CAPNOMAC

ULTIMA™

SERVICE MANUAL

CE
0537

Manual No. 878131-1

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2 WARNINGS AND CAUTIONS

WARNINGS

A WARNING indicates that there is a possibility of injury to yourself or others.

PROPER GROUNDING: For protection against shock hazards, connect this monitor only to a three-wire, grounded, hospital grade receptacle. Do NOT remove the grounding prong from the power plug. Do NOT use extension cords or adapters of any type. The power cord and plug must be intact and undamaged. Should the power cord or plug become cracked, frayed, broken or otherwise damaged, it must be replaced. When connecting an external AC-operated equipment to the monitor, make sure that the equipment is properly grounded.

Do NOT perform any testing or maintenance on medical instruments while they are being used to monitor a patient.

Monitor models not including the automatic agent identification cannot distinguish between anaesthetic agents. Manufacturer assumes no liability for an incorrect anaesthetic selection.

When doing any work on the SpO_2 board care has to be taken that the patient isolation is not violated.

EXPLOSION HAZARD: Never use this monitor in the presence of flammable anaesthetics.

FUSE REPLACEMENT: For continued protection against fire hazard, replace only with the same type and rating of fuse.

Do not make any modifications to the patient cables without consulting the manufacturer.

ELECTRIC SHOCK HAZARDS:

The CRT display unit contains high voltage circuitry.
In case of mechanical damage, carefully inspect the integrity of the patient isolation circuitry, CRT unit high voltage circuitry, the power supply transformer and primary wiring.

Do NOT immerse the monitor or probe in any liquid. An SpO_2 probe that is damaged or has been immersed may cause burns during electrosurgery.

Switch the power off and unplug the power cord before cleaning or service.

Do NOT touch any exposed wiring or conductive surface while the cover is off and the monitor is energized. The voltages present when the electric power is connected to the monitor can cause injury or death.

After doing any repair or calibration procedure to the monitor, perform a final electrical safety check and current leakage test.

The manufacturer accepts no responsibility for any modifications made to the monitor outside the factory.

CAUTIONS

A CAUTION indicates a condition that may lead to equipment damage or malfunction.

The tests and repairs described in this manual should only be done by trained personnel with proper tools and test equipment. Unauthorized service may void the monitor warranty.

Check the rear panel voltage setting before connecting the monitor to AC mains power outlet.

When the monitor is in use, leave space for ventilation to minimize heat accumulation inside the monitor.

Connect sample gas outlet on the monitor's rear panel to scavenging system to prevent room air pollution. Diameter of scavenging system tubing must be 2 to 3 times larger than that of sample out tubing to avoid changing the operating pressure of the monitor and consequent inaccurate readings or internal damage.

Diameter of calibration gas delivery tube must be 2 to 3 times larger than that of the sampling line to avoid overpressurization and consequent inaccurate calibration or internal damage of the monitor.

After performing any service always check the oxygen transducer by breathing into the sampling line and observing O_2 waveform display. After a moment's delay the wave should drop from the room air (21 %) to between 13 and 17 % O_2. The oxygen transducer uses room air as reference gas. It is possible for the transducer to malfunction or for the connecting tubing to be disconnected, and the digital display read 21 % O_2.

Before use, allow two minutes for warm-up and note any error messages or deviations from normal operation.

Always switch the monitor off before making any connections with external equipment.

Avoid ammonia-, phenol-, or acetone-based cleaners for they may damage the monitor's surface.

Electrostatic discharge through the pc boards may damage the components of the monitor. Handle all pc boards by their non-conductive edges and use anti-static containers when transporting them. Before replacing and repairing pc boards, wear a static control wrist strap to discharge any accumulated static charge.

Do not disassemble the ACX measuring unit. The unit is repaired and adjusted at the factory.

When removing or inserting any part into the monitor, be careful not to kink or damage the gas sample tubes. Leakages in the gas sampling system affect accuracy of measurement and are difficult to detect.

When servicing the sampling system, make sure not to leave any tubes touching the sampling pump. Abrasion may damage the tubes.

Do not apply tension to the power cord.

Do not autoclave the monitor nor probes.

Do not gas sterilize the monitor.

Equipment classification

Classification according to IEC 601-1:

* CLASS 1 equipment according to the type of protection against electrical shock.

* TYPE BF equipment according to the degree of protection against electrical shock.

* ORDINARY equipment according to the degree of protection against harmful ingress of water.

* Equipment not suitable for use in the presence of FLAMMABLE ANAESTHETIC MIXTURE with air or with OXYGEN/NITROUS OXIDE.

* CONTINUOUS OPERATION according to the mode of operation.

3 INTRODUCTION AND APPLICABILITY OF THIS MANUAL

3.1 Introduction and applicability of this manual

This service manual (Doc. No. 878131) and the Panasonic CRT Data Display Model M-K9101NB service manual (available from DATEX-ENGSTROM Division, order code 572760) provide information required to maintain and repair the CAPNOMAC ULTIMA™ ULT-1/ULT-S/ULT-V/ULT-SV/ULT-i/ULT-Si/ULT-Vi/ULT-SVi model monitors. This manual is applicable for the current production revision of the monitors. Differences between monitor revisions are summarized in Section 3.2 and the technical details of earlier revisions given in Chapter 11. Section 3.3 lists the technical (hardware) changes made to the monitor and Section 3.4 the software changes.

The revision of a monitor is changed when technical changes are made to the monitor resulting in new spare parts that are incompatible with earlier units. The last two digits of the monitor type designation denote the revision of the monitor (e.g. ULT-1-23-00 is a revision -00 unit).

Functional units of the monitor (pc boards) will have ID code stickers indicating the modification level of the production documentation. The code is shown as xxxxxx-y, where the "xx..." represents the part number and "y" the revision level, which is referred to when hardware changes are indicated in this manual.

The following list shows the models and their monitoring parameters.

Model	Monitoring parameters
ULT-1	CO_2, N_2O, O_2, AA
ULT-S	CO_2, N_2O, O_2, AA, SpO_2
ULT-V	CO_2, N_2O, O_2, AA, Patient Spirometry™
ULT-SV	CO_2, N_2O, O_2, AA, SpO_2, Patient Spirometry™
ULT-i	CO_2, N_2O, O_2, AA, Agent ID
ULT-Si	CO_2, N_2O, O_2, AA, SpO_2, Agent ID
ULT-Vi	CO_2, N_2O, O_2, AA, Patient Spirometry™, Agent ID
ULT-SVi	CO_2, N_2O, O_2, AA, SpO_2, Patient Spirometry™, Agent ID

The basic CAPNOMAC ULTIMA™ model ULT-1 measures CO_2, N_2O, O_2, and AA. The additional parameters and their symbols are explained below.

S	SpO_2
V	Patient Spirometry™
i	Agent ID

This manual describes all the functions offered by the CAPNOMAC ULTIMA™ monitor. Some of the functions may not be available in the monitor you are using.

ACX-200 Measuring board measures sevoflurane and desflurane in addition to halothane, isoflurane, and enflurane. The difference between the ACX-200 Measuring board and ACX-100 Measuring board is that the former contains several precision resistors. The ACX-200 Measuring board can simply be used to replace the ACX-100 Measuring board but not vice versa. Unless otherwise noted, the description of ACX-100 Measuring bench/board is also valid to ACX-200 Measuring bench/board.

ASX-100 identifies halothane, isoflurane, and enflurane. ASX-200 identifies halothane, isoflurane, enflurane, sevoflurane, and desflurane.

If ASX-100 is replaced by ASX-200 (or i-kit which includes ASX-200 is installed in the monitor), ACX must be upgraded to ACX-200 and the main software replaced (the i-kit includes the main software).

Please review the Operator's Manual to obtain a clear understanding of the monitor.

The manufacturer reserves the right to make changes in product specifications at any time and without prior notice. The information in this document is believed to be accurate and reliable; however the manufacturer assumes no responsibility for its use.

3.2 Summary of revision changes

Revision -00

Initial production revision of the monitor.

Revision -01
(except ULT-1/S-27-00)

Main differences to the revision -00 are:

The color of front panel, side and top covers, and bottom plate changed to white.

Revision -02
(except ULT-1/S-27-01 and ULT-V-xx-00)

Main differences to the revision -01 are:

ACX measuring board modified.

Software.

CPU board jumper X3 shorting pins 2 and 3 in order to use 2Mbit EPROM.

Revision -03
(except ULT-S/SV-25-00, ULT-1/S-27-02, ULT-V-xx-01, and ULT-i/Si/Vi/SVi-xx-00)

Main differences to the revision -02 are:

ACX-100 measuring unit is replaced by ACX-200 measuring unit.

Anaesthetic agent identification parameter (i) is added to Ultima.

Revision -04

Main differences to the revision -03 are:

ASX-100 identification unit is replaced by ASX-200.

Power supply board.

Software.

Revision -05 (-27 only)

Main differences to the revision -04 are:
- Improved EMC protection.

Revision -06

Current production revision of the monitor. Main differences to the revision -04/05 are:
- Improved EMC protection.
- CPU board (16 MHz High Speed CPU board installed).
- Improved SpO_2 Measuring board.
- Main software.

Additionally;
- PVX software and front mask for pediatric PVX measurement (all except -27 and -43).

> **NOTE:** New main software and the High Speed CPU board are compatible with the old and new SpO_2 Measuring board, and with ASX-100, ASX-200, ACX-100, and ACX-200 sensors.

> **NOTE:** New SpO_2 Measuring board operates only with the new main software and the High Speed CPU board.

Revision -07 (-27, -43)

- Software and front panel for paediatric PVX measurement are applied also to adaptations -27 and -43.
- In adaptation -27: new transformer case and new video display unit.
- Desflurane measurement is applied to adaptation -43.

Revision -07 (all except -27 and -43)

- CE mark
- new SpO_2 board, new oxygen sensor
- adaptations -21, -23, -25 replaced by -22

Revision -08 (-27 and -43)

- adaptation -43 CE mark
- adaptations -27 and -43 new SpO_2 board, new oxygen sensor

Revision -08 (all except -27 and -43), Revision -09 (-27, -43)

- new mains switch
- new rear panel
- main software
- video board (ASIC)

3.3 Manual updates

3.3.1 CAPNOMAC ULTIMA™ service manual changes

This is the update number 6 to the CAPNOMAC ULTIMA™ service manual. After this update, the manual covers 00 to 08 revision monitors, and revision 09 monitors of adaptations 27 and 43.

Manual update 6

Of all the pages taken out of this manual the following pages should be filed in chapter 11:

5-3, 5-4, 5-5, 5-31--5-34a, 5-36, 7-4

Page	Change
Header page	new address and date
Section 1	index revised
3-4	rev 07, 08 and 09 added
3-5	manual update page revised
3-6	update 6 added
3-12, 3-13	software changes for rev 07, 08 and 09 added
4-13	block diagram revised
5-3	gas sampling system diagrams revised
5-4, 5-5	gas sampling system layouts revised
5-7	ACX-100 replaced with ACX in general description
5-13	O2 field frequency changed from 165Hz to 110Hz
5-23	SpO2 board P/N changed
5-29	jumpers x4 and x6 removed from CPU parts layout
5-31, 32, 33	video ASIC board information added
5-35	data retention voltage source changed from 15V to 5V
5-36	block diagram revised
5-38a	adaptation 23 replaced by 22
6-4, 6-5	information concerning N2O zero constant added
6-15, 6-16	troubleshooting table revised
6-20	trobleshooting instruction revised
6-23	troubleshooting table revised
6-24	instruction for ACX measuring chamber cleaning added
7-1	ASX-100 replaced by ASX in text
7-4	gas sampling system adjustment chart revised
7-6	O2 gain adjustment instruction changed
7-10,11	Philips Video Display Unit schematics added
8-2	preoperative check list revised
8-6	preventive maintenence check list revised
8-7...8-12	preventive maintenance instructions added
9-1, 2, 3, 4	spare parts list revised
9-6	revision and main software history revised
9-9	text added to expl. picture of adaptation 27
9-10	expl. picture of adaptation 27 rev 09 added
12-9	information concerning PBJ-124 printer added

3.3.2 Record of manual updates carried out

Update number	Carried out by Name	Date
1	Datex	May 2nd, 1991
2	Datex	September 1st, 1992
3	Datex	March 1st, 1993
4	Datex	November 1st, 1993
5	Datex	June 1st, 1994
6	Datex-Engstrom	January 15th, 1997
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3.4 Software changes

The software code (six numbers) and revision number (if other than initial revision) are displayed on the screen during the startup sequence.

Software P/N 875345-4 is the initial production English language, 877340-2 is the initial production French language and 877412 is the initial production German language versions. These software are installed also in revision -01 monitors (see Section 9.1 for detail).

Software P/N 879016 is the revision -02 (except ULT-1/S-27-01 and ULT-V-xx-00) production English language, 879244 is the German language, and 879245 is the French language versions.

Differences to the initial software versions are:

30-minute trend added to Graphic trends of 2 h, 6 h, and 12 h.

Parameter configurations of the trend pages have been modified and a fourth page is added in order to include V-model parameters.

Numeric trend is added. Its time scale is 12 hours.

Selection of anaesthetic agent became easy. Pressing of the SET key is no longer necessary.

SEIKO DPU-411 printer is added to the printer selection.

Selection of O_2 scale is added in the SETUP SCREEN menu. The choices are 0 to 100 %, 10 to 60 %, DIFF/30 %, or DIFF/X % (X is the same number as in CO_2 scale selected, e.g., 6, 10, or 15). This selection is valid both in waveform and trends.

In the Start-up menu the user can now select to display either balance gas or MAC values. This selection also has an effect on graphic trends page 3.

Pleth amplitude indicating bar is now shown at the left corner of Pleth waveform field.

Display field of SpO_2 value digits can be moved from the lower right side (factory default) to the lower left side in Start-up menu.

$EtCO_2$ value digits can be enlarged as big as SpO_2 digits in Start-up menu. Factory default is the normal small size.

A 1.2 % scale is added for the anaesthetic agents display.

Anaesthetic agent concentration is now displayed with two decimals when the concentration is below 1 %.

Count-down display for the silence alarm suspend and apnea have been added.

Audible alarm for apnea can now be silenced in Start-up menu (except in French version).

Audible alarms for O_2 and anaesthetic agent are now activated only when breathing is detected.

Cautionary high and low alarms for anaesthetic agent have been added. The adjustment can be made between 0.1 % and 15 %.

User preset alarm limits for anaesthetic agents are now adjusted in MAC values which will then automatically be applied in corresponding percentages when an anaesthetic agent is selected.

Number of beeps in different alarm situation has been modified.

Shadow traces is now displayed when the user goes to any of the menus and returns to the normal display, so that the user will not lose waveform information during the menu period. These shadow traces are available for CO_2, O_2, and anaesthetic agent slow sweep speed waveforms.

Both serial string and graphic output are now sent via SERIAL & ANALOG I/O connector. The output selection is made in Start-up menu. AUX connector for graphic output will not be used any more.

Software P/N 879016-2.1 is the revision -03 (except ULT-S/SV-25-00, ULT-1/S-27-02, ULT-V-xx-01, and ULT-i/Si/Vi/SVi-xx-00) production English language, 879244-1.0 is the German language, and 879245-1.1 is the French language versions.

Differences to the previous level software versions are (see the Operator's Manual for more information):

Sevoflurane is measured and displayed (ACX-200 measuring unit).

Anaesthetic agent is identified and displayed (ASX unit in Ultima models with i-parameter).

MAC value of Isoflurane is changed from 1.3 % to 1.15 %

Numeric trends are now printed in graphic printers.

A line of numeric data of pressures and volumes is printed every 30 minutes and whenever the MARK key is pressed beside the graphic printout in graphic printer.

Software P/N 882312-1.0 is the revision -04 production English language, 882313-1.0 is the German language, and 882314-1.0 is the French language versions.

Differences to the previous level software versions are (see the Operator's Manual for more information):

Desflurane is measured and displayed (ACX-200 measuring unit).

Sevoflurane and desflurane are identified and displayed (ASX-200 unit in Ultima models with i-parameter).

Mixture of two agents is identified, and inspiratory and expiratory values for both agents are displayed.

While agent mixture is present, both agents' ET- and Fi- values are shown in U01-serial data string.

Selection "ID or SEV/DES" in user configuration menu is deleted.

ASX service page changed:
Total concentration of agent and relative proportions of all agents are displayed. Amplitude of spectrum is depending on concentration.
ASX delay measurement is added in gas service page.

High alarm limits for anaesthetic agent are changed as follows:

Halothane, Isoflurane	6 %
Enflurane, Sevoflurane	8 %
Desflurane	20 %

ACX measuring board compatibility with ACX benches.

P/N 874773-x...Can be used with ACX-100 bench only

P/N 875736-x...Can be used with ACX-100 bench only

P/N 878738-x...Can be used with ACX-100 bench only

P/N 880270-x...Can be used with ACX-100 and ACX-200 benches.

Software P/N 882916-1.0 is the revision -06 production English language, 882917-1.0 is the German language, and 882918-1.0 is the French language version. Those softwares operate only in 16 MHz (High Speed) CPU board.

Main differences to the previous level software versions are (see the Operator's Manual for more information):

1. Possibility to measure pediatric airway pressure and volume with Pedi-Lite sensor and new PVX software (884013).

2. Flow calibration in PVX is no longer necessary.

3. Spirometry parameter selections are added to normal screen.

4. Error message "MEMORY CHIP FAILURE" is added to indicate flatness of internal battery in SRAM D4 on CPU board.

The production softwares for revision -06 and -07 monitors were:

P/N 882916-3.0 in English (revision -06, except for adaptation -27 revision -07), P/N 882917-3.0 in German (revision -06), P/N 884234-2.0 in French (revision -07 for adaptation 43), and P/N 884203-3.0 in French (revision -06 for adaptation 29).

Changes made:

- PVX-measurement is improved
- Paediatric PVX-measurement and desflurane measurement are added to the French software

The production softwares for revision -06, -07 and -08 monitors were:

882916-3.1 in English (revision -07 except for adaptation -27 revision -08)
882917-3.1 in German (revision -07)
884203-2.0 in French (adaptation -43 revision -08, adaptation -29 revision -07)

Changes made:

- a bug in -3.0 fixed (missing 'SELECT AGENT' message in models without agent identification)
- 884203-2.0 for all french spoken countries since Sevoflurane and Desflurane were accepted also in France.

The current production softwares for revision -08 and -09 monitors are:

882916-4.0 in English (revision -08 except for adaptation -27 revision -09)

882917-4.0 in German (revision -08)

884203-4.0 in French (adaptation -29 revision -08, adaptation -43 revision -09)

889859-4.0 for model ULT-1A only. English revision -09.

890662-4.0 in Spanish (adaptation -40 revision -08)

Changes made:

- MAC value for Sevoflurane changed to 2.05%
- IBM-PRO added to the printer selection list
- Changes in Patient Spirometry recall function
- Text references "Datex" changed to "Datex-Engstrom"
- Time-out for ASX calibration extended from 15 seconds to 30 seconds
- Synchronization of the gas curves improved

4 GENERAL DESCRIPTION

4.1 Operational specifications

Automatic compensation for atmospheric pressure variation, CO_2/N_2O and CO_2/O_2 collision broadening effects

Gas Sampling Flow Rate:		200 ± 20 ml/min
Warm-up Time:		3 min to operation, 30 min for full specifications
CO_2	Measuring Range:	0 to 10 % (0 to 76 mmHg, 0 to 10 kPa)
	Extended range: (unspecified)	10 to 15 % (76 to 114 mmHg, 10 to 15 kPa)
	Rise Time:	≤360 ms
	Gain Drift:	≤0.2 vol %/24h (0 to 8 %) ≤0.4 vol %/24h (8 to 10 %)
	Gain Temperature Drift:	≤0.2 vol %/10°C (0 to 8 %) ≤0.4 vol %/10°C (8 to 10 %)
	Nonlinearity:	≤0.2 vol % (0 to 8 %) ≤0.4 vol % (8 to 10 %)
	Display:	
	Numeric	End tidal and inspired CO_2
	Waveform	Continuous, Scale 0 to 6, 0 to 10, or 0 to 15 % (0 to 6, 0 to 10, 0 to 15 kPa 0 to 50, 0 to 80, 0 to 110 mmHg) Sweep speeds 7 mm/s and 0.7 mm/s (15 and 150 seconds/full screen sweep)
O_2	Measuring Range:	0 to 100%
	Rise Time:	≤480 ms
	Gain Drift:	≤2 vol %/24 h
	Gain Temperature Drift:	≤3 vol %/10°C
	Nonlinearity:	≤2 vol %
	Display:	
	Numeric	End tidal and inspired O_2
	Waveform	Continuous, difference waveform scale is same as in CO_2 waveform, Sweep speeds 7 mm/s and 0.7 mm/s.

N_2O	Measuring Range:	0 to 100 %
	Rise Time:	≤360 ms
	Gain Drift:	≤2 vol %/24 h
	Gain Temperature Drift:	≤3 vol %/10°C
	Nonlinearity:	≤2 vol %
	Display:	End tidal and inspired

Anaesthetic Agent (performance with pure agents)

		Measuring Range		Accuracy
HAL, ISO, ENF		0 to 5 %		≤0.2 vol %
	Extended	5 to 15 %		unspecified
SEV		0 to 8 %		≤0.2 vol %
	Extended	8 to 15 %		unspecified
DES		0 to 18 %	(0 to 5 %)	≤0.2 vol %
			(5 to 10 %)	≤0.5 vol %
			(10 to 18 %)	≤1.0 vol %
	Extended	18 to 30 %		unspecified

Rise Time:	≤520 ms
Gain Drift:	≤0.4 vol %/24 h
Gain Temperature Drift:	≤0.4 vol %/10°C
Display:	
Numeric	End tidal and inspired
Waveform	Scale 0 to 1.2 %, 0 to 2.5 %, 0 to 5 %, 0 to 10 %, 0 to 20 %, Sweep speeds 7 mm/s and 0.7 mm/s.

Agent identification

Identified agents:	HAL, ENF, ISO, DES, SEV
Identification threshold*):	0.15 vol %
Identification time*):	30 seconds
Mixture warning:	Typically minor component concentration >0.3 vol % and >15% of total agent concentration

*) Typical performance with pure agents

Airway Pressure (P_{aw})**

Accuracy:	±1.5 cmH_2O
Resolution:	1 cmH_2O
Measuring Range:	-20 to +80 cmH_2O
Extended Range:	-99 to +99 cmH_2O (unspicified)

Flow**

Measuring Range (Adult):	1.5 to 100 l/min for both directions
(Pediatric):	0.25 to 25 l/min -"-
Display:	Waveform Two sweep speeds Flow-volume loop

Tidal Volume (TV)**

Accuracy:	(Adult) ±6 % or 30 ml (Pediatric) ±6 % or 4 ml
Resolution:	1 ml
Measuring range:	(Adult) 150 to 2000 ml (Pediatric) 15 to 300 ml

Minute Volume (MV)**

Resolution:	0.1 l
Measuring range:	(Adult) 2 to 15 l/min (Pediatric) 0.5 to 5 l/min

**Values applicable if: Respiration rate is 4 to 50 breaths/min
I:E ratio is 1:3 - 1:05
Inner diameter of ET tube is ≥5.5 mm (adult) or 3 to 6mm (pediatric)

Respiratory Rate

Measuring Range:	4 to 60 breaths/min
Breath Detection:	1 % (7.6 mmHg) change in CO_2 level
Display Update Rate:	breath-by-breath

Saturation (SpO_2)

Measuring Range:	40 to 100 %
Accuracy (SD):	100 to 80 % ± 2 %
	80 to 50 % ± 3 %
	50 to 0 % unspecified
Resolution:	1 digit (=1 %)

1 SD = 68 % of all readings in stable conditions.

The pulse oximeter accuracy measurements are statistically derived and correlated to simultaneous SaO_2 measured on an Instrumentation Laboratory IL/282 CO-oximeter

Display Averaging Time:	10 seconds, 5 seconds, or beat-to-beat

Pulse Rate

Measuring Range:	30 to 250 beats/min
Accuracy:	30 to 100 ±5 %
	100 to 250 ±5 beats/min
Resolution:	±1 digit (1 bpm)
Display Averaging Time:	10 seconds, Updated every 5 seconds

Plethysmographic Pulse Wave

Scale (gain) auto-set during start-up

Adjustable scale:	2, 5, 10, 20, 50

Alarms	Adjustable:	$ETCO_2$ (high and low) FiO_2 (high and low) Anaesthetic agent (high and low) Respiratory rate (high and low) CO_2 rebreathing SpO_2 (high and low) Pulse rate (high and low) Peak airway pressure (high and low) PEEP (high) Expiratory minute volume (high and low)
	Non-adjustable:	$FiN_2O \geq 82$ % $FiO_2 \leq 18$ % Apnea Anaesthetic agent detected although not selected for display Occlusion Air leak Pulse search No probe Probe off Leak Disconnection Obstruction

4.2 Technical specifications

Size (D x W x H):	34 x 33 x 21.2 cm (excluding feet) (13.6 x 13.2 x 8.3 in)
Weight:	12.5 kg (27.6 lb)
Display:	9 inch monochrome video
Water Trap:	D-FEND™, operation based on the hydrophobic membrane, volume of the container 9 cm^3.

Electrical requirements

Voltage:	100/115/220-240 V
Stability:	±10 % of nominal voltage
Frequency:	50-60 Hz
Power consumption:	100 VA
Grounding:	Hospital grade
Interruptibility:	Data memory and alarm settings are saved during power failures up to 15 minutes

Environmental requirements

Space:	50 x 50 x 30 cm (19 x 19 x 12 in)
Temperature (operation):	+10 to +35°C (50 to 95°F)
(storage):	-5 to +50°C (23 to 122°F)
Atmospheric pressure:	500 to 800 mmHg (660 to 1060 mbar)
Humidity:	10 to 90 % non-condensing (in airway 10 to 100 % condensing)

Standards fulfilled:	IEC 601-1, Safety Class I, Type BF CSA C22.2, No. 125-M1984

4.3 Equipment classification

Classification according to IEC 601-1:

* CLASS 1 equipment according to the type of protection against electrical shock.

* TYPE BF equipment according to the degree of protection against electrical shock is specified in the specifications of each parameter module.

* ORDINARY equipment according to the degree of protection against harmful ingress of water.

* Equipment not suitable for use in the presence of FLAMMABLE ANAESTHETIC MIXTURE with air or with OXYGEN/NITROUS OXIDE.

* CONTINUOUS OPERATION according to the mode of operation.

4.4 Principle of operation

4.4.1 Principle of CO_2/N_2O/AA measurement

The CO_2, N_2O, and anaesthetic agent gas measurements are based on absorption of infrared light as it passes through the gas sample in measuring chamber in the photometer. The light absorption is measured at three wavelengths using an infrared detector. One of the wavelengths is that of the CO_2 absorption peak at 4.3 micrometers, the second is that of the N_2O absorption peak at 3.9 micrometers, and the third is that of the anaesthetic agent absorption peak at 3.3 micrometers. The signal processing electronics receive the signals from the IR detector and demodulate it to get DC components out of these signals which correspond to the content of each gas in the sample.

Figure 4.1 shows the CO_2/N_2O/AA gas absorption spectra.

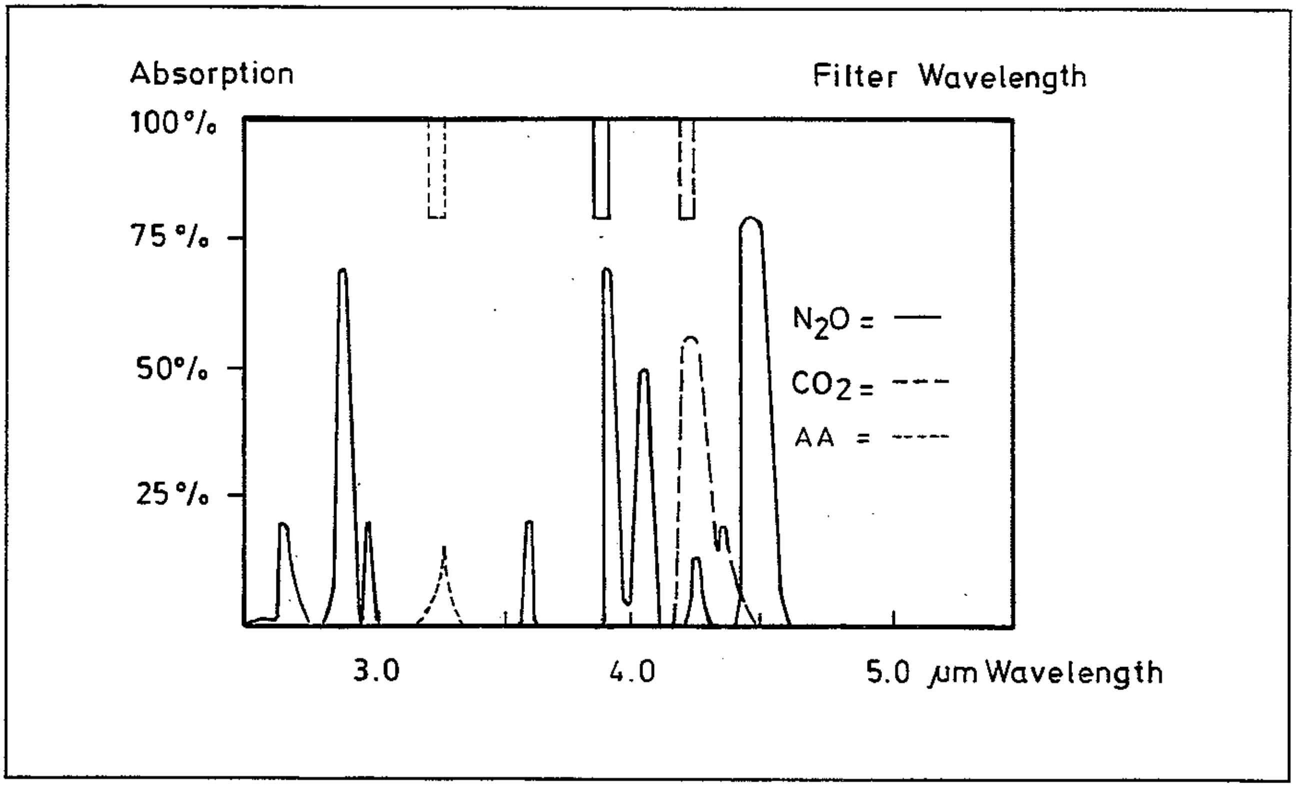


Figure 4.1 CO_2/N_2O/AA gas absorption spectra

4.4.2 Principle of O_2 measurement

The differential oxygen measuring unit uses the paramagnetic principle in a pneumatic bridge configuration. The signal picked up with a differential pressure transducer is generated in a measuring cell with a strong magnetic field that is switched on and off at a frequency of 110 Hz or 165 Hz. The output signal is a DC voltage proportional to the O_2 concentration difference between the two gases to be measured.

4.4.3 Principle of SpO_2 measurement

SpO_2

Oxygen is the most acutely necessary substrate for survival. A major concern during and after anesthesia is prevention of tissue hypoxia. Pulse Oximetry provides immediate and direct information on tissue oxygenation and, therefore, it is at present seen as a prerequisite of patient safety in anaesthesia departments.

Most of oxygen needed by the body is transported bound to hemoglobin. The total hemoglobin of blood is composed of oxygenated oxyhemoglobin (HbO_2), reduced or deoxygenated hemoglobin (Hb), and other forms of hemoglobin such as carboxyhemoglobin (HbCO) and methemoglobin (MetHb).

The absorption of light of normal human blood at different wavelengths is mainly determined by HbO_2 and Hb (see Figure 4.2). A Pulse Oximeter measures the relative absorption of light of blood at two wavelengths, one in the near infrared (about 900 nm) and the other in the red region (about 660 nm) of light spectrum. These wavelengths are emitted by LEDs in the SpO_2 probe, the light is transmitted through peripheral tissue and is finally detected by a PIN-diode opposite to LEDs in the probe. Pulse Oximeter derives the oxygen saturation SpO_2 using empirically determined relationship between the relative absorption at the two wavelengths and the arterial oxygen saturation SaO_2.

The total relative absorption of blood can be divided into components of tissue, venous blood, arterial blood, and the pulse added volume of arterial blood.

In order to focus the measurement on the arterial blood and thus to measure the arterial saturation accurately, Pulse Oximeters use the component of light absorption giving variations synchronous with heart beat as primary information on the arterial saturation. In fact, this invention was most essential for Pulse Oximetry and eventually made feasible the measurement of oxygen saturation noninvasively.

A general limitation of the above pulse oximetry principle is that due to only two wavelengths used only two hemoglobin species can be discriminated by the measurement.

The modern Pulse Oximeters are empirically calibrated either against fractional saturation SaO_{2frac},

$$SaO_{2frac} = HbO_2/(HbO_2+Hb+Dyshemoglobin),$$

or against functional saturation SaO_{2func},

$SaO_{2func} = HbO_2/(HbO_2+Hb)$,

which is more insensitive to changes of carboxyhemoglobin and methemoglobin concentrations in blood.

The oxygen saturation percentage SpO_2 measured by Datex-Engstrom Monitor is calibrated against the functional saturation SaO_{2func}. The advantage of this method is that the accuracy of SpO_2 measurement relative to SaO_{2func} can be maintained even at rather high concentrations of carboxyhemoglobin in blood. Independent of the calibration method Pulse Oximetry is not able to correctly measure oxygen content of the arterial blood at elevated carboxyhemoglobin or methemoglobin levels, which clinically may be harmful for patient.

Plethysmographic pulse wave

The plethysmographic waveform is derived from the IR signal and reflects the blood pulsation at the measuring site. Thus the amplitude of the waveform represents the perfusion.

Pulse rate

The pulse rate calculation is done by peak detection of the plethysmographic pulse wave. The signals are filtered to reduce noise and checked to separate artifacts.

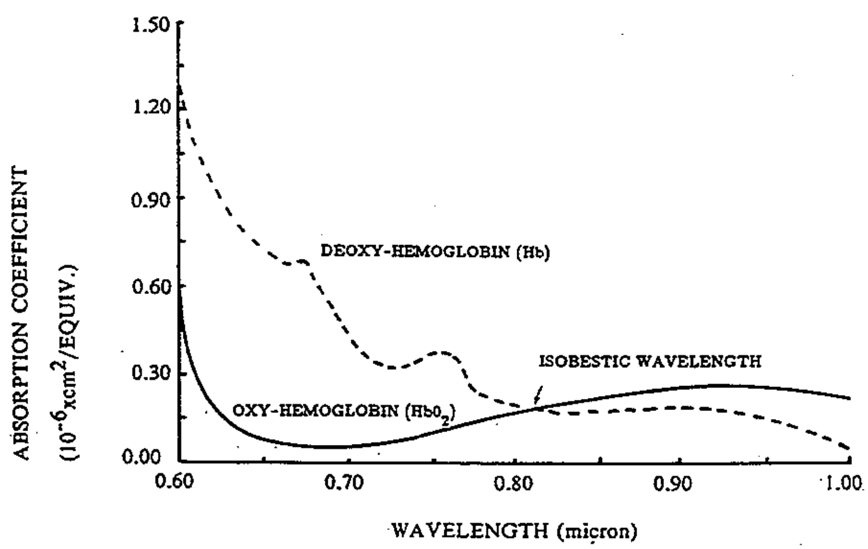


Figure 4.2 Absorption coefficients of oxy- and deoxy-hemoglobin in the red and near-infrared regions

4.5 General block diagram

The monitor consists of the following modular parts (see page 3-1 for the parts included in the monitor you are using):

- The gas sampling system for $CO_2/N_2O/O_2$ Anaesthetic agent measurement
- ACX measuring unit
- ASX agent identification unit
- OM-101 oxygen measuring unit
- Measuring electronics
- PVX board for measuring airway volume and pressure
- Main CPU board including analog signal multiplexer, A/D converter, and real time clock
- Video control board to convert the CPU commands into video signal
- Video display module
- Transformer and power supply board to generate necessary voltages and I/O functions
- Mother board including signal buses and analog input signal buffers
- Tactile membrane keyboard
- Loudspeaker unit
- Probe and SpO_2/pulse oximeter measuring board

See Figure 4.3 for the monitor block diagram.

For monitor parts locations see the exploded view (Figure 9.1) in Chapter 9.

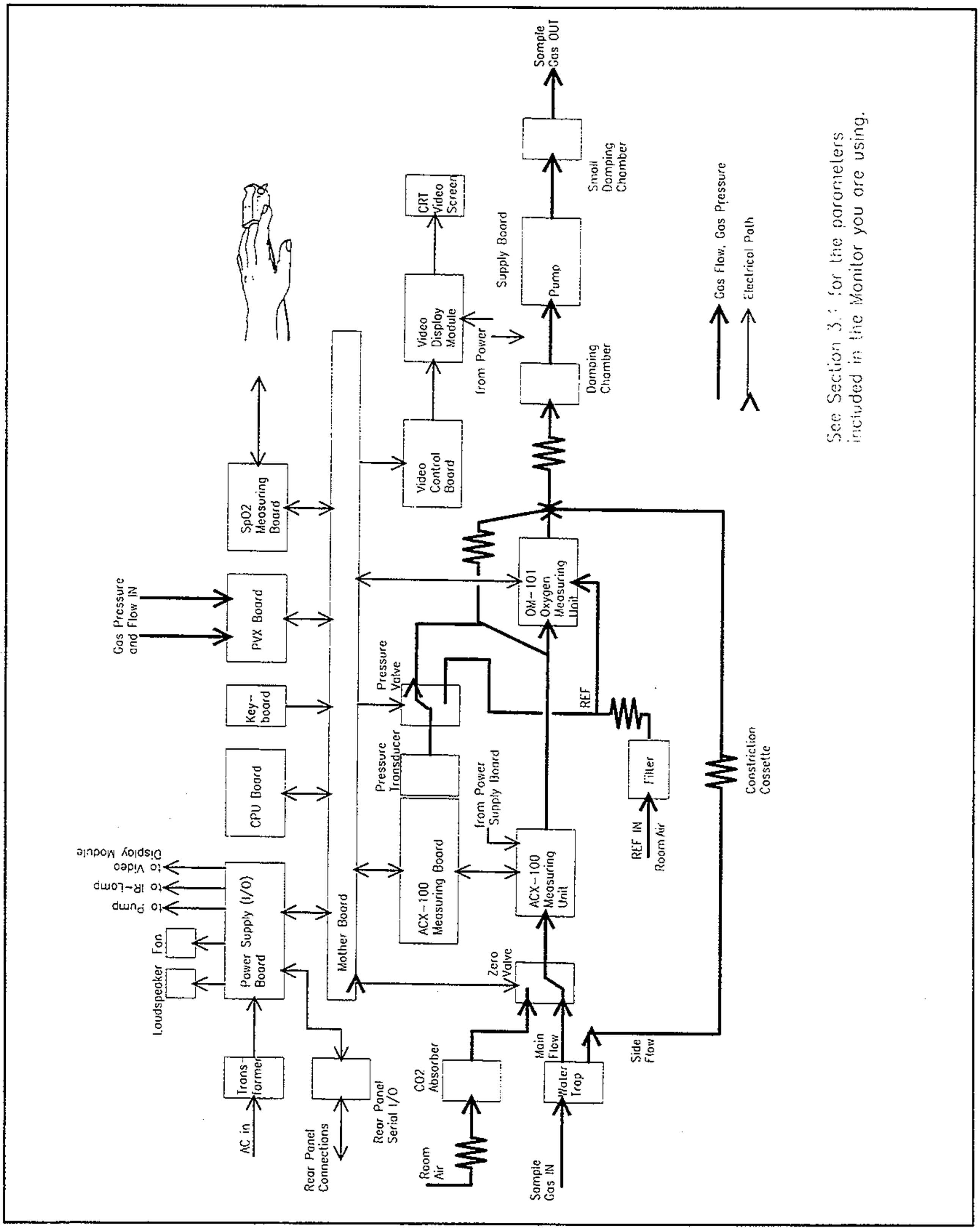


Figure 4.3 General block diagram

4.6 Wiring diagram

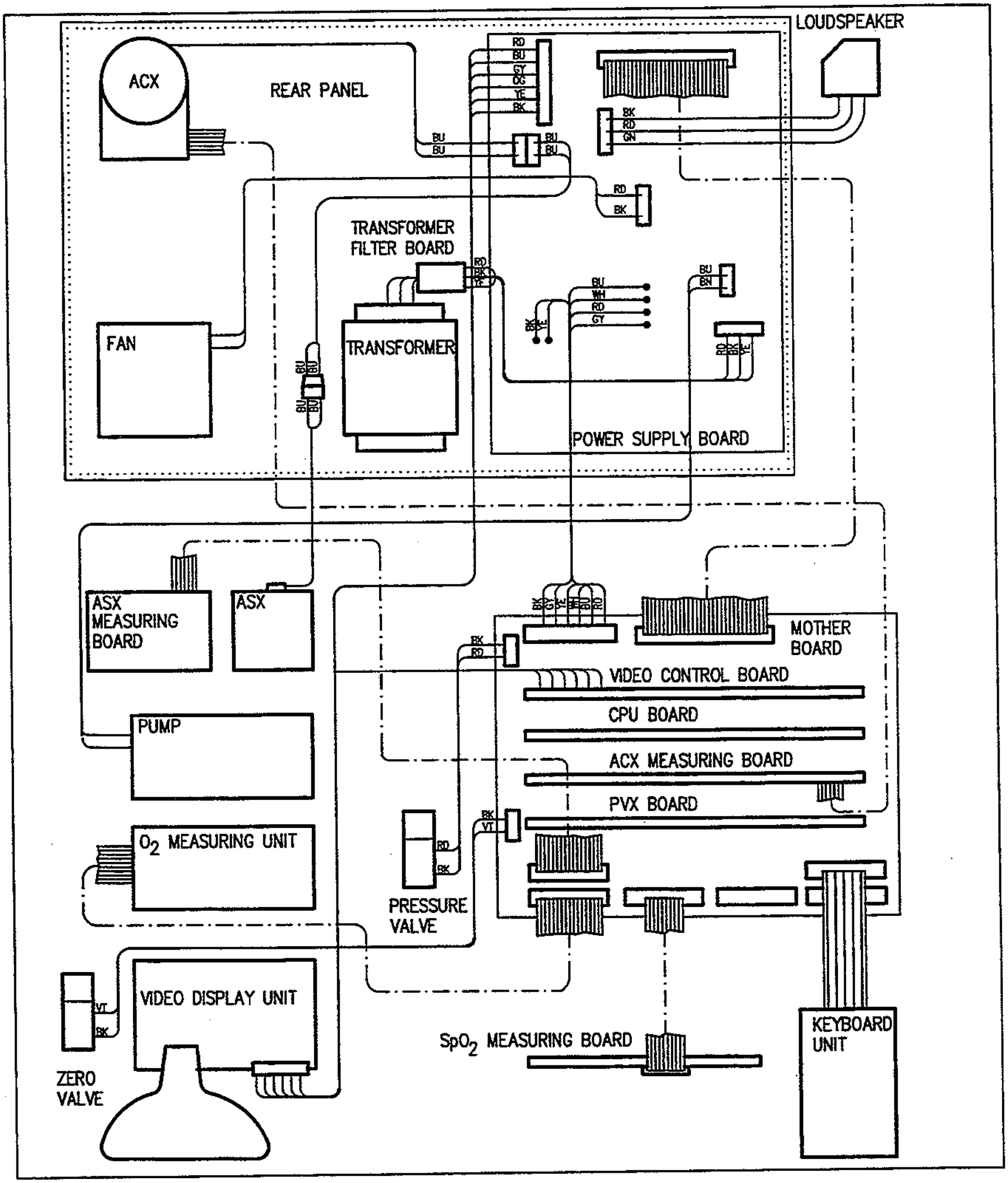


Figure 4.4 Wiring diagram

4.7 External connector configurations

4.7.1 Input/Output specifications

Analog output	Scale	Output voltage
CO_2	0 to 10 %	0 to 10 V
O_2	0 to 100 %	0 to 10 V
N_2O	0 to 100 %	0 to 10 V
HAL, ENF, ISO, SEV	0 to 10 %	0 to 10 V
DES	0 to 20 %	0 to 10 V
SpO_2	0 to 100 %	0 to 10 V
Pleth wave	same as on screen	0 to 10 V
Airway pressure	-20 to 0 cmH_2O	0 to 2 V
	0 to 80 cmH_2O	2 to 10 V
Flow	-100 to 0 l/min	0 to 5 V
	0 to 100 l/min	5 to 10 V
Volume	-2.5 to 0 l	0 to 5 V
	0 to 2.5 l	5 to 10 V

4.7.2 Connectors

Table 4.1 Pin order of the pulse oximeter probe connector

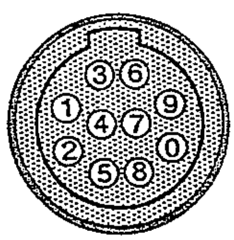
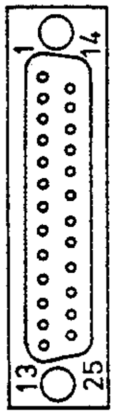
	PIN	SIGNAL
Front view	1	Is
	2	Ib
	3	no connection
	4	Probe identification
	5	Probe identification
	6	Ground
	7	Iled
	8	$V_B(-)$ (+0.8 V)
	9	$V_B(+)$ +5 V
	0	Ground

Table 4.2 Pin order of the SERIAL & ANALOG connector



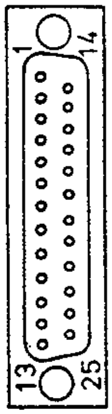
PIN	SIGNAL	PIN	SIGNAL	
1	Analog ground	14	O_2[1)]	0-100 %
2	Serial out	15	+5 V	
3	Serial in	16	N_2O[1)]	0-100 %
4	RTS	17	Anaesthe-tic agent[1)]	3)
5	CTS	18	v' or V	
6	Gas freeze	19	SpO_2[1)]	0-100 %
7	Signal ground	20	CO_2[1)]	0-10 %
8	Test	21	+26 VDC out	
9	+12 VDC	22	Pleth[1) 2)]	
10	-12 VDC	23	-26 VDC out	
11	+15 VDC	24	22 VAC	
12	-15 VDC	25	22 VAC	
13	V or P			

1) 0 to 10 V

2) same scale as on screen

3) HAL, ENF, ISO, SEV: 0 to 10 %
DES 0 to 20 %

Table 4.3 Pin order of the AUX I/O connector



PIN	SIGNAL	PIN	SIGNAL
1	Analog ground	14	Serial out(B)
2	Serial out (A)	15	+5 VDC
3	Serial in (A)	16	Serial in (B)
4	RTS (A)	17	PA5
5	CTS (A)	18	PA6
6	PB1	19	RTS (B)
7	Signal ground	20	PA7, 5 V (Nurse call)*
8	PB0	21	+26 VDC
9	+12 VDC	22	not in use
10	-12 VDC	23	-26 VDC
11	not in use	24	22 VAC
12	not in use	25	22 VAC
13	CTS (B)		

* max. 2 mA.

Video Connector Output

1 Vpp, 24 MHz, 75 Ohm, hsync 15.75 kHz, vsync 50 Hz

For internal connector pin configurations see Tables 5.3 to 5.23.

4.8 Principle of Patient Spirometry™

In anaesthesia, CMV (Controlled Mechanical Ventilation) is the mostly used ventilation mode. In this mode, mechanical breaths are delivered to the patient by a ventilator with a proper tidal volume (TV), respiration rate (RR), and inspiration/expiration ratio in time (I:E) determined by the settings of the ventilator.

Delivery of life support gases is based on pressure. However, without knowing volume measured of exhalation, one cannot be sure that a breath occurred. The ultimate goal of ventilation is to use the least amount of pressure to generate the most appropriate volume for each breath.

The Patient Spirometry™ monitors ventilation in anaesthesia. Both patient breathing circuit and the function of the ventilator are monitored. The following parameters are displayed:

Expiratory and inspiratory tidal volume (TV) in ml.

Expiratory and inspiratory minute volume (MV) in l/min.

Expiratory volume in first second (V1.0) in per cent.

Inspiration/expiration ratio in time (I:E)

Airway pressures: Peak pressure (P_{peak}), End inspiratory pressure (P_{plat}), Positive end expiratory pressure (PEEP), Real-time airway pressure waveform (P_{aw})

Flow: Real-time volume waveform (V')

Compliance (C)

Pressure volume loop

Flow volume loop

Airway pressure

PEEP, P_{peak}, and P_{plat} are measured by pressure transducer on the PVX board. Atmospheric pressure is used as a reference in measurement. The pressure measurement is made from the airway part that is closest to the patient between patient circuit and intubation tube.

Airway flow

The measurement is based on measuring the kinetic gas pressure and is performed using Pitot effect. Pressure transducer is used to measure the Pitot pressure. The obtained pressure signal is linearized and corrected according to the density of the gas. Speed of the flow is calculated from these pressure values and TV value is then integrated. MV value is further calculated and averaged using TV and RR (respiratory rate) values.

Real-time airway pressure and flow waveforms are displayed on the screen as shown in Figure 4.5.

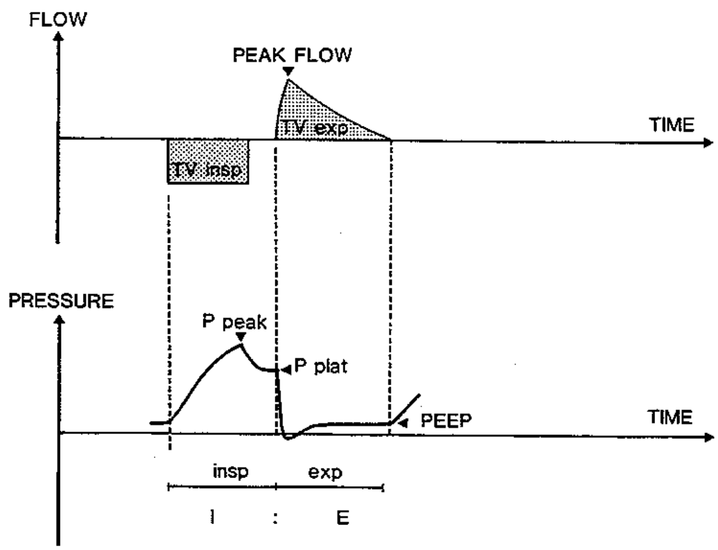


Figure 4.5 Example of Flow and Pressure Waveform

P_{peak} = Maximum pressure
P_{plat} = plateau pressure
PEEP = positive end expiratory pressure

V1.0 (V0.5 in Pedi mode)

During CMV, inspiration is an active phase done by a ventilator, while expiration is passive, caused by the elasticity of the chest wall, diaphragm and the lungs. Thus the expired volume during first second may change due to bronchial obstructions caused by lung diseases or mechanical obstacles.

Compliance

Compliance is the elasticity of the lungs and the chest wall. It is the subtotal of several parameters such as tidal volume, plateau pressure, and PEEP.

$$\text{Compliance} = \frac{\text{Expired tidal volume}}{\text{End inspiratory pressure - PEEP}}$$

The lower the compliance value is the more stiff the lungs are. Normal value for adults are 30 to 100 ml/cmH_2O.

Compliance is shown on the display in three different ways:
1. Actual digital value on the screen
2. In trend form
3. Angle of pressure-volume loop

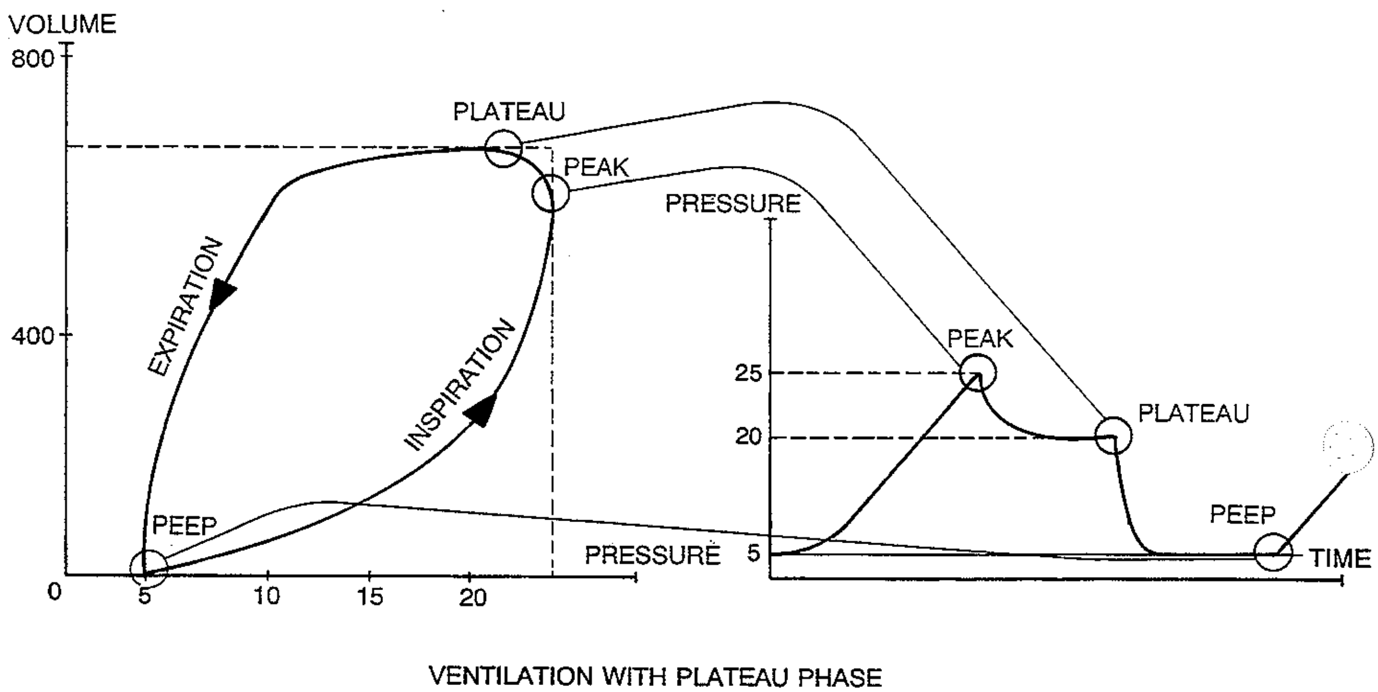
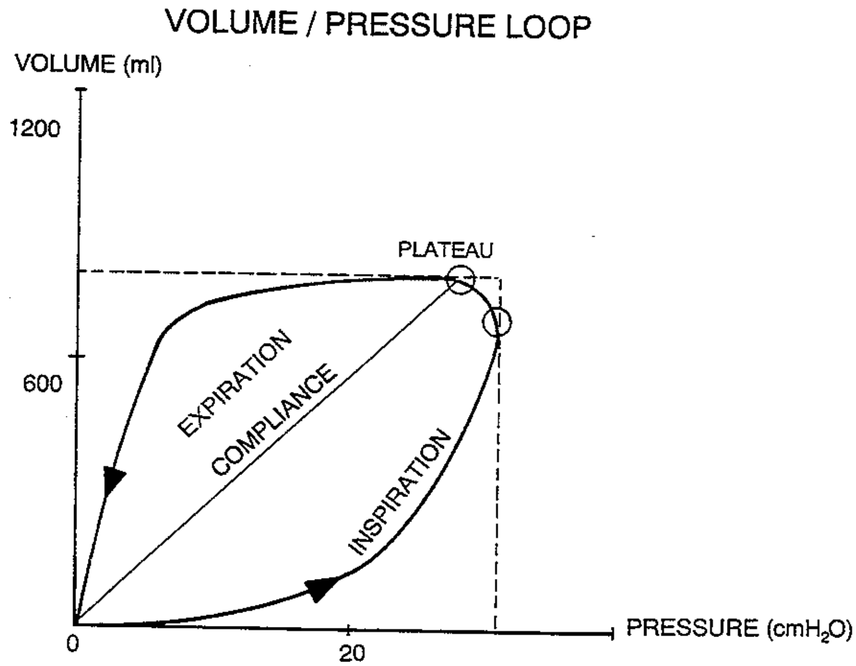


Figure 4.6 How to Find Corresponding Pressures From the Loop



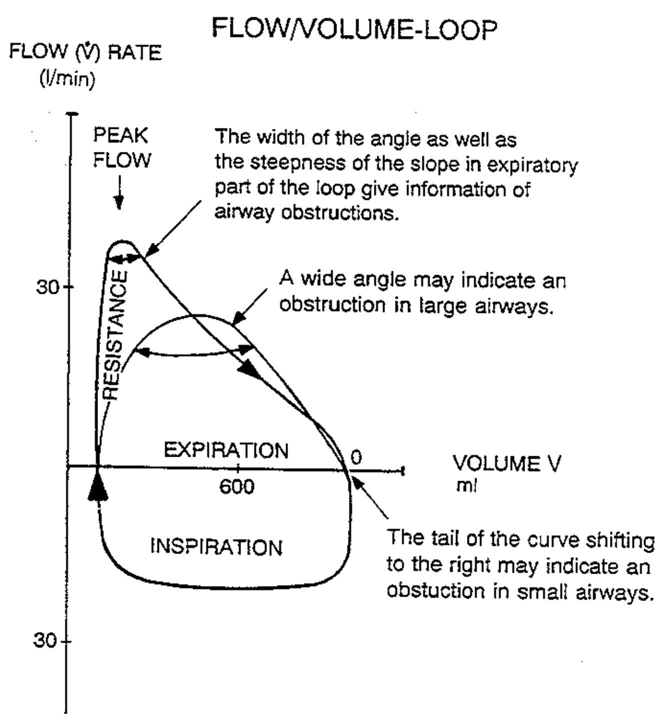


Figure 4.7 **Pressure-volume loop, Flow-volume loop, and their interpretations**

D-lite™ sensor

Two types of the **D-lite™** sensors are available: disposable and reusable.

D-lite™ is designed to measure kinetic pressure by two-sided Pitot tube. The pressure reduction caused by measuring cross is taken into account, too, especially in small flows.

Velocity is calculated from pressure difference according to Bernoulli's law. Flow is then determined using the calculated velocity.

v = 2 x dP / (Bernoulli's law)

F = v x A

where,	F	=	flow (l/min)
	v	=	velocity (m/s)
	A	=	cross area (m^2)
	dP	=	pressure difference (cmH_2O)
		=	density (kg/m^3)

Finally the volume information is obtained by integrating the flow signal.

From revision 06 the monitors (except for adaptations -27 and -43 only from the revision -07 on) can measure paediatric spirometry with **Pedi-lite™** sensor. This sensor is used for patients of 3 to 30 kg, and is available as a reusable sensor only.

4.9 Principle of Agent Identification

The anaesthetic agent identification bench identifies halothane, enflurane, isoflurane, desflurane and sevoflurane.

The operation of the bench is based on infrared absorption at 3.3 um range. It measures the spectrum of the gas between 3.24 um and 3.39 um. Because the spectrum of each of the anaesthetic agents is different it is possible to identify them.

The bench consists of an infrared source, a measuring chamber, a rotating filter and a detector. The peak wavelength of the narrow bandpass filter changes when the angle between the light path and the filter is changed. When the filter rotates the required spectrum is scanned through.

The agent or a mixture of agents is calculated from the measured spectrum using stored reference spectrums of each agent.

Figure 4.8 shows the absorption spectra of anaesthetic agents.

