

**Overview** This script, *FV\_online.s2s*, is one of a family of three (*Ptcal*, *FV\_online* and *Resp*) intended for recording and analysing respiratory data. They require Spike2 v8.05 or higher for correct performance. Keep these scripts, sampling configurations and related files together in the same folder e.g., *scripts*, inside your *Spike<sub>n</sub>* directory in *My Documents*.

- *Ptcal.s2s* calibrates a pneumotachograph (air flow meter) by analysing the flow trace generated by repeated strokes of a syringe of known volume. The calibration information is saved to a sampling configuration.
- *FV\_online.s2s* uses this sampling configuration together with data on the ambient recording conditions to record respiratory data and convert the raw air-flow signal into ATPS and BTPS flow and BTPS volume traces *on-line*.
- *Resp.s2s* analyses respiratory data recorded using *Ptcal* and *FV\_online*. However, it can also generate BTPS-corrected volume and flow traces from an ATPS flow signal. Thus, it can be used as a *stand-alone* script for analysing respiratory signals recorded by other methods.

The *FV\_online* script controls the sampling of respiratory data. You specify the sampling configuration to use and enter the ambient temperature, atmospheric pressure and humidity (or correction factors) via a dialog. The sampling configuration creates a calibrated flow signal in a Virtual channel and the script modifies this further to generate flow and volume channels corrected to BTPS.

Despite our best efforts to calibrate the pneumotach, the volume trace may be subject to a residual drift. This drift can be removed properly later, by reference to IC manoeuvres during the analysis with the *Resp<sub>x</sub>* script. However, during the recording the script uses temporary measures to keep the volume trace within the visible range by applying a *DC Remove* channel process to the flow trace and optimising the volume axis automatically at user-defined intervals. These temporary fixes are un-done when you stop sampling. However, the on-line drift removal method should make it possible to measure FVC manoeuvres with reasonable accuracy during the recording session. The script has an FVC button on the toolbar to make these measurements semi-automatically.

There is an option to plot ventilation online, that is, the volume breathed over a user-defined time interval, for example 1 minute. This is also a best estimate given the imperfect drift removal. You can also opt to display respiratory rate and tidal volume channels on-line.

The script can generate digital output pulses when a chosen waveform crosses a user-defined threshold. These pulses can be used to trigger an external device such as an isolated electrical stimulator. The results are then saved for later analysis using the *Resp<sub>xx</sub>* script.

**Use of Two Monitors** In some situations, it is necessary to provide the subject with visual feedback about their performance. To do this, there is an option to display copies of one or more of the data windows generated by the script on a second monitor that the subject can see. This option will only be available if you have configured the Windows *Display settings* to position the second (subject's) monitor *below* the primary monitor.

Right-click on the desktop and choose *Display Settings* from the context menu. In the subsequent dialog choose *Extend these displays* and drag the secondary monitor directly **below** the primary monitor. Click on *Apply* and then close the dialog. This means that you can move the mouse pointer between screens via up and down movements of the mouse rather than side- to side.

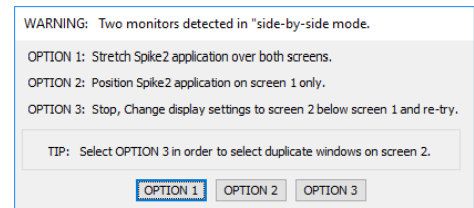
If the system is configured for two monitors in this way, you can choose which windows to duplicate on the second screen by checking boxes in a dialog. You can select any or all of: *Sampled data*, *FVC manoeuvres* and *Tables of FVC statistics*.

The duplicate windows on the second monitor are intended for viewing only. You can adjust their size and position using the mouse and use the *Show/Hide* dialog to display only the relevant channels. However, you should carry out any other manipulations on the main copies of these windows on the primary monitor.

The system will remember which channels you choose to display in the duplicate data view for next time. Note that the *Show/Hide channel* list includes a number of hidden channels that store intermediate steps in the calculation of ventilation, tidal volume and respiratory rate. If you do not recognise the channel title then leave the channel hidden!

If you have two monitors with the displays aligned *side by side*, you will have three options

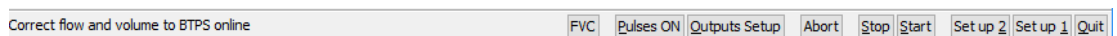
- to stretch the Spike2 application over the two monitors
- confine the Spike2 application to one screen.
- Close the script so that you can re-align the displays one above the other and re-try.



While the script allows you to stretch the Spike2 application over two side-by side monitors, there are significant disadvantages in that all the Windows and Spike2 tools are also stretched across both screens and data windows may cross the boundary between screens.

**User Guide** Delete any previous *FVonline* hotkey from the Script Bar via *Script/Script bar list/Delete selected* on the Spike2 drop-down menus. The first time that you run the script, it will (re-)install a hotkey labelled *FVonline* on the *Script Bar*. In future, you can run the script by clicking on this button.

