

LUCAS® 2

Chest Compression System Service Manual



Important User Information

All Service technicians must read this entire Service Manual before opening or disassembling the LUCAS device.

SCOPE

This service manual covers the LUCAS® 2 Chest Compression System, also known as LUCAS in this manual. For older versions of LUCAS use the LUCAS service manual (Art # 100469-00).

REQUIRED SKILLS

Service technicians must be properly qualified and trained to perform maintenance according to this manual.

Technician must meet at least one of the following requirements (or the equivalent):

- Associate of Applied Science, with an emphasis in biomedical electronics
- Certificate of Technical Training, with an emphasis in biomedical electronics
- Equivalent biomedical electronics experience

DISCLAIMER

Jolife AB does not accept liability for injury to personnel or damage to equipment that may result from misuse of LUCAS. Under no circumstances shall Jolife AB be liable for incidental or consequential damage arising from the use of LUCAS.

PATIENT SAFETY RELATED FAULTS

All discovered failures that directly or indirectly have, or may have, affected patient or user safety shall, with no delay, be reported directly to the Quality Department at Physio-Control, Inc. or Jolife AB.

TRADEMARKS

LUCAS®2 is a trademark of Jolife AB.

OTHER RELATED INFORMATION

For more information regarding LUCAS please read: *LUCAS® 2 Chest Compression System - Instruction for Use (LUCAS 2.0 and LUCAS 2.1 Art. #:100666-XX)*
(LUCAS 2.2 Art. # 100901-XX)

REPORTING

All performed service shall be reported to Physio-Control, Inc. on a monthly basis.

The information shall comprise:

- Serial number of device serviced
- Detailed description of symptoms and problem description
- Actions taken
- Replaced parts, with serial number or batch number when applicable
- Person performing service actions (service technician)

DEVICE TRACKING

All performed service where modules are replaced, the serial no./batch no. of each module shall be stated in the service report. This information is then sent to Physio-Control, Inc. on a monthly basis.

The modules that have traceability are:

- Compression Module
- Electronic PCBs
- Electric Motor
- Battery
- Back Plate
- Main Body
- Support Leg
- Hood

RECYCLING INFORMATION

Important!

The battery used in LUCAS shall be returned to the local recycling station or dealer/distributor for correct recycling.

LUCAS contains of several materials as listed below:

- Polyamide reinforced with 30% glass fiber
- Polycarbonate/Polybutylene Terephthalate
- Polycarbonate
- Polyurethane
- PVC
- POM
- Silicone
- Chloroprene
- Aluminum
- Stainless steel
- Brass

For further recycling information please contact Jolife AB, Sweden or Physio-Control, Inc.

RESPONSIBILITY FOR INFORMATION

The Technical Manager at Jolife AB and Physio-Control, Inc. are responsible for the information in this Service Manual.

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1. Introduction

1.1. Intended Use

LUCAS® 2 Chest Compression System is to be used for performing external cardiac compressions on adult patients who have acute circulatory arrest defined as absence of spontaneous breathing and pulse, and loss of consciousness.

LUCAS must only be used in cases where manual chest compression would be used. LUCAS is only intended for temporary use.

This manual is a part of the Service Education Program that, together with hands-on technical training, will provide the Service Technician with the knowledge to examine and repair LUCAS.



2. Warnings and Precautions

Except the warnings stated below, there are also warnings and precautions mentioned in the following documents that are of relevance during service and maintenance of LUCAS.

LUCAS® 2 Chest Compression System - Instruction for Use

(LUCAS 2.0 and LUCAS 2.1 Art. #: 100666-XX)

(LUCAS 2.2 Art. #: 100901-XX)

2.1. Electrical Hazard

Use caution when examining or operating the device without its covers.

2.2. Chemical Hazard

The battery contains chemicals that are harmful. In case of leakage, use extreme caution to avoid injuries.

WARNING: Never try to open the casing of the battery.

2.3. ESD Protection

Always use ESD protection when handling electronic boards and connections.

3. The Function of LUCAS

3.1. Electronics System

3.1.1. The Battery

LUCAS is driven by a rechargeable Lithium Ion Polymer (LiPo) battery. The battery can be charged during operation by an external Power Supply, connected to a wall outlet, or with a car power cable. You can also remove the battery from LUCAS and recharge it in a separately sold battery charger of desktop model.

IMPORTANT: The battery must be connected even when the device is supplied by the power supply.

The battery is mechanically keyed to LUCAS and the battery charger to make sure you get the correct installation. The top of the battery has connections for power and communication to the battery charger and to LUCAS.

The battery has built in intelligence to monitor the number of usage cycles and battery age to tell the user when to replace the battery. The battery intelligence also monitors the battery's internal temperature.

The battery supplies power to the electronics and the electrical motor. The motor is connected to the linear unit via a drive belt.

3.2.1. The Printed Circuit Boards

The electronics is divided into three parts that are situated on two separate PCB's:

- The Control System that controls the motor with information from the user interface and from the rotation and linear sensors.
- The Protective System that controls inputs and outputs and shut off in case of a problem.
- The internal Battery Charger that controls the charging sequence of the battery.

There are two separate linear measuring sensors that monitor the movement of the Suction Cup. One is for the Control System; the other one works as a reference to the Protective System.

The User Control Panel is the user interface with which the device can be controlled and monitored through six button switches and a number of LED's. The User Control Panel is situated on the hood and is connected to the protective/charger system that sends the signals to the control system. For further details on the User Control Panel please read chapter 2.7 in the Instructions for Use which also explains the different states on the Battery indicator.

An electrical fan is situated at the bottom of the device for cooling the electrical motor and other electronics. The fan starts when the internal temperature reaches 40°C and stops when the temperature is below 30°C.

See pictures on the following page.

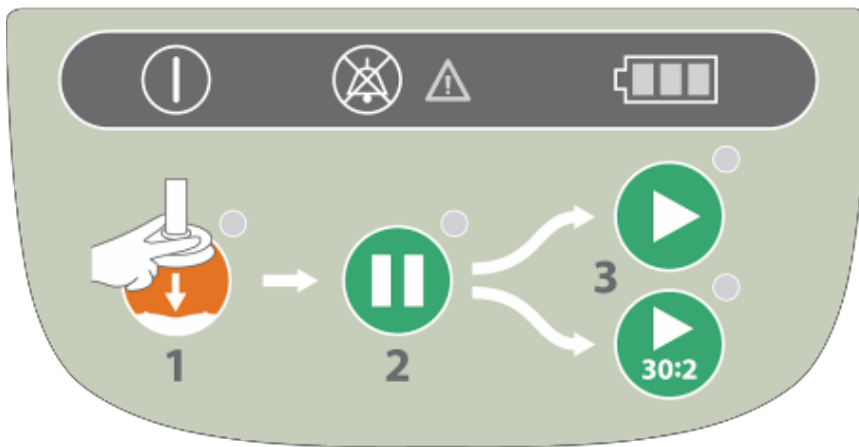


Figure 3.1-1: LUCAS User Control Panel

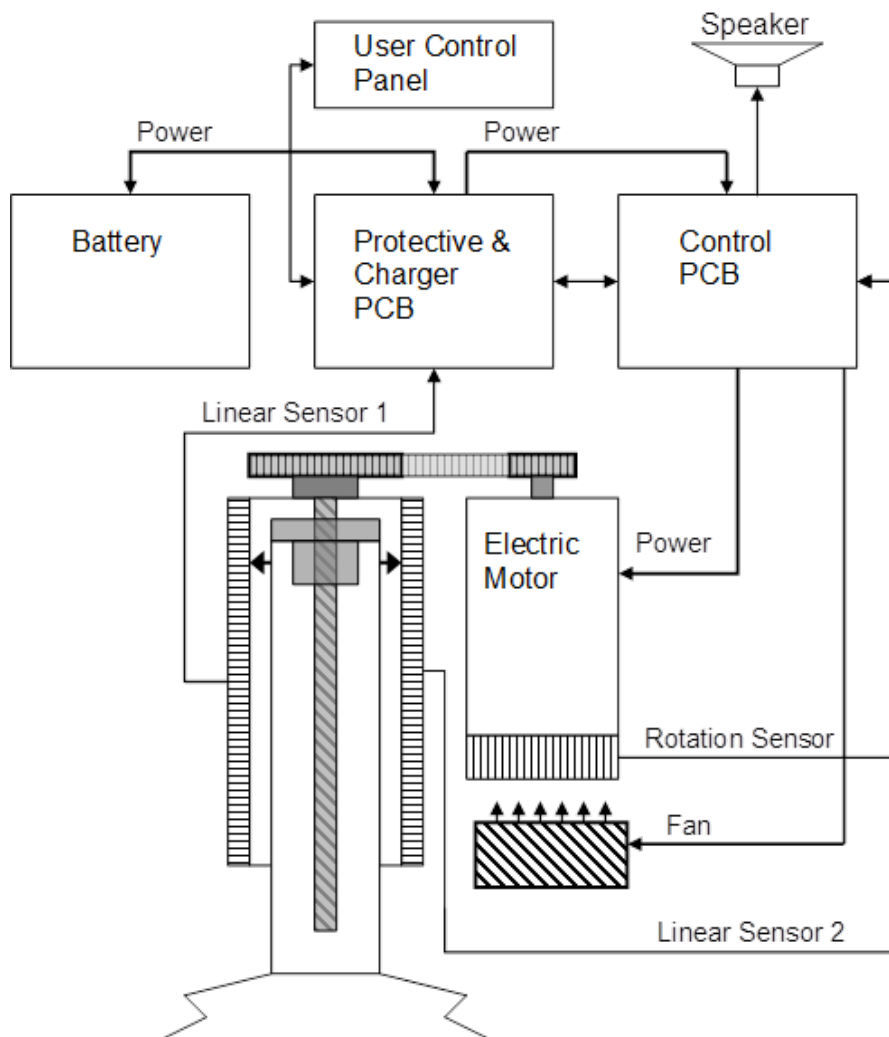


Figure 3.1-2: Schematic picture of the electronics of LUCAS

3.2. Compression Mechanism

The Drive Belt, driven by the Electrical Motor, drives the Carry Ball screw, forcing the carry ball nut up and down.

The nut is fitted to a piston that moves the suction cup piston up and down.

The Decompression Spring reduces the upstroke force

The Suction Cup is adjusted to the patients' chest with a servo aid system. It can easily be replaced with respect to hygiene.

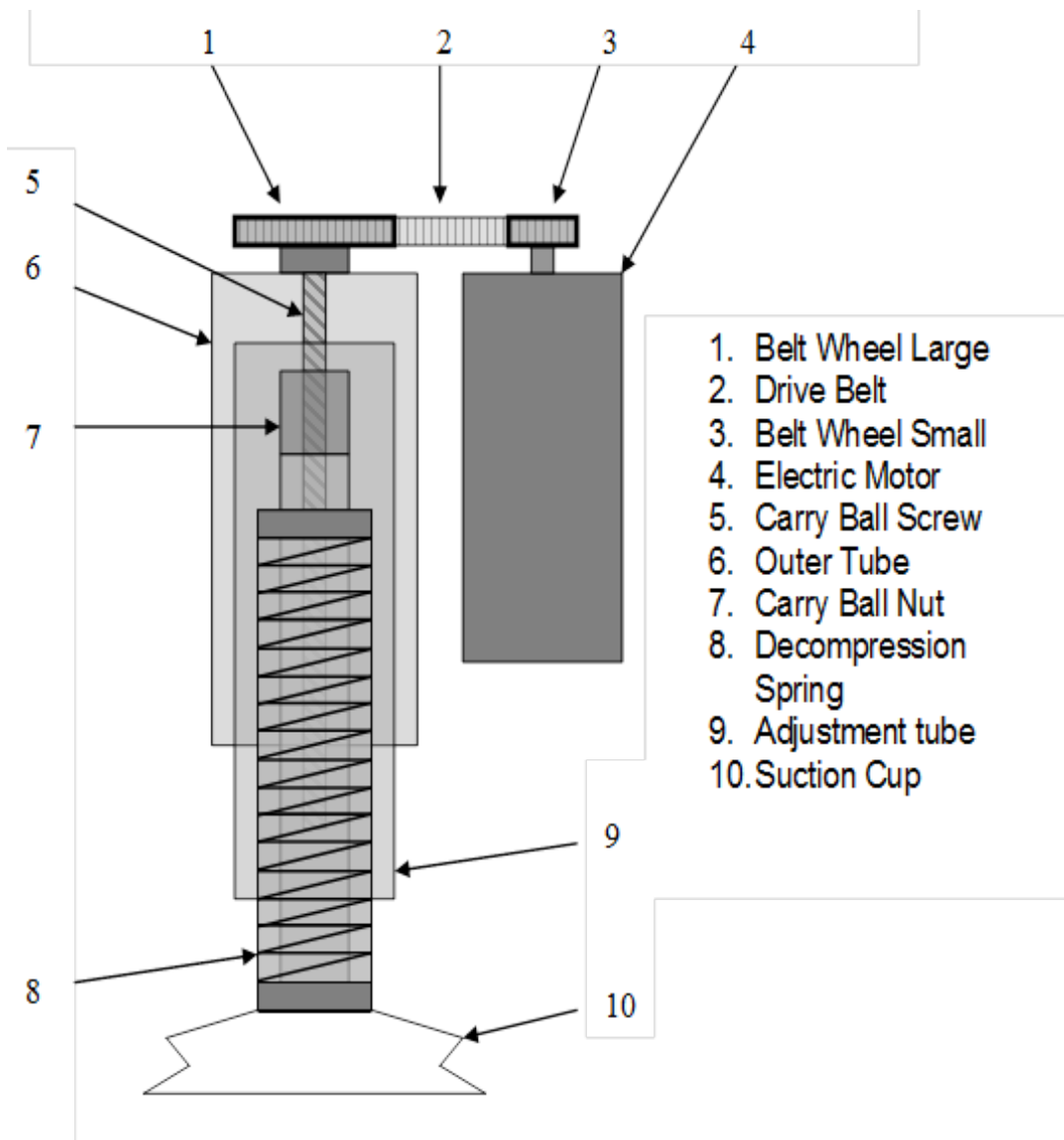


Figure 3.2-1: Schematic picture of the Compression Mechanism of LUCAS

3.3. Components of the LUCAS® 2 Chest Compression System

LUCAS has two Support Legs that lock to the Back Plate with Claw Locks. The Support Legs are foldable for convenient transportation.

The Claw Locks automatically lock to the Back Plate when LUCAS is pressed on to it.

To unlock the Claw Locks, pull the Release Rings.