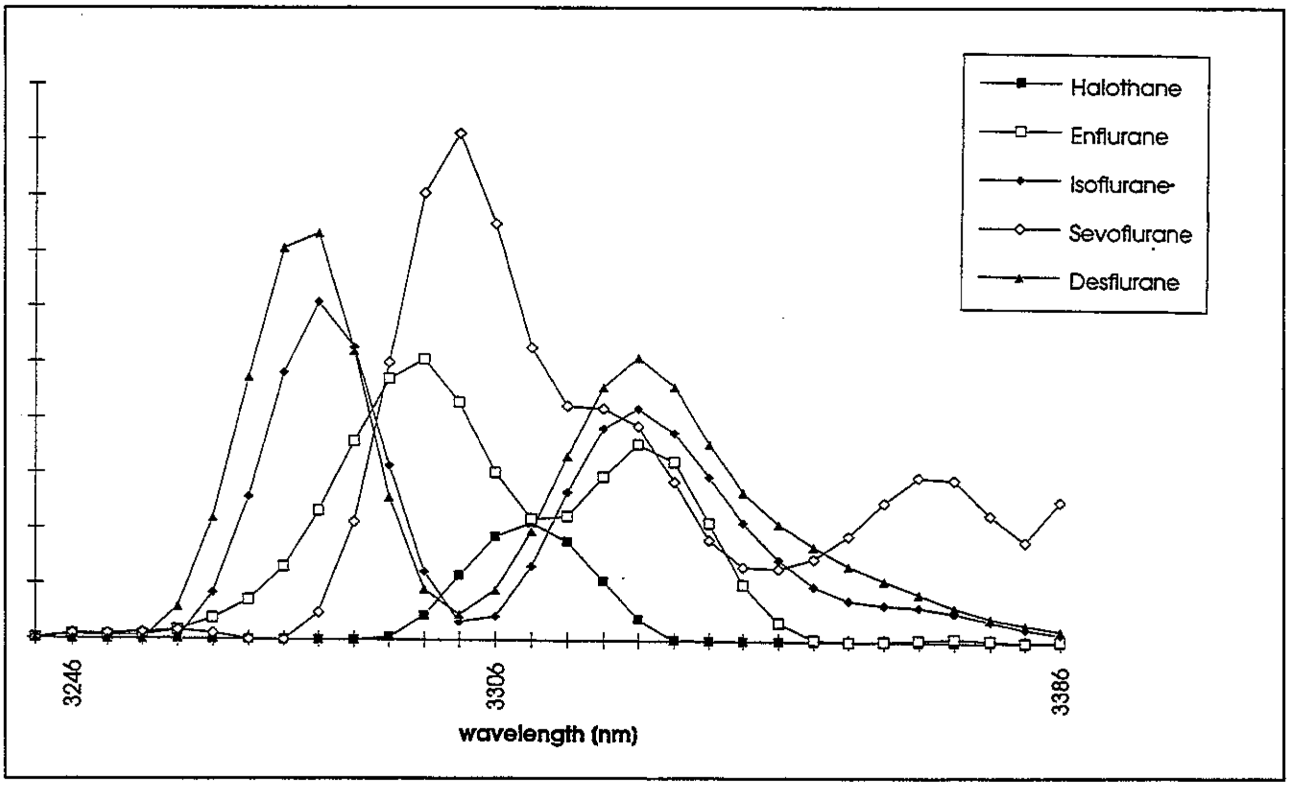


Figure 4.8 Anaesthetic Agents Gas Absorption Spectra

5 DETAILED DESCRIPTION OF MODULES

5.1 Gas sampling system

The function of the gas sampling system is to draw sample gas into the monitor at a fixed rate and to separate impurities and condensed water from the stream.

The sample gas enters the monitor through the water trap, where it is divided into two flows (see Figures 5.1). The main flow goes into the measuring system (described in Section 5.2) and the side flow goes to damping chamber. The task of the side flow is to cause slight atmospheric depression inside the trap container and thus pull down moisture in gas into the container. Both flows are separated from the sample in flow by hydrophobic filter. Incoming water does not pass the filter but falls into water container.

Because the sampling line is narrow, thick fluids like blood or mucus will not propagate at all. When the line is clogged, it cannot be cleaned but replaced.

Special tube(s) is used to balance the sample gas humidity with that of ambient air (see Figures 5.2 and Tables 5.1). The tube will prevent errors caused by the effect of water vapor on gas partial pressure when humid gases are measured after calibration with dry gases.

CAUTION: The material of this special tube is mechanically fragile. Small leakages may occur if the tube is bent or kinked.

Ahead of the ACX measuring unit there is a magnetic valve, which is used to set the zero point for each gas. Room air is drawn into the system through this zero valve.

After the ACX measuring unit the main flow is divided into two in models with i-parameter. One flow goes into oxygen measuring unit and the other into ASX agent identification unit.

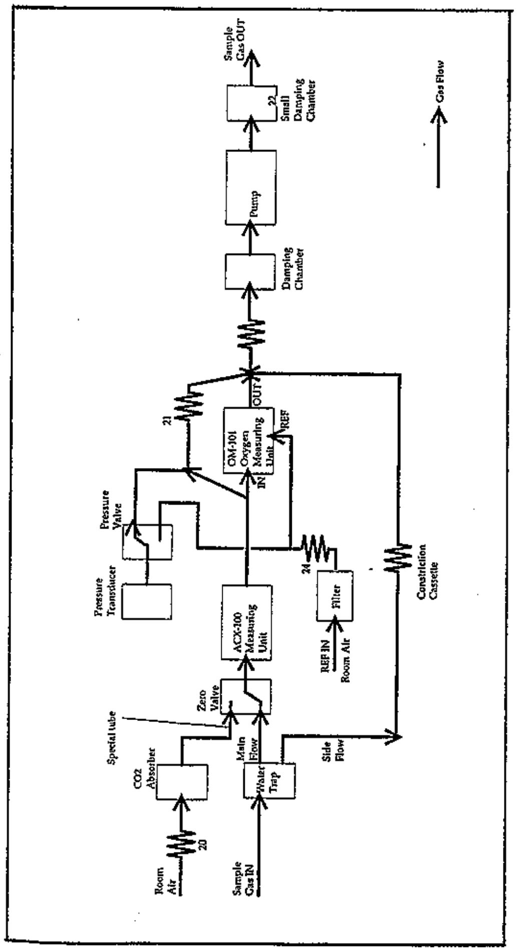
The pressure valve opens and measures the pressure gradient between the O_2 measurement flow and the O_2 reference flow. This pressure gradient reflects the condition of the D-FEND™ water trap filter. The measurement is performed 30 seconds after every auto-zeroing, occlusion, and gas calibration. It is also performed whenever software detects the difference value to be less than -5 mmHg (the pressure gradient is greater than 5 mmHg). If the difference value is less than -5 mmHg, the message 'REPLACE TRAP' results.

Special tubes are used in the sampling system. PVC and silicone tubes cannot be used in those parts of the sampling circuit because they will react with the anaesthetic agent, causing delayed a response time and an inaccurate zero point.

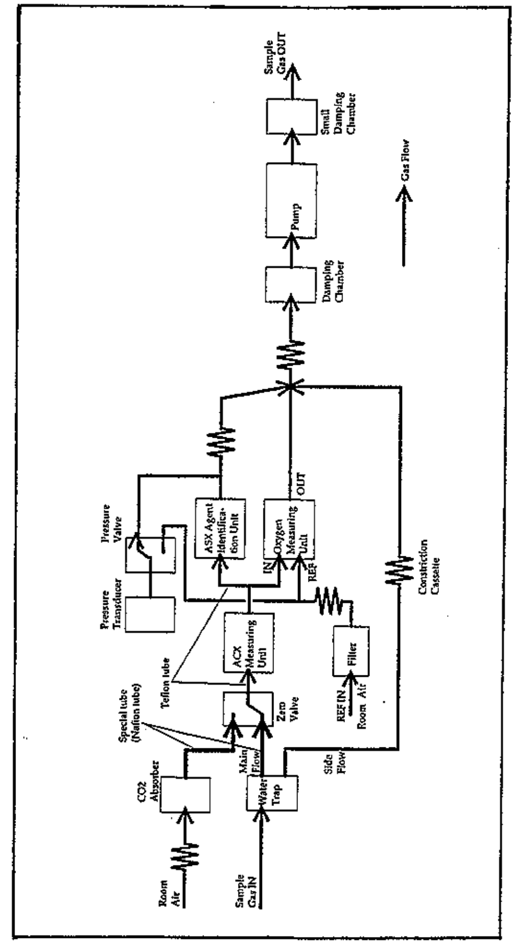
The sampling pump is a vibrating membrane pump driven by a 50Hz/12V/0.4A square wave current.

The purpose of the damping chambers is to even out the pulsating flow and silence the exhaust flow. The correct flow rates are set using five flow constriction cassettes.

Figure 5.1 Gas sampling system schematic diagrams



Gas Sampling System without i-parameter



Gas Sampling System with i-parameter

Figure 5.2.1 Gas sampling system layout (without i-parameter)

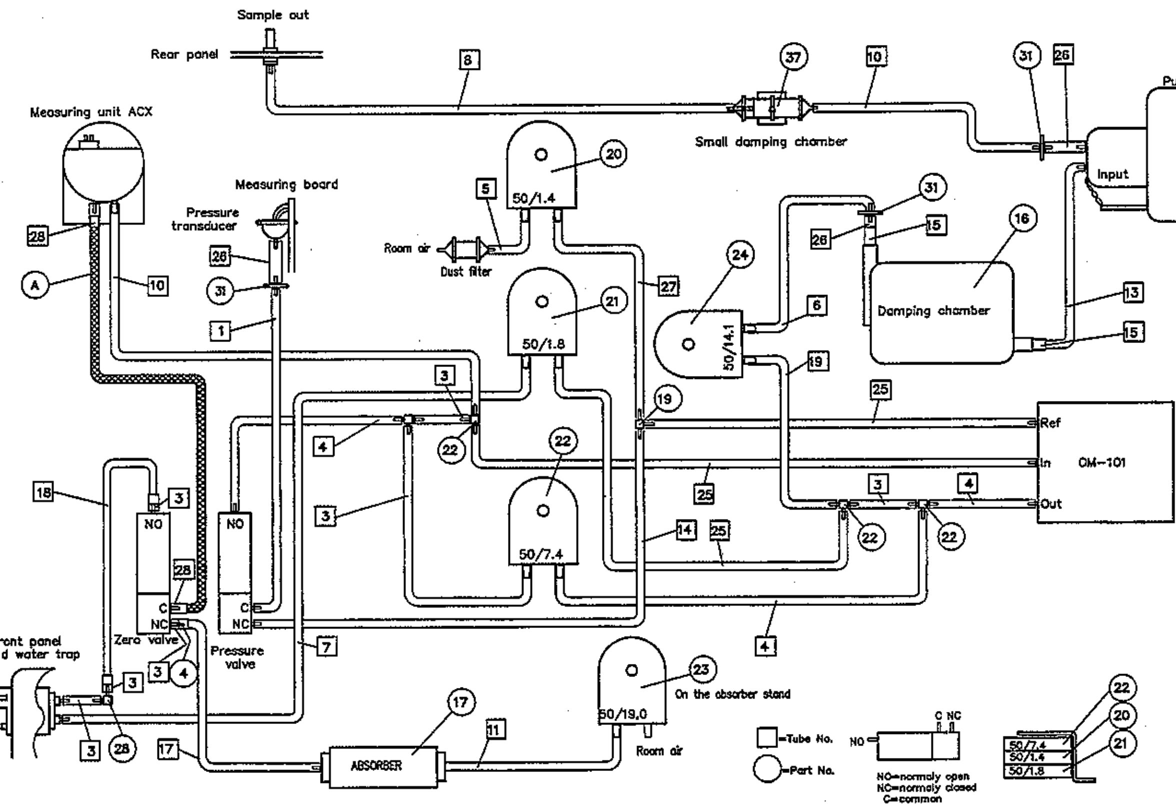


Table 5.1.1 Tube lengths (without i-parameter)

Tube No.	Part	Code	Pcs	Length/mm
A	Special sample tube	733383	1	500
1	1.7/1.05 mm Silicone	73373	1	280
3	1.7/1.05 mm Silicone	73373	7	20
4	1.7/1.05 mm Silicone	73373	3	50
5	1.7/1.05 mm Silicone	73373	1	60
6	1.7/1.05 mm Silicone	73373	1	42
8	1.7/1.05 mm Silicone	73373	1	110
9	1.7/1.05 mm Silicone	73373	1	300
10	1.7/1.05 mm Silicone	73373	2	400
11	1.7/1.05 mm Silicone	73373	1	150
13	3.18x6.35 mm Silicone	73375	1	180
14	1.7/1.05 mm Silicone	73373	1	70
15	4.8x9.5 mm Silicone	73376	2	25
17	1x2 mm PVC	73341	1	200
18	1.2x0.3 mm PTFE	73332	1	400
19	1.7/1.05 mm Silicone	73373	1	500
25	1.7/1.05 mm Silicone	73373	3	30
26	3.18/6.35 mm Silicone	73375	3	20
27	1.7/1.05 mm Silicone	73373	1	40
28	1.7/1.05 mm Silicone	73373	2	15

Part No.	Part	Code
20-24	Constriction cassette	Selected individually, see Table 5.2 for alternatives
16	Damping chamber	57150
17	Absorber	890641
22	T-piece	733821
28	L-piece	733811
31	Adapter piece	73388
36	Dust filter	86901
4	CNO metal tube	871925
37	Small damping chamber	879355

Note: Constriction cassettes are selected to adjust proper flow rates. See Table 5.2 for alternatives.

Figure 5.2.2 Gas sampling system layout (with i-parameter)

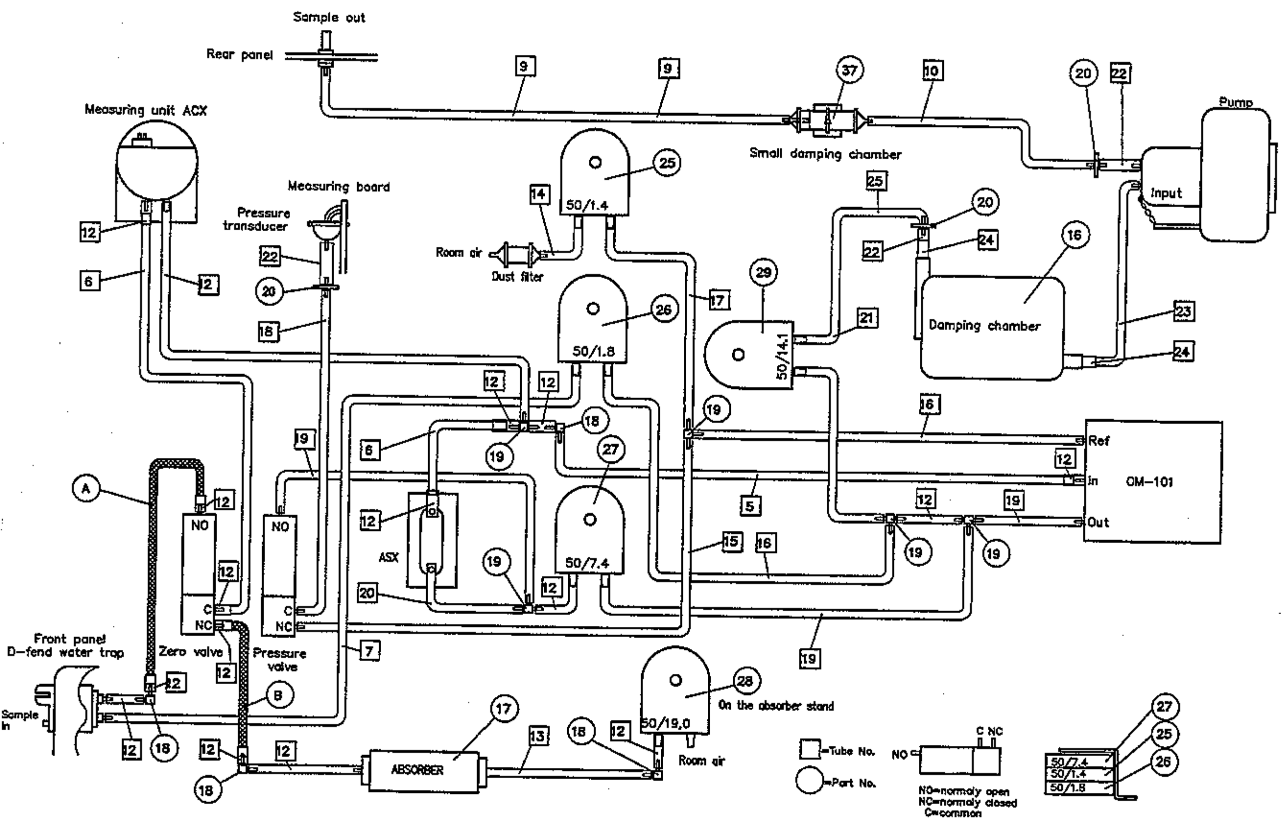


Table 5.1.2 Tube lengths (with i-parameter)

Tube No.	Part	Code	Pcs	Length/mm
A	Special sample tube	733383	1	500
B	Special sample tube	733382	1	300
5	1.2/0.3 mm PTFE	73332	1	400
6	1.2/0.3 mm PTFE	73332	2	320
7	1.7/1.05 mm Silicone	73373	1	300
8	1.7/1.05 mm Silicone	73373	1	85
9	1.7/1.05 mm Silicone	73373	1	110
10	1.7/1.05 mm Silicone	73373	1	400
12	1.7/1.05 mm Silicone	73373	16	20
13	1.7/1.05 mm Silicone	73373	1	140
14	1.7/1.05 mm Silicone	73373	1	60
15	1.7/1.05 mm Silicone	73373	1	70
16	1.7/1.05 mm Silicone	73373	2	30
17	1.7/1.05 mm Silicone	73373	1	40
18	1.7/1.05 mm Silicone	73373	1	280
19	1.7/1.05 mm Silicone	73373	3	50
20	1.7/1.05 mm Silicone	73373	1	220
22	3.18x6.35 mm Silicone	73375	3	20
23	3.18x6.35 mm Silicone	73375	1	180
24	4.8x9.5 mm Silicone	73376	2	25
25	1.7/1.05 mm Silicone	73373	1	420
26	10x2.5 mm Silicone	73377	1	500

Part No.	Part	Code
25-29	Constriction cassette	Selected individually, see Table 5.2 for alternatives
16	Damping chamber	57150
17	Absorber	890641
18	L-piece	733811
19	T-piece	733821
20	Adapter piece	73388
36	Dust filter	86901
37	Small damping chamber	879355

Note: Constriction cassettes are selected to adjust proper flow rates. See Table 5.2 for alternatives.

Table 5.2 Flow constriction cassettes

Constriction cassette	Code
50/26.0	878048
50/19.0	873800
50/16.3	878047
50/15.3	873801
50/14.1	878046
50/13.1	873802
50/12.4	878045
50/11.2	874770
50/10.4	873803
50/9.2	874509
50/8.7	873804
50/7.4	873805
50/6.5	878044
50/5.8	873806
50/5.1	878043
50/4.4	873807
50/3.8	878042
50/3.2	873808
50/3.0	878040
50/2.8	878039
50/2.5	878038
50/2.3	873809
50/2.0	878037
50/1.8	873810
50/1.6	878036
50/1.4	873811
50/1.1	873812

NOTE: The latter number is a relative figure for the flow through the constriction, e.g., 50/26.0 is the shortest constriction and 50/1.1 the longest.

5.2 $CO_2/N_2O/AA$ measurements

5.2.1 In general

The measuring electronics block diagram is in Figure 5.3. The functions are divided between the ACX measuring unit (photometer) and the ACX measuring board.

5.2.2 ACX measuring unit

> **CAUTION:** The ACX photometer and its components are repaired/calibrated at the factory. Attempts to repair/calibrate the unit elsewhere will adversely affect operation of the unit. DATEX-ENGSTROM supplies spare ACX photometers. The information provided for the ACX is for reference only.

The ACX photometer is of dual path type. The infrared light beam passes through a measuring chamber containing the gas to be analyzed, and a reference chamber, which is free of CO_2, N_2O, and AA. The measurement is made by determining the ratio between the two light intensities.

The ACX photometer is shown in Figure 5.4.

A filter wheel is used to control the light from an incandescent lamp that passes through the photometer. The filters are arranged so that the light is passed sequentially:

- first at the CO_2 absorption wavelength through the reference chamber
- then through the measuring chamber
- finally it is blocked completely

The same sequence is repeated at the N_2O and anaesthetic agent gas absorption wavelengths.

After passing through the filters the light is reflected and focused by a mirror onto the infrared detector. This detector measures the three light levels for each gas described above.

There is an optical sensor incorporated in the photometer which detects light from a reflective surface on the filter wheel once every revolution. The pulses from this sensor are used to synchronize the electronics to the signal from the infrared detector. A stabilizing diode measures the temperature, which is needed to compensate for thermal drifts. The infrared detector, the optical sensor and the stabilizing diode are mounted on the preamplifier board (see Figure 5.5).

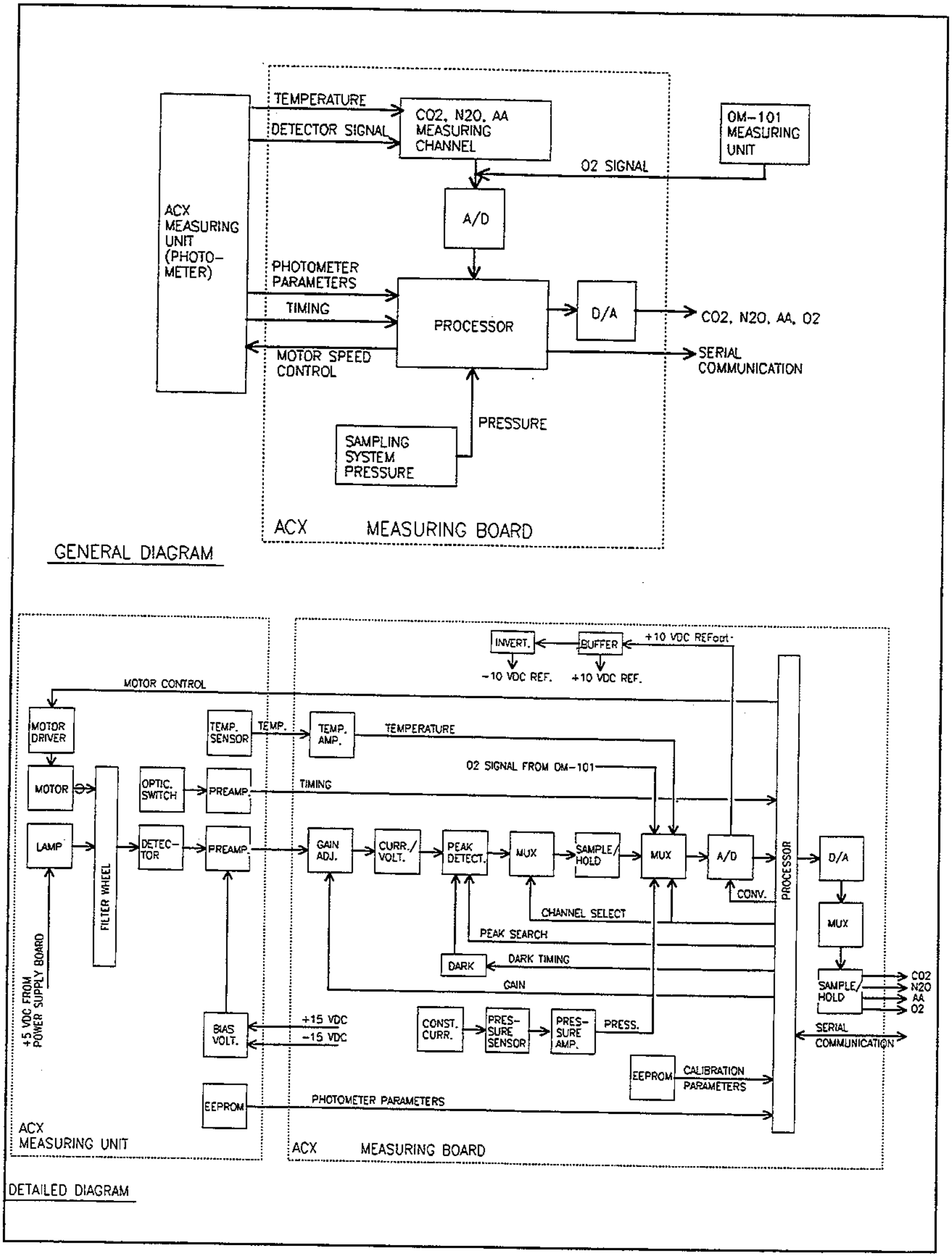


Figure 5.3 CO_2/N_2O/AA measurement block diagram

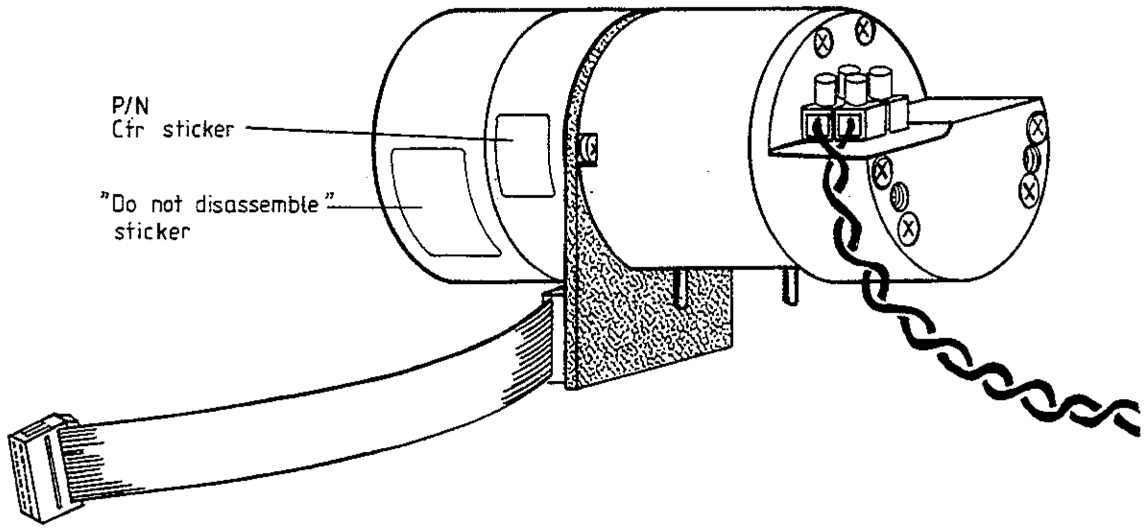


Figure 5.4 ACX photometer (ACX-100 measuring unit)

5.2.3 Preamplifier board

Parts layout and schematic diagram **Figure 5.5**

Voltage regulation

Voltage regulators A3 and A4 provide regulated ±12 V for the preamplifiers and the detector bias generator.

Preamplifiers

The purpose of preamplification is to amplify the signals from the infrared detector and timing sensor and to convert them into lower impedance level.

The infrared detector (R2) signal is amplified with A2A which is connected as a straightforward non-inverting AC amplifier.

The current signal from the timing optical sensor is converted into voltage with the remaining section of A2.

Detector bias generator

The lead selenide detector is a resistor, whose resistance decreases in infrared light. For this reason it is advantageous to supply the detector with a high bias voltage, as a higher signal is then achieved.

The bias voltage generator utilizes one section of A1, which is a square wave oscillator, and a conventional voltage doubler built of diodes V1, V2, V3, and V5 and capacitors C1 through C4. The circuit produces an output voltage of approximately +/-34 V.

Temperature measurement

The voltage across the 2.1 V stabilizing diode V14 decreases as the temperature of the photometer rises. This voltage signal is used for temperature compensation.

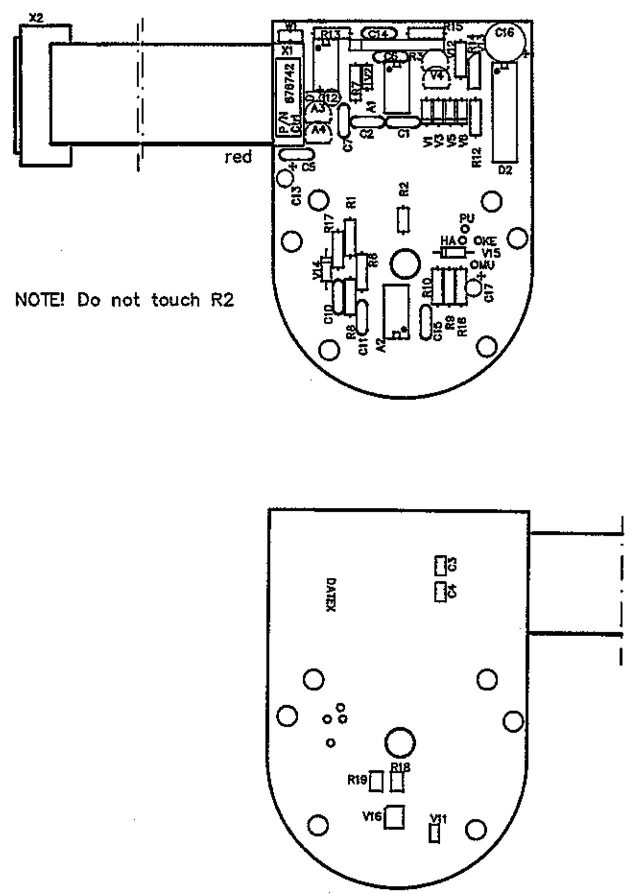
EEPROM

EEPROM D1 stores the photometer factory set gain and zero coefficients and compensation factors.

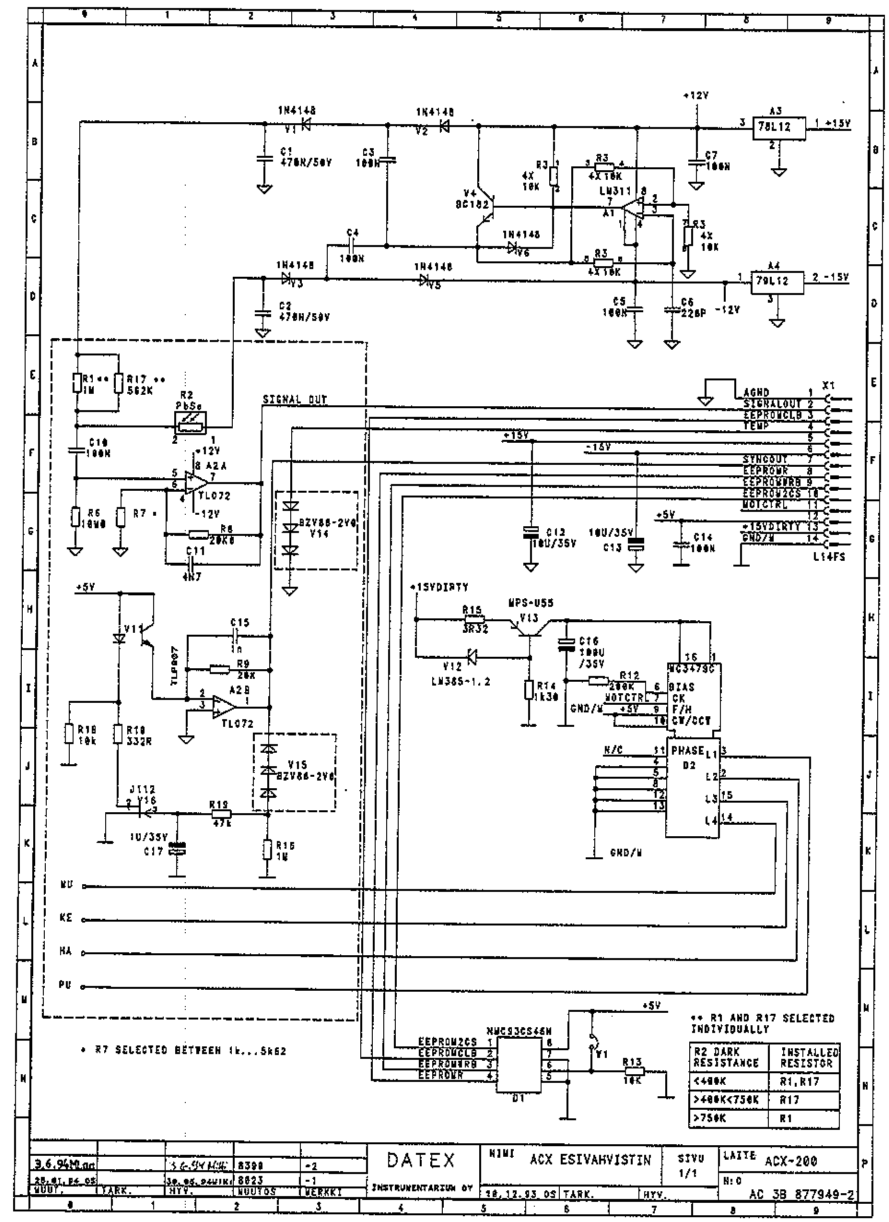
Filter wheel motor control

A stepper motor rotates the filter wheel at approximately 83 revolutions/second. Stepper motor is driven by D2.

Figure 5.5 Preamplifier parts layout and schematic diagram (board modification level 8 and higher)



NOTE! Do not touch R2



5.3 O_2 measurement

The oxygen measurement is based on the paramagnetic susceptibility, which is a unique property of oxygen among all gases generally present in a breathing gas mixture. The gas to be measured and the reference gas, which usually is room air, are conducted into a gap in an electromagnet with a strong magnetic field switched on and off at a frequency of approximately 110 Hz.

An alternating differential pressure is generated between the sample and reference inputs due to forces acting to the oxygen molecules in a magnetic field gradient.

The pressure is measured with a sensitive differential transducer, rectified with a synchronous detector and amplified to produce a DC voltage proportional to the oxygen partial pressure difference of the two gases.

> **CAUTION:** Due to the complicated and sensitive mechanical construction any service inside the O_2 measuring unit should not be attempted, and therefore the detailed description of the circuitry and layout of the transducer is omitted from this manual.

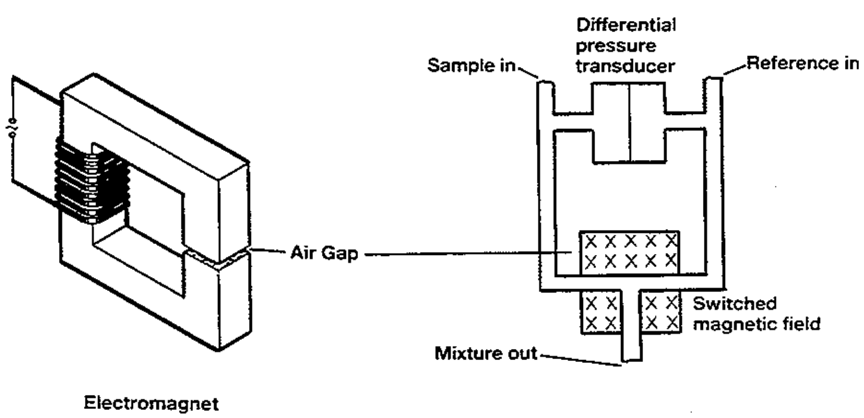


Figure 5.6 O_2 measurement principle

5.4 ACX measuring board

Block diagram and schematic diagram part 1 **Figure 5.7**
Parts layout and schematic diagram part 2 **Figure 5.8**
Timing diagram and schematic diagram part 3 **Figure 5.9**

The measuring electronics can be divided into a few functional blocks, which are described below (See the block diagram).

> **CAUTION:** Do not attempt to repair or replace the pressure transducer (B1). Its calibration values are stored in EEPROM (D2) and can be programmed only at the factory.

The ACX measurement board controls gas measurements. It converts the photometer signal to digital data, calculates results and transmits it to main CPU board. The board contains, in addition to the 80C51FA processor, EPROM, RAM, and EEPROM, several analog and digital I/O functions.

Internal and external bus

The processor D1, has access to the measurement board peripherals (memory, A/D converter, D/A converters, etc) via an internal bus. For communication between the CPU board and the measurement board, there is an external bus in connector X1. The external bus is driven by D21 (data lines), D3 (address lines) and D18 (read and write lines).

Memory

Memory components include 64 x 8 kbit program memory EPROM (D4), 32 x 8 kbit low current CMOS RAM (D22) powered by a data retention voltage generation circuit in power supply board, and EEPROM (D2) for permanent calibration values and setup memory.

Reference voltages

Reference voltages are established by the A/D-converter (D14) reference voltage output (REFOUT, pin 8). This +10 V voltage is buffered by A2D. -10 V reference voltage is obtained by inverting and buffering +10 V with amplifier A2C.

O_2 measuring electronics

The signal from the O_2 measuring unit is sent to pin a9/X1 and processed in the processor and passes to the main CPU board at a5/X1.

Measuring electronics for CO_2, N_2O, and AA

CO_2, N_2O, and anaesthetic agent measurement is accomplished by measuring each of these gases from the reference and measuring chambers of the ACX-100 photometer. The gas signals are transmitted from the ACX-100 photometer assembly through connector X2 pin 2 of the ACX measuring board and applied to the reference input of a D/A converter (D8). D8 is controlled by the microprocessor and is used for automatic gain control. The output current from D8 is proportional to the incoming signal and the gain is established for each gas, (CO_2 reference and measuring, N_2O reference and measuring, and AA reference and measuring) by software.

The signals are converted to a voltage and amplified by A24D, then applied to capacitor C30 which removes the DC offset. The dark level is established on C30 when the synchronous switch A28A is closed.

Each signal is sampled by the peak detection circuit, consisting of A24C, V26, A28B, R97, R201, and C15. When the peak voltage of a signal is sampled, the switch A28B is open, sending the signal through V26, which acts like a diode. The peak signal is then applied to the capacitor C15. C15 is brought down to ground potential between signal peaks when A28B is closed and the dark signal is transmitted to it.

The voltage peak of each gas (both measure and reference) is applied to an instrumentation amplifier (A24B) then to the input of a multiplexer (D23). D23 separates the signal to each of its components, (CO_2 reference and measuring, N_2O reference and measuring, and AA reference and measuring). For CO_2, the offset voltage is subtracted from the reference signal at A13B. For AA, the offset voltage is subtracted from the reference signal at A12B.

Each gas signal, the temperature compensation signal and the pressure signal are transmitted to D13 which serves as a demultiplexer whose output is applied to an A/D converter (D14) through an instrumentation amplifier.

A/D-conversion

A/D conversion is made with a 12-bit A/D-converter (D14). Input signal is multiplexed with D10 and D13. After conversion is completed, signal ADCRDY rises to +5 V.

D/A-conversion

D/A conversion is made with a 12-bit D/A-converter (D11). D12 multiplexes the analog output to 8 sample and hold circuits. Two of these are used to drive offset voltages for N_2O and CO_2 measurement. The others are used for external analog outputs (CO_2OUT, N_2OOUT, VOLC, O_2OUT etc).

Timing of CO_2, N_2O, and AA signals

A timing pulse is produced when light is reflected to a phototransistor from a reflectorized surface on the filter wheel. The pulse produced is shaped by A28 on the preamplifier board and transmitted to port 3 of the microprocessor on the ACX measuring board.

The processor produces the necessary address information to cause the PAL (D15) to produce the control pulses for the synchronous switches A28A and A28B (Dark and Clear).

Motor speed control

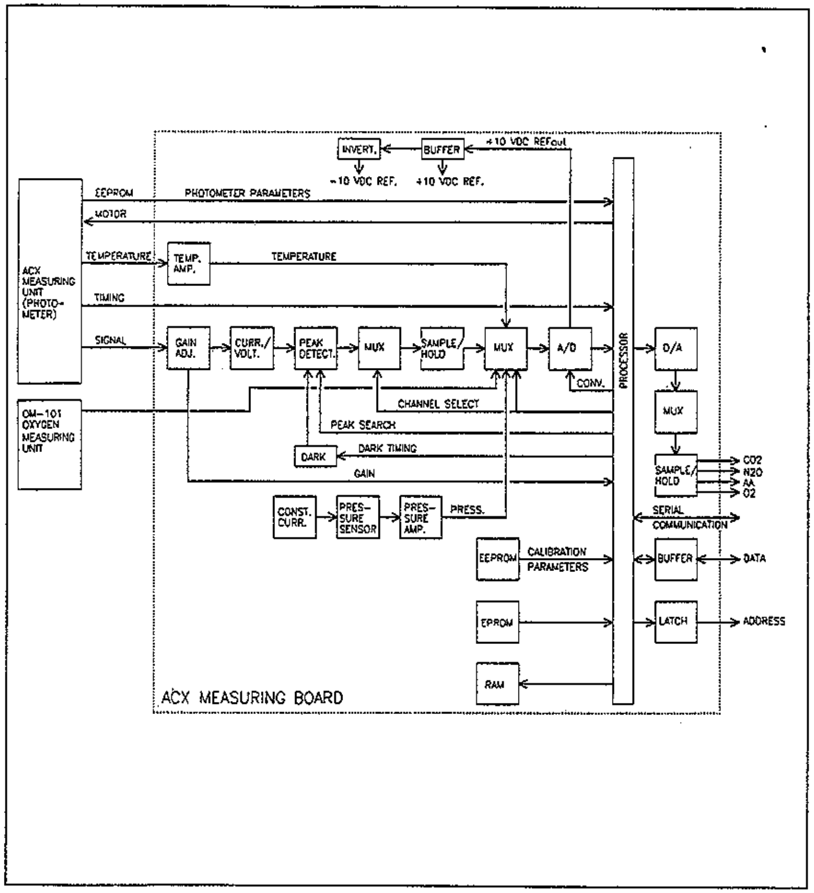
The speed of the stepper motor in the ACX-100 photometer is controlled with MOTOR-signal from the processor. This signal is buffered by D6.

Pressure measurement

The pressure transducer (B1) measures the sampling system pressure after the photometer. Voltage reference V1, resistors R17, R108, R89 and amplifier A31C supply the pressure measurement bridge with 4 mA current. The pressure signal is amplified with A31A and A31B. The output of A31A corresponds to pressures 400 to 900 mmHg and is within -9.5 V and +9.5 V range.

Temperature measurement

Temperature measurement exitation voltage for photometer stabilizing diode is fed from +10 V through resistor R104. The stabilizing diode voltage is proportional to photometer temperature. This voltage is amplified with A31D.



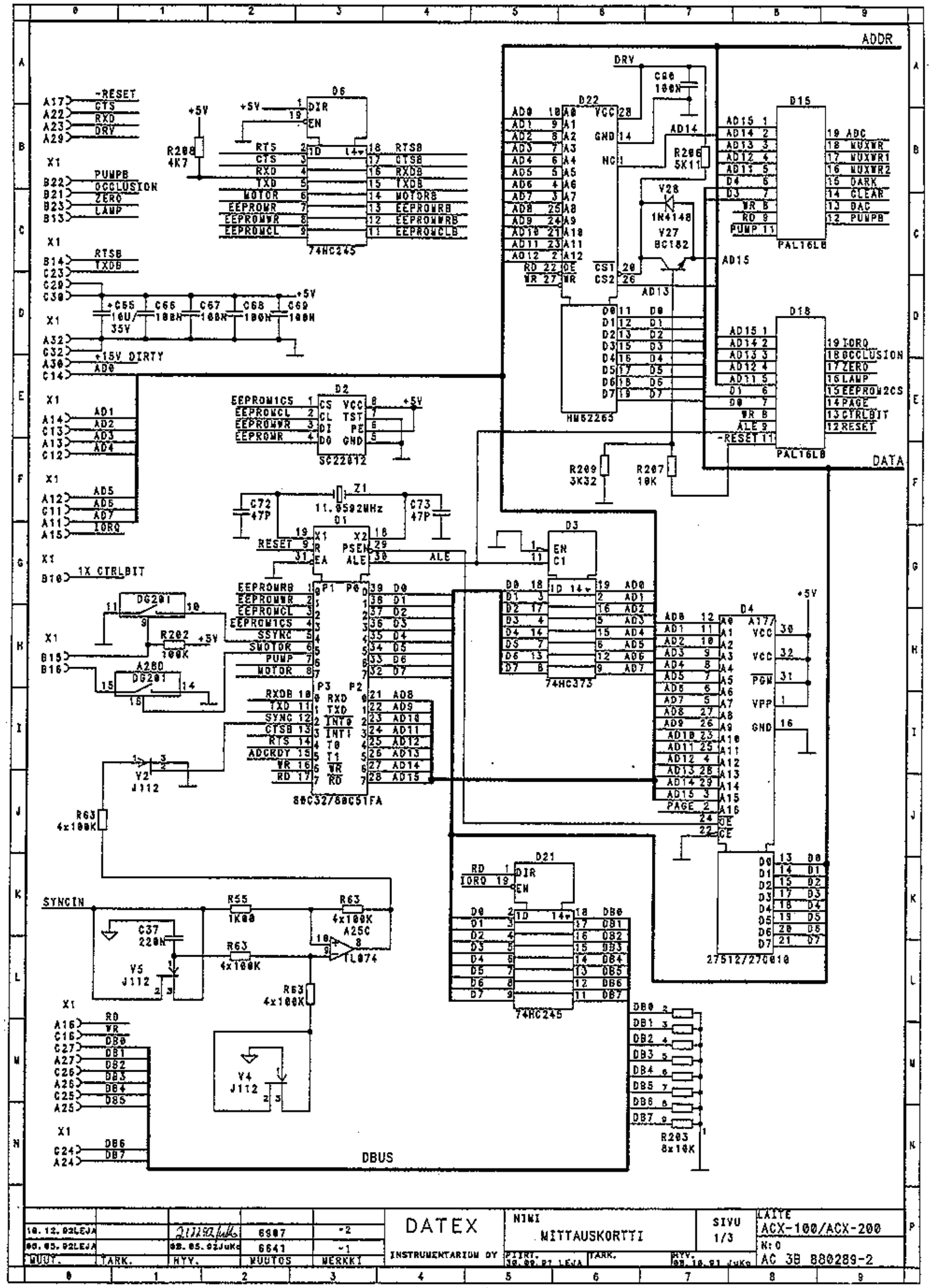
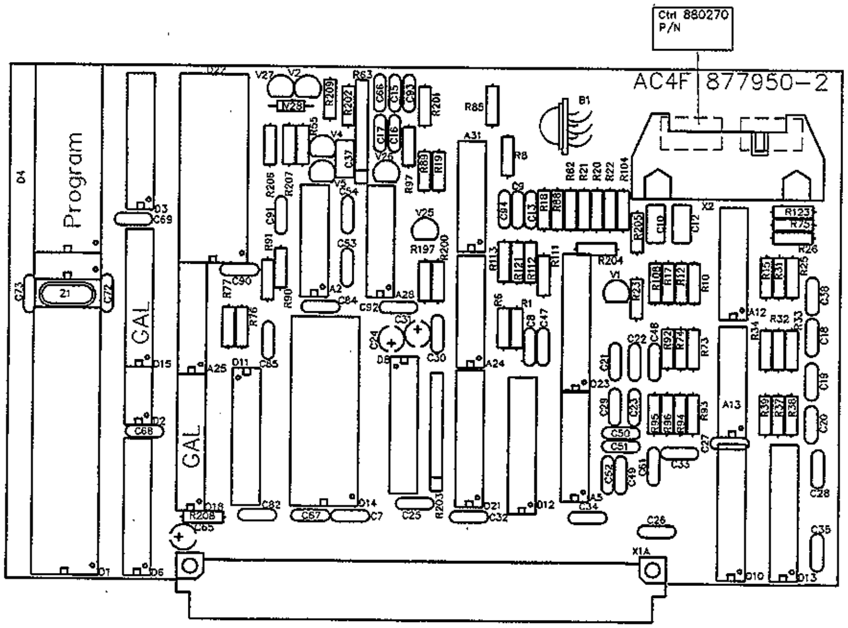


Figure 5.7 ACX Measuring board block diagram and schematic diagram part 1 (board modification level 4 and higher)

Figure 5.8 ACX Measuring board parts layout and schematic diagram part 2 (board modification level 4 and higher)



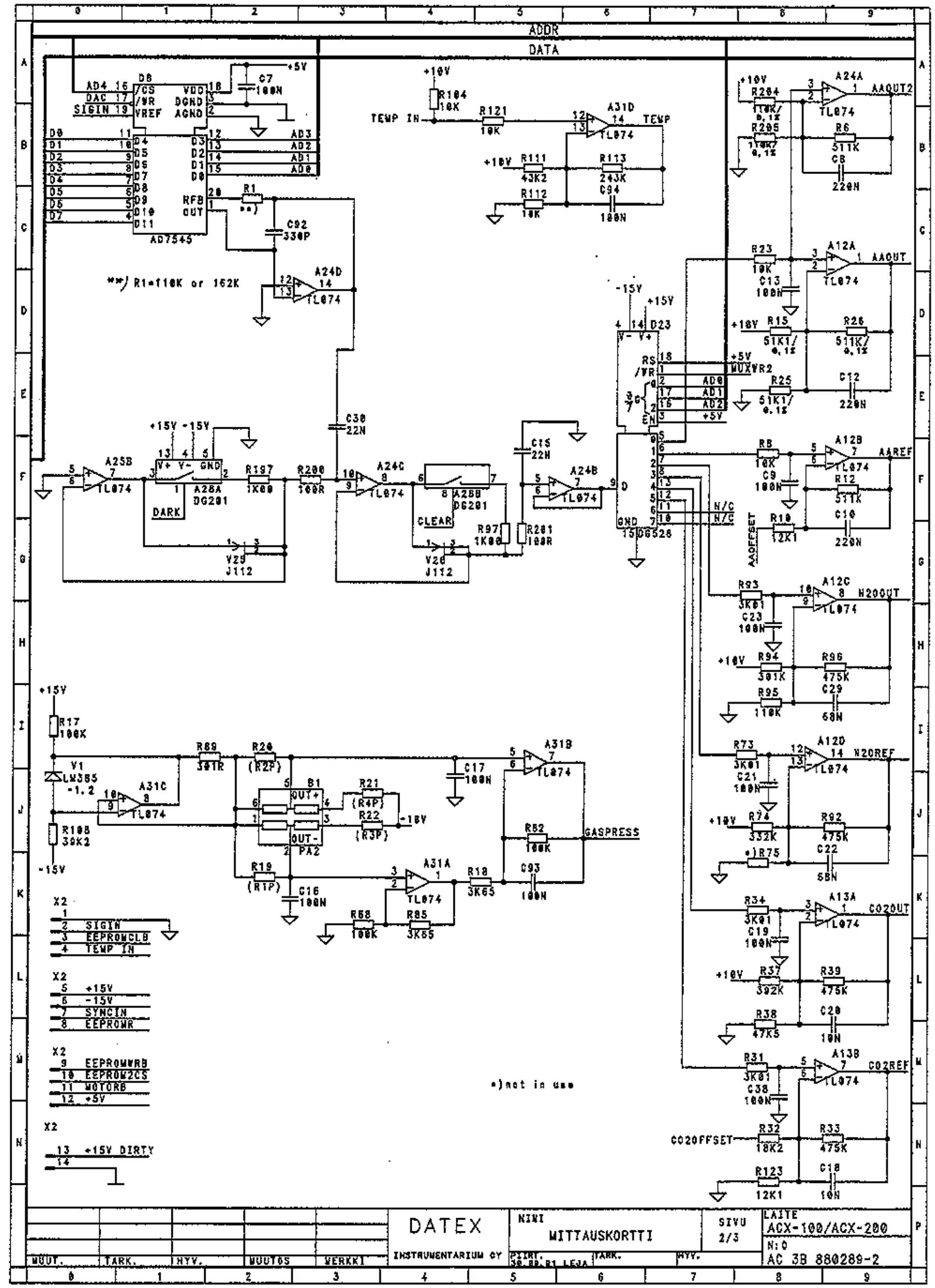
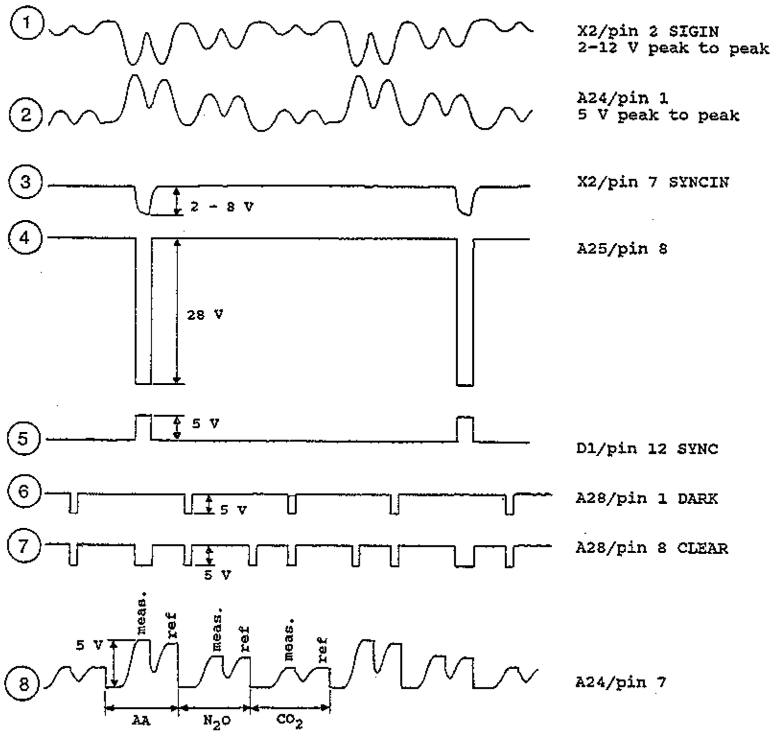
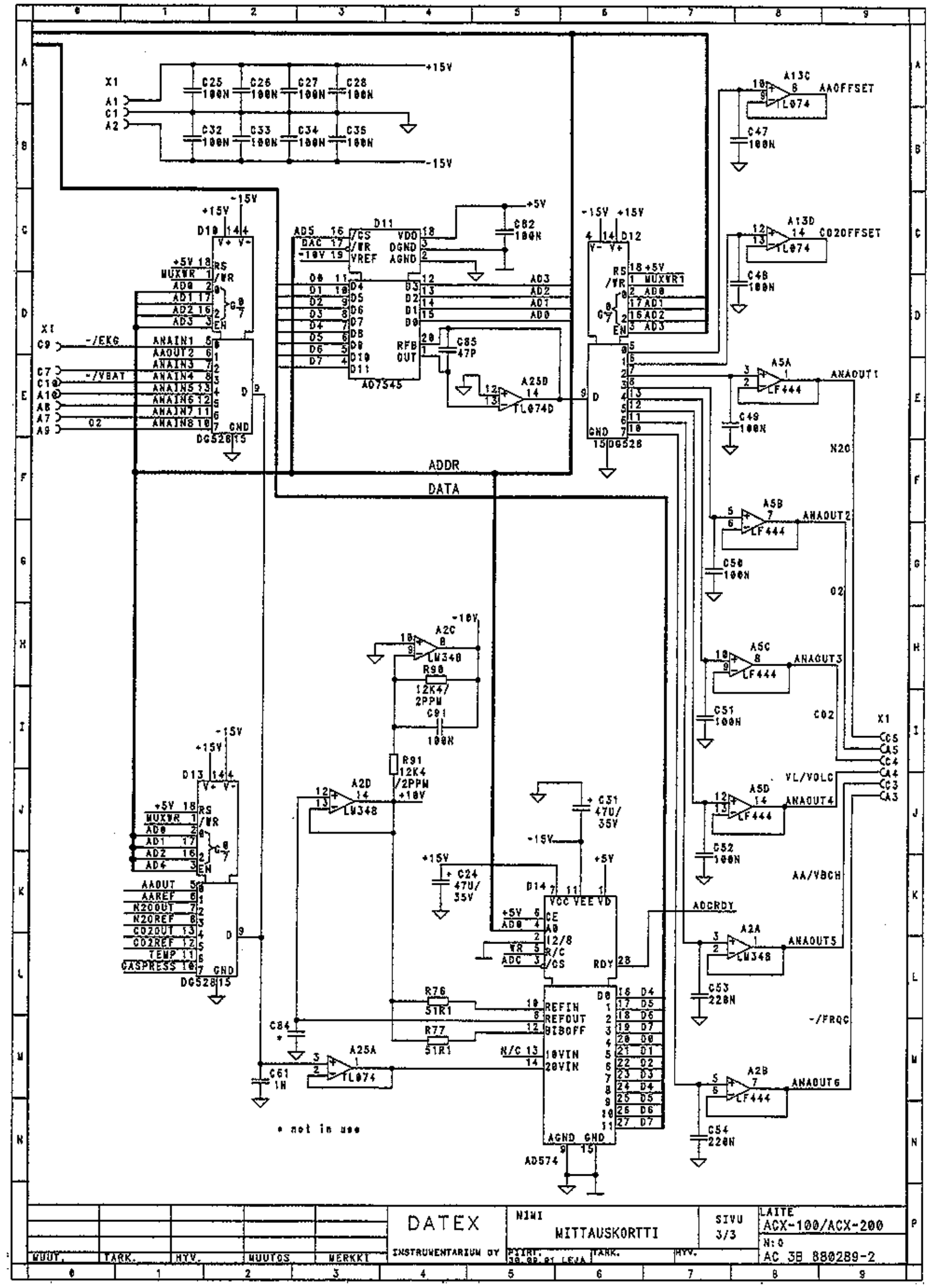


Figure 5.9 ACX Measuring board timing diagram and schematic diagram part 3 (board modification level 4 and higher)





5.5 SpO_2 measuring board (Rev. 06 and up)

The board is intended to perform the following tasks:

- Control the LED light sources of the probe.
- Amplify the signal coming from the detector and separate the red and infrared signal components to respective channels.
- Multiplex in both channels the alternating component of the signal (plethysmographic pulse) with the signal proportional to the total intensity measured with the respective wavelength.
- Provide isolated output from the multiplexer channels (red channel and IR channel) to the SpO_2 Processor board.

Power supply

The isolated power supply consists of:

- 32.768 Hz oscillator.
- Half-bridge converter with isolation transformer.
- Stabilization and filtering of the output voltages with linear regulators.
- Protection of the overloading with PTC-type thermistor.

Timing/LED control

The timing pulses are produced by a PAL (Programmable Array Logic) D3. The input signal for D3 (SYNC.) is taken from the switching power supply as a 32.768 Hz square wave. All timing signals are synchronized at this switching frequency. The timing circuit controls the LED driver circuitry (signals LED_R and LED_{IR}), the RC time constants in amplifier chain (MEASURE) and sampling ($SAMPLE_R$, $SAMPLE_{IR}$).

LEDs in the probe are driven with constant current pulses, (90 or 300 mA). The pulse duration and duty cycle can be seen in timing diagram in Figure 5.11. A positive voltage pulse at 1/X1 corresponds to the red LED current and a negative one to the IR-LED, respectively.

Detector signal processing

The signal produced by the detector is a current. The first amplifier stage is a current-to-voltage converter. A signal current passes through the resistors between pins 13 and 14 of A3 and produces a negative voltage pulse at 14/A3. Notice that the part of the feedback resistance is located in the probe connector.

The bias voltage of the detector (4.2 V) is the voltage difference between the connector pins 3/X1 (5 V) and 5/X1 (0.8 V).

