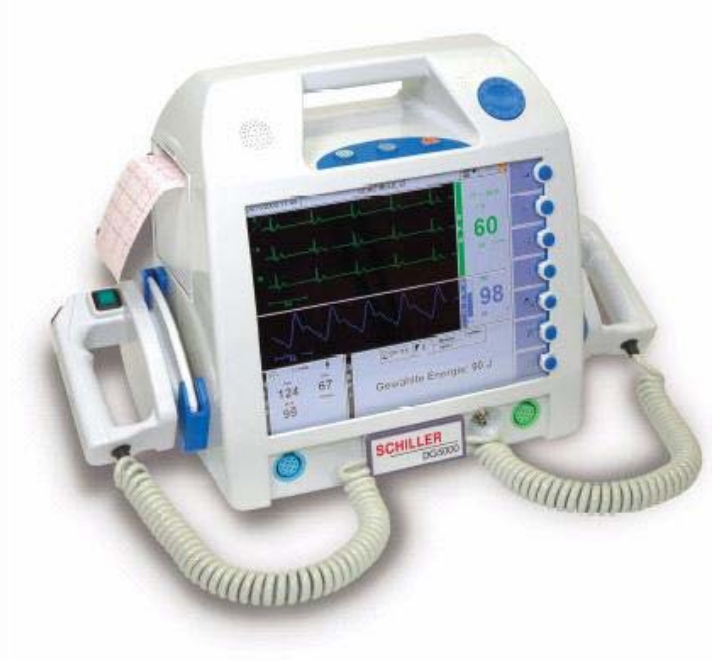
SCHILLER

MEDICAL S.A.S.

DEFIGARD 5000

Service Manual

Version 01.00



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THE ART OF DIAGNOSTICS

Part : 0-48-0065

Revision history
of the service manual

Version 01.00 : June 2005

WARNING

This manual shall be considered to form an integral part of the device described.

This technical manual is intended for qualified personnel and describes the operating, maintenance and troubleshooting procedures for DEFIGARD 5000.

Compliance with its content is a prerequisite for proper device performance and for the safety of the patient and operator.

The manufacturer shall only be liable for the safety, reliability and performance of the device if:

- **assembly, extensions, adjustments, modifications or repairs are performed by the manufacturer or by persons authorised by the manufacturer.**

- **the electrical installation of the facility of use complies with the requirements applicable in the country.**

- **the device is used in accordance with its instructions for use.**

- **the spare parts used are original parts from SCHILLER.**

This manual describes the device at the time of printing.

The supply of this manual does not in any event constitute permission or approval to modify or repair a device.

The manufacturer agrees to supply all the spare parts for a period of ten years.

The DEFIGARD 5000 device shall be used as described in the User's Manual. The device may not be used for any purpose that has not been specifically described in the manual, as such use could be hazardous.

SAFETY INFORMATION

- **The product is marked as follows:**

  CE- 0459

  in accordance with the requirements of Council Directive 93/42/EEC relating to medical equipment, based on the essential requirements of annex I of the directive.

- **It fully meets the electromagnetic compatibility requirements of standard IEC 60601-1-2/EN 60601-2 "Electromagnetic compatibility of medical electrical devices".**

- **The device has undergone interference suppression in accordance with the requirements of standard EN 50011, class B.**

- **In order to optimise patient safety, electromagnetic compatibility, accurate measurement indication and proper device performance, users are advised to use only original spare parts supplied by SCHILLER. Any use of accessories other than original accessories shall be at the exclusive risk of the user. The manufacturer shall not be liable for any damage due to the use of incompatible accessories or consumable supplies.**

- **The manufacturer shall only be liable for the safety, reliability and performance of the device if:**

  - **assembly, configuration, modifications, extensions or repairs are made by personnel from SCHILLER MEDICAL or personnel duly authorised by SCHILLER MEDICAL.**
  - **the device is used in accordance with its instructions for use.**

- **Any use of the device other than as described in the instructions for use shall be made at the exclusive risk of the user.**

- **This manual covers the device version and the safety standards applicable at the time of printing. All rights reserved for the circuits, processes, names, software and devices appearing in this manual.**

- **The quality assurance system in use in the facilities of SCHILLER meets international standards EN ISO 9001 and EN 46001.**

- **Unless otherwise agreed in writing by SCHILLER, no part of the manufacturer's literature may be duplicated or reproduced.**

Safety symbols used on the device

Danger! High voltage

Conventions used in the manual

Danger:	**indicates an imminent hazard which, if not avoided, will result in death or serious injury to the user (and/or others).**

Caution:	**Warning indicating conditions or actions that could lead to device or software malfunctioning.**

Note:	**Useful information for more effective and practical device operation.** **Additional information or explanation relating to the paragraphs preceding the note.**

Manufacturer:

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PRECAUTIONS WHILE TESTING THE DEVICE

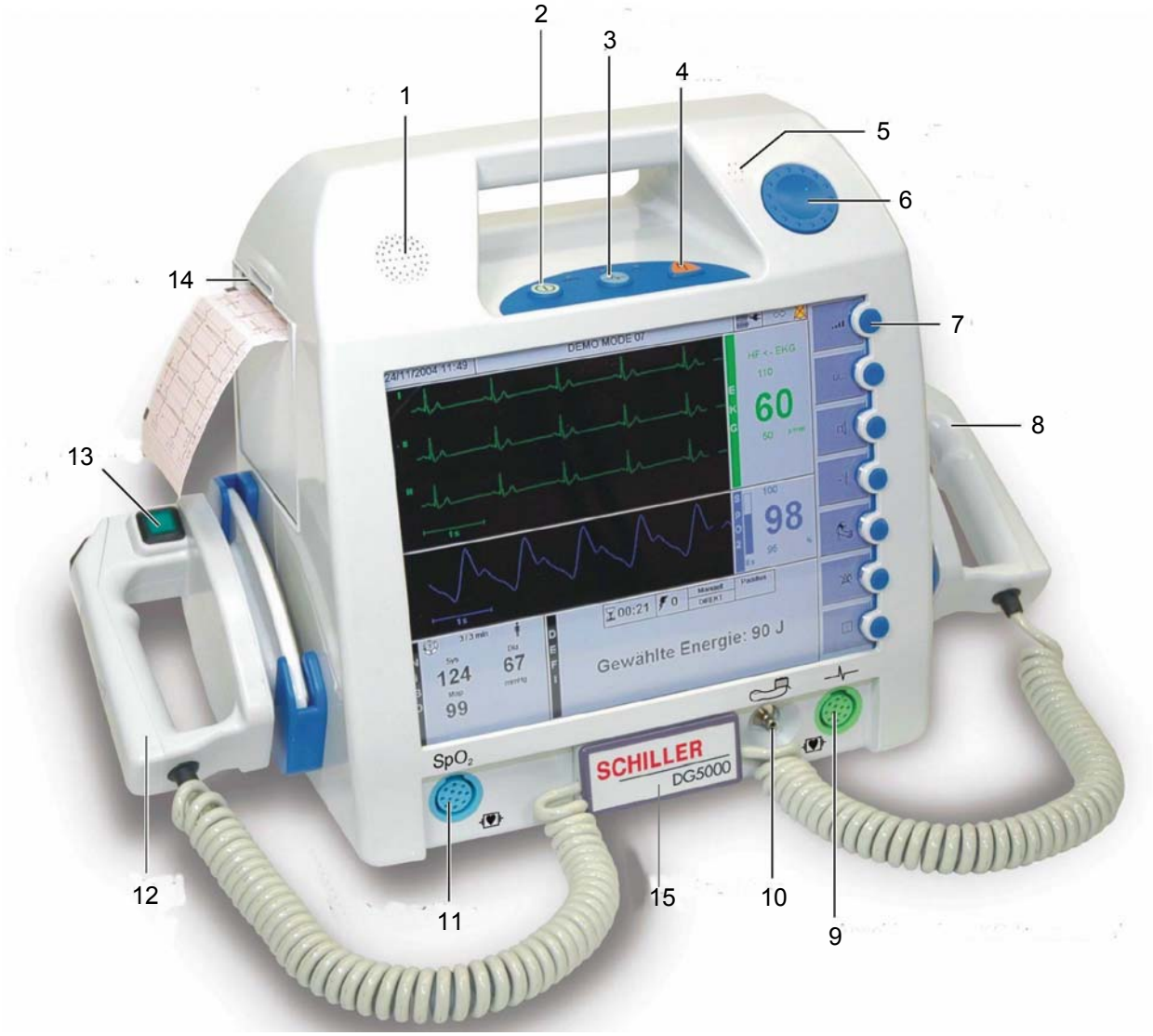
While testing the DEFIGARD 5000 defibrillator, the patient may only be simulated with fixed high-voltage and high-power resistors that are well insulated from the ground or earth. Poorly insulated devices or devices with loose contacts or devices containing components such as spark arresters or electronic flash lamps may never be used as they could irremediably destroy the device..

CONTENTS

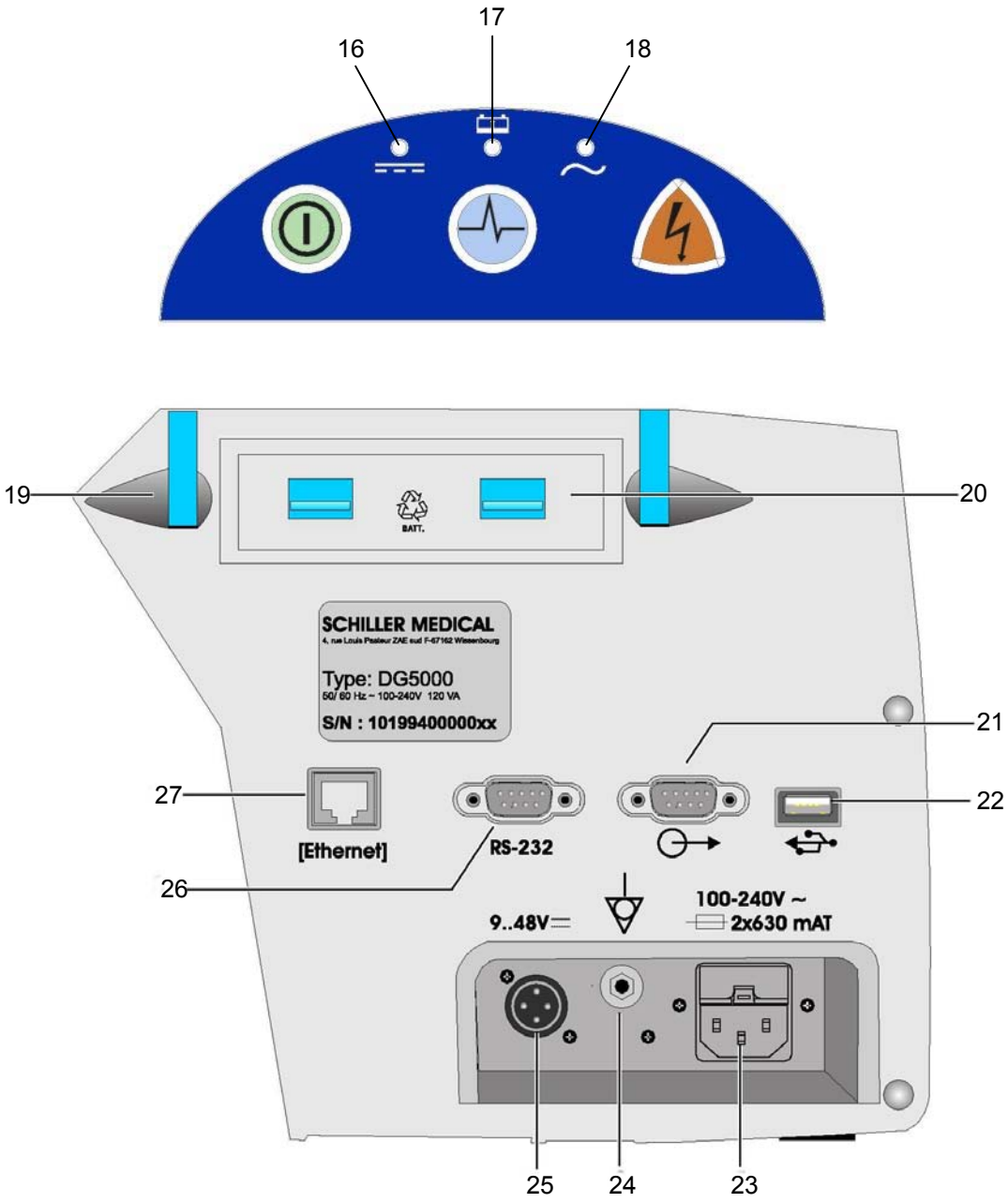
1. Operation

This section briefly outlines the operating of the device. For more detailed information, please refer to the User's Manual.

1.1. Display and controls.



1 : Loudspeaker
2 : ON / OFF key
3 : Analysis key
4 : Shock key
5 : Microphone
6 : Navigation, and programming key
7 : Softkeys
8 : Right paddle
9 : ECG patient cable connection
10 : NIBP connection
11 : SOP2 connection
12 : Left paddle
13 : Printer start key
14 : Paper compartment release
15 : Adapter module for the different electrodes



16 : Indicator when the device is powered from an external constant power source

17 : Indicator to indicate that the batteries are charging

18 : Indicator when the device connected to the main

19 : Swing-out fastening bows

20 : Additional battery (option)

21 : Signal output (QRS-Trigger, 1-channel ECG, remote alarm)

22 : USB connector

23 : Mains connector

24 : Potential equalisation

25 : External 9…48 VDC connector

26 : RS232 interface

27 : Ethernet connector

1.2. Explanation of symbols used

Symbols used on the device.

	BF type signal input, protected from defibrillation
	CF type signal input, protected from defibrillation
CE 0459	Notified body of the CE certification (G-MED)
	Follow the instructions for use
	Potential equalisation
	Device may not be disposed of with domestic refuse.

Symbols used on the electrode package.

	Open the electrode package
	Peel off the protective foil
	Disposable item; do not reuse
	Do not bend packing
	Storage temperature for the electrodes
	Expiration date

Symbols used on the battery

	The unit/component can be recycled.
	Battery may not be disposed of with domestic refuse.
	Do not burn the battery
	Do not saw up the battery
	Do not crash the battery
	The battery can be recharged
	Do not short the battery
	Storage temperature for the battery. Unlimited: 0 ... +40 °C

1.3. Device operation.

DEFIGARD 5000 is a monitor/defibrillator designed for in-hospital use. It is started up by keeping the On/Off key on the upper keypad pressed down for two seconds or more.

Power supply:

The device is powered by the mains, a battery (lithium ion battery only) or an external 9 - 48 VDC power supply. It has a fixed battery in the lower slot, which can be charged from the mains or the external VDC power supply. The capacity of the battery is sufficient for:

- 70 shocks at the maximum energy or
- 2 hours of monitor operation.

A second removable battery (optional) may be inserted in the upper slot to double the life.

Defibrillation:

DEFIGARD 5000 is a defibrillator that uses pulse biphasic waveforms - ***Multipulse Biowave®***.
The device offers two operating modes, the semiautomatic mode, called SAD, and the manual mode. These two operating modes depend on the type of defibrillation cartridge inserted. There are three types of cartridge - adhesive electrode cartridge, internal electrode cartridge and handheld paddle electrode cartridge. A window on the screen indicates the defibrillator settings.

Possibilities offered by the defibrillator**:**

- ***Manual defibrillation with adhesive electrodes***

For manual defibrillation with adhesive electrodes, you need to use the cartridge for adhesive electrodes. The charge and energy selection buttons are located on the side keypad, whilst the shock button is located on the upper keypad.

- ***Semiautomatic defibrillation with adhesive electrodes***

The same cartridge is used with adhesive electrodes. The device must offer the semiautomatic function. Adhesive electrodes are available for children and adults. The device recognises the type of electrode applied and selects the defibrillation energy levels accordingly. The control buttons for analysing and shock delivery are located on the upper keypad.

- ***Internal manual defibrillation (optional)***

Use the cartridge that offers the facility to use the internal defibrillation paddles. The charge and energy selection buttons are on the side keypad. The shock button is located on the upper keypad.

- ***Manual defibrillation with handheld electrodes (optional)***

Use the handheld electrode cartridge. The charge/shock button and the energy selection button can be found on the electrodes.

Semiautomatic mode:

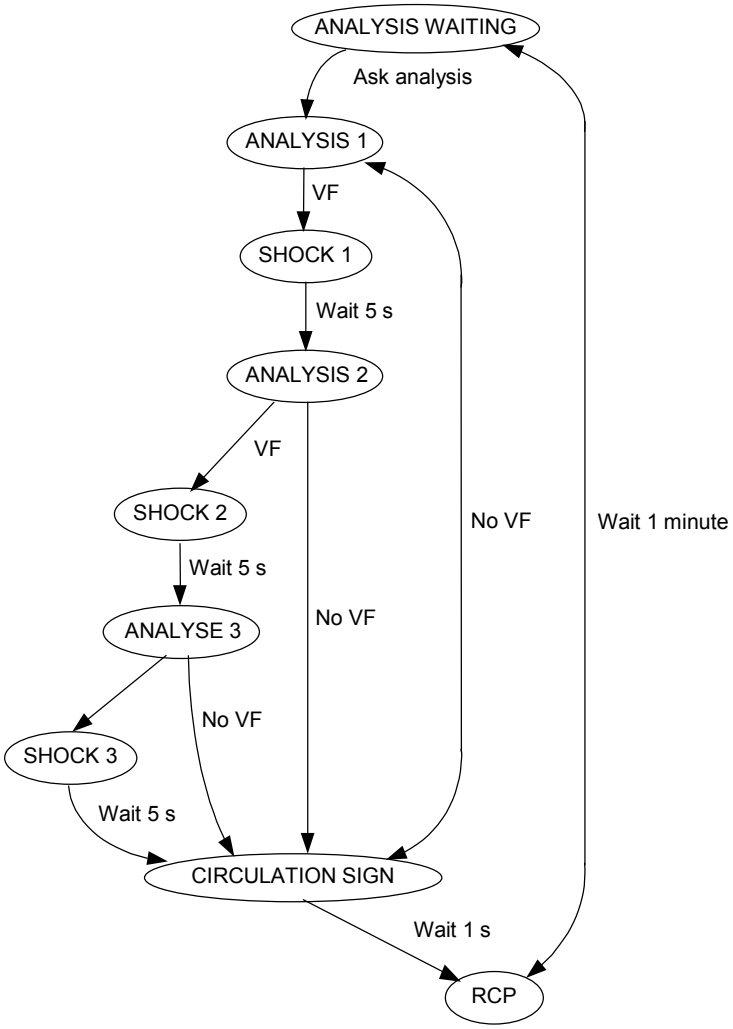
In the SAD mode, the user takes action on the basis of the messages sent by the system (in accordance with AHA/ERC protocols).
At any time (except during CPR), if an electrode fault is detected, the AHA/ERC protocol is stopped. It is resumed when the fault disappears.
During the analysis (which is set off by pressing the Analyse key), if a loose contact is detected, the analysis is interrupted throughout the duration of the fault. It is automatically resumed when the fault disappears.
After an initial analysis, if the analysed ECG signal is too weak, a message asks the user to apply CPR (cardiac pulmonary resuscitation) for one minute. The display lasts during that time, when pressing the Analyse key starts off the analysis cycle.
After an initial analysis, if there is noise in the ECG signal, a message is displayed for one minute to ask the user to apply CPR (cardiopulmonary resuscitation). The display lasts during that time, when pressing the Analyse key starts off the analysis cycle.

The energy is selected automatically by the system in accordance with the AHA/ERC protocol. An energy sequence is available:

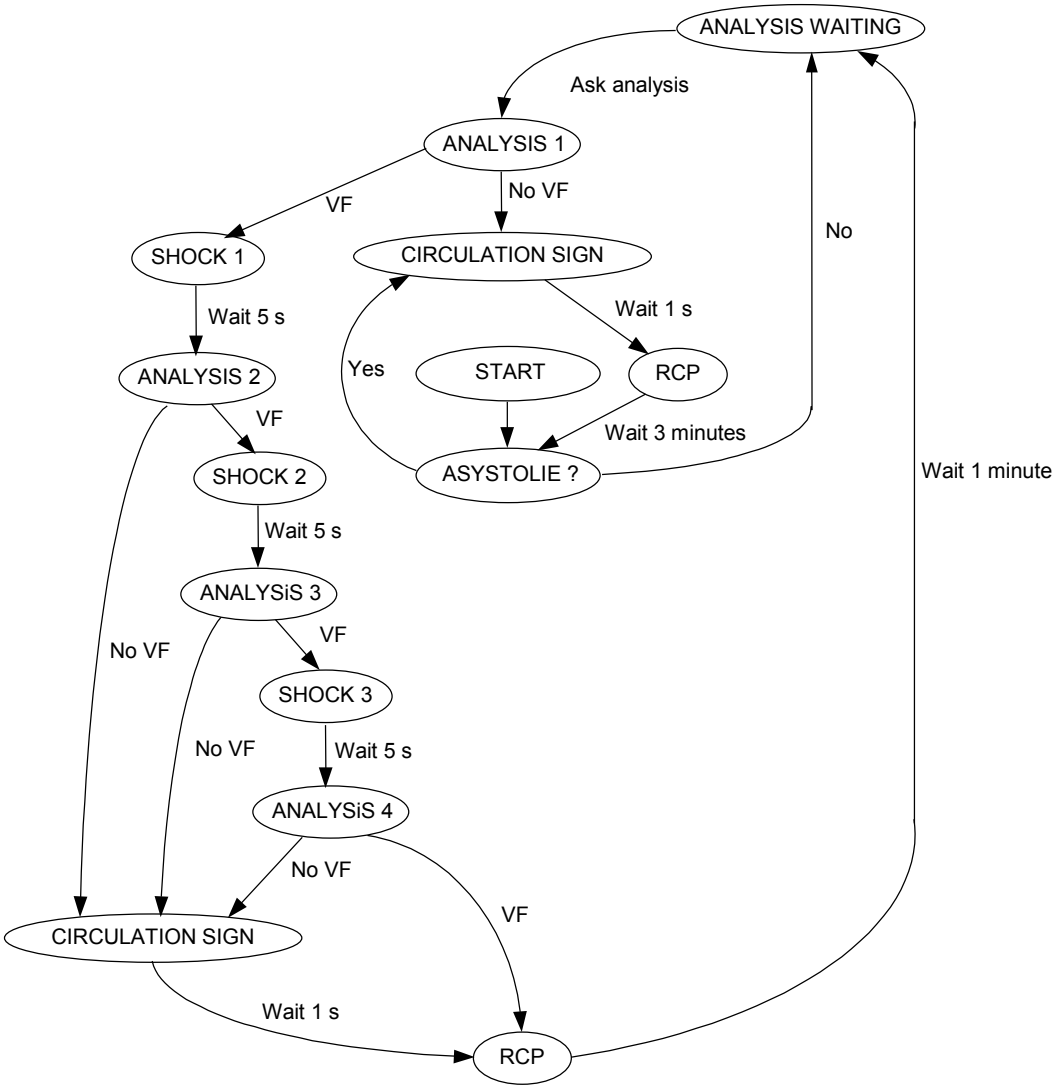
Shock 1 : Energy selected 130 J
Shock 2 : Energy selected 130 J
Shock 3 : Energy selected 150 J
.....
Shock N : Energy selected 150 J

If VF is recognised during the analysis, the software automatically starts charging the capacitor with the appropriate energy. If the charge lasts too long, it is discharged internally.
The shock is delivered manually. Pressing a key automatically delivers the energy stored in the capacitor.
The system receives the values of the delivered energy, the patient current and the patient impedance.
If the shock is not given within a given time or if the system detects a heart rhythm that does not call for a shock, the energy is discharged internally.

ERC 2000 one-minute protocol



ERC 2000 three-minute protocol



Manual mode:
The manual mode is accessible directly when the device is turned on or when the Physician key is pressed while in the semiautomatic mode. It unlocks the use of the defibrillator, allowing the operator to control the device entirely.
In the manual mode, the user can defibrillate patients synchronously with an ECG.

Pacemaker (optional)

For the pacemaker function, you need to use the cartridge for adhesive electrodes. The keys for starting up the pacemaker and setting the pacing frequency or current and the fixed, demand or overdrive mode are located on the side keypad. If the pacemaker is operating, the defibrillation function is disabled.

ECG function

This module is always powered and the ECG signal can be collected with 3, 4 or 10-lead cable. Depending on the configuration, the device can display up to 12 leads at the same time. Four amplitude values may be set (0.25, 0.5, 1 and 2 cm/mV), as may two signal scanning speeds (25 and 50 mm/s).
The QRS frequency is also displayed.

SPO2 function (optional)

The window of this function is only displayed on the screen when the SPO2 connector is detected by the device. The window displays the SPO2 curve and the saturation rate.
When the screen displays the 12 leads of the ECG, the SPO2 curves disappears, but the saturation rate remains displayed.

NIBP function (optional)

The NIBP may be set to Adult or Infant. For each configuration, you can take manual, continuous or cyclical measurements.
The Sys, Dia and MAP values are displayed on the screen.

Memory function

The ECG curve and the trends are saved in a compact flash memory in the device.

Data transmission function

- A connection for GSM or standard modems is provided for transmitting the 12-lead ECG
- A USB connector is provided for retrieving data from the device
- An Ethernet link for upgrading software

All the connectors are located at the rear of the device.

Recorder function (optional)

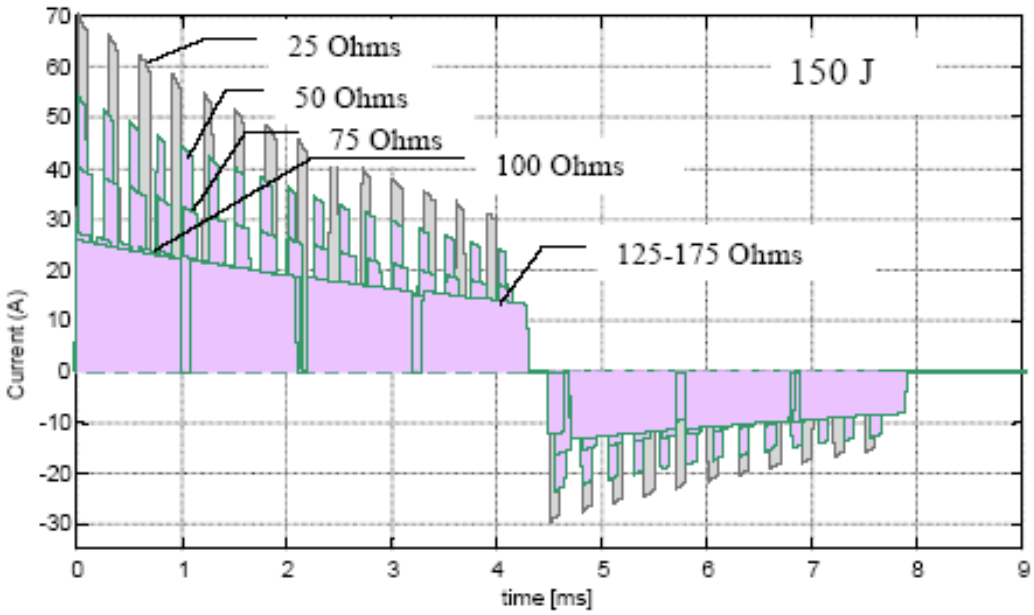
The recorder can print ECG, SPO2 or trend curves.

1.4. Technical specifications

- Manufacturer : SCHILLER MEDICAL
- Device type : DEFIGARD 5000
- Dimensions : 289 x 271 x 177 mm (height x width x depth)
- Weight : 5,3 kg
- Protection case : IPX 1
- Power supply
  - Voltage : 100 - 240 VAC, 50/60Hz
  - Power consumption : 120 VA
  - Battery operation : Up to 2 hours, option with additional battery up to 4 hours.
  - Fuses : 2 x 200 mAT at 250 VAC, 2 x 315 mAT at 115 VAC
  - External power supply : 9 - 48 VDC max. 2,5 A
  - : The unit is suitable for use in networks according to IEC 60601-1-2
- Batteriy
  - Battery type : Lithium / ion 10,8 V 4,3 A.
  - Autonomy : 70 schocks with maximum energy or 4 hours of monitoring (alternately 30 min on, 30 min off).
- Environmental conditions
  - Transport / storage : Temperature -10 to + 50 °C
  - : Relative humidity 0 to 95 %, no condensation
  - : Atmospheric pressure 700 à 1060 hPa
  - Operating : Temperature 0 à + 40 °C
  - : Relative humidity 30 à 95 %, no condensation
  - : Atmospheric pressure 500 à 1060 hPa
- Display
  - Type : High resolution colour LCD (800 X 600) with backlight
  - Dimensions : 214 mm x 158,4 mm (10,4")
- Printer
  - Resolution : 8 dots / mm (amplitude-axis), 40 dots / mm (time-axis) at 25 mm / s
  - Paper : Thermoreactive, Z-foldet, 72 mm width, length approx. 20 m.
  - Print speed : 25, 50 mm / s
  - Recording tracks : 3-channel display, with optimal width of 72 mm.
- Connections : ECG patient cable, SPO2, PNI.
- Interfaces : RS-232
  - : Analogue for QRS trigger, 1-chanel ECG and remote alarm
  - : USB
  - : Ethernet
- Défibrillation pulse form
  - Biphasic pulsed defibrillation impulse with fixed physiological optimum phase durations.
  - Near stabilisation of the emitted energy in function with the patient resistance us ing pulse-pause modulation depending on the measured patient resistance.

- Standard energy settings :

Adult	: 130 -130 -150 J (configurable)
Paediatric	: 15 -30 -50 J (configurable) (automatic switch when the paediatric electrodes are connected) :
Paddle	: 0 - 2 - 4 - 8 - 15 - 30 - 50 - 90 - 130 - 180 J.
Adhesive electrodes	: 2 - 4 - 8 - 15 - 30 - 50 - 70 - 90 - 110 - 130 - 150 - 180 J.
Internal	: 2 - 4 - 6 - 8 - 15 - 30 J.
Tolerance at 50 Ω	: Tolerance à 50 Ω : ± 3 J or ± 15 % (the higher value is assumed).



- Charging time for shock (with new batteries and after 15 discharges at max. energy output).

From shock recommendation to shock standby	: 8 s pour 180 J
Max. energy from analysis efter 15 shocks	: 25 s
Max. energy after switching on	: 29 s

- Operating modes.
  - Synchronised with heart action 25 ms after R wave.
  - Unsychronised
  - AED

- Cycle time shock - shock : < 25 s

- Charge control and monitoring :
  - Automatic shock recommendation of analysis in AED mode.
  - Using the set wheel on the paddle
  - Using the device's keyboard

- Patient resistance 30 to 220 Ω .
- Display of shock standby : Key is lit.
- Shock delivery

- Safety discharge when :
  - the heart rate does not call for defibrillation.
  - after 20 seconds of the device indicating its readiness for a shock, no shock is delivered
  - there is an electrode fault
  - the battery voltage is insufficient.
  - the device is defective
  - the device is turned off.

- Shock delivery.
  - Via applied disposable adhesive defibrillation electrodes.
  - Via paddles.
  - Via spoons

- Defibrillation electrode connection.
  External defibrillation : Type BF.
  Internal defibrillation : Type CF.

- Defibrillation electrodes:
  - Adult electrode : 78 cm2 de surface active
  - Paediatric electrode : 28 cm2 de surface active
  - Electrode cable length : 2 m

- VF/VT detection :
  - Shock recommendation : in case of VF and VT (VT > 180 p/min)
  - Sensitivity : 98.43 %
    Specificity: 99.8 %. These values have been found with the AHA database, which contains cases of VF and VT with and without artefacts..
  - Conditions required for ECG analysis :
    Minimum amplitude for the signals used > 0.15 mV , signals of < 0.15 mV are considered to show asystole
  - Definition :
    Sensitivity: Correct detection of heart rates for which defibrillation shocks are recommended.
    Specificity: Correct detection of heart rates for which defibrillation shocks are not recommended.

- ECG :
  Leads : Simultaneous, synchronous recording 12 leads
  Patient cable : 3-,4-, 10-lead cable, type CF
  Heart rate : 30 – 300 beats/min
  Lead display : Selection of 1 to 12 simultaneous leads
  Band pass : 0.5...35 Hz or 0.05...150 Hz (depending on the ECG source)

- NIBP - non-invasive blood pressure :
  Measurement : Automatic or manual
  Measuring method : Oscillometric
  Connection : Type CF
  Measurement range :
  Adults : Sys 30...255 mmHg, dia 15...220 mmHg
  Neonates : Sys 30...135 mmHg, dia 15...110 mmHg
  Accuracy : ± 3 mmHg et ± 2 B/min

- SPO2 (pulsoximetry) :
  Amplifier : Masimo
  Using the Monitor : Normal and sensitive
  Accuracy : - SPO2
  Adults 1…100% ± 2
  Neonates 70…100% ± 3
  - PP
  25 …240/min ± 4
  Calibration range : 70…100%
  Connection : Type CF
  Measurement range : SPO2 1…100%
  : PP 25 …240/min
  Displayed range : 1…100%

- Saving
  ECG : 1 hour
  Events : 500

2. Testing and maintenance

This section describes the test and maintenance procedures recommended with **DEFIGARD 5000**.

2.1. Functional testing

The device runs an automatic test every time is switched on. The test lasts less than 5 seconds and consists in checking all the hardware functions. If a blocking error is found, an error message is displayed on the screen and a sound alarm is emitted till the device is switched off by the operator (by pressing the Off key). The device is blocked and goes off automatically after five minutes.

The device can run a periodic automatic test at a configurable frequency. That automatic test may be daily, weekly or user-defined by indicating the number of days between two tests (1 to 30 days). A key for immediately starting up the test is available as well. During the self test, all the hardware functions and the battery charge status are tested. No information is displayed on the screen during the test. The test result is saved and can be retrieved subsequently. The last 30 tests are saved.
If the tests do not show any error, the system goes off automatically.
If, on the other hand, a serious error is found, a sound alarm is emitted for 10 seconds every 2 minutes till the device is switched on again. At that time, the error is displayed on the screen. The device is blocked.
A selection is available to restart all the tests.
If the tests do not show any error, the system starts up nominal operation.
If, on the other hand, a blocking error is found, the error is displayed on the screen and a sound alarm is emitted till the device is switched off by the operator (by pressing Off). The device is blocked.

2.2. Cleaning and disinfecting

Caution: **Switch the device off before cleaning it. Remove the cell before you start cleaning the device in order to eliminate the risk of the device starting up accidentally. Also disconnect the defibrillation electrodes of the device before cleaning.**

No liquid shall be allowed to enter into the device. However, if that does happen, the device may not be used before it is verified by the after-sales service department.

The device or electrodes may never be cleaned with substances such as ether, acetone, esters, aromatic chemicals etc.
Never use phenol-based cleaners or cleaners containing peroxide derivatives to disinfect the surfaces of the housing of the device.

