



## General-Purpose Pocket Programmable Resistance Substitution Box

# User Manual

### (Since Kickstarter Campaign Batch)



### Warranty

The manufacturer warrants this instrument is free from defects in material and workmanship under normal use and service for the period of one / two years from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, single-use batteries or any product that has been subject to misuse, neglect, accident, or abnormal conditions of operation. Changes in this product not approved by the manufacture or application of voltages or currents greater than those allowed by the specifications shall void this warranty.

In the event of failure of a product covered by this warranty, the manufacturer will repair the instrument when it is returned by the purchaser, freight prepaid, to an authorized Service Facility within the applicable warranty period, provided manufacturer's examination discloses to its satisfaction that the product was defective. The manufacturer may, at its option, replace the product in lieu of repair.

With regard to any covered product returned within the applicable warranty period, repairs or replacement will be made without charge and with return freight paid by the manufacturer, unless the failure was caused by misuse, neglect, accident, or abnormal conditions of operation or storage, in which case repairs will be billed at a reasonable cost. In such a case, an estimate will be submitted before work is started, if requested.

The foregoing warranty is in lieu of all other warranties, expressed or implied. The manufacturer shall not be liable for any special, incidental or consequential damages, whether in contract, tort, or otherwise.



) is indicated.

WHENEVER HAZARDOUS VOLTAGES (> 36 V) ARE USED, TAKE ALL MEASURES TO AVOID ACCIDENTAL CONTACT WITH ANY LIVE COMPONENTS AND TERMINALS.

Isolated AC voltage as application power supply is recommended.

Use USB-Serial COM to control the instrument is recommended when applied for high –voltage circuits, and if possible, add an USB isolator (USB to USB isolation module) between the host device and this instrument.

Output of the instrument is passive (resistance), it has well isolated with driver circuits that powered by Li-Polymer battery. There will be no high power voltage generated or stored by the instrument itself.

DO NOT APPLY ANY VOLTAGES TO THE TERMINALS OF THIS INSTRUMENT IN EXCESS OF THE MAXIMUM LIMITS, ELSE ACCURACY MAY BE AFFECTED OR HAVE IT DAMAGED PERMINIENTLY. SET OUTPUT LIMIT IN ADVANCE TO AVIOD "SHORT CUT" DANGER DURING OPERATION.

#### 1. Introduction

As a candidate of replacing/upgrading conventional resistance decade box<sup>1</sup>, QR10 has as good as, if not better than, top class of the latter on accuracy, range, resolution/step, repeatbility and T.C.R. It provides "better operation experience<sup>2</sup>" on user interface, and, much higher rated power and much smaller dimensions<sup>3</sup>. More importantly, it's just a "programmable" resistance substitution box the way it should be - user can either set desired output value by integrated keypad or remotly control it via USB-Serial COM port. The COM port mentioned makes it suitable for advanced applications such as data acquisition and auto-tests, for example, sensor simulation and sensor auto calibration.

What's more, thanks to the design solution and approach chosen, QR10 can use standard key components to improve quality and reduce cost; And, allowing user calibration makes it easy for maintainance and keeps long-term accuacy as well.

This manual is mainly divided into two parts, which respectively introduce *the key operation* and *the proprietary AT command set* used in USB-to-serial communication. In addition, we also list self-check codes and instrument maintenance suggestions. By the way, *please remind that should always pay attention to danger especially for high voltage application.* 

#### 2. Recommended connection



To check the accuracy of QR10, 4-wire connection is recommended as the image illustrated above. To avoid noise, a proper grounding of QR10 is recommended especially for > 1  $M\Omega$  measurement. And, if possible, use shielding cables that also properly grounded.

While for 2-wire connection, should always consider the cables' resistance<sup>4</sup>.

2 . Based on a questionnaire. Operating experience is subjective and varies from person to person.

4. Accessory calble resistance is around  $25 \text{ m}\Omega$ .

<sup>1.</sup> Refers to the conventional resistance substitution box using mechanical or other types of switches that need to be manually operated.

<sup>3 .</sup> According to incomplete statistics, the rated power of ordinary wire-wound resistance boxes is mostly 0.2 W  $\sim$  0.5 W. The QR10 series offers 1.0 W  $\sim$  2.0 W power rating.

