F1066-B

2 2 MAI 2001

Attached is Service Manual for 780110 Rev.A

REV	STATUS FOR UTGIVELSE/STATE OF ISSUE	ECO NR.	UTSTEDER/ORIGINATOR	VERIFISERT/VERIFIED	GODKJENT/APPROVED
			DATE AND SIGN	DATE AND SIGN	DATE AND SIGN
B	Change of fuse F1	01-081	DATE AND SIGN HG 22.05.01 HG	DATE AND SIGN	DATE AND SIGN AH 22/5-01
A	Release	NA	DATE AND SIGN HG	DATE AND SIGN	DATE AND SIGN AH

Laerdal
helping save lives
POB 337
N-4001 STAVANGER
NORWAY

EKSTERNT REF NR/EXTERNAL REF NO: N/A	ERSTATTER/REPLACES: NA	REV: -
EKSTERN LEVERANDØR/EXTERNAL SUPPLIER: N/A		
PRODUKTGRUPPE/PRODUCT GROUP: 78	ARTIKKEL/ITEM NO: 780110	
FILEREF: 780110	STATUS:	AVDELING/DEPARTMENT: 300

TITTEL/TITLE

Service Manual LSU4000

KAT./CAT. DOK TYPE/DOC TYPE SEKV. NR/SEQ. NO	SIDE / SHEET	REV
PRO-P16-0001	1/1	B

Laerdal Suction Unit

TECHNICAL MANUAL AND BLOCK DIAGRAMS

Laerdal
helping save lives

Cat. no. 780110 Rev. B

Table of Contents

1. General

The information provided in this manual is limited to what is required for checking, maintenance and board replacement. The intended users of this manual are technical personnel who have been trained in the safe and proper servicing of the LSU.

Detailed information regarding controls, operation and capabilities of the suction unit can be found in the Direction for Use that was shipped with the product. This Technical Manual assumes you are familiar with the controls and with the basic operations.

The information of this manual is subject to changes without notice.

Laerdal Medical shall not be liable for errors contained herein or for incidental or consequential damage in connection with the furnishing, performance, or use of this manual.

2. Technical Specification.

2.1 Overview.

The LSU electronics consists of three PCB's (*Power Bd.*, *MMI Bd.* and *Battery Bd.*), internal cables, and a *Front Panel* (LED foil).

Main features:

- Operation from a 12V / 2Ah Lead-Acid battery
- Operation and charging from an external AC power supply (110-240VAC 50/60/400 Hz).
- Operation and charging from an external DC power source (12-28VDC).
- The external power source has priority over the internal battery.
- When two external power sources are connected, the AC has the highest priority.
- An LSU in "OFF" mode automatically enters charging mode if connected to an external power source.
- Fast charging (80% capacity in 3 hrs)

2.1.1 Power Board.

The *Power Board* incorporates two separate galvanic isolated power supplies, one AC/DC converter and one DC/DC converter. Both supplies are able to supply power to the LSU during 1) operation and 2) charging. The Power Bd. output is a "raw" DC voltage of roughly 18 – 20 V.

2.1.2 MMI Board.

The *MMI Board* includes a µC system for control of all functions in the LSU. The two main functions of the µC software are 1) *Suction control* and 2) *Charging control*. During *suction* the µC controls both flow and vacuum applied to the patient (according to the pre-set flow/vacuum level). During *charging* The µC provides efficient charging of the internal battery. The motor is supplied from the external power source whenever the unit is connected to either an external AC or a DC supply.
Simultaneous charging and operation from external power is not possible.

2.1.3 Battery Board.

The *Battery Board* connects the battery to the MMI Bd. This board also includes a communication port, RS-232 (logic levels not RS232 levels), for µC programming, calibration, assembly testing and future software upgrades.

2.1.4 Main Rotary Switch.

The LSU *main rotary switch* consists of three optical switches and a micro switch placed on the MMI Bd. The micro switch disconnects the battery if the internal SLA battery is the only available power source AND the LSU is in "Off" position. The position of the main rotary switch (i.e. decoding of the optical receivers) decides both the flow and the vacuum parameters.

2.1.5 Front Panel.

The LSU is equipped with a *Front Panel* (LED foil) with indicators and a test button. The Front Panel has a vacuum indicator bar graph that indicates the vacuum applied to the patient. The foil also has LEDs indicating "On", "External power", "Error" and remaining battery capacity.

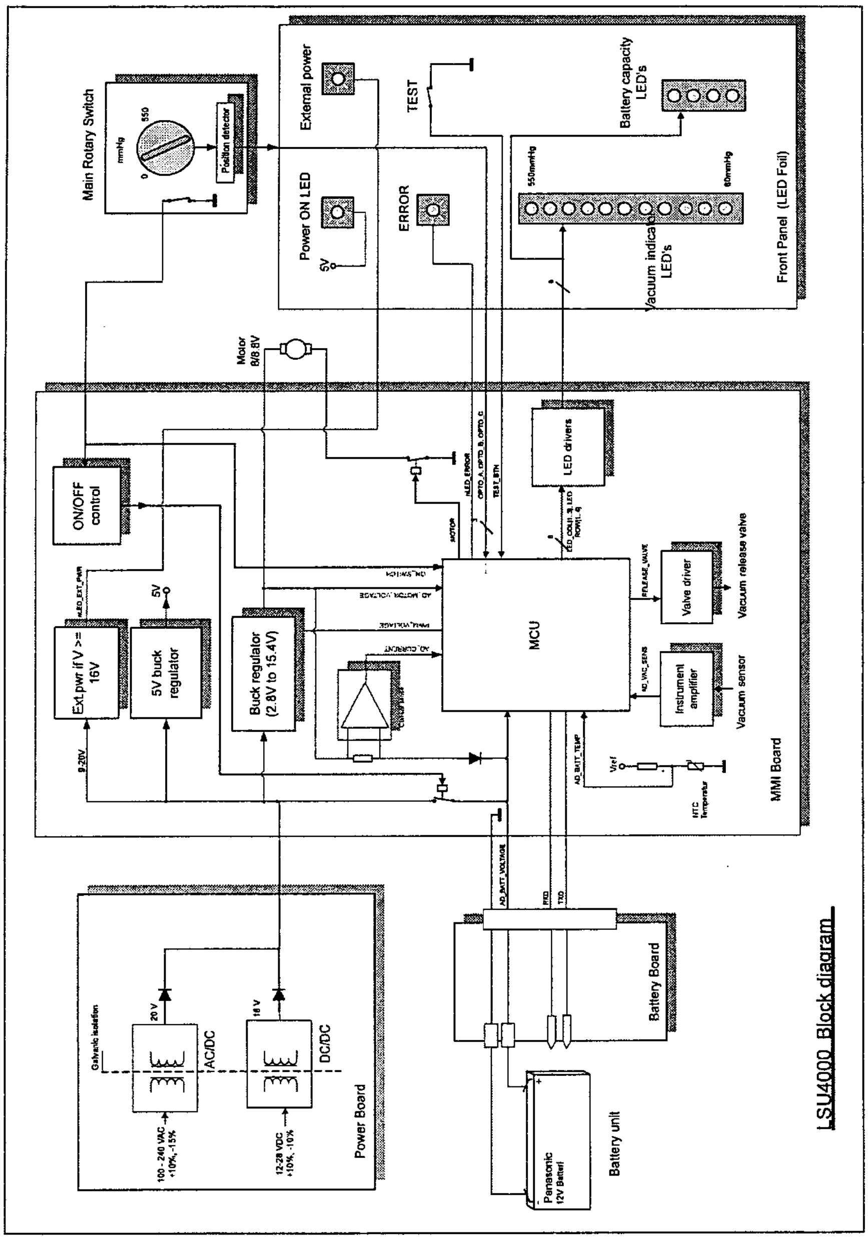


Figure 1

Main features:

- Operation from a 12V / 2Ah Lead-Acid battery
- Operation and charging from an external AC power supply (110-240VAC 50/60/400 Hz).
- Operation and charging from an external DC power source (12-28VDC).
- The external power source has priority over the internal battery.
- When two external power sources are connected, the AC has the highest priority.
- An LSU in "OFF" mode automatically enters charging mode if connected to an external power source.
- Fast charging (80% capacity in 3 hrs)

2.2 Power Supply.

2.2.1 Battery.

Voltage/capacity:	12 V / 2Ah
Type:	Panasonic Sealed Lead-Acid battery LC-TA122P(a). This is a high capacity long trickle life battery that also can be used in cyclic application.
Size (h*l*w):	61.7 mm * 182.0 mm * 23.85 mm
Weight:	0.635 kg
Battery lifetime:	To be replaced after 3 years. (Panasonic recommends 10 years under optimum conditions)
Fuse Type:	5A / 125V (slow)

Environmental conditions.

Temperature range – storage:	–15°C to 40°C [recommended by Panasonic].
Temperature range – discharging:	–15°C to 50°C [recommended by Panasonic].
Temperature range – charging:	0°C to 40°C [recommended by Panasonic].

Interval of refresh charge at storage temperatures < 20°C:	9 months
Interval of refresh charge at storage temperatures 20°C < T < 30°C:	6 months
Interval of refresh charge at storage temperatures 30°C < T < 40°C:	3 months

Battery charging.

Fast charging i.e. 80% restored capacity in 3 hrs (fast charging function at 20°C).
Full capacity within 24 hours.
Temperature compensated charging voltage.

2.2.2 AC Mains.

The AC Mains supply is a switch mode power supply that is part of the Power Board. The AC/DC supply converts 110-240VAC to a 20VDC output. The output voltage is a raw voltage for the Buck converter on the MMI board. A fully electrical isolation barrier between the primary circuit and the applied part that may come in contact with the secondary part (due to filter failure) is ensured by the use of transformers and optocouplers.

A 2-pin type appliance inlet according to IEC 320-1 is used as AC input.

Rating:	250VAC / 10A according to IEC 320-1 6.
Classification:	Class II, cold conditions according to IEC 320-1 7.1.
Dimensions and Compatibility:	Standard sheet C18 according to IEC 320-1 9.
Lifetime:	> 3600 cycles (one connection / disconnection daily for 10 years)
Other:	UL/CSA approval
Fuse type:	1.5A / 250VAC (slow)

Varistor operating voltage: 275V

Input voltage range:	100 VAC to 240 VAC +10/-15 %
Input frequency:	50 or 60 ± 3 Hz (100 - 240VAC), 400 ± 3 Hz (100 - 120VAC)

According to IEC 601-1 15:
The equipment is so designed that 1 second after disconnection of the plug the voltage between the supply pins of the plug and between either supply pin and the enclosure does not exceed 60V.

Output voltage: 20.0 VDC +1.0/-0.5 VDC

Max input power occurs at 85VAC input voltage and is at a load of 2.25A@20.0V: 59W ± 4W

2.2.3 DC Mains.

The DC Mains supply is a switchmode power supply that is part of the Power Board. The DC/DC supply converts 12-28VDC to an 18VDC output. The output voltage is raw voltage for the Buck converter on the MMI board. A fully electrical isolation barrier between the primary circuit and the applied part that may come in contact with the secondary part (due to filter failure) is ensured by the use of transformers and optocouplers.

A 2-pin type custom designed appliance inlet according to IEC 320-1 is used as DC input.

Lifetime: > 3600 cycles (one connection/ disconnection daily for 10 years)

Keying / polarity indication:	Yes
Other:	UL/CSA approval
Fuse type:	5A / 125V (slow)

Varistor operating voltage: 40V

The keying of the connector will protect the electronics against wrong polarity while using cables supplied by Laerdal.

Input voltage range: 12VDC to 28VDC ±10 %

Max input power occurs at 12VDC input voltage and is at a load of 2.25A@18.2V: 59W ± 4W

Output voltage: 18.2 VDC +0.5 / -1.0 VDC

Average output power, $P_{average}$ @ 18.2VDC:	approx. 27.0W
Peak output power, P_{peak} @ 18.2VDC:	45.0W

Note: These values are given for the “500+” setting of the LSU.

2.2.4 Indicators.

General:

The Front Panel (LED foil) has 18 LEDs:

- One "Operation" indicator
- One "External power" indicator
- One "Error" indicator
- Four LEDs indicating "Remaining Battery Capacity", "Low Battery" and "Charging".
- Eleven LEDs indicating "Vacuum level"

Operation:

Colour:	Green
Max current (pr. LED):	
At D.C. 1/8 and 2ms pulse:	Max 80mA
Controlled by the µC:	Yes

External Power:

Colour:	Green
Max current:	20mA - continuous
Controlled by the µC:	No

Error:

Colour:	Red
Max current:	20mA - continuous
Controlled by the µC:	Yes

Battery Capacity and Charging:

Number of LEDs:	Four
Colour:	Green
Pulse width:	2ms
Duty cycle:	1/8
Max current (pr. LED):	
At D.C. 1/8 and 2ms pulse:	Max 80mA
Controlled by the µC:	Yes

Vacuum Indicators:

Number of LEDs:	Eleven
Colour:	Green
Pulse width:	2ms
Duty cycle:	1/8
At D.C. 1/8 and 2ms pulse:	Max 80mA
Continuous:	Max 20mA
Controlled by the µC:	Yes

2.2.5 Battery Charging.

Fast charging i.e. 80% restored capacity in 3 hrs (fast charging function at 20°C).
Full capacity within 24 hours.
Temperature compensated charging voltage.

2.3 Vacuum.

2.3.1 Vacuum sensor.
A piezoresistive pressure sensor, Honeywell No. 22PCCFB6G, is used to measure the vacuum during operation.

Vacuum range:	0 - 550mmHg
Accuracy:	± 20 mmHg
Voltage output range:	0.5 – 4.5 V
AD_VAC_SENS voltage tolerance:	± 0.15 V
Sensitivity shift compensation ($0 < t < 45°C$):	- 0.22 % / °C

2.3.2 Vacuum Valve.
The vacuum is controlled using the µC and an air valve. During free flow the valve is closed. The µC opens the valve when the pre-set vacuum is exceeded. An open valve results in a leakage that decreases the vacuum.

Type:	Normally Closed (NC)
Operational voltage:	+5 V
Power consumption:	1.2W
Current consumption:	210mA

2.4 Flow: 12sl/min at 80 mmHg, >25sl/min at 500+ mmHg

2.5 Noise: 46 dBA at 80 mmHg, 56 dBA at 500+mmHg

2.6 Size (l*w*d)**:** 315 mm (12,4 in) x 330mm (13 in) x 160 mm (6,3in)

2.7 Weight: 4 kg (8,9 lbs) including battery

2.8 Environmental Conditions.

Operating temperature:	0°C to 40°C (-18°C to 44°C according to KKK)
Long term storage temperature:	0°C to 40°C (-34°C to 52°C according to KKK)
Max. 24 h. storage temperature:	-30°C to 70°C
Charging:	0°C to + 40°C

2.9 Classification.

2.9.1 Various classifications of LSU.

- "Electrically Powered Suction Equipment" according to NS-EN ISO 10079-1 (1999)
- "For field and transport use" according to NS-EN ISO 10079-1 (1999)
- "High vacuum / high flow" according to NS-EN ISO 10079-1 (1999)
- "Class II type BF" according to IEC 601-1 (1988)
- "Splash-proof IP34D" according to IEC 529 (1976/1989)
- Risk class IIA according to MDD (93/42/EEC), annex IX, rule 2, 11.

2.9.2 Other approvals, regulations etc.

- CE marking according to Medical Device Directive (93/42/EEC)
- FDA: 510(k) registration
- UL/CSA approval
- Japanese approval
- Australian approval (Tick It system)

2.9.3 .Relevant regulations.

- Medical Device Directive (93/42/EEC) (European Union and EEA-countries)
- FDA Quality System Regulation (United States of America)

3. Functional Description.

3.1 Electronic Overview.

3.1.1 Power Board.

The Power Board includes two switchmode power supplies. The AC/DC supply converts 110-240VAC to a 20VDC output, and the DC/DC supply converts 12-28VDC to an 18VDC output. The output voltages from both supplies are raw voltages for the Buck converter on the MMI board. A fully electrical isolation barrier between the primary circuit and the applied part that may come in contact with the secondary part (due to filter failure) is ensured by the use of transformers and optocouplers.

3.1.1.1 AC/DC.

The AC/DC converter is based on the switching regulator IC TOP227Y (U6) from Power Integration. The regulator has a built-in switching power-FET.

Power input is from an AC mains connector. The converter is protected against over voltage by varistor RV1 (275V) and a 1.5A fuse, F1, limits the current drawn. Inductors L3, L9 and common mode inductor L2 together with capacitors C32 and C33, provide EMC protection.

