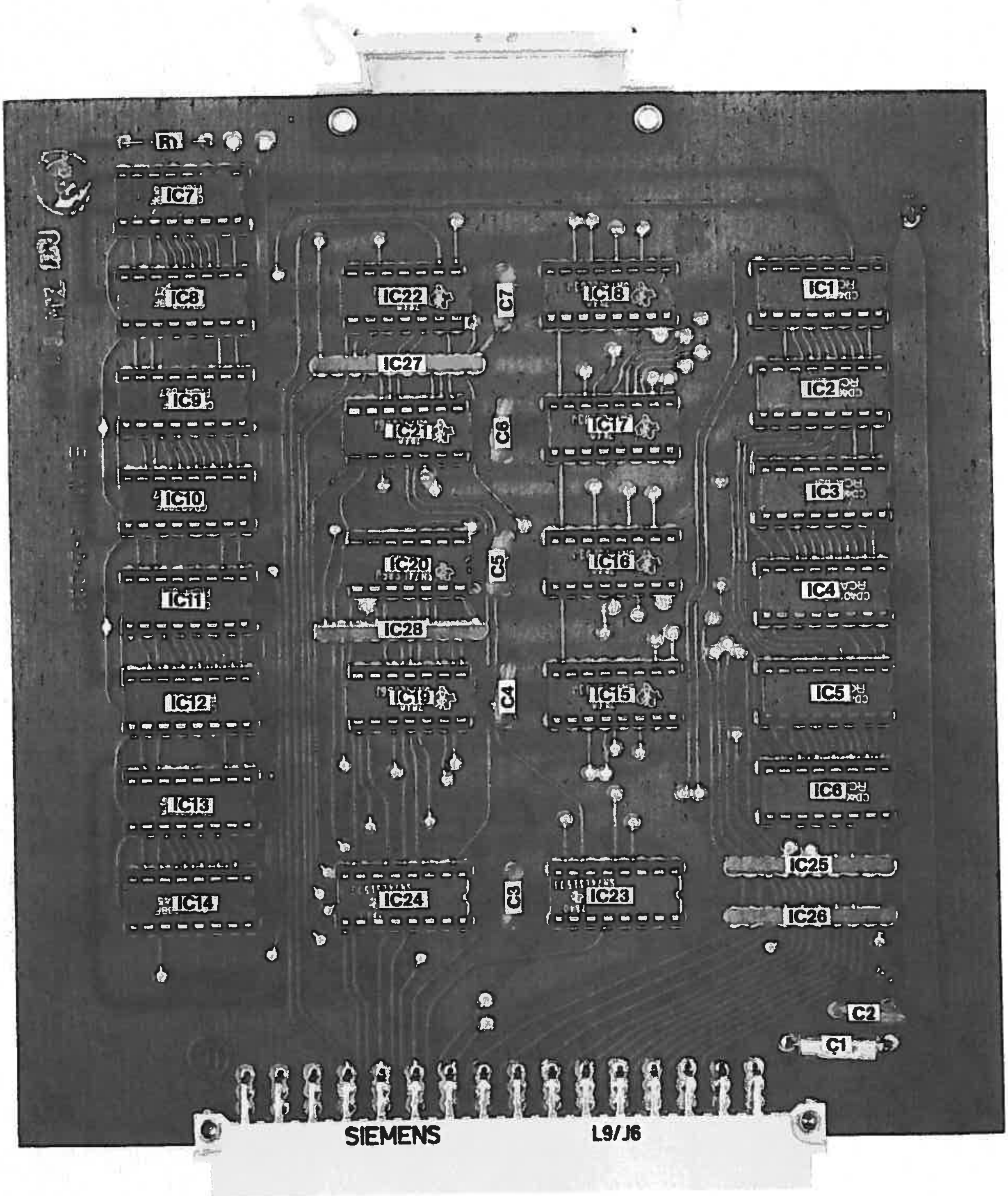


6-3-221 PE Oscillator Part B
Circuit Diagram

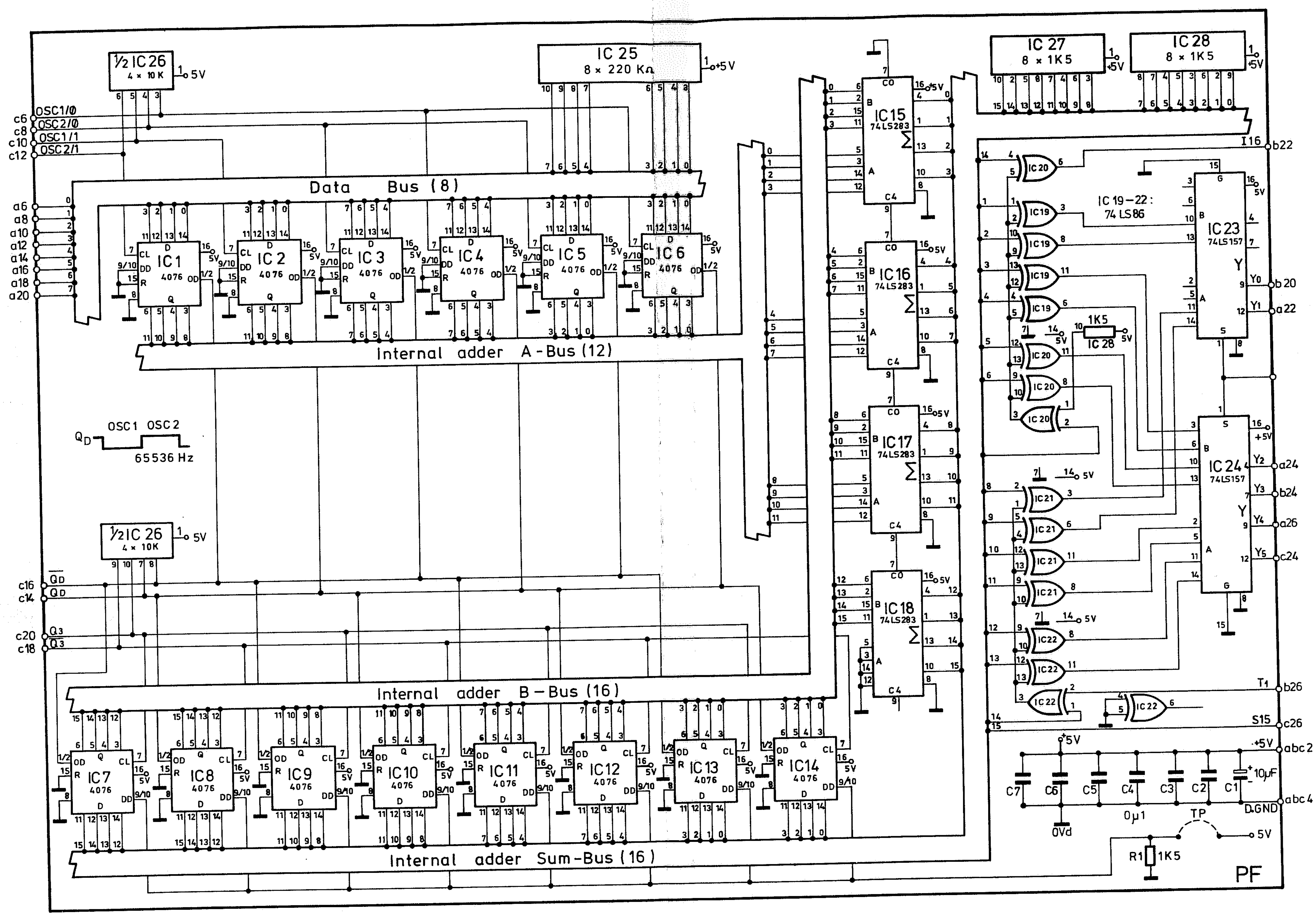
Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			CARBON FILM RESISTOR type CR25 0,33W ±5%	
R1	1		1K5 2322-211-13152	Philips
			RESISTOR NETWORKS	
IC25	1		220K 4310-101-224	Bourns
IC26	1		10K 103	"
IC27,28	2		1K5 152	"
			CAPACITOR ELECTROLYTE TANTAL	
C1	1		10 uF 20V type 150D	Spraque
			CAPACITORS CERAMIC	
C2-7	6		100 nF 9/0145 - A	Ferroperm
			INTEGRATED CIRCUITS	
IC1-14	14		CD 4076 BF	RCA
IC15-18	4		74 LS 283	Texas
IC19-22	4		74 LS 86 J	"
IC23,24	2		74 LS 157	"
			CONNECTORS	
	1		C 42334-A191-701	Siemens
	20		16 pins type C93-16-02	Texas
	4		14 pins " " 14-02	"
	1	6-2-222	Printed Circuit Board	Elmi

