Current Clamp performance with the EPC 800 USB

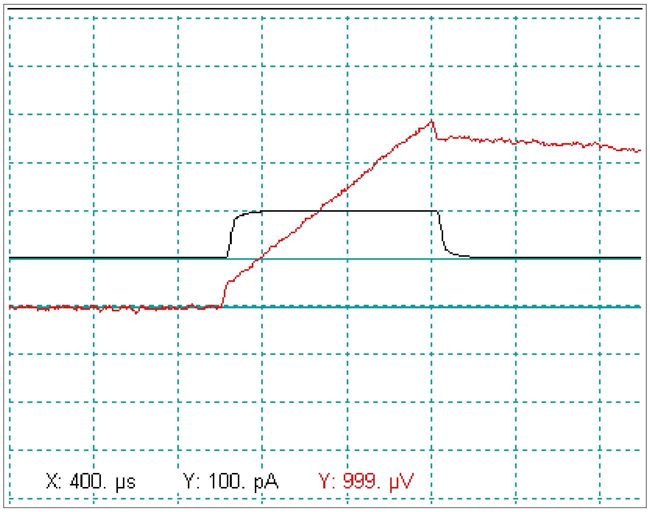
Current-clamp amplifiers, in general, are designed to control the current and measure the corresponding membrane voltage signal. A known constant or time-varying current is passed to stimulate a cell or modify its resting membrane potential during intracellular voltage recordings. The current clamp mode of the EPC 800 USB can be used to measure the resting potential or spontaneous or evoked action potentials.

In current clamp mode, the input of the headstage acts as a high-impedance voltage follower circuit. The feedback resistor is used for stimulation in current clamp mode by having a defined voltage applied to it. This voltage follower circuitry not only increases the speed but also the stability of the current clamp in comparison with older generation amplifiers.

CC + Bridge Mode

The current clamp mode of the EPC 800 USB is referred to as "CC + Bridge". Bridge compensation in current clamp mode acts in a similar way as RS compensation does in voltage clamp mode. It can be thought of as an enhanced current clamp mode that compensates the voltage drop via the series (access) resistance of the electrode (RS). The voltage drop across RS is seen as an instant step in the voltage trace when injecting a current step into the cell. With the Bridge compensation of the EPC 800 USB ON, the stimulus artifact that is typically generated when injecting current is fully eliminated.

A)



B)

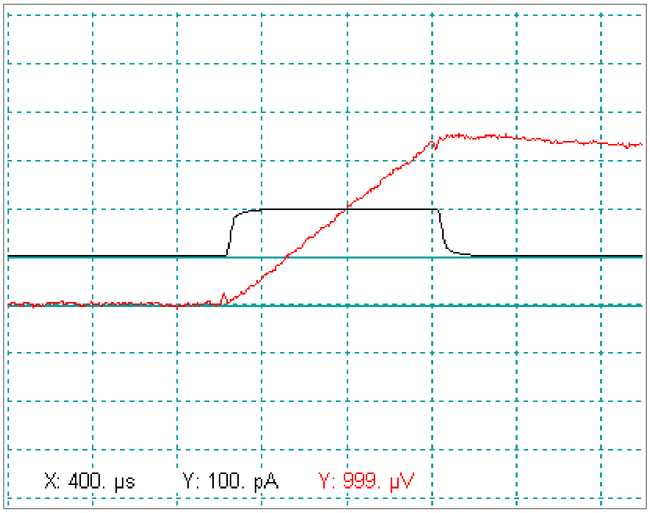


*Figure 1:Illustrating current injection to MC-10 model circuit with Bridge Compensation OFF (A) and ON (B). Current step is 100 pA. RS = 5.1 MΩ with the model circuit. An initial voltage drop of RS * i-step = 0.51 mV is expected and shown. Length of the test pulse is 1 ms.*

CC Performance

To illustrate the current clamp capability of the EPC 800 USB, evoked action potentials were recorded in current clamp mode from isolated guinea pig ventricular cardiomyocytes using a patch pipette with a resistance of approximately 1.7 MΩ. Bridge compensation was ON and C-Fast was correctly compensated. A full action potential is displayed in panel A with an enlargement of the stimulus and action potential upstroke regions in panel B.

