## 16.2 NC150

### 16.2.1 General Information

The NC150 counter module is mainly used for positioning tasks. The most important areas of use are the single or dual axis controller and calculating path and position.

### 16.2.2 Order Data

| Model Number | Short Description | Image |
|---|---|---|
| 3NC150.6 | 2005 counter module, 2 inputs for incremental encoder, 32-bit, input frequency 100 kHz, encoder supply 5 to 30 VDC, 2 analog outputs +/- 10 V, 12-bit, 8-pin. Terminal block is included in the delivery. |  |
| Additional accessories see sections "Accessories" and "Manuals". | | |



Table 371: NC150 order data

### 16.2.3 Technical Data

| Product ID | NC150 |
|---|---|
| **General Information** | |
| C-UL-US Listed | Yes |
| B&R ID Code | $98 |
| Slot<br>Main Rack<br>Expansion Rack | <br>Yes<br>Yes |
| Status Display | LEDs |
| Power Consumption<br>5 V<br>24 V<br>Total | <br>Max. 1.5 W<br>Max. 3.5 W<br>Max. 5 W |
| **Encoder 1 and 2** | |
| Design of the Signal Encoder Connections | Two 9-pin DSUB sockets |
| Encoder Inputs | Symmetric and asymmetric |
| Electrical Isolation<br>Input - PLC<br>Input - Input | <br>Yes<br>No |
| Encoder Supply<br>Module Requirements | 5 to 30 V external<br>Typically 40 mA at 5 V / 120 mA at 30 V |
| Input Filter | 2 times can be set using software |
| Input Frequency<br>Short Filter Time<br>Long Filter Time | <br>Max. 100 kHz<br>Max. 20 kHz |
| Counter Frequency with 4x Evaluation | Max. 400 kHz |
| Phase Offset between Counter Channels A and B | 90° ±45° |
| Counters<br>Amount<br>Counter Size<br>Operating Modes [1)] | <br>2<br>32-bit<br>Incremental (4x, 2x and 1x evaluation) up/down counter |
| **Analog Outputs** | |
| Amount | 2 |
| Output Voltage | -10 V to +10 V |
| Digital Converter Resolution | 12-bit |
| Max. Load per Output | ±10 mA (load ≥1 kΩ) |
| Conversion Time for All Outputs | 35 µs |
| Short Circuit Protection (current limit) | Current limit to >20 mA |

Table 372: NC150 technical data

| Product ID | NC150 |
|---|---|
| Precision<br>Basic Accuracy (at 20° C)<br>Precision (0 to 60° C) | <br>±0.5%<br>±1.0% |
| Electrical Isolation<br>Output - PLC<br>Output - Output<br>Counter Channels - Analog Outputs | <br>Yes<br>No<br>Yes |
| **Mechanical Characteristics** | |
| Dimensions | B&R 2005 single-width |

Table 372: NC150 technical data

1) Can be selected using software.

### 16.2.4 Status LEDs

| Image | LED | Description |
|---|---|---|
|  | UP | Counter counts upwards. |
| | DOWN | Counter counts downwards. |
| | REF | Counter is referenced. |
| | GND OFFSET | The potential offset current on the analog outputs is >15 mA. |

Table 373: NC150 status LEDs

### 16.2.5 Operational and Connection Elements

Two 9-pin DSUB sockets and an 8-pin terminal block are located behind the module door of the NC150 module:

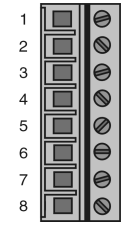
① Connecting socket for encoder 1 (9-pin DSUB socket)

① Connecting socket for encoder 2 (9-pin DSUB socket)

③ 8-pin terminal block with extraction clip for connecting the external encoder supply and two analog outputs.