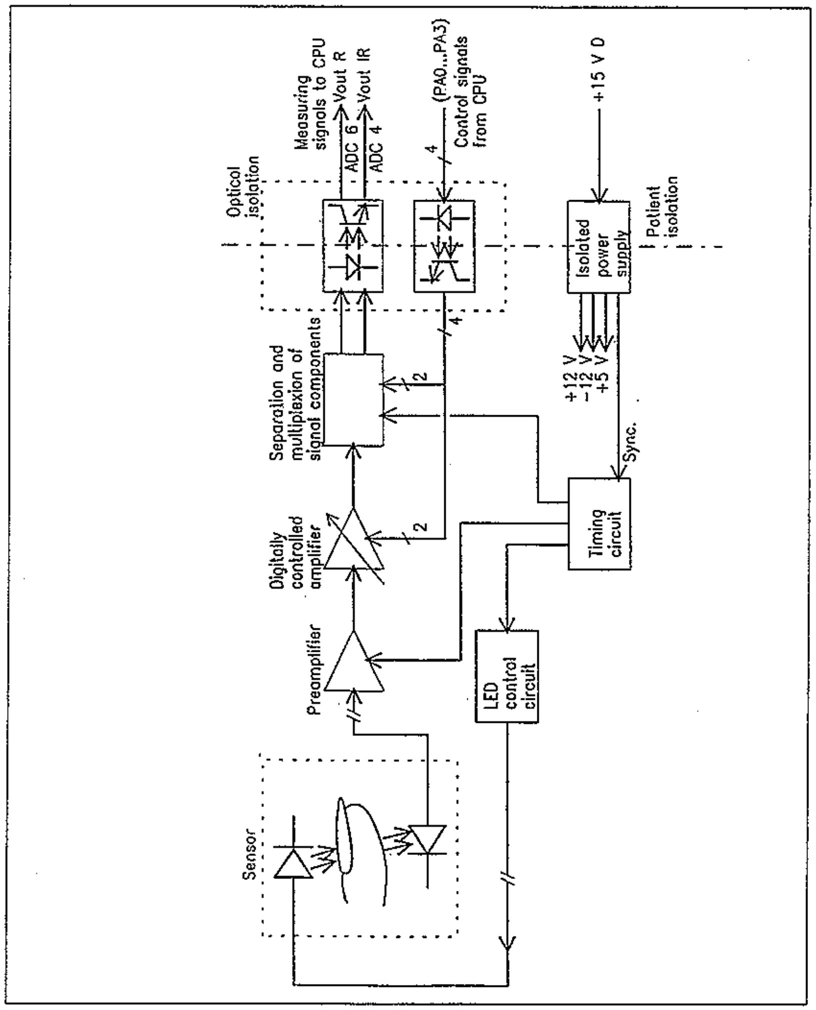
At 8/A3 the detected voltage pulses are inverted to positive value.

The digitally controlled amplifier is a Digital to Analog Converter (DAC), D5. The signal is fed to the reference input of D5. The 8-bit digital control word is transferred over the patient isolation barrier in serial mode (PA2) and is converted into parallel mode by a shift register D4. The signal level at the output, 7/A3, is adjusted to 3 to 8 V by the CPU.

The amplified signal pulses are separated to red and infrared channels by sample-and-hold circuitry (S/H). Voltages V_R and V_{IR} are proportional to the total intensity of the light detected at the respective wavelength. V_{Rac} and V_{IRac} are the amplified alternating components (plethysmographic pulses).

The signals are multiplexed into two channels by a 2 x 4 MUX, A5. Also +5 V and GND are connected to MUX input. The value of the resistor R_c in the probe connector can be read through the red channel, if needed.

The two output channels of MUX A5 are transferred across the patient isolation by two identical pulse width modulator/optoisolator/demodulator-chains. The frequency of the pulse width modulator is about 20 kHz. The demodulated signal is inverted.



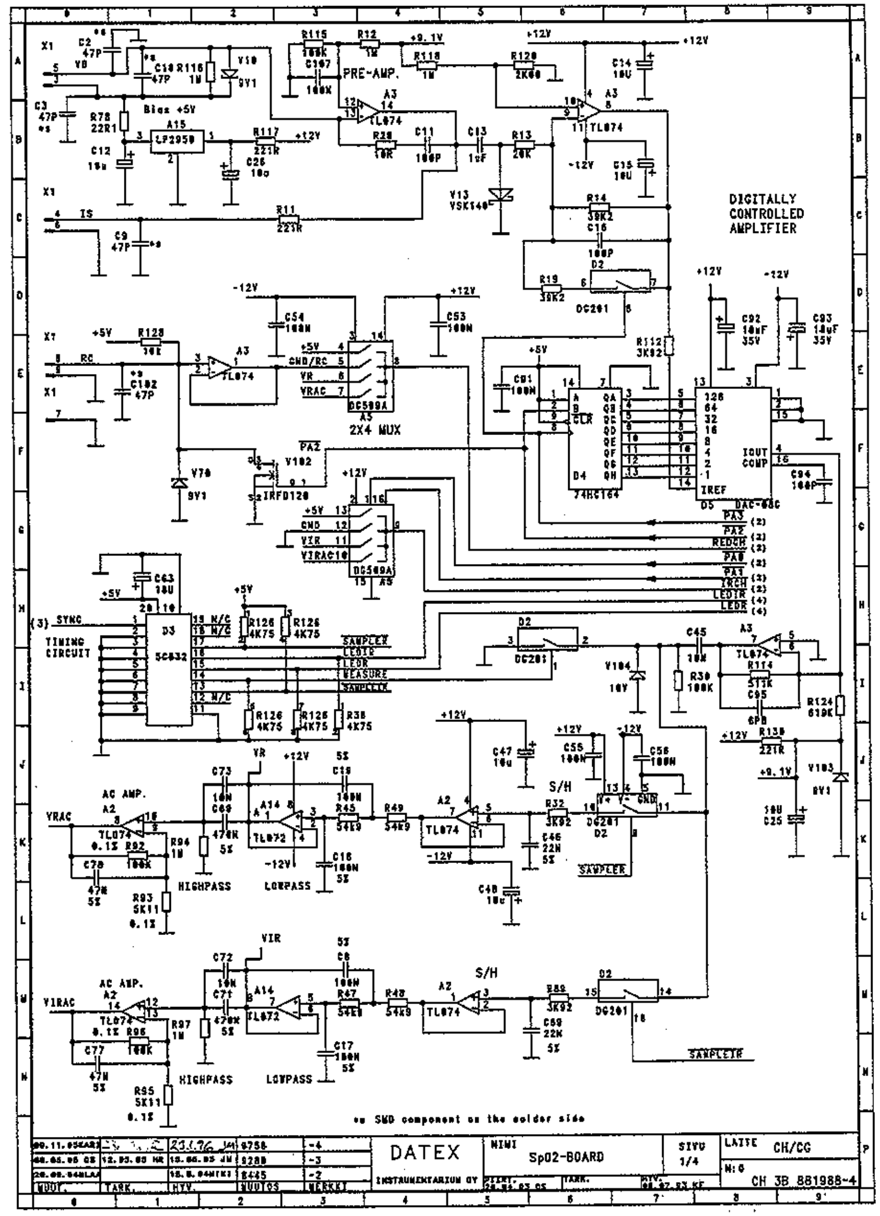
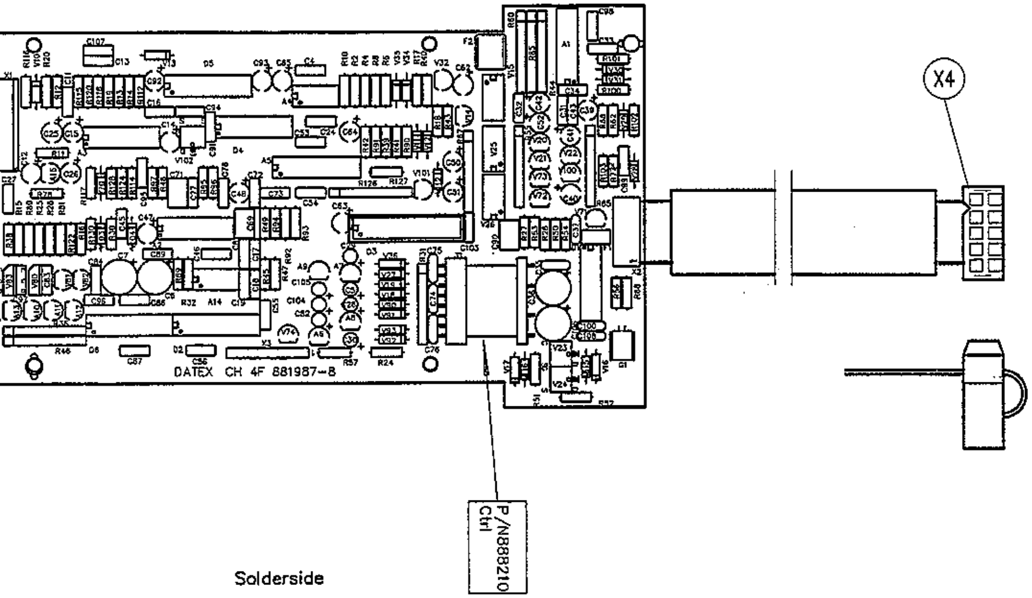
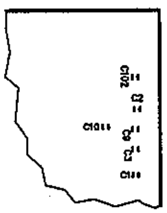


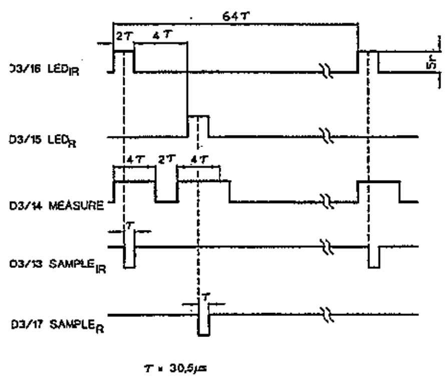
Figure 5.10 SpO2 Measuring board block diagram and schematic diagram part 1

Figure 5.11 SpO_2 Measuring board parts layout, timing diagram and schematic diagram part 2



Solderside





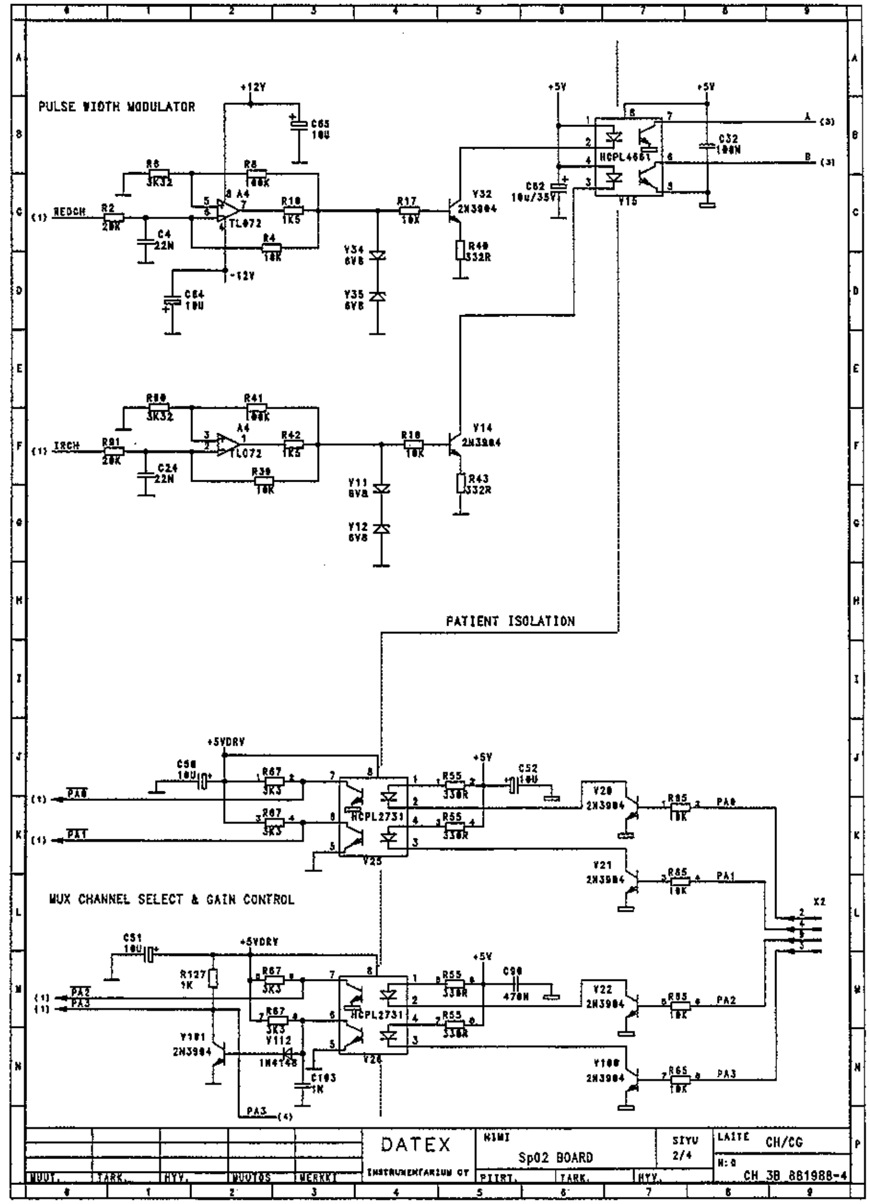
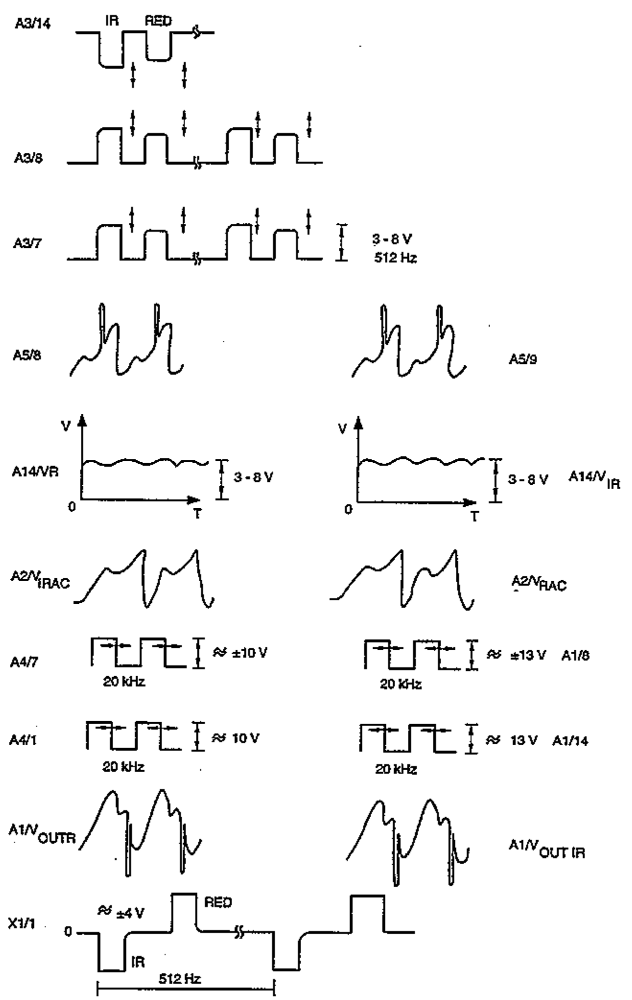


Figure 5.12 SpO2 Measuring board signal waveforms and schematic diagram part 3



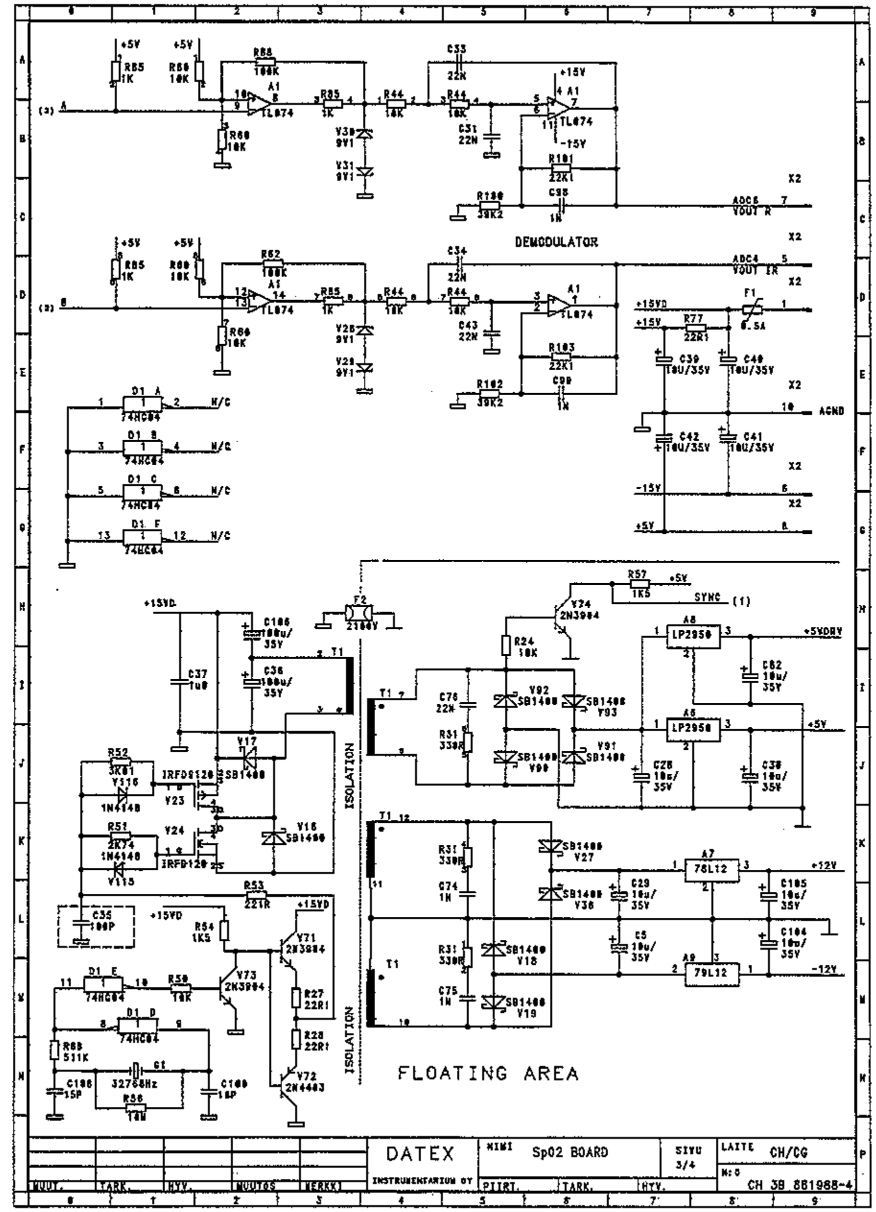
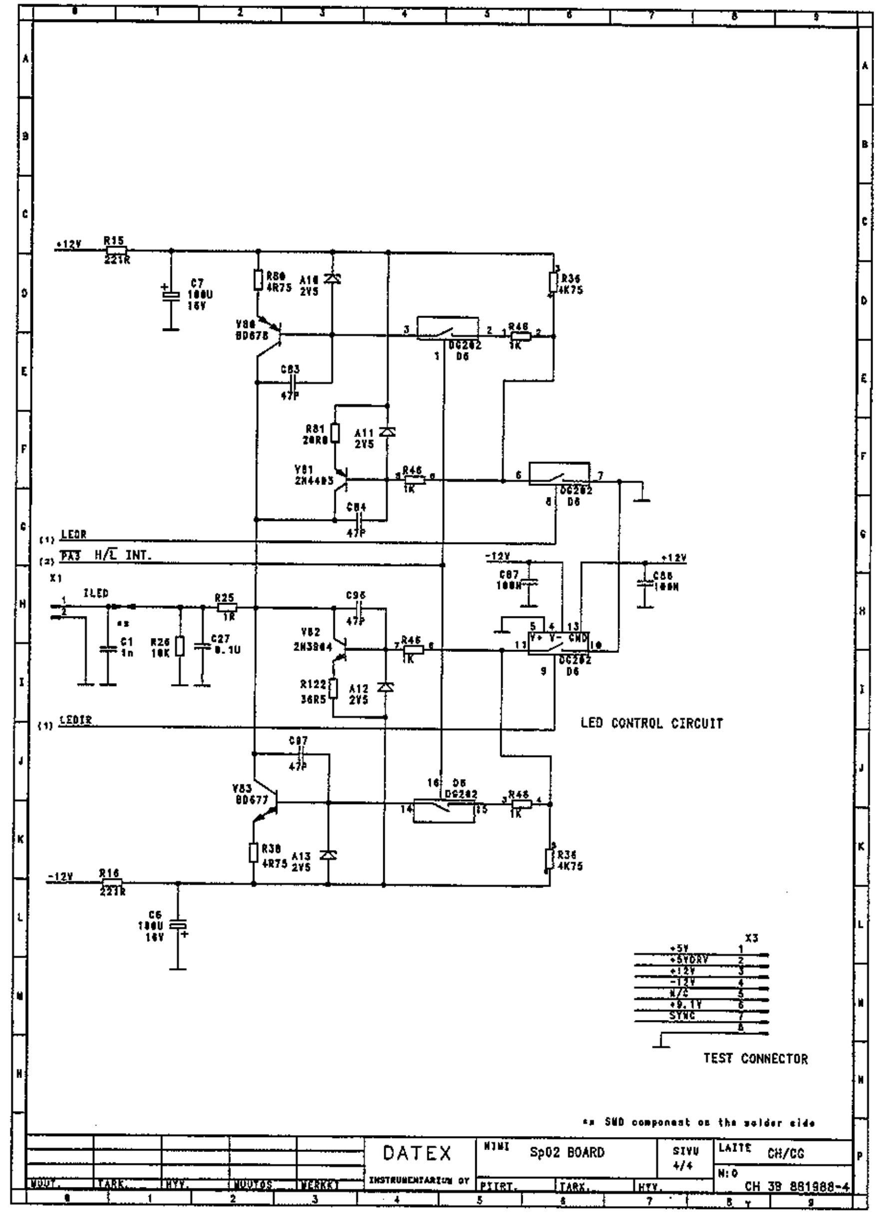


Figure 5.13 SpO2 Measuring board schematic diagram part 4



5.6 CPU board (Rev. 06 and up)

Principle of operation

The High Speed CPU board contains 16 MHz oscillator (previously 11.059 MHz), 80C32 CPU, standard EPROM and SRAM, and several analog and digital I/O functions. See the CPU board block diagram.

The CPU (D5) uses the CPU board internal bus to access most of the peripheral circuits; the on-chip peripheral ports are directly used for analog multiplexers (MUX) and serial channel 0 (ASCII computer output). The computer output is explained in Appendix A.

There are jumpers to select memory chips. They are 2M bit program EPROM (D1), 128 x 8 kbit low current CMOS SRAM (D6) powered by the data retention voltage, and battery back-up 8 kbit SRAM (D4) for permanent calibration value memory. See the jumper configuration.

Analog input signals are read through the multiplexer (A3) to the A/D-converter A2.

Control signals of MUX are in port 1 on the microprocessor as follows:

P1	pins 3-5	MUX A0-A2 (both)
	pin 6	MUX enable (both)
	pin 7	MUX 0 Write (ADC)
	pin 8	MUX 1 Write (DAC)
	ADC 4	Ired signals
	ADC 6	Red signals
	DAC 2	SpO_2
	DAC 6	Ired pleth
	DAC 5	Loudspeaker volume
	DAC 7	Loudspeaker pitch

Ports on the PPI is used for as follows:

PA (output)	PB (input)	PC (low input,high output)
PA0: SpO_2 control	PB0: not used (AUX)	PC0: not used
PA1: SpO_2 control	PB1: not used (AUX)	PC1: not used
PA2: SpO_2 control	PB2: not used	PC2: not used
PA3: SpO_2 control	PB3: Test (S&A)	PC3: not used
PA4: not used	PB4: Gas freeze (S&A)	PC4: not used
PA5: not used (AUX)	PB5: CTSB (AUX)	PC5: not used
PA6: not used (AUX)	PB6: CTSA (AUX)	PC6: not used
PA7: Nurse call (AUX)	PB7: not used	PC7: Alarm LED

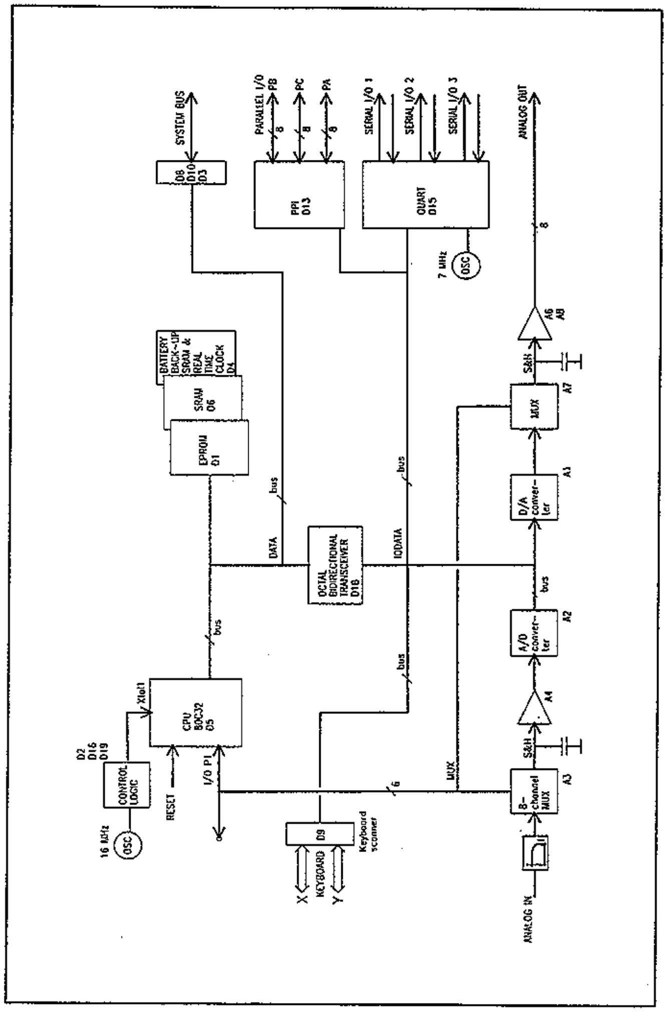
When a key is pressed, keyboard scanner (D9) interrupts the microprocessor and this reads from the scanner which key was pressed.

The Quart channel C is connected to Serial & Analog I/O connector (computer output). Quart channel A is connected to Aux I/O connector (graphic output) and quart channel B is used for communication between the microprocessor and the ACX measuring board.

Real time clock is controlled by D4 which contains lithium battery inside.

Software features are described in the Operator's Manual. Main differences between software revisions are described in Section 3.4.

CAUTION: The board contains an IC (D4) which has lithium battery inside. Danger of explosion if the IC is incorrectly replaced. Replace only with same or equivalent type recommended by DATEX-ENGSTROM. Do not dispose faulty IC:s of in fire. They are hazardous waste. Discard them according to local regulations.



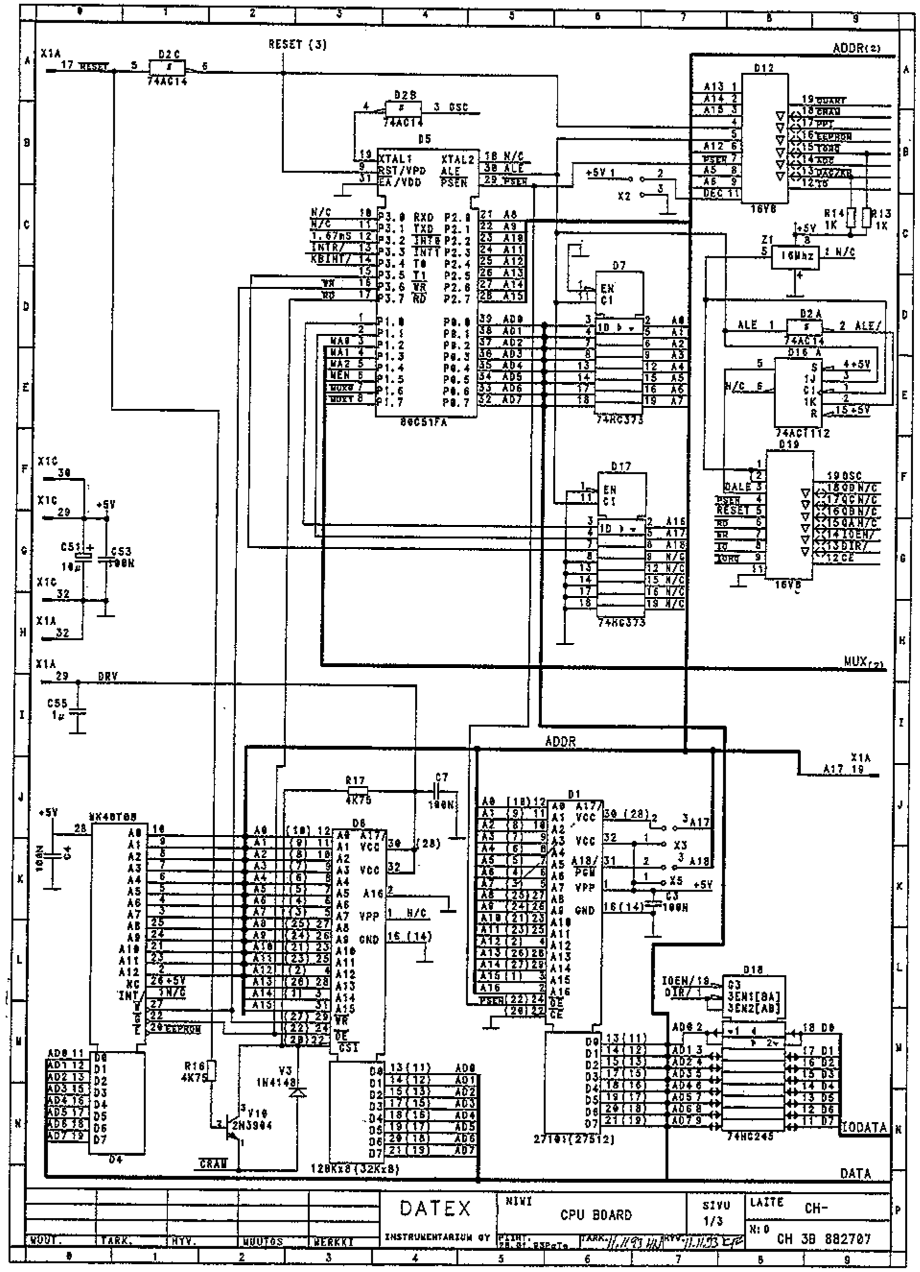
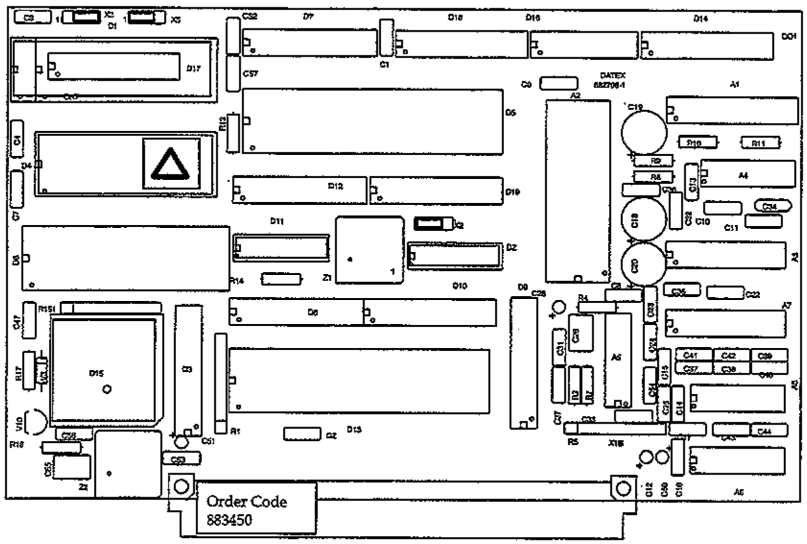


Figure 5.14 CPU board block diagram and schematic diagram part 1

Figure 5.15 CPU board parts layout and schematic diagram part 2



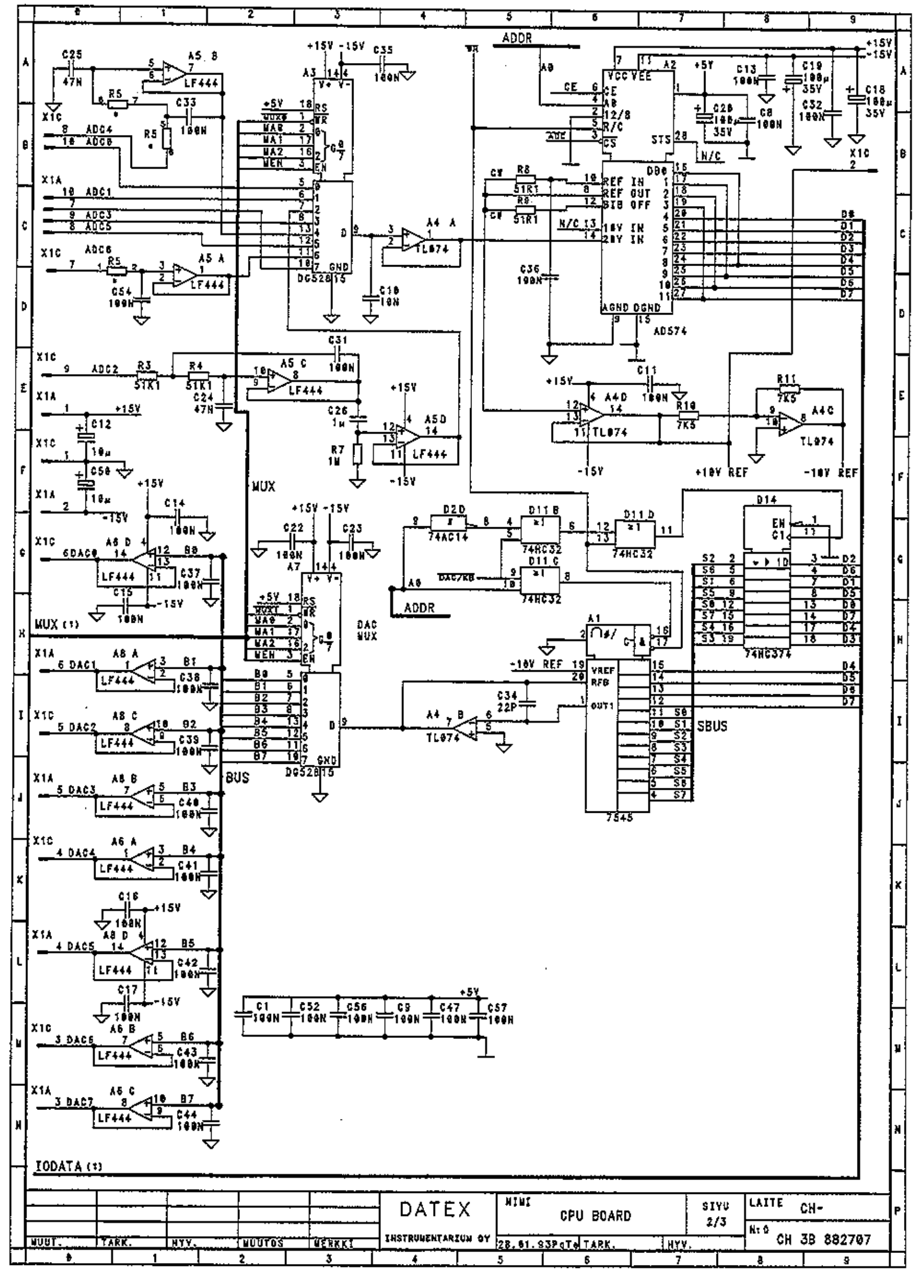
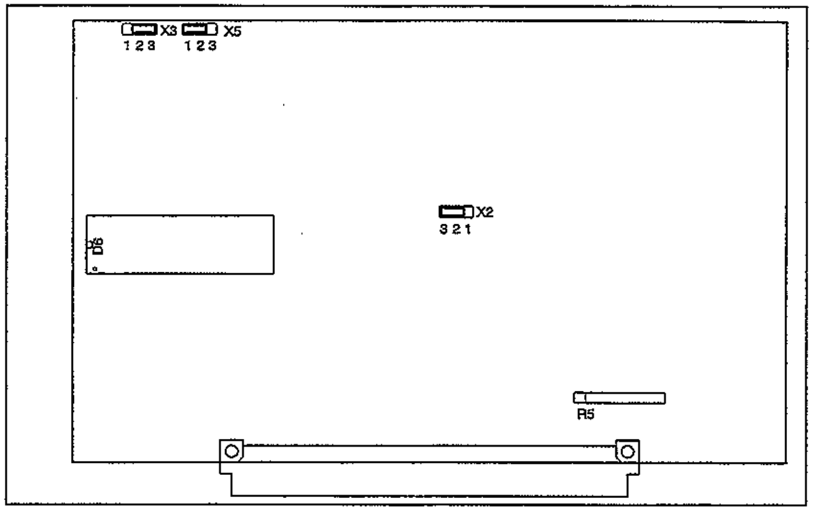
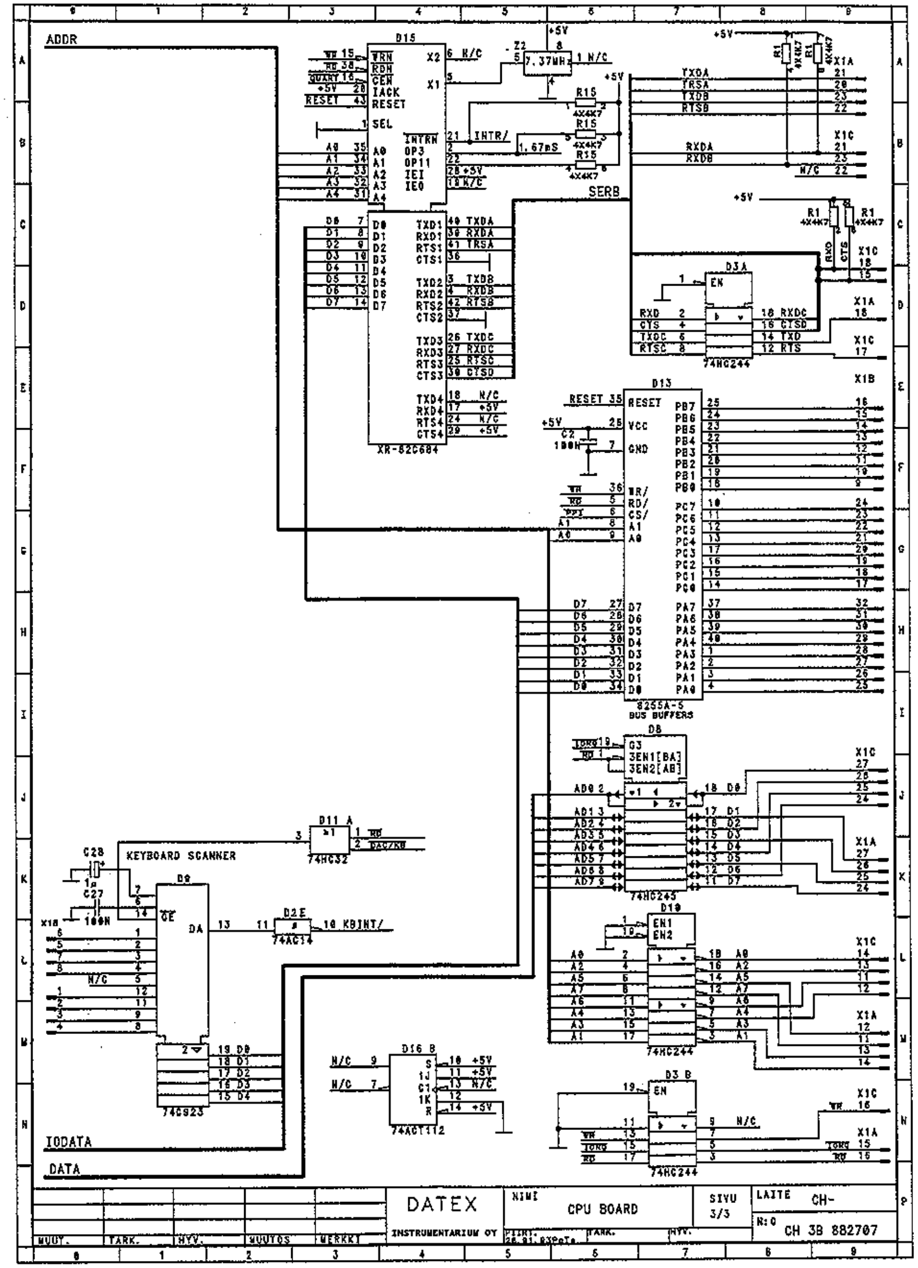


Figure 5.16 CPU board jumper configuration and schematic diagram part 3

CONNECTOR	JUMPER	MEMORY TYPE
X2	1-2	D6 : 32k x 8 RAM
	2-3	D6 : 128k x 8 RAM
X3	1-2	D1 : 512k, 1M EPROM
	2-3	D1 : 2M, 4M EPROM
X5	1-2	D4:512k,1M,2M EPROM
	2-3	D4 : 4M EPROM





5.7 Video ASIC Board

The video ASIC board replaces video control board from revision -08 (adaptation -27 and -43 revision -09). ASIC board includes ASIC IC and some other components. Due to the number of components we recommend changing the complete board in case of failure.

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Figure 5.17 (no figure)

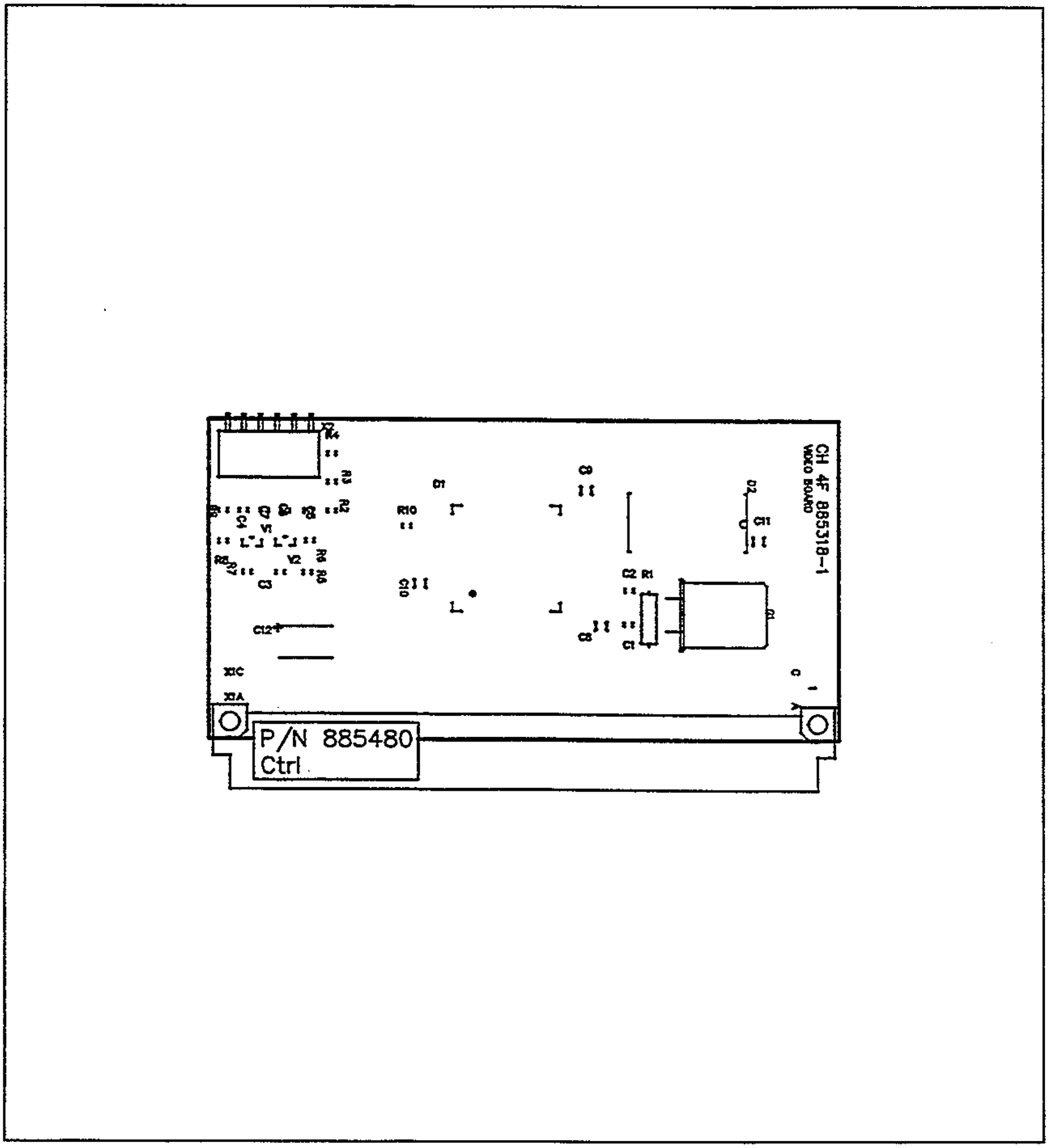
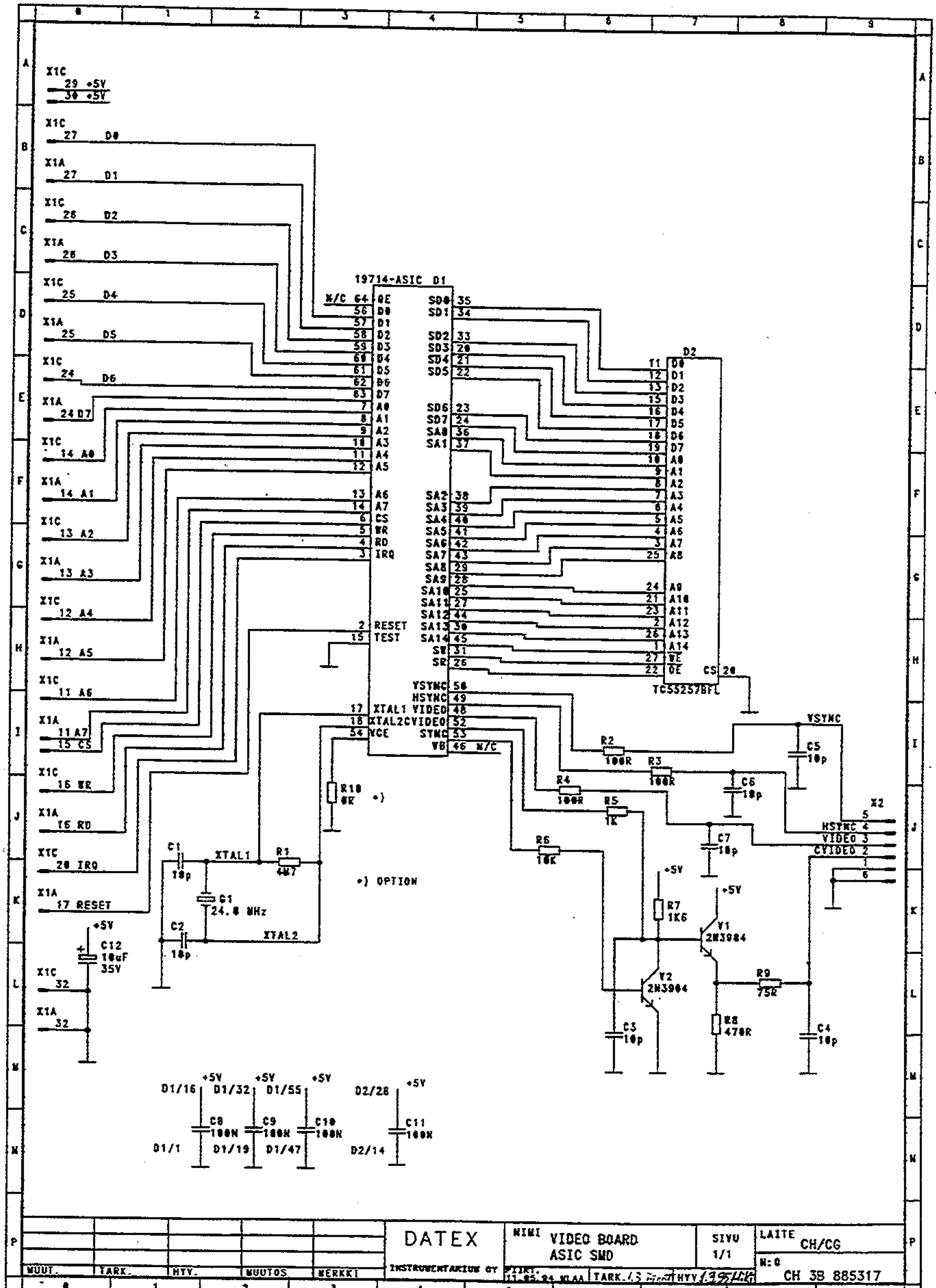


Figure 5.18 Video ASIC board parts layout

Figure 5.19 (on the next page)
Video ASIC board schematic diagram


19714-ASIC D1
D2
TC55257BFL
X1C
X1A
X2
24.0 MHz
2N3904
+) OPTION
DATEX
INSTRUMENTARIUM OY
VIDEO BOARD
ASIC SMD
SIVU 1/1
LAITE CH/CG
CH 3B 885317
MUUT.
TARK.
HYV.
MUUTOS
MERKKI

5.8 Power supply board

Principle of operation

The primary of the power supply is designed to double insulation requirements for added safety. Depending on model there is either one (100-120 V countries) or two (220-240 V countries) fuses. The primary operating voltage is factory selected by insulating and folding the unused primary leads inside the additional insulation tube.

The mains transformer is magnetically shielded to minimize screen disturbance.

The power supply board contains basically four DC sources:

- + 5 V switched, for digital circuitry and ACX measuring unit
- + 15 V switched, for motors, pumps and other components.
- +/-15 V for analog amplifiers.

Data retention voltage generation circuit supplies +5 V DRV voltage for memory from switched +5 V supply.

Also, +12 V/1 A for the CRT unit and serial drivers/receivers is derived from the +15 V switched voltage. The -12 V for the serial I/O is derived from -15 V.

The +5 V for the infrared lamp is controlled by the ACX measuring board via the LAMP ON signal, which cuts the lamp power in case of a stalled optical chopper wheel or a missing timing signal.

The gas sampling pump is driven by a 50 Hz/15 V/0.4 A square wave signal generated by the CPU.

In addition to the power supply functions the board contains drivers for two serial channels (including the modem control signals CTS and RTS), a RESET control, which generates a 200 ms reset pulse to the CPU if the +5 V line goes below 4.75 V, and miscellaneous I/O functions like a buzzer driver. Some signals from the mother board are passed directly to the rear panel connectors.

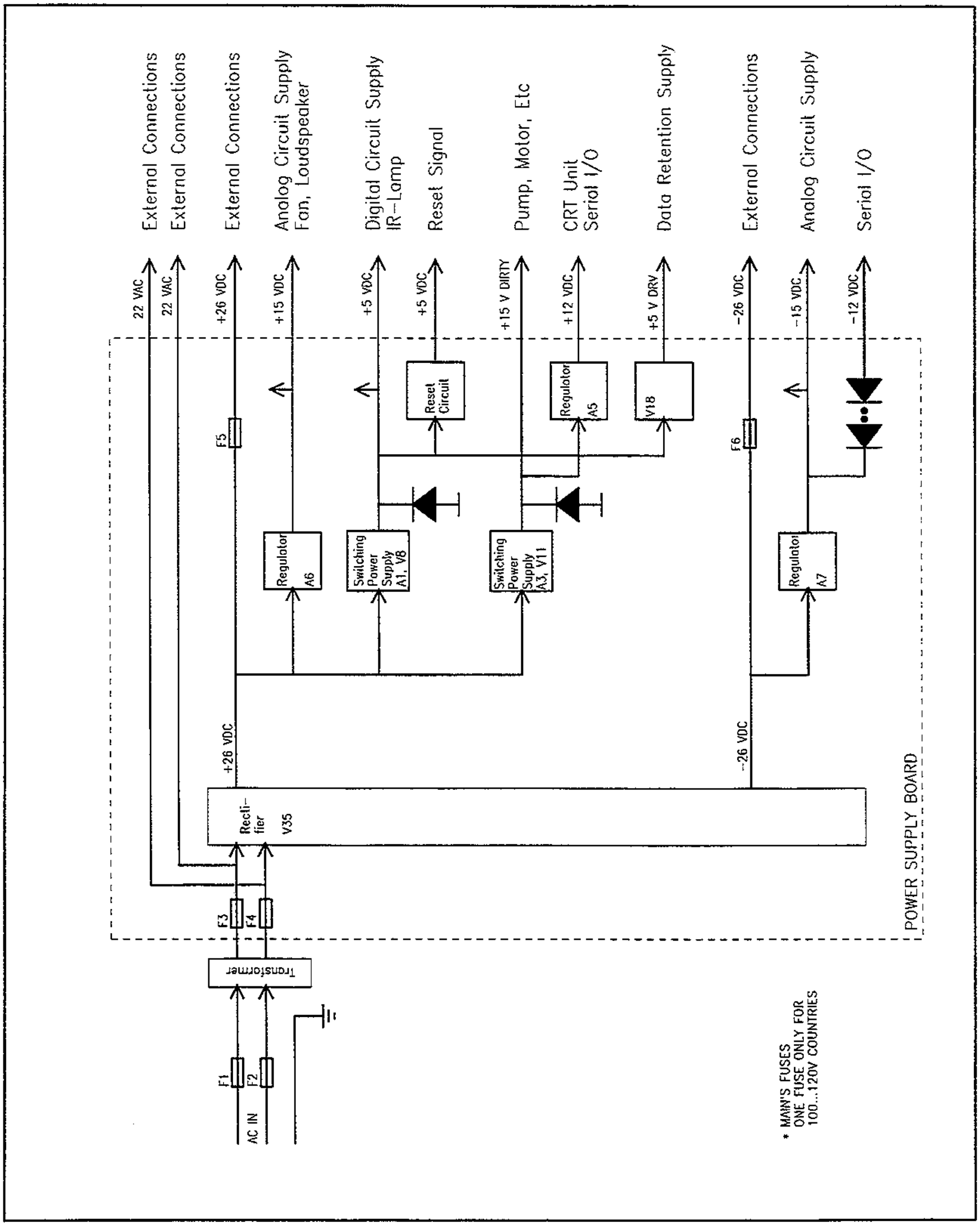
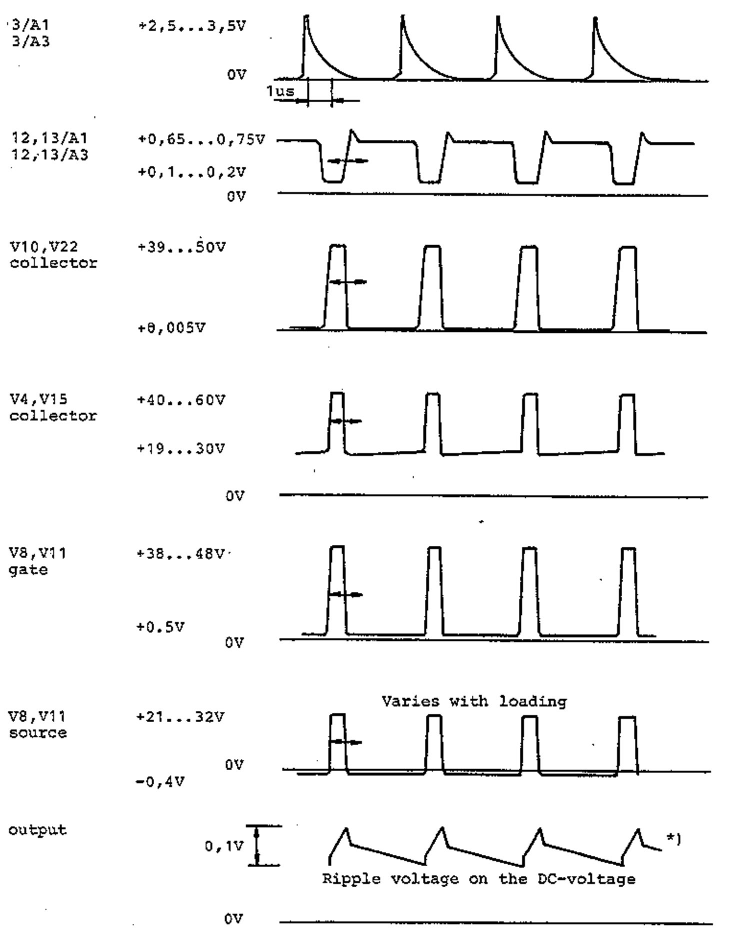


Figure 5.20 Power supply board block diagram and transformer diagram

Figure 5.21 Power supply board signal waveforms and schematic diagram part 1 (board modification level 3 and higher)



*) The ripple on the 12V voltage may be higher because of the uneven loading

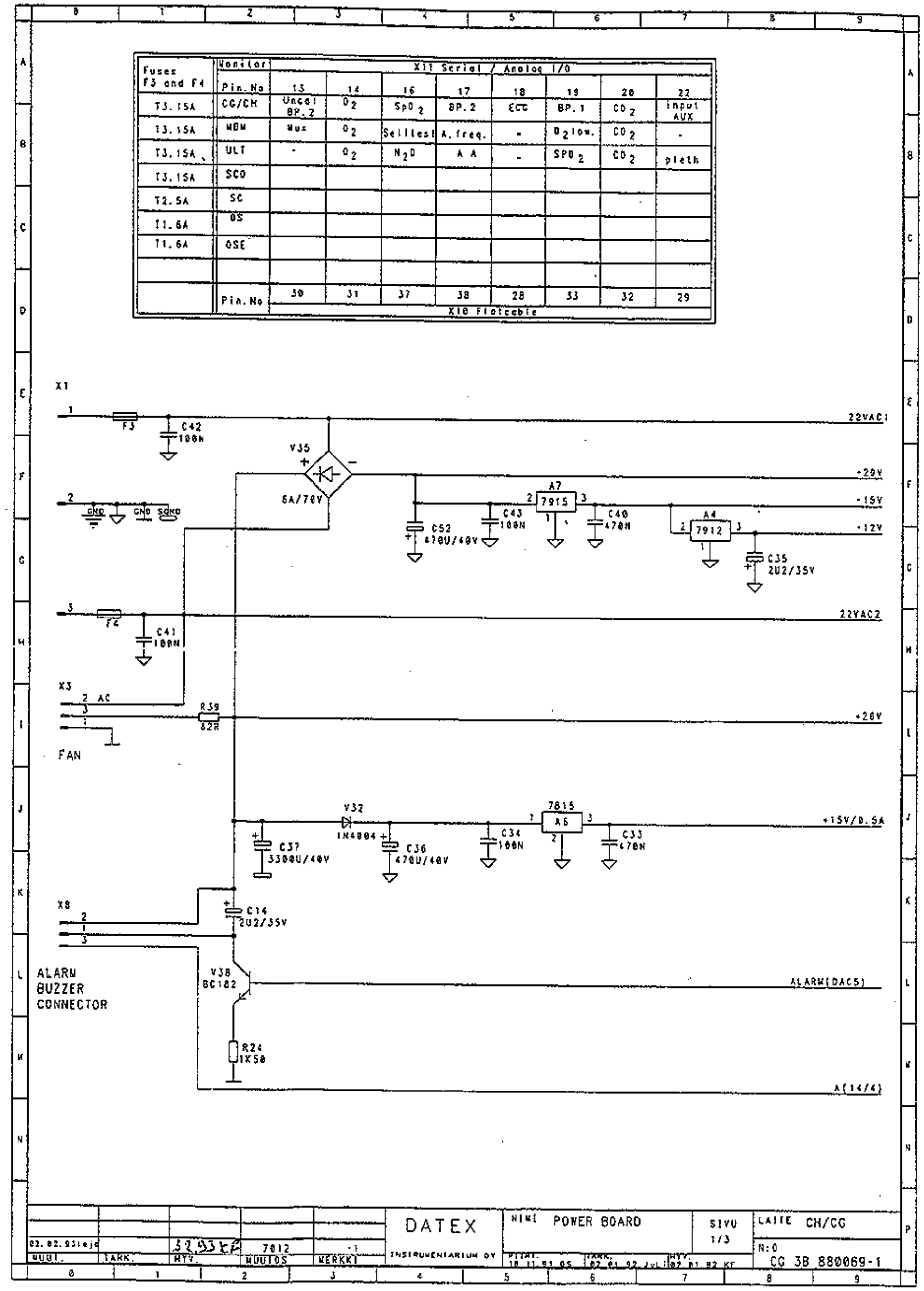
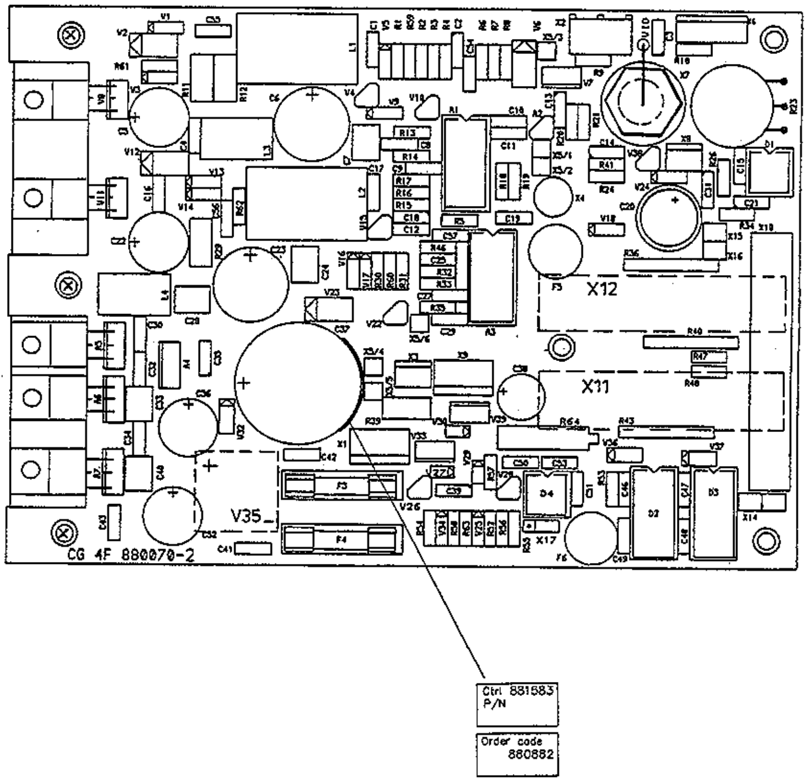