- Dispose of all single-use electrodes immediately after use in order to eliminate the risk of accidental reuse (disposal with hospital waste).
- Before cleaning the electrode cables of sensors, disconnect them from the device. For cleaning and disinfecting, wipe the cables with a gauze cloth moistened with cleaner or disinfectant. Never immerse the connectors in liquid. The cleaning solution used may be any cleaning or disinfecting solution that is commonly used in hospitals.
- Proceed likewise with the device housing, with a cloth moistened with cleaner or disinfectant. No liquid may be allowed to penetrate into the device during the operation.

3. Troubleshooting

This section addresses the troubleshooting procedures for **DEFIGARD 5000**. If you have trouble locating or correcting the problem, contact the after-sales service department of SCHILLER.

Note: **If an error message is displayed before you call in a Schiller technician, note the error number and restart the device to check that the reason for the problem is not merely a program crash.**

Precautions during troubleshooting

While testing the DEFIGARD 5000 defibrillator, the patient may only be simulated with fixed high-voltage and high-power resistors that are well insulated from the ground or earth. Poorly insulated devices or devices with loose contacts or devices containing components such as spark arresters or electronic flash lamps may never be used as they could irremediably destroy the device.

Danger: **Before any work on an open device, you need to IMPERATIVELY CHECK IF THE HV CAPACITOR IS PROPERLY DISCHARGED.**

ERROR	FINDING	POSSIBLE CAUSES	CORRECTIVE ACTION
ERROR MESSAGES			
Board error (in the ECG window)		1. CPU board problem	1. Replace the CPU board
Board error (in the SPO2 window)		1. SPO2 board problem	1. Replace the SPO2 board
Board error (in the NIBP window)		1. NIBP board problem	1. Replace the NIBP board
Analogue board		1. CPU board fault	1. Replace the CPU board
Power board error		1. POWER board fault	1. Replace the POWER board
VF error		1. CPU board fault	1. Replace the CPU board
NIBP error		1. NIBP module fault	1. Replace the NIBP board
DEFIBRILLATOR ERROR MESSAGES			
Board error (in DEFI window)		1. DEFI board problem	1. Replace the DEFI board
PROCESSOR ERROR		1. DEFI board fault	1. Replace the DEFI board
PROGRAM ERROR		1. Program problem with DEFI board	1. Reload the program
ERROR DETECTION CIRCUIT ERROR		1. DEFI board fault	1. Replace the DEFI board
SELECTED ENERGY VOLTAGE REFERENCE ERROR		1. DEFI board fault	1. Replace the DEFI board
ADC CONVERTER ERROR		1. DEFI board fault	1. Replace the DEFI board
CHARGE TRANSISTOR ERROR		1. DEFI board fault	1. Replace the DEFI board
DISCHARGE TRANSISTOR ERROR		1. DEFI board fault	1. Replace the DEFI board
COMPENSATION EPROM ERROR		1. DEFI board fault	1. Replace the DEFI board
SHOCK BUTTON ERROR		1. Problem with handheld paddle cartridge 2. UPPER KEYPAD board fault	1. Replace the cartridge 2. Replace the UPPER KEYPAD board

4. Replacement of parts

This section addresses the issue of how to dismantle **DEFIGARD 5000** in order to replace faulty parts. The warnings below apply to all work inside the device.

Warning:	**The DEFIGARD 5000 is a defibrillator with a high-voltage capacitor that can be charged to a fatal voltage. The device may only be dismantled by specially authorised and trained personnel.** **Before any work on an open device, you need to IMPERATIVELY CHECK IF THE HV CAPACITOR IS PROPERLY DISCHARGED.**

Caution:	**Before dismantling the device, remove the battery or the cell from its slot.**

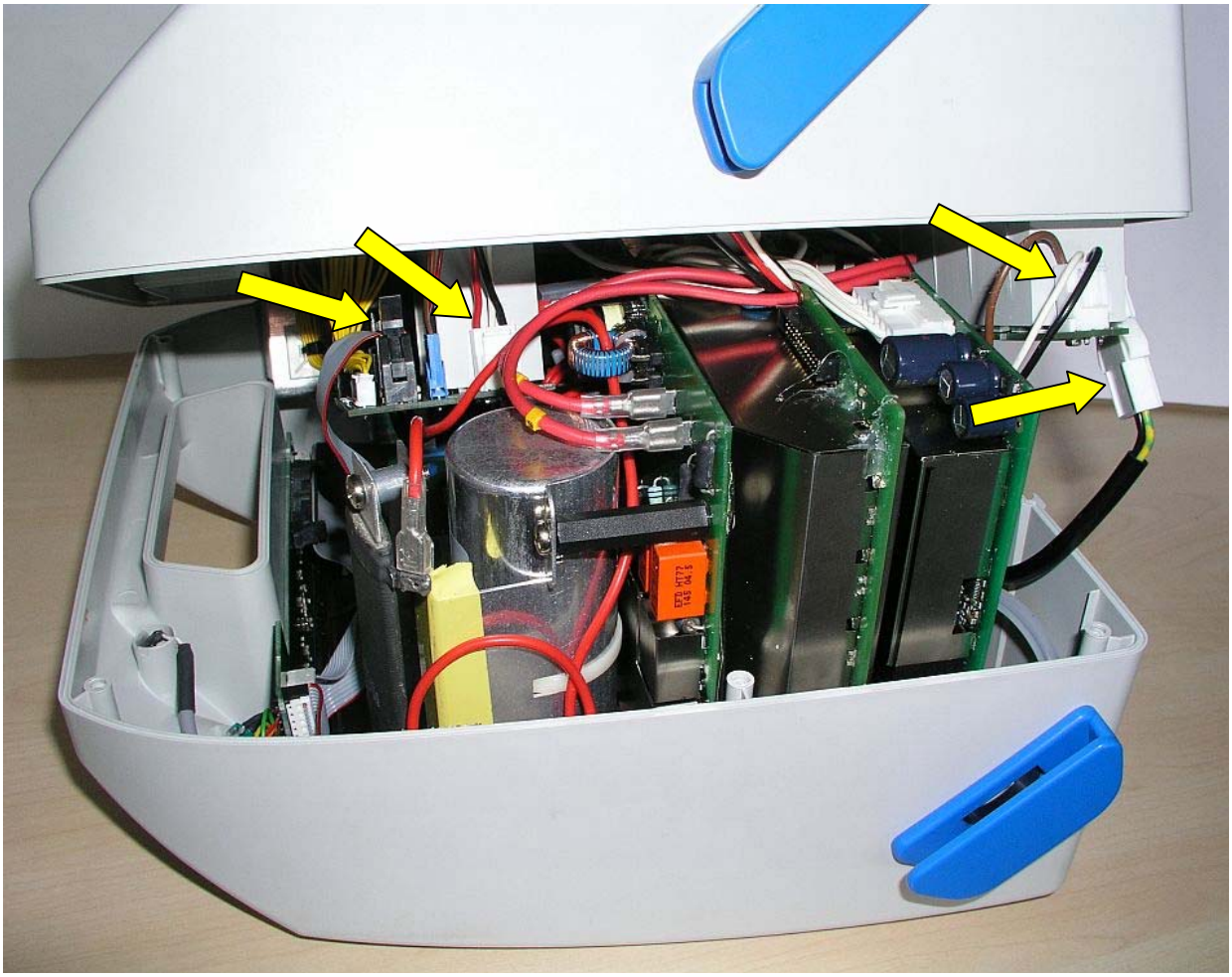
Caution:	**The device contains circuits sensitive to electrostatic discharge. All work on the DEFIGARD 5000 device shall be performed in accordance with ESD rules. The repairs shall be performed on an antistatic mat connected to the earth and the operator shall wear an antistatic strap also connected to the mat. In the event of any work on the high-voltage part of the defibrillator, remove the antistatic strap.**

Caution:	**A general device test shall be performed each time the device is opened.**

4.1. Device disassembly procedure

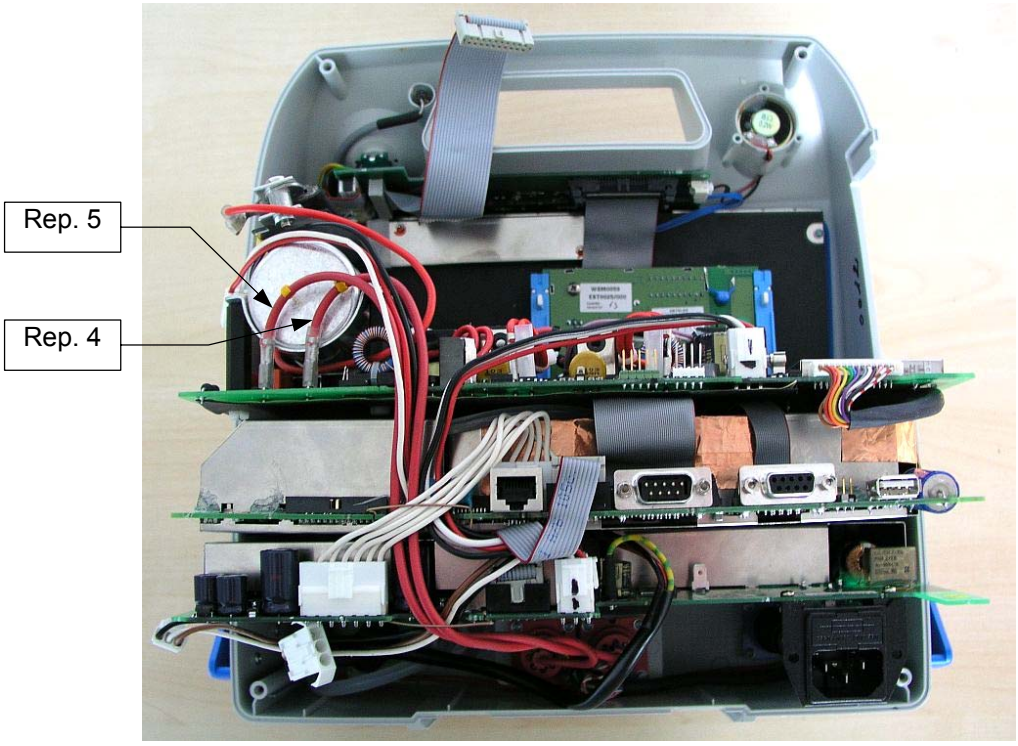
Unfasten the 8 screws at the locations shown by the arrows.

Open the housing halfway on the right side and disconnect the four cables shown by the arrows.

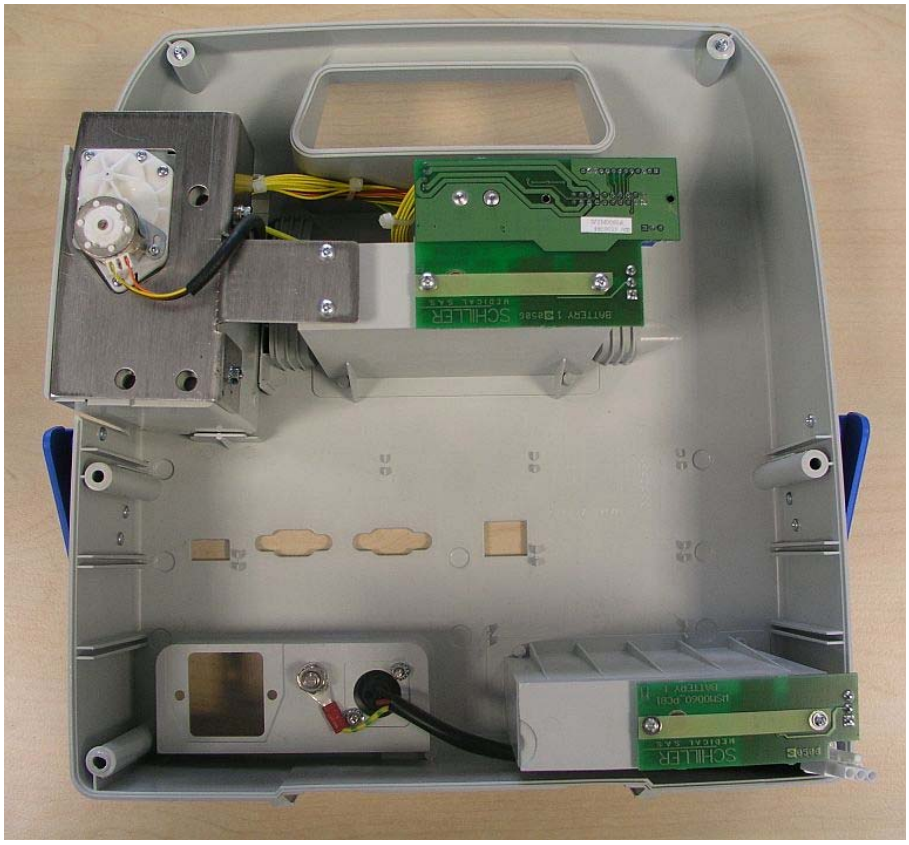


Now remove the two parts.

View of the front



View of the rear



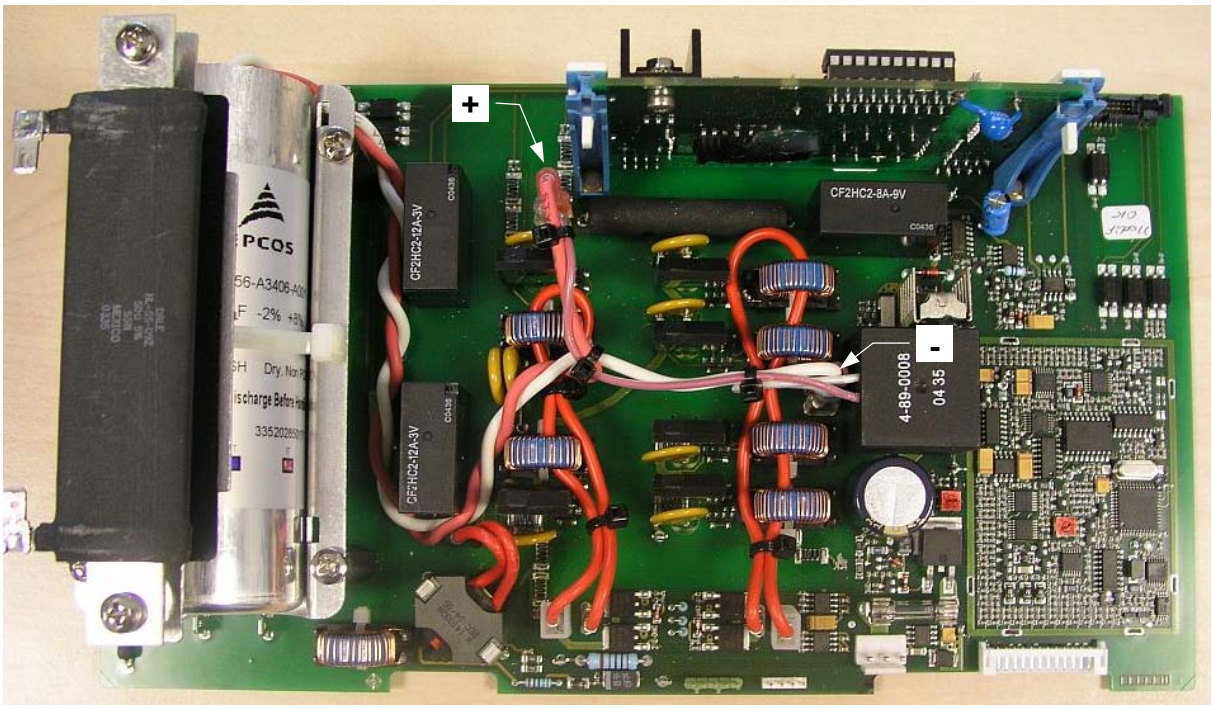
4.2. Replacing the high-voltage capacitor

Warning:	**This operation relates to the high-voltage capacitor, which can carry fatal charges. Before starting to work, take care to discharge the high-voltage capacitor completely. The terminals of the high-voltage capacitor must never be touched directly. The high-voltage capacitor may never be replaced by people other than specially authorised and trained personnel.**

The replacement of the HV capacitor is an extremely rare operation, as the life of an HV capacitor is very long. However, if that is ever necessary, the HV capacitor may be replaced in accordance with the instructions below:

IMPORTANT! IMPERATIVELY CHECK IF THE HV CAPACITOR IS PROPERLY DISCHARGED.

- Take off the cable ties and disconnect the wires.
- Lift off the capacitor, using a tool (e.g. screwdriver) for leverage, as it has been glued in place with strong glue.



After removing the (fully discharged) high-voltage capacitor from the lower part, short the three terminals of the capacitor with conducting wire.

While replacing the HV capacitor, glue it onto the support with a piece of double-sided adhesive tape. Twist the wires and connect them, minding the polarity. Also, make sure that the wire path is as instructed.

Check that nothing has been forgotten before you start up the device.

Caution:	**This operation relates to an essential component of the high-voltage part. It may only be performed by specially authorised personnel who have been trained in repairing FRED® easy devices.** **The delivered energy must undergo testing.**

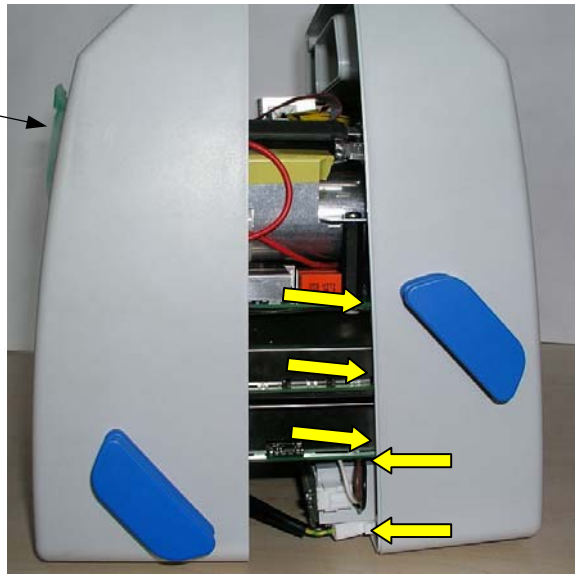
4.3. Reassembling the device

Reverse the procedure to reassemble the device.
Place the boards one layer after the other, starting from the bottom.
Do not forget to connect the various cables..

Important :	**Follow the connection direction of the DEFI input HV cables, refs. 4 and 5 (see photograph "View of front").** **Check if all the boards in their grooves.** **Check that the cables will not get caught when the device is closed.**

- Put the device into this position and connect the four cables.

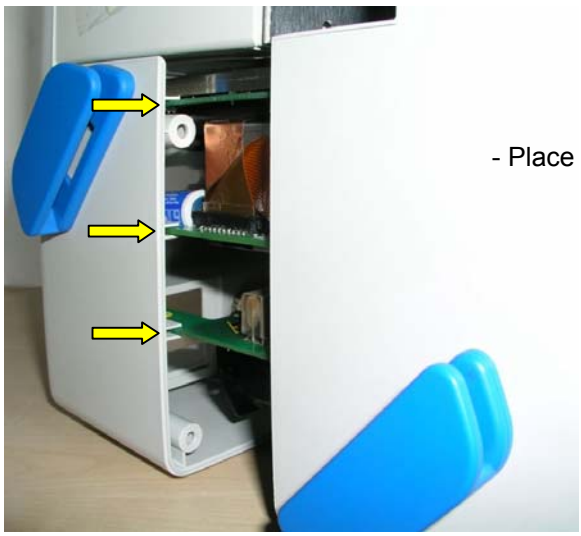
Front



- Set the device straight and place the boards in the three grooves (right-hand side).

- The battery tank wiring must be placed between the board and tank.

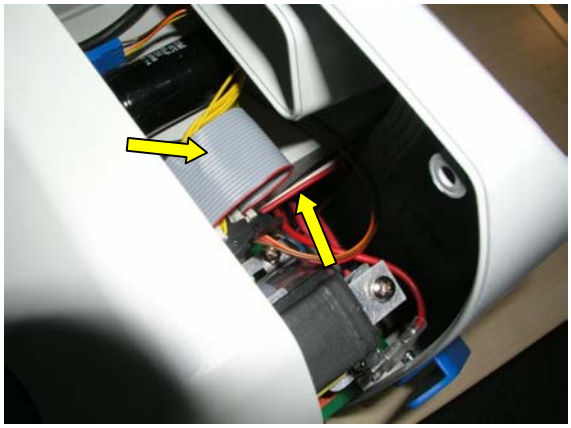
- The external VDC connector must be place between the tank and the bottom of the



- Place the boards in the three grooves (left-hand side).

- Fold the cable. It must not get caught in the housing when it is closed.

- The battery tank wiring must lie alongside the tank.

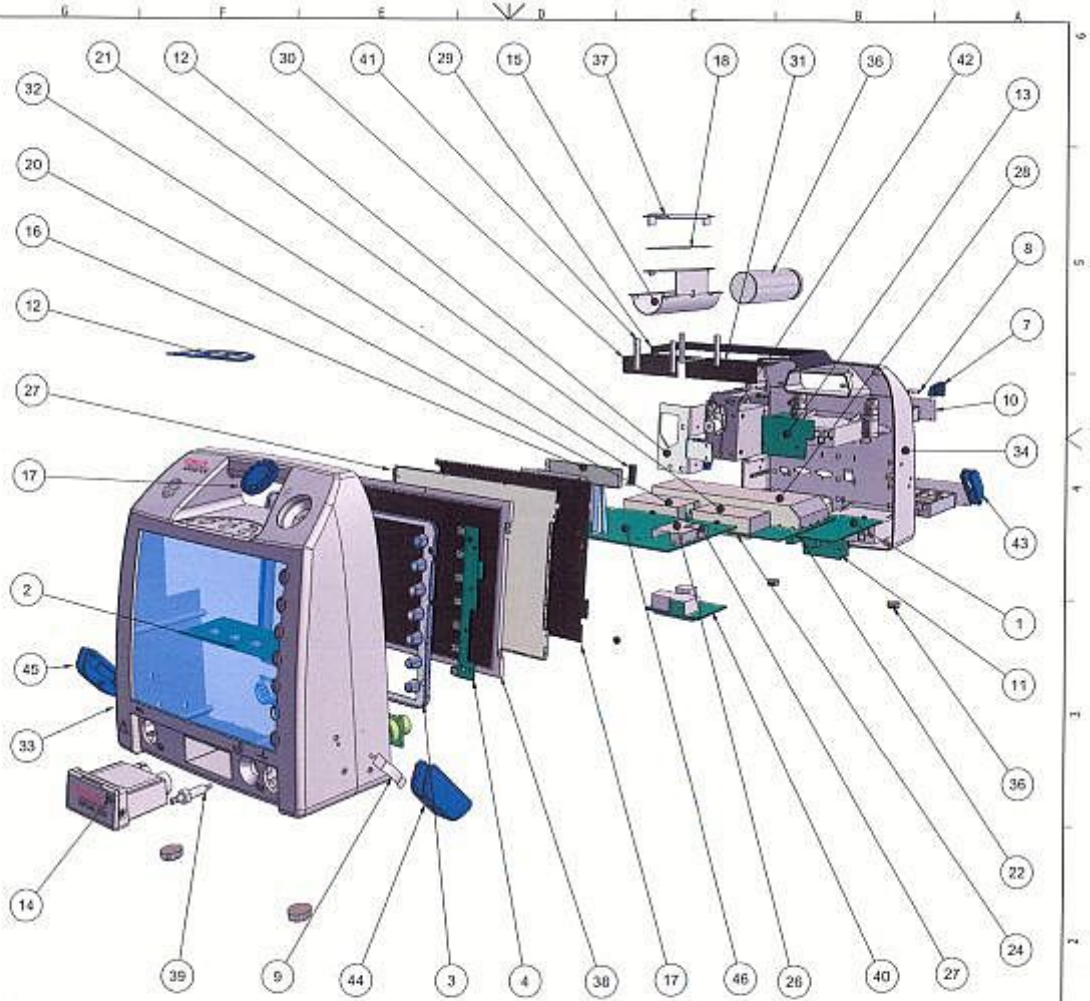


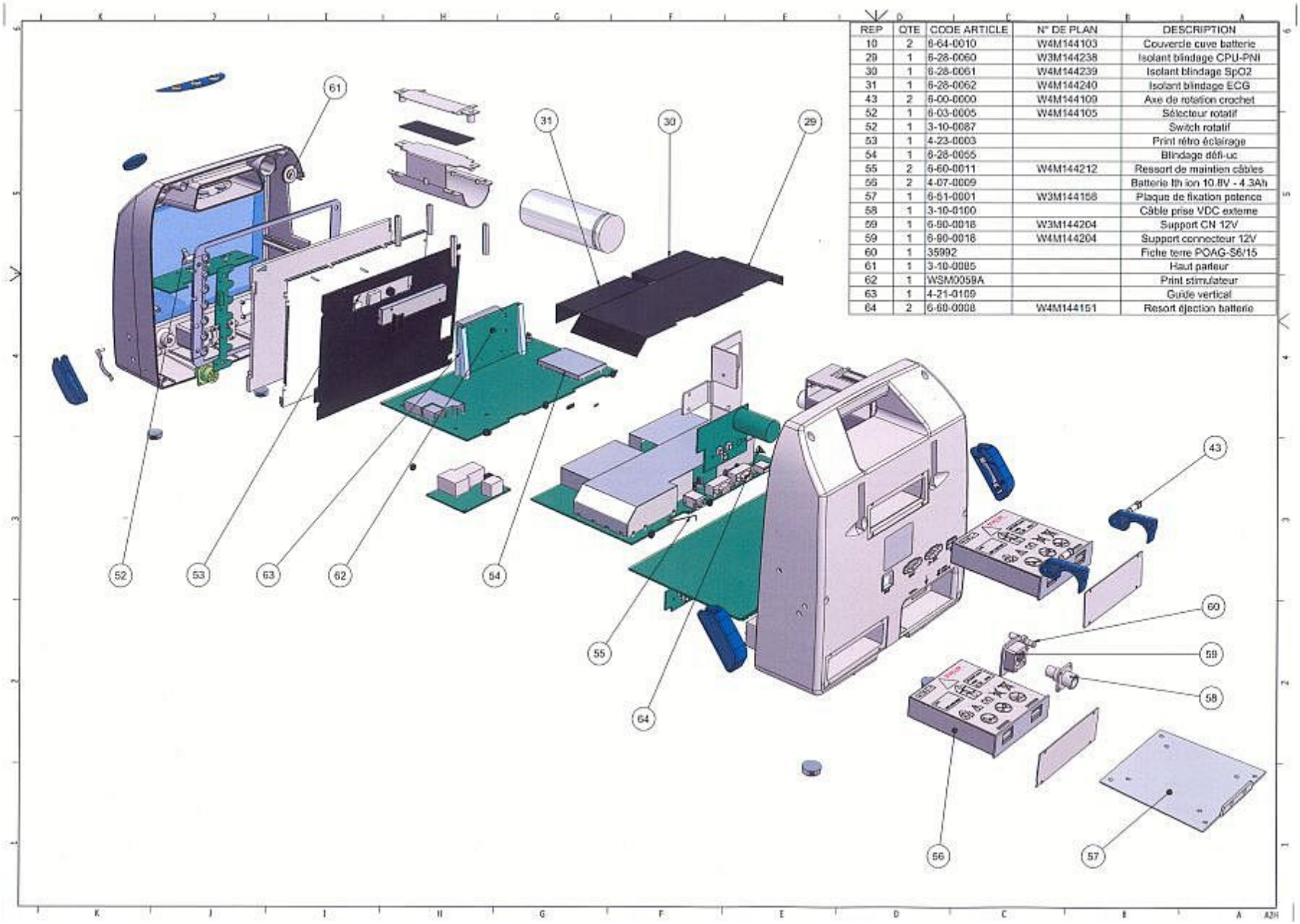
4.4. Replacement of parts

Warning:	**Parts may only be replaced by personnel who have been specially trained and authorised by SCHILLER.** **Besides, the replacement parts shall be original SCHILLER parts.**

Note:	To order a new part from SCHILLER, provide the part number and the serial number of the device located under the device. After that, specify the item code of the part..

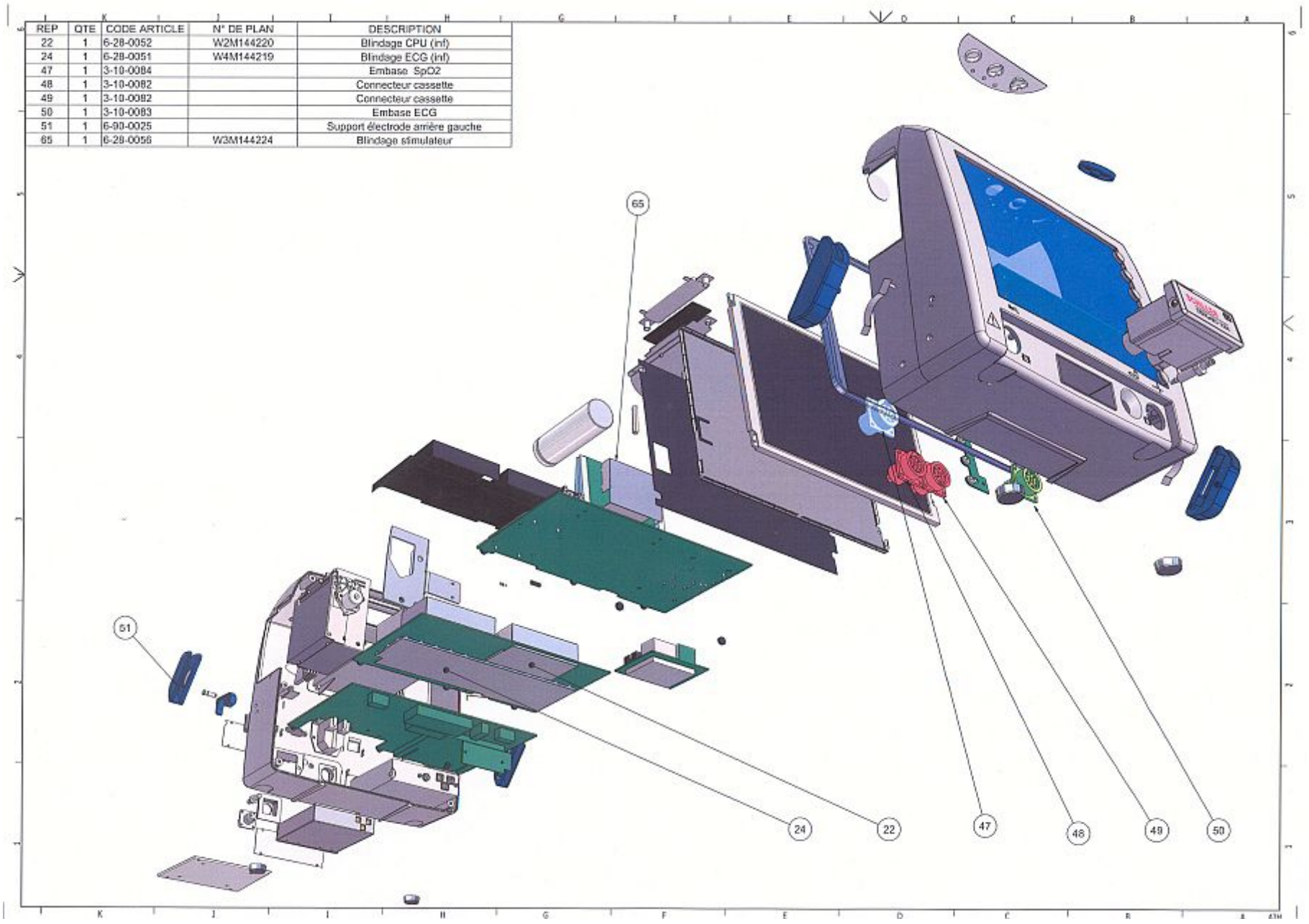
REP	QTE	CODE ARTICLE	N° DE PLAN	DESCRIPTION
1	1	1-101-0402	W3M144119	Print ALIM
2	1	WSM0052A	W4M144096	Print supérieur
3	1	6-06-0005	W3M144099	Clavier frontal
4	1	WSM0050A	W4M144100	Print clavier frontal
5	1	6-03-0004	W4M144102	Bouton menu
6	1	6-03-0005	W4M144105	Sélecteur rotatif
7	3	6-14-0040	W3M144108	Crochet
8	2	6-00-0000	W4M144109	Axe de rotation crochet
9	1	6-73-0002	W4M144111	Contact de décharge
10	2	6-64-0010	W4M144103	Couvercle cuve batterie
11	1	WSM0060A	W4M144116	Print batterie
12	1	6-06-0004	W3M144128	Clavier supérieur
13	1	WSM0060A	W4M144116	Print batterie
14	1	6-39-0027	W4M144117	Etiquette K7 électrodes de poings
15	1	6-90-0019	W3M144205	Support condensateur
16	1	6-28-0047	W4M144208	Blindage print rétro éclairage
17	1	6-28-0045	W3M144164	Isolant blindage écran
18	1	6-28-0049	W4M144213	Isolant résistance de décharge
19	1	6-28-0057	W3M144216	Blindage CPU
20	1	6-28-0049	W4M144217	Blindage SpO2
21	1	6-28-0050	W4M144218	Blindage ECG (sup)
22	1	6-28-0052	W2M144220	Blindage CPU (inf)
23	1	6-28-0056	W3M144224	Blindage stimulateur
24	1	6-28-0051	W4M144219	Blindage ECG (inf)
25	1	6-28-0055	W4M144223	Blindage defi-uc
26	1	6-28-0053	W3M144221	Blindage préampli défi
27	1	6-28-0054	W4M144222	Blindage DEFI-OSC
28	1	6-28-0058	W3M144232	Blindage CPU + PNI version 1
29	1	6-28-0060	W3M144238	Isolant blindage CPU-PNI
30	1	6-28-0061	W4M144239	Isolant blindage SpO2
31	1	6-28-0062	W4M144240	Isolant blindage ECG
32	1	6-28-0063	W4M144241	Isolant blindage rétro éclairage
33	1	6-02-0032	W0M144177	Boîtier avant
34	1	6-02-0031	W0M144176	Boîtier arrière
35	1	4-19-0021		Condensateur
36	4	72107		pied
37	1	72510		Résistance de décharge
38	1	4-30-0001		LCD display
39	1	72762		Raccord PNI
40	1	3-55-0000		Print PNI
41	4	6-13-0014		Entretoise
42	1	3-55-0022SC		Enregistreur
43	1	6-90-0027	W2M144113	Support électrode arrière droit
44	1	6-90-0024	W2M144110	Support électrode avant droit
45	1	6-90-0026	W2M144149	Support électrode avant gauche
46	1	WSM0050A		Print défi





REP	QTE	CODE ARTICLE	N° DE PLAN	DESCRIPTION
10	2	6-64-0010	W4M144103	Couvercle cuve batterie
29	1	6-28-0060	W3M144238	Isolant blindage CPU-PNI
30	1	6-28-0061	W4M144239	Isolant blindage SpO2
31	1	6-28-0062	W4M144240	Isolant blindage ECG
43	2	6-00-0000	W4M144109	Axe de rotation crochet
52	1	6-03-0005	W4M144105	Sélecteur rotatif
52	1	3-10-0087		Switch rotatif
53	1	4-23-0003		Print rétro éclairage
54	1	6-28-0055		Blindage défi-uc
55	2	6-60-0011	W4M144212	Ressort de maintien câbles
56	2	4-07-0009		Batterie lth ion 10.8V - 4.3Ah
57	1	6-61-0001	W3M144158	Plaque de fixation potence
58	1	3-10-0100		Câble prise VDC externe
59	1	6-90-0018	W3M144204	Support CN 12V
59	1	6-90-0018	W4M144204	Support connecteur 12V
60	1	35992		Fiche terre POAG-S6/15
61	1	3-10-0085		Haut parleur
62	1	WSM0059A		Print stimulateur
63	1	4-21-0109		Guide vertical
64	2	6-60-0008	W4M144151	Ressort éjection batterie

REP	QTE	CODE ARTICLE	N° DE PLAN	DESCRIPTION
22	1	6-28-0052	W2M144220	Blindage CPU (inf)
24	1	6-28-0051	W4M144219	Blindage ECG (inf)
47	1	3-10-0084		Embase SpO2
48	1	3-10-0082		Connecteur cassette
49	1	3-10-0092		Connecteur cassette
50	1	3-10-0083		Embase ECG
51	1	6-90-0025		Support électrode arrière gauche
65	1	6-28-0056	W3M144224	Blindage stimulateur



5. Technical description of boards

5.1. Overall description of the DEFIGARD 5000.

Overview of DEFIGARD 5000 :

DEFIGARD 5000 is made up of the following subassemblies:

- The DEFI board, which contains the various digital processing functions specific to the defibrillator, the analogue processing functions and the high-voltage circuit of the defibrillator. The board may also have an (optional) PACEMAKER board.
- The CPU board, which contains the various digital processing, analogue processing and saving functions. It may also have (optional) SPO2 and NIBP boards.
- The POWER board, which supplies the power required for all the functions.
- Two KEYPAD boards that act as the interface between the user and the device.
- Two BATTERY boards that act as the interface between the batteries and the device.
- An LCD SCREEN with a BACKLIGHTING board that acts as the visual interface between **DEFIGARD 5000** and the user.

