electronplus

CTL503 User Manual

Curve Tracer

software version: V26600

manual version: June 2026

language: English

Check for latest version of this manual here:

http://electron.plus/pages/manuals

1 Notices

1.1 Copyright

Electron Plus is a trading style of Electron Plus Instruments Limited.

1.2 Part Number

CTL503_V26600_EN.PDF

1.3 Issue

V26600, June 2026

1.4 Location

The latest version of this document can be found on our website:

www.electron.plus/pages/manuals

1.5 Published By

Electron Plus Instruments Limited
Unit 8 Manor Farm Business Centre
Manor Lane
Stutton
Suffolk
IP9 2TD
UK

Hereafter referred to as **Electron Plus**.

1.6 Notes

- We frequently update our manuals and add new features and improvements as they become available, please ensure that you check our website for an updated version of this document, especially if updating your **Electron Plus** software.
- We make every effort to ensure the accuracy of this manual's contents. If you find any errors, have suggestions for expanding on a feature, or feel that we can improve its contents then please contact us at `support@electron.plus`
- Copying or reproducing this document or any part of this document without written permission of **Electron Plus** is strictly prohibited.

1.7 Trademark Acknowledgement

Electron Plus fully recognises and acknowledges any trademark(s) of the respective trademark holder.

Windows™ is a trademark of Microsoft Corporation.

Transzorb™ is a trademark of Vishay General Semiconductor, LLC.

1.8 Purpose of Manual

The purpose of this manual is to enable you to safely setup, configure and operate your **Electron Plus** instrument, associated software and/or accessories.

Please pay particular attention to any section with a warning symbol.

1.9 Safety Warnings

Warnings, cautions and notes are colour coded through-out this manual. These are divided into several categories and are described below:

WARNING - Pay special attention to anything written here - this is for your safety and continued protection and is critical information!

CAUTION - Damage may occur to your equipment or any DUT (device under test).

NOTE - General text, with useful information or tips.

1.10 REACH / CLP Compliance Statement

Statement on Safety Data Sheet (SDS) for product:
CTL503 Curve Tracer

According to EU Regulation (EC) N° 1907/2006 (REACH) and Regulation (EC) N° 1272/2008 (CLP), no Safety Data Sheet is required for this product.

This product is classified as an article under REACH and:

- has no hazardous classification under CLP
- contains no Substances of Very High Concern (SVHC) in concentrations above 0.1% w/w and no intentional released under normal or reasonably foreseeable conditions of use (REACH Article 33)
- complies with Directive 2011/65/EU (RoHS) as amended by Directive (EU) 2015/863 (RoHS 3)

For safe use, please refer to the user manual and product labelling.

Should any changes occur in product composition or regulations, we will notify affected customers promptly.

Issued by:
Electron Plus Instruments Limited

Issue date:
April 2026

---

2 Getting Started

Welcome to the EPIC software for the **CTL503 Curve Tracer** by **Electron Plus**. This manual covers every aspect of operating the instrument and the EPIC V26600 software, which features improved performance, modern visuals, and new measurement features.

2.1 What is the CTL503?

The CTL503 is a low-cost, computer-controlled semiconductor curve tracer designed for measuring and diagnosing component faults. It can test devices up to **100V** and **3A**, offering superior capabilities compared to simpler curve tracing units. The CTL503 is ideal for electronics engineers, educators, repair technicians, and hobbyists who need to characterise BJTs, FETs, diodes, SCRs, and optocouplers.

2.2 What is a Curve Tracer?

A curve tracer is an electronic test instrument used to analyse the characteristics of semiconductor devices. It works by applying a swept voltage to the device under test (DUT) while stepping a secondary parameter (such as base current), and plotting the resulting current-voltage characteristics as a family of curves on a graph.

2.3 Key Specifications

Parameter	Specification
Collector sweep voltage	0V to +100V (or -100V)
Peak collector current	3A (pulsed mode)
Step generator current mode	1uA to 20mA across four ranges
Step generator voltage mode	-10V to +10V via 270R gate resistor
Collector resistor options	24R, 270R, 2K45, 27K (relay-selectable)
Step generator	1 to 24 steps, with offset
Pulse modes	Continuous, 300us, 80us
Interface	USB 2.0
Software	EPIC V26600 (free updates)

The four relay-selectable collector resistances (24R, 270R, 2K45, 27K) enable testing everything from the smallest BJTs and FETs to larger devices in TO3 and TO247 packages.

2.4 What's New in V26301

EPIC V26301 is a ground-up rewrite of the EPIC software for improved performance and modern visuals. The hardware interface and serial protocol are unchanged – your CTL503 instrument works identically. The key improvements are:

- **Modern dark-themed UI** with a professional instrument-panel appearance
- **Smorgasbord panel** – click the Advanced button to reveal the full control panel for toggling features, device types, and export options
- **Blue ring/solid dot system** – each smorgasbord button has a ring indicator; solid blue dot means the button is visible on the top toolbar, ring outline means it is hidden
- **Double-click custom entry** – double-click any numeric value (voltage, current, power, step size, offset, step count) to type an exact number
- **PNG Capture with configurable naming** – right-click the PNG button to set prefix, counter, and filename components
- **Graph key labels** – four display states for trace labels (off, below-axis, right-margin, at-endpoint)
- **X/Y Cursors with three states** – OFF, ON, LOCK (padlock icon; locked cursors move together)
- **Slope line** – a dotted line drawn between cursor intersections when both X and Y cursors are active
- **hFE calculation display** – dedicated hFE/gm measurement columns in the key table
- **Early Voltage (VA) display** – VA, rO, and gO measurement columns for BJT output characteristics
- **TRIAC Q1-Q4 device types** – four independent TRIAC quadrant buttons in the smorgasbord, each with its own ring/dot for toolbar visibility
- **Display panel toggles (Key X / Key Y / Key L)** – show or hide the right ribbon panels and bottom results panel; right ribbon auto-collapses when both Key X and Key Y are off
- **Resizable bottom panel** – drag the horizontal grab handle between the graph and bottom results panel to adjust the height split

- **Graph Info overlay** – five states (OFF, Lower-Right, Lower-Left, Upper-Left, Upper-Right) showing sweep parameters on the graph
- **Text size toggle** – cycle between small, normal, and large graph text
- **Key order toggle** – reverse the legend order from 0-to-N to N-to-0
- **Light dismiss on edit dialogs** – click outside a value-entry dialog to cancel and close it
- **Context-sensitive help** – clicking Help from different sections of the interface opens the manual at the relevant heading

2.5 System Requirements

- Windows 10 or later (64-bit)
- USB 2.0 port for instrument connection
- Minimum 1440x900 display resolution (1920x1080 recommended)
- EPIC software (free download from www.electron.plus)

2.6 What is in the Box

See **Package Contents** in the Safety and Handling section for the full list of items included with your CTL503.

2.7 Instrument Indicators

The CTL503 has two LED indicators:

- **RED LED** - Signals that the HV (High Voltage) generator is active. When this LED is lit, voltages are present at the test socket.
- **GREEN LED** - Indicates the unit is connected and communicating with the EPIC software.

2.8 Quick Start

1. Connect the CTL503 to your computer via the USB cable
2. Connect the mains power supply to the CTL503
3. Launch the EPIC software
4. Select **CTL503** as the active instrument (if not already selected)
5. Click the **Connect** button to establish communication
6. Select a device type (e.g. **NPN**, **DIODE**)
7. Insert your device under test into the test socket
8. Enable **HV** (power supply output) by clicking the HV button - this enables the instrument's output, required before running any sweep
9. Press **Run** to begin a sweep

Always ensure HV is disabled before inserting or removing devices from the test socket. The RED LED on the instrument must be OFF before handling the test socket.

3 Introduction

3.1 Welcome

Congratulations and thank you for purchasing an **Electron Plus** product.

Please take a few minutes to read the 'Before you start' section of this manual, especially as misusing this product can result in damage to it, your device-under-test or potentially place you in-danger.

3.2 Before You Start

General

Please ensure you use the power supply adaptor supplied. It is important that this device is powered with 11.75 to 12.5V, damage may occur if you exceed 12.5V.

Do not over-tighten the RED/BLUE/BLACK terminal post connections. You won't end up with better curves and you will risk damaging the instrument.

If you wish to make a permanent safety connection to EARTH read the Earthing for function and safety section.

Like most 'old-style' curve tracers, the CTL503 is capable of generating voltages in excess of 100V, users are expected to be fully aware of the risks posed by these higher voltages and the precautions and procedures required to maintain the safety of personal operating the instrument and those nearby.

If the red light is lit on the Curve Tracer, assume there could be high voltages present and act accordingly!

3.3 Safety and Handling

WARNING - Read this section carefully before operating your Curve Tracer

3.4 Maximum Ratings

The CTL503 has the following absolute maximum ratings that must never be exceeded:

Parameter	Maximum Rating
Collector sweep voltage	0V to ±100V DC
Peak collector current	3A (pulsed mode)

Parameter	Maximum Rating
Maximum power	300W
Step generator voltage	-10V to +10V
Step generator current	1μA to 20mA
Collector resistor options	24R, 270R, 2K45, 27K
Operating temperature	0°C to 40°C
Storage temperature	-20°C to 60°C
Humidity	20% to 80% RH, non-condensing

Exceeding these limits may permanently damage the instrument and void your warranty

3.5 Electrostatic Discharge (ESD) Precautions

The CTL503 contains sensitive electronic components that can be damaged by electrostatic discharge. When handling the instrument:

- Use an anti-static wrist strap when connecting/disconnecting measurement leads
- Store the instrument in its anti-static packaging when not in use
- Avoid touching the BNC connector centre pins directly
- Discharge yourself by touching a grounded metal object before handling

3.6 Package Contents

Your CTL503 package should contain:

- 1x CTL503 Curve Tracer instrument
- 1x USB 2.0 cable (1.8m, Type A to Type B)
- 1x 12V 1.5A Mains PSU with country plug adaptor
- 1x Calibration resistor token PCB
- 1x CTL011 device adaptor PCB

If any items are missing or damaged, please contact Electron Plus immediately at support@electron.plus

3.7 Initial Inspection

Before use, inspect your CTL503 for any damage that may have occurred during shipping:

1. Check the enclosure for cracks, dents, or other physical damage
2. Inspect the BNC connectors for bent centre pins or damaged threads
3. Examine the USB connector for damage
4. Verify the rear or underside panel label shows your serial number

If you notice any damage, do not operate the instrument. Contact Electron Plus or your distributor immediately.

