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# Voltage Protocols for e4 and e16 devices

## Revision History

Date	Version	Description
06/04/2021	1.1	Updated protocols 3, 6 and 7
10/09/2020	1.0	First version of document



## Introduction

This document illustrates the parametric voltage protocols available for e4 and e16 devices.

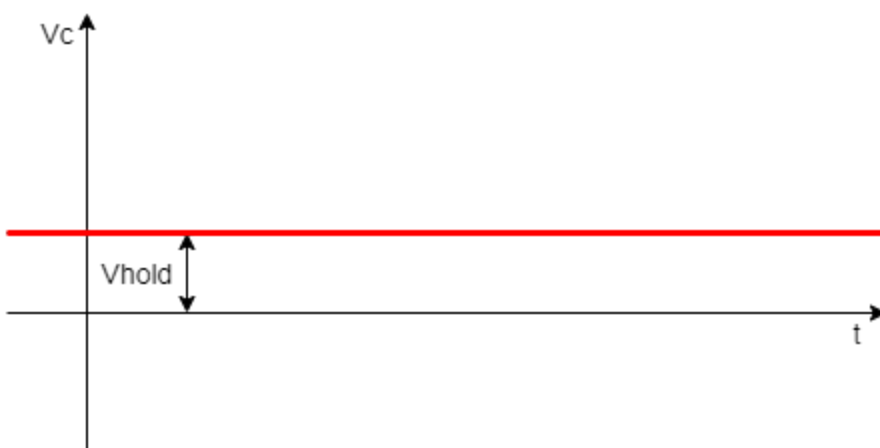
Part 1 of this document describes the protocols available for e4 devices starting with firmware version 12 and e16 devices starting with firmware version 10. For older firmware versions, please refer to Part 2.

In order to check the firmware version connect your device to EDR, click the “?” menu and select “Device Information”. If your device uses the older protocols version and you want to update it, please send an email to [support@elements-ic.com](mailto:support@elements-ic.com) attaching a screenshot of the Device Information window.

## Part 1: Voltage protocols list for e4 v12 and higher and e16 v10 and higher

### 0) Holding voltage

Protocol applied by default when nothing else is applied. Applies a constant voltage.



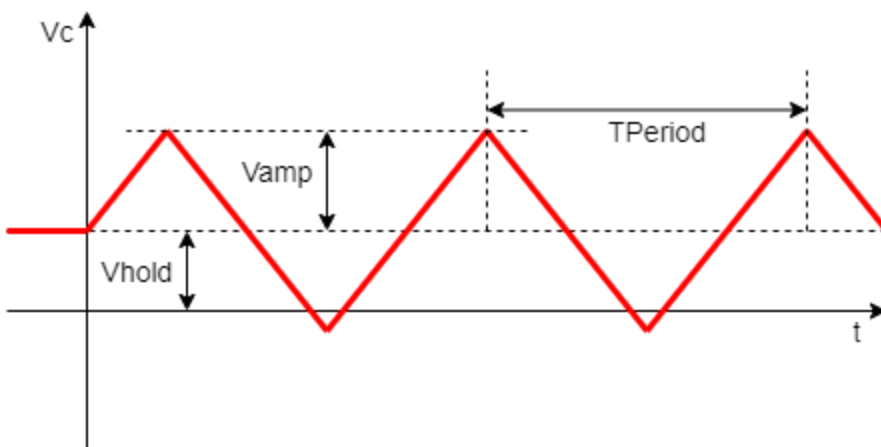
### Parameters

$V_{hold}$ : holding voltage, range [-500, +500]mV, resolution 1mV



## 1) Triangular wave

Repeats a triangular wave indefinitely.