The mains voltage is rectified and filtered in BR1 and C30. This voltage is applied through the transformer primary to the regulator.

The transformer T2 has one primary and two secondary windings. One secondary winding produces the output voltage while the other generates power to the regulator (U6).

The regulator has three connections. The Control pin is a combined power supply pin and feedback from the output (regulated) voltage. Source is the SOURCE-terminal on the internal power-FET transistor and is connected to GND. Drain is the DRAIN-terminal on the power-FET and is connected to the "low side" of the primary winding of the transformer.

At start-up the regulator is for a short period supplied from the rectified mains. When the converter has started, the regulator IC will get power and feedback from the one of the secondary windings, via the optocoupler, U7. The other secondary winding produces the output voltage. The output is rectified by diode D8 and filtered in C28 and C40.

Controlling the voltage on the 'Control'-pin of the regulator regulates the output voltage. The output voltage is divided through resistors R35, R34 and R5 to provide a voltage to the reference-pin of U3. U3, LM431, is an adjustable zener/regulator. When the reference input, pin2, reaches 2.5V the regulator starts to conduct.

A current through the LED of the optocoupler results, the transistor of the optocoupler starts to conduct and the voltage of the Control pin will increase leading to reduction of the output voltage. The output voltage is thus regulated to a voltage producing 2.5V at the reference-pin of U3.

D19 and D20 limit the voltage peaks applied to regulator. Snubber components C39, R20, R21, R41 and R42, as well as C34, reduce EMC.

To protect the output rectifier, D8, the tranzorber, D2, is used. Snubber components C11, R12, R14, R29 and R30 reduce voltage spikes and EMC.

The diode D9 prevents current to enter this circuit when there is no AC mains present.

C38, 1nF/4kV safety type capacitor, provides an AC path between primary and secondary GND. This capacitor is important for EMC reduction.

3.1.1.2 DC/DC.

The DC/DC converter is based on the switching regulator SI9114A, from Vishay Siliconix, with an external switching power-FET, Q1.

Power input is from a DC power source of 12V-28V. The converter is protected against over voltage by varistor RV2 (40V) and a 5A fuse, F2, limits the current drawn. The unit's electronics is protected from wrong polarity by diode D14, but the fuse will blow.

Common mode filters L4 and L1 together with capacitors C15 and C14 and C20 provide EMC protection. C9 and C16 provide energy storage.

To power the regulator U9, power-FET driver and the feedback, a 12V supply is requested. The adjustable version of LM2931 does not take the high input voltage that can occur at the highest input voltages, a fixed 5V regulator is, therefore, used. To obtain 12V, the ground pins are 'lifted' by means of the zenerdiode D21. R4 provides current to the zener and C3 reduces the impedance over the zener. The diode D1 limits the positive voltage of GND-pins of the regulator, relative to the output pin, which can occur for a short period after the input supply has been removed. This prevents any problem in getting the regulator started if there is a voltage "bouncing" while connecting power.

R51 and C52 set the operation frequency of the switching regulator. In this application the operating frequency is about 220kHz.

Output from the switching regulator is the on/off signal to the switching transistor, Q1. The two-stage buffer consisting of Q10-Q13 buffers this signal. R13 slows the gate drive somewhat, for EMC reasons.

R49 produces a signal proportional to the current through Q1. This signal is filtered by R56 and C44 and fed back to the regulator, this signal is an important regulation parameter. The switching regulator gets feedback from the output voltage via the optocoupler, U10. Components R44-R47 and C49-C49 set the operation point, amplification and stability for the regulator feedback op-amp.

The transformer, T1, has two windings on the primary side. They have the same number of turns. The one connected between pin 2 and 4, carries the switched current while the other one together with D22, dissipate the energy from the rest inductance. D10, R11, R58 and C57 form a snubber network to reduce peak voltage on Q1. Also, snubber network C53, R8 and R51 help reduce peak voltage on Q1.

One secondary winding on the transformer produces the output voltage. Double-diode D4 is a combined rectifier and freewheeling diode. Inductor L6 is power storage for the feed forward converter. C17 and C18 are output filtering and energy reservoir. The freewheeling diode is protected by a tranzorbers D5 and D6. Two resistors are connected in series with the tranzorbers to share some of the energy dissipated. Also, there are snubbers on both halves of D4, consisting of C13, R9 and R19 for the rectifier and C56, R10 and R10 for the freewheeling diode. The snubbers have influence on voltage peaks on D4 and Q1 as well as on EMC.

Feedback from output voltage to the regulator is through the optocoupler. The output voltage is divided through resistors R3, R6, R7 and R18 to provide a voltage to the reference-pin of U2. U2, LM431, is an adjustable zener/regulator. When the reference input, pin2, reaches 2.5V the regulator starts to conduct. A current through the LED of the optocoupler results and the transistor of the optocoupler starts to conduct. The voltage across R48 will increase and hence the voltage on the regulator's feedback terminal (FB), leading to reduction of the output voltage. The output voltage is thus regulated to a voltage producing 2.5V at the reference-pin of U2.

The diode D7 prevents current to enter this circuit when there is no DC mains present.

C54, 10nF/250V safety type capacitor, provides an AC path between primary and secondary GND. This capacitor is important for EMC reduction.

3.1.1.3 Interface.

AC and DC input:

Connector type: Molex Art. No: RFQ9ER47017 (Custom design)

Pin #	Signal Name	Description
1		AC input
2		AC input
3		+ DC input
4		- DC input

Power Board to MMI Board:

Connector type: Molex Art. No: 43650-0203

Pin #	Signal Name	Description
1	GND	GND
2	18/20V	18 / 20 V output to MMI Bd.

3.1.2 MMI Board.

The MMI Board includes a micro-controller, a switch mode voltage regulator (Buck converter) for motor control and battery charging, a switch mode 5V supply, a magnet air valve and a vacuum sensor for vacuum control, and drivers for the LEDs on the front panel (LED-foil). An EEPROM contains 1) *Set up parameters*, 2) *Calibration data*, 3) *Operating data.* The MMI Board also contains circuits to detect the position of the Operating Knob.

The micro controller:

- Regulates the motor speed according to selected level, by adjusting the Buck converter and measuring the Buck regulator output voltage.
- Keeps the vacuum at or below the selected level, by measuring the actual vacuum and letting in air through the air valve, when required.
- Estimates the remaining battery capacity.
- Controls charging of the internal battery whenever the unit is in OFF position and there is external power connected.
- Presents measured vacuum and battery status by means of LEDs on the front panel.

The MMI Board electronics are explained in order of schematic sheets.

3.1.2.1 Top Level. Sheet 1 of 6.
This sheet gives an over view of schematic sheets with inter sheet signal connections. Also, shown are the input and output connectors (except the LED foil connector), transistor Q1 that switches the MOTOR on/off, transistor Q12 that switches the AIR VALVE on/off, resistor R68 that is used to measure the charging current to the battery and D14 that prevents current to flow back from battery to the charging circuit.

3.1.2.2 Buck Regulator. Sheet 2 of 6.
Power line 9-20V is supplied from Power Board when external power is connected. If no external power is connected, 9-20V is powered from battery if Operation Knob is in any position other than “0”.

A voltage level detector detects an input voltage of more than about 15V, turning on Q3 and, thereby, turning ON the LED_EXT_PWR on the front panel.

Motor and charging voltage is regulated by the Buck converter, which consists of regulator, U1, inductor L1, freewheel diode D5, input and output capacitors. The voltage divider R12, R22, R92 and R13 define absolute maximum output voltage. The regulator will always try to regulate the output voltage to get 1.21V at the feedback terminal (FB). By adding a voltage to the voltage divider, the regulator can be forced to reduce the output voltage to maintain the feedback terminal at 1.21V.

The microcontroller generates a PWM signal according to required voltage. The PWM signal is demodulated/LP-filtered in U3 to present a DC voltage at the summing point, R25. The diode, D2, prevents the demodulator from drawing a current from the summing point and thus increase output voltage. C48 blocks a DC high from a faulty microcontroller, to result in maximum high voltage from the Buck regulator. Diode D18 limits the negative voltage on the base of Q2. Q2 shapes the incoming pulse-train to square 5V pulses for the demodulator/filter.

Regulator U2, with surrounding components, also makes up a buck converter. Divider R17 and R11 set the output voltage to nominally 5.25V. This is the system’s “+5V” supply.

3.1.2.3 Interface for LED Panel. Sheet 3 of 6.
This sheet shows the LED drivers. The microcontroller controls the LED matrix by means of 4 column and 4 row signals. Resistors R30-R33 limits current through the LEDs. Capacitors on all lines provide ESD protection. LED_ERROR and LED_EXT_PWR have separate controls. The LED_ERROR is controlled by the microcontroller, while the external voltage detector controls LED_EXT_PWR.

The signal TEST_BTN is a HIGH if test button on the front panel is pressed.

3.1.2.4 MCU. Sheet 4 of 6.

The microcontroller is a PIC16C77 controller from Microchip. This is a 44-pin PLCC chip with an 8-bit A/D converter, 8K x 14 Words Program Memory and 368 x 8 RAM. The table below gives the pin assignments:

Pin#	Pin Name	Signal Name	Function	Note
1	NC			
2	xMCLR/Vpp			+5V
3	RA0/AN0	AD_MOTOR_VOLTAGE	AI from Buck reg.	0-5V
4	RA1/AN1	AD_BATT_TEMP	AI from NTC at battery	0-5V
5	RA2/AN2	AD_BATT_VOLTAGE	AI from battery	0-5V
6	RA3/AN3/V_{ref}	V_{ref}	+5V reference for ADC	+5V
7	RA4/T0CK1	HW_VER_BIT0	DI - HW address Bit 0 (LSB)	GND
8	RA5/xSS/AN4	AD_VAC_SENS	AI from vacuum sensor	0-5V
9	RE0/xRD/AN5	AD_CURRENT	AI from charging current measurement	0-5V
10	RE1/xWR/AN6	9-20V	AI from PWR Bd. and battery voltage.	0-5V
11	RE2/xCS/AN7		AI from +5V (½)	0-5V
12	VCC	VCC		+5V
13	GND	GND		GND
14	OSC1/CLKIN		CLK In	4MHz
15	OSC2/CLKOUT		CLK Out	4MHz
16	RC0/T1OSO/TICK1	RELEASE_VALVE	DO to air valve	L/H
17	NC			
18	RC1/Y1OSI/CCP2	PWM_VOLTAGE	PWM to Buck. Reg.	4kHz
19	RC2/CCP1	HW_VER_BIT1	DI - HW address Bit 1	GND
20	RC3/SCK/SCL	SCL	Serial Clock for I^2C bus	L/H
21	RD0/PSP0	LED_COL_1	DO for LED control	L/H
22	RD1/PSP1	LED_COL_2	DO for LED control	L/H
23	RD2/PSP2	LED_COL_3	DO for LED control	L/H
24	RD3/PSP3	LED_COL_4	DO for LED control	L/H
25	RC4/SDI/SDA	SDA	Serial Data for I^2C bus	L/H
26	RC5/SDO	HW_VER_BIT2	DI - HW address Bit 2	L/H
27	RC6/TX/CK	TXD	Transmit – Serial Com.	L/H
28	NC			
29	RC7/RX/DT	RXD	Receive – Serial Com.	L/H
30	RD4/PSP4	LED_ROW_1	DO for LED control	L/H
31	RD5/PSP5	LED_ROW_2	DO for LED control	L/H
32	RD6/PSP6	LED_ROW_3	DO for LED control	L/H
33	RD7/PSP7	LED_ROW_4	DO for LED control	L/H
34	GND	GND		GND
35	VCC	VCC		+5V
36	RB0/INT	ON_SWITCH	DI from SW1	L/H
37	RB1	TEST_BTN	DI from Test Button	L/H
38	RB2	MOTOR	DO to connect the motor to the Buck. Reg.	L/H
39	RB3	LED_ERROR	DO to switch ERROR LED	L/H
40	NC			
41	RB4	OPTO_ON	DO to activate opto sensors	L/H
42	RB5	OPTO_C	DI from opto sensor C	L/H
43	RB6	OPTO_B	DI from opto sensor B	L/H
44	RB7	OPTO_A	DI from opto sensor A	L/H

Transistors Q10 and Q14 only connects the AD_BATT_VOLTAGE to the controller when the +5V is present, i.e. an external power supply is present or the Operating Knob is in any position other than "0".

U5 provides a 5V-reference voltage for the A/D converter.

NTC1 is a termistor used to measure temperature and located close to the vacuum sensor. Temperature is used to compensate the vacuum measurement and the battery charging voltage.

All signals to the A/D converter are filtered and some also have a voltage divider to adjust the input voltage to the A/D converter range of 0-5V.

Y1 is a 4MHz resonator controlling the processor clock.

Diode D19 prevents programming voltage to enter the +5V during in circuit programming.

Diode D3 and resistor R79 provides a limitation of Vcc input to the controller.

Diodes D16 and D17 provide over voltage protection for the serial communication inputs.

EEPROM, U8, keeps various parameters and operation/service data. The controller communicates with the EEPROM on an I^2C bus.

Resistors R97-R99 and R101-R103 are used to indicate the HW and/or SW version.

3.1.2.5 Vacuum Sensor Amplifier. Sheet 5 of 6.
The sensor output is amplified in a differential amplifier with fixed amplification of about 30, U7A-U7C. Op-amp U7D provides additional adjustable amplification as well as LP-filtering.

POT1 is a dual digital potentiometer. POT1A is used to adjust the offset of the sensor. POT1B is used to adjust the amplification in U7D to produce the requested output signal for maximum vacuum. POT1C is the communication part of the potentiometer. The microcontroller communicates with the potentiometer on an I^2C bus. During calibration the offset is set to 0.5V and the amplification is adjusted to give 4.5V output at 550mmHg.

3.1.2.6 Switch Interface & Battery Power Interface. Sheet 6 of 6.
To determine the position of the Selector Knob the optical sensors D10-D12 are utilized. The Selector Knob has several flags that pass through the sensors as the knob is operated. Each position of the Selector Knob generates a unique combination of sensor output OPTO_A, OPTO_B and OPTO_C. The microcontroller turns the sensor LEDs on only during read-periods, by means of transistor Q8.

Decoding of the optical receivers:

Opto A	Opto B	Opto C	Hex value	"Setting"
0	1	1	0x03	O
1	0	0	0x04	80
0	0	1	0x01	120
1	0	1	0x05	200
1	1	0	0x06	350
0	0	0	0x00	500
0	1	0	0x02	N/A
1	1	1	0x07	N/A

The Selector Knob also, operates the micro-switch SW1. With the Selector Knob in position "0", the micro-switch shorts signal ON_SWITCH to GND. If an external supply is connected, this will start battery charging. Any other positions of the Selector Knob will switch SW1 to connect between 1 and 3, this opens Q21 and the battery will be connected to "9-20V" through D6. Regardless of power source, the unit will be switched ON and operation is according to the position of Selection Knob. If an external supply is connected, a voltage higher than the battery voltage is applied to "9-20V" and no power is drawn from battery.

D4 and D7 limit power supply voltage for U4 (and U7 sheet 5) to a maximum of about 14.2V.

Charging current measurement is built around op-amp U4. Input (I_sens+ and I_sens-) is taken from across resistor R68. Resistors R5, R6, R9 and R10 are high precision to achieve high common mode rejection in the differential amplifier, U4A. The ratio between R5,R6 and R9,R10 ensures that that the common mode voltage on the input of U4A is sufficiently lower than the power supply to the op-amp. U4D provides additional amplification. Voltage divider R90 and R88 together with U4B generate a reference voltage, one volt above GND, for the amplifier. This ensures that the signal passed to the A/D converter is always positive, even when op-amp offset and common mode "signal" caused by resistor errors will produce a negative voltage.

A 4MHz crystal is connected between OSC1 and OSC2.

Serial EEPROM

- 2k bits i.e. 256 bytes x 8
- I^2C interface
- HW address [A2, A1, A0] = [0, 0, 0]

Digital potentiometer

- Double 10k 256-position potentiometer
- I^2C interface
- HW address [A2, A1, A0] = [0, 0, 0]

The vacuum sensor is calibrated to achieve the required accuracy. The data for both *offset* and *gain adjustment* is stored in the serial E^2PROM and will be transferred to the digital potentiometer at start up.

Serial communication.

TXD (from µC):	HIGH / LOW (logic level)
RXD (from µC):	HIGH / LOW (logic level)

NOTE: An external driver is required to establish a serial communication with the on-board µC (RS232 signal levels).

Motor selection:

The µC connects the motor to the Buck regulator output by enabling the MOTOR control line (active HIGH).