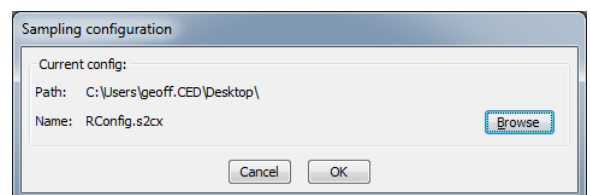
When you are ready to record respiratory data, switch on the 1401 interface and run the script. Additional dialogs will appear to configure your displays if you have two monitors enabled.



The script toolbar has 9 buttons and multiple dialogs. The dialogs are -stickyø in the sense that you can move them to convenient screen positions by clicking and dragging their title bars. The positions that you choose will become the new defaults.

**Set up 1** Click here to begin. In the *Sampling configuration* dialog that opens, you can accept the current configuration or browse to, and open a configuration that holds a valid PT calibration.

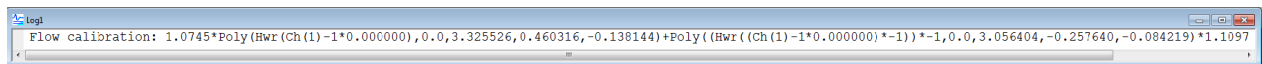
When you click on OK, the name of the file containing the calibration data (i.e. syringe strokes) will display on the script toolbar. Alternatively, you will get an error message if the sampling configuration that you chose does not contain a flow calibration.



**BTPS correction** The next dialog allows you to enter the correction factors necessary to convert the flow to BTPS. Alternatively, you can enter the ambient conditions and the script will calculate and display the correction factors.

When you click on OK, the expression that will be used to convert pneumotach output to flow in litres at BTPS will display in the log window at the bottom of the screen.

### Calibration expression



**Setup 2.** The dialog has six main items for configuring the display:

- A check box to show or hide the raw flow trace. The script uses this channel to generate a calibrated btps flow trace. If you do not need to see this trace, you can hide it so that other channels have more space on the screen.
- Flow and volume traces are optimised at intervals, that is, the Y-axis range is adjusted so that all the data in the currently displayed time range is visible. Set the time interval between optimisations here.
- A *DC Remove* process is applied to the volume trace. Set the time constant for drift removal here. Normally, the duration should be set longer than one typical breath cycle. (See the *Spike2* online help on *Channel Processes* for more information on *DC Remove*. The volume trace will wander around slightly during the drift removal phase. A cursor marks the position where the volume trace has settled. You can turn off drift removal by setting the time constant to zero. If you do this, you will probably require a short optimisation interval in order to prevent the volume trace from drifting out of range.
- If you require a ventilation plot, then check the box. The *Time range* and *Volume range* items will enable. Adjust the time range for ventilation, e.g., set 60 for *minute* ventilation. *Volume range* sets the upper limit of the ventilation Y-axis. Set this value for to an appropriate upper limit for ventilation in the chosen time range.
- You can also select respiratory rate (RR) and tidal volume channels via checkboxes. If either box is checked, then you will need to set suitable breath detection parameters. In the case of respiratory rate, you can opt to display instantaneous breath frequency (recommended) or Mean frequency. If you choose mean frequency, you must also set a time range for calculation of the mean (*Time bin*). These traces are calculated when the volume trace has settled to its stable value and therefore lag behind the volume and flow traces by the drift remove time constant that you set.

- *On-line flow –volume loops.* Set the initial axis ranges in the dialog and the time range to display. The axis ranges will update automatically to keep the current breath in the visible range. Data is added to the FV loop at the cursor position and therefore will lag behind the incoming data by the chosen drift remove time constant. You can adjust the duration of FV loops during recording in the range 2 to 20 seconds,

Press OK to close the dialog. You are now ready to start recording. You can click on Set up 2 again during recording if you need to adjust any of these parameters.

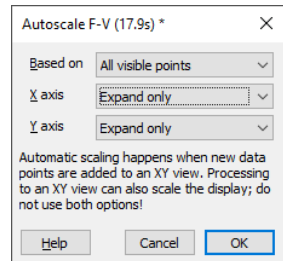
**Start** Along with all the other channels in the sampling configuration, you should see a Virtual BTPS flow channel and a corresponding Volume trace. Note that the volume trace will not settle for a few seconds. This is an inevitable consequence of the drift removal process. The settling time is the *DC Remove* time constant that you chose in **Set up. 2.** The settling time is marked by a vertical cursor. Data to the left of the cursor has reached a steady state. We make no attempt to remove drift from the flow trace.

**Ventilation channel** If you enabled the ventilation channel, the channel will be labelled *Ventil.* The time range over which it is measured is stored in the channel comment and will appear in a tipobox if you place the mouse pointer over the channel title. Initially, the ventilation trace will build up from zero and will reach a steady state when the chosen time range is exceeded.

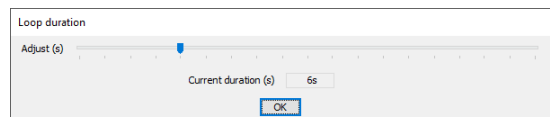
The ventilation trace is provisional and is only intended as an estimate. The ventilation channel will be deleted when you stop recording. You can create a more reliable minute ventilation trace off-line using the *Resp* script after compensating for drift using IC manoeuvres. Similarly, provisional respiratory rate and tidal volume channels will be deleted when you click on **Stop**.