### Parameters

$V_{hold}$ : holding voltage, range  $[-500, +500]$ mV, resolution 1mV

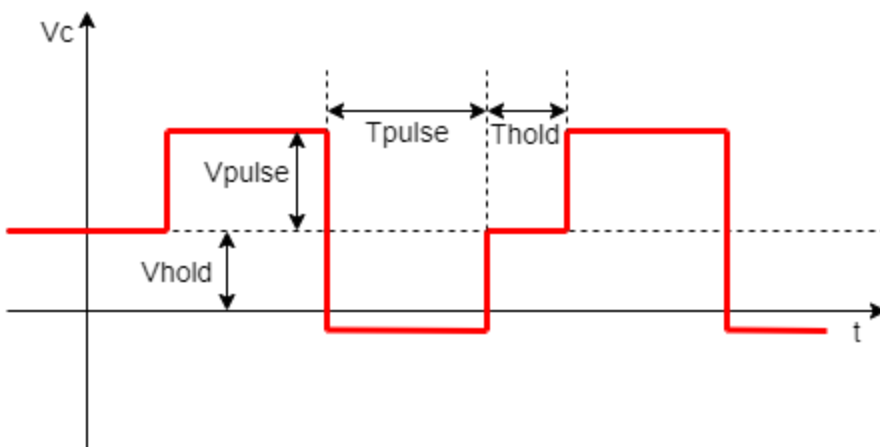
$V_{amp}$ : voltage amplitude wrt  $V_{hold}$ , available values  $\{25, 50, 75, 100\}$ mV

$T_{Period}$ : repetition period, range  $[1, 1000]$ ms, resolution 1ms



## 2) Seal test

Repeats pairs of positive and negative rectangular pulses indefinitely.



### Parameters

$V_{hold}$ : holding voltage, range [-500, +500]mV, resolution 1mV

$V_{pulse}$ : voltage amplitude wrt  $V_{hold}$ , range [-500, +500]mV, resolution 1mV

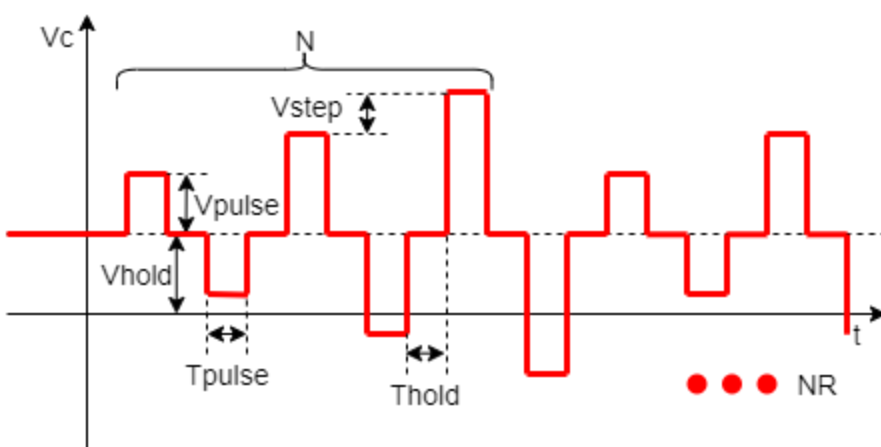
$T_{hold}$ : time between consecutive pairs of pulses during which  $V_{hold}$  is applied, range [0, 2000000]ms, resolution 1ms

$T_{pulse}$ : pulses duration, range [1, 2000000]ms, resolution 1ms



### 3) Conductance estimation

Repeats a series of pairs of positive and negative rectangular pulses of changing amplitude. The series can be repeated for a given number of times or indefinitely.



#### Parameters

Vhold: holding voltage, range [-500, +500]mV, resolution 1mV

Vpulse: voltage amplitude of the first pair of pulses in the series wrt Vhold, range [-500, +500]mV, resolution 1mV

Vstep: increase (decrease if negative) of the amplitude of any following pair of pulses, range values [-500, +500]mV, resolution 1mV

Thold: time between consecutive pulses during which Vhold is applied, range [0, 2000000]ms, resolution 1ms