Figure 5.22 Power supply board parts layout and schematic diagram part 2 (board modification level 3 and higher)



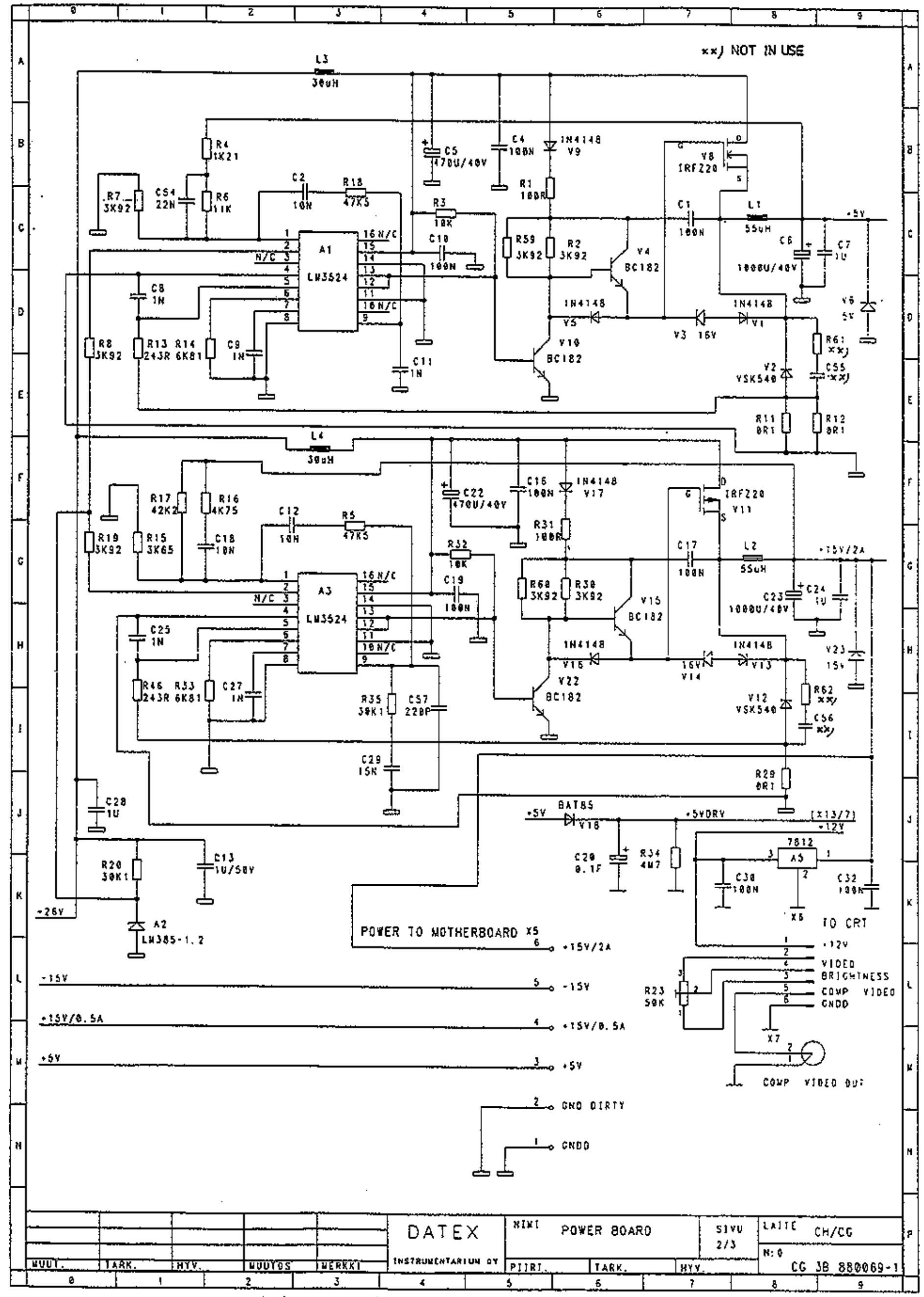
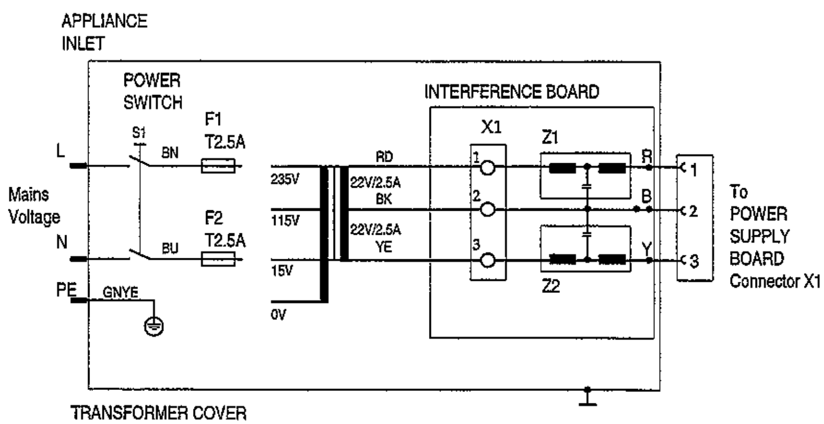
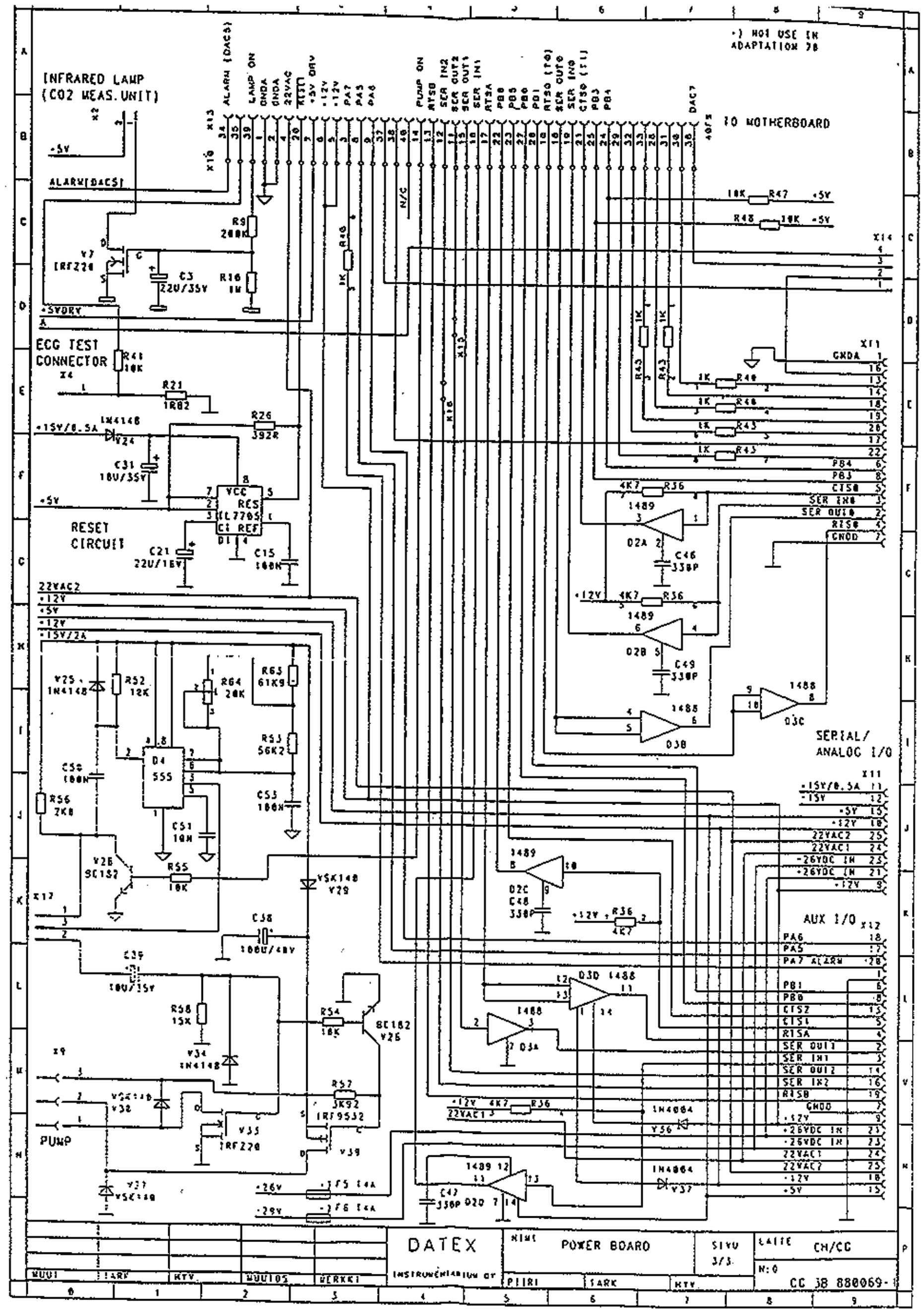


Figure 5.22a Transformer diagram and schematic diagram part 3 (board modification level 3 and higher)



ADAPTIONS	WIRING
22, 33, 40, 43	BN to 235V, BU to 0V
27, 28, 29	BN to 115V, BU to 0V
31	BN to 115V, BU to 15V



5.9 Mother board

Parts layout and schematic diagram **Figure 5.23**

The mother board contains mainly the system bus interconnections and connectors. Also on the board are power bypass capacitors and driver transistors for the sampling system magnetic valves (gas zero and pressure valves).

For signals in each bus, see the Tables in Section 5.12.

5.10 Keyboard

Parts layout and schematic diagram **Figure 5.24**

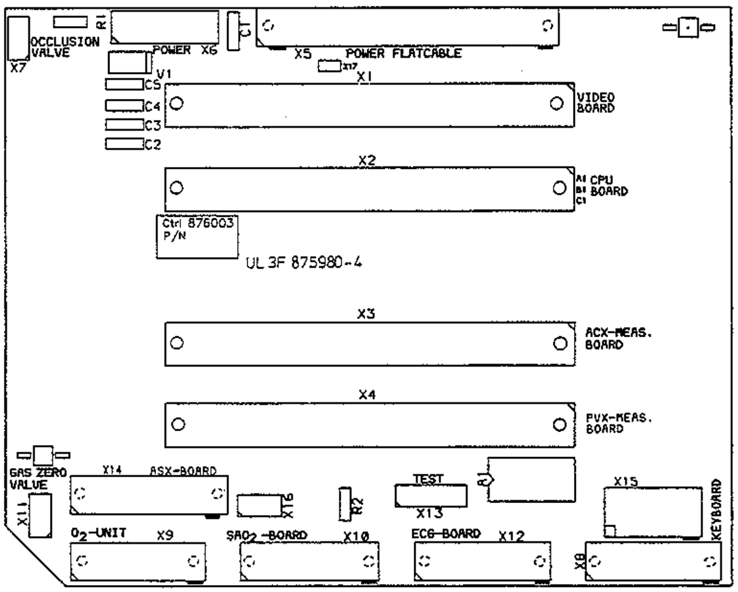
The keypad pc board is a simple 4x4 matrix which is scanned by the keyboard controller on the CPU board.

5.11 Loudspeaker unit

Parts layout and schematic diagram **Figure 5.25**

Audible alarms and beeps are generated by a separate loudspeaker unit. It contains an 8 ohm/0.4 W speaker and the associated driving circuitry.

Figure 5.23 Mother board parts layout (board modification level 4 and lower)



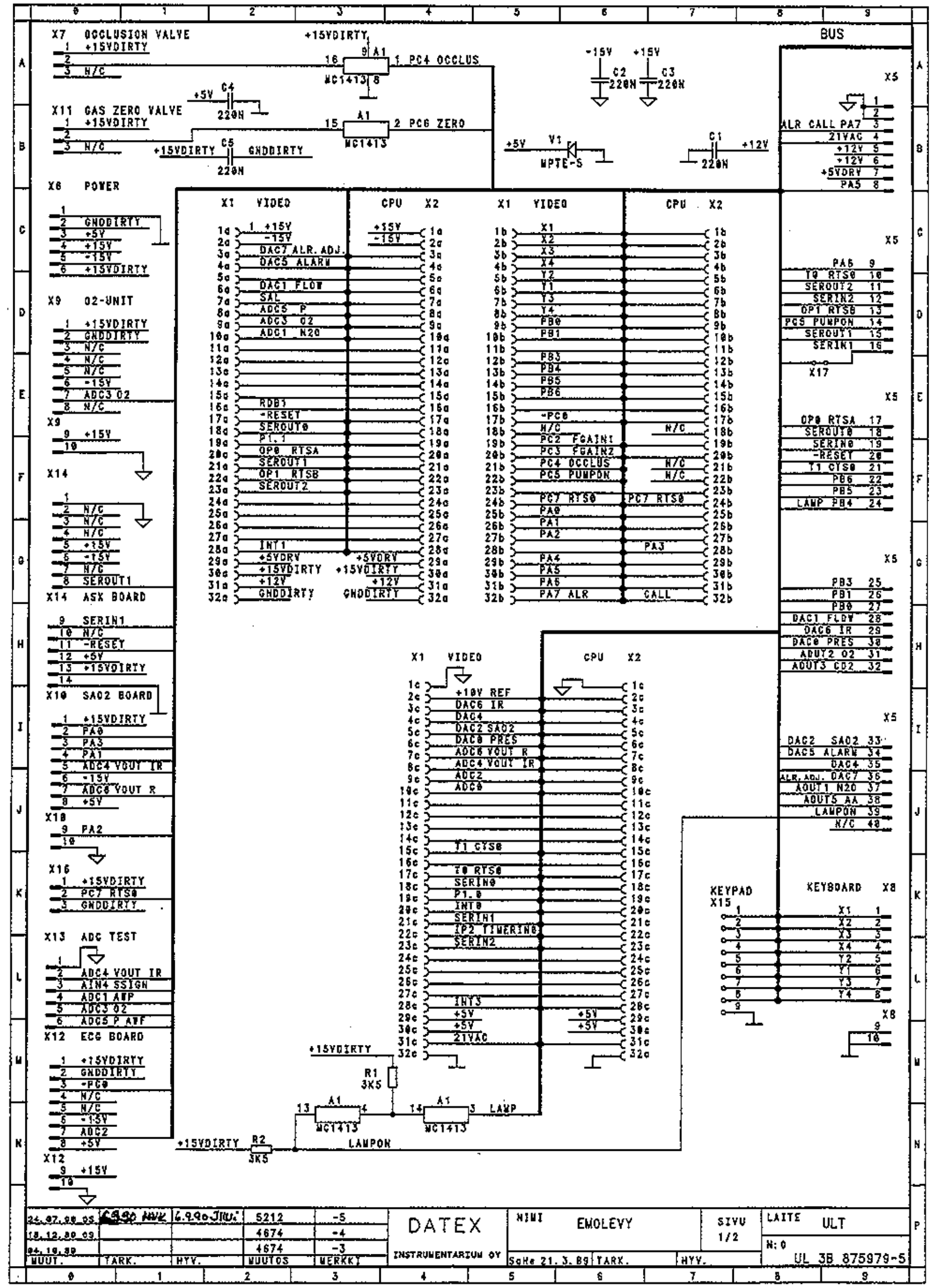


Figure 5.23a Mother board schematic diagram (board modification level 4 and lower)

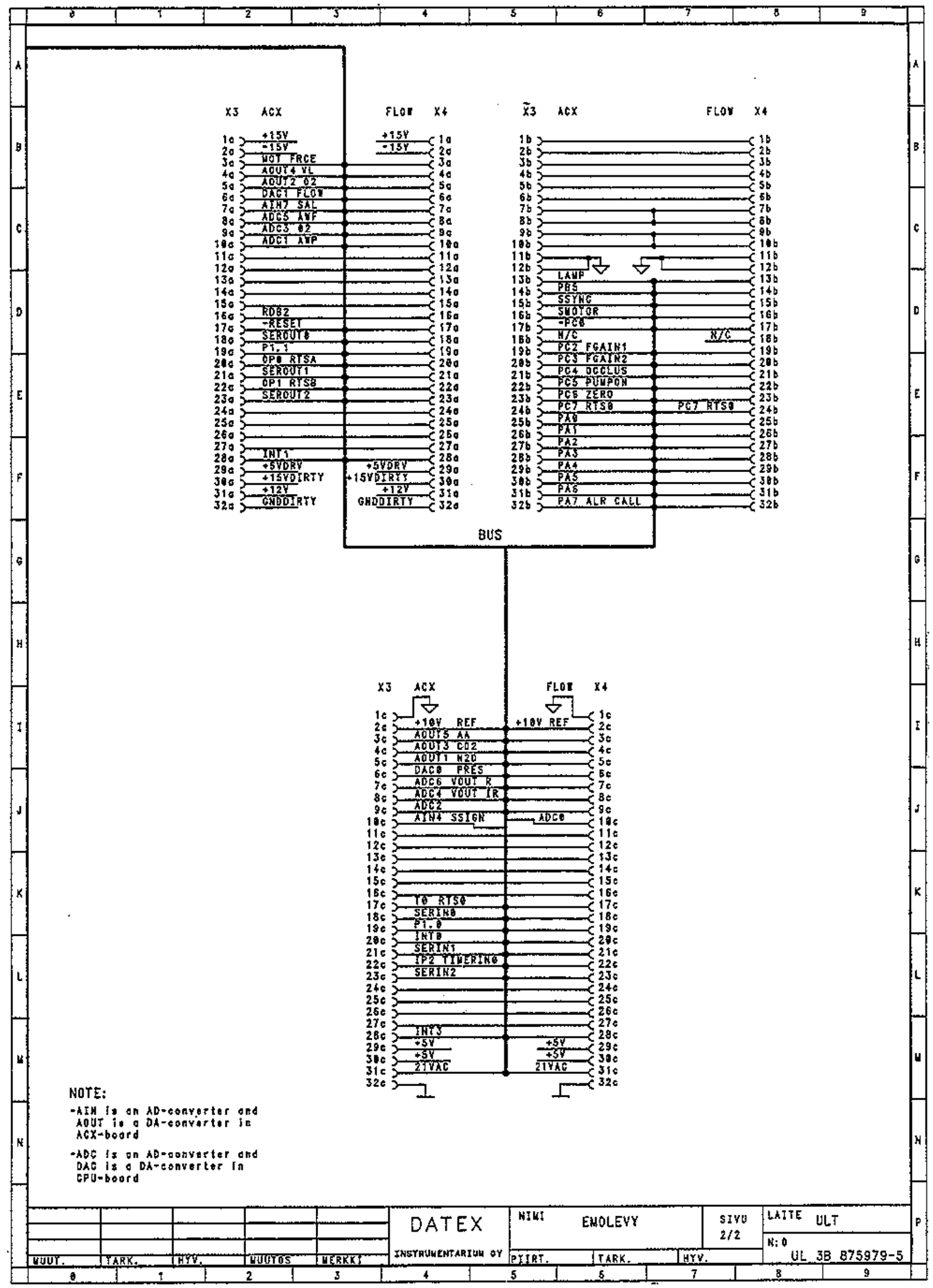
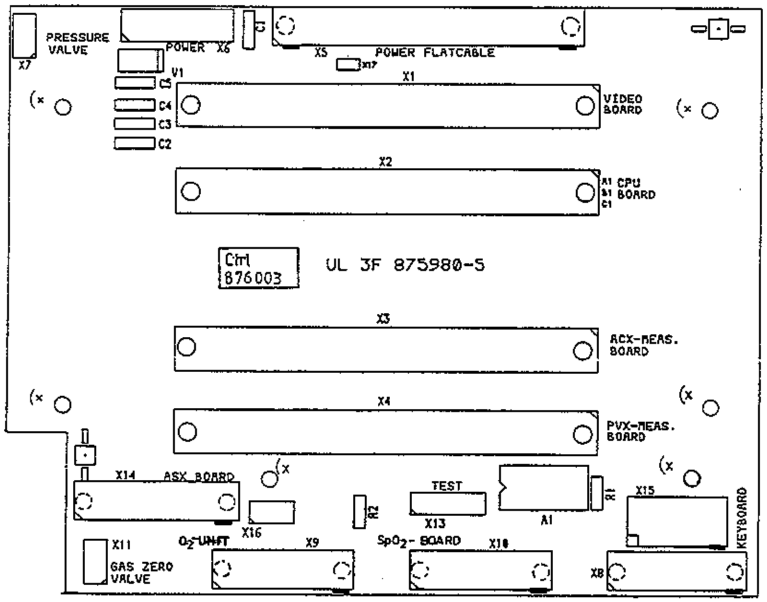


Figure 5.23b Mother board parts layout and schematic diagram part 1 (board modification level 5 and higher)



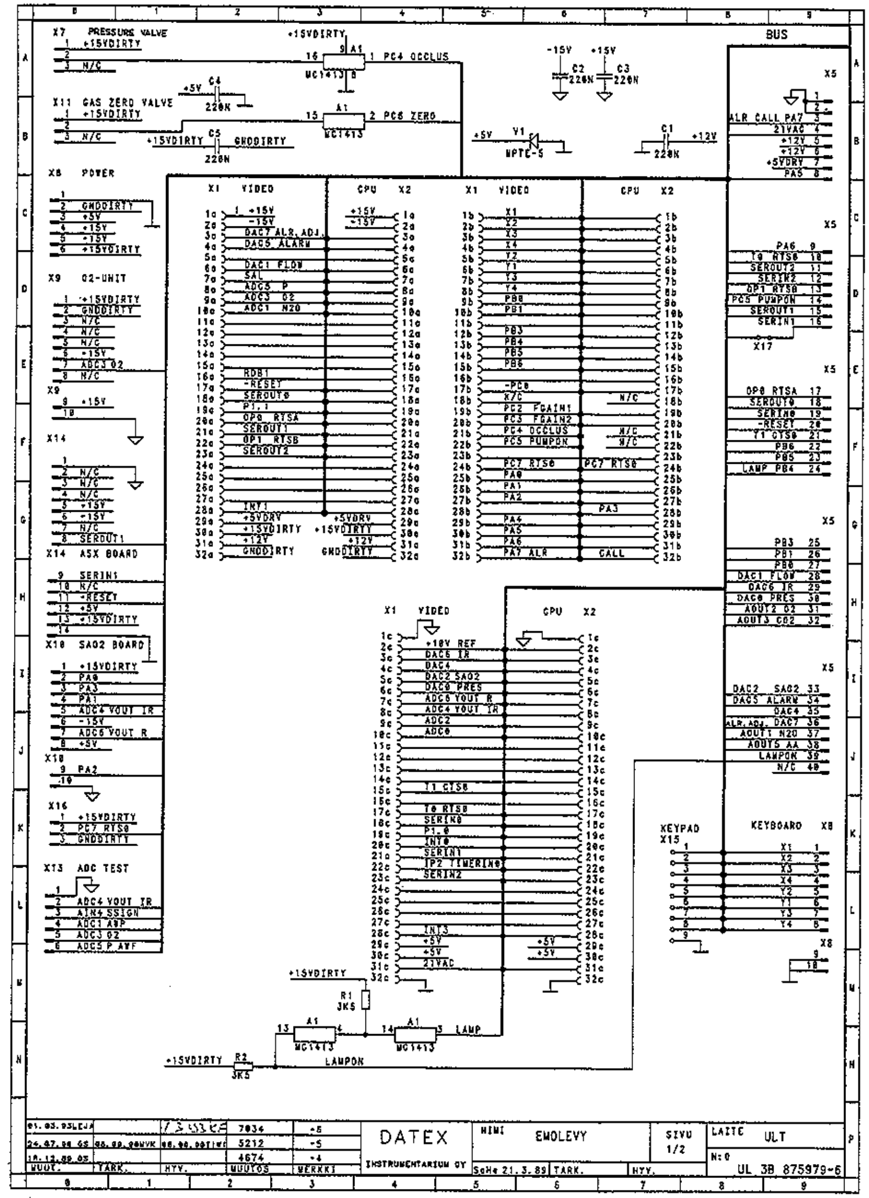


Figure 5.23c Mother board schematic diagram part 2 (board modification level 5 and higher)

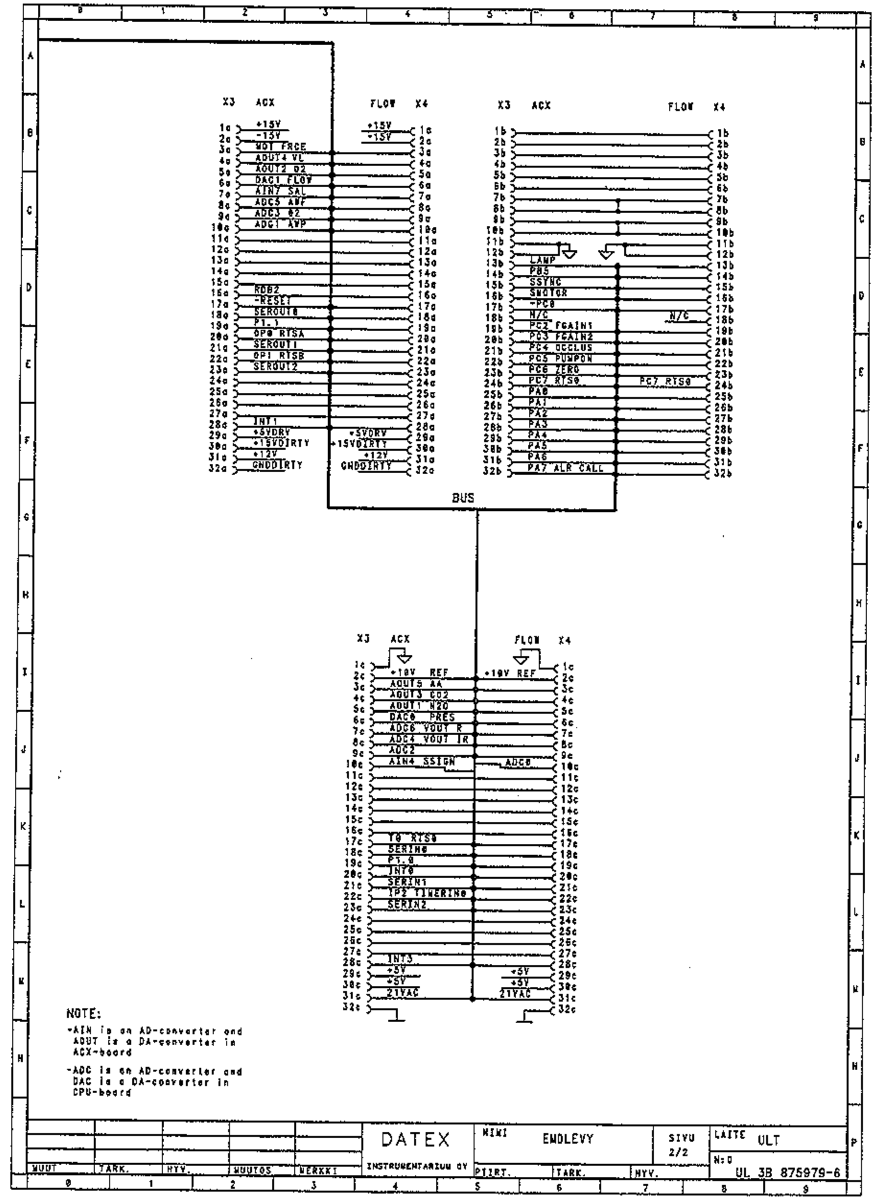
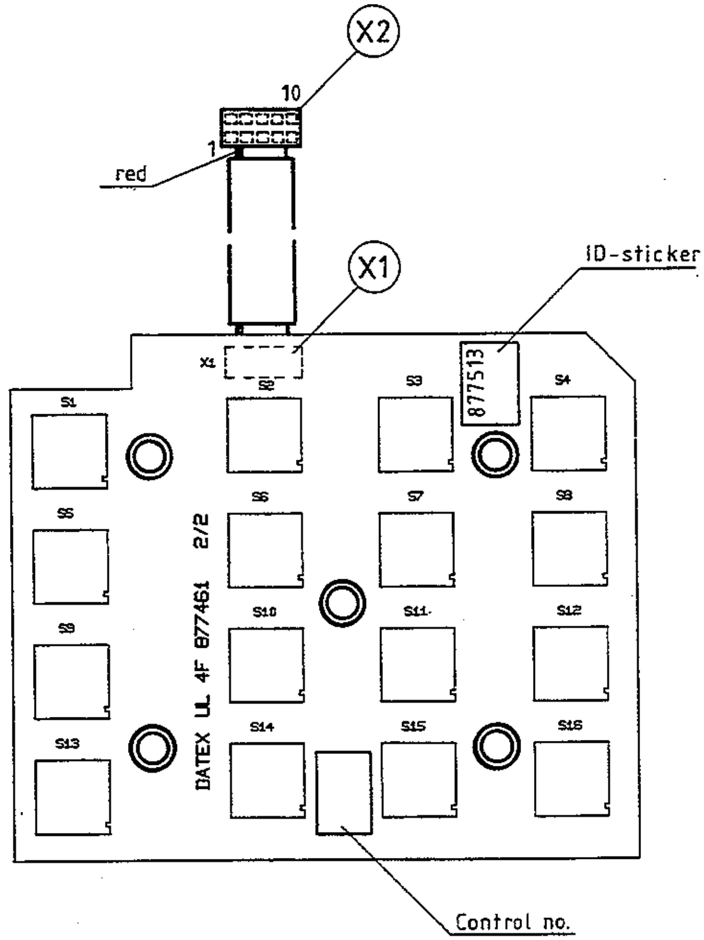


Figure 5.24 Keyboard parts layout and schematic diagram (board modification level 0 and higher)



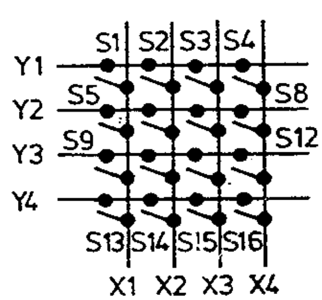
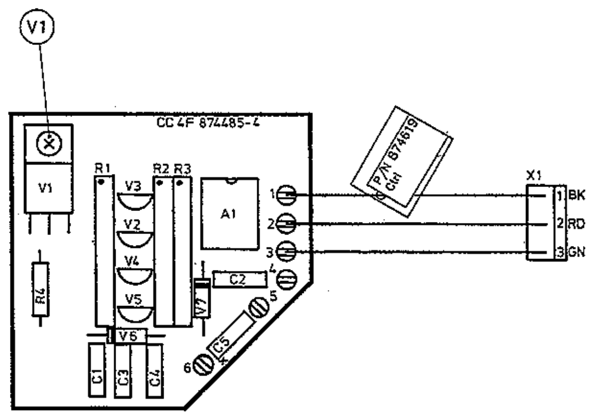
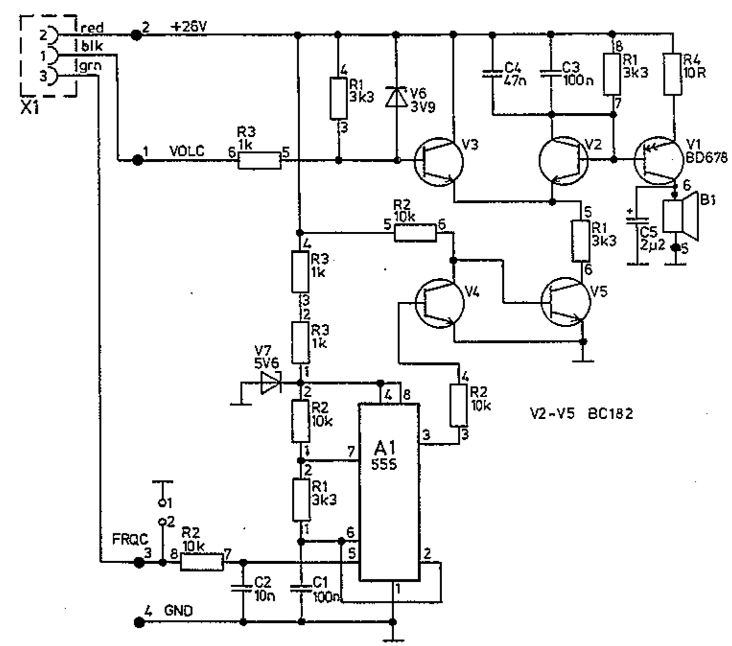


Figure 5.25 Loudspeaker unit parts layout and schematic diagram (board modification level 4 and higher)





5.12 Internal connector configurations

Table 5.3 Video control board (X1) - Mother board (X1)

Pin No.	a	b	c
1	NC	NC	NC
2	NC	NC	NC
3	NC	NC	NC
4	NC	NC	NC
5	NC	NC	NC
6	NC	NC	NC
7	NC	NC	NC
8	NC	NC	NC
9	NC	NC	NC
10	NC	NC	NC
11	A7	NC	A6
12	A5	NC	A4
13	A3	NC	A2
14	A1	NC	A0
15	-10RQ	NC	NC
16	-RD	NC	NC
17	NC	NC	NC
18	NC	NC	NC
19	NC	NC	NC
20	NC	NC	INT0
21	NC	NC	NC
22	NC	NC	NC
23	NC	NC	NC
24	D7	NC	D6
25	D5	NC	D4
26	D3	NC	D2
27	D1	NC	D0
28	NC	NC	NC
29	NC	NC	+5 V
30	NC	NC	+5 V
31	NC	NC	NC
32	DGND	NC	DGND

NC = not connected
AIN is an A/D-converter and AOUT is a D/A-converter in ACX board.
ADC is an A/D-converter and DAC is a D/A-converter in CPU board.

Table 5.4 CPU board (X1) - Mother board (X2)

Pin No.	a	b	c
1	+15 V	X1	AGND
2	-15 V	X2	+10 V REF
3	DAC7 ALR ADJ	X3	DAC6 IR
4	DAC5 ALARM	X4	DAC4
5	NC	Y2	DAC2 SpO_2
6	DAC1 FLOW	Y1	DAC0 PRES
7	SAL	Y3	ADC6 VOUT R
8	ADC5 P	Y4	ADC4 VOUT IR
9	ADC3 O_2	PB0	ADC2
10	ADC1 N_2O	PB1	ADC0
11	A7	NC	A6
12	A5	PB3	A4
13	A3	PB4	A2
14	A1	PB5	A0
15	-10RQ	PB6	T1 CTS0
16	RDB1	NC	-WR
17	-RESET	-PC0	TO RTS0
18	SEROUT 0	NC	SERIN0
19	P1.1	PC2 FGAIN 1	P1.0
20	OP0 RTSA	PC3 FGAIN 2	INT0
21	SEROUT1	NC	SERIN1
22	OP1 RTSB	NC	IP2 TIMERIN0
23	SEROUT2	NC	SERIN2
24	D7	PC7 RTS0	D6
25	D5	PA0	D4
26	D3	PA1	D2
27	D1	PA2	D0
28	INT1	PA3	INT3
29	+5 V DRV	PA4	+5 V
30	+15 VDIRTY	PA5	+5 V
31	+12 V	PA6	21 VAC
32	GND DIRTY	PA7 ALR CALL	DGND

NC = not connected
AIN is an A/D-converter and AOUT is a D/A-converter in ACX board.
ADC is an A/D-converter and DAC is a D/A-converter in CPU board.

Table 5.5 ACX measuring board (X1) - Mother board (X3)

Pin No.	a	b	c
1	+15 V	NC	AGND
2	-15 V	NC	+10 V REF
3	AOUT6	NC	AOUT5 AA
4	AOUT4 VL	NC	AOUT3 CO_2
5	AOUT2 O_2	NC	AOUT1 N_2O
6	DAC1 FLOW	NC	DAC0 PRES
7	AIN7 SAL	NC	ADC6 VOUT R
8	ADC5 AWL	NC	ADC4 VOUT IR
9	ADC3 O_2	NC	ADC2
10	ADC1 AWP	NC	AIN4 SSIGN
11	NC	AGND	NC
12	NC	AGND	NC
13	NC	LAMP	NC
14	NC	PB5	NC
15	NC	SSYNC	NC
16	RDB2	SMOTOR	NC
17	-RESET	-PC0	TO RTSO
18	SEROUT 0	NC	SERIN0
19	P1.1	PC2 FGAIN 1	P1.0
20	OP0 RTSA	PC3 FGAIN 2	INT0
21	SEROUT1	PC4 OCCLUS	SERIN1
22	OP1 RTSB	PC5 PUMPON	IP2 TIMERIN0
23	SEROUT2	PC6 ZERO	SERIN2
24	NC	PC7 RTS0	NC
25	NC	PA0	NC
26	NC	PA1	NC
27	NC	PA2	NC
28	INT1	PA3	INT3
29	+5 V DRV	PA4	+5 V
30	+15 VDIRTY	PA5	+5 V
31	+12 V	PA6	21 VAC
32	GND DIRTY	PA7 ALR CALL	DGND

NC = not connected
AIN is an A/D-converter and AOUT is a D/A-converter in ACX board.
ADC is an A/D-converter and DAC is a D/A-converter in CPU board.

Table 5.6 Power supply board (X10) - Mother board (X5)

Pin No.	Signal	Pin No.	Signal
1	AGND	2	AGND
3	PA7 ALR CALL	4	21 VAC
5	+12 V	6	+12 V
7	+5 V DRV	8	PA5
9	PA6	10	T0 RTS0
11	SEROUT2	12	SERIN2
13	OP1 RTSB	14	PC5 PUMPON
15	SEROUT1	16	SERIN1
17	OP0 RTSA	18	SEROUT0
19	SERIN0	20	-RESET
21	T1 CTS0	22	PB6
23	PB5	24	PB4 LAMP
25	PB3	26	PB1
27	PB0	28	DAC1 FLOW
29	DAC6 IR	30	DAC0 PRES
31	AOUT2 O_2	32	AOUT3 CO_2
33	DAC2 SpO_2	34	DAC5 ALARM
35	DAC4	36	DAC7 ALR ADJ
37	AOUT1 N_2O	38	AOUT5 AA
39	LAMPON	40	NC

NC = not connected
AIN is an A/D-converter and AOUT is a D/A-converter in ACX board.
ADC is an A/D-converter and DAC is a D/A-converter in CPU board.

Table 5.7 SpO_2 measuring board (X2) - Mother board (X10)

Pin No.	Signal
1	+15 VDIRTY
2	PA0
3	PA3
4	PA1
5	ADC 4 VOUT IR
6	-15 V
7	ADC 6 VOUT R
8	+5 V
9	PA2
10	AGND

Table 5.8 Keyboard (X1) - Mother board (X8)

Pin No.	Signal	
1	X1	X1 row
2	X2	X2 row
3	X3	X3 row
4	X4	X4 row
5	Y2	Y2 column
6	Y1	Y1 column
7	Y3	Y3 column
8	Y4	Y4 column
9	GND	
10	GND	

Table 5.9 O_2 measuring unit - Mother board (X9)

Pin No.	Signal
1	+15 VDIRTY
2	GND DIRTY
3	NC
4	NC
5	NC
6	-15 V
7	ADC3 O_2
8	NC
9	+15 V
10	AGND

Table 5.10 Gas zero valve - Mother board (X11)

Pin No.	Signal
1	+15 VDIRTY
2	ZERO SIGNAL
3	NC

Table 5.11 Power supply board - Mother board (X6)

Pin No.	Signal
1	DGND
2	GND DIRTY
3	+5 V
4	+15 V
5	-15 V
6	+15 VDIRTY

Table 5.12 Pressure valve - Mother board (X7)

Pin No.	Signal
1	+15 VDIRTY
2	OCCLUS SIGNAL
3	NC

Table 5.13 Mother board test connector (X13)

Pin No.	Signal
1	AGND
2	ADC4 VOUT IR
3	AIN4 SSIGN
4	ADC1 AWP
5	ADC3 O_2
6	ADC5 P AWF

Table 5.14 Video control board (X2) - Video unit main pc board (X13)

Pin No.	Signal
1	GND
2	Comp. Video signal
3	Video
4	HSYNC
5	VSYNC
6	GND

Table 5.15 ACX measuring board (X2) - Preamplifier board (X1)

Pin No.	Signal
1	AGND
2	Signal IN, OUT
3	EEPROM CLB (dark)
4	Temp IN, OUT
5	+15 V
6	-15 V
7	SYNC IN, OUT
8	EEPROM R
9	EEPROM WRB
10	EEPROM 2CS (clear)
11	MOTOR B
12	+5 V
13	+15 VDIRTY
14	DGND

Table 5.16 Front panel SpO_2 connector - SpO_2 measuring board (X1)

Pin No.	Signal
1	Is
2	Ib
3	NC
4	Probe identification
5	Probe identification
6	Ground
7	Iled
8	Vb (-4 ±0.3 V)
9	Ground
0	+12 Vp

Table 5.17 Power supply board (X1) - Line transformer

Pin No.	Signal	
1	22 VAC	secondary voltage of
2	GND	the line transformer and
3	22 VAC	ground

Table 5.18 Power supply board (X2) - IR lamp

Pin No.	Signal	
1	+5 VDC	voltage for IR-lamp
2	Lamp ON/OFF	

Table 5.19 Power supply board (X3) - Fan

Pin No.	Signal	
1	GND	
2	NC	
3	+26 V	supply voltage for fan

Table 5.20 Power supply board (X6) - Video unit main pc board

Pin No.	Signal
1	+12 V
2	Video brightness control
3	Video brightness control
4	Video brightness control
5	Comp video
6	DGND

Table 5.21 Power supply board (X8) - Loudspeaker

Pin No.	Signal
1	DAC5 ALARM
2	+26 V power for loudspeaker
3	DAC7

Table 5.22 Power supply board (X9) - Pump

Pin No.	Signal
1	PUMP ON SIGNAL
2	NC
3	+15 VDIRTY supply voltage for pump

5.13 PVX board

Block diagram and schematic diagram part 1	**Figure 5.26**
Parts layout and schematic diagram part 2	**Figure 5.27**

> **NOTE:** Pressure transducers B1, B2, and EEPROM D4 are replaced only at the factory.

> **NOTE:** Never apply overpressure or negative pressure of more than 300 cmH_2O to the flow and volume tubing.

The board is intended to perform the following tasks

- Measure the pressures in airways and the speed of breathing flow.
- Calculate tidal volume, minute volume, compliance and other useful information on a patient lungs.

Pressure transducers

There are two pressure transducers on the PVX board for airway pressure measuring purpose.

The breathing flow of a patient passing through D-LITE™ creates pressure difference. This pressure difference is measured by pressure transducer, B1. Overpressure and negative pressure in airways are measured by another pressure transducer B2.

Signal amplification

After the transducer B2 the PRESS-signal is sent to differential amplifier A6, whose gain is 375, which contains low pass filter suppressing signals over 31 Hz. Then the signal is sent to the multiplexer A9 through voltage follower A7.

After the transducer B1 the FLOW-signal is sent to differential amplifier, A5 and A4, whose gain is 27 and which contains low pass filter where signals over 30 Hz are suppressed. After the filter the signal is fed to another amplifier A3, whose gain is 11 and who contains a low pass filter which suppresses signals over 48 Hz. From this point the signal (FLOW0) goes two different ways: one goes straight to the multiplexer A9 (FLOW0). Another goes yet to the third amplifier A3, whose gain is 11 and which contains a low pass filter of 72 Hz. This sensitive signal (FLOW1) is also sent to the multiplexer A9.

Temperature compensation

Temperature is measured by B1. The signal TEMP is sent to the multiplexer A9 via A7. This signal is used only for temperature compensation of the pressure transducer B1 on the PVX board.

Data processing

After the multiplexer A9, the signals, PRESS, FLOW0, FLOW1, and TEMP are A/D converted in A2 for data processing.

Signal output

D/A converter A1 converts digital data to analog form. The one half of the multiplexer A9 multiplexes the analog output to PRESS, FLOW, and VOL signals after the voltage follower A8.

Transducer offset control

One signal (DAC3) from the multiplexer A9 is used by software to control offset voltage of the pressure transducer B1.

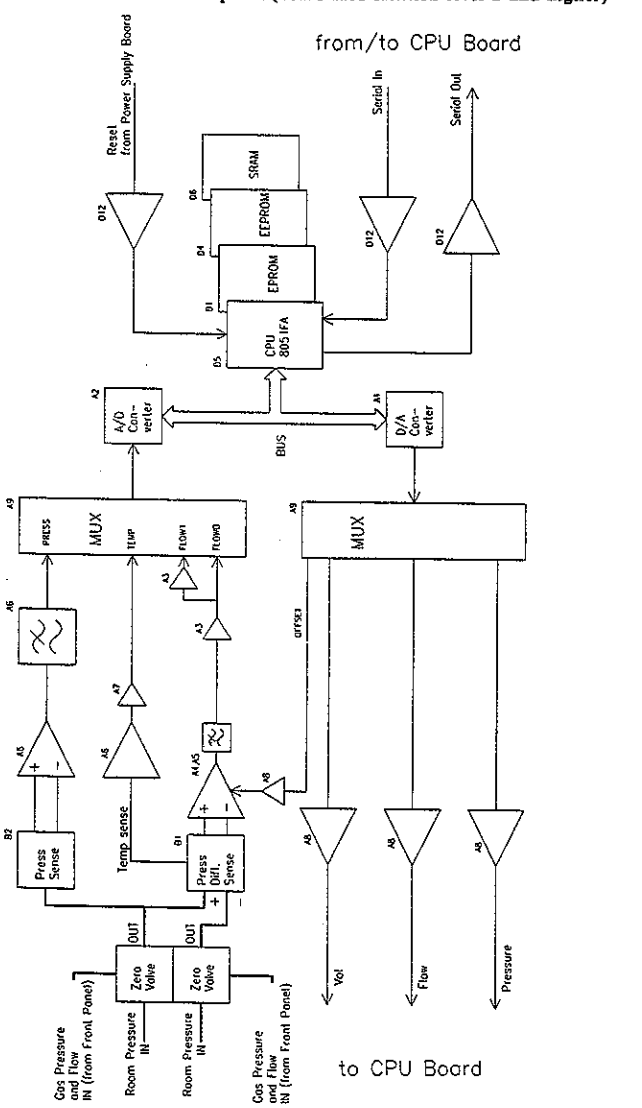
External communication

Communication between the PVX board and the CPU board is established in serial form, using the serial channel (pins 10 and 11) of CPU D5 on the PVX board. These channels are buffered by GAL IC D12. Address decoding is also realized by D12.

Test point signals

X2	1	FIN	X3	1	10 VREF
	2	PR		2	TP2
	3	FLOW1		3	-10 VREF
	4	FLOW0		4	B3

Figure 5.26 PVX board block diagram and schematic diagram part 1(board modification level 2 and higher)



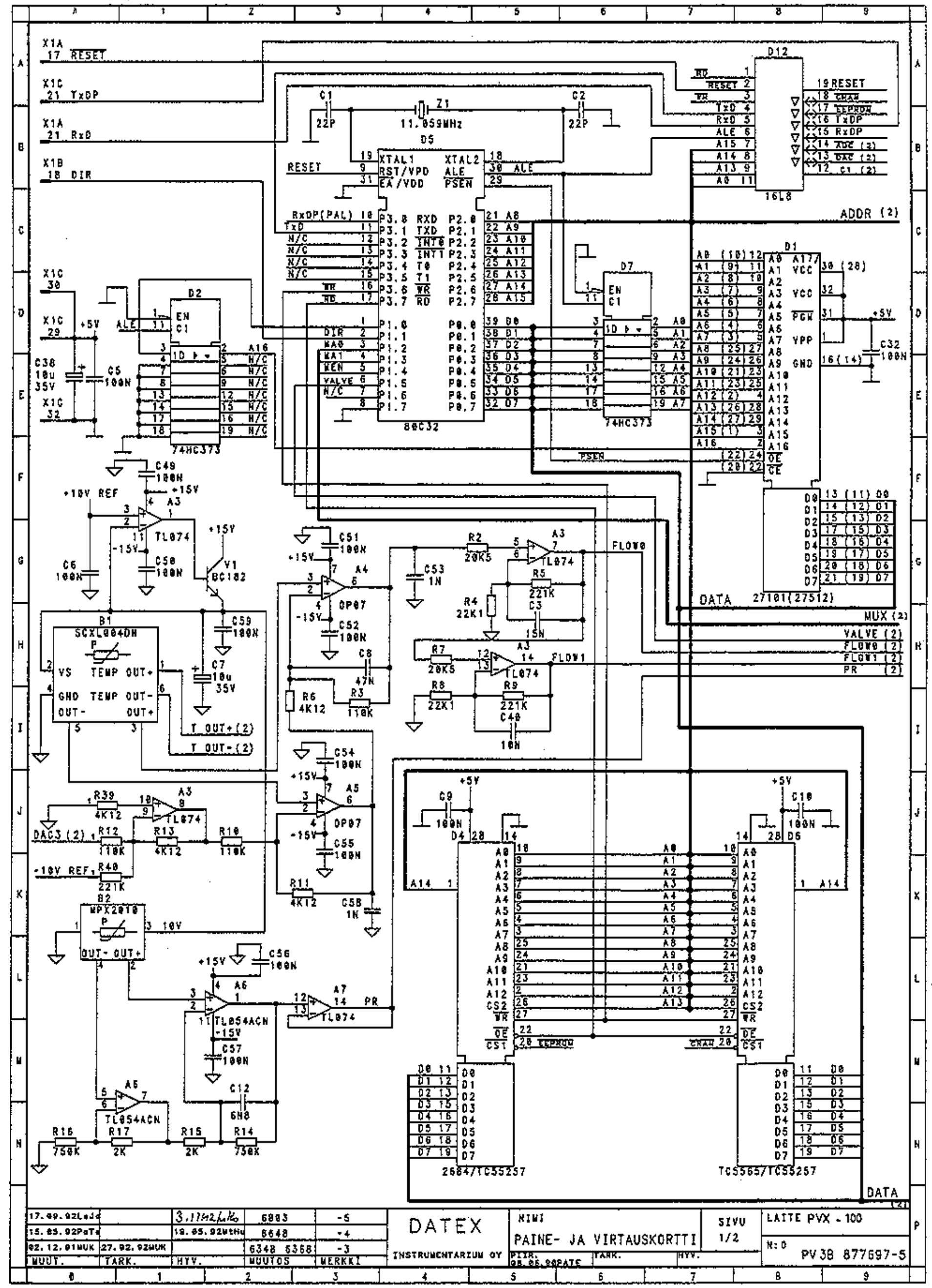
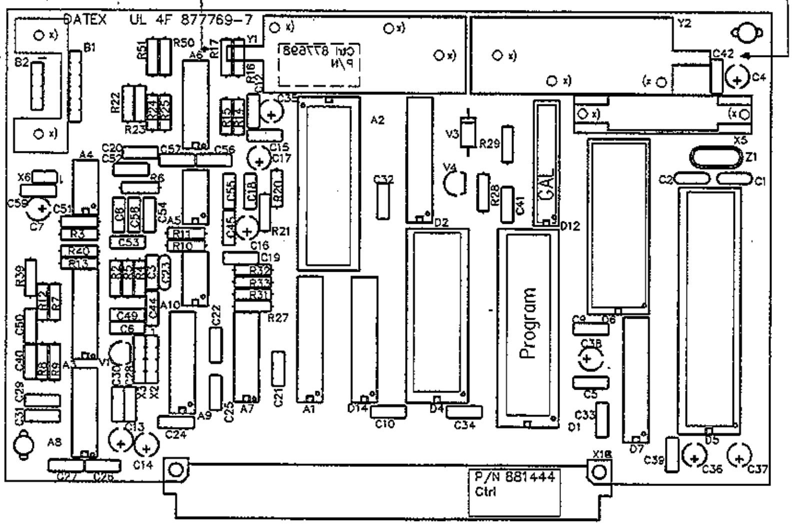


Figure 5.27 PVX board parts layout and schematic diagram part 2 (board modification level 2 and higher)

Left (or lower) inlet from the back of front panel

Right (or upper) inlet from the back of front panel



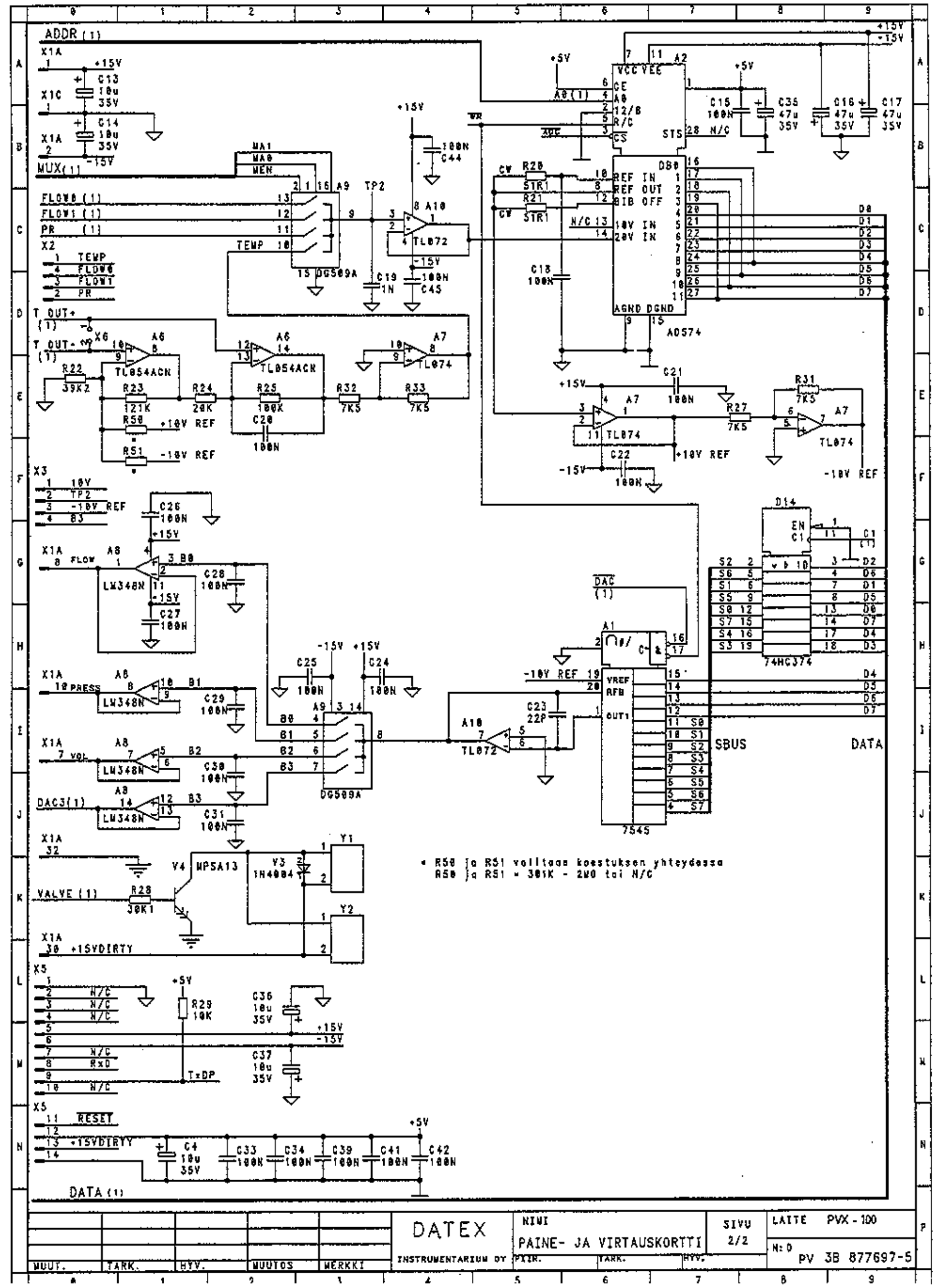
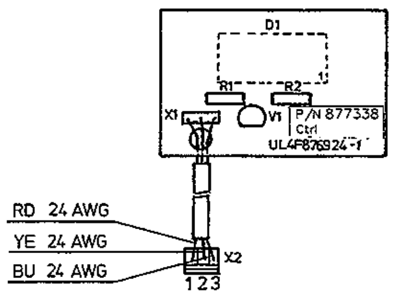


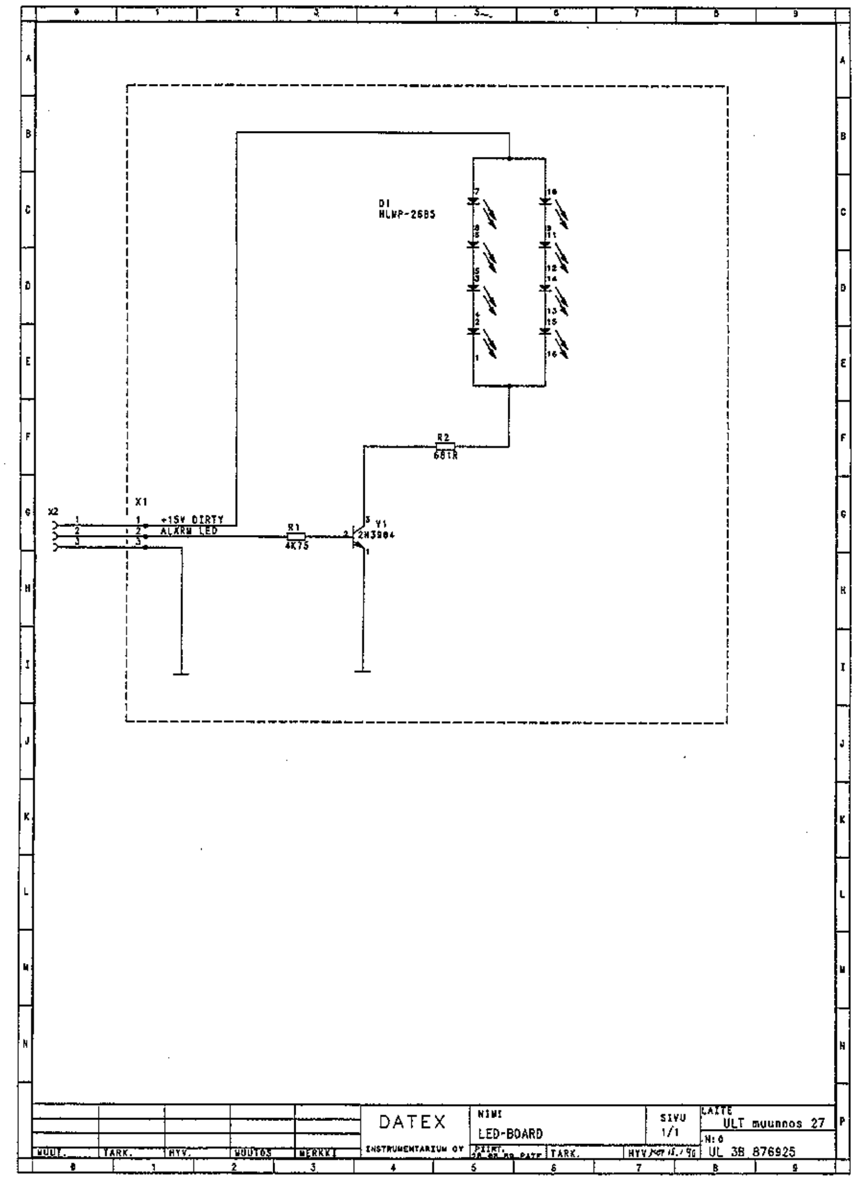
Table 5.23 PVX board (X1) - Mother board (X4)

Pin No.	a	b	c
1	+15 V	NC	AGND
2	-15 V	NC	+10 VREF
3	NC	NC	NC
4	NC	NC	NC
5	NC	NC	NC
6	DAC1 FLOWY	NC	DAC0 PRES
7	VOL	NC	NC
8	FLOW	NC	NC
9	NC	NC	NC
10	PRESS	NC	NC
11	NC	NC	NC
12	NC	NC	NC
13	NC	NC	NC
14	NC	NC	NC
15	NC	NC	NC
16	NC	NC	NC
17	-RESET	NC	NC
18	NC	DIR	NC
19	NC	NC	NC
20	NC	NC	NC
21	RxD	NC	TxDP
22	NC	NC	NC
23	NC	NC	NC
24	NC	NC	NC
25	NC	NC	NC
26	NC	NC	NC
27	NC	NC	NC
28	NC	NC	NC
29	NC	NC	+5 V
30	+15 VDIRTY	NC	+5 V
31	NC	NC	NC
32	GND DIRTY	NC	DGND

Figure 5.28 LED board parts layout and schematic diagram (board modification level 1 and higher)

NOTE: This board is included in adaptation -27 monitors only.





