NASCOR

SERIES 2B (M2) HIGH DEPENDENCY MONITOR

REPAIR & SERVICE MANUAL

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Version 12

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NASCOR HIGH DEPENDENCY MONITOR 2B

PREVENTATIVE MAINTENANCE SCHEDULE

To be undertaken six monthly by suitably qualified personnel.

1) Inspect monitor enclosure for trauma, cracks and damage.

2) Check, and if necessary tighten, bolts and sockets on back panel and sucker feet on base.

3) Test peizo sounder function by switch-on. Test loud and soft alarm tones using rear DIP switch 4.

4) Check plug pack :
   a) mains connection on plug-pack.
   b) integrity of plug-pack enclosure.
   c) electrical safety check in accordance with local requirements.

5) Test alarm LEDs, button LEDs and functional LEDs by switch-on.

6) Test all segments of digital displays using 'SET' button. Scroll through all alarm settings and respiratory sensitivity settings.

7) Using simulator, test :
   a) Heart rate function 0.1mV impulse at 180BPM, alarms.
   b) Respiratory function 0.2 ohms variation, base impedance of 250-500 ohms, alarms.
   c) Pulse simulator on SpO_2 probe. Check rate, alarms.
   c) Leads off.

8) Battery life check :
   a) Recharged light 'on'.
   b) Apply simulator. Heart rate 120/min
      Resp rate 60/min
   c) Unplug plug-pack
   d) Time to 'BAT Lo'
   e) Time to 'BAT dEd'
   f) If 'BAT dEd' less than 3 hours : replace batteries.
   THE BATTERIES CONTAIN LEAD. DISPOSE OF USED BATTERIES IN ACCORDANCE WITH ENVIRONMENTAL SAFETY STANDARDS.

9) Test Oxygen sensor in room air. Calibration knob should be able to alter digital display from '00' to at least '25'. If not, replace sensor.

10) Test temperature circuit with test jack:
   (eg 1300 ohms = 38.3 in display.).

NASCOR

Neonatal/High Dependency, Series 2B Monitor

SERVICE MANUAL

Introduction

Nascor High/Dependency Series 2B is a high quality cardio-respiratory monitor which also includes facilities
a) for the analysis and monitoring of SpO_2 and pulse rate,
b) for the analysis and monitoring of ambient oxygen concentration and
c) the monitoring of temperature in the neonatal, paediatric or adult patient.

CLEANING

If it is necessary to return the unit to Nascor or your local agent for repair or maintenance, please clean the unit with surface disinfectant before return.

This will remove the small risk of cross contamination or infection from surface borne organisms.

To clean enclosure or patient cable and wires, wipe down with neutral detergent or, if hospital protocol dictates, hospital grade disinfectant.

Do NOT use solvents to clean the case, front or back screen, as this may well cause permanent damage.

Do not immerse the monitor or cable and patient wires in any fluid.

Discard and replace chest electrodes between patients.

CLASSIFICATION

The equipment complies with

IEC 60601/1 1990. (AS 3200.1 (1990))

It is classified as CLASS II equipment

with:

1) CARDIO-RESPIRATORY: **type CF defibrillator-proof** applied parts.

2) PULSE OXIMETRY: **type CF applied part**.

3) TEMPERATURE : **type CF applied part**

4) OXYGEN ANALYSER : **type CF applied part**

It is not suitable to used in the presence of flammable anaesthetic gases.

It is recommended that the documents be read before the equipment is used.

Use this monitor ONLY with '**S2A513**' coded plug-packs, which are non-rewirable. For replacements please contact NASCOR direct or your local Nascor dealer.

