# Spyder Model 5

## WEB-RxxN ROOM CONTROLLERS

**INSTALLATION GUIDE**

## GENERAL INFORMATION

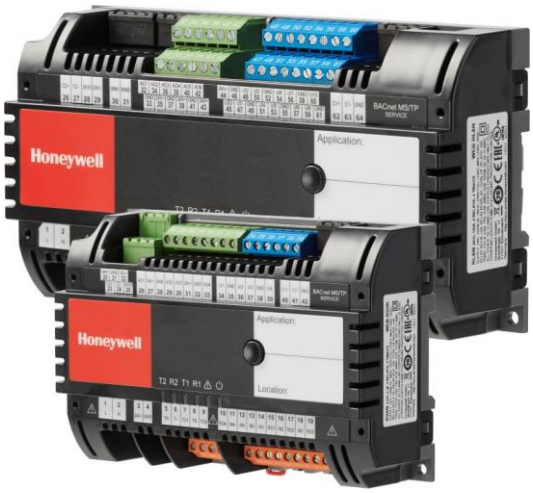


**Fig. 1. WEB-RxxN (without optional covers)**

## BEFORE INSTALLATION

***IMPORTANT***

*It is recommended that the unit be kept at room temperature for at least 24 hours before applying power; this is to allow the evaporation of any condensation resulting from low shipping / storage temperatures.*

*US requirement, only: This device must be installed in a UL-listed enclosure offering adequate space to maintain the segregation of line voltage field wiring and Class 2 field wiring.*

## ⚠ CAUTION

To avoid electrical shock or equipment damage, you must switch OFF the power supply before attaching / removing connections to/from any terminals.

**Table 1. Overview of models**

| | OS no.: | power supply | AOs | UIs | BIs | relays[A] | triacs[B] | total no. of I/Os | remarks |
|---|---|---|---|---|---|---|---|---|---|
| **large housing (7-13/16 x 4-5/16 x 2-5/16) (198 x 110 x 57.5 mm)** | WEB-RL6N | 24 VAC | 6 | 10 | 0 | 4 | 4 | 24 | 72-hr data retention |
| **small housing (6-3/8 x 4-5/16 x 2-5/16) (162 x 110 x 57.5 mm)** | WEB-RS5N | 24 VAC | 4 | 4 | 0 | 4 | 2 | 14 | 24-hr data retention |

[A] See also section “

Relay Current Limitations” on pg. 15.

[B] See also section "Triac Current Limitations" on pg. 12.

CPU: 32-bit MK24FN Freescale Kinetis Cortex M4

# DIMENSIONS AND MOUNTING

## Housings

The controller is available in two housing sizes, both conforming to IP20:

- WEB-RL6N (large housing): W x L x H = 4-5/16 x 7-13/16 x 2-5/16 in (110 x 198 x 59 mm) and
- WEB-RS5N (small housing): W x L x H = 4-5/16 x 6-3/8 x 2-5/16 in (110 x 162 x 59 mm)

See also Fig. 2 and Fig. 3.

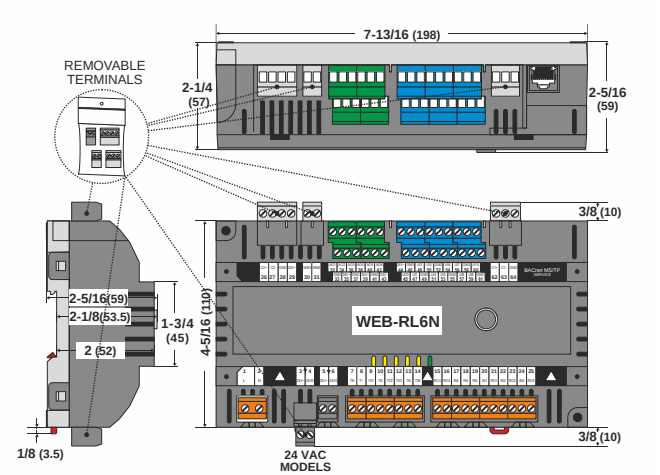


**Fig. 2. WEB-RL6N dimensions in inch (mm)**

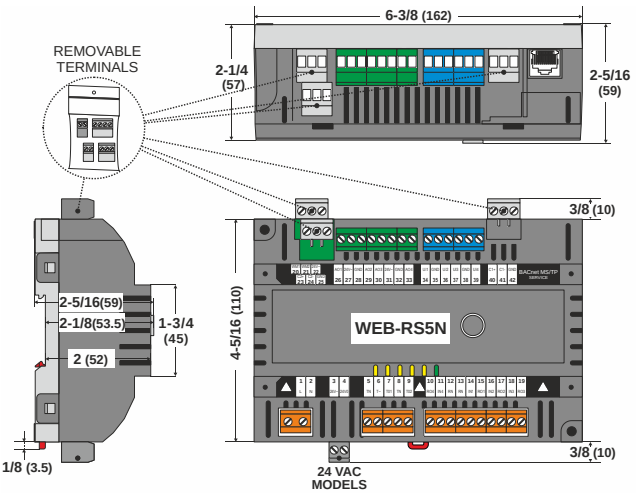


**Fig. 3. WEB-RS5N dimensions in inch (mm)**

The unit is suitable for mounting on a standard rail, on walls, as well as in wiring cabinets or fuse boxes.

**NOTE:**

- IP20 provides, Ingress Protection against solid objects over 12.5mm e.g. hands, large tools. No protection against liquids.
- IP30 provides, Ingress Protection against solid objects over 2.5mm e.g. wire, small tools. No protection against liquids

## Terminal Protection Covers for IP30

In the case of controllers mounted outside of a cabinet, before applying power to the device, Terminal Protection Covers (10-pc. bulk packs, order no.: IRM-RLC for large housings and IRM-RSC for small housings) must be mounted so as to provide IP30.

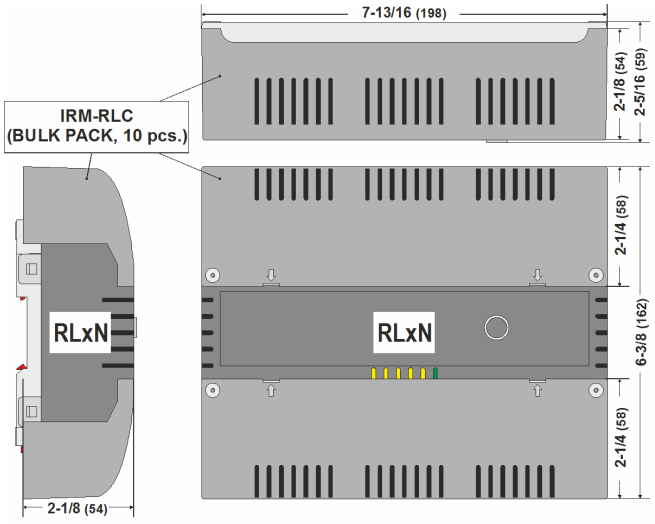


**Fig. 4. Large housing, with terminal protection covers, dimensions in inch (mm)**

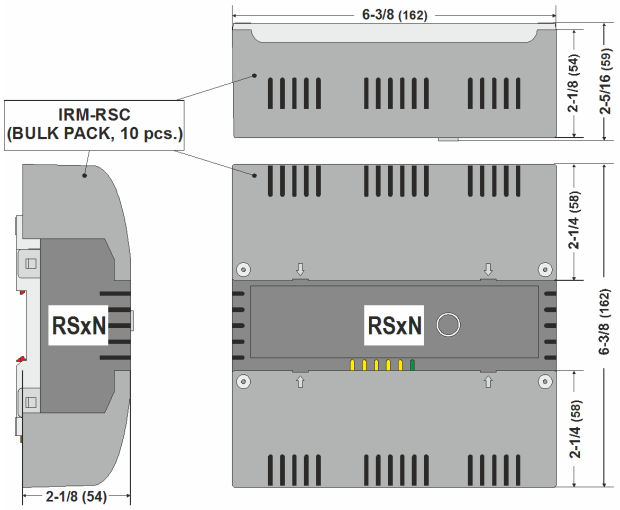


**Fig. 5. Small housing, with terminal protection covers, dimensions in inch (mm)**

## DIN Rail Mounting/Dismounting

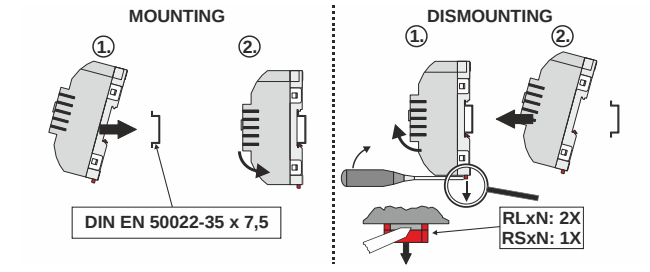


**Fig. 6. Mounting and dismounting**

The unit can be mounted onto the DIN rail simply by snapping it into place. It is dismounted by gently pulling the stirrup(s) located at the base of the housing (see Fig. 6).

When mounted vertically on a DIN rail, the unit must be secured in place with a stopper to prevent sliding.