5.14 Agent Identification

5.14.1 ASX Agent Identification Bench

Agent identification is accomplished by using special properties of optics and filters that allow the unique waveform patterns of each anaesthetic agent to be "drawn" into memory. This "drawing" is compared with data in the software algorithm from which identification can be made and displayed.

IR light is emitted from a light source into a long single measurement chamber. After passing through the measurement chamber, the light passes through a rotating quarter wavelength interference filter. This filter has a bandwidth of approximately 17 nM. The filter is rotated in such a manner that the angle that the light approaches it changes. As the angle changes, the wavelength of the IR light that is allowed to pass through the filter changes. 30 samples of the signal are taken of the signal during the first 90 degrees rotation. The process is repeated during the second 90 degrees of rotation so that a mirror image is created. This provides a confirmation of the measurement before identification is made by the software.

Timing used for control of the sampling process, is initiated with a sync. pulse that is produced once per revolution of the filter.

When the ACX-200 is zeroed, the ASX bench measures the background spectrum (room air). During normal measurement, ASX subtracts the background spectrum from the measurement spectrum, then identification is made.

The ASX bench consists of the following major components:

- IR lamp
- single measurement chamber
- filter assembly driven by a DC motor
- a preamp board that includes the photo detector and preamplifier
- a processor (ASX) board

The ASX assembly is pneumatically installed after the ACX-200 bench and in parallel with the OM oxygen sensor (see pages 5-3 and 5-5).

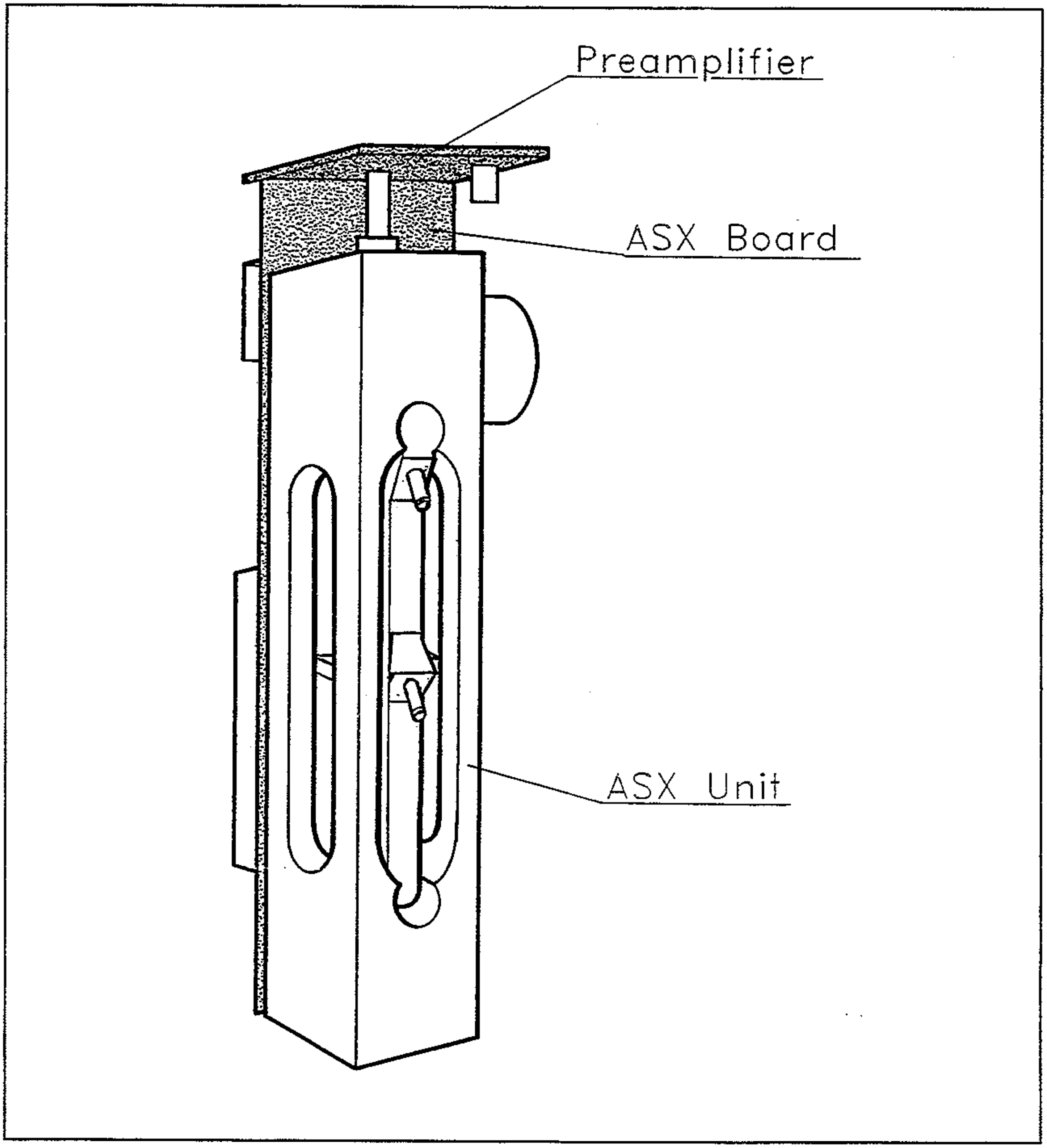


Figure 5.29 ASX Agent identification benches

5.14.2 ASX preamplifier board

The absorption of infrared light is measured with a lead selenide detector R1. The signal is amplified with A1 and then led to the measuring board.

5.14.3 ASX board

The measuring electronics can be divided into a few functional blocks, which are described below (See the block diagram).

The ASX board controls gas measurements. It converts the ASX photometer signal to digital data, calculates results and communicates with the main CPU through a serial channel. The board contains, in addition to the 80C196 processor, EPROM, RAM, and EEPROM, several analog and digital I/O functions.

Processor section

Processor D2 is a 80C196 and works at 12 MHz. It has an internal A/D-converter with a multiplexer. One channel is used for converting temperature signal. Two others are for the measurement signal from preamplifier board.

The processor uses an internal bus to access EPROM D7 (64k x 8bit), SRAM D6 (8k x 8bit) and two D/A-converters. It communicates with the main CPU through a serial channel (RXD,TXDB).

EEPROM D5 is a 64 x 16 bit serial chip. It is partly protected so that if jumper X1 is installed the processor can erase or write the protected registers by serial communication commands. The protected section contains permanent factory calibrations.

Sync-pulse

Sync-pulse is detected with a reflectance sensor A1. A2a converts the output current of the isolator to negative voltage pulse. Its peak voltage is charged to C2. Output of A2b changes from -13 V to +13 V when the pulse's voltage exceeds half of the peak voltage.

The pulse is modulated to TTL-level (5 V pulse) in V1.

V22 controls the LED current in the optical isolator so that the amplitude of the pulse stays constant.

Signal processing

The signal is sent to a low-pass filter and then to adjustable amplifier which consists of D1 and A3b.

Bias voltages

Supply voltages of +15 V and -15 V are first regulated by A6 and A8 to +12 V and -12 V to prevent interference in the supply voltages from disturbing the bias voltages. Frequency of A7 oscillator is 200 KHz and amplitude 24 V. When its output is -12 V, C19 is charged up to 24 V. When the output goes up to +12 V, C19 is discharged and charges C20 via diode V15. Thus C20 is charged to about +34 V (12 V + 24 V - threshold voltage of V15). Correspondingly C23 is charged to about -34 V.

Resistors R32 and R35 are both for short-circuit protection and a part of low-pass filter with C6 and C7 on the preamplifier board.

Motor control

The motor is driven by DC voltage generated by D/A converter D8 and operational amplifier A9.

The output of D8 is between 0 to -5 V. With A9b the voltage is inverted to between 5.4 to 7.7 V, suitable to drive the motor. V 20 is an emitter-follower which buffers the output of the operational amplifier.

Temperature measurement

Temperature is measured by diode V6 whose threshold voltage changes 6 mV per one degree °C. The signal is amplified by A3d to get suitable level (0 to 5 V) for A/D converter. Diode V7 protects the A/D converter input.

Test point signals

Connector X4 on the board is for test purpose. Note that pin 1 is TP6 and vice versa.

X4	1	TP6	A/D reference, A4
	2	TP5	Motor voltage
	3	TP4	signal after AGC
	4	TP3	Temperature
	5	TP2	Sync pulse
	6	TP1	Sync test input

5.14.4 Signal processing

As the filter rotates the wavelength allowed through the filter changes. The 30 samples are taken at predetermined time intervals after the synchronizing pulse. Each time represents a certain angle and these angles correspond to the required wavelengths.

The time intervals are determined during calibration.

The samples are then linearized. After that the background spectrum is subtracted. Background is measured during the zeroing of ACX and ASX.

In ASX-100, the linearized spectrum is scaled to the same scale as the stored reference spectra of each anaesthetic agent. By comparing the measured spectrum to the reference spectra, the anaesthetic agent is identified. A low squared error value indicates that the measured agent corresponds to that reference spectrum.

In ASX-200, the concentrations of individual agents in a mixture are calculated using the reference spectra.

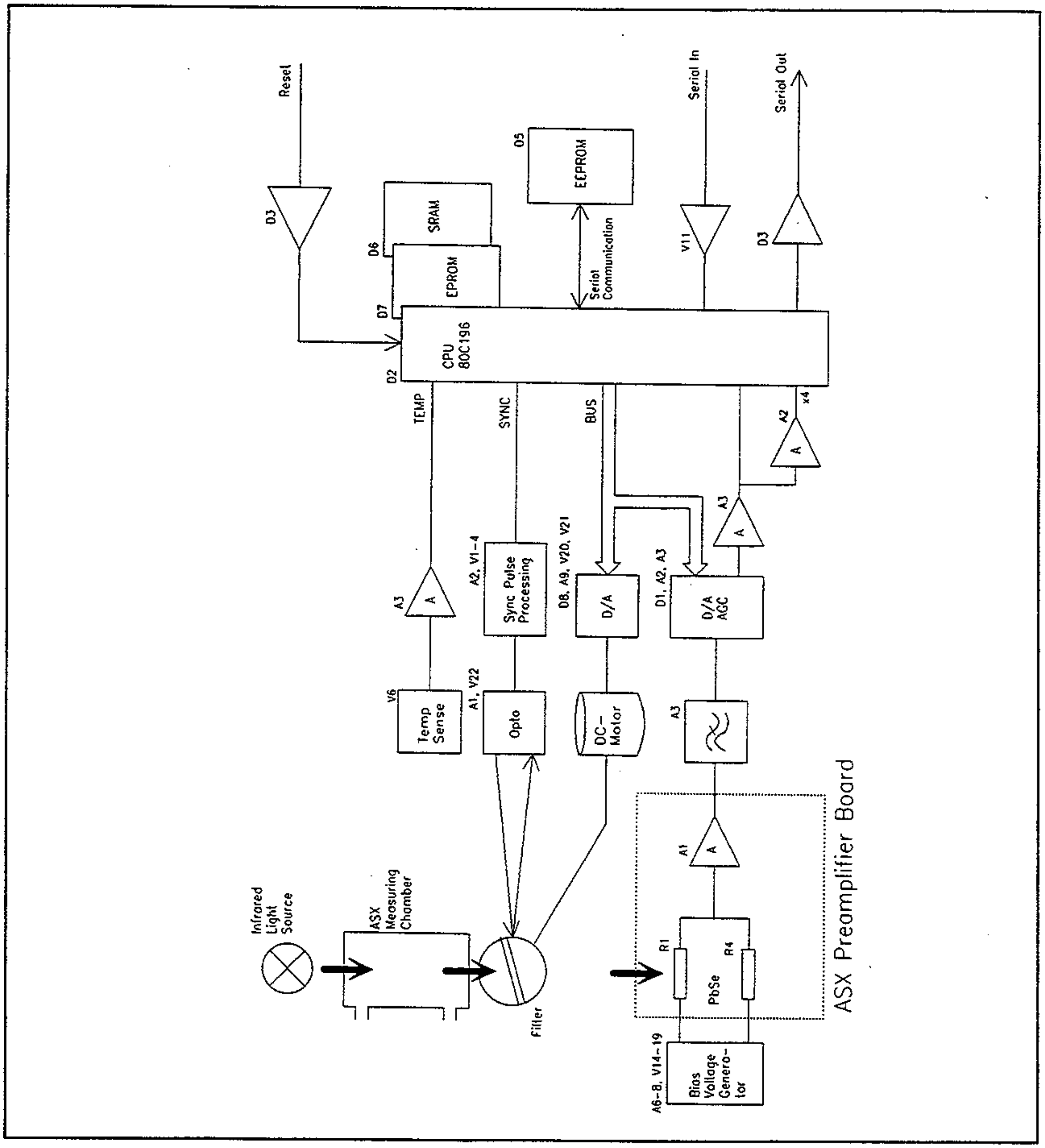


Figure 5.30 ASX board block diagram

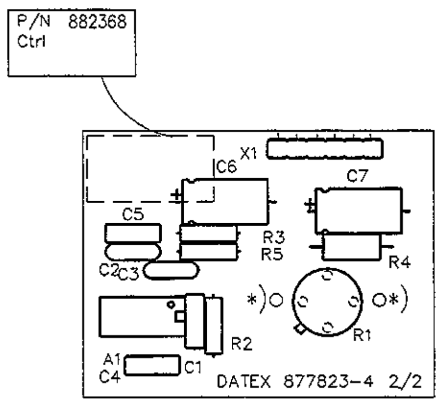
Table 5.24 ASX preamplifier board (X1) - ASX board (X2)

Pin No.	Signal
1	Ground
2	+12 V
3	-12 V
4	signal
5	+VBIAS
6	-VBIAS

Table 5.25 ASX board (X5) - Mother board (X14)

Pin No.	Signal
1	Analog ground
2	NC
3	NC
4	NC
5	+15 V
6	-15 V
7	DIRB (not used)
8	RXD
9	TXDB
10	NC
11	-RESET
12	+5 V
13	+15 VDIRTY
14	Digital ground

Figure 5.31 ASX-200 preamplifier board parts layout and schematic diagram



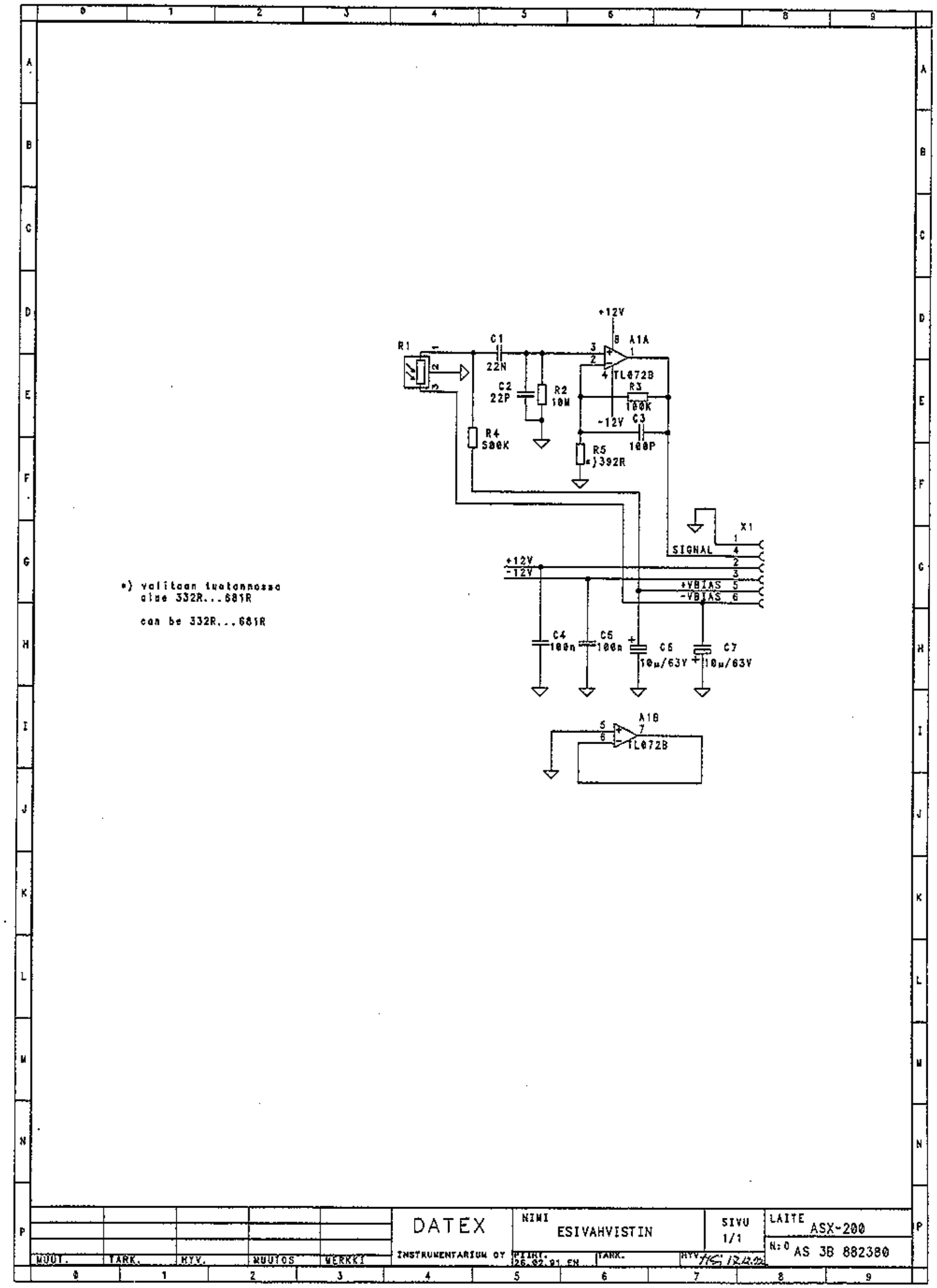
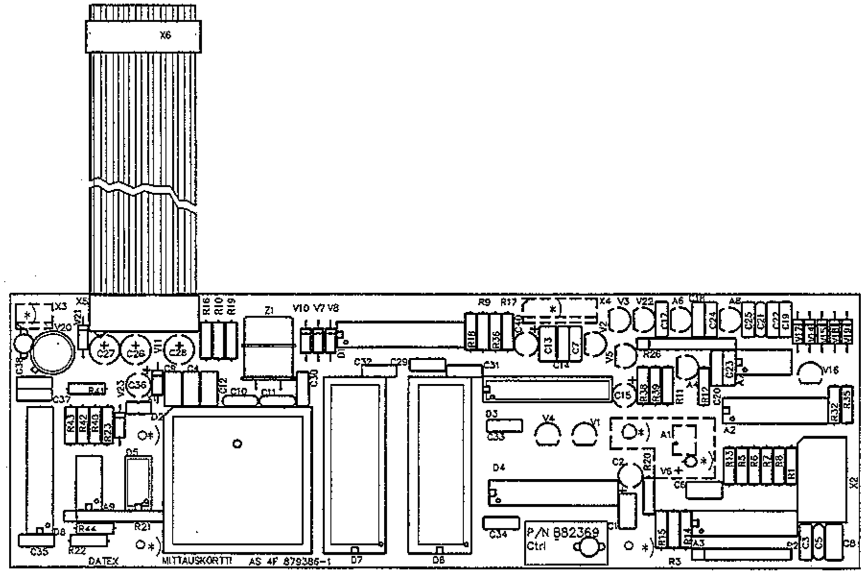
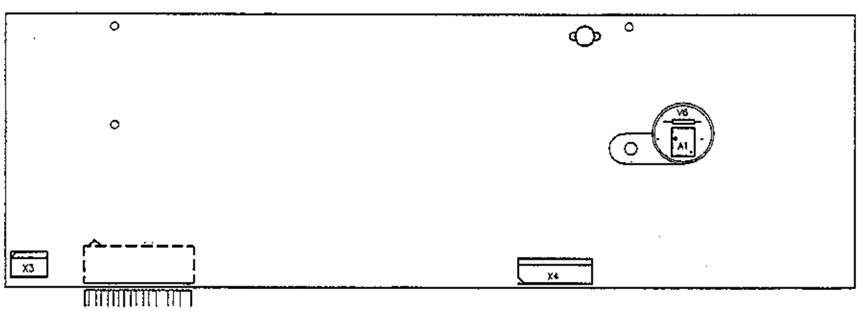


Figure 5.32 ASX-200 board parts layout and schematic diagram part 1





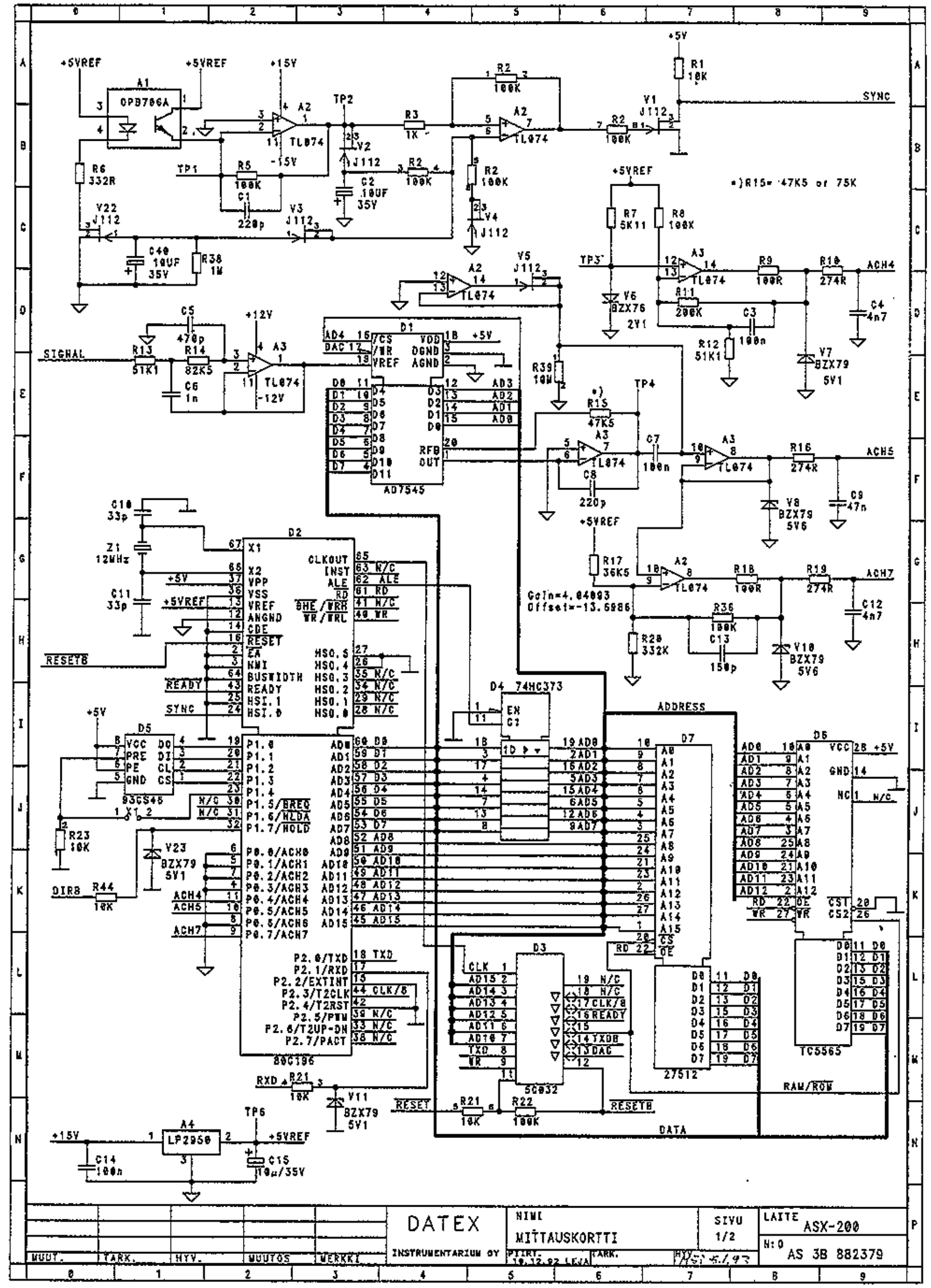


Figure 5.33 ASX-200 board schematic diagram part 2

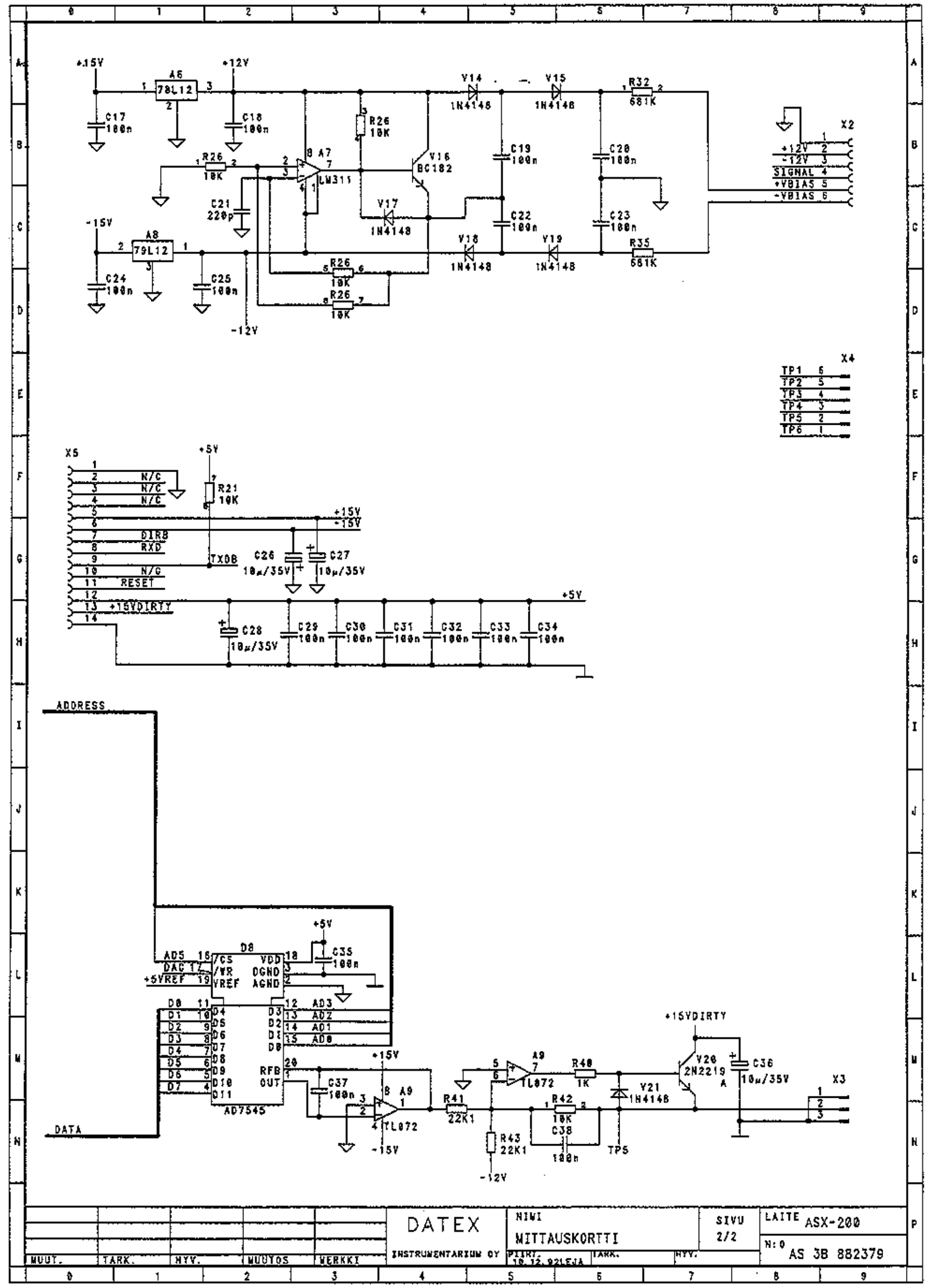
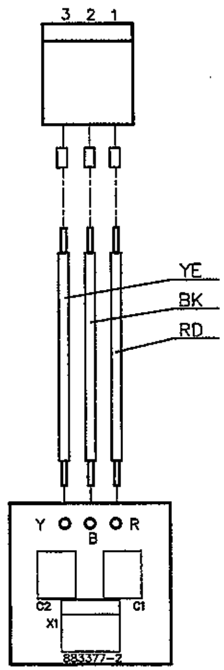
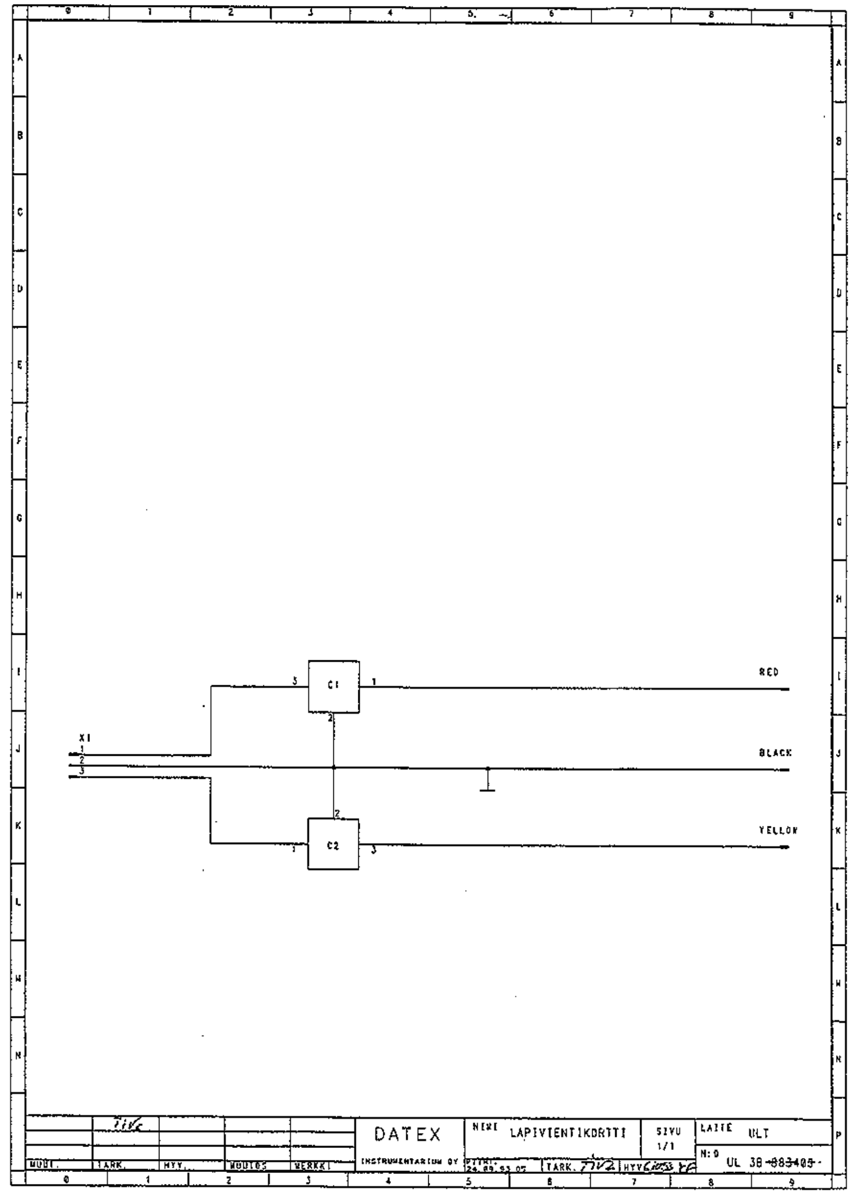


Figure 5.34 Transformer filter board parts layout and schematic diagram





5 DETAILED DESCRIPTION OF MODULES

5.1 Gas sampling system

The function of the gas sampling system is to draw sample gas into the monitor at a fixed rate and to separate impurities and condensed water from the stream.

The sample gas enters the monitor through the water trap, where it is divided into two flows (see Figures 5.1). The main flow goes into the measuring system (described in Section 5.2) and the side flow goes to damping chamber. The task of the side flow is to cause slight atmospheric depression inside the trap container and thus pull down moisture in gas into the container. Both flows are separated from the sample in flow by hydrophobic filter. Incoming water does not pass the filter but falls into water container.

Because the sampling line is narrow, thick fluids like blood or mucus will not propagate at all. When the line is clogged, it cannot be cleaned but replaced.

Special tube(s) is used to balance the sample gas humidity with that of ambient air (see Figures 5.2 and Tables 5.1). The tube will prevent errors caused by the effect of water vapor on gas partial pressure when humid gases are measured after calibration with dry gases.

CAUTION: The material of this special tube is mechanically fragile. Small leakages may occur if the tube is bent or kinked.

Ahead of the ACX measuring unit there is a magnetic valve, which is used to set the zero point for each gas. Room air is drawn into the system through this zero valve.

After the ACX measuring unit the main flow is divided into two in models with i-parameter. One flow goes into oxygen measuring unit and the other into ASX agent identification unit.

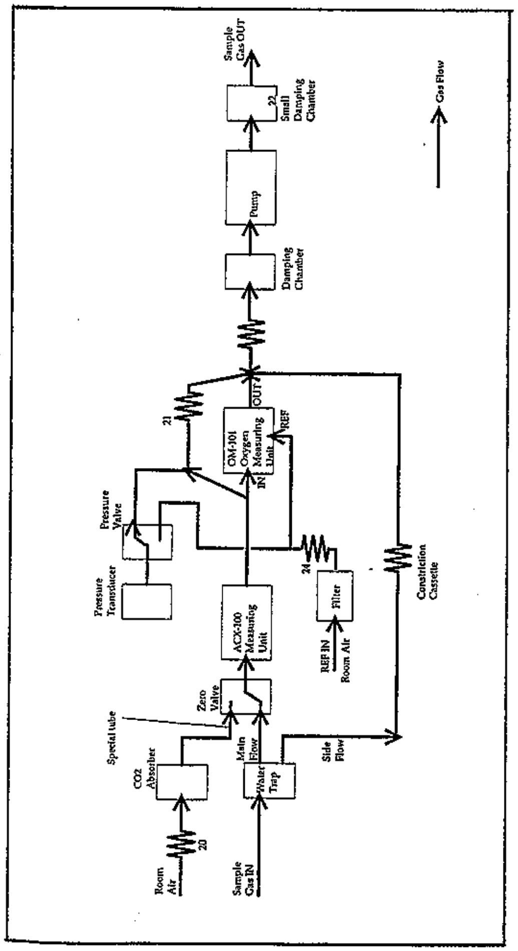
The pressure valve opens and measures the pressure gradient between the O_2 measurement flow and the O_2 reference flow. This pressure gradient reflects the condition of the D-FEND™ water trap filter. The measurement is performed 30 seconds after every auto-zeroing, occlusion, and gas calibration. It is also performed whenever software detects the difference value to be less than -5 mmHg (the pressure gradient is greater than 5 mmHg). If the difference value is less than -5 mmHg, the message 'REPLACE TRAP' results.

Special tubes are used in the sampling system. PVC and silicone tubes cannot be used in those parts of the sampling circuit because they will react with the anaesthetic agent, causing delayed a response time and an inaccurate zero point.

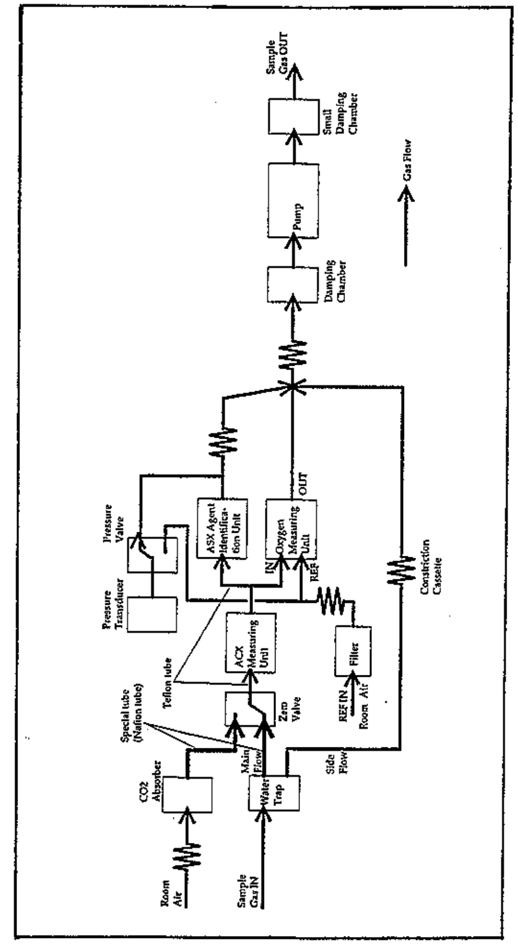
The sampling pump is a vibrating membrane pump driven by a 50Hz/12V/0.4A square wave current.

The purpose of the damping chambers is to even out the pulsating flow and silence the exhaust flow. The correct flow rates are set using five flow constriction cassettes.

Figure 5.1 Gas sampling system schematic diagrams



Gas Sampling System without i-parameter



Gas Sampling System with i-parameter

Figure 5.2.1 Gas sampling system layout (without i-parameter)

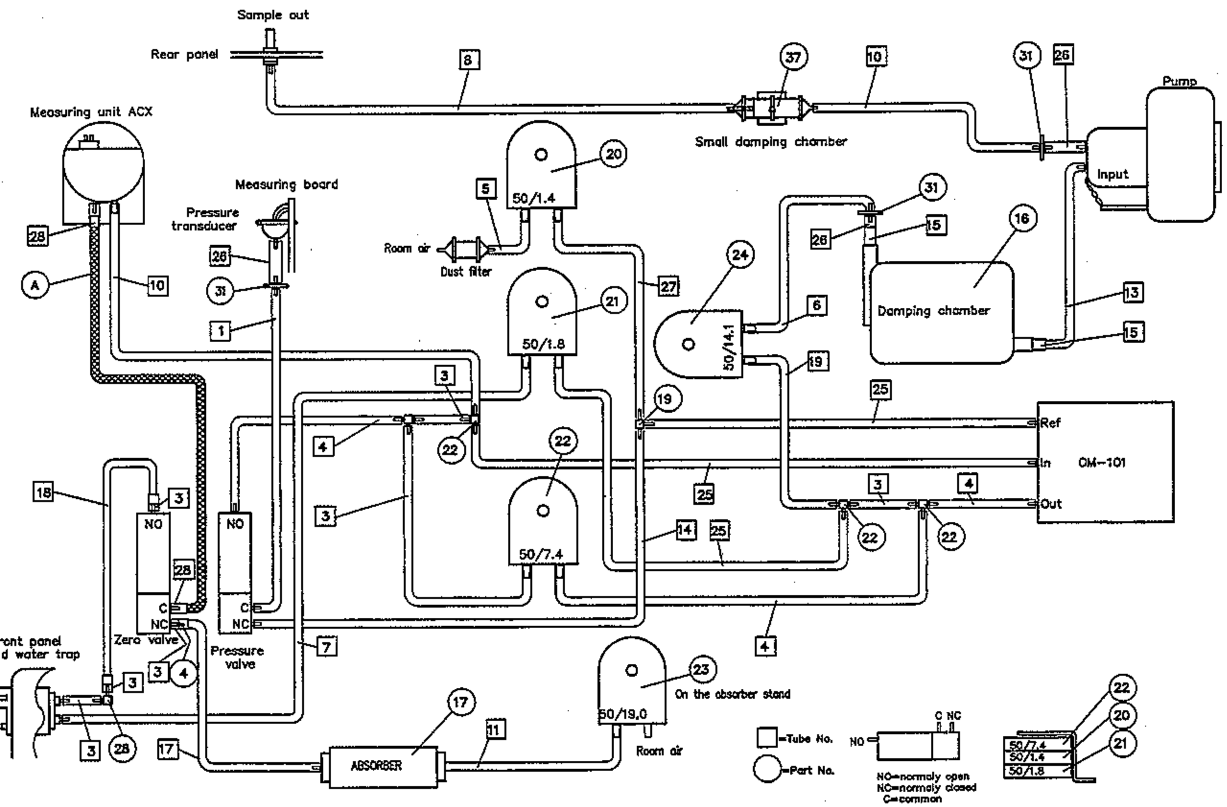


Table 5.1.1 Tube lengths (without i-parameter)

Tube No.	Part	Code	Pcs	Length/mm
A	Special sample tube	733383	1	500
1	1.7/1.05 mm Silicone	73373	1	280
3	1.7/1.05 mm Silicone	73373	7	20
4	1.7/1.05 mm Silicone	73373	3	50
5	1.7/1.05 mm Silicone	73373	1	60
6	1.7/1.05 mm Silicone	73373	1	42
8	1.7/1.05 mm Silicone	73373	1	110
9	1.7/1.05 mm Silicone	73373	1	300
10	1.7/1.05 mm Silicone	73373	2	400
11	1.7/1.05 mm Silicone	73373	1	150
13	3.18x6.35 mm Silicone	73375	1	180
14	1.7/1.05 mm Silicone	73373	1	70
15	4.8x9.5 mm Silicone	73376	2	25
17	1x2 mm PVC	73341	1	200
18	1.2x0.3 mm PTFE	73332	1	400
19	1.7/1.05 mm Silicone	73373	1	500
25	1.7/1.05 mm Silicone	73373	3	30
26	3.18/6.35 mm Silicone	73375	3	20
27	1.7/1.05 mm Silicone	73373	1	40
28	1.7/1.05 mm Silicone	73373	2	15

Part No.	Part	Code
20-24	Constriction cassette	Selected individually, see Table 5.2 for alternatives
16	Damping chamber	57150
17	Absorber	890641
22	T-piece	733821
28	L-piece	733811
31	Adapter piece	73388
36	Dust filter	86901
4	CNO metal tube	871925
37	Small damping chamber	879355

Note: Constriction cassettes are selected to adjust proper flow rates. See Table 5.2 for alternatives.

Figure 5.2.2 Gas sampling system layout (with i-parameter)

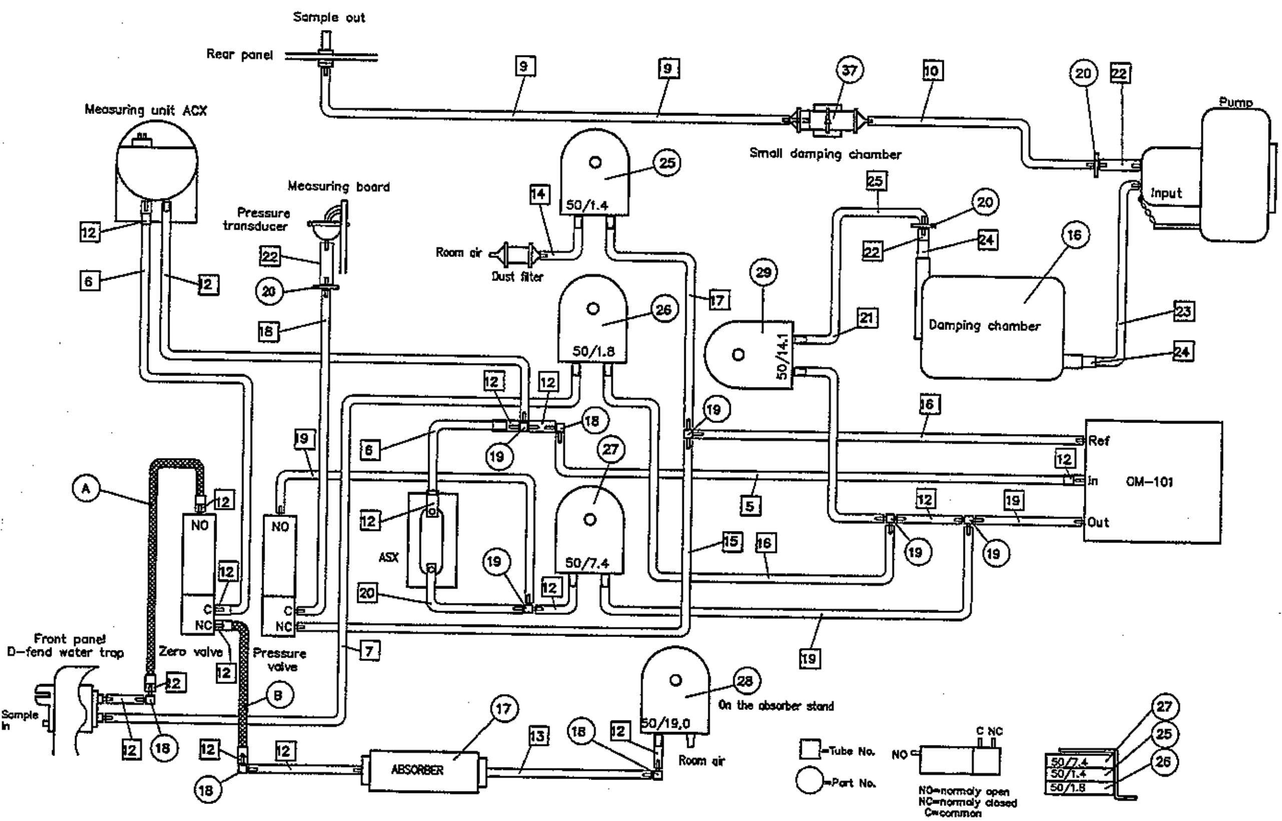


Table 5.1.2 Tube lengths (with i-parameter)

Tube No.	Part	Code	Pcs	Length/mm
A	Special sample tube	733383	1	500
B	Special sample tube	733382	1	300
5	1.2/0.3 mm PTFE	73332	1	400
6	1.2/0.3 mm PTFE	73332	2	320
7	1.7/1.05 mm Silicone	73373	1	300
8	1.7/1.05 mm Silicone	73373	1	85
9	1.7/1.05 mm Silicone	73373	1	110
10	1.7/1.05 mm Silicone	73373	1	400
12	1.7/1.05 mm Silicone	73373	16	20
13	1.7/1.05 mm Silicone	73373	1	140
14	1.7/1.05 mm Silicone	73373	1	60
15	1.7/1.05 mm Silicone	73373	1	70
16	1.7/1.05 mm Silicone	73373	2	30
17	1.7/1.05 mm Silicone	73373	1	40
18	1.7/1.05 mm Silicone	73373	1	280
19	1.7/1.05 mm Silicone	73373	3	50
20	1.7/1.05 mm Silicone	73373	1	220
22	3.18x6.35 mm Silicone	73375	3	20
23	3.18x6.35 mm Silicone	73375	1	180
24	4.8x9.5 mm Silicone	73376	2	25
25	1.7/1.05 mm Silicone	73373	1	420
26	10x2.5 mm Silicone	73377	1	500

Part No.	Part	Code
25-29	Constriction cassette	Selected individually, see Table 5.2 for alternatives
16	Damping chamber	57150
17	Absorber	890641
18	L-piece	733811
19	T-piece	733821
20	Adapter piece	73388
36	Dust filter	86901
37	Small damping chamber	879355

Note: Constriction cassettes are selected to adjust proper flow rates. See Table 5.2 for alternatives.

Table 5.2 Flow constriction cassettes

Constriction cassette	Code
50/26.0	878048
50/19.0	873800
50/16.3	878047
50/15.3	873801
50/14.1	878046
50/13.1	873802
50/12.4	878045
50/11.2	874770
50/10.4	873803
50/9.2	874509
50/8.7	873804
50/7.4	873805
50/6.5	878044
50/5.8	873806
50/5.1	878043
50/4.4	873807
50/3.8	878042
50/3.2	873808
50/3.0	878040
50/2.8	878039
50/2.5	878038
50/2.3	873809
50/2.0	878037
50/1.8	873810
50/1.6	878036
50/1.4	873811
50/1.1	873812

NOTE: The latter number is a relative figure for the flow through the constriction, e.g., 50/26.0 is the shortest constriction and 50/1.1 the longest.

5.2 CO_2/N_2O/AA measurements

5.2.1 In general

The measuring electronics block diagram is in Figure 5.3. The functions are divided between the ACX measuring unit (photometer) and the ACX measuring board.

5.2.2 ACX measuring unit

> **CAUTION:** The ACX photometer and its components are repaired/calibrated at the factory. Attempts to repair/calibrate the unit elsewhere will adversely affect operation of the unit. DATEX-ENGSTROM supplies spare ACX photometers. The information provided for the ACX is for reference only.

The ACX photometer is of dual path type. The infrared light beam passes through a measuring chamber containing the gas to be analyzed, and a reference chamber, which is free of CO_2, N_2O, and AA. The measurement is made by determining the ratio between the two light intensities.

The ACX photometer is shown in Figure 5.4.

A filter wheel is used to control the light from an incandescent lamp that passes through the photometer. The filters are arranged so that the light is passed sequentially:

- first at the CO_2 absorption wavelength through the reference chamber
- then through the measuring chamber
- finally it is blocked completely

The same sequence is repeated at the N_2O and anaesthetic agent gas absorption wavelengths.

After passing through the filters the light is reflected and focused by a mirror onto the infrared detector. This detector measures the three light levels for each gas described above.

There is an optical sensor incorporated in the photometer which detects light from a reflective surface on the filter wheel once every revolution. The pulses from this sensor are used to synchronize the electronics to the signal from the infrared detector. A stabilizing diode measures the temperature, which is needed to compensate for thermal drifts. The infrared detector, the optical sensor and the stabilizing diode are mounted on the preamplifier board (see Figure 5.5).

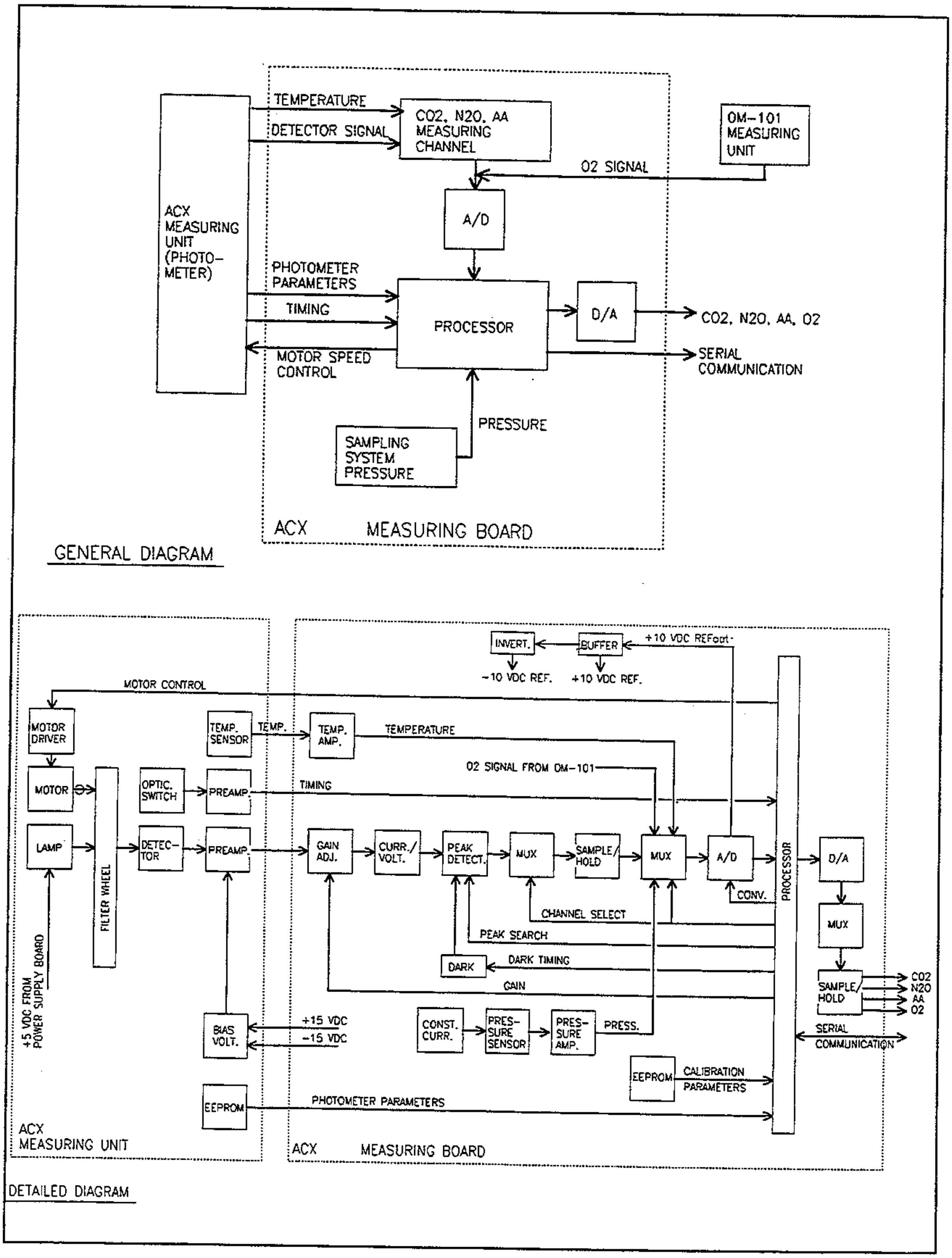


Figure 5.3 $CO_2/N_2O/AA$ measurement block diagram

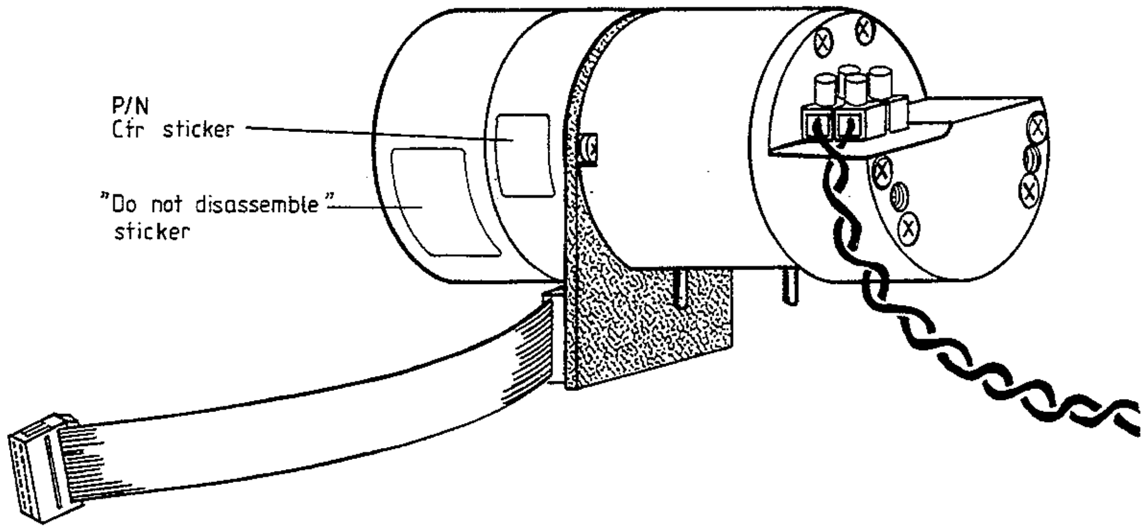


Figure 5.4 ACX photometer (ACX-100 measuring unit)

5.2.3 Preamplifier board

Parts layout and schematic diagram **Figure 5.5**

Voltage regulation

Voltage regulators A3 and A4 provide regulated ±12 V for the preamplifiers and the detector bias generator.

Preamplifiers

The purpose of preamplification is to amplify the signals from the infrared detector and timing sensor and to convert them into lower impedance level.

The infrared detector (R2) signal is amplified with A2A which is connected as a straightforward non-inverting AC amplifier.

The current signal from the timing optical sensor is converted into voltage with the remaining section of A2.

Detector bias generator

The lead selenide detector is a resistor, whose resistance decreases in infrared light. For this reason it is advantageous to supply the detector with a high bias voltage, as a higher signal is then achieved.

The bias voltage generator utilizes one section of A1, which is a square wave oscillator, and a conventional voltage doubler built of diodes V1, V2, V3, and V5 and capacitors C1 through C4. The circuit produces an output voltage of approximately +/-34 V.

Temperature measurement

The voltage across the 2.1 V stabilizing diode V14 decreases as the temperature of the photometer rises. This voltage signal is used for temperature compensation.

