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User Manual

Ambulatory monitoring with the VU-AMS version 5fs

Requirements

Two AA batteries:	Use 1.2V rechargeable NiMH batteries or non-rechargeable 1.5V alkaline batteries. Make sure the bottom contact sticks out (in some batteries it is the covered by an outer plastic ring; these won't work properly with the VU-AMS). Leave rechargeable batteries in the loader up till the very last moment.
Compact flash card:	External memory card. The VU-AMS.5fs has been extensively tested with the 1GB 80x CompactFlash card from Transcend (TS1GCF80). Other CompactFlash cards should work too.
Compact flash card reader:	Card reader unit to extract the AMS data from the CompactFlash card after recording and to erase the card for a next recording. Any brand or built-in CompactFlash card reader will do.
Electrodes:	Seven electrodes are needed for a single recording. We use the 'UltraTrace®' single use clear tape ECG electrode with Wet Gel.
Lead wire connector:	A blue lead wire connector with 7 lead wires is used for the recording of the ECG and thorax impedance. Optionally a second yellow connector for skin conductance recording is needed.
VU-AMS.5fs:	The ambulatory recording device.
VU-AMS*i* (for RS232 or USB):	An infrared interface cable that either connects to the RS232 serial port of a PC or to an USB port.
Flashcard with latest firmware (optional):	Typically the VU-AMS comes with the latest firmware installed. From time to time updates may be mailed to users. These need to be installed once from a CompactFlash card. Detailed instructions on how to install the update will be sent with the update-flashcard.
Software:	*AmsConfigure*: Start and stop measurements.
	AmsMerge: merge multiple AMS files of a person
	AmsPreProcessor: Put the various signals in separate files.
	AmsQRS: Extract the inter beat interval time (IBI) series from the ECG.
	AmsRevertFormat: Create input files for AMSIMP/AMSRES.
	AMSIMP: Impedance cardiography (PEP) scoring
	AMSRES: Respiration signal and RSA scoring

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Signal recording

Always use an empty CompactFlash Card with all previous files removed from the card before each new measurement. Put the flash card bottom up in the VU-AMS and then place two completely charged AA batteries in the battery holder. Battery clips are vulnerable so do this carefully. Successful placement is signaled by a triple beep tone. The green indicator light flashes 'nervously' until the battery lid is closed. When the lid has been closed shake the VU-AMS to make sure the battery contact is solid.

When the VU-AMS is on standby the green light will flash twice every ten seconds. This indicates the VU_AMS is ready, but *not* recording. When the VU-AMS is recording the green light will flash once every three seconds.

Connect the VU-AMS to the PC with the interface cable (marked: AMS*i*). Connect the infrared end of the interface cable to the VU-AMS; the electronic end of the interface cable goes to the serial port or the USB port of the PC.

Now start the AmsConfigure program from the new VUAMS5fs package (note that

NOTE: Before you start AmsConfigure, make sure to set date and time of the PC correctly. All dates and times in the AMS data files will be based on the time and date read from the PC at start-up, so it is important to make sure your PC has the correct time and date. The VU-AMS will verify time and date of the PC against its internal Real Time clock; deviations > 5 minutes (configurable in 'Warnings') will be flagged by AmsConfigure.