3.8 Measurement Best Practices

For accurate low-current measurements, follow these guidelines:

- Allow the instrument to warm up for at least 30 minutes before precision measurements
- Keep measurement cables as short as practical
- Use high-quality, low-noise BNC cables (such as those with solid PTFE dielectric)
- Avoid fluorescent lighting and other sources of electromagnetic interference near the measurement area
- For sub-nanoampere measurements, use a Faraday cage or shielded enclosure
- Ensure all connections are clean and free from oxidation
- Allow the measurement to stabilize - settling time increases for lower current ranges

3.9 Operating Environment

- **Temperature:** 0°C to 40°C (32°F to 104°F) operating, -20°C to 60°C storage
- **Humidity:** 20% to 80% relative humidity, non-condensing
- **Altitude:** Up to 2000m above sea level
- **Location:** Indoor use only, in a clean, dry environment
- **Ventilation:** Ensure adequate airflow around the instrument

3.10 What You Will Need

To operate the CTL503, you will require:

- A Windows PC meeting the system requirements
- Available USB 2.0 port supplying at least 0.3A
- EPIC software (free download from www.electron.plus/pages/software)
- CH340 USB driver (free download from www.electron.plus/pages/software)

3.11 Installation Sequence

Please install the **EPIC** software and the associated USB driver software BEFORE connecting your device to a computer.

You do not need to remove a previous copy of **EPIC**, the new copy will overwrite the necessary existing file(s). The "settings.txt" file will only be created if it is not present.

When **EPIC** is first started, it will build a number of files (unless they are already there from a previous installation) in the installation directory.

EPIC software is specifically for the **Electron Plus** range of products including curve tracers, pico-ammeters, analog signature analysers, power analysers ONLY.

If upgrading from an earlier version of EPIC please be aware that the program EXE is named after the version (e.g. EPIC_26600.exe). Previous desktop shortcuts may not work or may link to the previous version.

3.12 Installing EPIC Software

Electron Plus products require a USB connection to a PC running **EPIC** (our proprietary software) in order to function.

You can download the latest copy of **EPIC** for free from www.electron.plus/pages/software. **EPIC** is being constantly revised with new features, updates and bug fixes.

1. Download the installer ZIP file from the software page (e.g. EPIC_26600.zip)
2. Open the downloaded file (Windows will recognise the ZIP format and display the contents like a folder), then double click the EXE installer inside
3. Follow the on screen instructions to complete the installation

Before starting **EPIC**, we recommend installing the USB driver – see next section for details.

This manual MAY NOT represent the most up-to-date features and screen-shots, if something is unclear, please contact support@electron.plus and we will promptly try to assist you.

3.13 Installing the USB Driver

This product communicates with the host PC via USB using a CH340 bridge IC made by WCH.

A copy of the official WCH device driver is available from the SOFTWARE section of our website www.electron.plus/pages/software, device drivers can also be downloaded directly from WCH's website.

The driver we use with Windows machines is: CH341SER and is available as .EXE or a .ZIP

3.14 Earthing for Function and Safety

For functional and/or safety reasons you may wish to EARTH the casing of your **Electron Plus** instrument. This is not necessary under most normal operating conditions.

In this case, we recommend loosening (and re-tightening) the M3 stainless steel chassis screw (2mm HEX drive) and fitting an earthing wire using either ring terminal or spade terminal.

If in doubt please contact **Electron Plus** for further details.

USB 0V, rear panel, front panel, casing and any external power supply 0V are all the same potential and connected via low impedances (PCB, metalwork, etc.) - Avoid creating 'ground loops' with your setup!

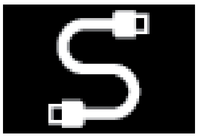


Figure 1: Connect Button

Some earlier production CTL503 units may have a TORX T10 headed stainless steel earthing screw fitted instead of the 2mm HEX drive type. If you would like a 2mm HEX drive screw (our part# SCREW014), please contact the factory and we will supply one free-of-charge.

4 Connecting Your Instrument

4.1 USB Connection

The CTL503 connects to your computer via a USB 2.0 cable. The instrument uses a CH340 USB-to-serial bridge which creates a virtual COM port.

Pulse testing mode (80us/300us) minimises device heating and enables USB-powered operation for low-power tests. For full-power operation, always connect the mains power supply.

4.2 COM Port Selection

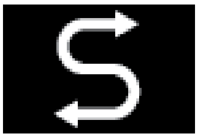
The software will attempt to auto-detect the CTL503 on startup. If auto-detection fails:

1. Open **Settings** by clicking the Settings button 
2. Navigate to the **Comms** tab
3. Use the **Scan** button to search for available COM ports
4. Select the correct COM port from the dropdown list
5. Click **Set** to confirm

4.3 Connection Status

The connection status is displayed in two places:

- **Connect button** in the top toolbar – shows the current connection state. The icon is tinted green when connected.

- **Comms Status widget**  (if enabled via the Advanced panel) – shows calibration status, TX/RX rates (kB/s), and COM port number.

Status	Meaning
Connected	Instrument is communicating normally
Disconnected	No communication with instrument
Searching	Software is attempting to find the instrument
Error	Communication error detected

4.4 Troubleshooting Connection Issues

- Ensure the USB cable is firmly connected at both ends
- Check that the green LED on the CTL503 is lit (indicates power and USB connection)
- Try a different USB port on your computer
- Check that the correct COM port is selected in Settings
- Ensure no other software is using the same COM port
- Check Windows Device Manager for the COM port listing
- Try restarting both the software and the instrument

---

5 The EPIC Interface

EPIC V26600 uses a dark-themed interface. The main window is divided into five areas:

- **Top Toolbar** – a horizontal strip across the top containing the primary action buttons (Connect, HV, Run, Advanced, Settings, Help) and any additional buttons you have chosen to show via the smorgasbord. The Electron+ logo is displayed at the far right.
- **Left Ribbon** – a vertical panel on the left containing the device type selector, test select control, collector supply controls, step generator controls, and displayed results navigator.
- **Graph Area** – the central area where traces are plotted. Axis labels, cursors, key labels, the watermark logo, and the Graph Info overlay all appear here.
- **Right Ribbon** – an optional vertical panel on the right that displays the key measurements table and cursor readouts. Controlled by the Key X and Key Y display panel toggles; collapses entirely when both are off.
- **Bottom Panel** – an optional panel below the graph that displays the DISPLAYED RESULTS table with per-step measurement data. Controlled by the Key L toggle. A draggable horizontal splitter between the graph and this panel allows height adjustment.

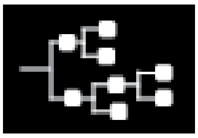


Figure 2: Advanced

5.1 Top Toolbar Buttons

Each toolbar button has an icon and a text label below. The toolbar background is near-black in all states. There is no hover effect on toolbar buttons – this is by design for a clean, distraction-free look.

The standard toolbar buttons (always visible) are:

Button	Function
Connect	Toggle connection to the instrument. Shows "Connect?" when disconnected, "Connected" (green icon tint) when connected.
HV	Enable or disable the instrument's power supply output. Despite the name "HV" (High Voltage), this controls all output voltages including low-voltage operation. The CTL503 can output from millivolts to 60V - the HV button must be enabled before any sweep can run. Three states: Disabled (dimmed), Enable? (full brightness), On (red icon tint).
Run	Start or stop a sweep. Three states: Disabled (dimmed), Run? (ready), Running (green icon tint).
Advanced	Toggle the smorgasbord panel. Background changes to dark olive when active.
Settings	Open the Settings dialog.
Help	Open context-sensitive help. Clicking Help while viewing different sections of the interface will jump to the relevant heading in this manual.

The hFE, VA, and DUT shortcut buttons appear on the toolbar when their blue ring is set to solid in the smorgasbord. (X Cursors, Y Cursors, Slope, PNG Capture, CSV Export, and Graph Info are permanent toolbar buttons.)

5.2 The Smorgasbord Panel

The **smorgasbord** is the extended control panel that slides in from the right of the toolbar when you click the **Advanced** button. It contains every feature toggle and shortcut button organised into sections.

5.2.1 Blue Ring / Solid Dot System

Most smorgasbord buttons have a small indicator in the top-left corner:

- **Solid blue dot** – the feature's button IS shown on the top toolbar for quick access
- **Blue ring outline** – the feature's button is NOT shown on the toolbar (it is only accessible from the smorgasbord)

Click the ring area to toggle between solid and outline without affecting the feature itself. Ring clicks are always available regardless of whether the feature is currently active or its dependencies are met.

Ring states are saved between sessions, so your toolbar layout is remembered.

Action-only buttons (CSV Export, Save Setup, Load Setup, Bit Step, Graph Keys, Key Order) do not have a ring indicator because they are not toolbar-eligible.

5.2.2 Smorgasbord Sections

The smorgasbord is organised top-to-bottom as follows:

Section	Buttons
Cursor/Measurement functions	Key X, Key Y, Key L
Derived measurements	hFE/gm, VA
DUT selector functions	NPN, PNP, N-ENH, P-ENH, N-DEP, P-DEP, N-JFET, P-JFET, DIODE, ZENER, OPTO, SCR, TRIAC Q1, TRIAC Q2, TRIAC Q3, TRIAC Q4
Graph functions	Key Order, Graph Keys
Miscellaneous	Save Setup, Load Setup, Bit Step

Note: CSV Export, PNG Capture, X Cursors, Y Cursors, Slope, and Graph Info are buttons on the top toolbar, not in the smorgasbord.

---

6 Device Types

The CTL503 supports testing a wide range of semiconductor devices. Each device type button configures the instrument with appropriate default settings for polarities, output modes, and test configurations.

6.1 DUT Selector

Select a device type by clicking its button in the **left ribbon** (the *DEVICE TYPE* section) or in the **smorgasbord**. The currently selected DUT is highlighted with a blue background and stays lit until another DUT is chosen.

Each DUT button in the smorgasbord has a small ring at its top-left corner that controls **left-ribbon visibility** with two states:

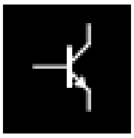


Figure 3: NPN Button

- **Hollow ring** - DUT is hidden from the left ribbon (smorgasbord-only).
- **Solid blue dot with □ arrow** - DUT is shown in the left-ribbon DEVICE TYPE section.

Click the ring to toggle. Ring states are persisted across sessions, so your favourite DUT shortlist stays put.

> **Only DUTs with a solid □ dot in the smorgasbord appear in the left ribbon. If none are flagged, the entire DEVICE TYPE section is hidden.**

6.2 NPN Transistors

Selects settings appropriate for NPN bipolar junction transistors:

- **Collector polarity:** Positive
- **Base polarity:** Positive
- **Step output mode:** Current (I)
- **Template range:** 100-199

Typical test: Apply a positive collector-emitter voltage (VCE) while stepping the base current (IB) in positive increments. The resulting IC vs VCE family of curves shows the transistor's output characteristics, saturation region, and active region.