Figure 197: NC150 operational and connection elements

### 16.2.6 External Encoder Supply / Analog Outputs




8-pin terminal block

| Pin Assignments | |
|---|---|
| 1 | + Analog output 1 |
| 2 | - Analog output 1 |
| 3 | Shield |
| 4 | + Analog output 2 |
| 5 | - Analog output 2 |
| 6 | Shield |
| 7 | + External encoder supply |
| 8 | GND external encoder supply |

Table 374: NC150 external encoder supply / analog outputs

### Encoder Supply

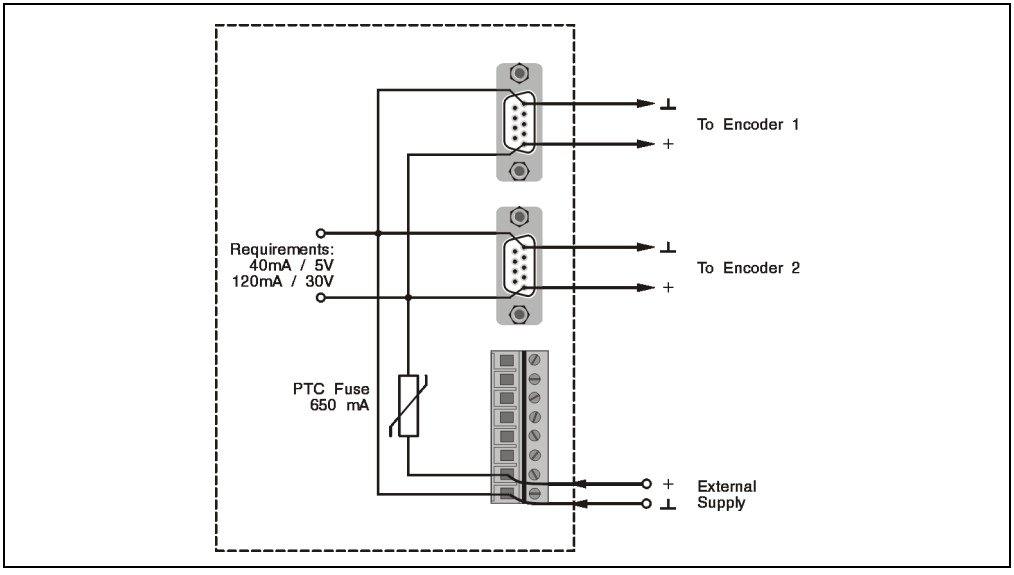



Figure 198: NC150 encoder supply

The encoder must be externally supplied. The encoder supply is fed through the 8-pin terminal block to the module through a polymer PTC protective element (Polyswitch™ [1]). The supply for the input stage of approx. 80 mA (at 24 V) is necessary. The encoder supply is passed on to the encoders using 2 pins on the DSUB sockets.

1) Polyswitch™ is a registered trademark of RAYCHEM.

**The encoders are not permitted to be supplied directly from an external source!**

**Metallic DSUB connectors and shielded cables must be used to connect the encoder (see Chapter 2 "Installation", Section 3 "Grounding and Shielding Measures", on page 69)**

Both symmetrical encoder signals (A, A\, B, B\, Z, Z\), and asymmetrical signals (A, B, Z) can be processed. If an asymmetrical encoder is connected, the inverted inputs are to be linked with pin 9 (trigger level). The connection should be made in the DSUB connector and not in the encoder cable (as shown in the diagram below).

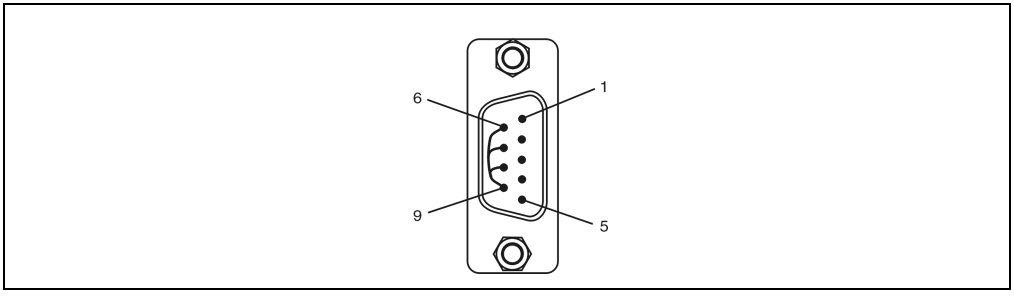



Figure 199: NC150 asymmetrical encoder: inverted inputs connected to the trigger level

The cutoff threshold of the PTC protective element depends on the environmental temperature (at 0° C approx. 800 mA, at 60° C approx. 450 mA). The internal supply (consumption) must also be considered. At a supply of 30 V, consumption of 120 mA and an environmental temperature of 60° C, the maximum amount of current available for the encoder supply would be 330 mA (450 mA - 120 mA).