6-2-222 PF Oscillator Part A
Electrical Parts List

ELMI A/S
COPENHAGEN DENMARK



6-2-222 PF Oscillator Part A
Electrical Parts Location

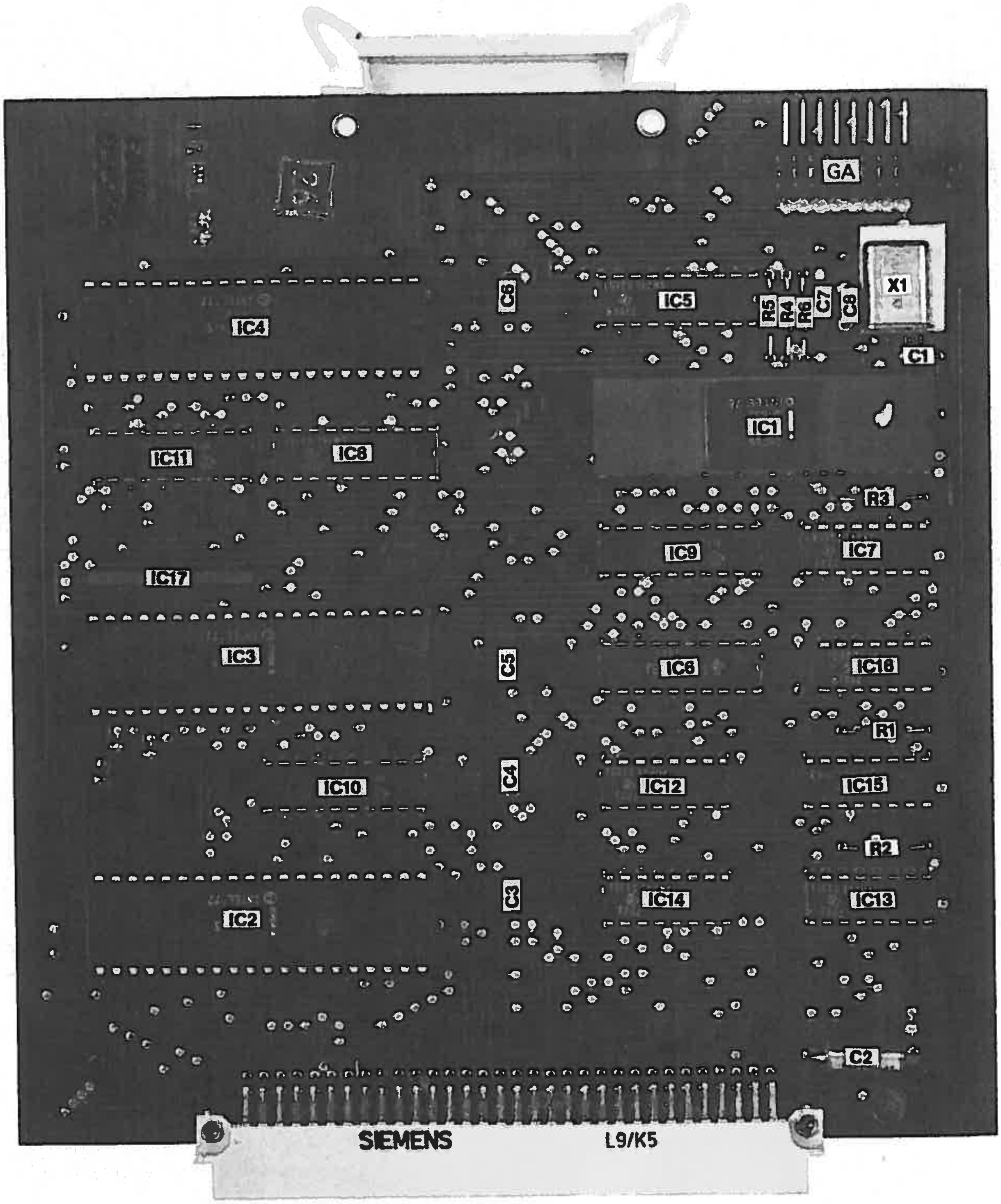


6-2-222 PF Oscillator Part A
Circuit Diagram

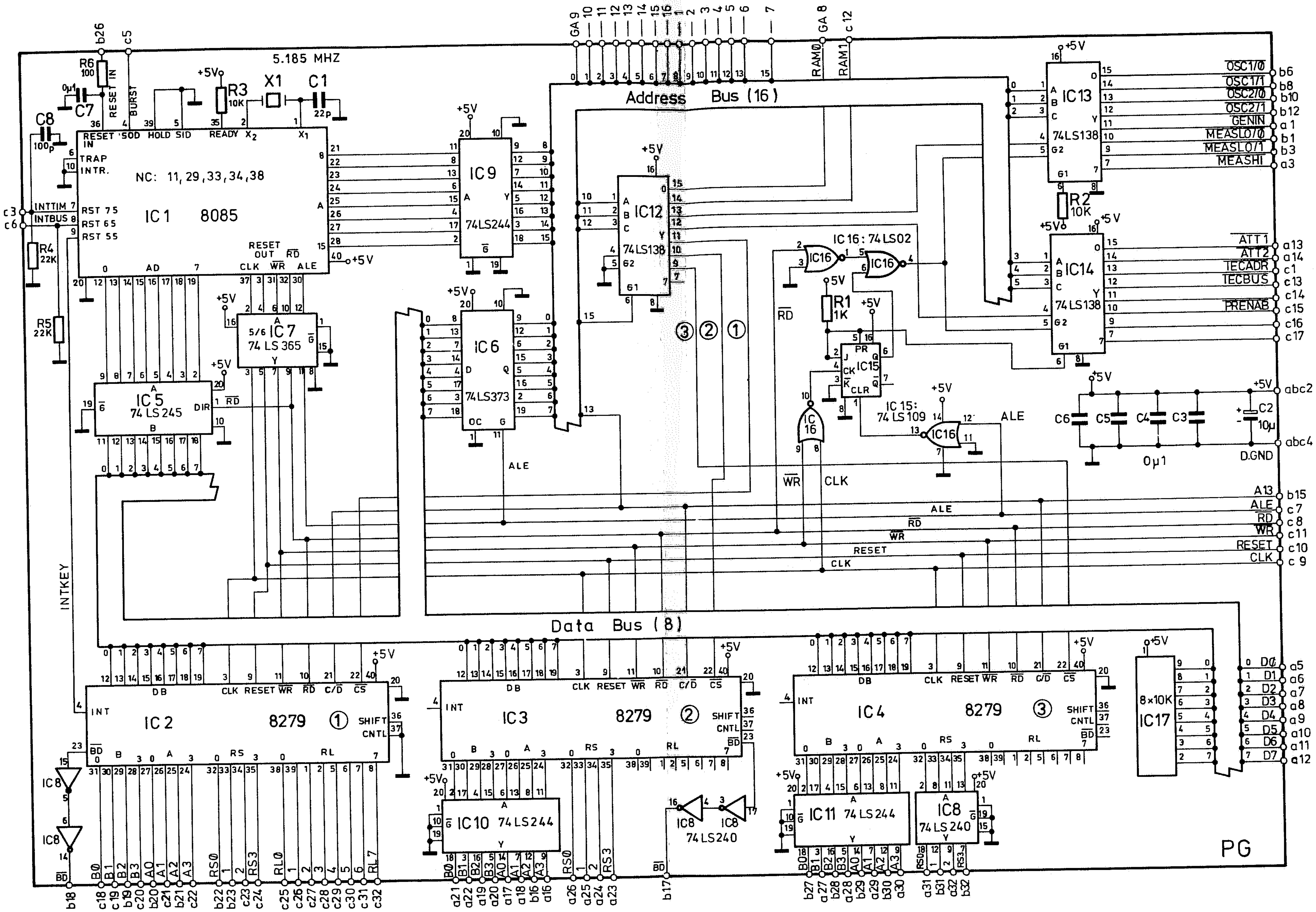
Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			CARBON FILM RESISTORS type CR25 0,33W ±5%	
R1	1		1K 2322-211-13102	Philips
R2-3	2		10K 13103	"
R4-5	2		22K 13223	"
R6	1		100R 13101	"
			RESISTOR NETWORK	
IC17	1		1oK 4310-101-103	Bourns
			CARAMIC CAPACITORS	
C1	1		22 pF 2222-638-10229	Philips
C8	1		100 pF 10101	"
C3-7	5		100 nF B37449-6104-S2	Siemens
			ELECTROLYTE CAPACITOR TANTAL	
C2	1		10 uF, 20V, type 150D	Sprague
			INTEGRATED CIRCUITS	
IC1	1		D8085	Intel
IC2-4	3		D8279	"
IC5	1		74LS 245J	Texas
IC6	1		74LS 373J	"
IC7	1		74LS 365J	"
IC8	1		74LS 240	"
IC9-11	3		74LS 244J	"
IC12-14	3		74LS 138J	"
IC15	1		74LS 109J	"
IC16	1		74LS 02J	"
			X-TAL	
X1	1		5.185 MHz ± 50ppm; ±100ppm ^{0}C Serie res.	N.D.K.
			CONNECTORS	
	1		C42334-A191-A501	Siemens
	4		40 pins C93-40-02	Texas
	1		GOSD 16 A4BEAA	Cannon
	1	6-3-223	Printed Circuit Board	Elmi

6-3-223 PG CPU Unit
Electrical Parts List I

ELMI A/S COPENHAGEN DENMARK



6-3-223 PG CPU Unit
Electrical Parts Location

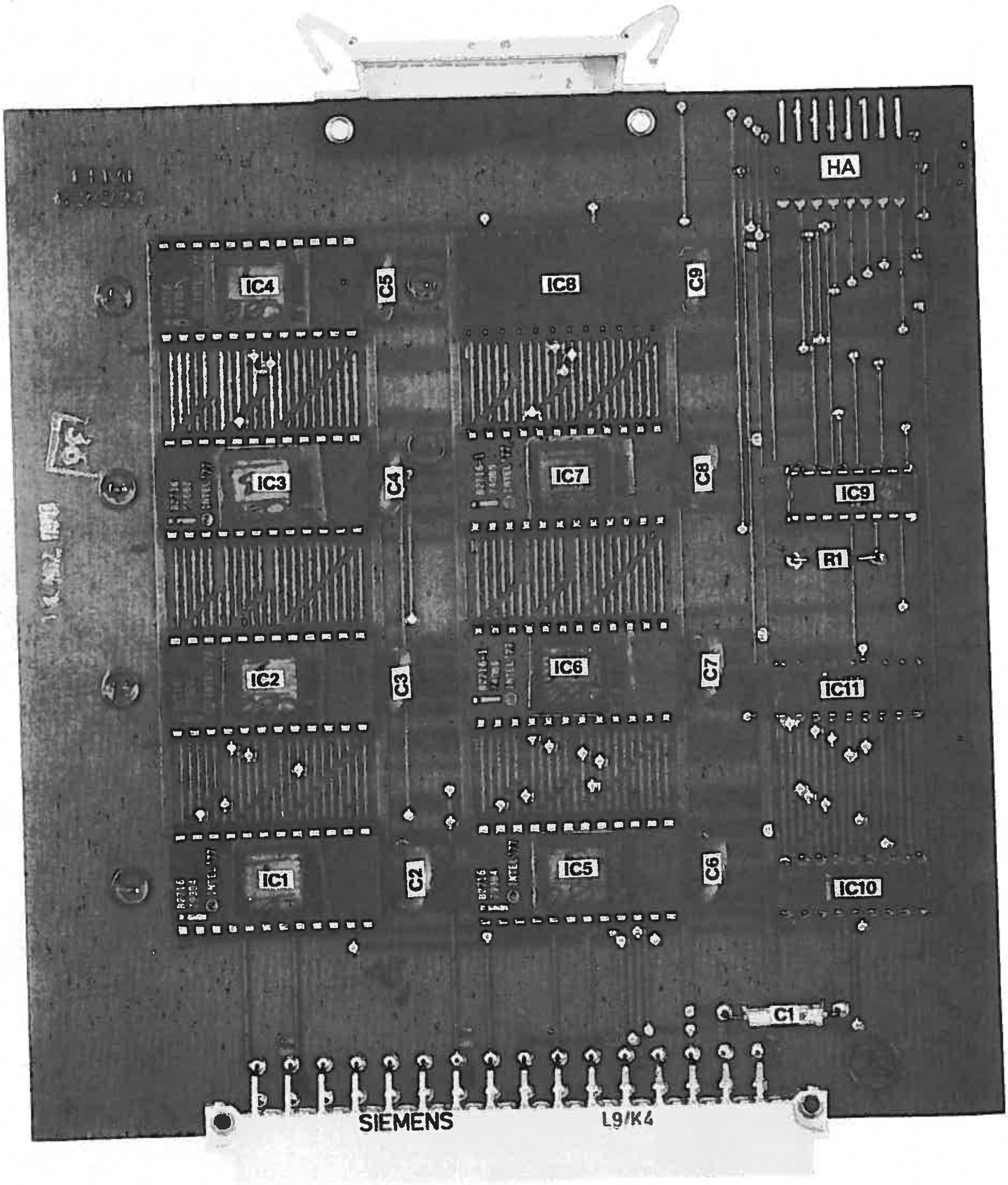


6-3-223 PG CPU Unit
Circuit Diagram

Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			CARBON FILM RESISTOR type CR 25 ± 5%	
R1	1		10 K 2322-211-13103	Philips
			CAPACITOR ELECTROLYTE TANTAL	
C1	1		10uF, 20V, type 150D	Spraque
			CAPACITORS CERAMIC	
C2-9	8		100nF, 16V, 9/0145-A	Ferroperm
			INTEGRATED CIRCUITS	
IC1-8	7		2716	Intel
IC9	1		74 LS 138 J	Texas
IC10-11	2		2114 L	Intel
			CONNECTORS	
	1		C 42334-A191-A702	Siemens
	1		G08D 16A4 BEAA	Cannon
	8		24 pins C93-24-02	Texas
	1	6-2-224	Printed Circuit Board	Elmi