5.2. DEFI BOARD (part no. WSM0050A)

5.2.1. DEFIBRILLATOR PCB

The Defibrillator PCB (part no. WSM 0050_PCB) includes the various parts below:

- **ECG preamplifier**
  The ECG preamp part acquires the ECG signal collected through the defibrillation electrodes and measures the contact impedance.
- **Input interface circuit**
  The input interface circuit part acts as the interface between the various defibrillation cartridges and the defibrillator control circuit.
- **Defibrillator control circuit**
  The defibrillator control circuit part controls the charging and discharging of the HV capacitor through the electrode cartridges or the keys on the front of the device.
- **High-voltage circuit and HV capacitor**
  The high-voltage circuit charges and discharges the HV capacitor and measures the charging voltage and the patient current during the defibrillation shock.
- **IGBT control circuit**
  The IGBT control circuit controls the IGBTs of the high-voltage unit in order to generate a pulse biphasic waveform with patient impedance compensation.
- **Fault detection circuit**
  The fault detection circuit monitors the critical components in order to detect any fault.

5.2.2. FUNCTIONING OF THE DEFIBRILLATOR PART

The explanation of the working of the defibrillator part refers to **chart DG 5000 Defibrillator..**

5.2.2.1. OVERALL DESCRIPTION

The defibrillator circuit has seven connectors:

- connector JP1 (3 contacts) for powering the defibrillator circuit
- connector JP2 (20 contacts) for connecting with the CPU board and the front
- connectors JP3 & JP4 (high-voltage contacts) connected to the HV cables of the defibrillator electrode base
- connector JP7 (10 contacts) connected to the floating part of the 10-channel ECG preamplifier
- two connectors JP3 (14 contacts) connected to the LV cables of the defibrillator electrode base

The power circuit of the defibrillator part, which charges the HV capacitor, is directly powered by DC voltage with a protective fuse (voltage DC_FUSED). The defibrillator control circuits, the IGBT control circuits and the fault detection circuit is powered by +5 V generated on the defibrillator board from the +12 V voltage. The ECG preamplifier circuit is powered from the power supplied by the 10-channel ECG preamplifier via connector JP7. The voltage references used by the defibrillator part are generated locally on the defibrillator circuit.

The defibrillator function of DG 5000 is a sequential circuit with six distinct phases:

1) Standby phase: Phase where DG5000 is on (monitoring function); the defibrillator part is standing by (no demand for a charge).

2) Charge phase: Phase during which the HV generator charges the HV capacitor (40 µF / 3.1 kV). The charge phase in the semiautomatic mode may be initiated by two different controls:
    1. Pre-charge control
    2. Charge control

3) Pre-charge completed: Phase that follows initiation by the pre-charge control (in semiautomatic mode), when the selected energy has been reached. After pre-charging is completed, the delivery of the defibrillation shock is not allowed.

4) Hold phase: Phase that follows initiation by the charge control, when the selected energy is reached. This phase lasts for no more than 20 seconds, when the HV capacitor remains charged. DG5000 is ready to deliver a defibrillation shock.

5) Shock phase: This is the phase where DG5000 delivers the pulse biphasic defibrillation shock with patient impedance.

6) Safety discharge: This is the phase where the energy stored in the HV capacitor is delivered into a safety discharge circuit of DG5000.

5.2.2.2. ECG PREAMPLIFIER

The preamplifier part carries out the following functions:
- Powering the floating defibrillator ECG part
- Acquisition of the ECG signal
- Amplification and processing of the ECG signal
- Verification of the acquisition chain
- Patient impedance measurement
- Transmission of QRS pulses from the 10-channel ECG preamplifier

OVERALL DESCRIPTION:
On the defibrillator PCB, the floating part of the defibrillation ECG preamplifier is located under the two metal shields that occupy the space under the high-voltage capacitor.
The floating power of the defibrillation ECG preamplifier is provided through transformer TR3 from the voltages supplied by the 10-channel ECG preamplifier. The defibrillator ECG preamplifier part amplifies the ECG signal and measures the patient impedance sent by the defibrillation electrodes (handheld paddles or adhesive electrodes).
The amplified ECG signal and the patient impedance signal are sent by an optocoupler to the floating ECG part of the 10-channel ECG preamplifier. The signals are transmitted by cyclic ratio modulation. The 10-channel ECG preamplifier therefore receives two possible sources of ECG signals: the ECG signal through the patient cable and the ECG signal through the defibrillation electrodes.
The 10-channel ECG preamplifier directly controls the defibrillator ECG preamplifier if pacemaker pulses are detected (signal INH_PACE). The test of the ECG signal acquisition chain by the defibrillation electrodes is also controlled by the 10-channel ECG preamplifier board during the self test of DG5000 (10 Hz signal). The QRS signal detected and formed by the 10-channel ECG preamplifier is sent by an optocoupler to the defibrillator control circuit in order to control working during cardioversion (signal –QRSTRIG_DEF).
The defibrillator ECG preamplifier part measures the patient impedance through a 30 kHz sine-wave signal. After processing, the signal with the patient impedance value is sent to the 10-channel ECG preamplifier. The defibrillator ECG preamplifier circuit has a window comparator where the output signal is used by the defibrillator control circuit in order to authorise the defibrillation shock only if the defibrillation electrodes are glued correctly (signal –PIMP_DEF).

ECG PREAMPLIFIER AMPLIFICATION:
The power supply for the floating part of the ECG preamplifier is generated through voltages +VFM and –VFM supplied by the 10-channel ECG preamplifier. Oscillator U47 controls transformer TR3 through driver U46. The secondary voltages are rectified, filtered and regulated by means of linear regulators U44 and U45. The power supply voltages obtained, +VFD (+5 V) and –VFD (-5 V), together power all the elements of the floating part connected to the potential of the defibrillation electrodes.

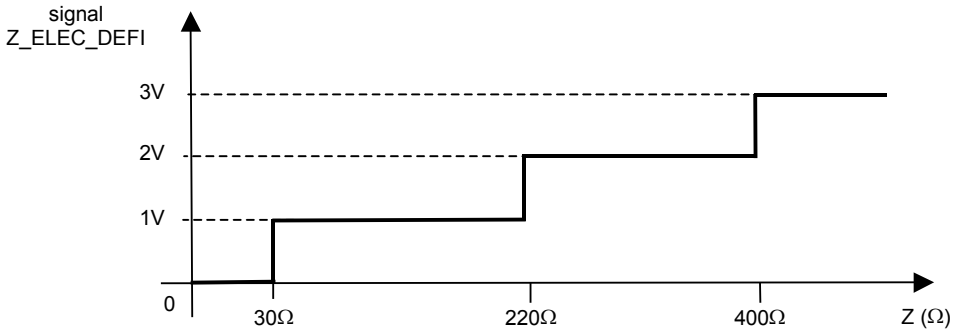
ECG SIGNAL ACQUISITION:
The ECG signal collected by the defibrillation electrodes is acquired through following stages U28A, U28B and resistive networks made up of R376 - R384. The input stage of the ECG preamplifier is protected from the defibrillation shocks by means of sparker E3 and clipping diodes D39 and D40. The clipping diodes are polarised in relation to reference voltages +2.5 VD and –2.5 VD generated by voltage references U32 and U33.

AMPLIFICATION AND PROCESSING OF THE ECG SIGNAL:
The two circuits U27A and U27B make up a differential amplifier with a gain of 4. Capacitor C112 is used to attenuate the amplitude of the 30 kHz sine-wave signal used to measure patient impedance. The two stages U27C and U27D make up an amplifier with a gain of about 47 with continuous-component compensation by elements R301 and C174. If pacemaker pulses are recognised by the microprocessor of the 10-channel ECG preamplifier, the analogue switch U30C is opened by signal INH_PACE_FL in order to limit the continuous component overrun. Signal INH_PACE_FL from the 10-channel ECG preamplifier circuit is sent by means of optocoupler U36. Output signal ECG_DEFI_FL is transmitted to the 10-channel ECG preamplifier through optocoupler U37. Stages U26A and U26B make up the ramp wave generator that makes it possible to modulate the cyclical ratio for the transmission of signals from the floating part to the 10-channel ECG preamplifier. The ECG signal is demodulated by stages U39A and U39D, hysteresis comparator and low-pass filter respectively. The output signal from U39D, ECG_DEFI, is the input source of the ECG signal from the defibrillation electrodes of the 10-channel ECG preamplifier.
The output signal from U27D that corresponds to the amplitude of the continuous component of the ECG signal is compared with reference limits through window comparator U29A and U29B. If the polarisation voltage of the ECG signal is high (above +/-1 V at the input), window comparator U29 blocks transistor Q29, which activates analogue switch U30D. The activation of U30D leads to the addition of +5V offset voltage through R266 at the inverting adder U51B.
Under those conditions, the patient impedance measurement signal (ZPAT) becomes equal to 0 V, which informs the user by means of a message "CONNECT THE ELECTRODES".

VERIFICATION OF THE ECG SIGNAL ACQUISITION CHAIN:
The ECG signal acquisition chain is verified when the device is switched on through the 10-Hz signal generated on the 10-channel ECG preamplifier and transmitted in the floating part by optocoupler U35. Signal 10 Hz_FL ranging between +5 V and –5 V controls transistor Q28, which generates a differential signal with an amplitude of about 1.5 mV. The signal is injected at the inputs of the differential amplifier U27A and U27B through analogue switches U30A, U30B and resistors R319 and R320. The control signal of U30A and U30B is also generated by signal 10 Hz_FL through D2, R323 and C92. While verifying the acquisition chain, the oscillator used for measuring the patient impedance built around U31A and U31B is blocked by means of transistor Q27.

PATIENT IMPEDANCE MEASUREMENT:
Patient impedance is measured by oscillator U31A and U31B, which injects a sine-wave current of about 30 kHz into the patient through networks R374, R373, C172, R258 and R375, R372, C171, R257. The sine-wave oscillator is protected during the defibrillation shock by sparker E2 and clipping diodes DZ29 and DZ30. Patient impedance is measured by processing the amplitude of the 30-kHz signal contained in the ECG signal. The 30-kHz is extracted by means of cells C160, R134 and C161, R135, which are preceded by voltage followers U25A and U25B. Stage U25C makes up a differential amplifier with a gain of 10. The following stage, U25D, is a peak-to-peak rectifier where the amplification is adjustable with P2, which is used to make the overall adjustment of the gain of the patient impedance measurement chain. Peak-to-peak rectifier U25D is followed by unit gain differential amplifier U51A. The output of U51A supplies an analogue voltage located from 0 V and –5 V proportional to the patient impedance. The output signal of inverting adder U51B attacks the cyclical report modulation stage made up by comparator U26C. Signal IMP_ELEC_DEFI_FL is transmitted to the 10-channel ECG preamplifier by optocoupler U38, controlled by transistor Q31.

The signal is demodulated by means of stages U39B and U39C and the associated components. Operational amplifier U39, which demodulates signals ECG_DEFI and Z_ELEC_DEFI, is powered through linear regulator U40, which supplies a stabilised +4.5 V voltage. The output signal of demodulation stage U39C attacks differential amplifier U42B, which generates signal Z_PAT proportional to the patient impedance. Signal transfer function: Z_PAT (V) = 0.01 x Patient impedance (Ω). Adjustable P3 is used to adjust the zero point (0 Ω corresponds to 0 V in Z_PAT).
The signal proportional to patient impedance Z_PAT, attacks three hysteresis comparators U43B, U43C and U43D. The comparator outputs attack a non-inverting adder stage U43A which generates signal Z_ELEC_DEFI transmitted to the 10-channel ECG preamplifier represented below:



The two hysteresis comparators U43B and U43C also attack window comparator U48A and U48B (open collector) in order to generate a signal that makes it possible to permit the delivery of the shock only when the patient impedance is located from 30 Ω to 220 Ω.
The output signal of the window comparator U48A and U48B is transmitted to the defibrillator control circuit by means of optocoupler U50. Signal –PIMP_DEFI is used by the defibrillator control circuit in order to verify the proper contact of the defibrillation electrodes. When the patient impedance ranges from 30 Ω to 220 Ω, signal –PIMP_DEFI is in the high state.

TRANSMISSION OF QRS PULSES:
QRS pulses from the 10-channel ECG preamplifier are transmitted by means of transistor Q32 and optocoupler U49, which isolates the 10-channel ECG preamplifier and the defibrillator control circuit. Output signal –QRSTRIG_DEF is used by the defibrillator control circuit to synchronise the defibrillation shock with the QRS wave while functioning during cardioversion.

5.2.2.3. CIRCUIT INTERFACE D'ENTREE.

The input interface circuit performs the following functions:
- Interfacing of signals from defibrillation cartridges
- Interfacing of signals to defibrillation cartridges

OVERALL DESCRIPTION:
The input interface circuit forms the signals from the defibrillation cartridges and controls the functioning of the indicators of the handheld paddle electrodes or the front of the device.
If the handheld paddle electrode cartridge is being used, the input interface circuit generates analogue voltage corresponding to the selected energy, signal AWSEL. The various signals –PCIS, DKY1 and DKY2 relating to the pressing of Charge/Shock keys in order to set off the charging of the HV capacitor or the defibrillation shock. Besides, the input interface circuit also supplies a signal when the graph starting key is pressed, namely signal RECB. The LEDs of the handheld paddles are switched on by signal DEFREADY from the defibrillator control circuit. If the adhesive electrode cartridge is being used, the signals for energy selection and triggering the charging of the HV capacitor come from the CPU board through the serial link. Signal –ANAB corresponds to pressing the Analyse key. Signal –ANAKL is used to control the lighting of the Analyse LED. Signals –DMPR and DMTP are used to verify the presence of a defibrillation cartridge and for the identification of the type of cartridge by the defibrillator control circuit.

INPUT SIGNAL INTERFACE:
The energy selection by means of the knob on the handheld paddles is achieved by analogue voltage WREF made up by divider R101 and R336 in parallel with the resistor put into the circuit by the energy selector in the paddles themselves. Signal WREF is buffered by voltage follower U22A before it attacks analogue multiplexer U14.
The type of defibrillation cartridge put in place in DG5000 is identified by means of analogue voltage MOD1 polarised by R280, R330 and a fixed resistor inside the various cartridges.
The insertion of a defibrillation cartridge in the slot provided for that purpose is recognised by means of signal MOD0.
The connection of a pair of adhesive electrodes at the connector provided on the adhesive electrode cartridge is detected by signal –ELECTR, which switches to the low status in that case.
The triggering of a charge by means of the handheld paddles is achieved by signal –DCIS, which corresponds to the pressing of one of the keys Charge/Shock on the paddle electrodes. Signal –DCIS is generated by comparator U22B and the associated components from signal –PCIS from the handheld paddle electrodes. Signal –DCIS switches to the low level when a Charge/Shock key is pressed.
Signal DDIS1 corresponds to pressing a Charge/Shock key. The signal generated by comparator U22C is used by the defibrillation microcontroller during the defibrillation shock.
Signal –DDIS2 from line DKY2, corresponds with the second signal used by defibrillation microcontroller U16 during a defibrillation shock. Signal –DDIS2 generated by U22D switches to the low level when the two Charge/Shock keys are pressed.
The pressing of the graph starting key on a handheld paddle is detected by signal REC and through comparators U23A, U23B and logical gates U24A, U24B and U24C if the paddle electrode cartridge is used.
Pressing the Analyse key on the front is recognised by means of signal –ANAKEY, which switches to the low level when the key is pressed.

OUTPUT SIGNAL INTERFACE:
The DEFI READY indication LEDs of the handheld paddles are switched on by means of lines READY and –READY. These signals are generated by transistor Q24 and open-collector driver U12F and also buffer U21A driven by signal EPDU generated by the defibrillation microcontroller U16.
If the adhesive electrode cartridge is being used, the LED of the Analyse key on the front is switched on by line ANALED. Line ANALED is driven by transistor Q23 and driver U12A, which is driven by signal ANKL generated by defibrillation microcontroller U16.

5.2.2.4. DEFIBRILLATOR CONTROL CIRCUIT

The defibrillator control circuit part carries out the following functions:
- Self test of the defibrillator part
- Transfer of information through a serial link to the CPU board
- Handling of information from defibrillation cartridges
- Control of the charging of the high-voltage capacitor
- Measurement of the energy stored in the high-voltage capacitor
- Triggering of the defibrillation shock if the Shock key is pressed
- Control of synchronised shock
- Determination of patient impedance during defibrillation shocks
- Control of the pulse biphasic waveform with patient impedance compensation
- Safety discharge of the high-voltage capacitor.

OVERALL DESCRIPTION:
The defibrillator control circuit contains a microcontroller that carries out all the functions described above. When the device is switched on, the defibrillator control circuit runs a self test of the defibrillator part. The microcontroller of the defibrillator control circuit exchanges information with the CPU board through a serial link that is decoupled from the CPU board by an optocoupler.
During manual use (handheld paddle electrode cartridge), the microcontroller of the defibrillator control circuit takes account of the various signals from the input interface circuit in order to control the high-voltage circuit. Signal AWSEL is an analogue voltage that is determined by the energy selected by means of the knob on the handheld paddle electrodes. The two signals –DMPR and DMTP indicate the presence of a defibrillation cartridge and the type of defibrillation cartridge respectively. If the graph triggering key on the handheld paddle electrodes is pressed (signal RECB), the microcontroller transmits the information corresponding with the pressing of the key to the CPU through the serial link.
Signal –PCIS which indicates the pressing of one of the Charge/Shock keys of the handheld paddle electrodes sets off the charting of the HV capacitor at the selected energy. Before triggering the charging of the HV capacitor, the microcontroller of the defibrillator control circuit checks if the Charge transistor is operating correctly by means of signal CTFC. When the test is completed, the defibrillator control circuit generates the Charge transistor activation signal (signal EHVG). The safety discharge relay is also excited by means of signal WDRA. When the different operations are performed, the charging of the HV capacitor is triggered by the activation of the HV generator (signal LHVC). While the HV capacitor is being charged, the microcontroller measures the energy stored in the HV capacitor through signal THVM. The microcontroller also generates two signals that block the IGBTs (signals PHASE1_B and PHASE2_B). If, during the charging of the HV capacitor, the user selects a lower energy value, the microcontroller sets off a safety discharge of the HV capacitor by deactivating all the active outputs (deactivation of signals LHVC, WDRA and EHVG). If the user selects a higher energy, the microcontroller sets off a compensation charge by means of signal LHVC till the new selected energy value is reached. When the stored energy is equal to the selected energy, the microcontroller stops the HV generator by means of signal LHVC.
The defibrillator is now in the hold phase, during which the two LEDs of the handheld paddle electrodes are switched on by means of signals EPDU and READY. During this phase, the stored energy is measured by signal CHVM. During the hold phase, simultaneously pressing the two keys Charge/Shock triggers the defibrillation shock through two independent channels. The first channel for triggering the shock is directly made up of the signal resulting from the serial arrangement of the two keys Charge/Shock in the handheld paddle electrodes (signal DKY2). The second channel for triggering the defibrillation shock is made up of the microcontroller of the defibrillator control circuit (signal UPRA) lasting 100 ms. The two signals above activate the patient relay of the high-voltage unit. After a 25-ms time, the first defibrillation pulse is generated by the IGBT control circuit. During the first pulse, the microcontroller measures the defibrillation current by means of signal IPAT in order to determine the patient impedance. Once that has been determined, the microcontroller adapts the cyclic ratio of the defibrillation wave to the calculated impedance.
During the shock, the IGBTs are driven by the IGBT control circuit (signals PHASE1_C and PHASE2_C) to generate the pulse biphasic wave with patient impedance compensation. After a duration of 100ms, signal UPRA deactivates the patient relays and disables the IGBT control circuit. The microcontroller deactivates all the outputs and the energy remaining in the HV capacitor is dissipated in the safety discharge circuit. During the defibrillation shock, the microcontroller calculates the energy delivered and transmits the value and the peak current and the patient impedance to the CPU board.
In the case of synchronised defibrillation, the microcontroller generates signal UPRA only in the presence of a synchronisation pulse in relation to the QRS wave, signal –QRSTRIG.
If the adhesive electrode cartridge is being used, the energy is selected (in manual mode) by means of the function keys on the front of the device and the selected energy value is transmitted by the CPU board to the defibrillator microcontroller by means of the serial link.

In the SAD operating mode, the microcontroller of the defibrillator control circuit checks if the Analyse key of the front has been pressed (signal -ANAB) and transmits the corresponding information through the serial link to the CPU board. If the master microprocessor of the CPU board recognises VF/VT, the CPU board sends a request for pre-charging and the selected energy through the serial link. That pre-charge control starts off the process of charging the HV capacitor as described above. When the energy stored is equal to the selected energy, the microcontroller stops the HV generator and the defibrillator circuit is located in the phase when the pre-charge is completed, where the defibrillation shock is as yet not authorised. During that phase, the microcontroller measures the energy stored in the HV capacitor by means of signal CHVM. If, during the previous phase, an analysis of the ECG signal of the CPU board confirms VF/VT, the CPU board sends a new request for charging to the defibrillator circuit. The defibrillator control circuit once again activates the HV generator (signal LHVC) till the new selected energy is reached. When the energy stored in the HV capacitor is equal to the selected energy, the microcontroller stops the HV generator and authorises the defibrillation shock (signal EPDU). In that case, the Defi Ready LEDs of the Shock key on the front go on and the defibrillation shock is triggered by pressing by the Shock button.

SELF TEST OF THE DEFIBRILLATOR PART:

The defibrillator control circuit part is powered by the +5V voltage that is generated independently by linear regulator U13. When the DG 5000 device is started up, circuits U12D and U7D generate a reset of the microcontroller of the defibrillator control circuit. The +5V power voltage is monitored by the BOR function integrated to microcontroller U16, which resets U16 if it fails (when the voltage drops below +4.5 V). The master microprocessor of the CPU board can also generate a reset of U16 through signal DE_µC_RST that drives optocoupler U19. The voltage reference of the ADC internal to U16 is made up by U20.

When the DG 5000 device is switched on, microcontroller U16 of the defibrillator control circuit runs a self test of the defibrillator part. During the self test, microcontroller U16 does the following:

- Configuration of input/output ports
- Check of the proper operating of the serial link with the CPU board
- Check of program integrity
- Check of the proper operating of the fault detection circuit
- Check of the proper operating of the ADC
- Check of the proper operating of the voltage reference of the fault detection circuit (U8) and analogue multiplexer U14.
- Check of signal –DDIS2.
- Check of the status of the Charge transistor (Q1)
- Check of the charging voltage of the HV capacitor

During the self test, all the output ports of the microcontroller are deactivated. The operating of fault latch U10A is tested by signal –SFDU, which must trigger latch U10A by means of gate U7B. In order to check the proper working of the latch, microcontroller U16 reads signal FDUO by means of multiplexer U15. During the test, signal FDUO must be high. When the test result confirms the proper operating of the safety latch, microcontroller U16 resets U10A by means of signal –RFDU.

The ADC internal to microcontroller U16 is tested by reading the +5 V and GND voltage via analogue multiplexer U14. Voltage reference U8 (+2.5 V) is also verified by analogue multiplexer U14. That voltage reference is used by the fault detection circuit comparators.

During the self test, the microcontroller also checks the status of buttons Charge/Shock by means of signal –DDIS2. Signal –DDIS2 comes from the serial arrangement of the two keys Charge/Shock and is formed by U22D and the associated components. During the test (when the two keys are not pressed), signal –DDIS2 must be on the high level.

The status of Charge transistor Q1 is verified by means of signal CTFC. Signal CTFC corresponds to the voltage present on the drain of Q1, divided by R140 and R141. During the self test, signal CTFC must be close to 0 V.

The charging voltage of the HV capacitor is verified by means of signal CHVM, also via analogue multiplexer U14. During the self test, the charging voltage of the HV capacitor must be close to 0 V (HV capacitor discharged).

In a fault is detected during the self test, microcontroller U16 sends an error message to the CPU board by means of the serial link. In that case, U16 deactivates all the outputs so as to block the operating of the high-voltage part of the defibrillator. When the defibrillator circuit self test is completed without detecting a fault, the defibrillator enters the standby phase.

EXCHANGE OF INFORMATION BY THE SERIAL LINK WITH THE CPU BOARD:

The transfer of information between the CPU board and the defibrillator part is achieved by means of a serial link. In the defibrillator circuit, the serial link is directly managed by microcontroller U16, signals RxD and TxD. The transmission of the information from the serial link to the CPU board is achieved by means of optocouplers U17 and U18. The dialogue through the serial link takes place by sending a frame every 100ms. The serial link transmits the following information:

- Information for testing proper communication between the CPU board and the defibrillator
- Information about the malfunctioning of the defibrillator part
- Information about the standby phase of the defibrillator part
- Information about the charging phase of the HV capacitor
- Information about the pre-charge completed status
- Information about the hold phase of the HV capacitor
- Information about the application of the shock defibrillation
- Information about the safety discharge phase
- Real time information about the energy stored during the charging or hold phase of the HV capacitor
- Information about operating in direct or synchronous mode
- Information about the energy delivered during the application of the defibrillation shock
- Information about the peak current during the application of the defibrillation shock
- Information about the identification of the defibrillation cartridge put in place and the connection of a pair of adhesive electrodes
- Information about the pressing of a graph triggering key on the handheld paddle electrodes
- Information about the pressing of the Analyse key on the front of the device
- Information leading to a battery test
- Information about the energy selected if an adhesive electrode cartridge is in use
- Information about the triggering of the pre-charge to the selected energy value
- Information about the triggering of the charge to the selected energy value
- Information about the safety discharge of the HV capacitor

CONTROL OF THE HIGH-VOLTAGE CAPACITOR CHARGE:

STANDBY PHASE:

During the standby phase, microcontroller U16 dialogues with the master microprocessor of the CPU board by means of the serial link. The high-voltage circuit of the defibrillator part is disabled. The controlling of the charging of the HV capacitor is started either by signal –DCIS, if the handheld paddle electrode cartridge is being used, or by the master microprocessor of the CPU board via the serial link if the adhesive electrode cartridge is being used. In semiautomatic mode, two pieces of information are used to trigger the charging of the HV capacitor - the pre-charge information and the charge information. In both cases, the procedure of c charging the HV capacitor is identical. The difference lies in the status of the defibrillator after charging is complete. If the HV capacitor is charged by the pre-charge command, the defibrillator goes into the pre-charge completed state when charging is complete. During the pre-charge completed phase, the defibrillator stands by for a new charging request and does not allow the delivery of defibrillation shocks. If the HV capacitor is charged by the charge command, the defibrillator enters the hold phase when charging is complete. During the hold phase, the defibrillator authorises the defibrillation shock. When the charging or pre-charging is triggered, the master microprocessor also sends a signal corresponding to the selected energy.

CHARGE PHASE:

The charge phase is either triggered by signal –DCIS or, while using the adhesive electrode cartridge, by the charge signal from the master microprocessor to the serial link. When charging is triggered, microcontroller U16 checks the Charge transistor (Q1) through signal CTFC. After verifying signal CTFC, microcontroller U16 activates Charge transistor Q1 and Q2 through signal EHVG and open-collector driver U12B. The activation of Q1 generates the high-current power voltage of the HV generator +UCHARGE from the DC voltage supplied by the Power Board. That +UCHARGE voltage is protected by fuse F1. The activation of transistor Q2 generates the power supply voltage of chopping regulator U1.

Microcontroller U16 also activates signal WDRA, which excites the safety discharge relay RL1 by means of buffer U21E and transistor Q11A. After a 50-ms time, microcontroller U16 activates the HV generator by means of signal LHVC and buffer U21B. When all the conditions are met, the HV capacitor starts charging. The maximum time of the charge initiated by signal –DCIS or a charge command via the serial link is limited to 30 s (in the event of a problem), after which U16 triggers the safety discharge of the HV capacitor by deactivating all the active outputs.

In order to actively block the IGBTs of the HV switching circuit, microcontroller U16 also generates two signals PHASE1_B and PHASE2_B with a period of 16 ms and a duration of 200 µs. The two signals PHASE1_B and PHASE2_B generate blocking pulses in the cores that drive the gates of the IGBTs through drivers U5B and U6B and transistors Q19 and Q21. Microcontroller U16 generates these IGBT blocking pulses during the charge, pre-charge completed and hold phases.
During the charge phase of the HV capacitor, microcontroller U16 measures the charging voltage of the HV capacitor through signal THVM via multiplexer U14. The energy stored in the HV capacitor is calculated by U16. When the value is equal to the selected energy, U16 deactivates the LHVC signal, which stops the charging of the HV capacitor.

HOLD PHASE:
When the defibrillator enters the hold phase, microcontroller U16 determines the energy stored in the HV capacitor by means of signal CHVM and checks that it is located within the permitted tolerances. If that is not so, U16 triggers a safety discharge of the HV capacitor. During the hold phase, microcontroller U16 activates signal EPDU, which makes Q11B conduct through open-collector driver U12C. In these conditions, the defibrillation shock may be delivered to the patient. The hold phase does not last longer than 20 s, after which microcontroller U16 triggers a safety discharge.

PRE-CHARGE PHASE:
In the semiautomatic mode using the adhesive electrode cartridge, the master microprocessor of the CPU board initiates a pre-charge of the capacitor during the analysis of the ECG signal. The pre-charge command and the selection of the corresponding energy value is transmitted by the serial link to the defibrillator. The pre-charge process is identical to the charge process, and the maximum duration of the pre-charge phase is 20 s. When the energy stored in the HV capacitor is equal to the selected energy, microcontroller U16 enters the pre-charge completed phase.

PRE-CHARGE COMPLETED PHASE:
After the pre-charge phase, the defibrillator enters the pre-charge completed phase. During this pre-charge completed phase, microcontroller U16 calculates the energy stored in the HV capacitor by means of signal CHVM and stands by for a new charging request. During the pre-charge completed phase, signal EPDU remains low and the defibrillation charge is not validated. The maximum duration of the pre-charge completed phase is set to 15 s. After that time, microcontroller U16 triggers a safety discharge of the HV capacitor by deactivating all the outputs.
If, during the pre-charge completed phase, U16 receives a new signal requesting a charge to the selected energy, the microcontroller goes back to the charge phase by activating signal LHVC.

MEASUREMENT OF THE ENERGY STORED IN THE HIGH-VOLTAGE CAPACITOR:
The energy stored in the HV capacitor is measures by means of two independent signals, THVM and CHVM.
During the HV capacitor charge sequences, the stored energy is measured by signal THVM. Signal THVM comes from the primary winding of the HV converter and is formed by Q3, U2A and U2C. Signal THVM is directly proportional to the charge voltage of the HV capacitor.
During the pre-charge completed and hold phases, the stored energy is measured by signal CHVM. Signal CHVM is directly taken at the terminals of the HV capacitor, by means of resistive dividers with a high ohmic value (R251, R252 and R259 and R253, R254 and R206) referenced in relation to the ground. The two symmetrical voltages obtained are amplified by differential amplifier U4C.

TRIGGERING OF THE DEFIBRILLATION SHOCK:
If, during the hold phase, the two keys Charge/Shock of the handheld paddle electrodes or the Shock key on the front is pressed, the defibrillator triggers the defibrillation shock. When the two keys Charge/Shock of the handheld paddle electrodes or the Shock key on the front of the device are pressed in, line DKY2 is connected to the ground. When line DKY2 is low, patient relays RL2 and RL3 are excited by two independent control channels.
The first channel for activating the patient relay RL2, RL3 is made up of transistor Q12B and buffer U21D driven by signal UPRA generated by microcontroller U16. When one of the Shock keys is pressed, comparator U22D makes signal –DDIS2 switch to low. Signal –DDIS2 is taken into account by microcontroller U16. When signal–DDIS2 is active for more than 150ms, U16 generates a high level on signal UPRA for 100ms.
The second channel for activating the patient relay is made up of transistor Q12A that is activated directly by line DKY2 and transistors Q9 and Q10. In order to excite the patient relay, the two triggering channels must be active.

Direct or synchronised shock operation is defined by the master microprocessor through a piece of information in the serial link. In the event of synchronised defibrillation, the shock is only delivered in the presence of a syncing pulse on the QRS wave, signal -QRSTRIG. In this operating mode, the shock is also given by the two distinct control channels. The first of them is made up by microcontroller U16, which in this case generates signal UPRA, only when the two keys Charge/Shock are pressed and there is a synchronisation pulse on signal –QRSTRIG. The second channel is made up by gate U7C driven by U16 according to the operating mode - direct or synchronous. In the synchronous shock operating mode, the signal SYNC is high. In this case, the syncing pulses from U21C and the differentiating network C146, R347 triggers high syncing pulses at the output of U7C. These pulses enable the activation of transistor Q10 through open-collector driver U12E. If, in these conditions, the Shock key or keys are simultaneously pressed and a synchronising pulse is present, the patient relays are activated by transistors Q9, Q10, Q12A, Q12B and the associated components. The activation duration of patient relays RL2 and RL3 is defined by signal UPRA, which lasts 100 ms.
During the 100 ms of activation of patient relays RL2 and RL3, the patient is connected to the high-voltage circuit of the defibrillator.