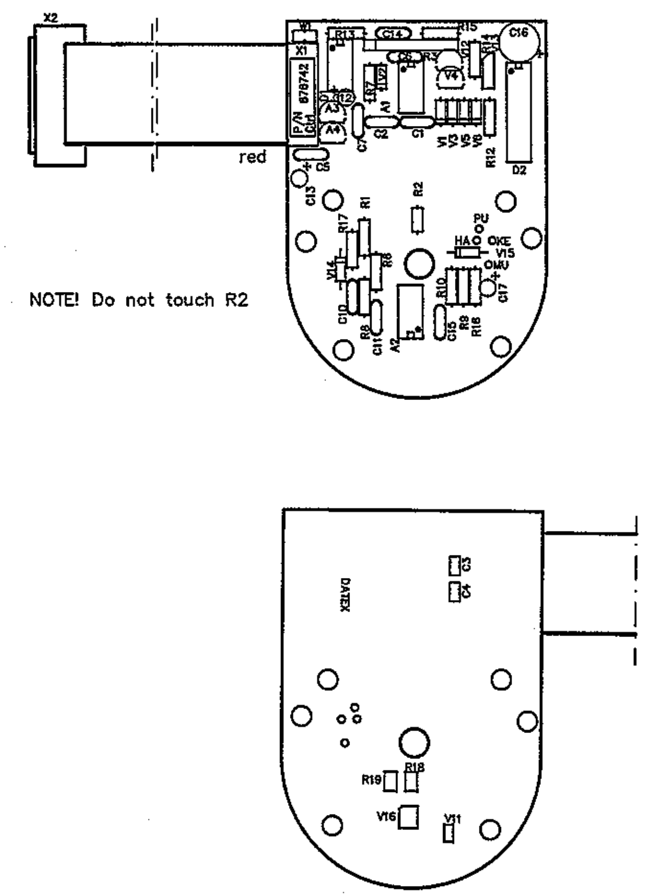
EEPROM

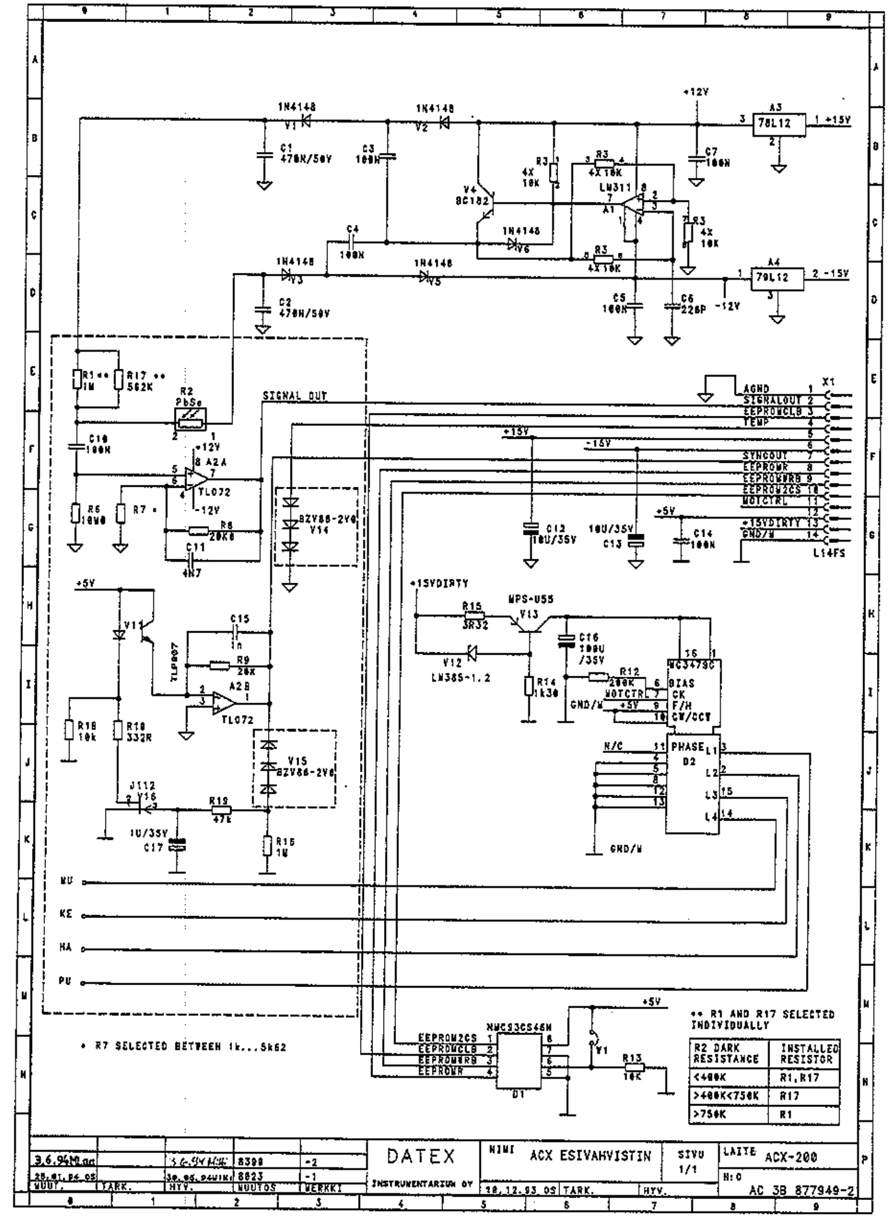
EEPROM D1 stores the photometer factory set gain and zero coefficients and compensation factors.

Filter wheel motor control

A stepper motor rotates the filter wheel at approximately 83 revolutions/second. Stepper motor is driven by D2.

Figure 5.5 Preamplifier parts layout and schematic diagram (board modification level 8 and higher)





5.3 O_2 measurement

The oxygen measurement is based on the paramagnetic susceptibility, which is a unique property of oxygen among all gases generally present in a breathing gas mixture. The gas to be measured and the reference gas, which usually is room air, are conducted into a gap in an electromagnet with a strong magnetic field switched on and off at a frequency of approximately 110 Hz.

An alternating differential pressure is generated between the sample and reference inputs due to forces acting to the oxygen molecules in a magnetic field gradient.

The pressure is measured with a sensitive differential transducer, rectified with a synchronous detector and amplified to produce a DC voltage proportional to the oxygen partial pressure difference of the two gases.

> **CAUTION:** Due to the complicated and sensitive mechanical construction any service inside the O_2 measuring unit should not be attempted, and therefore the detailed description of the circuitry and layout of the transducer is omitted from this manual.

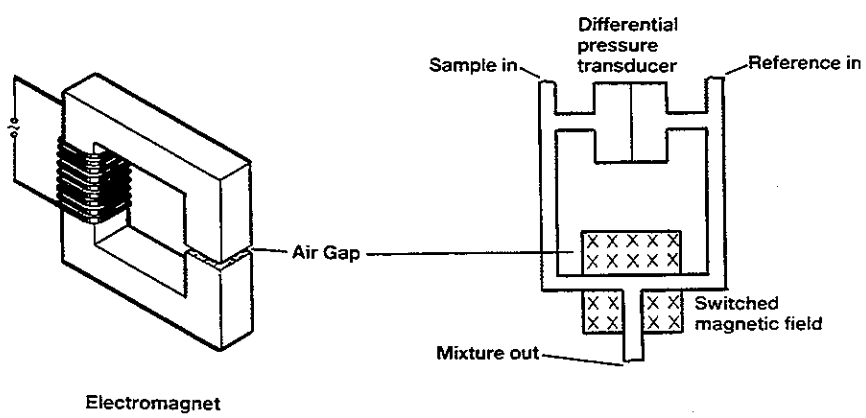


Figure 5.6 O_2 measurement principle

5.4 ACX measuring board

Block diagram and schematic diagram part 1	**Figure 5.7**
Parts layout and schematic diagram part 2	**Figure 5.8**
Timing diagram and schematic diagram part 3	**Figure 5.9**

The measuring electronics can be divided into a few functional blocks, which are described below (See the block diagram).

> **CAUTION:** Do not attempt to repair or replace the pressure transducer (B1). Its calibration values are stored in EEPROM (D2) and can be programmed only at the factory.

The ACX measurement board controls gas measurements. It converts the photometer signal to digital data, calculates results and transmits it to main CPU board. The board contains, in addition to the 80C51FA processor, EPROM, RAM, and EEPROM, several analog and digital I/O functions.

Internal and external bus

The processor D1, has access to the measurement board peripherals (memory, A/D converter, D/A converters, etc) via an internal bus. For communication between the CPU board and the measurement board, there is an external bus in connector X1. The external bus is driven by D21 (data lines), D3 (address lines) and D18 (read and write lines).

Memory

Memory components include 64 x 8 kbit program memory EPROM (D4), 32 x 8 kbit low current CMOS RAM (D22) powered by a data retention voltage generation circuit in power supply board, and EEPROM (D2) for permanent calibration values and setup memory.

Reference voltages

Reference voltages are established by the A/D-converter (D14) reference voltage output (REFOUT, pin 8). This +10 V voltage is buffered by A2D. -10 V reference voltage is obtained by inverting and buffering +10 V with amplifier A2C.

O_2 measuring electronics

The signal from the O_2 measuring unit is sent to pin a9/X1 and processed in the processor and passes to the main CPU board at a5/X1.

Measuring electronics for CO_2, N_2O, and AA

CO_2, N_2O, and anaesthetic agent measurement is accomplished by measuring each of these gases from the reference and measuring chambers of the ACX-100 photometer. The gas signals are transmitted from the ACX-100 photometer assembly through connector X2 pin 2 of the ACX measuring board and applied to the reference input of a D/A converter (D8). D8 is controlled by the microprocessor and is used for automatic gain control. The output current from D8 is proportional to the incoming signal and the gain is established for each gas, (CO_2 reference and measuring, N_2O reference and measuring, and AA reference and measuring) by software.

The signals are converted to a voltage and amplified by A24D, then applied to capacitor C30 which removes the DC offset. The dark level is established on C30 when the synchronous switch A28A is closed.

Each signal is sampled by the peak detection circuit, consisting of A24C, V26, A28B, R97, R201, and C15. When the peak voltage of a signal is sampled, the switch A28B is open, sending the signal through V26, which acts like a diode. The peak signal is then applied to the capacitor C15. C15 is brought down to ground potential between signal peaks when A28B is closed and the dark signal is transmitted to it.

The voltage peak of each gas (both measure and reference) is applied to an instrumentation amplifier (A24B) then to the input of a multiplexer (D23). D23 separates the signal to each of its components, (CO_2 reference and measuring, N_2O reference and measuring, and AA reference and measuring). For CO_2, the offset voltage is subtracted from the reference signal at A13B. For AA, the offset voltage is subtracted from the reference signal at A12B.

Each gas signal, the temperature compensation signal and the pressure signal are transmitted to D13 which serves as a demultiplexer whose output is applied to an A/D converter (D14) through an instrumentation amplifier.

A/D-conversion

A/D conversion is made with a 12-bit A/D-converter (D14). Input signal is multiplexed with D10 and D13. After conversion is completed, signal ADCRDY rises to +5 V.

D/A-conversion

D/A conversion is made with a 12-bit D/A-converter (D11). D12 multiplexes the analog output to 8 sample and hold circuits. Two of these are used to drive offset voltages for N_2O and CO_2 measurement. The others are used for external analog outputs (CO_2OUT, N_2OOUT, VOLC, O_2OUT etc).

Timing of CO_2, N_2O, and AA signals

A timing pulse is produced when light is reflected to a phototransistor from a reflectorized surface on the filter wheel. The pulse produced is shaped by A28 on the preamplifier board and transmitted to port 3 of the microprocessor on the ACX measuring board.

The processor produces the necessary address information to cause the PAL (D15) to produce the control pulses for the synchronous switches A28A and A28B (Dark and Clear).

Motor speed control

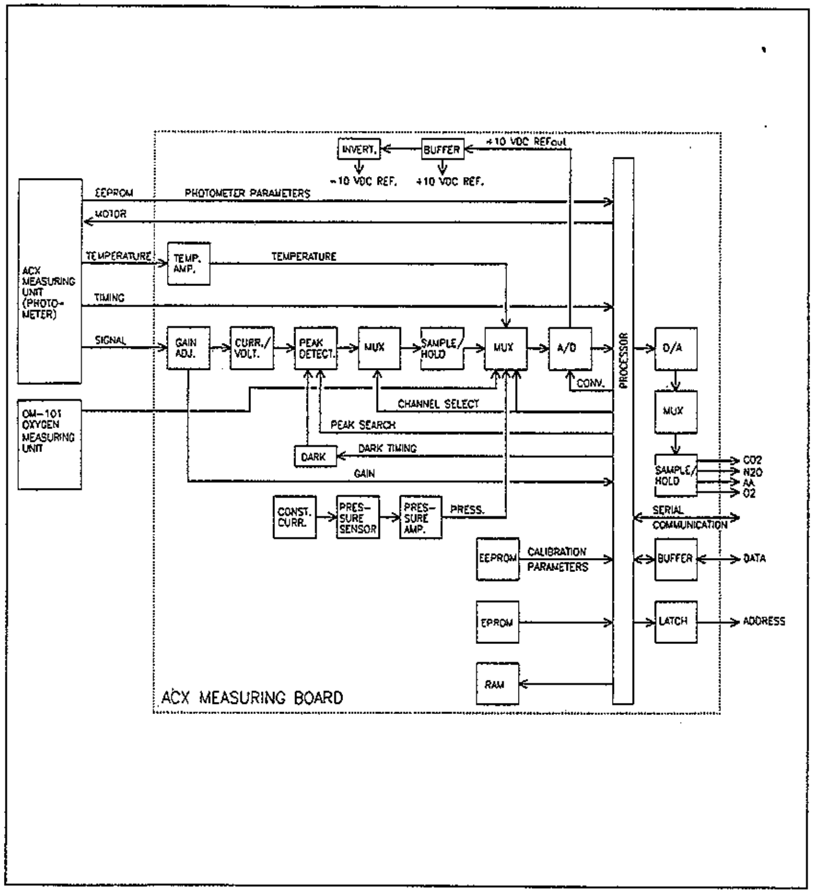
The speed of the stepper motor in the ACX-100 photometer is controlled with MOTOR-signal from the processor. This signal is buffered by D6.

Pressure measurement

The pressure transducer (B1) measures the sampling system pressure after the photometer. Voltage reference V1, resistors R17, R108, R89 and amplifier A31C supply the pressure measurement bridge with 4 mA current. The pressure signal is amplified with A31A and A31B. The output of A31A corresponds to pressures 400 to 900 mmHg and is within -9.5 V and +9.5 V range.

Temperature measurement

Temperature measurement exitation voltage for photometer stabilizing diode is fed from +10 V through resistor R104. The stabilizing diode voltage is proportional to photometer temperature. This voltage is amplified with A31D.



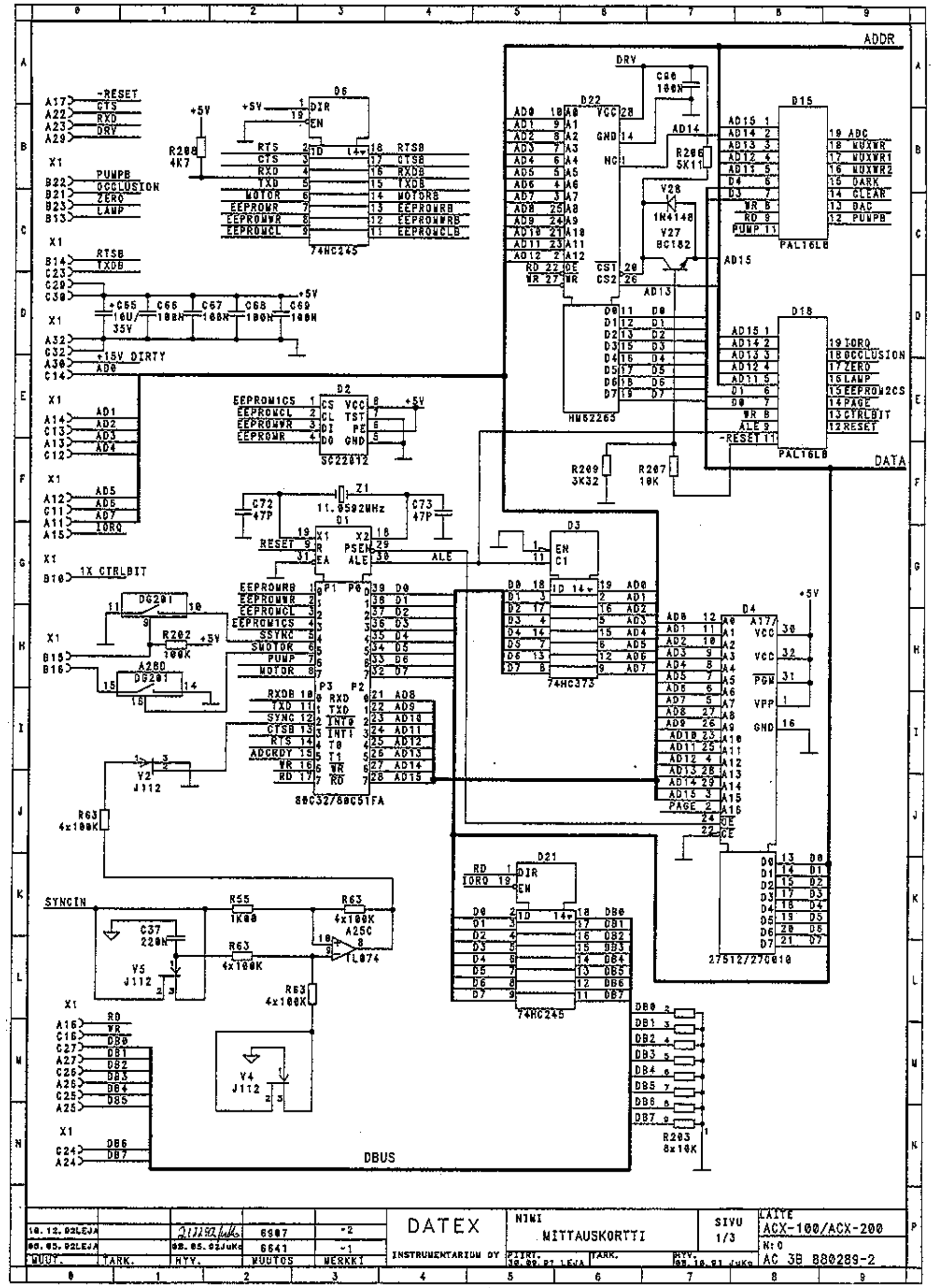
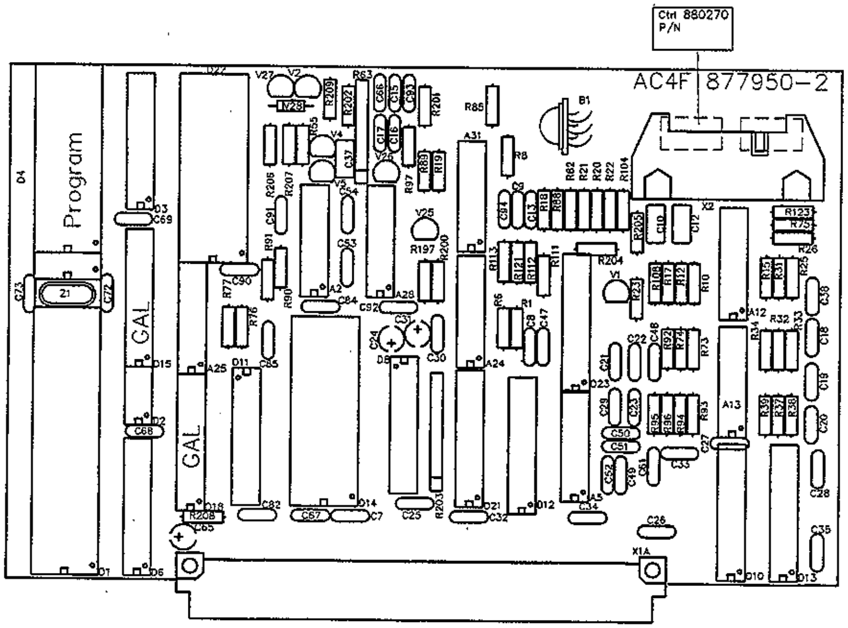


Figure 5.7 ACX Measuring board block diagram and schematic diagram part 1 (board modification level 4 and higher)

Figure 5.8 ACX Measuring board parts layout and schematic diagram part 2 (board modification level 4 and higher)



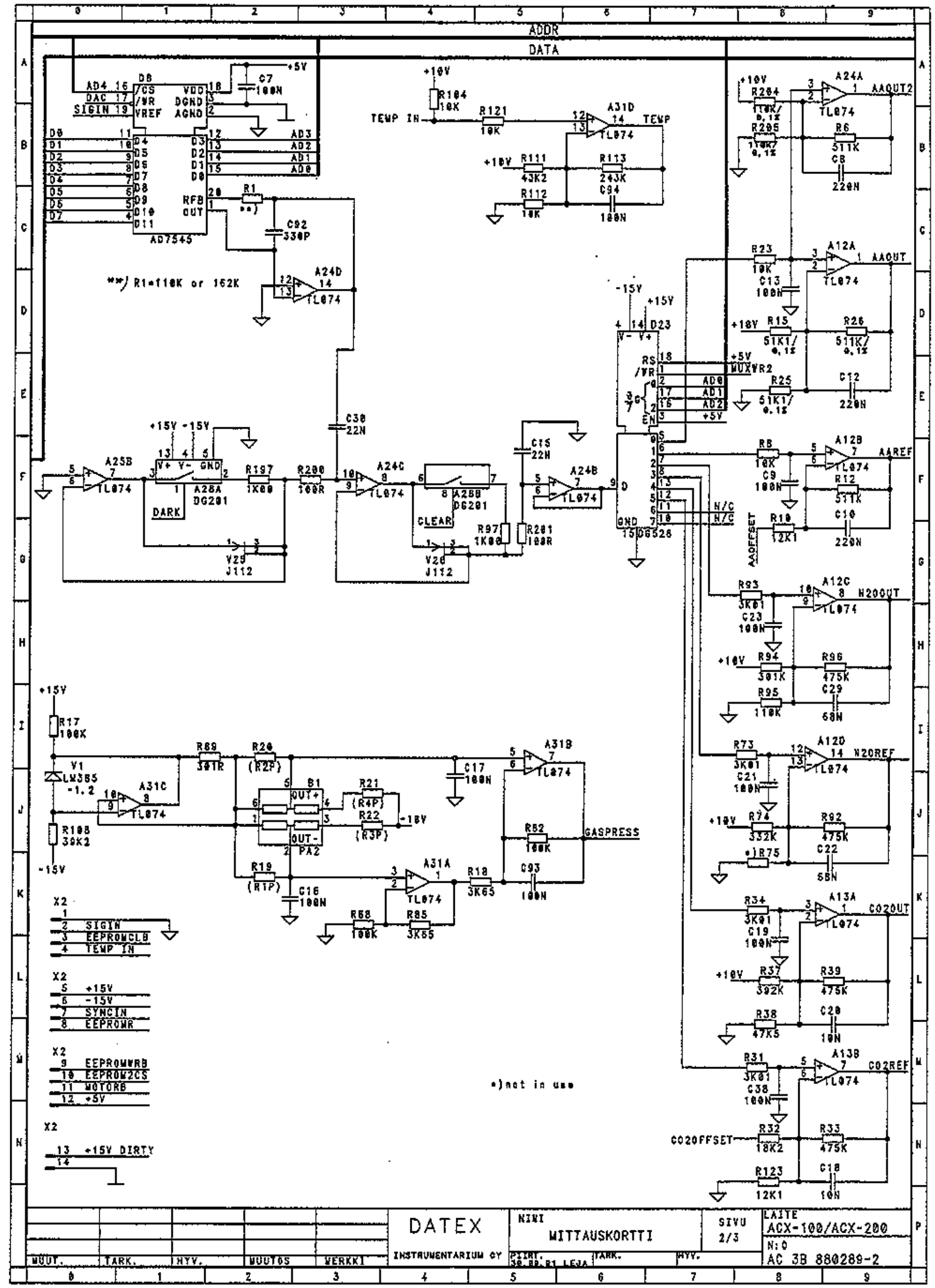
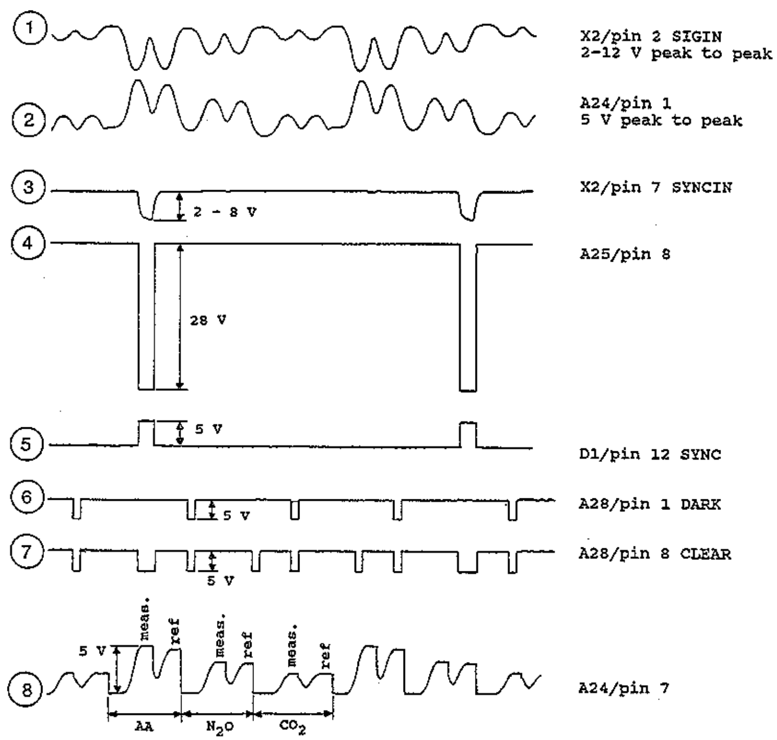
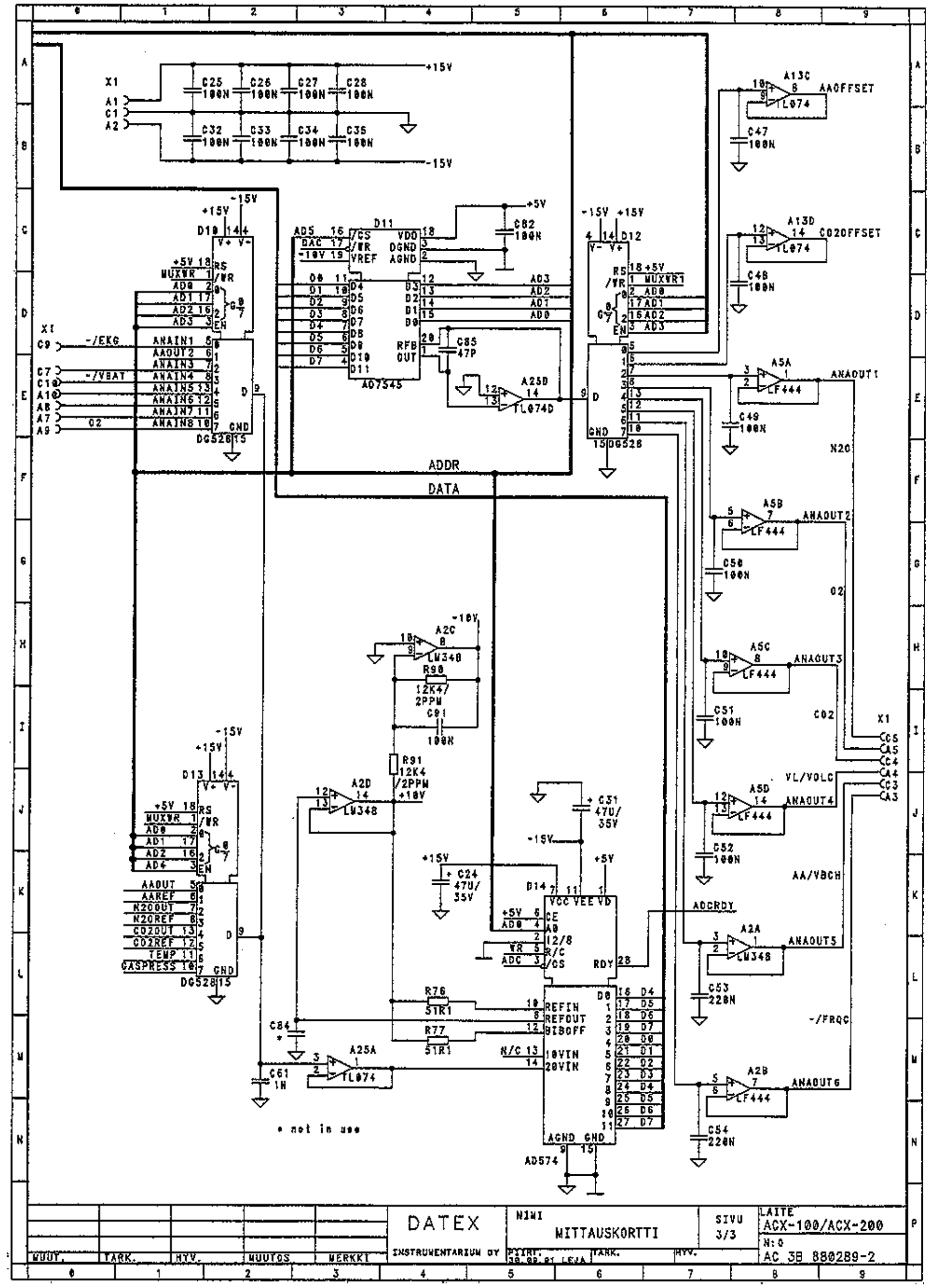


Figure 5.9 ACX Measuring board timing diagram and schematic diagram part 3 (board modification level 4 and higher)





5.5 SpO2 measuring board (Rev. 06 and up)

Block diagram and schematic diagram part 1 — Figure 5.10
Parts layout, timing diagram, and schematic diagram part 2 — Figure 5.11
Signal waveforms and schematic diagram part 3 — Figure 5.12
Schematic diagram part 4 — Figure 5.13

The board is intended to perform the following tasks:

- Control the LED light sources of the probe.
- Amplify the signal coming from the detector and separate the red and infrared signal components to respective channels.
- Multiplex in both channels the alternating component of the signal (plethysmographic pulse) with the signal proportional to the total intensity measured with the respective wavelength.
- Provide isolated output from the multiplexer channels (red channel and IR channel) to the SpO_2 Processor board.

Power supply

The isolated power supply consists of:

- 32.768 Hz oscillator.
- Half-bridge converter with isolation transformer.
- Stabilization and filtering of the output voltages with linear regulators.
- Protection of the overloading with PTC-type thermistor.

Timing/LED control

The timing pulses are produced by a PAL (Programmable Array Logic) D3. The input signal for D3 (SYNC.) is taken from the switching power supply as a 32.768 Hz square wave. All timing signals are synchronized at this switching frequency. The timing circuit controls the LED driver circuitry (signals LED_R and LED_{IR}), the RC time constants in amplifier chain (MEASURE) and sampling ($SAMPLE_R$, $SAMPLE_{IR}$).

LEDs in the probe are driven with constant current pulses, (90 or 300 mA). The pulse duration and duty cycle can be seen in timing diagram in Figure 5.11. A positive voltage pulse at 1/X1 corresponds to the red LED current and a negative one to the IR-LED, respectively.

Detector signal processing

The signal produced by the detector is a current. The first amplifier stage is a current-to-voltage converter. A signal current passes through the resistors between pins 13 and 14 of A3 and produces a negative voltage pulse at 14/A3. Notice that the part of the feedback resistance is located in the probe connector.

The bias voltage of the detector (4.2 V) is the voltage difference between the connector pins 3/X1 (5 V) and 5/X1 (0.8 V).

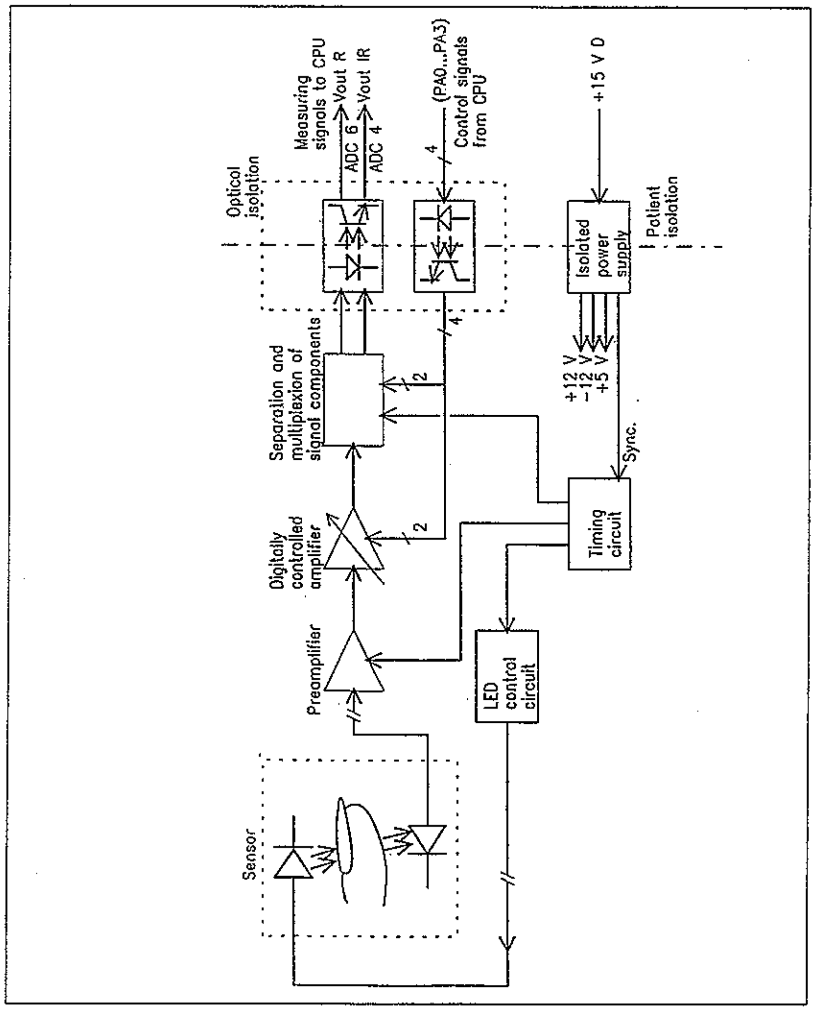
At 8/A3 the detected voltage pulses are inverted to positive value.

The digitally controlled amplifier is a Digital to Analog Converter (DAC), D5. The signal is fed to the reference input of D5. The 8-bit digital control word is transferred over the patient isolation barrier in serial mode (PA2) and is converted into parallel mode by a shift register D4. The signal level at the output, 7/A3, is adjusted to 3 to 8 V by the CPU.

The amplified signal pulses are separated to red and infrared channels by sample-and-hold circuitry (S/H). Voltages V_R and V_{IR} are proportional to the total intensity of the light detected at the respective wavelength. V_{Rac} and V_{IRac} are the amplified alternating components (plethysmographic pulses).

The signals are multiplexed into two channels by a 2 x 4 MUX, A5. Also +5 V and GND are connected to MUX input. The value of the resistor R_c in the probe connector can be read through the red channel, if needed.

The two output channels of MUX A5 are transferred across the patient isolation by two identical pulse width modulator/optoisolator/demodulator-chains. The frequency of the pulse width modulator is about 20 kHz. The demodulated signal is inverted.



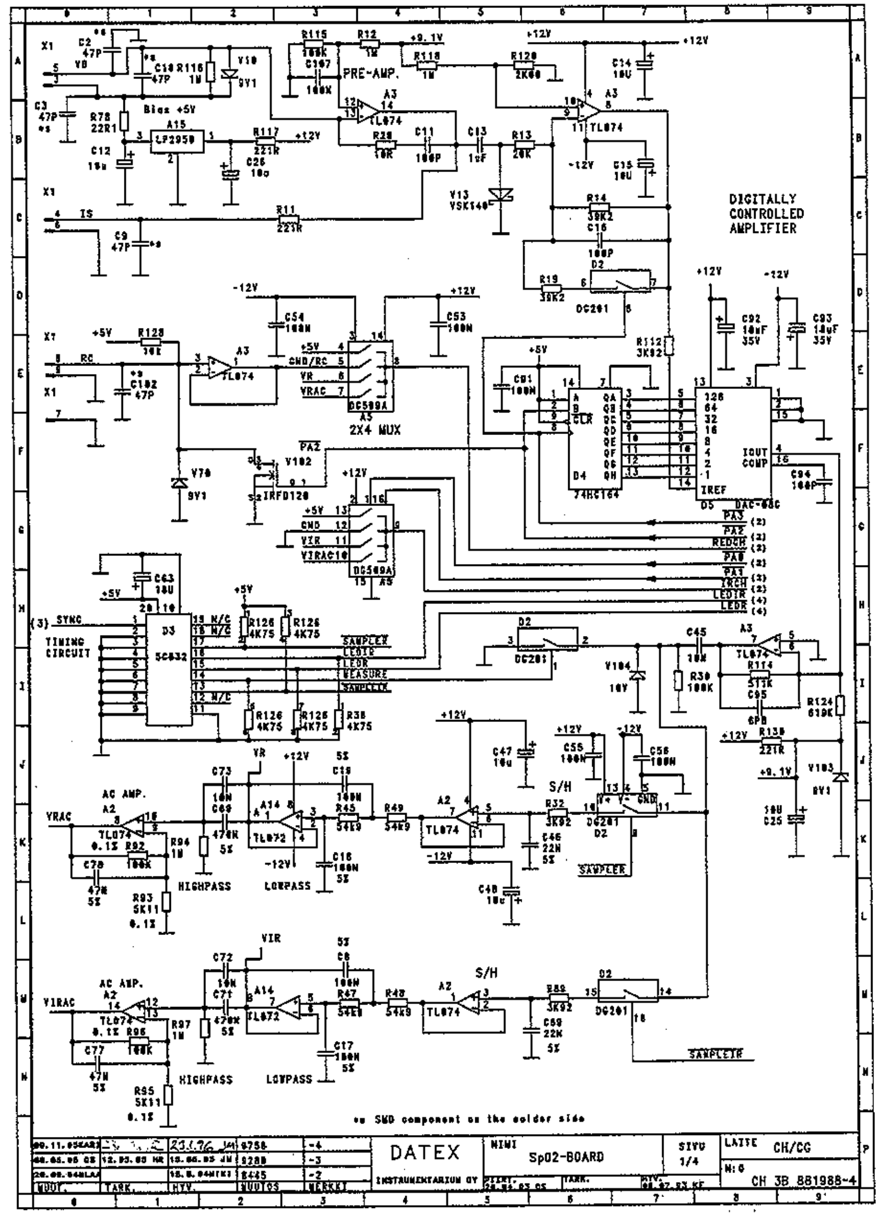
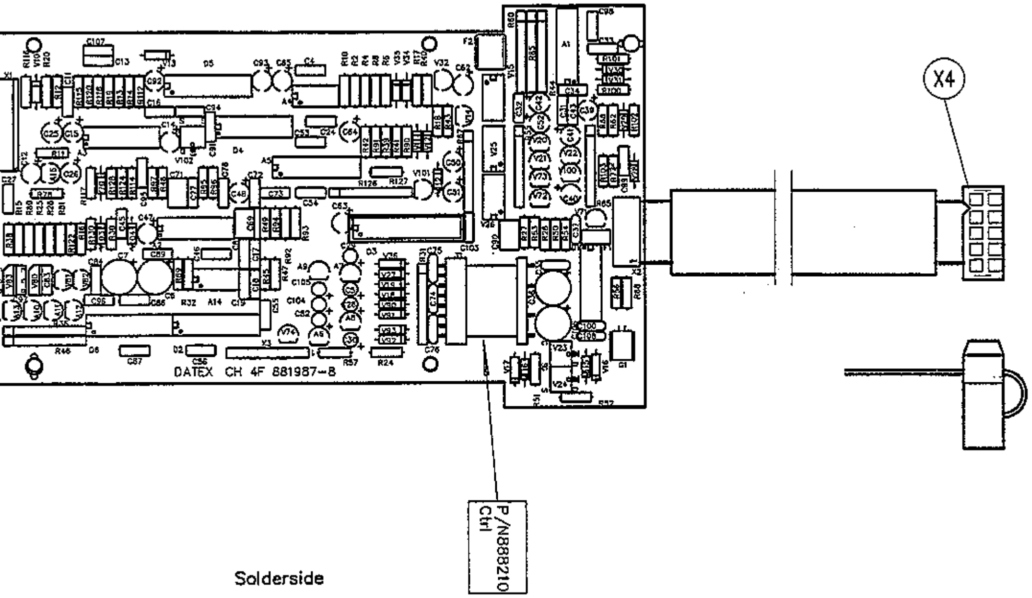
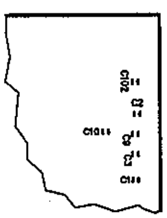
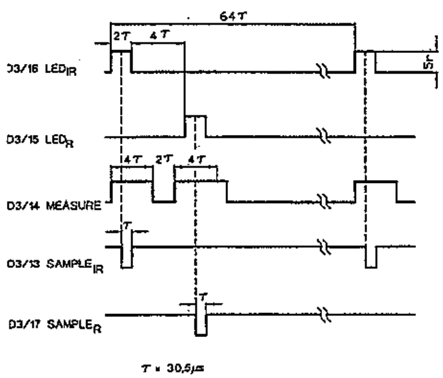


Figure 5.10 SpO2 Measuring board block diagram and schematic diagram part 1

Figure 5.11 SpO_2 Measuring board parts layout, timing diagram and schematic diagram part 2







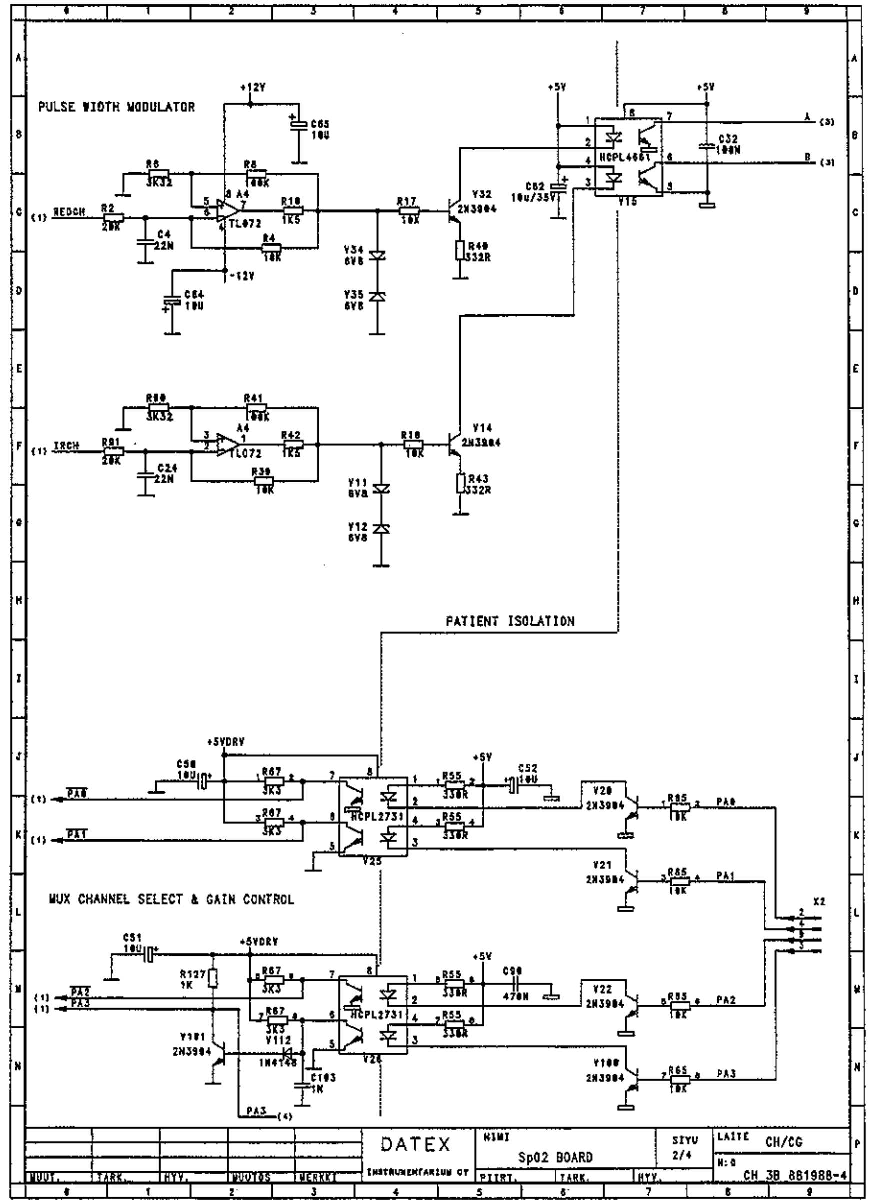
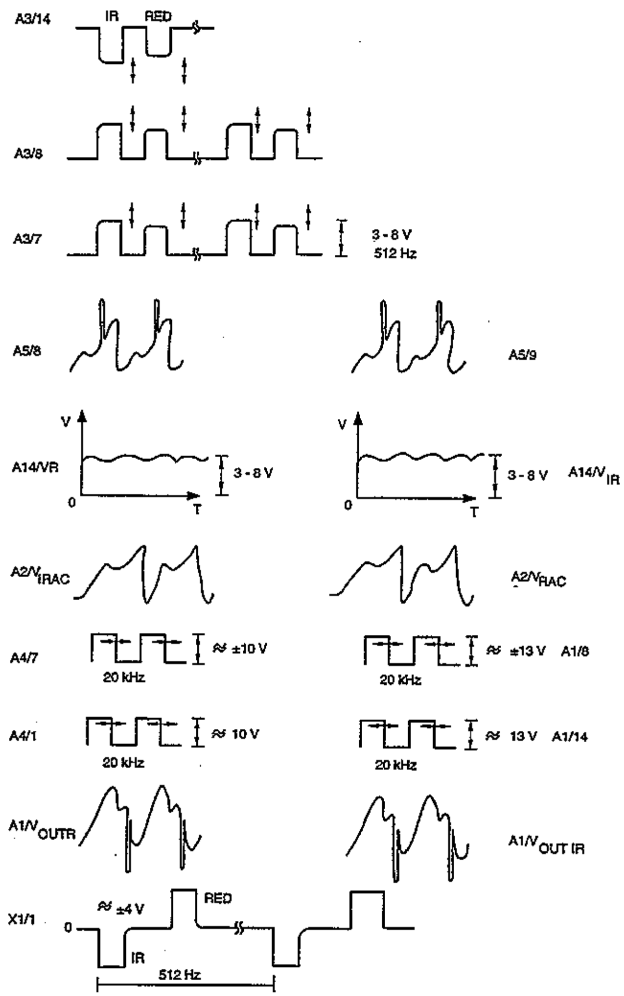


Figure 5.12 SpO2 Measuring board signal waveforms and schematic diagram part 3



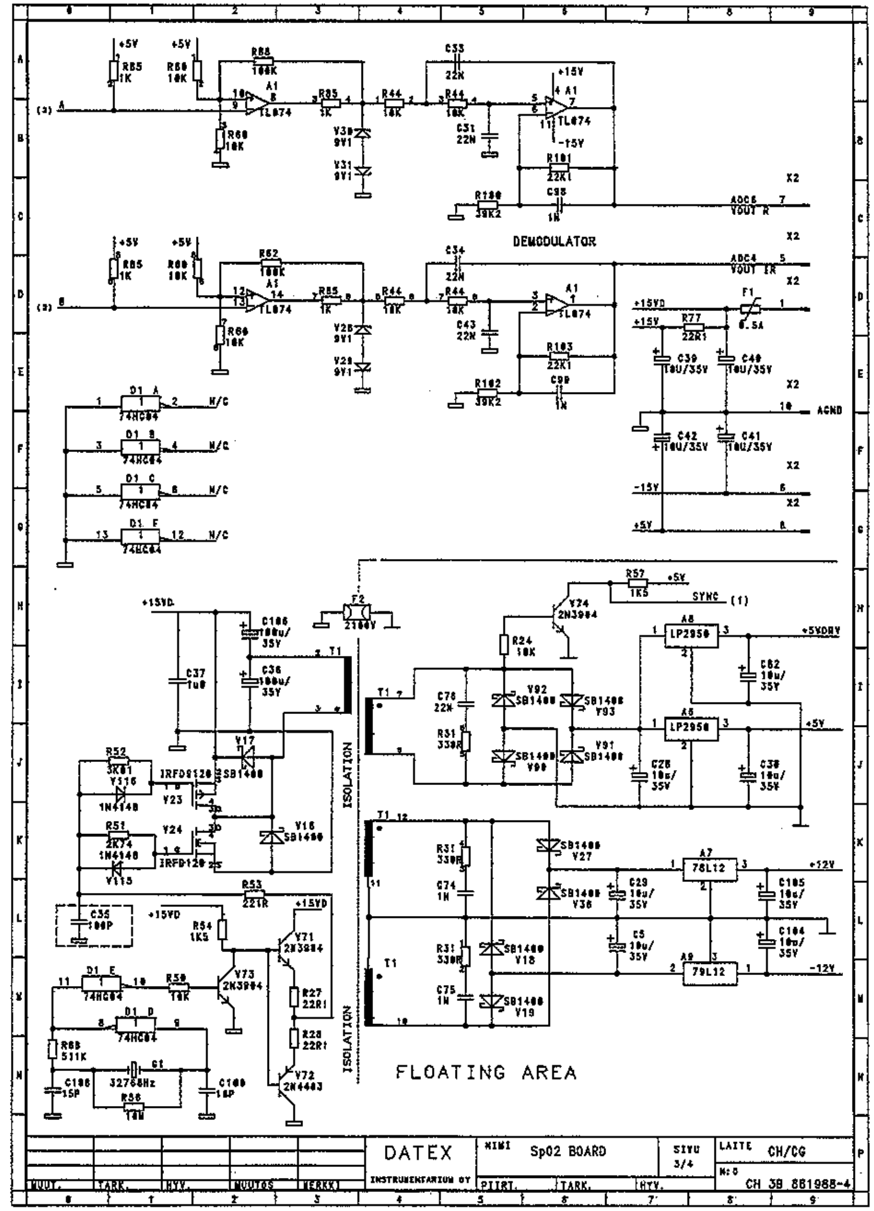
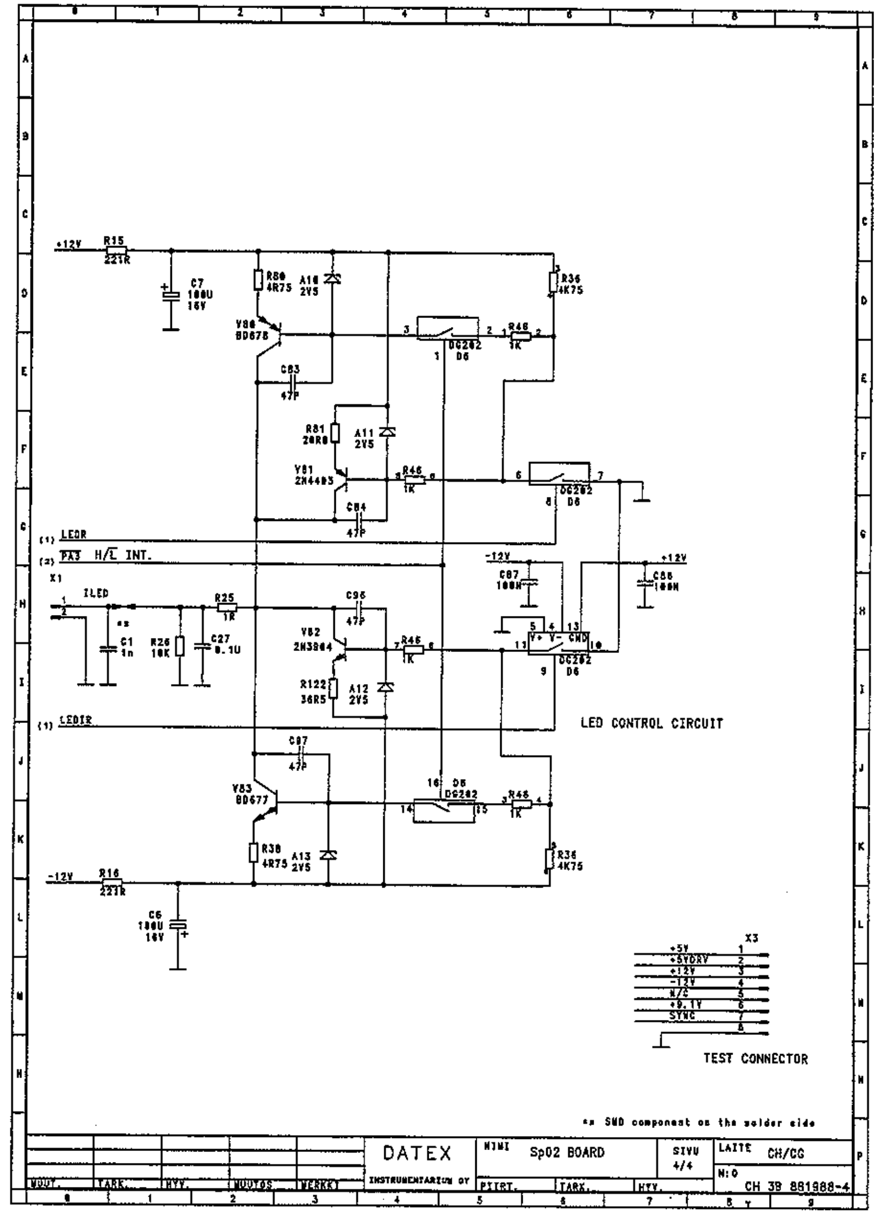


Figure 5.13 SpO2 Measuring board schematic diagram part 4



5.6 CPU board (Rev. 06 and up)

Principle of operation

The High Speed CPU board contains 16 MHz oscillator (previously 11.059 MHz), 80C32 CPU, standard EPROM and SRAM, and several analog and digital I/O functions. See the CPU board block diagram.

The CPU (D5) uses the CPU board internal bus to access most of the peripheral circuits; the on-chip peripheral ports are directly used for analog multiplexers (MUX) and serial channel 0 (ASCII computer output). The computer output is explained in Appendix A.

There are jumpers to select memory chips. They are 2M bit program EPROM (D1), 128 x 8 kbit low current CMOS SRAM (D6) powered by the data retention voltage, and battery back-up 8 kbit SRAM (D4) for permanent calibration value memory. See the jumper configuration.

Analog input signals are read through the multiplexer (A3) to the A/D-converter A2.

Control signals of MUX are in port 1 on the microprocessor as follows:

P1	pins 3-5	MUX A0-A2 (both)
	pin 6	MUX enable (both)
	pin 7	MUX 0 Write (ADC)
	pin 8	MUX 1 Write (DAC)
	ADC 4	Ired signals
	ADC 6	Red signals
	DAC 2	SpO_2
	DAC 6	Ired pleth
	DAC 5	Loudspeaker volume
	DAC 7	Loudspeaker pitch

Ports on the PPI is used for as follows:

PA (output)	PB (input)	PC (low input,high output)
PA0: SpO_2 control	PB0: not used (AUX)	PC0: not used
PA1: SpO_2 control	PB1: not used (AUX)	PC1: not used
PA2: SpO_2 control	PB2: not used	PC2: not used
PA3: SpO_2 control	PB3: Test (S&A)	PC3: not used
PA4: not used	PB4: Gas freeze (S&A)	PC4: not used
PA5: not used (AUX)	PB5: CTSB (AUX)	PC5: not used
PA6: not used (AUX)	PB6: CTSA (AUX)	PC6: not used
PA7: Nurse call (AUX)	PB7: not used	PC7: Alarm LED

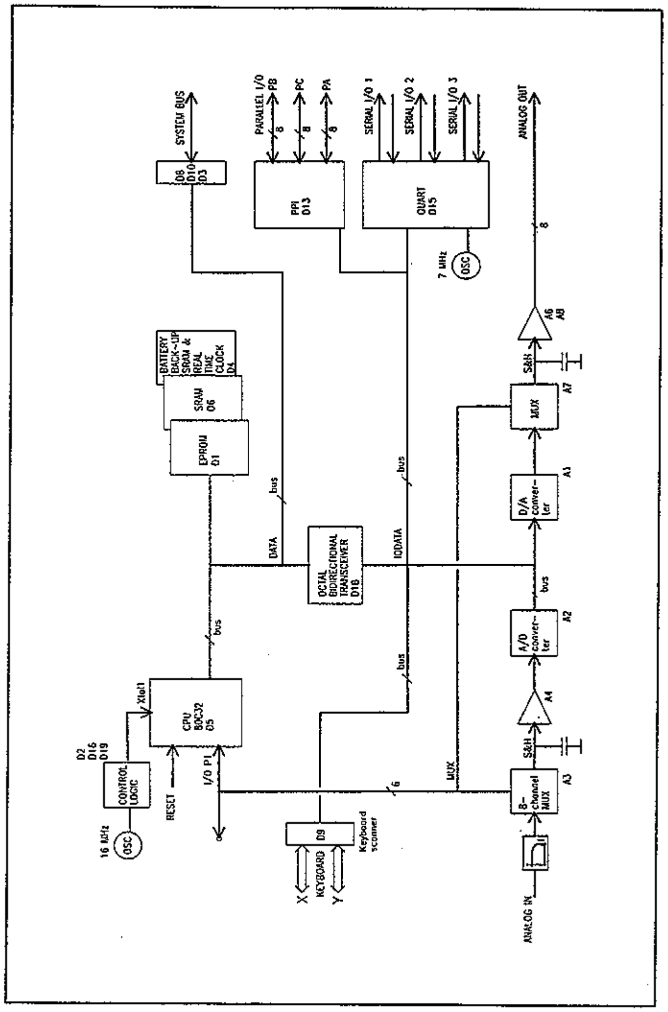
When a key is pressed, keyboard scanner (D9) interrupts the microprocessor and this reads from the scanner which key was pressed.

The Quart channel C is connected to Serial & Analog I/O connector (computer output). Quart channel A is connected to Aux I/O connector (graphic output) and quart channel B is used for communication between the microprocessor and the ACX measuring board.

Real time clock is controlled by D4 which contains lithium battery inside.

Software features are described in the Operator's Manual. Main differences between software revisions are described in Section 3.4.

CAUTION: The board contains an IC (D4) which has lithium battery inside. Danger of explosion if the IC is incorrectly replaced. Replace only with same or equivalent type recommended by DATEX-ENGSTROM. Do not dispose faulty IC:s of in fire. They are hazardous waste. Discard them according to local regulations.