the old VUAMS46 package also has an AMSCOM program: this will no longer work!). AmsConfigure tries to automatically detect the VU-AMS device on all available COM ports. If successful, the opening screen (see figure below) will be displayed.
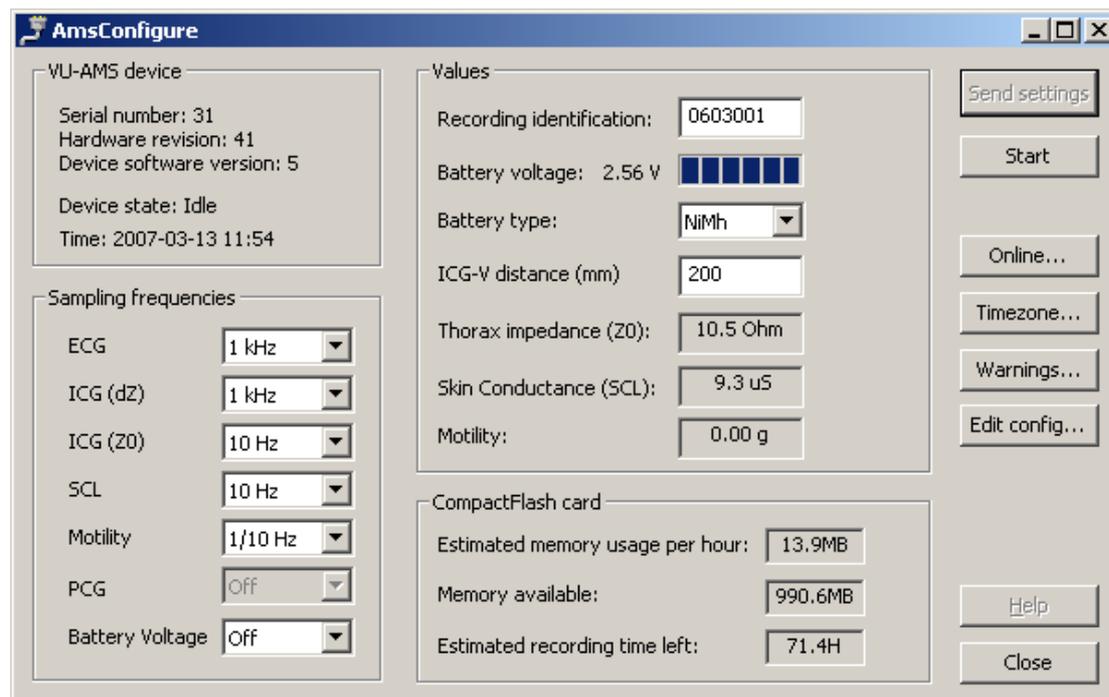
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Check the battery type, battery voltage indication (should be about 3.4 Volt for alkaline and about 2.4 Volt for rechargeable NiMH batteries), and re-check time and date. Fill out the identification field. *NB:* If you intend to use our preprogrammed SPSS scripts, make sure the identifier is exactly 7 characters long. Try to use a numerical name only (e.g. 0603001).

The typical sampling frequencies are as shown in the figure. AmsConfigure allows you to set sampling frequencies for the various signals. You can also disable signals here by setting them to 'Off'. When you change the any setting, **make sure to send the settings to the device before closing the screen!**

Attach the electrodes as explained in the instruction leaflet "How to attach the VU-AMS version 5fs" (Appendix 1).

After connecting the ECG/ICG lead wire plug, the 'Online' option of the AmsConfigure program should be used to display the ECG, dZ (=respiration) and dZ/dt (=ICG). A clear QRST-complex should be detectable in the ECG. The R-wave should be upward and it should be the peak with the largest (absolute) amplitude in either direction. If either S-wave or T-wave are of comparable magnitude re-attach the black ECG electrode first more laterally then more medially until a satisfactory QRS complex is seen.

NOTE: In ambulatory paradigms, this is your *only* opportunity to re-attach faulty electrodes.

The dZ should be within -0.5 and +0.5 Ohm most of the time. Z0 should always stay within an 8 to 20 Ohm range. The dZ signal should reflect deep breathing clearly. In the ICG the typical upward waveform of the cardiac ejection phase should be clearly detectable. Light movement of the subject should not overly distort it. If these criteria are not met, re-attach the electrodes in the order 7,6,1,3,4,5,2 until satisfactory signals are obtained. The Scrollbar on the Y-axis can be used to scale the signals.

When satisfied, start data recording by pressing the 'start' button. A beep will be heard to acknowledge the start of the recording and the green light will start flashing once every three seconds. Close the AmsConfigure program. You may now disconnect the VU-AMS device from the interface.

Synchronize the watch of the subject/observer to the exact time of the PC used to start up the VU-AMS for optimally time-locked self-report diary and physiological data. When electronic diaries are used make sure that their clocks are synchronized with this PC too.

Measurements can be stopped in the field by pressing the button for three seconds or longer (the light will flash every 10 seconds to indicate stand by mode). Once the VU-AMS has stopped you may disconnect the lead wire plug(s) from the connector(s) and the lead wires from the electrodes. The subjects can also do this themselves at home at a designated time.

