SCONTEL
SUPERCONDUCTING NANOTECHNOLOGY

8 Level photon number discriminator (SDC0108)

User Manual

SCONTEL

Software version 0.1.0



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1 General information

1.1 Purpose of the device

This manual describes the **8 Level photon number discriminator** (hereafter **Discriminator**), model `SDC0108`, manufactured by Scontel. **Discriminator** takes the signal from one input of a PNR SSPD receiver, a superconducting single-photon detector with photon-number resolution (photon number resolving). Such a receiver answers an optical pulse with an electrical pulse whose amplitude is proportional to the number of detected photons.

The instrument assigns each input pulse, in real time, to one of eight amplitude levels and counts how many pulses fell on each level. There is one input and eight counting channels: a channel shows the number of pulses in a given amplitude range. Over the selected time interval the counter shows eight values and allows the interval duration and the thresholds that separate the discrimination levels to be set.

The `fc-client.exe` software connects to **Discriminator** through a USB interface or through a network interface. The software is intended for control and monitoring of the device.

1.2 Who this manual is for

The text is written for a specialist who puts **Discriminator** into operation and makes measurements. Familiarity with a receiving system based on SSPDs is assumed, as are the ordinary Windows actions: installing a program, selecting a serial port, and setting an address on the local network.

This manual does not describe building the programs from source code, the electrical circuit, or the internal communication protocol. Button and item names are given as they are written on the screen. The explanations are in English.

1.3 System requirements

Discriminator is powered from a 220–240 V, 50/60 Hz mains supply. It shows information about its operation on its own display and can work in autonomous mode without control from a personal computer. The computer program and its installer are intended for 64-bit Windows 10 or Windows 11. To link a computer to the counter, a free USB port or a local network shared with the counter is required. The USB and Ethernet connectors are on the rear panel.

1.4 Basic concepts

- **Channel** — assignment of an input pulse to one of eight amplitude ranges. On the screens a channel is marked `CH 0` … `CH 7`. A channel trigger is sent as a logic signal

to the `Logic OUT` connector on the rear panel of the device.

- **Gate** — the time interval over which pulses are accumulated. The duration is set in milliseconds; in the program it is `Gate Period`. Until the current time interval has finished, the displayed readings belong to the previous completed interval. The initial value is 1000 ms.
- **Counts per gate** — the number of pulses of that amplitude the channel counted during the last time interval. The on-screen label is `counts / gate`. This is not the sum of pulses over the whole time since power-on.
- **Comparator threshold** — the trigger voltage of the channel input comparator. A trigger of the comparator of channel `CH X` is counted if the next channel does not trigger at the same time. In the settings and during calibration the comparator threshold is set in millivolts, from 0 to 1000 mV. On the screen the threshold is called `Comparator threshold`.
- **USB** — connection of **Discriminator** to a computer with a USB cable. In the Windows program the instrument appears in the list of COM ports.
- **TCP** — connection over a local Ethernet network. The instrument address can be found by a network search or entered manually. The instrument itself obtains the address automatically when a DHCP server is present, or from an IP address, a mask, and a gateway entered manually.

1.5 Version

This user manual corresponds to version 0.1.0 of the counter software. The same number is shown on the title page and is part of the installer name `FastCounterPNR_Setup_0.1.0.exe`. In the header of the Windows program window the version number is shown next to the name `SNSPD-PNR-Counter`.

2 Principle of operation

2.1 Signal under measurement

The PNR SSPD electrical signal is applied to the SMA input connector on the front panel. The receiver answers an optical pulse with one electrical pulse, and the amplitude of that pulse is proportional to the number of detected photons.

In real time the instrument determines which amplitude range the pulse fell into and increases the count of the corresponding channel. The electrical circuit and the list of assemblies are not part of this manual.

2.2 Measured amplitude ranges

Channels `CH 0` … `CH 7` are eight amplitude ranges of one input signal. The boundary of a range is set by the comparator threshold of the channel. On the screen the threshold is named `Comparator threshold`. It is set in millivolts, from 0 to 1000 mV.

A pulse of sufficient amplitude exceeds the threshold of more than one channel. The count of channel `CH X` increases if the comparator of that channel has triggered and the comparator of the next channel has not triggered at the same moment. Channel `CH 7` has no next channel, so its trigger is counted when its own comparator has triggered.

As a result, one input pulse increases the trigger count of only one channel, the channel of the amplitude range the pulse fell into. The logic signal of that trigger is sent to the `Logic OUT` connector on the rear panel.

2.3 Gate measurement interval

The time interval during which pulses are accumulated is called `Gate` in the device's terms. Its duration is set in the program by the `Gate Period` parameter, in milliseconds. The initial value is 1000 ms.

Until the current interval has finished, the screen shows the numbers of the previous completed interval. When the interval ends, these numbers are replaced: each one shows how many pulses of its range arrived during the `Gate` that has just finished.

3 Composition of the instrument

The front panel of **Discriminator** (Figure 1) has an SMA input connector and a touch display. The display shows information about the counter operation and is used to control it.



Figure 1: Front panel

The rear panel (Figure 2) has a power connector marked `220-240 VAC, 50/60 Hz`, a USB connector for a computer, a standard Ethernet connector for a network cable, and a DHS-15 connector. The DHS-15 connector is labeled `Logic OUT`. It carries logic signals that correspond to the triggers of the individual channels.

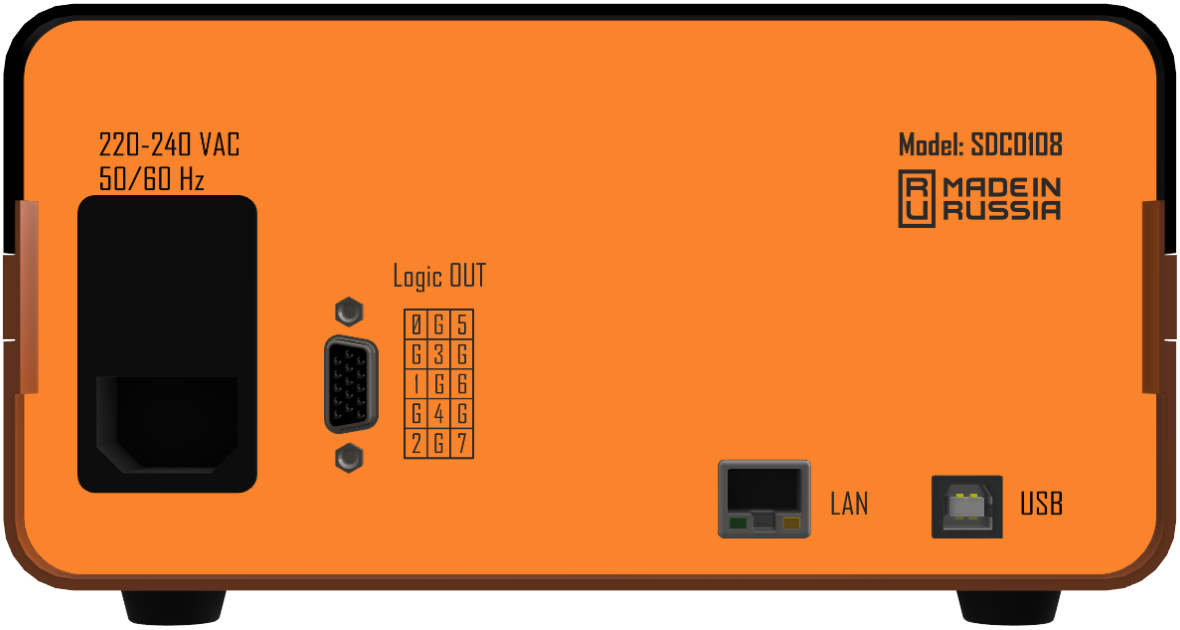


Figure 2: Rear panel

4 Preparation for use

Power is applied to the rear-panel connector marked `220-240 VAC, 50/60 Hz`. After it is switched on, **Discriminator** runs in autonomous mode and shows information on the display.

The PNR SSPD electrical signal is applied to the SMA connector on the front panel.

To control and monitor **Discriminator**, connect it to a computer through the USB or Ethernet connector on the rear panel and start `fc-client.exe`.

5 Display interface

When the instrument is switched on, the display briefly shows the logo, then opens the main screen.

5.1 Main screen

Figure 3 shows the main screen of the application immediately after the device has started. To the right of the title are two unlabeled buttons: one switches the data view (bars/cards), and the other opens the `Settings` screen. The logo on the left opens the device information.

