# General electrical information

No fault identification measures have been implemented in RENCO products. The operational safety of the application in connection with the encoders is to be ensured in the total system.

**Voltage supply**
Connect the encoders only to subsequent electronics whose power supply is generated from PELV systems (EN 50 178). The R35i and RCML15 rotary encoders fulfill the requirements of standard IEC 61010-1 only if the voltage is supplied from a secondary circuit with current limitation as per IEC 61010-1[3rd Ed.], Section 9.4 or with power limitation as per IEC 60950-1[2nd Ed.], Section 2.5 or from a Class 2 secondary circuit as specified in UL1310.[1)]

The encoders require a stabilized DC voltage supply $U_P$. The required voltage supply and the current consumption are given in the respective *Specifications*.

The permissible ripple content of the DC voltage is:
- High frequency interference
  $U_{PP}$ < 250 mV with dU/dt > 5 V/µs
- Low frequency fundamental ripple
  $U_{PP}$ < 100 mV

However, the limits of the supply voltage must not be violated by the ripple content.

The voltage values must be complied with at the encoder, i.e., without cable influences. The voltage drop ΔU in the supply lines is calculated as follows:

$$\Delta U = 2 \cdot \frac{1.05 \cdot L_C}{56 \cdot A_P} \cdot I_M \cdot 10^{-3}$$

Where:

| | |
|---|---|
| ΔU | Line voltage drop in V |
| $L_C$ | Cable length in m |
| $A_P$ | Cross section of supply lines in $mm^2$ |
| $I_M$ | Current consumption in mA |
| 2 | Outgoing and incoming lines |
| 1.05 | Length factor due to twisted wires |
| 56 | Electrical conductivity of copper |

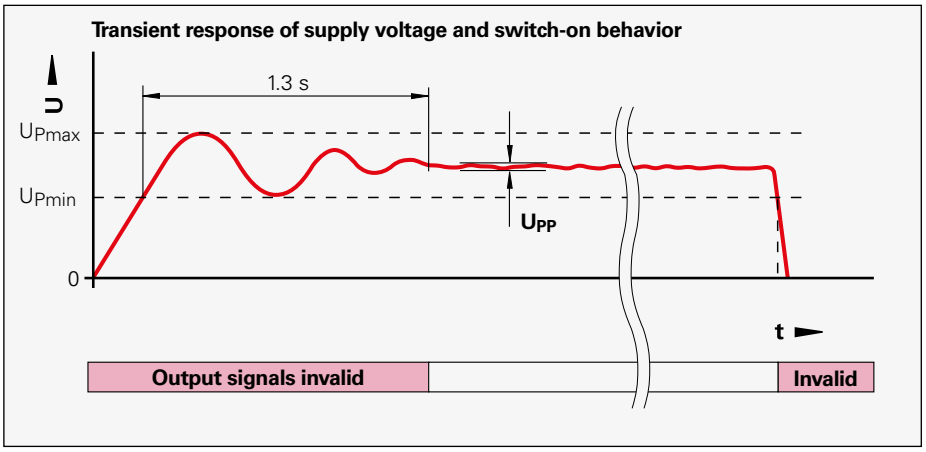
If the value for the voltage drop is known, the parameters of voltage at the encoder, current consumption, as well as power consumption of the encoder and the power provided by the subsequent electronics can be calculated for the encoder and subsequent electronics.

**Transient response of supply voltage and switch-on behavior**
The output signals are invalid outside of the permissible supply voltage range at the encoder (see *Specifications*).

**Electrically permissible speed**
The maximum permissible speed of an encoder is derived from
- the mechanically permissible speed (see *Specifications*) and
- the electrically permissible shaft speed.

The electrically permissible speed is limited by the maximum permissible scanning frequency and the maximum permissible output frequency (see *Specifications*).

**Block commutation**
Number of signal periods ≙ pole pairs
1 pole pair ≙ 2 motor poles




[1)] Instead of IEC 61 010-1[3rd Ed.], Section 9.4, the corresponding sections of DIN EN 61 010-1, EN 61 010-1, UL 61 010-1 and CAN/CSA-C22.2 No. 61 010-1 can also be used, and instead of IEC 60 950-1[2nd Ed.], Section 2.5, the corresponding sections of DIN EN 60 950-1, EN 60 950-1, UL 60 950-1, CAN/CSA-C22.2 No. 60 950-1 can also be used.

