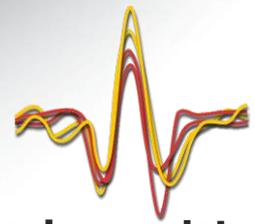


Version 10

**Spike2**



**Life sciences data  
acquisition & analysis system**



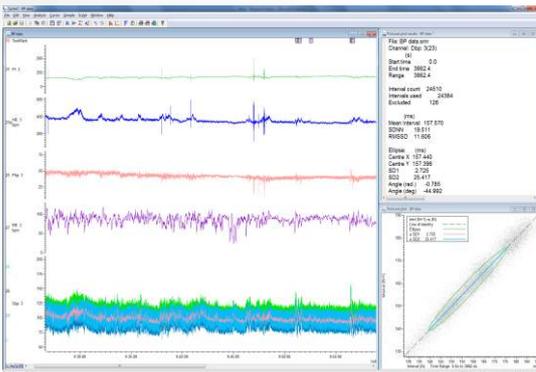
Spike2 is a multi-channel continuous data acquisition and analysis package. Users range from a simple chart recorder to complex applications requiring stimulus generation, data capture, scrolling or triggered displays, control of external equipment and custom analysis. This flexibility makes it suitable for a wide range of applications for specific analysis tasks.

- Spike2 is ideal for applications in many fields including electrophysiology, neurophysiology, sports science, pharmacology, and many more
- Spike2 provides power and flexibility for demanding applications, such as extracellular multi-electrode recording and complex stimulus timing
- Spike2 features a built-in script language to customise the program and provide control from simple automation to addition of complex analyses
- Spike2 imports data recorded by many other systems; you can take advantage of this extremely versatile software to analyse existing data
- Spike2 can export data to spreadsheet, text, binary and MATLAB® files
- Spike2 is continually updated; the latest version adds new features for free throughout the versions life cycle

The powerful data capture and analysis functions, together with one of the CED1401 family of laboratory interfaces, make Spike2 an extremely flexible, cost-effective and time-saving addition to any laboratory.

## Features

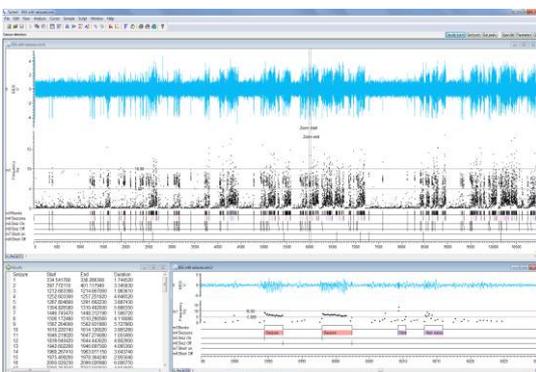
- Navigate through your data quickly and simply using the intuitive user interface; zoom and scroll with the mouse or keyboard
- Record multiple data types, including waveforms, event times, coded markers, and discriminated single and multi-unit spike data
- Generate simple and complex protocols of waveform and pulse outputs
- Acquire data from third-party devices using CED Talker software modules. Data can be sampled with or without a 1401 interface
- Detect data features automatically or manually and take measurements based on triggered and cyclical data with 'active' cursors
- Analyse multiple channels of waveform and event data on-line and off-line
- Process data with functions including filtering, rectification, interpolation, spectral analysis and inter-channel arithmetic
- Display and export images as you want them, with versatile display options including: triggered update with optional overdraw and 3D display, and duplicated windows with independent display settings
- Record larger numbers of channels by synchronising multiple CED 1401s
- Replay data files, with simultaneous output of waveform data through 1401 analogue outputs (DACs) or computer sound card



*Heart rate and blood pressure variability analysis including Poincaré plot with fitted ellipse*



*Multi-channel on-line spike discrimination with 'spike monitor' display*



*Script driven detection and classification of seizure activity in EEG*

## Data acquisition using a CED 1401

- Record to the 64-bit format for files of virtually unlimited size and duration or use the established 32-bit format for backwards compatibility
- Set different waveform sample rates per channel
- Capture and classify single and multi-unit spike activity in real-time
- Continuous, internally timed and triggered recording modes
- Store up to 8 channels of event data with microsecond timing resolution
- Log accurately-timed 8-bit coded digital inputs
- Annotate data records with text notes and keyboard markers
- Sample data from other equipment using the CED Talker interface
- Swap between experiment setups quickly with a single mouse click
- Calibrate waveforms with multiple methods including values, areas, slopes
- Automatically save and sequence multiple files with optional trigger start
- Recover data files in the event of an un-commanded system shutdown
- Configure software controllable amplifiers including the CED1902, Digitimer D360 (32-bit only), D360R, D440 and Power1401 gain option

## Experiment control and stimulus sequencing

The Spike2 output sequencer can run complex experiment control and stimulus sequencing protocols during data capture using up to 16 TTL and 8 waveform outputs. Timing is precise as it is controlled at the CED 1401 interface, not the host computer. The output sequencer can be changed while sampling.