Figure 3.3-1: Components of LUCAS Chest Compression System

- | | |
|-----------------------|-----------------------------------|
| 1. User Control Panel | 12. Power Supply cord |
| 2. Hood | 13. Battery |
| 3. Patient Strap | 14. Pressure pad |
| 4. Release ring | 15. Upper Part |
| 5. Support leg | 16. Vent holes |
| 6. Claw locks | 17. Car Power Cable |
| 7. Back Plate | 18. Carrying Bag |
| 8. DC input | LUCAS Stabilization Strap: |
| 9. Bellows | 19. Cushion strap |
| 10. Suction Cup | 20. Buckle |
| 11. Power Supply | 21. Support leg strap |

4. LUCAS® 2 Program Loader

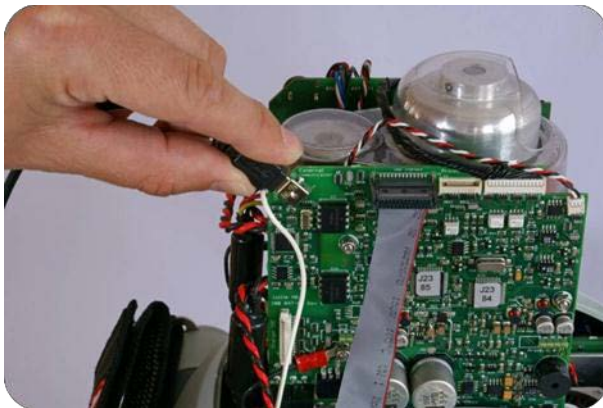
LUCAS® 2 PROGRAM LOADER IS SOFTWARE FOR UPDATING THE PROGRAM IN LUCAS. IT CAN ALSO BE USED TO READ ERRORS AND WARNINGS FROM THE DEVICE. THIS SECTION EXPLAINS HOW THE SOFTWARE WORKS.

4.1. Software Installation

Installation of a USB driver must be completed to connect to the Lucas device. Run the application directly by clicking on the USB Driver icon. (This is only needed the first time the LUCAS 2 Program Loader is installed, independent of which version. Then copy the file (LUCAS2_V2X.exe) file from the media to the desktop, or to another location, and then create a shortcut on the desktop.

4.2. Connect the Device

Connect an USB cable between the computer and the device, the connector is situated at the lower left side of the Control PCB on LUCAS 2.2. (On LUCAS 2.0 and LUCAS 2.1 the connector is situated at the top left corner of the Protective PCB, according to picture below.)



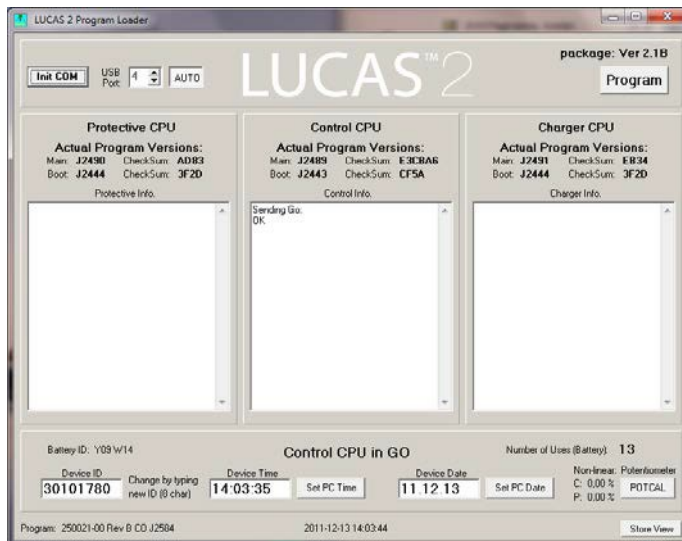
Start the device.

Start the software by executing the .exe file for the device you are working on. For example, if you are working on a LUCAS 2.2, you will execute LUCAS2_V22.exe file.



4.3. Using the Software

When the program is started this window should appear:

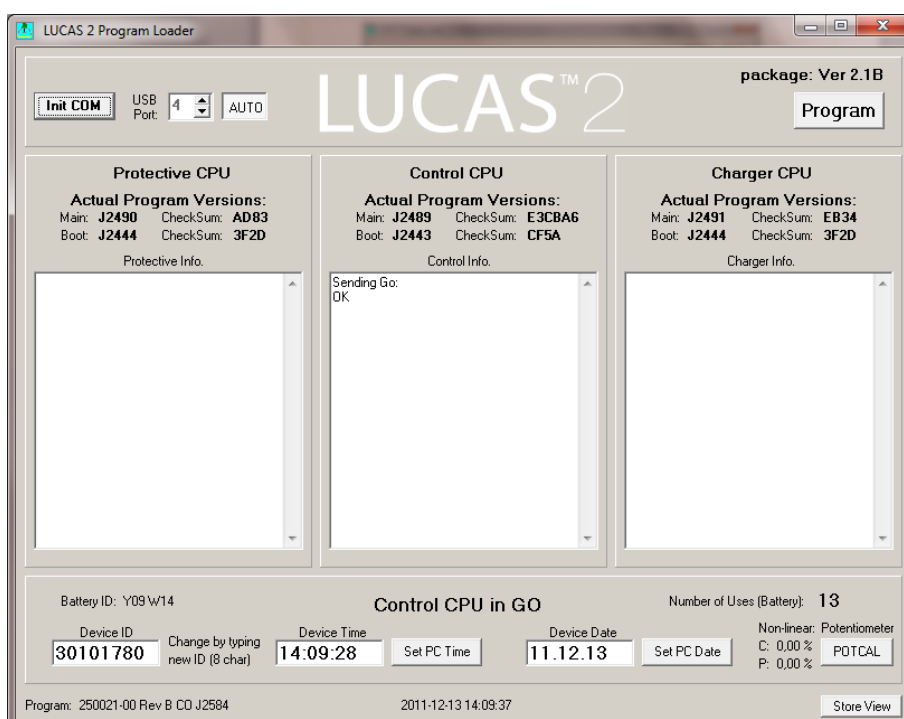


The picture shows software LUCAS2_V21B.

Normally the software detects the device at start. If not, set the USB Port setting to AUTO and then Click "Init COM".



Now the information about the device should appear in the designated windows.



The present Errors and Warnings appear in each CPU's box window.
It's also possible to set the Device ID, Time and Date (uses the PC time and date).

4.4. Update the Program

To update the program, click Program in the upper right corner.

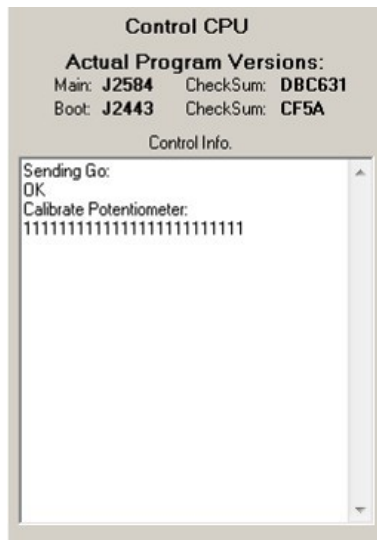


The programming process will start and update the software for each CPU.

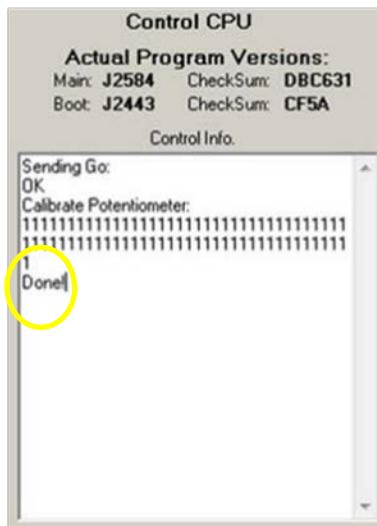
When all three CPU's are updated this window will appear where you are prompted to make a Linear Sensor Calibration. Before you click the Start button please make sure that nothing can influence the movement of the suction cup and that the device is in its upright position.

Click START.

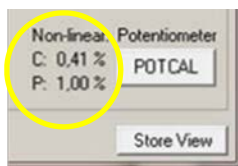
Now the Calibration process will start. The progress can be followed in the Control CPU's window.



When the calibration is finished you'll get this message:



Now the calibration result is shown in the lower right corner.



Click Store View to print and save the result.

4.5. Failed Calibration

If the value for Control exceeds 6% or if the value for Protective exceeds 3.1% the device will make an alarm and an error code will be shown in the Control CPU window.

If this happens, mute the alarm, check that nothing interferes with the movement of the suction cup and that the device is upright. Click POTCAL to make a new calibration.

If also the second calibration fails it might be necessary to replace the Compression Module.

4.6. Checksum

To identify the installed program version, you can check the checksums acc. to table below:

Program ver:	Protective CPU		Control CPU		Charger CPU	
	Main	Boot	Main	Boot	Main	Boot
2.0	AD83	3F2D	E3CBA6	CF5A	EB34	3F2D
2.1	C5FF	3F2D	D9B3A1	CF5A	5221	3F2D
2.1B	C5FF	3F2D	DBC631	CF5A	5221	3F2D
2.2	7A33	5F05 or A20C or E561	E37FFD	1182 or 12C5	48DD	5F05 or A20C or E561

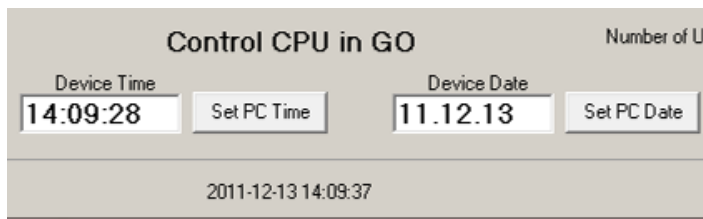
4.7. Change Device ID

The Device ID (=Serial number of the device) can be set simply by typing in the wanted ID (8 char), typically 3014XXXX. The ID is automatically saved. The software LUCAS2_V22 also shows the Battery S/N if the Battery contains this Serial number.



4.8. Set Time and Date

To set the time and date first make sure that time and date is correctly set at the computer, then click “Set PC Time” or “Set PC Date”.



For Version 2.0, it may be necessary to temporarily set your computer's regional settings to Sweden for the format to take correctly.

4.9. Store View

The view can be stored for future reference by clicking “Store View”.



The window will then be saved in a folder “Pictures” with the serial number as file name. At the same time, the window will be printed at the selected default printer. If no printer is connected a message will appear which can be cancelled. The picture will be saved and can be printed at any time

5. Troubleshooting

IN THIS SECTION WE WILL EXPLAIN THE WAY OF TROUBLESHOOTING LUCAS

5.1. Indications and Alerts During Normal Operation

Below table describe the different situations of audible and visible signals that can occur during normal operation. The audible signals were updated in LUCAS 2.2 with regards to sound patterns; please refer to Instructions for Use 100901-XX for more information. Below the audible and visible signals for LUCAS 2 are showed in four different tables.

LUCAS 2.2

Situation	Visual LED Indication	Audible signals	User action
LUCAS is in the ON mode and there is more than 90% Battery capacity remaining.	 Fully charged Battery: All 3 green Battery indication LEDs show a constant light.	None	None
LUCAS is in the ON mode and there is more than 60% and less than 90% Battery capacity remaining.	 2/3 charged Battery: The 2 green Battery indication LEDs to the right show a constant light.	None	None
LUCAS is in the ON mode and there is more than 30% and less than 60% Battery capacity remaining.	 1/3 charged Battery: The green Battery indication LED farthest to the right shows a constant light.	None	None
LUCAS is in the ON mode and there is less than 30% Battery capacity remaining (approximately 10 minutes of operating capacity).	 Low Battery: The orange Battery indication LED farthest to the right illuminates intermittently.	Medium priority alarm ■ ■ ■ (5s) ■ ■ ■ (5s) ...	Replace the Battery or connect to the external power supply.
An external LUCAS Power Supply is connected and charging the Battery.	 Charging Battery: The 3 green Battery indication LEDs show a "running" light.	None	None
An external LUCAS Power Supply is connected and the Battery is fully charged.	 Fully charged Battery: All 3 green Battery indication LEDs show a constant light.	None	None
The Battery has been used more than 200 times with compressions of more than 10 minutes each or is older than 3 years.	 End of Battery service life: The Battery indication LED farthest to the right shows orange light instead of green, in all the above situations.	None	Dispose of Battery.

Figure 5.1-1: Table 1/2 – Indications and alerts during normal operation LUCAS 2.2

Situation	Visual LED indication	Audible signals	User action
In the ADJUST mode.	 The ADJUST LED shows a green light.	None	None
In the PAUSE mode.	 The PAUSE LED shows a green light.	None	None
In the ACTIVE (continuous) mode	 The ACTIVE (continuous) key, LUCAS performs continuous chest compressions. The green LED signal will blink 8 times per minute	None	This is to alert for ventilation during ongoing compressions.
In the ACTIVE (30:2) mode	 The ACTIVE (30:2) LED shows a green light with an intermittent LED during compressions number 26, 27, 28, 29 and 30.	Audible signal during compressions 	This is to alert the operator to ventilate the patient when LUCAS temporarily stops the compressions at number 30.
When the Suction Cup is in a lower position than for the minimum patient (sternum height below 6.7 inches / 17 cm) and you cannot enter the PAUSE mode or ACTIVE mode, the patient is too small.	None	3 fast signals  (0.25s)	Continue with manual compressions.
Too large gap between the pressure pad and the patient's chest during operation. The patient will get too shallow compressions.	None	3 fast signals during operation  (0.6s)	Push ADJUST and readjust the Start Position to eliminate the gap. Restart the compressions.

Figure 5.1-1: Table 2/2 – Indications and alerts during normal operation LUCAS 2.2

LUCAS 2.1 and LUCAS 2.0

Situation	Visual LED indication	Audible signals	User action
LUCAS is in the ON mode and there is more than 90% Battery capacity remaining.	 Fully charged Battery: All 3 green Battery indication LEDs show a constant light.	None	None
LUCAS is in the ON mode and there is more than 60% and less than 90% Battery capacity remaining.	 2/3 charged Battery: The 2 green Battery indication LEDs to the right show a constant light.	None	None
LUCAS is in the ON mode and there is more than 30% and less than 60% Battery capacity remaining.	 1/3 charged Battery: The green Battery indication LED farthest to the right shows a constant light.	None	None
LUCAS is in the ON mode and there is less than 30% Battery capacity remaining (approximately 10 minutes of operating capacity).	 Low Battery: The orange Battery indication LED farthest to the right illuminates intermittently.	Intermittent alarm	Replace the Battery or connect to the external power supply.
An external LUCAS Power Supply is connected and charging the Battery.	 Charging Battery: The 3 green Battery indication LEDs show a "running" light.	None	None
An external LUCAS Power Supply is connected and the Battery is fully charged.	 Fully charged Battery: All 3 green Battery indication LEDs show a constant light.	None	None
The Battery has been used more than 200 times with compressions of more than 10 minutes each.	 End of Battery service life: The Battery indication LED farthest to the right shows orange light instead of green, in all the above situations.	None	Dispose of Battery.
In the ADJUST mode.	 The ADJUST LED shows a green light.	None	None
In the PAUSE mode.	 The PAUSE LED shows a green light.	None	None

Figure 5.1-2: Table 1/2 – Indications and alerts during normal operation LUCAS 2.0 and LUCAS 2.1

Situation	Visual LED indication	Audible signals	User action
In the ACTIVE (continuous) mode	 The ACTIVE (continuous) key, LUCAS performs continuous chest compressions. The green LED signal will blink 8 times per minute	None	This is to alert for ventilation during on-going compressions.
In the ACTIVE (30:2) mode	 The ACTIVE (30:2) LED shows a green light with an intermittent LED during compressions number 26, 27, 28, 29 and 30.	Alarm signal alert during compressions number 28 ("ding"), 29 ("ding") and 30 ("dong").	This is to alert the operator to ventilate the patient when LUCAS temporarily stops the compressions at number 30.
When the Suction Cup is in a lower position than for the minimum patient (sternum height below 6.7 inches / 17 cm) and you cannot enter the PAUSE mode or ACTIVE mode, the patient is too small.	None	3 fast signals	Continue with manual compressions.
Too large gap between the pressure pad and the patient's chest during operation. The patient will get too shallow compressions.	None	3 fast signals during operation	Push ADJUST and readjust the Start Position to eliminate the gap. Restart the compressions.