If an overload or short circuit occurs, the protective element becomes highly resistive and breaks the flow of current. In this case the external supply must be switched off (removing the overload or the short circuit is normally not enough). The reset time of the PTC is approximately 20 seconds.

### 16.2.7 Output Diagram for Analog Outputs

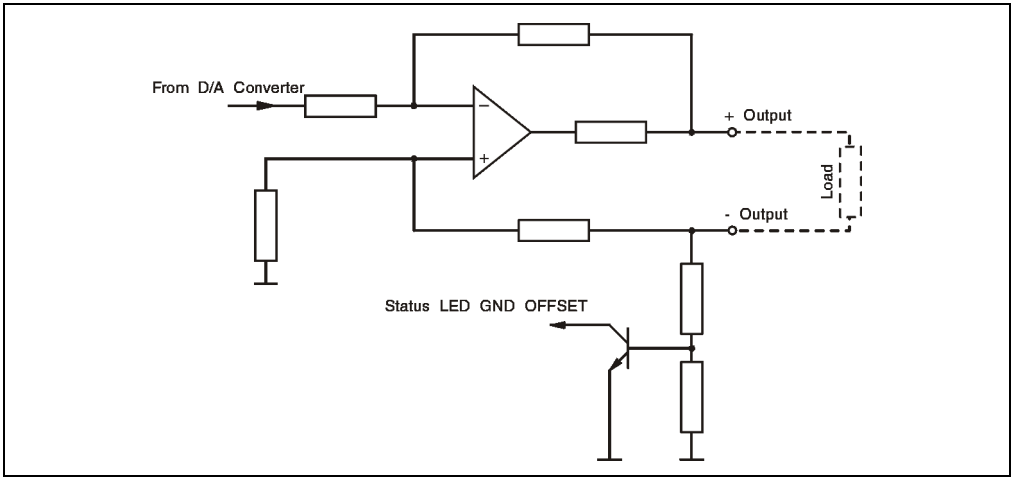
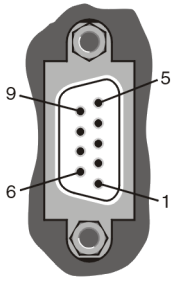



Figure 200: NC150 output diagram for analog outputs

### 16.2.8 Counter Inputs

Both symmetrical and asymmetrical incremental encoders can be connected to the counter inputs. When connecting asymmetrical encoders, the inverted inputs A\, B\ and Z\ are to be connected with the trigger level (pin 9).

**Counter 1 / Counter 2**




9-pin DSUB socket

| Pin Assignments | |
|---|---|
| 1 | + Encoder supply |
| 2 | Counter input A |
| 3 | Counter input B |
| 4 | Reference pulse Z |
| 5 | GND encoder supply |
| 6 | Counter input A\ |
| 7 | Counter input B\ |
| 8 | Reference pulse Z\ |
| 9 | Trigger level |

Table 375: NC150 counter inputs

### Input Circuit for Counter Inputs

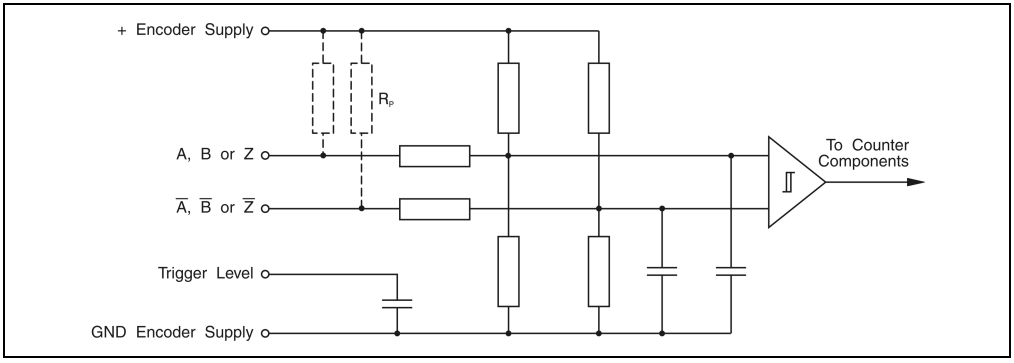



Figure 201: NC150 input circuit for counter inputs

### Signal Level for Counter Inputs

The maximum input level permitted depends heavily on the encoder supply. In practice, the following levels are defined for the most frequently used encoders:

| **5 V Encoder with Differential Outputs (symmetrical encoder)** | |
|---|---|
| Encoder Supply | 5 to 8 V |
| Input Signals<br>Differential Voltage<br>Common Mode Voltage | <br>±0.4 V<br>±7 V |
| **Asymmetrical Encoder with Transistor Outputs** | |
| Encoder Supply | 5 to 30 V (= $V_{encoder}$) |
| Input Signals<br>HIGH<br>LOW<br><br>Switching Threshold | <br>0.4 x $V_{encoder}$ to 2 x $V_{encoder}$ (30 V may not be exceeded)<br>-10 V to 0.16 x $V_{encoder}$<br><br>The thresholds corresponds with TTL levels |
| **Symmetrical Encoder with Transistor Outputs** | |
| Encoder Supply | 5 to 30 V (= $V_{encoder}$) |
| Input Signals<br>HIGH<br>LOW<br><br>Idle Threshold | <br>A, B, Z > A\, B\, Z\ + differential voltage<br>A, B, Z < A\, B\, Z\ - differential voltage<br><br>The idle threshold is logical 0 |
| Differential Voltage for Input Signals ($V_{IN}$) within the Encoder Supply | Differential Voltage = 0.15 x $V_{encoder}$ when GND encoder supply < $V_{IN}$ < $V_{encoder}$ |
| Differential Voltage for Input Signals ($V_{IN}$) for the Entire Modulation Range | Differential voltage = 0.2 x $V_{encoder}$ at 10 V < $V_{IN}$ < 2 x $V_{encoder}$<br>(30 V may not be exceeded) |

Table 376: NC150 signal level for counter inputs

| Encoder with Open Collector Outputs | |
|---|---|
| When using encoders with open collector outputs, an external pull-up resistor ($R_P$) must be switched on. To achieve the HIGH threshold for asymmetrical inputs the pull-up resistor (independent of the external encoder supply) is permitted to have a maximum of 30 kΩ. Normally, the pull-up resistor is not used in situations dealing with speed. | |
| Recommended Values<br>Encoder supply 5 V<br>Encoder supply 24 V | <br>$R_P$ = 300 Ω - 2 kΩ<br>$R_P$ = 1.5 kΩ - 10 kΩ |

Table 376: NC150 signal level for counter inputs (cont.)

### 16.2.9 Variable Declarations

The variable declaration is made in B&R Automation Studio™:

| Function | Variable Declarations | | | | |
|---|---|---|---|---|---|
| | Scope | Data Type | Length | Module Type | Chan. |
| Counter 1 | tc_global | DINT | 1 | Transp.In | 0 |
| Reset Register 1 | tc_global | USINT | 1 | Status Out | 0 |
| Mode Register 1 | tc_global | USINT | 1 | Status Out/In | 1 |
| Counter 2 | tc_global | DINT | 1 | Transp.In | 4 |
| Reset Register 2 | tc_global | USINT | 1 | Status Out | 2 |
| Mode Register 2 | tc_global | USINT | 1 | Status Out/In | 3 |
| Analog Output 1 | tc_global | INT | 1 | Analog Out | 5 |
| Analog Output 2 | tc_global | INT | 1 | Analog Out | 6 |

Table 377: NC150 variable declaration

#### Reset Register X

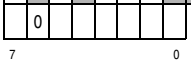
| Reset Register X | Bit | Description |
|---|---|---|
| | 7 | Software reset of the counter status |
| | 0 - 6 | 0 |

| | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|
| 7 | | | | | | | 0 |

Clearing bit 7 in reset register x causes a software reset of the counter status for counter x. Since the status of the variables is transferred after every cycle to the module, this reset is also performed after every cycle . For this reason, bit 7 must be written to with log. 1 again in the following cycle.