Tpulse: pulses duration, range [1, 2000000]ms, resolution 1ms

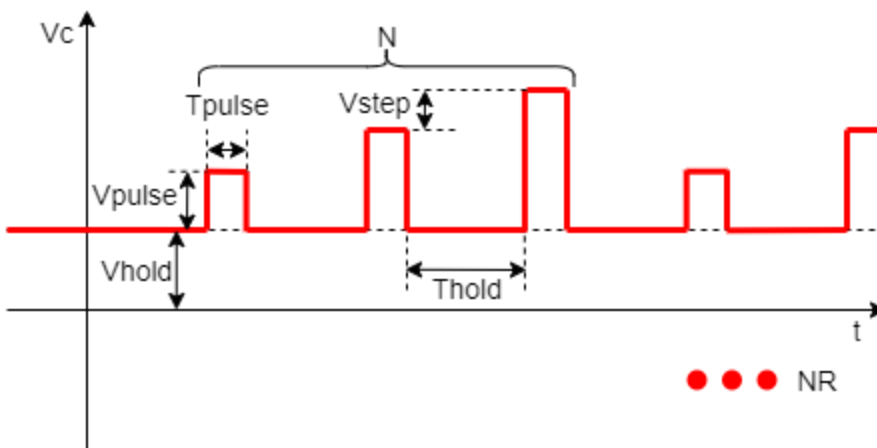
N: number of pairs of pulses in each series, range [1, 1000]

NR: number of repetitions of the whole series, range [0, 1000]. NOTE: set to 0 for infinite repetitions



## 4) Rectangular pulses with variable amplitude

Repeats a series of rectangular pulses of changing amplitude. The series can be repeated for a given number of times or indefinitely.



### Parameters

Vhold: holding voltage, range [-500, +500]mV, resolution 1mV

Vpulse: voltage amplitude of the first pulse in the series wrt Vhold, range [-500, +500]mV, resolution 1mV

Vstep: increase (decrease if negative) of the amplitude of any following pulse, range [-500, +500]mV, resolution 1mV

Thold: time between consecutive pulses during which Vhold is applied, range [0, 2000000]ms, resolution 1ms

Tpulse: pulses duration, range [1, 2000000]ms, resolution 1ms

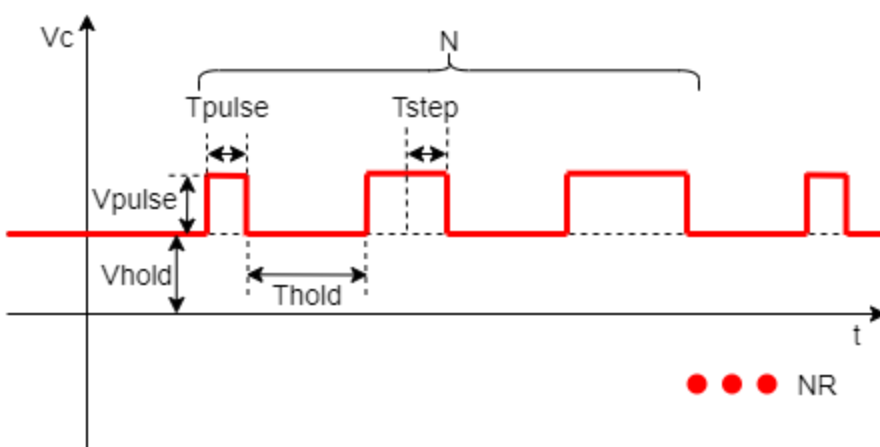
N: number of pulses in each series, range [1, 1000]

NR: number of repetitions of the whole series, range [0, 1000]. NOTE: set to 0 for infinite repetitions



## 5) Rectangular pulses with variable duration

Repeats a series of rectangular pulses of changing duration. The series can be repeated for a given number of times or indefinitely.



### Parameters

Vhold: holding voltage, range [-500, +500]mV, resolution 1mV

Vpulse: pulses voltage amplitude wrt Vhold, range [-500, +500]mV, resolution 1mV

Thold: time between consecutive pulses during which Vhold is applied, range [0, 2000000]ms, resolution 1ms

Tpulse: duration of the first pulse in the series, range [1, 2000000]ms, resolution 1ms

Tstep: increase (decrease if negative) of the duration of any following pulse, range [-100000000, +100000000]ms, resolution 1ms