MOTOR:	HIGH / LOW

Flow control.

The µC provides an active flow control using AD_MOTOR_VOLTAGE and PWM_VOLTAGE.

For each setting of the main rotary switch there is a predefined motor voltage. The µC is continuously monitoring the motor voltage by reading AD_MOTOR_VOLTAGE and maintaining the correct motor voltage by regulating the PWM_VOLTAGE output.

The motor voltage for the "500+" setting for the US version has to be calibrated to achieve the required accuracy.

PWM frequency:	4kHz
AD_MOTOR_VOLTAGE:	0 – 5V
Hysteresis @16V (regulation):	± 62,5mV (± 1 bit)

Ref. section 10.10.3 for motor voltages.
Vacuum control.
The µC provides an active vacuum control using AD_VAC_SENS and RELEASE_VALVE.

For each setting, except "500+", there is a predefined maximum vacuum level. The µC is continuously monitoring the vacuum level by reading AD_VAC_SENS and thereby securing that the precept vacuum level is not exceeded. If the set vacuum level is exceeded, the µC opens the magnet valve by pulling RELEASE_VALVE HIGH. To be able to detect errors in the vacuum sensor amplifiers, the legal vacuum sensor output voltage has to stay within a window of 0.5 V to 4.5V. If AD_VAC_SENS is measured to 0V, a serious error has occurred and the µC will then detect this.

AD_VAC_SENS valid voltage window:	0.5 – 4.5 V
Hysteresis @5V (regulation):	± 97.7mV (± 5 bit)
RELEASE_VALVE:	HIGH / LOW

3.1.2.7 Temperature.

A thermistor (NTC) is used for temperature measurement. The temperature measurements has two purposes:

1) Temperature compensation of the vacuum measurement during operation.
2) Temperature compensation of the charging voltage.

The thermistor is located on the MMI Bd. close to the vacuum sensor.

3.1.2.8 Vacuum Sensor.

A piezoresistive pressure sensor, Honeywell No. 22PCCFB6G, is used to measure the vacuum during operation.

The µC will base the vacuum indication on the voltage AD_VAC_SENS (in combination with temperature compensation). To be able to detect errors in the sensor and the succeeding amplifiers, an offset of 0.5 V is used. Railing of the signal will then indicate that an error has occurred.

Vacuum range:	0 - 550mmHg
Accuracy:	± 20 mmHg
Voltage output range:	0.5 – 4.5 V
AD_VAC_SENS voltage tolerance:	± 0.15 V
Sensitivity shift ($0 < t < 45°C$):	- 0.22 % / °C

AD_VAC_SENS at 25°C:

	Vacuum [mmHg]	AD_VAC_SENS [V]
1	0	0.50
2	25	0.68
3	50	0.86
4	75	1.05
5	100	1.23
6	125	1.41
7	150	1.59
8	175	1.77
9	200	1.95
10	225	2.14
11	250	2.32
12	275	2.50
13	300	2.68
14	325	2.86
15	350	3.05
16	375	3.23
17	400	3.41
18	425	3.59
19	450	3.77
20	475	3.95
21	500	4.14
22	525	4.32
23	550	4.50

3.1.2.9 NTC vs. Vacuum Sensor temperature.

NTC type:	10k @ 25°C, ± 2%, 0805
LSU temperature range:	0 – 70°C

Accuracy:

For 0 – 40°C: ± 2°C

For 41 – 70°C: ± 3°C

AD_BATT_TEMP voltage tolerance: ± 0.09V

AD_BATT_TEMP voltage values are based upon resistance values given per °C specified by Fenwal.

	Temp [°C]	Voltage (AD_BATT_TEMP) [V]	AD Value
1	0	3.83	196
2	1	3.78	194
3	2	3.73	191
4	3	3.68	189
5	4	3.64	186
6	5	3.59	184
7	6	3.54	181
8	7	3.49	178
9	8	3.43	176
10	9	3.38	173
11	10	3.33	170
12	11	3.27	168
13	12	3.22	165
14	13	3.17	162
15	14	3.11	159
16	15	3.06	156
17	16	3.00	154
18	17	2.94	151
19	18	2.89	148
20	19	2.83	145
21	20	2.78	142
22	21	2.72	139
23	22	2.67	136
24	23	2.61	134
25	24	2.56	131
26	25	2.50	128
27	26	2.45	125
28	27	2.39	122
29	28	2.34	120
30	29	2.28	117
31	30	2.23	114
32	31	2.18	112
33	32	2.13	109
34	33	2.08	106
35	34	2.03	104
36	35	1.98	101
37	36	1.93	99
38	37	1.88	96
39	38	1.83	94
40	39	1.78	91
41	40	1.74	89
42	41	1.69	87

43	42	1.65	84
44	43	1.61	82
45	44	1.56	80
46	45	1.52	78
47	46	1.48	76
48	47	1.44	74
49	48	1.40	72
50	49	1.36	70
51	50	1.32	68
52	51	1.29	66
53	52	1.25	64
54	53	1.22	62
55	54	1.18	61
56	55	1.15	59
57	56	1.12	57
58	57	1.09	56
59	58	1.06	54
60	59	1.03	53
61	60	1.00	51
62	61	0.97	50
63	62	0.94	48
64	63	0.91	47
65	64	0.89	45
66	65	0.86	44
67	66	0.84	43
68	67	0.81	42
69	68	0.79	40
70	69	0.77	39
71	70	0.75	38

3.1.2.10 Charging.

In order to control charging of the internal SLA battery, the charging current is measured. Due to amplifier offset and Common Mode error the charging current function has to be calibrated in the assembly department.

Current range:	0 – 900 mA
Accuracy:	± 50mA
Voltage range:	1 – 5 V
Max offset voltage:	340 mV
Max Common Mode (CM) error voltage:	20 mV/V_{CM}
Max total error (offset and CM error):	654 mV

At a CM voltage of 14.7V ± 0.2V:

Max total error:	650mV
Linearity:	max 150mV deviation from a straight line drawn between the voltage at 100mA and 800mA.

	Current [mA]	AD_CURRENT [V]
1	0	1.0 ± 0.65
2	100	1.4 ± 0.65
3	200	1.8 ± 0.65
4	300	2,2 ± 0.65
5	400	2.6 ± 0.65
6	500	3.0 ± 0.65
7	600	3.4 ± 0.65
8	700	3.8 ± 0.65
9	800	4.2 ± 0.65
10	900	4.6 ± 0.65

The charging algorithm consists of *three* phases. In the first phase the battery is charged using a *constant bulk (fast) current*, $I_{max.}$ This will bring the battery voltage up to a defined level, V_T, before the constant voltage *high float charging* starts. To secure a long battery life the high float voltage charging is replaced with a lower constant voltage *(low float charging)* after 48 hours.

Phase 1:
Constant bulk current, I_{max}: 0.75 A ± 50 mA

Phase 2:
High float charging voltage, V_{T0}, at 0°C: 15.4V ± 0,25V
High float charging voltage, V_{T40}, at 40°C: 14.2V ± 0,25V
Tolerances: ± 0,125V

The charging voltages for temperatures between 0° and 40°C shall be found by interpolation.

Phase 3:
Low float charging voltage, V_{L0}, at 0°C: 14.1V
Low float charging voltage, V_{L40}, at 40°C: 13.4V
Tolerances: ± 0,125V

The charging voltages for temperatures between 0° and 40°C shall be found by interpolation.

3.1.2.11 Switches.

General:

The suction unit is equipped with two switches. The *Operating Knob* works as both an On / Off switch and a flow / vacuum selector. The T*est Button* is used (together with the main rotary switch) to enter *User Test Mode.*

Operating Knob:

The Operating Knob consists of a knob with a number of flags that operate a micro switch and three optical switches. The micro switch disconnects the battery whenever this is the only power source present. Activation of the micro switch will cause ON_SWITCH to go HIGH.

OPTO_ON:	HIGH / LOW
OPTO_A:	HIGH / LOW
OPTO_B:	HIGH / LOW
OPTO_C:	HIGH / LOW
ON_SWITCH:	HIGH / LOW

Micro switch specifications

Rating:	0.1A / 250VAC
Actuator type / length:	Roller lever 18mm
Operation Force (O.F):	Max 60 g

Optical switch specifications

IR emitter:	
Forward Voltage:	Max 1.6V
Continuos Forward Current:	Max 50mA
Phototransistor:	
CE Breakdown Voltage:	Min 30V
Collector DC Current:	Max 30mA

Decoding of the optical receivers:

Opto A	Opto B	Opto C	Hex value	"Setting"
0	1	1	0x03	O
1	0	0	0x04	80
0	0	1	0x01	120
1	0	1	0x05	200
1	1	0	0x06	350
0	0	0	0x00	500
0	1	0	0x02	N/A
1	1	1	0x07	N/A

Test Button:

Activation of the test button will cause TEST_BTN to go HIGH.

TEST_BTN: HIGH / LOW

Interface connectors:
MMI Board to Power Board:
Connector type: Molex Art. No. 43045-0221

Pin #	Signal Name	Description
1	18/20V	18 / 20 V input from PWR Bd.
2	GND	GND

MMI Board to Motor:
Connector type: Molex Art. No. 43650-0315

Pin #	Signal Name	Description
1	MOTOR_+	+ to motor
2	MOTOR_-	Connected to GND when MOTOR line from µC is enabled.
3	N/A	NC

MMI Board to Battery Board:
Connector type: Molex Art. No. 43650-0415

Pin #	Signal Name	Description
1	GND	GND
2	BATT_+	+12 on the internal battery
3	RXD	RXD for serial communication
4	TXD	TXD for serial communication

MMI Board to Front Panel (LED Foil):
Connector type: Molex Art. No. 52207-1290

Pin #	Signal Name	Description
1	+5V	+5V
2	nLED_EXT_PWR	LOW when external power is connected
3	nLED_ERROR	Pulled LOW by the µC when an error occurs.
4	TEST_BTN	HIGH when the TEST button is activated
5	LED_ROW_4	Row 4 in the 4x4 LED matrix
6	LED_ROW_3	Row 3 in the 4x4 LED matrix
7	LED_ROW_2	Row 2 in the 4x4 LED matrix
8	LED_ROW_1	Row 1 in the 4x4 LED matrix
9	LED_COL_1	Column 1 in the 4x4 LED matrix
10	LED_COL_2	Column 2 in the 4x4 LED matrix
11	LED_COL_3	Column 3 in the 4x4 LED matrix
12	LED_COL_4	Column 4 in the 4x4 LED matrix

3.1.3 Battery Board.

Connection to/from the MMI Board is through J1.

L1 is a common mode filter for EMC.

J2 and J3 provide the connection to the internal battery.

The battery board also has two contacts, J4 and J5, for serial communication between internal controller and an external computer. This communication is utilised for service and calibration purposes. An external driver is required to achieve a serial communication with the µC.

Battery Board to MMI Board interface:
Connector type: Molex Art. No. 43650-0403

Pin #	Signal Name	Description
1	GND	GND
2	BATT_+	+12 on the internal battery
3	RXD	RXD for serial communication
4	TXD	TXD for serial communication

3.1.4 LED Foil.

The LED foil presents the following information to the operator:

- Applied vacuum is presented on a column of 11 LEDs representing vacuum from 0 to 550mmHg.
- A column of 4 LEDs indicates the remaining battery capacity, when the unit is operated from battery. When the unit is off and connected to an external power source, the LED column indicates charging status.
- 3 additional LEDs provide the following indicators: <u>Power ON</u>, <u>External Power</u> connected and <u>Failure Mode</u> indicating that the microcontroller has detected an ERROR conditions.

The front panel includes a test button that is used to:

- In combination with the Operation Knob to start the microcontroller in a test mode.
- Identify an error when ERROR is indicated in operation mode.

REF. LSU Software Specification for details on TEST-function and ERROR-identification.

3.1.5 Internal Cables.

There are four internal cables:

- A two conductor cable connecting the Power Board to the MMI Board
- A four-conductor cable connects the Battery Board to the MMI Board. Two conductors are for power to and from the battery, and two are used for the serial communication between the controller and an external computer.
- Motor cable.
- MMI Board to Front Panel (LED Foil).

Power – MMI.

Connector type (Power Bd. side): Molex Art. No. 43645-0200
Connector type (MMI Bd. side): Molex Art. No. 43025-0200

Cable length (including the connectors):	380mm ± 5mm
Cable size:	20 AWG
Twisted pair:	Black / Red
Number of turns:	17- 18

Two ferrites have to be included for EMC purposes.

Ferrite type:	Fair-Rite No. 2643023002 or equivalent

Pin # Pwr. Bd.	Cable Colour	Signal Name	Pin # MMI Bd.
1	Black	GND	2
2	Red	18/20V	1

Battery – MMI.

Connector type: Molex Art. No. 43645-0400

Cable length (including the connectors)	180mm ± 5mm
Cable size:	20 AWG
Twisted pairs:	Black / Red and Yellow / Blue
Number of turns:	8-9

Pin # Batt. Bd.	Cable Colour	Signal Name	Pin # MMI Bd.
1	Black	GND	1
2	Red	BATT_+	2
3	Yellow	RXD	3
4	Blue	TXD	4

Motor.

The motor is delivered with a three pin connector from the producer.

Connector type: Molex Art. No. 43645-0300

Pin #	Signal Name	Cable Colour
1	MOTOR_+	Red
2	MOTOR_-	Black
3	N/A	N/C

MMI Board to Front Panel (LED Foil).

Connector type (on MMI Bd.): Molex Art. No. 52207-1290

Pin #	Signal Name	Description
1	+5V	+5V
2	NLED_EXT_PWR	LOW when external power is connected
3	NLED_ERROR	Pulled LOW by the μC when an error occurs.
4	TEST_BTN	HIGH when the TEST button is activated
5	LED_ROW_4	Row 4 in the 4x4 LED matrix
6	LED_ROW_3	Row 3 in the 4x4 LED matrix
7	LED_ROW_2	Row 2 in the 4x4 LED matrix
8	LED_ROW_1	Row 1 in the 4x4 LED matrix

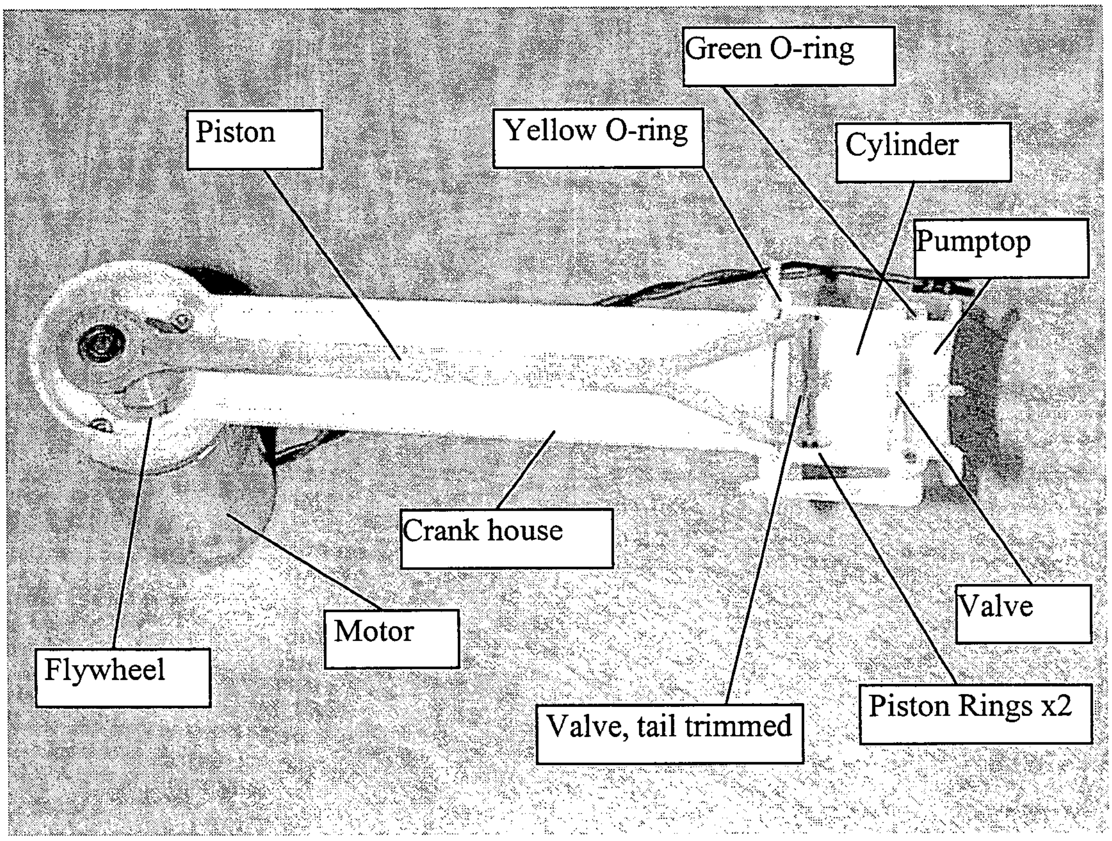
9	LED_COL_1	Column 1 in the 4x4 LED matrix
10	LED_COL_2	Column 2 in the 4x4 LED matrix
11	LED_COL_3	Column 3 in the 4x4 LED matrix
12	LED_COL_4	Column 4 in the 4x4 LED matrix

4. Mechanical Construction.

4.1. Pump and Motor.

Description.:
A DC motor driven single mode piston pump, where the membrane valves are controlled by pressure.