## Mode Register X - Write (Status Out)

| Mode Register X<br>Write | Bit | Description |
|---|---|---|
| | 7 | DIS - Mode register disabled |
| | 6 | 0 |
| | 5 | HS - Home Search |
| | 4 | FT - Filter Time |
| | 3 | OM3 |
| | 2 | OM2 - Operating Mode (OM1 - OM3) |
| | 1 | OM1 |
| | 0 | DIR - Counting direction |




**DIS** 0..... The module uses the current values when writing to the mode register.
1..... Changes to bits 0 to 6 have no effect when writing to the module.

Since the status of the variables is transferred to the module after every cycle, the mode register is written to after each cycle when DIS = 0. For this reason, bit 7 must be written to with log. 1 to again in the following cycle.

**RF** 0..... Home search mode is disabled: Reference pulse for the encoder has no affect.
1..... Home search mode is enabled: If a reference pulse occurs, counter x is reset to zero.

**FT** 0..... large filter time (maximum input frequency 20 kHz)
1..... small filter time (maximum input frequency 100 kHz)

**OMx** The operating mode for the counter is set with these three bits:

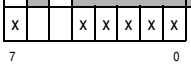
| OM3 | OM2 | OM1 | Operating Mode |
|---|---|---|---|
| 0 | 0 | 0 | Positioning, 4x evaluation |
| 1 | 0 | 0 | Positioning, 2x evaluation |
| 1 | 1 | 0 | Positioning, 1x evaluation, positive |
| 0 | 1 | 0 | Positioning, 1x evaluation, negative |
| 1 | 0 | 1 | 2 channel up/down counter, positive edge |
| 0 | 0 | 1 | 2 channel up/down counter, negative edge |
| 1 | 1 | 1 | 1 channel up/down counter, positive edge |
| 0 | 1 | 1 | 1 channel up/down counter, negative edge |

**DIR** 0..... positive counting direction
1..... negative counting direction

The status of bits DIS, HS, FT, OMx and DIR are set as default to log. 0 after start up.

## Mode Register X - Read (Status In)

| Mode Register X<br>Read | Bit | Description |
|---|---|---|
| | 7 | x |
| | 6 | PV - Potential variation of the analog outputs |
| | 5 | HS - Home search mode |
| | 0 - 4 | x |




**PV** This bit is identical to the GND OFFSET status LED.

0 ..... Compensating current between the channels is within the range ±15 mA

1 ..... Compensating current between the channels lies outside the range ±15 mA; The PV bit remains set, even if the value returns inside the valid range. The PV bit in both registers and the LED are cleared again when one of the two mode registers is read.

**RF** If the home search mode has been enabled, it can be used to indicate whether the reference pulse has already arrived and the counter is reset (see also Section 16.2.12 "Home Search Procedure", on page 562).

0 ..... The reference pulse has been recognized and the counter is reset. The LED REF is lit. Home search mode has been disabled. If the counter is referenced again (e.g. from the other direction), home search mode must be first activated.

1 ..... The reference pulse has still not been recognized.

### 16.2.10 Basic Counting Direction

The counting direction can be switched between positive and negative using software. The counting direction effects only the counting mode. An example of operating mode positioning:

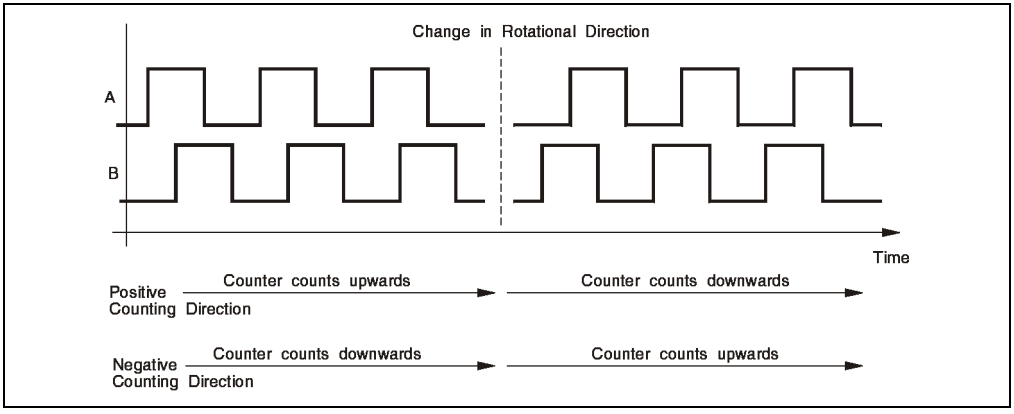



Figure 202: NC150 counting direction in operation mode positioning

The evaluation of reference pulse Z is independent of the counting direction. It is always referenced by a negative edge at Z.