When the device is returned to you, check if the measurement has been stopped already (the light flashes twice every ten seconds), is still recording (the light flashes every three seconds) or has stopped because of empty batteries (the light does not flash at all). Reconnect the device to the PC and restart

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AmsConfigure. You can now confirm the state of the device, and when needed actively stop the recording. Close AmsConfigure and remove the interface cable. Now remove the batteries and place the CompactFlash Card in the reader unit. Move the AMS files to a designated directory. Use the same name for the directory as was used as a subject identifier (see the AmsPreProcessor Help for details). It is best to backup the original '.5fs' AMS-data files as soon as possible (extension '.5fs' discriminates the version 5fs AMS-data files from the '.ams' files generated by previous versions).

If the recording has been interrupted by the experimenter or by the subject, multiple .5fs files with different start times will be generated Use the AmsMerge tool to concatenate the .5fs files into a single .5fs file that spans the entire recording. Interruptions will be marked in this file as hold-continue periods.

Processing VU-AMS.5fs data

Use the VU-AMS software suite to process the VU-AMS data. Starting form the original .5fs file the various programs in this suite will create new data files, that in turn become input for other programs in the suite. Filenames will be maintained from the original filename given to the .5fs raw data file, but extensions will change depending on the type of information produced. A schematic of the various programs and the file extensions they produce is given below.

VU-AMS5fs software suite
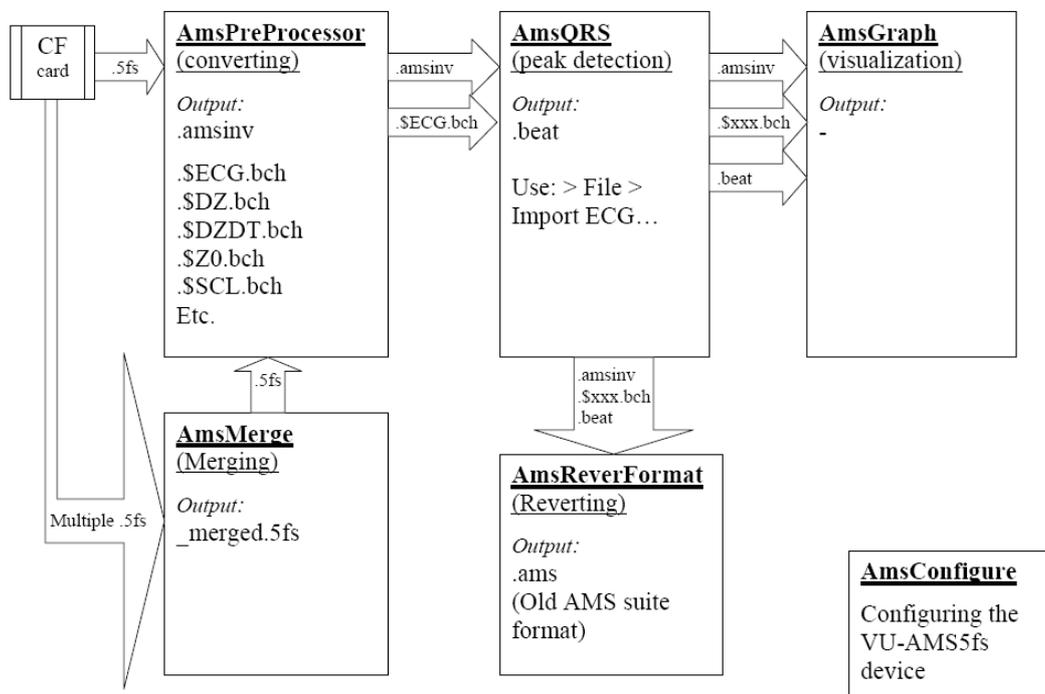
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The typical flow of events is:
1. AmsMerge
2. AmsPreProcessor
3. AmsQRS (R-wave detection)
4. AmsRevertFormat (to .ams)
5. AMSGRA(data labeling&HR+RMSSD)
6. AMSRES (RSA scoring)
7. AMSIMP (PEP scoring)

1. AmsMerge
If you have multiple files for a single recording (because the participant took a shower, or because an electrode had been loose), first merge all files into a single recording with AmsMerge.