- The piston movement is generated by a DC motor by a eccentric flywheel
- The piston has build in a membrane valve and two piston rings.
- The vacuum is produced in a vacuum chamber, where another membrane valve via pressure controls the flow direction.



4.2 Disassembly/Assembly

A. Opening the Unit:

1. If there is a bottle/hose holder attached remove it by unscrewing 3 screws.
2. Untie the screw in the bottom of the unit.
3. Unscrew 5 large and 8 small screws (2 are hidden under the handle).
4. Remove the back.
5. Take the large foam part away from the bottom and free the cable.
6. Unhook the bottom.

B. Exchange of the Power PCB:

7. Remove Power PCB, unlocking cable from contact.

C. Exchange of the Pump

8. Lift the pump from the unit
9. Unhook 3 silicone hoses
10. Unlock cable from MMI PCB

D. Exchange of the MMI PCB

11. Remove pump see section C
12. Unscrew 4 screws
13. Disconnect the tail from the display
14. Exchange the MMI PCB. NOTE: It is possible to break the micro-switch, the selector shall therefore not be in Off/0 position when the MMI PCB is placed in the front.

E. Exchange of the display

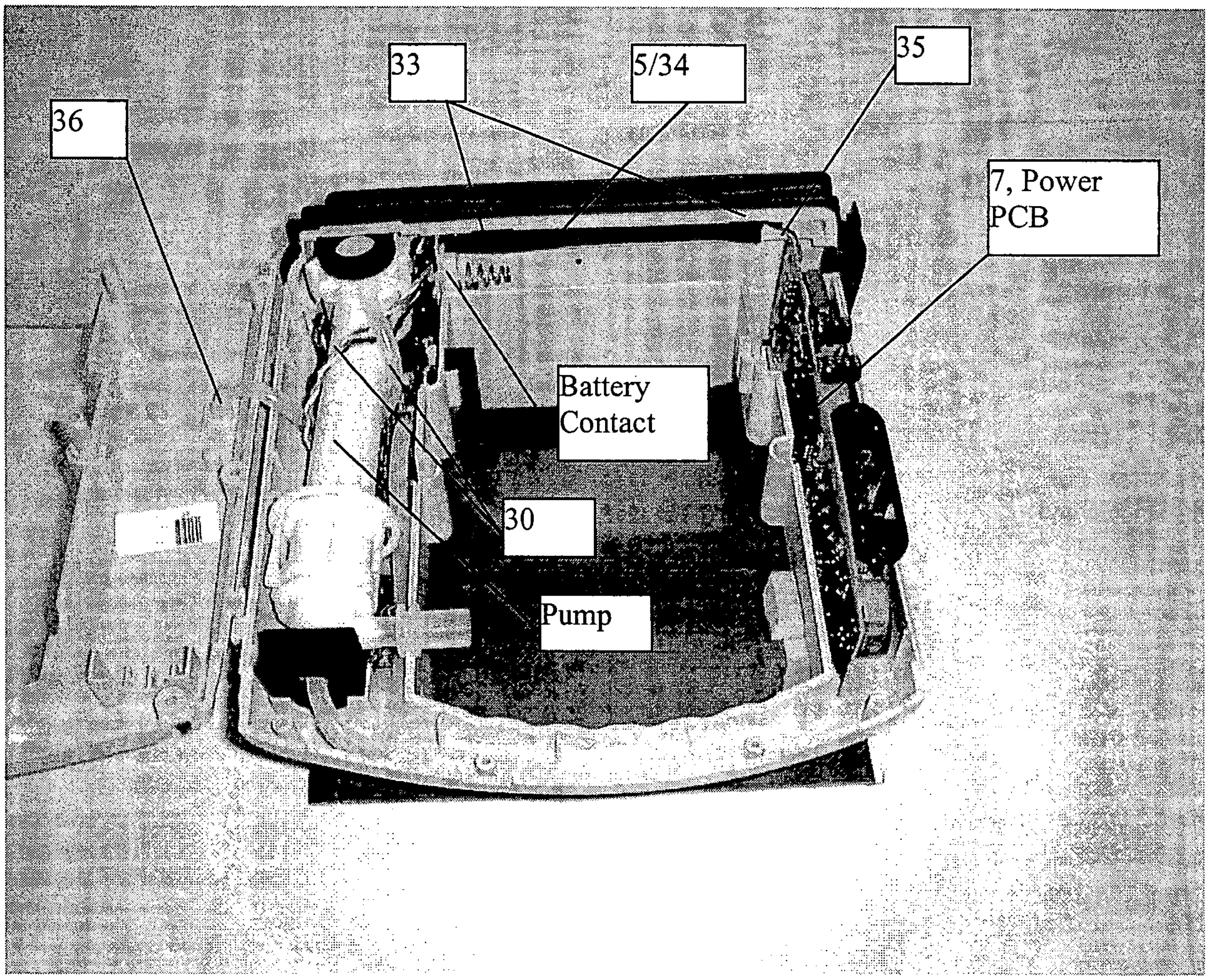
15. Remove MMI PCB see section D
16. Turn unit and pull the display off
17. Exchange the display, take care to press and hold the two "ends" in the bottom of the display firmly down.

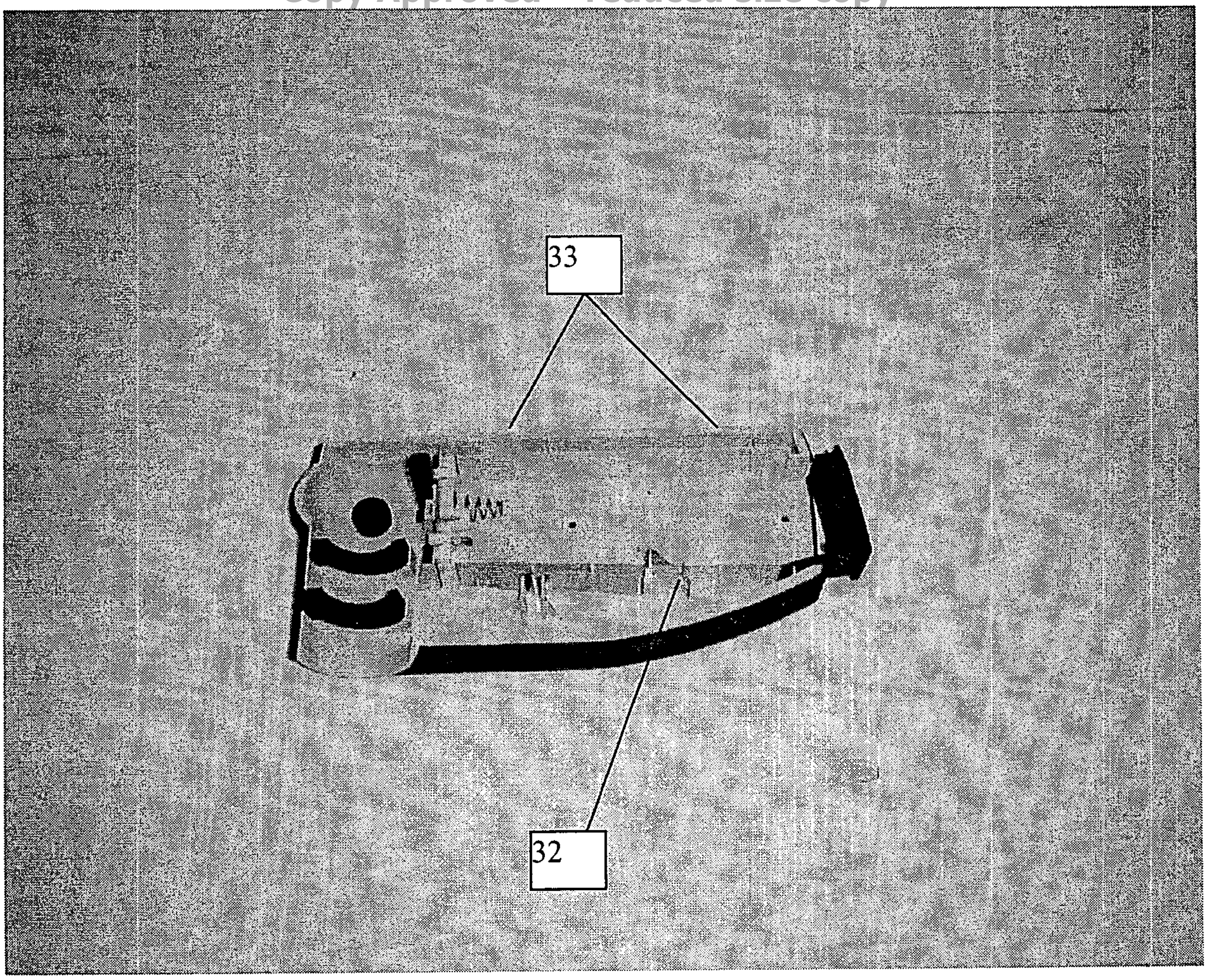
G. Exchange of the spring for the selector

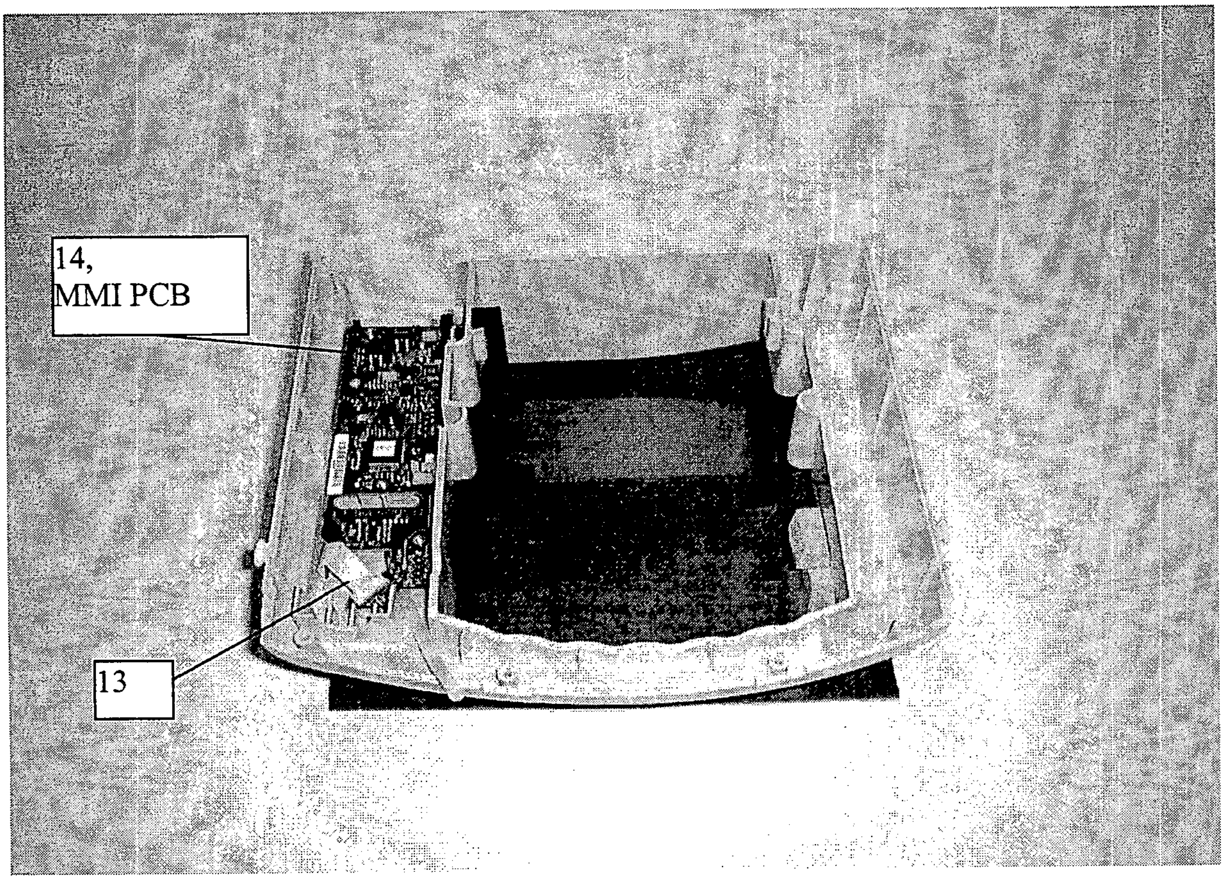
18. Remove MMI PCB see section D
19. Remove the selector by unscrewing 1 screw.
20. Exchange the spring by unscrewing the 2 small screws. NOTE the legs of the spring have to be on the outside of the two small plastic pins.