Available graph types:

> **Note:** The X-Axis / Y-Axis columns below describe the *intended* layout per template. The chart does not currently switch axes by template - it always plots the VCE-IC family (see Graph Mode). This applies to all device-type template tables in this section.

Template	Description	X-Axis	Y-Axis	Slope
100	VCE-IC	Collector-Emitter Voltage	Collector Current	ΔIC/ΔVCE (Output Conductance, 1/rO)
101	VBE-IC	Base-Emitter Voltage	Collector Current	ΔIC/ΔVBE (Transconductance, gm)
102	VCE-IB	Collector-Emitter Voltage	Base Current	ΔIB/ΔVCE

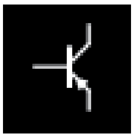


Figure 4: PNP Button

Template	Description	X-Axis	Y-Axis	Slope
103	IC-IB	Collector Current	Base Current	ΔIB/ΔIC (1/hFE)
104	VCE-HFE	Collector-Emitter Voltage	DC Current Gain	ΔHFE/ΔVCE
105	IC-HFE	Collector Current	DC Current Gain	ΔHFE/ΔIC

6.3 PNP Transistors

Selects settings appropriate for PNP bipolar junction transistors:

- **Collector polarity:** Negative
- **Base polarity:** Negative
- **Step output mode:** Current (I)
- **Template range:** 100-199

PNP transistors operate with reversed polarities compared to NPN. The software automatically configures all polarities when you select PNP. The same graph types (100-105) are available as for NPN. Graph axes automatically display negative values where appropriate (e.g. VBE 0 to -0.6V on template 101, VCE 0 to -10V on template 100).

6.4 N-Channel Enhancement MOSFET

Selects settings for N-channel enhancement mode MOSFETs:

- **Collector polarity:** Positive (Drain-Source)
- **Gate polarity:** Positive
- **Step output mode:** Voltage (V)
- **Template range:** 300-399

Enhancement mode N-channel MOSFETs require a positive gate-source voltage (VGS) above the threshold voltage to turn on. The step generator provides voltage steps to the gate via the 270R gate resistor, supporting a range of -10V to +10V.

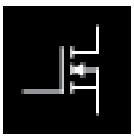


Figure 5: N-ENH Button

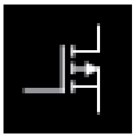


Figure 6: P-ENH Button

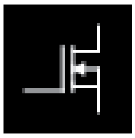


Figure 7: N-DEPL Button

Available graph types:

Template	Description	X-Axis	Y-Axis	Slope
300	VDS-ID	Drain-Source Voltage	Drain Current	ΔID/ΔVDS (Output Conductance, gds)
301	VGS-ID	Gate-Source Voltage	Drain Current	ΔID/ΔVGS (Transconductance, gm)
302	VDS-VGS	Drain-Source Voltage	Gate-Source Voltage	ΔVGS/ΔVDS

6.5 P-Channel Enhancement MOSFET

Selects settings for P-channel enhancement mode MOSFETs:

- **Collector polarity:** Negative (Drain-Source)
- **Gate polarity:** Negative
- **Step output mode:** Voltage (V)
- **Template range:** 300-399

P-channel MOSFETs operate with reversed polarities. A negative VGS is applied to turn the device on. The same graph types (300-302) are available. Graph axes automatically display negative values where appropriate (e.g. VDS 0 to -10V, VGS 0 to -5V).

6.6 N-Channel Depletion MOSFET

Selects settings for N-channel depletion mode MOSFETs:

- **Collector polarity:** Positive
- **Gate polarity:** Positive
- **Step output mode:** Voltage (V)
- **Template range:** 300-399

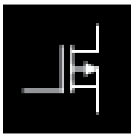


Figure 8: P-DEPL Button

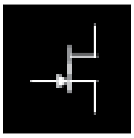


Figure 9: N-JFET Button

Depletion mode MOSFETs conduct with zero gate voltage and require a negative gate voltage to turn off. The offset feature of the step generator is particularly useful here, allowing you to sweep from negative to positive gate voltages to explore the full VGS range including the zero-crossing capability (-10V to +10V).

6.7 P-Channel Depletion MOSFET

Selects settings for P-channel depletion mode MOSFETs:

- **Collector polarity:** Negative
- **Gate polarity:** Negative
- **Step output mode:** Voltage (V)
- **Template range:** 300-399

6.8 N-Channel JFET

Selects settings for N-channel JFETs:

- **Collector polarity:** Positive
- **Gate polarity:** Positive
- **Step output mode:** Voltage (V)
- **Template range:** 700-799

JFETs are depletion-mode devices that conduct with zero gate voltage. A negative gate-source voltage pinches off the channel. Use the step generator offset to apply a negative bias and step towards zero.

6.9 P-Channel JFET

Selects settings for P-channel JFETs:

- **Collector polarity:** Negative
- **Gate polarity:** Negative
- **Step output mode:** Voltage (V)
- **Template range:** 700-799

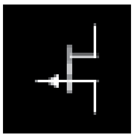


Figure 10: P-JFET Button

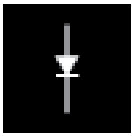


Figure 11: DIODE Button

6.10 Diode

Selects settings for diode testing:

- **Collector polarity:** Positive
- **Step output mode:** Current (I)
- **Pulse mode:** 300us (preset to protect the device)
- **Template range:** 400-499

Available graph types:

Template	Description	X-Axis	Y-Axis	Slope
500	Forward Voltage	Forward Voltage (VFWD)	Anode-Cathode Current (IAK)	ΔIAK/ΔVFWD (1/rd, Dynamic Conductance)
501	Reverse Leakage	Reverse Voltage (VREV)	Leakage Current (ILEAK)	ΔILEAK/ΔVREV (Leakage Conductance)
502	Zener Breakdown	Zener Voltage (VZ)	Zener Current (IZ)	ΔIZ/ΔVZ (1/rZ, Zener Conductance)

Forward voltage test (500): Sweeps a positive voltage across the diode and measures the forward current. The resulting curve shows the diode's turn-on voltage (typically 0.6V for silicon, 0.3V for germanium) and dynamic resistance.

Reverse leakage test (501): Applies reverse voltage and measures the small leakage current. Useful for checking diode quality and identifying degraded or damaged devices.

Zener breakdown test (502): Tests the reverse breakdown characteristic of Zener diodes. The sharp knee in the curve indicates the Zener voltage. Useful for verifying Zener voltage ratings and checking regulation quality.

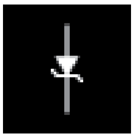


Figure 12: ZENER Button

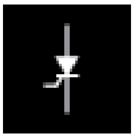


Figure 13: SCR Button

Diode tests are preset to pulse mode (300us) to prevent overheating during high-current tests.

6.11 Zener Diode

Selects settings specifically for Zener diode testing. This is a **separate device type** from the standard Diode selection, with its own template range optimised for reverse breakdown characterisation.

- **Collector polarity:** Negative (reverse biased)
- **Step output mode:** Current (I)
- **Pulse mode:** 300us (preset)
- **Template range:** 450-499

Available graph types:

Template	Description	X-Axis	Y-Axis
450	Zener V-I	Zener Voltage (VZ)	Zener Current (IZ)
451	Forward V-I	Forward Voltage (VF)	Forward Current (IF)
452	Dynamic Impedance	Zener Voltage (VZ)	Dynamic Impedance (rZ)

Zener V-I (450): The primary test - sweeps reverse voltage through the Zener and measures the current. The sharp knee shows the Zener voltage. Use cursors to measure the exact breakdown voltage and slope (dynamic impedance).

Dynamic impedance (452): A derived graph showing how the Zener's impedance varies with voltage. Lower impedance indicates better voltage regulation. Useful for comparing Zener devices or verifying datasheet specifications.

6.12 SCR (Silicon Controlled Rectifier)

Selects settings for SCR (thyristor) testing:

- **Collector polarity:** Positive
- **Step output mode:** Current (I)
- **Pulse mode:** 300us (preset)

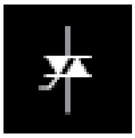


Figure 14: TRIAC Button

- **Template range:** 600-699

Available graph types:

Template	Description	X-Axis	Y-Axis	Slope
600	Forward Blocking	Anode-Cathode Voltage	Anode-Cathode Current	ΔIAK/ΔVAK
601	Forward Conduction	Anode-Cathode Voltage	Anode-Cathode Current (with gate steps)	ΔIAK/ΔVAK (Forward Conductance)
602	Gate Trigger	Gate-Cathode Voltage	Gate Current	ΔIG/ΔVGK (Gate Conductance)
603	Reverse Blocking	Cathode-Anode Voltage	Cathode-Anode Current	ΔIKA/ΔVKA

Forward blocking (600): Tests the SCR's ability to block forward voltage with no gate signal applied. The SCR should show very low leakage until the breakover voltage is reached.

Forward conduction (601): Applies gate current steps while sweeping the anode voltage. Shows how different gate currents affect the triggering point and the forward voltage drop once conducting.

Gate trigger (602): Characterises the gate trigger requirements by sweeping gate voltage and measuring gate current. Helps determine the minimum gate trigger current (IGT) and voltage (VGT).

Reverse blocking (603): Tests the SCR's reverse blocking capability by applying reverse voltage and measuring leakage current.

SCR tests use pulse mode to prevent device damage from sustained high current.

6.13 TRIAC (Bidirectional Thyristor)

TRIACs are bidirectional thyristors that can conduct in both directions. Unlike an SCR, a TRIAC can be triggered in four different quadrant modes depending on the polarity of the main terminal voltage and the gate current. The CTL503 provides four dedicated TRIAC buttons (Q1, Q2, Q3, Q4) as separate device type entries in the smorgasbord DUT Selector. Each quadrant button

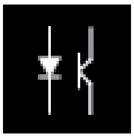


Figure 15: OPTO Button

has its own independent blue ring/solid dot indicator, so you can choose which quadrants appear in the left ribbon's Device Type section and on the toolbar. This pre-configures the correct polarities for each quadrant:

Button	Main Terminal (Collector)	Gate Polarity	Template
TRIAC Q1	Positive	Positive	650
TRIAC Q2	Positive	Negative	651
TRIAC Q3	Negative	Negative	652
TRIAC Q4	Negative	Positive	653

- **Step output mode:** Current (I)
- **Pulse mode:** 300µs (preset for all quadrants)
- **Template range:** 650-699

Selecting a TRIAC quadrant button automatically sets the collector polarity, gate polarity, and pulse mode to the correct values for that quadrant. This avoids having to manually reconfigure polarity settings when testing different quadrants of the same device.