## Wall Mounting/Dismounting

The unit can be mounted on floors, walls, and ceilings in any desired orientation. (See also section "Ambient Environmental Limits" on pg. 17 for temperature range restrictions with floor/ceiling mounting.)

The unit is mounted by inserting optional screws (recommended: DIN EN ISO 7049 – ST4,2x22 – C - H) through the corresponding screwing noses.

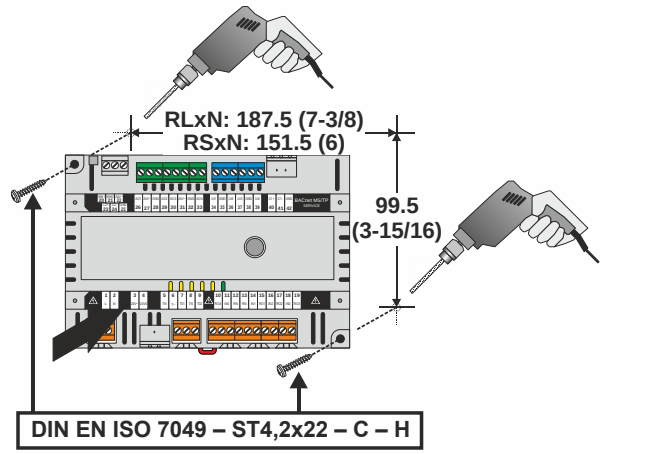


**Fig. 7. Drilling template (view from above)**

After mounting the unit onto the wall, snap the appropriate terminal protection covers (see Fig. 4 and Fig. 5 on pg. 2) into place onto the housing by hand.

**NOTE:** In the case of wall-mounting, two optional terminal protection covers (in the case of the WEB-RL6N [large housings]: IRM-RLC; in the case of the WEB-RS5N [small housings]: IRM-RSC) must be installed in order to comply with IP30.

The covers can be fixed into place using optional screws (recommended: DIN EN ISO 7049 – ST2,9x9,5 – C (F) – H). To remove a cover, place a screwdriver in the two leverage slots (marked with arrows) and pry it loose.

# TERMINAL ASSIGNMENT

## General

For a complete list of all terminals and a description of their functions, see Table 2 and Table 6 on pg. 4 and pg. 6.

**NOTE:** All terminal blocks capable of carrying either low voltage or line voltage are orange-colored.

Depending upon the given hardware model, the delivery includes a plastic bag containing additional, removable terminal blocks.

Every controller features a terminal assignment label on the top of the housing.

## Power Supply Terminals

- In the case of the 24VAC models, power is supplied via a removable terminal plug (terminals 3 and 4).

See also section "Power Supply" on pg. 9.

## Input / Output Terminals

The controller features rows of terminal blocks on the top and bottom.

- In the case of the WEB-RL6N (large housing), the controller has double rows of analog outputs (AOs) and universal inputs (UIs) at the top and a single row of binary outputs (BOs) - triacs (TRs) and relay outputs (ROs) - at the bottom.
- In the case of the WEB-RS5N (small housing), the controller has a single row of analog outputs (AOs) and universal inputs (UIs) at the top and a single row of binary outputs (BOs) - triacs (TRs) and relay outputs (ROs) - at the bottom.

**NOTE:** According to VDE guidelines, it is not allowed to mix low-voltage and high-voltage signals on the relays and triacs.

See also section "I/O Terminals" on pg. 12.

## Communication Interfaces

All models of the controller feature the following communication interfaces:

- A Sylk Bus interface (WEB-RS5N: terminals 20 and 21; WEB-RL6N: terminals 30 and 31), for connection to TR40x/42x Wall Modules;
- A BACnet MS/TP interface (WEB-RS5N: terminals 40, 41, and 42; WEB-RL6N: terminals 62, 63, and 64);
- An RJ45 connector for future use with BACnet WiFi Adapter;
- A second RS485 interface for future use with Modbus.

**Table 2. WEB-RS5N Room Controllers: Overview of terminals and functions (by model)**

| term. | printing | function | WEB-RS5N |
|---|---|---|---|
| 1, 2 | -- | -- | -- |
| 3, 4 | 24V~, 24V0 | Removable 24 VAC power supply input and aux. output voltage (24 VAC) for all triacs | X |
| 3, 4 | 24V~, 24V0 | Aux. output voltage (24 VAC) for all triacs | X |
| 5 | TN | Aux. term. for triac neutral wiring (internally connected with terminal 8) | X |
| 6 | T~ | Triac input voltage (24 VAC for all triacs; triac-switched | X |
| 7 | T01 | Triac-switched output | X |
| 8 | TN | Aux. term. for triac neutral wiring (internally connected with terminal 5) | X |
| 9 | T02 | Triac-switched output | X |
| 10, 11 | RO4, IN4 | Output of Relay 4, Input for Relay 4 | type 2 |
| 12, 13 | RN, RN | Aux. terminals for relay neutral wiring | X |
| 14, 15 | IN1, RO1 | Input for Relay 1, Output of Relay 1 | type 1 |
| 16, 17 | IN2, RO2 | Input for Relay 2, Output of Relay 2 | type 1 |
| 18, 19 | IN3, RO3 | Input for Relay 3, Output of Relay 3 | type 1 |
| 20, 21 | WM1, WM2 | Removable interface for Sylk Bus | X |
| 22, 23, 24, 25 | 24V~, C2+, C2-, 24V0 | Aux. power (24 VAC ±20%, 50/60 Hz), RS485 Modbus interface and corresponding GND | X |
| 26 | AO1 | Analog Output 1 | type 2 |
| 27 | 24V~ | 24 VAC power for field devices | X |
| 28 | GND | Ground for AOs | X |
| 29 | AO2 | Analog Output 2 | type 1 |
| 30 | AO3 | Analog Output 3 | type 1 |
| 31 | 24V~ | 24 VAC power for field devices | X |
| 32 | GND | Ground for AOs | X |
| 33 | AO4 | Analog Output 4 | type 1 |
| 34 | UI1 | Universal Input 1 | type 1 |
| 35 | GND | Ground for UIs | X |
| 36 | UI2 | Universal Input 2 | type 1 |
| 37 | UI3 | Universal Input 3 | type 1 |
| 38 | GND | Ground for UIs | X |
| 39 | UI4 | Universal Input 4 | type 1 |
| 40, 41, 42 | C1+, C1-, GND | Removable BACnet MS/TP interface and corresponding GND | X |

Relay output types: See Table 3. Universal input types: Table 4. Analog output types: See Table 5.

-- : Terminal not used.

X : Terminal used.

Type x: Type of an I/O as per its characteristic. Mode details given on each type in following tables.

**Table 3. Relay output types and characteristics**

| | type 1 (standard) | type 2 (high in-rush current) |
|---|---|---|
| corresponding ROs of WEB-RS5N | RO1, RO2, RO3 | RO4 |
| corresponding ROs of WEB-RL6N | RO2, RO3 | RO1, RO4 |
| contact | N.O. | N.O. |
| min. load | 5 VAC, 100 mA | 24 VAC, 40 mA |
| switching voltage range | 15 to 253 VAC | 15 to 253 VAC |
| max. continuous load at 250 VAC (cos $\varphi$ = 1) | 4 A | 10 A |
| max. continuous load at 250 VAC (cos $\varphi$ = 0.6) | 4 A | 10 A |
| in-rush current (20 ms) | -- | 80 A |
| usage | fan motor | fan motor |

**NOTE:** The max. sum load of all relay currents at the same time is 14 A.

**Table 4. Universal input types and characteristics**

| | **type 1** | **type 2** | **type 3** |
|---|---|---|---|
| | UI1, UI2, UI3, UI4, UI5, UI6 | UI7, UI8, UI9, UI10 | UI1, UI2, UI3 |
| dry contact (closed: res. <10 kΩ; open: res. > 20 kΩ; max. 0.2 Hz; pull-up voltage: 10 V) | X | X | -- |
| dry contact (closed: res. <10 kΩ; open: res. > 20 kΩ; max. 0.2 Hz; pull-up voltage: 24 V); | -- | -- | X |
| fast binary (=counter) input with below characteristics.<br>(max. 30 Hz; pulse ON = min. 16 ms; pulse OFF = min. 16 ms; closed: voltage < 1 V; open: voltage > 5 V; pull-up voltage: 10 V) | X | X | -- |
| fast binary (=counter) input with below characteristics.<br>(max. 30 Hz; pulse ON = min. 16 ms; pulse OFF = min. 16 ms; closed: voltage < 1 V; open: voltage > 5 V; pull-up voltage: 24 V) | -- | -- | X |
| 0(2) to 10 V | X | X | -- |
| NTC20kΩ | X | -- | -- |
| SetPoint and FanSpdSW | X | -- | -- |
| NTC10kΩ (Type II) | X | -- | -- |
| PT1000 + Ni1000TK5000 | -- | X | -- |