EMI TESTING:

This monitor complies to:

EN55011:1991 (Group 1, Class A) and
EN55082-1:1992,(IEC 801-2:1991-94, IEC 801-3:1984, IEC 801-4:1988)
EN61000-4-4 and EN61000-4-5

THE CIRCUITS

A) Cardiac Circuit

Input from the patient is from an ground-isolated DIN connector.
Surge protection and strike for defibrillator voltages is provided by neon lamps SP1-3 on LA and RA leads. Additional protection is provided by series resistors and clipping diodes D2,D3,D4 & D5 connected to +/-15 volt rails.
In order to maintain CMRR, resistors R15, R16, R17, R18 on the input network should be high precision (0.1% tolerance). The signal feeds into an AD524 high precision instrument operational amplifier U3 with high CMRR.
Gain through U3 X 1,000. Output signal at [TP 8].

C37 and R64 comprise a 1st. order high pass filter: -3dB. point at 50Hz.
This is followed by low pass 6 Pole 2nd order Butterworth filter with -3dB. point at 28 Hz : $U16_{1,2,3}$.
Filtered signal then passes through inverting gain (X 9.1) stage $U16_{4}$.
Output signal is at [TP 9]. There follows a further 2nd. order high pass filter (-3dB. point at 50Hz) and a full wave rectifier to convert all waves to positive deflections before entering U14.

$U14_{1,2}$ is a peak detector. A resistor network (R59,R60,R61) keeps quiescent voltage at 42mV.(+/- 0.2mV) on pin 9 & 13 of U14. Minimum cardiac signal responded : 0.1mV differential at inputs to circuit.
Output of peak detector $U14_{8}$ passed to optocoupler U18.
Output of U18 connects to microprocessor pin 17.

B) Respiration Circuit

$U13_{1,2}$ comprise an oscillator.
Output is at $U13_{14}$: (7V p-p at 44K Hz).
Chest electrodes from patient connect via two series resistors and decoupling capacitors to primary of transformer T2. Surge protection is provided by back to back 5.1V zener diodes between LA and RA leads.
The patient impedance on the secondary acts as variable gain to $U13_{3}$.
Output to this stage at [TP 7].
$U13_{4}$ is a half-wave rectifier followed by a filter. Output goes to $U17_{1,2}$: a band-pass filter with a gain of 47 at $U17_{8}$.
C44 decouples signal for $U17_{4}$: an impedance buffer.
U20 is an signal integrator with a gain of 47.
Output at [TP10] is a wave depicting impedance change.

Using a Biotek ECG/R simulator with impedance variation of 0.2 ohms (any baseline impedance) on patient leads LA and RA. Connect the CRO earth to isolated earth (TP 17), and measure the output at [TP 10]. It should be 1.0V p-p.
RV4 is an offset adjustment potentiometer. It adjusts the output to $U20_{6}$, and is used to adjust the respiratory calibration. The signal is passed to optocoupler U19. This behaves as a diode transferring only the positive part of the wave form to pin 21 of the micro-processor.

CALIBRATION OF RESPIRATORY SENSITIVITY:
Use a respiratory simulator (such as Bio-tek ECG/R). Connect LA and RA patient leads. Set baseline impedance to 250 ohms, impedance variation to 0.2 ohms, and rate to 60 bpm.
Connect CRO earth to [TP 11] (non-isolated earth) and CRO probe to $U19_4$ [TP 16].
Turning potentiometer RV4 will alter the bias of the half sine wave on the CRO.
Select the most sensitive level of respiration detection (S-1)
At the 'S-1' sensitivity level, the minimum respiration wave peak detectable lies at 0.5V.
Set the impedance variation on the simulator to 0.1 ohms.
The peak of the simulator wave should be just below 0.5V on the CRO. With a variation setting of 0.2 ohms the peak should be just above 0.5V.
Adjust RV4 to achieve this.
In essence, 0.15 ohms variation should just trigger a respiration at the sensitivity level of S - 1.

C) Leads-off Circuit

$U14_3$ comprises a leads off warning switch.
$U14_2$ is held at an appropriate voltage by a voltage divider comprising a potentiometer RV5.