In the card view the screen shows eight cards, `CH 0` … `CH 7` (Figure 3). A card shows the number of detector triggers that correspond to the amplitude range of that channel. When the device starts, before the first data arrive, the channel value is `---`.

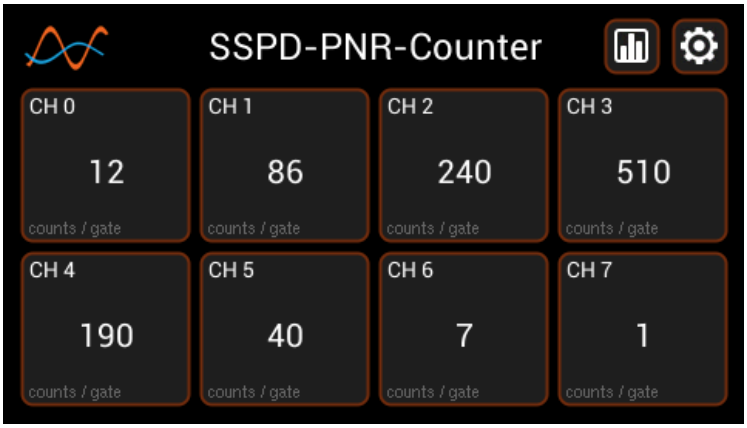


Figure 3: Main screen, card view

In the bar view the channel values are shown as a bar histogram (Figure 4). The count is written above the bar, and the channel name is written below it. The bar height is normalized to the maximum value.

5.2 Settings screen

The `Settings` screen contains all instrument settings. Here the measurement-interval duration, the comparator thresholds, and the network address can be set (Figure 5). Not all settings are shown on the screen. The list can be scrolled with the scrollbar on the right side of the screen, and the list itself also acts as a scrollbar. The arrow in the upper-left corner returns to the main screen and saves the settings.

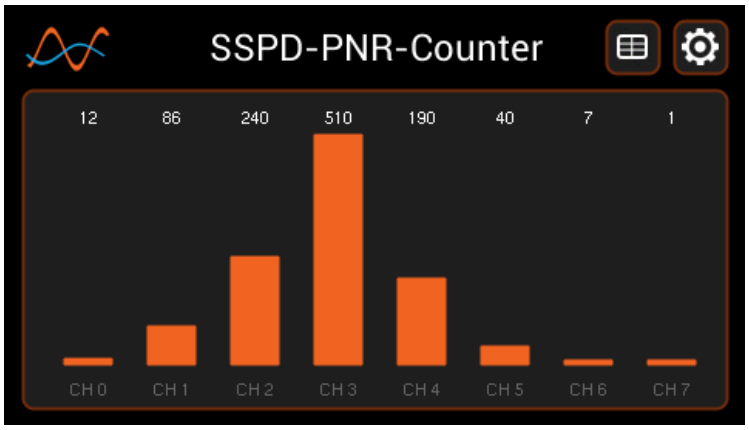


Figure 4: Main screen, bar view

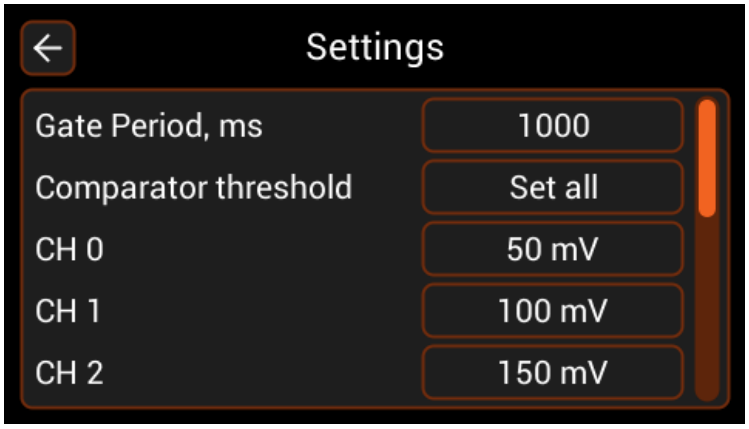


Figure 5: Settings screen

Settings that can be changed: `Gate Period, ms` changes the count measurement period, `Comparator threshold` with the `Set all` button sets one comparator level for all channels at once, `CH 0` … `CH 7` shows the current comparator level of each channel and accepts a new value for the selected channel, and the `Network` switch together with `IP`, `Netmask`, and `Gateway` configures the network for an Ethernet connection. The `Network` switch has the positions `static` and `auto`. In the `auto` position the `IP`, `Netmask`, and `Gateway` rows cannot be edited (Figure 6).

5.3 Entering a value

Pressing the button next to a setting opens the data-entry screen (Figure 7). The entry screen has a keypad, the < button erases the last character, and the `Ok` button applies the entered value. The arrow returns to the `Settings` screen without saving.

For `IP`, `Netmask`, and `Gateway` the entry screen has a `.` key (Figure 8).

`Gate Period, ms` accepts a value from 1 to 60000. Comparator levels accept a value from 0 to 1000.

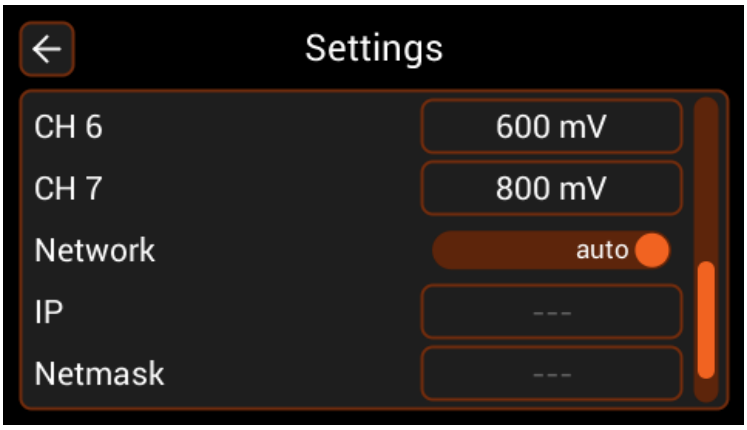


Figure 6: Settings screen, auto position

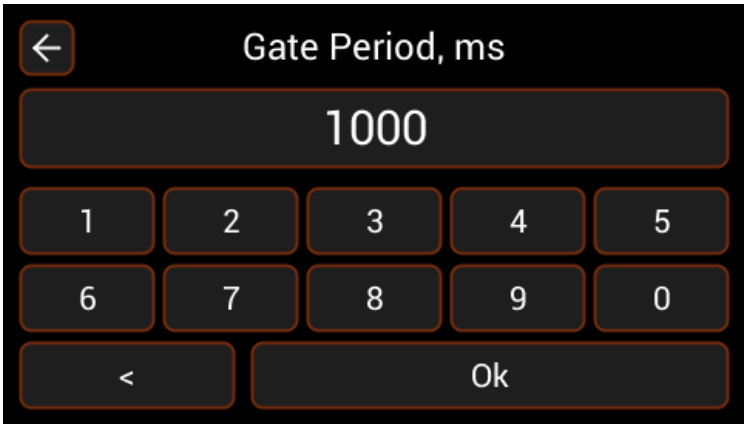


Figure 7: Entering Gate Period, ms

5.4 Device information

The device information screen provides information about the device (Figure 9). The `Close` button returns to the main screen.

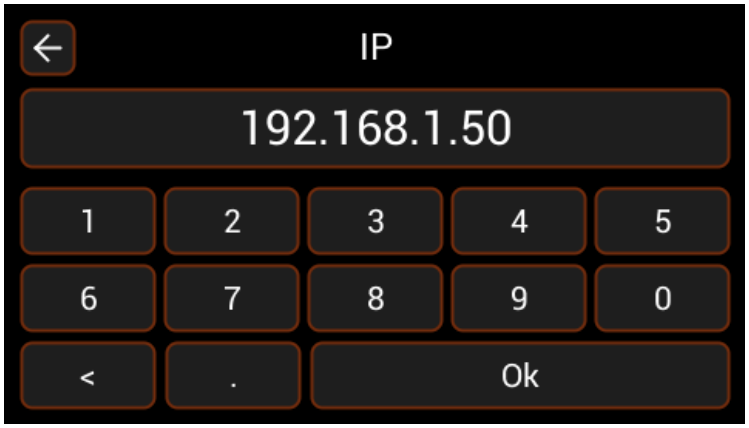


Figure 8: Entering IP

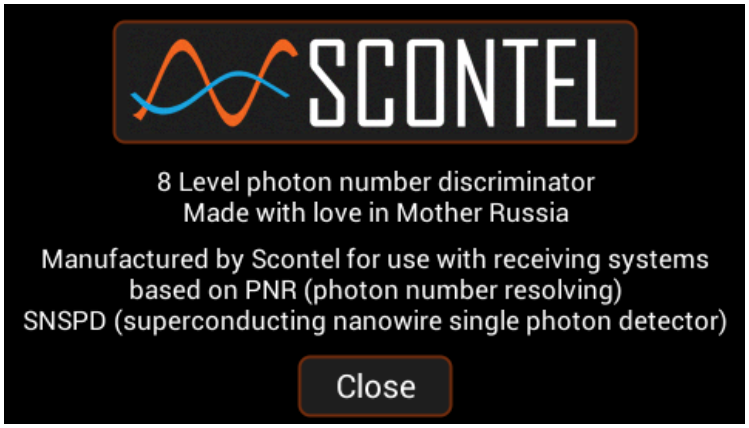


Figure 9: Device information

6 Specifications

The specifications of **Discriminator** are given in Table 1.