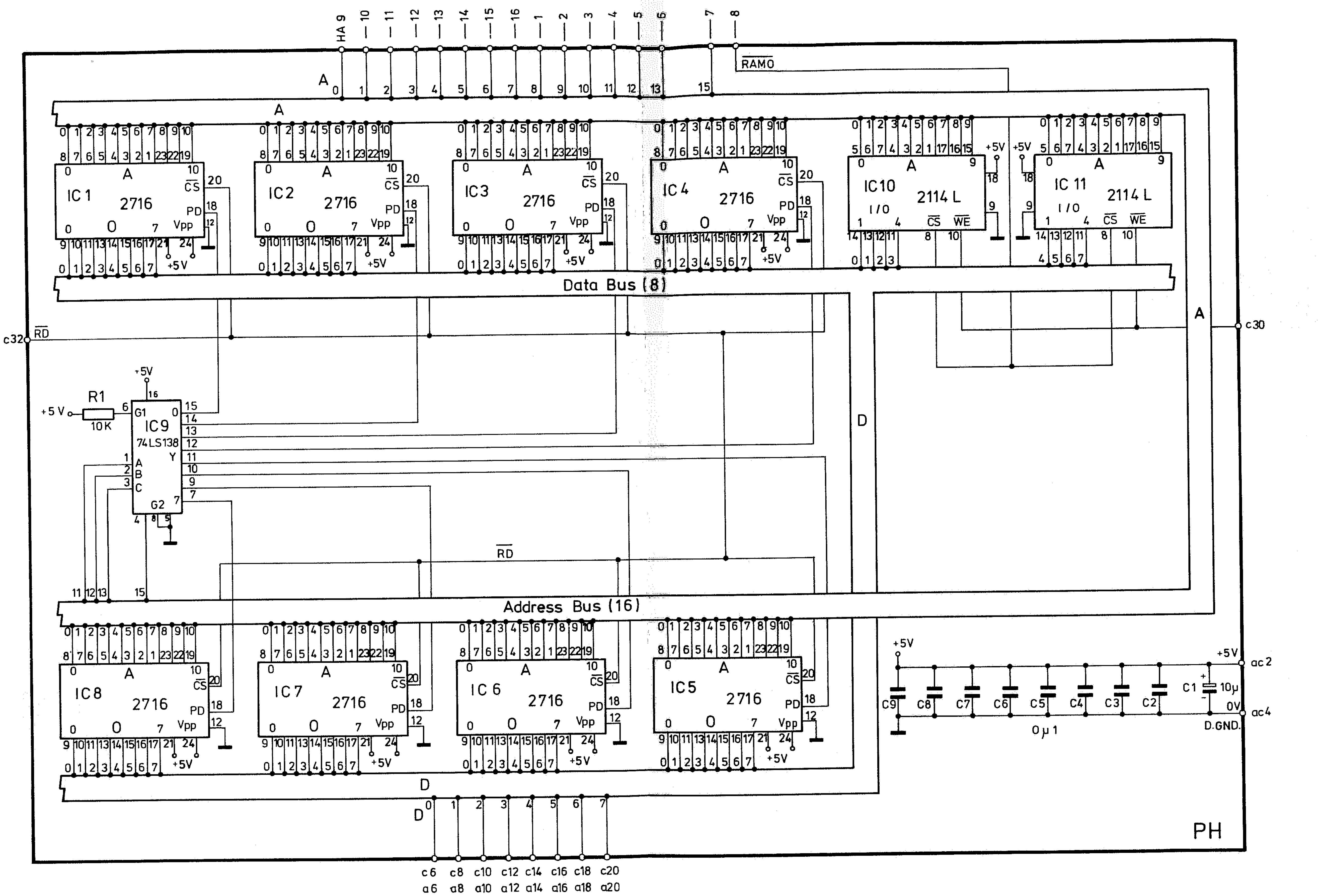
6-3-224 PH Memory
Electrical Parts List

ELMI A/S
COPENHAGEN DENMARK



6-3-224 PH Memory
Electrical Parts Location

ELMI A/S
COPENHAGEN DENMARK



6-3-224 PH Memory
Circuit Diagram

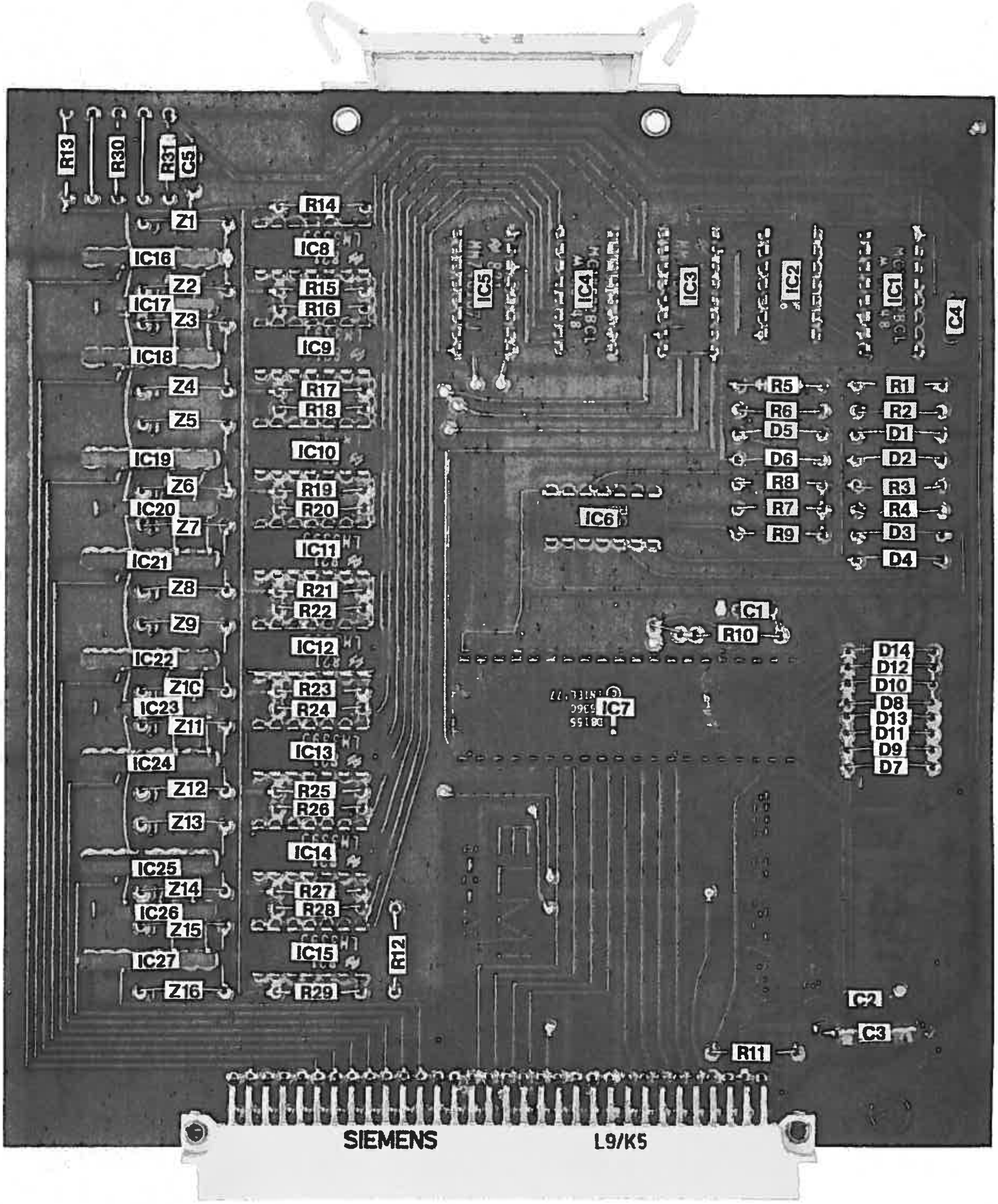
ELMI A/S COPENHAGEN DENMARK

Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			CARBON FILM RESISTORS type CR25 0.33W ±5%	
R1,3,5	3		22K 2322-211-13223	Philips
R7-9	3		220K 13224	"
R10	1		100R 13101	"
R11-12 R14-29	18		4K7 13472	"
			PTC RESISTORS	
R2,4,6	3		1K5 2322-660-93001	Philips
			METAL FILM RESISTORS type MR25 ±1%	
R13	1		1K 2322-151-21002	Philips
R30	1		953R 29531	"
R31	1		909R 29091	"
			RESISTOR NETWORKS	
IC16,18 19,21, 22,24, 25,27	8		47K 4308-102-473	Bourns
IC17,20 23,26	4		100K 4306-101-104	"
			CAPACITORS CERAMIC	
C1	1		100 pF 2222-638-10101	Philips
C2,4,5	3		100 nF B37449-6104-S2	Siemens
			CAPACITOR ELECTROLYTE TANTAL	
C3	1		10 uF/20V 150D	Sprague
			INTEGRATED CIRCUITS	
IC1,4	2		MC 14532 BCL	Motorola
IC2	1		CD 4071 BF	RCA
IC3,5	2		74 C 157 J	N.S.
IC6	1		CD 4023 BF	RCA
IC7	1		D8155	Intel
IC8-15	8		LM 339 J	N.S.
			DIODES SILICIUM	
D1-14	14		1N4448	Texas
			DIODES ZENER	
Z1-16	16		BZX 7915 C	Philips

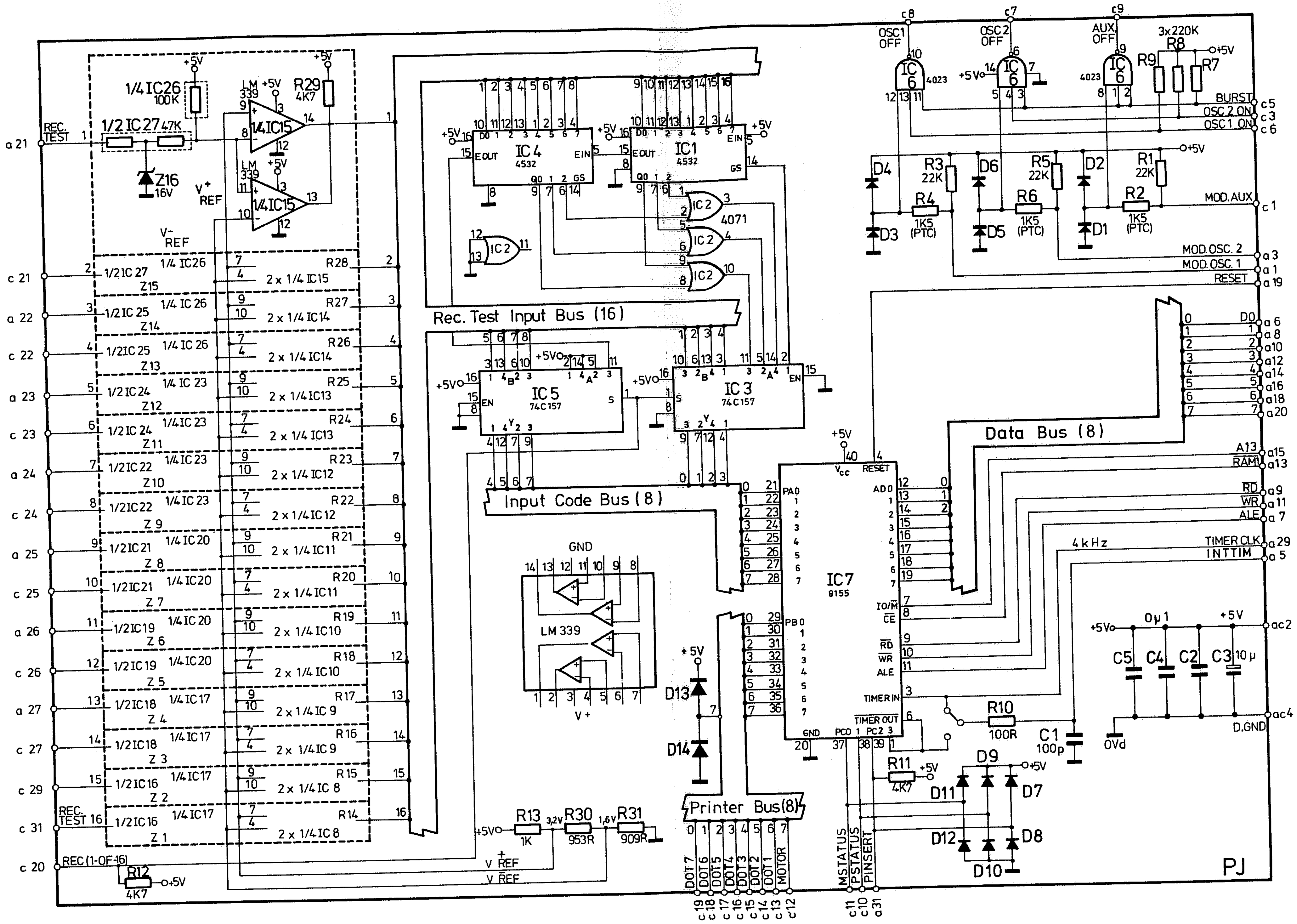
6-2-225 PJ Receiver Test Input
Electrical Parts List I

Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			CONNECTORS	
	1		C42334-A191-A502	Siemens
	1		40 pins C93-40-02	Texas
	1	6-2-225	Printed Circuit Board	Elmi

6-2-225 PJ Receiver Test Input
Electrical Component List II



6-2-225 PJ Receiver Test Input
Electrical Parts Location



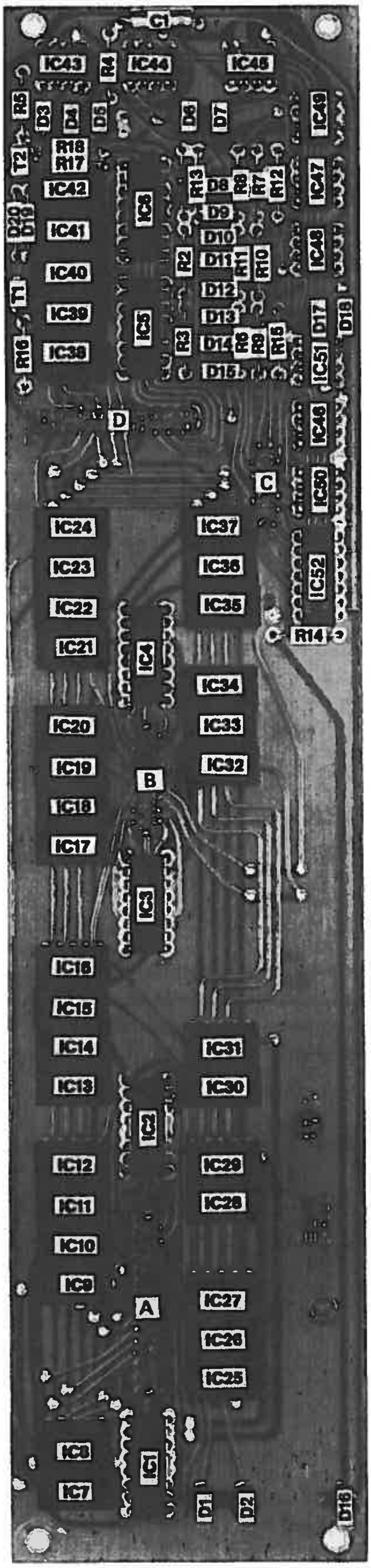
6-2-225 PJ Receiver Test Input
Circuit Diagram

ELMI A/S COPENHAGEN DENMARK

Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			RESISTORS CARBON FILM CR25 $\pm 5\%$	
R1-3	3		33R 2322-211-13339	Philips
R4-16	13		22R 13229	"
R17	1		1K5 13152	"
R18	1		1K 13102	"
			CAPACITORS ELECTROLYTE TANTAL	
C1	1		10 uF 20V 150D	Spraque
			DIODES	
D1-5, 7-18	17		CQX 40	Telefunken
D6	1		CQX 11	"
D19,20	2		1N4448	Texas
			INTEGRATED CIRCUIT	
IC1-5	5		ULN 2064 A	Spraque
IC6	1		ULN 2074 A	"
IC7-42	36		FND 367	Fairchild
IC43-51	9		SN 75452 BJG	Texas
IC51	1		SN 74 LS 32 J	"
			TRANSISTORS	
T1,2	2		BC 327-40	Siemens
			CONNECTORS	
	1		G08D 28A 4 BBAA	ITT
	1		G08D 18A 4 BBAA	"
	1		G08D 12A 4 BBAA	"
	1		D08D 24A 4 BBAA	"
	36		CA-10S-10SD	C.A.
	1	6-1-226	Printed Circuit Board	Elmi

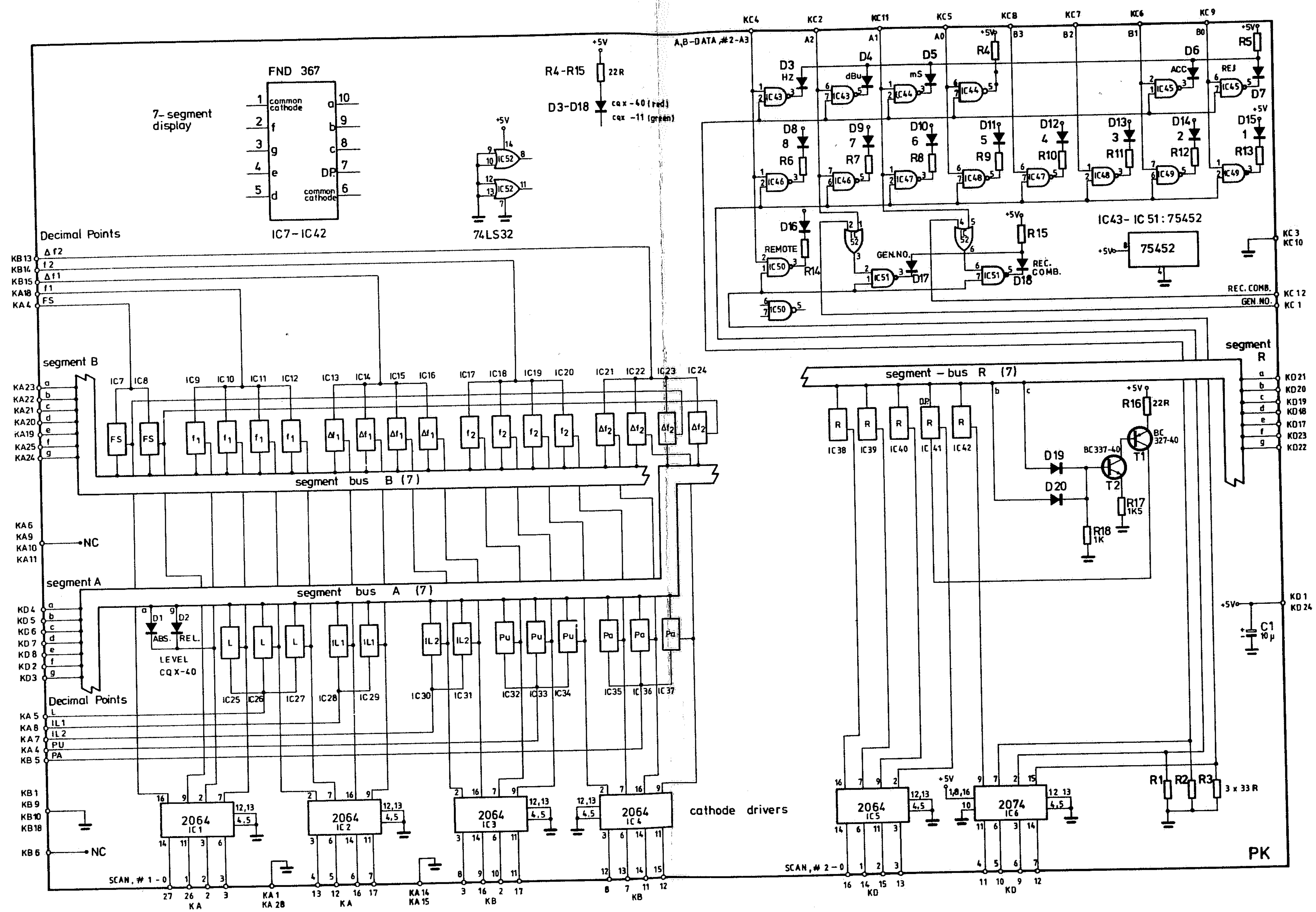
6-1-226 PK Display
Electrical Parts List