To calibrate the leads-off chest impedance level place 2K5 total resistance between the chest leads LA and RA. Adjust the potentiometer RV5 until the displays on the front board just switch to read 'LdO'. Seal the potentiometer at this position.

The d.c. voltage at $U14_3$ is proportional to the a.c. amplitude at [TP 7].
$U14_1$ switches high when the impedance between the patient electrodes becomes greater than that set by RV3 (should be 2.5K ohms).
This signal passes to octocoupler U15 hence to pin 18 on the microprocessor.

D) Power Supply Circuit

Input power is from a double insulated, approved 9V 650-800mA DC plug pack.

The input power is regulated by U1 and U21 (LM 2940T-8) low overhead 8 volt regulators. [TP 1] held at 8V.
U1 supplies power to the monitor when the plug pack is powered. This causes the 'POWER' LED on the switch/display board to illuminate.

U21 supplies the battery recharging circuit.

The battery recharging circuit is controlled by U5 (UC3906). This I.C.is custom designed for the recharging of lead-acid batteries.
U5 HAS BEEN CONFIGURED AS A DUAL LEVEL FLOAT CHARGER.
This has three states, a high current bulk charging state, an overcharge state and a float charge state. A charge cycle consists of these three states in sequence.
1) Bulk charge state : constant current charge at a maximum of 200mA. controlled by current limiting resistor R27 and pass transistor Q7. As a transition voltage, as sensed by U5, is reached the next state is initiated...
2) Overcharge state : U5 regulates the voltage of the battery to 6.9V (at 25^{O}C) until the current drops to a threshold level. At this level the battery is nearly 100% charged. U5 then switches to the float state.
3) In this state the battery is held at a very precise voltage (6.81V at 25^{O}C) by a voltage regulator which is temperature compensated. The temperature compensation coefficient is the same as that of the batteries. Float voltage is proportional to the R31+R32/R33 voltage divider and is set at 25^{O}C. U5,$_{16}$ will pull the base of PNP pass transistor Q7 and allow only trickle current to flow to the batteries.
When the batteries enter the 'float' voltage state, U5,$_{10}$
causes the LM393 on the switch/display board to switch. This illuminates the 'RECHARGED' LED.

If the plug-pack power is removed, relay RO1 will switch allowing the battery voltage to be applied to the on/off switch and hence the circuitry at [TP 3].
This voltage is applied to the input of U4, a low dropout 5V regulator, the output of which supplies the microprocessor on pins 7 & 4.

Battery Low / Battery Dead levels are 5.5 V and 5.2 V respectively. The system voltage is stepped down by 2.5 V through U9, a reference diode, before passing to pin 24 of the microprocessor.

In the case of serious overvoltage (>7.3 V), U22, an overvoltage protector will pull down Q4, an SCR, this will kill the 'power' LED on the front panel and ground the power to the recharging circuit until the plug-pack is removed. On sensing such an overvoltage state from pin 24 the microprocessor will
a) via pin 30, pull down on the base of transistor Q3 which will cause U5 to pull down maximally on U5 $_{16}$ to shut down current through the pass transistor Q7, and
b) force displays to read 'Bat Hi' when the monitor is switched on.

Battery Care

The batteries in the monitor are sealed LEAD-ACID batteries. Unlike Ni-Cads they thrive on being fully charged all the time. They do **not** like to be run down below ' Bat ded' level, as this 'sulphates' up the chemicals within and damages them leading to decreased battery time.
As there is a dedicated chip within the monitor which keeps the batteries at the right voltage level:

1) Always leave the monitor on the charger.

2) When the batteries are depleted on a transport - put the monitor back on the charger as soon as possible on your return. Leaving it allows the voltage to sag even lower and potentially sulphate them.

DISPOSAL OF BATTERIES

The batteries are lead-acid gel type. They are potentially hazardous to the environment. When changing batteries dispose of the used batteries in an appropriate disposal facility or contact your Nascor distributor to advise you.