**Flow Volume loops** If selected, this window appears in the lower left quadrant of the primary monitor. It displays a flow óvolume plot of the duration set in the **Setup 2** dialog and ending at the cursor position. The leading edge of the loop is highlighted red for easier visibility when several loops overlap. By default, the x- and y-axis ranges will auto-expand to accommodate new data that is outside the initial axis ranges.

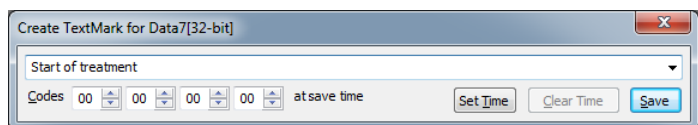
You can select other display options by right-clicking on the loop view and selecting *XY Auto-scale* from the context menu. For example, “*fixed size following data*” allows you to keep the most recent loops centered in the visible range.



To change the time range, click on **FV loop duration** on the main script toolbar. A slider control opens. Drag the slider to the right to increase the loop duration. You can leave the slider control open during recording if you wish. However, buttons on the main script toolbar will be unavailable until you close it by clicking on **OK**.

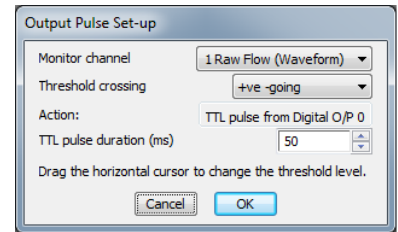


**Add TextMarks** If the sampling configuration that you are using contains an online TextMark channel, then you can add comments to the data file as you record. You can do this via the *Create a TextMark* option on the *Spike2 Sample* menu or its keyboard shortcut, *Ctrl + T*. See the *Spike2* online help for full details.



## Generate Outputs

If required, the script can generate pulses from digital output 0 on the front panel of the 1401 interface. Pulses are generated when a selected waveform rises above or falls below a user-defined threshold level. You can adjust the threshold level by dragging a horizontal cursor in the relevant channel. The TTL pulses can be used to trigger external equipment.



Click on **Outputs Set up** to configure outputs via a dialog. After closing the *Setup* dialog with **OK**, the **Pulses On /Pulses Off** buttons will enable so that you can turn this feature on or off.

## Pulse On

Pulses start when you click on this button (Hotkey: **P**) and stop when you press the button again. You can change the threshold by cursor dragging at any time.

To change channel, type of threshold crossing or pulse duration, you must stop the pulses and press **Outputs Set up** again.

In order to monitor the pulse output, add an *Event+* or *Level* channel to your sampling configuration and save it with *Save Configuration As...* on the *Spike2 File* menu.

Split the *Dig o/p 0* output with a T-piece to Event input 0. (Use a level channel if you are interested in the duration of the pulse).

## Measure FVCs On-Line

### FVC

In order to take measurements from an FVC manoeuvre, first make sure that the X-range of the sampling window is long enough to display the entire FVC with some time to spare on either side.

Instruct the subject to perform the manoeuvre and wait until the entire FVC is visible in the sampling window.

Now click on the **FVC** button or its hotkey *Space bar*. This will take a snapshot of the currently visible time range and display it in a second window. The script will attempt to position a cursor within the FVC.

Drag the cursor into position if the default location is incorrect.

Press **FVC** or *Space bar* again to take the first set of measurements. Drag the two cursors to the start and end of the FVC if the automatic positions are not to your liking.

When satisfied, click on the **Save** button in the *FVC* dialog or press *Space bar* to copy the contents of the dialog to the Table of results.

Cursors will now detect the *PEF* and *PIF* values. Once again, you can drag the cursors if the positions are incorrect.

Press, *Save* again (or *Space bar*) to add the results to the table. At this point, the snapshot of the FVC disappears.

You can record further FVCs in the same way and the results will be added to the table.

### Abort

Click here to halt sampling and discard the sampled data and any table of FVC results. There is an *Are you sure?* query so that you can change your mind.

**Stop** Click here to stop sampling and perform the next stage of processing flow and volume channels. The provisional drift remove channel process applied to the flow trace during recording is cleared and the btps volume trace is re-calculated with no drift removed. The script also creates an *atps* flow trace and saves these channels to disk. You can perform a more accurate drift removal using the *Resp* script.

**Quit** This button closes the script leaving the data files on the desktop. You can save the data file and /or table of FVC statistics via the commands on the Spike2 *File* menu. If you press **Quit** while sampling is in progress, there will be an *Are you sure?* Query so that you can step back from the brink before sampling stops.

If you are not satisfied with the BTPS correction applied on-line and you want to try alternative correction factors, you can do this using the Vol from Flow option in the *Resp* script. Simply, hide the current *Volume* and *BTPS-flow* traces, and create new ones with alternative corrections based on the *ATPS-flow* trace.