**Table 5. Analog output types and characteristics**

| | **type 1** | **type 2** | **type 3** | **type 4** | **type 5** |
|---|---|---|---|---|---|
| output voltage | 0-11 V | | | | |
| output current | 0-1 mA | 0-5 mA | 0-10 mA | 0-20 mA | -1- +1 mA |
| min. accuracy | ±150 mV | | | | |
| max. ripple | ±100 mV | | | | |
| accuracy at zero point | 0-200 mV | | | | ±150 mV |

**Table 6. WEB-RL6N Room Controllers: Overview of terminals and functions (by model)**

| term. | printing | function | WEB-RL6N |
|---|---|---|---|
| 1, 2 | -- | -- | -- |
| 3, 4 | 24V~, 24V0 | Removable 24 VAC power supply input | X |
| 5, 6 | 24V~, 24V0 | Aux. output voltage (24 VAC) for all triacs | X |
| 7 | TN | Aux. terminal for triac neutral wiring (internally connected with terminals 10 and 13) | X |
| 8 | T~ | Triac input voltage (24 VAC) for all triacs; triac-switched | X |
| 9 | T01 | Triac-switched output | X |
| 10 | TN | Aux. terminal for triac neutral wiring (internally connected with terminals 7 and 13) | X |
| 11 | T02 | Triac-switched output | X |
| 12 | T03 | Triac-switched output | X |
| 13 | TN | Aux. terminal for triac neutral wiring (internally connected with terminals 7 and 10) | X |
| 14 | T04 | Triac-switched output | X |
| 15 | -- | Not used | -- |
| 16, 17 | RO4, IN4 | Output of Relay 4, Input for Relay 4 | type 2 |
| 18 | RN | Aux. terminal for relay neutral wiring | X |
| 19 | RN | Aux. terminal for relay neutral wiring | X |
| 20, 21 | IN1, RO1 | Input for Relay 1, Output of Relay 1 | type 2 |
| 22, 23 | IN2, RO2 | Input for Relay 2, Output of Relay 2 | type 1 |
| 24, 25 | IN3, RO3 | Input for Relay 3, Output of Relay 3 | type 1 |
| 26, 27, 28, 29 | C2+, C2-, 24V0, 24V~ | RS485 Modbus interface, corr. GND, + aux. power (24 VAC ±20%, 50/60 Hz) | X |
| 30, 31 | WM1, WM2 | Removable interface for Sylk Bus | X |
| 32 | AO1 | Analog Output 1 | type 3 |
| 33 | GND | Ground for AOs | X |
| 34 | AO2 | Analog Output 2 | type 3 |
| 35 | 24V~ | 24 VAC power for field devices | X |
| 36 | AO3 | Analog Output 3 | type 1 |
| 37 | GND | Ground for AOs | X |
| 38 | AO4 | Analog Output 4 | type 1 |
| 39 | 24V~ | 24 VAC power for field devices | X |
| 40 | AO5 | Analog Output 5 | type 1 |
| 41 | GND | Ground for AOs | X |
| 42 | AO6 | Analog Output 6 | type 1 |
| 43 | 24V~ | 24 VAC power for field devices | X |
| 44 | 24V~ | 24 VAC power for field devices | -- |
| 45 | LED | Output to LED of CLCMx | -- |
| 46 | GND | Ground for UIs | X |
| 47 | UI1 | Universal Input 1 | type 1 |
| 48 | UI2 | Universal Input 2 | type 1 |
| 49 | GND | Ground for UIs | X |
| 50 | UI3 | Universal Input 3 | type 1 |
| 51 | UI4 | Universal Input 4 | type 1 |
| 52 | GND | Ground for UIs | X |
| 53 | UI5 | Universal Input 5 | type 1 |
| 54 | UI6 | Universal Input 6 | type 1 |
| 55 | GND | Ground for UIs | X |
| 56 | UI7 | Universal Input 7 | type 2 |
| 57 | UI8 | Universal Input 8 | type 2 |
| 58 | GND | Ground for UIs | X |
| 59 | UI9 | Universal Input 9 | type 2 |
| 60 | UI10 | Universal Input 10 | type 2 |
| 61 | GND | Ground for UIs | X |
| 62, 63, 64 | C1+, C1-, GND | Removable BACnet MS/TP interface and corresponding GND | X |

Relay output types Table 3: See. Universal input types: Table 4. Analog output types: See Table 5.

--: Terminal not used.

X: Terminal used.

Type x: Type of an I/O as per its characteristic. Mode details given on each type in following tables.