E) Sounder Circuit

The sounder is controlled by 2 transistors Q1 and Q2 which act as switches.
R5 is a resistor placed in series with the voltage supply to the sounder when the DIP switch configuration (switch 4) selects quiet alarms/beep volume.

F) Patient Isolation Area Power Supply

Microprocessor pins OSC1 and OSC2 oscillate a 32,767Hz crystal.

The output frequency is buffered then goes to a flip-flop which generates the phased outputs which is applied to transistors Q5 & Q6.

This is applied to the primary of T1 at 14V p-p.

The secondary generates 48V p-p waveform which passes it through a bridge WO4 bridge (B1).

Positive voltage is passed to U12, a low overhead 15V regulator
[TP 5] (+15V).
Negative voltage is passed to U11, a MC7915CT regulator
[TP 6] (-15V).

G) Oxygen Analyser Circuit

The power from a Teledyne R17 fuel cell is applied to a network of voltage dividers hence to the input U2 $_2$. Amplified output [TP 2] is passed to pin 23 of the microprocessor.

CALIBRATION: Without oxygen sensor in the input, connect a digital voltmeter, positive lead to [TP 2],negative lead to pin 20 of the 40 pin connector. Adjust RV2 to get 0.482 V between these points.

RV3 is the potentiometer accessible from the back panel. It is for users to calibrate the oxygen reading when the sensor is applied to the input as described in the user manual.

H) Temperature Circuit

This circuit is compatible with the Yellow Springs Instruments, 400 series temperature probes. It consists of a network of 4 precision resistors (0.1% accuracy). An accurate voltage divider is utilised to standardise the voltage on U2 $_6$ (negative input). The voltage from the temperature probe is applied via another accurate voltage divider to U2 $_5$ (positive input). To avoid self-heating, the temperature probe the voltage applied to the system is rapidly oscillating and derived from the microprocessor.
No calibration is required to this circuit.
To check oscillation, apply CRO probe to U8 $_2$. CRO earth to digital earth.
To confirm accuracy, use the following table:

RESISTOR AT INPUT	TEMPERATURE READING
1894 ohms	29
1599 ohms	33
1301 ohms	38
1200 ohms	40
1108 ohms	42

I) Microprocessor

a) The microprocessor is a: a Motorola MC68HC908GP32CFB which controls all of the digital processing, switching and display functions of the monitor. It is not repairable and contains proprietary software.
b) An isolation barrier bridged by 2 optoisolators (4N35).
c) These optoisolators (U6, U24) mate with serial data outputs from the NELLCOR module.

d) A DC/DC converter steps down power from the +15V rail to +5V for the NELL-2 module.
e) A strap connects a display of green LEDS on the right side of the front panel depicting pulse/oximetry signal strength. It is output from the microprocessor via J2/JD2 6-pin socket/plug. U2 (a 4094) processes the signal.

The motherboard is interchangeable. Do not attempt repair. Return to NASCOR P/L.

J) NELLCOR$_{(R)}$ OEM NELL-2 Pulse Oximetry Module.

This connects to standard Nellcor$_{(R)}$ OxiMax$_{(R)}$ sensors and provides oxygen saturation and pulse rate via a serial digital interface. The host system provides isolated power from the motherboard (+5V). The NELL-2 is a 6-layer PCB with surface mounted components. Its specifications are confidential and proprietary. Any problems with this module should be referred to NASCOR P/L.