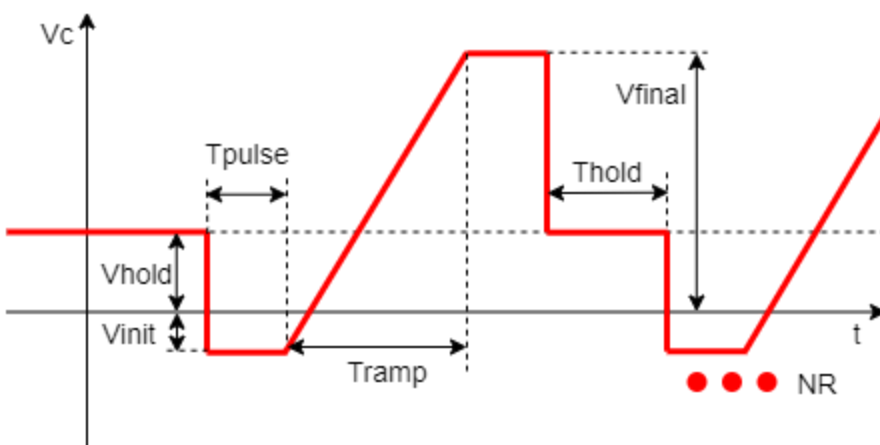
N: number of pulses in each series, range [1, 1000]

NR: number of repetitions of the whole series, range [0, 1000]. NOTE: set to 0 for infinite repetitions



## 6) Ramp

Repeats a ramp. The ramp can be repeated for a given number of times or indefinitely.



### Parameters

Vhold: holding voltage, range [-500, +500]mV, resolution 1mV

Vfinal: final absolute voltage of the ramp, range [-500, +500]mV, resolution 1mV

Vinit: initial absolute voltage of the ramp, range [-500, +500]mV, resolution 1mV

Thold: time between ramp repetitions during which Vhold is applied, range [0, 2000000]ms, resolution 1ms

Tpulse: duration of the plateaus at Vmax and Vmin, range [1, 2000000]ms, resolution 1ms

Tramp: time it takes to go from Vinit to Vfinal, range [1, 30000000]ms, resolution 1ms

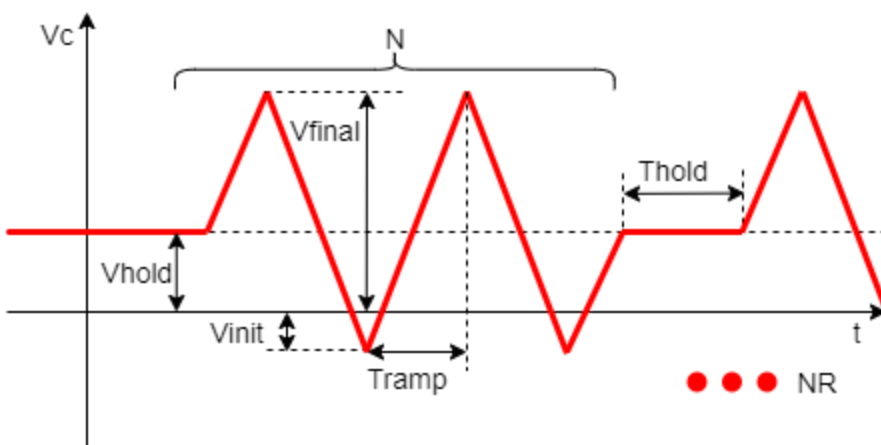
NR: number of ramp repetitions, range [0, 1000]. NOTE: set to 0 for infinite repetitions





## 7) Cyclic voltammetry

Repeats a series of pairs of positive and negative ramps. The series can be repeated for a given number of times or indefinitely.



### Parameters

Vhold: holding voltage, range [-500, +500]mV, resolution 1mV

Vfinal: final absolute voltage of the ramps, range [-500, +500]mV, resolution 1mV

Vinit: initial absolute voltage of the ramps, range [-500, +500]mV, resolution 1mV

Thold: time between consecutive series during which Vhold is applied, range [0, 2000000]ms, resolution 1ms

Tramp: time it takes to go from Vinit to Vfinal, range [1, 30000000]ms, resolution 1ms

N: number of pairs of ramps in each series, range [1, 1000]

NR: number of repetitions of the whole series, range [0, 1000]. NOTE: set to 0 for infinite repetitions

