

# **SERVICE INFORMATION PHYACTION SUPPORTA**

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## CHAPTER 1 GENERAL INFORMATION

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### 1.1 introduction

The Phyaction Supporta is suitable for administering electrotherapy and ultrasound therapy, as well as for a combination of both types of therapy. There is one 2-pole medium frequency interferential current that can be applied. There are also two TENS currents, TENS continuous and TENS burst. The ultrasound therapy can be applied with a 4 cm<sup>2</sup> or 1 cm<sup>2</sup> (optional) ultrasound head. It is possible to use ultrasound therapy in combination with the interferential current or TENS continuous.

For detailed information about the features and operation of the device we suggest that you should read the user manual.

### 1.2 Safety test

To ensure the patient's safety a safety test has to take place every time after the equipment has been serviced. The Phyaction Supporta is a class II BF appliance. Carry out the safety test with a safety tester that complies with the IEC 601-1 demands. See section 3.2 for further details.

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## CHAPTER 2      THEORY OF OPERATION

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### 2.1            Introduction

In this chapter the electronics of the Phyaction Supporta will be explained. A description on the level of functional block diagrams will be used. The electronics will be described in more depth when safety aspects are concerned.

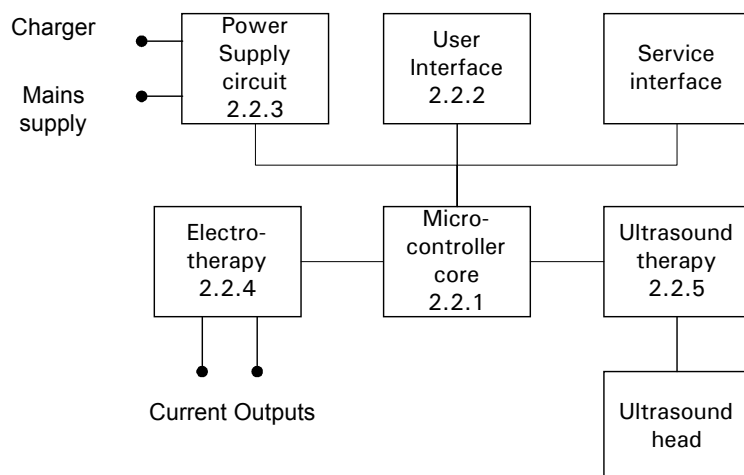
The Phyaction Supporta is a device for ultrasound-, electro- and combinationtherapy. The user -the physical therapist- can set a number of parameters. The parameters are converted in electric signals for the ultrasound and electrotherapy circuits by a microcontroller.

The microcontroller continuously checks whether the ultrasound circuit produces the proper amount of ultrasound power.

The microcontroller also checks the safety circuit each time the Supporta is switched on. Further it checks the patient resistance during treatment to verify the patient current.

### 2.2            General block diagram

The block diagram of the Phyaction Supporta is shown in the figure below.



The microcontroller core ( $\mu\text{C}$ ) controls the complete device.

All interactions between the device and the user are executed via the user interface. The user interface contains the switch panel, the ultrasound intensity knob, the LCD and the LEDs.

The power supply circuit selects the power source (a battery or a mains supply) and also converts this voltage to 5 Volts. The device can be switched on with a switch at the back.

The electrotherapy circuit consists of a switch-mode power supply, a generator, the intensity knob and the safety circuit.

The ultrasound circuit consists of a switch-mode power supply, a generator and a head identification circuit.

The serial service interface is used for extended service features.

### **2.2.1 The microcontroller core**

The microcontroller used in the Phyaction Supporta is an 80C166. The 80C166 is a 16-bit RISC controller with the following features on the chip:

- 1k byte RAM memory
- 5 timer / counters
- 10 channel 10-bit AD converter
- 76 general I/O lines
- 2 UART for serial data transfer (e.g. RS232)
- watchdog timer
- capture / compare system

Besides the microcontroller the following parts are present in the core:

- (32 kByte) RAM data memory
- 1 Mbit EPROM program and constant data memory
- 512 byte I<sup>2</sup>C E<sup>2</sup>PROM non-volatile data memory
- HCMOS IC's for decoding and buffering purposes
- a power-on reset circuit

### **2.2.2 The User Interface**

#### **2.2.2.1 The switch panel and LEDs**

The switch panel is a matrix of 14 metal dome membrane keys, a matrix of 20 LEDs and two single LEDs. The matrices of the keys and the LEDs are connected to the  $\mu$ C via a tail. The user can use the keys to set and change a number of parameters such as pulse width, duty-cycle and treatment time.

The top layer of the switch panel is made of polyester.

#### **2.2.2.2 The ultrasound intensity control**

See section 2.2.5.1,

#### **2.2.2.3 LCD**

An alpha numerical LCD with LED backlight is used for the display. During battery operation the backlight will be switched off by the  $\mu$ C for power saving when no keys are pressed.

The LCD displays the treatment time and some parameter settings of the electrotherapy.

The contrast is controlled by the  $\mu$ C through a switched-capacitor voltage inverter.

### **2.2.3 The power supply circuit**

#### **2.2.3.1 The supply selector**

If present the device is powered by the battery unless an active mains supply is connected. The supply selector determines whether the battery or the mains supply is to be used.

#### **2.2.3.2 The Battery**

The battery consists of ten rechargeable NiCd cells with a capacity of 1.7Ah. The battery voltage is typical 12 V with a maximum of 15 V. The battery voltage is monitored by the  $\mu$ C and it switches the device off if the voltage drops to 10 V.

### **2.2.3.3 The charger**

The battery can be charged with an external charger which fully charges the battery in 14 hours. The charger is a transformer and rectifier (without smoothing capacitor), generating a DC current of 200 mA average. The open circuit voltage is approximately 24 Vdc.

The charger comes in 3 different models:

model 401	100 ...120 V with an American style mains plug
model 403	220 .. 240 V with an European style mains plug
model 404	220 .. 240 V with a British style mains plug

The charge current can only reach the pcb if a battery is connected, because this current is routed through the battery connector which contains a shorting link.

### **2.2.3.4 The mains supply**

The mains supply is a switch-mode power supply with a voltage of 18 V typical and a maximum average DC current of 1.8 A.

The voltage supplied to the pcb must never exceed 20 V due to limited component voltages. The voltage should be 16 V minimum, because at lower voltages the internal power source selector will not operate properly.

### **2.2.3.5 Internal battery charger**

When the mains supply is connected and a battery is present, a current source serves as internal battery charger, charging the battery with approximately 170 mA.

### **2.2.3.6 The +5 V power supply**

The voltage from the supply selector is converted to +5 V by a switch-mode power supply (SMPS). This SMPS can be switched off by the controller, in case of a low battery voltage, with the signal '5V-SD\'' (active low). After power-up there is a limited time in which the  $\mu$ C should take over the SMPS enable signal from the bootstrap circuit. For fault finding purposes jumper J101 'force 5V' is provided. Shorting this jumper will keep the +5V up even if the  $\mu$ C fails to assert the '5V-SD/' signal.

### **2.2.3.7 The charge indicator**

When the battery is charged the charge indication LED, on the console, is activated.

The circuit driving the LED is independent of the 5 V SMPS (see paragraph 2.2.3.6), because the circuit (and the LED) should also work when the device is switched off.

## **2.2.4 Electrotherapy circuits**

### **2.2.4.1 General**

To ensure the safety of the patient both the  $\mu$ C and the safety circuit monitor the generated current against the set value and limit value allowed by the IEC-standard.

### **2.2.4.2 Signal generator**

The 4 kHz carrier wave of the MF signal is a square wave (not a sine wave) generated directly by the  $\mu$ C. The amplitude modulation is done by an 8-bit multiplying DAC. This DAC is controlled by

the  $\mu\text{C}$  with DMA-control. The reference voltage for the DAC is directly derived from the wiper voltage of the current control potentiometer.

The TENS pulses are also generated by the  $\mu\text{C}$ . There is an additional hardware TENS pulse limiter ensuring the pulse width not to exceed  $200\ \mu\text{s}$  and that the pulse frequency not to exceed 400 Hz.

#### **2.2.4.3 Output stage**

The signal from the signal generator drives the output stage. This circuit has two adjustments, one for the maximum current of 100 mA peak and one for the minimum current of less than  $300\ \mu\text{A}$ . The output stage consists of a transformer driven by 2 FETs with a very low on-resistance, to limit the power loss. Because the losses in the FETs are very low no heat sink is needed. A third FET is used exclusively for TENS generation operating as a gated current source.

#### **2.2.4.4 Switch-mode power supply**

The SMPS supplies the output stage with a voltage between 0 V and 5 V. In case of MF current, the control circuit regulates the voltage of the SMPS in such a way that the set current (ETset) flows, independent of the patient resistance. If the patient resistance is too high the voltage will clip at 5V.

In case of TENS current the SMPS is set to maximum, because the control circuit is too slow to follow the TENS pulses.

#### **2.2.4.5 Intensity control**

The electrotherapy intensity is set by a potentiometer with a switch. The switch signals to the  $\mu\text{C}$  that the operator has put the control into operation. The position of the sweeper of the potentiometer is a direct measure for the set value of the current. The sweeper is the reference voltage (ETref) for the signal DAC. Also it is used for comparison with the read value of the current by the safety circuit.

#### **2.2.4.6 Safety circuit**

In this circuit the primary output current is used to monitor whether the output exceeds the limit of  $100\ \text{mA}_{\text{peak}}$  or 150% of the set value by the intensity control. Also the intensity control is monitored for interruptions of the ground and guard terminal. All the safety functions are achieved by comparators, fully independent of the  $\mu\text{C}$ . In case of a fault the comparators switch the safety relay off, which interrupts the patient current. Even in case of maximum intensity, this will happen so fast that the energy contents of the resulting pulse will be below the allowed limit. Once the safety relay has been switched off, it remains in this state and the device must be switched off.

#### **2.2.4.7 Reference voltages**

There are two reference voltages in the safety circuit: 4.096 V, used for the safety comparators and 2.50 V, used for the ET potentiometer and ET and US signal generation.

The reference voltage (ETref) for the DAC is derived from the 2.50 V via the electrotherapy potentiometer.

#### **2.2.4.8 Test control circuit**

During the selftest of the device the safety circuit is tested: guard and ground connection of the potentiometer, 150% and the limit, to ensure that the safety circuit works.

During a fixed time the  $\mu\text{C}$  can activate the safety relay. After this time has expired, the  $\mu\text{C}$  can only switch off the safety relay, e.g. when an error has been detected. The relay 'De-energize' ensures that no current can flow through the patient during the selftest.

## **2.2.5            Ultrasound circuits**

### **2.2.5.1            The ultrasound intensity control**

The ultrasound intensity is set by a potentiometer with a switch. Both the potentiometer and switch are directly connected to the  $\mu\text{C}$ . From the position of the potentiometer the  $\mu\text{C}$  calculates the amount of power that is to be supplied to the output stage. The switch signals to the  $\mu\text{C}$  that the operator has put the control into operation.

### **2.2.5.2            PLL**

The required ultrasound frequency of 0.7 MHz to 1.0 MHz is generated by a phase locked loop (PLL). The PLL transforms the low-frequency signal (Refclk), generated by the  $\mu\text{C}$ , up to the required drive frequency which is twice the ultrasound frequency. The modulator divides this frequency by two and mixes it with the desired duty-cycle.

If the PLL is out of lock, the Lock-error signal (USerror\ ) is used to stop the modulator in order to prevent erroneous frequencies produced by the treatment head.

### **2.2.5.3            The modulator**

To obtain a symmetrical drive signal for the power stage, the modulator switches its outputs with half the input frequency. Synchronously the modulator mixes the duty-cycle signal with the ultrasound frequency.

With the Lock-error signal the modulator can be forced to shutdown if the PLL is out of lock.

### **2.2.5.4            The switch-mode power supply (SMPS)**

The SMPS supplies the output stage with a voltage between 0 V and 5 V.

The SMPS for the ultrasound circuit is only active if the ultrasound therapy is chosen. The  $\mu\text{C}$  deactivates the SMPS via a shut-down (US-SD\ ).

The SMPS output voltage is linear proportional to its input voltage (Usset). Thus the  $\mu\text{C}$  can change the ultrasonic power by setting Usset proportional to the square root of the desired output power.

The  $\mu\text{C}$  continuously monitors the output voltage (USV) of the SMPS. If the output voltage is too high e.g. due to a hardware failure, the  $\mu\text{C}$  will shut down the ultrasound circuit and give an error message.

### **2.2.5.5            The power stage**

The power stage is a switched half bridge. The generated output is controlled by USV, generated by the SMPS. The above mentioned modulator controls whether the power stage is active. Power MOSFETs are used as switching elements. The MOSFETs are driven by with a small delay in the on-ramp, to prevent them of being active simultaneously.