TRIAC tests use pulse mode to prevent device damage from sustained high current. Test all four quadrants to fully characterise a TRIAC's triggering behaviour – most TRIACs have different sensitivity in each quadrant, with Q1 and Q3 typically being the most sensitive.

6.14 Optocoupler

Selects settings for optocoupler testing:

- **Collector polarity:** Positive
- **Step output mode:** Current (I)
- **Pulse mode:** Continuous (preset)
- **Maximum voltage:** 13V (preset - optocouplers are low-voltage devices)
- **Maximum power:** 1W (preset)
- **Template range:** 500-599

Available graph types:

Figure 16: Collector Supply

Template	Description	X-Axis	Y-Axis	Slope
700	CTR (Current Transfer Ratio)	LED Forward Current (IF)	Collector Current (IC)	ΔIC/ΔIF (CTR, Current Transfer Ratio)

The CTR test measures the relationship between the LED input current and the phototransistor output current. The Current Transfer Ratio is defined as **CTR = IC / IF**, typically expressed as a percentage. A typical optocoupler might have a CTR of 50% to 200%.

> **Optocoupler tests run in continuous mode at low voltage (13V) and limited power (1W) to protect both the LED and phototransistor.**

---

7 Collector Supply

The **Collector Supply** section controls the main output voltage and current applied to the device under test. These controls are located in the left-hand ribbon of the main display. The CTL503 provides a collector sweep from 0V to +100V (or -100V) with a peak current of 3A.

7.1 Maximum Voltage

Sets the maximum voltage that the collector supply will output during a sweep. Use the **+** and **-** buttons to step through preset voltage levels.

Preset voltage steps: 3, 6.5, 13, 20, 30, 40, 50, 60, 70, 80, 90, 100V

Custom entry: Double-click the voltage value to open a dialog where you can type any voltage to one decimal place (e.g. 48.5V, 72.0V). The entered value is used as-is and is not rounded to the nearest preset step. The minimum is 3V and the maximum is 100V.

After entering a custom value, pressing **+** or **-** reverts to step mode. The step index jumps to the next preset above (for +) or below (for -) the custom value. For example, a custom value of 48.5V followed by + gives 50V; followed by - gives 40V.

The adjustable peak voltage limiting prevents device damage by capping the sweep at your chosen maximum.

Always start with a low voltage when testing an unknown device and increase gradually.

7.1.1 Over-Voltage Protection

If you double-click the voltage value and enter a number that significantly exceeds the instrument's maximum, the dialog rejects the entry and displays a warning message. Values slightly above 100V are silently clamped to 100V.

7.1.2 Polarity Warning

If the sign of the value you enter does not match the current collector polarity setting, the dialog displays "WARNING: DIFFERENT POLARITY" in red for 1.5 seconds and then closes without applying the value. This prevents accidental reverse-voltage tests.

7.2 Maximum Current

Sets the maximum current that the collector supply can deliver. Use the **+** and **-** buttons to step through preset current levels.

Custom entry: Double-click the current value to open a unit-aware dialog with **mA** and **A** toggle buttons. The entered value is snapped to the closest preset current step.

The CTL503 supports peak currents up to 3A. Current limiting protects both the device under test and the instrument. If the DUT draws more current than the set limit, the voltage will be reduced to maintain the current limit.

7.3 Maximum Power

Sets the maximum power dissipation limit for the device under test.

How it works:

- **Continuous mode:** P = V × I (peak power)
- **Pulsed mode:** P = V × I × DutyCycle (average power accounting for duty cycle). For example, 60V × 1A at 300µs pulse / 50Hz repetition rate = 0.9W average, not 60W peak.
- When the calculated power exceeds the limit, the control turns **red** with a "WARNING: EXCEEDED MAX POWER" message
- The **Run** button is blocked ("Run Blocked") if power exceeds the limit - click it for an explanation and suggestions
- The power limit display shows both the set limit (centre) and the calculated power (bottom-left, bold)

Use the **+** and **-** buttons to step through preset power levels (ranging from 10mW to 300W).

Custom entry: Double-click the power value to open a unit-aware dialog with **mW** and **W** toggle buttons. You can enter any value between 10mW and 10W. The custom value is stored as-is (not snapped to a preset step).

Preset power levels: 10mW, 25mW, 50mW, 100mW, 250mW, 500mW, 1W, 2W, 5W, 10W

The power warning indicator turns red when the calculated power exceeds the set limit. This is a visual warning to alert you to potential thermal danger.

7.4 Polarity

The collector supply polarity determines whether a positive or negative voltage is applied. Click the **polarity toggle** (bottom-left of the voltage control) to switch between Positive and Negative.

- **Positive:** Used for NPN transistors, N-channel FETs, diodes in forward bias
- **Negative:** Used for PNP transistors, P-channel FETs, diodes in reverse bias

When you select a device type, the polarity is automatically configured to the correct setting.

Manually changing the polarity clears the current DUT selection, since the manual change invalidates the preset.

7.5 Pulse Mode

The pulse mode control sets whether the collector supply output is continuous or pulsed. Click the **pulse mode toggle** (bottom-right of the current control) to cycle through modes.

Mode	Pulse Width	Description
Continuous	N/A	Output is always on during a sweep
300us	300 microseconds	Short pulse, suitable for most devices
80us	80 microseconds	Very short pulse for sensitive or high-power devices

Why use pulsed mode?

Pulsed testing minimises device heating and reduces the average power dissipated in the DUT. This is essential for:

- High-power devices (TO3, TO247 packages) that would overheat under continuous DC
- Small-signal devices with low power ratings
- Diode and SCR testing where short pulses prevent thermal damage
- USB-powered operation (pulse mode reduces peak power demand)

The power calculation automatically accounts for the pulse mode when computing power dissipation.

Both collector and base/gate pulse lengths synchronise automatically: selecting 80µs for the collector also sets 80µs for the base, and the same for 300µs.

7.6 Collector Resistor

The CTL503 has four relay-selectable collector resistances that set the current range and sensitivity:

Resistor	Best For
24R	High-current devices (TO3, TO247), power transistors
270R	General-purpose testing, medium-current devices
2K45	Small-signal transistors, low-current devices
27K	Very low-current devices, leakage measurements

Auto mode: By default, the collector resistor is set to **Auto**. In Auto mode, the software automatically selects the most appropriate collector resistor value based on the current collector supply settings, optimising the measurement range and sensitivity for the device under test.

Changing from Auto to a fixed resistor value: To manually select a specific collector resistor, click the collector resistor control to cycle through the available options: **Auto**, **24R**, **270R**, **2K45**, and **27K**. Each click advances to the next value. Selecting a fixed resistor overrides the automatic selection, which is useful when you need a specific current range or when testing unusual devices where the auto selection may not be optimal. To return to automatic selection, cycle through until **Auto** is displayed again.

7.7 Double-Click Value Editing

All numeric values in the Collector Supply section (voltage, current, power) and the Step Generator section (step size, offset, step count) support **double-click editing**. Double-click on the displayed value text (e.g. "30 V", "100 mA", "1 W") to open an input dialog.

Value Edit Dialog (used for Maximum Voltage):

- A simple text input with no unit buttons
- Pre-filled with the current value, fully selected for easy overtyping
- Press **Enter** to apply, **Escape** to cancel
- Click outside the dialog to cancel and close it (light dismiss)

Unit Edit Dialog (used for Maximum Current, Maximum Power, Step Size, Offset Level):

- A text input with two unit toggle buttons on the right (e.g. mA / A, or mW / W)
- Clicking a unit button converts the displayed value between units automatically
- The result is always stored in base units (amps, volts, watts)
- Press **Enter** to apply, **Escape** to cancel
- Click outside the dialog to cancel and close it (light dismiss)

Integer Edit Dialog (used for Step Count):

- A text input with no unit buttons, clamped to the range 1-24
- Press **Enter** to apply, **Escape** to cancel
- Click outside the dialog to cancel and close it (light dismiss)

All edit dialogs have a yellow or green border matching their section (yellow for Collector Supply, green for Step Generator).

Figure 17: Step Generator

8 Step Generator

The **Step Generator** provides the secondary stimulus for the device under test. For BJT testing, this is typically the base current (IB). For FET testing, it is the gate-source voltage (VGS). The CTL503 supports 1 to 24 steps with an offset function for both current and voltage modes.

The step generator section is located in the left ribbon, below the Collector Supply controls. It consists of six controls arranged vertically: Step Size, Output Mode, Offset Level, Offset Range, Step Quantity, and Continuous/Pulsed indicator.

8.1 How the Step Generator Works

Each sweep consists of multiple "steps." At each step, the CTL503:

1. Sets the base/gate drive to the value for that step
2. Ramps the collector voltage from 0V up to the maximum voltage setting
3. Records the collector current (IC) and voltage (VC) at each point during the ramp
4. Plots the resulting curve on the graph

The step values are calculated as: **Step[n] = Offset + n × StepSize × StepDirection**

For example, with offset = 0, step size = -5μA, and 7 steps: - Step 0: 0 μA, Step 1: -5 μA, Step 2: -10 μA, Step 3: -15 μA, Step 4: -20 μA, Step 5: -25 μA, Step 6: -30 μA

Each step produces one curve on the graph, colour-coded and labelled in the key.

8.2 Step Size

The step size determines the increment between each step. Use the **+** and **-** buttons to select from preset step sizes.

- In **current mode (I):** 0.5μA, 1μA, 2μA, 5μA, 10μA, 15μA, 20μA, 25μA, 30μA, 50μA, 75μA, 100μA, 200μA, 500μA, 1mA, 2mA, 5mA, 10mA
- In **voltage mode (V):** 1mV, 2mV, 5mV, 10mV, 20mV, 50mV, 100mV, 200mV, 500mV, 1V, 2V, 5V

Custom entry: Double-click the step size value to open a unit-aware dialog. In current mode, the toggle buttons are **uA** and **mA**. In voltage mode, they are **mV** and **V**. You can enter any value within the range; the custom value is stored as-is. After entering a custom value, pressing +/- reverts to step mode.

Step polarity: The polarity button (bottom-left) controls whether steps go positive or negative from the offset. For NPN BJTs and N-channel FETs, steps typically go negative. For PNP and P-channel, steps go positive.

Custom step sizes are cleared when you switch between current and voltage mode.

8.3 Offset Level

The offset level sets the starting point for the step generator (Step 0). This is a powerful feature that allows you to:

- **Start stepping from a non-zero value** - e.g. set offset to -10µA, steps of -5µA gives: -10, -15, -20, -25µA
- **Apply a DC bias** - the offset value is maintained as the "idle" level between pulses (in pulsed mode)
- **Zero-crossing** - sweep from negative to positive values (e.g. offset = -2V, step = +0.5V, 8 steps = -2V to +2V)
- **Centre around an operating point** - useful for measuring small-signal parameters around a specific bias

The offset has its own polarity control (bottom-left of the offset control) and its own range selector (bottom-right).