Output protocols can be set up in two ways. A graphical editor provides all the functionality most users require, allowing creation of multiple sets of pulse outputs including square pulses, sine waves, ramps, pre-recorded and user-defined waveforms. For more demanding applications, a text editor is available in which you can edit the sequencer steps directly. This makes it possible to control the sequence interactively through the script language by use of variables and tables.

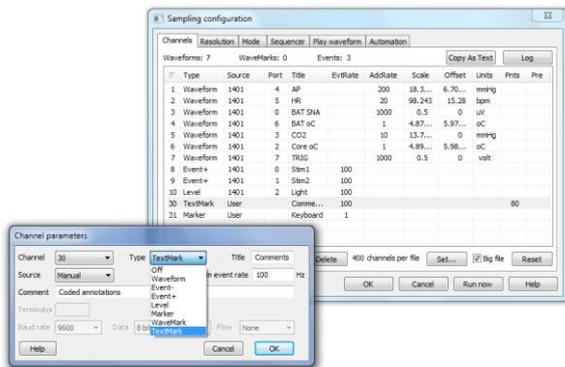
The sequencer can access the incoming waveform and event data in real-time, enabling a very fast response to changes in waveform levels and events.

## Spike detection and sorting

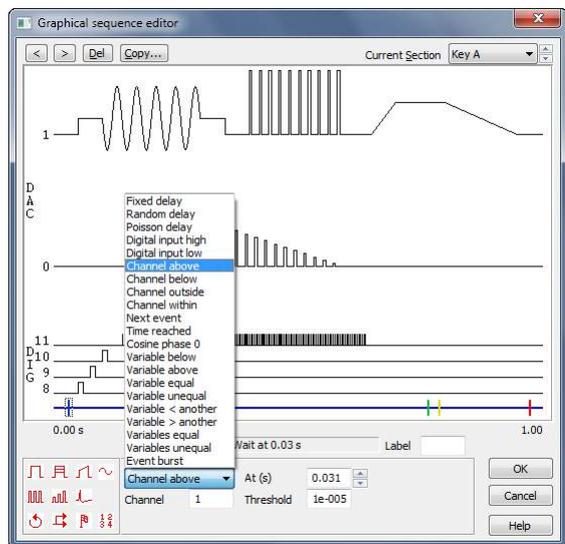
Spike2 identifies and sorts single and multi-unit activity both on- and off-line. It can mark events using simple threshold crossings or sort up to 32 channels on-line with whole wave spike shape template matching of single trace and n-trode data.

For multi-unit recordings, Spike2 contains tools for sorting spikes based on the spike waveform shape. All events crossing a threshold are captured. A combination of template matching and cluster cutting based on Principal Component Analysis (PCA), user-defined measurements, correlations or errors is then used to sort spikes into different units. Spikes can also be sorted interactively by dragging a line through spikes and classifying any which intersect. Spike collision analysis can separate unit collisions by comparing the current spike shape with pairs of existing templates.

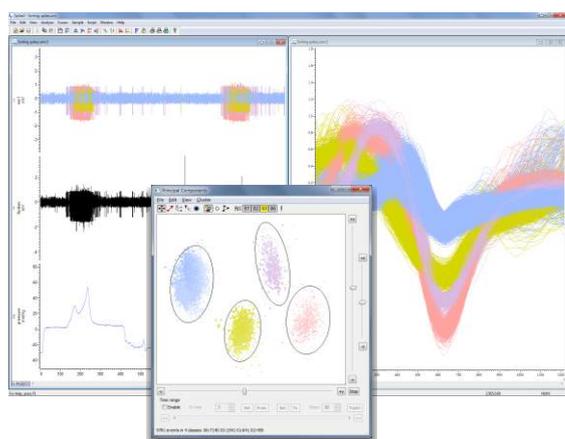
Cluster cutting methods plot measured values into a 3D view that can be rotated and replayed to show the occurrence of the spikes through time. Clusters are formed by automatic algorithms or manually by placing ellipses or drawing polygons. Interactive features include INTHs for current cluster classes, tracking over time, and selection of an individual spike by clicking on its dot in the cluster.