Figure 5.1-2: Table 2/2 – Indications and alerts during normal operation LUCAS 2.0 and LUCAS 2.1

5.2. LUCAS Malfunction Alarm

Below is a list on all alarms that can occur on the LUCAS. The alarms can be muted for 60

seconds by pressing MUTE.



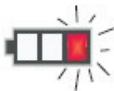
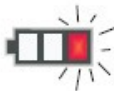
The audible alarms were updated in LUCAS 2.2 with regards to sound patterns. Please refer to Instructions for Use 100901-XX for information.

LUCAS 2.2

Priority	Reason	Visual LED indication	Audible alarms	Result
N/A	Rising temperature in LUCAS	None	Information Signal ■ (4s) ■ (4s) ...	None
High Priority	Compression pattern outside limit (too deep, too shallow or timing failure)	 Intermittent red alarm LED	High Priority Alarm ■ ■ ■ (..) ■ ■ (..) (2.5s) ■ ■ ■ (..) ■ ■ (..) (2.5s) ■ ■ ■ (..) ■ ■ (..) (2.5s) ■ ■ ■ (..) ■ ■ (..) (2.5s) LATCHING ALARM SIGNAL	Compressions stop
High Priority	Too high temperature in LUCAS	 Intermittent red alarm LED	High Priority Alarm ■ ■ ■ (..) ■ ■ (..) (2.5s) ■ ■ ■ (..) ■ ■ (..) (2.5s) ■ ■ ■ (..) ■ ■ (..) (2.5s) ■ ■ ■ (..) ■ ■ (..) (2.5s) LATCHING ALARM SIGNAL	Compressions stop
High Priority	Hardware error	 Intermittent red alarm LED	High Priority Alarm ■ ■ ■ (..) ■ ■ (..) (2.5s) ■ ■ ■ (..) ■ ■ (..) (2.5s) ■ ■ ■ (..) ■ ■ (..) (2.5s) ■ ■ ■ (..) ■ ■ (..) (2.5s) LATCHING ALARM SIGNAL	Compressions stop
High Priority	Too high Battery temperature	  Red Battery alarm: The red Battery Indication LED farthest to the right lit intermittently.	High Priority Alarm ■ ■ ■ (..) ■ ■ (..) (2.5s) ■ ■ ■ (..) ■ ■ (..) (2.5s) ■ ■ ■ (..) ■ ■ (..) (2.5s) ■ ■ ■ (..) ■ ■ (..) (2.5s) LATCHING ALARM SIGNAL	Compressions stop
High Priority	Battery charge too low	  Red Battery alarm: The red Battery Indication LED farthest to the right lit intermittently.	High Priority Alarm ■ ■ ■ (..) ■ ■ (..) (2.5s) ■ ■ ■ (..) ■ ■ (..) (2.5s) ■ ■ ■ (..) ■ ■ (..) (2.5s) ■ ■ ■ (..) ■ ■ (..) (2.5s) LATCHING ALARM SIGNAL	Compressions stop. The Battery must be recharged.

5.2-1: Table – Malfunction alarms LUCAS 2.2

LUCAS 2.0 and LUCAS 2.1

Reason	Visual LED indication	Audible alarms	Result
Compression pattern outside limit (too deep, too shallow and timing failure)	 Red alarm LED	Alarm	Compressions stop
Rising temperature in LUCAS		Warning alarm	None
Too high temperature in LUCAS	 Red alarm LED	Alarm	Compressions stop
Hardware error	 Red alarm LED	Alarm	Compressions stop
Too high Battery temperature	 Intermittent red Battery warning: The red Battery indication LED farthest to the right illuminates intermittently.	Intermittent alarm	Compressions stop
Battery charge too low	 Intermittent red Battery warning: The red Battery indication LED farthest to the right illuminates intermittently.	Intermittent alarm	Compressions stop. The Battery must be recharged in the external Battery Charger.
Battery error	 Constant red Battery warning: The red Battery indication LED farthest to the right shows a constant light.	Alarm	Compressions stop. The Battery cannot be used anymore.

5.2-2: Table – Malfunction alarms LUCAS 2.0 and LUCAS 2.1

5.3. Error Codes

In the software, LUCAS 2 Program Loader, it is possible to read error codes from the device. Below tables show these codes and an explanation on how to find the cause and point out which module to replace.

5.3.1. Error Codes from the Control CPU

Error Code	Explanation	Probable cause	Module to check / replace
T1_C_EE No=0x10	Control EE-Prom CheckSum data error	CPU fault	Replace Control board
T1_START_CO M No=0x13	No Communication between Protective and/or Battery-Charger CPU's at start	I2C communication faults. Halted Protective or Charger CPU.	Replace cable between boards or Protective board.
T1_PB_FLASH No=0x14	Incompatible programs in Protective board	Change of boards.	Reprogram device.

T1_CAL_EE No=0x15	Control Potentiometer Calibration data Checksum fault	Un-calibrated or Too un-linear or CPU fault	Perform a new calibration. If un-linear fault replace compression module. If CPU fault replace Control board
T1_C_INITCUR R No=0x20	High Current detected at Start	Fault read current to motor or broken driver FET's. +/- 12V supply fault.	If needed replace Control board
T1_P_STATE_ 1 No=0x21	Start of Release Test time out (from Protective)	Protective start Error's. I2C communication faults.	Check for Protective Error's. Cable between boards.
T1_C_RELEAS E No=0x22	Current detected at release/disable test by Control	P45 module fault or in cable between boards.	Cable between boards. Protective or Control board.
T1_P_STATE_ 3 No=0x23	Start of Current Test time out (from Protective), Current detected by Protective	Current detected by Protective or I2C communication faults.	Check for Protective Error's. Protective board.
T1_C_LOWCU RR No=0x24	Too low Current at Current test	Motor not connected or broken. HALL sensor signal faults or Internal voltages.	Motor, HALL cable. Check for internal voltages faults. Control board
T1_P_DISABLE No=0x25	Protective Disable at current test	P45 module fault or in cable between boards.	Cable between boards. Protective or Control board.
T1_C_MOVE No=0x26	Moving down at lock Current test	Unknown	Unknown
T1_P_POT No=0x27	Read Protective POT time out	I2C communication faults. Halted Protective CPU.	Cable between boards. Protective board.
T1_C_POT No=0x28	Pot value incorrect (Miss match at start)	Control and Protective POT value divergence > 10mm at start. POT fault or un- linear. Reference voltage faults.	Check POT values and POT cables. Compression module. Check for voltages faults.

Figure 5.2-3: Table 1/5 – Error code Control CPU

Error Code	Explanation	Probable cause	Module to check / replace
T1_P_STATE_5 No=0x29	No end of Protective Current Test (time out)	Protective current read fault. I2C communication faults.	Check for Protective Error's. Protective board.
T1_B_OFF No=0x2A	No Battery Charger Power OFF test done (time out)	Charger CPU not done T1 test correct or I2C communication faults.	Check for Charger Error's. Protective board.
T1_C_BUZZER No=0x2B	Control Buzzer error	Unknown	Unknown
T1_P_BUZZER No=0x2C	Protective Buzzer error (time out)	Unknown	Unknown
T1_C_DOWN No=0x2D	Control not moving down before REW test	Motor connections. Protective stop by disable line.	Motor. Check for Protective Error's.
T1_P_REW No=0x2E	Protective Time out at Rew test	Motor connections. Protective POT signal. Locked compression module.	Motor. Protective POT. Check for Protective Error's.
T1_C_TOTOP No=0x2F	Control Time out at move to top	Motor and HALL connections. Locked compression module.	Motor. Compression module.
INT_P_5V No= 0x30	Protective 5V < 4.5V or > 5.5V	Cable between boards. Incorrect Protective 5V. Internal reference faults.	Check cable. Protective 5V. Control internal voltages faults. Protective board.
INT_C_5V No=0x31	Control 5V < 4.5V or > 5.5V	Electrical fault. Control board pin connected to back plate.	Control board.
INT_C_24V No=0x32	Control 24V < 18V or > 35V	Battery fault. Internal reference faults.	Check charger errors or other Control internal voltages faults.
INT_C_REF No=0x33	Control 2.5V Ref < 2V or > 3V	Electrical fault. Control board pin connected to back plate or POT +2.5V shortcut.	Check POT or replace Control board.
INT_C_TEMP No=0x34	To High internal board temp. > 85°C if Error > 70°C if Warning	Fan disconnected or jammed. Broken Temp sensor or internal reference faults.	Fan. Control PCB
INT_C_TEMP1 No=0x35	To High External temp 1 (> T1_OFF °C)	Unknown	Unknown

Figure 5.3-1: Table 2/5 – Error code Control CPU

Error Code	Explanation	Probable cause	Module to check / replace
INT_CODE No=0x36	Access of vital function Code fault	Halted or disturbed Control CPU.	Control board.
INT_POTBALL No=0x37	PotPos./Hall sensor mismatch	Control POT fault or un- linear. A start with 13N release. Rough compression movement.	Assure correct start (no 13N release). If needed replace the compression module.
INT_CURRENT No=0x38	Current fault	Mean current to motor >20A. Jam of compression module. Current read fault.	Motor, compression module. Control board.
INT_P_REBOOT No=0x39	Protective reboot in active mode	Protective electrical fault.	Protective board.
INT_CODE No=0x3A	Warning Access of 1ms Code timeout.	Halted or disturbed Control CPU.	Control board.
INT_C_TEMPW No=0x3B	Warning High internal board temp (> 70 °C)	Fan disconnected or jammed. Broken Temp sensor or internal reference faults.	Fan. Control PCB
INT_C_HALL No=0x3C	Motor Hall sensor fault.	Motor or Hall sensor cable fault.	Check Hall sensor cable or replace Motor.
INT_C_POTCAL No=0x3D	Control Potentiometer linearity fault	Too un-linear Control potentiometer or influenced at calibration	Repeat calibration or replace compression module.
INT_P_POTCAL No=0x3E	Protective Potentiometer linearity fault	Too un-linear Protective potentiometer or influenced at calibration	Repeat calibration or replace compression module.
RUN_TIMEOUT No=0x40	Piston not moved during active mode (> 1s)	Disconnected motor (mechanical/electrical) or locked compression module.	Compression module. Motor connections.
RUN_TO_DEEP No=0x41	Piston to deep	Control potentiometer fault. Rough or influenced compression movement at run with no load. Hall signal missing.	Assure un- influenced movement of the compression module (re-test). Check Hall. Replace motor or compression module.
RUN_TO_SHALLOW No=0x42	Piston to shallow	50 strokes < Target stroke length - 10mm. To high load and/or to low battery voltage. Locked module.	Assure correct movement of the compression module. If needed replace the compression module.

Figure 5.3-1: Table 3/5 – Error code Control CPU

Error Code	Explanation	Probable cause	Module to check / replace
RUN_FREQUENCY No=0x43	Piston frequency fault	Unknown	Unknown
RUN_RATIO No=0x44	Piston Ratio fault	To high load.	Check load.
RUN_PROTECTIVE No=0x45	Halt or reverse by Protective System	Active mode disabled by the Protective system.	Check Protective error's
RUN_ADJUST No=0x46	Incorrect Piston movement at adjust mode	To high Motor Power (>25W) at Adjust servo. Incorrect current read.	Motor. Control board.
RUN_TIMEUP No=0x47	Time Up to long > 0.15s	Large 13N release in active mode or mechanical locked compression.	Assure correct movement of the compression module. If needed replace the compression module.
RUN_TIMEDOWN No=0x48	Time Down too long or To Shallow	To high load and/or to low battery voltage. Motor fault.	Check load and motor.
RUN_13N No=0x49	13N release (force UP to high)	13N release > 10mm. To high start position or mechanical locked compression movement.	Assure correct start and movement of the compression module. If needed replace the compression module.
RUN_POTCAL No=0x4A	Potentiometer Calibration fault, not moved or pot read	Movement fault at calibration or large potentiometer fault	Check potentiometer connections and mechanical movement, repeat calibration.
RUN_NO_POTCAL No=0x4B	Potentiometer not calibrated	Not calibrated or other calibration fault.	Check for other fault or perform a new calibration.
RUN_P_STOP No=0x4C	Protective system have stopped operation	Protective system error or fault in cable between boards.	Check Protective system error codes for cause.
COM_P_TIMEOUT No=0x50	I2C Protective Com Timeout	No I2C life tick from Protective system > 100s. I2C communication fault or halted Protective CPU.	Restart LUCAS2 and run for 30 minutes. If fault repeats replace Protective board.
COM_MODE No=0x51	Incorrect Mode change	Unknown	Unknown
COM_ACCESS No=0x52	DAF Protocol access violation	Unknown	Unknown

Figure 5.3-1: Table 4/5 – Error code Control CPU

Error Code	Explanation	Probable cause	Module to check / replace
COM_RTC No=0x53	Real Time Clock Fault	Real Time Clock read fault at start. I2C fault or to low "BAT1" voltage.	Charge "BAT1" by starting the LUCAS2 and press PAUSE leave the machine ON for 30 minutes, set correct time and date with the LUCAS2.exe program. After this restart and check for COM_RTC warning. If needed replace the Control board.
COM_SD_MEM No=0x54	Fault SD Com	SD card not inserted or broken.	re-insert or replace SD card
COM_B_TIMEOUT No=0x55	I2C Battery Charger Com Timeout	No I2C life tick from Charger system > 100s. I2C communication fault or halted Charger CPU.	Restart LUCAS2 and run for 30 minutes. If fault repeats replace Protective board.
COM_I2C No=0x56	I2C Com faults too high	Disturbed I2C communication.	Protective or Control board.