ELMI A/S COPENHAGEN DENMARK



6-1-226 PK Display
Electrical Parts Location

ELMI A/S COPENHAGEN DENMARK



6-1-226 PK Display
Circuit Diagram

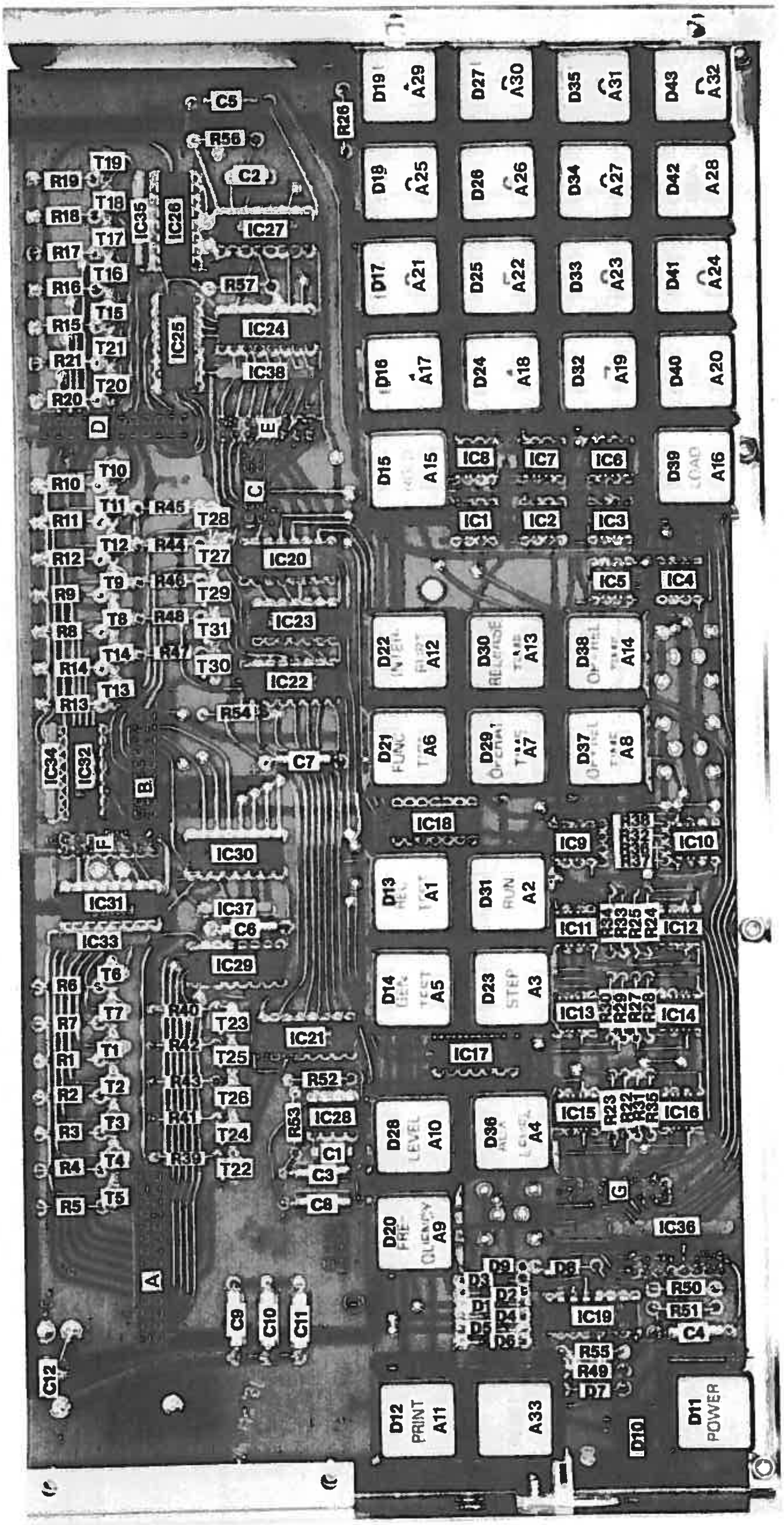
Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			CARBON FILM RESISTORS CR25 ±5%	
R1-38	38		18R 2322-211-13189	Philips
R39,42,43	3		47R 13479	"
R40,44-46	4		22R 13229	
R41,47-48	3		27R 13279	"
R49,55,57	3		15K 13153	"
R50	1		56K 13563	"
R51,52	2		470R 13471	"
R53	1		68K 13683	"
R54	1		1K5 13152	"
			RESISTOR NETWORKS	
IC33-35	3		1K5 type 4308R-101-152	Bourns
IC36	1		1K5 " 4310R-101-152	"
IC37	1		3K3 " 4306R-101-332	"
IC38	1		3K3 " 4308R-101-332	"
			CAPACITORS PLASTIC	
C1	1		10 nF B32560-B3103-3	Siemens
C2	1		22 nF B3223-3	"
			CAPACITORS CERAMIC	
C12	1		100 nF B37449-A6104-S2	Siemens
			CAPACITORS ELECTROLYTE TANTAL	
C3-11	9		10 uF/20V 150D	Spraque
			DIODES	
D1-7	7		SFD 129 B germanium	Sescosem
D8,9	2		1N4448 silizium	Texas
D10	1		CQX40	Telefunken
D11-43	33		CQX13II	Siemens
			INTEGRATED CIRCUITS	
IC1-16	16		SN 7552 BJG	Texas
IC17,18	2		SN 74LS 32J	"
IC19	1		SN 74LS 138J	"
IC20-22, 25,29-30	6		CD 4099 BF	RCA
IC23	1		CD 4071 BF	"
IC24	1		CD 4556 BF	"
IC26,31, 32	3		9374 DC	Fairchild
IC27	1		SN 74LS 123J	Texas
IC28	1		NE 555 JG	"

6-2-227 PL Keyboard
Electrical Parts List I

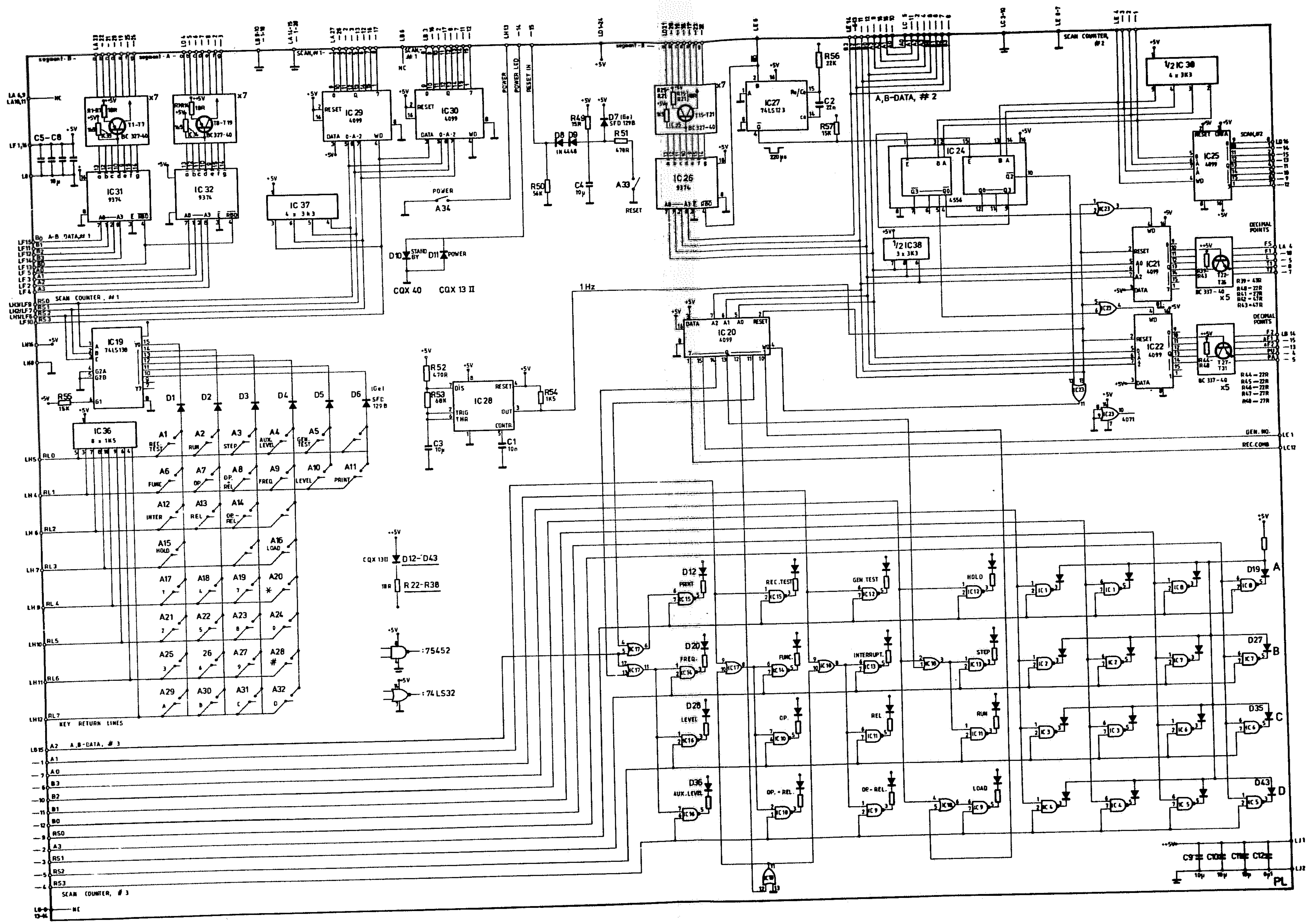
Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			TRANSISTORS	
T1-21	21		BC 327-40	Siemens
T22-31	10		BC 337-40	"
			KEYS	
A1-33	33		RL 1 T	Sadar
A34	1		RLP 1 T	"
			CONNECTORS	
	4		G08A08A4BBAA	ITT
	1		UBS4A028C4DL	"
	1		UBS4A018C4DL	"
	1		UBS4A012C4DL	"
	1		UBS4A024C4DL	"
	4		Power Connector 128-254	R.S.
	1	6-1-227	Printed Circuit Board	Elmi

6-2-227 PL Keyboard
Electrical Parts List II

ELMI A/S COPENHAGEN DENMARK



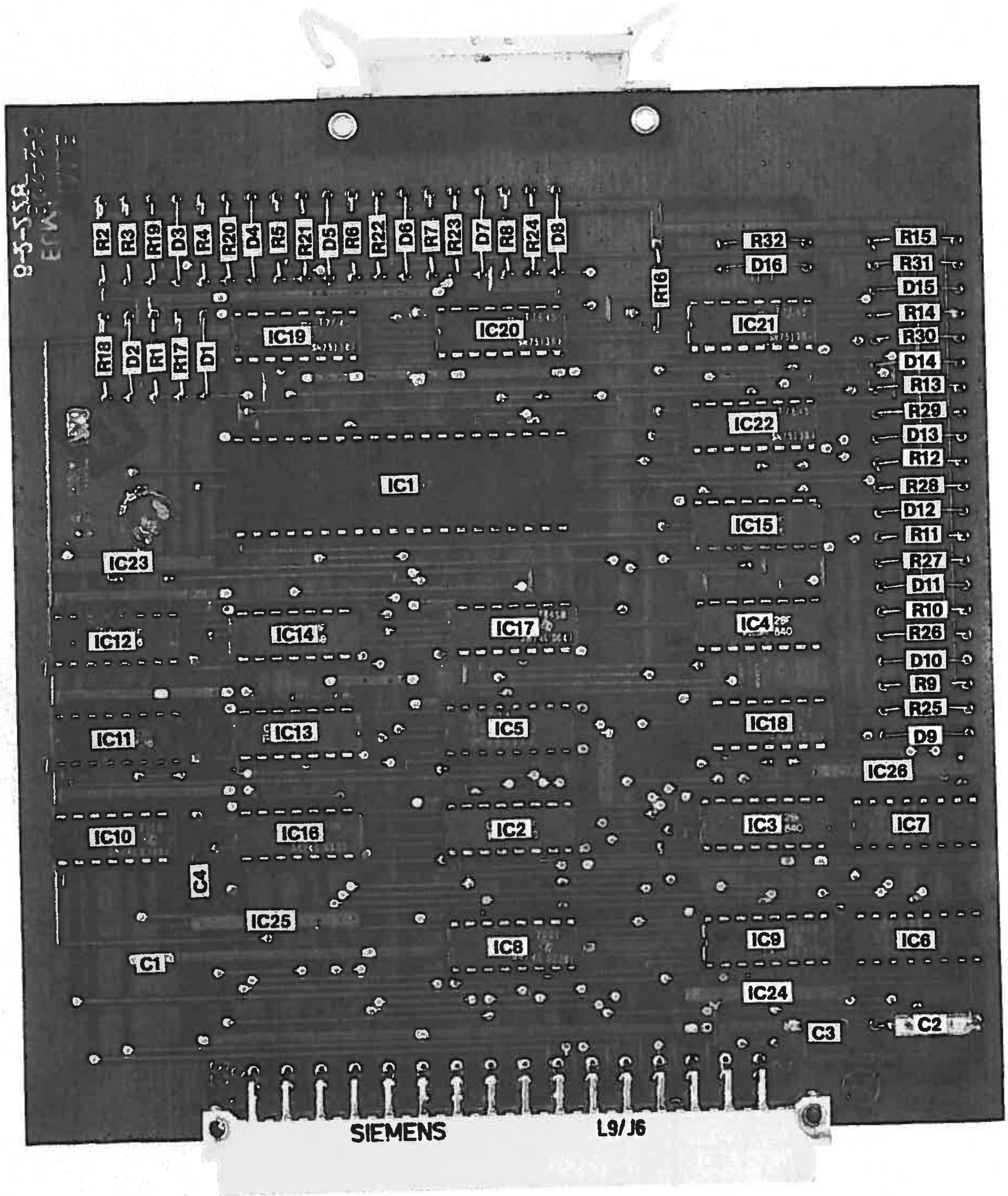
6-2-227 PL Keyboard
Electrical Parts Location