Table 1: Specifications

Parameter	Value
Power	220–240 V, 50/60 Hz
Signal input	one, SMA connector
Amplitude ranges	8, `CH 0` … `CH 7`
`Comparator threshold`	0…1000 mV
`Gate Period`	1…60000 ms, initial value 1000 ms
Display	touch screen
Connection to a computer	USB or Ethernet
`Logic OUT`	DHS-15, channel logic signal

7 Installing and removing the PC software

The program `fc-client.exe` is installed with the file `FastCounterPNR_Setup_online.exe`.

An Internet connection is required for installation: the installer downloads the program while the wizard is running (Figure 10).

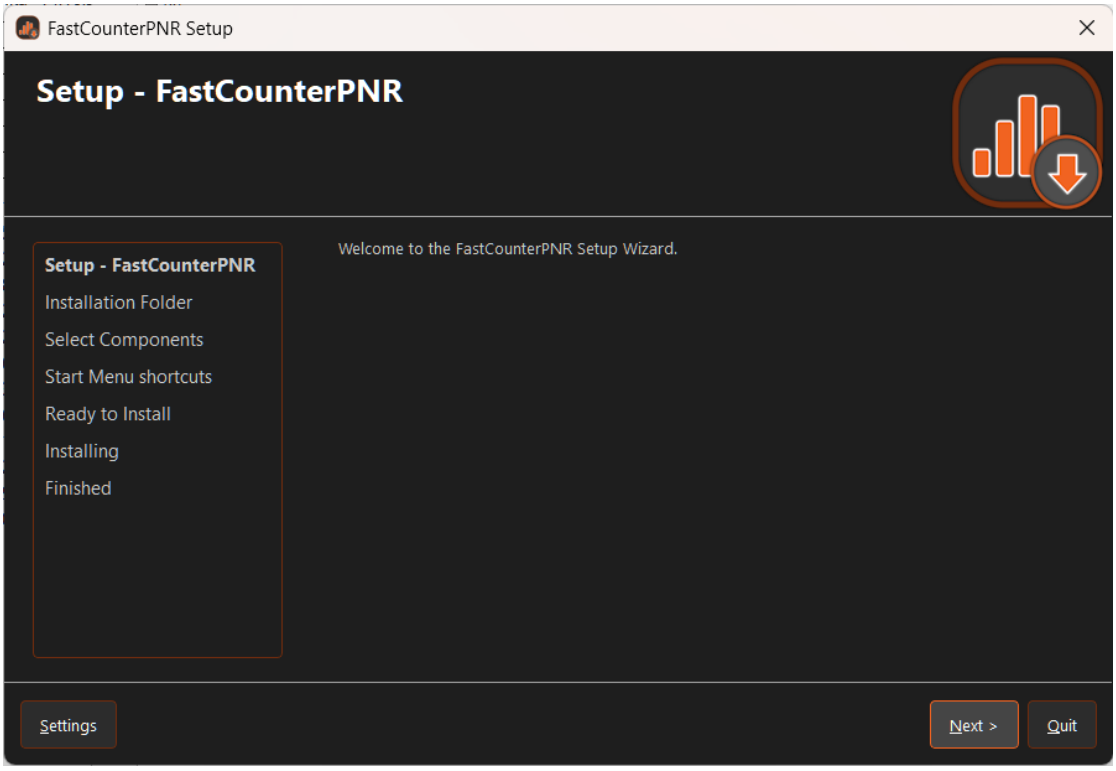


Figure 10: First page of the application setup wizard

The wizard offers an installation folder (Figure 11). By default the path ends with `Scontel/FastCounterPNR`. The folder can be changed.

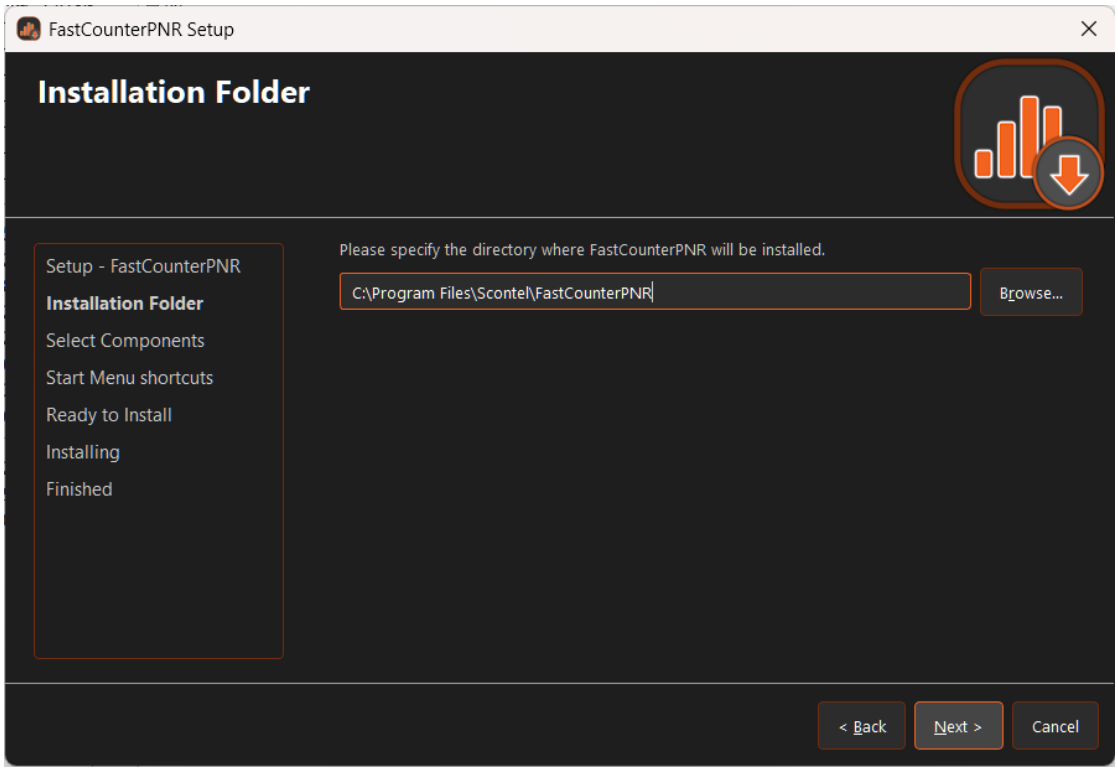


Figure 11: Installation folder

The installation contains one component, `FastCounterPNR Client` (Figure 12).