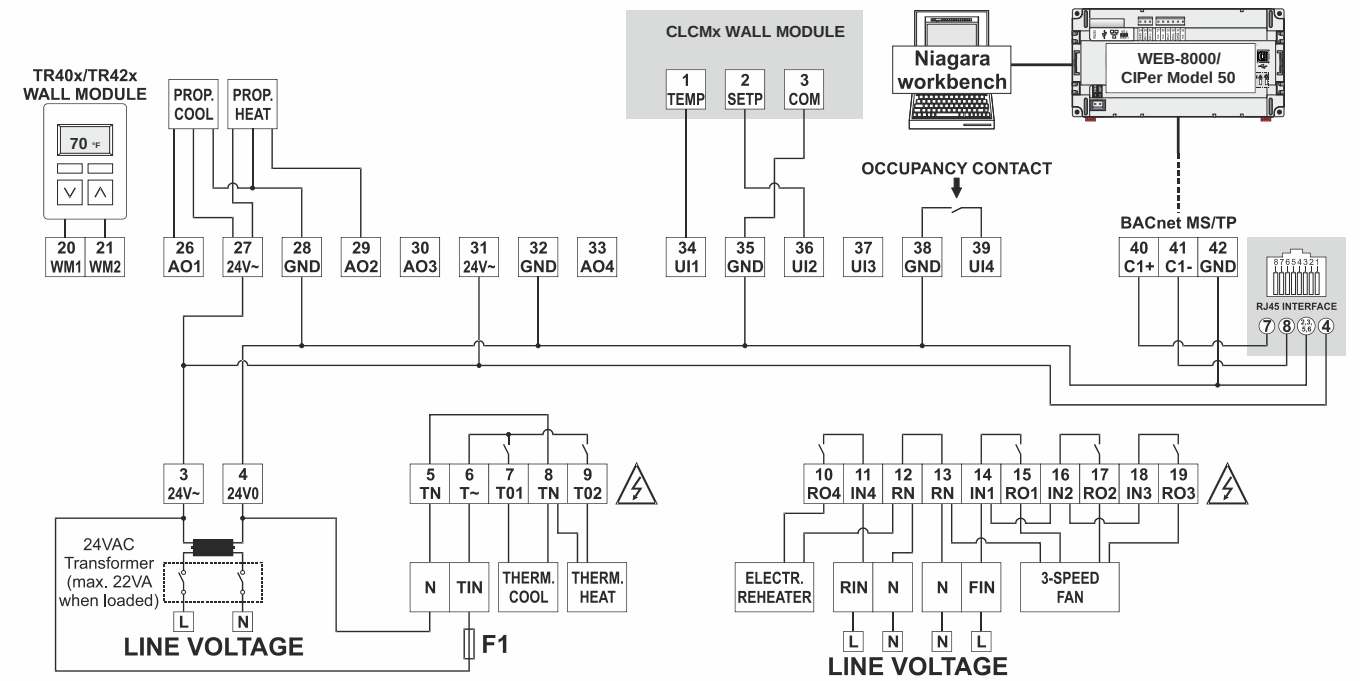


**Fig. 8. WEB-RS5N (24 VAC models) and example wiring**

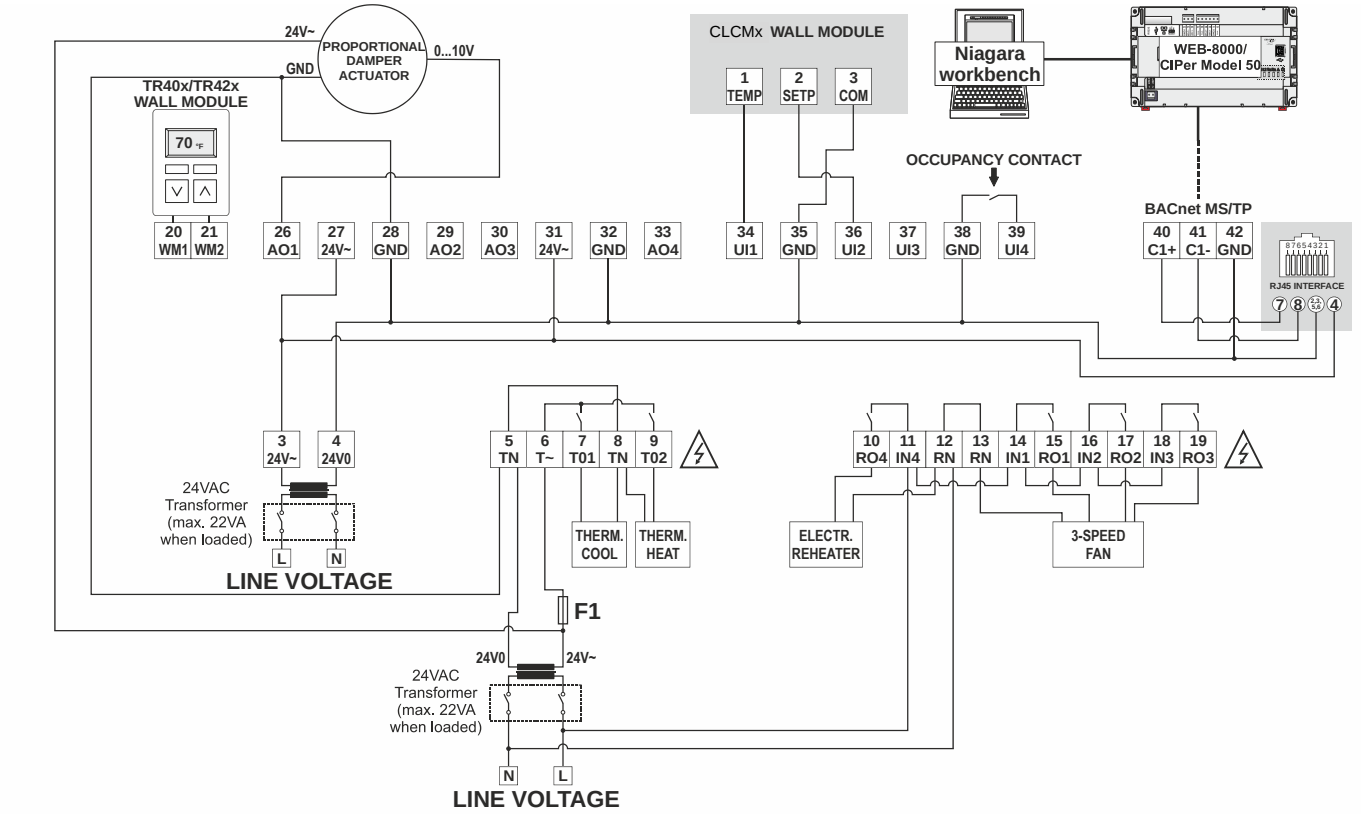


**Fig. 9. WEB-RS5N (24 VAC models) and example wiring (with actuator powered by extra transformer)**

**NOTE:** See Fig. 11 on pg. 9 for information on how to connect multiple controllers to a single power supply.

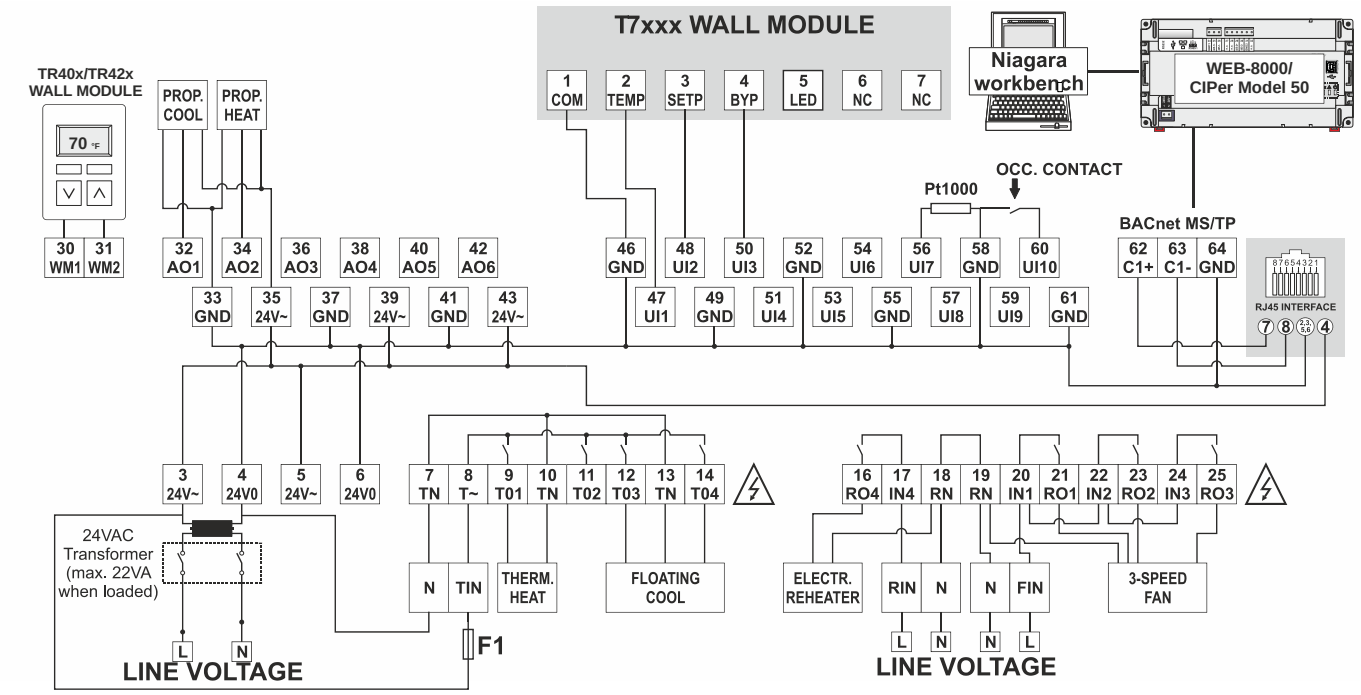


**Fig. 10. WEB-RL6N (24 VAC models) and example wiring**

# POWER SUPPLY

## General Information

### ⚠ CAUTION

To prevent a risk of injury due to electrical shock and/or damage to device due to short-circuiting, low-voltage and high-voltage lines must be kept physically separate from one another.
Further, to prevent a risk of short-circuiting and damage to your unit, do not reverse the polarity of the power connection cables, and avoid ground loops (i.e., avoid connecting one field device to several controllers).

**NOTE:** All wiring must comply with applicable electrical codes and ordinances. Refer to job or manufacturers' drawings for details. Local wiring guidelines (e.g., IEC 364-6-61 or VDE 0100) may take precedence over recommendations provided in these installation instructions.

**NOTE:** To comply with CE requirements, devices having a voltage of 50-1000 VAC or 75-1500 Vdc but lacking a supply cord, plug, or other means for disconnecting from the power supply must have the means of disconnection incorporated in the fixed wiring. This means of disconnection must have a contact separation of at least 3 mm at all poles.

## Wiring

### 24 VAC Terminals for Auxiliary or Field Devices

All 24 VAC auxiliary power supply terminals support 1 x 2.5 $mm^2$ or 2 x 1.5 $mm^2$ wiring.

### 24 VAC Models

The 24 VAC models are powered via a black removable terminal plug (terminals 3 and 4), thus allowing daisy chain wiring of the power supply. See also Fig. 1. These terminals support 1 x 2.5 $mm^2$ or 2 x 1.5 $mm^2$ wiring.

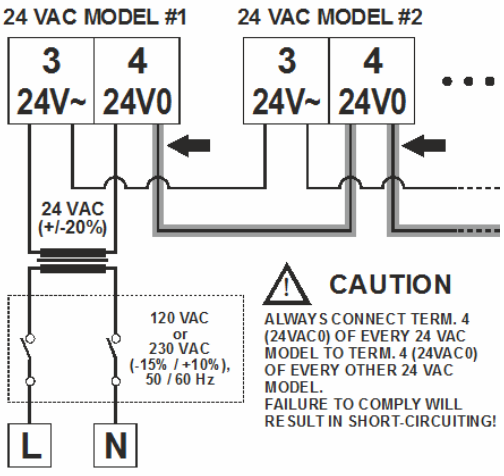


**Fig. 101. Multiple 24 VAC models connected to single power supply**

### Communication / Signal Terminals

All other communication / signal terminals (except for the Sylk Bus – see Table 10 on pg. 15) support 1 x 2.5 $mm^2$ or 2 x 1.5 $mm^2$ wiring. Two wires with a total thickness of 2.5 $mm^2$ (14 AWG) can be twisted together and connected using a wire nut (include a pigtail with this wire group and attach the pigtail to the individual terminal block). Deviations from this rule can result in improper electrical contact. Local wiring codes may take precedence over this recommendation.

## Electrical Data

### WEB-RL6N, WEB-RS5N (24 VAC)

Power via terminals 3,4: 24 VAC ±20%, 50/60 Hz.

Max. current consumption (when unloaded): 300 mA.

Max. current consumption (when loaded): 900 mA.

A 24 VAC model is "loaded" when, besides the inherent load (300 mA), an additional sum load resulting from max. **600 mA** is applied to the 24 VAC output terminals. The max. unloaded output voltage at terminals 3 and 4 (WEB-RS5N) or terminals 5 and 6 (WEB-RL6N), respectively, is identical with the output voltage of the external supplying transformer. A maximum 22VA rating transformer is needed when loaded.

# FREELY PROGRAMMABLE APPLICATIONS

All models can be used with freely programmable applications. The application engineer performs this task on a PC on which the Niagara software program has been installed (see also corresponding Technical Literature listed in Table 11 on pg. 18).

## Supported Actuators

The application supports a variety of actuators.