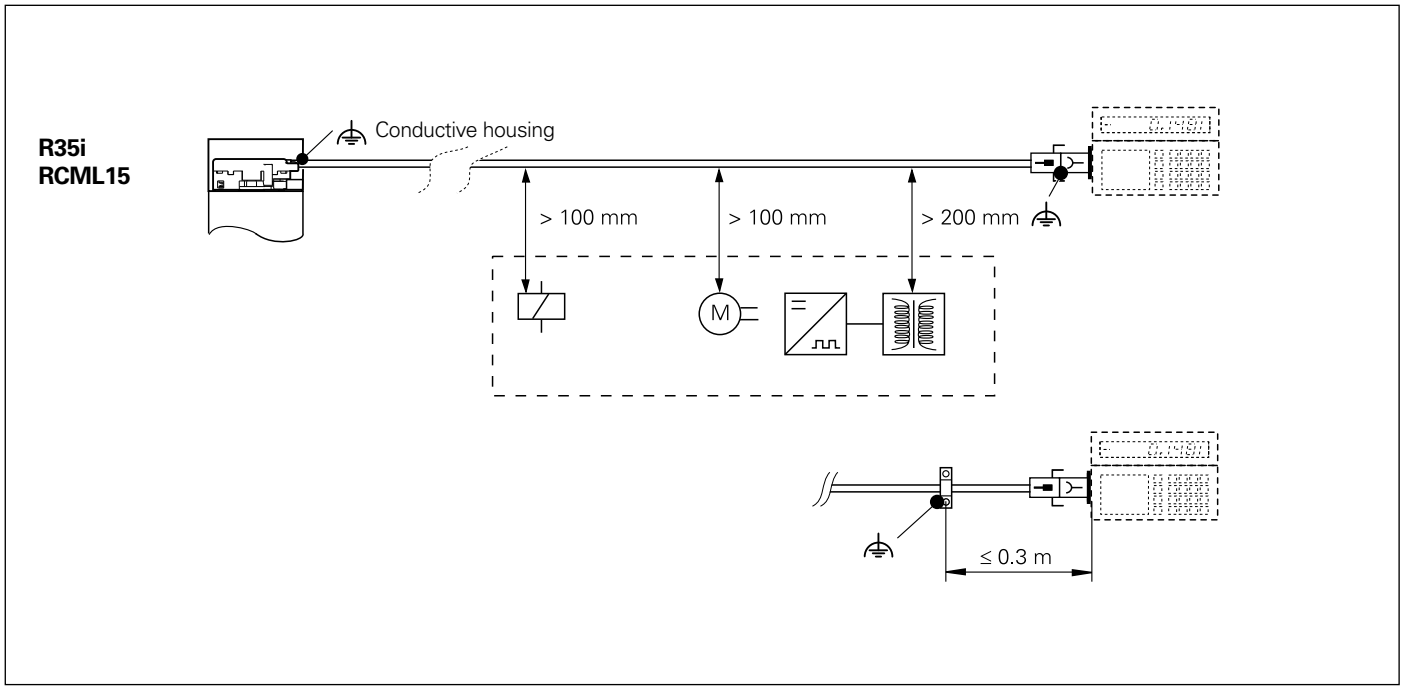
**Electromagnetic compatibility (EMC)**
CE compliance of the complete system must be ensured by taking the correct measures during installation, e.g. through the use of a suitable shielding measures (conductive housing, shield connection of encoder cable, etc.).

**Sources of electrical interference**
Electrical interference is caused mainly through capacitive or inductive transfer. Inductive transfer can be introduced into the system over signal lines and input or output terminals. Typical sources of electrical interference include:

- Strong magnetic fields from transformers, brakes and electric motors
- Relays, contactors and solenoid valves
- High-frequency equipment, pulse devices, and stray magnetic fields from switch-mode power supplies
- AC power lines and supply lines to the above devices

**Measures**
The following measures must be complied with for disturbance-free operation. If other actions are taken, specific measures regarding electrical safety and EMC are required.