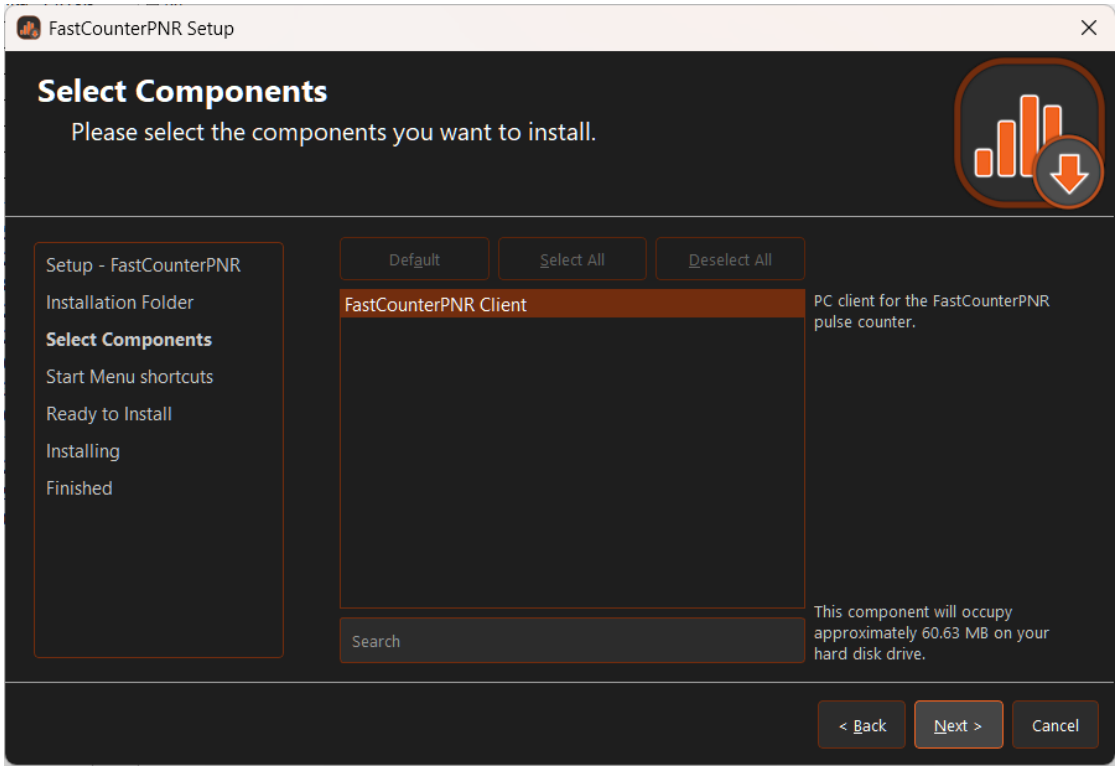


Figure 12: Installation component

A `FastCounterPNR` folder is created in the Start menu (Figure 13).

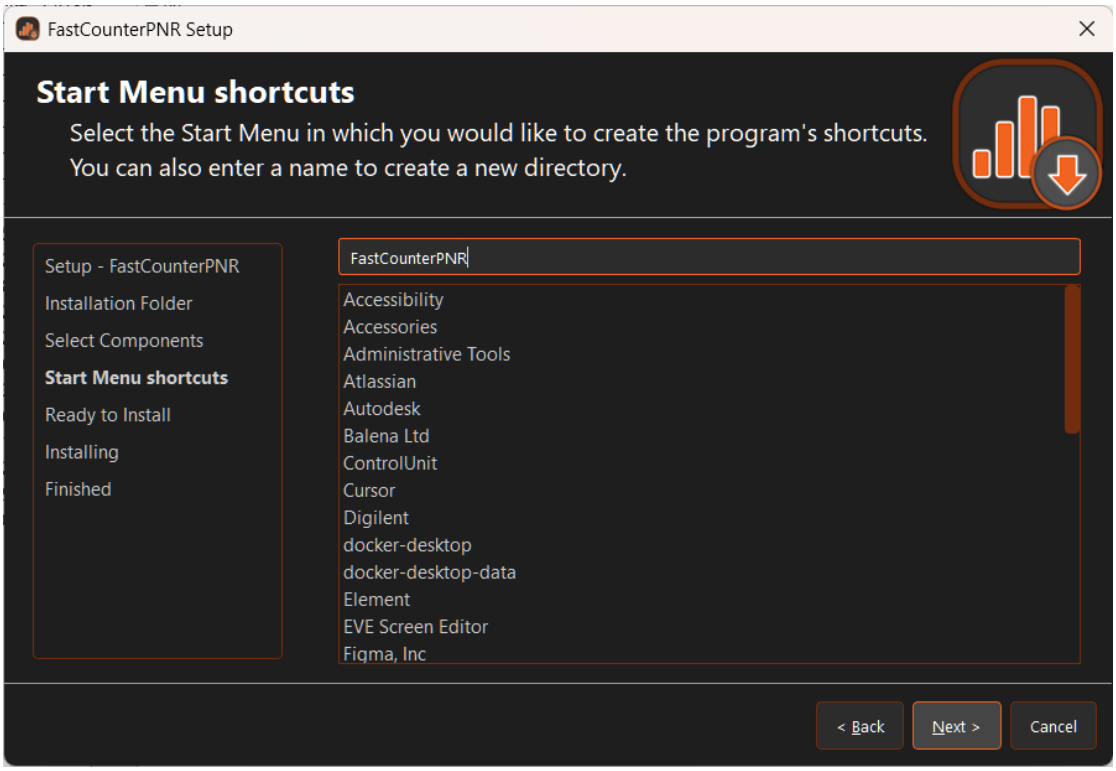


Figure 13: Start menu folder

The `FastCounterPNR` shortcut starts `fc-client.exe`. The same folder contains `FastCounterPNR-Maintenance`.

After confirmation the wizard is ready to install (Figure 14).

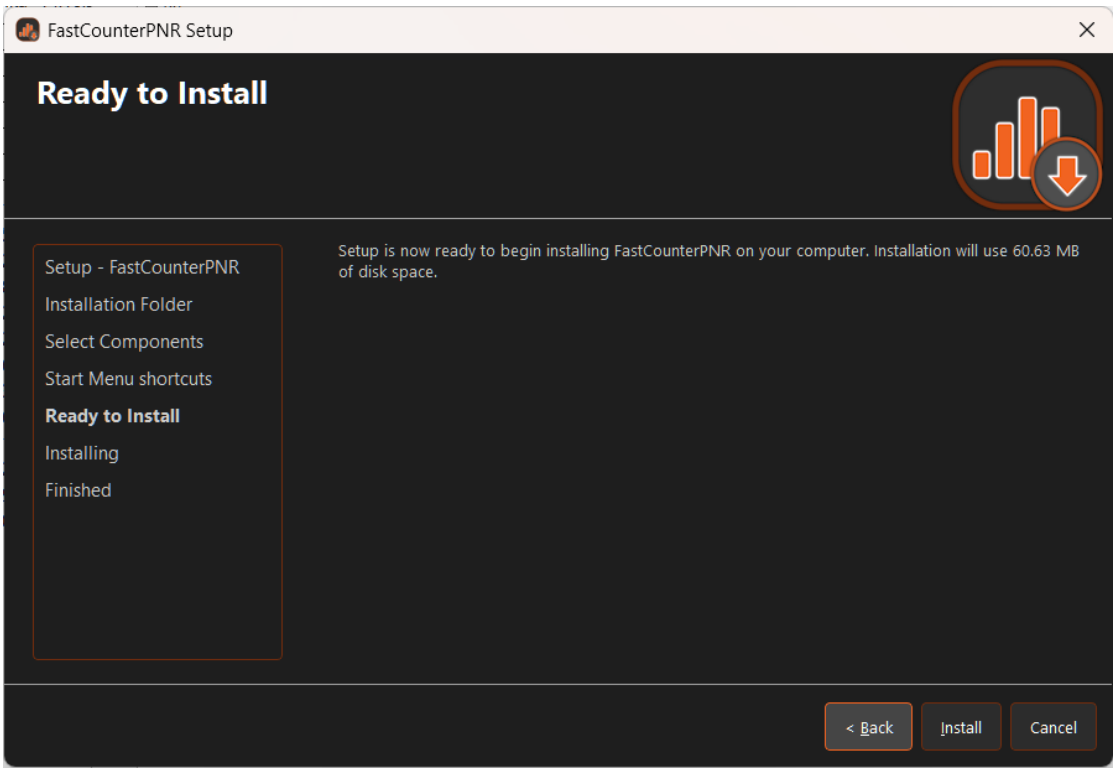


Figure 14: Installation confirmation

The installation then runs (Figure 15).