DRIVING THE BIPHASIC WAVE WITH PATIENT IMPEDANCE COMPENSATION:
The first IGBT control pulse (first defibrillation shock pulse) is generated 25 ms after the rising edge of signal UPRA. That first pulse of signal PHASE1_C makes the first-phase IGBTs conduct, namely Q13 and Q14. While the IGBTs are conducting the microcontroller measures the patient peak current.
The patient peak current is measured by means of signal IPAT taken from the patient discharge circuit by current transformer TR2. The signal from the secondary winding of current transformer TR2 is filtered and buffered by U2B and the associated components before it is amplified by U2D to supply signal IPAT.
From the charging voltage of the HV capacitor (signal CHVM) and the patient current value (signal IPAT), microcontroller U16 determines the value of the patient impedance.
After calculating the patient impedance value, microcontroller U16 direct adapts the cyclic ratio of the IGBT control signals to the patient impedance. Signals PHASE1_C and PHASE2_C lead to the driving of the IGBTs of the first phase (Q13, Q14) and the second phase (Q15, Q16 and Q17, Q18) respectively. Durations Ton and Toff (determined by microcontroller U16) of signals PHASE1_C and PHASE2_C make the IGBTs of the high-voltage switching circuit conduct or not in order to generate the pulse biphasic wave with patient impedance.
After 100 ms, signal UPRA deactivates patient relay RL2, RL3. Microcontroller U16 deactivates all its outputs, signals EPDU, WDRA and EHVG are switched to low, leading to a safety discharge of the energy remaining in the HV capacitor. During the defibrillation shock, microcontroller U16 also calculates the energy delivered to the patient and transmits the corresponding information and the value of the peak current and the patient impedance to the master microprocessor of the CPU board.

SHOCK OUTSIDE THE NOMINAL IMPEDANCE RANGE:
When the Shock key or keys is/are pressed, microcontroller U16 first checks the status of signal -PIMP which corresponds to the patient impedance range in which the defibrillation shock is permitted. When signal -PIMP is high, the patient impedance ranges from 30 Ω to 220 Ω and the defibrillation shock is allowed. When signal -PIMP is low, microcontroller U16 does not permit the defibrillation shock and directly leads to a safety discharge of the HV capacitor. Signal -PIMP is taken from the ECG preamplifier part and transmitted by optocoupler U50.

HV CAPACITOR SAFETY DISCHARGE:
The HV capacitor safety discharge may be initiated either directly by microcontroller U16 when it enters the safety discharge phase or by a safety discharge command from the master microprocessor of the CPU board, or by the fault detection circuit by means of fault latch U10A. In any event, the safety discharge of the HV capacitor is triggered by a return to the low level of signal WDRA.

5.2.2.5. HIGH-VOLTAGE CIRCUIT

The high-voltage circuit part carries out the following functions:

- Patient insulation from the high-voltage circuit
- Charging the HV capacitor to the defined energy value
- Measuring the HV capacitor charging voltage
- Blocking the high-voltage switching circuit
- Generating the pulse biphasic wave with patient impedance compensation
- Measuring the peak value of the defibrillation current
- Safety discharge of the HV capacitor

OVERALL DESCRIPTION:

The high-voltage circuit insulates the patient from the high-voltage unit of the defibrillator by means of two patient relays. The defibrillator charging circuit is directly powered by the DC voltage from the power circuit - Power Board. The high-voltage unit is activated by the Charge transistor (signal EHVG). The HV capacitor is charged by the HV generator (signal LHVC). When the HV capacitor is charged, the safety discharge relay is also activated (signal WDRA). During the charging of the HV capacitor, the HV generator supplies a signal to measure the charge voltage by the primary winding of the HV converter (signal THVM). The signal is used by the defibrillator control circuit to determine the energy stored in the HV capacitor. When the energy stored in the HV capacitor is equal to the selected energy, the HV generator is deactivated, which stops the charge. When the defibrillator is in the hold phase, the charge voltage is measured by two symmetrical high-voltage dividers at the terminals of the HV capacitor (signal CHVM). The two HV dividers are referenced in relation to the ground. During the charge and hold phases, the high-voltage circuit actively blocks the IGBTs of the HV switching circuit by means of the pulse transformers associated with the IGBTs. The active blocking of the IGBTs is controlled by the microcontroller (signals PHASE1_B and PHASE2_B). During the entire duration of the hold phase, the activation of the patient relay control stage is authorised (signal EPDU). When the two keys Charge/Shock are pressed on the handheld paddle electrodes are pressed simultaneously or the Shock key on the front is pressed, the defibrillator control circuit activates the patient relay for 100ms (signals UPRA and DKY2). The IGBT control circuit controls the high-voltage switching stage with IGBTs in order to generate the pulse biphasic wave with patient impedance compensation (signals PHASE1_C and PHASE2_C). In the event of synchronised defibrillation, shock synchronisation is also driven by two distinct channels. The first of these is made up of signal –SYNC and it directly activates the patient relay if a synchronisation pulse is present on the QRS wave while the two Charge/Shock keys are pressed. The second channel is made up of the microcontroller, which generates the UPRA signal in the synchronised defibrillation mode only if the there is a QRS synchronisation pulse and the two keys Charge/Shock are pressed. The syncing signal – QRSTRIG_DEF is taken from the floating part of the 10-channel ECG preamplifier and transmitted to the defibrillator control circuit by means of an optocoupler in the defibrillator ECG preamplifier part.

During the first current pulse of the defibrillation wave, the high-voltage circuit measures the patient current value by means of current transformer TR2, which generates signal IPAT after it is formed. This piece of information enables the defibrillator control circuit to determine the patient resistance in order to drive the IGBT control circuit.

The high-voltage circuit also enables the safety discharge of the HV capacitor through a power resistance and the safety discharge relay. The safety discharge of the HV capacitor is driven by the defibrillator control circuit (signal WDRA). The safety discharge may be initiated either directly by the microcontroller of the defibrillator circuit or by information transmitted by the serial link from the CPU board.

PATIENT INSULATION FROM THE HIGH-VOLTAGE CIRCUIT:

The patient is insulated from the high-voltage circuit by means of the open contacts of patient relay RL2 and RL3 of the defibrillator part. In the idle position, the HV contacts of the defibrillation electrodes are connected to the optional pacemaker if it is present. During the 100-ms activation time during the defibrillation shock, the pacemaker is disconnected from the defibrillator through working contacts of the patient relay.

An ECG signal taken by the defibrillation electrodes is sent by means of optocoupler U37 in the floating part of the 10-channel ECG preamplifier. The floating part of the defibrillation ECG preamp is further insulated by optocouplers U35, U36, U38 and transformer TR3.

CHARGING THE HV CAPACITOR TO THE DEFINED ENERGY VALUE:

If the handheld paddle electrode cartridge is being used, the energy is selected by means of signal WREF. If the adhesive electrode cartridge is being used, the energy is selected by the master microprocessor, which transmits the corresponding information to microcontroller U16 via the serial link. After receiving a charge request, either through signal –DCIS or through charge information in the serial link, the microcontroller checks the CTFC signal to check that there is no voltage at the drain of the Charge transistor Q1. When that condition is met, signal -EHVG switches to low, which makes Q1 and Q2 conduct. When Charge transistor Q1 conducts, that makes voltage +UCHARGE appear. When Q2 conducts, chopping regulator U1 is supplied with +12 V. Microcontroller U16 also controls the activation of the safety discharge relay, RL1, by signal WDRA and transistor Q11A. In those conditions, the contacts of the safety discharge relay RL1 are open, making it possible to charge the HV capacitor. The charging of the HV capacitor is started by means of signal LHVC, which switches to high. When signal LHVC is high, transistor Q5 unlocks the HV generator built around U1, Q6, Q7 and associated components, leading to the charging of the HV capacitor 40 µF / 3.1 kV by means of the secondary winding of transformer HT, TR1.

MEASUREMENT OF THE CHARGING VOLTAGE OF THE HV CAPACITOR:

The charging voltage of the HV capacitor is measured by means of two different circuits.

The first circuit that measures the charging voltage of the HV capacitor is made up of resistors R251, R252 and R259 and also R253, R254 and R260, which directly take the charging voltage at the terminals of the HV capacitor. Signals HV_M+ and HV_M- generated by the resistive divider attack the differential amplifier U4C, which supplies signal CHVM used as the measuring signal by microcontroller U16. Signal CHVM indicates the charging voltage of the HV capacitor divided by 850.

The second circuit that measures the charging voltage of the HV capacitor only generates a signal during the charging phases of the HV capacitor. The measurement signal is taken by means of the primary winding of HV transformer TR1, which reflects the charging voltage of the HV capacitor when transistor Q7 is blocked. The signal from the primary winding of TR1 is taken by transistor Q3 and the associated components. Stages U2A and U2C make up the forming circuits of the signal supplied by Q3. The output signal from U2C, THVM, also indicates the charging voltage of the HV capacitor divided by 850. Signal THVM is used by microcontroller U16 to measure the charging voltage of the HV capacitor in order to stop charging the HV generator. The charge stopping is adjusted by means of adjustable P1.

HV SWITCHING CIRCUIT BLOCKING:

During the charge, pre-charge completed and hold phases, the microcontroller generates two signals, PHASE1_B and PHASE2_B, which actively block IGBTs Q13, Q14, Q15, Q16, Q17 and Q18 of the HV switching circuit. The IGBTs are blocked by signals PHASE1_B and PHASE2_B, which control the primary current of the IGBT control cores L1, L2, L3, L4, L5 and L6 through drivers U5B, U6B and transistors Q19 and Q21. While driving the cores of transistors Q19 and Q21, the secondary windings of the controls cores generate a negative gate voltage in order to effectively block the IGBTs of the two phases.

GENERATION OF THE BIPHASIC WAVE WITH PATIENT IMPEDANCE COMPENSATION:

The biphasic wave with patient impedance is generated by means of signals PHASE1_C and PHASE2_C. These two signals drive the primary current of the control cores of the IGBTs by means of drivers U5A, U6A and transistors Q20 and Q22. The primary current of cores is limited by resistors R237, R420 and R238, R239. While the cores are driven by transistors Q20 and Q22, the secondary windings generate positive gate voltage (on the rising edges of signals PHASE1_C and PHASE2_C), which makes the IGBTs of phase 1 or phase 2 conduct, and negative gate voltage (on the falling edges of signals PHASE1_C and PHASE2_C), which blocks the IGBTs of phase 1 or phase 2.

The biphasic wave defibrillation shock with patient impedance compensation is achieved by the successive conducting and blocking phases of IGBTs Q13 - Q18, which form an H bridge enabling biphasic discharge.

The first phase of the biphasic wave is provided by conduction by Q13 and Q14 and the second by conduction by Q15, Q16 and Q17, Q18. The high-voltage switching circuit with IGBTs is connected to the patient by means of the patient relay made up of RL2 and RL3. The patient relay control is made up of signal UPRA and line DKY2. The first signal UPRA, which drives transistor Q12B, is generated by microcontroller U27 of the defibrillator control circuit. Signal UPRA has a duration of 100 ms. The second control signal comes directly from the serial application of the two Charge/Shock keys of the handheld paddle electrodes or the Shock key on the front of the device. In the direct shock operating mode (Q10 saturated), line DKY2 activates transistor Q9, which saturates Q12A by means of network D6, C91 and R123. Transistor Q10 controls the hardware of the patient relay in the event of a synchronised shock. When the two transistors Q12A, Q12B conduct and the defibrillator is in the hold phase, the patient relay is activated for a duration of

100 ms. The defibrillation shock is authorised during the hold phase by means of transistor Q11B and signal –EPDU generated by open-collector driver U12C.

MEASURING THE DEFIBRILLATION PEAK CURRENT:
During the first control pulse (PHASE1_C) of the IGBTs generated by microcontroller U16, IGBTs Q13 and Q147 are made to conduct. During this conduction time, microcontroller U16 acquires the value of the peak current in order to determine the patient impedance value. The defibrillation peak current is measured by means of current transformer TR2, which is located in the patient discharge circuit. Signal IPAT_M taken at the terminals of the secondary winding of the current transformer loaded by R262, R263 and C71 attacks follower U2B by means of a protection and clipping network to generate signal IPAT after amplification by U2D. Signal IPAT has the value of the peak defibrillation current divided by about 35 (P4 adjustment function).

SAFETY DISCHARGE OF THE HV CAPACITOR:
The safety discharge of the HV capacitor is achieved by means of the safety discharge relay RL1 and power resistor R240. When signal WDRA generated by microcontroller U16 switches to low, transistor Q11A is blocked. In that case, the coil of the safety discharge relay RL1 is de-excited, which closes the contacts of the relay and the safety discharge of the HV capacitor into power resistor R240.

5.2.2.6. FAULT DETECTION CIRCUIT

The fault detection circuit part carries out the following functions:
- Detection of hardware faults in the critical components of the defibrillator

OVERALL DESCRIPTION:
The fault detection circuit monitors the critical fault conditions that may be generated by a technical fault in the defibrillator part. When the DG 5000 device is switched on, the defibrillator control circuit tests the fault detection circuit to verify proper operation (signals –SFDU and –RFDU). The fault detection circuit monitors the following fault conditions:
- Abnormal leakage currents from the IGBT switching circuits (signal IGFD).
- Short circuit in the patient relay activation transistors (signal DUFD).
- Charging voltage of the HV capacitor out of the limits (signal CHVM).

The various fault conditions above trigger latch U10A, which directly deactivates the whole high-voltage unit, and also leads to a safety discharge of the HV capacitor. The safety latch also supplies a fault signal to the defibrillator control circuit microcontroller (signal FDUO), which deactivates all its outputs and sends an error message to the CPU board.

FAULT DETECTION CIRCUIT TEST:
When the DG 5000 is switched on, microcontroller U16 tests the working of fault latch U10A. When the +5 V supply voltage appears, the circuit made up of R128 and C49 leads to a reset of latch U10A by mans of gate U7A. During the self test, microcontroller U16 triggers fault latch U10A by means of signal –SFDU and gate U7D. After verifying the proper operating of the latch by reading signal FDUO, microcontroller U16 resets the fault latch to zero by means of signal –RFDU.

MONITORING OF THE HV SWITCHING CIRCUIT:
Abnormal leakage currents from the IGBT switching circuits are detected by means of two resistor chains R243, R244, R187 and R245, R246, R188 that form a potential balancing network of the two points at the middle of the H bridge. If the leakage current is too high, the potential is no longer balanced. The two signals IGBT_FD1 and IGBT_FD2 at the output of the balancing network attack differential amplifier U4D through the protection and clipping networks. When the amplitude at the output of U4D exceeds the limits set by window comparator U4A and U4B, signal IGFD switches to low. The negative voltage of circuit U4 is generated locally on the board by means of U3 and the associated components.
Signal IGFD makes fault latch U10A trip by means of comparators U11B, U9D and U9A. The tripping of the fault latch makes transistor Q25 conduct through signal FDUO, which deactivates signal –EHVG. In that

case, the power supply voltage +UCHARGE disappears, which stops the HV generator if it is charging and the leads to the safety discharge of the HV capacitor. The tripping of fault latch U10A also generates fault information recognised by microcontroller U16 by means of signal FDUOS. Microcontroller U16 deactivates all its outputs and supplies an error message transmitted to the CPU board by means of the serial link.

MONITORING OF THE PATIENT RELAY ACTIVATION TRANSISTORS:

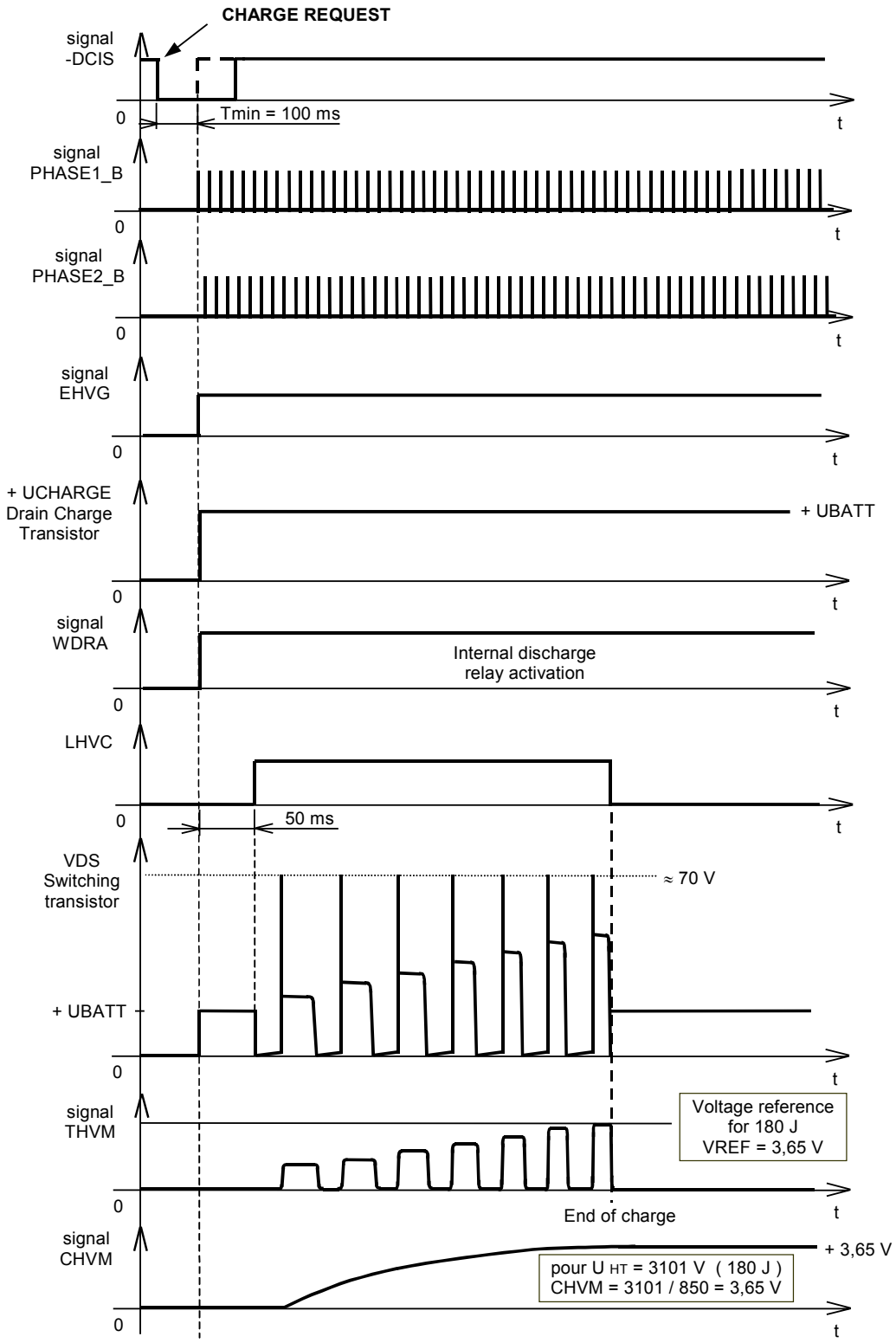
The detection of faults in transistors Q12A and Q12B that activate the patient relay is achieved by means of signal DUFD. If one of the transistors is shorted, the idle potential of signal DUFD polarised by resistors R97 and R98 is modified. The variation is detected by means of the window comparator made up of U11C and U11D. After a duration of about 2.5 s, fault latch U10A is tripped by means of U11A, U9C and U9A. As described above, the tripping of the fault latch makes transistor Q25 conduct by means of signal FDUO and therefore the safety discharge of the HV capacitor (see previous paragraph, Monitoring of the HV switching circuit).

MONITORING OF THE HV CAPACITOR CHARGE VOLTAGE:

Overvoltage in the event of a fault in the charge stopping circuit is detected by comparator U9B, which monitors the amplitude of signal CHVM. When the charging voltage of the HV capacitor reaches approximately 3.3 kV, signal CHVM divided by R269 and R273 makes comparator U9B trip, which activates fault latch U10A by means of U9A. The safety discharge of the HV capacitor and the stopping of the HV generator is achieved as described earlier (see previous paragraph, Monitoring of the HV switching circuit).

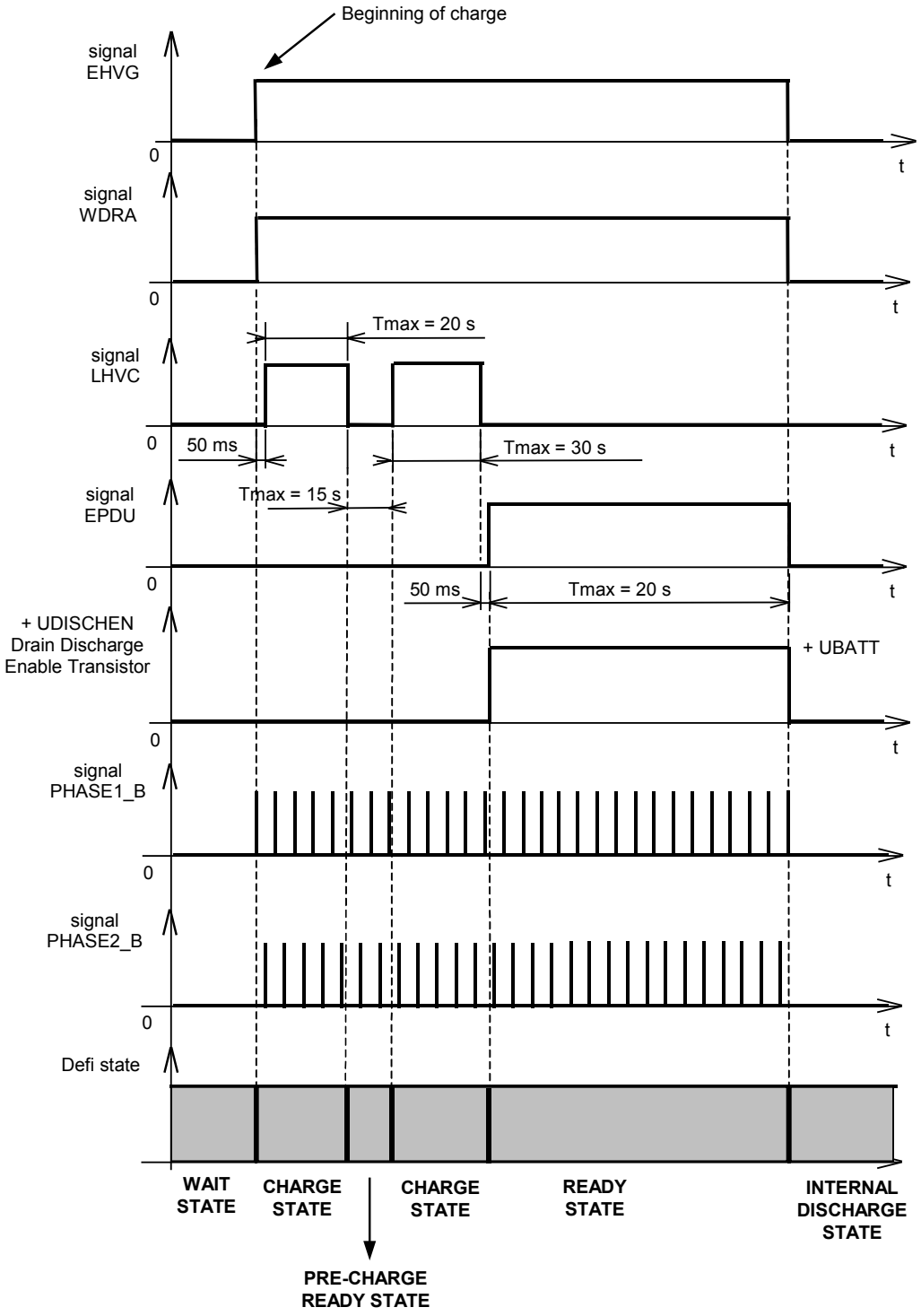
5.2.3. CHRONOGRAMS

5.2.3.1. HV CAPACITOR CHARGE.

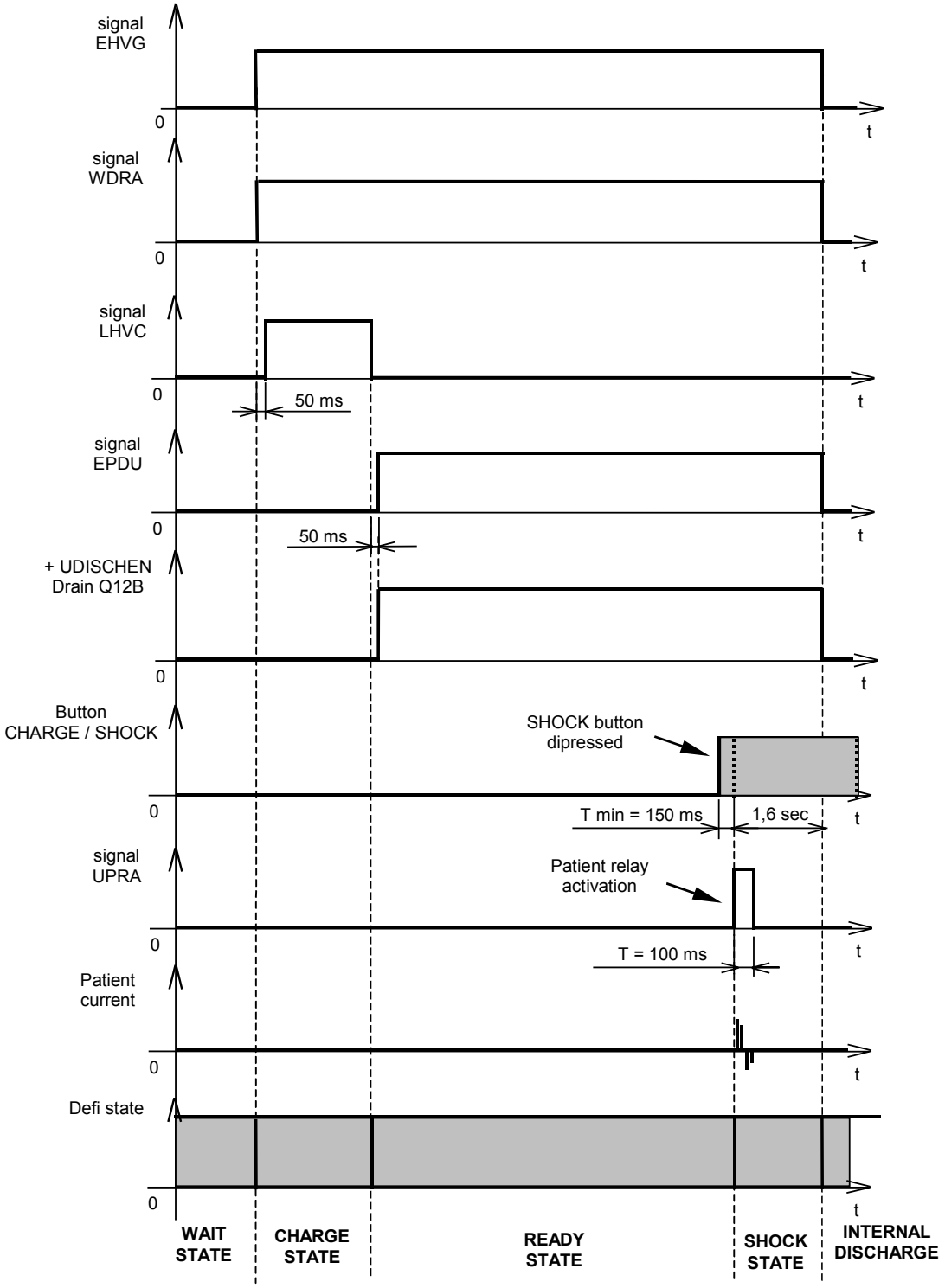


5.2.3.2. HV CAPACITOR PRE-CHARGE AND CHARGE

Semiautomatic mode operation



5.2.3.3. HOLD PHASE AND DEFIBRILLATION SHOCK.



5.2.4. DESCRIPTION OF SIGNALS

The names of signals refer to **chart DG 5000 Defibrillator circuit.**

5.2.4.1. ECG PREAMPLIFIER

ECG preamplifier input signals:

+VFM: Positive floating power supply voltage.
+5 V supply voltage generated in the floating part of the 10-channel ECG preamplifier circuit.
⇒ This power supply voltage ranges from +4.8 V to +5.2 V.

-VFM: Negative floating power supply voltage.
-6 V supply voltage generated in the floating part of the 10-channel ECG preamplifier.
⇒ This power supply voltage ranges from –5.5 V to –6.5 V.

FGND: Floating reference potential
Reference potential (floating ground) of the floating part of the 10-channel ECG preamplifier.
⇒ Floating reference potential 0 V.

STERNUM: ECG signal from the defibrillation electrode connector
Signal STERNUM is used to acquire the patient ECG signal by means of the defibrillation electrodes connected to the defibrillation electrode connector.
During the defibrillation shock, signal STERNUM is connected to the high-voltage circuit of the defibrillator by the patient relay.
⇒ Signal for acquiring the patient ECG through the defibrillation electrodes.

APEX: ECG signal from the defibrillation electrode connector.
Signal APEX is used to acquire the patient's ECG signal through the defibrillation electrodes connected to the defibrillation electrode connector.
During the defibrillation shock, signal APEX is connected to the high-voltage circuit of the defibrillator by the patient relay.
⇒ signal for acquiring the ECG patient through the defibrillation electrodes.

INH_PACE: Pacemaker Inhibition.
Logical signal generated by the microcontroller in the floating part of the 10-channel ECG preamplifier circuit for activating an analogue switch in the amplification chain of the ECG signal if pacemaker pulses are recognised. Signal INH_PACE is referenced in relation to FGND. If pacing pulses are detected, signal INH_PACE becomes active for the duration of the pacing pulse.
⇒ Input signal INH_PACE ranges from 0V to +5V. The signal is active when low (active at 0V).

10 Hz: 10 Hz Test Signal.
Logical signal generated by the microcontroller in the floating part of the circuit 10-channel ECG preamplifier circuit which is used to test the ECG acquisition chain when the device is switched on. During the test of the ECG signal acquisition chain, the 10-Hz signal produces a 10-Hz square signal oscillating between 0 V and +5 V. When the 10-Hz signal is inactive, it is at +5 V.
⇒ The 10-Hz input signal oscillates from 0 V to +5 V during the acquisition chain test. Normally (signal inactive), the 10-Hz signal is at +5 V.

QRS_TRIG_F: QRS Trigger Signal.
Logical signal generated by the microcontroller in the floating part of the 10-channel ECG preamplifier circuit, enabling the operating of synchronised defibrillation. Signal QRS_TRIG_F is referenced in relation to FGND. The duration of pulse QRS_TRIG_F is 100 ms. Signal QRS_TRIG_Fest is active during the QRS wave.
⇒ Input signal QRS_TRIG ranges from 0 V to +5 V. The signal is active when low (active at 0 V).

ECG preamplifier output signals:

ECG_DEFI: Defibrillator ECG Signal.
Analogue signal that corresponds to the ECG signal of the patient collected by means of the defibrillation electrodes. Signal ECG_DEFI has a gain of 35 in relation to the input signal.
⇒ Signal ECG_DEFI is located in the 0 V to +5 V range, centred on +2.048 V.

Z_ELEC_DEFI: Defibrillator Electrode Impedance Signal.
Analogue signal where the amplitude (in steps) corresponds with an impedance range connected between the two defibrillation electrodes. This signal is used to determine the patient-electrodes impedance range in order to check if the defibrillation electrodes are stuck properly.
⇒ Signal Z_ELEC_DEFI ranges from 0 V to +3 V maximum.

DEFI_AVALAIBLE: Defibrillator Available Signal.
⇒ Signal DEFI_AVALAIBLE is connected to FGND.

-PIMP_DEF: Patient Impedance Out of Range.
Logical signal from the patient impedance measurement chain via the defibrillation electrodes. Signal –PIMP_DEF is referenced in relation to GND. Signal –PIMP_DEFI is high when the patient impedance is located between 30 Ω and 220 Ω. Out of these limits, the signal is low.
⇒ Signal –PIMP_DEF ranges from 0 V to +5 V.

-QRSTRIG_DEF: Defibrillator QRS Trigger Signal.
Logical signal from signal QRS_TRIG_F transmitted by the microcontroller in the floating part of the 10-channel ECG preamplifier circuit. Signal -QRSTRIG_DEF is referenced in relation to GND. Signal -QRSTRIG_DEF is active during the QRS wave.
⇒ Signal -QRSTRIG_DEF ranges from 0 V to +5 V. The signal is active when low (active at 0 V).

5.2.4.2. DEFIBRILLATOR CONTROL CIRCUIT

Defibrillator control circuit input signals

-PCIS: Paddle Charge Input Signal.
Signal used to trigger the charge with the two Charge/Shock buttons of the handheld paddle electrodes.
⇒ Input signal –PCIS is active when low, when either of the Charge/Shock keys is pressed (0V if the key is pressed).

-ELECTR: Sticking electrode connected.
Logical signal to detect the connection of defibrillation electrodes into the adhesive electrode cartridge.
⇒ Input signal–ELECTR is active when low when a pair of adhesive electrodes is connected to the cartridge (0V if electrodes connected).

DKY 1: Discharge Key 1.
Signal corresponding to the mid point of the two Charge/Shock keys connected in series of the handheld paddle electrodes.
⇒ Input signal DKY 1 is active when low when the Charge/Shock key connected to the ground is pressed (0 V if the key is pressed).

WREF: Energy Reference.
Analogue reference voltage that corresponds to the energy value selected by means of the energy selector of the handheld paddle electrodes.
⇒ Input signal WREF ranges from 0 to +4 V.

FPR_LED: Front Panel Ready Led.
Signal that directly controls the lighting of the LEDs corresponding to the Defibrillator Ready phase in the Shock key on the front. This signal is interconnected to the Ready signal in the adhesive electrode cartridge.
⇒ Signal FPR_LED is active when high (+5 V for lighting the LEDs).

DKY 2: Discharge Key 2.
Logical signal corresponding to the signal from the two Charge/Shock keys connected in series of the handheld paddle electrodes or from the Shock key on the front of the device, if the adhesive electrode cartridge is being used. This signal is used activate the entirely hardware channel for triggering the shock.
⇒ Input signal DKY 2 is active when low when the Charge/Shock key/s is/are pressed (0 V if key pressed).

MOD 0: Defibrillator Module Presence.
Logical signal used to verify the presence of a defibrillation cartridge.
⇒ Input signal MOD 0 is active when low (0 V if cartridge present).

MOD 1: Defibrillator Module Type.
Analogue signal that is used to identify the type of defibrillation cartridge.
⇒ Input signal MOD 1 ranges from 0 to + 5 V.
⇒ If handheld paddle electrodes cartridge: signal MOD 1 = + 0.6 V.
⇒ If internal electrode cartridge: signal MOD 1 = + 2.6 V.
⇒ If adhesive electrode cartridge: signal MOD 1 = + 3.0 V with child electrodes
⇒ If adhesive electrode cartridge: signal MOD 1 = + 3.4 V with adult electrodes

REC: Recorder Start.
Analogue signal that corresponds with the status of the Recorder key on one of the two handheld paddle electrodes, which is used to trigger the graph from the electrodes.
⇒ During the standby phase, the REC input signal ranges from 0 to + 5 V with the key pressed in.
⇒ During the hold phase, the REC input signal ranges from +4.0 V to + 3.6 V with the key pressed in.