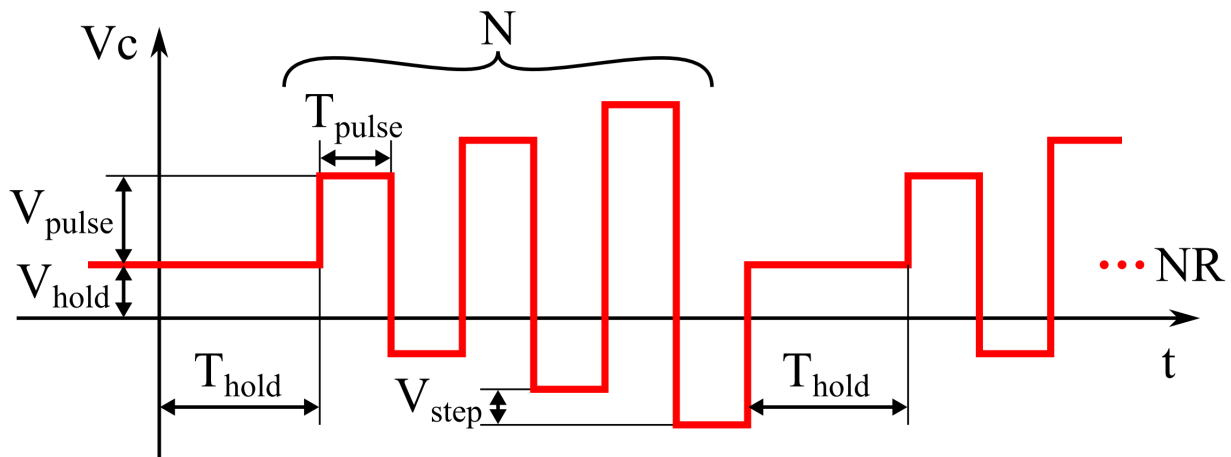


## Part 2: Voltage protocols for e4 v11 and lower and e16 v9 and lower

For protocols 0, 1, 2, 4, and 5 refer to Part 1 since they didn't change.

### 3) Conductance estimation

Repeats a series of pairs of positive and negative rectangular pulses of changing amplitude. The series can be repeated for a given number of times or indefinitely.



#### Parameters

Vhold: holding voltage, range [-500, +500]mV, resolution 1mV

Vpulse: voltage amplitude of the first pair of pulses in the series wrt Vhold, range [-500, +500]mV, resolution 1mV

Vstep: increase (decrease if negative) of the amplitude of any following pair of pulses, range values [-500, +500]mV, resolution 1mV

Thold: time between series of pulses during which Vhold is applied, range [0, 2000000]ms, resolution 1ms

Tpulse: pulses duration, range [1, 2000000]ms, resolution 1ms

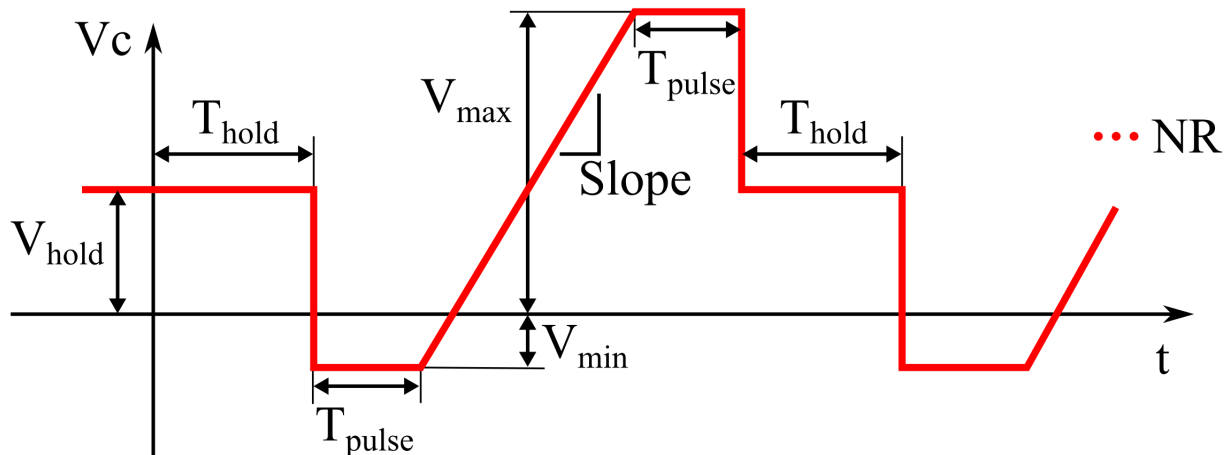
N: number of pairs of pulses in each series, range [1, 1000]