- Consider the voltage drop in the supply wires.
- Use connecting elements (such as connectors or terminal boxes) with metal housings. Only the signals and power supply of the connected encoder may be routed through these elements.
- Connect the conductive housing of the encoder, connecting elements and subsequent electronics through the shield of the cable. Ensure that the shield has complete contact over the entire surface (360°).
- Connect the shield to functional ground as per the mounting instructions.
- Prevent contact of the shield (e.g. connector housing) with other metal surfaces. Pay attention to this when installing cables.
- Do not install signal cables in the direct vicinity of interference sources (inductive consumers such as contactors, motors, frequency inverters, solenoids, etc.).
- Sufficient decoupling from interference-signal-conducting cables can usually be achieved by an air clearance of 100 mm or, when cables are in metal ducts, by a grounded partition.
- A minimum spacing of 200 mm to inductors in switch-mode power supplies is required.
- If compensating currents are to be expected within the overall system, a separate equipotential bonding conductor must be provided. The shield does not have the function of an equipotential bonding conductor.
- Provide power only from PELV systems (see EN 50 178 for an explanation of the term) to position encoders, and provide high-frequency grounding with low impedance (see EN 60204-1 Chapter EMC).



# LD square-wave signals

For incremental and commutation signals with differential line driver as per EIA standard RS 422.

| | |
|---|---|
| **Incremental signals** | Two square-wave signals $U_{a1}$, $U_{a2}$ with 90° elec. phase shift and their inverted signals $\overline{U_{a1}}$, $\overline{U_{a2}}$ |
| **Reference mark signal**<br>Pulse width | One square-wave pulse $U_{a0}$ and its inverted pulse $\overline{U_{a0}}$<br><br>90° elec. or 270° elec.<br>*For ordering key, see the Selection Guide or the Specifications* |
| **Commutation signals** | Three square-wave signals U, V, W and their inverse signals $\overline{U}$, $\overline{V}$, $\overline{W}$ |
| **Signal amplitude** | Differential line driver as per EIA standard RS-422 |
| **Permissible load** | $Z_0 \geq 100\ \Omega$ Between associated outputs<br>$\lvert I_L \rvert \leq 20$ mA Maximum load per output<br>$C_{load} \leq 1000$ pF With respect to 0 V<br>Outputs protected against short circuit to 0 V |
| **Switching times**<br>(10 % to 90 %) | $t_r$ / $t_f \leq 30$ ns (typically 10 ns)<br>with 1 m cable and recommended input circuitry |

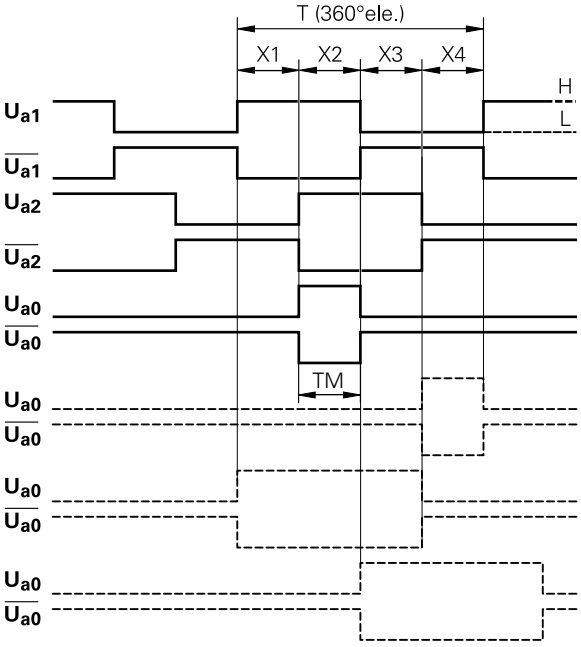
**$U_{a1}$, $\overline{U_{a1}}$, $U_{a2}$, $\overline{U_{a2}}$** **On-off ratio**
X1+X2 = 0.5T ±0.2T
X2+X3 = 0.5T ±0.2T
**Phase angle**
0.375T ≥ Xn ≥ 0.125T
(n = 1, 2, 3, 4)