### 3. Keypad operation (since FW v5.93)

Item	Function/Display	Operation	Note/Example
1	Boot up (ON)	Press and hold the red key $igodoldsymbol{\Theta}$ until you see the startup screen	
1.1	Display auto turn off	The screen turns off automatically after 1 minute of inactivity. Press any key to wake up the screen.	USB-Serial COM still working properly under this condition
2	Shutdown (OFF)	Press and hold the red key 🛑 until the screen dims or shuts off	
2.1	Auto shutdown	Without USB cable power supply, the system will shut down automatically after 1 hour of inactivity of key operation; With USB cable, auto shutdown is disabled.	
		Page 0 (main page)	
3	Page O (main page)	If there is no other operation after booting, the screen that displays "UBy default, row SP is hidden (except SP unit). To show SP, hold • for 1.5 s.	
3.1	Set SP	On page 0: Number key 0~9 / the black key ● (decimal point) + the red key ● (enter/ok)	Note: The first digit of the set value cannot be a decimal point.
3.2	Cancel SP setting	<ul> <li>During 3.1 editing (before click the red key):</li> <li>double click ● to cancal editing.</li> <li>Two decimal points in the SP string like "123.45." will also cancel editing.</li> </ul>	The system will return to page 0
3.3	Change SP unit	On page 0: Click $\bullet$ , SP unit changes in the order of " $\Omega$ " $\rightarrow$ "K(k $\Omega$ )" $\rightarrow$ "M(M $\Omega$ )"	
3.4	Rated power	On page 0: The first line "U<" indicates the rated voltage of the current PV	After each update of SP, the corresponding rated voltage value also refreshed.
3.5	Output value (PV)	On page 0/2, row 3	Definition of the accuracy is based on PV and its corresponding reference value.
		Page 1 (sensor page)	
4	Page 1	On page 0, click ● to switch to page 1	
4.1	Battery voltage (VB)	On page 1 (row 1)	Cannot boot up if VB<3.6 V. Normal VB ranges from 3.6 V (low power) ~ 4.2 V (fully charged)
4.2	Temperature Sensor (TS)	On Page 1 (row 2)	It might be 1~2 degrees higher than ambient temperature when the device warmed up
4.3	Back to page 0	On page 1, click 🖲,	

### Keypad operation(continued)

Page 2 (output limit page)					
5	Page 2	On page 1, click ● to switch to page 2			
5.1	Output min. limit (R>)	On the first row of page 2	"R>"default value is "0", i.e. any SP that greater than "0" is allowed		
5.2	Set output min. limit (R>)	On page 2: Number key 0~9 / the black key ● (decimal point) + the red key ● (enter/ok)	If current SP < limit value, Output (PV) will be forced to be the latter and with a mark "*" on display near "PV".		
5.3	Set output min. limit (R>) unit	On page 2: Click $\bigcirc$ , unit changes in the order of " $\Omega$ " $\rightarrow$ "K(k $\Omega$ )" $\rightarrow$ "M(M $\Omega$ )"	The weight of number key changes according to "unit".		
5.4	Back to page 0	<ul> <li>After set a new limit value, click </li> <li>again to return to page 0;</li> <li>Click </li> <li>back to page 0.</li> </ul>			
	Device information				
6	Device info. (1/3)	On page 0: Use combination keys "• + number key ①" to view device info. (1/3): - Device Type / order code - Step (STP) - Tolerance (TOL) - Output range (RGE)	Note: When device info. is displaying, some AT commands cannot be executed in real time. Screen demo of device info. (1/3): STP 0.1R TO 1K-R1 KGE 18:877 KGE 19:877 KGE 19:8777 KGE 19:8777 KGE 19:8777 KGE 19:8777 KGE 19:87777 KGE 19:87777 KGE 19:87777777 KGE 19:8777777777777777777777777777777777777		
6.1	Device info. (2/3)	In the state of item 6: Click •: - T.C.R(TCR) - Calibration temperature (C/T) - Rated power (PWR) - Operating Temperature Range (OTR)	Screen demo of device info. (2/3):		
6.2	Device info. (3/3)	In the state of item 6.1: Click  - Hardware version (H/W) - Firmware version (H/W) - Serial Number (S/N) - Production date (PRD), yyyymmdd	Screen demo of device info. (3/3):		
6.3	Back to page O	In the state of item 6.2: Click ● or wait about 30 sec.			