J) The Front Panel

The front panel contains the LED displays, alphanumeric displays and micro-switches of the control panel. There are 2 ICs involved in the processing of the switch functions and micro-processor outputs : U1 (7445) & U2 (74ACT14).
The LEDs are arranged in a x,y matrix. The rows are normally held high and the columns normally low. In order to illuminate a LED therefore, the rows are pulled down and the columns are pulled up.
The 7445 is a decoder that pulls the selected row low. The 74ACT14 is a hex inverter that holds unwanted columns low and pulls required columns high.
One pole of the switches is connected to the column driver,the opposite pole is held low through a series resistor. Pressing the switch pulls up the column which is connected to the microprocessor
The function LEDs and the alphanumeric displays and function outlets are of low current type, the rectangular LEDs are not. The displays are multiplexed yielding significant power economy.
U3 (LM393) is a switch to control the 'RECHARGED' LED.

NOTES

SIGNAL PROCESSING

Cardio-respiratory signals are processed in analog within an area electrically isolated from the mains supply. The signals are then communicated to the micro-processor utilising optocouplers with >10K breakdown voltage. The micro-processor, Motorola type MC68HC908GP32CFB handles the processing of the signals, the switching and the display.

CARDIAC FILTERING

A 1st. order high pass filter: -3dB. point at 50Hz. is followed by low pass 6 Pole 2nd order Butterworth filter with -3dB. point at 28Hz then a further 2nd. order high pass filter: -3dB. point at 50Hz.
Filtered signal passes through inverting gain stage and a full wave rectifier to convert all negatively deflecting signals to positive to be detected by the peak detector.

This configuration of filters / software algorithms has been specifically designed to allow accurate peak detection with a wide variety of electrode positions and poor electrode contact.

(a) The low pass filter has a very steep cutoff it obviates the need for a notch filter for 50/60 Hz.

(b) The high pass filters remove baseline wander and flatten T waves. Software algorithms avoid double counting of widened QRS complexes.

(c) It produces a large bi-phasic signal and no T wave when the electrodes are placed in the recommended location on the chest.

(d) The QRS waves are rectified before (positive-voltage only) peak detection.

(e) These strategies greatly minimise the possibility of

- double counting on high T-waves
- miscounting of negatively deflecting QRS waves because of aberrant electrode placement
- miscounting of baseline deflections from body movement

and allows for safe heart-rate counting in cardiac or electrolyte abnormalities.

RESPIRATORY SENSITIVITY

At the highest sensitivity setting (S-1), the monitor will detect variations of 0.15 ohm in the baseline impedance of the chest. This is the lowest necessary for even the smallest babies; most produce variations of the order of 0.2 - 1.0 ohm. Nevertheless even in these infants cardiac and intrathoracic blood movement can produce impedance variations of up to 0.3 ohms. Cardiac respiratory artefact is almost never greater than 0.5 ohms variation.

The sensitivity levels in the Series 2 are detected by the microprocessor at :

S - 1 ..... 0.45 Volt
S - 2 ..... 1.45 Volt
S - 3 ..... 2.6 Volt

When setting the sensitivity level the simulator (Biotek ECG/R) should be configured with baseline impedance of 250 ohms and a variation of 0.1 ohms. The potentiometer RV4 is then used to position the peak of the impedance wave to just below 0.5 V, the setting at a variation of 0.2 ohms should be set just above the 0.5 V level.

It will be found that the sensitivity levels will then correspond approximately to :

S - 1 ..... 0.15 ohm variation
S - 2 ..... 0.5 ohm variation
S - 3 ..... 2.0 ohm variation

RESPIRATORY CARDIAC COINCIDENCE DETECTION

As described above (Cardiac Filtering) impedance pneumonography can misinterpret cardiac movement or the movement of blood through the thorax as respiratory movement. This is more likely to occur in

1) inappropriate electrode placement or

2) if circulation is hyperdynamic, for instance in preterm babies with a patent ductus arteriosus.

It is potentially hazardous as this artefact may not be apparent or detectable until apnoea occurs.

To guard against this eventuality the monitor is programmed to alarm, and the display 'rCC' will be forced up on the right hand display, if a respiratory rate remains exactly the same as the cardiac rate for 5 seconds or more.