**$U_{a0}$, $\overline{U_{a0}}$** **Pulse width/position**
1: TM = 0.25T ±0.125T

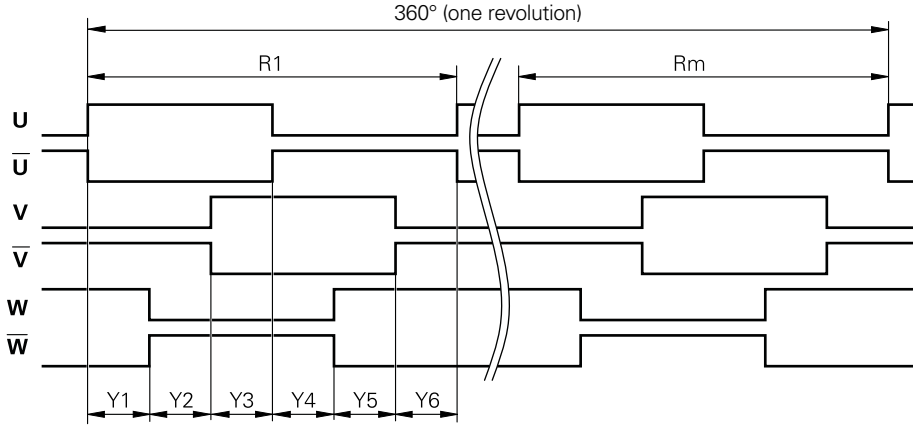
6: TM = 0.25T ±0.125T

7: TM = 0.75T ±0.125T

8: TM = 0.75T ±0.125T

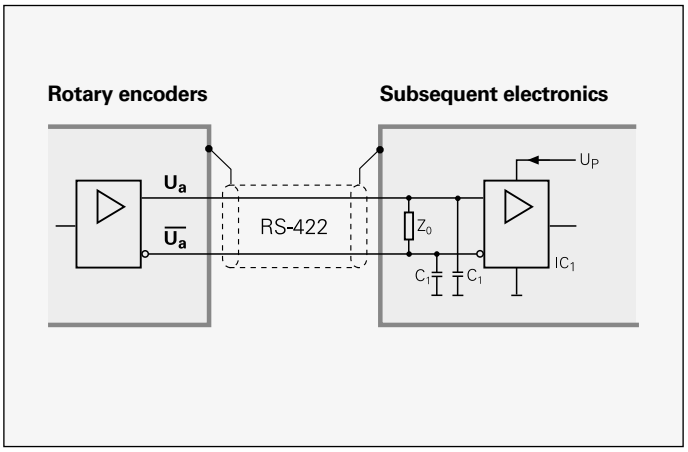



**U, $\overline{U}$, V, $\overline{V}$, W, $\overline{W}$** **On-off ratio**
Rm = (360° mech./ number of signal periods) ±2° mech.
**Phase angle**
Yn = Rm / 6 ±2° mech.



## Input circuitry of subsequent electronics

For incremental, reference-mark and commutation signals

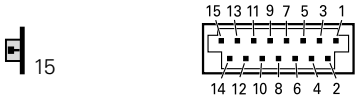



**Dimensioning**

$IC_1$ = Recommended differential line receiver DS 26 C 32 AT
$Z_0$ = 120 Ω
$C_1$ = 220 pF (serves to improve noise immunity)

## R35i pin layout

**15-pin PCB connector**




| | Voltage supply | | Incremental signals | | | | Reference mark signal | | Commutation signals | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | **13** | **14** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| **LD/0** | $U_P$ | 0 V | $U_{a1}$ | $\overline{U_{a1}}$ | $U_{a2}$ | $\overline{U_{a2}}$ | $U_{a0}$ | $\overline{U_{a0}}$ | – | – | – | – | – | – |
| **LD/LD** | $U_P$ | 0 V | $U_{a1}$ | $\overline{U_{a1}}$ | $U_{a2}$ | $\overline{U_{a2}}$ | $U_{a0}$ | $\overline{U_{a0}}$ | U | $\overline{U}$ | V | $\overline{V}$ | W | $\overline{W}$ |
| **LD/PP** | $U_P$ | 0 V | $U_{a1}$ | $\overline{U_{a1}}$ | $U_{a2}$ | $\overline{U_{a2}}$ | $U_{a0}$ | $\overline{U_{a0}}$ | U | – | V | – | W | – |

Vacant pins must not be used!