Spike2 sampling configuration dialog



Spike2 graphical sequence editor showing different outputs and additional control options



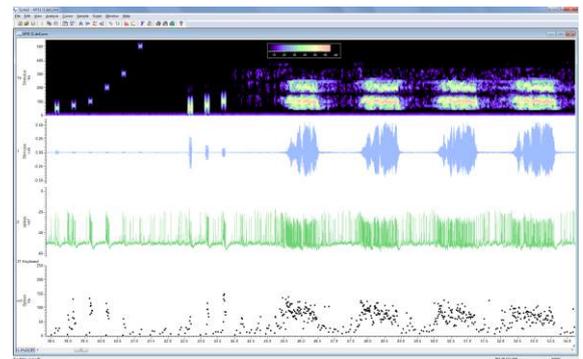
Multi-unit spike discrimination using PCA clustering

## Display

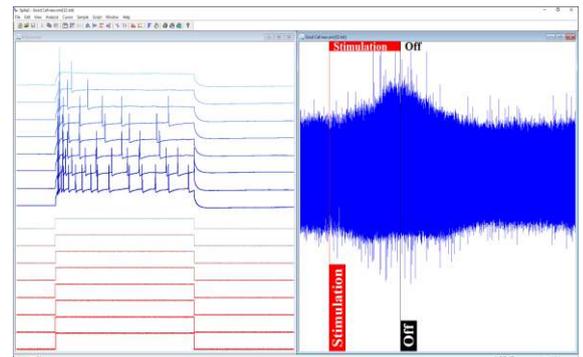
- Review multiple files simultaneously, even when sampling
- Navigate through data files with simple mouse pan and zoom, axis dragging, scroll bar and keyboard control
- Display events, spikes and markers as times, rates, mean and instantaneous frequencies. Discriminated spikes can be overdrawn
- Use duplicated channels to display data in different ways and show selected markers and discriminated spikes separately for cross analysis
- Overlay multiple triggered 'sweeps' with optional 3D display
- Draw waveforms with optional linear and cubic spline interpolation or as frequency sonograms with preset and user-defined colour scales
- Draw marker type data in State and Vertical marker modes for condition marking. Extend markers across all channels in the data view and display stored text in the channel area
- Set independent colours for each channel's data and background
- Arrange vertical space and order of channels displayed, including option to overlay multiple channels
- Display linear or logarithmic axes in result and XY views
- Expand your display area with built-in multiple monitor support
- Utilise info windows to display user-defined information such as timers, time of day, data values and measurements for specialised aid during data capture

## Processing and Analysis

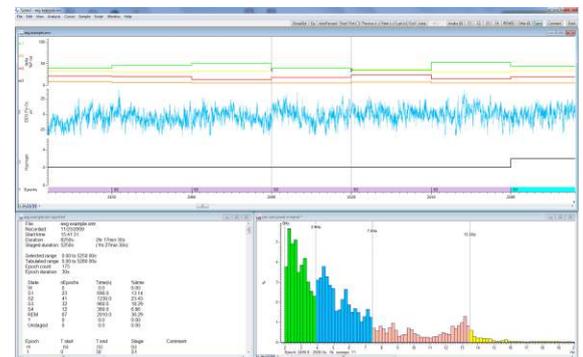
- Waveform analyses including averaging, power spectra and correlations
- Event analyses including INTH, PSTH, auto and cross-correlations, frequency and phase histograms
- Process data automatically around captured markers or events using 'gates' of variable or fixed length
- Automatically find data features including triggers and features in evoked, spontaneous activity and cyclical data with 'active' cursors
- Generate XY plots and data file channels holding measurements based on 'active' cursor feature detection, and output tables of measurement values
- Take absolute and relative measurements such as time points, data values, curve area, slope, max/minimums, mean, modulus and peak to peak
- Quickly take time and amplitude measurements using the mouse pointer
- Derive 'virtual channels' from existing waveform and event channels defined by user-supplied expressions (channel arithmetic). Options include mathematical functions, spectral analysis and comparison operators
- Generate functions in 'virtual channels', including sine, square, triangle waves, envelopes and polynomials
- Process waveforms dynamically on-line and off-line. Processes include rectify, smooth, DC remove, downsample, interpolate, median filter and RMS amplitude
- Create editable temporary channels containing copied or derived data
- Digitally filter waveforms (FIR and IIR) with interactive filter design
- Interactively fit data with functions including exponential, Gaussian, polynomial, sinusoid and sigmoid
- Automate repetitive, multi-step and custom analyses using the script language
- Script advanced processes, for example hum removal from any number of waveform channels using the CED 4001-16 Line Frequency Pulser