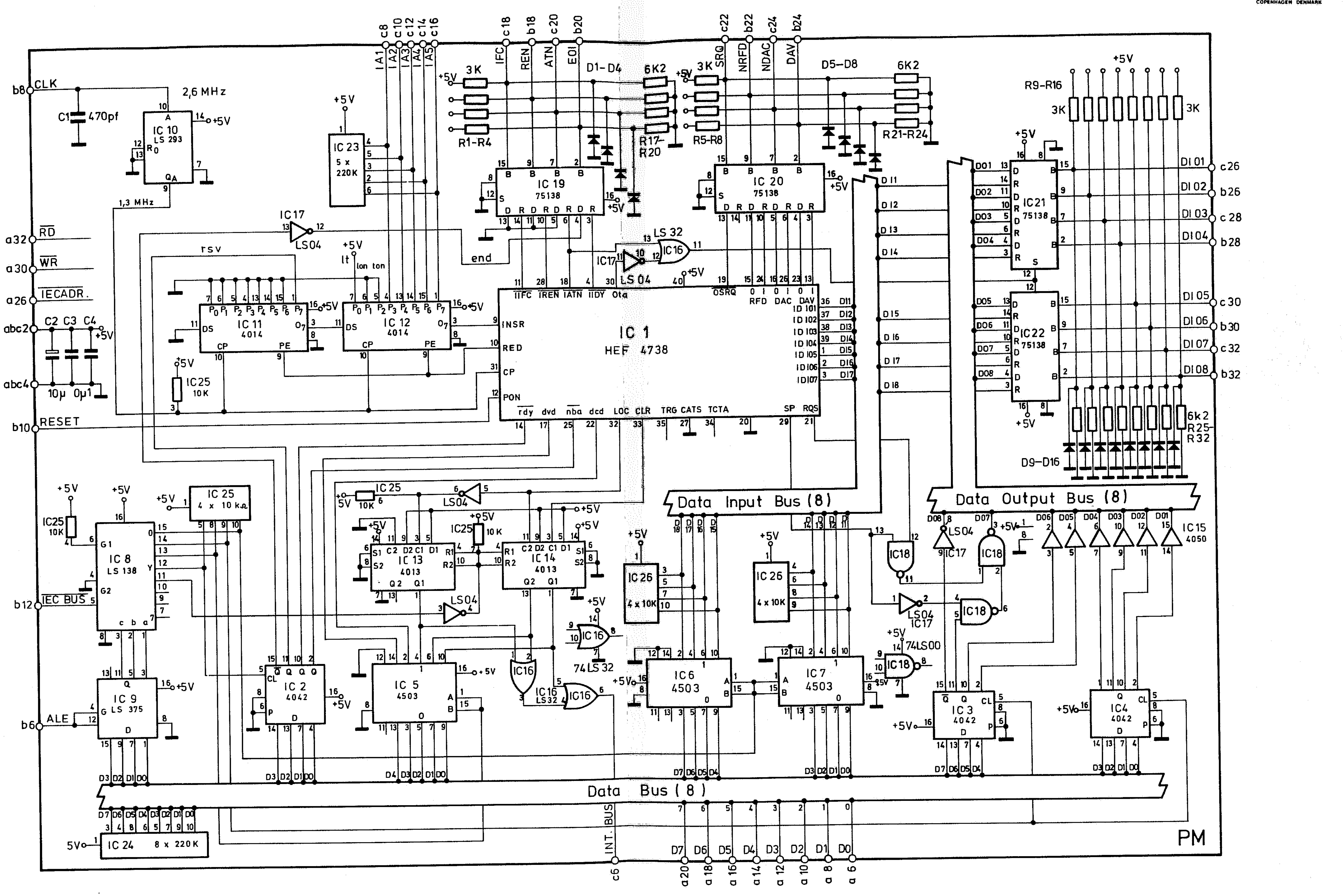
6-2-227 PL Keyboard
Circuit Diagram

Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			CARBON FILM RESISTORS type CR25 0.33W ± 5%	
R1-16	16		3K0 2322-211-13302	Philips
R17-32	16		6K2 13622	"
			RESISTOR NETWORK	
IC23,24	2		220K 4310R-101-224	Bourns
IC25,26	2		10K 103	"
			CERAMIC CAPACITORS	
C1	1		470pF 222-630-03471	Philips
C3-4	2		100nF B37449-6104-S2	Siemens
			ELECTROLYTE CAPACITORS TANTAL	
C2	1		10uF/20V type 150D	Spraque
			INTEGRATED CIRCUITS	
IC1	1		HEF 4738	Philips
IC2-4	3		CD 4042 BF	RCA
IC5-7	3		MM80C97J	N.S.
IC8	1		74LS138J	Texas
IC9	1		74LS375J	"
IC10	1		74LS293J	"
IC11,12	2		CD 4014 BF	RCA
IC13,14	2		CD 4013 BF	"
IC15	1		CD 4050 BF	"
IC16	1		74LS32J	Texas
IC17	1		74LS04J	"
IC18	1		74LS00J	"
IC19-22	4		75138J	"
			DIODES, SILICIUM	
D1-16	16		1N4448	Texas
			CONNECTORS	
	1		C42334-A191-A701	Siemens
	1		40 pins C93-40-02	Texas
	1	6-3-228	Printed Circuit Board	Elmi

6-3-228 PM IEC-BUS
Electrical Parts List



6-3-228 PM IEC-BUS
Electrical Parts Location



6-3-228 PM IEC-BUS
Circuit Diagram

ELMI A/S
COPENHAGEN DENMARK

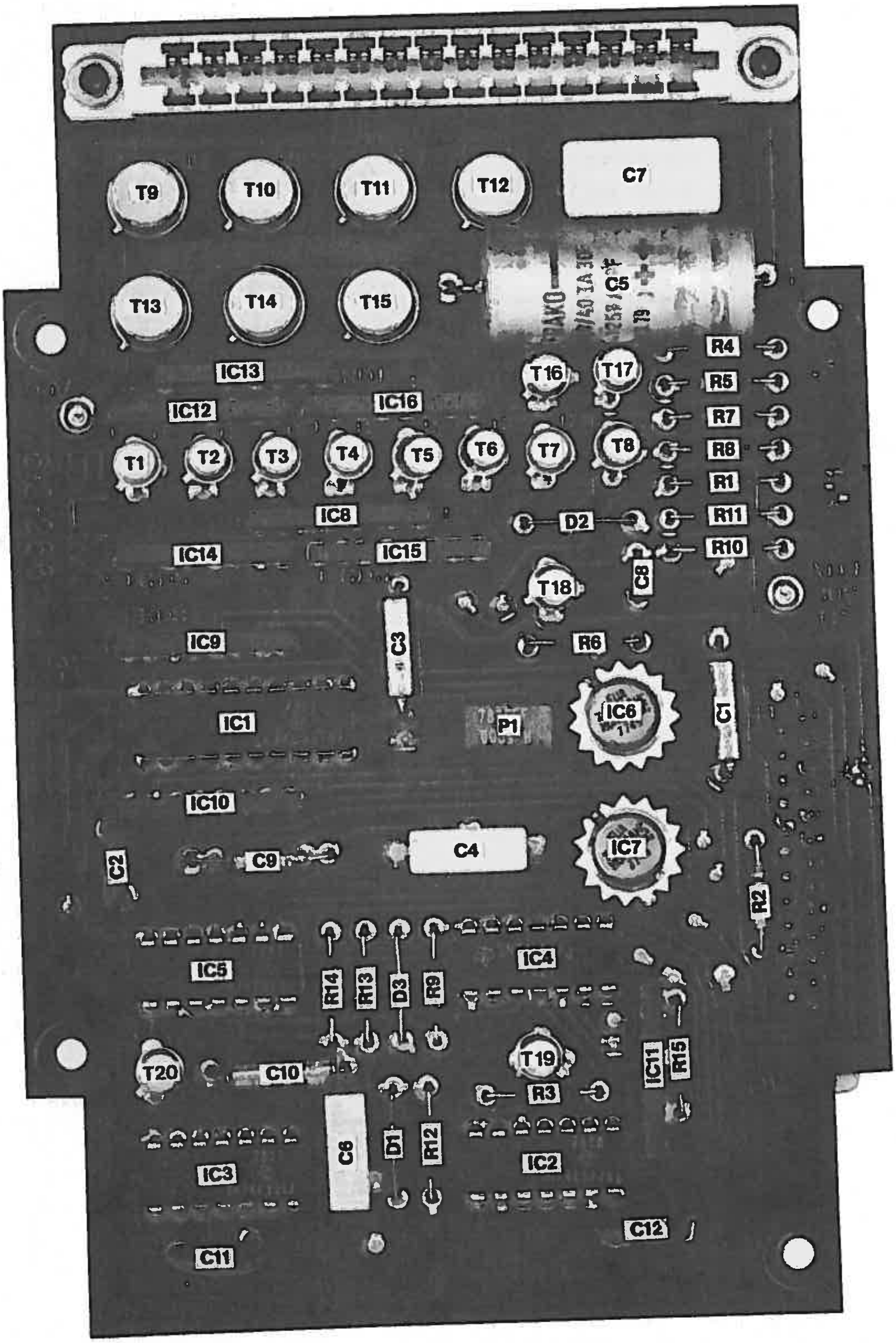
Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			TRANSISTORS	
T1-8, 17	9		2N2907A	Texas
T9-15	7		BSS45	Telefunken
T16, 18-20	4		2N2222A	Texas
			DIODES SILICON	
D1,3	2		1N4448	Texas
D2	1		BZX 87 B6V2	Philips
			CONNECTORS	
	1		C11A015P2ABB2	ITT
	1		DB-25S-0L2	"
			SOCKET	
	1		20 pins C932002	Texas
	2		Heatsink 105259/10	Assmann
			PRINTER	
	1		National EUY-10E014-RE	Matsushita
	1	6-3-266	Printed circuit Board	Elmi

6-3-266 PP Printer Interface
Electrical Parts List I

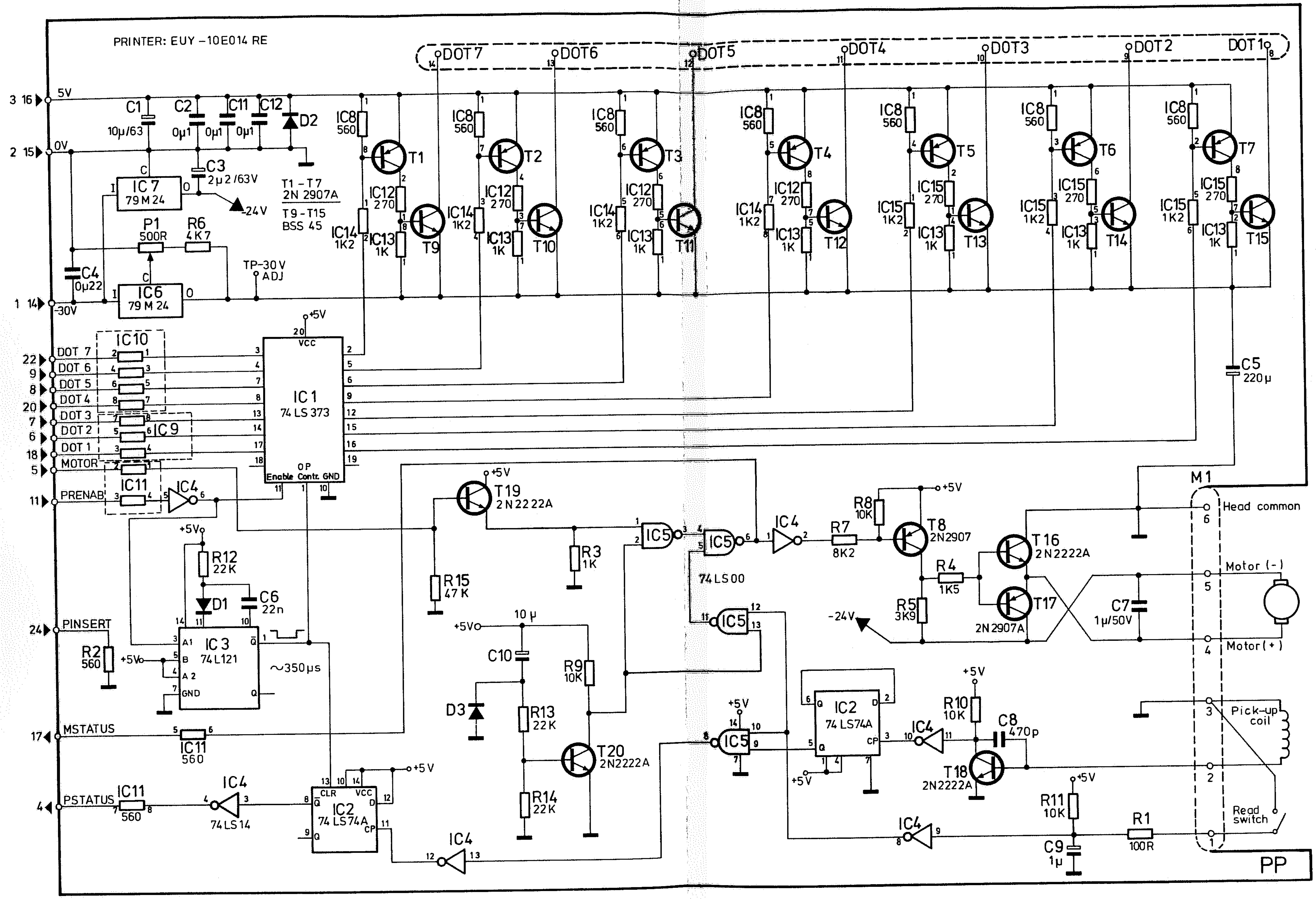
Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			CARBON FILM RESISTORS CR25 0.33W $\pm$5%	
R1	1		100R 2322-211-13101	Philips
R2	1		560R 13561	"
R3	1		1K 13102	"
R4	1		1K5 13152	"
R5	1		3K9 13392	"
R6	1		4K7 13472	"
R7	1		8K2 13822	"
R8-11	4		10K 13103	"
R12-14	3		22K 13223	"
R15	1		47K 13473	"
			RESISTOR NETWORKS	
IC8	1		560R 4308R-101-561	Bourns
IC9-11	3		560R 102-561	"
IC12, 16	2		270R 102-271	"
IC13	1		1K 101-102	"
IC14,15	2		1K2 102-122	"
			POTENTIOMETER CERMET	
P1	1		500R type 3386 H	Bourns
			CAPACITORS CERAMIC	
C2,11,12	3		0,1 uF/16V	Ferroperm
C8	1		470 pF C052K471K2X5CA	Kemet
			CAPACITORS, POLYESTER	
C4	1		0,22 uF 2222-344-20224	Philips
C6	1		o,o22uF 20223	"
C7	1		1,0 uF 20105	"
			CAPACITORS, ELECTROLYTE	
C1,10	2		10 uF/10V type 150D	Spaque
C3	1		2,2 uF/35V " "	"
C5	1		220 uF/40V EHF 220/401A	Frako
C9	1		1 uF/10V type 150D	Spraque
			INTEGRATED CIRCUITS	
IC1	1		SN 74LS 373J	Texas
IC2	1		SN 74LS 74J	"
IC3	1		SN 74L 121J	"
IC4	1		SN 74LS 14J	"
IC5	1		SN 74LS 00J	"
IC6,7	2		uA 79M 24 AHC	Fairchild