# PP square-wave signals

For incremental and commutation signals with single-ended push/pull driver output.

| | |
|---|---|
| **Incremental signals** | Two square-wave signals $U_{a1}$, $U_{a2}$ with 90° elec. phase shift |
| **Reference mark signal**<br>Pulse width | One square-wave pulse $U_{a0}$<br><br>90° elec. or 270° elec.<br>*For ordering key, see the Selection Guide or the Specifications* |
| **Commutation signals** | 3 square-wave signals U, V, W |
| **Signal amplitude** | *Voltage supply +5 V:*<br>$U_H > 2.5$ V at $-I_H = 4$ mA<br>$U_L < 0.5$ V at $I_L = 4$ mA |
| **Permissible load** | $\|I\| \leq 4$ mA maximum load per output<br>Outputs are not short-circuit proof |
| **Switching times**<br>(10 % to 90 %) | $t_r / t_f \leq 30$ ns<br>With indicated input circuit (without cable) |

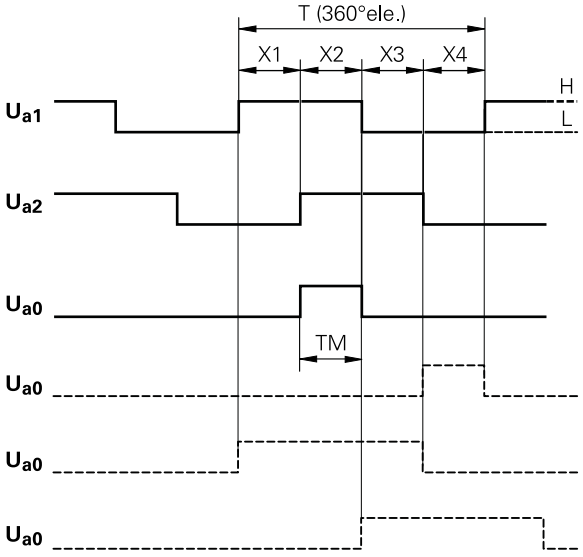
**$U_{a1}$, $U_{a2}$** **On-off ratio**
X1+X2 = 0.5T ±0.2T
X2+X3 = 0.5T ±0.2T
**Phase angle**
0.375T ≥ Xn ≥ 0.125T
(n = 1, 2, 3, 4)

**$U_{a0}$** **Pulse width/position**
1: TM = 0.25T ±0.125T

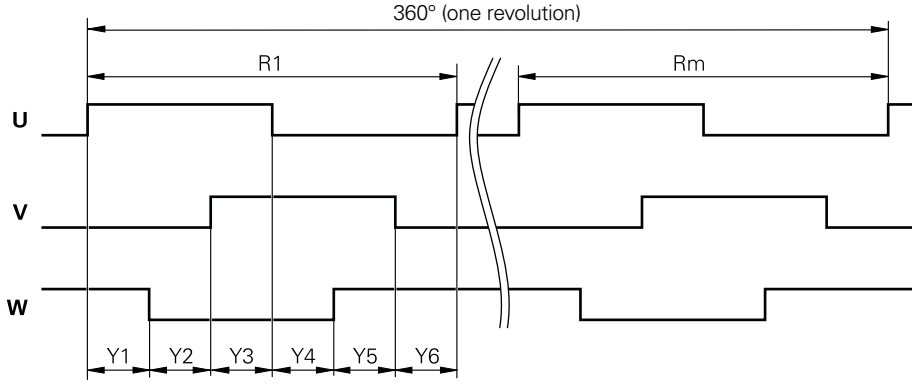
6: TM = 0.25T ±0.125T

7: TM = 0.75T ±0.125T

8: TM = 0.75T ±0.125T

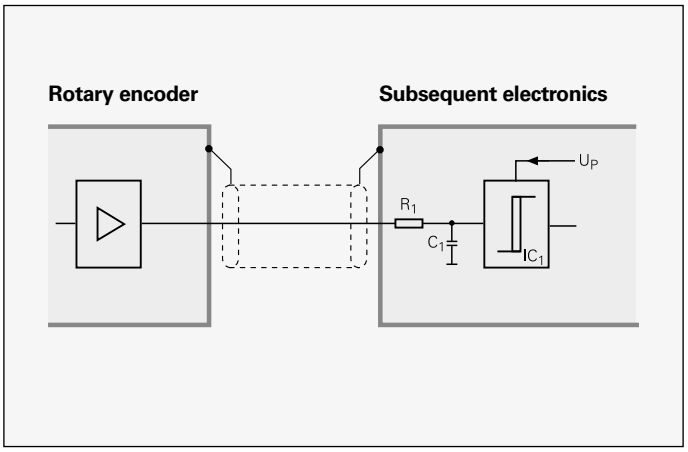



**U, V, W** **On-off ratio**
Rm = (360° mech./ number of signal periods) ±2° mech.
**Phase angle**
Yn = Rm / 6 ±2° mech.



## Input circuitry of subsequent electronics

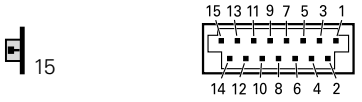
For incremental, reference-mark and commutation signals