2. AmsPreProcessor
To further process the data you need to convert the raw '.5fs' AMS-data files to a format of choice, using the AmsPreProcessor program. Different formats are supported including Biopac, ASCII, EDF and EDF+.
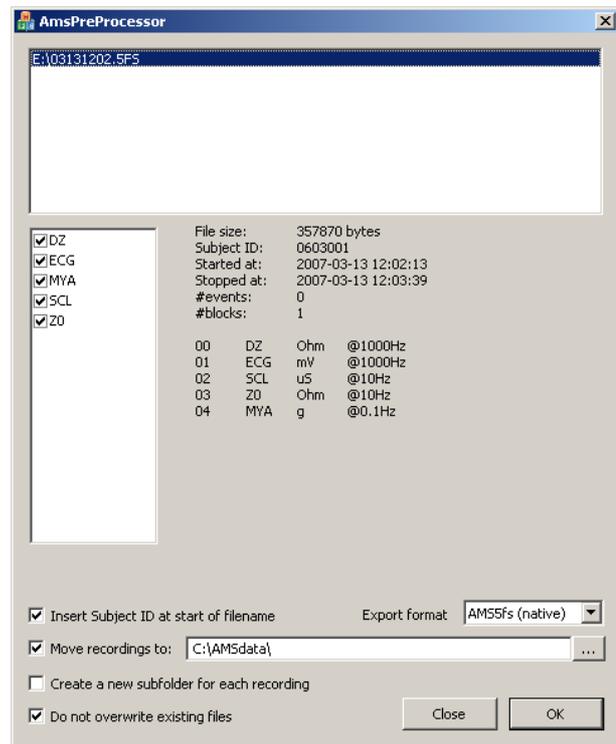
The default is to convert the files to the native VU-AMS5fs format. Native format creates a different file for each of the signals which is visible in the file name e.g.
0603001_03131202$DZ.bch;
0603001_03131202$DZDT.bch; 0603001_03131202$ECG.bch;
0603001_03131202$MYA.bch;
0603001_03131202$SCL.bch;
0603001_03131202$Z0.bch;
0603001_03131202.amsinv.
The binary amsinv (AMS inventory) file indicates the exact times of event button pushes and restarts).

3. AmsQRS
After conversion to native AMS5fs format **FIRST** extract the IBI time series from the ECG signal. This is done using "File > Import ECG…" in the AmsQRS program. The AmsQRS program displays the IBI time series of the complete recording in the top panel and the raw ECG signal in the lower panel. The middle panel also displays the IBI time series, but only for the interval selected in the top panel.

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Clicking in the top panel will automatically scroll the middle and lower panel to the corresponding point in time. Visual inspection of the top panel will rapidly identify 'spikes' which can occur because an R-wave was missed and/or a T-wave was used instead. The spikes can be corrected in the lower window by dragging the cursor to the correct R-wave peak. A single left-click in the ECG panel will automatically insert a new R-peak cursor at the selected location. A single right-click on an existing cursor will remove that cursor. The left and right arrow keys of the keyboard allow you to step through all scored R-peaks. The active (blue) cursor can also be deleted by pressing the delete key. The corrected time series is saved in the '.beat' file. Detailed information on how to tailor automatic scoring is found under the 'Help' option of the AmsQRS program.

> NOTE: All time spent correcting the IBI time series is well spent, since it is the basis of many other variables extracted from the VU-AMS.

4. AmsRevertFormat

After corrections with the AmsQRS program, the AMS.5fs signals can be converted to the old VU-AMS file format of the VU-AMS 4.6 series (.ams) with the AmsRevertFormat program. The immediate advantage of this is that all existing software for labeling (AMSGRA) and impedance scoring (AMSIMP) and respiration scoring (AMSRES) is now available.

The old VU-AMS 4.6 series did not yet combine ECG/SCL and ECG/ICG in a single device. You will have to choose the appropriate signal at the AmsRevertFormat open screen. For instance to create an .ams file with ECG/ICG signals use the following settings in AmsRevertFormat:

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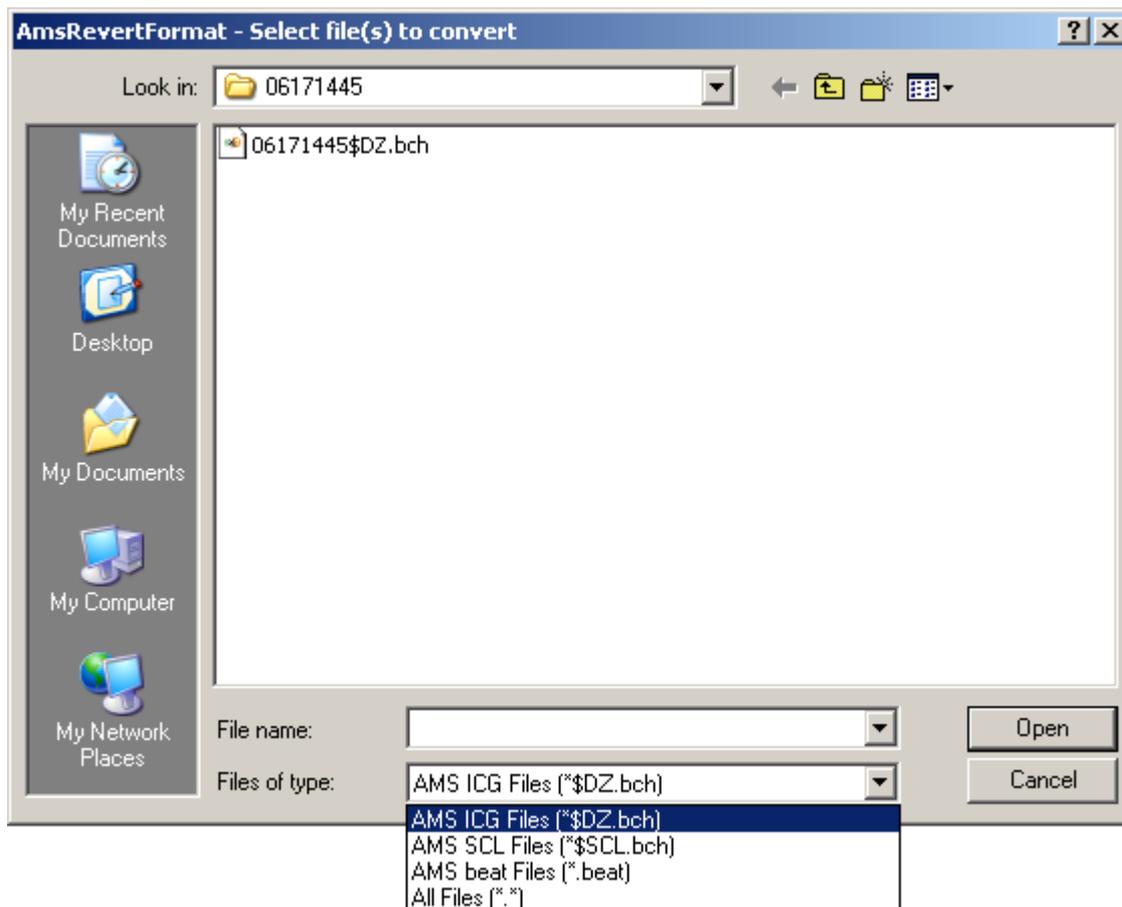
5. AMSGRA(data labeling&HR+RMSSD)
Before using any of the VU-AMS programs that extract physiological parameters (like AMSRES and AMSIMP), it is important to first create a so-called label data file (default extension .lbl).

The aim of data labeling is to classify all activities of your subjects into a fixed number of activity categories with a fixed number of levels.

Labeling divides the entire measurement period into separate smaller periods. For each period start and end times are given as well as a set of codes and text labels describing the state of subject during that period in terms of posture, activity, physical load, social situation, mood state, work load, etc.. To create these labeled periods you have to use the AMSGRA program in combination with the subject's diary or your observation chart/video recording. In the label data file all descriptive information on the subject's activity you might want to use in future analyses should be present. Make sure you have labeled all periods that might be considered of interest. There seems to be no urgent need to also label periods that you consider to be "irrelevant" or that are expected to occur in only a few subjects. However, we advise to always label the entire 24 hour recording. For example if the labeled periods are 18 minutes on average, this adds up to 78 labels per subject.

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The actual labels used will entirely depend on the research question. Here are some examples of categories that could be considered:

Category:		Items in Category:
Type of activity		Reading, attending a meeting, eating, dancing, PC work, conversing, watching TV, exercising, attending a musical, car driving, ironing, etc.
Posture		Sitting, standing, lying, walking, etc.
Physical activity		Heavy, moderate, light, none
Social situation		Alone, with significant other, with friends, With colleagues, etc.
Location		At home, at the office, travelling, restaurant, etc.
Time of day		Work, leisure time, sleep
Mood state		Angry, friendly/happy, sad, anxious, tired

Label configuration file
When you have decided on the type of categories you want to use during labeling you need to summarize these in a 'label configuration file' (default name label.cfg).