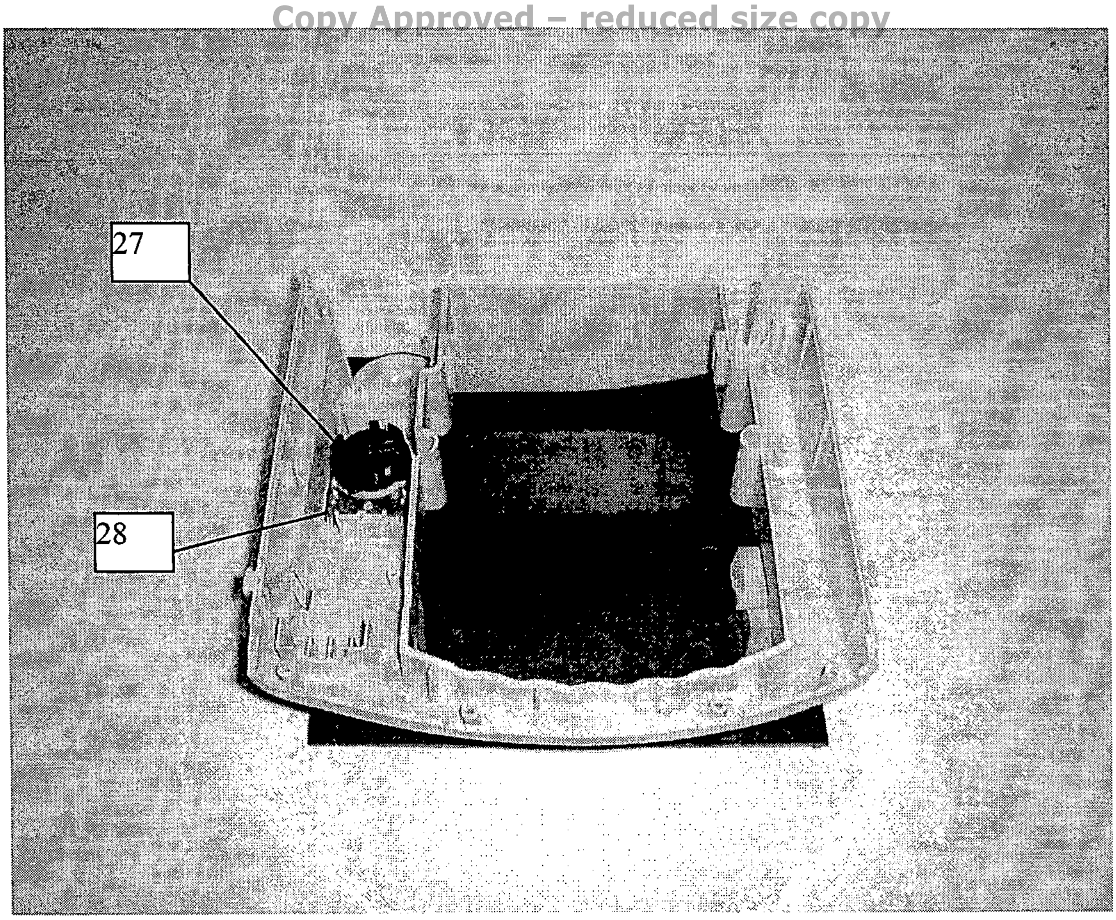
H. Assembling the unit

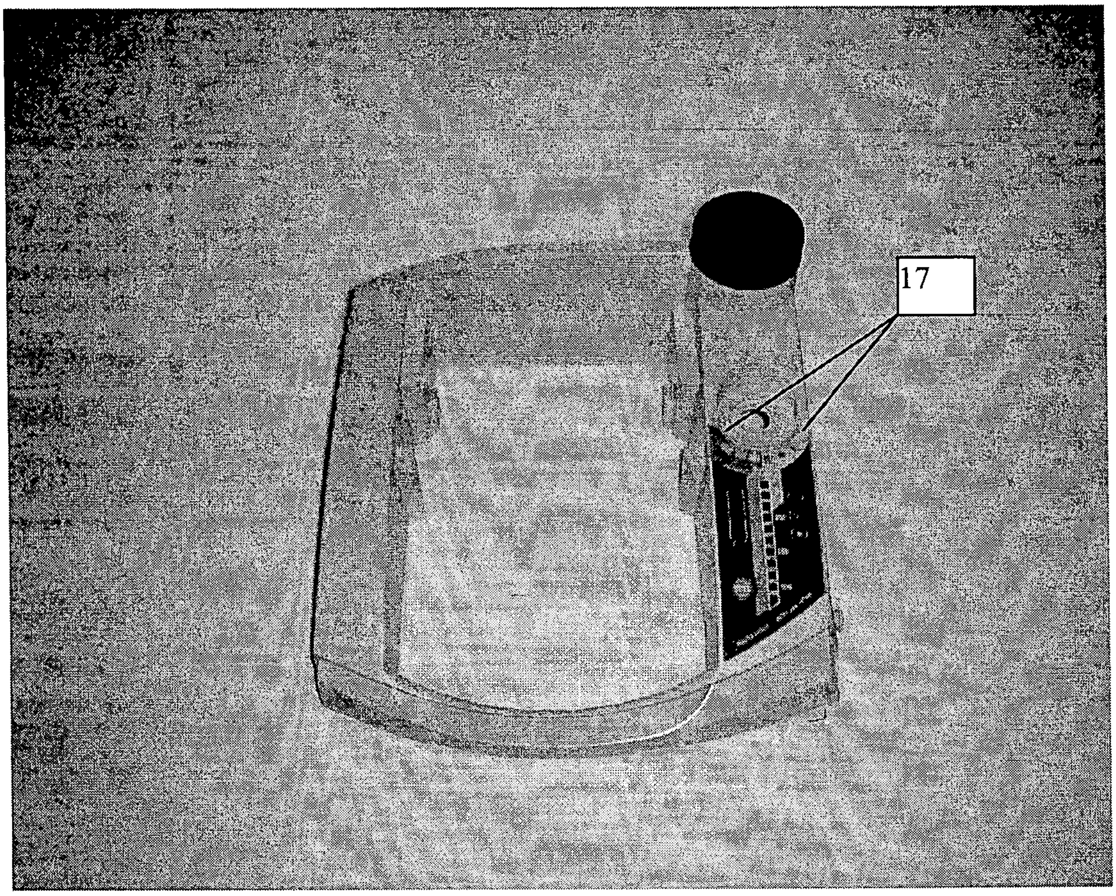
21. Reverse the disassembling done. But PLEASE note the following:
22. Take care that the battery cable is over the pump and that the exhaust hose is under the pump.
23. If the battery side spring has been exchanged, make sure that the end of the spring is not in the battery area. Simply pushing the spring to the side can check this. The spring must be able to move.
24. Take care that the ferrite pieces on the cable are in their slots in the bottom.
25. Take care that the foam covering the cable in the bottom is pushed fully down.
26. Take care that the power cable is bend down just after it clears the power PCB so the back shall not cut the cable when reassembling the unit.
27. Take care that the exhaust hose is firmly attached to the back and that it isn't bend before the back is screwed back on the front. (It is possible to see if there is any bend on the hose, by seeing from the side just before the back is put on the front. The hose has to go straight down).
28. Take care to press down the handle when it is screwed on with the 2 last screws.

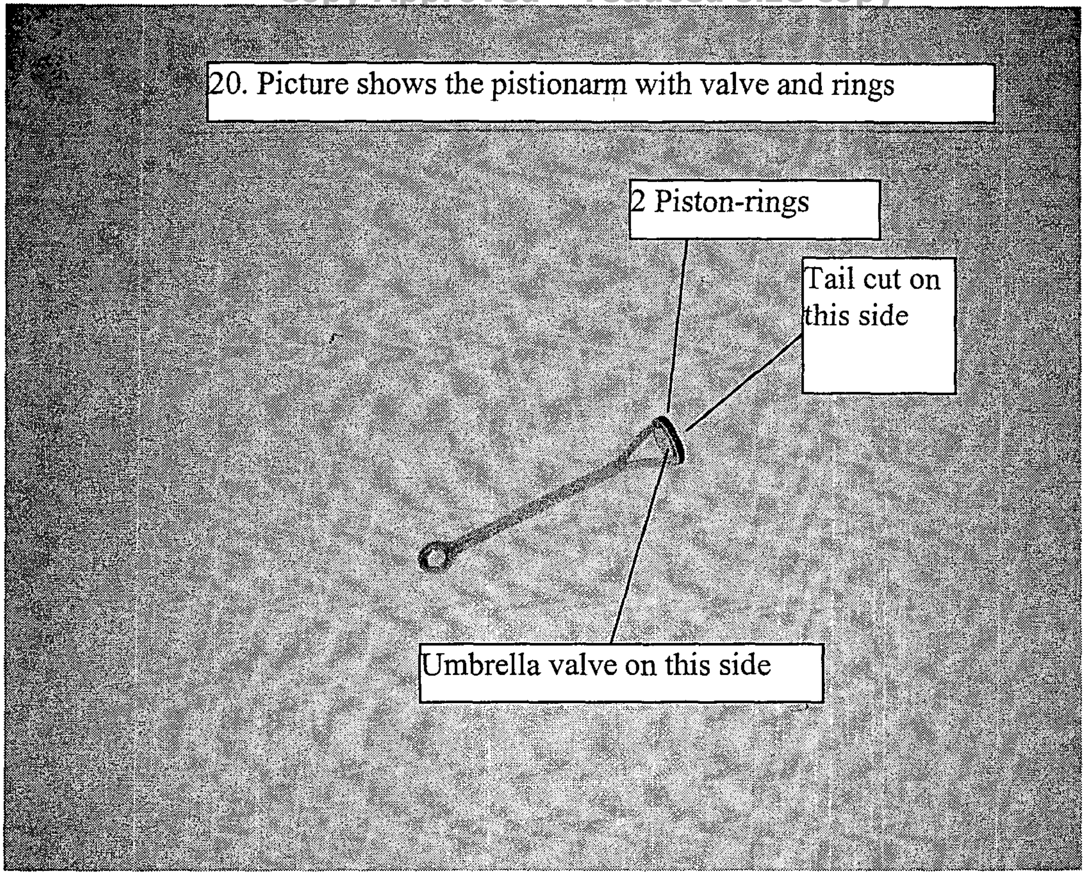

33
5/34
35
36
7, Power PCB
Battery Contact
30
Pump


33
32


14,
MMI PCB
13


27
28


17



5 Service and Maintenance.

5.1 Exchange of wear and tear parts in the pump

29. Please note that it is important that the piston arm, cylinder and piston rings are exchanged at the same time. The piston arm and rings are selected so they fit each other and they should be used with a new cylinder to allow for controlled wear and tear.
30. Remove pump see section C
31. Assemble the piston arm with 1 umbrella valve and 2 piston rings. Note the tail of the valve has to be cut off after it is pulled though the piston arm. The valve has to be on lover side of the piston arm.
32. Remove the cylinder at the top of the pump by turning the valve-top counter clockwise.
33. Remove the exhaust manifold
34. Unhook the piston arm.
35. Exchange the piston arm.
36. Exchange all 5 O-rings
37. Exchange the umbrella valve in the valve-top.

5.2 Pump returned because of:

5.2.1 Overflow:
If there is suspicion on decontamination then the pump unit including motor shall be replaced!
Note: Do not soak pump parts. The inner parts of the pump shall not be exposed to decontamination as described for the Reusable Canister in the Direction for Use section 5.4.5.

- Check for corrosion on the motor and flywheel. If corrosion is present exchange the pump (Cat. No. 780500). If no corrosion is present clean the inner of the pump with mild detergent, as described in the Direction for Use section 5.3, before reassembling the pump.
- Check the inner of the LSU for liquids.

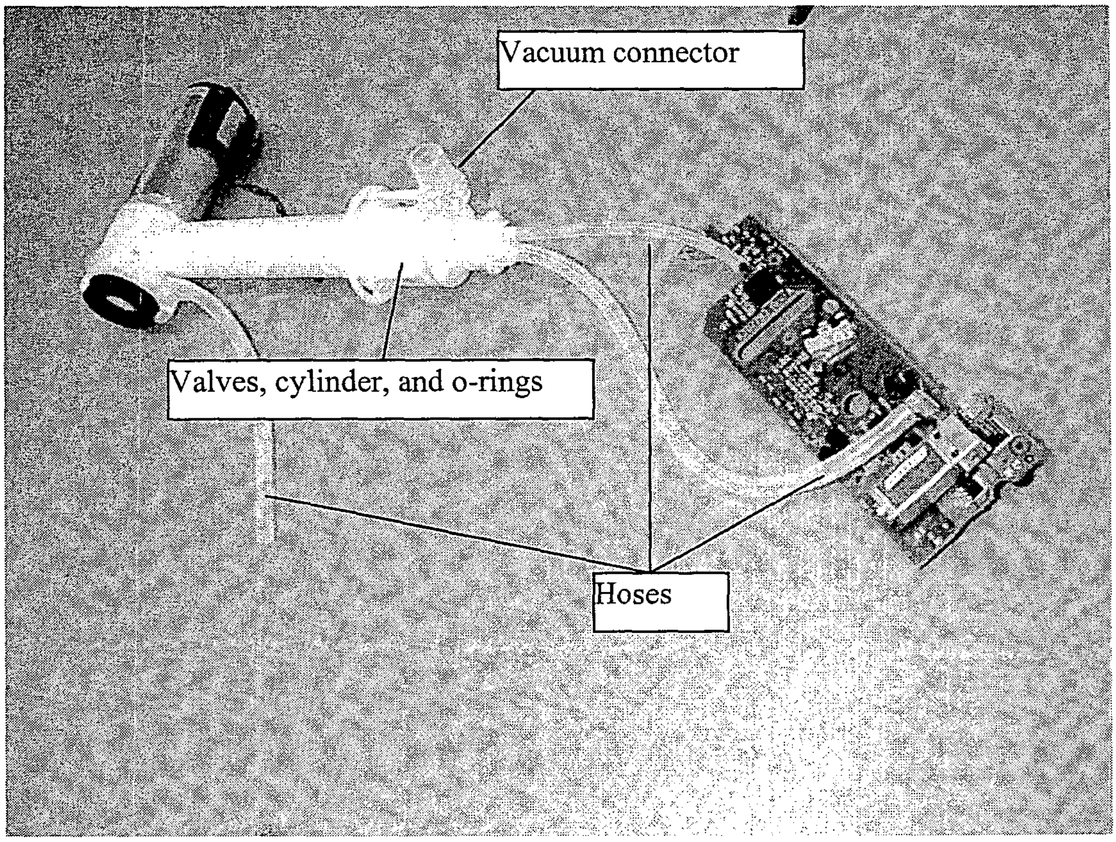
Failure mode:

All failures indicated on the display are from the MMI Board , the MMI board can be exchanged to solve the problem or use the correction below:

Vacuum LED lit (lowest is #1)	Error	Correction
2	Switch error. There is detected signal on a opto sensor receiver before sender is turned on	Check D10, D11 and/or D12 Check Q8
3	5V system voltage too high error. 5V system voltage is measured to be too high	Measure +5V (test pin 7) Check R66 and/or R64. Check U5. Check U2 (5V regulator)
4	5V system voltage too low error. 5V system voltage is measured to be too low	Measure +5V (test pin 7) Check R66 and/or R64. Check U5. Check U2 (5V regulator)
5	Vacuum sensor error. Vacuum sensor has too high or too low voltage output	Check U5 Check R81 Check C51
6	Charge current error. The battery is charged with too high current	Check R68 Check U5 Check Buck Regulator Check Isens amp
7	Charge voltage error. The battery charge voltage is outside limits	Check U5 Check R68, D14, R42, R43, R83, R76, Q10, Q14, R46, R45, R84, and/or C14. Check Buck Regulator (page 2 in PRO-T35-0009 The system is checking U6 pin 3, pin 5 and pin 9.
8	Calibration error. Calibration data in EEPROM cannot be read. POT1 cannot be set.	Check U8, R63, R29, and/or POT1.

Test results:

Step 1 – Occlusions:	Check for foreign object and remove if any.
Step 2 – Vacuum build up:	Check for leakage at the vacuum connector, valves, rings, cylinder, o-rings, and the small silicone hoses with connections.
Step 3 – Max vacuum:	Check for leakage at the vacuum connector, valves, rings, cylinder, o-rings, and the small silicone hoses with connections.
Step 4 – Air Leakage:	Check for leakage at the vacuum connector, valves, o-rings, and the small silicone hoses with connections.



5.2.2 Annual maintenance

Inspect the LSU to determine the state of the unit and replace if necessary worn parts
Inspect the following parts wear and tear: AC/DC inlet, display, battery plug, battery Board, rotor, and rotor spring and replace if necessary parts.

5.2.3 3 years service

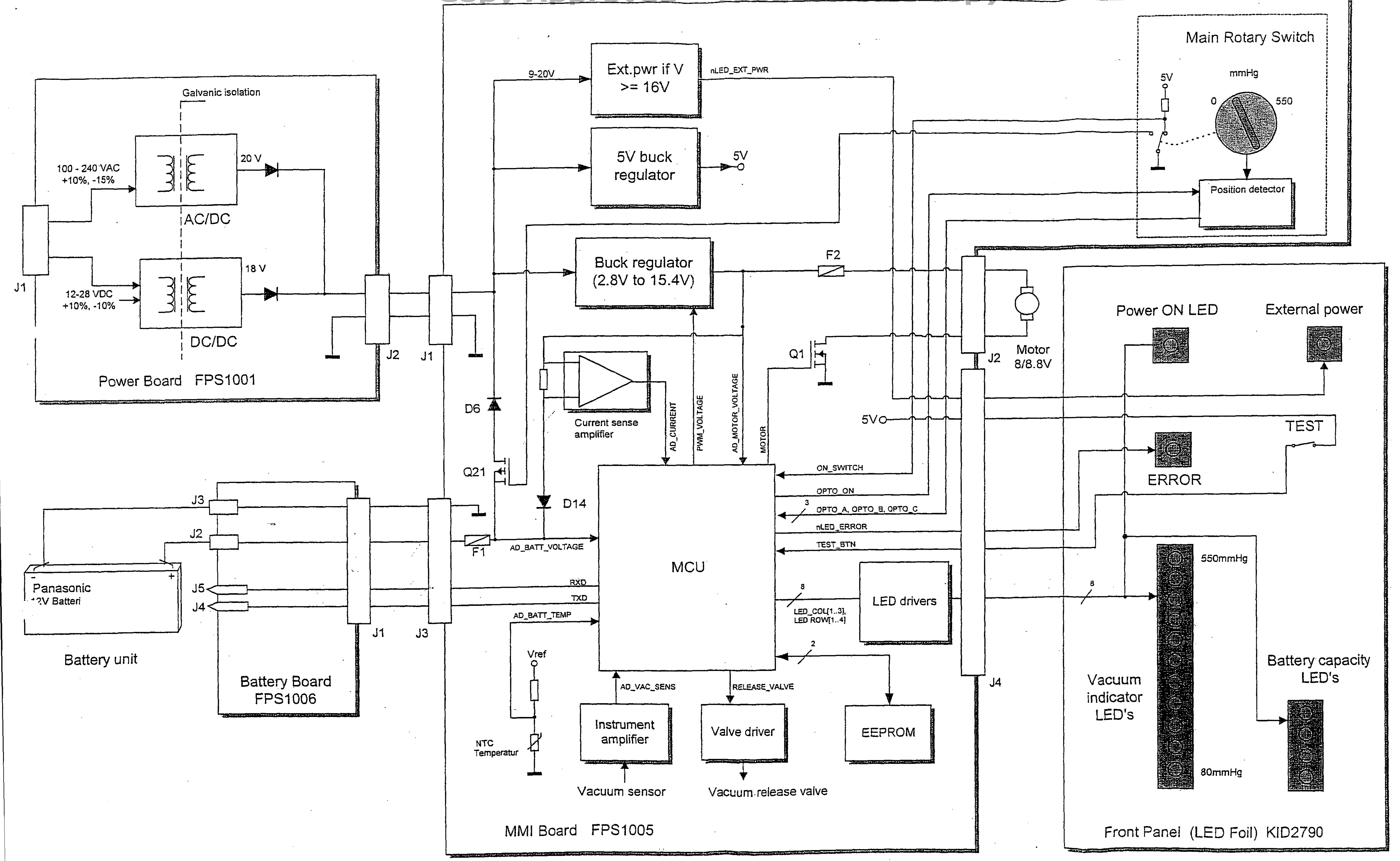
Inspect the LSU to determine the state of the unit and replace if necessary worn parts
Inspect the following parts for wear and tear: AC/DC inlet, display, battery plug, battery Board, rotor, and rotor spring and replace if necessary parts.
Exchange wear and tear parts in the pump: Cat. No. 780510