Figure 5.3-1: Table 5/5 – Error code Control CPU

5.3.2. Error Codes from The Protective CPU

Error Code	Explanation	Probable cause	Module to check / replace
T1_RAM	Internal RAM test detect fault at start.	Protective CPU fault.	Protective board
T1_E2_PROM	Internal E2 prom test detect fault at start.	Protective CPU fault.	Protective board
T1_P_SOUND_CHECK	Buzzer fault	Buzzer fault	Protective board
T1_PISTON_REVERSE_ERROR	Reverse test not done correct at start	Motor not moved correct or fault current read.	Protective board, check cable between boards or Control board (P45 fault)
T1_PISTON_RELEASE_ERROR	Protective release line operation fault at start	Current detected at disable test or moved to low at enable test.	Check cable between boards, Protective board or Control board (P45 fault)
TO_DEEP_COMPRESSION	To deep compression detected in active mode.	Protective potentiometer fault. Jam of compression module at run with no load.	Check smoothness in compression module, Protective potentiometer.
TO_SHALLOW_COMPRESSION	To shallow compression detected in active mode.	Protective potentiometer fault. Compression module runs with too high load.	Check load or Protective potentiometer at different heights.
INTERNAL_TEMPERATURE	Protective board temperature detected > 85°C	Fan or Protective board fault	Fan, Protective board
PISTON_TIME_OUT	Protective potentiometer not detected a movement of 50% stroke for 10s.	Protective potentiometer fault. To high load. I2C communication fault at mode change.	Protective potentiometer at different heights. Check for communication time outs.
CONTROL_LIFETICK	I2C communication fault with Control CPU	I2C communication fault at mode change. Other fault detected by Control.	Check if other fault is detected by Control. Check cable between boards.
ALARM_TYPE_ROM_TEST	Internal ROM test detect fault at start.	Protective CPU fault.	Protective board
CHARGER_STOP	Charger fault detected	See Charger errors	See Charger errors
CONTROL_STOP	Control system fault detected	See Control errors	See Control errors

Figure 5.3-2: Table 1 – Error code Protective CPU

5.3.3. Error Codes from The Charger CPU

Error Code	Explanation	Probable cause	Module to check / replace
T1 RAM ALARM	Internal RAM test detect fault at start.	Charger CPU fault.	Protective board
T1 E2 PROM ALARM	Internal E2 prom test detect fault at start.	Charger CPU fault.	Protective board
T1 POWER OFF ALARM	T1 test not ended correct.	Power ON lock fault by Protective CPU or T1 fault detected by other CPU's	Check other faults.
BATT HIGH TEMP ALARM	Battery temperature detected to be >70°C	Battery fault	Battery
BATT EMPTY ALARM	Battery continues below 25V	Uncharged battery. Battery, DCIN or charging fault.	Battery, Protective board, DCIN adaptor
BATT 10 MIN ALARM	Battery continues below 25.3V	Uncharged battery.	Battery
BATT ERROR ALARM	Fault type of battery.	Fault type of battery.	Battery
T1 ROM ALARM	Internal ROM test detect fault at start.	Charger CPU fault.	Protective board
T1 BATT COM ALARM	Battery communication fault	Connector fault.	Check connections. Unplug and insert battery, check for fault. Or replace battery.
T1 BATT CS ALARM	Battery communication check- sum fault	Connector fault.	Check connections. Unplug and insert battery, check for fault. Or replace battery.
T1 BATT COPYRIGHT ALARM	Incorrect copyright string read from battery	Incorrect battery type or communication fault	Check connections. Unplug and insert battery, check for fault. Or replace battery.
TOO MANY USES	Inserted battery is used more than 200 times.	Worn out battery.	Battery
TOO OLD BATTERY	Inserted battery is too old.	Too old battery used.	Battery

5.3-3: Table 1 – Error code Charger CPU

5.4. Practical Troubleshooting

With the help of the tables above, try to locate which module to check.

Before replacing a board, connect the new board while allowing it to hang lightly on the side of LUCAS. If the problem disappears when testing, then continue to replace the board.

It can be a good start to check that all connectors are connected and that internal cables are intact. In some cases a Multimeter can be useful to test voltage outputs.

In chapter 12 Appendix A there is a wiring diagram that can be helpful when troubleshooting.

If the device doesn't start, first check the battery and if that's ok check the connections from the Hood and the User Control Panel.

6. Spare Parts and Accessory List

6.1. Service Spare Parts List

Catalog#	Product description	Drawing#	Note
21576-000006	LUCAS 2 COMPRESSION MODULE	150401-00	Including motor
21576-000066	LUCAS 2.2 COMPRESSION MODULE	150401-20	Including motor
21576-000016	LUCAS 2 REFURBISHING KIT	150402-00	Carrying case, patient straps and stabilization strap
21576-000008	LUCAS 2 HOOD WITH USER PANEL	150403-00	
21576-000067	LUCAS 2.2 HOOD WITH USER	150403-20	
21576-000009	LUCAS 2 BELLWS	150404-00	Including brackets
21576-000010	LUCAS 2 ELECTRIC FAN	150405-00	
21576-000011	LUCAS 2 ELECTRIC MOTOR	150406-00	Including drive belt
21576-000068	LUCAS 2 ELECTRIC MOTOR 2.2	150406-20	Including drive belt
21576-000012	LUCAS 2 SHAFT SEAL	150407-00	
21576-000013	LUCAS 2 SUPPORT LEG	150408-00	Including angle shafts, strap holders, snap rings, and torsion-spring
21576-000014	LUCAS 2 CONTROL BOARD	150409-00	Including bracket
21576-000069	LUCAS 2 CONTROL BOARD 2.2	150409-20	Including bracket
21576-000015	LUCAS 2 PROTECTIVE BOARD	150410-00	Including bracket
21576-000071	LUCAS 2 PROTECTIVE BOARD 2.2	150410-20	Including bracket
21576-000007	LUCAS 2 DRIVE BELT	150411-00	
21576-000019	LUCAS 2 INTERNAL COMMUNICATION CABLE	150413-00	15-pin cable between control board and protective board
21576-000070	LUCAS 2 INTERNAL COMMUNICATION CABLE 2.2	150413-20	15-pin cable between control board and protective board
21576-000020	LUCAS 2 HOOD COMMUNICATION CABLE	150414-00	Flat cable between hood and protective board
21576-000025	LUCAS 2 BATTERY CONNECTOR BOARD	150415-00	Including O-rings
21576-000026	LUCAS 2 FRAME ASSY	150416-00	Main body with support legs mounted
21576-000027	LUCAS 2 POWER INLET	150417-00	DC-inlet connector (main body) including cable
21576-000072	LUCAS 2 POWER INLET 2.2	150417-20	DC-inlet connector (main body) including cable

Figure 6.1-1: Table – Service Spare Parts List

6.2. Other Orderable Spare Parts

Catalog#	Product description	Drawing#	Note
21576-000073	MAIN BODY COMPLETE	100652-00	
21576-000047	SCREW PT K40X12 WN 1452 A2	10150120-43	QTY: 4, Used to attach Hood to main body
21576-000049	WASHER 3X10X3.4 ARAN LOCK	10150085-29	QTY: 4, Used to attach Thread Plate to main body
21576-000050	AXEL-ANGLE SHAFT	240-3	QTY: 4, Used to attach Support Leg to Main Body
21576-000051	TORSION SPRING	240-9	
21576-000053	SCREW K40X14 WN1452	10150120-35	QTY: 6, For one Support Leg
21576-000054	SCREW DELTA PT 40X22 WN5452	10150461-00	QTY: 3, For one Support Leg Assembly Used to attach two pieces of Support Leg. These three screws are in the middle of the Support Leg.
21576-000055	BELT COVER	100654-00	
21576-000056	SCREW MRT M3X6 A2 ISO 7045	1015007161	QTY: 4, Used to attach Control and Protective Board Assembly to the Compression Module Assembly
21576-000057	SERRATED LOCK W ASHER M3 DIN	1015021803	QTY: 4, Used to attach Belt Cover to Compression Module Assembly
21576-000058	SCREW MRT M4x12 A2 ISO 7045	1015007178	QTY: 4, Used to attach Motor with Belt Wheel Assembly to Compression Module Assembly
21576-000059	SERRATED LOCK W ASHER M4 DIN	1015021804	QTY: 1, Used between one screw and the Terminal
21576-000060	TERMINAL M4 AMP 181949	1067227820	QTY: 1, Used to attach Ground Cable from Hood Assembly
21576-000061	SCREW MFX-H M3x6 A2 DIN 965	724322040	QTY: 4, Used to attach Mesh and Threaded Plate on air intake side.
21576-000062	SCREW MFS M3x40 A2 DIN 963	723123842	QTY: 4, Used to attach Mesh, Fan Washer, Fan cable assembly and Threaded Plate.
21576-000063	SCREW MRX-H M3x50	724124040	QTY: 4, Used to attach Hood
21576-000064	SCREW MFT M5x20 A2	1015007248	QTY: 8, Used to attach Compression Module Assembly and Protective and Control board assembly to Upper Part Assembly
21576-000065	SCREW MRT M3x12 A2 ISO 7045	1015007163	QTY: 2, Used for tightening the clamp on Bellows
21501-002658	TYPE LABEL	100630-00	2.0/2.1 serial
21501-002854	TYPE LABEL LUCAS	100905-00	2.2 serial
21501-002855	LABEL, UDI	100952-00	QTY: 1, LUCAS 2 UDI Label, placed on the opposite leg compared to the Type Label
21576-000089	BRACKET, HOOD, LUCAS	100909-00	QTY: 1, metal bracket for fixation HOOD
21576-000090	CARD, MEMORY, SD	300027-00	QTY: 1, LUCAS SD Card for storing Log files, positioned on the Control Board

Figure 6.2-1: Table – Other Orderable Spare Parts List

6.3. Accessory List

Catalog#	Product description	Drawing#	Note
11576-000038	LUCAS 2 CARRYING BAG	150200-00	
11576-000039	LUCAS 2 BATTERY	150201-00	
21996-000064	LUCAS STABILIZATION STRAP	300020-00	
11576-000050	LUCAS PATIENT STRAP (PAIR)	300021-00	
11576-000046	LUCAS SUCTION CUP	100593-00	3-PACK
11576-000048	LUCAS CAR CABLE	150206-00	12-24 V DC
11576-000060	LUCAS BATTERY CHARGER US	150207-00	
11576-000061	LUCAS BATTERY CHARGER EU	150207-01	
11576-000062	LUCAS BATTERY CHARGER GB	150207-02	
11576-000063	LUCAS BATTERY CHARGER AU	150207-03	
11576-000068	LUCAS BATTERY CHARGER JP	150207-04	
21996-000044	LUCAS BACK PLATE	100179-00	
11576-000052	LUCAS BACK PLATE GRIP TAPE	150209-00	
11576-000056	LUCAS POWER SUPPLY EU	150210-01	
11576-000057	LUCAS POWER SUPPLY GB	150210-02	
11576-000058	LUCAS POWER SUPPLY JP	150210-03	
11576-000059	LUCAS POWER SUPPLY AU	150210-04	
11576-000067	LUCAS POWER SUPPLY CH	150210-05	
11576-000071	LUCAS POWER SUPPLY	150210-06	
11576-000064	LUCAS PCI BACK PLATE	150211-00	(Radio translucent)
11576-000070	LUCAS BUMPER, PAIR	150212-00	
11576-000072	LUCAS 2 BUMPER INTEGRATED SHAFT	150213-00	

Figure 6.3-1: Table – Accessory List

7. Tools list

IN THIS SECTION IT IS LISTED THE RECOMMENDED TOOLS FOR PERFORMING SERVICE AND MAINTENANCE OF LUCAS 2

7.1. Standard tools

Torx Driver T10, T20, T25 (or set of Torx Keys)

Philips Driver PH1

Small Flat Screw Driver

Flat Screw Driver 5.5x0.8 mm

Micrometer Adjustable Torque Screwdriver with minimum range of 1.0-4.0 Nm

Bits Philips 1 (PH1)

Bits Flat 5.5x0.8 mm (5.5)

Bits Torx 10 (T10)

Bits Torx 20 (T20)

Bits Torx 25 (T25)

Hammer

Mandrel Cutting

Pliers Adjustable

Pliers ESD

Protection kit

Break -Over torque wrench, 17mm open head, torque setting of 1.0 Nm

REDEL extracting tool

7.2. Special tools

Description	Art. No:	Picture
Hood Holder Bracket Service Tool	100838-00	
Mandrel, LUCAS Hinge Insertion (Optional Tool)	300040-00	

7.3. Substances

Description	Catalog#
Thread Lock Fluid	11996-000220
PTFE Spray Lubricant	21576-000023
Carry Ball Screw Grease	21576-000018
Compressed Air, Can	21300-001335

7.4. Software

Description	Catalog#
LUCAS® 2 Program Loader 2.1B	21340-000787
LUCAS® 2 Program Loader 2.0	21340-000788
LUCAS® 2 Program Loader 2.2	21340-000833

8. Preventive Maintenance of LUCAS

NOTE: Use PIP checklist 3323774 Rev B to record PIP results during the maintenance procedure.

8.1. Yearly Maintenance Procedure

- The device is cleaned according to instructions in the IFU.
- Check that the Bellows and the Suction Cup is intact and clean, replace if necessary.
- All fabrics (Patient Straps, Stabilization Strap and the Carrying Bag) are checked with the aspect of cleanliness and that the Velcro and buckles isn't worn and fulfils its function. Replace if necessary.
- The hood is opened according to instructions in Section 9.1. With the hood off, lubricate the Compression Module according to Section 8.3.
- Connect the device to a laptop with the LUCAS 2 Program Loader Software according to Section 4. Check the software version in the device and upgrade if possible.
- Start the device and let it run for a minute to check that no errors or warnings occur according to section 10.
- Disconnect the USB cable and put the Hood back on according to 9.1.2. Lubricate the Claw Lock Mechanism according to Section 8.4.
- Perform a function check according to chapter 10.

See table below:

Routine	Ref. / Instr.
Cleaning	6.1 in the IFU*
Check/Replacement Bellows	9.2
Check/Replacement Suction Cup	6.2 in the IFU*
Check/Replacement Patient Straps	6.3 in the IFU*
Check/Replacement Stabilization Strap	6.4 in the IFU*
Check/Replacement Carrying Bag	6 in the IFU*
Check/Upgrade Software	4
Check for Errors and Warnings	10
Clean Fan and Mesh Grill	8.2
Compression Module Lubrication	8.3
Claw lock lubrication	8.4
Function Check	10

Figure 8.1-1: Table – Maintenance procedure

* Instructions For Use
(LUCAS 2.0 and LUCAS 2.1 Art # 100666-XX)
(LUCAS 2.2 Art # 100901-XX)

Apply the grease onto the Carry Ball Screw with the syringe (0.5 ml).

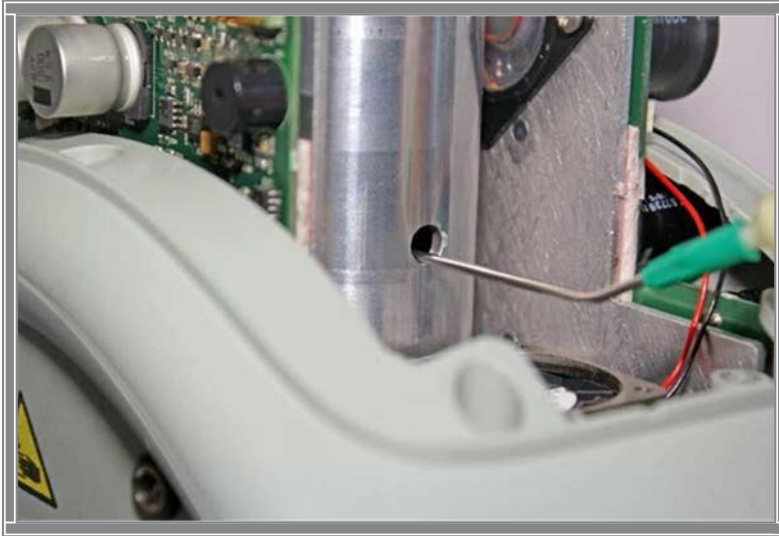


Figure 8.2-3: Lubrication of the Carry Ball Screw

Move the piston manually up and down 5 times over the full range to work the grease in.