Custom entry: Double-click the offset value to open a unit-aware dialog. In current mode, the toggle buttons are **nA** and **uA**. In voltage mode, they are **mV** and **V**. The entered value is clamped to the current range maximum.

Offset ranges (current mode): 0-200nA, 0-2µA, 0-20µA, 0-200µA, 0-2mA, 0-30mA

Offset ranges (voltage mode): 0-20mV, 0-200mV, 0-2V, 0-5V, 0-10V

8.3.1 Offset Range Warning

If the offset you enter exceeds the valid range for the current step configuration, the value is clamped to the maximum allowed. The display updates to show the clamped value so you can see the limit that was applied.

8.3.2 Idle Values and Why They Matter

In pulsed mode, the "idle" value is what the base/gate drive returns to between pulses. When offset is zero, idle is zero - the device is fully off between pulses. When offset is non-zero, idle equals the offset - the device maintains the offset bias between pulses. This is important for:

- **FET threshold characterisation:** Set offset to near-threshold voltage, step above and below
- **Thermal testing:** A non-zero idle keeps the device slightly on between pulses, affecting junction temperature

8.4 Step Quantity

The number of steps (1 to 24) determines how many curves are drawn in a single sweep. More steps give a more detailed family of curves but take longer to acquire.

The display shows the current step count and the maximum base/gate value that will be reached (e.g. “Max: -30 μA” for 6 steps at -5μA).

Custom entry: Double-click the step count to type a number directly. The value is clamped to the range 1-24.

8.5 Output Mode

The step generator can operate in two modes:

- **Current mode (I):** Outputs a controlled current - typical for BJT base drive. The CTL503 has four base/gate current ranges (20μA, 200μA, 2mA, 20mA) selected automatically based on the peak current demand.
- **Voltage mode (V):** Outputs a controlled voltage - typical for FET gate drive. Range: -10V to +10V via the 270R base/gate resistor.

Click the **output mode toggle** (bottom-right of the step size control) to switch between I and V.

8.5.1 Base/Gate Resistor Auto-Selection

In current mode, the CTL503 automatically selects the optimal base/gate resistor based on the peak current (maximum of offset + all steps):

Peak Current	Resistor	Range
≤ 30μA	270KΩ	±20μA
≤ 300μA	27KΩ	±200μA
≤ 3mA	2.7KΩ	±2mA
> 3mA	270Ω	±20mA

In voltage mode, the 270Ω resistor is always selected.

Switching between current and voltage mode clears any custom step size or offset values you have entered.

8.6 Clamp On Idle Behaviour

When operating in current mode with zero offset, the **Clamp On Idle** feature is automatically enabled. This shorts the base/gate output to ground between pulses, ensuring the device is completely off. The status indicator at the bottom of the left ribbon shows “Clamp: On Idle” when active.

When offset is non-zero, clamp is automatically disabled - the base/gate must hold the offset current between pulses.

In voltage mode, clamp is always off (voltage sources maintain their level naturally).

8.7 Sample Rate

The default sample rate is **50 Hz** (50 collector ramp cycles per second). This determines the timebase and pulse repetition rate. Each step in a sweep runs for a configurable ramp time (default 10 seconds) during which the collector voltage ramps up and data is captured.

The sample rate is adjustable from **10 Hz to 100 Hz in 10 Hz steps** via the **Settings** window - see Sweep Settings below.

8.8 Polarity Warning

If you double-click to enter a value and the sign doesn't match the current polarity setting (e.g. entering a positive voltage when the polarity is set to Negative), the dialog displays "WARNING: DIFFERENT POLARITY" in red for 1.5 seconds and rejects the entry. This prevents accidental reverse-bias errors.

8.9 Polarity

The step generator polarity can be set independently of the collector supply polarity. Click the **polarity toggle** to switch between Positive and Negative.

- **Positive:** For NPN/N-channel devices
- **Negative:** For PNP/P-channel devices

8.10 Bit Step Mode

Bit Step Mode changes the step size selector to operate in **DAC bit increments** rather than fixed voltage or current presets. This gives fine-grained, precisely repeatable stepping at the lowest level the hardware can resolve.

- **Enable:** Toggle Bit Step Mode via the **Advanced Panel** (Graph Functions section), or click the **Bit Step Mode** button on the toolbar when visible.
- **Offset:** The offset level continues to operate in Volts or mA as normal.
- **Step size:** The +/- buttons on the Step Size control now select a number of DAC bits (1, 2, 3, 5, 10, 20, 30, 50, 100, 200). In current mode additional bit counts are available up to 15000.
- **Display:** The step size button shows the equivalent real voltage or current, with an **"N bits"** annotation in the top-right corner (e.g., "0.610 mV" with "2 bits").
- **Key readings:** The graph key displays the actual voltage or current for each step to 3 decimal places.

Bit Step Mode is useful when characterising devices with very small step increments, ensuring each step corresponds to an exact integer change in the DAC output.

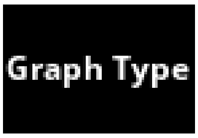


Figure 18: Graph Type

8.11 Key Reading Precision

The graph key (legend) displays step generator output values with 3 decimal places (e.g., "4.000 V", "4.005 V", "4.010 V"). This allows closely-spaced traces to be clearly distinguished.

9 Graph Mode

> **Current behaviour (important):** Selecting a graph type / template does **not** yet change the plotted chart axes. Regardless of the template chosen, the live chart always draws the **VCE-IC family** (collector current vs collector-emitter voltage). The graph-type catalogue below documents the **intended** axis layout for each template; alternate-axis and derived plots (for example HFE, RDS, rZ, CTR) are planned but not rendered today. Use the cursor read-outs (which compute hFE, gm, etc. from the plotted VCE-IC data) for derived values in the meantime.

The **Test Select** control in the left ribbon displays the currently selected graph type. Use the **+** and **-** buttons to cycle through available graph types within the current device type group.

Each graph type is *intended* to define:

- **X-axis source** - Which measurement appears on the horizontal axis
- **Y-axis source** - Which measurement appears on the vertical axis
- **Step source** - Which parameter is stepped (if applicable)
- **Axis labels** - Units and descriptions for each axis

As noted above, these axis definitions are not yet applied to the chart: every template currently plots the VCE-IC family.

The graph type number is displayed on the control. Numbers are grouped by device type:

Range	Device Type
100-199	BJT (NPN/PNP)
300-399	MOSFET (enhancement + depletion)
400-499	Diode / Zener
500-599	Optocoupler
600-699	SCR / TRIAC
700-799	JFET

The +/- buttons will not cross group boundaries. For example, if you are on test 102 (BJT), pressing + will go to 103 but will never exceed 199.

9.1 The Graph Engine

EPIC V26600 uses a custom graph engine. Key characteristics:

- **Origin at bottom-left:** 0,0 is always at the bottom-left of the plot area. Both positive and negative values extend rightward (X) and upward (Y) from the origin.
- **Auto-scaling:** The graph automatically scales to fit the data using 5 major divisions per axis and a "nice step" sequence for clean division values.
- **Graticule:** Major grid lines are drawn in dark green at each major division. Minor grid lines in faint green appear between majors. Axis tick labels appear only at major divisions.
- **Watermark:** A small Electron+ logo (grey "e", blue "+") is displayed at the top-right of the graph area.
- **Trace colours:** An 8-colour cycle repeats across all 25 possible steps (0-24), providing clear visual separation between curves.

9.2 Graph Key Labels

The graph key shows a labelled legend identifying which step value corresponds to each trace colour. The **Graph Keys** button in the smorgasbord (Graph Functions section) cycles through four display states:

State	Description
0	Off – no key labels displayed
1	Below-axis legend – a separate line of labels appears below the X-axis title
2	Right-margin labels – labels are aligned with trace endpoints in the right margin
3	At-endpoint labels – labels are drawn directly at each trace's endpoint on the graph

9.3 Key Order Toggle

The **Key Order** button in the smorgasbord toggles the order in which step labels are listed:

- **0 to N** (default) – steps are listed from the first step (0) to the last (N)
- **N to 0** – steps are listed in reverse order

9.4 Text Size Controls

9.4.1 Graph Text Size

The **"Aa" button** in the bottom-right corner of the graph area cycles through four sizes for all graph text (axis labels, tick labels, key legend, cursor labels, marker labels, title text):

Mode
XS
Small (default)
Normal
Large

9.4.2 Key L Text Size

The **"Aa" button** in the top-right corner of the Key L results table header cycles through four font sizes for the Key L table only (headers and data rows):

Mode
Small
Normal (default)
Medium
Large

Both text size preferences are saved between sessions. The graph and Key L text sizes are independent - changing one does not affect the other. Key X and Key Y tables are not affected by either control.

9.5 Graph Title

The graph title appears at the top of the graph display area. Tap or click anywhere in the **Graph Title** area to open the title editor flyout.

9.5.1 Editing the Title

1. Tap/click on the **Graph Title** area at the top of the main graph
2. A flyout popup appears with:
   - A text box for typing a custom title (watermark: "Enter graph title...")
   - A **Use CSV Export name** checkbox that auto-generates a title from the CSV export prefix, graph type, and counter (e.g. "Export VCE-IC 00002")
   - A live preview showing the current title in green
3. Changes apply immediately on each keystroke or toggle – there is no confirm button
4. Click outside the flyout to close it (light dismiss)

When the **Use CSV Export name** checkbox is ticked, the text box is disabled and shows the auto-generated name from the CSV export settings. Uncheck it to type a custom title.

9.5.2 Title Persistence

The graph title is saved in two ways:

- **Settings**: The title and checkbox state are saved in the application settings so they persist across sessions.
- **CSV write-back**: When you edit the title while viewing a file from DISPLAYED RESULTS, the new title is written back into that CSV file's `GraphTitle` column (all data rows). This makes the title persistent with the data itself.

The working data files are modified by EPIC during operation. **CSV Export** creates separate user copies – the working files and exported files are independent.

Write-back is non-critical: if the file is locked or inaccessible, the title still changes on screen but will not persist in the file.

9.6 Graph Info Overlay

The Graph Info overlay displays key test settings as a semi-transparent table on the graph. Toggle it using the **Graph Info** button on the toolbar. Each click cycles through five states:

State	Position
0	OFF – overlay not displayed
1	Lower-Right corner of the graph
2	Lower-Left corner of the graph
3	Upper-Left corner of the graph
4	Upper-Right corner of the graph

After state 4, the next click returns to OFF (state 0).