### **2.2.5.6            Impedance matching**

The ultrasound transducer shows mainly a capacitive load. Its impedance differs, among other things, with the size of the transducer and its operating frequency. For this reason the  $\mu\text{C}$  can match the impedance by switching one or two inductors in series depending on the head being



used. To ensure that all devices give the same output, the coils, for both the large head and the small head, are each adjusted to a specific inductance. **Do not change this adjustment.**

The  $\mu\text{C}$  monitors the match of inductor(s) and head by checking the current (USI) through the MOSFETs. This current is proportionally to the current through the head. If there is a mismatch, due to bad acoustic coupling, USI will increase and signal the  $\mu\text{C}$  to decrease the ultrasonic power. The duty-cycle is set for the ultrasonic output power not to exceed  $0.2 \text{ W/cm}^2$ . When the match is established ultrasonic output power is restored to the set ultrasonic power.

#### **2.2.5.7          Ultrasound head**

The ultrasound head converts the electric signal into ultrasonic vibrations. The transducer, with a diameter depending on the head size, is glued in an aluminium cup that minimises electromagnetic radiation and enables the transducer to be used on the operating frequencies. The aluminium cup can also be used as a second electrode for combination therapy. A separate electrode needs to be connected to the safety socket for combination therapy.

An OTP in the connector of the head enables the  $\mu\text{C}$  to detect whether a head is connected and to recognise the type of head that is connected. This OTP also contains specific head related information. Thus enabling the  $\mu\text{C}$  to set the head specific frequencies and ultrasonic power.

#### **2.2.5.8          Head Identification Circuit**

The head identification circuit enables the  $\mu\text{C}$  to read the contents of the OTP in the connector of the ultrasound head. If the checksum calculated by the  $\mu\text{C}$  differs from the checksum in the OTP, the head will not be recognised.

If a head parameter, necessary for the ultrasound circuit to generate the ultrasound power, exceeds its limits, the  $\mu\text{C}$  will produce an error message.

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## CHAPTER 3

## PERFORMANCE CHECK

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### 3.1 Safety inspection

This inspection is for technical maintenance purposes only. It is recommended that this test is carried out once a year. If the appliance is serviced, the full IEC 601-1 tests have to be carried out. A short description of these tests is given in section 3.2.

#### 3.1.1 Visual inspection

Passed, when all applicable items are answered with YES.

	yes	no
Is the user manual there?	<input type="checkbox"/>	<input type="checkbox"/>
Is the casing of the appliance undamaged?	<input type="checkbox"/>	<input type="checkbox"/>
Is the label well readable?	<input type="checkbox"/>	<input type="checkbox"/>
Are the controls, display, lights and connectors all right?	<input type="checkbox"/>	<input type="checkbox"/>
Are the power input and the equipotentiality busbar all right?	<input type="checkbox"/>	<input type="checkbox"/>
Are ultrasound treatment heads, cables and connectors undamaged? (Pay special attention to possible leaks in the treatment heads, such as cracks or loosened seams.)	<input type="checkbox"/>	<input type="checkbox"/>
Are the labels on the ultrasound treatment heads readable?	<input type="checkbox"/>	<input type="checkbox"/>

#### 3.1.2 Functional test

Passed, when all applicable items are answered with YES (or not applicable).

	yes	no
Is the automatic selftest executed successfully at power on?	<input type="checkbox"/>	<input type="checkbox"/>
Is the appliance able to detect both treatment heads?	<input type="checkbox"/>	<input type="checkbox"/>
	1 cm <sup>2</sup>	
	4 cm <sup>2</sup>	
Is the ultrasound output correct for both treatment heads	<input type="checkbox"/>	<input type="checkbox"/>
at maximum intensity?	1 cm <sup>2</sup>	
	4 cm <sup>2</sup>	

#### 3.1.3 Test of the electrical safety according to VDE 0751

Parameter	Measured value	Limit	Remarks
Enclosure leakage current	μA	< 1000 μA	
Patient leakage current	μA	< 5000 μA	

Also register the measured values in the device records and compare them with the values measured in the past to alert for a possible potentially dangerous tendency.

### 3.2 IEC 601-1 safety tests

For the full description of these tests we refer to the IEC 601-1 (1988) for Class II, Type BF equipment. Here is just a short reminder list of the tests and the test limits.

Measurements	limits
Insulation resistance applied part	> 2.0 MΩ
Enclosure leakage current normal	< 100 μA
Enclosure leakage current open lead	< 500 μA
Enclosure leakage current reverse	< 100 μA
Enclosure leakage current open lead	< 500 μA
Patient leakage current normal	< 100 μA
Patient leakage current open lead	< 500 μA
Patient leakage current reverse	< 100 μA
Patient leakage current open lead	< 500 μA
Mains on applied part normal	< 5000 μA
Mains on applied part reverse	< 5000 μA
Dielectric strength A.P. + CASE to MAINS *	> 1500 V <sub>rms</sub>
Dielectric strength MAINS + CASE to A.P. *	> 1500 V <sub>rms</sub>

\* These tests need only be executed if repairs have been made in the mains part or in the output circuits.

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## CHAPTER 4            TROUBLE SHOOTING

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### 4.1            Introduction

If a Phyaction Supporta is defective, in most cases the unit will detect an error in the automatic self test. A full description of this test will therefore help the service technician in finding the fault. In the next section you will find this description. In section 4.3 you will find a list of all possible error messages and possible causes.

### 4.2            Description of the automatic selftest.

#### 4.2.1        General

The selftest checks proper functioning of the safety relay and circuits and is activated every time the unit is switched on. The tests are performed by the microprocessor and last for approximately 3 seconds. Both intensity regulators should be in the zero position i.e. maximum counter clock wise. This is checked at the start of the selftest. If an intensity regulator is not at zero an error will be reported by graphic symbols prompting to turn ET intensity to 0 and/or turn US intensity to 0) and an error shutdown procedure will be initiated as described below.

The safety relay driver circuitry is accessible to the microprocessor for 3 seconds after power up of the unit. After this period the microprocessor will not be able to switch the safety relay on any more. The control lines used for test purpose are only accessible by the microprocessor if the ET intensity regulator is in the zero position as an extra precaution against hard- or software errors.

#### 4.2.2 ERROR shutdown procedure

The safety circuit will switch off the safety relay immediately in the event of an error, thus disconnecting the drive signals from terminals to avoid hazards to the patient.

In addition to this the  $\mu$ C will, if it detects an error either from the safety circuit or otherwise, call an error function ("Error") which will perform the following actions:

- All interrupts are disabled.
- ET Dac to zero: no signal to the ET SMPS
- US Dac to zero: no signal to the US SMPS
- ET SMPS is switched off
- ET testlines are switched to inactive state
- ET output drive signals are switched off ET-PHA, ET-PHB
- ET Safety relay is switched off: the patient circuit disconnected. This is a latched state that can only be exited by switching off the unit.
- Dummy relay is switched on: The output is short circuited.
- De-energize relay is switched on.
- The US testline will be switched to inactive
- The US SMPS is switched off
- The US dutycycle is switched off
- An error message ( "Err", an error number and a value) is displayed on the LCD display.
- Wait in an endless loop.

In the endless loop the state of the power supply is observed. If only a battery is connected and the power supply voltage drops to the "deep discharge" voltage (10 V) the microprocessor will also shut down the +5V SMPS.

For processor kernel errors (processor, RAM or EPROM) the processor will display the error message for 5 seconds and then shut down the +5V SMPS.

#### 4.2.3 General test description

The microprocessor circuits are tested first, followed by the ET and finally the US circuits.

In case the unit does not complete this selftest and no error message is displayed and the internal wiring is connected properly the following items are suspect:

- Supplies (mains and other)
- Microprocessor
- Program EPROM
- Address, data or control lines

#### 4.2.4 Microprocessor test

Any fault found will stop the selftest and an error message will be displayed

The following tests are performed:

1. Microprocessor internal check. Some ALU instructions are executed and verified against the known results. Also verified is whether, the contents of some special function registers which should be 0 after a RESET, are indeed 0. In case of a failure: 100-xx (errCPU).
2. Internal RAM. The internal RAM will be tested with a write/read test. In case of a failure: 100-00 (errCPU), 100-10 (errCPU\_IRAM).
3. External data storage. The external 32K RAM will be tested with a write/read test. This also checks most address, data and read/write control lines. In case of a failure: 110-xx (errXMEM).

4. External program storage. By means of a checksum test on the accessible part of the 128K EPROM the data integrity of the program stored is tested. In case of a failure: 110-20 (enrXMEM\_ROM0). A small part of the EPROM memory space is overlapped by processor internal addresses. These are not checked.

After these tests it can be assumed that the processor kernel operates correctly.

#### 4.2.5 ET Initial Test

The following power up conditions are checked:

1. ET-ERROR line should be active. If not: 420-40 (enrETERROR).
2. Intensity regulator should be at zero, checked by means of the potentiometer switch and analog input. If switch not at zero: 400-10 (enrSWNOT0). If analog input larger than 0.16V (10%): 400-20 (enrTOHIGH).
3. As there should not be any ET output generated the ETV signal should be very low. If it is higher than 0.1V: 410-10 (enrETV).
4. As there is no ET output the ETI signal also should be very low. If it is higher than 0.1V: 410-20 (enrETI).

#### 4.2.6 ET Relay test

In the following test sequence the safety, standby and dummy relays are tested for proper functioning. All tests are executed with the de-energize relay active: the output circuit is disconnected from a possibly connected patient. If the de-energize relay is not open and a patient is connected an error will be given during this part of the selftest. It is not tested any further, if it remains open no current will reach the patient.

The DAC is programmed in such a way that with a test reference voltage applied via the TEST Y3 line approximately 4 mA DC will flow through the output circuit, if connected either through an external connection or the dummy relay. The voltage level of the ET power supply is proportional to the resistance in the output (patient) circuit with a given current. This level is used to test the output circuit resistance. When checking for an open circuit a voltage on this point below 0.5V is recognised as an error. Conversely a voltage above 0.1 V while testing for a closed circuit is recognised as error.

When the safety relay is energised the contacts in both channels are closed. The dummy relay will short circuit the output channels if energised. The initial condition of these relays prior to test is safety relay off and dummy relay on.

1. Test if the safety relay is off.  
A low current (approximately. 4 mA) is applied to the output circuit. If a closed circuit is detected 420-10 (enrRELSAFETY) will occur.
2. Test if the ET errorline becomes activated if the safety relay is switched on.  
The output is set to 0 (testline TEST Y3 is disabled). The ET safety relay is switched on. If the errorline is activated it means that the safety circuit has activated it and 420-11 (enrRELSAFETY1) will occur.
3. Test if the safety relay makes contact.  
The testline TESTY3 is enabled: a low current (4 mA) is applied to the output circuit). The ET errorline should still be inactive, otherwise 420-40 (enrETERROR) will occur.  
With the safety relay on and the dummy relay on a closed circuit should exist, an open circuit will result in 420-12 (enrRELSAFETY2).

4. Test for external (patient) connections.  
The dummy relay is switched off.  
The ET errorline should still be inactive, otherwise 420-40 (enrETERROR) will occur.  
The output circuit should be open again. A closed circuit suggests an external load and will result in 420-20 (enrRELDUMMY).
5. Test if the dummy relay makes contact.  
The dummy relay is energized.  
The ET errorline should still be inactive, otherwise 420-40 (enrETERROR) will occur.  
The outputs should be shorted, else 420-22 (enrRELDUMMY2) will be given.
6. Check the ET errorline.  
The safety relay is switched off.  
An open circuit should exist, else 420-30 (enrETSAFETY3). The ET errorline should have become active. If it hasn't 420-31 (enrSAFETY4) will be given.

If these tests have passed the safety and dummy relay are functioning and the de-energize relay has disconnected the sockets.

In the next test the safety relay is tested under full load conditions.

1. Check the ET errorline  
The output is set to 0 mA. The safety relay is set to 'on'.  
The ET errorline should remain inactive, else 420-32 (enrRELSAFETY5) is given.
2. Test if the safety relay switches under full load.  
The DAC's are programmed for an output current of 125% maximum operating current.  
The safety limit check circuits should activate the ET error line causing the safety relay to open.  
If the ET errorline is not activated 420-33 (enrSAFETY6) is generated.
3. Test if the safety relay contacts open.  
If the above test passes but a closed circuit is detected (ET power supply voltage below 2.5 V) 420-34 (enrRELSAFETY7) is generated.

This test completes the verification of the safety relay.

#### **4.2.7 safety limit check**

In this test sequence the 150% comparator circuits are tested. The safety relay is energised and a closed output circuit is created by switching on the dummy relay.

1. ET testline TESTY2 is activated, this changes the reference voltage of the 150% comparator. If the ET error line is not activated 430-12 (enrET150REF) is given.
2. With the ET testline TESTY4 an output of 8 mA is simulated. As this is above the 3.3 mA the ET errorline should become active. If it doesn't 430-11 (enrET150OFF) is given.

This completes the 150% comparator check.

#### 4.2.8 Maximum current safety limit check

This comparator checks for currents above the maximum allowable output current and should report an error if the output current rises above 110% of the maximum allowable. The maximum current is simulated by a testline connected to the comparator network.

1. Test the maximum current safety limit.  
Activate testline TESTY1, this changes the voltage of the limit comparator. If the ET errorline does not become active 440-10 (enrETLIMIT) is given.