**Dimensioning**
$IC_1$ = 74HC14 CMOS
R = 2.7 kΩ
C = 25 pF

## R35i pin layout

**15-pin PCB connector**

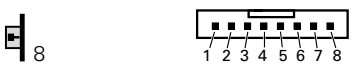



| | Voltage supply | | Incremental signals | | | | Reference mark signal | | Commutation signals | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | **13** | **14** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| **PP/0** | $U_P$ | 0 V | $U_{a1}$ | – | $U_{a2}$ | – | $U_{a0}$ | – | – | – | – | – | – | – |
| **PP/PP** | $U_P$ | 0 V | $U_{a1}$ | – | $U_{a2}$ | – | $U_{a0}$ | – | U | – | V | – | W | – |

Vacant pins must not be used!

## RCML15 pin layout

**8-pin PCB connector**



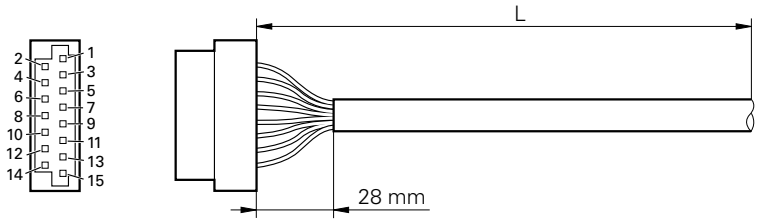

| Interface | Voltage supply | | Incremental signals | | Reference mark signal | Commutation signals | | |
|---|---|---|---|---|---|---|---|---|
| 8 | **4** | **1** | **3** | **5** | **2** | **6** | **7** | **8** |
| **PP/0** | $U_P$ | 0 V | $U_{a1}$ | $U_{a2}$ | $U_{a0}$ | – | – | – |
| **PP/PP** | $U_P$ | 0 V | $U_{a1}$ | $U_{a2}$ | $U_{a0}$ | U | V | W |

Vacant pins must not be used!

# Encoder cable

**Encoder cable**
R35i rotary encoder

**With one** 15-pin PCB connector (cable cut off)
Foil shield with drain wire (cut off at end of cable sheath)
Temperature range –30 °C to 105 °C (rigid configuration)

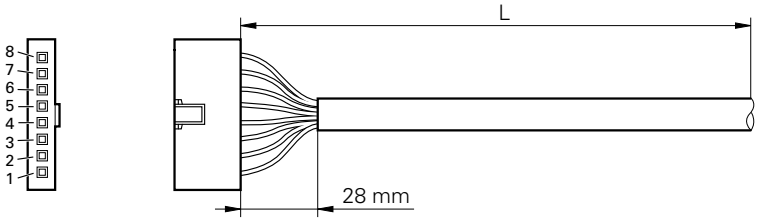



| **Cable length L** | **Without** commutation signals | **With** commutation signals |
|---|---|---|
| 0.5 m | 679489-02 | 606544-02 |
| 1.0 m | 679489-04 | 606544-04 |

| **Pin** | **Signal function** | **PVC cable Ø 4.6 mm** (4x2 AWG28) | **PVC cable Ø 6 mm** (8x2 AWG28) |
|---|---|---|---|
| 1 | $U_{a1}$ | Yellow | Yellow |
| 2 | $\overline{U_{a1}}$ | White/Yellow | White/Yellow |
| 3 | $U_{a2}$ | Blue | Blue |
| 4 | $\overline{U_{a2}}$ | WH/BL | WH/BL |
| 5 | $U_{a0}$ | Orange | Orange |
| 6 | $\overline{U_{a0}}$ | White/Orange | White/Orange |
| 7 | U | – | Green |
| 8 | $\overline{U}$ | – | White/Green |
| 9 | V | – | Brown |
| 10 | $\overline{V}$ | – | White/Brown |
| 11 | W | – | White |
| 12 | $\overline{W}$ | – | White/Gray |
| 13 | $U_P$ | Red | Red |
| 14 | 0V | Black | Black |
| 15 | Vacant | – | Gray |
| | | | Violet* |