Field	Description
Max Voltage	Maximum collector/drain voltage
Collector Z	Collector impedance setting
Max Current	Maximum collector/drain current
Collector Pulse	Collector pulse width
Base/Gate Pulse	Base or gate pulse width
Sample Rate	Current sample rate

The INFO box draw order (in front of or behind traces) can be changed in **Settings > Graph Tab**.

---

10 Display Panels

The EPIC interface has several collapsible panels that can be toggled to maximise the graph area or reveal measurement tables. Three smorgasbord buttons control panel visibility: **Key X**, **Key Y**, and **Key L**. All visibility states persist across sessions.

10.1 Key X Panel

The **Key X** button toggles the **KEY/MEASUREMENTS - X CURSORS** panel on the right-hand ribbon. When enabled, this panel displays the X cursor readouts, measurement values at cursor XA and XB, and delta calculations.

- **ON:** The right ribbon shows the X cursor measurement table
- **OFF:** The X cursor measurement table is hidden

The button icon dims when the panel is off and is full brightness when on.

10.2 Key Y Panel

The **Key Y** button toggles the **KEY/MEASUREMENTS - Y CURSORS** panel on the right-hand ribbon. When enabled, this panel displays the Y cursor readouts, measurement values at cursor YA and YB, and delta calculations.

- **ON:** The right ribbon shows the Y cursor measurement table
- **OFF:** The Y cursor measurement table is hidden

10.2.1 Right Ribbon Auto-Collapse

When **both** Key X and Key Y are turned off, the entire right-hand ribbon collapses and the graph area expands to fill the freed space. As soon as either Key X or Key Y is turned back on, the right ribbon reappears.

10.3 Key L Panel

The **Key L** button toggles the **DISPLAYED RESULTS** panel at the bottom of the screen. This panel shows the tabular results grid containing per-step measurement data, including cursor intersections, hFE, VA, rO, gO, and slope columns when their respective modes are active.

- **ON:** The bottom results panel is visible below the graph
- **OFF:** The bottom results panel collapses and the graph expands vertically to fill the space

10.4 Resizable Bottom Panel

When the bottom results panel is visible (Key L is on), a **horizontal grab handle** (grid splitter) appears between the graph area and the bottom panel. Click and drag this handle up or down to adjust the height split between the graph and the results table.

- Drag **up** to give more space to the bottom results table
- Drag **down** to give more space to the graph

The splitter uses standard drag behaviour – the cursor changes to a vertical resize indicator when hovering over the handle.

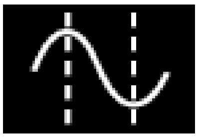


Figure 19: X Cursor

11 Cursors

Cursors are measurement tools that allow you to read precise values from the displayed curves. In EPIC V26600, each cursor pair has three states accessed by clicking the button: **OFF**, **ON**, and **LOCK** (indicated by a padlock icon).

11.1 X Cursors

X cursors are two vertical dashed lines (XA and XB) that can be placed on the graph to read values at specific X-axis positions.

To use X cursors:

1. Enable X cursors by clicking the **X Cursors** button on the toolbar
2. Click and drag the cursor lines to position them on the graph (click near the line, or drag the label text)
3. The cursor readout displays the X and Y values at each cursor position

Each cursor line has a **flying label** displayed directly on the graph showing the cursor's X-axis position and units (e.g. "A -534 mV" or "B 5.00 V"). These labels are formatted to 4 significant digits for readability, and are positioned next to the **<** and **>** nudge arrows that allow fine cursor adjustment.

11.1.1 Cursor States

State	Icon	Behaviour
OFF	Dimmed icon	Cursors not visible
ON	Active icon	Cursors visible and independently draggable
LOCK	Padlock icon	Moving one cursor moves the other by the same delta, maintaining the gap between them

Click the X Cursors button to cycle: OFF -> ON -> LOCK -> OFF.

11.1.2 Cursor Edge Clamping

When you switch between graph types (e.g. from VDS-ID at 0-56V to VGS-ID at 0-4V), the cursor positions may fall outside the new graph's axis range. Rather than resetting or losing cursor positions:

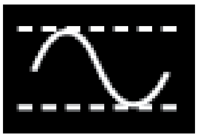


Figure 20: Y Cursor

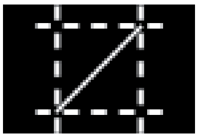


Figure 21: Slope

- **Cursors clamp to the graph edge** - they sit visibly at the nearest edge of the graph area
- **Drag from the edge** - click and drag the clamped cursor back onto the graph to reposition it
- **Original value preserved** - if you switch back to the previous graph type, the cursor returns to its original position

This means cursors never disappear off-screen - they're always visible and grabbable.

11.2 Y Cursors

Y cursors are two horizontal dashed lines (YA and YB) for reading values at specific Y-axis positions. They work identically to X cursors but on the vertical axis.

11.2.1 Cursor States

State	Icon	Behaviour
OFF	Dimmed icon	Cursors not visible
ON	Active icon	Cursors visible and independently draggable
LOCK	Padlock icon	Moving one cursor moves the other by the same delta

Click the Y Cursors button to cycle: OFF -> ON -> LOCK -> OFF.

11.3 Slope Measurement

The slope measurement draws a **dotted white line** between the intersections of cursor XA/YA and XB/YB. This requires both X cursors and Y cursors to be active (in either ON or LOCK state). If either cursor pair is turned off, the slope line automatically deactivates.

Slope = (Y2 - Y1) / (X2 - X1)

This is useful for measuring:

- **Transconductance (gm)** of FETs: slope of ID vs VGS
- **Dynamic resistance** of diodes: slope of I vs V curve
- **Current gain (hFE)** of BJTs: slope of IC vs IB

The Slope button's ring click is always available for controlling toolbar visibility, even when the slope function itself is unavailable due to a cursor dependency.

11.4 hFE and Transconductance (gm) Measurements

The **hFE** toggle button adds device-specific gain measurement columns to the bottom DISPLAYED RESULTS table. The measurements are calculated at the current X cursor positions, so X cursors must be active for values to appear.

Enable the button from the smorgasbord (Derived measurements section), then toggle it on from the toolbar or smorgasbord.

11.4.1 hFE for BJTs (graph types 100-199)

When engaged, three additional columns appear in the bottom results table:

Column	Formula	Description
hFE@XA	hFE = IC / IB	DC current gain calculated at cursor XA position
hFE@XB	hFE = IC / IB	DC current gain calculated at cursor XB position
hFE Avg	(hFE@XA + hFE@XB) / 2	Average of the two hFE values

Where IC is the collector current read from the trace at the cursor position, and IB is the theoretical base current for that step as set by the calibrated step generator.

Each row in the results table corresponds to one step (one trace), so you can compare hFE across different base current steps at a glance. Values are displayed to one decimal place. If IB is zero (e.g. the zero step), hFE displays as "INF".

11.4.2 gm for FETs (graph types 300-399)

When engaged, the results table shows:

Column	Formula	Description
gm	gm = ΔIC / ΔVGS	Transconductance between cursors XA and XB

Where ΔIC is the change in drain current (Y-axis) between the two cursor positions, and ΔVGS is the change in gate-source voltage (X-axis) between the two cursor positions. The result is in siemens (S).

11.4.3 Other Device Types

For diodes, SCRs, and optocouplers, the hFE toggle has no effect and normal cursor values are displayed.

The hFE/gm toggle state is saved and restored with setup files.

11.5 Early Voltage (VA) and Output Resistance

The **VA** toggle button measures the Early voltage (VA), output resistance (rO), and output conductance (gO) from BJT output characteristic curves. These are key parameters for analogue circuit design, telling you how much the collector current changes with collector-emitter voltage in the active region. The measurements are displayed in the bottom DISPLAYED RESULTS table when the VA button is active.

Enable the button from the smorgasbord (Derived measurements section), then toggle it on from the toolbar or smorgasbord.

Only active on template 100 (VCE-IC). For all other graph types the toggle has no effect.

11.5.1 What is the Early Effect?

In an ideal BJT, the collector current (IC) would be completely independent of the collector-emitter voltage (VCE) once the transistor is in its active region. In reality, IC increases slightly as VCE increases. This is the **Early effect**, named after James Early who first described it.

The cause is base-width modulation: as VCE increases, the collector-base depletion region widens, narrowing the effective base width. A thinner base means less recombination and a steeper minority-carrier gradient, so IC rises.

If you extend the flat portion of each IC-VCE curve backwards (towards negative VCE), all the lines converge at approximately the same point on the VCE axis. The magnitude of this intercept is the **Early voltage (VA)**. A higher VA means flatter curves and a more ideal current source.

11.5.2 What the Columns Show

When engaged, three additional columns appear in the bottom results table:

Column	Formula	Description
VA (Volts)	VA = |IC_A / gO - VCE_A|	Early voltage, calculated from the collector current at cursor XA and the output conductance. A higher VA means flatter curves and a more ideal current source.
rO (Ohms)	rO = ΔVCE / ΔIC	Output resistance between cursors XA and XB. Higher rO means the collector current is more stable with changing VCE.
gO (Siemens)	gO = ΔIC / ΔVCE	Output conductance between cursors XA and XB. This is the inverse of rO. Lower gO means flatter curves.

Where IC_A is the collector current at cursor XA, VCE_A is the collector-emitter voltage at cursor XA, and ΔIC and ΔVCE are the changes in collector current and voltage between the two cursor positions.

11.5.3 How to Measure

1. Run a sweep of your BJT on **template 100 (VCE-IC)** with several base current steps
2. Enable the **VA** button in the ribbon or smorgasbord
3. Position cursor **XA** and cursor **XB** in the **flat active region** of the curves (avoid the saturation knee at low VCE and any breakdown region at high VCE)
4. Read VA, rO, and gO for each step in the bottom results table

For best accuracy, space XA and XB well apart within the active region. The wider the span, the more representative the slope measurement.

11.5.4 Typical Values

Device Type	Typical VA	Typical rO (at 1mA IC)
Small-signal BJT (2N3904, BC547)	100 - 200 V	100 kOhm - 200 kOhm
General-purpose BJT (2N2222)	80 - 150 V	80 kOhm - 150 kOhm
Power BJT (TIP31, 2N3055)	20 - 80 V	2 kOhm - 20 kOhm
High-VA types (cascode-optimised)	200 - 500 V	200 kOhm+

rO is inversely proportional to collector current: at higher IC, rO drops. Compare rO values at the same operating point when matching transistors.