8.4. Claw Lock Lubrication

Use PTFE Spray Lubricant (21576-000023)

Spray a small quantity of lubricant on all movable parts (gliding surfaces of the claws, where the axle goes into the plastic and the locking pin), see picture below.

Open and lock the mechanism continuously to work in the lubricant.

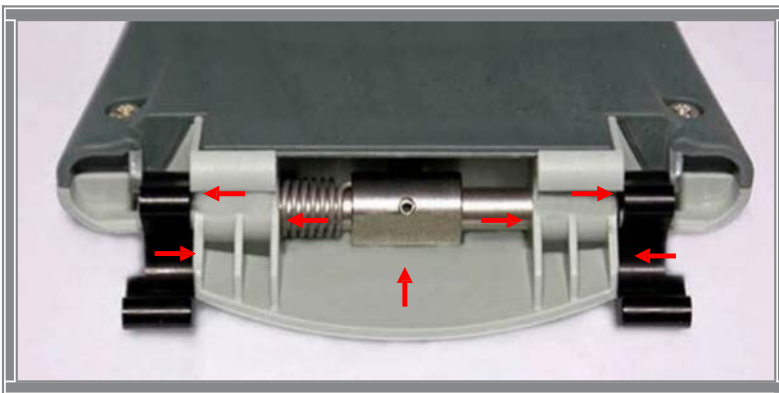


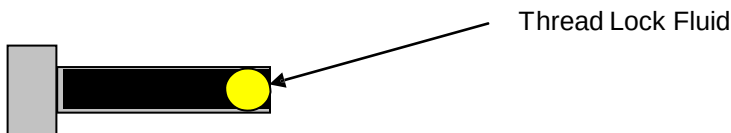
Figure 8.4-1: The picture shows where to lubricate the claw mechanism

9. Replacing Parts/Modules in LUCAS

IN THIS SECTION IT IS EXPLAINED HOW TO REPLACE SOME OF THE MOST COMMON PARTS/MODULES.

HOW TO APPLY THREAD LOCK FLUID

The normal amount of Thread Lock Fluid should be corresponding to the diameter of the screw and the Thread Lock Fluid should be applied at the lower end of the screw, see picture below:



This general description shall apply on all use of Thread Lock Fluid on LUCAS according to this manual.

WARNING: TAKE OFF THE BATTERY BEFORE OPENING THE DEVICE!

Do not connect the battery to hood cover without the hood holder service tool installed. The weight of the battery in a hood cover that isn't installed on the device can damage the wires or connections

Use caution when examining or operating the device without its covers.

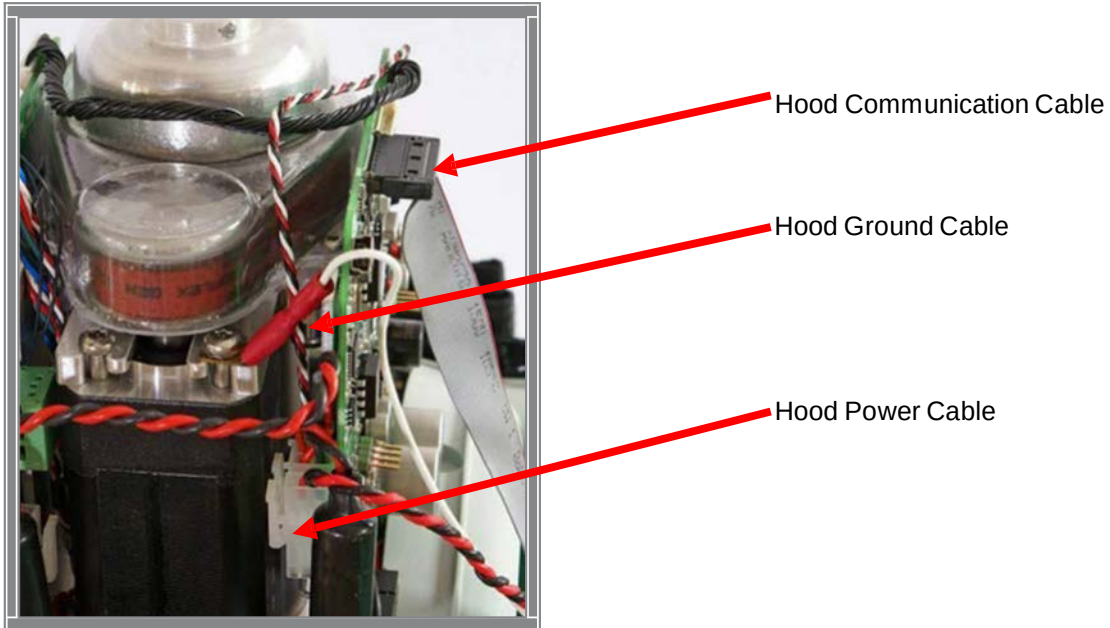
9.1. Replacing the Hood and Hood Bracket

9.1.1. Disassembling

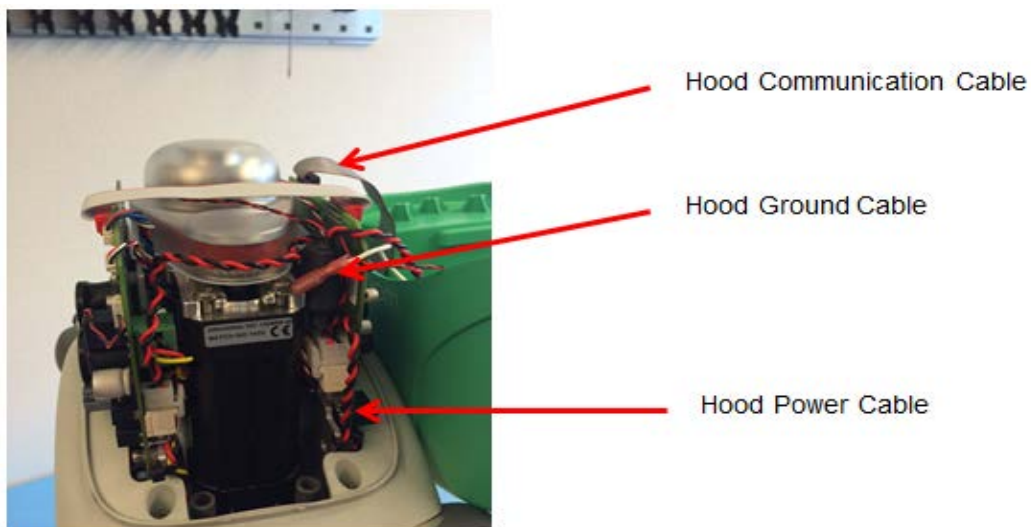
Remove all four screws for the hood *PH1*. Set aside screws for reuse during assembly.



Carefully lift off the Hood and disconnect the three cables between the Hood and the Protective PCB. Below the LUCAS 2.0 and LUCAS 2.1 is depicted, the Hood Communication Cable is released perpendicularly to the PCB.



Below the LUCAS 2.2 is depicted, the Hood Communication Cable is released upwards.



Remove the two mounting screws to remove the Hood Bracket if replacement is needed *Torx 20 (T20)*.

9.1.2. Reassembling

Install the Hood Bracket if removed and tighten the two *Torx 20* screws to 13 in-lbs / 1.5 Nm

Re-connect the three cables.



Carefully put the hood back in place, make sure not to damage any cables.

Lock the four screws with thread lock fluid and tighten to 5 in-lbs / 0.6 Nm *Torque wrench PH1*.

9.1.3. Test

Perform a Function Check according to Section 10.

9.2. Replacing the Bellows

Note: there are two older versions of the Bellows

9.2.1. Disassembling

Take off the suction cup

Remove the clamp by removing the two screws *Torx 10 (T10)* or *Torx 20 (T20)*.



Remove the Bellows ring, start by treading the bellows over the ring, then continue to take off the ring as described in picture.



Remove the Bellows by treading it over the Piston.

9.2.2. Reassembling

Carefully thread the Bellows over the piston and position it as far up as possible.



Place the clamp and fixate the bellows by tightening the two screws to 9.0 in-lbs / 1.0 Nm *Torque Screwdriver Torx 10 (T10)* or 13.0 in-lbs / 1.5 Nm *Torque Screwdriver Torx 20 (T20)* depending on the Bellows Clamp. The clamp should be positioned as far up as possible.



Place the Bellows ring above the retaining ring. Thread the edge of the Bellows over the Bellows ring.



Put back the Suction Cup.

9.2.3 Test

Perform a Function Check according to Section 10.

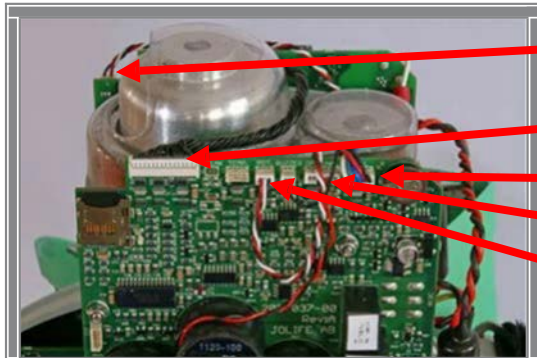
9.3. Replacing the Compression Module

9.3.1. Disassembling

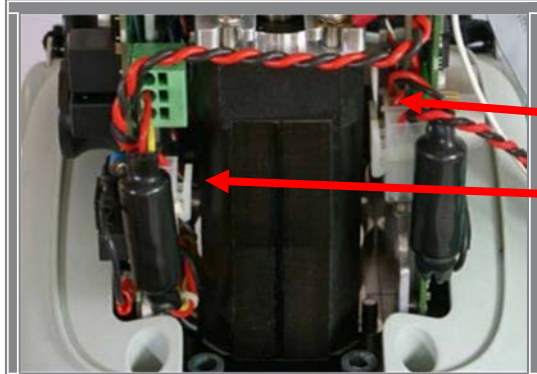
Take off the Suction Cup and remove the Bellows according to instructions in

Section 9.2.1. Remove the Hood according to instructions in 9.1.1.

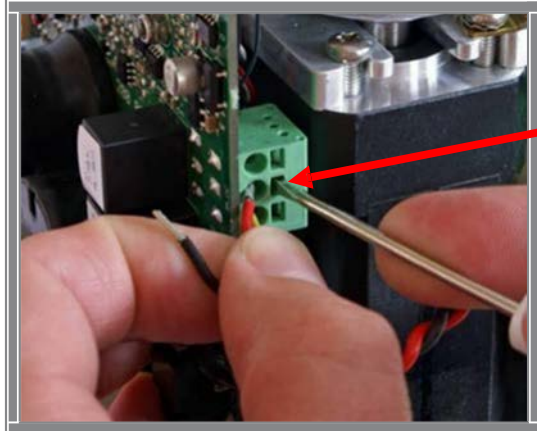
Disconnect the following cables on LUCAS 2.0 and LUCAS 2.1 according to pictures below:



- Protective Pot Cable
- Communication Cable
- Motor Rotation Sensor Cable
- Fan Cable
- Control Pot Cable



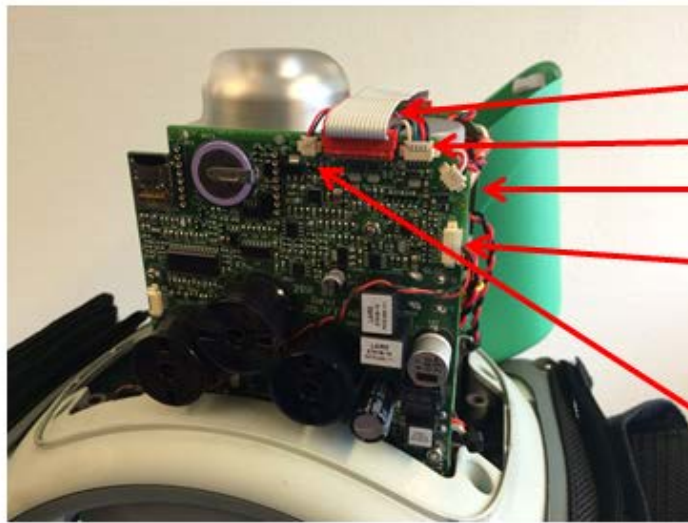
- Protective Power Cable (cut the cable tie)
- Control Power Cable



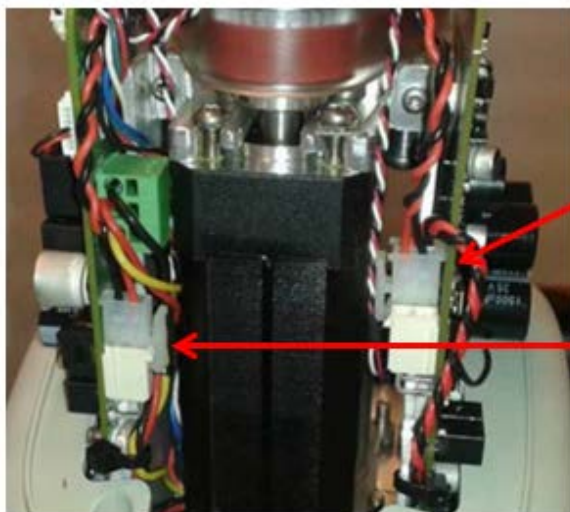
Motor Power Cable; use a small flat screwdriver to remove the cables.