NR: number of repetitions of the whole series, range [0, 1000]. NOTE: set to 0 for infinite repetitions



## 6) Ramp

Repeats a ramp. The ramp can be repeated for a given number of times or indefinitely.



### Parameters

Vhold: holding voltage, range [-500, +500]mV, resolution 1mV

Vmax: maximum absolute voltage of the ramp, range [-500, +500]mV, resolution 1mV

Vmin: minimum absolute voltage of the ramp, range [-500, +500]mV, resolution 1mV

Thold: time between ramp repetitions during which Vhold is applied, range [0, 2000000]ms, resolution 1ms

Tpulse: duration of the plateaus at Vmax and Vmin, range [1, 2000000]ms, resolution 1ms

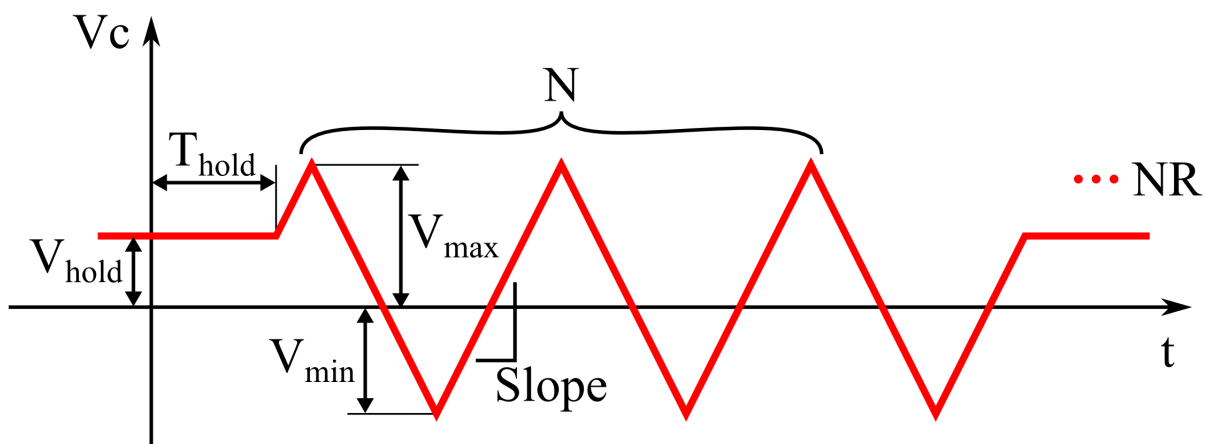
Slope: slope of the voltage during the ramps, range [1, 1000]mV/ms, resolution 1mV/ms

NR: number of ramp repetitions, range [0, 1000]. NOTE: set to 0 for infinite repetitions



## 7) Cyclic voltammetry

Repeats a series of pairs of positive and negative ramps. The series can be repeated for a given number of times or indefinitely.



### Parameters

$V_{hold}$ : holding voltage, range [-500, +500]mV, resolution 1mV

$V_{max}$ : maximum absolute voltage of the ramp, range [-500, +500]mV, resolution 1mV

$V_{min}$ : minimum absolute voltage of the ramp, range [-500, +500]mV, resolution 1mV

$T_{hold}$ : time between consecutive series during which  $V_{hold}$  is applied, range [0, 2000000]ms, resolution 1ms

Slope: slope of the voltage during the ramps, range [1, 1000]mV/ms, resolution 1mV/ms

$N$ : number of pairs of ramps in each series, range [1, 1000]

$NR$ : number of repetitions of the whole series, range [0, 1000]. NOTE: set to 0 for infinite repetitions