6-3-266 PP Printer Interface
Electrical Parts List II

ELMI A/S
COPENHAGEN DENMARK



6-3-266 PP Printer Interface
Electrical Parts Location



6-3-266 PP Printer Interface
Circuit Diagram

ELMI A/S
COPENHAGEN DENMARK

Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			CARBON FILM RESISTORS Type CR25 0,33W ±5%	
R1-3	3		56R 2322-211-13569	Philips
			METAL FILM POWER RESISTOR	
R4	1		1K5 2322-191-31502	Philips
R5	1		1K 2322-191-31002	"
			POLYESTER FILM CAPACITORS	
C1,C3	2		0,15 uF/100V 2222-344-32154	Philips
C2	1		0,15 uF/250V 2222-344-44154	"
			ELECTROLYTE CAPACITORS	
C4	1		470 uF/70V EHF 470/70 IA	Frako
C5,C6	2		470 uF/40V EHF 470/40 IA	"
			DIODES	
D1-12	12		BYW 76	Telefunken
D13-14	2		1N4448	Texas
			RELAY	
RE1	1		NC4-JP-24V	S.D.S.
			CONNECTOR	
	1		type 10.31 4-pole	Davila
	1	6-3-253	Printed Circuit Board	Elmi

6-3-253 PR Rectifiers Circuits
Electrical Parts List

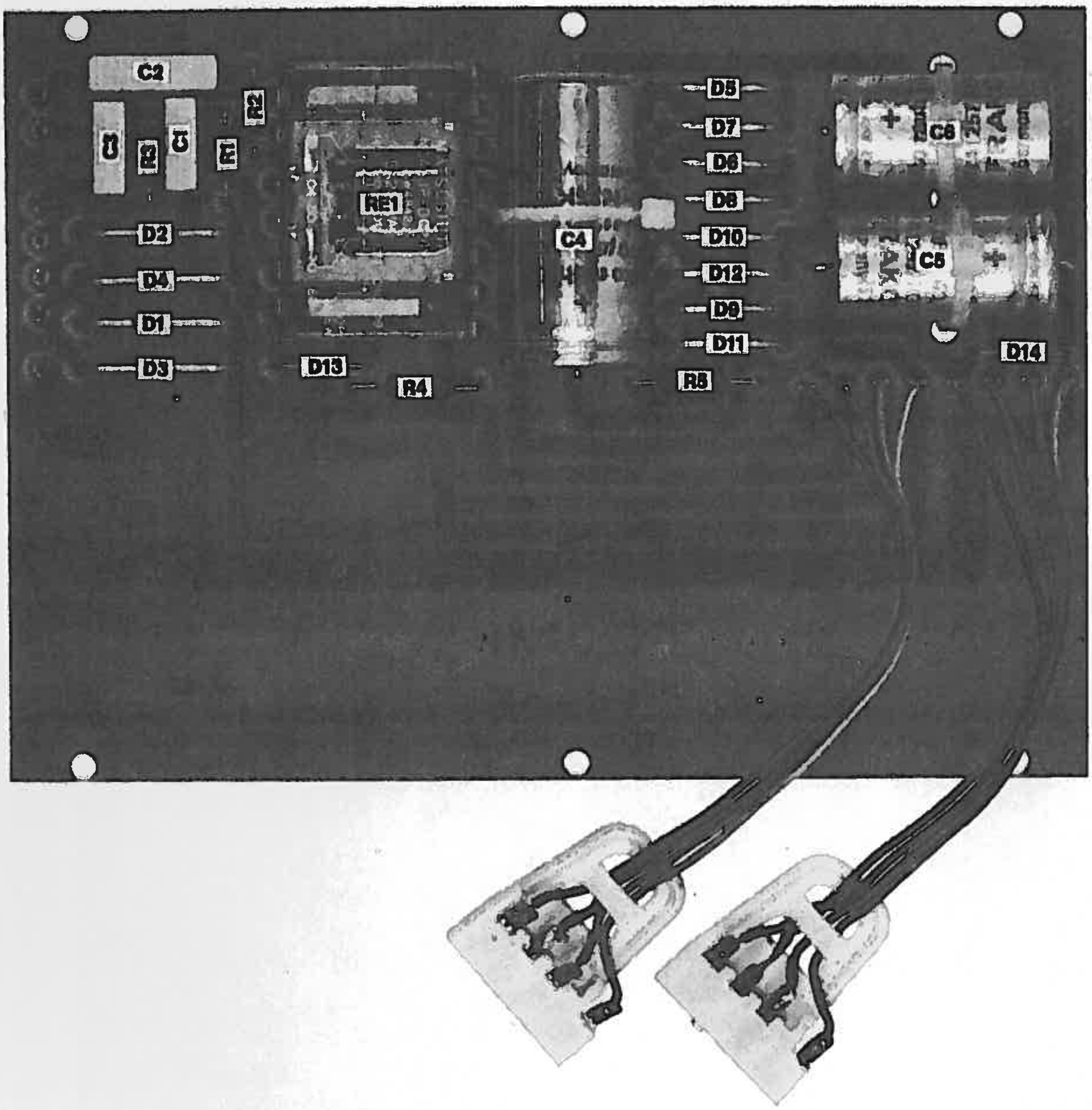
ELMI A/S
COPENHAGEN DENMARK

ELMI A/S
COPENHAGEN DENMARK

Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			CARBON FILM RESISTORS type CR25 0.33W ±5%	
R6	1		1K5 2322-211-13152	Philips
R7	1		2K2 13222	"
R8	1		15K 13153	"
R9	1		4K7 13472	"
R10-11	2		100R 13101	"
R12-13	2		2R2 13228	"
R14	1		10K 13103	"
			POTENTIOMETER CERMET	
P1	1		100K 3386H-1-104	Bourns
			CERAMIC CAPACITORS	
C7	1		33 pF 2222-638-10339	Philips
C8-9	2		1.5 nF " 630-03152	"
			ELECTROLYTIC CAPACITOR TANTAL	
C10-11	2		10 uF/20V 150D	Spraque
			INTEGRATED CIRCUIT	
IC1	1		MC 1468 G	Motorola
			TRANSISTORES	
T1	1		2N2907 A	Siemens
T2,T4	2		2N3054	RCA
T3	1		2N5955	RCA
			ZENERDIODES	
D15	1		BZ X 87 C 33	Philips
			CONNECTOR	
	1		DB 25S1AON	ITT
	1		Heat Sink 105259/10	Asmann
	1	6-3-254	Printed Circuit Board	Elmi

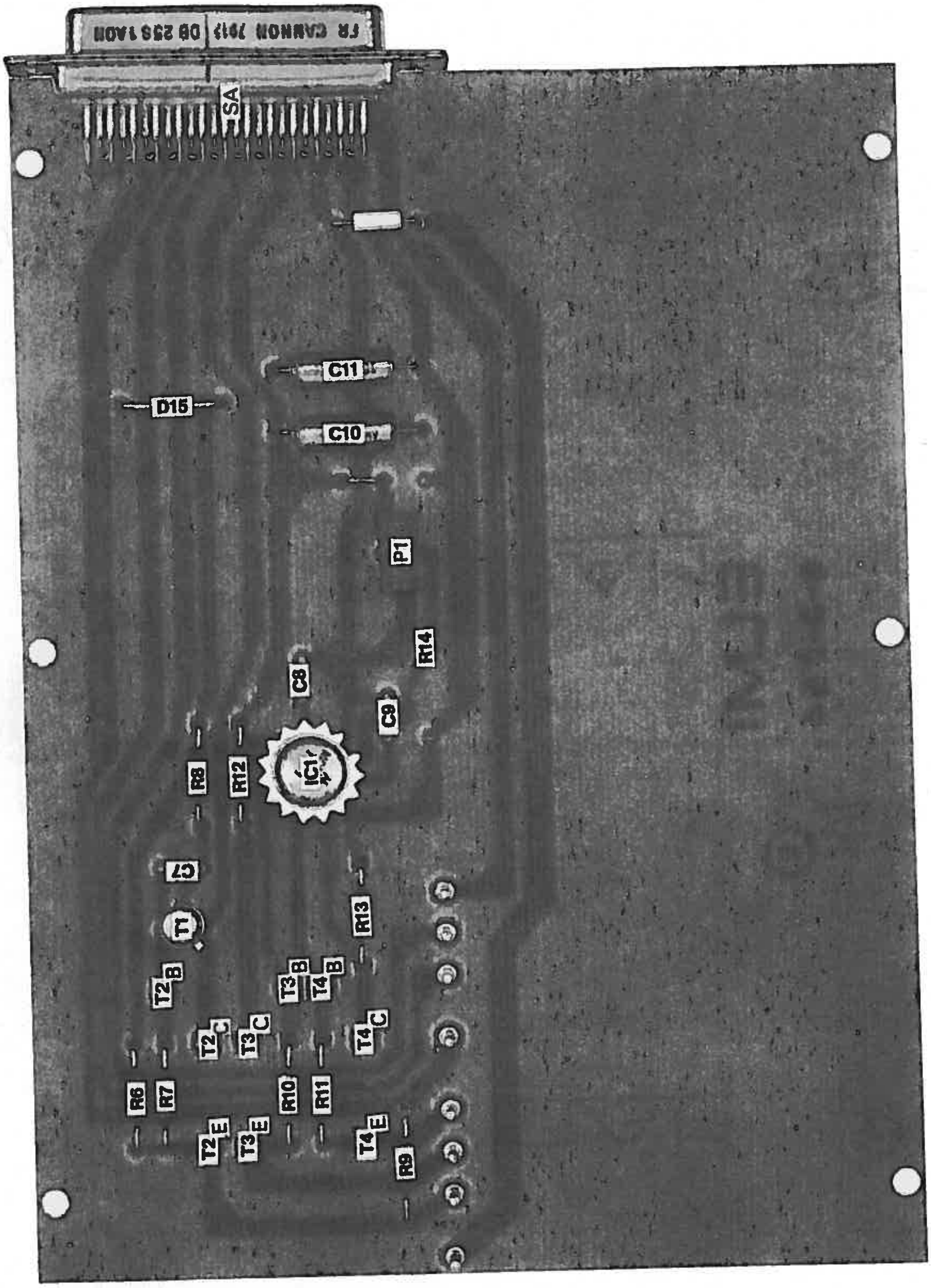
6-3-254 PS Power Supply
Electrical Parts List

ELMI COPENHAGEN DENMARK



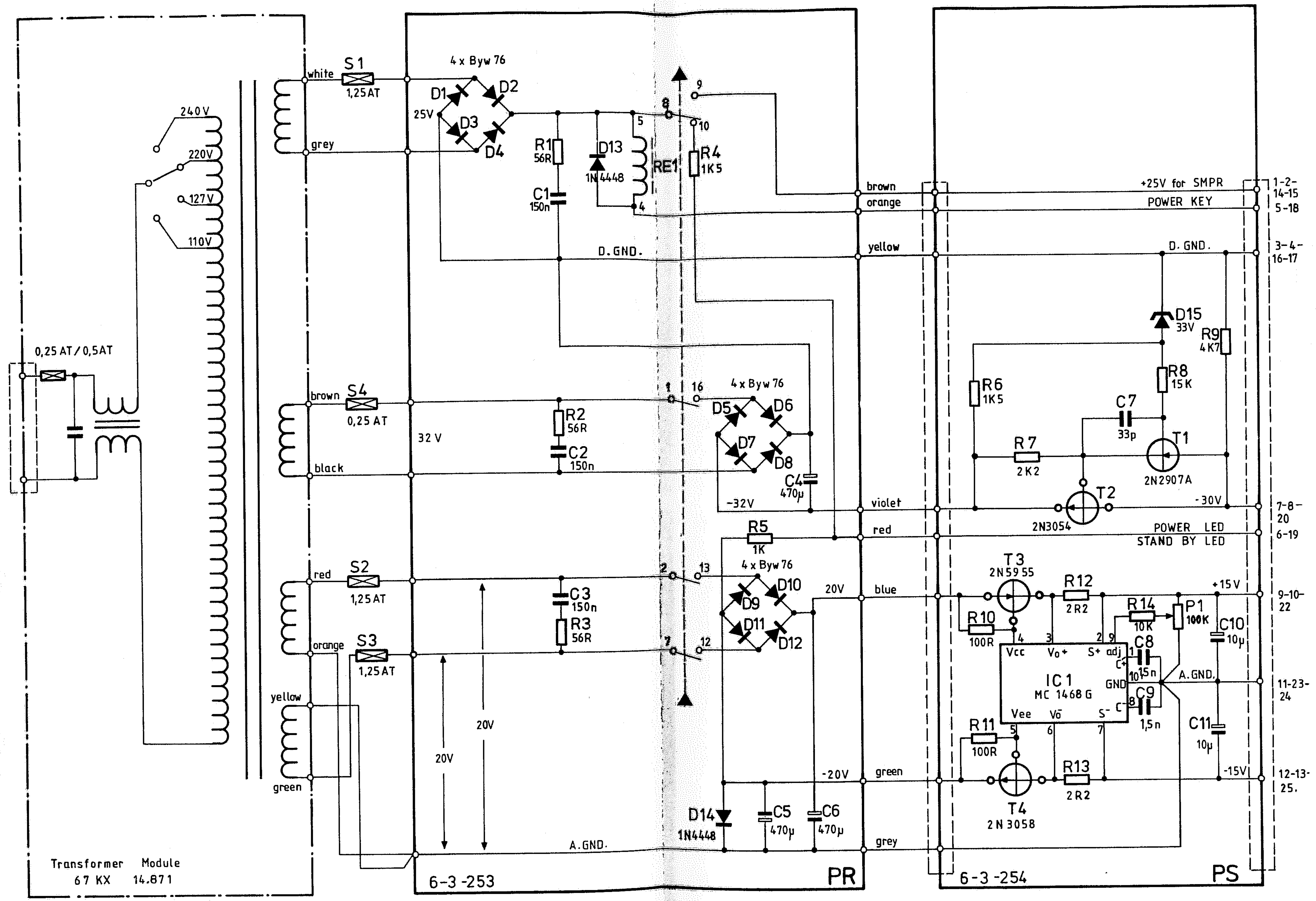
6-3-253 PR Rectifiers Circuits
Electrical Parts Location