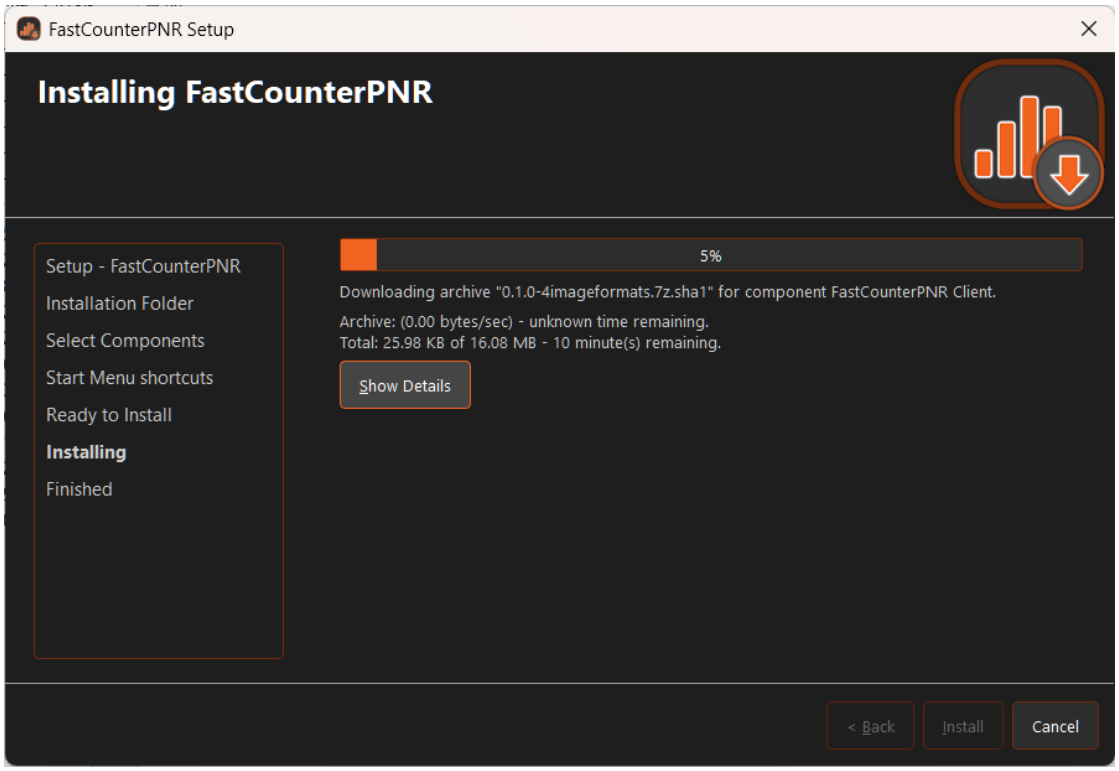


Figure 15: Installation progress

On the last page the `FastCounterPNR Client` item starts the program (Figure 16).

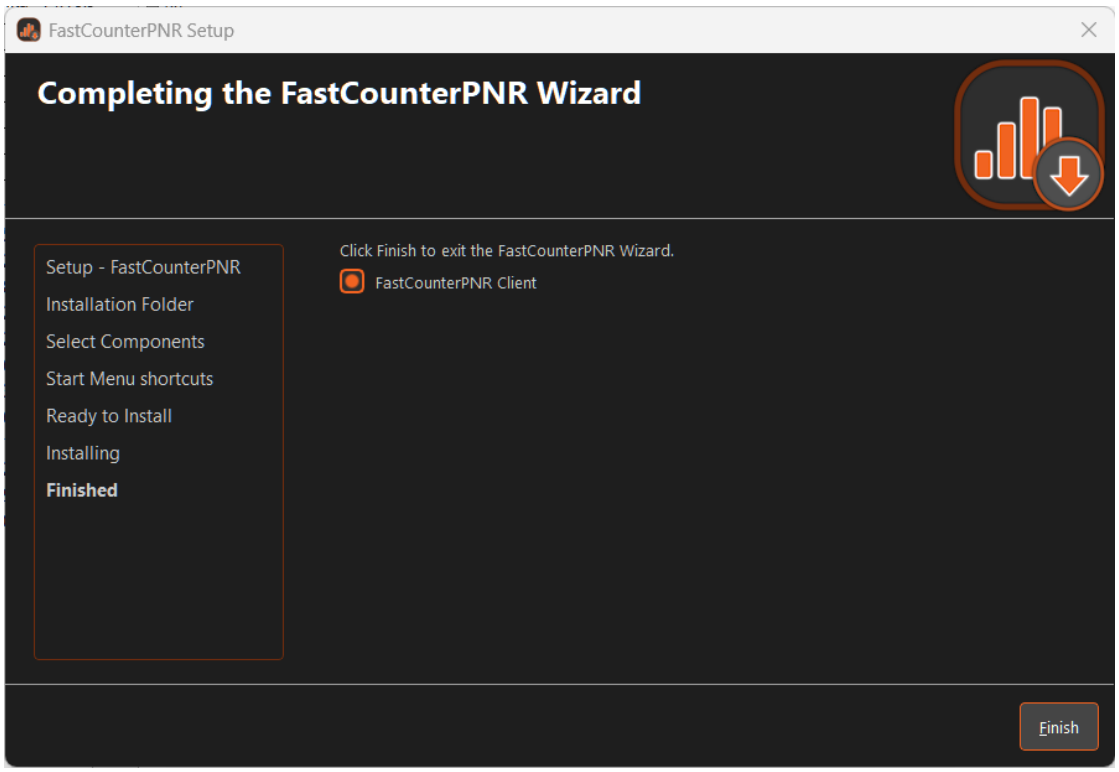


Figure 16: Installation finished

Removal, update, and modification are performed by the `FastCounterPNR-Maintenance` utility, located in the directory where the program was installed. The same utility is started when the software is removed or changed by the standard Windows methods. The first page of the utility contains three items (Figure 17).

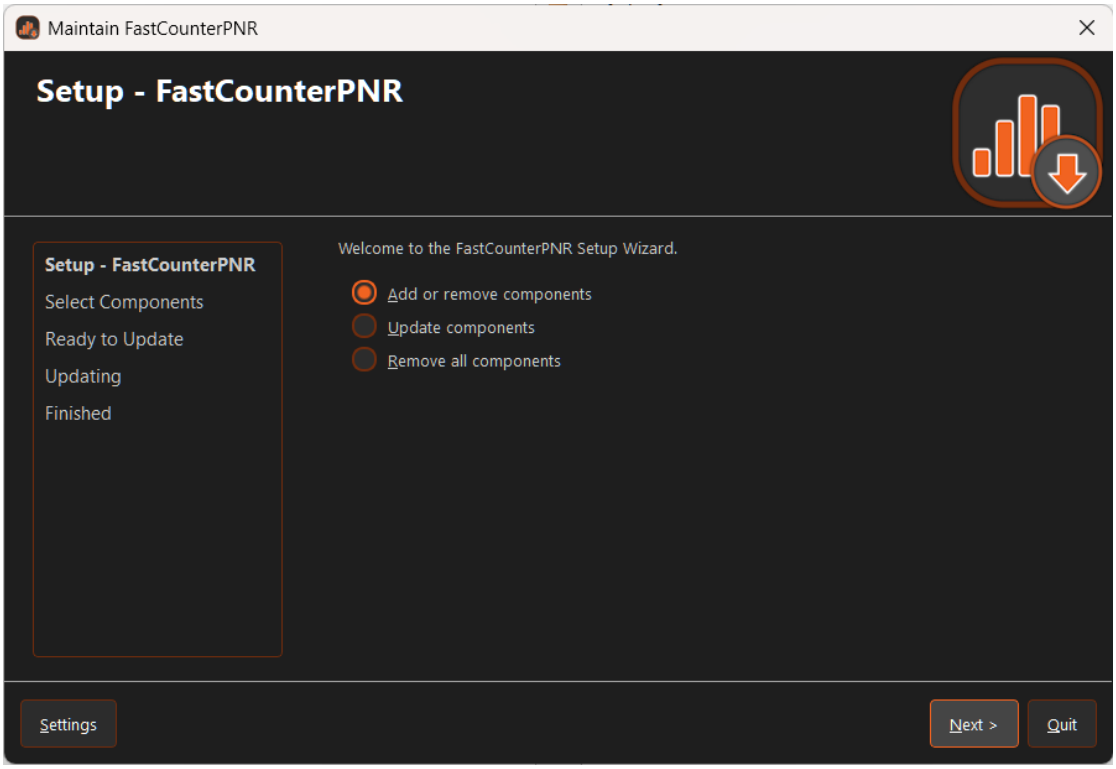


Figure 17: First page of the software update and removal utility

To remove the software, choose `Remove all components`. The `Ready to Uninstall` page opens (Figure 18). It states that the program directory will be deleted entirely. The `Uninstall` button starts the removal.