- Analog 0(2) - 10 V
- Floating
- PWM
- Staged actuators
- 6-way valve actuators

## Supported Sensors

A variety of sensors (e.g., room temperature sensors, supply temperature sensors, condensation switch, window sensors, occupancy sensors, card readers, etc.) may be used to optimize control quality.

## Automatic MAC Addressing

In contrast to other controllers (e.g., WEB-8000 controllers, whose MAC addresses must be assigned manually – done using their two dip switches), the WEB-RxxN controller features automatic MAC addressing.

The MAC addresses which the individual WEB-RxxN controllers in the BACnet MS/TP channel assign to themselves are not assigned in sequential order.

Rather, they assign those numbers (MAC Addr) in the range of 1 to maxMaster currently not in use by another device in the BACnet MS/TP channel (the MAC Addr of "0" is reserved by default for the router / plant controller, itself).

All WEB-RxxN controllers are BACnet MS/TP masters. Every master performs periodic polling for the possible appearance of new masters. Each master "knows" the identity of the "next" master (i.e., that WEB-RxxN controller with the next-highest MAC Addr) on the BACnet MS/TP bus and to which it must therefore pass the token. The polling process includes a search for new masters which might have MAC addresses lying between its own MAC address and that of the "next" master.

The property maxMaster specifies the highest-allowable address for master nodes. maxMaster is set to **32** by default, thus guaranteeing that, on a BACnet MS/TP bus with, e.g., 32 WEB-RxxN controllers, all of the other WEB-RxxN controllers will be found. Both the property maxMaster and the property MAC address are writeable properties that can be changed.

**NOTE:** You should not attempt to program a MAC Addr outside the range of 1 to maxMaster.

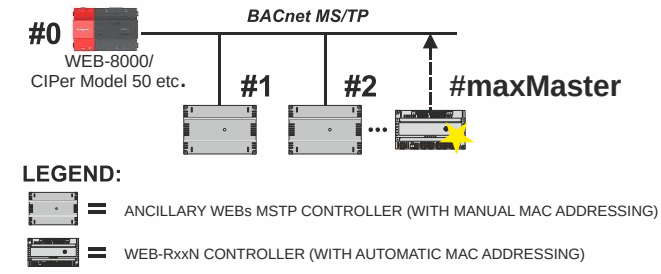


**Fig. 12. Automatic MAC addressing**

In the scenario depicted in Fig.15, some of the controllers in the BACnet MS/TP channel do not feature automatic MAC addressing; rather, their MAC addresses were assigned manually (e.g., using their two dip switches). Thus, when a new WEB-RxxN is added to the channel, when its automatic MAC addressing function is triggered, it will assign itself an available (i.e., unoccupied) MAC address.

During the automatic MAC addressing process, LED behavior #7 (see Table 7) is displayed.

# OPERATOR INTERFACES

## LEDs

The controller features the following LEDs:


**Fig. 113. Controller LEDs**

**Table 7. Description of LED behaviors**

| symbol | color | function, description |
|---|---|---|
| T2 | yellow | Not used |
| R2 | yellow | Not used |
| T1 | yellow | LED indicating transmission of communication signals via the BACnet MS/TP interface. |
| R1 | yellow | LED indicating reception of communication signals via the BACnet MS/TP interface. |
| ⚠ | yellow | Status LED indicating firmware problems, hardware problems, etc. (see Table 8). |
| ⏻ | green | Power LED indicating firmware problems, hardware problems, etc. (see Table 8). |

**Table 8. Status LED and power LED behaviors**

| # | Mode | Power LED (green) | Status LED (yellow) |
|---|---|---|---|
| 1 | Power failure | Stays OFF | Stays OFF |
| 2 | Device error* | Stays ON | Stays ON |
| 3 | Firmware download | ON/OFF (1 Hz) | ON/OFF (1 Hz) |
| 4 | No application | ON/OFF (0.5 Hz) | ON/OFF (0.25 Hz) |
| 5 | Broken sensor | ON/OFF (0.25 Hz) | Stays ON |
| 6 | Short-circuiting | ON/OFF (0.5 Hz) | Stays ON |
| 7 | Auto-MAC | ON/OFF (1 Hz) | ON/OFF (0.5 Hz) |
| 8 | Unacknowledged alarm | ON/OFF (2 Hz) | ON/OFF (2 Hz) |
| 9 | Normal operation | ON/OFF (0.5 Hz) | Stays OFF |

*Please return the controller for repair. Contact Honeywell WEBs Customer Care for assistance.

## Service Button

The Service Button is used to trigger dedicated events.

It is important to distinguish different controller behaviors which are elicited depending upon whether the Service Button is pressed when the controller is powering up or when it is in normal operation. See the following sub-sections.

### Pressing Service Button during Power-Up

During controller power-up, pressing the Service Button until LED behavior #3 (see Table 8) is displayed will reset the controller to its factory settings, which are as follows:

- The application is cleared from the controller.
- The MAC address will be set to 0xFF, meaning that the controller will now search for a new mac address (Auto MAC will be automatically triggered after controller power-up).

- The maxMaster setting will revert to its default value of 32.
- The Max info frames will revert to 10.
- The device instance will revert to its default of 4194302.
- The device name will revert to WEB-[ModelName].
- The values of automac min_mac and max_mac will be reset to 1 and maxMaster, respectively.

### Pressing Service Button during Normal Operation

During normal operation of the controller, a short press (< 1 sec) of the Service Button will cause a Service Pin Message (BACnet WhoAmI as a Private Transfer (SerialNo. = 130)) to be sent.

# COMMUNICATION INTERFACES

## BACnet MS/TP Interface

The controller features an RS485 interface (WEB-RL6N: terminals 62, 63, and 64; WEB-RS5N: terminals 40, 41, and 42) suitable for BACnet MS/TP communication. The terminal block containing it is black. The cable length affects the baud rate. See Table 9

**Table 9. Baud rate vs. max. cable length**

| baud rate | max. cable length (L) |
|---|---|
| 9.6, 19.2, **38.4**, 57.6, and 76.8 kbps | (3600 ft) 1200 m |

The controller supports auto-baud rate adaption for BACnet MS/TP communication at all of the aforementioned baud rates (default: 38.4 kbps).

For information on wire gauge, max. permissible cable length, possible shielding and grounding requirements, and the max. number of devices which can be connected to a bus, refer to standard EIA-485.

### Connecting to BACnet MS/TP Buses

The controller communicates via its BACnet MS/TP interface with other BACnet MS/TP-capable devices (e.g., other room controllers or MS/TP controllers). In doing so, the following considerations should be taken into account.

- Max. BACnet MS/TP bus length (= "L" in Fig.17): See Table 9.
- Twisted-pair cable, e.g.:
  - AWG 18;
  - J-Y-(St)-Y 2 x 2 x 0,8;
  - CAT 5,6,7 cable – use only one single pair for one bus;
  - Belden 9842 or 9842NH;

  and daisy-chain topology.
- Must conform to EIA-RS485 cabling guidelines and ANSI/ASHRAE Standard 135-2010.
- Max. no. of BACnet MS/TP devices per BACnet MS/TP channel (interface) of the plant controller: 32 unit loads. (Each WEB-RxxN controller represents ¼ of a unit load, and auto MAC addressing supports a max. of 62 addresses). Effectively, the maximum possible number of BACnet MS/TP devices (= "N" in Fig.17) per channel of the Master, incl. the Master itself, is 64.
  - maxMaster is set by default to **32** devices (this is because some plant controllers support only 32 devices). In the event that you have a plant controller capable of supporting more than 32 devices, it will therefore be necessary for you to increase the maxMaster setting to the actual required number of devices (e.g., to 64). Refer to the IRM BACnet Device Manager – User Guide (EN2B-0414GE51) for more information on how to do this.
  - Depending upon your actual performance needs and required communication rates, we recommend connecting a lower number of BACnet MS/TP devices per channel.

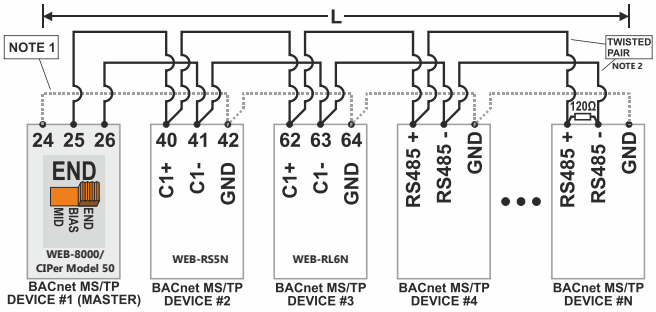


**Fig. 124. Connection to a BACnet MS/TP Bus**

**NOTE 1 :** If any of the devices are electrically isolated, it is recommended that those devices be connected to signal ground.

**NOTE 2 :** The 120-Ohm termination resistor must be inserted directly into the terminals of the final BACnet MS/TP device.

**NOTE 3 :** If shielding is used, the shielding of each individual bus segment should be separately connected at one end to earth.