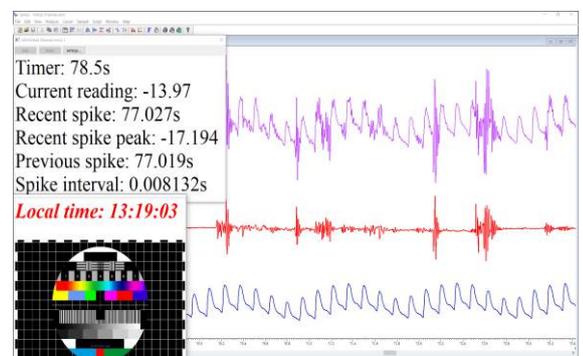
*Response of insect auditory receptor to pure tone stimuli and calling song*



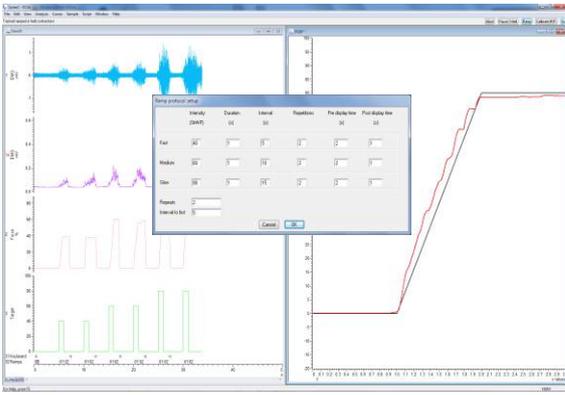
*3D overlay of data 'sweeps' (left), vertical markers for condition marking and displaying text notes (right)*



*Scripted sleep stage scoring and analysis*



*Info window provides user-defined information; Channel arithmetic using virtual channels*



Force-time target following experiment. Script generated target template with overlaid subject response. Target recorded in data file with associated EMG



Spike2 user training days



The CED Micro1401 and Power1401

## Script language

Anyone, from complete beginners to experienced programmers, can benefit from the built-in Spike2 script language. Simple automation of repetitive tasks with known parameters can save hours or even days of tedious analysis. Advanced applications include complete experiment control with on-line application of original algorithms to sampled data in real-time.

The script language not only links Spike2 features but also allows you to generate your own interfaces and algorithms. A simple macro recording facility provides a starting point for new scripts. The script language also includes data manipulation tools such as multi-dimensional arrays and matrix functions.

CED maintains a collection of scripts for a wide range of common and specialised applications. If the scripts included with the Spike2 software or those available from our web site do not fulfil your requirements, please contact us to discuss the available options. These include modification of existing scripts as well as a dedicated script-writing service.

## Service and Support

When you buy a system from CED, you are buying from a company with over 50 years of experience in data acquisition. We have one of the best customer support packages currently available, which includes:

- Free software and hardware help desks
- Software and hardware development responsive to user feedback
- 3 year warranty on major hardware
- Software updates available free within major revisions
- Swift fault diagnosis and hardware servicing
- Regular email newsletters
- Invitations to CED training days
- Access to our user forum where you can post questions for the CED team and browse topics posted by ourselves and other CED users

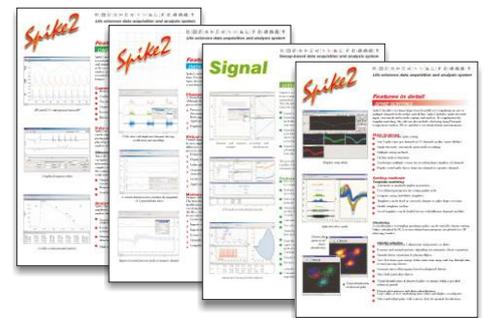
## System requirements

For sampling, Spike2 version 10 requires a CED laboratory interface (Power1401/Micro1401 MkII or later) and a PC (or Intel Macintosh) with Windows7/8/10. We recommend that the PC has 8GB minimum of RAM and runs Windows10.

Both 32-bit and 64-bit versions of Spike2 are supplied; either version of the software can be used on systems running a 64-bit OS. The 64-bit version provides a performance increase and access to more memory.

## Further information

Additional information sheets covering specific aspects of the Spike2 software and applications areas, as well as our episodic capture and analysis software, Signal are available. Please contact CED or visit the web site.



# CED

[www.ced.co.uk](http://www.ced.co.uk)

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