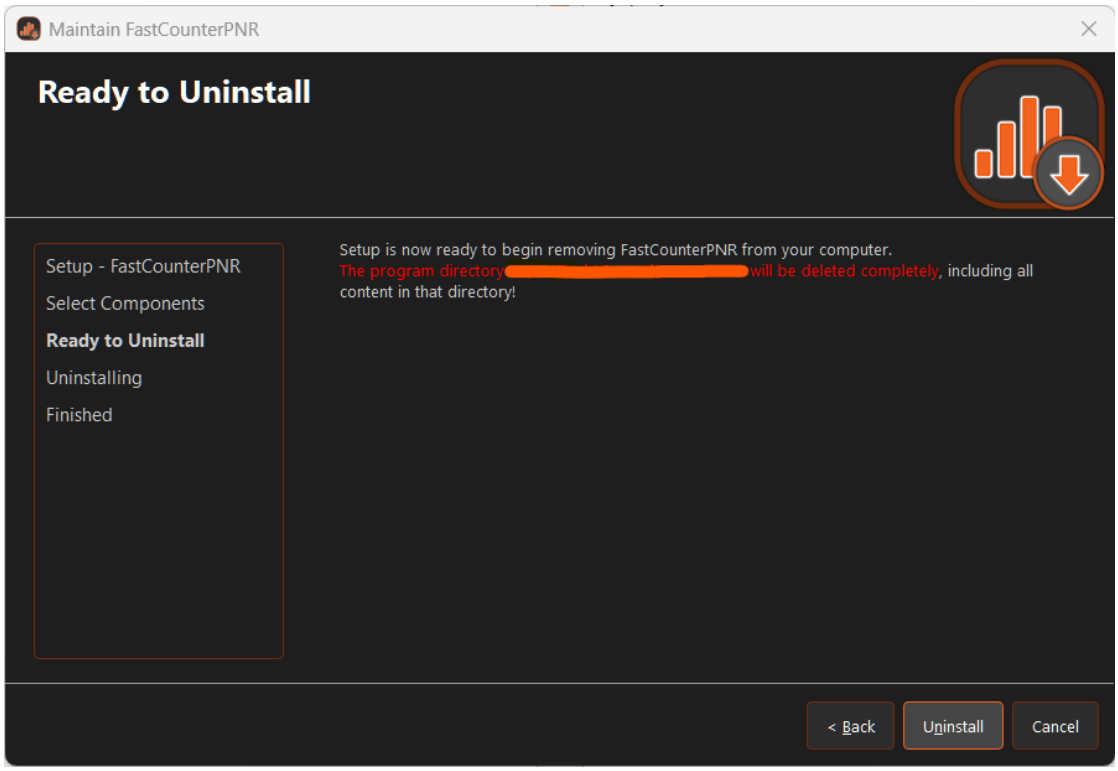


Figure 18: Removal confirmation

The `Finish` button closes the wizard (Figure 19).

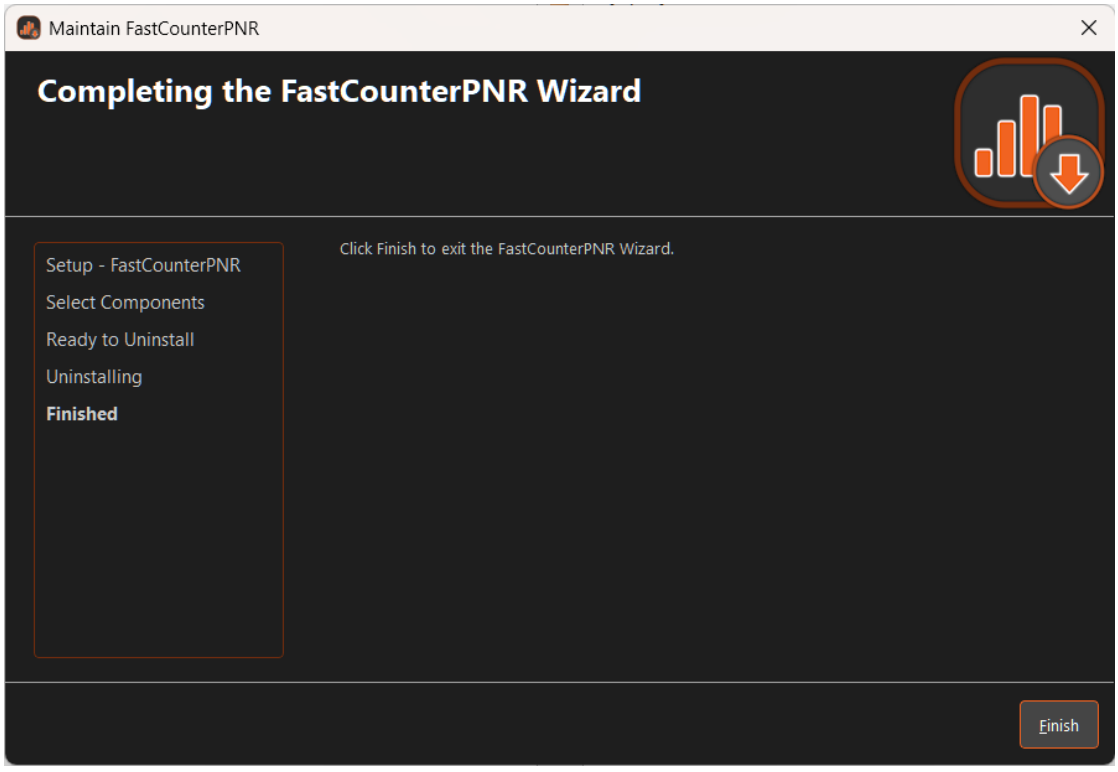


Figure 19: Removal finished

`Update components` checks for updates. An Internet connection is required for this.

`Add or remove components` shows the installation contents. There is one component, `FastCounterPNR Client`. Its check mark cannot be cleared.

8 Working with the program

8.1 Program window

The program `fc-client.exe` shows the **Discriminator** counts on the computer, their change over time, and writes the data to a file. Device calibration is available for choosing the correct comparator level of each channel. The interval duration, the thresholds, and the network address are set with the same parameters as on the instrument display.

On the left of the top row of the main window are the USB and TCP buttons, the COM-port and TCP-address field, and the `Connect` button. After connection this button is named `Disconnect`. On the right are the `Cards`, `Counts vs time`, `Bar chart`, `Calibration`, and `Settings` buttons. The buttons have no captions: the name appears as a tooltip when the pointer is over the button.

When the program starts, the `Cards` view is open. The `Counts vs time`, `Bar chart`, and `Calibration` views and the `Settings` screen open after a connection to **Discriminator**.

The left side of the bottom row shows the connection state. Before a connection, the state is `Disconnected`. On the right are the name and the software version number (Figure 20).

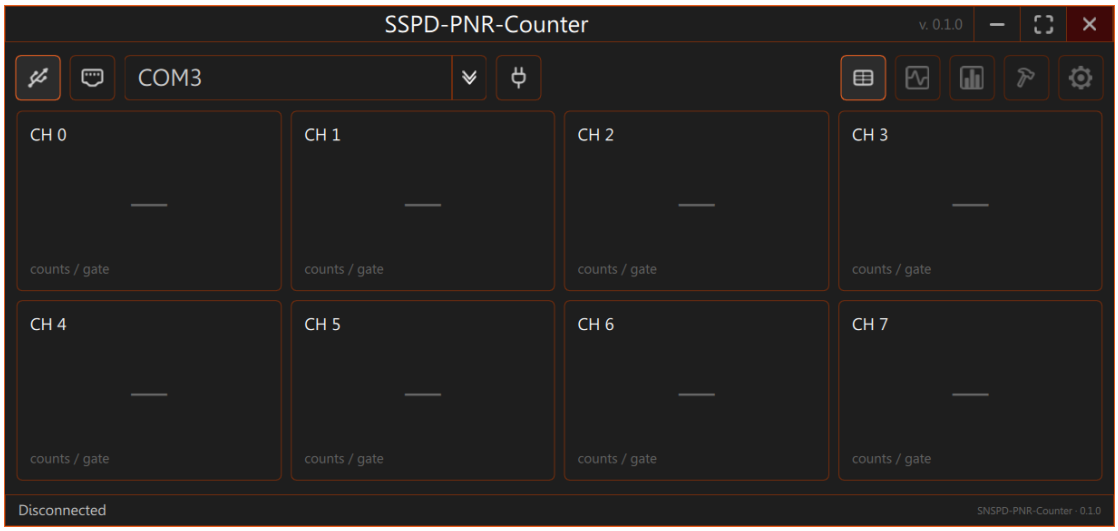


Figure 20: `fc-client` window at startup

8.2 Connection

When the program starts, connection by a USB cable is selected. The field next to it lists the available automatically detected COM ports. If no devices are available, the field shows `No COM ports`. The `Connect` button is available when a port is selected.