Occasionally there are babies who will breath for some seconds at their heart-rate (cardio-respiratory reflex). However this phenomenon is unusual and is typically not maintained for very long.

SPECIFICATIONS

Power Requirements

110 - 130 VAC, 220 - 240 VAC / 9V DC 750mA double insulated plug-pack.

USE ONLY PLUG-PACKS CODED 'S2A513' WITH THIS MONITOR.

Operating Conditions

Temperature	$0^{\circ}C$ to $40^{\circ}C$

Storage and Transport Conditions

Temperature	$0^{\circ}C$ to $60^{\circ}C$
Conditions	Use Nascor Packing Material. Keep Dry.

ECG

Input	Differential, isolated.
Minimum signal	0.1 mV
Sensitivity adjustment	Automatic
Frequency Range	6 - 30 Hz
Input impedance	10 Mohms
Defibrillation Shock Protection	> 5KV, 500J discharge.
Defibrillation Reset Time	< 5 secs
'Leads-off' Threshold	2.5 K ohms
Range	40 - 255 BPM
Accuracy	+/- 1%
Range	0 – 255 bpm
Resolution	1 bpm

RESPIRATION

Principle	Impedance Pneumography
Frequency	49K Hz
Patient auxiliary current	6.3 mA
Minimum signal	0.15 ohm
Apnoea period	15 or 20 sec
Sensitivity adjustment	Switchable, 3 levels
Cardio-respiratory coincidence	5 secs to alarm
Accuracy	+/- 1%
Range	0 – 255 breaths per minute
Resolution	1 bpm

OXYGEN ANALYSER

Sensor	Teledyne R17
Range	0 – 100%
Accuracy	1%
Alarm	> 2% from set level.
Fuel cell life	> 1 year with normal usage

TEMPERATURE

Probe	YSI 400 Series or equivalent
Range	29 - 45 degrees Celsius
Accuracy & Resolution	0.1 degrees Celsius