### 16.2.11 Counter Operating Modes

#### Positioning

In this operating mode, the encoder provides two square wave signals (A and B), at a defined time difference to each other. Both signals are 90 ° out of phase, allowing the counting direction to be recognized. The following positioning operating modes are possible. [1] [2]

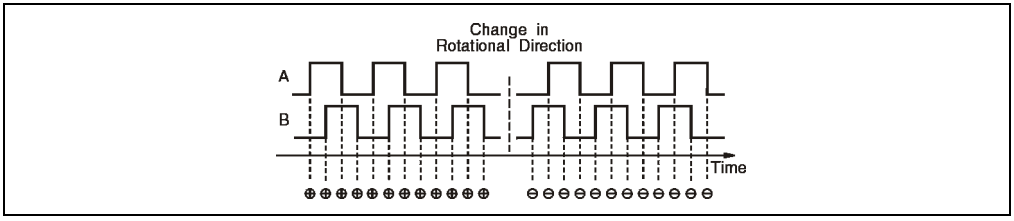



Figure 203: NC150 4x evaluation

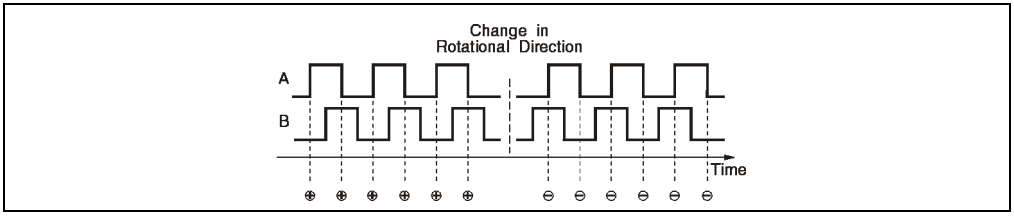



Figure 204: NC150 2x evaluation

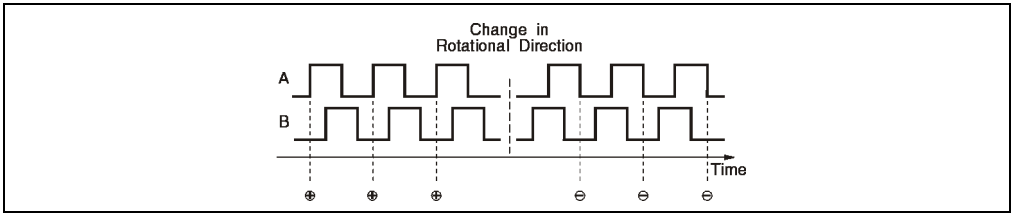



Figure 205: NC150 1x evaluation, positive

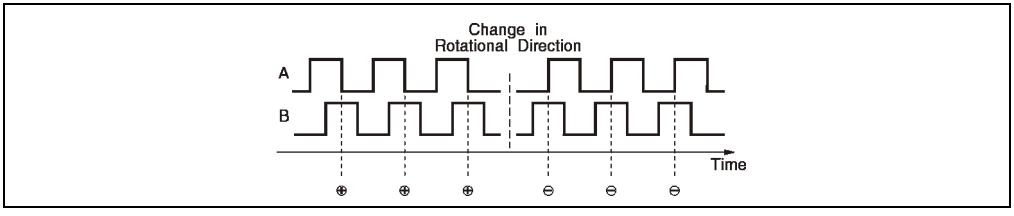



Figure 206: NC150 1x evaluation, negative

1) (+) => counter counting upwards; (-) => counter counting downwards
2) The diagram refers to the positive counting direction. For the negative counting direction, the symbols (+) and (-) are exchanged.