-FPS_KEY: Front Panel Shock Key.
Logical signal that is used to trigger the shock by means of the Shock key on the front panel. The signal is interconnected with signals DKY1 and DKY2 in the internal electrode and the adhesive electrode cartridges.
⇒ Input signal –FPS_KEY is active when low when the internal or adhesive electrode cartridges are used, and the Shock key on the front is pressed in (0 V if key pressed).

-ANAKEY: Analyse Key.
Logical signal corresponding to the status of the Analyse key on the front.
⇒ Input signal –ANAKEY is active when low (0 V when the key is pressed).

FDUOS: Failure Discharge Unit Output.
Logical signal that corresponds to the tripping of the safety latch. The safety latch is voluntarily triggered upon powering up by signal -SFDU to check its proper operation. If any hardware faults are detected, the fault latch is tripped by one of the input signals - CHVM, DUFD, IGFD. When the latch is triggered, signal FDUOS is high.
⇒ Input signal FDUOS is active when high (active at +5 V).

-PIMP: Patient Impedance Out of Range.
Logical signal from the patient impedance measurement chain. Signal -PIMP is high when the patient impedance is located between about 30 Ω and 220 Ω. Outside these limits, the signal is low.
⇒ Input signal -PIMP is located between 0 V and +5 V.

-QRS: Defibrillator QRS Trigger Signal.
Logical signal from signal –QRSTRIG_DEF transmitted by microcontroller in the floating part of the 10-channel ECG preamplifier. Signal –QRS corresponds to buffered signal –QRSTRIG. Signal -QRS is active during the QRS wave.
⇒ Signal -QRS is active when low (active at 0 V).

-MCLR: Master Clear Defibrillator Microcontroller.
Logical signal for resetting the defibrillator microcontroller when the device is switched on or through the microprocessor of the CPU board.
⇒ Input signal -MCLR is active when low.

RxD_Defi: Defibrillator Data Receiver.
Logical signal of data reception from the serial link, sent by the microprocessor of the CPU board. The data are transmitted in frames every 100 ms.
⇒ Input signal RxD_Defi is normally high. The frames corresponding to the data are active when low.

-TDEF: Test defibrillator.
Logical signal from the circuit including the defibrillator test circuit detection core, which is used to differentiate 'external' defibrillation and a defibrillator test. During a defibrillator test, signal –TDEF switches to low during the shock.
⇒ Signal –TDEF is active when low (active at 0 V).

THVM: Transformer High Voltage Measurement.
Analogue signal that makes up the first channel for measuring the charging voltage of the HV capacitor. This measurement is taken by means of the primary winding of the HV converter. Signal THVM is taken into account by the defibrillator microcontroller to stop charging the HV generator.
⇒ Signal THVM ranges from 0 to +4 V maximum.
⇒ Scale factor: THVM (V) = U_{HT} (V) / 850 where U_{HT} → charging voltage of the HV capacitor.

CHVM: Capacitor High Voltage Measurement.
Analogue signal that makes up the second channel for measuring the charging voltage of the HV capacitor. This measurement is taken by means of two voltage dividers with a high resistive value, which are referenced to the ground and balance the high-voltage circuit voltage. Signal CHVM is taken into account by the defibrillator microcontroller and transmitted by the serial link to the host CPU to display the energy stored, corrected for 50 Ω. The signal is also used if there is a fault in the stopping of the charge by latch FDU. The maximum charging voltage of the HV capacitor must not exceed 3.4 kV.
⇒ Signal CHVM ranges from 0 to +4 V maximum.
⇒ Scale factor: CHVM (V) = U_{HT} (V) / 850 where U_{HT} → charging voltage of the HV capacitor.

CTFC: Charge Transistor Fault Condition.
Analogue signal that is used to detect any short circuit in the Charge transistor Q1, which powers the high-voltage unit. The transistor is considered to have failed when signal CTFC is greater than 1.0 V before the start of the charging of the HV capacitor.

IPAT: Patient Defibrillation Current.
Analogue signal that corresponds to the measurement of the patient current during a defibrillation shock. The signal is used to compensate the pulse biphasic wave according to the patient impedance. For a maximum voltage value of 3100 V, the maximum patient current is 103 A (for a patient impedance of 30 Ω).
⇒ Signal IPAT ranges from 0 to +4 V maximum.
⇒ Scale factor: IPAT (V) = I peak (A) / 35 where I peak → patient peak current.

Defibrillator control circuit output signals:

TxD_Defi: Defibrillator Data Transmitter.
Logical signal of data transmission from the serial link, sent by the defibrillator microcontroller. The data are transmitted in frames every 100 ms.
⇒ Input signal TxD_Defi is normally high. The frames corresponding to the data are active when low.

ANALED: Analyse LED
Buffered logical signal that directly controls the switching on or flashing of the corresponding LED of the Analyse key on the front panel.
⇒ Output signal ANALED is active when high (+5 V to switch on the LED).

-READY: Defibrillator Ready (inverse)
Buffered logical signal that allows the switching on of the Defibrillator Ready indicator LED in the handheld paddle electrode that has the Recorder key that is used to trigger the graph.
⇒ Output signal -READY is active when low (0 V for switching on the LED).

READY: Defibrillator Ready.
Buffered logical signal that enables the switching on of the Defibrillator Ready indicator LED in the handheld paddle electrodes with the energy selector and the Defibrillator Ready LEDs in the Shock key on the front panel.
⇒ Output signal READY is either at a high impedance or at + 5 V maximum.

DEFREADY: Defibrillator Ready.
Logical signal that corresponds to the buffered EPDU signal generated by the microcontroller of the defibrillator part. The signal is active during the entire duration of the hold phase. The duration of the signal is limited to 20 seconds maximum.
⇒ Input signal DEFREADY is active when high (active at +5 V).

EHVG: Enable High Voltage Generator.
Logical signal that powers the high-voltage unit. When it is active, the signal activates the Charge transistor and the power supply to chopping regulator U1, in order to authorise a request for charging the HV capacitor or a battery test.
⇒ Output signal EHVG is active when high (active at +5 V).

WDRA: Energy Dump Relay Activation.
Logical signal that activates the safety discharge relay of the high-voltage unit through a transistor. The signal is active during the entire duration of the defibrillation cycle. During a battery test, signal WDRA is not activated.
⇒ Output signal WDRA is active when high (active at +5 V).

LHVC: Load High Voltage Capacitor.
Logical signal that directly activates the HV generator in order to charge the HV capacitor. The signal is active throughout the duration of the charging of the HV capacitor till charging stops.
⇒ Output signal LHVC is active when high (active at +5 V).

EPDU: Enable Patient Discharge Unit.
Logical signal that switches on the shock delivery hardware circuit through a transistor. The signal is active during the entire hold phase, till the shock is delivered.
⇒ Output signal EPDU is active when high (active at +5 V).

UPRA: Micro-Controller Patient Relay Activation.
Logical signal from the defibrillator microcontroller, which activates a channel for triggering the patient relay by means of a transistor. The signal is active for 100 ms during the defibrillation shock.
⇒ Output signal UPRA is active when high (active at +5 V).

SYNC: Synchronisation.
Logical signal that controls either a DIRECT SHOCK or a SYNCHRONISED SHOCK depending on the operating mode transmitted by the microprocessor of the CPU board by means of the serial link. In the direct mode, signal SYNC is low. In synchronised mode, signal SYNC is high.
⇒ Output signal SYNC is active when high for synchronised shocks.

-SFDU: Set Failure Detection Unit.
Logical signal from the defibrillator microcontroller, which trips the safety latch when the device is powered up, before it is tested by the microcontroller. Signal –SFDU is active for 5 ms.
⇒ Output signal -SFDU is active when low (active at 0 V).

-RFDU: Reset Failure Detection Unit.
Logical signal that directly resets the safety latch to zero after it is tested upon power up. Signal –RFDU is active for 5 ms.
⇒ Output signal -RFDU is active when low (active at 0 V).

PHASE1_C: Phase 1 conduction.
Logical signal that makes the first-phase IGBTs conduct. The signal is only generated during the defibrillation shock. The Ton/Toff ratio of the signal is variable depending on the patient impedance.
⇒ Output signal PHASE1_C is active when high.

PHASE1_B: Phase 1 blocking.
Logical signal that blocks the first-phase IGBTs. During the charge, pre-charge completed and hold phases, signal PHASE1_B has a period of 16 ms and is offset by 8 ms in relation to signal PHASE2_B. During the shock phase, signal PHASE1_B is generated after every 30 ms and offset by 5 ms in relation to signal PHASE2_B.
When it is active, signal PHASE1_B has a duration of 200 µs.
⇒ Output signal PHASE1_B is active when high.

PHASE2_C: Phase 2 conduction.
Logical signal that makes the second-phase IGBTs conduct. The signal is only generated during the defibrillation shock. The Ton/Toff ratio of the signal is variable depending on the patient impedance.
⇒ Output signal PHASE2_C is active when high.

PHASE2_B: Phase 2 blocking.
Logical signal that blocks the second-phase IGBTs. During the charge, pre-charge completed and hold phases, signal PHASE2_B has a period of 16 ms and is offset by 8 ms in relation to signal PHASE1_B. During the shock phase, signal PHASE2_B is generated after every 30 ms and offset by 5 ms in relation to signal PHASE1_B.
When it is active, signal PHASE2_B has duration of 200 µs.
⇒ Output signal PHASE2_B is active when high.

5.2.4.3. HIGH-VOLTAGE CIRCUIT

High-voltage circuit input signals:

DC: DC Power Supply.
Filtered power supply voltage from the power supply circuit of DG5000. The DC power supply voltage is used to supply current for the working of the HV generator while charging the HV capacitor.
⇒ The DC power supply voltage ranges from +9 V to +15 V.

-EHVG: Enable High Voltage Generator.
Logical signal (buffered open-collector) that that switches on the high-voltage unit. When it is active, the signal activates the Charge transistor and the power supply of chopping regulator U1 in order to authorise a request for a charge of the HV capacitor or a battery test.
⇒ Input signal -EHVG is active when low (active at 0 V, open collector).

WDRAb: Energy Dump Relay Activation.
Buffered logical signal that activates the safety discharge transistor of the high-voltage unit by means of a transistor. The signal is active during the entire duration of a defibrillation cycle. During a battery test, signal WDRAb is not activated.
⇒ Input signal WDRAb is active when high (active at +5 V).

LHVCb: Load High Voltage Capacitor.
Buffered logical signal that directly activates the HV generator in order to charge the HV capacitor. The signal is active during the entire duration of the charge phase of the HV capacitor till charging stops.
⇒ Input signal LHVCb is active when high (active at +5 V).

-EPDU: Enable Patient Discharge Unit.
Logical signal (buffered open collector) that switches on the shock delivery hardware circuit by means of a transistor. This signal is active during the entire duration of the hold phase till the shock is delivered.
⇒ Input signal -EPDU is active when low (active at 0 V, open collector).

UPRAb: Micro-Controller Patient Relay Activation.
Buffered logical signal from the defibrillator microcontroller that activates one channel for triggering the patient relay by means of a transistor. This signal is active for 100 ms during the defibrillation shock.
⇒ Input signal UPRAb is active when high (active at +5 V).

-SYNC: Synchronisation.
Logical signal (buffered, open collector) that controls either a DIRECT SHOCK or a SYNCHRONISED SHOCK depending on the operating mode of the device. Signal –SYNC drives a transistor in the patient relay activation chain. Signal–SYNC corresponds to signal SYNC generated by the defibrillator microcontroller and hard coupled to the QRS pulses.
⇒ Input signal -SYNC is active when low (active at 0 V, open collector).

DKY 2: Discharge Key 2.
Logical signal that corresponds to the signal from the two Charge/Shock keys connected in series of the handheld paddle electrodes or from the Shock key on the front panel, if the adhesive electrode cartridge is being used. This signal is used to activate the entirely hardware channel for triggering the shock.
⇒ Input signal DKY 2 is active when low and when the Charge/Shock key or keys is/are pressed in (0 V when the key is pressed).

PHASE1_C: Phase 1 conduction.
Logical signal that makes the first-phase IGBTs conduct. This signal is only generated during the defibrillation shock. The Ton/Toff ratio of the signal varies depending on the patient impedance.
⇒ Output signal PHASE1_C is active when high.

PHASE1_B: Phase 1 blocking.
Logical signal that makes the first-phase IGBTs block. During the charge, pre-charge completed and hold phases, signal PHASE1_B has a period of 16 ms and is offset by 8 ms in relation to signal PHASE2_B. During the shock phase, signal PHASE1_B is generated after every 30 ms and offset by 5 ms in relation to signal PHASE2_B.
When it is active, signal PHASE1_B has a duration of 200 µs.
⇒ Output signal PHASE1_B is active when high.

PHASE2_C: Phase 2 conduction.
Logical signal that makes the second-phase IGBTs conduct. The signal is only generated during the defibrillation shock. The Ton/Toff ratio of the signal is variable depending on the patient impedance.
⇒ Output signal PHASE2_C is active when high.

PHASE2_B: Phase 2 blocking.
Logical signal that blocks the second-phase IGBTs. During the charge, pre-charge completed and hold phases, signal PHASE2_B has a period of 16 ms and is offset by 8 ms in relation to signal PHASE1_B. During the shock phase, signal PHASE2_B is generated after every 30 ms and offset by 5 ms in relation to signal PHASE1_B.
When it is active, signal PHASE2_B has duration of 200 µs.
⇒ Output signal PHASE2_B is active when high.

PACE_NEG: Pacer negative
Reference potential of the pacemaker output stage that supplies the pacing pulses (optional pacemaker). This line is insulated during the shock by the inverting contacts of the patient relay.
⇒ Line PACER_NEG corresponds to the floating potential reference of the pacemaker.

PACE_POS: Pacer positive
Source of pacing pulses supplied by the pacemaker output stage. This line is referenced in relation to PACE_NEG (optional pacemaker). This line is insulated during the shock by the inverting contacts of the patient relay.
⇒ Line PACER_POS corresponds to the pacing pulses generated by the pacemaker.

High-voltage circuit output signals:

THVM: Transformer High Voltage Measurement.
Analogue signal that makes up the first channel for measuring the charging voltage of the HV capacitor. The measurement is taken by means of the primary winding of the HV converter. Signal THVM is applied by the defibrillator microcontroller to stop charging the HV generator.
⇒ Signal THVM ranges from 0 to +4 V maximum.
⇒ Scale factor: THVM (V) = U_{HT} (V) / 850 where U_{HT} → charging voltage of the HV capacitor.

CHVM: Capacitor High Voltage Measurement.
Analogue signal that makes up the second channel for measuring the charging voltage of the HV capacitor. The measurement is taken by means of two voltage dividers with a high resistive value referenced to the ground, which balance the voltage of the high-voltage circuit. Signal CHVM is applied by the defibrillator microcontroller and transmitted by a serial link to the host CPU to display the stored energy corrected for 50 Ω. The signal is also used if there is any fault in the stopping of the charge by means of latch FDU. The maximum charging voltage of the HV capacitor must not exceed 3.4 kV.
⇒ Signal CHVM ranges from 0 to +4 V maximum.
⇒ Scale factor: CHVM (V) = U_{HT} (V) / 850 where U_{HT} → charging voltage of the HV capacitor.

CTFC: Charge Transistor Fault Condition.
Analogue signal for detecting any short circuit of Charge transistor Q1, which switches on the high-voltage unit. The transistor is considered to be failing if signal CTFC is greater than 1.0 V before the starting of the charging of the HV capacitor.

IPAT: Patient Defibrillation Current.
Analogue signal that corresponds to the measurement of the patient current during a defibrillation shock. This signal is used to compensate the pulse biphasic wave on the basis of the patient impedance. With a maximum charging voltage of 3100 V, the maximum patient current is 103 A (with a patient impedance value of 30 Ω).
⇒ Signal IPAT ranges from 0 to +4 V maximum.
⇒ Scale factor: IPAT (V) = I peak (A) / 35 where I peak → patient peak current.

DUFD: Discharge Unit Failure Detection.
Analogue signal that corresponds to the mid point of the two transistors that activate the patient relay. Signal DUFD triggers the safety latch when one of the two relay activation transistors conducts for more than 2.5 s. That makes it possible to detect any short circuit in one of the two transistors (or both).
⇒ Input signal DUFD ranges from 0 V to the power supply voltage of the DC line.

IGFD: IGBT Failure Detection.
Analogue signal that corresponds to the differential potential between the mid points of the two branches of the H bridge. The signal is amplified and its amplitude is compared to a reference limit. Signal IGFD triggers the safety latch when the IGBT or IGBTs of one branch of the H bridge conduct/s for more than 1.5 s. That will enable the detection of a possible short circuit in the IGBTs of the HV switching stage.
⇒ Signal IGFD is active when low (active at 0 V).

APEX: Apex electrode of the defibrillator connector
Connection between the defibrillator/pacemaker part and the patient by means of the patient electrode connector. This connection makes it possible to collect the ECG signal from the patient, perform cardiac defibrillation and pacing (if the optional pacemaker is installed).
⇒ Line APEX is connected to the floating potential of the pacemaker by the inverting contacts of the patient relay. During the defibrillation shock (patient relay active), the pacemaker is disconnected from the defibrillator HV circuit.

STERNUM: Sternum electrode of the defibrillator connector
Connection between the defibrillator/pacemaker part and the patient by means of the patient electrode connector. This connection makes it possible to collect the ECG signal from the patient, perform cardiac defibrillation and pacing (if the optional pacemaker is installed).
⇒ Line STERNUM is connected to the floating potential of the pacemaker by the inverting contacts of the patient relay. During the defibrillation shock (patient relay active), the pacemaker is disconnected from the defibrillator HV circuit.

5.2.4.4. FAULT DETECTION CIRCUIT

Fault detection circuit input signals:

-SFDU: Set Failure Detection Unit.
Logical signal from microcontroller U27 that triggers the safety latch when the device is powered up before it is tested by the microcontroller. Signal –SFDU is active for 5 ms.
⇒ Input signal -SFDU is active when low (active at 0 V).

-RFDU: Reset Failure Detection Unit.
Logical signal that directly resets the safety latch to zero after it is tested when the device is powered up. Signal –RFDU is active for 5 ms.
⇒ Input signal -RFDU is active when low (active at 0 V).

CHVM: Capacitor High Voltage Measurement.
Analogue signal that makes up the second channel for measuring the charging voltage of the HV capacitor. This signal is used to activate the safety latch if there is any fault in stopping the charge. The maximum charging voltage must not exceed 3.4 kV.
⇒ Signal CHVM ranges from 0 to +4 V maximum.
⇒ Scale factor: CHVM (V) = U_{HT} (V) / 850 where $U_{HT} \rightarrow$ charging voltage of the HV capacitor.

DUFD: Discharge Unit Failure Detection.
Analogue signal that corresponds to the mid point of the two transistors that activate the patient relay. Signal DUFD triggers the safety latch when one or both relay activation transistors conduct for more than 2.5 s. That makes it possible to detect any short circuit in one of the two transistors (or both).
⇒ Input signal DUFD ranges from 0 V to the DC power supply voltage.

IGFD: IGBT Failure Detection.
Analogue signal that corresponds to the differential potential between the mid points of the two branches of the H bridge. The signal is amplified and its amplitude compared to a reference limit. Signal IGFD triggers the safety latch when the IGBT or IGBTs of a branch of the H bridge conducts for more than 1.5 s. That makes it possible to detect any short circuit in the IGBTs of the HV switching stage.
⇒ signal IGFD is active when low (active at 0 V).

Fault detection circuit output signals:

FDUO: Failure Discharge Unit Output.
Logical signal that corresponds to the triggering of the safety latch. The latch is triggered upon power up to check if it is operating correctly. It is triggered by means of signal –SFDU. If any hardware fault is detected, the fault latch is triggered by one of the input signals - CHVM, DUFD, IGFD. When the latch is triggered, signal FDUO is high.
⇒ Output signal FDUO is active when high (active at +5 V).

5.2.4.5. OPTIONAL PACEMAKER

Pacemaker input signals:

+12 V: +12 V Supply.
The +12V power supply voltage is used to supply the current required for the operating of the stage that generates the pacing pulses.
⇒ The +12 V power supply voltage comes from the power supply circuit of DG5000.

+5 V_CPU: +5 V Supply.
The +5 V_CPU power supply voltage powers the non-floating control circuit of the pacemaker circuit.
⇒ The +5 V power supply voltage comes from the CPU board of DG5000.

RxD_PACER: Pacemaker Data Receiver.
Logical signal relating to the reception of data through the serial link from the microprocessor of the CPU board. The data are transmitted in frames every 500 ms.
⇒ Input signal RxD_PACER is normally high. The frames corresponding to the data are active when low.

PACER_ON/OFF: Pacemaker On /Off
Logical signal from the CPU board via an optocoupler, which is used to control the starting or stopping the pacemaker function.
⇒ Signal PACER_ON/OFF ranges from 0 to +12 V. The signal is active when low (pacemaker operating).

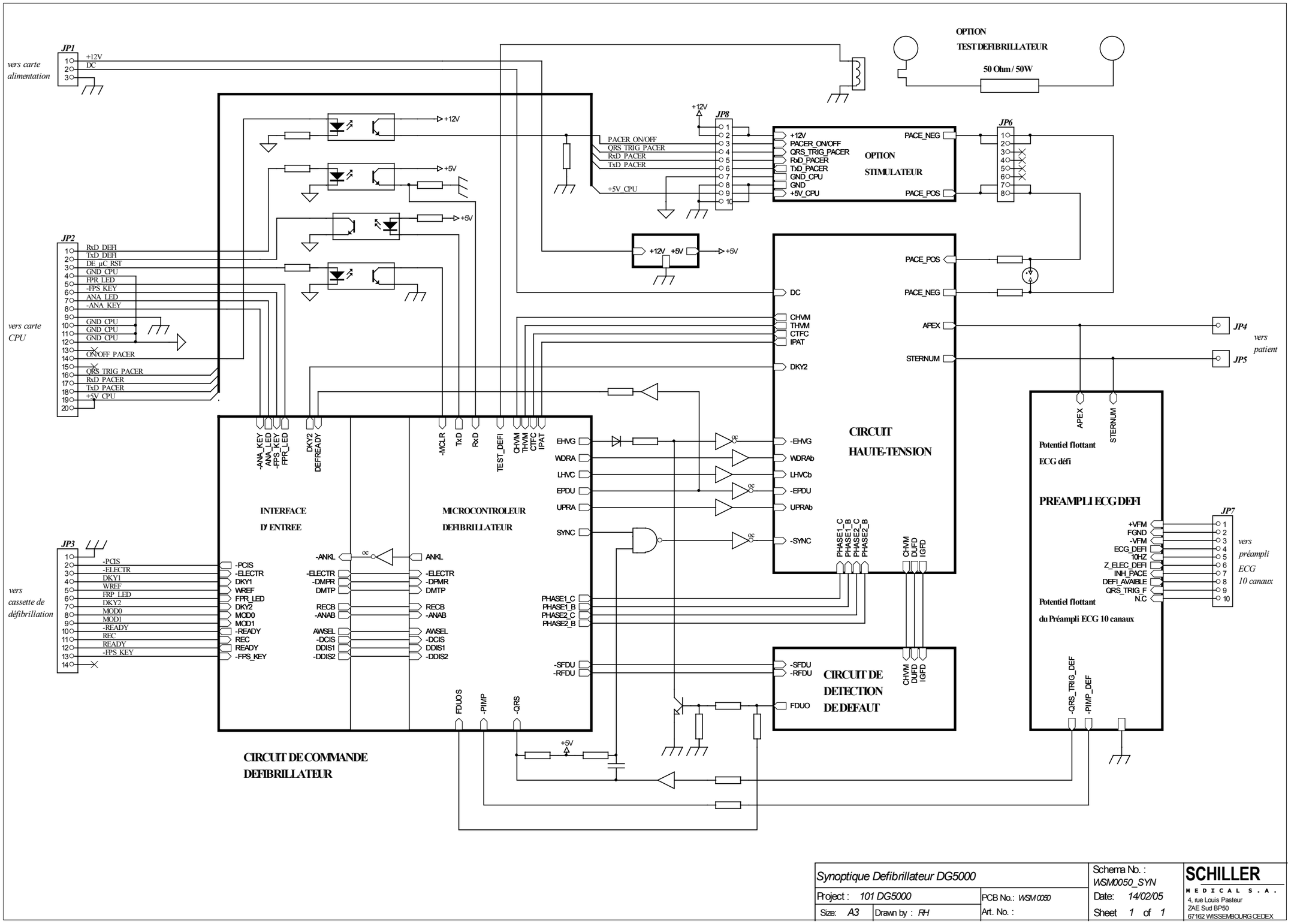
QRS_TRIG_PACER: QRS Trigger for Pacemaker.
Logical signal for QRS wave synchronisation from the CPU board. This signal is used for the Demand operating mode of the pacemaker.
⇒ Signal QRS_TRIG_PACER ranges from 0 to +5 V. The signal has a duration of 100 ms and is active when high (active at +5 V).

Pacemaker output signals:

TxD_PACER: Pacemaker Data Transmitter.
Logical signal relating to the transmission of data through the serial link from the pacemaker microcontroller. The data are transmitted in frames every 500 ms.
⇒ Input signal TxD_PACER is normally high. The frames corresponding to the data are active when low.

PACE_NEG: Pacemaker negative
Reference potential of the pacemaker output stage, which supplies pacing pulses. This line is insulated during the shock by the inverting contacts of the patient relay.
⇒ Line PACER_NEG corresponds to the floating reference potential of the pacemaker.

PACE_POS: Pacemaker positive
Source of pacing pulses supplied by the pacemaker output stage. This line is reference in relation to PACE_NEG and insulated during the shock by the inverting contacts of the patient relay.
⇒ Line PACER_POS corresponds to the pacing pulses generated by the pacemaker.



Synoptique Defibrillateur DG5000			Schema No. : *WSM0050_SYN*
Project : *101 DG5000*		PCB No.: *WSM0050*	Date: *14/02/05*
Size: *A3*	Drawn by : *RH*	Art. No. :	Sheet *1* of *1*

SCHILLER
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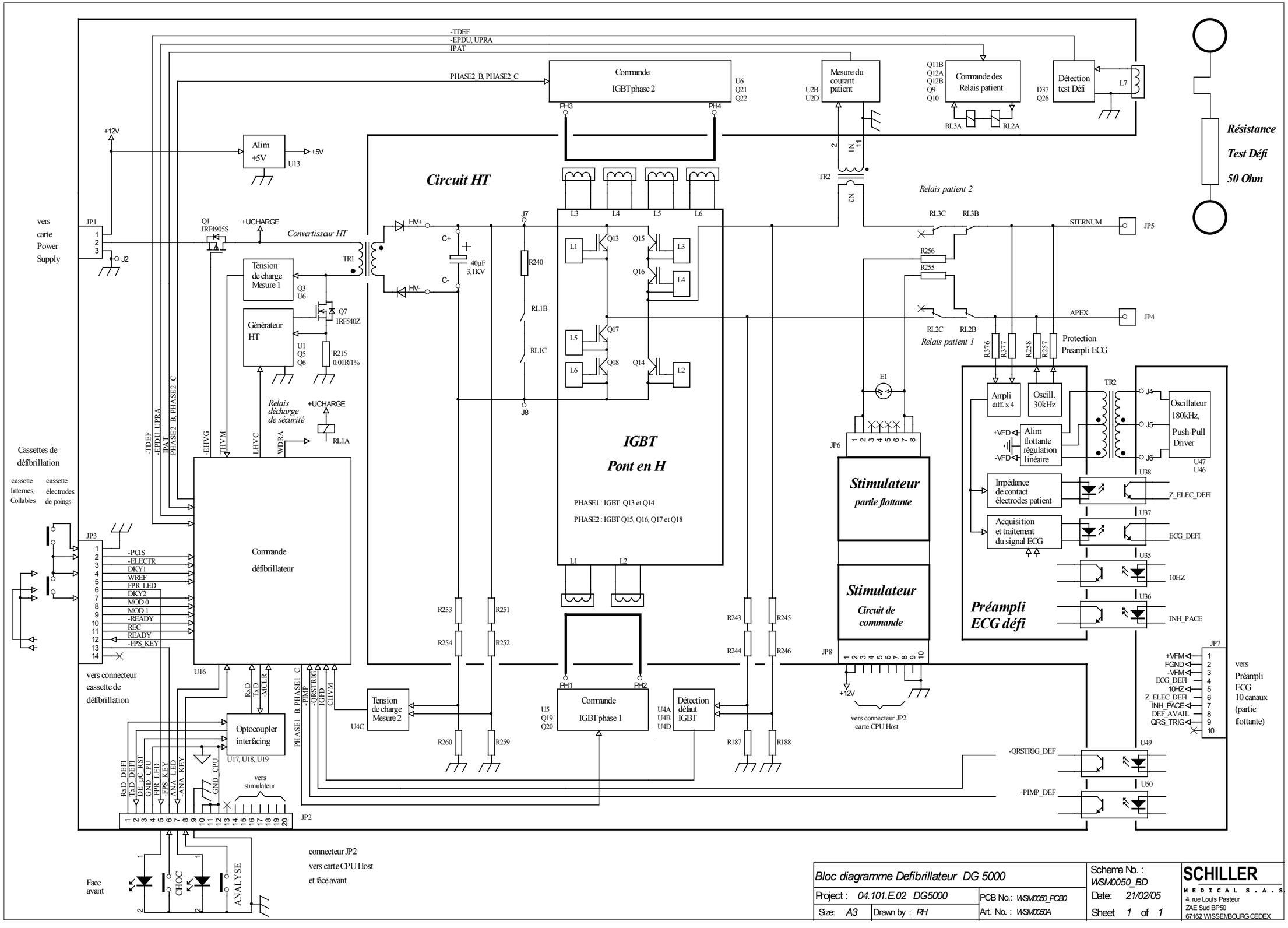
-TDEF
-EPDU, UPRA
IPAT
PHASE2_B, PHASE2_C
Commande
IGBT phase 2
U6
Q21
Q22
PH3
PH4
Mesure du
courant
patient
U2B
U2D
Q11B
Q12A
Q12B
Q9
Q10
Commande des
Relais patient
RL3A
RL2A
D37
Q26
Détection
test Défi
L7
Résistance
Test Défi
50 Ohm
+12V
Alim
+5V
+5V
U13
Circuit HT
TR2
N1
N2
Relais patient 2
vers
carte
Power
Supply
JP1
1
2
3
J2
Q1
IRF4905S
+UCHARGE
Convertisseur HT
TR1
HV+
HV-
C+
C-
40µF
3,1KV
J7
J8
L3
L4
L5
L6
L1
L2
Q13
Q15
Q16
Q17
Q18
Q14
R240
RL1B
RL1C
RL3C
RL3B
STERNUM
JP5
R256
R255
APEX
JP4
RL2C
RL2B
Relais patient 1
R376
R377
R258
R257
Protection
Preanpli ECG
Tension
de charge
Mesure 1
Q3
U6
Générateur
HT
Q7
IRF540Z
U1
Q5
Q6
R215
0.01R/1%
Relais
décharge
de sécurité
+UCHARGE
RL1A
-EHVG
-HVM
LHVC
WDRA
E1
JP6
Stimulateur
partie flottante
Stimulateur
Circuit de
commande
JP8
+12V
vers connecteur JP2
carte CPU Host
Ampli
diff. x 4
Oscill.
30kHz
TR2
J4
J5
J6
Oscillateur
180kHz,
Push-Pull
Driver
U47
U46
+VFD
-VFD
Alim
flottante
régulation
linéaire
U38
Impédance
de contact
électrodes patient
Z_ELEC_DEFI
U37
Acquisition
et traitement
du signal ECG
ECG_DEFI
U35
10HZ
U36
INH_PACE
Préampli
ECG défi
JP7
+VFM
FGND
-VFM
ECG_DEFI
10HZ
Z_ELEC_DEFI
INH_PACE
DEF_AVAIL
QRS_TRIG
vers
Préampli
ECG
10 canaux
(partie
flottante)
U49
-QRSTRIG_DEF
U50
-PIMP_DEF
Cassettes de
défibrillation
cassette
Internes,
Collables
cassette
électrodes
de poings
JP3
-PCIS
-ELECTR
DKY1
WREF
FPR_LED
DKY2
MOD 0
MOD 1
-READY
REC
READY
-FPS_KEY
Commande
défibrillateur
vers connecteur
cassette de
défibrillation
U16
RxD
TxD
-MCLR
Optocoupler
interfacing
U17, U18, U19
PHASE1_B, PHASE1_C
-PIMP
-QRSTRIG
IGFD
CHVM
Tension
de charge
Mesure 2
U4C
PH1
PH2
Commande
IGBT phase 1
U5
Q19
Q20
Détection
défaut
IGBT
U4A
U4B
U4D
R253
R254
R251
R252
R260
R259
R243
R244
R245
R246
R187
R188
IGBT
Pont en H
PHASE1 : IGBT Q13 et Q14
PHASE2 : IGBT Q15, Q16, Q17 et Q18
RxD_DEFI
TxD_DEFI
DE_µC_RST
GND_CPU
FPR_LED
-FPS_KEY
-ANA_LED
-ANA_KEY
GND_CPU
vers
stimulateur
JP2
Face
avant
CHOC
ANALYSE
connecteur JP2
vers carte CPU Host
et face avant
Bloc diagramme Defibrillateur DG 5000
Project : 04.101.E.02 DG5000
Size: A3
Drawn by : RH
PCB No.: WSM0050_PCB0
Art. No. : WSM0050A
Schema No. :
WSM0050_BD
Date: 21/02/05
Sheet 1 of 1
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5.3. CPU BOARD (part no. 3.2852)

This circuit has the part number 3.2652 or WSM0057A.

5.3.1. General

The CPU board is the main board of DG5000. It contains the operating system (Linux), all the associated applications, the display and the management of the keypad, the management of all the signals from the sensors and the management of all the inputs and outputs (devices).