5.3 Parts list:

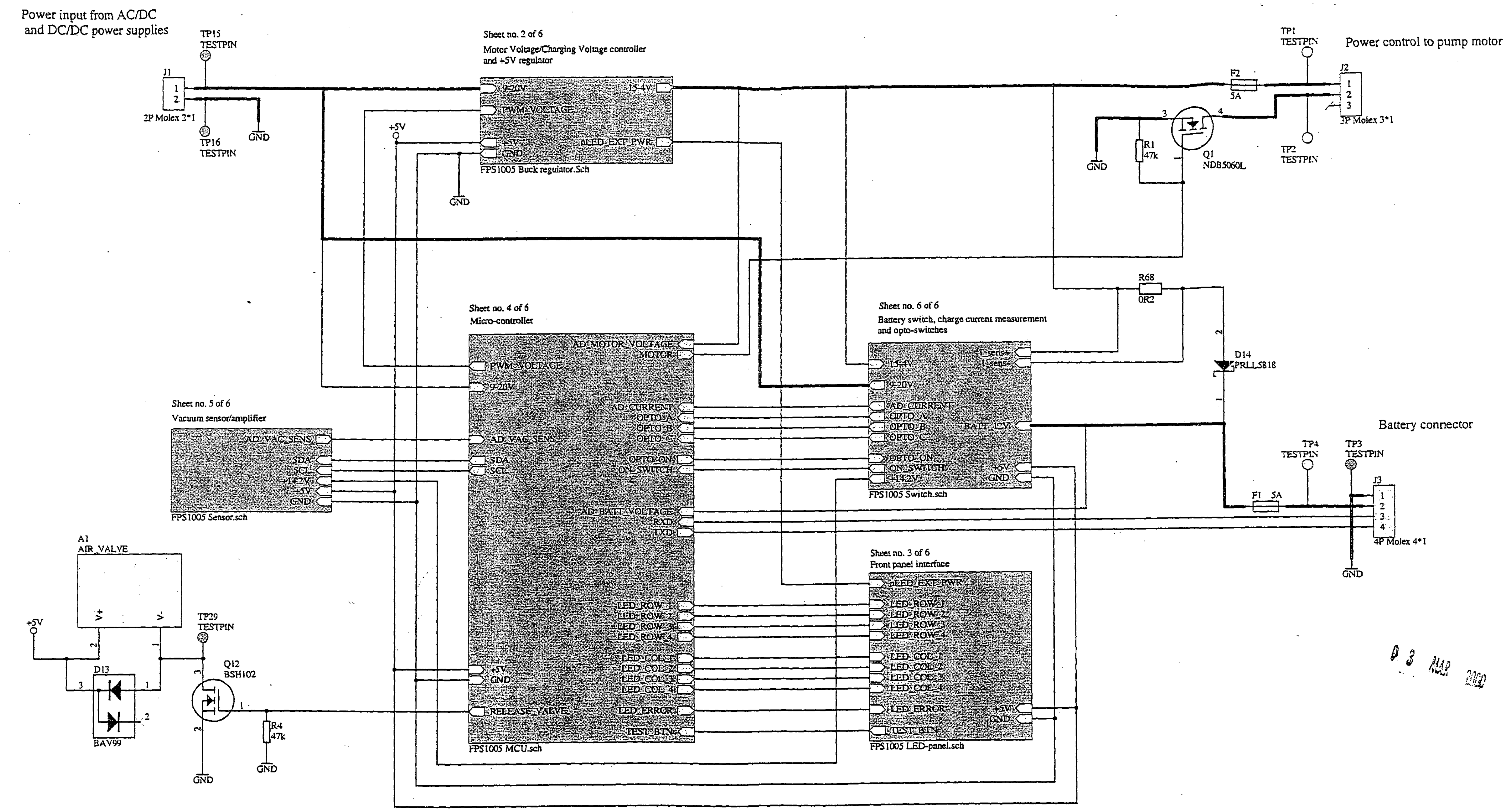
Cat. No.	Description
780100	Battery Cable
780110	Technical Manual
780120	Power Cable
780270	Battery contact w/spring
780130	Handle, protection
780140	Selector, main rotary switch
780150	Gasket
780160	Cabinet complete (front, back, handle, bottom, 11 screws)
780170	Vacuum connector
780510	Piston w/piston gasket
780500	Vacuum pump complete
780180	Foam absorbers (6 pcs.)
780190	Battery Lid
780240	Power Board
780250	MMI Board
780270	Battery contact w/spring
780500	Pump complete
780510	Pump wear and tear parts
780520	Piston-arm exchange tool
780530	Umbrella valves
780600	LED Display

6.0 Circuit Diagrams

LSU Block diagram
Top Level 1/6
Buck Regulator 2/6
Interface for LED panel 3/6
MCU 4/6
Vacuum Sensor Amplifier 5/6
Switch Interface & Battery Power
Top Level 1/3
AC/DC Flyback Converter 2/3
DC/DC Forward Converter 3/3



LSU4000 Block diagram



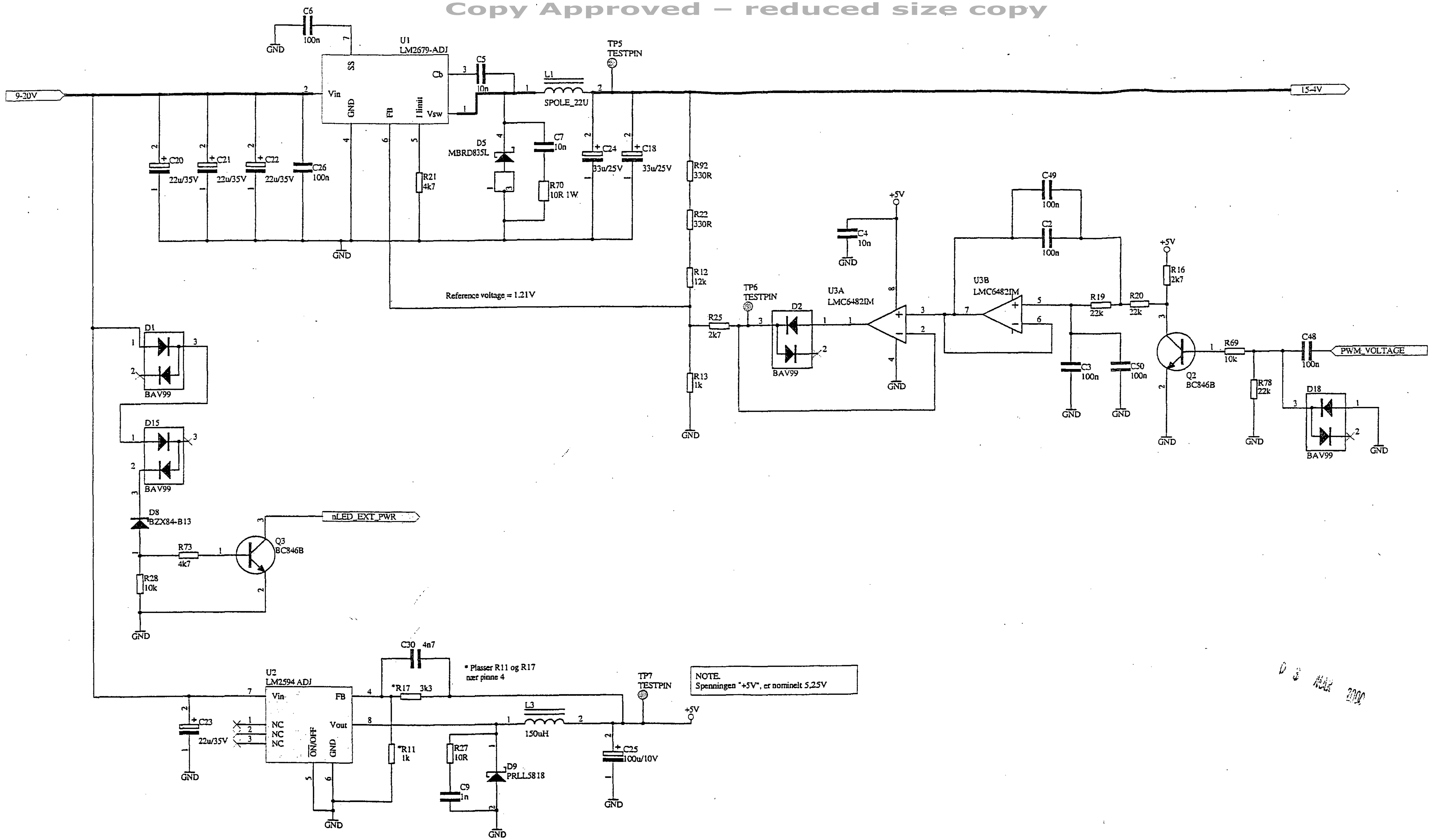
REV	STATUS FOR UTGIVELSE/STATE OF ISSUE	ECO NR.	ORGINATOR	VERIFIED	GODKJENT/APPROVED
A	Release	N/A	DATE AND SIGN 29-Feb-2000	DATE AND SIGN 01/03/00 LHS	DATE AND SIGN 1.3.00 PEC
			DATE AND SIGN	DATE AND SIGN	DATE AND SIGN
			DATE AND SIGN	DATE AND SIGN	DATE AND SIGN

Laerdal helping save lives — POB 377 N-4001 STAVANGER NORWAY

EKSTERNT REF NR/EXTERNAL REF NO: 950427
ERSTATTER/REPLACES: N/A
EKSTERN LEVERANDØR/EXTERNAL SUPPLIER: ProPartner
PRODUKTGRUPPE/PRODUCT GROUP: 78
ARTIKKEL/ITEM NO: FPS1005 — REV: A
FILEREF: U:\Prosjekt\2022-Lsu4000\Tekniske dokumenter\Design Output - Konstruksjonsresultater\HW\SCM_Fps1005 MMI Board
AVDELING/DEPARTMENT: 700

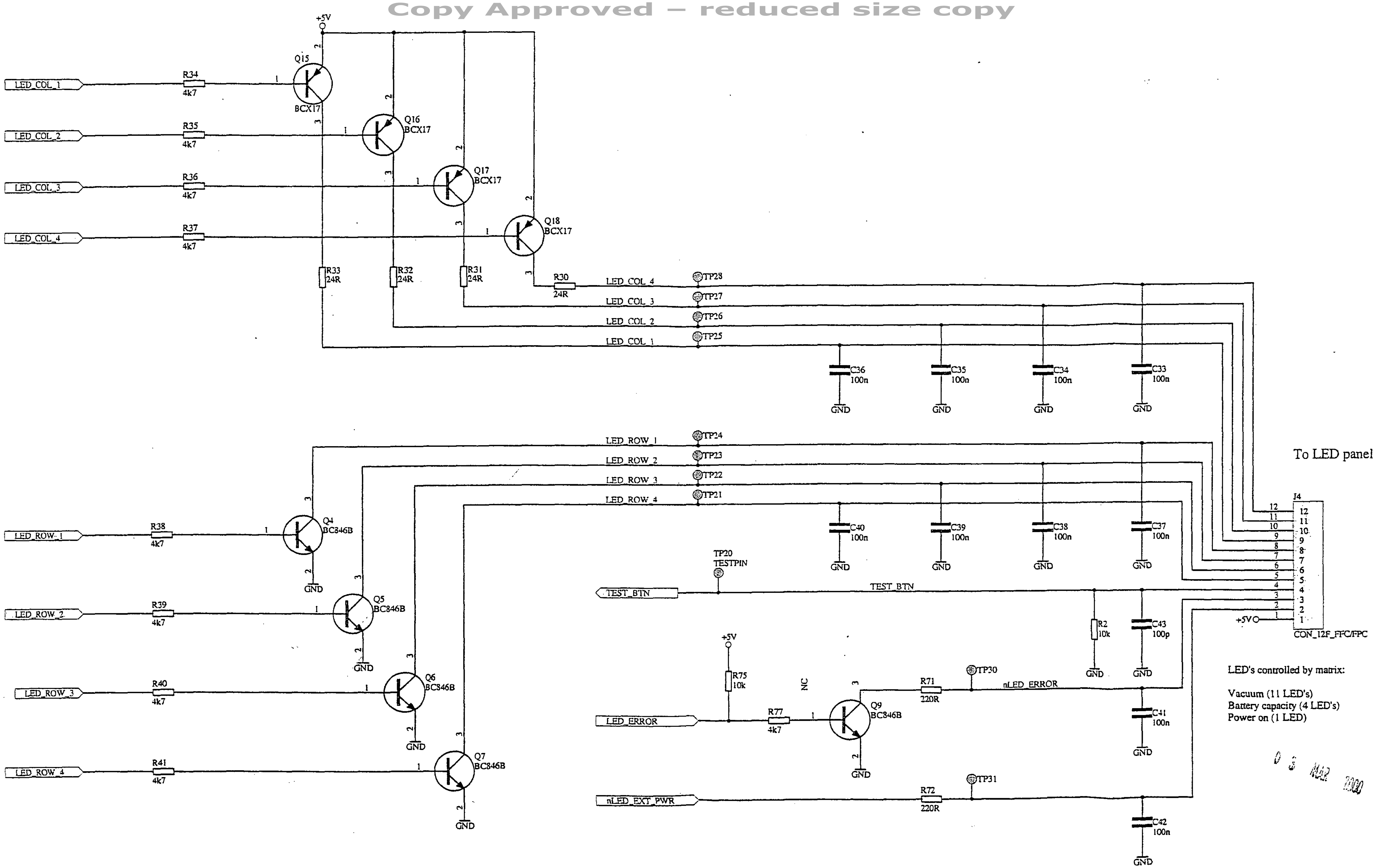
TITTEL/TITLE: FPS1005 MMI Bd. - LSU4000 Top Level

KAT/CAT. DOK.TYPE/DOC.TYPE SEKV.NR/SEQ.NO.: PRO - T35 - 0009
SIDE/SHEET: 1 of 6
REV: A



Laerdal POB 377 N-4001 STAVANGER NORWAY helping save lives	REV	STATUS FOR UTGIVELSE/STATE OF ISSUE	ECO NR.	ORGINATOR	VERIFIED	GODKJENT/APPROVED
	A	Release	N/A	DATE AND SIGN 29-Feb-2000 HA	DATE AND SIGN 01/03/00 LHS	DATE AND SIGN 1.3.00 PEC
				DATE AND SIGN	DATE AND SIGN	DATE AND SIGN
THE INFORMATION CONTAINED HEREON PROPRIETARY TO LAERDAL AND SHALL NOT BE USED FOR ANY PURPOSE DETRIMENTAL TO OR BE REPRODUCED WITHOUT PERMISSION OF LAERDAL				DATE AND SIGN	DATE AND SIGN	DATE AND SIGN

EKSTERNT REF NR/EXTERNAL REF NO: 950427	ERSTATTER/REPLACES: N/A	REV	TITTEL/TITLE: FPS1005 MMI Bd. - LSU4000 Buck Regulator
EKSTERN LEVERANDØR/EXTERNAL SUPPLIER: ProPartner			
PRODUKTGRUPPE/PRODUCT GROUP: 78	ARTIKKEL/ITEM NO: FPS1005	REV: A	
FILEREF: U:\Prosjekt\2022-Lsu4000\Tekniske dokumenter\Design Output - Konstruksjonsresultater\HW\SCM_Fps1005 MMI Board	AVDELING/DEPARTMENT: 700		KAT/CAT. DOK.TYPE/DOC.TYPE SEKV.NR./SEQ.NO.: PRO - T35 - 0009 · SIDE/SHEET: 2 of 6 · REV: A