ELMI A/S COPENHAGEN DENMARK



6-3-254 PS Power Supply
Electrical Parts Location

ELMI A/S COPENHAGEN DENMARK



6-3-253 PR Rectifiers Circuits 6-3-254 PS Power Supply
Circuit Diagram

ELMI A/S COPENHAGEN DENMARK

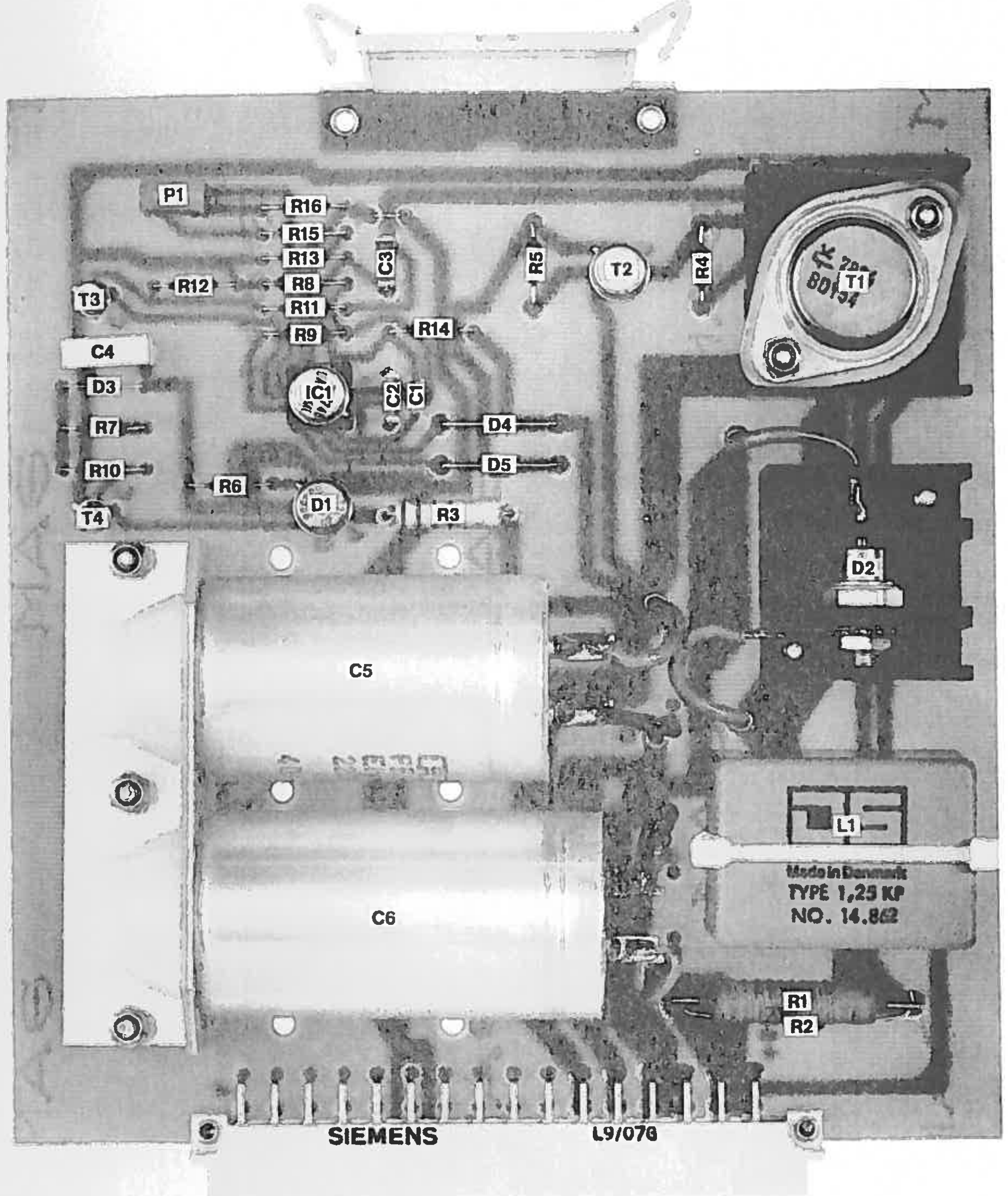
Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			CARBON FILM RESISTORS type CR 25 0,33W ±5%	
R2	1		1R0 2322-211-13108	Philips
R4	1		3R3 2322-211-13338	"
R5-7	3		100R 2322-211-13101	"
R8	1		10R 2322-211-13109	"
R9	1		22R 2322-211-13229	"
R10	1		1K 2322-211-13102	"
R11-13	3		1K5 2322-211-13152	"
R14	1		470K 2322-211-13474	"
			METAL FILM RESISTORS type MR25 ±1%	
R15	1		1K69 2322-151-51692	Philips
R16	1		4K64 2322-151-54642	"
			POWER RESISTORS	
R1	1		0R1, 2W 2322-326-51107	Philips
R3	1		2R2, 1W 2322-213-13228	"
			POTENTIOMETER CERMET	
P1	1		1K 3386H-1-102	Bourns
			CERAMIC CAPACITOR	
C1	1		560pF 2222-638-52561	Philips
			POLYESTER CAPACITORS	
C2	1		10nF B32560-B3103-J	Siemens
C3	1		15nF B32560-B3153-J	"
C4	1		150nF 2222-344-21154	Philips
			ELECTROLYTE CAPACITORS	
C5	1		2200uF/40V PEH139KC422	Rifa
C6	1		10000uF/10V PEH139ED510	"
			INTEGRATED CIRCUIT	
IC1	1		uA 723 CH	Texas
			DIODE SILICIUM	
D2	1		1N3880	RCA
			TRANSISTORS	
T1	1		BDY 53	Sescosem
T2	1		BSS 44	Telefunken

6-3-255 PT SMPR
Electrical Parts List I

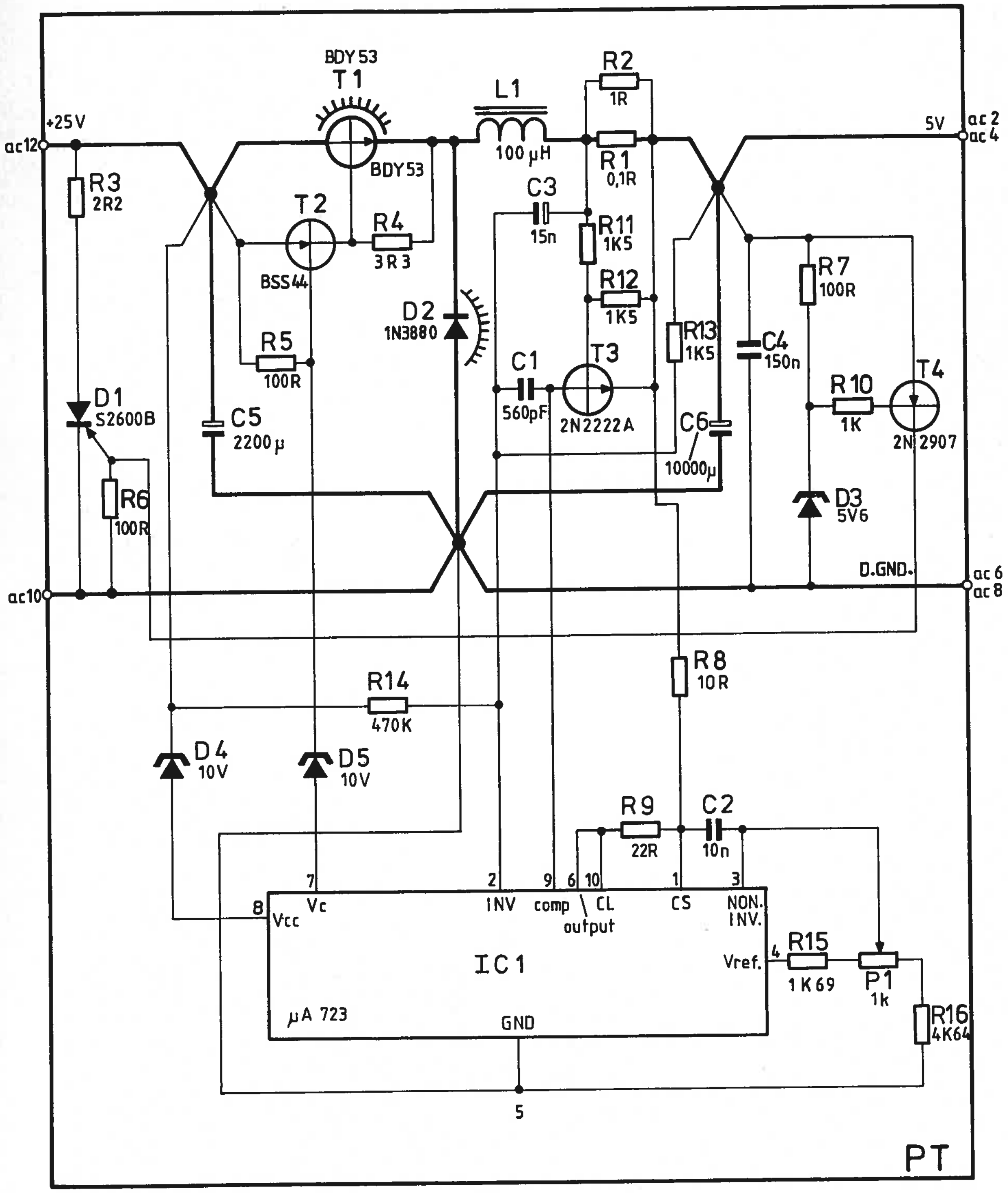
ELMI A/S
COPENHAGEN DENMARK

Cir. Ref.	Qty	Stock No.	Description	Manufacturer (Subject to change)
			TRANSISTORS	
T3	1		2N2222A	Simens
T4	1		2N2907A	"
			TYRISTOR	
D1	1		S 2600 B	RCA
			ZENER DIODES	
D3	1		BZX 79 C5 V6	Philips
D4-5	2		BZX 87 C10	"
			CHOKE	
L1	1		Type 1,25KP, 14862	J.Schou
			HEAT SINKS	
	1		SK 37/30/SA	Fischer
	1		UK 35/SA-3	"
			CONNECTOR	
	1		C42334-A191-A202	Siemens
	1	6-3-255	Printed Circuit Board	Elmi