**Encoder cable**
RCML15 rotary encoder

**With one** PCB connector, 8-pin (cable cut off)
Foil shield with drain wire (cut off at end of cable sheath)
Temperature range –30 °C to 105 °C (rigid configuration)




| **Cable length L** | **Without** commutation signals | **With** commutation signals |
|---|---|---|
| 0.15 m | 639110-03 | 619845-02 |
| 0.5 m | 639110-06 | 619845-12 |
| 1.0 m | 639110-02 | 619845-04 |

| **Pin** | **Signal function** | **PVC cable Ø 4.6 mm** (4x2 AWG28) | **PVC cable Ø 4.6 mm** (4x2 AWG28) |
|---|---|---|---|
| 1 | 0V | Black | Black |
| 2 | $U_{a0}$ | Orange | Orange |
| 3 | $U_{a1}$ | Yellow | Yellow |
| 4 | $U_P$ | Red | Red |
| 5 | $U_{a2}$ | Blue | Blue |
| 6 | U | – | Green |
| 7 | V | – | Brown |
| 8 | W | – | White |
| | | Green*, brown*, white* | |

* To prevent damage to the encoders, insulate any unused wires

# General mechanical information

**Certified by Nationally Recognized Testing Laboratory (NRTL)**
The R35i and RCML15 rotary encoders comply with safety regulations as per UL for the USA and as per CSA for Canada.

**RoHS**
HEIDENHAIN has tested the products for safety of the materials as per European Directives 2002/95/EC (RoHS) and 2002/96/EC (WEEE). For a Manufacturer's Declaration on RoHS, please refer to your sales agency.

**Acceleration**
The encoders are subject to various types of acceleration during operation and mounting.

- **Vibration**
  The encoders are qualified on a test stand to operate with the acceleration values listed in the Specifications at frequencies from 55 to 2000 Hz in accordance with EN 60068-2-6. However, if the application or poor mounting causes long-lasting resonant vibration, it can limit performance or even damage the encoder. **Comprehensive tests of the entire system are therefore required.**
- **Shock**
  On a test stand for non-repetitive semi-sinusoidal shock, the encoders are qualified for acceleration values and durations listed in the Specifications in accordance with EN 60068-2-27. This does not include **permanent shock loads**, which **must be tested in the application.**

The **maximum angular acceleration** is $10^5$ rad/s$^2$ (DIN 32878). This is the highest permissible acceleration at which the rotor will rotate without damage to the encoder. A sufficient safety factor is to be determined through system tests. For angular accelerations ≥ $10^4$ rad/s$^2$, HEIDENHAIN recommends the use of an adhesive bond on the shaft (see Chapter *Mounting*).

**Protection against contact (EN 60529)**
After encoder installation, all rotating parts must be protected against accidental contact during operation.

**Protection (EN 60 529)**
The R35i and RCML15 rotary encoders fulfill the specified degree of protection—see *Specifications*—for cable outlet and housing (R35i) when plug is engaged.

**Conditions for longer storage times**
To ensure storage times beyond 12 months, HEIDENHAIN recommends the following:

- Leave the encoders in the original packaging.
- The storage location should be dry, free of dust, and temperature regulated as well as free of vibration, mechanical shock or chemical influences.

**Temperature ranges**
For the unit in its packaging, the storage temperature range is –30 °C to +65 °C. The operating temperature range indicates the temperatures the encoder can reach during operation in the actual installation environment. The function of the encoder is guaranteed within this range (DIN 32878). The operating temperature is measured at the measuring point (see *Dimension drawing*) and must not be confused with the ambient temperature. The temperature of the encoder is influenced by the specific installation, the ambient temperature and encoder's own heat generation.

**System tests**
As a rule, the R35i and RCML15 rotary encoders are integrated as components in the total system. Such applications require comprehensive tests of the entire system regardless of the specifications of the encoder. The specifications shown in this brochure apply to the specific encoder, not to the complete system. Any operation of the encoder outside of the specified range or for any applications other than the intended applications is at the user's own risk.

**Mounting**
The work steps and dimensions valid for mounting are available in this catalog and in the installation videos at *www.renco.com*

**Changes to the encoder**
The function of the R35i and RCML15 rotary encoders is ensured only in unmodified condition. Any changes, even minor ones, can impair the operation and reliability of the encoders, and result in a loss of warranty. This also includes the use of additional retaining compounds, lubricants (e.g. for screws) or adhesives not explicitly prescribed. In case of doubt, we recommend contacting HEIDENHAIN in Traunreut.