From top:
Black
Red
Yellow

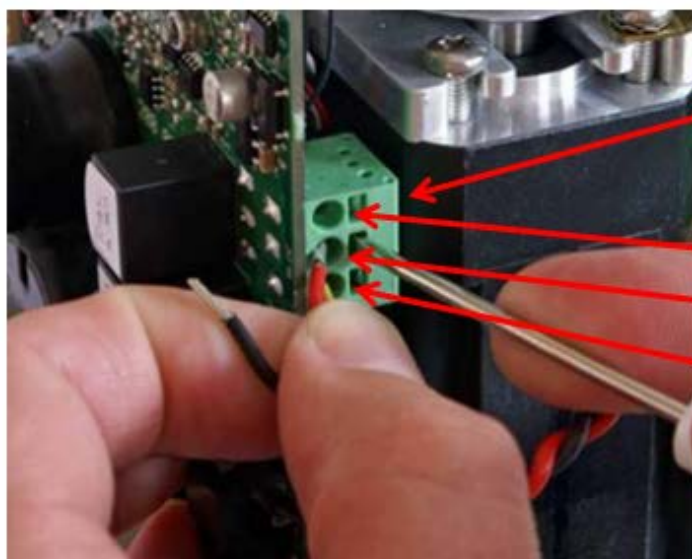
Disconnect the following cables on LUCAS 2.2 according to pictures below:



- Communication Cable
- Motor Rotation Sensor Cable
- Control Pot Cable
- Fan Cable
- Exciter Cable



- Protective Power Cable
- Control Power Cable



- Motor Power Cable Connector – use a small flat screwdriver to remove the cables
- Black Wire
- Red Wire
- Yellow Wire

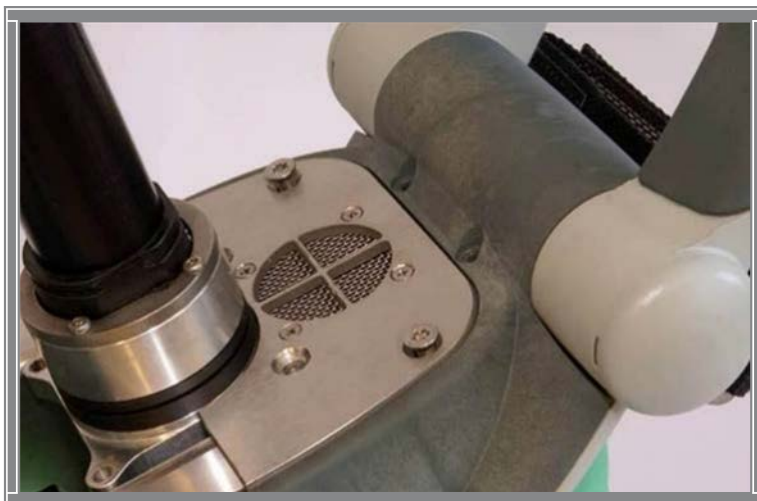
From beneath, remove the four screws that hold the Compression Module *Torx 25 (T25)*.



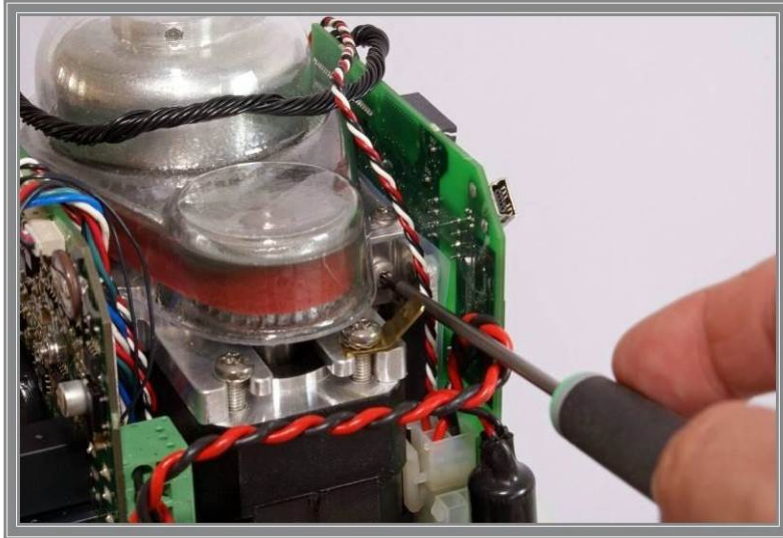
Remove the two screws holding the Fan Bracket and remove it *Torx 25 (T25)*.



Loosen the two remaining screws without removing them.



Remove the four screws that hold the PCB brackets against the Compression Module, two on each side according to pictures *Torx 10 (T10)*.



Carefully spread the PCB's and carefully lift out the Compression Module, make sure that no cables get stuck or harmed (especially the Pot Cables).



9.3.2. Reassembling

Carefully lower the Compression Module down between the PCB's.

Position the PCB's and fasten the Compression Module in the PCB brackets, use thread lock fluid and tighten to 9.0 in-lbs / 1.0 Nm *Torque Wrench Torx 10 (T10)*.

Put back the Fan Bracket, use thread lock fluid and tighten the two screws to 35 in-lbs / 4.0 Nm *Torque Wrench Torx 25 (T25)*.

Fasten the Compression Module with four screws, use thread lock fluid and tighten to 35 in-lbs / 4.0 Nm *Torque Wrench Torx 25 (T25)*.

Unscrew the two screws that are loose, apply thread lock fluid and tighten to 35 in-lbs / 4.0 Nm *Torque Wrench Torx 25 (T25)*.

Re-connect all cables according to picture in Section 9.3.1 and fasten the Power Cables with new cable ties.

For LUCAS 2.0 and LUCAS 2.1, make sure that the Protective Pot Cable is on the outside of the Communication Cable.

Re-install the Hood, the Bellows, and the Suction Cup.

9.3.3. Test

Perform a Function Check according to Section 10.

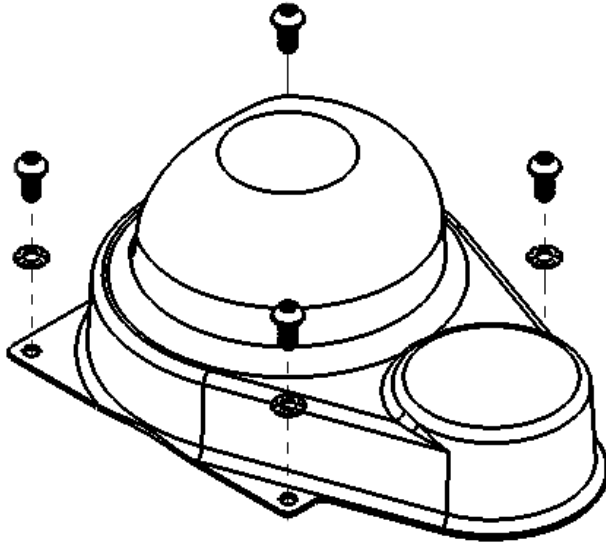


9.4. Replacing the Drive Belt

9.4.1. Disassembling

Remove the hood according to Section 9.1.

Remove the Belt Cover by removing the four screws; be careful not to lose the washers *Torx 10 (T10)*.



Cut the Belt with a *pliers or scissors* and remove it.

9.4.2. Reassembling

Thread the new Belt over the small Belt Wheel first.

Continue to Thread it over the Large Belt Wheel and turn the wheel at the same time to get the belt in place.



Fasten the Belt Cover according to picture in Section 9.4.1, tighten the screws to 9 in-lbs / 1.0 Nm

Torque Wrench Torx 10 (T10). **Note: Do not use any Thread Lock Fluid!**

Re-install the Hood, the Bellows, and the Suction Cup.

9.4.3. Test

Perform a Function Check according to Section 10.

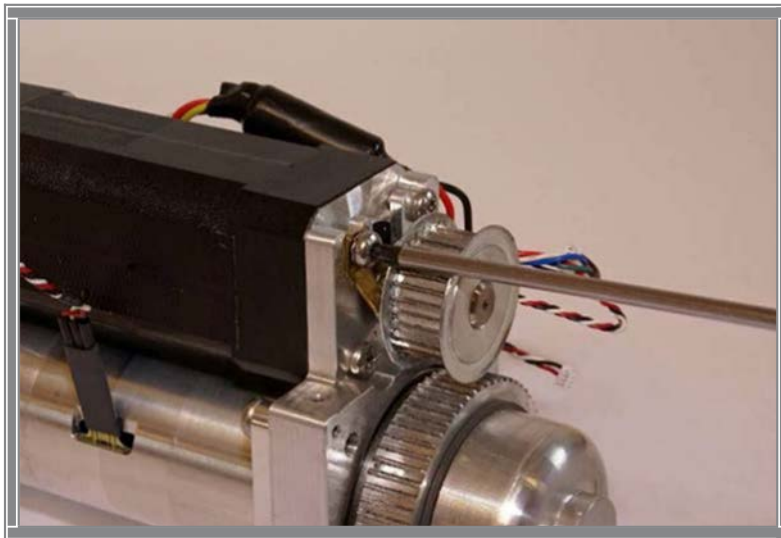
9.5. Replacing the Electric Motor

9.5.1. Disassembling

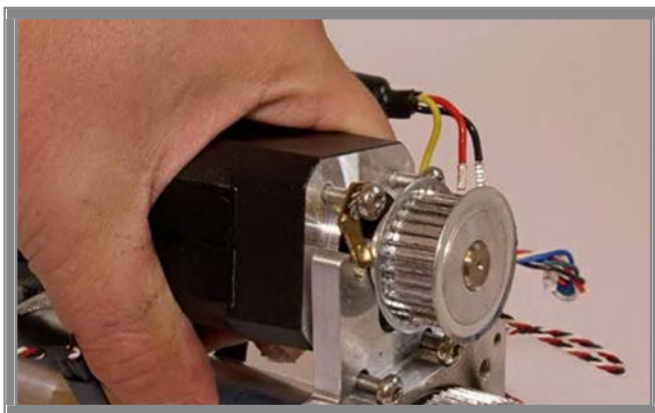
Follow the instructions in Section 9.3.1 to take out the Compression

Module. Remove the Drive Belt according to Section 9.4.

Remove the inner two screws and loosen the outer two screws holding the Motor *Torx 20 (T20)*.

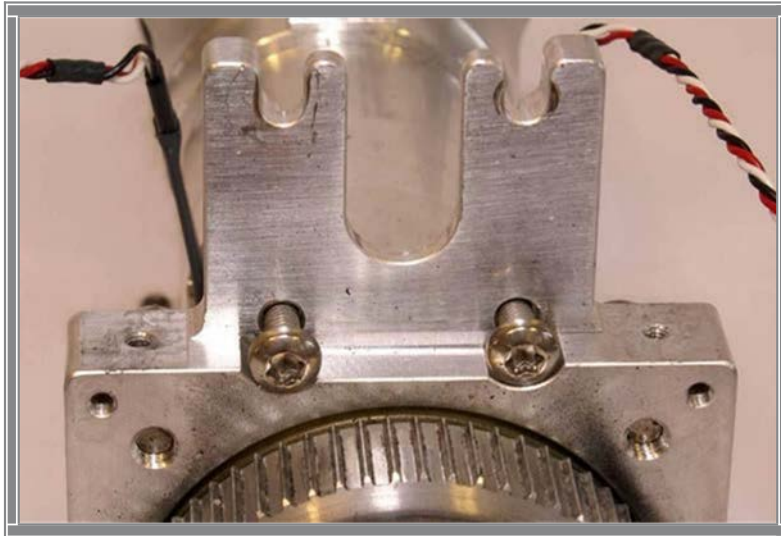


Slide the Motor out from its bracket.



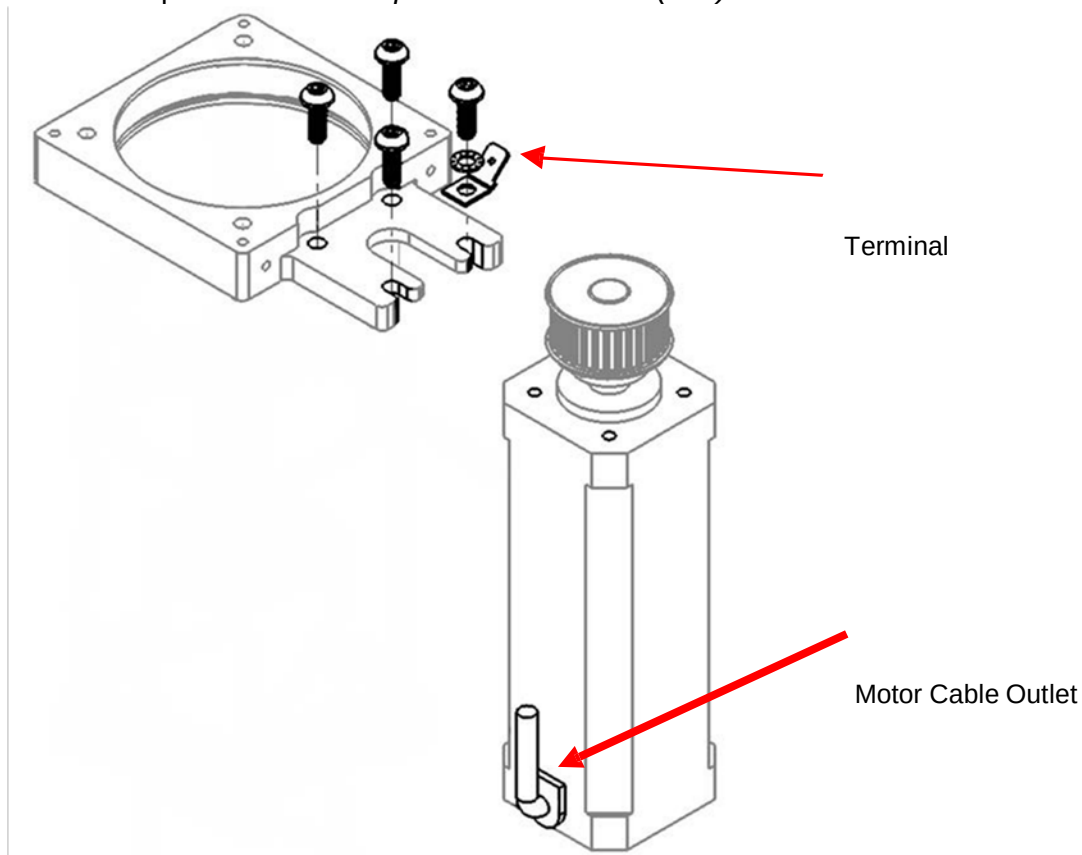
9.5.2. Reassembling

Apply Thread Lock Fluid on two of the screws and place them in the bracket according to picture below.



Apply Thread Lock Fluid to the other two screws and put them on the Motor together with the lock washer and terminal. Make sure that the cable outlet is oriented as figure below.

Slide the Motor onto the Bracket and tighten the screws to 17.5 in-lbs / 2.0 Nm, make sure to align the terminal as picture below *Torque Wrench Torx 20 (T20)*.



Re-install the Drive Belt.

Re-install the Compression Module and connect all cables.

Re-install the Hood.

Re-install the Bellows.

Re-install the Suction Cup.

9.5.3. Test

Perform a Function Check according to Section 10.

9.6. Replacing the Controller PCB

9.6.1. Disassembling

Follow the instructions in Section 9.3 to take out the Compression Module.

Remove the remaining screw from beneath and lift out the PCB carefully.

Remove SD-card from old Controller PCB. Check that the SD-card is intact and readable/writeable. If SD-card is working properly keep it for the new Controller PCB.

Warning: Always use ESD protection when handling PCB's!



9.6.2. Reassembling

Put the new PCB in place and fasten loosely with the screw together with the Bottom Plate *Torx 25 (T25)*.

Re-install the Compression Module and connect all cables. Connect the cables for the Hood, but do not fasten it.

Re-install the Bellows.

Re-install the Suction Cup.

9.6.3. Programming

Connect a laptop and program the Control PCB according to Section 4.

Tighten the Hood.

9.6.4. Test

Perform a Function Check according to Section 10.

9.7. Replacing the Protective PCB

9.7.1. Disassembling

Follow the instructions in Section 9.3 to take out the Compression Module.