### Up/Down Counters

The **2 channel**up/down counter counts the positive (negative) edges of channel A up and the positive (negative) edges of channel B down. [1] [2]

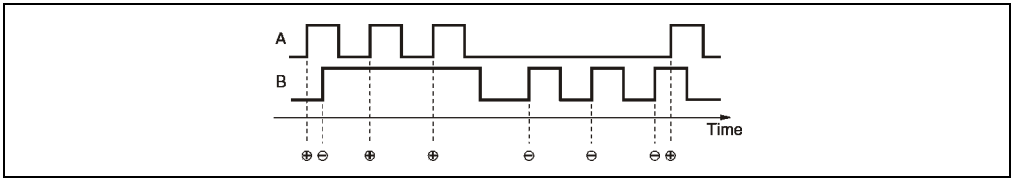



Figure 207: NC150 2 channel, positive edge

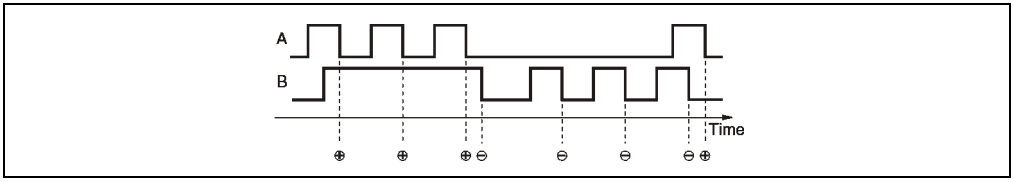



Figure 208: NC150 2 channel, negative edge

The **1 channel** up/down counter counts the positive (negative) edges of channel A up and the positive (negative) edges of channel B down. (counting direction: 1 => up, 0 => down). [1] [2]

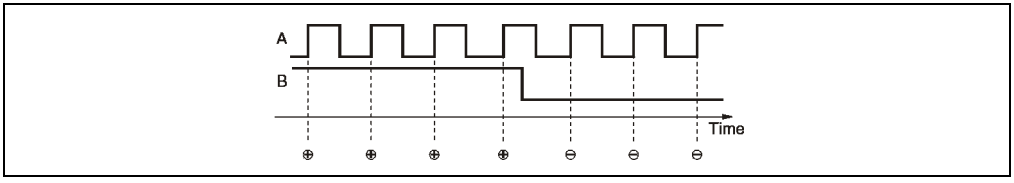



Figure 209: NC150 1 channel, positive edge

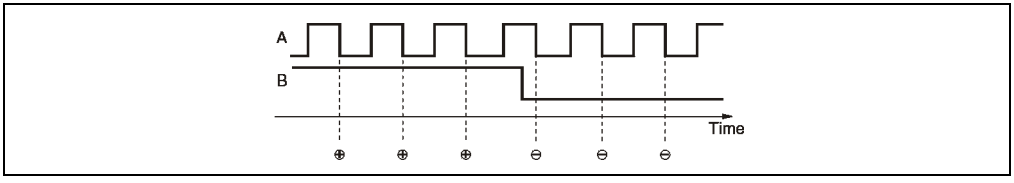



Figure 210: NC150 1 channel, negative edge

1) (+) => counter counting upwards; (-) => counter counting downwards
2) The diagram refers to the positive counting direction. For the negative counting direction, the symbols (+) and (-) are exchanged.

### 16.2.12 Home Search Procedure

With all positioning applications, determining the home position with incremental encoders is absolutely necessary. Normally, the reference pulse of the incremental encoder is generated once per rotation.

**Order for Homing Procedure**

1) The home search mode is activated by setting bit 5 in the mode register (status out). Bit 7 must be written to the respective mode registers with log. 0 for this write cycle.
2) Continually reading back bit 5 (mode register / status in) checks whether the reference pulse has occurred. Wait until bit 5 = 0, that means until a reference pulse has occurred.
3) If a reference pulse occurs, the counter status is set to zero and the LED REF is switched on. The counter counts in the rotation direction and the set operation mode.
4) If the homing procedure is repeated (e.g. with slower speeds in the opposite direction), the procedure begins again at step 1.

**In each operating mode where the home search mode is activated, the counter is reset to zero by the negative edge of the reference pulse.**