OXIMETER

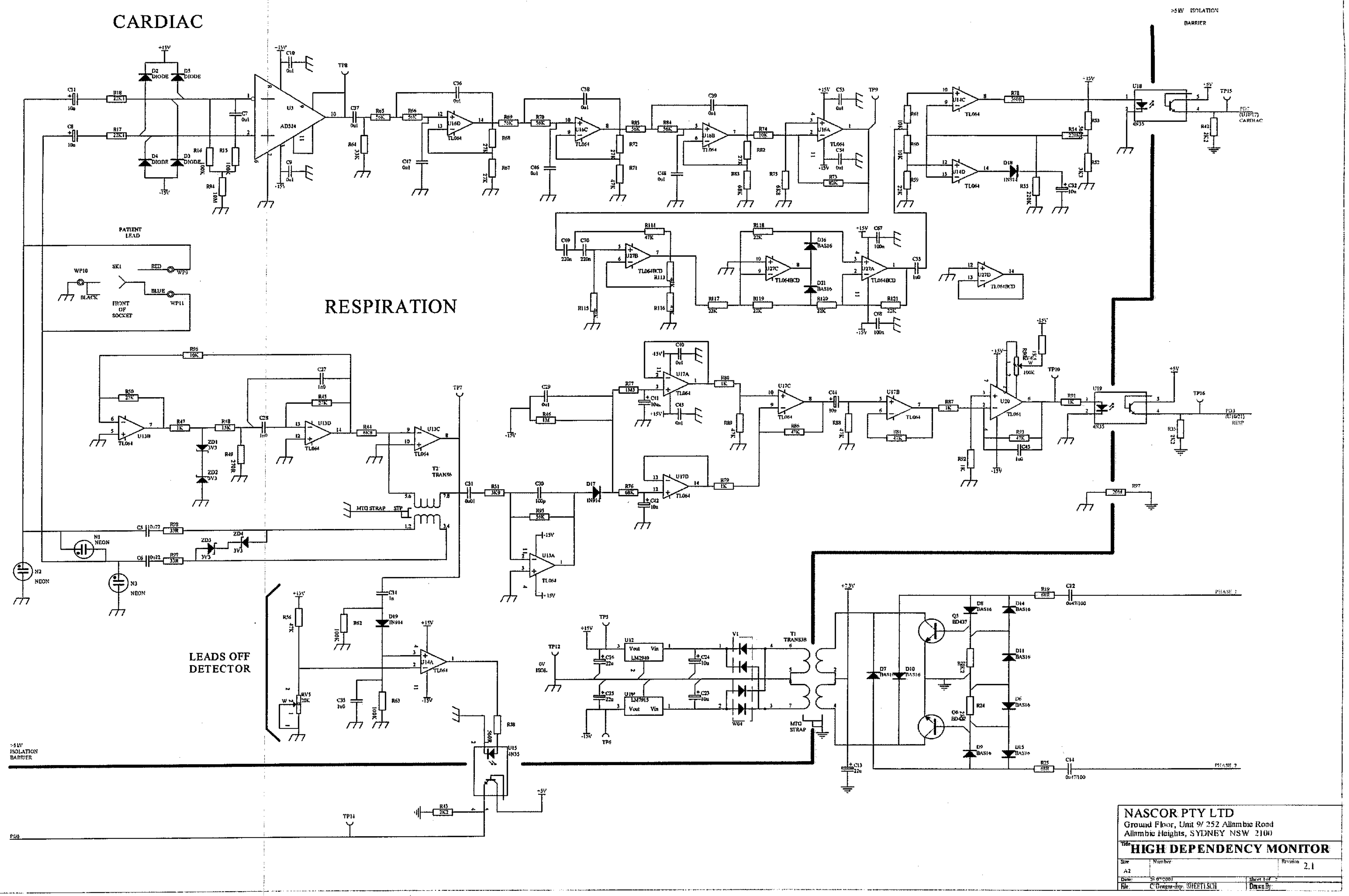
Oximeter unit	NELLCOR® NELL-2 Module		
Saturation	0 - 100%		
Pulse rate	20 - 250 bpm		
Pulse rate Accuracy	+/- 3 bpm		
Saturation Accuracy	Adults:	70-100%	+/- 2 digits
		50-69%	+/- 3 digits
		0 -49%	unspecified
	Neonates:	70-95%	+/- 3 digits

SENSORS: Compatible with NELLCOR$_{(R)}$ OxiMax$_{(R)}$ sensors.

NELLCOR$_{(R)}$, and OXIMAX$_{(R)}$, are registered trademarks of TYCO MALLINCKRODT.