This completes the maximum current safety limit check

#### 4.2.9 ET Intensity regulator guard test

1. Test the ET intensity regulator ground guard.  
The testline TESTY6 is activated, this changes the regulator guard voltage. If the ET errorline does not become active 450-20 (enrETPOT) is given.
2. Test the ET intensity regulator reference guard.  
The testline TESTY5 is activated, this changes the reference voltage of the guard circuit. If the ET errorline does not become active 450-10 (enrETREF) is given.

This completes the check of the ET intensity regulator guard.  
All testlines are deactivated and the output is set to 0 mA.

#### 4.2.10 Ultrasound generator test

After the device is switched on the ultrasound generator is initialized to generate no output. The dutycycle is set off and the US head frequency is set at 700 kHz.

1. Intensity regulator should be at zero  
This is checked by means of the potentiometer switch, if it is not at zero: errUSPOT, 0.
2. US errorline should be inactive.  
The US errorline is read, if it is active an 320-10 (enrLINE1) is given.
3. Check output 0  
As the intensity is set a 0 no output should be given. Therefore the voltage on the USI line should be smaller than 0.2V. If not 310-10 (enrVUSIO) is given. Also the voltage on the USV line should be smaller than 0.2V, else 310-11 (enrVUS2) is given.
4. Check the PLL guard.  
The US head frequency is set at 0 kHz.  
The PLL should now detect an 'out of lock' condition and the US errorline should become active. If it does not become active: 320-10 (enrLINE1).
5. The US head frequency is set at 700 kHz. If the US errorline remains active: 320-30 (enrLINE3).



### 4.3 ERROR code summary

With all error messages an error value is displayed as well. In most cases this may give extra information about the cause of the error. This list is an short overview of the error messages.

message	value	description
100	00	Internal processor
110	10	External RAM
	20	External ROM
	30	External EEPROM
200	10	ET hardware error line active
	20	US hardware error line active
300	00	Potmeter not at 0 at start of test
310	10	US supply
420	40	ET relay
430	12	ET 150% comparator
440	10	ET limit comparator
450	20	ET Dose regulator
620	10	Ultrasound frequency
	20	Tens frequency
	30	MF base frequency
	40	Spectrum frequency
	111	ET waveform
630	00	Potmeter
640	20	Display timeout
	30	Eeprom timeout
800	20	System temperature to low
	30	System temperature to high
820	10	Battery deep discharge
B10	50	US head record incorrect

#### 4.4 Adjustment procedures

There are no adjustments that can be carried out in the field. All adjustments should be carried out by Uniphy, because of the need for special test and measurement equipment.

#### 4.5 Jumper Settings Supporta

jumper	default setting	function
J101	not placed	to force the 5V power supply on (normally activated by the microcontroller)
J401	not placed	to verify the level of the 150% safety circuit (electrotherapy)
J403	p2-3 / p4-5	to connect the safety circuits to the safety relay driver and the microcontroller. In alternate position (p1-2 / p3-4) the safety circuit is disabled
TP408-TP409	not connected	if connected the timer that disables the safety relay on control line is stopped, so the microcontroller will be able to set the relay on as long as the test points are connected.  Note: The shunt should be applied before power-on.

## **5.1 Introduction**

The most frequent service operations will be the exchanging of boards or modules, because it would be too time consuming and costly to do component level service in the field. When exchanging boards or modules there are a few things that should be noticed. These attention points will be described in this chapter.

If you want to exchange a module or a board you will have to open the appliance. It is probably most convenient to place the appliance on its front side, with the bottom side up. Open the battery compartment by removing the two Allen screws. Disconnect and remove the battery. Inside the battery compartment are three Phillips screws. Unscrew the three screws and lift the bottom part off by tilting it slightly using the side of the handle as a pivot.

If you have exchanged a board or module, always test all the functions of the appliance. This functional test starts with switching the device on, checking all the LED's and the LCD. If no error messages appear, check the output currents and the ultra sound heads. After this you should run a safety test. A short description is given in section 3.1 and 3.2.

In general it is stressed that you should take the necessary precautions to prevent electrostatic discharges to the delicate electronic circuits of the unit. These precautions implicate that you should ground the unit, use a grounded desk overlay, ground the tools such as solder irons and you should be connected to ground by the usual wrist or ankle strap. You should also take precautions when you store or sent circuit boards, by using special ESD-protective packaging materials.

## **5.2 Replacing the battery**

To exchange the battery you first remove the two Allen screws on the bottom side. Remove the battery lid. Disconnect the battery connector and replace the battery. Connect the battery connector and close the battery compartment with the two screws. For the life of the battery it is best if you charge the battery completely every time you charge it (i.e. connecting it to the charger for 14 hours). It is not allowed to dispose of the battery with domestic refuse. Instead, it must be discarded as small chemical waste for recycling.

## **5.3 Exchanging the software or the main board (PCB 492)**

If you want to exchange the software or the main board of the appliance, you first open the appliance as described in section 5.1 and take the necessary precautions to prevent electrostatic discharges.

The software eeprom is mounted on an IC-socket and can be replaced without soldering. The software version is printed on the label of the Eeprom (i.e. V1.02). After replacing the Eeprom, close the appliance. Carry out the functional and safety test as described in section 5.1.

## **5.4 Exchanging the software or the main board (PCB 492)**

To exchange the main board, you first open the appliance as described in section 5.1. Remove the two intensity knobs. Remove the power cable and the output cables from the main board. Before removing the membrane panel flatcable first unlock the connector and carefully pull the flatcable out of the socket.

Unscrew the 5 Philips screws that tighten the main board to the front panel. These screws are located one in each corner of the main board and one in the middle. Now you can lift the main board from the front panel.

After replacing the main board, place the 5 screws back and connect the output and power cables. Carefully place the membrane flatcable in the connector and tighten the cable by locking the connector. After closing the unit mount the two intensity knobs. Perform a functional and safety test as described in section 5.1.

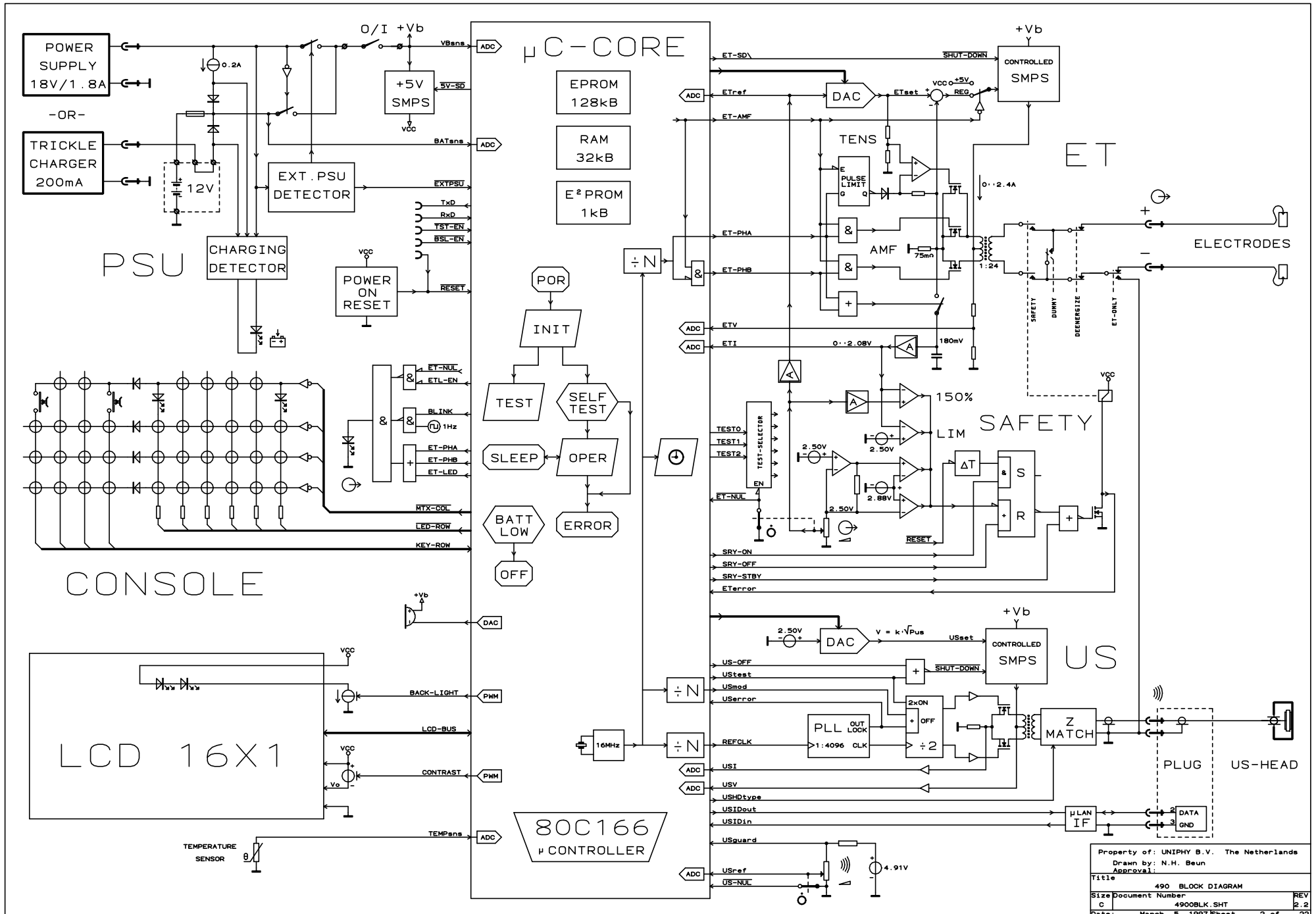
## **5.5 Exchanging the membrane panel or connector block**

To exchange the membrane panel first open the appliance as described in section 5.1. and take the necessary precautions to prevent electrostatic discharges. Remove the main board as described in section 5.3. Take out the four plastic rings before removing the membrane panel from the plastic front part. Now you can pull the connector block from the carrier plate of the membrane panel.

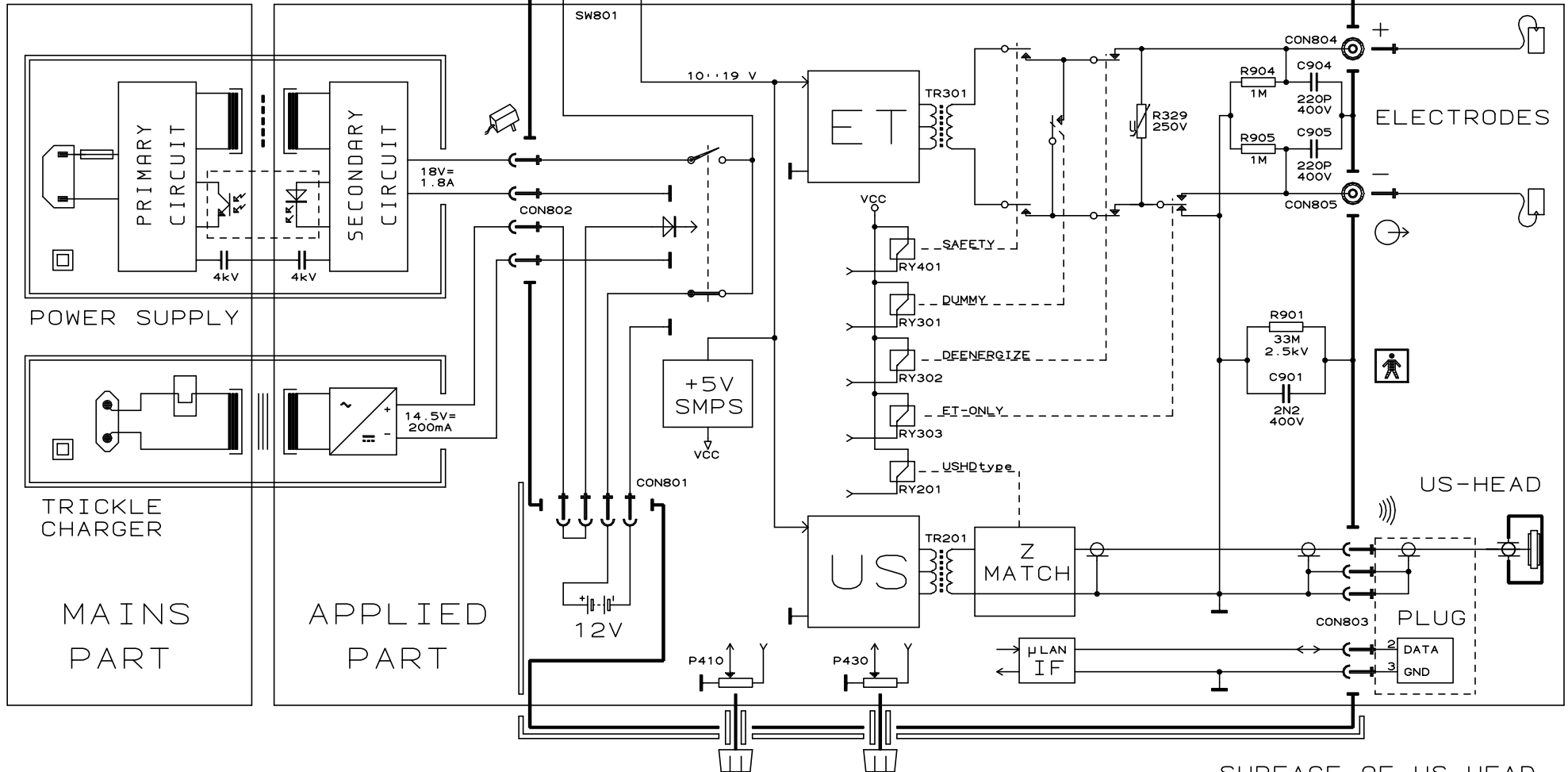
To assemble the front slide the connector block firmly on the membrane panel. Place the membrane panel on the plastic front part followed by the four plastic rings. Replace the main board as described in section 5.4 and close the appliance as described in section 5.1.