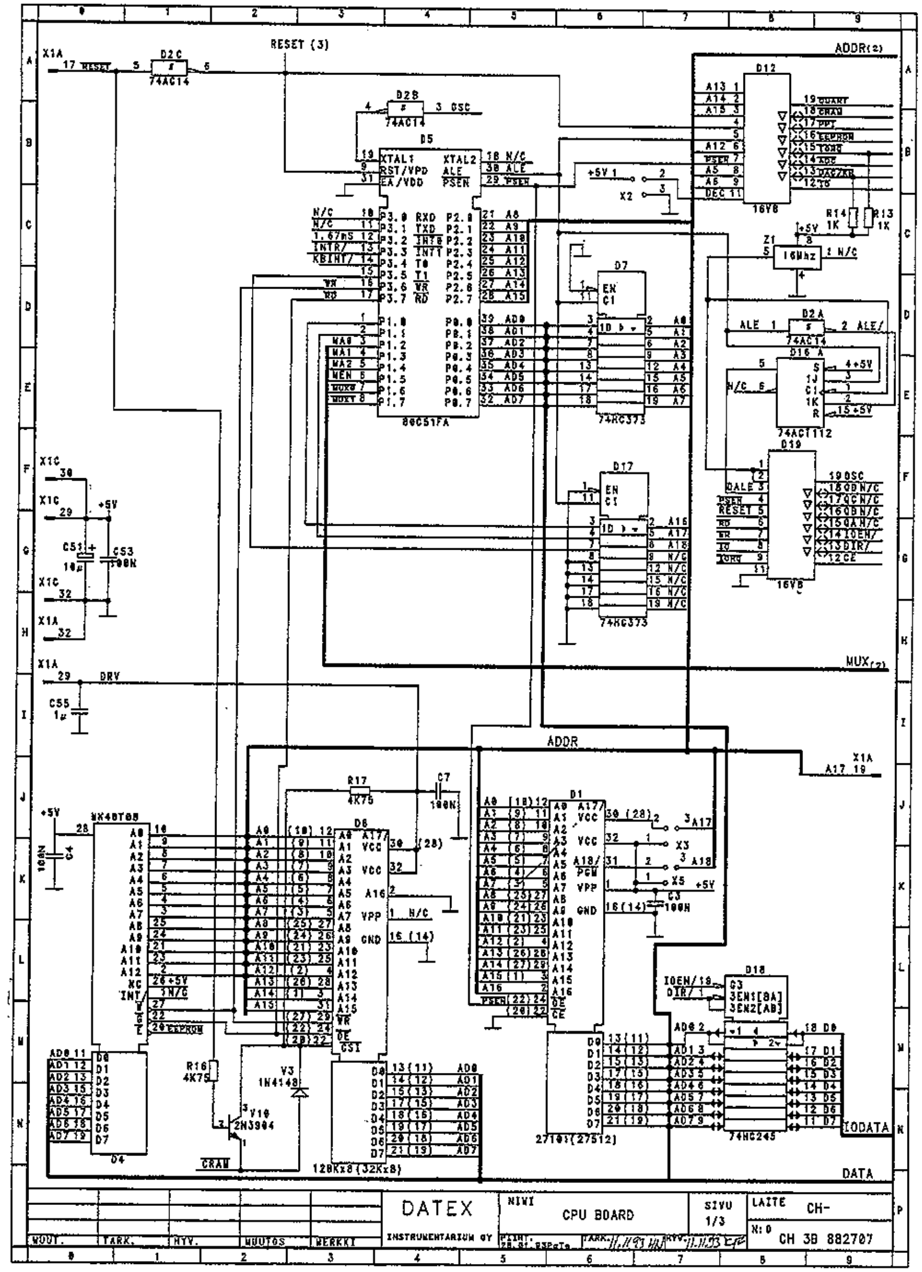
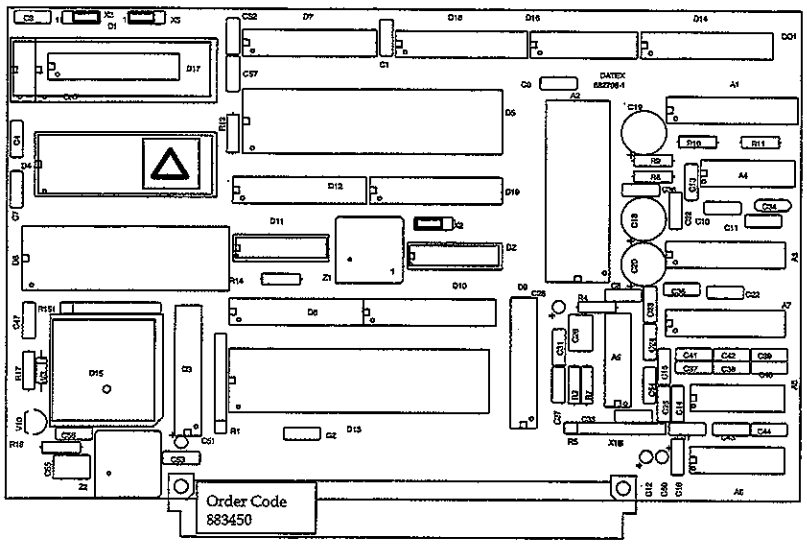


Figure 5.14 CPU board block diagram and schematic diagram part 1

Figure 5.15 CPU board parts layout and schematic diagram part 2



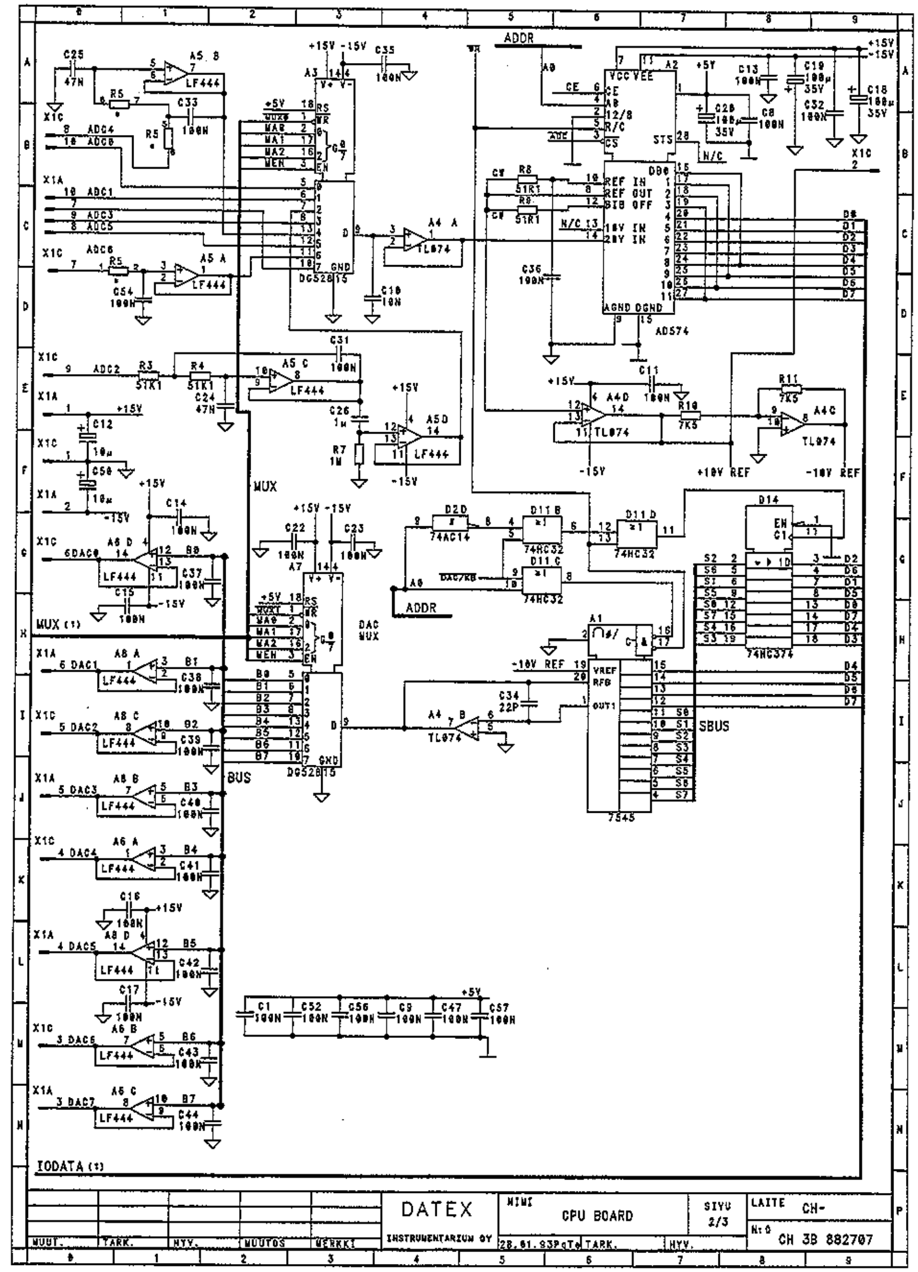
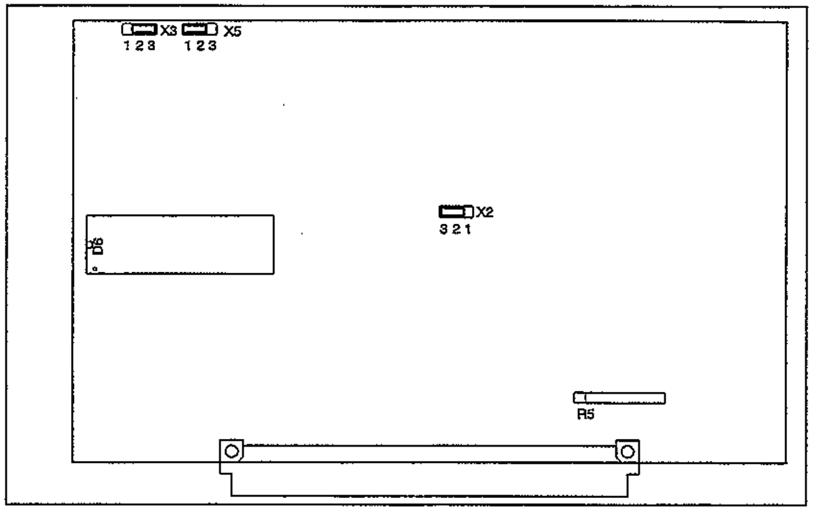
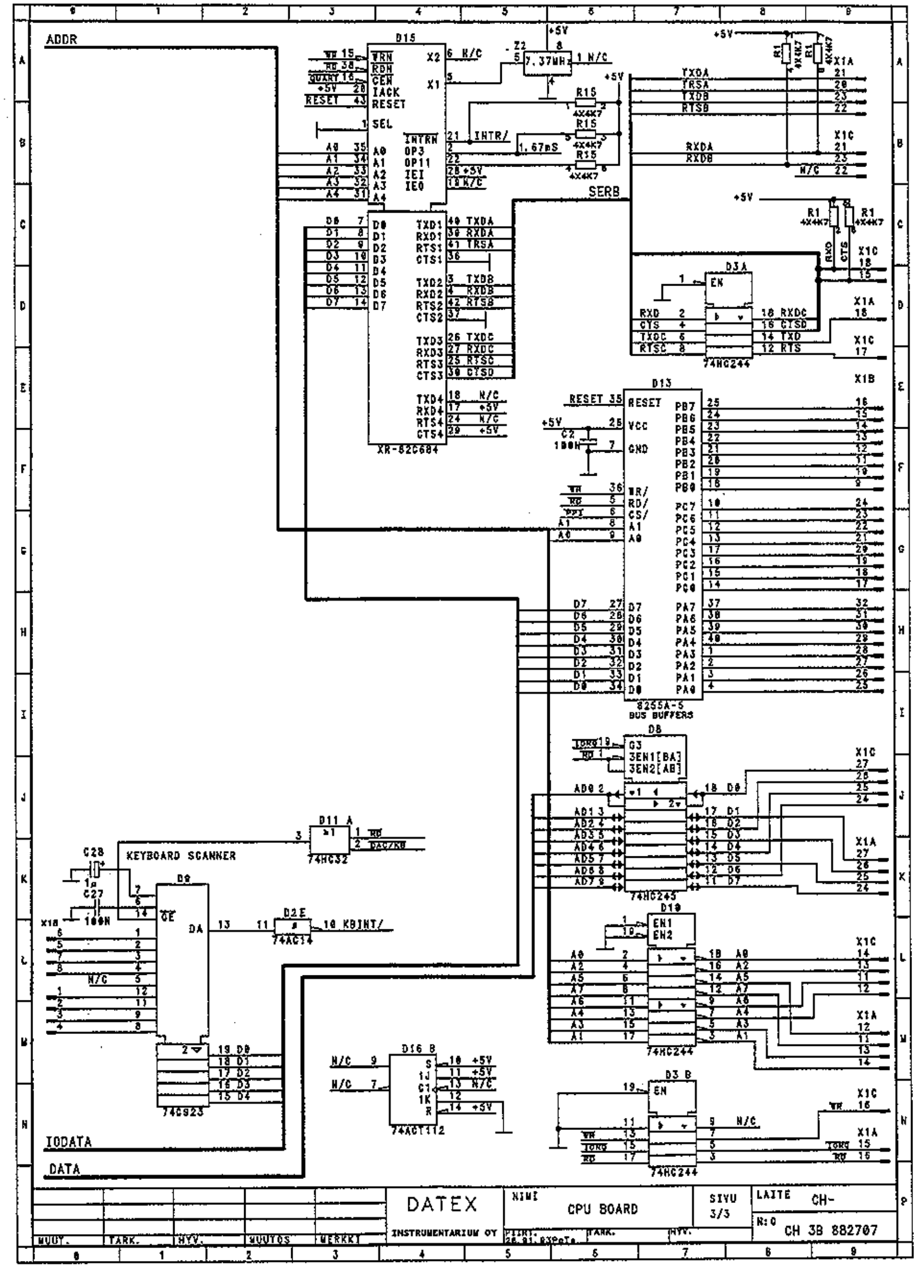


Figure 5.16 CPU board jumper configuration and schematic diagram part 3

CONNECTOR	JUMPER	MEMORY TYPE
X2	1-2	D6 : 32k x 8 RAM
	2-3	D6 : 128k x 8 RAM
X3	1-2	D1 : 512k, 1M EPROM
	2-3	D1 : 2M, 4M EPROM
X5	1-2	D4:512k,1M,2M EPROM
	2-3	D4 : 4M EPROM





5.7 Video ASIC Board

The video ASIC board replaces video control board from revision -08 (adaptation -27 and -43 revision -09). ASIC board includes ASIC IC and some other components. Due to the number of components we recommend changing the complete board in case of failure.

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Figure 5.17 (no figure)

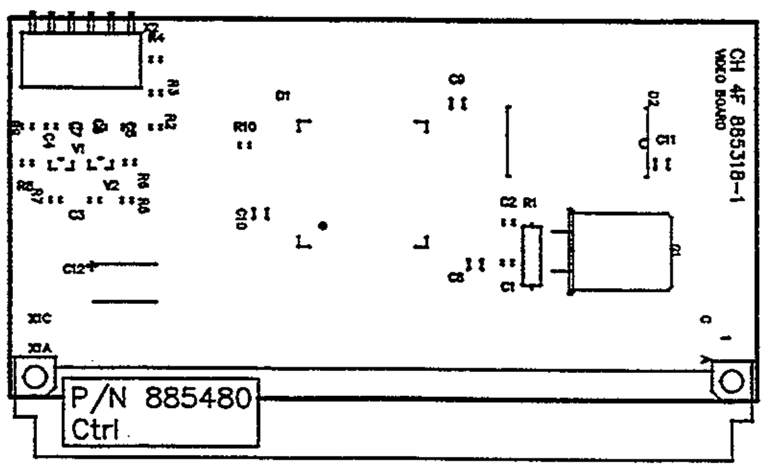
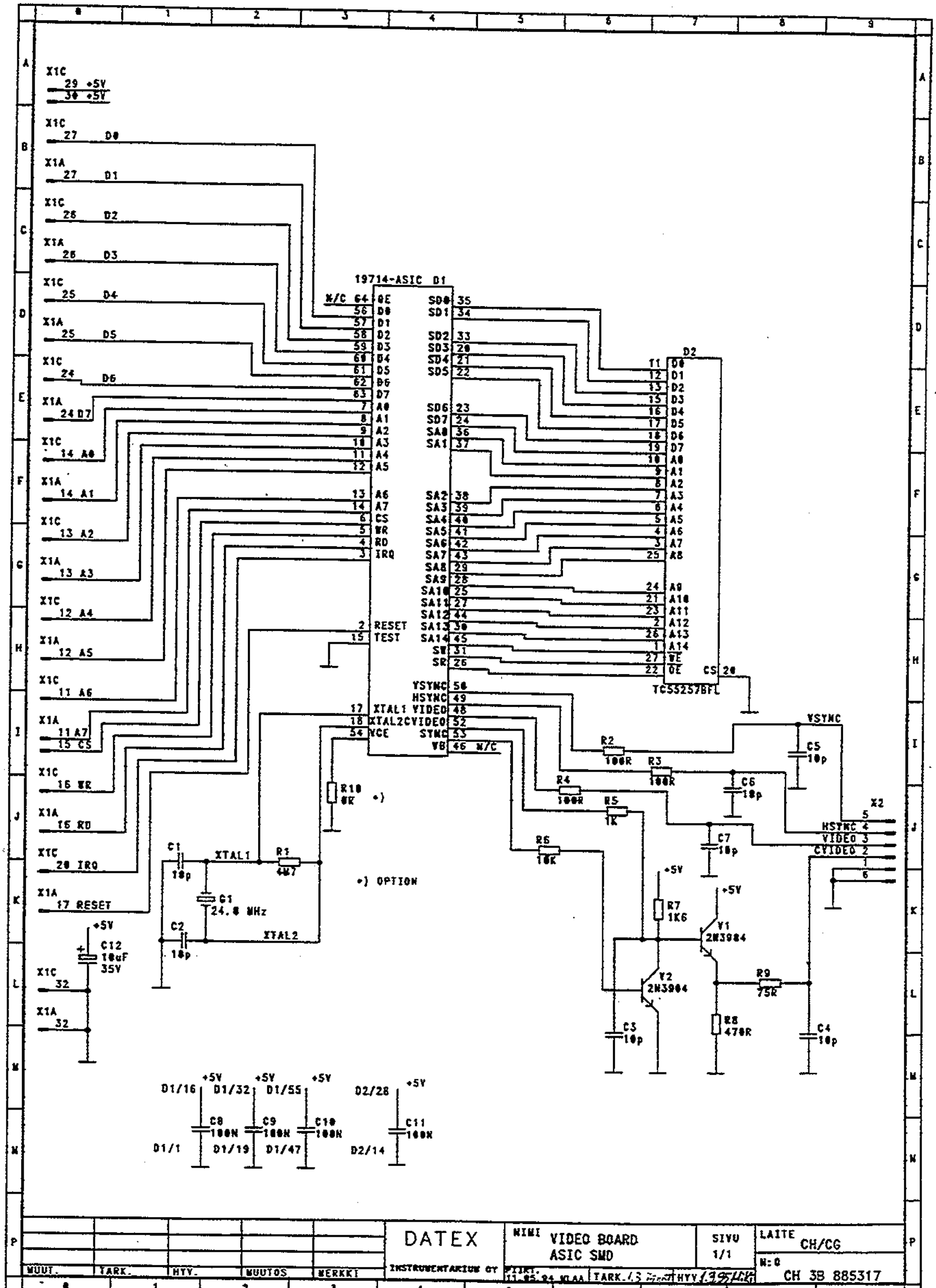


Figure 5.18 Video ASIC board parts layout

Figure 5.19 (on the next page)
Video ASIC board schematic diagram


19714-ASIC D1
D2
TC55257BFL
X2
VIDEO BOARD
ASIC SMD
DATEX
INSTRUMENTARIUM OY
CH/CG
CH 3B 885317
*) OPTION
24.0 MHz
XTAL1
XTAL2
VSYNC
HSYNC 4
VIDEO 3
CVIDEO 2
V1 2N3904
V2 2N3904

5.8 Power supply board

Block diagram and transformer diagram	Figure 5.20
Signal waveforms and schematic diagram part 1	Figure 5.21
Parts layout and schematic diagram part 2	Figure 5.22
Schematic diagram part 3	Figure 5.22a

Principle of operation

The primary of the power supply is designed to double insulation requirements for added safety. Depending on model there is either one (100-120 V countries) or two (220-240 V countries) fuses. The primary operating voltage is factory selected by insulating and folding the unused primary leads inside the additional insulation tube.

The mains transformer is magnetically shielded to minimize screen disturbance.

The power supply board contains basically four DC sources:

- + 5 V switched, for digital circuitry and ACX measuring unit
- + 15 V switched, for motors, pumps and other components.
- +/-15 V for analog amplifiers.

Data retention voltage generation circuit supplies +5 V DRV voltage for memory from switched +5 V supply.

Also, +12 V/1 A for the CRT unit and serial drivers/receivers is derived from the +15 V switched voltage. The -12 V for the serial I/O is derived from -15 V.

The +5 V for the infrared lamp is controlled by the ACX measuring board via the LAMP ON signal, which cuts the lamp power in case of a stalled optical chopper wheel or a missing timing signal.

The gas sampling pump is driven by a 50 Hz/15 V/0.4 A square wave signal generated by the CPU.

In addition to the power supply functions the board contains drivers for two serial channels (including the modem control signals CTS and RTS), a RESET control, which generates a 200 ms reset pulse to the CPU if the +5 V line goes below 4.75 V, and miscellaneous I/O functions like a buzzer driver. Some signals from the mother board are passed directly to the rear panel connectors.

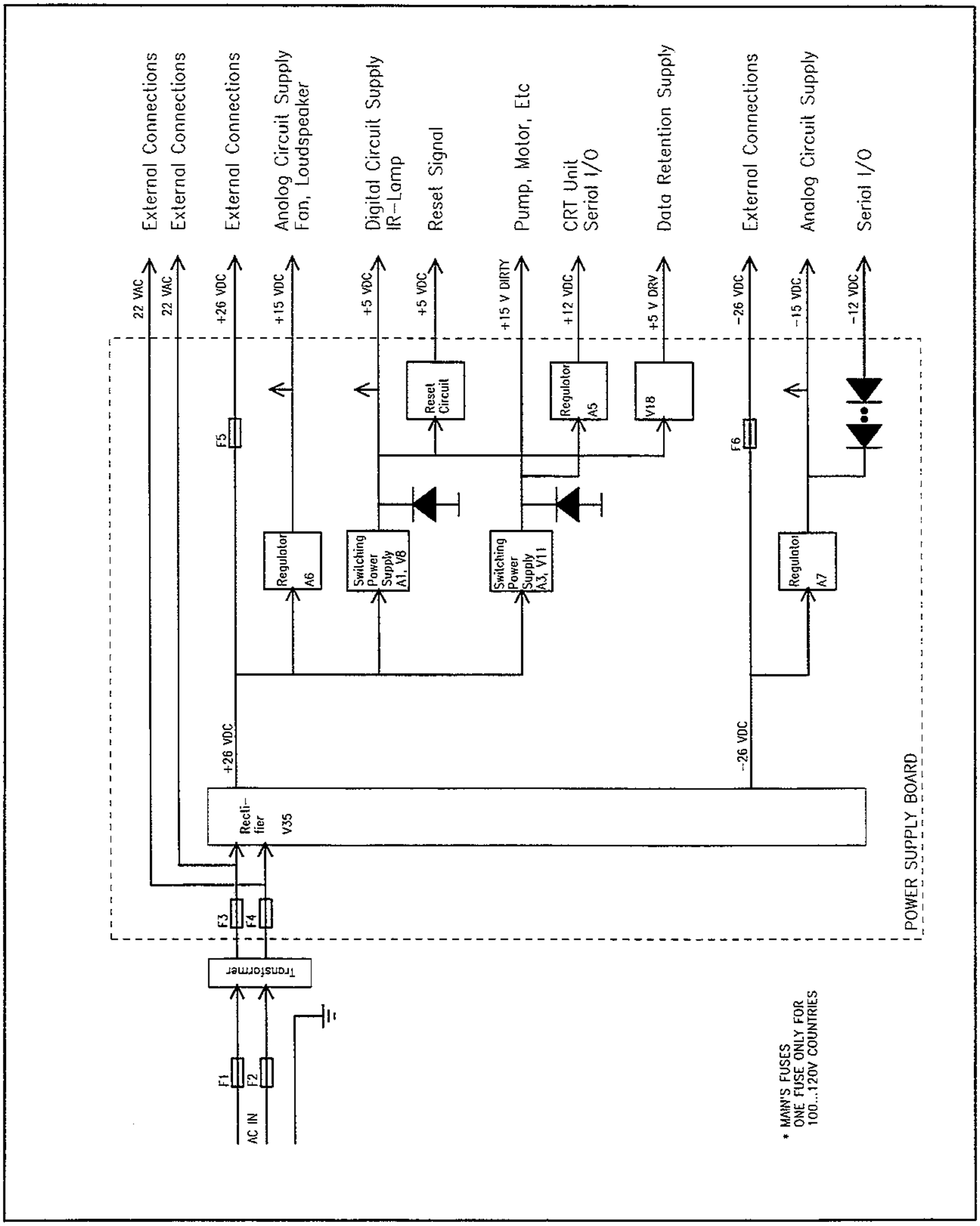
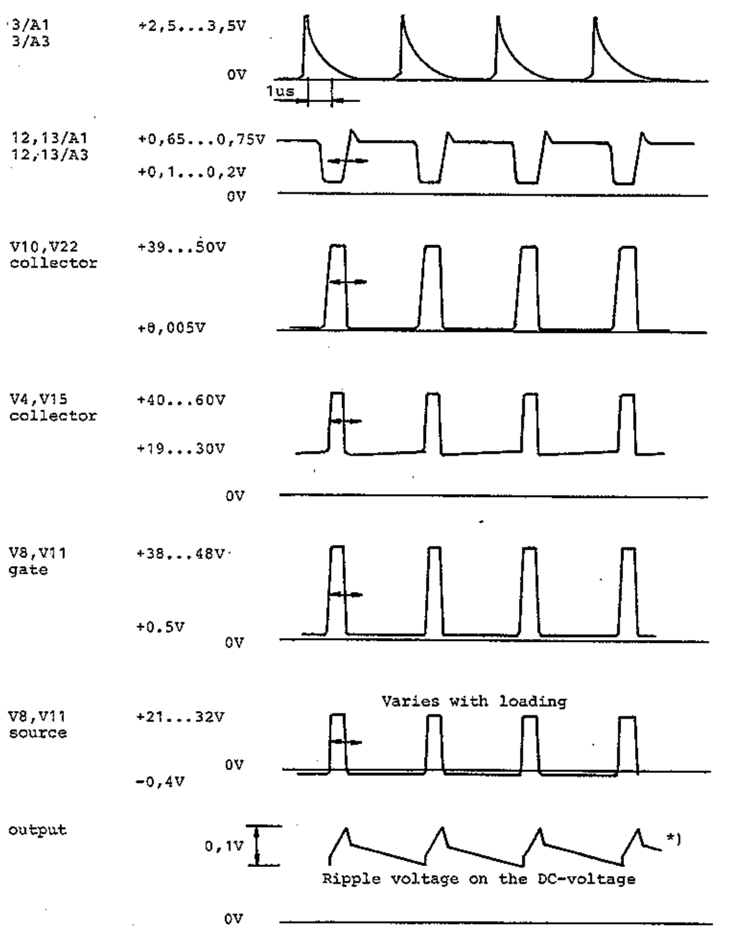


Figure 5.20 Power supply board block diagram and transformer diagram

Figure 5.21 **Power supply board signal waveforms and schematic diagram part 1 (board modification level 3 and higher)**



*) The ripple on the 12V voltage may be higher because of the uneven loading

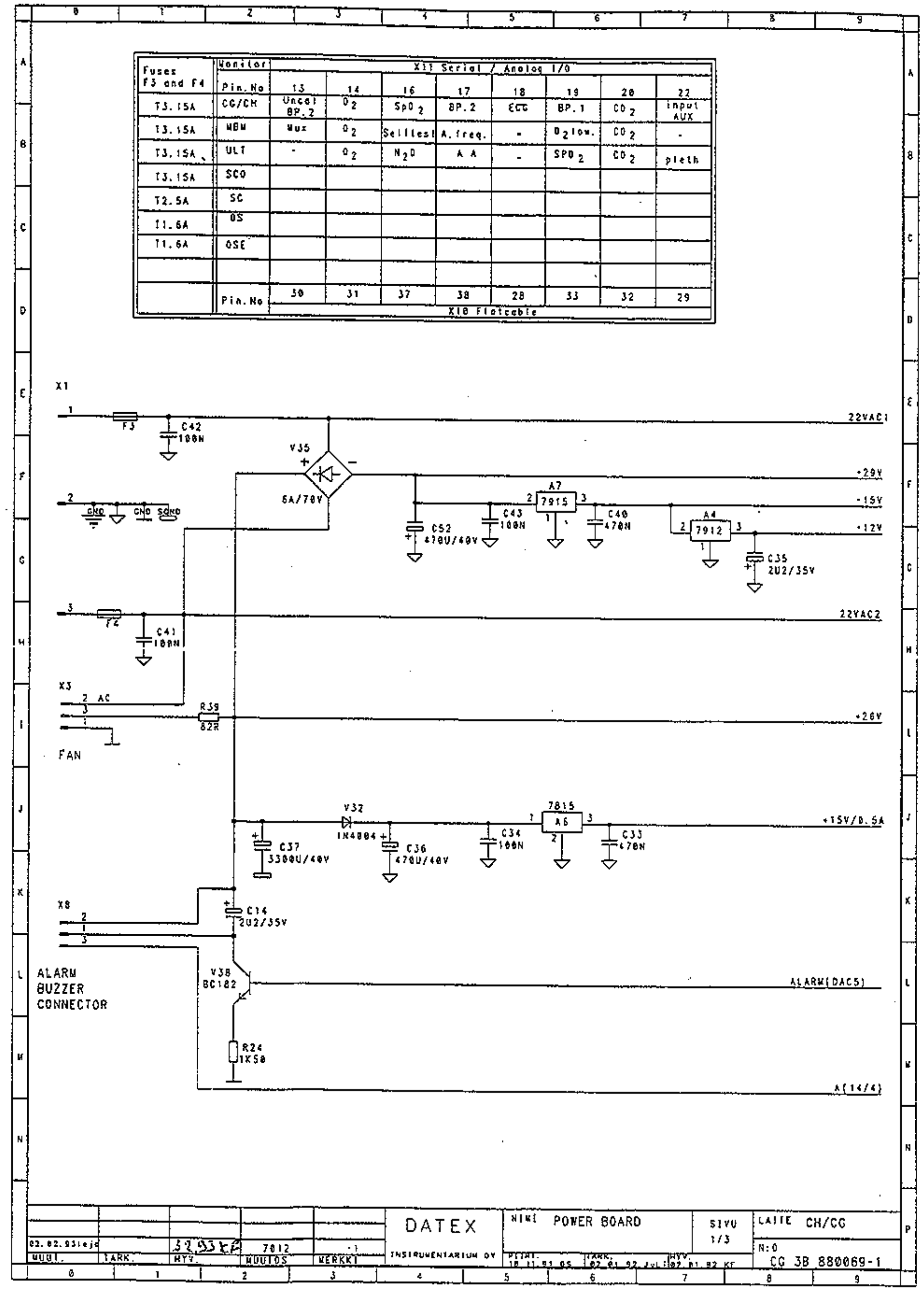
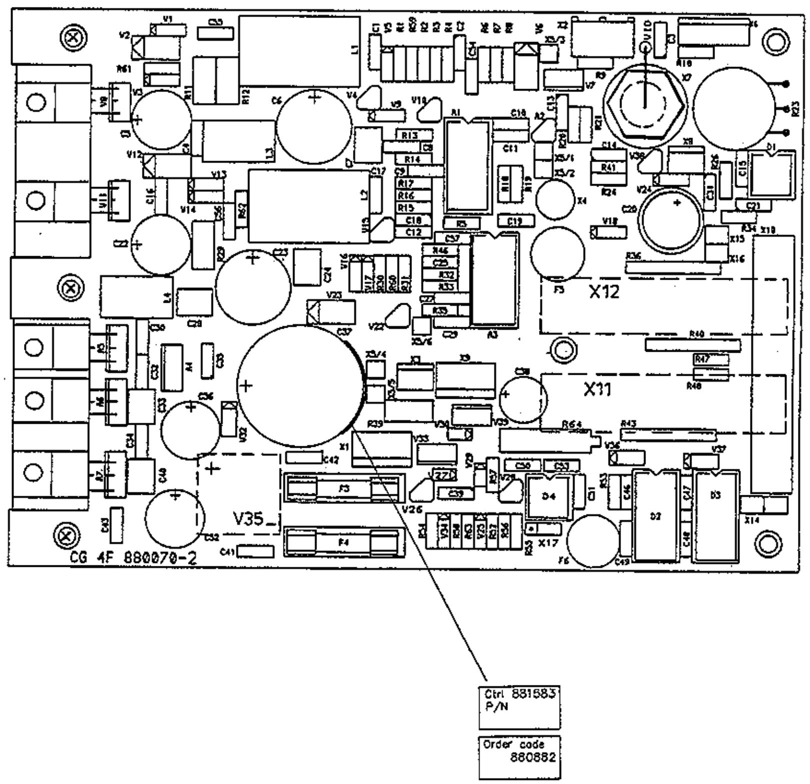


Figure 5.22 Power supply board parts layout and schematic diagram part 2 (board modification level 3 and higher)



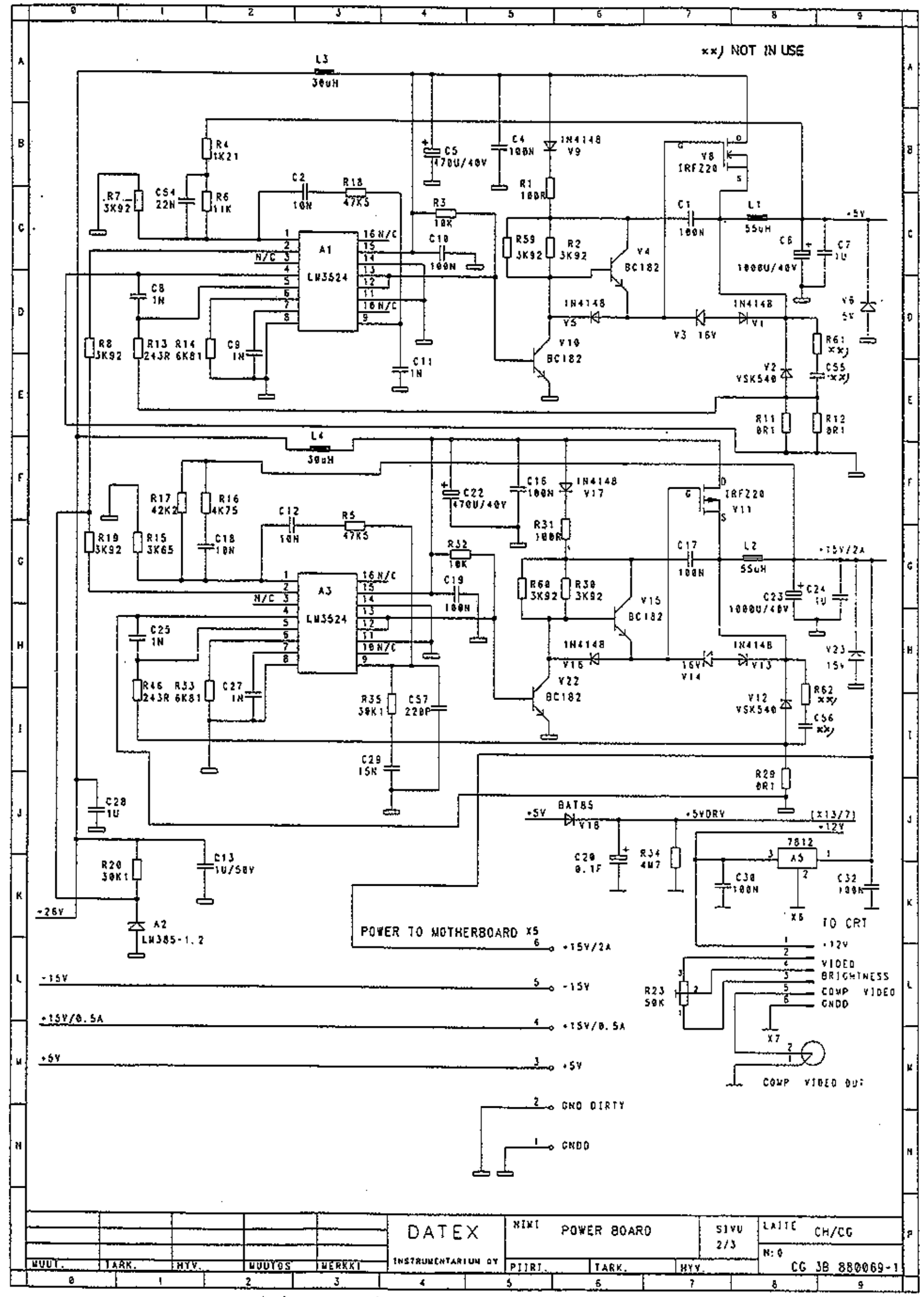
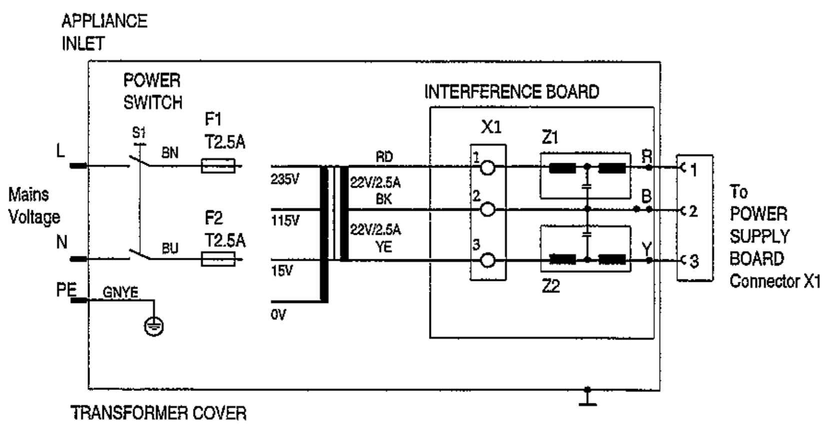
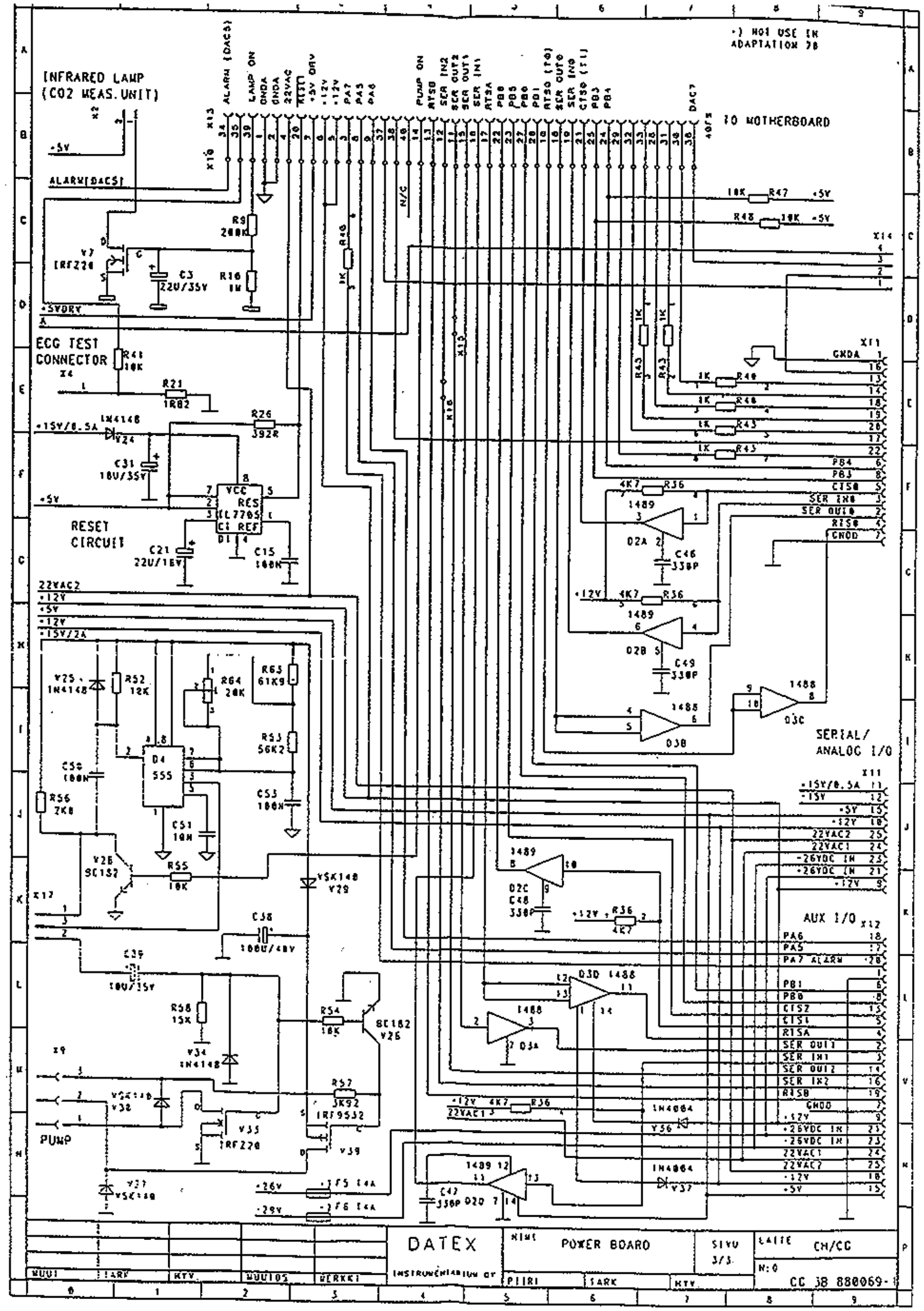


Figure 5.22a Transformer diagram and schematic diagram part 3 (board modification level 3 and higher)



ADAPTIONS	WIRING
22, 33, 40, 43	BN to 235V, BU to 0V
27, 28, 29	BN to 115V, BU to 0V
31	BN to 115V, BU to 15V



5.9 Mother board

Parts layout and schematic diagram **Figure 5.23**

The mother board contains mainly the system bus interconnections and connectors. Also on the board are power bypass capacitors and driver transistors for the sampling system magnetic valves (gas zero and pressure valves).

For signals in each bus, see the Tables in Section 5.12.

5.10 Keyboard

Parts layout and schematic diagram **Figure 5.24**

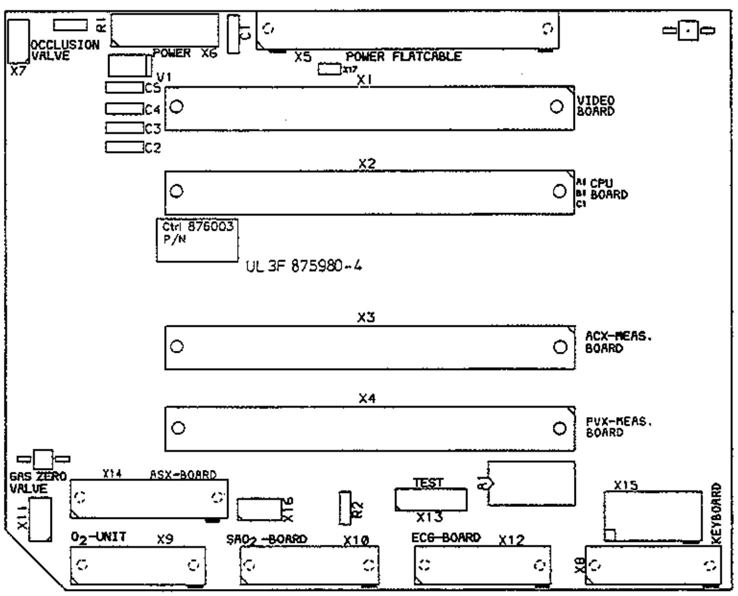
The keypad pc board is a simple 4x4 matrix which is scanned by the keyboard controller on the CPU board.

5.11 Loudspeaker unit

Parts layout and schematic diagram **Figure 5.25**

Audible alarms and beeps are generated by a separate loudspeaker unit. It contains an 8 ohm/0.4 W speaker and the associated driving circuitry.

Figure 5.23 Mother board parts layout (board modification level 4 and lower)



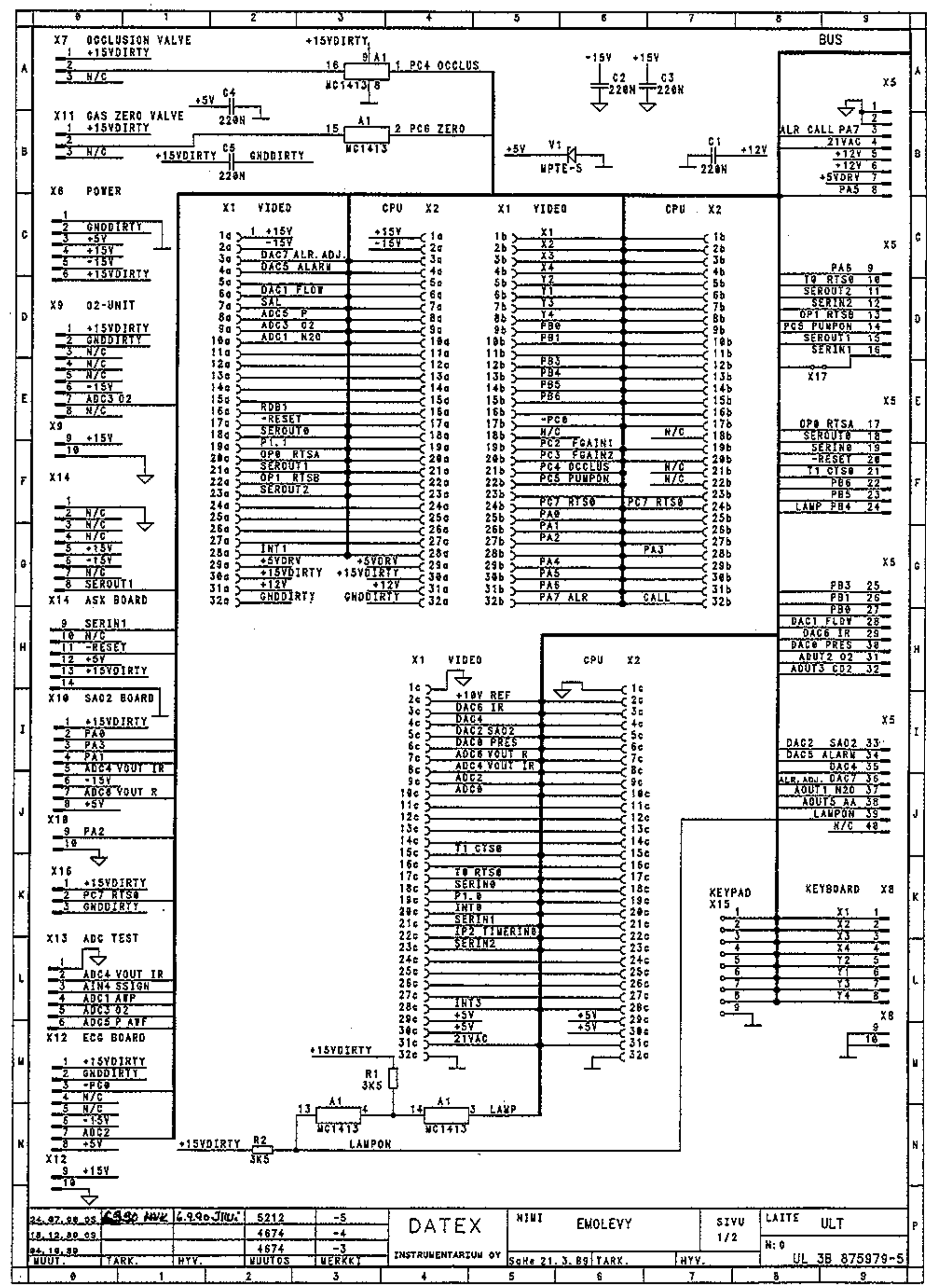


Figure 5.23a Mother board schematic diagram (board modification level 4 and lower)

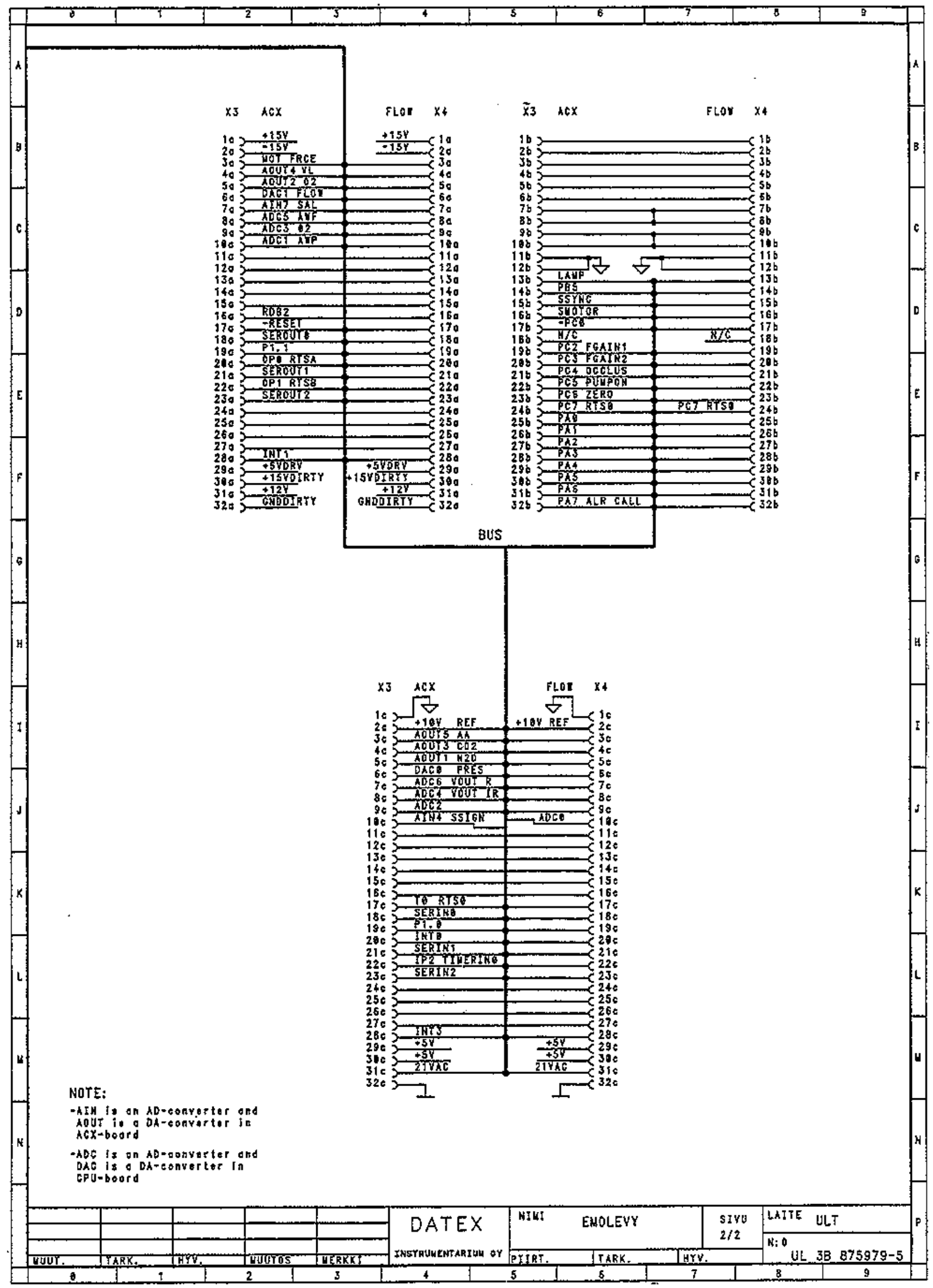
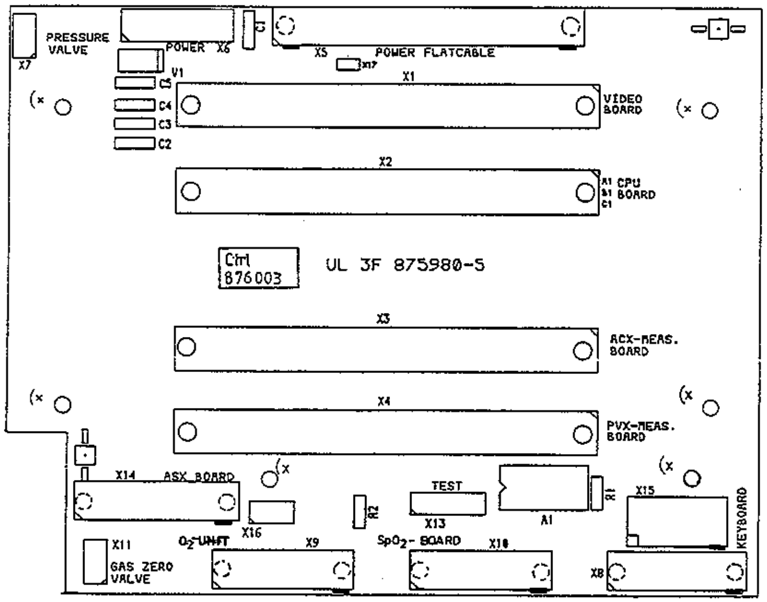


Figure 5.23b Mother board parts layout and schematic diagram part 1 (board modification level 5 and higher)



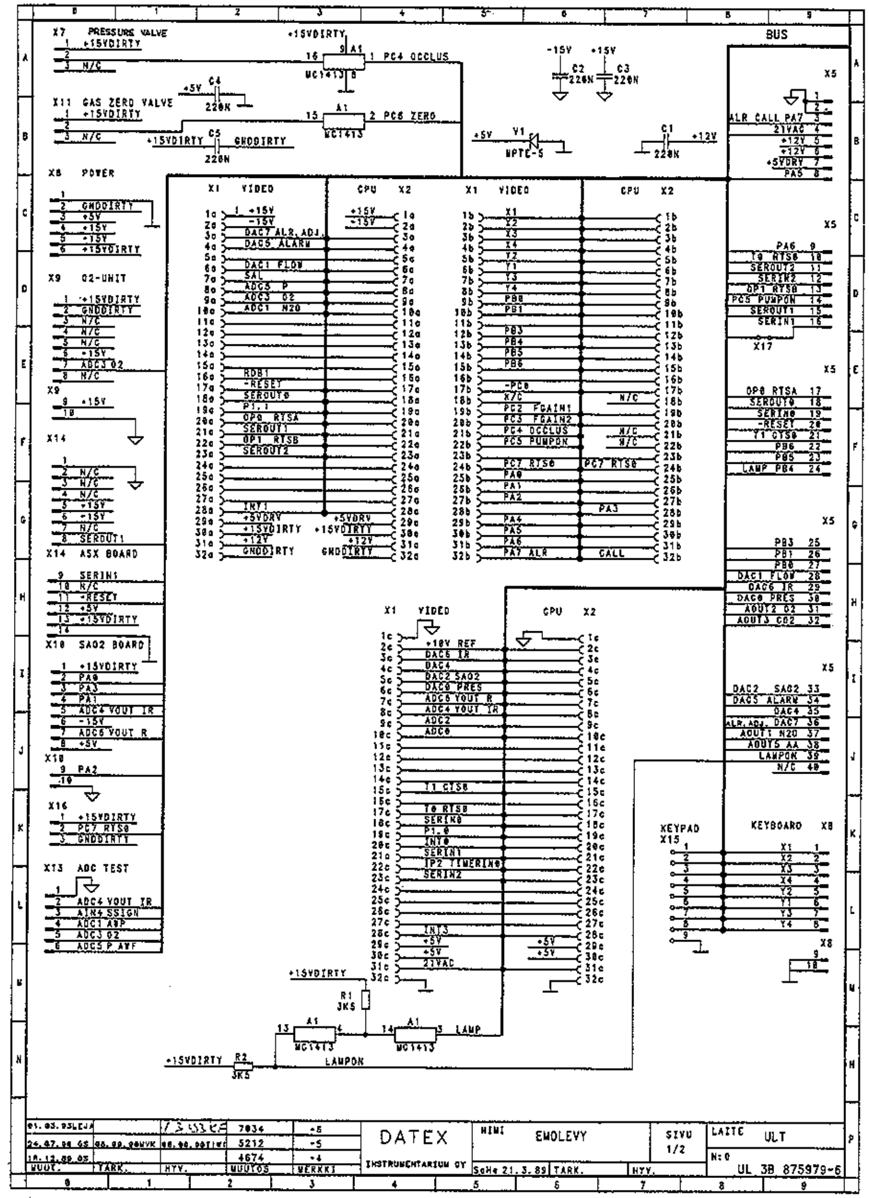


Figure 5.23c Mother board schematic diagram part 2 (board modification level 5 and higher)

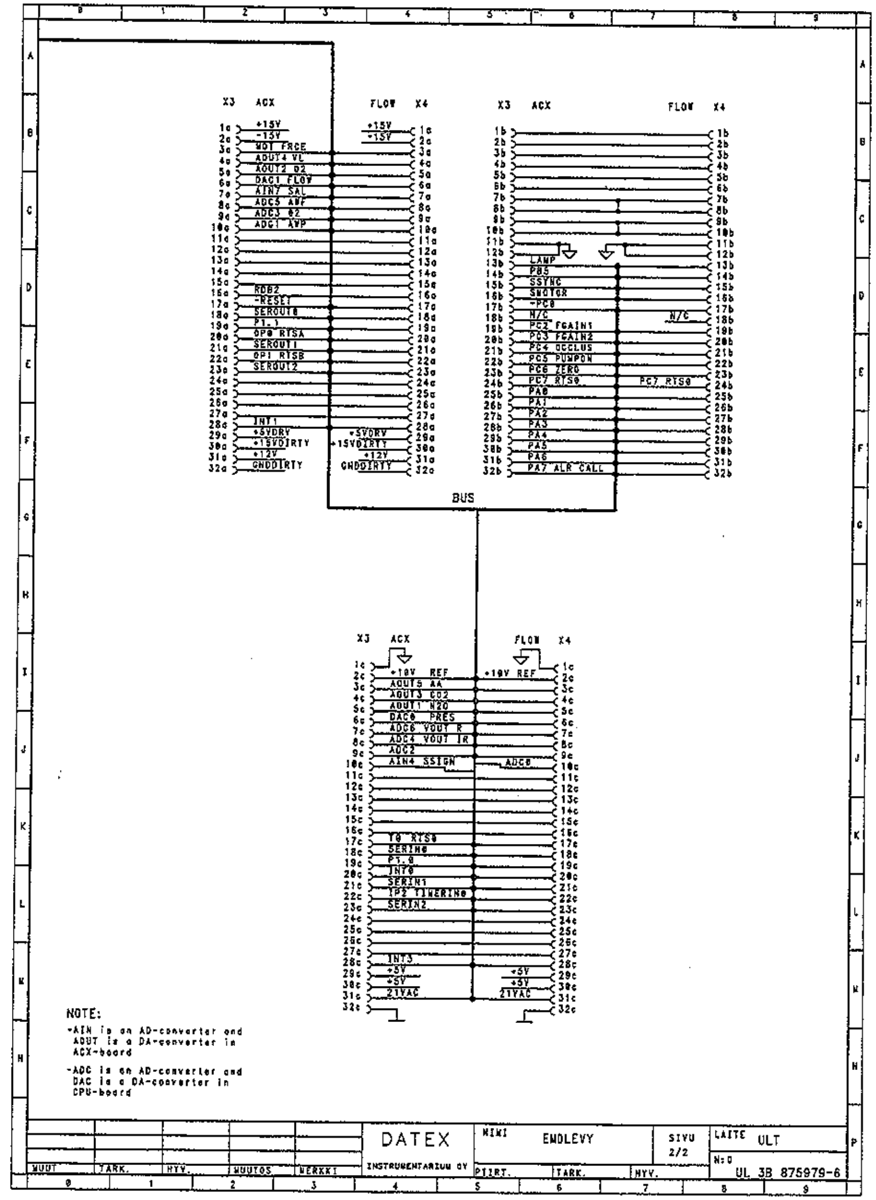
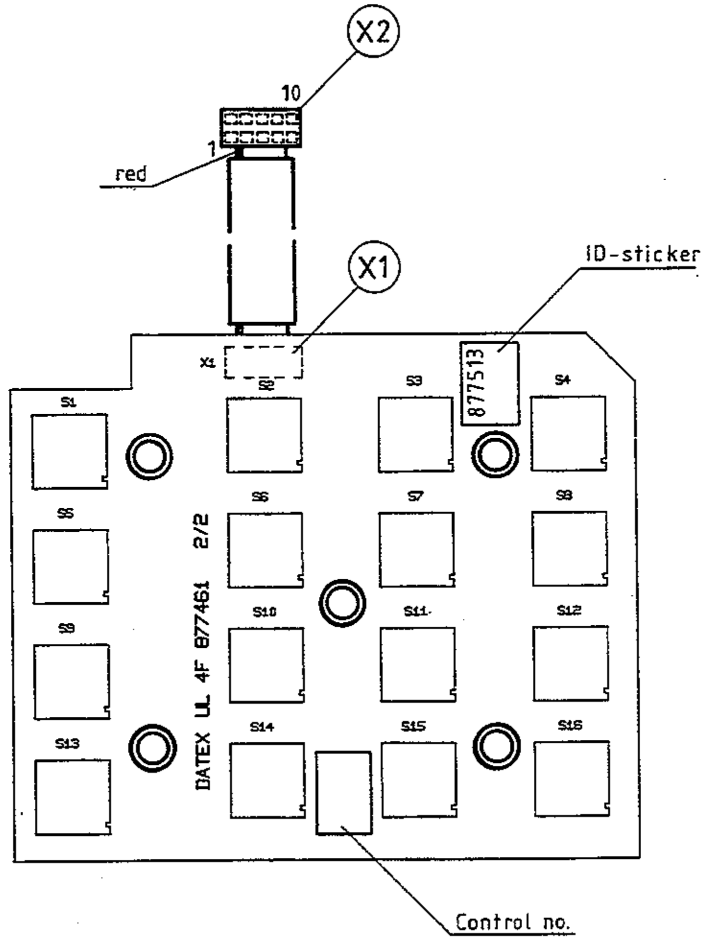


Figure 5.24 Keyboard parts layout and schematic diagram (board modification level 0 and higher)



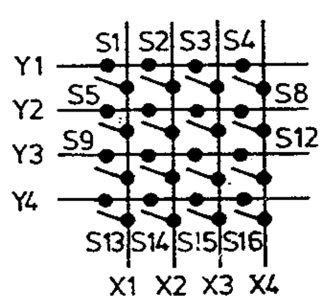
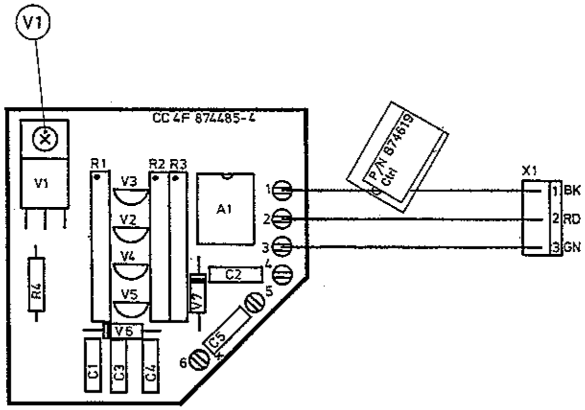
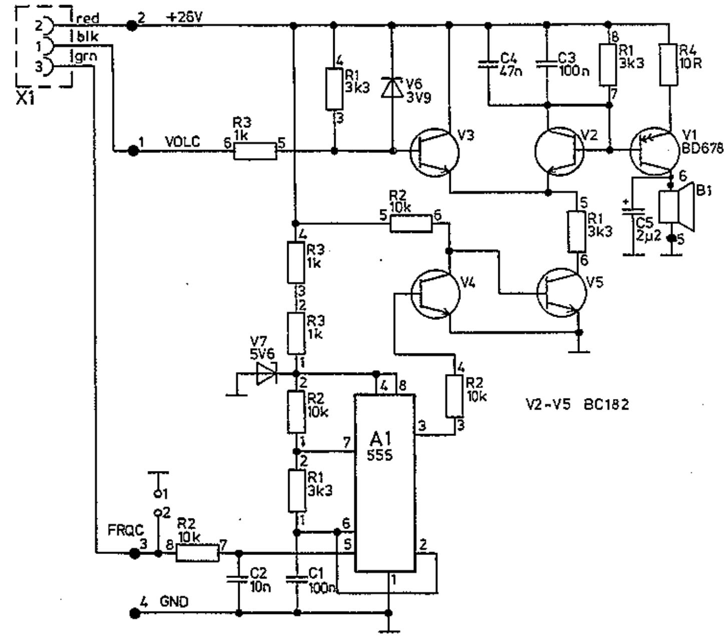


Figure 5.25 Loudspeaker unit parts layout and schematic diagram (board modification level 4 and higher)





5.12 Internal connector configurations

Table 5.3 Video control board (X1) - Mother board (X1)

Pin No.	a	b	c
1	NC	NC	NC
2	NC	NC	NC
3	NC	NC	NC
4	NC	NC	NC
5	NC	NC	NC
6	NC	NC	NC
7	NC	NC	NC
8	NC	NC	NC
9	NC	NC	NC
10	NC	NC	NC
11	A7	NC	A6
12	A5	NC	A4
13	A3	NC	A2
14	A1	NC	A0
15	-10RQ	NC	NC
16	-RD	NC	NC
17	NC	NC	NC
18	NC	NC	NC
19	NC	NC	NC
20	NC	NC	INT0
21	NC	NC	NC
22	NC	NC	NC
23	NC	NC	NC
24	D7	NC	D6
25	D5	NC	D4
26	D3	NC	D2
27	D1	NC	D0
28	NC	NC	NC
29	NC	NC	+5 V
30	NC	NC	+5 V
31	NC	NC	NC
32	DGND	NC	DGND

NC = not connected
AIN is an A/D-converter and AOUT is a D/A-converter in ACX board.
ADC is an A/D-converter and DAC is a D/A-converter in CPU board.