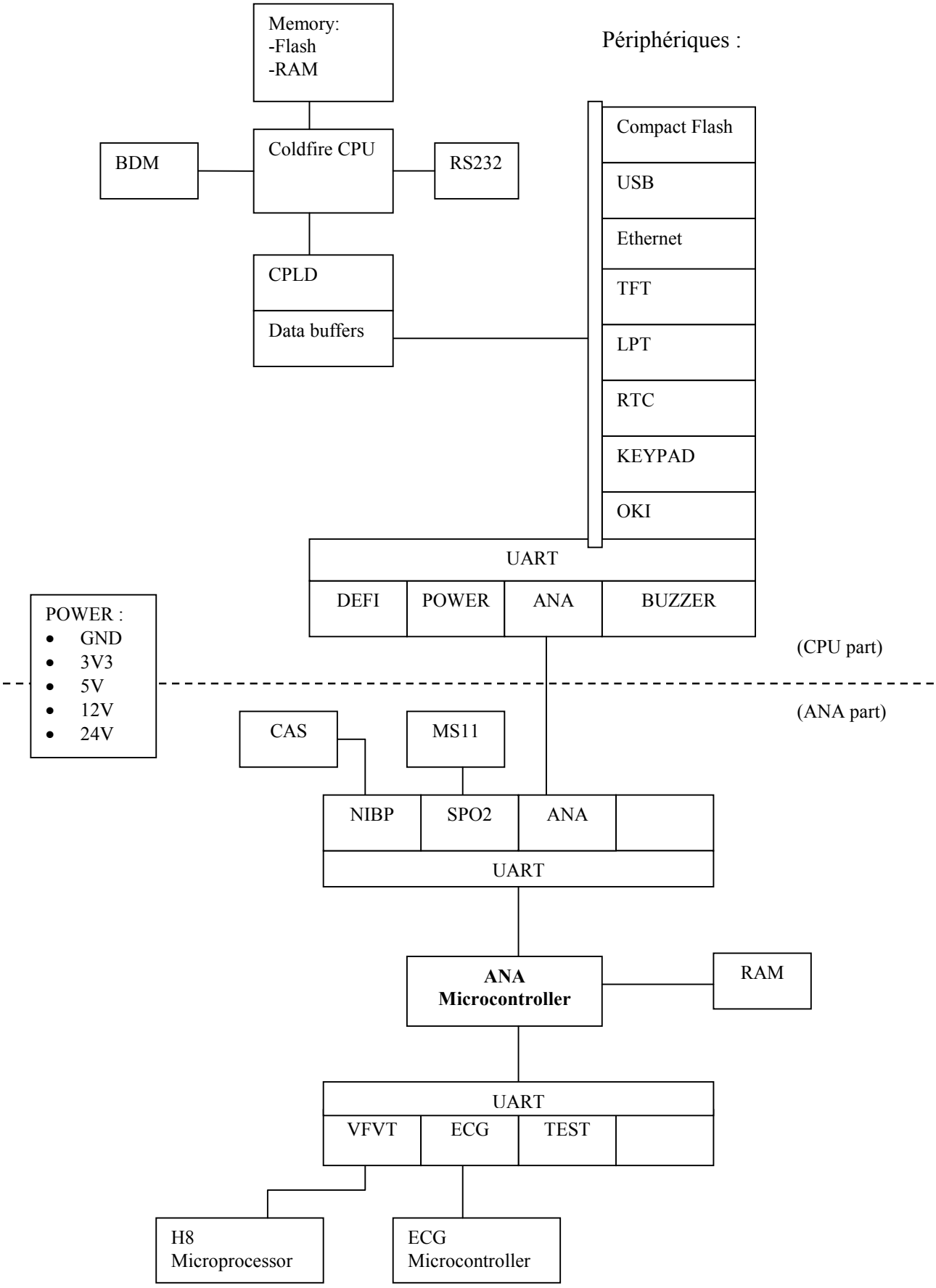
The CPU board can be divided into two large parts:
- CPU board
- ANA part

The CPU board contains the Coldfire microprocessor, the (RAM and flash) memory and devices such as Ethernet, USB, the TFT controller, the graph (LPT), the clock (RTC), the sound (OKI + Buzzer) and serial links. These serial links enable the board to communicate with the other boards of DG5000 (DEFIBRILLATOR and POWER) and the ANA part and the outside environment (RS232).
A programmable component (CPLD) is used to decode addresses (selecting the right device), generate reset signals and some control signals, managing the LPT port, keypad and the rotating button.

The ANA part is based on an Atmel microcontroller that manages the analogue signals of the sensors (Spo2, NIBP, ECG) and the VF data for detecting fibrillation. It communicates all the signals to the Coldfire microprocessor by means of a serial link.

The board is supplied with power by the POWER board.

5.3.2. Functional diagram:



5.3.3. Explanation of the various assemblies:

5.3.3.1. CPU board

The CPU is a Motorola Coldfire microprocessor, which executes the different programs (starting up, operating system and applications).

The flash memory contains the bootloader (booting program) and the operating system.

The programs that are running are contained in the RAM (working memory).

The BDM (Background Debug Mode) connector is used to debug and develop applications and hardware. It is also used for hardware tests.

A console connected to the RS232 output of the CPU shows what the microprocessor is doing and sends it instructions.

The CPU board access the flash memory and RAM directly. But data buffers are used for access to the different devices.

The CPLD handles address decoding and generates the Chip Select signals that individually activate each device. It also manages the signals of the keypad and the rotating button, the LPT port and the different control signals.

The compact flash memory contains the applications and configurations (options).

The CPU board of DG5000 has USB and Ethernet connections for communicating with the outside.

A 10"4 TFT screen is interfaced with a flat jumper.

An RTC (Real Time Clock) keeps the time of the device and wakes it up from time to time to perform the tests.

Alarms are generated by a Buzzer and an OKI component saves conversations and plays them back.

A QUAD UART is used for interfacing 4 serial links. These links are used to communicate with the buzzer, the Defibrillator boards (defibrillator status), the power board (battery status) and the ANA part (data from NIBP, SPO2, ECG, PACE and VF sensors).

5.3.3.2. ANA part

The ANA microcontroller collects the analogue signals from the various sensors (Spo2, NIBP, ECG, PACE and VFVT). It communicates all the signals to the Coldfire microprocessor through a serial link (ANA).

A CAS module is connected to the CPU board to calculate the non-invasive blood pressure (NIBP).

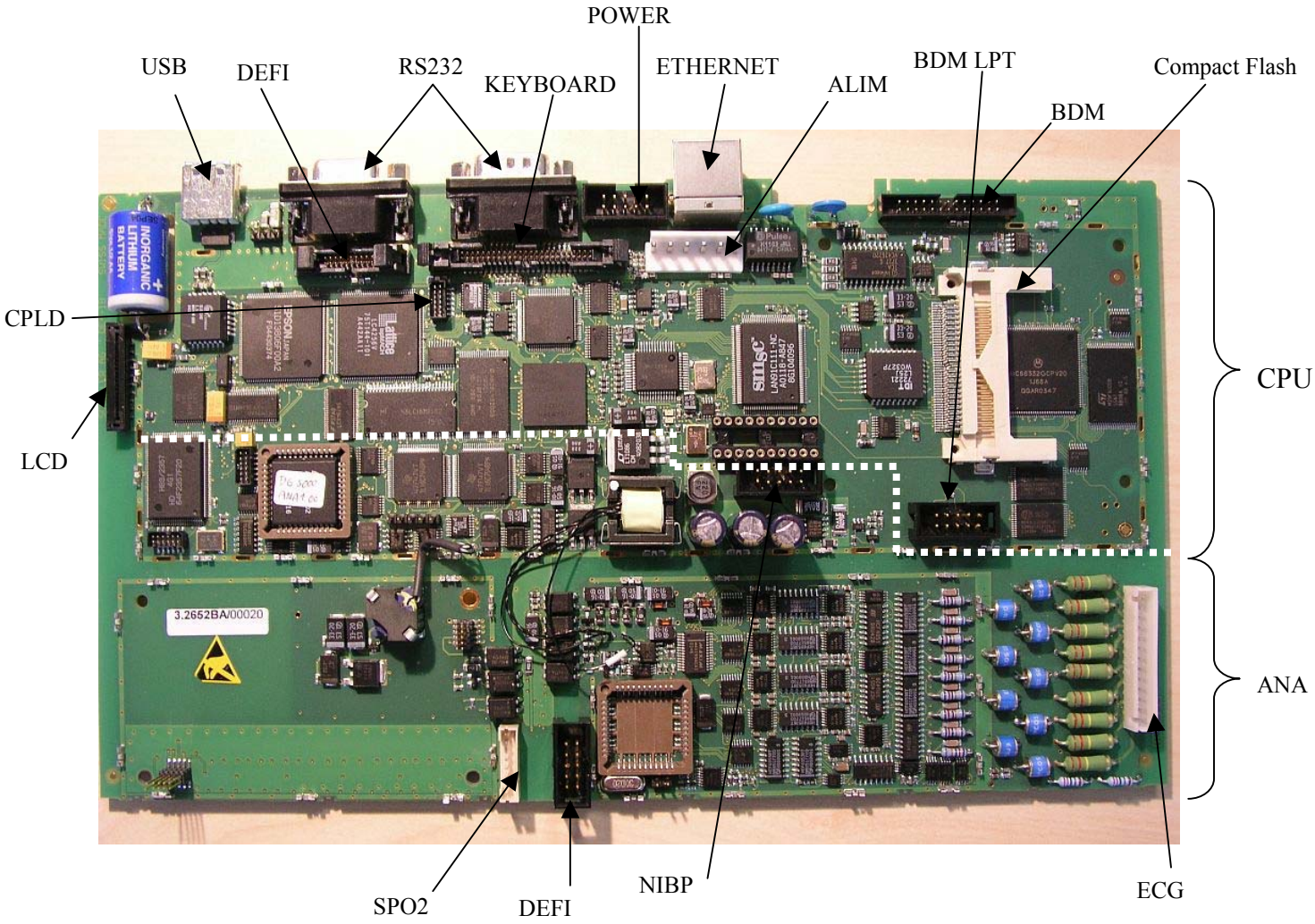
An MS11 module is used to calculate the SPO2 rate and pulse.

Microprocessor H8 is used to process signals and diagnose ventricular fibrillation or ventricular tachycardia.

An ECG microcontroller processes the data from the ECG chain and sends them to the ANA microcontroller.

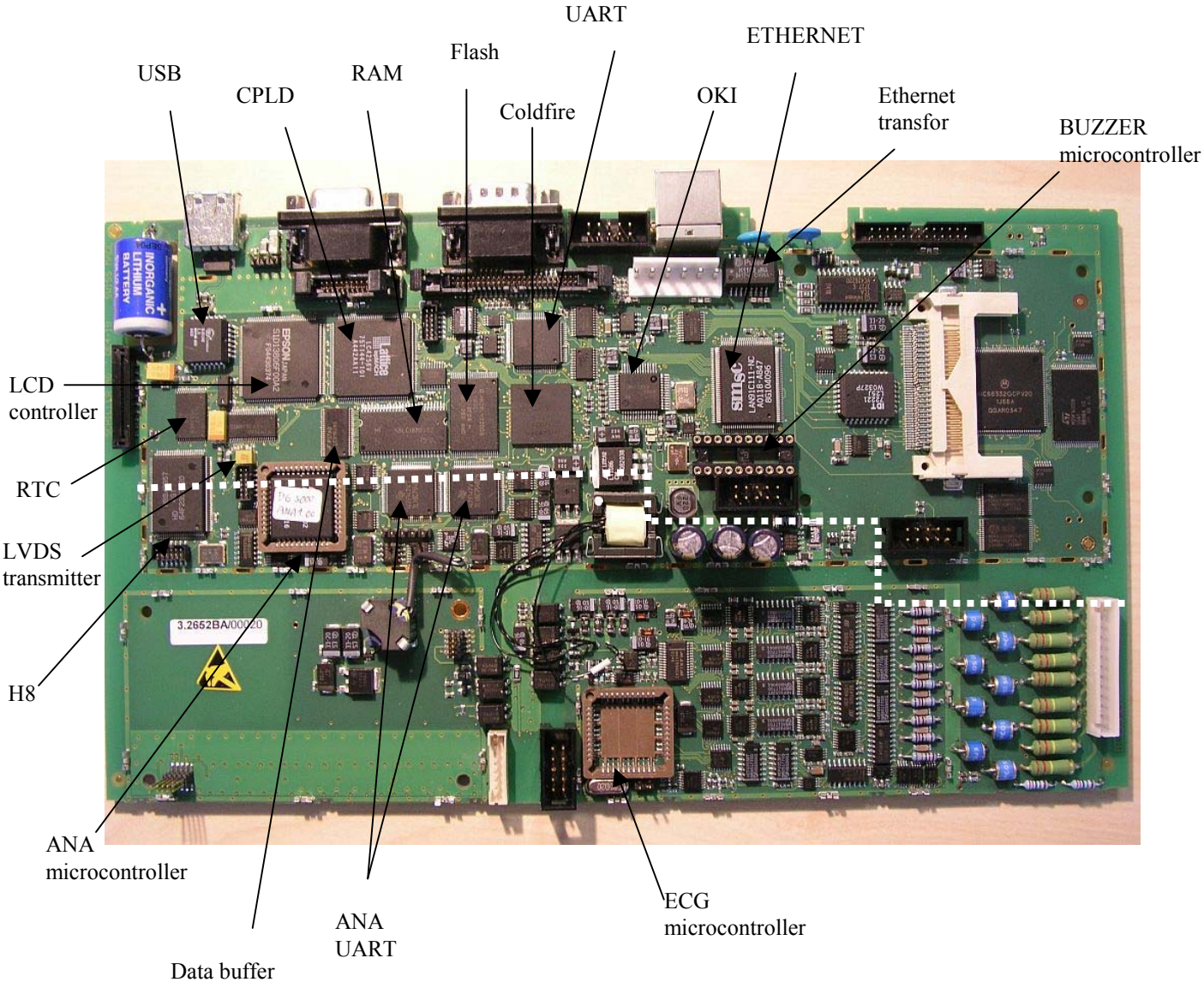
5.3.4. Connectors

The picture below shows the connectors of the CPU board of DG5000.



5.3.4.1. Components

The picture below shows the main components of the CPU board of DG5000.



5.4. POWER BOARD (part no. 3.2653)

The part number of this circuit is 3.2653 or WSM0065A.

5.5. UPPER KEYPAD BOARD (part no. WSM0062A)

5.5.1. General

This circuit is located at the top of the front housing. It enables the user to control the device through a foil and to see the proper execution of certain functions by means of indicators. The circuit also includes a CPU interface function.

5.5.2. Control and display

Pressing the On/Off button (S1) switches the ON/OFF signal to the ground and starts the device with the help of the CPU. Pressing the button once again sets of the device stopping procedure.

Pressing the Charge/Shock button (S2) switches signal -FPS KEY to the ground. Signal - FPS KEY is detected by the CPU and, depending on the device status, it charges the capacitor or triggers the shock. Three LEDs (LD4, LD5 and LD6) located around the button indicate if the shock is ready.

Pressing the Analyse button (S3) switches signal -ANA KEY to the ground. Signal - ANA KEY is detected by the CPU and if the three LEDs (LD7, LD8 and LD9) located around the button are illuminated, an analysis is started.

The pulses of signal CHARGE LED1 make LD1 flash to show the battery charge.
When high, signal DC LED1 switches on LD2 which shows that the external VDC power is present.
When high, signal AC LED1 switches on LD3, which shows that the mains power is present.

5.5.3. CPU interface

All the signals to the CPU via connector J405M come from the following components:

- Loud speaker (J401M)
- Microphone (J402)
- Side keypad (J403M)
- Rotating selector (J701M)
- Recorder (J703)
- Backlighting (J704)

5.6. KEYPAD + BATTERY BOARD: (part no. WSM0060A)

5.6.1. General

This circuit is a board made up of three different snap-off circuits. When the circuits are separated, they have separate part numbers, namely WSM0060B, WSM0060C and WSM0060D.

5.6.2. DG5000 SIDE KEYPAD PCB: WSM0060B

This circuit has 7 push-buttons and acts as the interface between the user and the machine. The control signals go through connector J702M circuit "UPPER KEYPAD" and then to the CPU.

5.6.3. DG5000 BATTERY 1 PCB: WSM0060C

This circuit is screwed to the lower battery tank and is only used as an adapter for battery 1. Contacts JP1, JP2 and JP3 form the connection with the battery and connector J306M is used to connect the assembly to the power circuit.

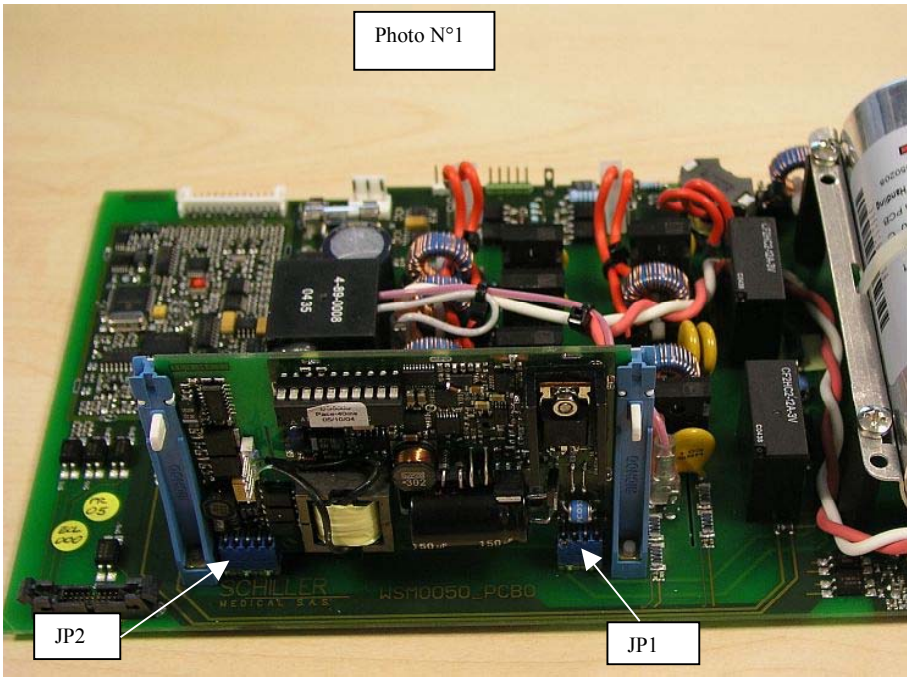
5.6.4. DG5000 BATTERY 2 PCB: WSM0060D

This circuit is screwed to the upper battery tank and is the adapter for battery 2 and the interface for the graph signals.

5.7. PACEMAKER BOARD: (part no. WSM0059A)

5.7.1. General

The pacemaker is an optional feature of DG5000. It is fitted perpendicular to the defibrillator board. It is mechanically held in place by two guides that are fixed on the defibrillator board. The electrical connection between the pacemaker and the defibrillator is made by two board-to-board connectors. Connector JP1 carries the pulses delivered by the pacemaker and connector JP2 carries the power supply and the pacemaker communication and control signals (photo 1).



The pacemaker is controlled from the control keys on the front panel. It has three operating modes and delivers current-regulated rectangular pacing pulses.
The Fixed operating mode is an asynchronous pacing mode that delivers pulses at the user-defined frequency. The pulse width is 40 ms.
The Overdrive operating mode is also an asynchronous pacing mode. It delivers pacing pulses at a frequency that is three times the frequency set by the user. The pulse width is 20 ms.
The Demand operating mode is a synchronous pacing mode. It is regulated by signal QRS_TRIGGER and its rate is determined by the user-defined frequency. The pulse width is 40 ms.
The current regulation of pacing pulses is specified for patient impedance values ranging from 200 Ω to 1000 Ω. However, it remains operational for impedance values located between 0 Ω and 200 Ω. Beyond 1000 Ω, current regulation is no longer operational. The rectangular shape of the pacing pulse gradually tends to become trapezoidal as the impedance increases..

The HV capacitor C16 may be charged to voltages above 200 V.
Before any work on the pacemaker, make sure that it is discharged.

5.7.2. Structure

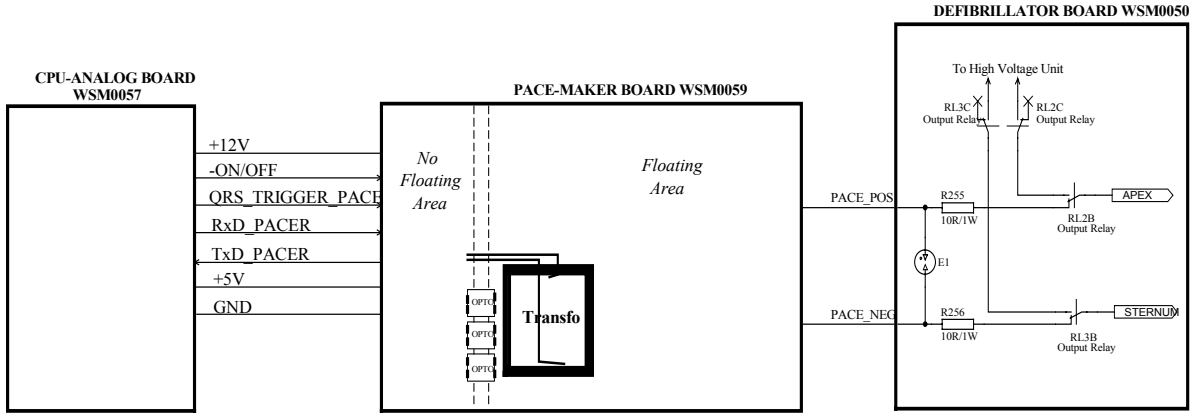
The pacemaker is under the control of the analogue microcontroller of the CPU board-ANALOGUE board by means of an RS232 serial link and dedicated control signals.
The pacemaker output channel is multiplexed with the defibrillator output channel with the help of an output relay. In the absence of a defibrillation shock, the pacemaker channel remains selected. The output relay is under the control of the defibrillator shock control circuit **(see Fig.1)**

The pacemaker is made up of two distinct areas, namely:

- The non-floating area
- The floating area

Insulation between the non-floating and the floating area is achieved by optocouplers and a transformer.
The non-floating area is chiefly made up of communication circuits and the DC/DC converter, which supplies power to the floating area.
The floating area is made up of the control, monitoring, measurement, safety and power circuits.

Fig. N°1



The pacemaker power supply is protected by a 750 mAT / 125 V fuse.

5.7.3. Description of the non-floating area

The non-floating part is powered from the CPU board-ANALOGUE board with +12 V and +5 V. The floating area power voltages are generated from the +12 V supply, through the DC/DC converter.

5.7.3.1. DC/DC converter

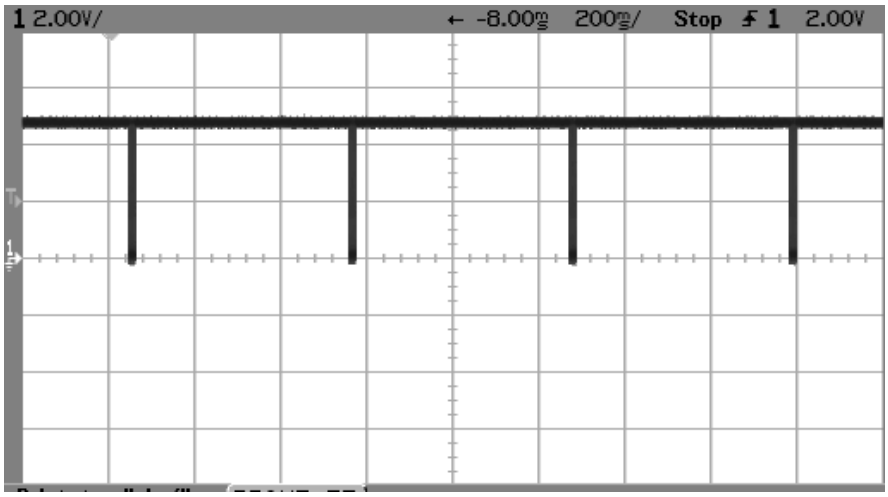
The DC/DC converter is powered from the +12 V voltage. It provides the power supply of the floating area to the secondary windings of transformer TR1. It is built around control circuit U7 and operates in the free-running mode at 90 kHz. The primary windings of transformer TR1 are attacked in the push-pull mode by means of a power stage made up of Q1 and Q2. The activation of the DC/DC converter is controlled by signal–ON/OFF_PACER delivered by an output latch of the Analogue microcontroller. It also corresponds to the starting up of the pacemaker.
Fuse F1 (750 mAT) and diode D1 protect the pacemaker if there is a short circuit and/or an incorrect polarity in the +12 V power supply voltage.
The time constant of circuit R3, C1 determines the chopping frequency of the converter and the time constant of circuit R11, C1 determines the dead time between the chopping pulses.

5.7.3.2. Communication circuits

Communication circuits are essentially made up of optocouplers (U8, U9 and U10) and associated control transistors (Q7 and Q11). They are powered in the non-floating area by +5 V and in the floating area by F-UPM.
Signals TxD_PACER and RxD_PACER form a serial RS-232 link that takes care of communication between the pacemaker microcontroller and the analogue microcontroller. It operates at a 4800 baud rate.
Signal QRS_TRIGGER delivers the heart frequency pulse required for the pacemaker when it operates in the Demand mode. The signal is delivered by the 8-channel preamplifier.

Note:

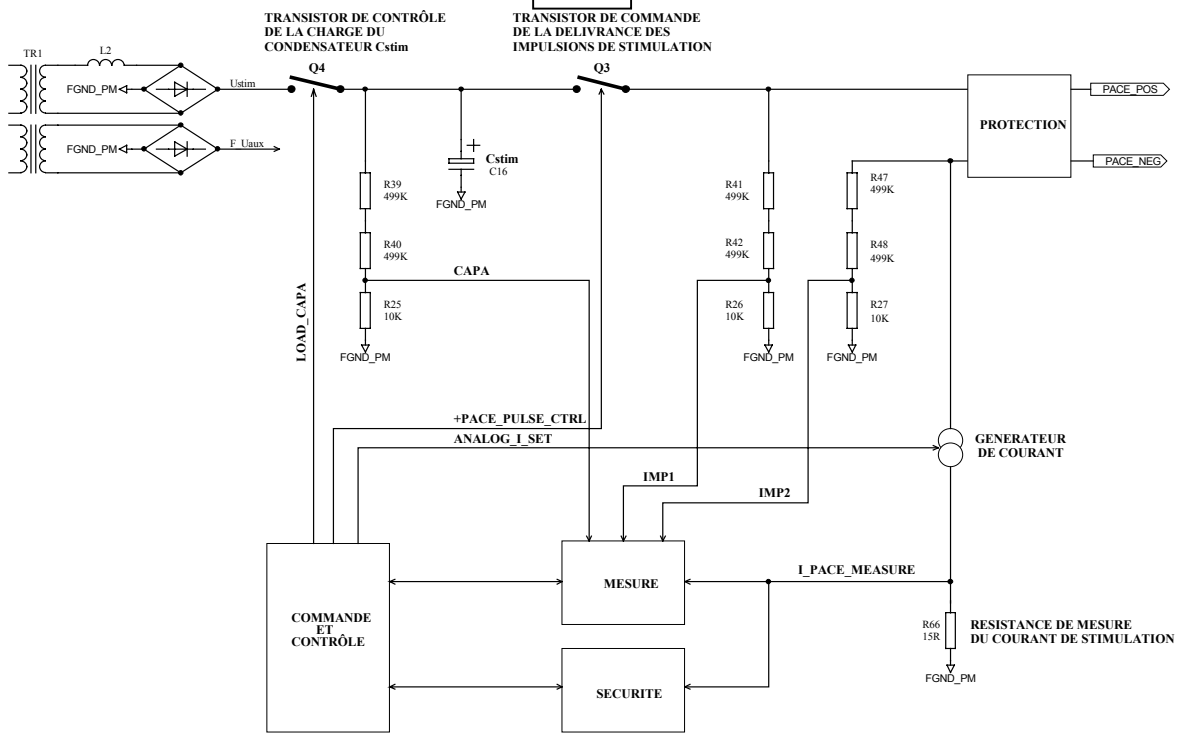
Signal TxD_PACER is delivered continuously when the pacemaker is started up. The frame recurrence frequency is 512 ms.



5.7.4. Description of the floating part:

The floating part is made up of the control, monitoring, measurement, safety and power circuits **(Fig.2).**

Fig.2



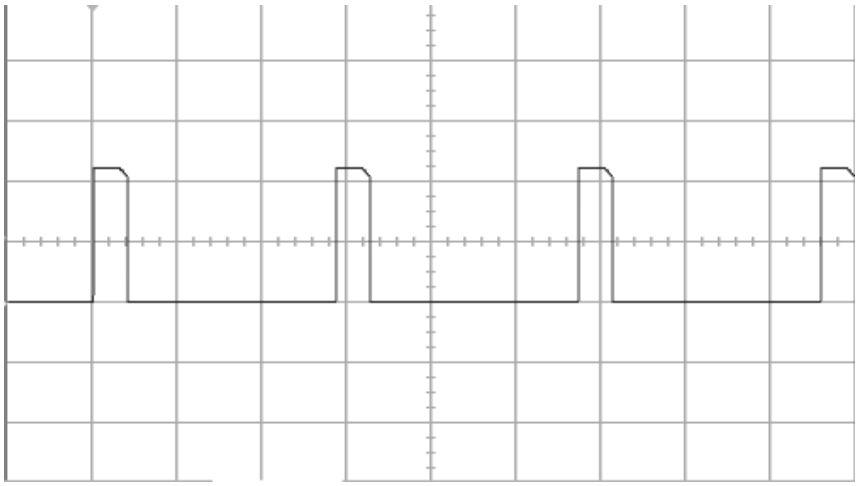
5.7.4.1. Power circuit

The role of the power circuit is to supply energy and form the pulses delivered by the pacemaker.
The pacing pulses are rectangular in shape and their current is regulated.

The power circuit is made up of the following elements:

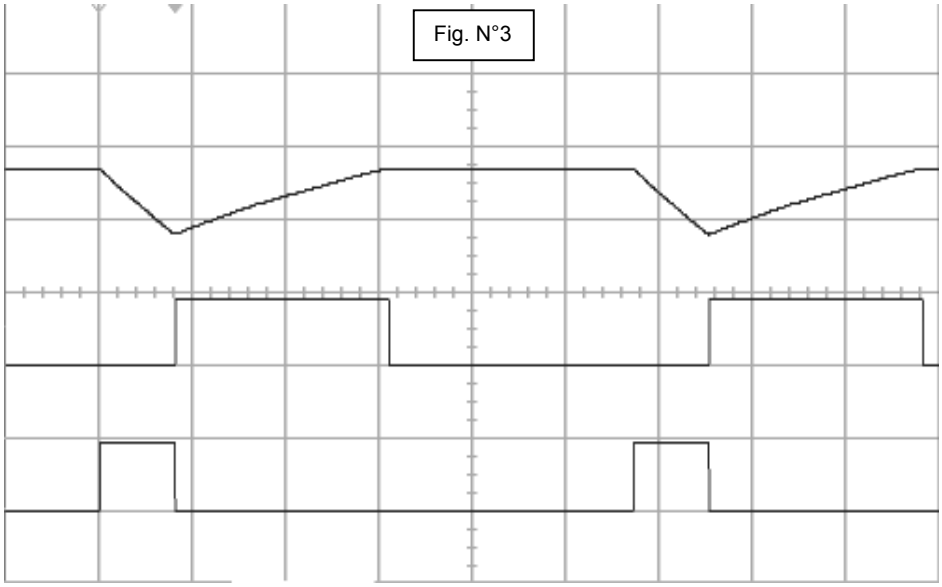
- An induction coil (L2) to limit the capacitor charging current (C16).
- Full wave rectification (D2, D3, D4 and D5).
- A transistor (Q4) that controls the charging of the capacitor (C16) and the storage of the pacing pulse energy.
- A capacitor (C16) that stores the pacing pulse energy.
- A transistor (Q5) that controls the delivery of pacing pulses.
- A current generator (Q13, U3A) that controls the current amplitude of the pacing pulses.

The rectangular shape of the pulse delivered by may be truncated (chipped at the corner) at the end of the plateau in the event of pacing at the maximum patient impedance and current.

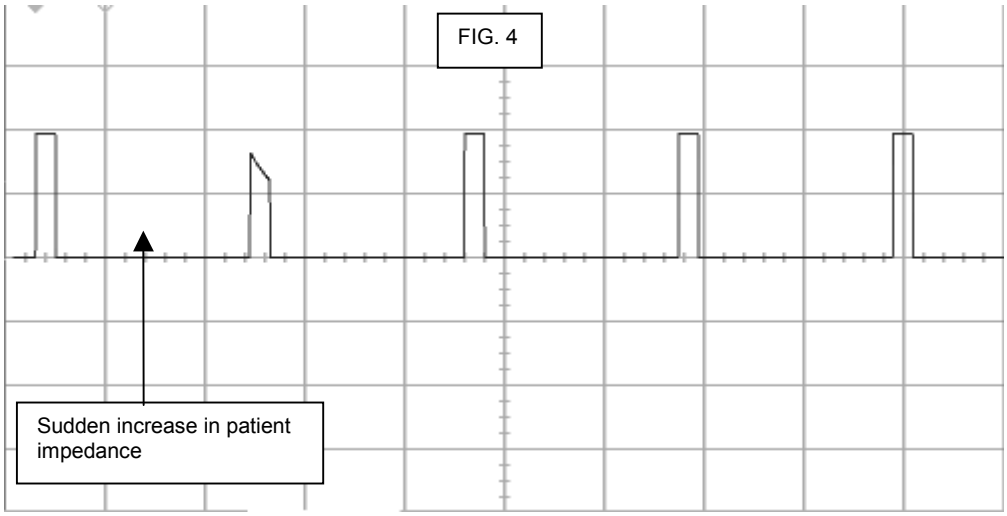


The energy of the pacing pulses is supplied by capacitor C16. The capacitor charge from compensating the energy delivered starts at the end of each pacing pulse **(Fig.3).** The charging voltage of capacitor C16 is measured by means of the divider bridge made up of R39, R40 and R25. The amplitude of the charging voltage of capacitor C16 is controlled by the measurement of the voltage at the patient terminals. It is used to limit the power dissipated into the current generator when the patient impedance becomes low. The voltage at the patient terminals is measured by means of the measurement bridges made up of R41, R42, R26 and R47, R48, R27.

Fig. N°3



The voltage of capacitor C16 is controlled on the basis of the measurement of the voltage at the patient terminals during the pacing pulse preceding the capacitor charge.
In the event of sudden variation (increase) in patient impedance, the rectangular shape and the amplitude of the current of the first pacing pulses delivered after the occurrence of the variation are no longer as required. The number of non-conforming pulses remains limited to three. The chronogram below **(Fig.4).** has been obtained for variation of 200 Ω to 1000 Ω.



5.7.4.2. Measuring circuit

The measuring circuit is chiefly made up of an ADC (U12), which is controlled by microcontroller U13 through an SPI serial link made up of signals CLK_ADC, CS_ADC, DI_ADC and DO_ADC.
The measurement circuit is responsible for measuring the following parameters:

- Pacing current: I_PACE_MEASURE
- Charging voltage of capacitor C16: CAPA
- Voltage at the patient terminals: IMP1 and IMP2

The reference voltage of the ADC is delivered by D16. It is equal to 2.5 V.

Pacing current I_PACE_MEASURE is measured at the terminals of measuring resistor R66. The voltage developed at the terminals of the measuring resistor by the pacing current is applied by means of follower U1A at the input of ADC U12. Network R55, C33 makes up a low-pass filter and R55, R56 in association with D11 offer protection from overvoltage.