## Index of the circuit diagrams

Sheet 2	Block diagram
Sheet 3	Isolation diagram
Sheet 4	Wiring diagram
Sheet 5	Main PCB
Sheet 6	Output filter
Sheet 7	Membrane keyboard foil
Sheet 8	Accompanying equipment
Sheet 9	Microcontroller core
Sheet 10	Console interface
Sheet 11	Ultrasound RF generator
Sheet 12	Electrotherapy current generator
Sheet 13	Electrotherapy safety circuit
Sheet 14	Power supply
Sheet 16	Connector definition
Sheet 17	Components reflow side PCB 4922
Sheet 18	Component solder side PCB 4922
Sheet 19a	Copper layout reflow side PCB 4922
Sheet 19b	Copper layout layer 1 PCB 4922
Sheet 19c	Copper layout layer 2 PCB 4922
Sheet 19d	Copper layout solder side PCB 4922
Sheet 20	Layout PCB 4930
Sheet 21	Component index (9 pages)
Sheet 22	Label cross-reference (2 pages)



ONLY ONE OF THE UNITS BELOW  
CAN BE CONNECTED AT ONE TIME



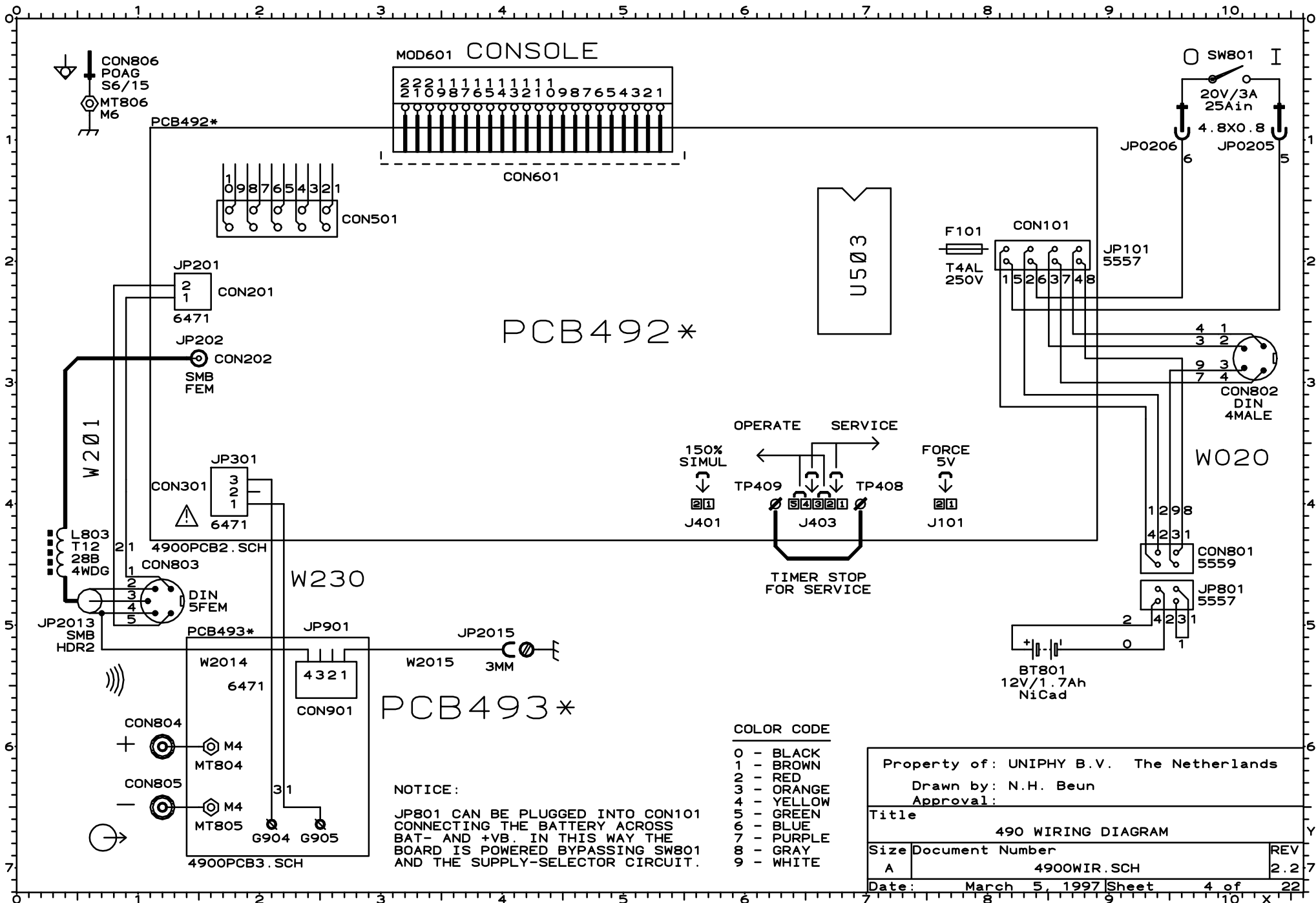
LEGEND:

- ▭ SYMBOLISES THE CABINET = EP
- ⊥ GROUND WITHIN THE APPLIED PART
- | CONDUCTIVE PARTS OF CABINET
- ▭ NONCONDUCTIVE PARTS OF CABINET

METAL SHAFTS OF  
POTENTIOMETERS  
ARE FLOATING.  
POTENTIOMETERS  
CARRY 0/+5V MAX

SURFACE OF US-HEAD  
IS GROUND OF A.P.

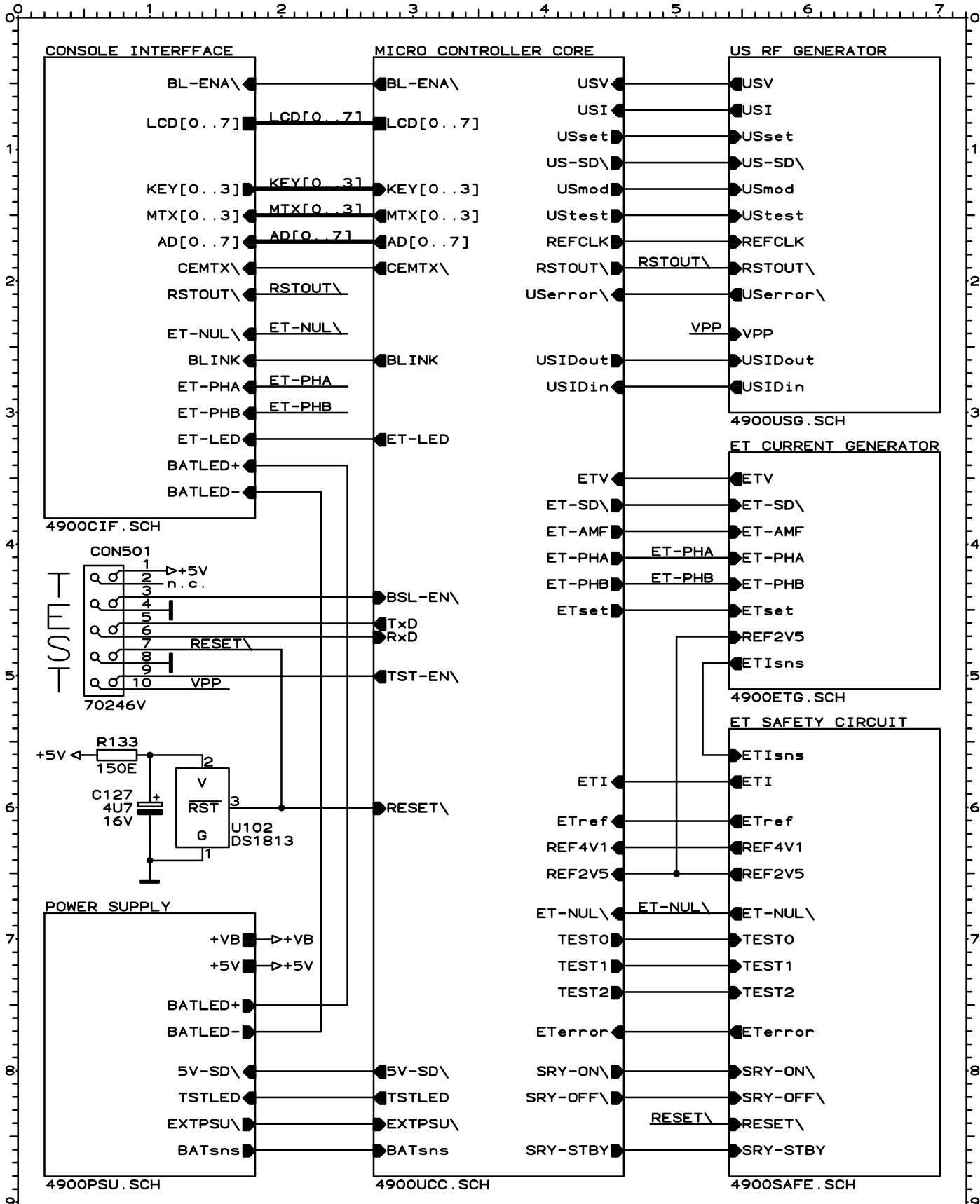
Property of: UNIPHY B.V. The Netherlands		
Drawn by: N.H. Beun		
Approval:		
Title 490 ISOLATION DIAGRAM		
Size	Document Number	REV
B	4900ISO.SHT	2.2
Date:	March 5, 1997	Sheet 3 of 22



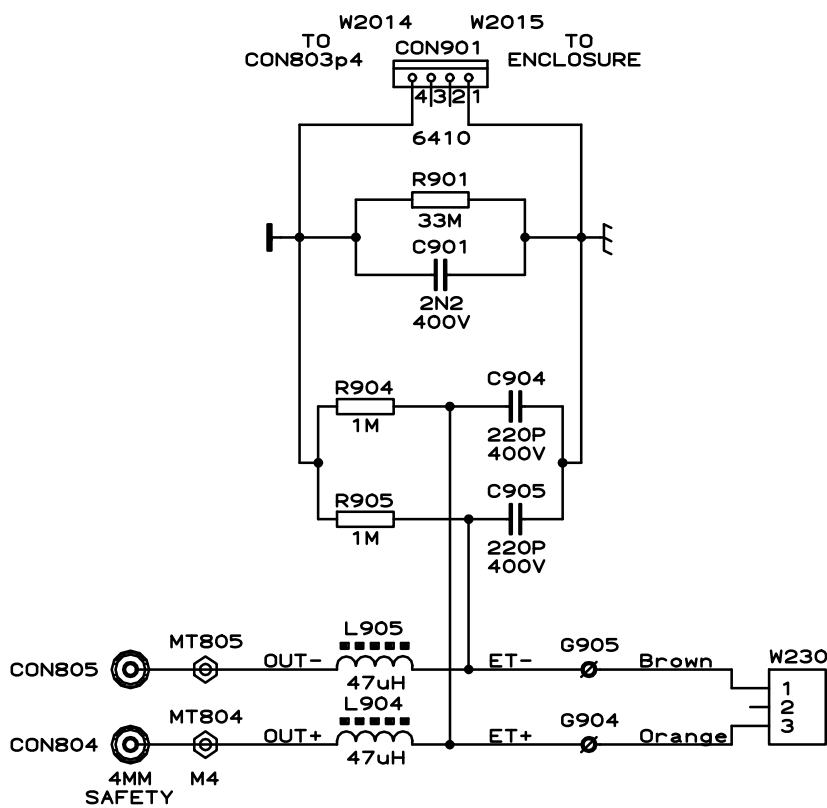
- COLOR CODE
- 0 - BLACK
  - 1 - BROWN
  - 2 - RED
  - 3 - ORANGE
  - 4 - YELLOW
  - 5 - GREEN
  - 6 - BLUE
  - 7 - PURPLE
  - 8 - GRAY
  - 9 - WHITE

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Title		
490 WIRING DIAGRAM		
Size	Document Number	REV
A	4900WIR.SCH	2.27
Date:	March 5, 1997	Sheet 4 of 22