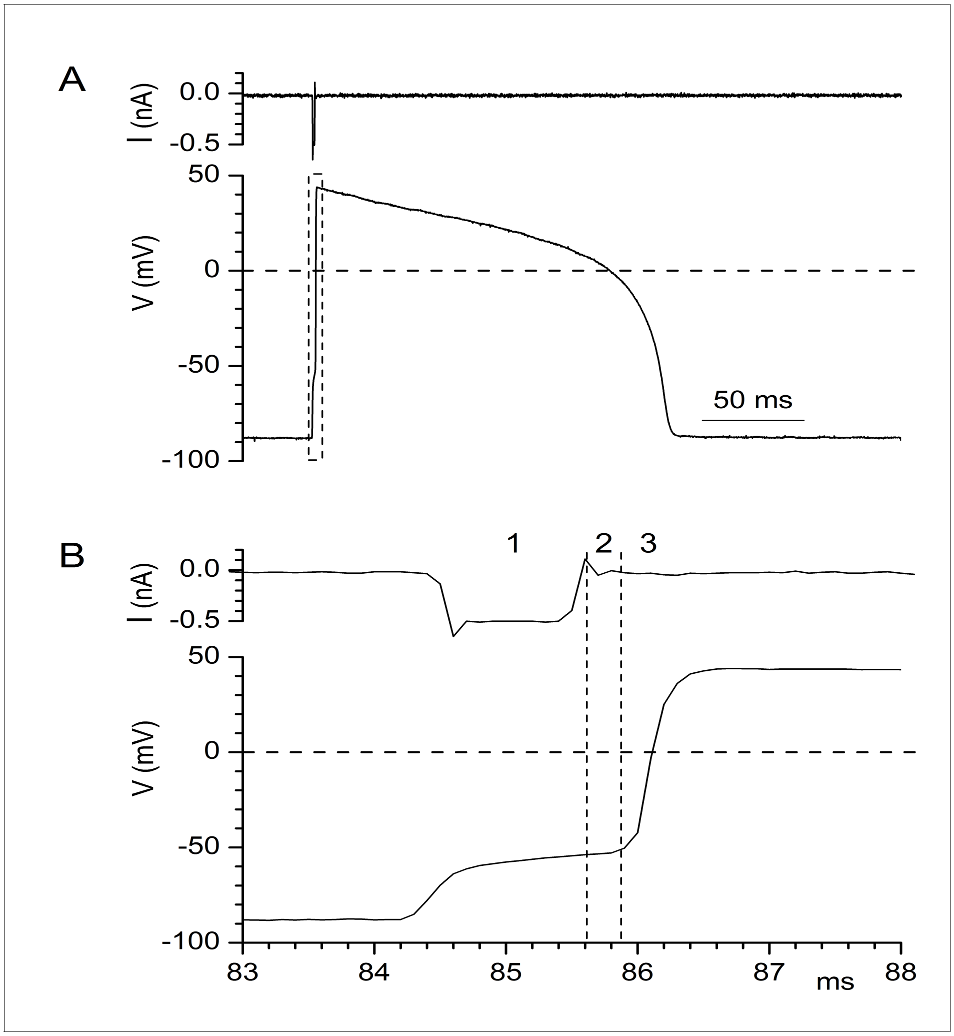


Figure 2:
A. Current stimulus trace on top with an evoked guinea pig ventricular action potential below. The area of interest is highlighted by the dashed box and is enlarged to full scale in B.

B. Enlargement of dashed area in A. Region #1 is the stimulus itself. Region #2 is the delay between the stimulus and the upstroke of the action potential. Region #3 is the upstroke of the action potential.

There are two critical points of interest that demonstrate the superior quality of the current clamp recording performed with the EPC 800 USB. First, the stimulus and resultant response to the stimulus are clearly distinguished from the onset of the action potential upstroke. The application of the stimulus itself resulted in a change in resting membrane potential from approximately -88 mV to -55 mV. Once the 1 ms current injection was over there was a brief delay between the end of the stimulus and the upstroke of the action potential (illustrated by region #2). It is within this period that most of the Na_{2+} channel activation occurs and the upstroke is generated.

The second critical point is that there are no signs of current deflections in the stimulus trace during the rapid rising phase of the action potential (i.e., within region #3). The calculated dV/dt in this region for this particular cell is 335 V/s. This illustrates the capacity of the EPC 800 USB to successfully follow fast, dynamic changes in potential while maintaining a set current level.

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