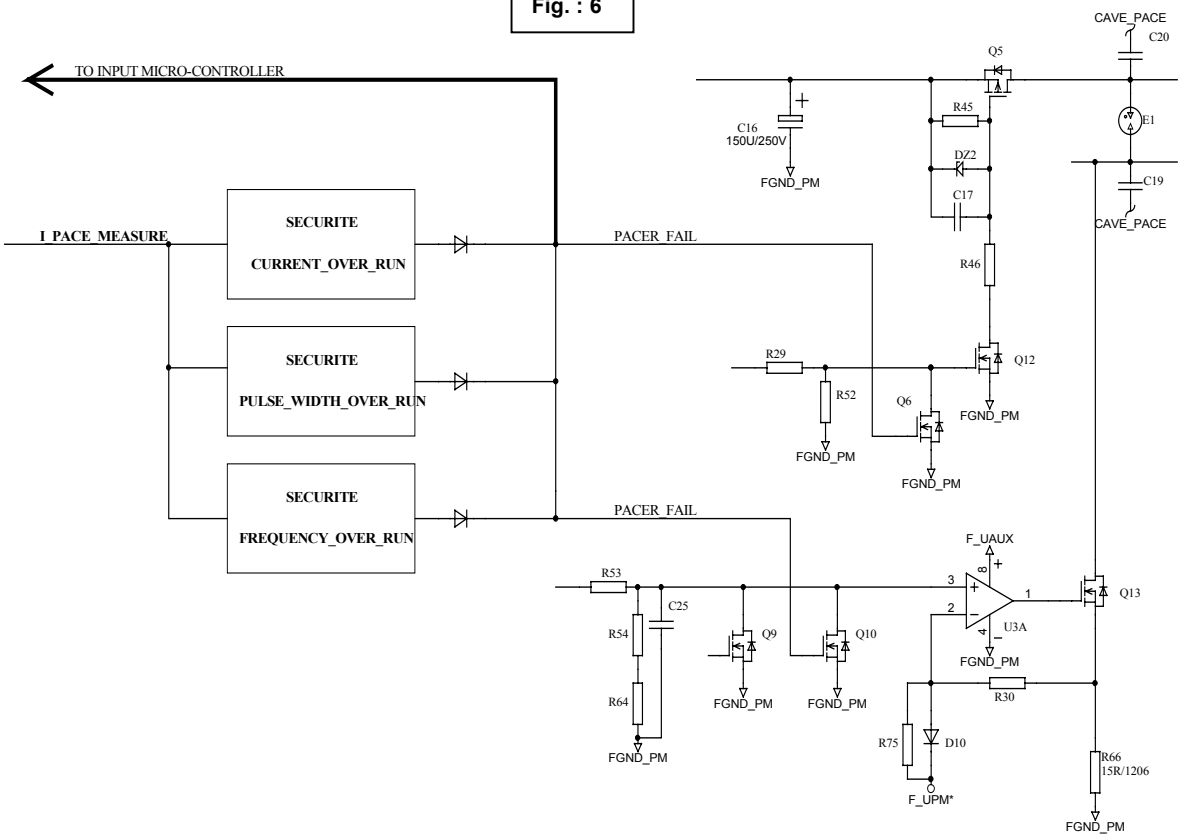
The charging voltage of capacitor C16 is measured by means of measuring bridge R39, R40 and R25 delivered by signal CAPA. The signal is applied by means of follower U1D at the input of ADC U12. The charging voltage of capacitor C16 is controlled by the voltage difference between signals IMP1 and IMP2 measured at the patient terminals. When it drops, the charging voltage of capacitor C16 drops as well. However, the maximum value is capped at 186 V and the minimum value is limited to 70 V.

The voltage at the patient terminals are measured by means of measuring bridge R41, R42, R26 and measuring bridge R47, R48, R27, which delivery signals IMP1 and IMP2. The two signals are applied by means of followers U1B and U1C at the inputs of ADC U12.

5.7.4.3. Safety circuits

The safety circuits are responsible for ensuring that the pacemaker does not deliver pacing pulses with parameters that exceed the maximum boundary values **(Fig. 6).**

Fig. : 6



The safety circuits have an effect on the following parameters:

- Pacing current: CURRENT_OVER_RUN
- Pacing pulse width: PULSE_WIDTH_OVER_RUN
- Pacing frequency: FREQUENCY_OVER_RUN

When the value of a parameter is exceeded, the appropriate safety circuit delivers an error signal that directly blocks the transistor that controls the delivery of packing pulses by means of the OR gate made up of D12, D13 and R65, and cancels the pacing current by modifying the current generator control signal. At the same time, signal PACER_FAIL is also transmitted to microcontroller U13.

The triggering of a safety circuit leads to the stopping of the pacemaker and the display of an error message.

The boundary values of the pacing pulse parameters are monitored from signal I_PACE_MEASURE. The signal carries information about the amplitude of the pacing pulse current, the width of the pacing pulse and the frequency of the pacing pulses. The comparator built around U2B logically forms signal I_PACE_MEASURE. It makes it possible to recognise pacing pulses with current amplitude below 35 mA.

CURRENT_OVER_RUN safety circuit

Signal I_PACE_MEASURE is applied by means of follower U1A at the input of comparator U2A. The comparison limit of U2A, which is achieved by the divider bridge made up of R63 and R68 sets the limit of the pacing current that triggers the CURRENT_OVER_RUN safety. When the limit has been overrun, the output of comparator U2A triggers latch R/S, which delivers error signal CURRENT_OVER_RUN. By means of diode D2, this signal generates signal PACER_FAIL that blocks the transistor that controls the delivery of pacing pulses and cancels the pacing current. Signal PACER_FAIL is also transmitted to microcontroller U13, which transmits the information, by means of the serial link, to the Analogue microcontroller that stops the pacemaker.

PULSE_WIDTH_OVER_RUN safety circuit

Signal I_PACE_MEASURE is applied by means of follower U1A at the input of comparator U2B, which forms signal I_PACE_MEASURE, which is used to apply the pacing pulses with currents that are as low as 25 mA. The signal delivered by the output of comparator U2B attacks its rising edge at the input of monostable U6A. U6A delivers an active pulse with the low status that sets the maximum limit of the pacing pulse width. The pulse is applied simultaneously with the signal delivered by comparator U2B to logical gate U4B. If the pacing pulse duration exceeds the duration of the pulse generated by monostable U6A, the output of logical gate U4B switches to low and triggers latch R/S. At its PULSE_WIDTH_OVER_RUN output, the latch delivers the error signal PACER_FAIL, which blocks the transistor that controls the delivery of pacing pulses and cancels the pacing current by modifying the control signal of the current generator. At the same time, signal PACER_FAIL is also transmitted to microcontroller U13, which transmits the information by means of the serial link to the Analogue microcontroller that controls the stopping of the pacemaker.
Latch R/S is reinitialised by signal–FOR_INHIB, which is active when low.

If there is a fault that affects the pacing current by reducing its amplitude beyond 25 mA, the PULSE_WIDTH_OVER_RUN and FREQUENCY_OVER_RUN safety circuits cease to operate.

FREQUENCY_OVER_RUN safety circuit

Signal I_PACE_MEASURE is applied by means of follower U1A at the input of comparator U2B, which forms signal I_PACE_MEASURE that is used to apply pacing pulses with currents as low as 25 mA. The signal delivered by the output of comparator U2B attacks the input of monostable U6B on its falling edge. U6B delivers a pulse that is active when high, which sets the maximum limit of the pacing frequency. The pulse is applied simultaneously with the signal delivered by comparator U2B to logical gate U5C. If the duration between two consecutive pacing pulses is smaller than the duration of the pulse delivered by monostable U6B, the output from logical gate U5C switches to low and triggers latch R/S. At its FREQUENCY_OVER_RUN output, latch R/S delivers error signal PACER_FAIL that blocks the transistor that controls the delivery of pacing pulses and cancels the pacing current by affecting the control signal of the current generator. At the same time, signal PACER_FAIL is also transmitted to microcontroller U13. U13 transmits the information by means of the serial link to the Analogue microcontroller that stops the pacemaker.
Latch R/S is reinitialised by signal –FOR_INHIB that is active when low.

The OVER_RUN_FREQUENCY safety circuit is disabled when the pacemaker is in Overdrive mode.
Such disabling is activated by means of signal –FOR_INHIB. The other safety circuits remain operational.

The RESET signal generated by voltage supervisor U14 also affects signal PACER_FAIL in the same way as the three safety circuits. However, the RESET pulse does not lead to the stopping of the pacemaker. It only prevents the delivery of a parasite pulse during the pacemaker starting and stopping phases.

5.7.4.4. Control and monitoring circuit

The control and monitoring circuit is chiefly made up of microcontroller U13. It operates with an 11,0592 MHz clock delivered by oscillator Q14. It delivers the various control and monitoring signals and receives the status signals from the safety circuits. It also supports communication signals with the ADC, the Analogue microcontroller and the 8-channel preamplifier.

- Signals CLK_ADC, CS_ADC, DI_ADC and DO_ADC form a synchronous serial link that communicates with ADC U12.
- Signals RxD_PACER and TxD_PACER form an RS232 serial link that communicates with the Analogue microcontroller.
- Signal QRS_TRIGGER_FLOAT delivers to microcontroller U13 the QRS synchronisation information fro the Demand operating mode.
- Signal LOAD_CAPA controls and monitors the charging of capacitor C16. Transistor Q3 translates the level between control signal LOAD_CAPA and transistor Q4 that controls the charging of capacitor C16.
- Signal PACE_PULSE_CTRL controls the delivery of pacing pulses. Transistor Q12 translates the level between control signal PACE_PULSE_CTRL and transistor Q5 that controls the delivery of pacing pulses.
- Signal –PACE_PULSE_CTRL affects the current generator adjustment voltage by means of transistor Q9. During the pacing pulse delivery phase, transistor Q9 remains blocked and has no effect on the current generator adjustment voltage. Away from the pacing pulse delivery phase, transistor Q9 is saturated and forces the current generator adjustment voltage to zero.
- Signal –FOR_INHIB delivered by microcontroller U13 is used as the reset signal of latches R/S of the safety circuits. It also controls the disabling of the FREQUENCY_OVER_RUN safety circuit when the pacemaker is operating in Demand mode.
- Error signal PACER_FAIL delivered by the safety circuits informs microcontroller U13 of the triggering of a safety circuit.
- Signal PWM_I_SET delivered by microcontroller U13 controls the pacing pulse current. It acts by modulating the pulse width. The low-pass filter built around U3B generates analogue signal ANALOG_I_SET from the pulse-width modulated signal for adjusting the current generator current. The time constant by R53, R54, R64 and C25 controls the rising edge of the pacing pulse current.

5.7.5. Description of signals:

Signal	Description
ANALOG_I_SET	Analogue pacing current adjustment signal
CAPA	Analogue capacitor charge voltage measuring signal
CLK_ADC	Clock signal from ADC U12. Delivered by microcontroller U13.
CS_ADC	Selection signal of ADC U12. Delivered by microcontroller U13. Active when low.
CURRENT_OVER_RUN	Error signal delivered by safety circuit CURRENT_OVER_RUN. Active when high.
FREQUENCY_OVER_RUN	Error signal delivered by safety circuit FREQUENCY_OVER_RUN. Active when high.
DI_ADC	Data signal that microcontroller U13 sends to ADC U12.
DO_ADC	Data signal that microcontroller U13 receives from ADC U12.
IMP1	Analogue signal for measuring the voltage on the positive pacemaker output. The difference from the signal measured at IMP2 provides the voltage at the patient terminals.
IMP2	Analogue signal for measuring the voltage on the negative pacemaker output. The difference from the signal measured at IMP1 provides the voltage at the patient terminals.
I_PACE_MEASURE	Analogue signal for measuring the pacing current.
-ON/OFF_PACER	Control signal for starting up the pacemaker. Active when low.
PACER_FAIL	Error signal delivered by the safety circuits. Active when high.
PULSE_WIDTH_OVER_RUN	Error signal delivered by safety circuit PULSE_WIDTH_OVER_RUN. Active when high.
PWM_I_SET	Pacing current adjustment signal. Pulse-width modulated.
QRS_TRIGGER_FLOAT	QRS sync signal of the floating part. Used for the Demand operating mode. Active when high.
QRS_TRIGGER_PACER	QRS sync signal delivered by the 8-channel preamplifier. Used for the Demand operating mode. Active when high.
RxD_PACER_FLOAT	Reception signal of the RS-232 serial link of the floating part. Signal transmitted by the Analogue microcontroller to the Pacer microcontroller.
TxD_PACER_FLOAT	Transmission signal of the RS-232 serial link of the floating part. Signal transmitted by the Pacer microcontroller to the Analogue microcontroller.
RxD_PACER	Reception signal of the RS-232 serial link. Signal transmitted by the Pacer microcontroller to Analogue microcontroller
TxD_PACER	Transmission signal of the RS-232 serial link. Signal transmitted by the Pacer microcontroller to the Analogue microcontroller.

6. Device modifications

6.1. Définition

ECL:

ECL is the board modification index. There are two types of ECG numbering:
- One has three digits (PNN).

  - P : board version number, incremented with each re-routing operation

  - NN : incremented with each modification on the board. NN is reset to 00 when the P version changes

- The other contains two letters (PN) of the board

  - P : board version number, incremented with each re-routing operation.

  - N : incremented with each modification on the board. N is reset to A when the P version changes

6.2. DEFI BOARD

Code article	ECL	Modifications
WSM0050A	100	1st version
WSM0050A	101	Modification 05.016.001 : addition of C181 et C182.
WSM0050A	200	Modification 05.021.005 : New layout, WSM0050_PCB1 goes to WSM0050_PCB2.

6.3. CPU BOARD

Code article	ECL	Modifications
3-2652	BB	1st version
3-2652	BC	Modification 05.017.002 : addition of an intermediate assembly to reduce the pull-up power supply to 3,3 V of pin PWR.
3-2652	BD	Modification 05.019.003 : - L4 and L501 are change of 4,7 ohms - change the value of R525.
3-2652	BE	Modification 05.024.007 : - deletion of R8 and R74. - addition of the connections towards J202M pin 1 and 3.
3-2652	BF	Modification 05.025.008 : - change the value of R73. - ECG software goes to version 02.01B1.
3-2652	CB	Modification 05.035.010 : - Addition of a resistance of 100K between U620(1) and U627(24). - CPLD software goes to version 02.01B1.
3-2652	CC	Modification 05.036.011 : change value of R168, R171 and R172.
3-2652	CD	Modification 05.037.012 : change value of R799.

6.4. POWER BOARD

Code article	ECL	Modifications
3-2653	BB	1st version
3-2653	BC	Modification 05.056.024 : change value of R546 and R547

6.5. UPPER KEYPAD BOARD

Code article	ECL	Modifications
WSM0062A	100	1st version

6.6. KEYPAD + BATTERY BOARD

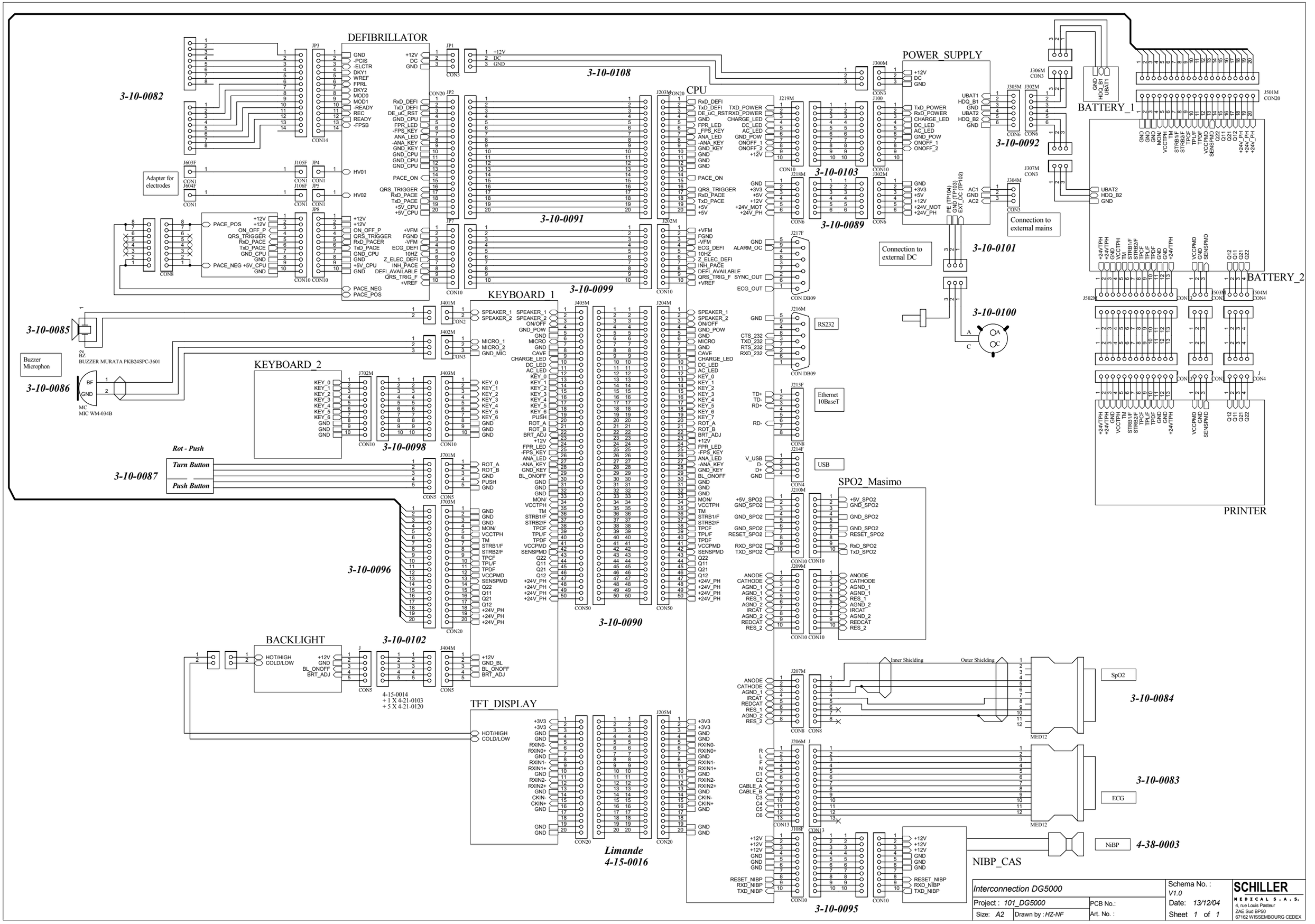
Code article	ECL	Modifications
WSM0060A	100	1st version

6.7. PACEMAKER BOARD

Code article	ECL	Modifications
WSM0059A	000	1st version
WSM0059A	100	05.020.004 : New layout, WSM0059_PCB0 goes to WSM0059_PCB1.

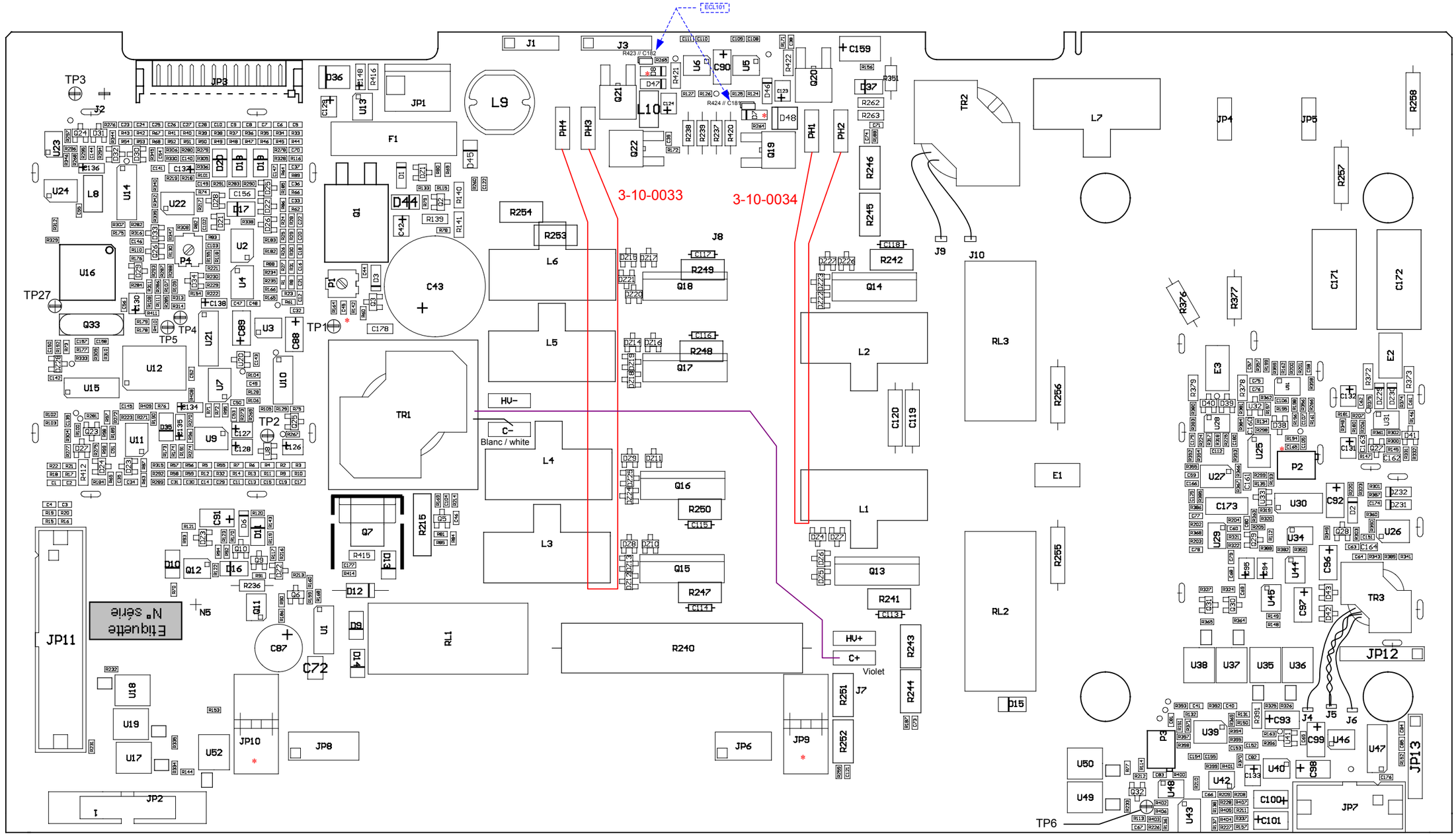
7. Diagrams and layout drawings

7.1. General synoptic


DEFIBRILLATOR
3-10-0082
3-10-0108
CPU
POWER_SUPPLY
3-10-0092
3-10-0103
3-10-0089
3-10-0091
3-10-0099
3-10-0101
3-10-0100
Connection to external mains
Connection to external DC
BATTERY_1
BATTERY_2
PRINTER
KEYBOARD_1
KEYBOARD_2
3-10-0085
Buzzer Microphon
BUZZER MURATA PKB24SPC-3601
3-10-0086
MIC WM-034B
Rot - Push
3-10-0087
Turn Button
Push Button
3-10-0098
3-10-0096
3-10-0090
3-10-0102
BACKLIGHT
4-15-0014
+ 1 X 4-21-0103
+ 5 X 4-21-0120
TFT_DISPLAY
Limande
4-15-0016
RS232
Ethernet 10BaseT
USB
SPO2_Masimo
3-10-0084
SpO2
3-10-0083
ECG
NiBP
4-38-0003
NIBP_CAS
3-10-0095
Inner Shielding
Outer Shielding
Interconnection DG5000
Project : 101_DG5000
Size: A2
Drawn by : HZ-NF
PCB No.:
Art. No. :
Schema No. : V1.0
Date: 13/12/04
Sheet 1 of 1
SCHILLER
MEDICAL S.A.S.
4, rue Louis Pasteur
ZAE Sud BP50
67162 WISSEMBOURG CEDEX

7.2. DEFI BOARD (part no. WSM0050A)

WSM0050_PCB1



* = pas monté / not mounted

Dimensions: 261 mm x 145 mm

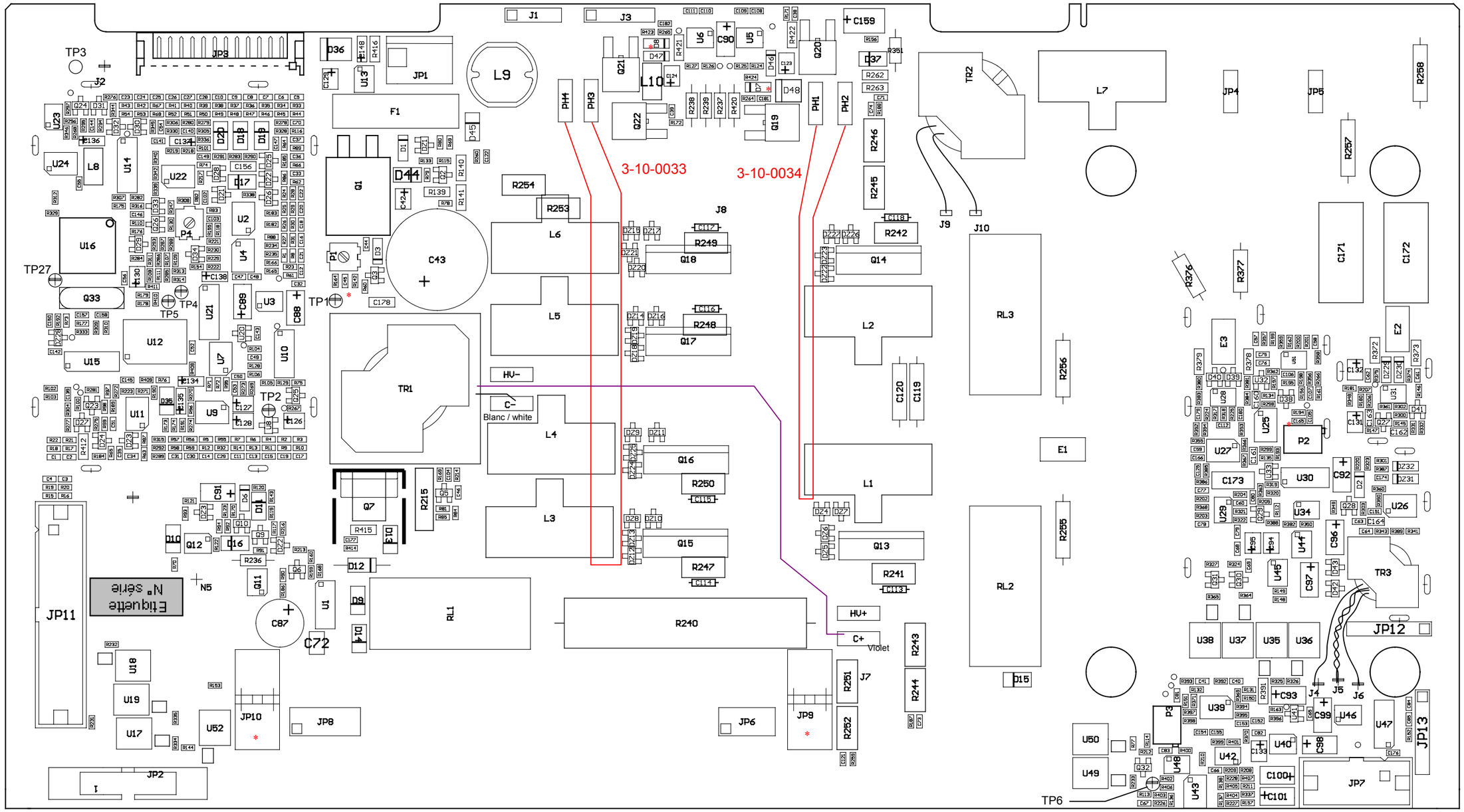
DEFIGARD 5000
Circuit Défi + préamplificateur
Defi + preamplifier board

DRAWN	APPROV	MODIFICATION			
CK	RH	CK			
ECL100 01 / 05	ECL100 01 / 05	ECL101 04 / 05			

ART : WSM0050A
PRT : WSM0050_PCB1
DGW : WSM0050AREF101
SHT : 1/1

SCHILLER MEDICAL S.A.S.

WSM0050_PCB2



* = pas monté / not mounted

Dimensions: 261 mm x 145 mm

DEFIGARD 5000
Circuit Défi + préamplificateur
Defi + preamplifier board

DRAWN	APPROV	MODIFICATION
CK ECL200 04 / 05	RH ECL200 04 / 05	

ART : WSM0050A
PRT : WSM0050_PCB2
DGW : WSM0050AREF200
SHT : 1/1

SCHILLER
MEDICAL S.A.S.

7.3. CPU BOARD (part no. 3.2852)

The part number of this board is 3.2652 or WSM0057A.

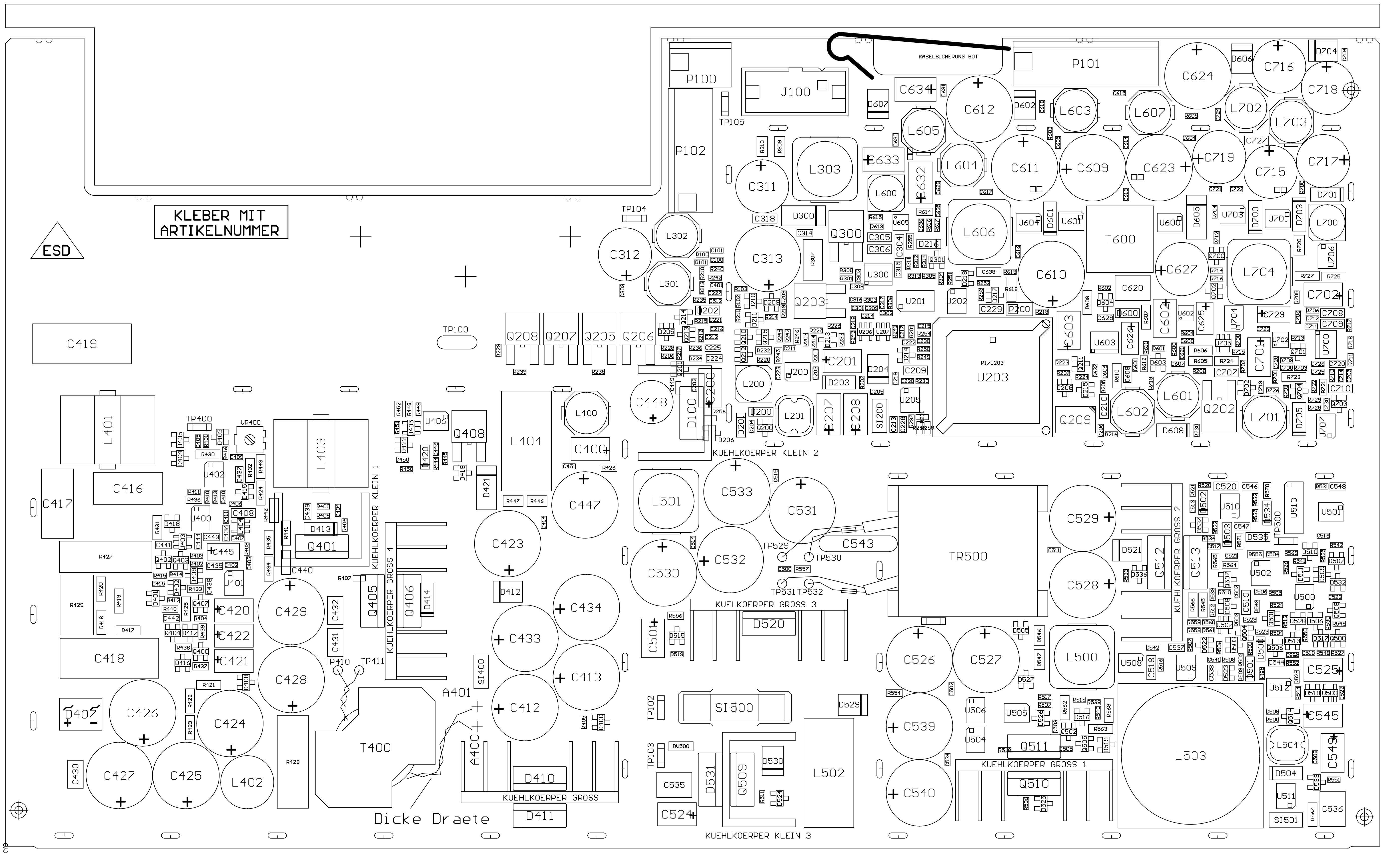
D2652BA

S2652CA
D2652CA

7.4. POWER BOARD (part no. 3.2653)

The part number of this board is 3.2653 or WSM0065A.