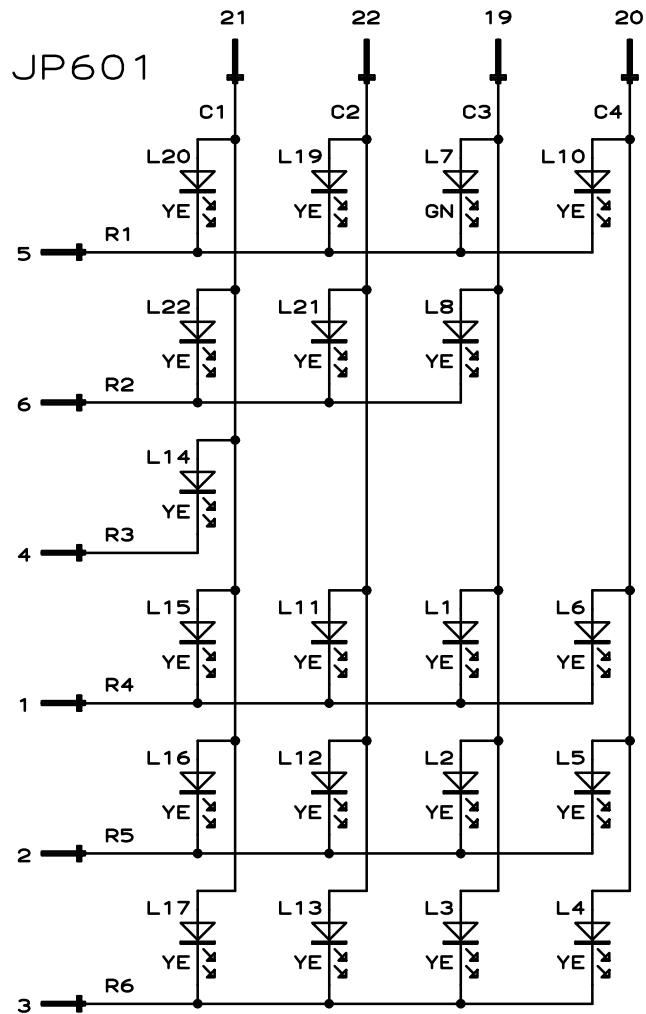


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Drawn by: N.H. Beun		
Approval:		
Location: PCB 492*		
Title		
490 MAIN PCB 4921		
Size	Document Number	REV
D	4900PCB2.SCH	2.2
Date:	March 5, 1997	Sheet 5 of 19

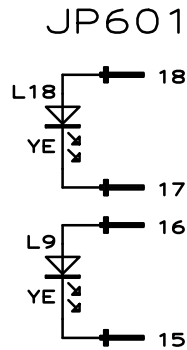


CREEPAGE ALL CIRCUITS TO CHASSIS (⌚)  
 IS MORE THEN 4 mm (CHASSIS = EP)  
 MUTUAL CLEARANCE ALL OTHER CIRCUITS  
 IS 1 mm OR MORE  
 ET: AND OUT: TRACES RATED FOR 100mArms

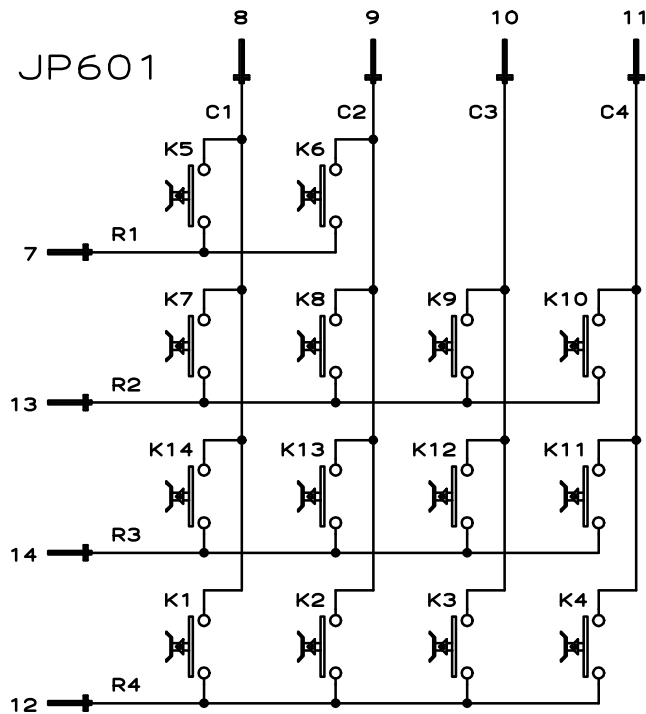
Property of: UNIPHY B.V. The Netherlands		
Drawn by: N.H. Beun		
Approval:		
Location: PCB 493*		
Title		
490 OUTPUT FILTER		
Size	Document Number	REV
D	4900PCB3.SCH	2.2
Date:	March 5, 1997	Sheet 6 of 22



LED-GRID



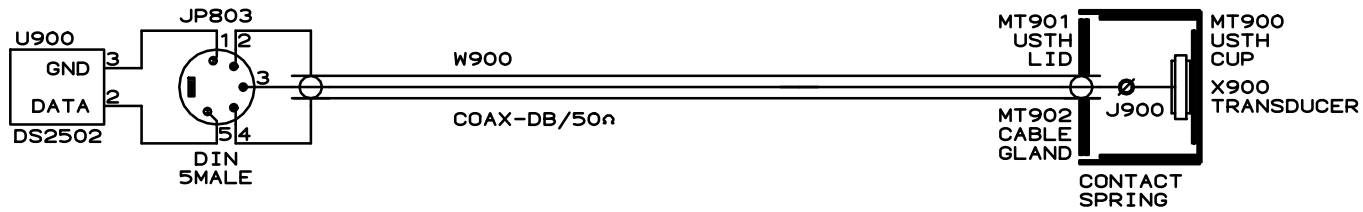
YE: HSMY-C670  
 GN: HSMG-C670  
 Mfr: HP



KEY-GRID

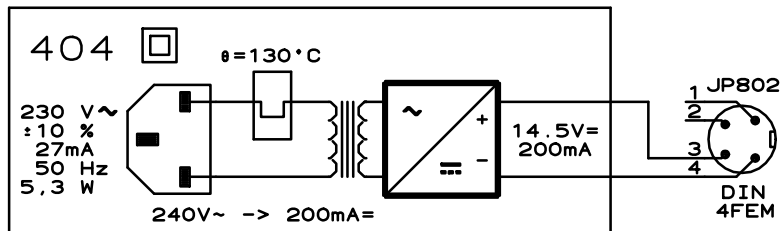
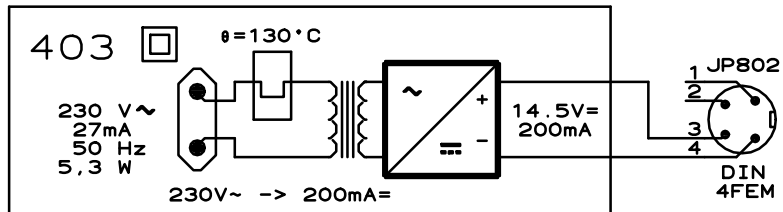
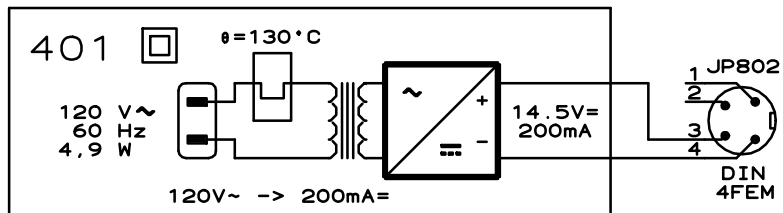
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Drawn by: Nico Beun		
Approval:		
Location: @ME 490001		
Title		
490 MEMBRANE KEYBOARD FOIL		
Size	Document Number	REV
A	4900MKF.SCH	2.27
Date:	March 5, 1997	Sheet 7 of 22

## ULTRASOUND TREATMENT HEADS

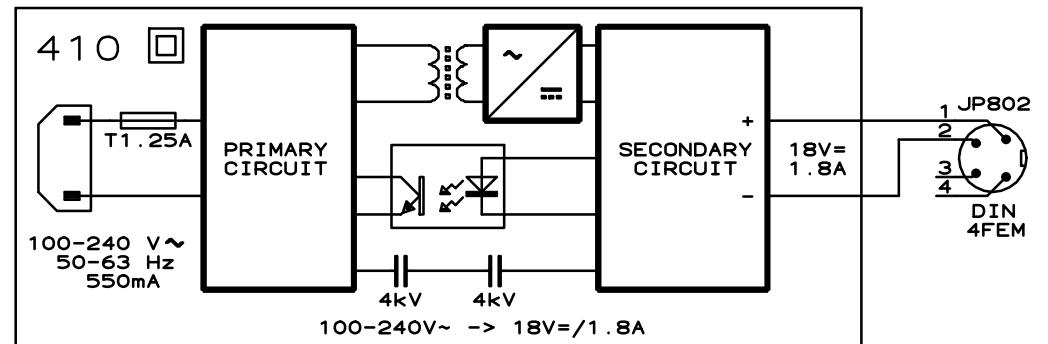


Type	X900	ERA
491	D13	1 cm <sup>2</sup>
492	D38	4 cm <sup>2</sup>

## TRICKLE CHARGERS



## UNIVERSAL MAINS POWER SUPPLY

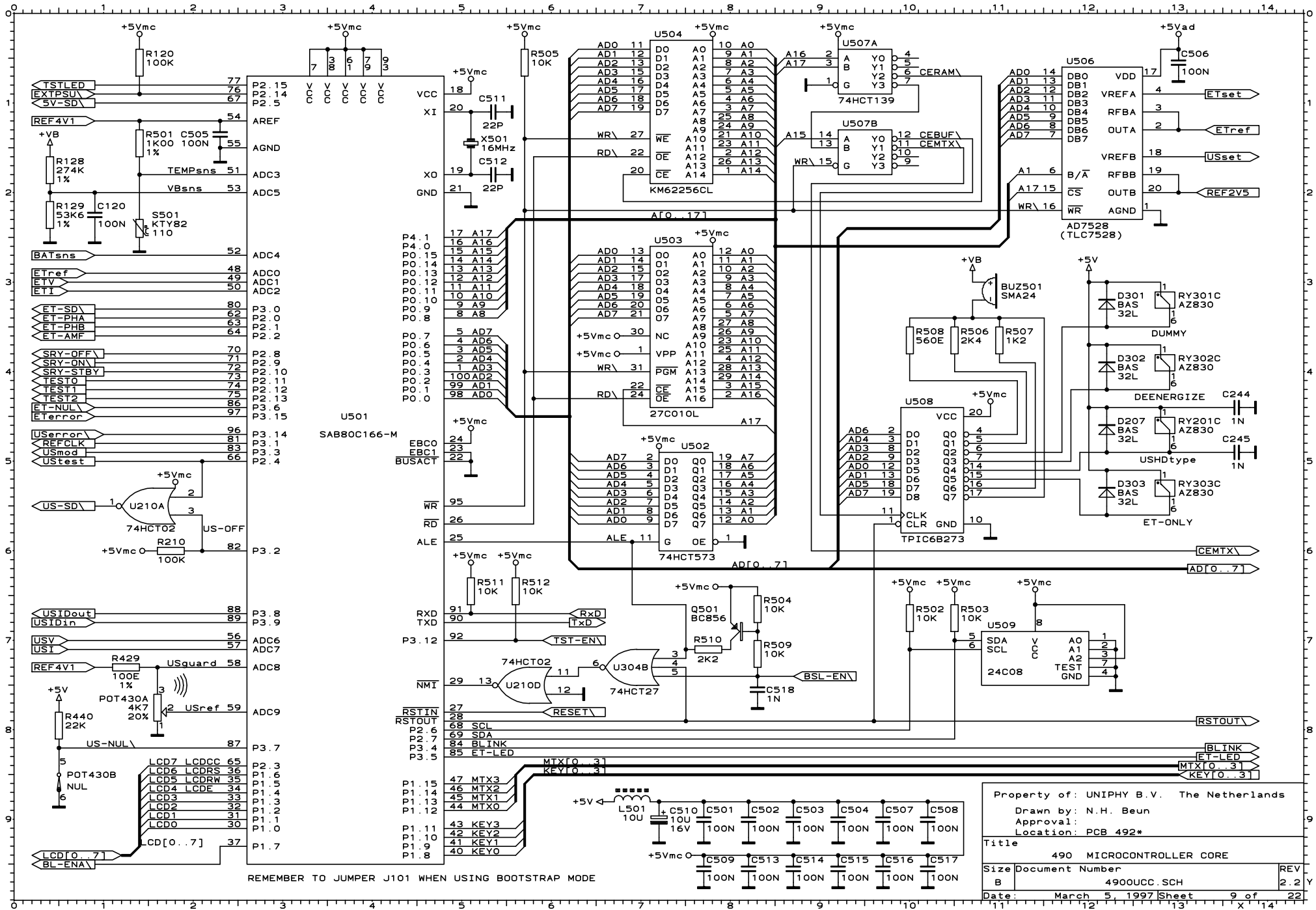


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 Drawn by: N.H. Beun  
 Approval:

Title  
 490 ACCOMPANYING EQUIPMENT

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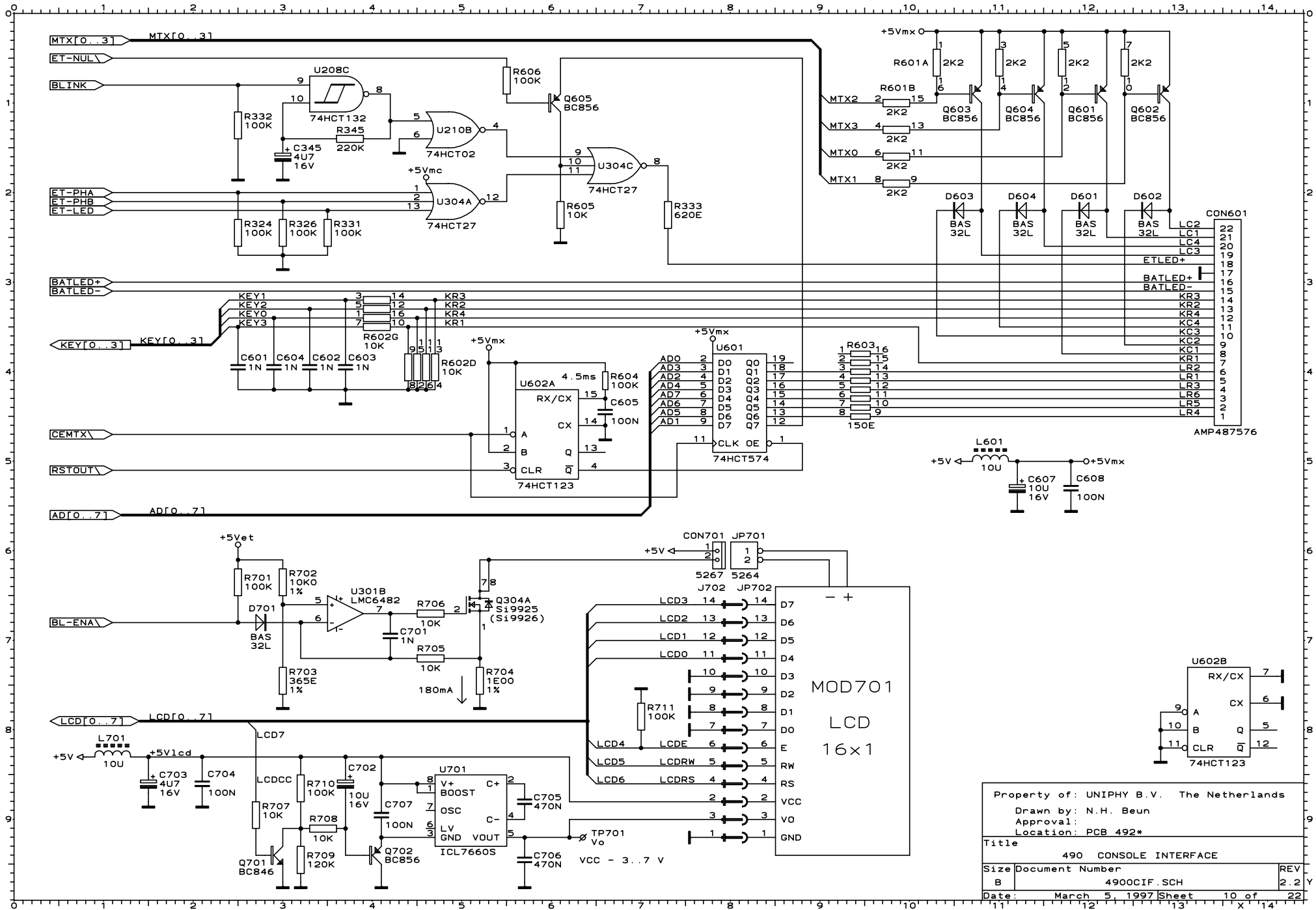
Date: March 5, 1997 Sheet 8 of 22



REMEMBER TO JUMPER J101 WHEN USING BOOTSTRAP MODE

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 Location: PCB 492\*

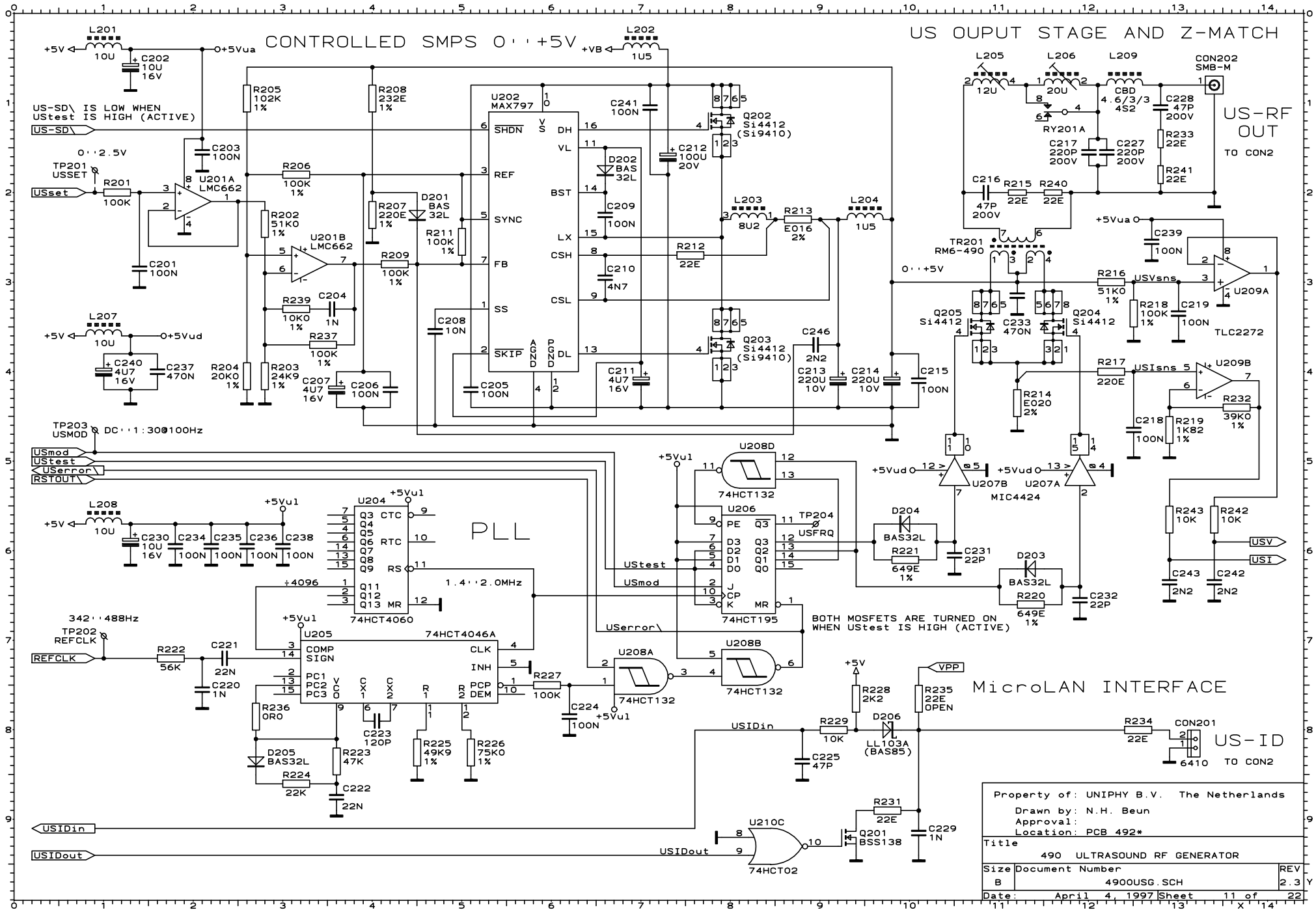
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 Size Document Number: B 4900UCC.SCH  
 Date: March 5, 1997 Sheet 9 of 22



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 Drawn by: N.H. Beun  
 Approval:  
 Location: PCB 492\*

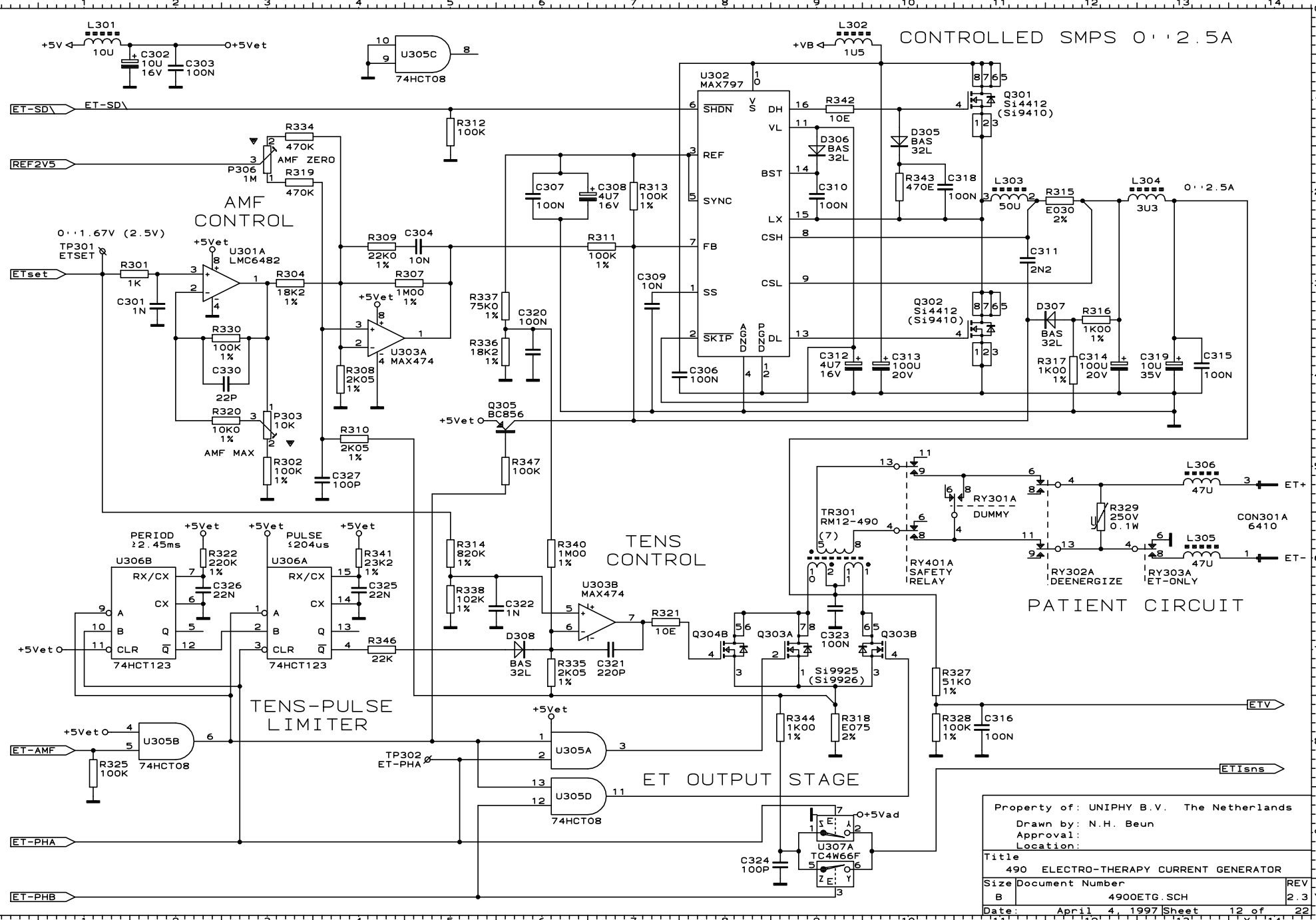
Title  
 490 CONSOLE INTERFACE

Size	Document Number	REV
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Date:	March 5, 1997	Sheet 10 of 22