The TCP button switches the device to a local-network connection and starts a search for **Discriminator** on the local network. While local devices are being searched for, a circular status indicator is shown in the center of the window (Figure 21). Found addresses are added to the list of available addresses. The device address can also be entered manually after the search ends. The Connect button is available when the device address field contains a valid TCP address.

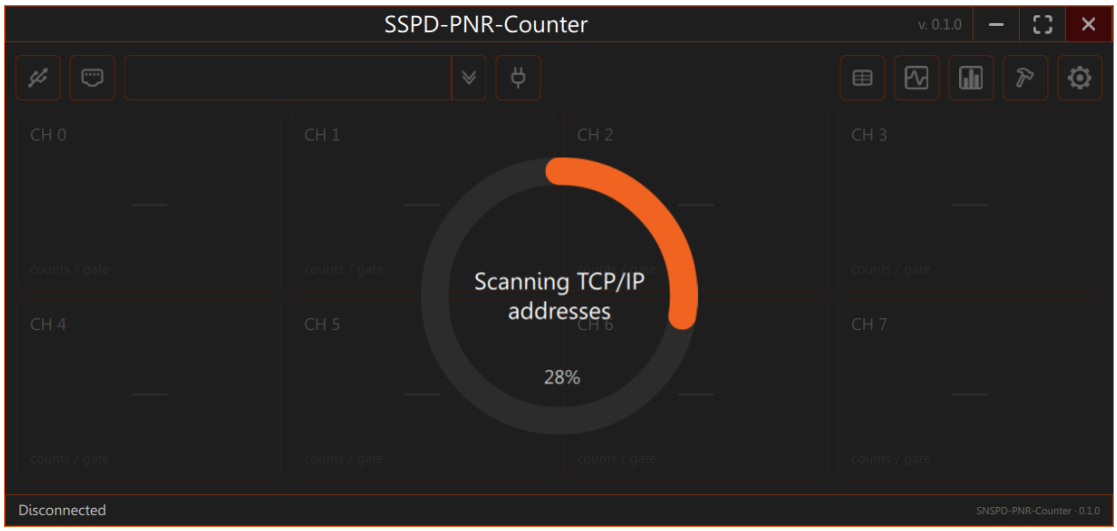


Figure 21: Search for available devices on the local network

After connection, the device status line on the left shows Connected · followed by the port name or the TCP address of the device. If the link was not established, the status line shows the error text.

8.3 Cards display mode

The Cards view shows eight fields, CH 0 … CH 7 (Figure 22). Each field shows the number of registered counts for the amplitude range that corresponds to that measurement channel.

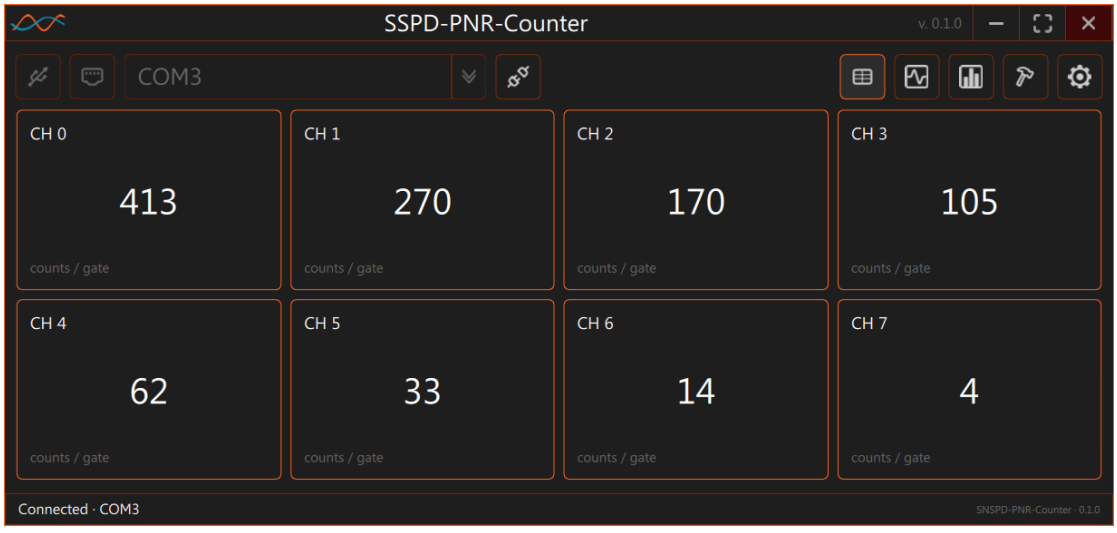


Figure 22: Cards information display

8.4 Software settings

The Settings button opens the device settings (Figure 23). The Back arrow returns to the previous view.

Gate Period, ms sets the count measurement interval. Accepted values: 1...60000 ms. The Apply button sends the selected interval to **Discriminator**.

Comparator thresholds (All channels) sets one comparator threshold for all channels. Accepted values: 0...1000 mV. The Set all button applies the entered value to all channels. The CH 0 … CH 7 fields show the threshold of the corresponding channel in millivolts. A new value is sent to **Discriminator** when the input field is changed.

The Save and Load buttons write and read the current device settings in JSON format.

The Network switch has the positions Static and Auto. In the Auto position the IP, MSK, and GW fields cannot be edited (Figure 24). The Apply button applies the network settings of the device.

Selecting the Write log checkbox saves all received count data to a CSV file. The data are appended to the file. The ... button opens the standard dialog for choosing the file name. Nothing is written during calibration.