Remove the remaining screw from beneath and lift out the PCB carefully.

Warning: Always use ESD protection when handling PCB's!

9.7.2. Reassembling

Put the new PCB in place and fasten loosely with the screw together with the Bottom Plate *Torx 25 (T25)*.

Re-install the Compression Module and connect all cables. Connect the cables for the Hood, but do not fasten it.

Re-install the Bellows.

Re-install the Suction Cup.

9.7.3. Programming

Connect a laptop and program the Protective PCB according to chapter 4.

Check that Device ID, Time and Date is correct.

Tighten the Hood.

9.7.4. Test

Perform a Function Check according to chapter 10.

9.8. Replacing the Electric Fan

9.8.1. Disassembling

Lift of the hood by following the instructions in Section 9.1. It's not necessary to disconnect the cables.

Disconnect the Fan Cable on the Control PCB, See picture in Section 9.3.1.

Remove the four screws that hold the Fan, *Flat .5x0.8 mm (5.5)*.



Take off the Threaded plate and lift out the Fan.

9.8.2. Reassembling

Make sure all parts are assembled as picture below. The screws shall be locked with thread lock fluid and tightened to 9 in-lbs / 1.0 Nm *Torque Wrench Flat 5.5x0.8 mm (5.5)*.

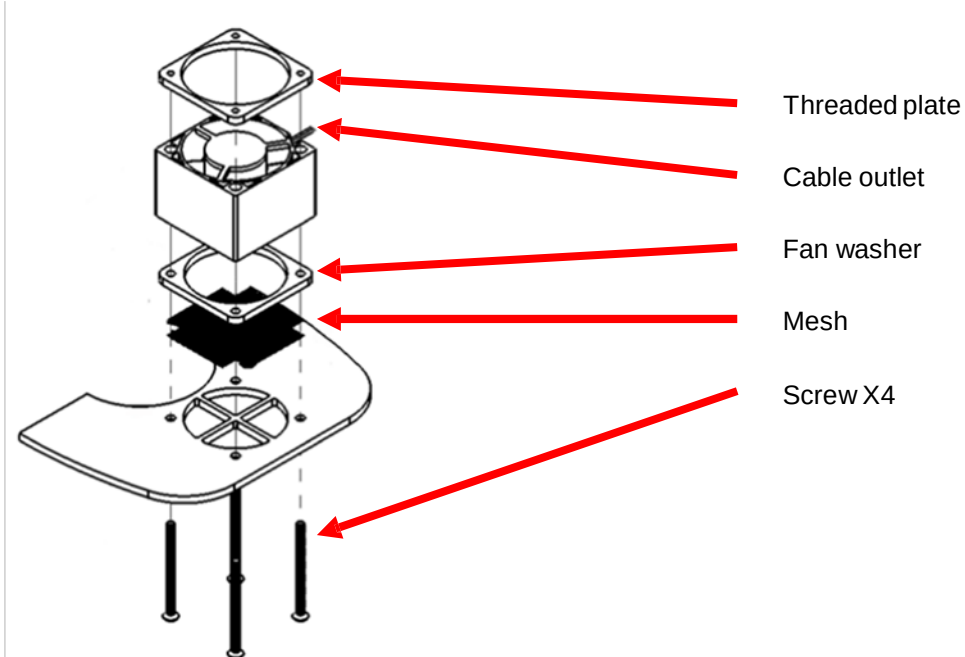
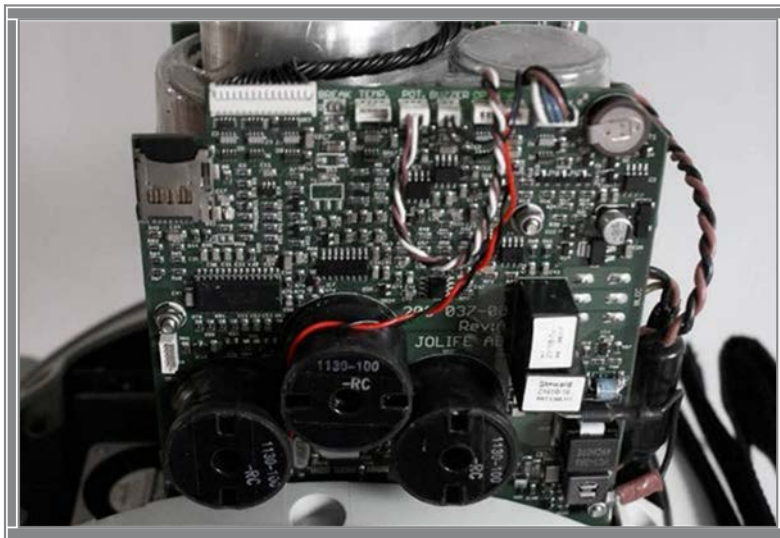


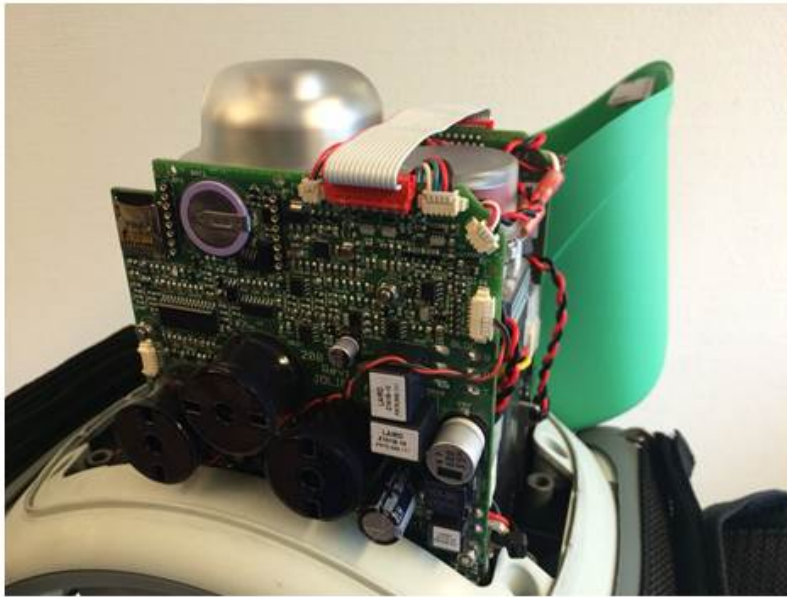
Figure 9.8-1: Fan assembly

Connect the Fan Cable to the “Optional” connector on the Control PCB. Place the cable between the coils according to pictures below.

LUCAS 2.0 and LUCAS 2.1



LUCAS 2.2



Re-install the Hood.

9.8.3. Test

Perform a Function Check according to Section 10.

When the device is in active mode let it run, after approximately 10 minutes the fan should start. Now set the device in adjust mode, the fan should continue running. Check that there is no unusual sound from the fan. When the temperature inside the hood has decreased to 30°C the fan should stop. Continue with the Function Check.

9.9. Replacing the Support Leg

9.9.1. Disassembling

LUCAS 2 devices with S/N up to 3012 4632 (LUCAS 2.0 and LUCAS 2.1) have Shaft Seals assembled. On LUCAS 2 devices with a S/N greater than 3012 4632, the Shaft Seals are replaced with a Snap Ring and a Bumper with integrated shaft seal.

Remove the Patient Strap. Remove the Bumper (if installed)

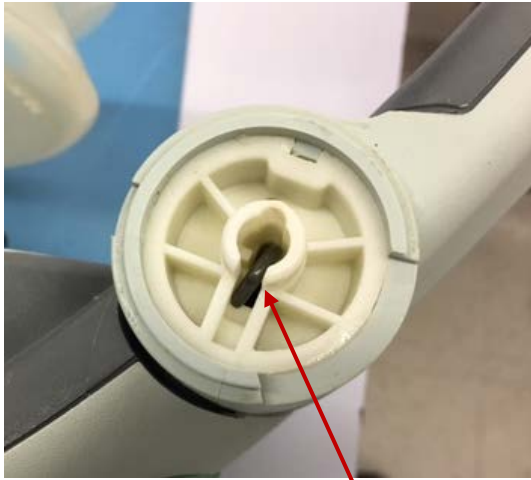
Remove the Shaft Seals by bending with a Flat Screwdriver. If the LUCAS 2 device has Snap Rings installed instead of Shaft Seals, remove Snap Rings.



Remove the Patient Strap Holders.



Lay LUCAS on the side of table with nothing blocking the shaft underneath. The round end of spring should be facing up according to the picture below.



Spring with a round end facing up (press fitted side)



Spring with a flat end facing down (non-press fitted side)

Knock the **Spring** out with a *Hammer* and a *Mandrel* or similar tool. Tap the spring downwards with the mandrel and hammer until it falls loose.



Knock the **Spring** from round end out of shafts.

When the **Spring** is removed from the Angle Shaft, turn the device over so the press fitted side is facing up. Using the metal Pin or similar tool and Hammer, push the bottom, non-press-fitted Angel Shaft out of Support Leg. Always knock out the non-press fitted Angle Shaft first.



↑
Metal Pin



↑
Angel Shaft



Press Fitted Side with Key



The bottom, non-press fitted
Angel Shaft

Turn the leg on the other side; and use the Angel Shaft Tool (optional tool) or similar tool with a Hammer to knock out the press fitted Angle Shaft, which is fitted into the Main Body.



Use this end to install

Use this end to remove

Angle Shaft Tool



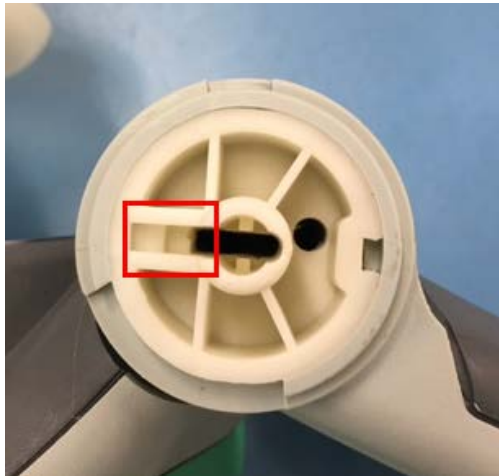
- Mandrel, LUCAS Hinge Insertion (Optional Tool) -

Remove the Support Leg.



9.9.2. Reassembling

With LUCAS still on the side, place the new support leg pointing straight out from LUCAS. Insert the Angle Shafts; start with the one that is press fitted into the Main Body, oriented as picture below. Knock it down so that its surface is on the same level as the Support Leg.



On the same level

Turn LUCAS over on the other side and insert the non-press fitted Angle Shaft by hand until it stops. Ensure that the keyways for the spring are aligned with each other. Insert the Spring with the rounded end first, all the way down through both Angle Shafts. Use a Mandrel to fully seat the spring into the Angle Shaft.



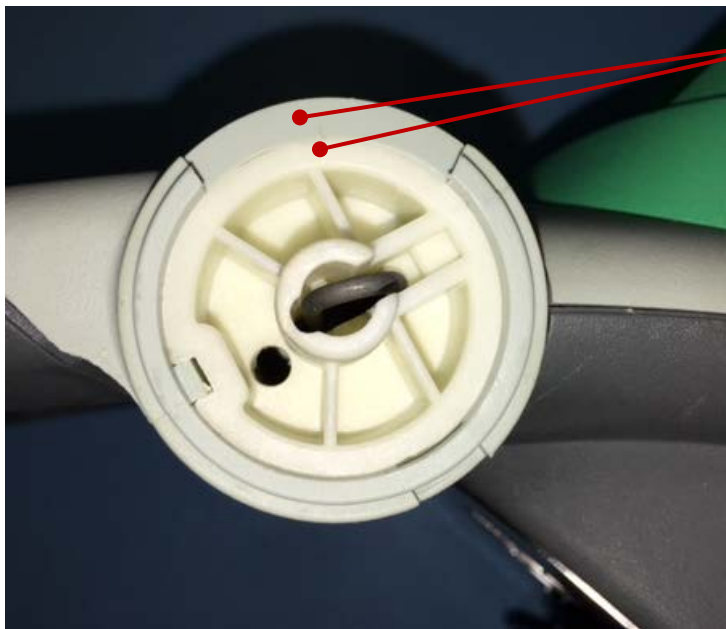
Turn the leg inwards to its correct position.



Ensure the L shaped end of the spring is properly seated inside the Angle Shaft



Carefully hammer down the Angle Shaft with a hammer and the Angle Shaft Tool (Optional Tool) or similar tool. The surface of the Angle Shaft should be on the same level as the Support Leg. Double check the L-shaped side of the spring to make sure it is still seated in the Angle Shaft. A mandrel can be used to tap it into place if not fully seated.

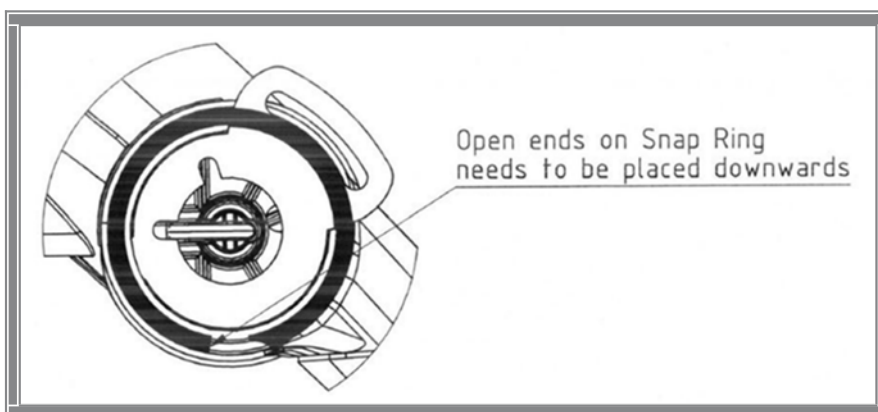


Angel Shaft and
Leg on the same
level

Put the Patient Strap Holder in place (two sides).

Install Shaft Seals if equipped.

If not equipped with Shaft Seals, install Snap Rings according to the picture below (two sides), place the open end of the ring downwards.



Install Snap Ring according to picture.

Slide the Bumper up over the support leg (note the direction)

Thread the Bumper over the shaft seals and the patient strap holder on both sides.

Note: There is only Shaft Seals on older LUCAS 2



Mount back the Patient Strap.

If the replaced Support Leg had a Type Label with serial number, contact Physio-Control to obtain a new label.

9.9.3. Test

Do the following tests to verify that the repair/replacement has been performed correctly:

Check the locking function by locking and unlocking against the Back plate.

Check the function of the torsion spring by folding and unfolding the Support legs.

9.10. How to replace the Battery Connector Board

9.10.1. Disassembling

Remove the Hood according to instructions in 9.1.

Warning: Always use ESD protection when handling PCB's!