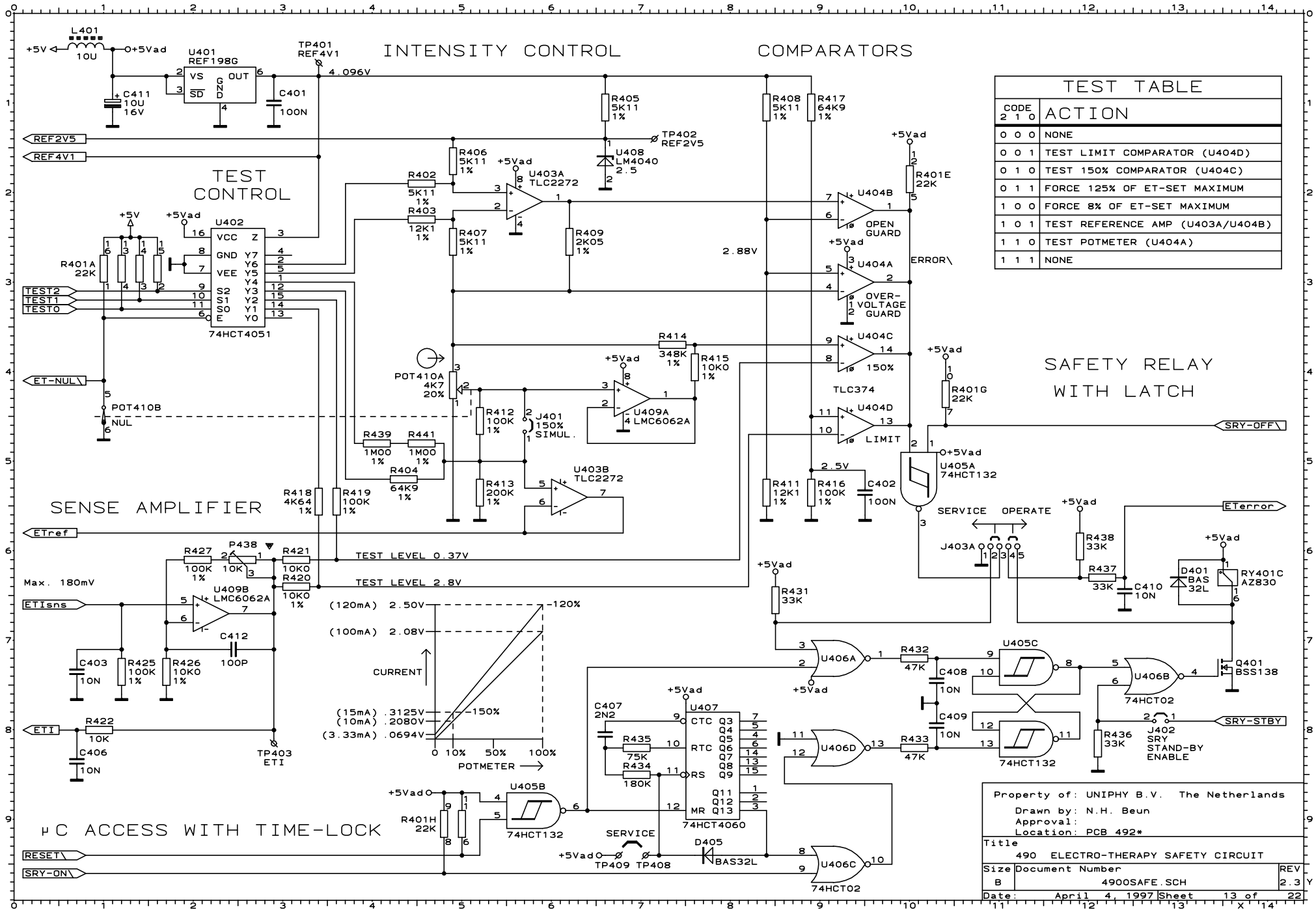
Property of: UNIPHY B.V. The Netherlands		
Drawn by: N.H. Beun		
Approval:		
Location: PCB 492*		
Title		
490 ULTRASOUND RF GENERATOR		
Size	Document Number	REV
B	4900USG.SCH	2.3
Date:	April 4, 1997	Sheet 11 of 22

CONTROLLED SMPS 0.2.5A



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Approval:		
Location:		
Title	490 ELECTRO-THERAPY CURRENT GENERATOR	
Size	Document Number	REV
B	4900ETG.SCH	2.3
Date:	April 4, 1997	Sheet 12 of 22





TEST TABLE	
CODE	ACTION
2 1 0	
0 0 0	NONE
0 0 1	TEST LIMIT COMPARATOR (U404D)
0 1 0	TEST 150% COMPARATOR (U404C)
0 1 1	FORCE 125% OF ET-SET MAXIMUM
1 0 0	FORCE 8% OF ET-SET MAXIMUM
1 0 1	TEST REFERENCE AMP (U403A/U404B)
1 1 0	TEST POTMETER (U404A)
1 1 1	NONE