REV	STATUS FOR UTGIVELSE/STATE OF ISSUE	ECO NR.	ORGINATOR	VERIFIED	GODKJENT/APPROVED
A	Release	N/A	DATE AND SIGN 29-Feb-2000	DATE AND SIGN 01/03/00 LHS	DATE AND SIGN 1.3.00 PEC
			DATE AND SIGN	DATE AND SIGN	DATE AND SIGN
			DATE AND SIGN	DATE AND SIGN	DATE AND SIGN

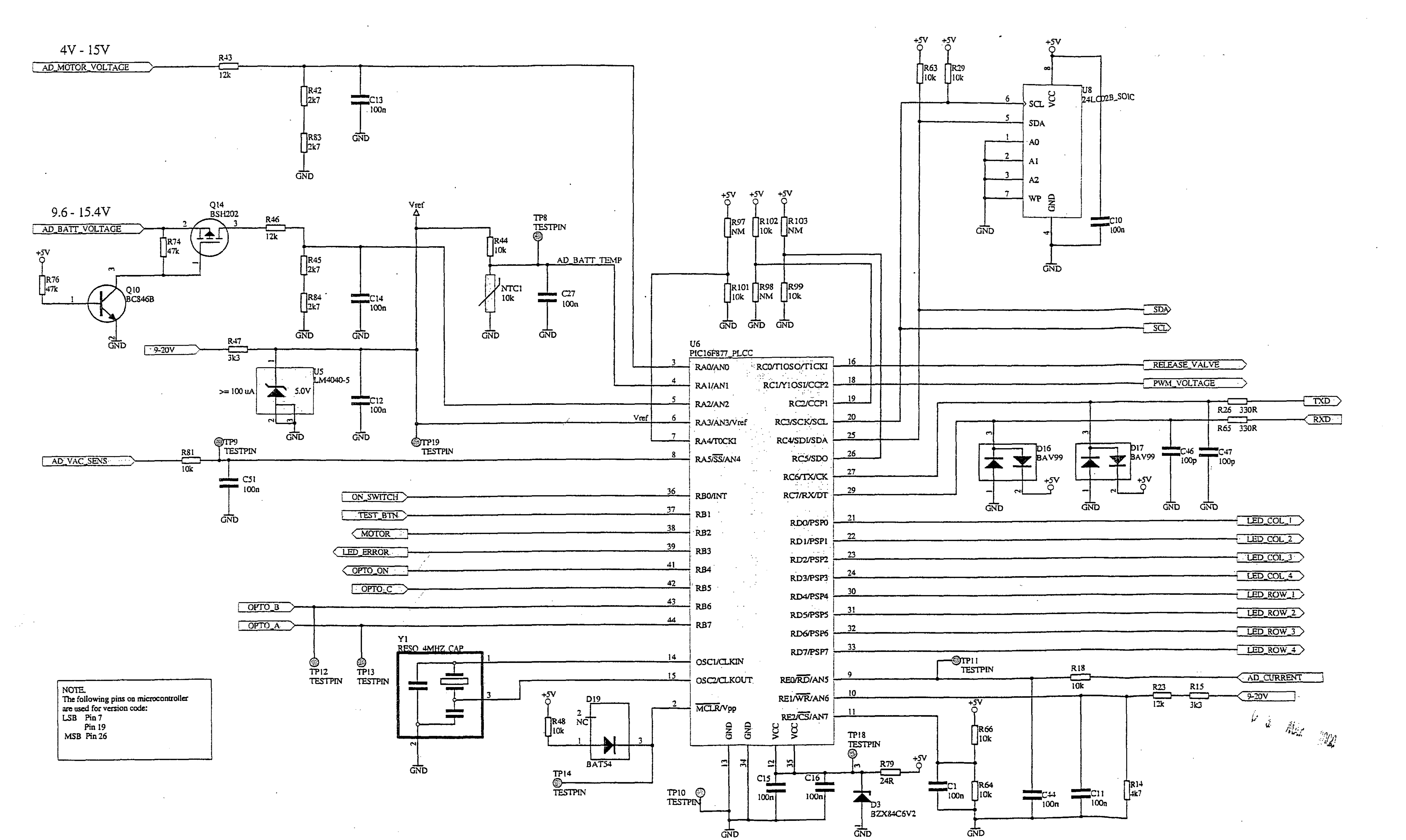
Laerdal helping save lives
POB 377 N-4001 STAVANGER NORWAY

EKSTERNT REF NR/EXTERNAL REF NO	950427
ERSTATTER/REPLACES	N/A
EKSTERN LEVERANDØR/EXTERNAL SUPPLIER	Propartner
PRODUKTGRUPPE/PRODUCT GROUP	78
ARTIKKEL/ITEM NO	FPS1005
REV	A
FILEREF	U:\Prosjekt\2022-Lsu4000\Tekniske dokumenter\Design Output - Konstruksjonsresultater\HW\SCM_Fps1005 MMI Board
AVDELING/DEPARTMENT	700

TITTEL/TITLE

FPS1005 MMI Bd. - LSU4000
Interface for LED panel

KAT/CAT. DOK.TYPE/DOC.TYPE SEKV.NR./SEQ.NO.	SIDE/SHEET	REV
PRO - T35 - 0009	3 of 6	A



REV	STATUS FOR UTGIVELSE/STATE OF ISSUE	ECO NR.	ORGINATOR	VERIFIED	GODKJENT/APPROVED
A	Release	N/A	DATE AND SIGN 29-Feb-2000	DATE AND SIGN 01/03/00 LHS	DATE AND SIGN 1.3.00 PEC
			DATE AND SIGN	DATE AND SIGN	DATE AND SIGN
			DATE AND SIGN	DATE AND SIGN	DATE AND SIGN

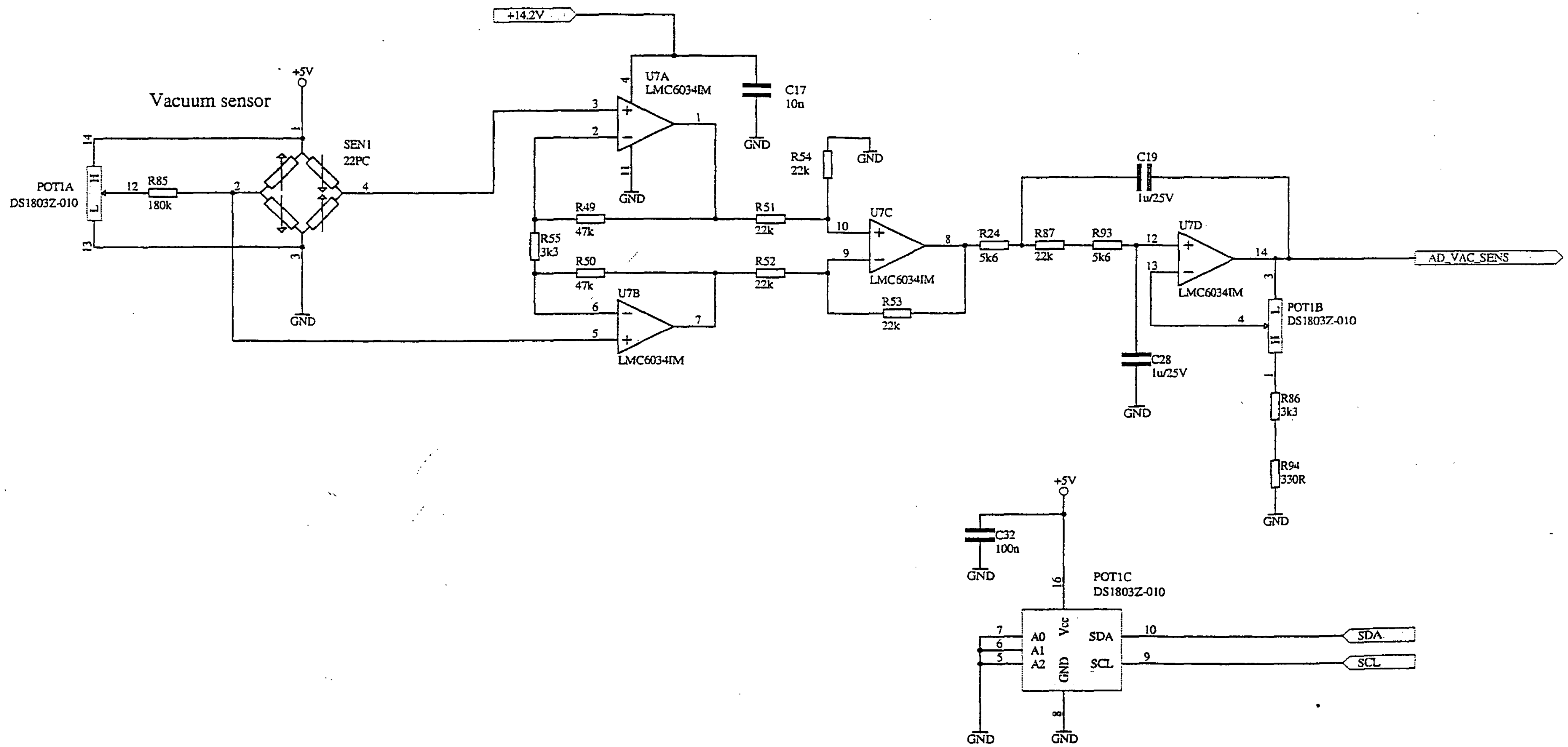
Laerdal — helping save lives
POB 377
N-4001 STAVANGER
NORWAY

IE INFORMATION CONTAINED HEREON
PROPRIETARY TO LAERDAL AND SHALL
OT BE USED FOR ANY PURPOSE
TRIMENTAL TO OR BE REPRODUCED
THOUT PERMISSION OF LAERDAL

EKSTERNT REF NR/EXTERNAL REF NO: 950427
ERSTATTER/REPLACES: N/A
EKSTERN LEVERANDØR/EXTERNAL SUPPLIER: ProPartner
PRODUKTGRUPPE/PRODUCT GROUP: 78
ARTIKKEL/ITEM NO: FPS1005
REV: A
FILER: U:\Prosjekt\2022-Lsu4000\Tekniske dokumenter\Design Output - Konstruksjonsresultater\HW\SCM_Fps1005 MMI Board
AVDELING/DEPARTMENT: 700

TITTEL/TITLE
FPS1005 MMI Bd. - LSU4000
MCU

KAT/CAT. DOK.TYPE/DOC.TYPE SEKV.NR/SEQ.NO.: PRO - T35 - 0009
SIDE/SHEET: 4 of 6
REV: A



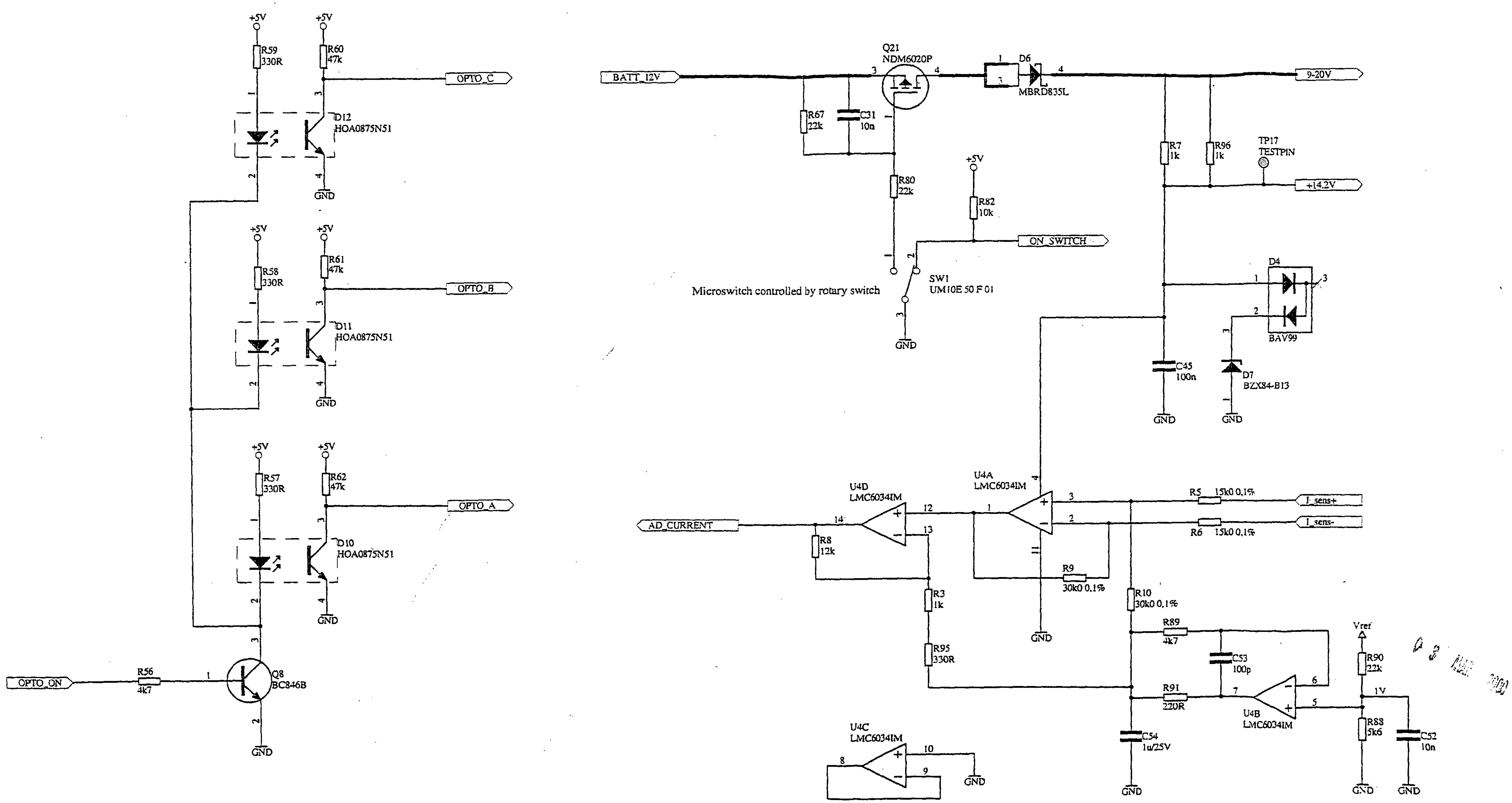
Laerdal POB 377 N-4001 STAVANGER NORWAY helping save lives	REV	STATUS FOR UTGIVELSE/STATE OF ISSUE	ECO NR.	ORGINATOR	VERIFIED	GODKJENT/APPROVED
	A	Release	N/A	DATE AND SIGN 29-Feb-2000	DATE AND SIGN 01/03/00 LHS	DATE AND SIGN 1.3.00 PEC
				DATE AND SIGN	DATE AND SIGN	DATE AND SIGN
THE INFORMATION CONTAINED HEREON IS PROPRIETARY TO LAERDAL AND SHALL NOT BE USED FOR ANY PURPOSE DETRIMENTAL TO OR BE REPRODUCED WITHOUT PERMISSION OF LAERDAL				DATE AND SIGN	DATE AND SIGN	DATE AND SIGN

EKSTERNT REF NR/EXTERNAL REF NO: 950427
ERSTATTER/REPLACES: N/A
REV
EKSTERN LEVERANDØR/EXTERNAL SUPPLIER: ProPartner
PRODUKTGRUPPE/PRODUCT GROUP: 78
ARTIKKEL/ITEM NO: FPS1005
REV: A
FILEREF: U:\Prosjekt\2022-Lsu4000\Tekniske dokumenter\Design Output - Konstruksjonsresultater\HW\SCM_Fps 1005 MMI Board
AVDELING/DEPARTMENT: 700