11.5.5 Why it Matters

- **Amplifier gain:** The voltage gain of a common-emitter amplifier is approximately gm x rO. A transistor with low rO limits the maximum achievable gain.
- **Current mirror accuracy:** In current mirrors, a finite rO causes the output current to vary with output voltage. Higher VA means better regulation.
- **Transistor matching:** When building differential pairs or current mirrors, matching VA (and therefore rO) between devices is as important as matching hFE.
- **SPICE modelling:** VA is a direct SPICE parameter (VAF for forward Early voltage). Measuring it from real curves lets you validate or create accurate simulation models.

The VA toggle state is saved and restored with setup files.

11.6 Cursor Measurements

The **Cursor Measurements** button toggles visibility of the cursor results table on the right ribbon. When enabled, a table displays cursor positions (XA, XB, YA, YB), deltas (XB-XA, YB-YA), and the slope value.

Activating Slope mode automatically enables Cursor Measurements, since the slope value is displayed in the cursor results table.

12 Box Zoom

The box zoom feature allows you to magnify a region of the graph to examine closely-spaced data (e.g. HFE curves clustered in a narrow band).

12.1 Controls

Four small buttons appear at the bottom-left corner of the graph area:

Button	Function
Zoom	Toggle zoom mode. Border turns green when active. Cursor changes to crosshair.
Back	Appears when zoomed. Steps back one zoom level.
Lock	Appears when zoomed. Freezes the current zoom level - file navigation and graph type changes won't reset the zoom. Border turns amber when locked.
Ref	Set or clear the reference trace overlay (see below).

12.2 Using Zoom

1. Click **Zoom** to enter zoom mode
2. Click and drag on the graph to draw a selection box (white dashed outline)
3. Release to zoom into the selected region
4. Zoom again within the zoomed view - up to 8 levels deep
5. Click **Back** to step back one level, or switch graph type to reset fully

Zoom mode stays active after zooming, so you can draw another box immediately to zoom deeper. Very small drags are ignored to prevent accidental zooms.

12.3 Zoom Lock

When **Lock** is active (amber), the zoom level persists as you navigate between CSV files using the file arrows. This is useful for comparing the same feature across multiple datasets at the same scale. Manual **Back** still works when locked.

12.4 Auto-Reset

Zoom is automatically reset to full scale when: - You change the graph type (pill bar selection) - A new sweep starts (Run button) - You navigate to a different file (unless Lock is active)

13 Reference Overlay

The reference overlay lets you compare two datasets visually by displaying one as "ghost traces" behind the other.

13.1 Setting a Reference

1. Load the file you want as your reference (e.g. a "golden" device)
2. Click **Ref** - the button turns blue
3. Navigate to another file - the new data draws in full colour on top of the reference traces

The reference traces appear as **dashed lines in the same step colours** at reduced opacity. A label "REF: filename.csv" appears in the top-left corner of the graph.

13.2 Opacity Slider

When Ref is active, a horizontal slider appears next to the Ref button. Drag it to adjust the reference trace opacity from 10% (barely visible) to 100% (full brightness). The default is 35%.

13.3 Clearing the Reference

Click **Ref** again to clear the reference traces. The button returns to its normal state.

13.4 Axis Scaling

When a reference is active, the graph's auto-range covers both the reference data and the active data. This means the axis limits expand to fit whichever dataset is larger. If the reference covers 0-60V but the active data only covers 0-30V, the axis will show 0-60V to keep both visible.

Important limitation: When navigating between files with a reference active, the axis scale may jump as different files have different data ranges. Use the **Lock** button (see Box Zoom section) to freeze the axis scale if you want consistent comparisons.

13.5 Combining Zoom and Reference

Zoom, Lock, and Reference are designed to work together for device comparison:

1. Load your "golden" reference device (e.g. 0123.csv)
2. Click **Ref** to capture it
3. Zoom into the region of interest (e.g. the saturation region)
4. Click **Lock** to freeze the zoom level

Figure 22: CSV Export

5. Navigate between other files (0150.csv, 0151.csv, etc.) - each file shows its data in full colour overlaid on the reference at the exact same scale

This workflow is ideal for production testing, incoming inspection, or matching devices.

---

14 Marker Toggle

The **Marker** button (bottom-right of the graph, next to the text size button) toggles data point markers on and off:

- **Auto** (default): Markers shown when a trace has fewer than 30 data points, hidden for dense traces
- **On**: Markers always shown
- **Off**: Markers always hidden

Markers are useful on derived graphs (HFE-IC, RO-IC, GM-VGS) where each step contributes a single data point. On standard VCE-IC traces with hundreds of points, markers would clutter the display.

---

15 Exporting Data

15.1 CSV Export

The CSV export saves measurement data in comma-separated values format for spreadsheet applications or analysis software.

15.1.1 Saving CSV Data

Click the **CSV** button on the toolbar to save the current sweep data.

15.1.2 Automatic Sweep Storage

Every completed sweep is automatically saved as a numbered CSV file in your EPIC data folder.

Files are named sequentially: `0001.csv`, `0002.csv`, `0003.csv`, and so on, up to a maximum of `9999.csv`. Each file contains the measured data from one sweep.

Figure 23: PNG Capture

15.1.3 Displayed Results Navigator

The **Displayed Results** panel in the left ribbon navigates previously saved sweep data. The panel displays the name of the currently selected CSV file (for example `0327.csv`). Use the controls to browse through your saved sweeps:

- **< >** arrows – step backwards or forwards through files one at a time
- **Goto First** – jump to the first file (`0001.csv`)
- **Goto Last** – jump to the most recent file

When you select a file, EPIC loads that sweep's data and displays it on the graph. This allows you to review and compare results from previous measurement sessions without re-running the sweep.

Click the **centre** of the Displayed Results panel (where the filename is shown, e.g. "0648.csv") to open a file chooser dialog. This lets you navigate directly to any CSV results file without stepping through files one at a time.

During a Live Sweep: While a sweep is running, the panel switches to show **..live Data..** and the arrow buttons change to +/- controls. Once the sweep completes, the results are saved as the next numbered CSV file and the panel returns to file navigation mode, pointing at the newly saved file.

> **The data folder is created automatically. Copy it to archive your data. The CSV files open directly in Microsoft Excel or similar.**

15.1.4 CSV Configuration

Configure CSV export in the **Settings** window under the **File Export** tab:

Setting	Description
Save Location	Folder where CSV files are saved
Auto-Name	Automatically generate sequential filenames
Prefix	Text prefix for auto-named files

15.2 PNG Capture

The PNG capture feature saves the current graph display as a PNG image file. Click the **PNG Capture** button on the toolbar to save immediately. A brief shutter animation confirms the capture, accompanied by an optional shutter click sound.

15.2.1 Capture Regions

The capture always includes the main graph area. You can optionally include additional regions:

Region	Default	Description
Sub-graph / bottom results	Included	The results panel below the graph
Top ribbon (toolbar)	Excluded	The toolbar across the top
Left ribbon (controls)	Excluded	The left-hand control panel
Right ribbon (key tables)	Excluded	The key measurements and cursor tables

15.2.2 File Naming

PNG files are saved to the `results/` subdirectory (configurable). The filename is built from optional components in this order:

```
[Prefix_][GraphTitle_][GraphType_][Counter].png
```

Each component is toggled independently. The counter is a 5-digit zero-padded number (00001-99999) that auto-increments with each capture.

Examples:

- All off, prefix="Capture": `Capture_00001.png`
- Graph title on ("2N3904"), prefix="Capture": `Capture_2N3904_00001.png`
- All on, prefix="Capture": `Capture_2N3904_VCE-IC_00001.png`
- No prefix, no title, no type: `00001.png`

15.2.3 Quick Configuration (Right-Click)

Right-click the PNG Capture button (on either the toolbar or the smorgasbord) to open a settings popup with:

- Save location (text field + browse button)
- Auto-name toggle
- Prefix text field
- Include Graph Title in filename (checkbox)
- Include Graph Type in filename (checkbox)
- Next counter number (editable)
- Play shutter sound (checkbox)

Changes take effect immediately and are saved to the settings file.

15.2.4 Full Configuration

All PNG export settings are also available in the **Settings** window under the **File Export** tab.

The capture includes all currently rendered elements: traces, cursors, axis labels, grid, title, and watermark.

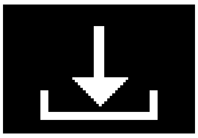


Figure 24: Save Setup

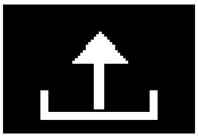


Figure 25: Load Setup

15.3 Save / Load Setups

15.3.1 Saving a Setup

1. Click the **Save Setup** button (in the smorgasbord Miscellaneous section)
2. Choose a filename and location in the save dialog
3. The current configuration is saved as a JSON file

What is saved:

- All smorgasbord button states (which buttons are visible)
- Collector supply settings (voltage, current, power limit, polarity, pulse mode)
- Step generator settings (step size, offset, polarity, output mode, step count)
- Timing settings (sample rate)
- Test configuration (template number, wizard state)
- Export settings (CSV/PNG paths, auto-naming, prefixes)
- Display settings (live readings, alternate colours, graph title)
- Direct entry values (custom voltage, current, step sizes)
- Device type visibility (DIODE, SCR, OPTO button states)

15.3.2 Loading a Setup

1. Click the **Load Setup** button
2. Select a previously saved setup file (.json)
3. All settings are restored from the file

The setup file includes the instrument type. A setup saved for CTL503 cannot be loaded on a different instrument type.

Figure 26: Settings

16 Settings

The **Settings** window provides access to application configuration options. Open it by clicking the **Settings** button on the toolbar.

The window is a single scrollable page (not tabbed) - sections appear in order from top to bottom.

16.1 Select Instrument

Choose the active instrument from the dropdown: CPA10, SPA100, SPA120, or CTL503. Switching here disconnects the previous instrument and rebuilds the UI for the new one.

16.2 COM Port Scanner

Scan the system for available COM ports, pick one from the result list, and press **Update + Save** to assign it to the active instrument. The current COM port for the selected instrument is shown above the scan table.

16.3 Calibration

Opens the 93-step CTL503 calibration window for the curve-tracer hardware.

16.4 SPA Calibration

Opens the 47-step calibration window for SPA100 / SPA120 picoammeter hardware.

16.5 CTL503 Sample Rate

Visible only when CTL503 is the active instrument. Sets the collector ramp cycles per second for the pulsed-mode power calculation. Available rates: **10, 20, 30, 40, 50 (default), 60, 70, 80, 90, 100 Hz**. The new rate takes effect on the next sweep and persists across application restarts.

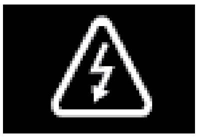


Figure 27: HV Enable

16.6 Advanced Layout

Visible only when SPA100 / SPA120 is the active instrument. Sets the per-instrument left- and right-ribbon width, from narrowest (1) to widest (4). Default 2. Takes effect on next restart.