### Keypad operation(continued)

Auto-scanning			
7	Auto-scanning (1/2)	<ul> <li>On page 0:</li> <li>Use combination keys "● + number key ②" to enter auto-scanning setting menu: <ul> <li>Enable auto-scanning (EN), click ● to switch between "ON" and "OFF"</li> <li>Loop (LOP), click ● to switch between "YES" and "NO"</li> <li>Scanning direction (DIR), click ● to switch between "+, INC (increasing)" and "-, DEC (decreasing)"</li> </ul> </li> </ul>	More flexible scanning functions can be realized via AT commands
7.1	Auto-scanning (2/2)	<ul> <li>Scanning period (ΔT), use number keys to enter a value from 1 s to 99 s.</li> <li>Scanning steps (ΔR), use number keys + ● (decimal point) to enter a value</li> <li>Scanning range low (MIN), same as above</li> <li>Scanning range high (MAX), ), same as above</li> </ul>	Units of $\Delta R$ , MIN and MAX are non-editable, but they can be changed automatically based on current (setting) value.
7.2	Save & activate following item	Click ● to save current item and activate the following item	The ■ is used to indicate the active row which is editable.
7.3	Set initial value for scanning	<ul> <li>Set it via SP on page 0 before auto- scanning is enabled (recommended)</li> <li>Set it on page 0 after auto-scanning is enabled (SP unit is fixed to "Ω")</li> <li>via AT command</li> </ul>	By default, scanning initial value is current SP.
7.4	Pause/start	Click ● to pause/start auto-scanning during the operation on page 0	(img) A "*" before SP to indicate SP is modified by auto-sacnning; a "  " means "pause of auto-scanning"

### Keypad operation(continued)

	User calibration				
8	User calibration	On page 0: Use combination keys "• + number key ③" to enter user calibration setting menu.	Connect reference multimeter probes to QR10 binding posts first. 4-wire conenction is recommended.		
8.1	Exit	Hold ● for 1.5 sec. to return to main page.	All editing items have saved before exit. For FW v5.93~v5.96, need to re- boot the device after new setting.		
8.2	Enable(EN)	<ul> <li>Click  <ul> <li>to switch between "ON" and "OFF".</li> <li>"ON": use user calibration data as reference</li> <li>"OFF" use factory calibration data as reference</li> </ul> </li> </ul>	On main page row 1, <b>F</b> indicates "factory calibration data is in application" while <b>U</b> stands for "user calibration data is in application".		
8.3	<i>Record calibration temperature (C/T) – 1/28</i>	<ul> <li>Click ● to load a value from the built-in temperature sensor (recommended)</li> <li>Click ● again to cancel, or click ● to confirm.</li> </ul>	Can also set the value via keypad (refer to 3.1). Still can edit (set a new value) after confirmation.		
8.4	Save & pagedown	Click ● to save current item and turning to next page			
8.5	Record min. output (RMIN – 2/28)	<ul> <li>Set the reference value via keypad (refer to 3.1),</li> <li>Or click ● to load a default value and click ● to confirm.</li> </ul>	Default values can be used to check the "healthy" of the device as relays getting aged.		
8.6	<i>Record calibration point 0 (R00 – 3/28)</i>	<ul> <li>Set the reference value via keypad (refer to 3.1),</li> <li>Or click ● to load a default value and click ● again to cancel / click ● to confirm.</li> </ul>			
8.7	<i>Record calibration point 1 (R01 – 4/28)</i>	<ul> <li>Set the reference value via keypad (refer to 3.1),</li> <li>Or click ● to load a default value and click ● again to cancel / click ● to confirm.</li> </ul>			
•••	<i>Record calibration</i> <i>Point 2 ~ point 23</i>		R02~R23, all the same operation as 8.5~8.7 methioned		
8.8	<i>Record calibration max. output(RMAX – 27/28)</i>	<ul> <li>Set the reference value via keypad (refer to 3.1),</li> <li>Or click ● to load a default value and click ● again to cancel / click ● to confirm.</li> </ul>	For $> 1 M\Omega$ value, may need to wait several minutes untill it get stable.		
8.9	<i>Record calibration</i> <i>date</i>	Set date via keypad nuber keys. A string of 8 bytes is free for saving.	After save & pagedown operation (8.4), return to main page and new setting take effect immediately (for FW <i>v5.93~v5.96, need to re-boot the device</i> )		

### 4. Proprietary AT Command Set

User can remotly control the instrument and check device information via serial COM software (there're many such kind of freewares available).

Configuration				
Driver IC	WCH CH340	<u>WIN driver link</u>		
Driver installation	Turn on the instrument, and connect it to PC via USB type-C cable. Select the driver to install manually or let PC do auto-scanning for installation.	After successful installation, following information can be found through Device Manager (Windows):		
Baudrate & settings	115,200 bps, 8 byte, none checksum, 1 bit stop			
End mark (EOT)	\r or \n	Necessary for each command.		