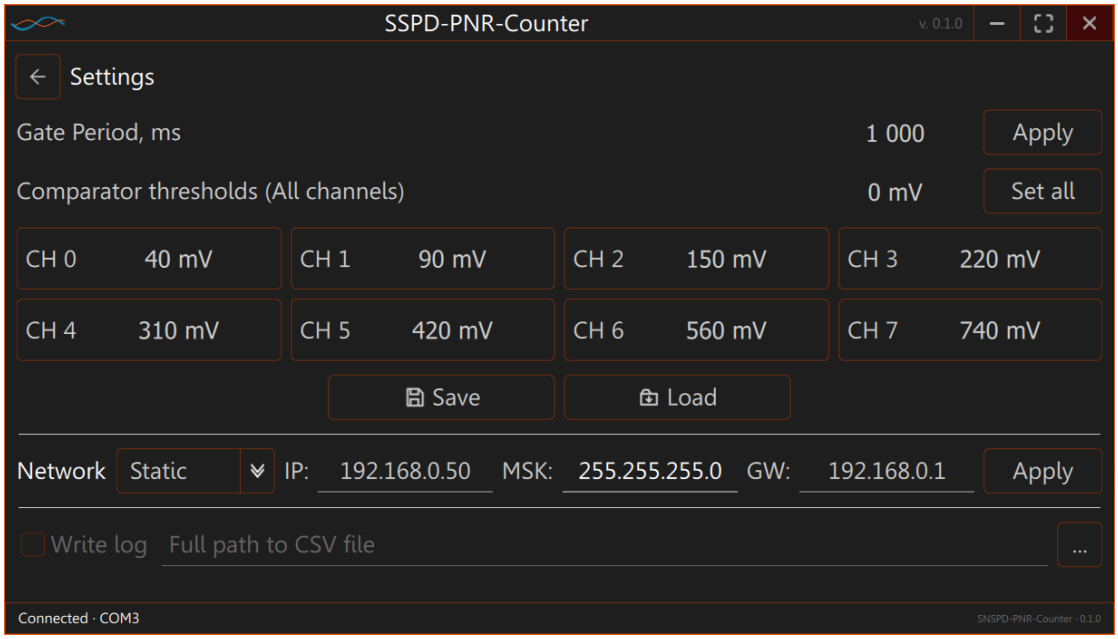


Figure 23: Settings screen

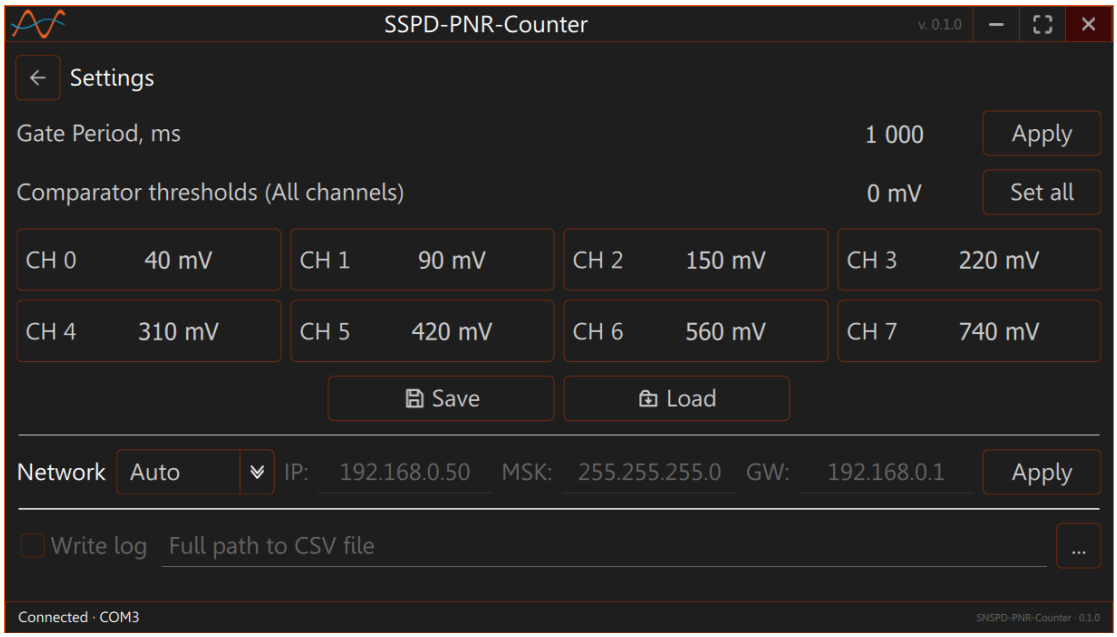


Figure 24: Settings screen, Auto position

8.5 Counts versus time

The `Counts vs time` view shows the channel counts as a function of time (Figure 25). The plot has the lines `CH 0` … `CH 7` and `Total`. A click on a legend label hides the line and shows it again. The button on the right switches the vertical scale between logarithmic and linear.

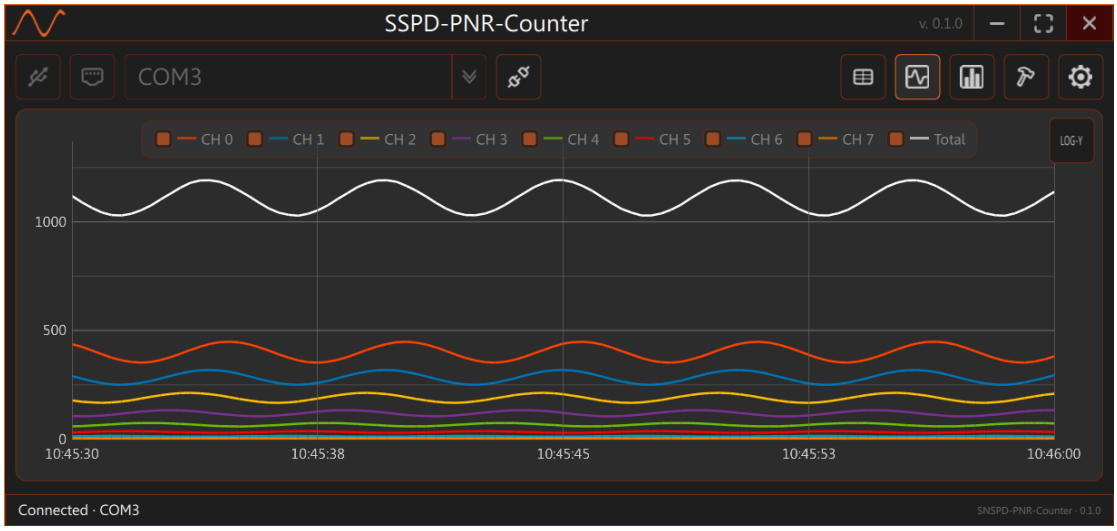


Figure 25: Counts vs time view

8.6 Bar chart

The `Bar chart` view shows the same eight channels as bars (Figure 26). The count is written above the bar. The button on the right switches the vertical scale between logarithmic and linear.

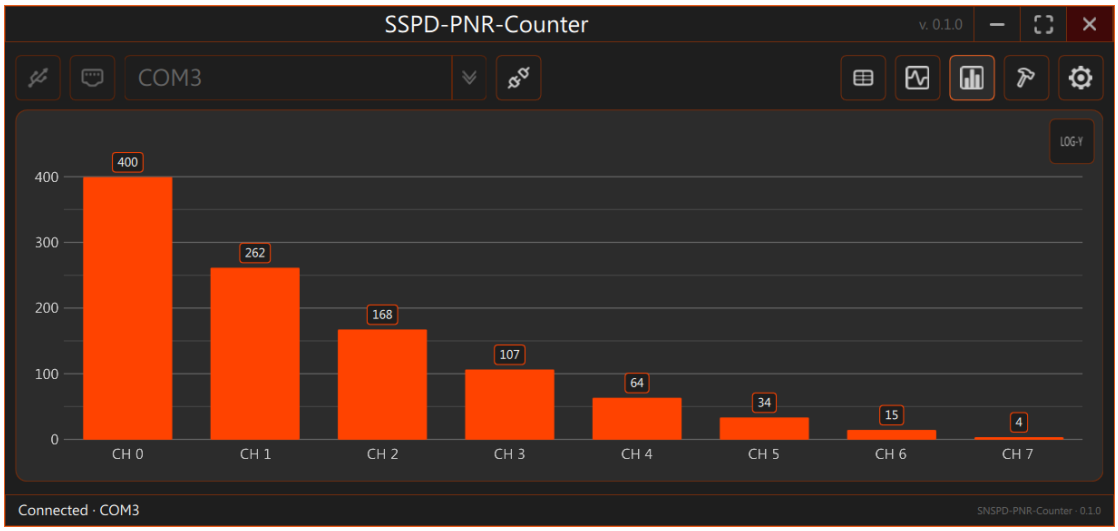


Figure 26: Bar chart view

8.7 Device calibration

In the `Calibration` mode, a measurement starts by changing the comparator threshold of the selected channel and measuring the number of counts against that threshold (Figure 27). In the `Sweep Parameter` block, `Channel`, `From (mV)`, `To (mV)`, and `Step (mV)` are set. The threshold fields accept values from 0 to 1000, and the step is from 1. `Start` begins the measurement, and `Stop` interrupts it.

For the duration of the sweep, the thresholds of the other channels are set to 1000 mV. When the sweep ends, or when `Stop` is pressed, the thresholds of all channels return to the values they had before the measurement.

A click on the plot opens an auxiliary context menu that sets the comparator threshold of the selected channel. `Save CSV` saves the calibration curve as `csv`. The button on the right switches the vertical scale between logarithmic and linear.

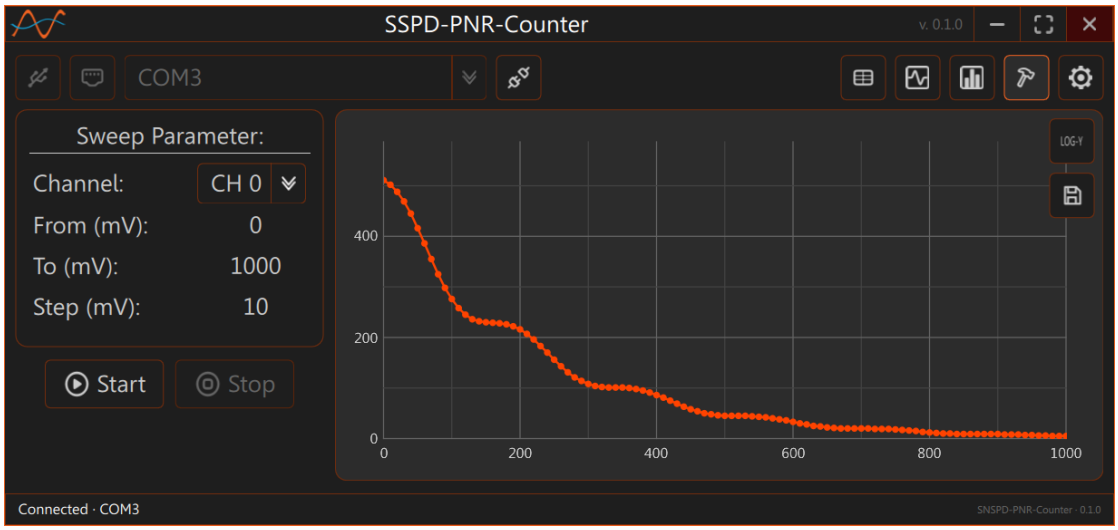


Figure 27: Calibration view