## Sylk Bus

Sylk Bus-capable devices (e.g., the TR40x / T42x) can be connected to the controller's Sylk Interface (WEB-RS5N: terminals 20 and 21; WEB-RL6N: terminals 30 and 31). Specifically:

- A max. of three TR40x / T42x can be supported by a single controller.
- The Sylk Bus is single pair, and polarity-insensitive.
- Max. current provided at the Sylk Bus interface: 96 mA.

**Table 10. Recommended max. distances from controller to TR40x / T42x wall modules**

| Sl. no. | single twisted pair, non-shielded, stranded or solid [A] | | standard non-twisted thermostat wire, shielded or non-shielded, stranded or solid [B, C] |
|---|---|---|---|
| 1 | 18 - 22 AWG (0.33to0.82 mm2) | 24 AWG (0.20 mm2) | 18 - 24 AWG (0.20to0.82 mm2) |
| 2 | 500 ft (150 m) | 400 ft (120 m) | 100 ft (30 m) |

[A] As a rule of thumb, single twisted pair (two wires per cable, only), thicker gauge, non-shielded cable yields the best results for longer runs.

[B] The 100 ft (30 m) distance for standard thermostat wire is conservative but is meant to reduce the impact of any sources of electrical noise (incl. but not limited to VFDs, electronic ballasts, etc.). Shielded cable recommended only if there is a need to reduce the effect of electrical noise.

[C] These distances apply also for shielded twisted pair.

# I/O TERMINALS

## ⚠ CAUTION

Failure to observe the following max. permissible current outputs of the power output terminals will result in damage to the device.

## Max. Current Output of Power Output Terminals of 24 VAC Controllers

The 24 VAC power output terminals of the WEB-RL6N controllers are terminals 5, 6, 35, 39, 43, and 44 plus pin 4 of the controller's RJ45 interface.

The 24 VAC power output terminals of the WEB-RS5N controllers are terminals 3, 4, 22, 23, 24, 25, 27, and 31 plus pin 4 of the controller's RJ45 interface.

The maximum permissible combined current output of these 24 VAC power output terminals is 300 mA.

## Relay Outputs

## ⚠ CAUTION

Mixing of different voltages within the relay block is not allowed.

The terminal blocks containing the controller's relay outputs are orange. Relay output types: See Table 3 pg.4.

**NOTE:** If inductive components are to be connected to the relays and if these relays switch more often than once every two minutes, these components must be prevented from causing harmful interference to radio or television reception (conformance with EN 45014).

### Relay Current Limitations

If the triacs are supplied with current from an external source, then a maximum of two relays may be loaded with a max. of 4 A per relay, even if two triacs are each simultaneously loaded with max. 300 mA.

If the triacs are supplied with current from an internal source, a maximum of two relays may be loaded as follows: a max. load of 4 A for a relay serving a fan and a max. load of 10 A for a relay serving a reheat, even if one triac is simultaneously loaded with 300 mA.

## Triac Outputs

**NOTE:** Recommended fuse (F1): 1.25 A time-lag fuse (IEC). User must consider the correct voltage and max. breaking capacity / interrupting rate (line voltage urgently requires high breaking capacity / interrupting rate).

The terminal blocks containing the controller's triac outputs are orange.

These triac outputs can be used for a variety of different functions, e.g., for connection to either a floating drive or to a thermal actuator. Once the triac outputs have been programmed, the corresponding devices can then be connected to them directly.

**NOTE:** The VC6983 actuator is intended for use at relay outputs, only and must not be used at the controller's triac outputs.

### Triac Current Limitations

The maximum allowed current with which the ensemble of a controller's triacs may be loaded is dependent upon whether the given model is powered with 24 VAC, upon whether the outputs are supplied by the controller's internal transformer or by an external current supply). Specifically:

- In the case of 24 VAC models, the ensemble of a controller's triacs may be loaded with 600 mA.

However, regardless of model and regardless of whether the triacs are supplied internally or externally, a single triac must never be loaded with a current of more than 300 mA (320 mA for maximum 2 minutes).

Nevertheless, the ensemble of triacs can be loaded for very short periods of time (on the order of milliseconds) with a current on the order of 2500 mA typically encountered when switching on multiple thermal actuators.

## Universal Inputs

The terminal blocks containing the controller's universal inputs are blue. Universal input types: See Table 4.

The universal inputs are protected against voltages of max. 29 VAC and 30 VDC (due to, e.g., miswiring).

### Bias Resistors

Each universal input is equipped with one bias resistor. See Fig.18.

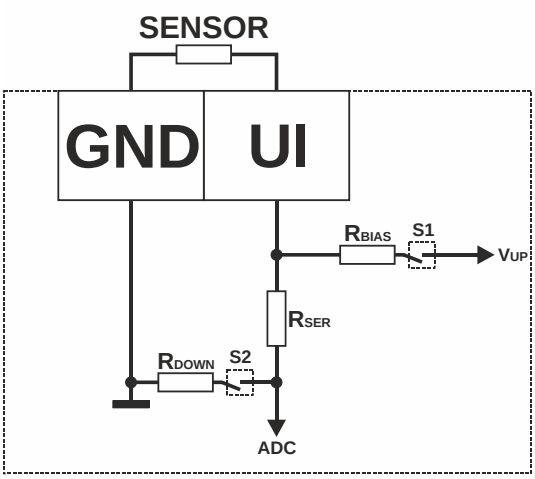


**Fig. 135. Schematic of universal inputs and bias resistors**

LEGEND:

$V_{UP}$ = 10 V.

$R_{BIAS}$ = Bias resistor (with a resistance of 24.9 kΩ in the case of NTC10kΩ (Type II) and NTC20kΩ sensor inputs, and 7.5 kΩ in the case of Pt1000 sensor inputs); can be switched OFF via software by S1 to support 0to10 V inputs without bias current (high impedance).

$R_{SER}$ = Series resistor for voltage dividing and filtering (with a resistance of 150 kΩ).

$R_{DOWN}$ = An internal load resistor (with a resistance of 49 kΩ); depending upon the given type of connected sensor, the firmware may switch this resistor OFF.

## Analog Outputs

The terminal blocks containing the controller's analog outputs are green. Analog output types: See Table 5 on pg.5.

The analog outputs of the WEB-RL6N controllers (large housing) are protected against voltages of max. 29 VAC and 30 VDC (due to, e.g., miswiring).

**NOTE:** Connecting 24 VAC to any analog output of the WEB-RS5N controllers (small housing) will damage the hardware.

# WALL MODULES

The TR40x/TR42x/CLCMx Wall Modules can be used in conjunction with the controller to perform room temperature sensing, setpoint adjustment, fan speed manual override, and occupancy override. The wall modules supported by the WEB-RS5N and WEB-RL6N are; TR40, TR40-H, TR40-CO2, TR40-H-CO2, TR42-H, TR42-CO2, TR42_H_CO2, CLCM1T, CLCM2T, CLCM4T, CLCM5T, CLCM6T.

Further, the LED and LCD of the wall modules can be programmed to provide information about:

- any override of the controller by, e.g., pressing the "occupancy" button of the wall module or receipt by the controller of a BACnet MS/TP network command (see section "LED of CLCMxT Programmed to Display Info on Overrides" below);
- the controller's effective occupancy mode (see section “LED of CLCMxT Programmed to Display Info on Occupancy” below).

**NOTE:** The intended use of the wall module's buttons must be programmed using the Niagara tool.

See also corresponding Technical Literature listed in Table 11 on pg. 18.

## Programming of Wall Module LED / LCD

The LED of a CLCMxT Wall Module can be programmed to provide information about, e.g., overrides or effective occupancy modes.

The LCD of the TR42x can likewise be programmed to display such information.

### LED of CLCMxT Programmed to Display Info on Overrides

The LED of a CLCMxT Wall Module connected to the controller can be programmed to indicate if an override has been activated because either the wall module's override button has been pressed or the controller has received a BACnet MS/TP network command. Specifically, the following modes are supported:

- NO OVERRIDE: If the wall module's LED is OFF, then no override is currently in effect.
- OVERRIDE OCCUPANCY: If the wall module's LED is ON continuously, then the wall module's override button or a BACnet MS/TP network command has placed the controller into the "occupied" or "override" mode (but if the override button is again pushed or if a cancellation network command is received or if the override time expires, the controller will return to its scheduled occupancy mode, and the wall module's LED will behave accordingly).
- OVERRIDE HOLIDAY: If the wall module's LED flashes 2 sec OFF and 1 sec ON, then the controller has received a network command and been placed in the "holiday" mode.
- OVERRIDE UNOCCUPIED: If the wall module's LED flashes once per sec, then the wall module's override button or a network command has placed the controller into the "unoccupied" mode (however, if the override button is again pushed or if a cancellation BACnet MS/TP network command is received, the controller will return to its scheduled occupancy mode, and the wall module's LED will behave accordingly).
- If the wall module's LED flashes twice per sec, then a BACnet MS/TP network command has placed the controller into either the "standby" or the "occupied" mode.