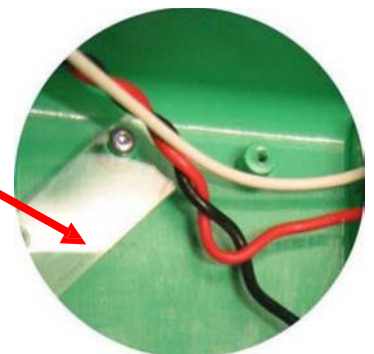
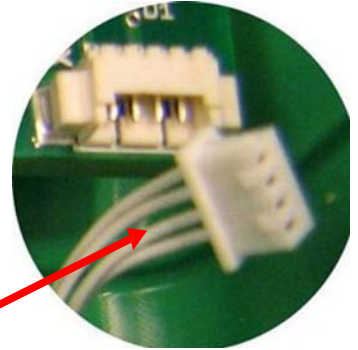
Place the hood upside down

Disconnect the communication cable from the connector board

Remove one of the screws for the cable holder (Torx 6).
Loosen the second screw enough to rotate the cable holder as shown in the picture.

Remove the four screws for the connector board (Torx20)

Remove the board
(make sure to remove all the old O-rings)



9.10.2. Reassembling

Place the supplied O-rings around all connector probes on the new board

Put the new board in place; make sure that the O-rings stay in place (Turn the hood and place the board from below).

Note: If the plastic hole around the collapsed hood probe has been deformed it can be drilled out by hand using a drill bit (Ø 4.6- 4.7 mm).

Place the four screws

Note: Turn the screws counter clockwise until the existing thread is found, then tighten to 13 in-lbs / 1.5 Nm.

Connect the communication cable and put back the cable holder.

Carefully re-install screws by turning the screws counter clockwise until the existing thread are found, then tighten finger tight.

Re-install the Hood.

9.10.3. Test

Perform a Function Check according to Section 10.

9.11. Replacing the Power Inlet

9.11.1. Disassembling

Follow the instructions in Section 9.3 to remove the Compression Module.

Follow the instructions in Section 9.6 to remove the Controller PCB

Follow the instructions in Section 9.7 to remove the Protective PCB

Warning: Always use ESD protection when handling PCB's!

Remove the four Torx 20 screws to remove the Main Body Lid.



Use the extraction tool to remove the wires from the Power Inlet.

With the wires removed you can now remove the nut and Power Inlet.



9.11.2. Reassembling

Install the Power Inlet with the white arrow on top.



Install the Power Inlet nut and tighten to 9 in-lbs / 1.0 Nm.



Insert the Power Inlet wires with the red on top.

Install the Main Body Lid and tighten all four *Torx* 20 screws to 13 in-lbs / 1.5 Nm

Re-install the Controller PCB, Protective PCB, Compression Module, and Hood.

9.11.3. Test

Perform a Function Check according to Section 10.

9.12. Replacing the Main Body/Frame Assembly

9.12.1. Disassembling

Follow the instructions in Section 9.3 to remove the Compression Module.

Follow the instructions in Section 9.6 to remove the Controller PCB.

Follow the instructions in Section 9.7 to remove the Protective PCB.

Follow the instructions in Section 9.11 to remove the Power Inlet.

If replacing the Main Body follow the instructions in Section 9.9 to remove the Support Legs.

Warning: Always use ESD protection when handling PCB's!

9.12.2. Reassembling

Re-install the Power Inlet using instructions in section 9.11.2.

Install the Main Body Lid and tighten all four Torx 20 screws to 13 in-lbs / 1.5 Nm.

Re-install the Controller PCB, Protective PCB, Compression Module, and Hood.

If removed, re-install the Support Legs.

9.12.3. Test

Perform a Function Check according to Section 10.

10. Function Check

10.1. Introduction

LUCAS® 2 is an advanced system consisting of both mechanics and electronics. After each repair or maintenance, a Function Check should be performed to establish all vital functions of the device.

10.2. Mechanics Test

With the device turned off perform the following tests:

Piston Check

Pull the Suction Cup down and up to check that the Decompression Spring moves smoothly and without any unusual noise.

Pull the Suction Cup down and continue to slowly pull down until the Carry Ball Nut has reached its lower position, check that it runs smoothly and without unusual noise.

Attention: If you push too fast you will feel resistance in steps because the Electrical Motor is affected, instead push slowly in one long stroke.

Push the Suction Cup back up to its top position, check that it runs smoothly and without unusual noise.

Claw Lock Mechanism Check

Check for play between the Release Ring and the Support Legs:

Pull the Release Ring gently to **unlock** the mechanism and **open** the Claws.

Move your finger around in the Release Ring; verify that you can detect some play between the Ring and the Support Leg. You should be able to hear a rattle from the play in the Ring when moving the Release Ring from side to side. If the Support Ring is tight against the Support Leg with no play, then the check has failed.



Figure 10.2-1: Release Ring Check

Check for the ability of the Claw Mechanism to remain locked:

Press the Claw Lock towards the center point of the Support leg (closed position) with your thumbs.

When locked, press hard with two thumbs on the two claws as shown in the Figure 10.2-2. If the claw mechanism unlocks, then the check has failed.



Figure 10.2-2: Claw Mechanism Lock Check

10.3. Electronics Test

Turn on the device and perform the following tests:

Check that the Internal Function Test is performed and that the ADJUST LED shows a green light.

Change mode to ACTIVE (30:2) and check that the ACTIVE (30:2) LED shows a green light. Let the device run for approximately two minutes and listen for unusual noise. Check that there is an audible alert sound prior to the ventilation pause (each 30 strokes) together with an intermittent LED.

Change mode to PAUSE and check that the PAUSE LED shows a green light.

Change mode to ACTIVE (continuous) and check that the ACTIVE (continuous) LED shows a green light. The LED will then blink each twelve strokes (ventilation alert).

Change mode to ADJUST, pull the Suction Cup down to test the Adjustment Servo. Push the Suction Cup back up to its top position. Check that it runs smoothly.

Connect a charger to the device and check that the charging sequence begins (the battery LED's show a "running" light). Disconnect the charger.

Turn the device off.

11. Accessories

11.1. LUCAS® Battery Charger

THE BATTERY CHARGER IS SOLD AS AN ACCESSORY.

FOR MORE INFORMATION ABOUT DIFFERENT COUNTRY SPECIFIC VARIANTS SEE THE ACCESSORY LIST, SECTION 6.

THERE ARE NO SERVICEABLE PARTS IN THE BATTERY CHARGER, IF BROKEN REPLACE WITH A NEW.



Figure 11.1-1: LUCAS® Battery Charger

11.2. LUCAS® Car Cable

THE CAR CABLE IS SOLD AS AN ACCESSORY WITH THE PRODUCT CAT #: 11576-000048.

THERE ARE NO SERVICEABLE PARTS IN THE CAR CABLE, IF BROKEN REPLACE WITH A NEW.



Figure 11.2-1: LUCAS® Car Cable

11.3. LUCAS® Power Supply

THE POWER SUPPLY IS SOLD AS AN ACCESSORY.

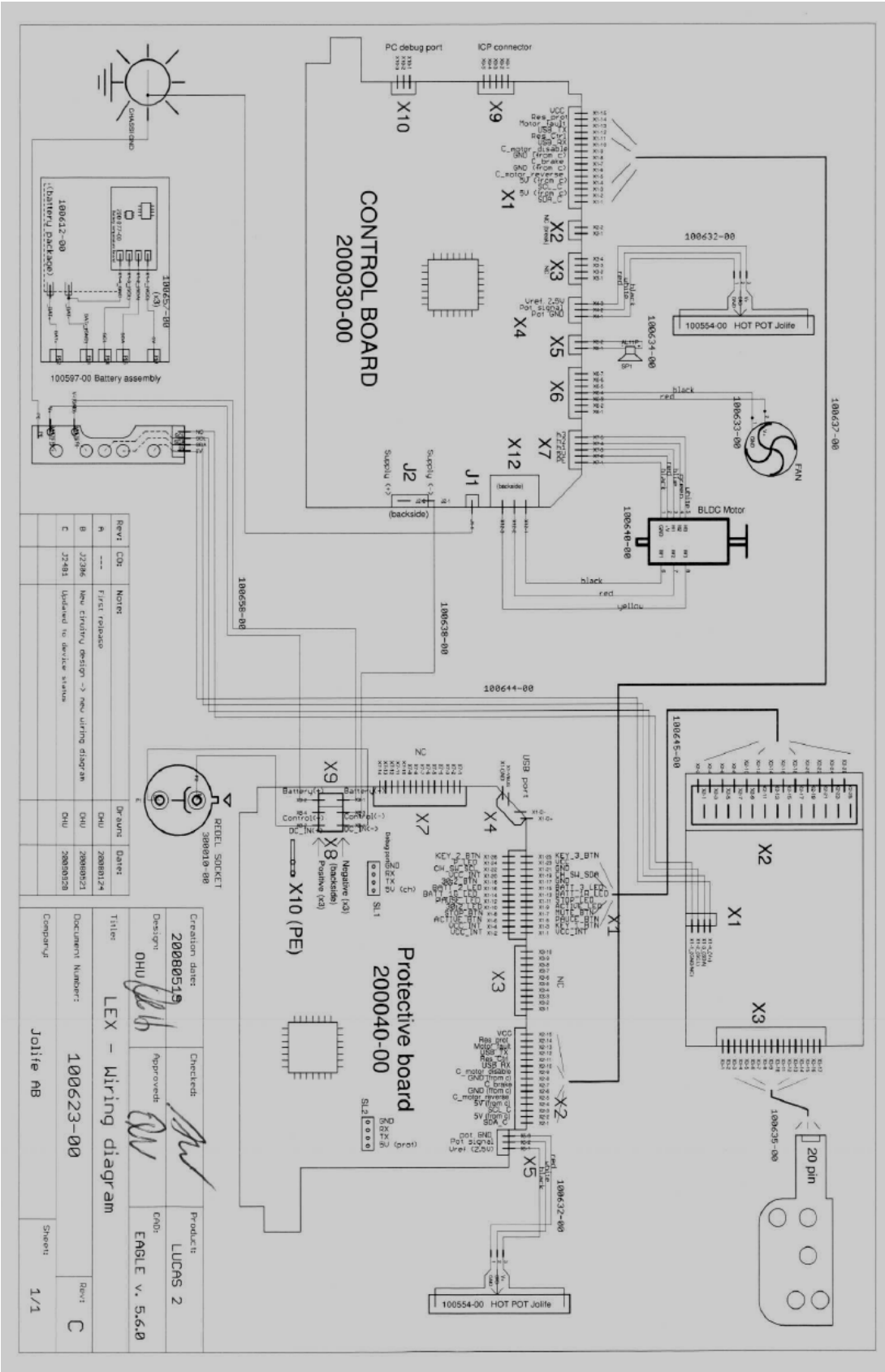
FOR MORE INFORMATION ABOUT DIFFERENT COUNTRY SPECIFIC VARIANTS SEE THE ACCESSORY LIST, SECTION 6.

THERE ARE NO SERVICEABLE PARTS IN THE POWER SUPPLY, IF BROKEN REPLACE WITH A NEW.

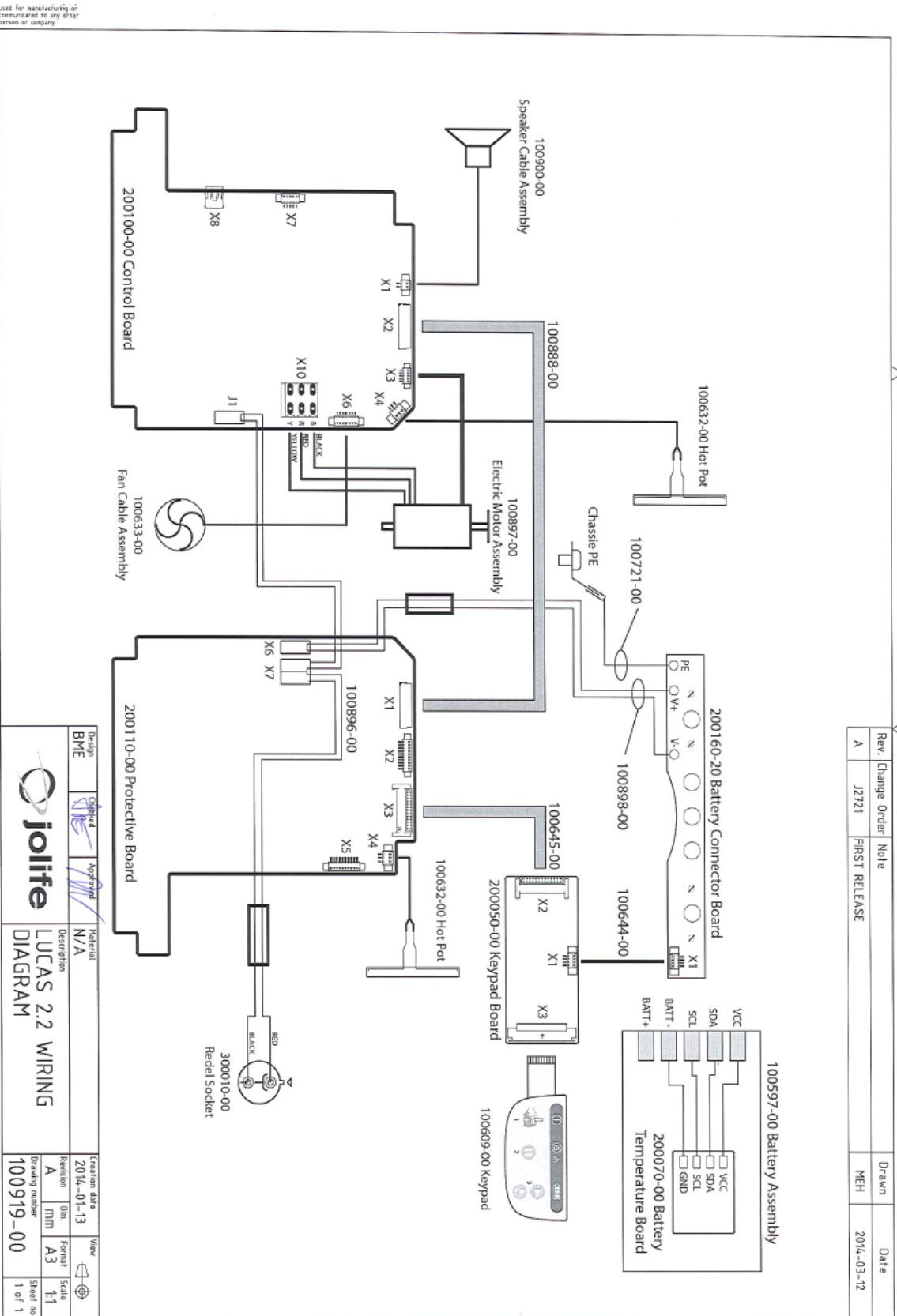


Figure 11.3-1: LUCAS® Power Supply

12. Appendix A (wiring diagram)



Rev.	Change Order	Note	Drawn	Date
A	J2721	FIRST RELEASE	MEH	2014-03-12



Design BME	Checked <i>[Signature]</i>	Approved <i>[Signature]</i>	Material N/A	Creation date 2014-01-13	View
				Description LUCAS 2.2 WIRING DIAGRAM	Revision A
				Drawing number 100919-00	Sheet no 1 of 1

used for manufacturing or
communication to any other
person or company.