#### AT Command Set Table

No.	Description	Instruction (need to add '\r' or '\n' at the end of each command)	Default Unit	Example (communication log.)
1	Get Setpoint(SP)	AT+USER.SP?	Ω	TX: AT+USER.SP? <mark>RX:</mark> +USER.SP=1.0000
2	Set SP	AT+USER.SP=< <i>float string</i> >	Ω	TX: AT+USER.SP=2 RX: +OK. RX: SP(R)=2.000 PV(R)=2.009 UMax(V)=1.5 RLimit(R)=0.000 InnerT(C)=27.68
3	Set SP (Increasingly)	AT+USER.SP+=< <i>float string</i> >	Ω	Initial status: SP=2.0 TX: AT+USER.SP+=1 RX: +OK. RX: SP(R)=3.000 PV(R)=3.014 UMax(V)=1.8 RLimit(R)=0.000 InnerT(C)=27.68
4	Set SP (Decreasingly)	AT+USER.SP-=< <i>float string</i> >	Ω	Initial status: SP=3.0 TX: AT+USER.SP-=1 RX: +OK. RX: SP(R)=2.000 PV(R)=2.009 UMax(V)=1.5 RLimit(R)=0.000 InnerT(C)=27.68
5	Get output value ("Process Value", PV)	AT+USER.PV?		TX: AT+USER.PV? <mark>RX</mark> : +USER.PV=10.024

### AT Command Set Table(continued)

6	Get min. output	AT+USER.RLIMIT?	Ω	TX: AT+USER.RLIMIT?
	limit			RX: +USER.RLIMIT=0.0000
7	Set min. output limit	AT+USER.RLIMIT=< <i>float string</i> >	Ω	TX: AT+USER.RLIMIT=10
				RX: +OK.
				RX: SP(R)=2.000
				PV(R)=10.024
				UMax(V)=3.4
				RLimit(R)=10.000
				InnerT(C)=27.59
8	Get inside	AT+USER.T_SENSOR?	°C	TX: AT+USER.T_SENSOR?
	temperature			RX: +USER.T_SENSOR=27.66
9	Get calibration data	AT+UCAL.EN?		TX: AT+UCAL.EN?
	reference source			RX: +UCAL.EN=0
				'1': User calibration data activated
				'0': Factory calibration data activated
10	Enable/disable user	AT+UCAL.EN=<'1'/'0'>		TX: AT+UCAL.EN?
	calibration data			RX: +UCAL.EN=0
				'1': Activate user calibration data
				'0': Activate factory calibration data
11	Get user calibration	AT+UCAL.INFO?	Ω	TX: AT+UCAL.INFO?
	info			RX: +UCAL.INFO:
				USEN =0
				DATE=20221025
				TEMP=27.13
				MAX(cali)=8553299
				MAX(math)=8553284
				MIN =1.0120
				CH0=2.1000
				CH1=3.0500
				CH2=4.9900
12	Get T.C.R	AT+DEV.TCR?	ppm	TX: AT+DEV.TCR?
				RX: +DEV.TCR=25
13	Get device type	AT+DEV.TYPE?		TX: AT+DEV.TYPE?
				RX: +DEV.TYPE=QR101B-AM-1R
14	Get production date	AT+DEV.PROD?		TX: AT+DEV.PROD?
				RX: +DEV.PROD= <yyyymmdd></yyyymmdd>
15	Get serial number	AT+DEV.SN?		TX: AT+DEV.SN?
				RX: +DEV.SN=00000127
16	Get HW version	AT+DEV.HW?		TX: AT+DEV.HW?
				RX: +DEV.HW=5.1N
17	Get FW version	AT+DEV.FW?		TX: AT+DEV.FW?
				RX: +DEV.FW=5.963KS

### 5. Self-check

Item	Display message	Action	
1	Show "VB<*V"	Refuse working if battery voltage <3.6 V. Should recharge it soon.	
	when powered up	"*" represents current battery voltage.	
2	ERR.01	Click the red key to shut down. Please contact the manufacture for solution.	
3	ERR.02	Click the red key to shut down. Please contact the manufacture for solution.	

#### 6. Maintenance (Important)

- Do not overload.
- Do not use it in moisture conditions and avoid water getting in.
- Keep the surface clean (sweat may infiltrate the painting surface of the brass housing and generate rust stain)
- Recharge it every 8 month (battery shelf-life is around 10 month).
   An annual calibration is recommended due to the (more or less) change of relay contact resistance and/or base resistors.



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