Example of a VU-AMS label configuration file (label.cfg):

#posture
10 lying
11 sitting
12 standing
13 walking
14 lying sitting
15 sitting standing
16 sitting standing walking
17 standing walking

#type of activity
29 desk work
30 administrative work
31 household activities
32 recreational activities
33 transportation (active)
34 transportation (passive)
35 telephone/talking
36 reading, internet or other recreative PC use
37 eating/drinking

38 watching TV
39 sleep

#location
50 work
51 home
52 friends house
53 on the road
54 public building
55 physicians, dentists, or therapists office
56 house of family

#social situation
60 alone
61 with SO
62 with own children
63 with friends
64 with colleagues
65 with others
66 unknown

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You can create your own label configuration file in two ways:
1) use the 'Create configuration file' option from the submenu of 'Labels' in AMSGRA or
2) use a previous made label.cfg. An example of the text in such a label configuration file is given below.

Make sure you copied the label.cfg file into the same directory as the .ams files that you want to label!

The label file really is central to the VU-AMS!! All further processing is tailored to it. By looking at start and end times of the labels, all programs adding variables like PEP and RSA will automatically attach the label information from the label data files. Time stamps, your activity and posture codes as well as any textual label will be attached automatically to each single value of the parameters that are being scored. Although this may appear to be extreme overkill, it is very convenient once you bring your final data matrix into your statistical program!

Use the 'Open AMS file' command from the 'File' menu to load a data file (.ams). The total registration of the subject is now shown in the upper display of your screen. The grey graded box between the two vertical bars indicates which part of this total registration is shown in the lower display. By moving the two vertical bars with your mouse, the size of the graded box and thus which part of the total registration is displayed enlarged in the lower panel, can be changed (a double headed arrow is displayed when this option is available). You can also move the whole box to the left or the right with your mouse (a 'hand' is displayed when this option is available).

For the heart rate (HRA), motility (MOT) and root mean squared successive differences of the heart rate (MSSD) settings can be changed by clicking on the colored box of the activated variable. By ticking the option 'visible' on or off a choice can be made which signals are displayed in the graphical panels.

HR and MSSD signals are highly sensitive to posture and physical activity. To obtain information about a subject's daily routine, all subjects have to keep a detailed diary during the ambulatory measurement day. This diary information about type of (changes in) posture and activity is used during the labeling procedure. The VU-AMS device also contained an accelerometer which is sensitive to changes in vertical acceleration (MOT signal). This motility signal can be used to confirm the activities and postures written down in the diary.

The actual labeling procedure is done in the lower graphical display. Use your left mouse button to select the start and end point of the new label you want to add. Releasing the mouse button shows which time period is covered by your new label. This label is still red chequered. Click on the appropriate Category and Code names for this time period to finish the label. The label is now red. Repeat this procedure until the whole .ams is labeled.

Close AMSGRA after you have labeled your .ams file. A label file (.lbl) will be saved. This .lbl file is an ASCII file. In the .lbl file an average HR, IBI, MSSD and MOT value is given for each labeled time period. Therefore, the .lbl file can be used for further statistical analyses in for example in SPSS.

7.+ 8. AMSRES (RSA scoring) & AMSIMP (PEP scoring)
Separate manuals for impedance scoring (AMSIMP) and respiration scoring (AMSRES) are available on the website (www.vu-ams.nl).

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Trouble shooting:

AMS file has zero bytes
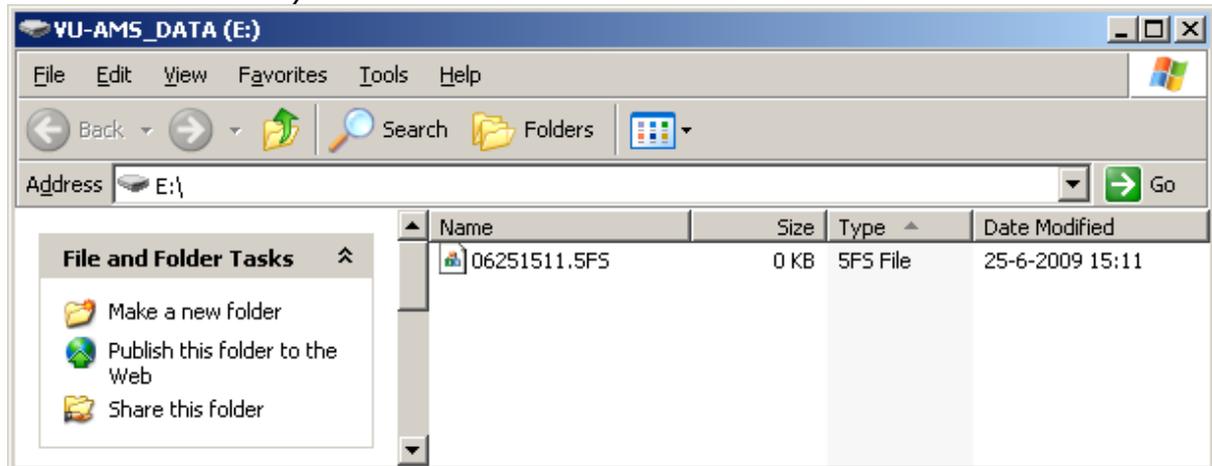
Cause: the VU-AMS has made a recording and probably all data are there but an end-of-file marker has not been placed.

Solution: This can be repaired by closely following the instructions on www.vu-ams.nl > Download > Video manual: How to repair a 0KB file recorded with the VU-AMS.5fs.

Alternatively, you can send the flashcard back to us.

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Appendix1: How to attach the VU-AMS.5fs?

CHEST   **BACK**
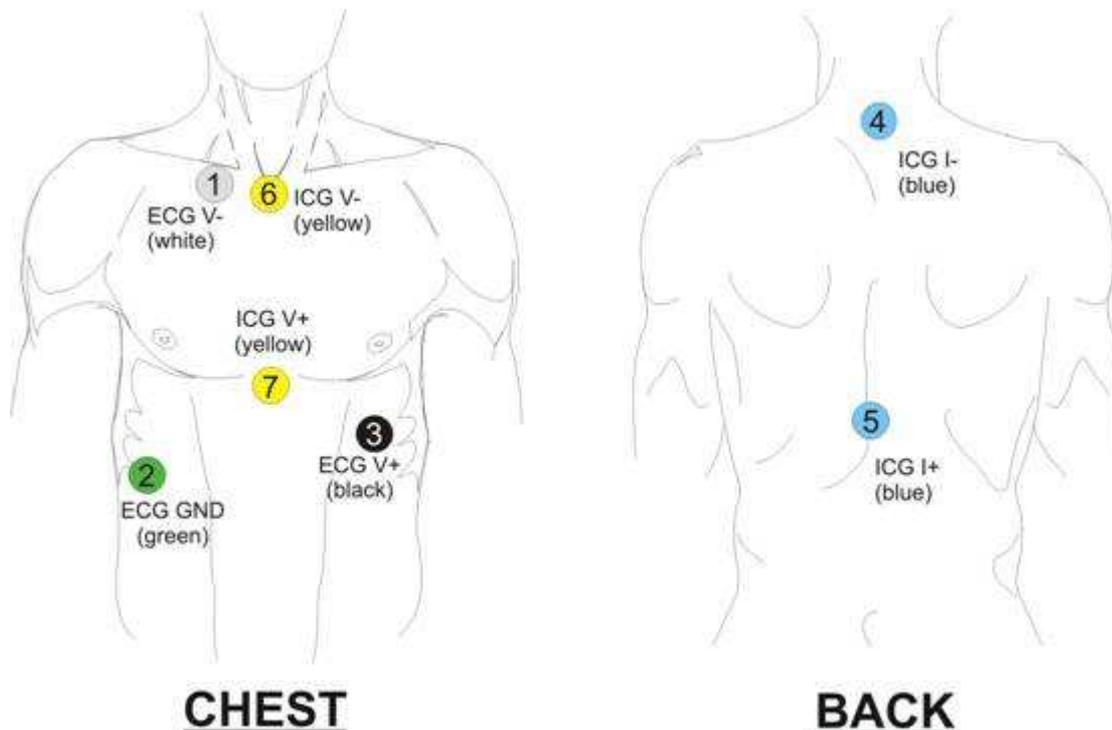
Attachment of the ECG/ICG electrodes

Clean the skin at the 7 positions indicated in the figure. Rub the skin firmly with an alcohol soaked tissue or, if alcohol is not available, use a clean dry tissue. Attach an electrode by pressing the sticky plastic brim of the electrode on the skin and subsequently pushing the metal stud at the center of the electrode firmly, to properly spread the contact gel.