### LED of CLCMxT Programmed to Display Info on Occupancy

The LED of a CLCMxT Wall Module connected to the controller can also be programmed to indicate the

controller's effective occupancy mode. Specifically, the following modes are supported:

- UNOCCUPIED: If the wall module's LED is OFF, then the controller is in the "unoccupied" mode.
- STANDBY: If the wall module's LED flashes once per sec, then the controller has received a network command and been placed in the "standby" mode.
- OCCUPIED: If the wall module's LED is ON, then the controller is in the "occupied" mode.
- BYPASS: If the wall module's LED is ON continuously, then the controller has received a network command and been placed in the "bypass" mode.
- HOLIDAY: If the wall module's LED is OFF, then the controller has received a network command and been placed in the "holiday" mode.

### LCD of TR42x Programmed to Display Info on Occupancy

The LCD of TR42x connected to the controller can be programmed to display various texts and symbols to indicate the effective occupancy mode of the controller. The following then applies.

### Unoccupied Mode

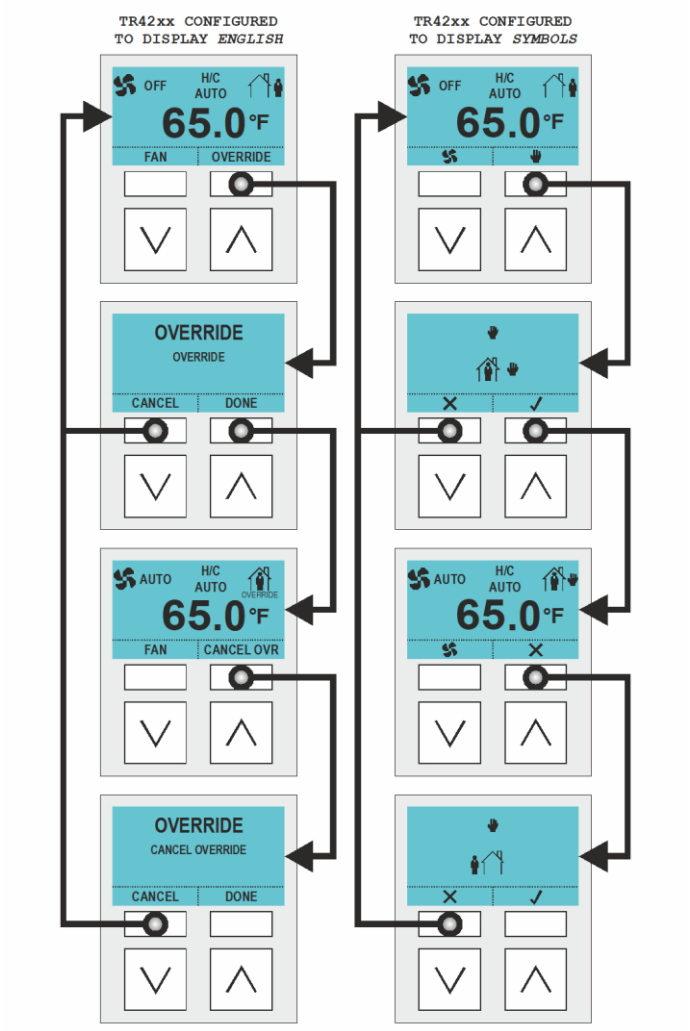


**Fig. 146. Example "unoccupied" screens**

If  is displayed, the controller is in the "unoccupied" mode.

The user can override the "unoccupied" mode by touching the upper right softkey. An intermediate screen will then flash for a few seconds, allowing the user to either cancel (upper left softkey) or confirm (upper right softkey). If the user neither cancels nor confirms, this will be considered a confirmation, and the controller will be placed in the "overridden to bypass" mode. If, on the other hand, the user cancels, the controller will revert to the "unoccupied" mode.

If  is displayed, the controller is in the "occupied" mode.

### Standby Mode

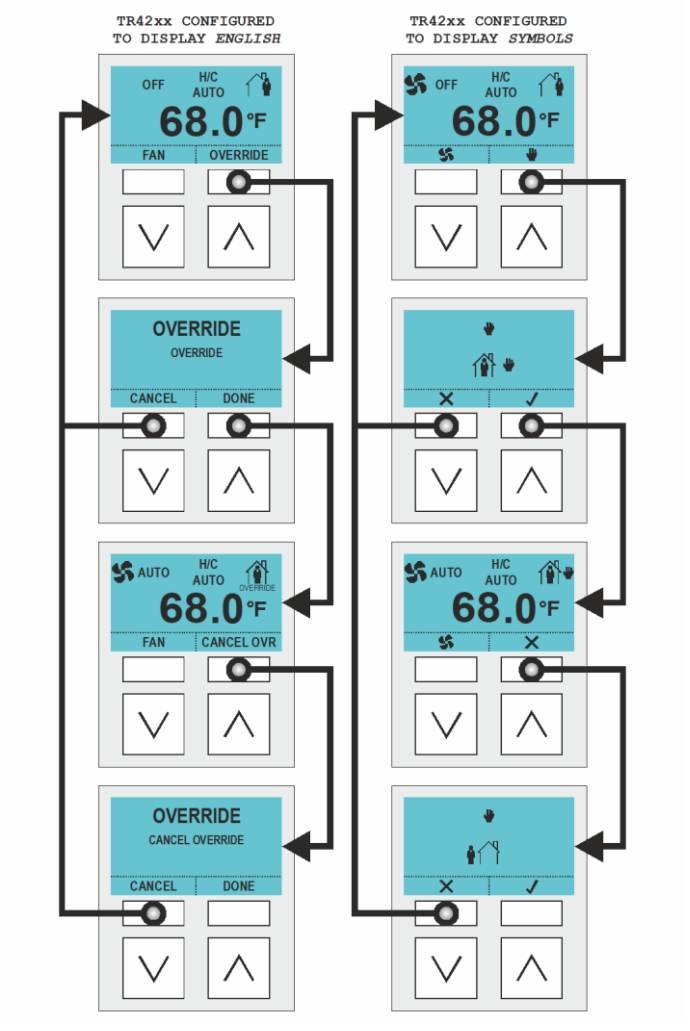


**Fig. 157. Example "standby" screens**

If  is displayed, the controller is in the "standby" mode.

The user can override the "standby" mode by touching the upper right softkey. An intermediate screen will then flash for a few seconds, allowing the user to either cancel (upper left softkey) or confirm (upper right softkey). If the user neither cancels nor confirms, this will be considered a confirmation, and the controller will be placed in the "overridden to bypass" mode. If, on the other hand, the user cancels, the controller will revert to the "standby" mode.

### Occupied Mode

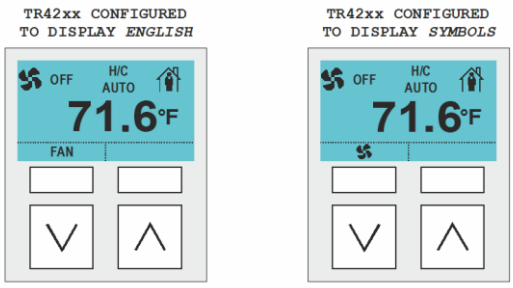


**Fig. 168. Example "occupied" display**

## LCD of TR42x Configured to Display Info on Fan

If OFF is displayed, the fan is switched OFF. Depending upon the given application configuration, the effective control mode for underfloor heating, radiator, ceiling heating, and ceiling cooling can then be switched OFF as well.

## Configuring the TR42x for Heating / Cooling

With the TR42x, the user can select whether he wants to have:

- cooling (C),
- heating (H), or
- cooling plus heating (auto) (H/C AUTO).

By doing so, inadvertent heating or cooling is prevented. Selecting "auto" results in automatic switching between cooling and heating.

To make these selections, the user must enter the expanded menu (see section below).

### Expanded Menu

The user can enter the expanded menu at any time (i.e., in any mode). This is done by touching both upper softkeys simultaneously (see Fig. 3). The "temperature" screen appears first. The user can scroll to further screens ("heating / cooling," "relative humidity," and "$CO_2$ concentration") using the left (V) or right (^) arrow softkey.

**NOTE:** The user can, at any time, exit the expanded menu using the upper left softkey (below the "⌂" symbol or the word "HOME") – or by simply waiting approx. 60 seconds.

In the expanded menu, the current temperature, relative humidity, and $CO_2$ concentration can be displayed.

The user can change automatic heating / cooling by scrolling (arrow softkeys) to the "heating / cooling" screen and then touching the upper right softkey, (below the "✎" symbol or the word "EDIT"). The actual setting will then flash at 1 Hz for approx. 7 seconds, during which time the user can either cancel the given setting (upper left softkey, below the "✕" symbol or the word "CANCEL") or confirm it (upper right softkey, below the "✓" symbol or the word "DONE"). If no action is taken within this time, the given setting is automatically confirmed.