6-3-255 PT SMPR
Electrical Parts List II

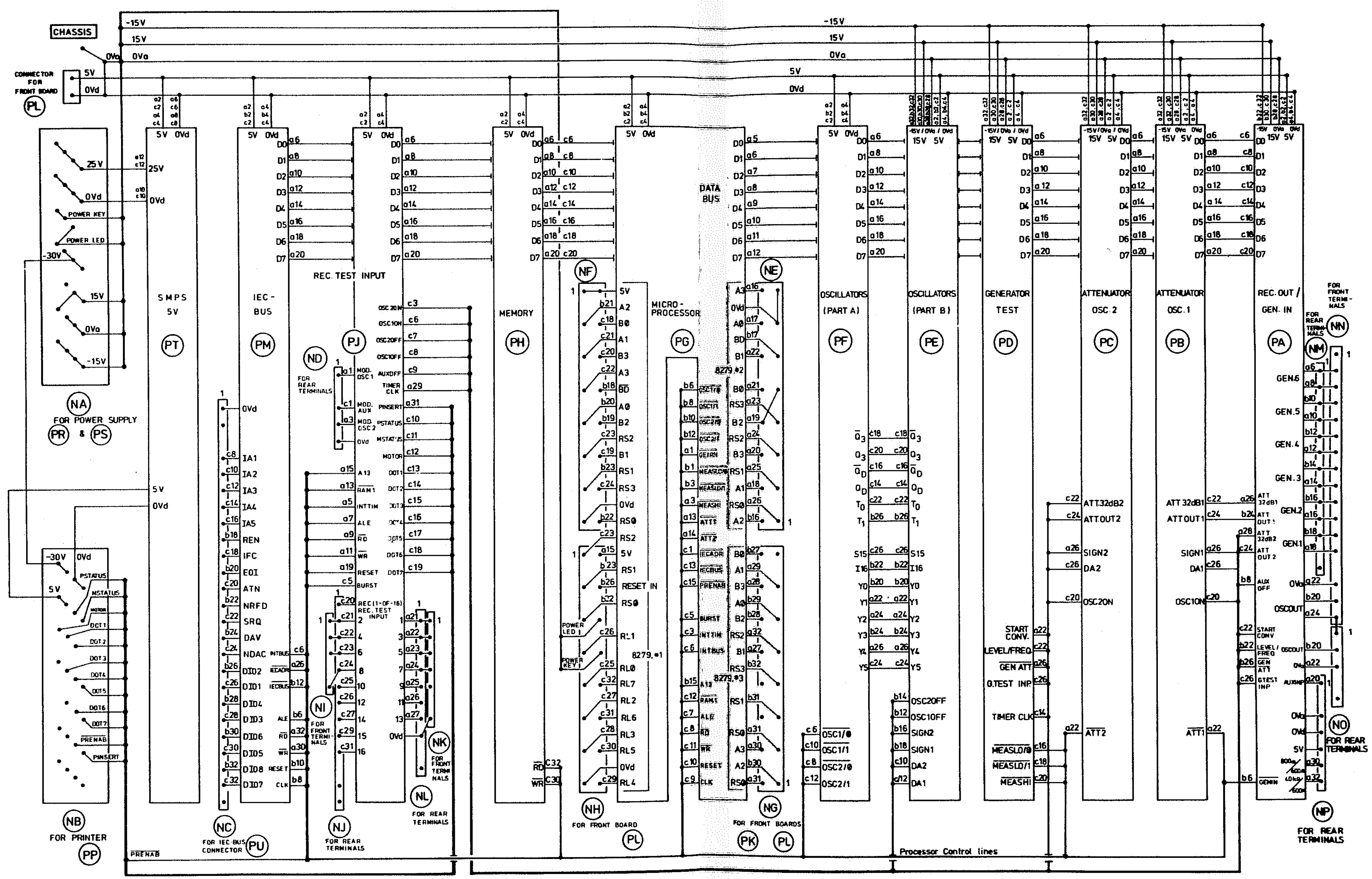


6-3-255 PT SMPR
Electrical Parts Location



6-3-255 PT SMPR
Circuit Diagram

ELMI A/S COPENHAGEN DENMARK



6-1-229 PN Mother Board
Circuit Diagram

ELMI A/S COPENHAGEN DENMARK

SYMPTOM	PROBABLE SOURCE	BOARD
No aux. signal or wrong level of aux. signal	Amplifier Aux. signal switch	PA PA
Wrong pulse or pause	Tone burst control 4 kHz oscillator	PJ PD
External tone burst modulation of no effect	Tone burst control Connector	PJ rear
<u>Receiver Test Input</u>		
Wrong active level of input	Test input reference	PJ
No reading of input	Test input Connectors	PJ rear, front
Wrong time measurement	4 kHz oscillator	PD
<u>IEC-Bus</u>		
No or wrong communication	IEC-Bus interface Connectors	PM rear
<u>Printer</u>		
Lack of dots in print-out	Dot drivers	PP
No or wrong print-out	Printer ports Printer interface	PJ PP
<u>Display/Keyboard</u>		
Wrong output of all displays or LEDs No flashing of LEDs or decimal points No key input	Interface circuits	PG
Wrong lighting of one display	Decoding, driving or display circuits	PK, PL
Wrong lighting of one result LED	Decoding circuits, driving circuits or LED	PK PL
Wrong lighting of one key LED	Decoding circuits, driving circuits or LED	PL

SYMPTOM	PROBABLE SOURCE	BOARD
No reading of one key	Decoding circuits or key	PL
Power Supply		
No or wrong +15 V, -15 V, -30 V	Rectifiers Regulator	PR PS
No or wrong +5 V	Rectifiers Svitch-mode power supply	PR PT
No voltages	Transformer module Power relays Power key Fuses	 PR PL
Program Execution		
Wrong program execution	Microprocessor Memory	PG PH

Some troubles may, however, stem from the connections on the motherboard PN.

4.2 PERFORMANCE CHECK

The performance check procedure may be used for checking the features ensuring correct performance of the instrument. The limits and demands for accuracy which must be observed by the instrument are described in the section 'Specifications' in the 'Operator's Manual'.

Test Equipment Required

A satisfactory performance check requires a minimum amount of test equipment as follows:

DESCRIPTION	MINIMUM SPECIFICATIONS	PURPOSE
Sine generator	Frequency range: 200 Hz - 6000 Hz Level range: 10 mVrms - 20 Vrms	To send measuring tone of Generator Test.
DC-generator	0 V - 10 V	To set input level of Receiver Test.
AC-voltmeter	Range: 10 mVrms - 20 Vrms Accuracy: 1%	To measure level of Generator Test and Receiver Test.

DESCRIPTION	MINIMUM SPECIFICATIONS	PURPOSE
DC-voltmeter	Input impedance: > 1 MΩ Range: 1 V - 10 V Accuracy: 5%	To measure input level of Receiver Test.
Selective voltmeter or	Range: 60 dB (Band width: 500 Hz) Accuracy: 1 dB	To measure harmonics of Receiver Test.
High-pass filter	60 dB/octave	To measure harmonics of Receiver Test.
Frequency counter	Range: 200 Hz - 6000 Hz Accuracy: 0.1 Hz	To measure frequency of Generator Test and Receiver Test.
Oscilloscope	Time division: 1 ms - 100 ms	To measure tone bursts of Receiver Test.

Generator Test Performance (Boards PA, PD)

a. Connect the sine generator, the AC-voltmeter and the frequency counter to Generator Test Input 1.

b. Press HOLD, FREQUENCY, LOAD and LOAD.

c. Check that the frequency measured corresponds to the measurement of the frequency counter.

d. Press LEVEL.

e. CHECK that the level measured corresponds to the measurement of the AC-voltmeter.

If the Receiver Test Output performance fulfils the specifications, the Generator Test performance may be checked by means of a self-test (see the 'Operator's Manual', section 3.1).

Receiver Test Output Performance

1) Frequencies of Signal Generators (Boards PE, PF)

a. Connect the frequency counter to the Receiver Test Output.

b. Press FUNCTION and enter the parameters with the values wanted, but turn off oscillator 2 and set PAUSE at 0 ms.

c. Check that the frequency measured corresponds to the parameter value read in.

d. Repeat a., b., and c. with oscillator 1 turned off instead of oscillator 2.

2) Harmonic Distortions (Boards PB, PC).

a. Connect the selective voltmeter (or the high-pass filter and the AC-voltmeter) to the Receiver Test Output.

b. Press FUNCTION and enter the parameters with the values wanted, but turn off oscillator 2 and set PAUSE at 0 ms.

c. Check that the level of harmonics of the oscillator 1 signal is 46 dB lower than the level of the fundamental.

d. Repeat a., b. and c. with oscillator 1 turned off instead of oscillator 2.

3) Output Level of Signal Generators (Boards PA, PE)

a. Connect the AC-volmeter to the Receiver Test Output and terminate by 600 Ω. Set the impedance switch at 600 Ω.

b. Press FUNCTION and enter the parameters with the values wanted, but set the output level at 15 dBm, turn off oscillator 2 and set PAUSE at 0 ms.

c. Check that the level measured is 15 dBm.

d. Repeat a., b. and c. with oscillator 1 turned off instead of oscillator 2.

4) Attenuators (Boards PB, PC)

a. Connect the AC-voltmeter to the Receiver Test Output and terminate by 600 Ω. Set the impedance switch at 600 Ω.

b. Press FUNCTION and enter the parameters with the values wanted, but turn off oscillator 2 and set PAUSE at 0 ms.

c. Check that the level measured corresponds to the parameter value read in at the following output levels: 14, 13, 12, 11, 8, 7, 0, -1, -16, -17, -48 and -49 dBm.

d. Repeat a., b. and c. with oscillator 1 turned off instead of oscillator 2.

5) Aux. Signal Input (Board PA)

a. Connect the sine generator to the Aux. Signal Input (rear panel) and the AC-voltmeter to the Receiver Test Output.

b. Press FUNCTION and enter the parameters, but turn off both oscillators and set PAUSE at 0 ms. PULSE

c. Check that the attenuation of the aux. signal is 0 dB.

6) Tone Burst (Boards PD, PJ)

a. Connect the oscilloscope to the Receiver Test Output.

b. Press FUNCTION and enter the parameters with the values wanted.

c. Check that the length of pulses and pauses is correct.

If the Generator Test Performance fulfils the specifications, Test Nos. 1, 3, 4 (partly) and 5 may be made by means of a self-test (see the 'Operator's Manual', section 3.1).

Receiver Test Input Performance

a. Connect the DC-generator to the Receiver Test inputs 1-8 and the reference ground (terminal 9). Connect the DC-voltmeter across the generator.

b. Press FUNCTION and enter the parameters with arbitrary values.

c. Check, by means of the result LEDs, that the active level of input is correct (note that the measurement must start with input levels being non-active).

4.3 ADJUSTMENT

Each printed circuit board is individually adjusted at the factory. If, therefore, a board needs replacement, no adjustment of the instrument will be necessary.

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If, in the course of time, the instrument needs adjustment, the following guidance may be used:

Test Equipment Required

A satisfactory adjustment requires a minimum amount of test equipment.

In addition, an extension board with a 96-terminal DIN-plug will be needed, which can be purchased from ELMI A/S.

DESCRIPTION	MINIMUM SPECIFICATIONS	PURPOSE
Sine/square-wave generator	Frequency range: 1 kHz - 10 kHz Level range: 0.1 Vrms - 1 Vrms	To send measuring tone of Generator Test.
AC-voltmeter	Range: 10 mVrms - 10 Vrms Accuracy: 0.1% Input Impedance: > 1 MΩ	To measure level of Generator Test. To measure output impedance and output level of Receiver Test.
DC-voltmeter	Range: 1 V - 20 V Accuracy: 1%	To measure power supply voltages.
Selective voltmeter	Range: 60 dB (Band width: 500 Hz) Accuracy: 1 dB	To measure harmonics of Receiver Test.
or		
High-pass filter	60 dB/octave	To measure harmonics of Receiver Test.

Level Measurement Adjustment

(Generator Test) - Board PD

1) AC/DC-Converter Symmetry

a. Reset the instrument.

b. Apply a tone to Test Point 1, TP1 (10 kHz square-wave, approx. 1 Vrms)

c. Measure the AC-voltage of TP2.

d. Adjust P1 to the minimum AC-voltage of TP2 (approx. 10 mVrms).

2) Offset and Gain

a. Apply a tone to Generator Test Input 1 (1 kHz sine, approx. 0.7 Vrms).

b. Make a Generator Test Frequency measurement on generator No.1

c. Adjust the generator until the TP5 voltage shows 6.887 Vrms (corresponding to 0.0 dBu at the Generator Test Input).

d. Ground TP4 (the MFTE will now show the output frequency of the V/F-converter).

e. Ground TP3 and adjust P2 until the result display shows 337.4 Hz.

f. Remove the ground from TP3 and adjust P3 until the result display shows 6000.0 Hz.

g. Repeat e. and f. until adjustment is no longer necessary.

Output Impedance

(Receiver Test) - Board PA

a. Make a Receiver Test measurement where OSC1 = 950 Hz, 15 dBm (freq. series 2, rec.comb. = f2/f4, deviation 1 = 50 Hz).
OSC2 = OFF; PULSE = 10 ms; PAUSE = 0 ms.

b. Set the impedance switch at 600Ω.

c. Measure the voltage at the Receiver Test Output.

d. Place a 600Ω resistor (0.1%) across the output and adjust P1 until the voltage is half (±o.1%) the voltage measured under c.

e. Set the impedance switch at 800Ω and remove the 600Ω resistor.

f. Measure the voltage at the Receiver Test Output.

g. Place an 800 Ω resistor (0.1%) across the output and adjust P2 until the voltage is half (±0.1%) the voltage measured under f.

Harmonic Distortion

(Receiver Test) - Boards PB, PC

a. Make a Receiver Test measurement where OSC1 = 2500 Hz, 15 dBm (freq. series 12, deviation 1 = 100 Hz).
OSC2 = OFF; PULSE = 10 ms; PAUSE = 0 ms.

b. Measure the level of the 3rd harmonic (7500 Hz) and adjust P1 (board PB) to the minimum level of that harmonic (typically between -50 dBm and -60 dBm).

c. Turn P1 further to the left (counter-clockwise) until the signal has increased by 2 dB.

d. Make a Receiver Test measurement where OSC1 = OFF
OSC2 = 2500 Hz, 15 dBm (freq. series 12, deviation 2 = -100 Hz)
PULSE = 10 ms; PAUSE = 0ms

e. Repeat b. and c. with P1 on board PC.

Output Level

(Receiver Test) - Board PE

a. Make a Receiver Test measurement where OSC1 = 950 Hz, 15 dBm (freq. series 2, rec. comb. = f2/f4, deviation 1 = 50 Hz)
OSC2 = OFF; PULSE = 10 ms; PAUSE = 0 ms.

b. Place a 600Ω resistor (o.1%) across the Receiver Test Output and adjust P1 until the output voltage is 4.356 V (= 15 dBm).

c. Make a Receiver Test measurement where OSC1 = OFF
OSC2 = 950 Hz, 15 dBm (freq. series 2, rec. comb. = f1/f2, deviation 2 = 50 Hz)
PULSE = 10 ms; PAUSE = 0 ms.

d. Repeat b. with P2.

Printer - Board PP

Cleaning and paper roll installation procedures are described in the 'Operator's Manual' (section 3.2).

The printing quality can be adjusted by means of P1.

Power Supply - Boards PS, PT

±15 V can be adjusted by means of P1 on the board PS.

+5 V can be adjusted by means of P1 on the board PT.

ELMI A/S COPENHAGEN DENMARK

5 REPLACEMENT PARTS

Orders for replacement parts should include information on:

a) Type and serial number of instrument.
b) Circuit reference.
c) Description

The type and serial number appear from a small sign on the rear panel of the instrument, whereas circuit references and descriptions may be found in the component lists.

To order a part not listed in the component lists, give a complete description of the part and include its function and location.

To order replacement parts, address order or inquiry either to your local reprensentative or to:

ELMI A/S

90, Kirkebjerg Alle

DK-2600 GLOSTRUP

Denmark

Phone: National: 02-45 42 11
International + 45 2 45 42 11

Telex: 33 423 ELMI DK

Cables: ELMIWORKS