ECG:
1. (V-)   Slightly below the right collar bone 4 cm to the right of the sternum
2. (GND)   On the right side, between the lower two ribs
3. (V+)   Under the left breast, 4 cm (1.5") under the nipple
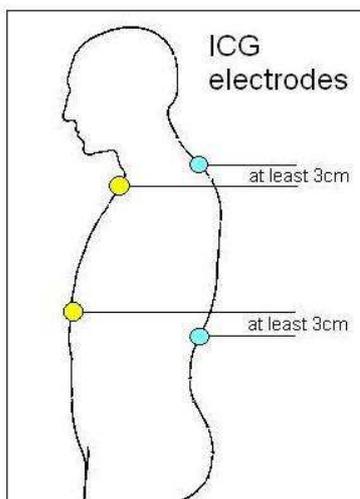
ICG:
4. (I-)   At the back, on the spine, at least 3 cm (1") above electrode 6
5. (I+)   At the back, on the spine, at least 3 cm (1") below electrode 7
6. (V-)   At the top end of the sternum, between the tips of the collarbones
7. (V+)   At the low end of the sternum, where the ribs meet

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Attachment of the lead wires and lead wire connector
Attach the lead wires to the electrodes according to the color-coding scheme in the figure above. Next, the blue ECG/ICG lead wire connector has to be plugged in the blue socket.

Starting the measurement by plugging in
The VU-AMS device is always standby. Measurement will (re-)start after you plug in the lead wire connector and press the event button for three seconds or longer. A beep will be heard to acknowledge the start of the recording and the green light will start flashing about once every three seconds.

Wearing the device
Put the VU-AMS device in its carrier bag with the lead wire connector facing up. Fasten the device with the Velcro strap in the bag and gird it on with the VU-AMS belt (if it is more convenient, you can also use your own belt). Make sure the device remains in a vertical position as much as possible.

Marking special events
A small black button is placed on top of the VU-AMS device next to the two lead wire plug connectors. To mark a special event, push this button for about one second. Pushing it will be confirmed by a short beep.

Stopping the measurement
If you want to stop the measurement temporarily (e.g. for taking a shower) press the event button for at least 3 seconds until the green light ceases flashing. Next, unplug the lead wire connector from its socket and disconnect the lead wires from the electrodes. The electrodes themselves are waterproof and need not be removed from the skin. To restart the measurement, simply follow the instructions above starting at 'Attachment of the lead wires'.

Still working?
A small indicator light on top of the device will be flashing about once every three seconds as long as the VU-AMS is recording.

Something is going wrong.
- The green light is flashing very rapidly
Diagnosis: The Compact Flash card is not (properly) installed.
Solution: Install the Compact Flash card in the proper way.
- The green light is flashing rapidly
Diagnosis: The battery lid is not (properly) fastened.
Solution: Fasten the battery lid in the proper way.
- You hear a double beep (the 'alert beep'), which is repeated after increasingly shorter intervals (from 30 to 10 seconds).
Diagnosis: The battery voltage is becoming low.
Solution: Replace the batteries with fresh ones.
- An electrode comes off, a lead wire gets disattched, or the lead wire connector is pulled out by accident.
Solution: No worries. Just attach the electrode again (use a spare one if necessary), reattach the lead wire, or plug the connector back into the socket.

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Appendix2: VU-AMS.5fs software suite

VU-AMS5fs software suite

CF card .5fs →

AmsPreProcessor
(converting)

Output:
.amsinv

.$ECG.bch
.$DZ.bch
.$DZDT.bch
.$Z0.bch
.$SCL.bch
Etc.

.amsinv →

.$ECG.bch →

AmsQRS
(peak detection)

Output:
.beat

Use: > File >
Import ECG…

.amsinv →

.$xxx.bch →

.beat →

AmsGraph
(visualization)

Output:
-

.5fs ↑

AmsMerge
(Merging)

Output:
_merged.5fs

Multiple .5fs

.amsinv
.$xxx.bch
.beat

AmsReverFormat
(Reverting)

Output:
.ams
(Old AMS suite
format)

AmsConfigure

Configuring the
VU-AMS5fs
device