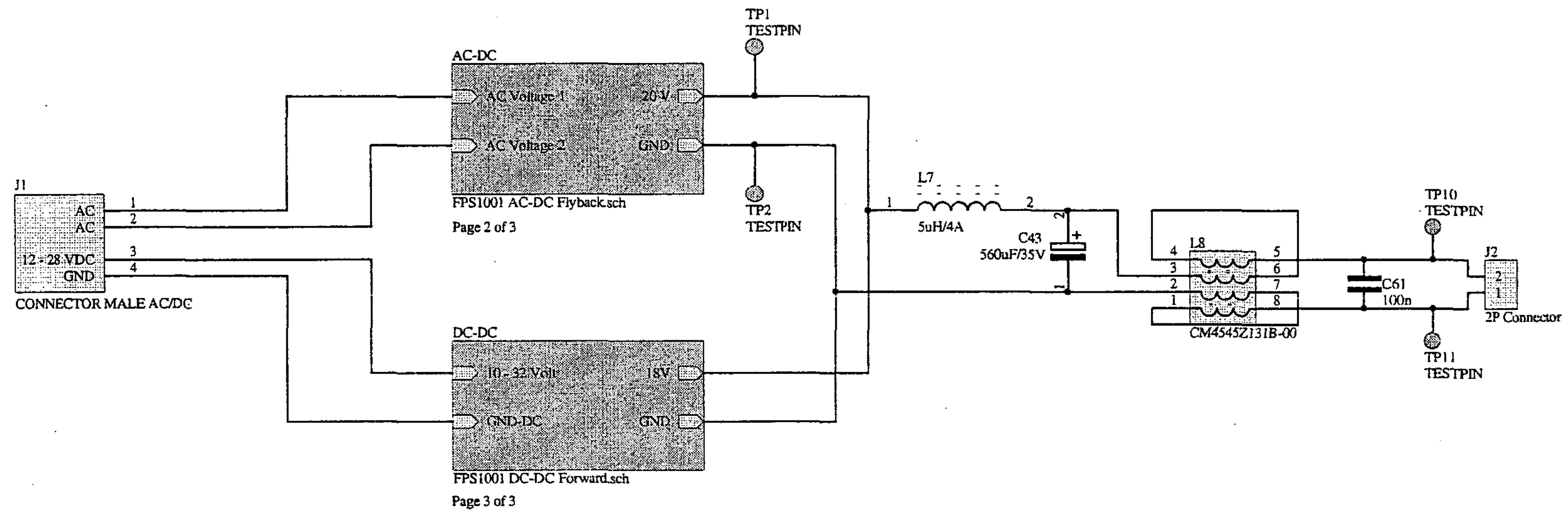
TITTEL/TITLE

FPS1005 MMI Bd. - LSU4000 Vacuum Sensor Amplifier

KAT/CAT. DOK.TYPE/DOC.TYPE SEKV.NR./SEQ.NO.	SIDE/SHEET	REV
PRO - T35 - 0009	5 of 6	A

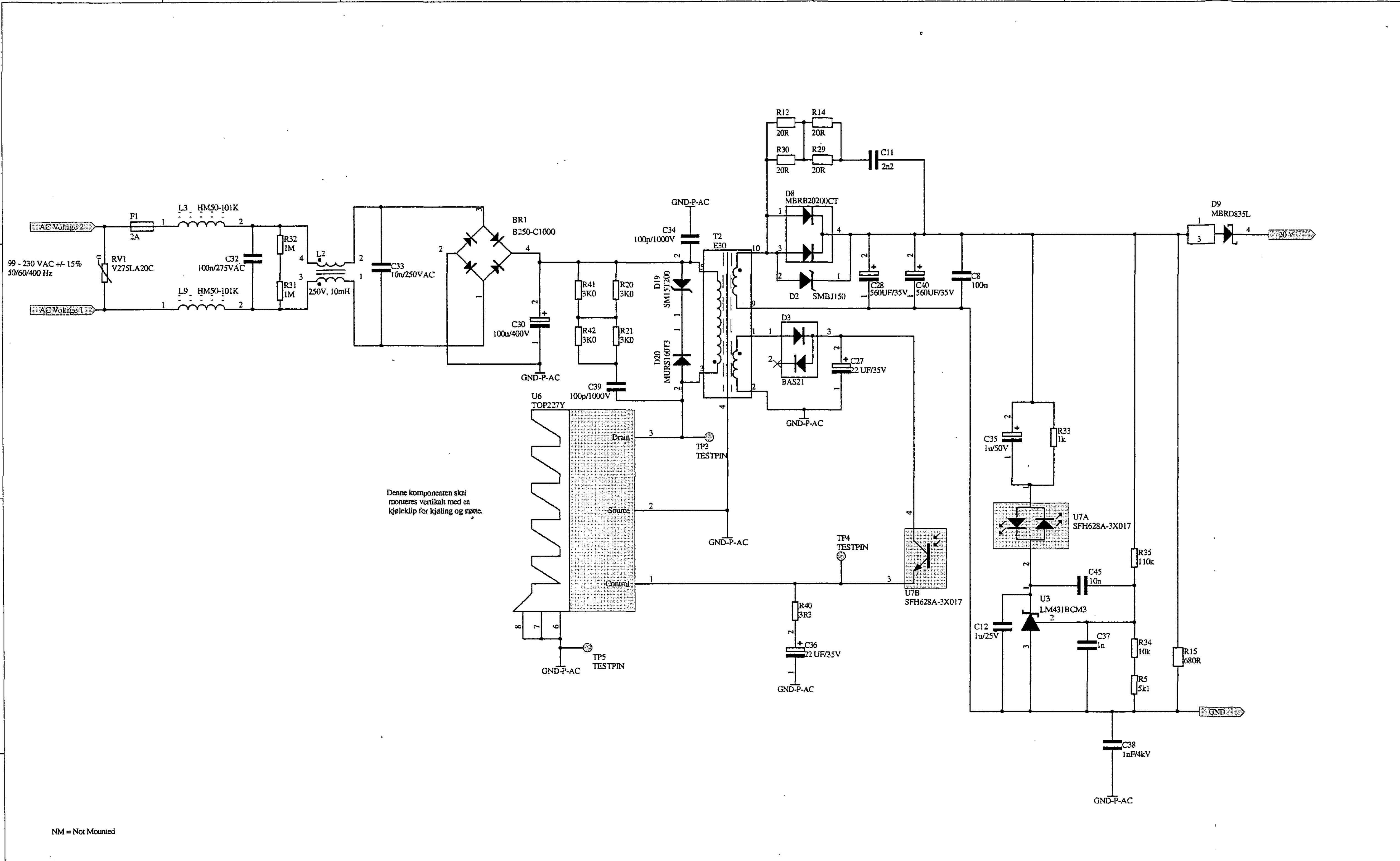


Laerdal POB 377 N-4001 STAVANGER NORWAY	REV	STATUS FOR UTGIVELSE/STATE OF ISSUE	ECO NR.	ORGINATOR	VERIFIED	GODKJENT/APPROVED	EKSTERNT REF NR/EXTERNAL REF NO 950427	ERSTATTER/REPLACES N/A	REV	TITTEL/TITLE
	A	Release	N/A	DATE AND SIGN 29-Feb-2000	DATE AND SIGN 01/03/00 LHS	DATE AND SIGN 1.3.00	EKSTERN LEVERANDØR/EXTERNAL SUPPLIER ProPartner			FPS1005 MMI Bd. - LSU4000 Switch Interface & Battery Power Interface
				DATE AND SIGN	DATE AND SIGN	DATE AND SIGN	PRODUKTGRUPPE/PRODUCT GROUP 78	ARTIKKEL/ITEM NO FPS1005	REV A	
INFORMATION CONTAINED HEREON PRIETARY TO LAERDAL AND SHALL E USED FOR ANY PURPOSE MENTAL TO OR BE REPRODUCED OUT PERMISSION OF LAERDAL				DATE AND SIGN	DATE AND SIGN	DATE AND SIGN	FILEREF U:\Prosjekt\2022-Lsu-4000\Tekniske dokumenter\Design Output - Konstruksjonsresultater\HW\SCM_Fps 1005 MMI Board	AVDELING/DEPARTMENT 700		KAT/CAT. DOK.TYPE/DOC.TYPE SEKV.NR/SEQ.NO. PRO - T35 - 0009; SIDE/SHEET 6 of 6; REV A



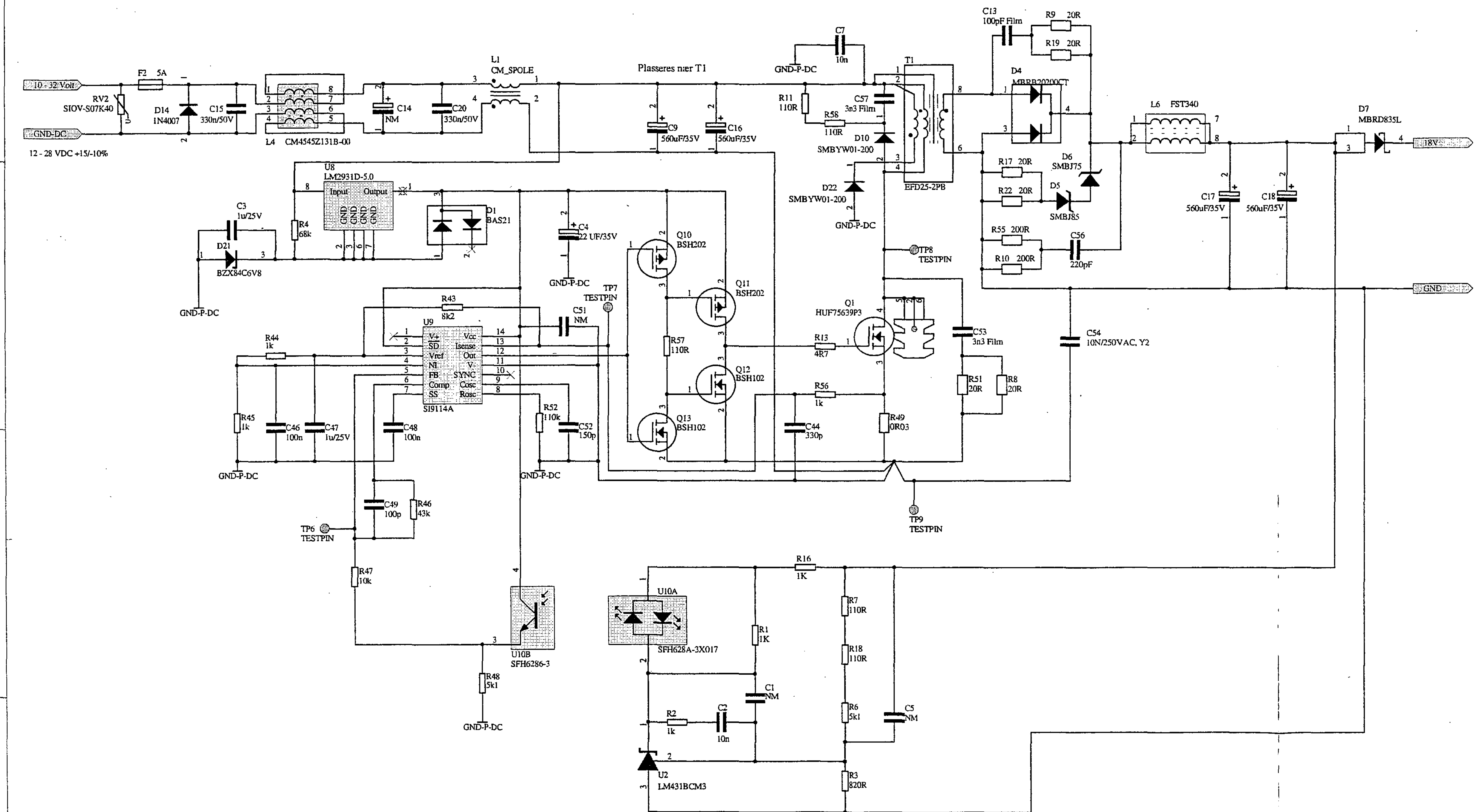
Laerdal helping save lives. POB 377 N-4001 STAVANGER NORWAY	REV	STATUS FOR UTGIVELSE/STATE OF ISSUE	ECO NR.	ORGINATOR	VERIFIED	GODKJENT/APPROVED
	A	Release	N/A	DATE AND SIGN 1-Mar-2000 HVa	DATE AND SIGN 1-Mar-2000 LHS	DATE AND SIGN 1-Mar-2000 PEC
	B	Change F1 from 1.5A to 2A	LN 01-081	DATE AND SIGN 3-May-2001 LHS	DATE AND SIGN 03.05.01	DATE AND SIGN
THE INFORMATION CONTAINED HEREON IS PROPRIETARY TO LAERDAL AND SHALL NOT BE USED FOR ANY PURPOSE DETRIMENTAL TO OR BE REPRODUCED WITHOUT PERMISSION OF LAERDAL				DATE AND SIGN	DATE AND SIGN	DATE AND SIGN

EKSTERNT REF NR/EXTERNAL REF NO 950426	ERSTATTER/REPLACES N/A	REV	TITTEL/TITLE
EKSTERN LEVERANDØR/EXTERNAL SUPPLIER ProPartner			FPS1001 Power Bd. - LSU4000 Top Level
PRODUKTGRUPPE/PRODUCT GROUP 78	ARTIKKEL/ITEM NO FPS1001	REV C	
FILERE U:\Prosjekt\2022-Lsu4000\Produkt dokumentasjon (DMR)\Produktspesifikasjoner og Tegninger\Skjema for elektroniken\FPS1001 Power Board\Rev_B\FPS1001	AVDELING/DEPARTMENT 700		KAT/CAT. DOK.TYPE/DOC.TYPE SEKV.NR./SEQ.NO. PRO - T35 - 0008 / SIDE/SHEET 1 of 3 / REV B



NM = Not Mounted

	REV	STATUS FOR UTGIVELSE/STATE OF ISSUE	ECO NR.	ORGINATOR	VERIFIED	GODKJENT/APPROVED	EKSTERNT REF NR/EXTERNAL REF NO 950426	ERSTATTER/REPLACES N/A	REV	TITTEL/TITLE
Laerdal helping save lives. POB 377 N-4001 STAVANGER NORWAY	A	Release	N/A	DATE AND SIGN 1-Mar-2000 HVa	DATE AND SIGN 1-Mar-2000 LHS	DATE AND SIGN 1-Mar-2000 PEC	EKSTERN LEVERANDØR/EXTERNAL SUPPLIER ProPartner			FPS1001 Power Bd. - LSU4000 AC/DC Flyback Converter
	B	Change F1 from 1.5A to 2A	LN 01-081	DATE AND SIGN 3-May-2001 LHS	DATE AND SIGN 03.05.01	DATE AND SIGN	PRODUKTGRUPPE/PRODUCT GROUP 78	ARTIKKEL/ITEM NO FPS1001	REV C	
THE INFORMATION CONTAINED HEREON IS PROPRIETARY TO LAERDAL AND SHALL NOT BE USED FOR ANY PURPOSE DETRIMENTAL TO OR BE REPRODUCED WITHOUT PERMISSION OF LAERDAL				DATE AND SIGN	DATE AND SIGN	DATE AND SIGN	FILEREF U:\Prosjekt\2022-Lsu4000\Produkt dokumentasjon (DMR)\Produktspesifikasjoner og Tegninger\Skjema for elektronikken\FPS1001 Power Board\Rev_B\FPS1001	AVDELING/DEPARTMENT 700		KAT/CAT. DOK.TYPE/DOC.TYPE SEKV.NR./SEQ.NO. PRO - T35 - 0008 · SIDE/SHEET 2 of 3 · REV B



Laerdal POB 377 N-4001 STAVANGER NORWAY helping save lives	REV	STATUS FOR UTGIVELSE/STATE OF ISSUE	ECO NR.	ORGINATOR	VERIFIED	GODKJENT/APPROVED
	A	Release	N/A	DATE AND SIGN 1-Mar-2000 HVa	DATE AND SIGN 1-Mar-2000 LHS	DATE AND SIGN 1-Mar-2000 PEC
	B	Change F1 from 1.5A to 2A	LN 01-081	DATE AND SIGN 3-May-2001 LHS	DATE AND SIGN 05.05.01	DATE AND SIGN
THE INFORMATION CONTAINED HEREON IS PROPRIETARY TO LAERDAL AND SHALL NOT BE USED FOR ANY PURPOSE DETRIMENTAL TO OR BE REPRODUCED WITHOUT PERMISSION OF LAERDAL				DATE AND SIGN	DATE AND SIGN	DATE AND SIGN

EKSTERNT REF NR/EXTERNAL REF NO: 950426	ERSTATTER/REPLACES: N/A	REV	TITTEL/TITLE: FPS1001 Power Bd. - LSU4000 DC/DC Forward Converter
EKSTERN LEVERANDØR/EXTERNAL SUPPLIER: ProPartner			
PRODUKTGRUPPE/PRODUCT GROUP: 78	ARTIKKEL/ITEM NO: FPS1001	REV: C	
FILEREF: U:\Prosjekt\2022-Lsu4000\Produkt dokumentasjon (DMR)\Produktspesifikasjoner og Tegninger\Skjema for elektronikken\FPS1001 Power Board\Rev_B\FPS1001	AVDELING/DEPARTMENT: 700		KAT/CAT. DOK.TYPE/DOC.TYPE SEKV.NR/SEQ.NO.: PRO - T35 - 0008 — SIDE/SHEET: 3 of 3 — REV: B