Table 5.4 CPU board (X1) - Mother board (X2)

Pin No.	a	b	c
1	+15 V	X1	AGND
2	-15 V	X2	+10 V REF
3	DAC7 ALR ADJ	X3	DAC6 IR
4	DAC5 ALARM	X4	DAC4
5	NC	Y2	DAC2 SpO_2
6	DAC1 FLOW	Y1	DAC0 PRES
7	SAL	Y3	ADC6 VOUT R
8	ADC5 P	Y4	ADC4 VOUT IR
9	ADC3 O_2	PB0	ADC2
10	ADC1 N_2O	PB1	ADC0
11	A7	NC	A6
12	A5	PB3	A4
13	A3	PB4	A2
14	A1	PB5	A0
15	-10RQ	PB6	T1 CTS0
16	RDB1	NC	-WR
17	-RESET	-PC0	TO RTS0
18	SEROUT 0	NC	SERIN0
19	P1.1	PC2 FGAIN 1	P1.0
20	OP0 RTSA	PC3 FGAIN 2	INT0
21	SEROUT1	NC	SERIN1
22	OP1 RTSB	NC	IP2 TIMERIN0
23	SEROUT2	NC	SERIN2
24	D7	PC7 RTS0	D6
25	D5	PA0	D4
26	D3	PA1	D2
27	D1	PA2	D0
28	INT1	PA3	INT3
29	+5 V DRV	PA4	+5 V
30	+15 VDIRTY	PA5	+5 V
31	+12 V	PA6	21 VAC
32	GND DIRTY	PA7 ALR CALL	DGND

NC = not connected
AIN is an A/D-converter and AOUT is a D/A-converter in ACX board.
ADC is an A/D-converter and DAC is a D/A-converter in CPU board.

Table 5.5 ACX measuring board (X1) - Mother board (X3)

Pin No.	a	b	c
1	+15 V	NC	AGND
2	-15 V	NC	+10 V REF
3	AOUT6	NC	AOUT5 AA
4	AOUT4 VL	NC	AOUT3 CO_2
5	AOUT2 O_2	NC	AOUT1 N_2O
6	DAC1 FLOW	NC	DAC0 PRES
7	AIN7 SAL	NC	ADC6 VOUT R
8	ADC5 AWL	NC	ADC4 VOUT IR
9	ADC3 O_2	NC	ADC2
10	ADC1 AWP	NC	AIN4 SSIGN
11	NC	AGND	NC
12	NC	AGND	NC
13	NC	LAMP	NC
14	NC	PB5	NC
15	NC	SSYNC	NC
16	RDB2	SMOTOR	NC
17	-RESET	-PC0	TO RTSO
18	SEROUT 0	NC	SERIN0
19	P1.1	PC2 FGAIN 1	P1.0
20	OP0 RTSA	PC3 FGAIN 2	INT0
21	SEROUT1	PC4 OCCLUS	SERIN1
22	OP1 RTSB	PC5 PUMPON	IP2 TIMERIN0
23	SEROUT2	PC6 ZERO	SERIN2
24	NC	PC7 RTS0	NC
25	NC	PA0	NC
26	NC	PA1	NC
27	NC	PA2	NC
28	INT1	PA3	INT3
29	+5 V DRV	PA4	+5 V
30	+15 VDIRTY	PA5	+5 V
31	+12 V	PA6	21 VAC
32	GND DIRTY	PA7 ALR CALL	DGND

NC = not connected
AIN is an A/D-converter and AOUT is a D/A-converter in ACX board.
ADC is an A/D-converter and DAC is a D/A-converter in CPU board.

Table 5.6 Power supply board (X10) - Mother board (X5)

Pin No.	Signal	Pin No.	Signal
1	AGND	2	AGND
3	PA7 ALR CALL	4	21 VAC
5	+12 V	6	+12 V
7	+5 V DRV	8	PA5
9	PA6	10	T0 RTS0
11	SEROUT2	12	SERIN2
13	OP1 RTSB	14	PC5 PUMPON
15	SEROUT1	16	SERIN1
17	OP0 RTSA	18	SEROUT0
19	SERIN0	20	-RESET
21	T1 CTS0	22	PB6
23	PB5	24	PB4 LAMP
25	PB3	26	PB1
27	PB0	28	DAC1 FLOW
29	DAC6 IR	30	DAC0 PRES
31	AOUT2 O_2	32	AOUT3 CO_2
33	DAC2 SpO_2	34	DAC5 ALARM
35	DAC4	36	DAC7 ALR ADJ
37	AOUT1 N_2O	38	AOUT5 AA
39	LAMPON	40	NC

NC = not connected
AIN is an A/D-converter and AOUT is a D/A-converter in ACX board.
ADC is an A/D-converter and DAC is a D/A-converter in CPU board.

Table 5.7 SpO_2 measuring board (X2) - Mother board (X10)

Pin No.	Signal
1	+15 VDIRTY
2	PA0
3	PA3
4	PA1
5	ADC 4 VOUT IR
6	-15 V
7	ADC 6 VOUT R
8	+5 V
9	PA2
10	AGND

Table 5.8 Keyboard (X1) - Mother board (X8)

Pin No.	Signal	
1	X1	X1 row
2	X2	X2 row
3	X3	X3 row
4	X4	X4 row
5	Y2	Y2 column
6	Y1	Y1 column
7	Y3	Y3 column
8	Y4	Y4 column
9	GND	
10	GND	

Table 5.9 O_2 measuring unit - Mother board (X9)

Pin No.	Signal
1	+15 VDIRTY
2	GND DIRTY
3	NC
4	NC
5	NC
6	-15 V
7	ADC3 O_2
8	NC
9	+15 V
10	AGND

Table 5.10 Gas zero valve - Mother board (X11)

Pin No.	Signal
1	+15 VDIRTY
2	ZERO SIGNAL
3	NC

Table 5.11 Power supply board - Mother board (X6)

Pin No.	Signal
1	DGND
2	GND DIRTY
3	+5 V
4	+15 V
5	-15 V
6	+15 VDIRTY

Table 5.12 Pressure valve - Mother board (X7)

Pin No.	Signal
1	+15 VDIRTY
2	OCCLUS SIGNAL
3	NC

Table 5.13 Mother board test connector (X13)

Pin No.	Signal
1	AGND
2	ADC4 VOUT IR
3	AIN4 SSIGN
4	ADC1 AWP
5	ADC3 O_2
6	ADC5 P AWF

Table 5.14 Video control board (X2) - Video unit main pc board (X13)

Pin No.	Signal
1	GND
2	Comp. Video signal
3	Video
4	HSYNC
5	VSYNC
6	GND

Table 5.15 ACX measuring board (X2) - Preamplifier board (X1)

Pin No.	Signal
1	AGND
2	Signal IN, OUT
3	EEPROM CLB (dark)
4	Temp IN, OUT
5	+15 V
6	-15 V
7	SYNC IN, OUT
8	EEPROM R
9	EEPROM WRB
10	EEPROM 2CS (clear)
11	MOTOR B
12	+5 V
13	+15 VDIRTY
14	DGND

Table 5.16 Front panel SpO_2 connector - SpO_2 measuring board (X1)

Pin No.	Signal
1	Is
2	Ib
3	NC
4	Probe identification
5	Probe identification
6	Ground
7	Iled
8	Vb (-4 ±0.3 V)
9	Ground
0	+12 Vp

Table 5.17 Power supply board (X1) - Line transformer

Pin No.	Signal	
1	22 VAC	secondary voltage of
2	GND	the line transformer and
3	22 VAC	ground

Table 5.18 Power supply board (X2) - IR lamp

Pin No.	Signal	
1	+5 VDC	voltage for IR-lamp
2	Lamp ON/OFF	

Table 5.19 Power supply board (X3) - Fan

Pin No.	Signal	
1	GND	
2	NC	
3	+26 V	supply voltage for fan

Table 5.20 Power supply board (X6) - Video unit main pc board

Pin No.	Signal
1	+12 V
2	Video brightness control
3	Video brightness control
4	Video brightness control
5	Comp video
6	DGND

Table 5.21 Power supply board (X8) - Loudspeaker

Pin No.	Signal
1	DAC5 ALARM
2	+26 V power for loudspeaker
3	DAC7

Table 5.22 Power supply board (X9) - Pump

Pin No.	Signal
1	PUMP ON SIGNAL
2	NC
3	+15 VDIRTY supply voltage for pump

5.13 PVX board

Block diagram and schematic diagram part 1	**Figure 5.26**
Parts layout and schematic diagram part 2	**Figure 5.27**

> **NOTE:** Pressure transducers B1, B2, and EEPROM D4 are replaced only at the factory.

> **NOTE:** Never apply overpressure or negative pressure of more than 300 cmH_2O to the flow and volume tubing.

The board is intended to perform the following tasks

- Measure the pressures in airways and the speed of breathing flow.
- Calculate tidal volume, minute volume, compliance and other useful information on a patient lungs.

Pressure transducers

There are two pressure transducers on the PVX board for airway pressure measuring purpose.

The breathing flow of a patient passing through D-LITE™ creates pressure difference. This pressure difference is measured by pressure transducer, B1. Overpressure and negative pressure in airways are measured by another pressure transducer B2.

Signal amplification

After the transducer B2 the PRESS-signal is sent to differential amplifier A6, whose gain is 375, which contains low pass filter suppressing signals over 31 Hz. Then the signal is sent to the multiplexer A9 through voltage follower A7.

After the transducer B1 the FLOW-signal is sent to differential amplifier, A5 and A4, whose gain is 27 and which contains low pass filter where signals over 30 Hz are suppressed. After the filter the signal is fed to another amplifier A3, whose gain is 11 and who contains a low pass filter which suppresses signals over 48 Hz. From this point the signal (FLOW0) goes two different ways: one goes straight to the multiplexer A9 (FLOW0). Another goes yet to the third amplifier A3, whose gain is 11 and which contains a low pass filter of 72 Hz. This sensitive signal (FLOW1) is also sent to the multiplexer A9.

Temperature compensation

Temperature is measured by B1. The signal TEMP is sent to the multiplexer A9 via A7. This signal is used only for temperature compensation of the pressure transducer B1 on the PVX board.

Data processing

After the multiplexer A9, the signals, PRESS, FLOW0, FLOW1, and TEMP are A/D converted in A2 for data processing.

Signal output

D/A converter A1 converts digital data to analog form. The one half of the multiplexer A9 multiplexes the analog output to PRESS, FLOW, and VOL signals after the voltage follower A8.

Transducer offset control

One signal (DAC3) from the multiplexer A9 is used by software to control offset voltage of the pressure transducer B1.

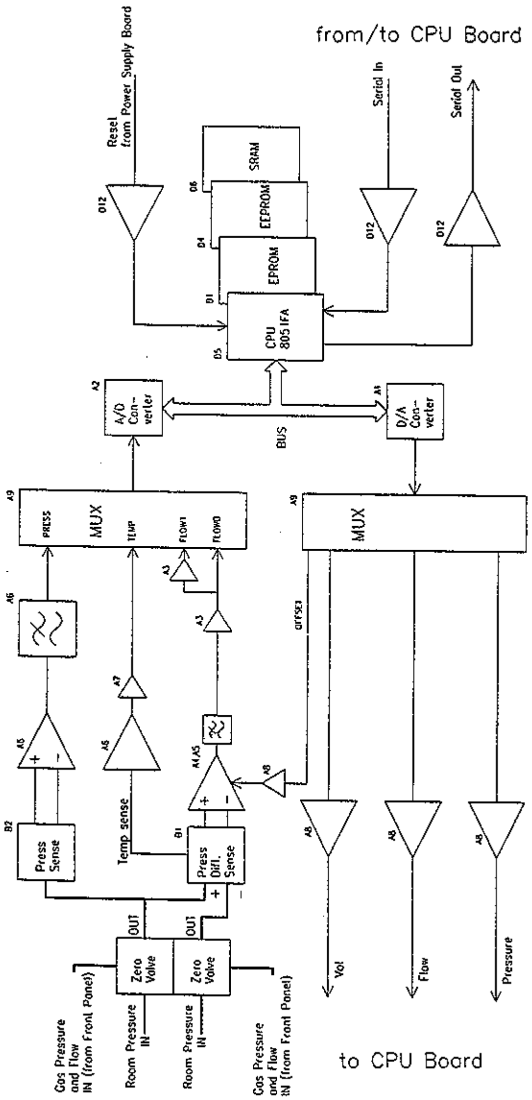
External communication

Communication between the PVX board and the CPU board is established in serial form, using the serial channel (pins 10 and 11) of CPU D5 on the PVX board. These channels are buffered by GAL IC D12. Address decoding is also realized by D12.

Test point signals

X2	1	FIN	X3	1	10 VREF
	2	PR		2	TP2
	3	FLOW1		3	-10 VREF
	4	FLOW0		4	B3

Figure 5.26 PVX board block diagram and schematic diagram part 1(board modification level 2 and higher)



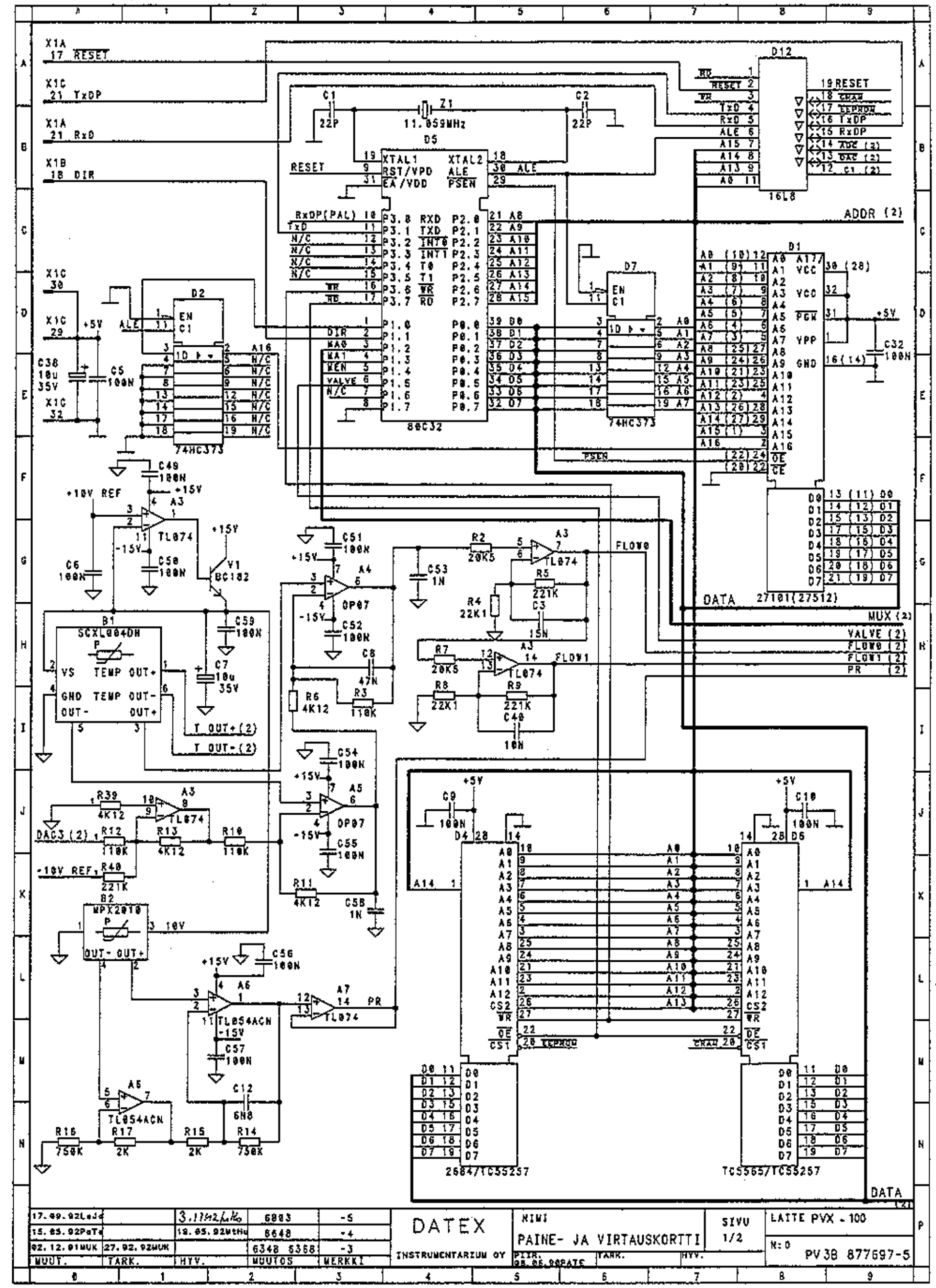
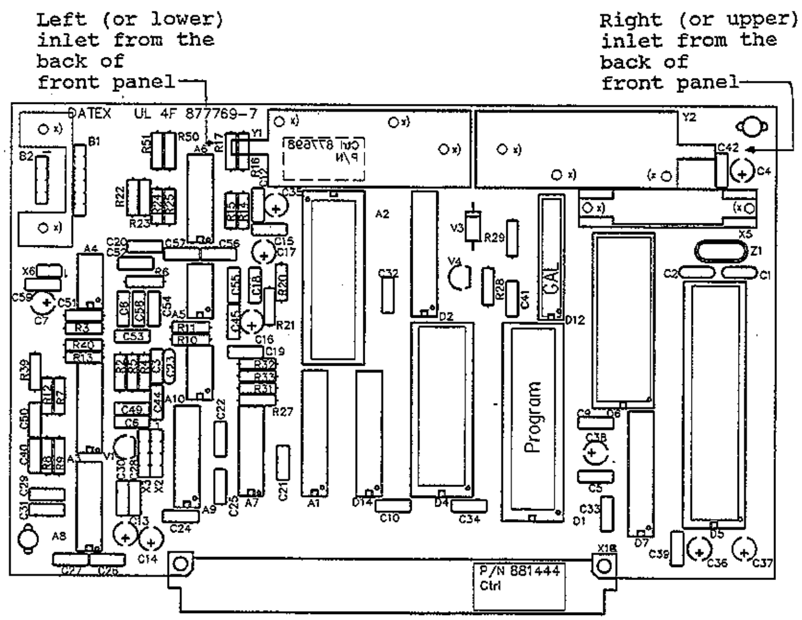


Figure 5.27 PVX board parts layout and schematic diagram part 2 (board modification level 2 and higher)



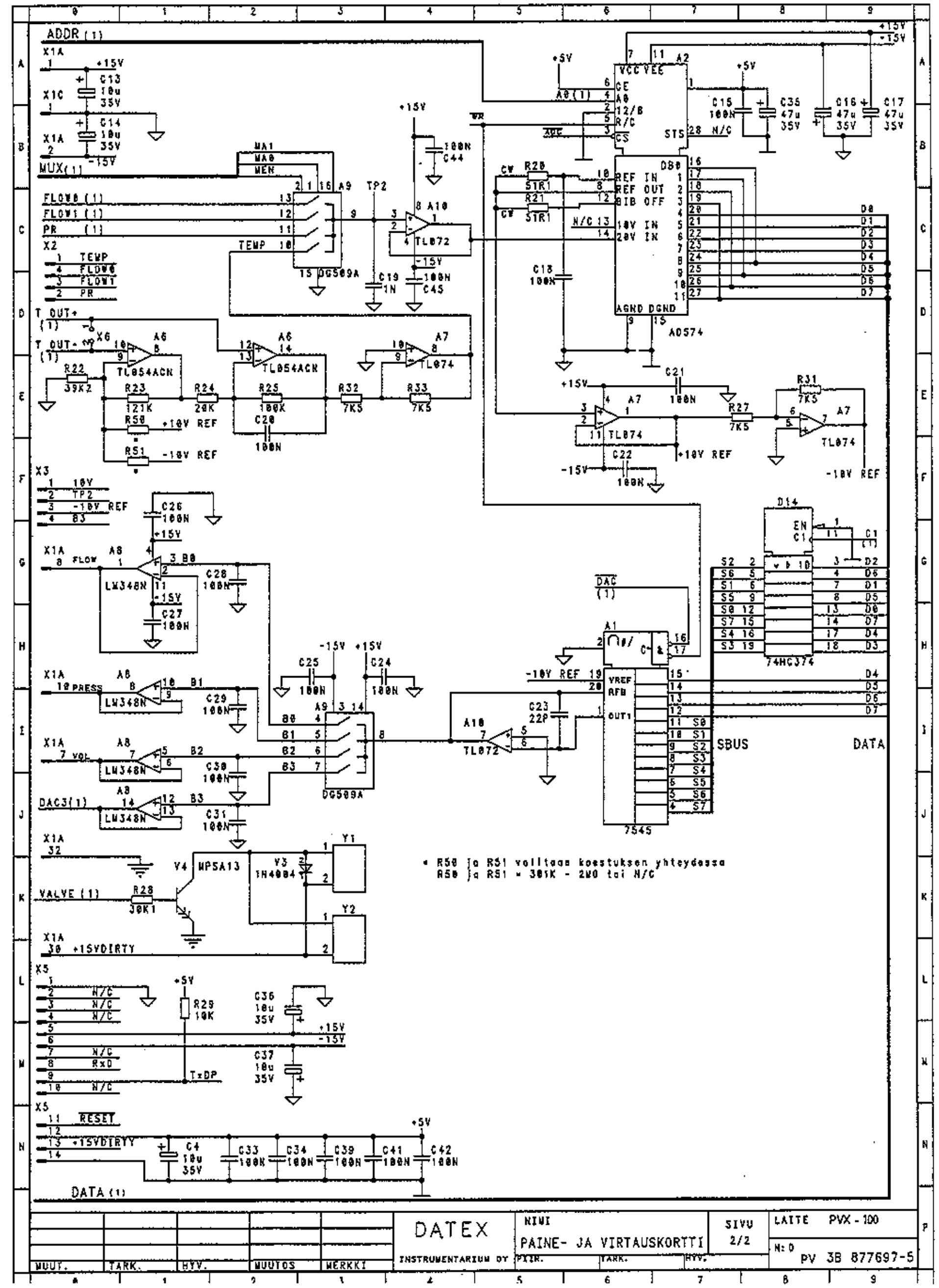
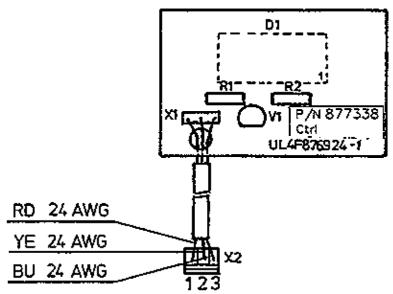


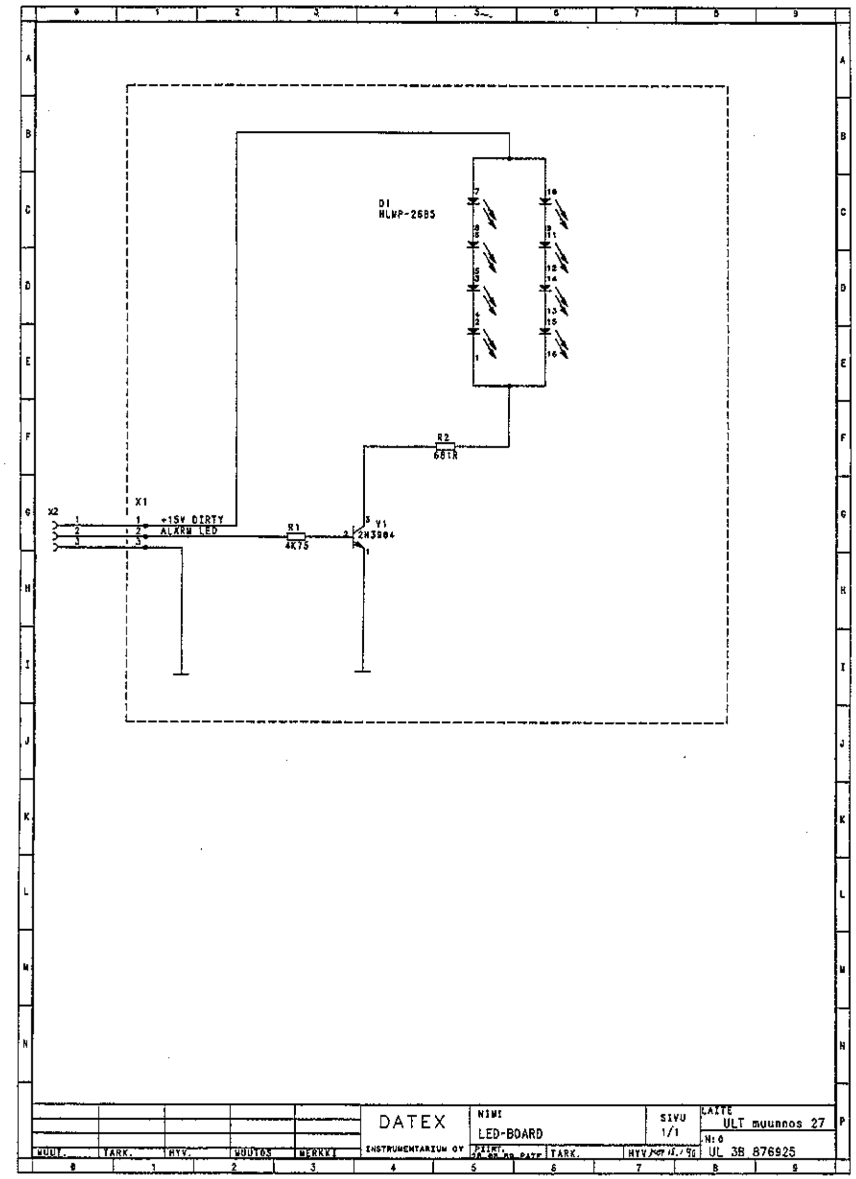
Table 5.23 PVX board (X1) - Mother board (X4)

Pin No.	a	b	c
1	+15 V	NC	AGND
2	-15 V	NC	+10 VREF
3	NC	NC	NC
4	NC	NC	NC
5	NC	NC	NC
6	DAC1 FLOWY	NC	DAC0 PRES
7	VOL	NC	NC
8	FLOW	NC	NC
9	NC	NC	NC
10	PRESS	NC	NC
11	NC	NC	NC
12	NC	NC	NC
13	NC	NC	NC
14	NC	NC	NC
15	NC	NC	NC
16	NC	NC	NC
17	-RESET	NC	NC
18	NC	DIR	NC
19	NC	NC	NC
20	NC	NC	NC
21	RxD	NC	TxDP
22	NC	NC	NC
23	NC	NC	NC
24	NC	NC	NC
25	NC	NC	NC
26	NC	NC	NC
27	NC	NC	NC
28	NC	NC	NC
29	NC	NC	+5 V
30	+15 VDIRTY	NC	+5 V
31	NC	NC	NC
32	GND DIRTY	NC	DGND

Figure 5.28 LED board parts layout and schematic diagram (board modification level 1 and higher)

NOTE: This board is included in adaptation -27 monitors only.





5.14 Agent Identification

5.14.1 ASX Agent Identification Bench

Agent identification is accomplished by using special properties of optics and filters that allow the unique waveform patterns of each anaesthetic agent to be "drawn" into memory. This "drawing" is compared with data in the software algorithm from which identification can be made and displayed.

IR light is emitted from a light source into a long single measurement chamber. After passing through the measurement chamber, the light passes through a rotating quarter wavelength interference filter. This filter has a bandwidth of approximately 17 nM. The filter is rotated in such a manner that the angle that the light approaches it changes. As the angle changes, the wavelength of the IR light that is allowed to pass through the filter changes. 30 samples of the signal are taken of the signal during the first 90 degrees rotation. The process is repeated during the second 90 degrees of rotation so that a mirror image is created. This provides a confirmation of the measurement before identification is made by the software.

Timing used for control of the sampling process, is initiated with a sync. pulse that is produced once per revolution of the filter.

When the ACX-200 is zeroed, the ASX bench measures the background spectrum (room air). During normal measurement, ASX subtracts the background spectrum from the measurement spectrum, then identification is made.

The ASX bench consists of the following major components:

- IR lamp
- single measurement chamber
- filter assembly driven by a DC motor
- a preamp board that includes the photo detector and preamplifier
- a processor (ASX) board

The ASX assembly is pneumatically installed after the ACX-200 bench and in parallel with the OM oxygen sensor (see pages 5-3 and 5-5).

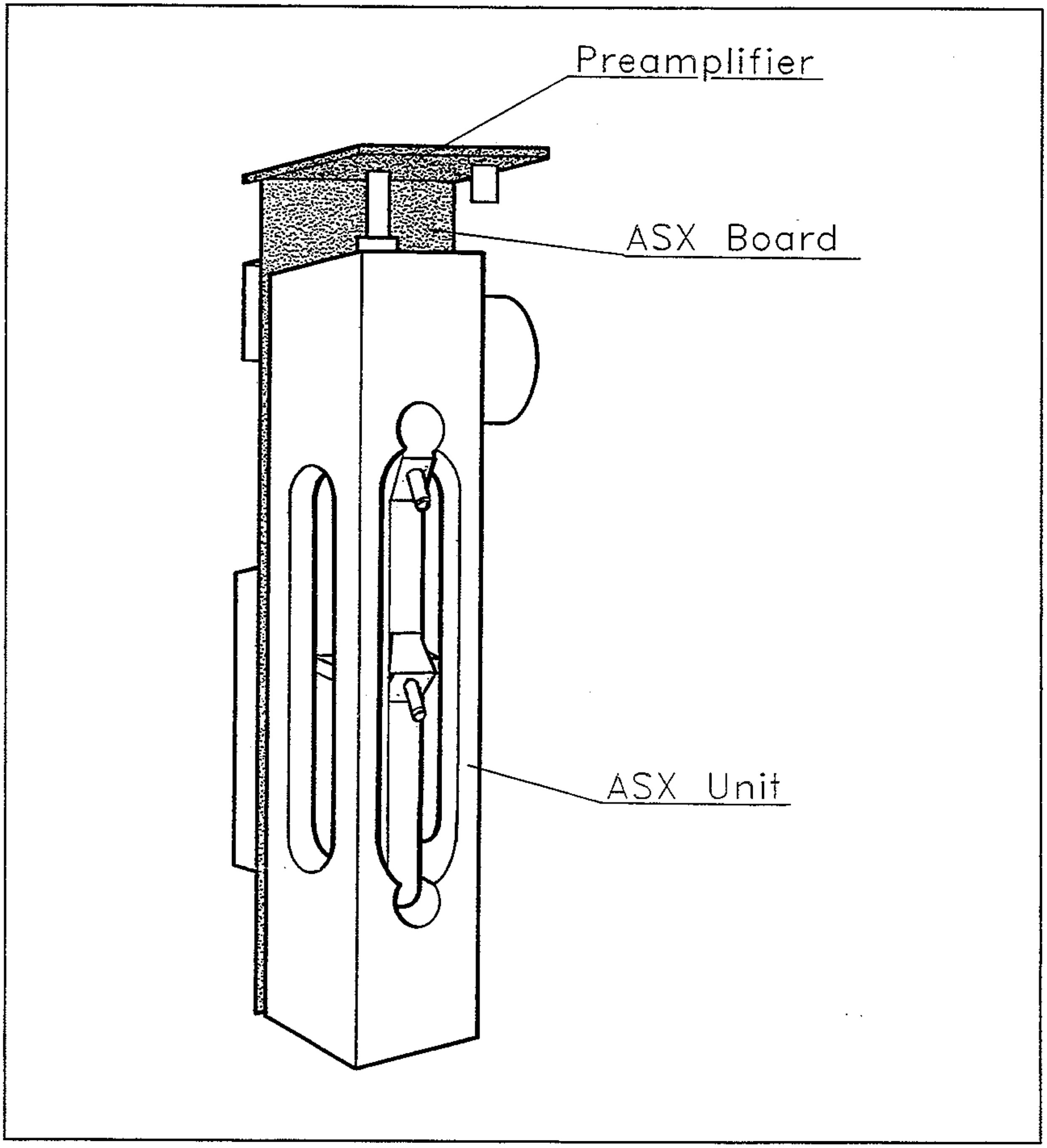


Figure 5.29 ASX Agent identification benches

5.14.2 ASX preamplifier board

The absorption of infrared light is measured with a lead selenide detector R1. The signal is amplified with A1 and then led to the measuring board.

5.14.3 ASX board

The measuring electronics can be divided into a few functional blocks, which are described below (See the block diagram).

The ASX board controls gas measurements. It converts the ASX photometer signal to digital data, calculates results and communicates with the main CPU through a serial channel. The board contains, in addition to the 80C196 processor, EPROM, RAM, and EEPROM, several analog and digital I/O functions.

Processor section

Processor D2 is a 80C196 and works at 12 MHz. It has an internal A/D-converter with a multiplexer. One channel is used for converting temperature signal. Two others are for the measurement signal from preamplifier board.

The processor uses an internal bus to access EPROM D7 (64k x 8bit), SRAM D6 (8k x 8bit) and two D/A-converters. It communicates with the main CPU through a serial channel (RXD,TXDB).

EEPROM D5 is a 64 x 16 bit serial chip. It is partly protected so that if jumper X1 is installed the processor can erase or write the protected registers by serial communication commands. The protected section contains permanent factory calibrations.

Sync-pulse

Sync-pulse is detected with a reflectance sensor A1. A2a converts the output current of the isolator to negative voltage pulse. Its peak voltage is charged to C2. Output of A2b changes from -13 V to +13 V when the pulse's voltage exceeds half of the peak voltage.

The pulse is modulated to TTL-level (5 V pulse) in V1.

V22 controls the LED current in the optical isolator so that the amplitude of the pulse stays constant.

Signal processing

The signal is sent to a low-pass filter and then to adjustable amplifier which consists of D1 and A3b.

Bias voltages

Supply voltages of +15 V and -15 V are first regulated by A6 and A8 to +12 V and -12 V to prevent interference in the supply voltages from disturbing the bias voltages. Frequency of A7 oscillator is 200 KHz and amplitude 24 V. When its output is -12 V, C19 is charged up to 24 V. When the output goes up to +12 V, C19 is discharged and charges C20 via diode V15. Thus C20 is charged to about +34 V (12 V + 24 V - threshold voltage of V15). Correspondingly C23 is charged to about -34 V.

Resistors R32 and R35 are both for short-circuit protection and a part of low-pass filter with C6 and C7 on the preamplifier board.

Motor control

The motor is driven by DC voltage generated by D/A converter D8 and operational amplifier A9.

The output of D8 is between 0 to -5 V. With A9b the voltage is inverted to between 5.4 to 7.7 V, suitable to drive the motor. V 20 is an emitter-follower which buffers the output of the operational amplifier.

Temperature measurement

Temperature is measured by diode V6 whose threshold voltage changes 6 mV per one degree °C. The signal is amplified by A3d to get suitable level (0 to 5 V) for A/D converter. Diode V7 protects the A/D converter input.

Test point signals

Connector X4 on the board is for test purpose. Note that pin 1 is TP6 and vice versa.

X4	1	TP6	A/D reference, A4
	2	TP5	Motor voltage
	3	TP4	signal after AGC
	4	TP3	Temperature
	5	TP2	Sync pulse
	6	TP1	Sync test input

5.14.4 Signal processing

As the filter rotates the wavelength allowed through the filter changes. The 30 samples are taken at predetermined time intervals after the synchronizing pulse. Each time represents a certain angle and these angles correspond to the required wavelengths.

The time intervals are determined during calibration.

The samples are then linearized. After that the background spectrum is subtracted. Background is measured during the zeroing of ACX and ASX.

In ASX-100, the linearized spectrum is scaled to the same scale as the stored reference spectra of each anaesthetic agent. By comparing the measured spectrum to the reference spectra, the anaesthetic agent is identified. A low squared error value indicates that the measured agent corresponds to that reference spectrum.

In ASX-200, the concentrations of individual agents in a mixture are calculated using the reference spectra.

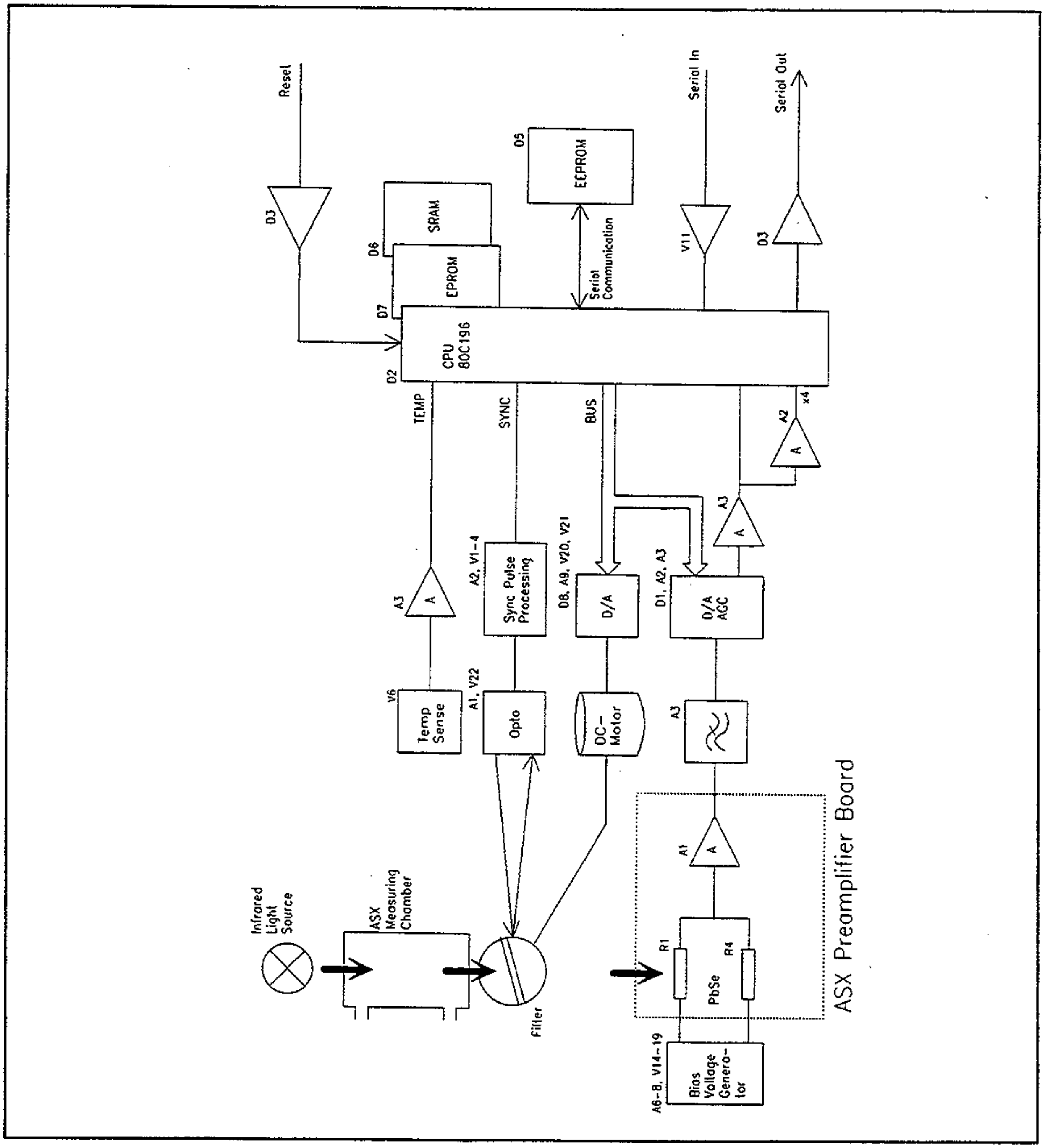


Figure 5.30 ASX board block diagram

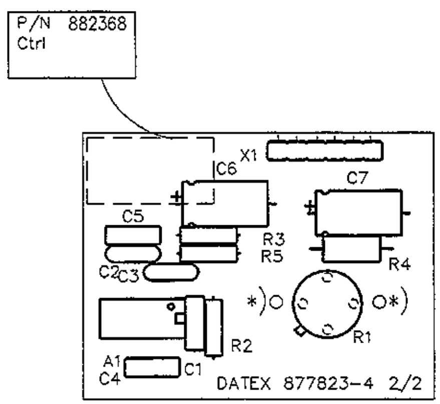
Table 5.24 ASX preamplifier board (X1) - ASX board (X2)

Pin No.	Signal
1	Ground
2	+12 V
3	-12 V
4	signal
5	+VBIAS
6	-VBIAS

Table 5.25 ASX board (X5) - Mother board (X14)

Pin No.	Signal
1	Analog ground
2	NC
3	NC
4	NC
5	+15 V
6	-15 V
7	DIRB (not used)
8	RXD
9	TXDB
10	NC
11	-RESET
12	+5 V
13	+15 VDIRTY
14	Digital ground

Figure 5.31 ASX-200 preamplifier board parts layout and schematic diagram



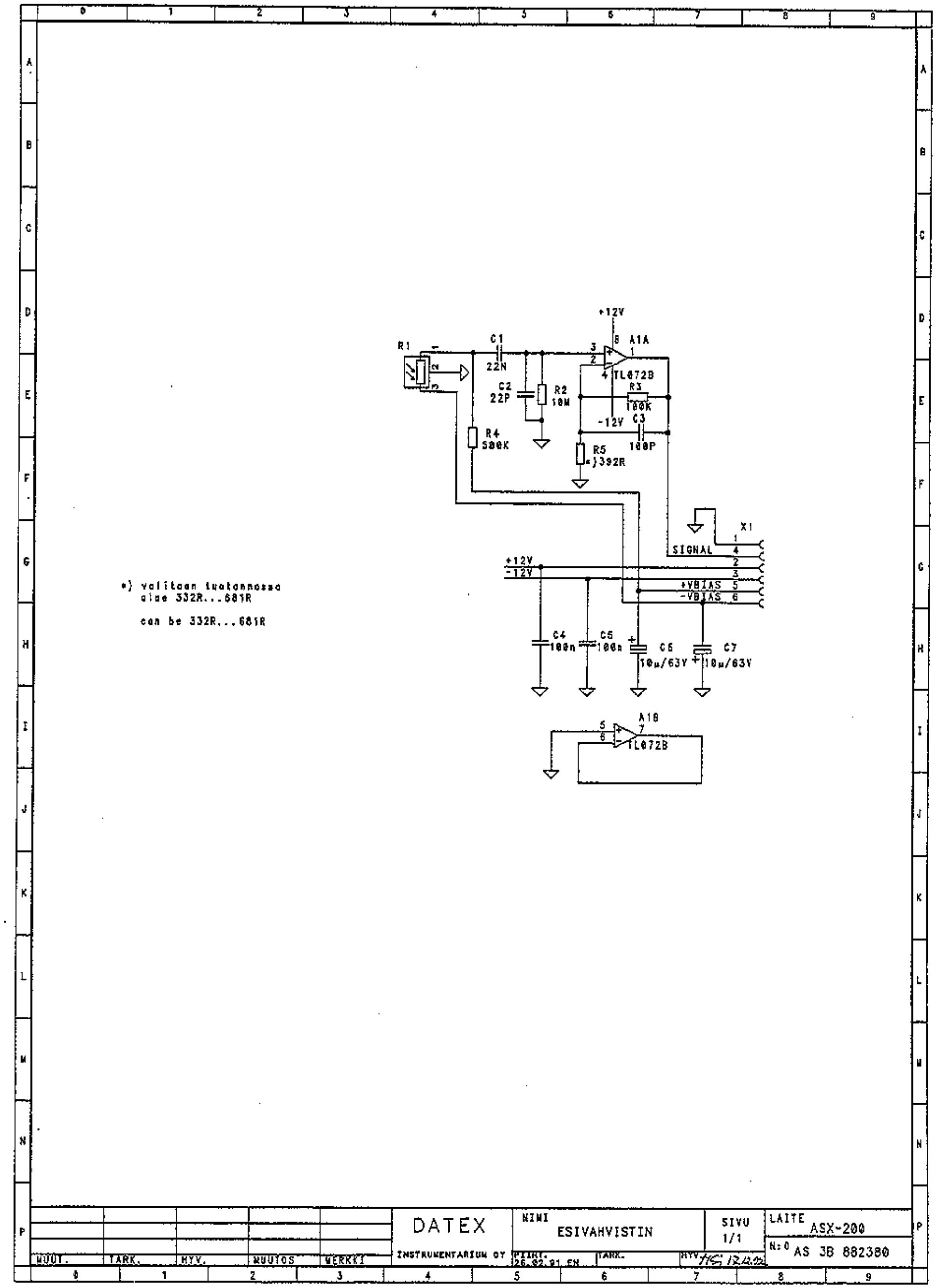
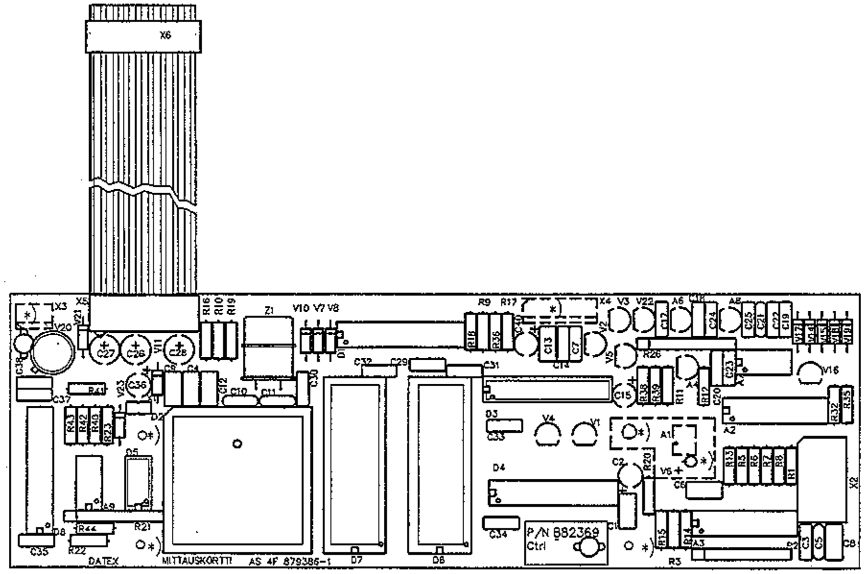
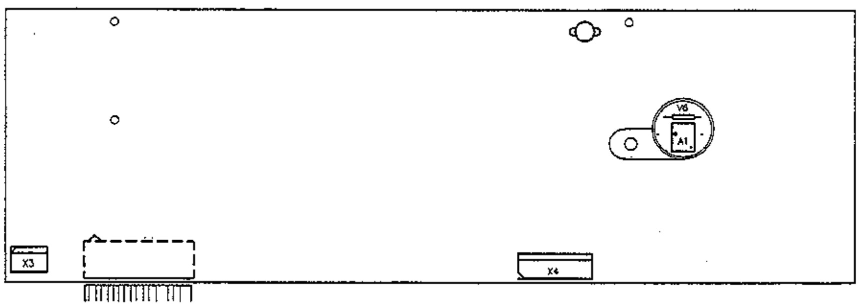


Figure 5.32 ASX-200 board parts layout and schematic diagram part 1





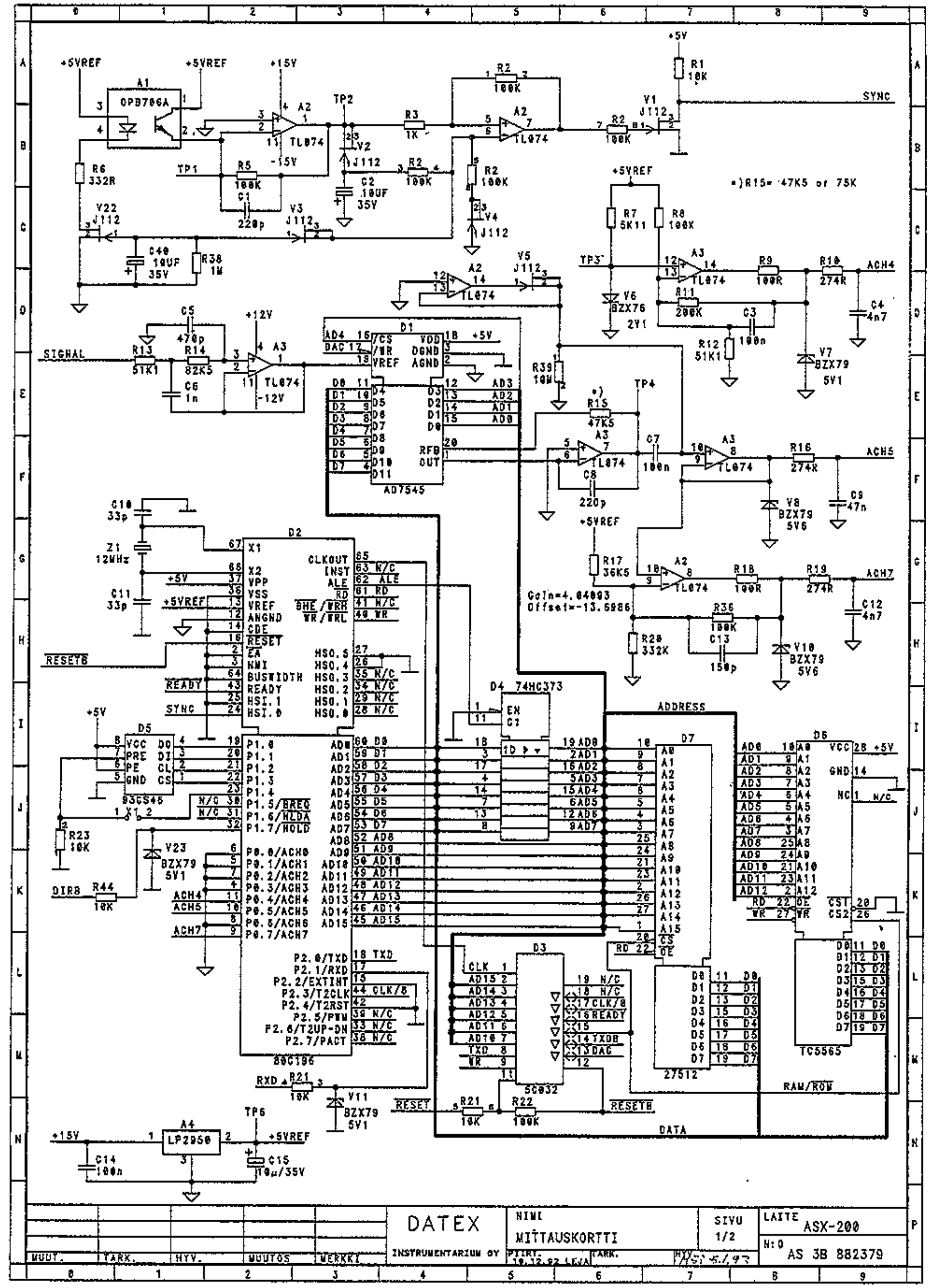


Figure 5.33 ASX-200 board schematic diagram part 2

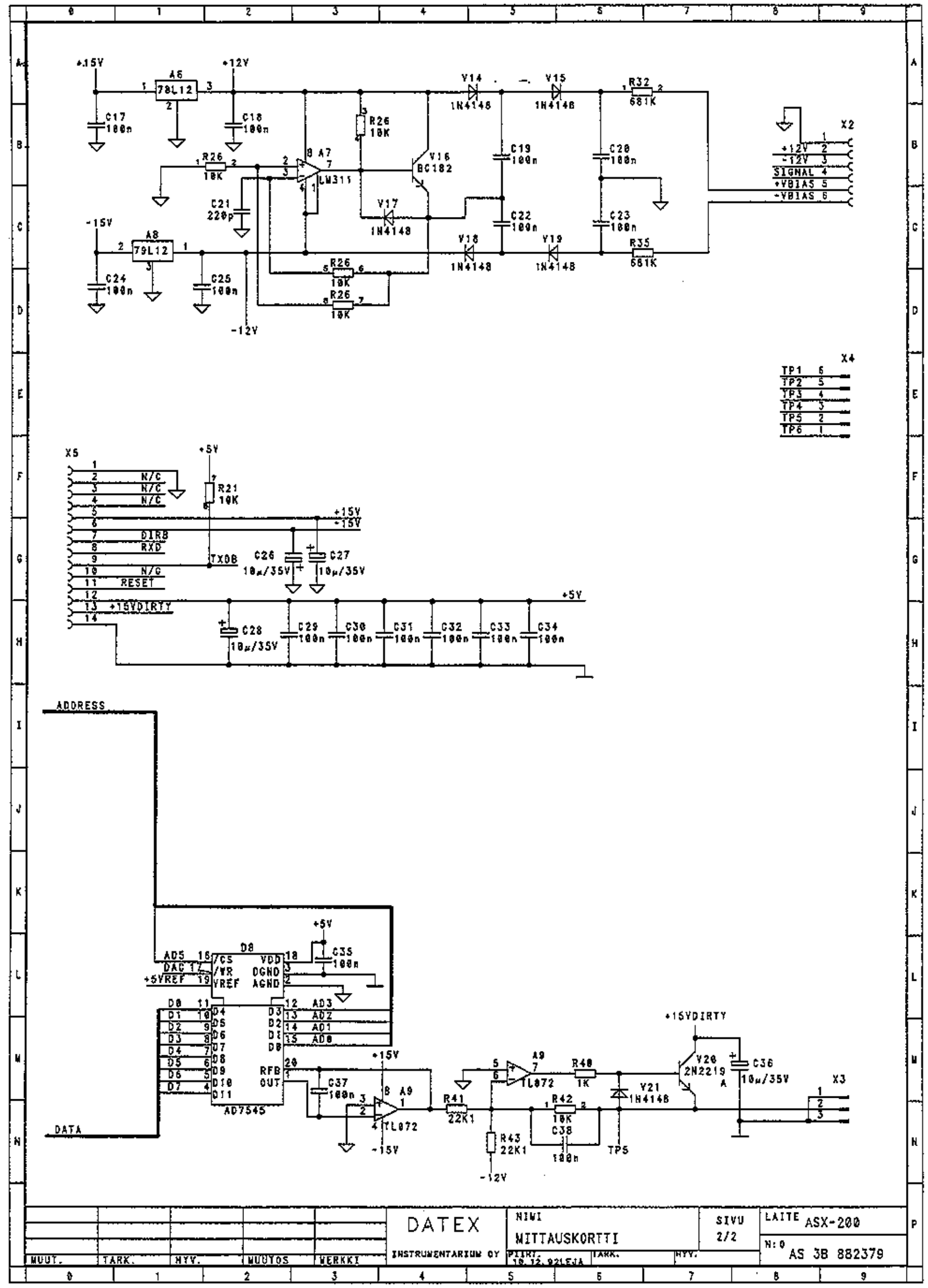


Figure 5.34 Transformer filter board parts layout and schematic diagram