NASCOR SERIES 2B (M2) HIGH DEPENDENCY MONITOR

<u>SCHEMATICS AND COMPONENT OVERLAYS</u>


CARDIAC
RESPIRATION
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DETECTOR
PATIENT
LEAD
FRONT
OF
SOCKET
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BARRIER
MTG STRAP
PHASE 2
PHASE 2
CARDIAC
RESP
NASCOR PTY LTD
Ground Floor, Unit 9/ 252 Allambie Road
Allambie Heights, SYDNEY NSW 2100
HIGH DEPENDENCY MONITOR
Size A2
Number
Revision 2.1
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Sheet 1 of
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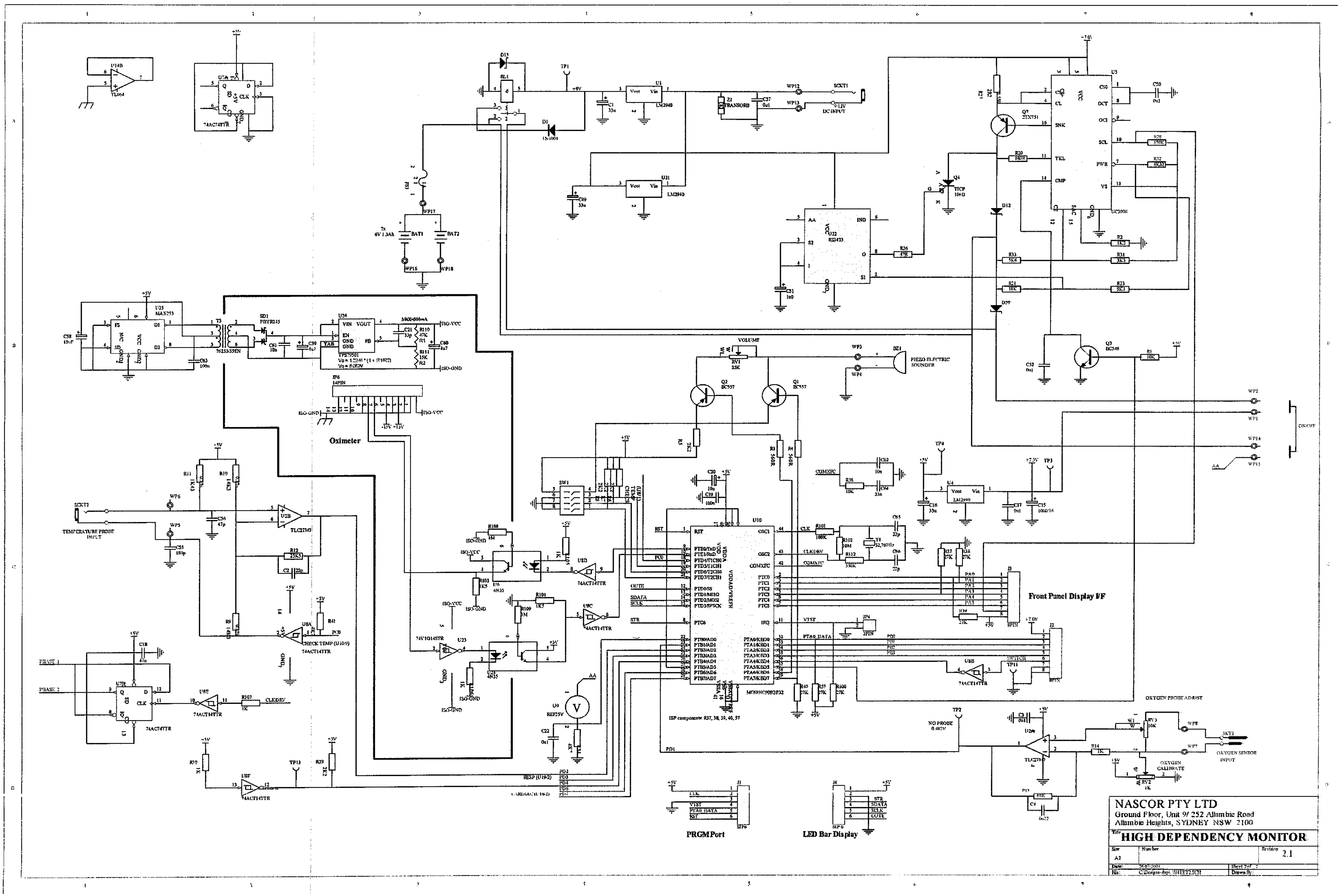
NASCOR PTY LTD
Ground Floor, Unit 9/ 252 Allambie Road
Allambie Heights, SYDNEY NSW 2100
HIGH DEPENDENCY MONITOR
Revision 2.1
Size A2
Front Panel Display I/F
Oximeter
PRGM Port
LED Bar Display
PIEZO ELECTRIC SOUNDER
TEMPERATURE PROBE INPUT
OXYGEN SENSOR INPUT
OXYGEN PROBE ADJUST
OXYGEN CALIBRATE
NO PROBE
DC INPUT
ON/OFF
CHECK TEMP
VOLUME