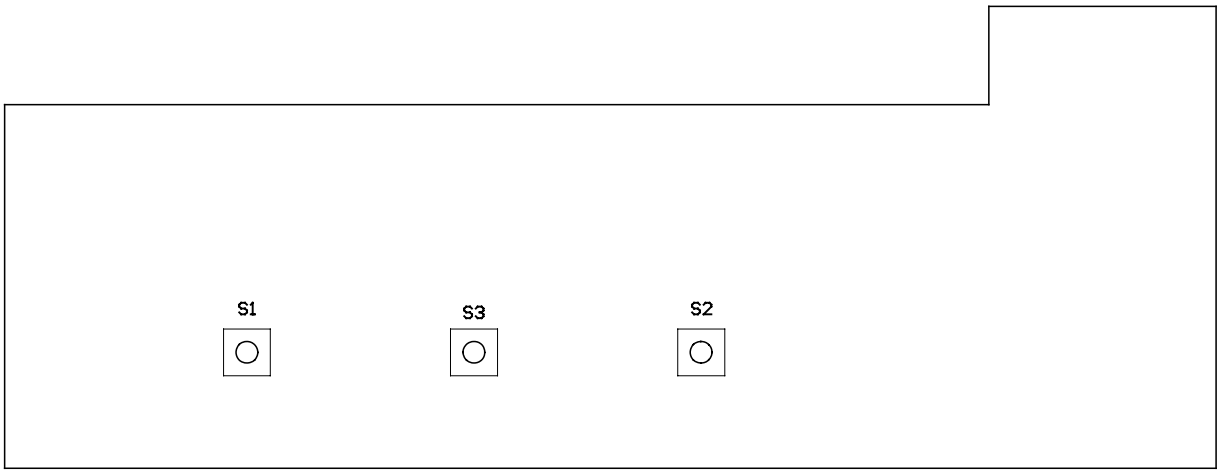
D2653BA

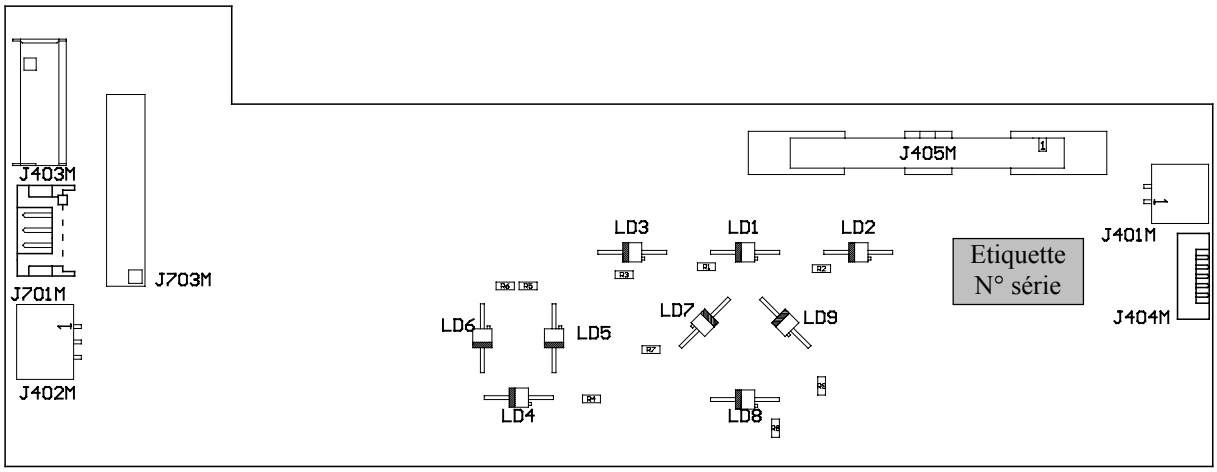


Title: DE4–6 POWER BOARD				D.2653BA	Schiller AG
Project: DG–5000					Altgasse 68
Visum:	Drawn By: HPSCH	Entw. HPSCH	Prod.	DATE: 25.01.05 — Sheet 1 of 2	CH–6340 Baar

7.5. UPPER KEYPAD BOARD (part no. WSM0062A)

WSM0062_PCB1





Dimensions: 160 mm x 61 mm

DEFIGARD 5000
Circuit clavier haut
Top keyboard

DRAWN	APPROV	MODIFICATION
CK ECL100 01 / 05	NF ECL100 01 / 05	

ART : WSM0062A
PRT : WSM0062_PCB1
DGW : WSM0062AREF100
SHT : 1/1

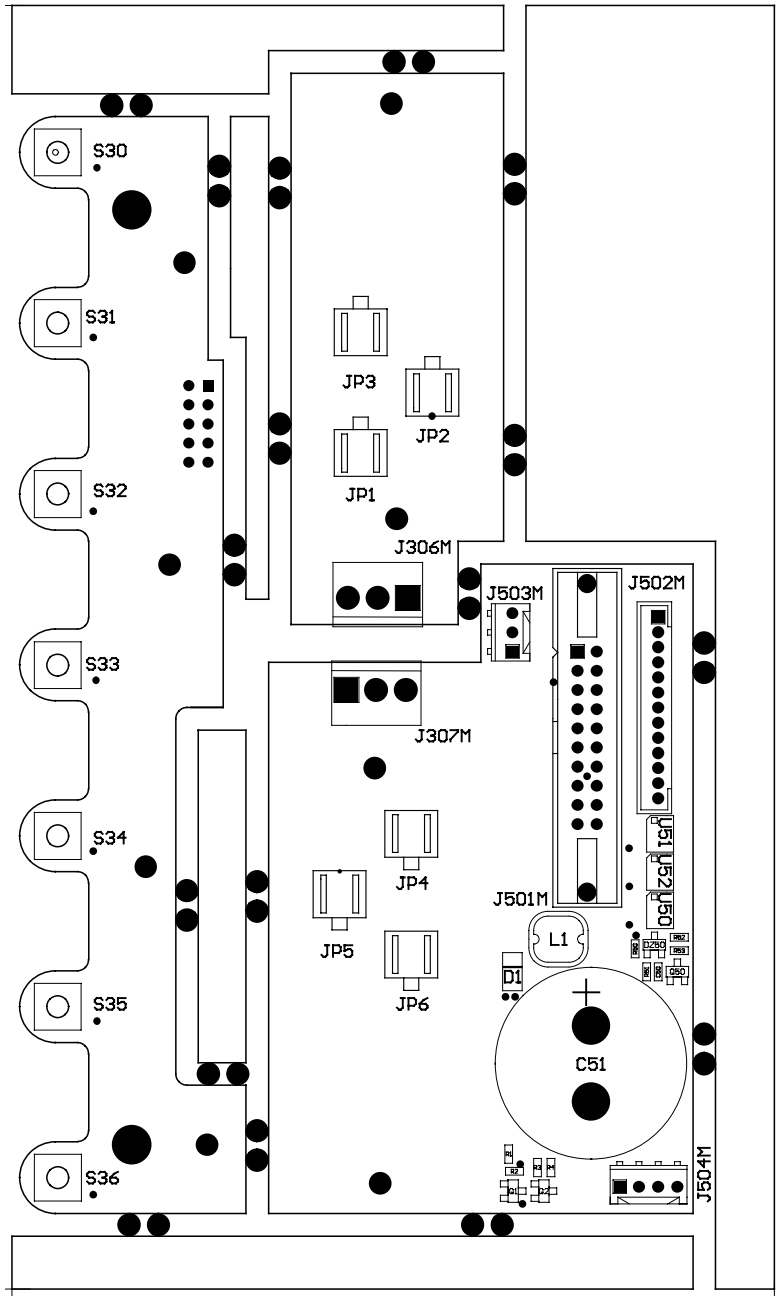
SCHILLER
MEDICAL S.A.S.

7.6. KEYPAD + BATTERY BOARD: (part no. WSM0060A)

This circuit is made up of three different snap-off circuits. When the circuits are separated, each has a different part number:

- WSM0060B: DG5000 SIDE KEYPAD PCB
- WSM0060C: DG5000 BATTERY 1 PCB
- WSM0060D: DG5000 BATTERY 2 PCB2

WSM0060_PCB1



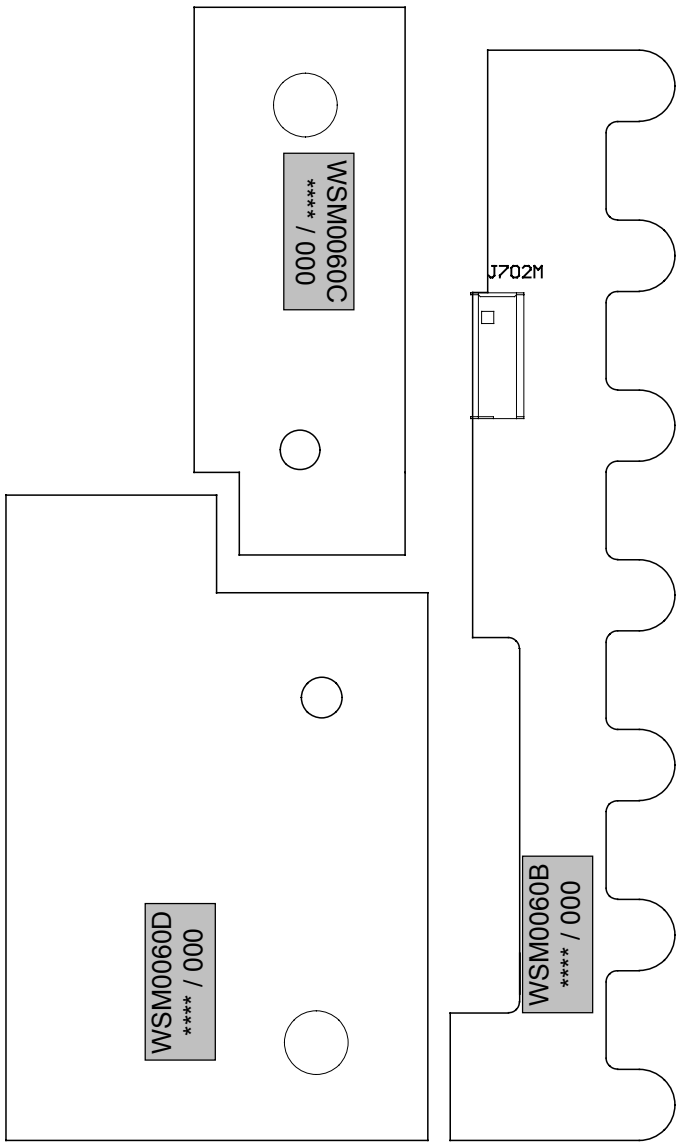
Dimensions: 170 mm x 101 mm

DEFIGARD 5000
Circuit batterie et clavier
Battery board and keyboard

DRAWN	APPROV	MODIFICATION
CK ECL100 01 / 05	NF ECL100 01 /	

ART : WSM0060A
PRT : WSM0060_PCB1
DGW : WSM0060AREF100
SHT : 1/2

SCHILLER
MEDICAL S.A.S.



DEFIGARD 5000
Circuit batterie et clavier
Battery board and keyboard

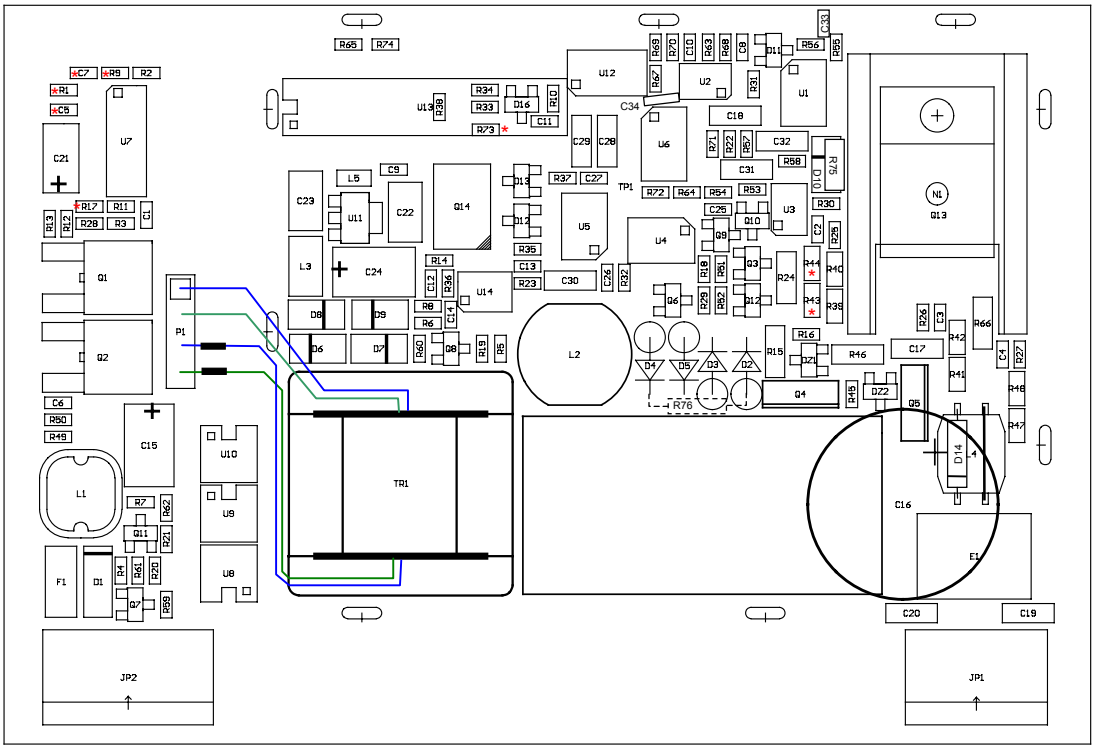
DRAWN	APPROV	MODIFICATION
CK ECL100 01 / 05	NF ECL100 01 / 05	

ART : WSM0060A
PRT : WSM0060_PCB1
DGW : WSM0060AREF100
SHT : 2/2

SCHILLER
MEDICAL S.A.S.

7.7. PACEMAKER BOARD: (part no. WSM0059A)

WSM0059_PCB0



* = pas monté / not mounted

Dimensions: 97 mm x 66 mm

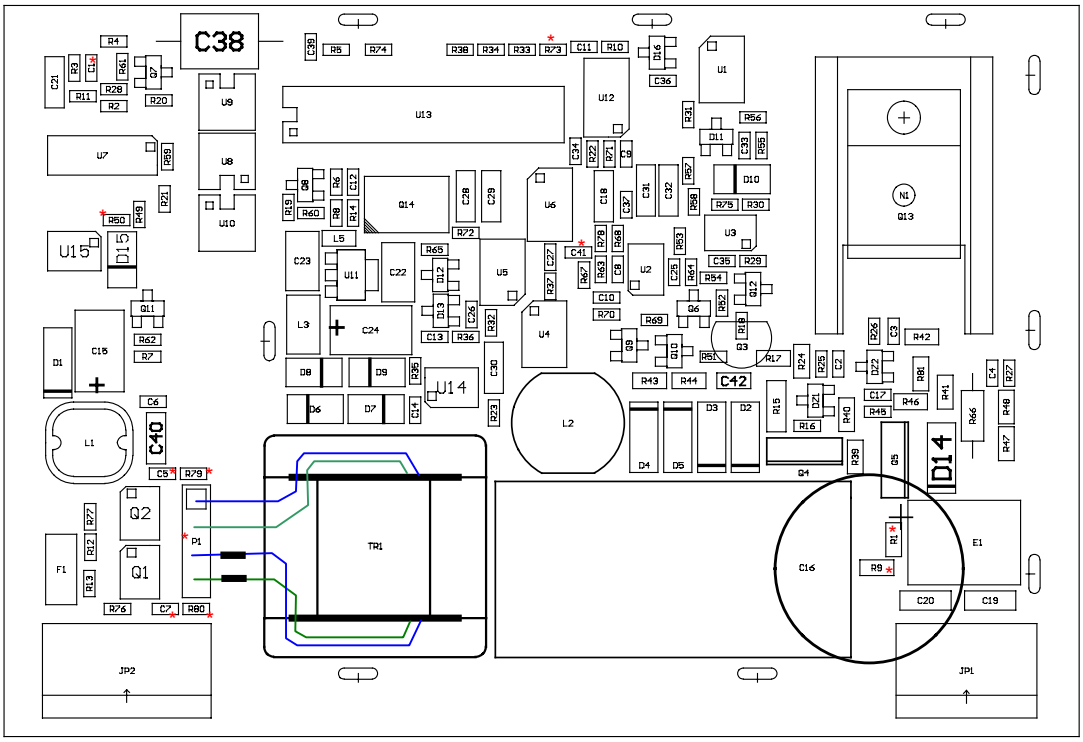
DEFIGARD 5000
Circuit stimulateur
Stimulator board

DRAWN	APPROV	MODIFICATION
CK ECL000 11 / 04	JM ECL000 11 / 04	

ART : WSM0059A
PRT : WSM0059_PCB0
DGW : WSM0059AREF000
SHT : 1/1

SCHILLER
MEDICAL S.A.S.

WSM0059_PCB1



* = pas monté / not mounted

Dimensions: 97 mm x 66 mm

DEFIGARD 5000
Circuit stimulateur
Stimulator board

DRAWN	APPROV	MODIFICATION
CK ECL100 04 / 05	JM ECL100 04 / 05	

ART : WSM0059A
PRT : WSM0059_PCB1
DGW : WSM0059AREF100
SHT : 1/1

SCHILLER
MEDICAL S.A.S.

7.8. LCD DISPLAY TFT 800X600 : (part no. 4-30-0001)

Référence AUO : G104SN03

1.0 Handing Precautions

1) Since front polarizer is easily damaged, pay attention not to scratch it.
2) Be sure to turn off power supply when inserting or disconnection from input connector.
3) Wipe off water drop immediately. Long contact with water may cause discoloration or spots.
4) When the panel surface is soiled, wipe it with absorbent cotton or other soft cloth.
5) Since the panel is made of glass, it may break or crack if dropped or bumped on hard surface.
6) Since CMOS LSI is used in this module, take care of static electricity and insure human earth when handling.
7) Do not open nor modify the module Assembly.
8) Do not press the reflector sheet at the back of the module to any directions.
9) In case if a module has to be put back into the packing container slot after once it was taken out from the container, do not press the center of the CCFL Reflector edge. Instead, press at the far ends of the CFL Reflector edge softly. Otherwise the TFT module may be damaged.
10) At the insertion or removal of the Signal Interface Connector, be sure not to rotate nor tilt the interface Connector of the TFT module.
11) After installation of the TFT module into an enclosure, do not twist nor bend the TFT module even momentary. At designing the enclosure, it should be taken into consideration that no bending/twisting forces are applied to the TFT module from outside. Otherwise the TFT module may be damaged.
12) Cold cathode fluorescent lamp in LCD contains a small amount of mercury. Please follow local ordinances or regulations for disposal.
13) Small amount of materials having no flammability grade is used in the LCD module should be supplied by power complied with requirements of Limited Power Source, or be applied exemption.
14) The LCD module is designed so that the CFL in it is supplied by Limited Current Circuit. Do not connect the CFL in Hazardous Voltage Circuit.

2.0 General Description

This specification applies to the 10.4 inch color TFT LCD module G104SN03 V.0.

This module is designed for General Display.

The screen format is intended to support the SVGA (800(H) x 600(V)) screen and 262k colors (RGB 6-bits data driver).

All input signals are LVDS interface compatible.

The module does not contain an inverter card for backlight.

Features

- SVGA 800(H) x600(V) resolution
- 1 CCFL(Cold cathode Fluorescent Lamp)
- High contrast ratio, High transmittance ratio
- Wide viewing angle
- High speed response
- Low power consumption
- LVDS interface

Applications

Information Appliance

Industrial Application

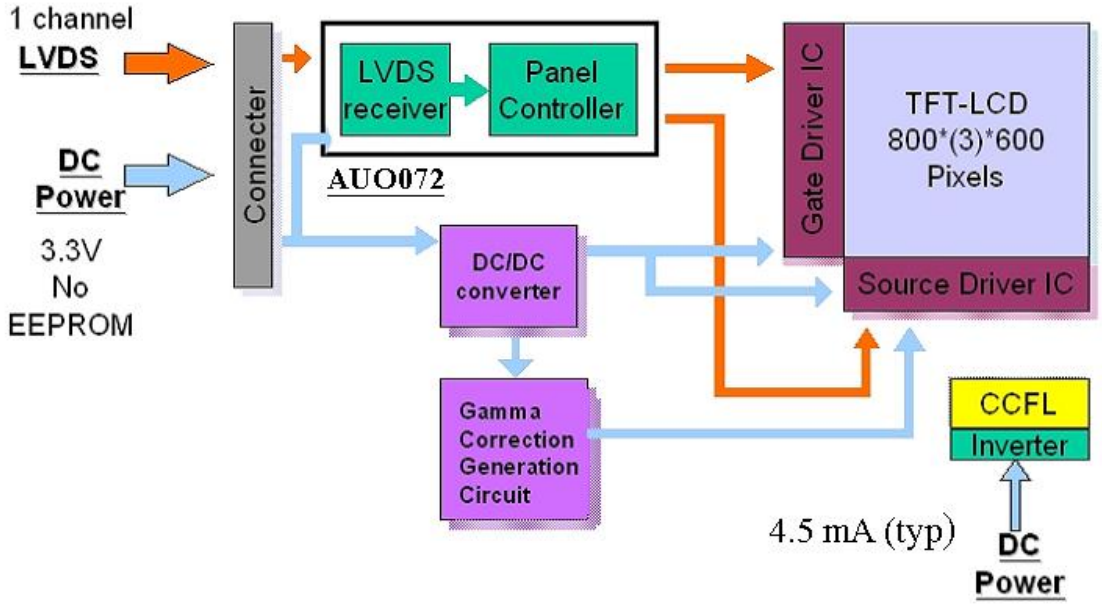
2.1 Display Characteristics

The following items are characteristics summary on the table under 25℃ condition：

Items	Unit	Specifications
Screen Diagonal	[inch]	10.4”
Outline dimension	[mm]	236.0(W) x 174.3(H) x 5.6(D)
Active Area	[mm]	211.2(H) x 158.4(V)
Resolution H x V		800(R, G,B x3) x 600
Pixel Pitch	[mm]	0.264(H) x 0.264(V)
Pixel Arrangement		R.G.B. Vertical Stripe
Display Mode		TN mode, Normally White
Typical White Luminance (ICFL=4.5 mA)	[cd/m^2]	230 Typ. (center)
Contrast Ratio		500：1 Typ.
Optical Rise Time/Fall Time	[msec]	10/25 Typ.
Viewing angle (CR≧10)		60/60/35/65 (L/R/U/D)
Nominal Input Voltage VDD	[Volt]	+3.3 Typ.
Typical Power Consumption (VDD line + VCFL line)	[Watt]	3.3 Typ
Weight	[Grams]	280 Typ ± 10
Surface treatment		Anti-glare,hard coating 3H
Electrical Interface		1 channel LVDS
Support Color		Native 262K colors (RGB 6-bit driver)
Temperature Range Operating Storage(Shipping)	 [℃] [℃]	 0 to +50 -20 to +60

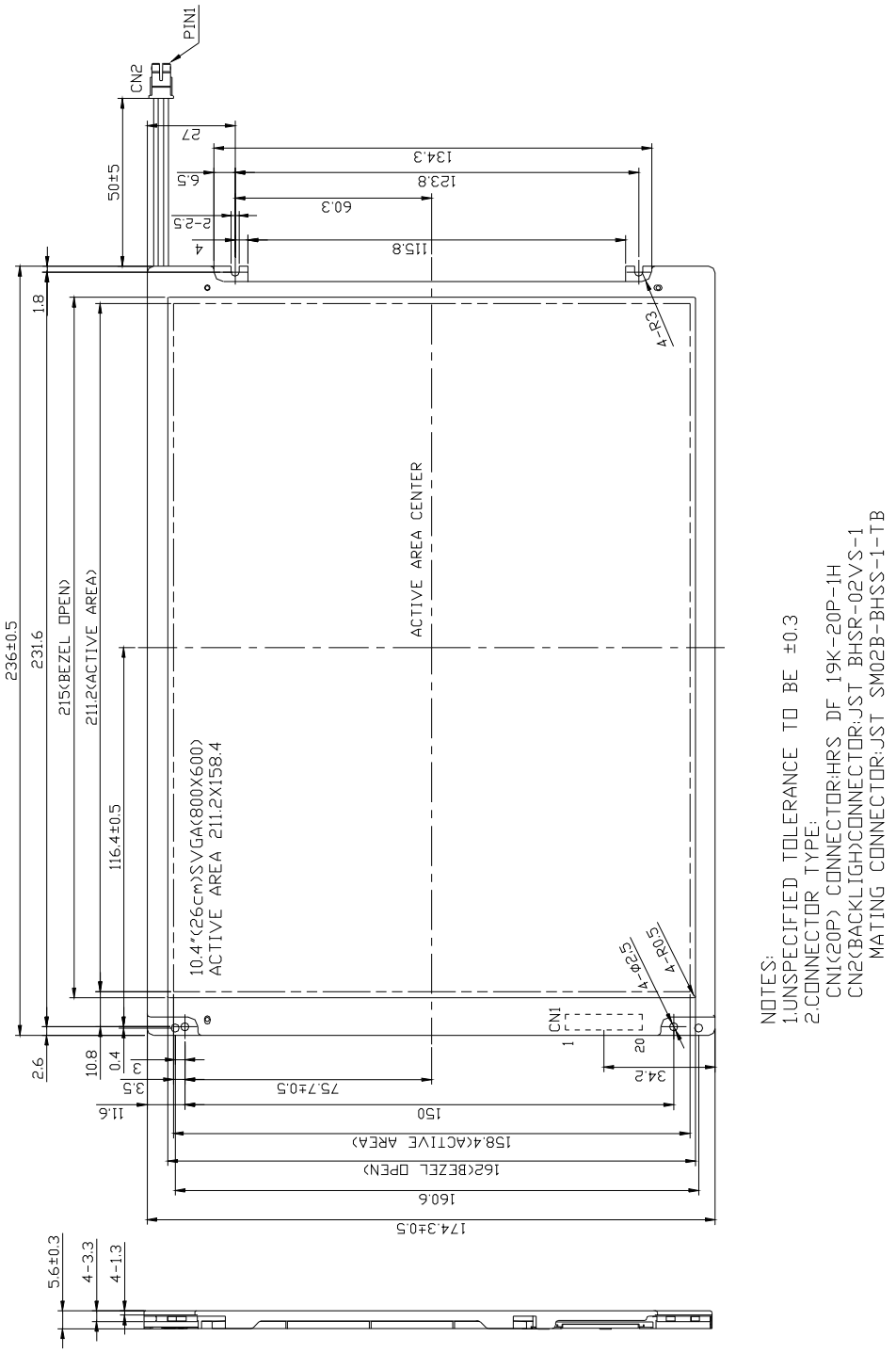
2.2 Functional Block Diagram

The following diagram shows the functional block of the 10.4 inches Color TFT LCD Module：



13.0 Mechanical Characteristic

LCM outline dimensions



7.9. LIGHTING BOARD: (part no. 4-24-0003)

Référence AUO : GH025A

GREEN C&C TECH	INVERTER SPECIFICATION (GH025A)	R&D DATE : 2001.03.30

1. APPLICATION

This Document Specified The Detailed Product Requirements of Inverter GH025A

2. SUITABLE LOAD

LCD MODULE : 10.4" 1 LAMP TFT LCD

3. ELECTRICAL CHARACTERISTICS

3-1. Absolute Maximum Ratings

ITEM	SYMBOL	SPEC	UNIT	REMARKS
INPUT VOLTAGE1	Vin1	8 ~ 20	V	
INPUT VOLTAGE2	Vin2	4.9~5.1	V	
OPERATING TEMPERATURE	Top	0~50	℃	
STORAGE TEMPERATURE	Tstg	-30~80	℃	
RELATIVE HUMIDITY	RH	80	%	

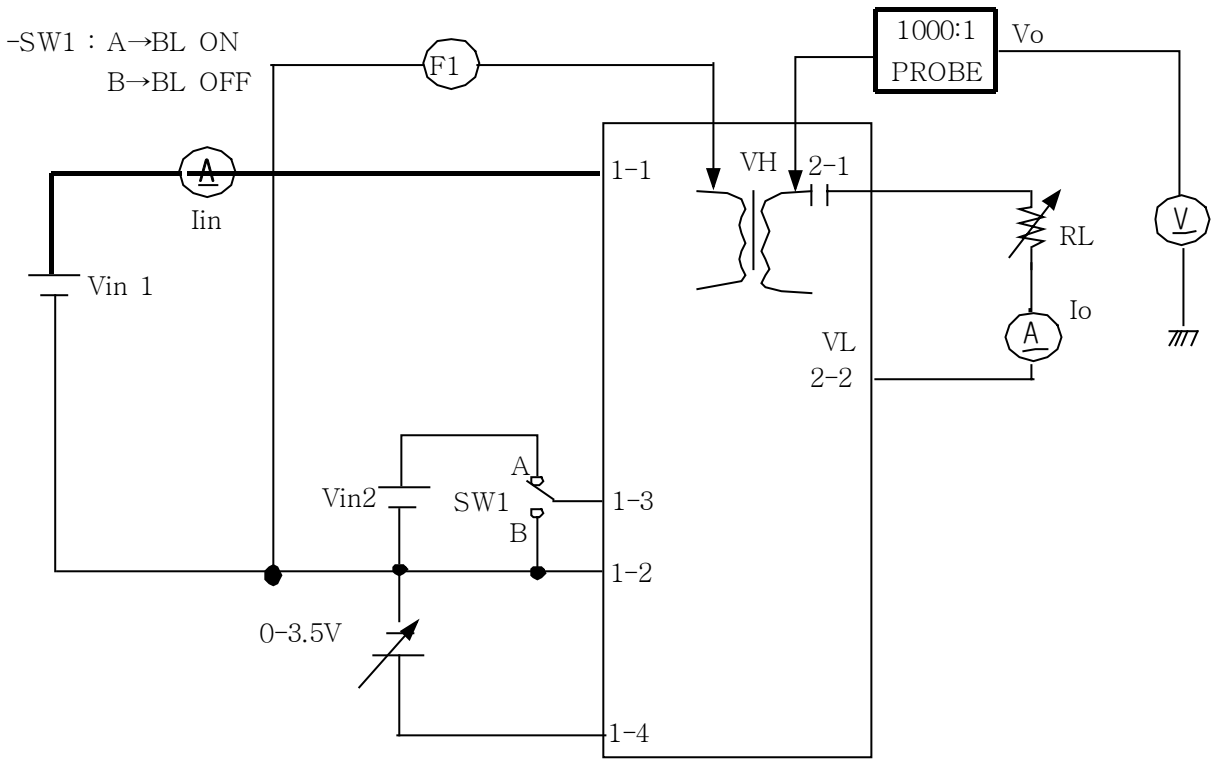
3-2. Control Signal

PIN NO.	SYMBOL	STATUS	ACTION	REMARKS
CN1 #3	BKLT_ON	HIGH	LAMP(CCFL)-ON	2.4~5.25V
		LOW	LAMP(CCFL)-OFF	0.8V MAX

3-3. Output Characteristics

ITEM	SYMBOL	CONDITION			SPECIFICATION			UNIT
		Vin1(V) (DC-IN)	BRT-ADJ	RL(kΩ)	MIN	TYP	MAX	
OUTPUT CURRENT	Io(max)	12	0V	80±0.5	6.0	6.5	7.0	mArms
	Io(min)	12	3.5V	80±0.5	2.0	2.5	3.0	
INPUT CURRENT	Iin	12	0V	80±0.5	0.3	0.4	0.5	ADC
FREQUENCY	F	12	OV	80±0.5	45	50	55	KHz
OPEN OUTPUT VOLTAGE	Vo	12	0V	∞	1.2	-	1.9	kVrms

3.4 Test Circuit



4. INTERFACE

4.1 CN1 CONNECTOR :53261-0590(MOLEX) or Equivalent

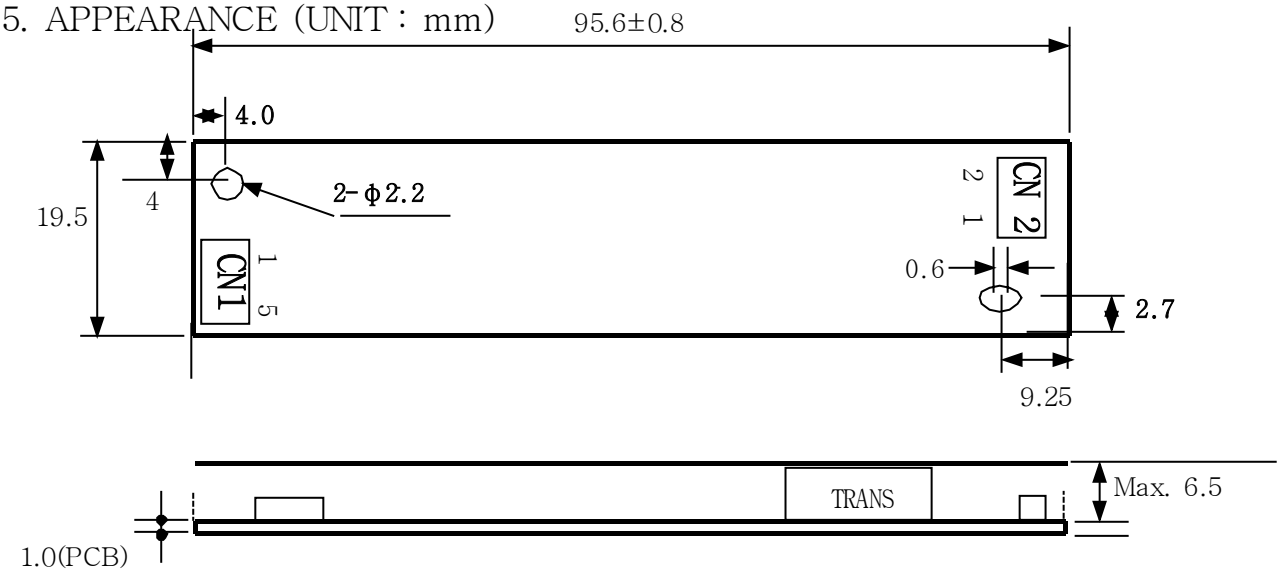
PIN NO	SYMBOL	REMARK
4	BRT_ADJ	0 ~ 3.5V
2	GND	GND
3	BL ON/OFF	CCFL Drive SIGNAL(Active HIGHT)
1	DC-IN(Vin)	DC INPUT Power (12V)
5	N.C	

4.2 CN2 CONNECTOR : SM02B-BHSS or Equivalent

PIN NO.	SYMBOL	REMARK
1	HOT	HIGH
2	COLD	LOW

GREEN C&C TECH	INVERTER SPECIFICATION (GH025A)	R&D DATE : 2001.03.30

5. APPEARANCE (UNIT : mm)



6. NOTATION OF LOT NUMBER

MARKING : BOTTOM OF PCB.

GH025A
YYWWMMM

GH025A : MODEL NAME

YY : YEAR OF PRODUCT 91,'92,'93,'94,...'00,'01

WW : WEEK OF PRODUCT 01,02,03,04,...54,55

MMMM : SERIAL NUMBER 0001,0002.....9998,9999

11. RELIABILITY TEST SPEC

NO.	ITEM	CONDITIONS AND METHOD
1	High Temperature Storage Test	Temp : 70℃ Duration 500hrs
2	Low Temperature Storage Test	Temp : -30℃ Duration 500hrs
3	High Temperature High Humidity Storage	Temp : 40℃ Humid 95%RH Duration 500hrs
4	High Temperature High Humidity Operation test	Temp : 40℃ Humid 95%RH Duration 1000hrs
5	Thermal Shock Test	Temp -30℃ ↔ 70℃,250cycle (30min) (30min)
6	Vibration test	Amplitude :1.5mm Frequency :10~55Hz Position : three perpendicular planes Duration 1000hrs
7	High Temperature Operation test	Temp : 50℃ Duration 72hrs
8	Low Temperature Operation test	Temp : 0℃ Duration 72hrs

1. MATERIAL LISTS FOR SAFETY GH025A

1.1 LIST

SYMBOL	NAME	TYPE NO.	MANUFACURER	DESCRIPTION
FI	FUSE	451001&452001	LITTELFUSE INC	UL FILE NO :E10480 CSA FILE NO :LR29862
		SSQ1	BEL	UL FILE NO :E20624 CSA FILE NO :LR39772
PCB	PRINTED WIRING BOARD	FR-4	WONKYENG	UL FILE NO :E202541
			YOUNG EUN ELECTRONICS	UL FILE NO:E173507
CN1	CONNECTOR	53261-0590	MOLEX	NYLON 4/6 UL94V-0
	"	12505WR-04	YEONHO	"
CN2,3	CONNECTOR	SM02B-BHSS	JST	PA46 UL94V-0
	"''	20015WR-05	YEONHO	"
	INSULATOR	PC	TEIJIN CHEMICALS	UL FILE NO:E50075(M)
T1	TRANSFORMER	TS-121A	DAISUNG TELECOMMUNICATIONS	CLASS A (105 de.C) SEE TRANS SPEC
			NAMYANG ELECTRONICS	CLASS A (105 de.C) SEE TRANS SPEC
			KYUNGIN ELECTRONICS	CLASS A (105 de.C) SEE TRANS SPEC
			DONGHUNG	CLASS A (105 de.C) SEE TRANS SPEC