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 Location: PCB 492\*

Title  
 490 ELECTRO-THERAPY SAFETY CIRCUIT

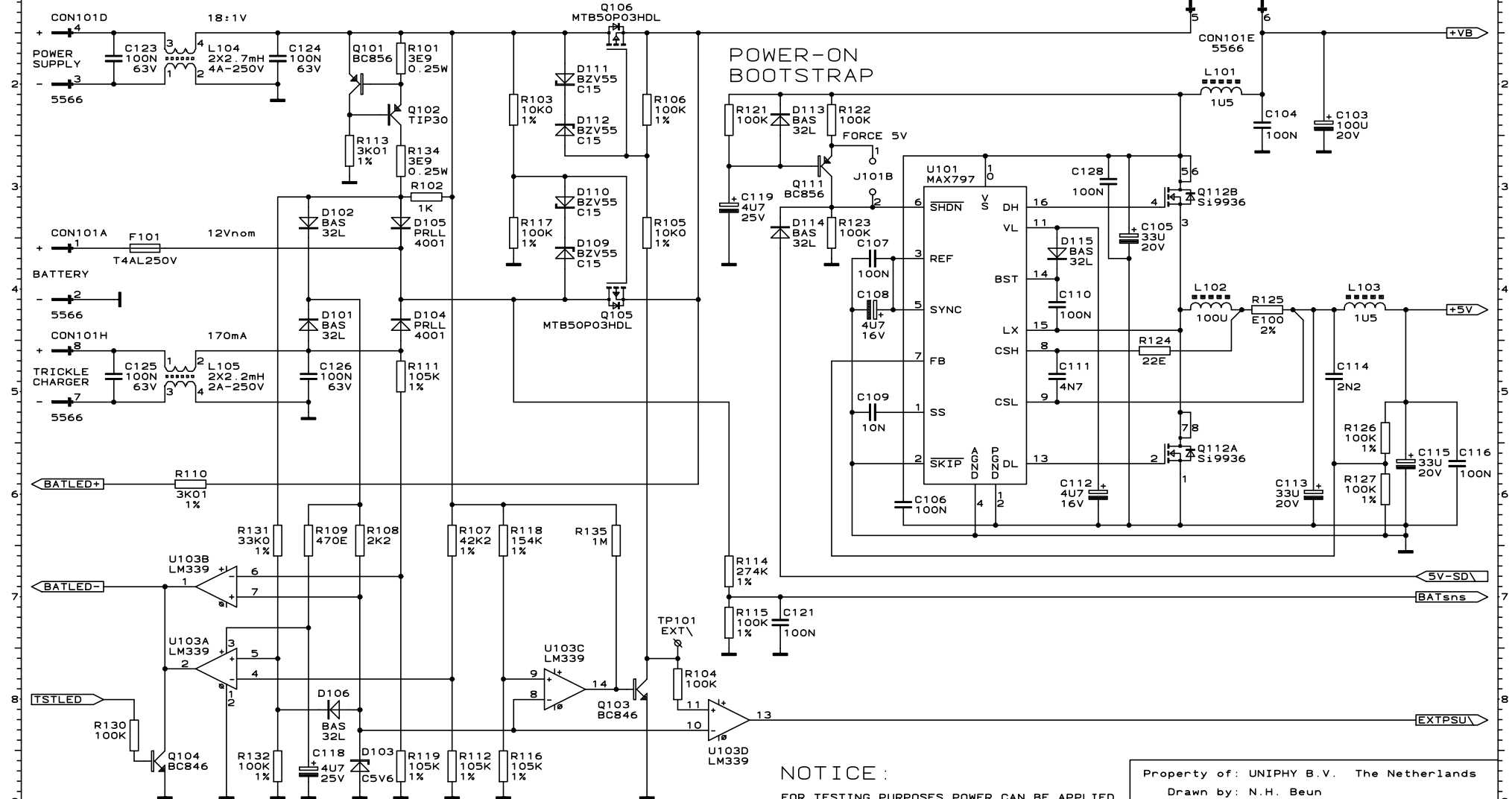
Size Document Number  
 B 4900SAFE.SCH

Date: April 4, 1997 Sheet 13 of 22

CHARGER SUPPLY-SELECTOR

+5V SMPS

ON/OFF SWITCH

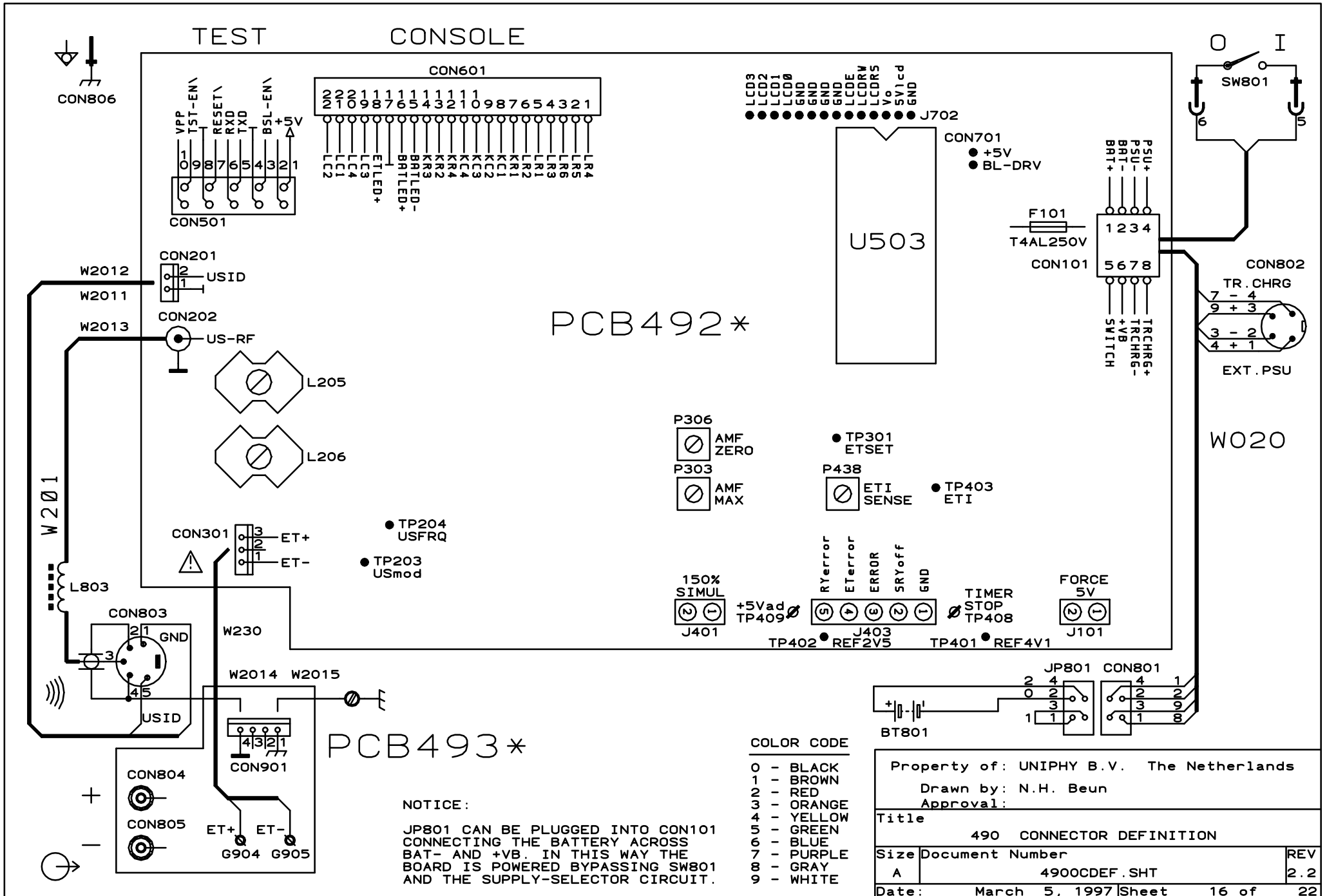


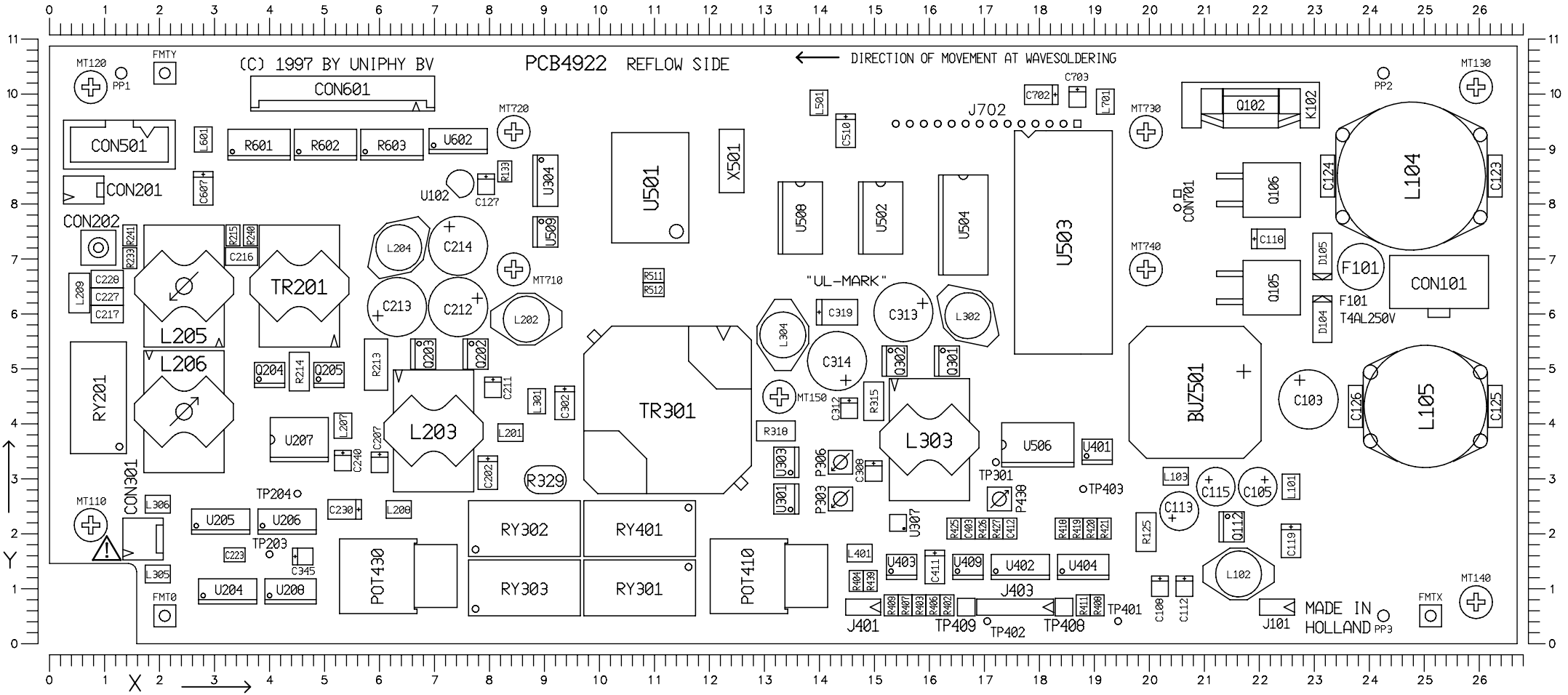
CHARGE INDICATOR

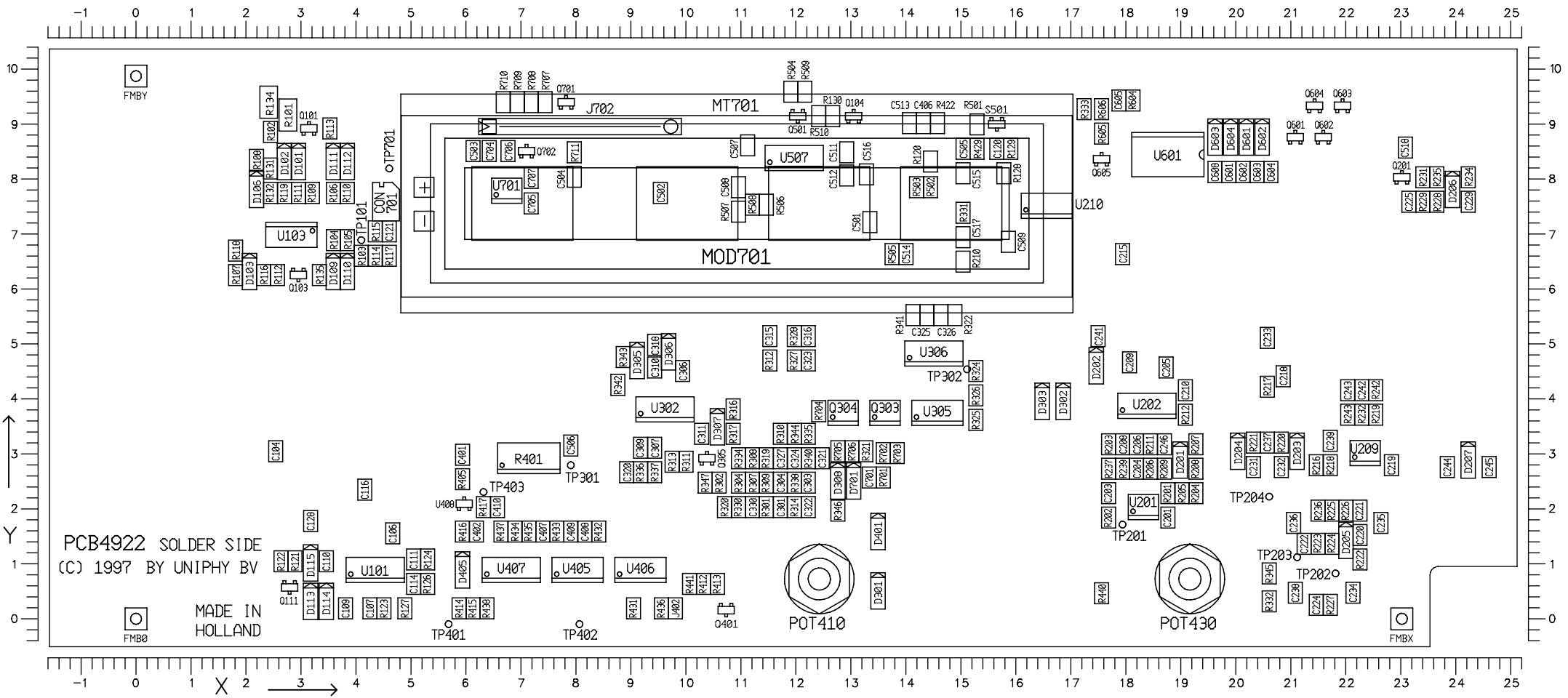
NOTICE :

FOR TESTING PURPOSES POWER CAN BE APPLIED AT PIN 6 (+) AND PIN 2 (-) OF CON101 THIS IS ALSO ACHIEVED BY PLUGGING IN THE BATTERY-PACK DIRECTLY ON CON101 WARNING: THIS WILL ALSO SHORT-CIRCUIT PIN 5 (TO-SW) TO PIN 1 (BAT+) SO BEWARE OF CONNECTING ANY OTHER POWER SUPPLY

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Location: PCB 492*		
Title		
490 POWER SUPPLY		
Size	Document Number	REV
B	4900PSU.SCH	2.3
Date:	May 6, 1997	Sheet 14 of 22

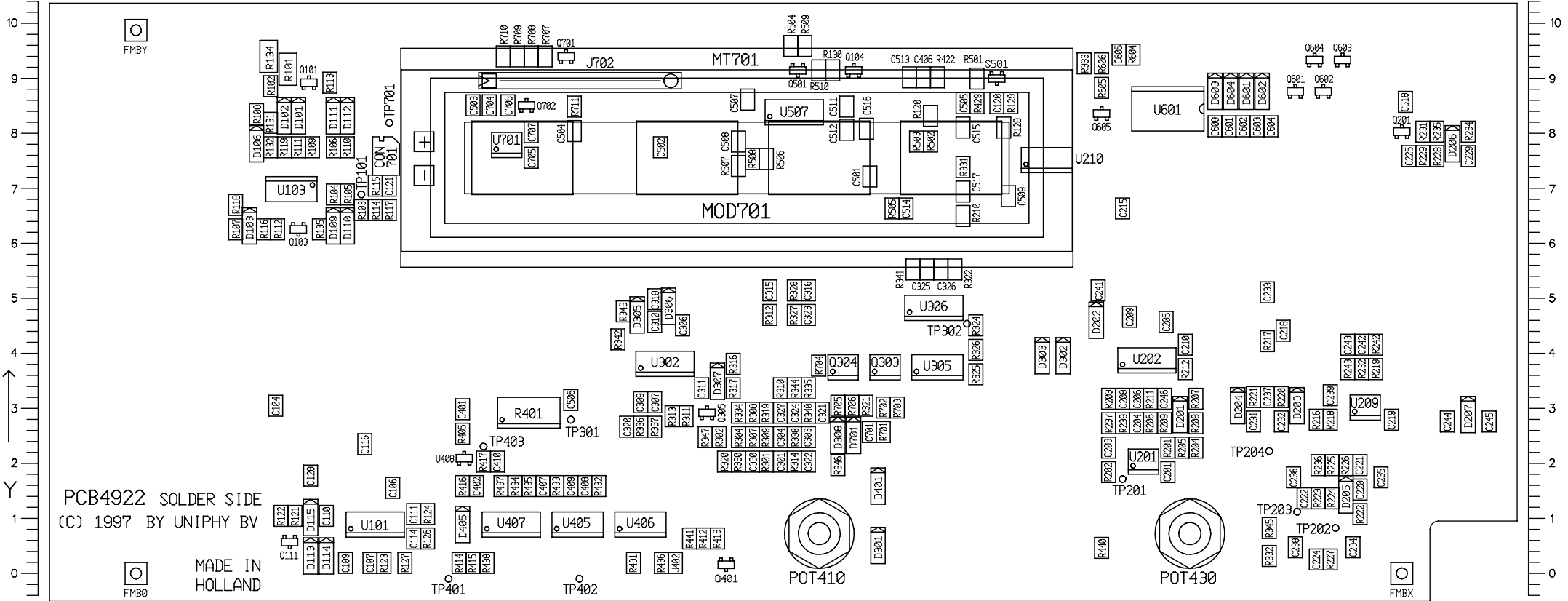


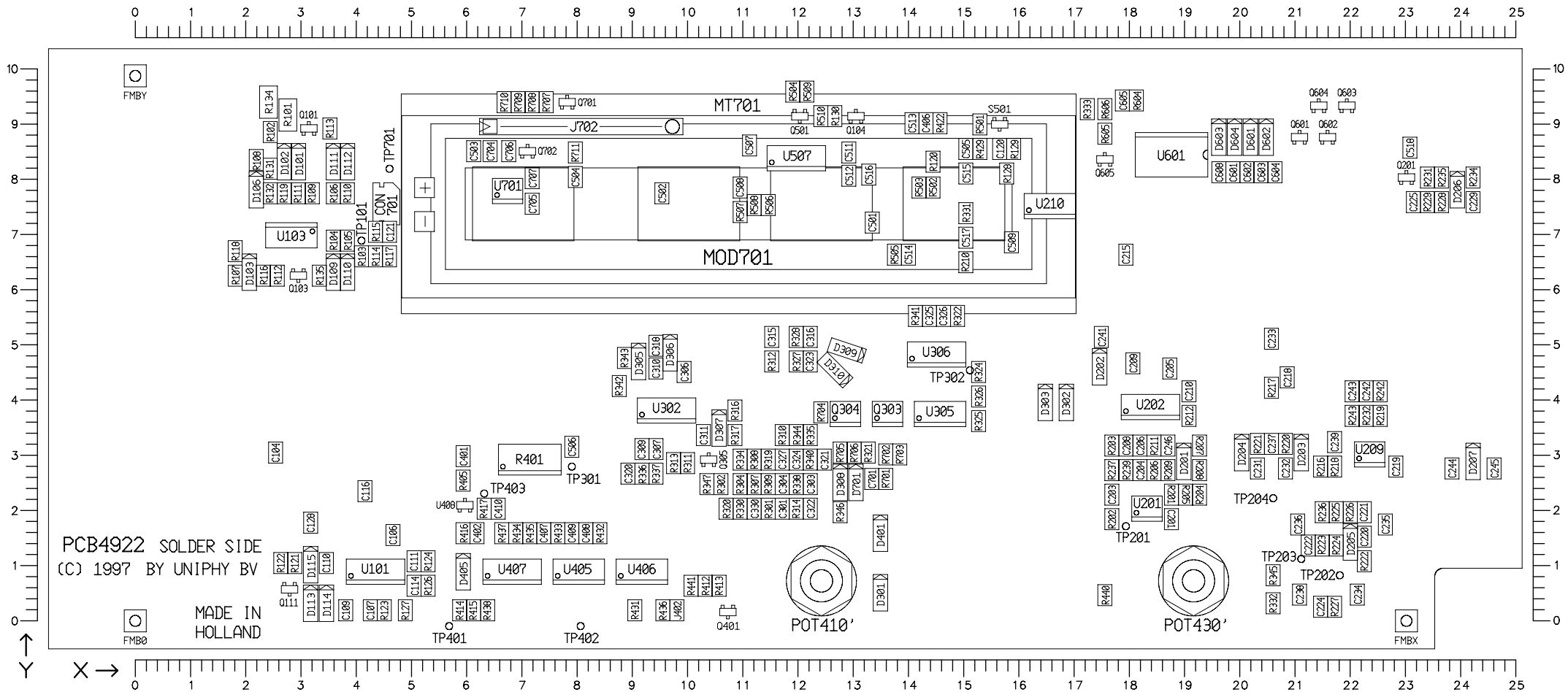




PCB4922 SOLDER SIDE  
 (C) 1997 BY UNIPHY BV

MADE IN  
 HOLLAND





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Drawn by: N.H. Beun		
Approval:		
Title		
Components Layout Solder Side PCB 4922		
Size	Document Number	REV
A	4922LS.ps	2.3
Date:	6 November 2000	Page: 18 of 22