16.7 Update Check

Toggles whether EPIC performs a daily check for new releases. Default ENABLED.

> Clamp-on-idle behaviour and idle-value rules are documented under Step Generator → Clamp On Idle Behaviour and Idle Values and Why They Matter since they are functional UI behaviours, not user-configurable settings.

---

17 HV Enable

The **HV Enable** button controls the high-voltage output of the instrument. When HV is enabled, the **RED LED** on the CTL503 unit will illuminate and the HV button icon is tinted red.

Always ensure the device under test is properly connected before enabling HV. Never touch the test socket connections while HV is enabled. The RED LED on the instrument must be OFF before handling the DUT.

- Click **HV Enable** to toggle the high-voltage output on or off
- The button indicator and the instrument's RED LED show the current state
- HV will automatically disable if a communication error occurs (configurable in Settings)
- Disconnecting the instrument automatically disables HV and stops any running sweep

Auto-Off feature: The software can be configured to automatically disable HV after a communication timeout. This safety feature prevents unattended high-voltage operation if the USB connection is lost.

---

18 Sweep Settings

The sweep settings control how data is acquired during a test run.

18.1 Sample Rate

The sample rate determines how fast the instrument acquires data points during each pulse or sweep step. Available rates are 10, 20, 30, 40, 50 (default), 60, 70, 80, 90 and 100 Hz. Higher sample rates give more detailed curves but may increase noise.

Adjust the sample rate from the **Settings** window - open Settings, scroll to the **CTL503 SAMPLE RATE** section, and select the desired rate from the dropdown. The new rate takes effect on the next sweep – it is not applied mid-sweep. The setting persists across application restarts.

---

19 Live Values Display

The **LIVE DATA / STATUS** panel is located in the left ribbon, below the Step Generator controls. It shows real-time information from the instrument:

19.1 Run Status

- **Run Status:** Shows “Idling”, “Running”, or “Disconnected”
- **Last Sweep Ended By:** Shows the stop reason for the last sweep (e.g. “Ramp -V Exceeded”, “Clean”, “Max Run Length”, “Remote/Manual”)

19.2 Live Measurements

When connected, the following values update continuously (even between sweeps):

Value	Description
Vc	Collector-emitter voltage (volts)
Vr	Ramp voltage (volts) - used for voltage limit monitoring
Ic	Collector current (amps)
Vb	Base/gate voltage (volts)

These values are useful for:

- **Verifying connections** - before running a sweep, check that Vc reads near zero with no device inserted
- **Monitoring quiescent points** - observe the bias point with the device inserted but no sweep running
- **Checking for thermal drift** - watch for creeping values that indicate device heating
- **Debugging** - if a sweep produces unexpected results, the live values show what the instrument is actually seeing

Live values are only available when the instrument is connected. The display shows "–" for each value when disconnected.

---

20 Context-Sensitive Help

Clicking the **Help** button on the toolbar opens this manual in a **separate resizable window**. You can move it to a second monitor, resize it freely, or keep it open alongside your work. The window can be resized freely.

If you click Help while focused on a particular section of the interface, the manual will scroll to the relevant heading:

- Clicking Help while viewing collector supply controls opens the **Collector Supply** section
- Clicking Help while viewing step generator controls opens the **Step Generator** section
- Clicking Help while viewing cursor controls opens the **Cursors** section
- Clicking Help from the smorgasbord opens the **Advanced Panel** section
- Clicking Help from the main toolbar opens the **Getting Started** section

Clicking Help again while the window is already open brings it to the front and scrolls to the current context. Press **Escape** in the main window to close the help window.

---

21 Troubleshooting

21.1 Connection Problems

Symptom: Cannot connect to the instrument

When a connection attempt fails, EPIC displays a **diagnostic dialog** showing: - The specific error message (e.g. "The port 'COM3' does not exist") - A list of all currently available COM ports on your system - Guidance to check Settings → COM port

To resolve: - Check USB cable is firmly connected at both ends - Verify the green LED on the CTL503 is lit - Check that the correct COM port is selected in Settings - Try scanning for COM ports again - Restart the instrument and software - Check Windows Device Manager for the COM port

Symptom: COM port not remembered between sessions

Your COM port selection is saved automatically when you close the Settings dialog and restored on next startup. If you find the port resets each time, check that your settings folder is writable (not read-only or in a protected location).

Symptom: Connection drops intermittently

- Use a shorter USB cable
- Avoid USB hubs - connect directly to the computer
- Check for electromagnetic interference near the USB cable
- Ensure the mains power supply is connected (some operations require more power than USB alone can provide)

21.2 Display Issues

Symptom: No curves displayed after pressing Run

- Verify HV is enabled (RED LED on instrument should be lit)
- Check that the device is properly inserted in the test socket
- Ensure voltage and current limits are set appropriately
- Verify the correct device type is selected
- Check that the collector resistor setting is appropriate for your device

Symptom: Curves appear noisy or distorted

- Try reducing the sample rate
- Use pulse mode to reduce thermal effects
- Check device connections for intermittent contact
- Ensure the device is not oscillating
- Try a different collector resistor setting

21.3 Measurement Problems

Symptom: Readings are zero or very small

- Check device orientation in the test socket
- Verify polarity settings match the device type
- Increase the voltage/current limits
- Ensure the step generator is providing sufficient drive
- Check that the collector resistor is appropriate (27K for very low currents)

Symptom: Power warning (red) appears unexpectedly

- Reduce the voltage or current limits
- Increase the power limit if the device can safely handle it
- Switch to pulse mode to reduce average power dissipation

21.4 File Export Issues

Symptom: Cannot save CSV or PNG files

- Check that the save location exists and is writable
- Verify there is sufficient disk space
- Check file permissions on the save directory
- Try changing the save location in Settings

21.5 Diagnostic Log Files

EPIC maintains log files in the `settings/` folder that can help diagnose issues:

File	Contents
`epic.log`	Connection attempts (success/failure with error details), disconnects, timeouts, available COM ports. Appends across sessions.
`calibration.log`	Calibration operations with timestamps and HV/connection state.

If you contact **Electron Plus** support, please include these log files along with your application settings.

---

22 Calibration

The CTL503 is factory-calibrated and adjusted during production testing at **Electron Plus** facilities. Calibration data is stored as JSON in the `settings/` folder.

22.1 Opening the Calibration Window

Open **Settings** → **Calibration** tab → **Open Calibration Window**. The window requires a connected CTL503 for most operations.

22.2 Equipment Required

- **CTL503** connected via USB
- **Calibrated DMM** (Digital Multimeter) with SCPI over TCP (port 5025)
- **Calibration Fixture** with relay switching (TCP port 10002)
- **Precision calibration resistors** (4 ranges: ~27kΩ, ~2.7kΩ, ~270Ω, ~27Ω)

22.3 Manual Calibration (Steps 1-104)

The calibration window guides you through a step-by-step procedure:

1. **Step 1a/1b:** Load an existing calibration file or use factory defaults
2. **Serial ID:** Enter the instrument's serial number (mandatory, 6+ characters). Live validation shows green when valid.
3. **Steps 3-22:** Base/Gate Voltage DAC calibration (Vb) - 6 points at ±10V and ±1.25V

4. **Steps 24-73:** Base/Gate Current DAC calibration (Ib) - 4 ranges × 4 points
5. **Steps 74-82:** Collector Voltage ADC calibration (Vc) - 2 points at ±10V
6. **Step 83:** Enter the parasitic resistance value
7. **Steps 84-99:** Collector Current ADC calibration (Ic) - ramp & capture through precision resistors
8. **Step 100:** CREATE calibration coefficients file (generates CalCertID)
9. **Step 101:** ERASE calibration data in device flash
10. **Step 102:** UPLOAD calibration data to device (with progress counter)
11. **Step 103a:** VERIFY uploaded data vs current values
12. **Step 103b:** VERIFY device vs a saved calibration file
13. **Step 104:** Calibration complete

Each step has a green tick (□) that appears when completed. The DAC adjustment controls (±250, ±25, ±1) allow fine-tuning of output values.

22.4 Ic Ramp & Capture

The collector current calibration uses a different technique from Vb/Vc: instead of measuring with a DMM, it drives voltage through a known precision resistor and captures both the raw Ic and Vc ADC values simultaneously. Since Vc is already calibrated, the real voltage is known, and I = V / R gives the true current. This avoids the need to measure high pulsed currents with an external DMM.

22.5 Automatic Calibration (AutoCal)

The **GO** and **STOP** buttons (bottom-right of the calibration window, next to the Fixture controls) run the entire calibration sequence automatically:

Pre-checks: The instrument must be connected with HV enabled, DMM and Fixture both connected, and a valid Serial ID entered.

The auto-cal sequence: - Loads default values (preserving the serial ID) - Runs all Vb, Ib, Vc calibration steps with 10-second settling before each DMM reading - Runs all Ic ramp captures (using resistor values from system settings) - Creates the calibration file, erases flash, uploads, and verifies

No human intervention is required once GO is pressed. The status text shows the current step. Press STOP to halt at any point.

22.6 Calibration Resistors

The five resistor values (parasitic + 4 Ic ranges) are fixture properties that persist across calibrations, stored separately from the calibration data. Edit them in the calibration window and they save automatically.

22.7 Verification Report

Both VERIFY buttons download the calibration data from the device and compare it value-by-value against a reference (either the current on-screen values or a saved JSON file). A markdown report is generated showing each of the 71 calibration values with PASS/FAIL status, and is saved to the `settings/` folder.

22.8 Calibration Logging

All calibration operations are logged to `settings/calibration.log` with timestamps and connection state. This file can be shared for remote diagnostics.

---

23 Safety Information

The CTL503 can generate voltages up to 100V which may be hazardous. Always observe the following safety precautions.

- **Never touch** the test socket connections while HV is enabled (RED LED lit)
- **Always disable HV** before inserting or removing devices from the test socket
- Use appropriate **current limiting** to protect devices under test
- Ensure proper **grounding** of the instrument
- Do **not** operate the instrument with damaged cables or connectors
- Keep the instrument in a **dry environment** away from liquids
- Use the **pulse mode** when testing high-power devices to prevent overheating
- The **mains power supply** must be the correct voltage and rating (12V, 1.5A)

---

24 Getting Help and Support

If you need further assistance:

- **Email:** support@electron.plus
- **Website:** www.electron.plus
- **Manuals:** Latest manuals are available for download from the **Electron Plus** website under the Manuals section

Electron Plus provides free software updates for all instruments. Check the website regularly for the latest version of EPIC.

Electron Plus is a trading name of Electron Plus Instruments Limited.

EPIC software and this manual are provided by Electron Plus Instruments Limited.