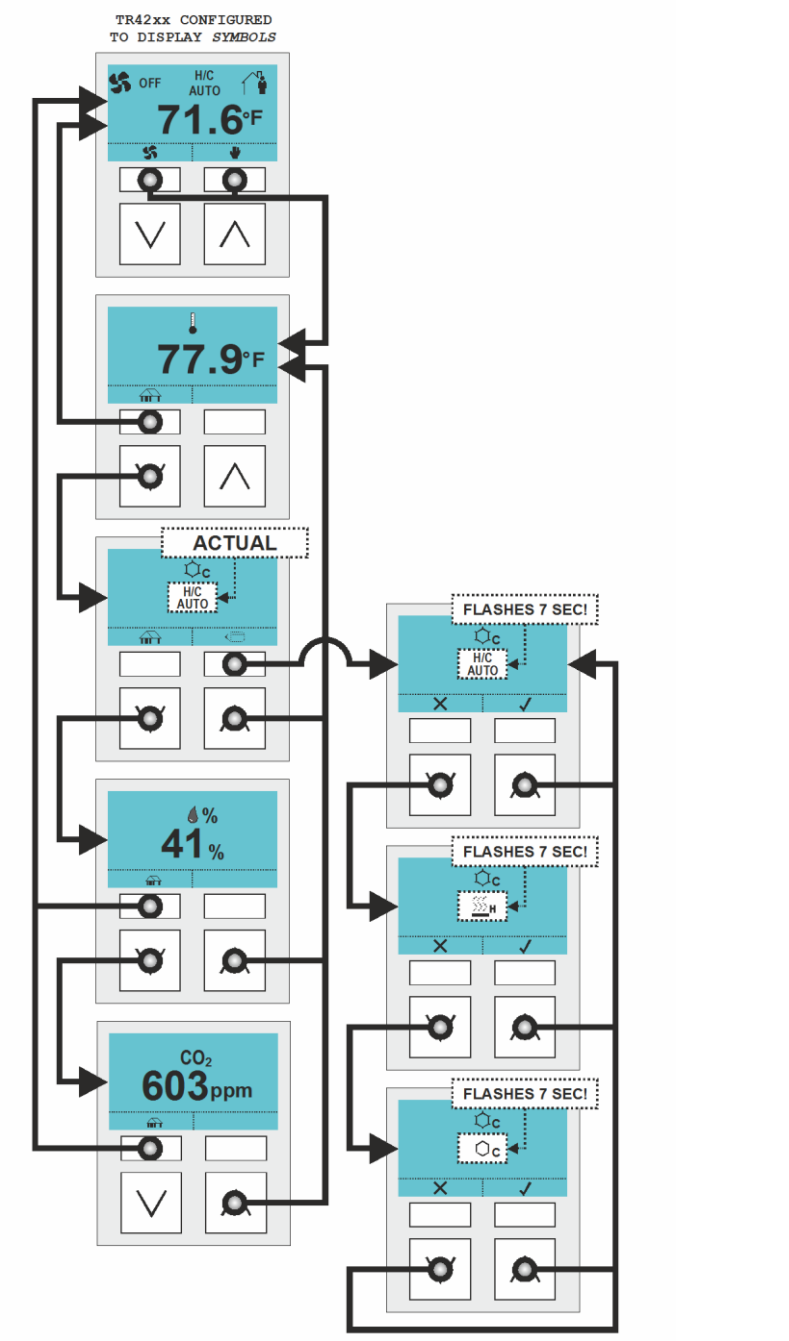


**Fig. 179. Accessing the expanded menu**

# TROUBLESHOOTING

All units feature a Service Button, Status LED, Power LED, and two additional LEDs (T1 and R1) for commissioning and troubleshooting. See also Table 7 and Table 8 and "Service Button".

Check if the Status LED's behavior is changed if you switch the power OFF/ON. Please contact Honeywell if this does not solve the problem.

# ACCESSORIES

Terminal Protection Cover; required for wall mounting. Bulk pack set of ten covers.

- For large controllers, order no.: IRM-RLC
- For small controllers, order no.: IRM-RSC

# APPROVALS, CERTIFICATIONS, ETC.

## Approvals and Certifications

- UL 60730-1, Standard for Automatic Electric Controls for Household and Similar Use, Part 1: General Requirements;
- CAN/CSA-E60730-1:02, Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements;
- Complementary listing for UL916, CSA C22.2 No. 205;
- BTL-listed, BACnet ASC profile;
- CE-approved;
- FCC part 15B-compliant: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio-frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment OFF and ON, the user is encouraged to try to correct the interference by one or more of the following measures:
  - Reorient or relocate the receiving antenna.
  - Increase the separation between the equipment and receiver.
  - Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
  - Consult the dealer or an experienced radio/TV technician for help.
- RoHS Conformity.

## Classification according to EN 60730-1

| | |
|---|---|
| EN 60730 sub part: | EN 60730-2-9 |
| Environmental conditions: | For use in home (residential, commercial, and light-industrial) environments |
| Construction: | independently mounted control, for panel-mounting |
| Action: | type 1.C |
| Rated impulse voltage: | 500 V at 24 V |
| Pollution degree: | 2 |
| Protection against shock: | Class 0 (without terminal covers)<br>Class II (with terminal covers) |
| Software class: | Class A |

## Classification according to EN 60529

(Degree of protection provided by enclosures)

IP20. In the case of controllers mounted outside of a cabinet, before applying power to the device, Terminal Protection Covers (10-pc. bulk packs, order no.: IRM-RLC for large housings and IRM-RSC for small housings) must be mounted so as to provide IP30.

## Ambient Environmental Limits

### 24 VAC Models (5to90% r.H., non-condensing)

| | |
|---|---|
| Operating temperature: | 32 to 122 °F (0 to +50 °C) |
| Storage temperature: | -4 to +158 °F (-20 to +70 °C) |

# RELATED TECHNICAL LITERATURE

**Table 11. Related Technical Literature**

| Title | Product Literature no. |
|---|---|
| Spyder Model 5 – Mounting Instructions | 31-00276ES |
| Spyder Model 5 – Product Data | 31-00280ES |
| Spyder Model 5 – Engineering Tool User Guide | 31-00282ES |
| TR40x/TR42x – Specification Data | 63-1389 |

# APPENDIX: SENSOR CHARACTERISTICS

## Sensor Input Accuracy

The controller's internal sensor inputs support NTC10kΩ (Type II) and NTC20kΩ sensors. The following table lists the typical minimum accuracies of the hardware and software for these temperature sensors.

**Table 12. Accuracies of internal NTC10kΩ and NTC20kΩ sensor inputs of the controller**

| range | measurement error (excluding sensor characteristics) | |
|---|---|---|
| | NTC10kΩ [A] (Type II) | NTC20kΩ |
| -58 to -4 °F (-50 to -20 °C) | ≤ 5.0 K | ≤ 5.0 K |
| -4 to +32 °F (-20 to 0 °C) | ≤ 1.0 K | ≤ 1.0 K |
| 32 to 86 °F (0 to 30 °C) | ≤ 0.5 K | ≤ 0.3 K |
| 86 to 158 °F (30 to 70 °C) | ≤ 0.5 K | ≤ 0.5 K |
| 158 to 212 °F (70 to 100 °C) | ≤ 1.0 K | ≤ 1.0 K |
| 212 to 266 °F (100 to 130 °C) | -- | ≤ 3.0 K |
| 266 to 302 °F (130 to 150 °C) | -- | ≤ 5.5 K |
| 302 to 752 °F (150 to 400 °C) | -- | -- |
| [A] NTC10kΩ (Type II) specified for -22 to 212 °F (-30 to +100 °C) only. | | |

**NOTE:** This is the accuracy of the internal sensor input (hardware + software [linearization]), only. This table does not include the characteristics of the sensors, themselves (see section "Sensor Characteristics" below). If a different sensor or sensor accuracy is required, one may instead use the inputs of, e.g., a connected Panel I/O module.

## Recognition of Sensor Failure of Sensor Inputs

The thresholds at which sensor failures – i.e., sensor breaks (SB) and short-circuits (SC) – are recognized depends upon the given sensor type. In the event of a recognized sensor failure, the sensor input is set to "invalid." The user may program safety functions based upon invalid sensor data. Table 13 lists the measurement ranges and the corresponding thresholds for the recognition of sensor failure for the various different sensor types:

**Table 13. Thresholds for short-circuit (SC) and sensor-break (SB) recognition**

| I/O configuration | measurement range | recognition thresholds |
|---|---|---|
| 2to10 V | 2to10 V / 4to20 mA (without pull-up) | SC: < 1.5 V / 3 mA; SB: no recognition |
| NTC10kΩ (Type II) | -58 to +212 °F (-50 to +100 °C) | SC: < 20 Ω; SB: < -94 °F (-70 °C) |
| NTC20kΩ | -58 to +302 °F (-50 to +150 °C) | SC: < 20 Ω; SB: < -94 °F (-70 °C) |
| PT1000 | -22 to +752 °F (-30 to + 400 °C) | SC: < 775 Ω; SB: < -58 °F (-50 °C) |
| Ni1000TK5000 | -94 to +266 °F (-70 to +130 °C) | SC: < 850 Ω; SB: < -58 °F (-30 °C) |

**NOTE:** In the case of temperatures lying *outside* the aforementioned ranges, the lowest/highest value *within* the range, instead, will be communicated. Thus, a temperature of -51 °F will be communicated as "-50 °F."

## Sensor Characteristics

The characteristics (resistance in relation to temperature) of the sensors and the resultant voltage are listed on the following pages. The stated values do not include failures due to sensor failures; wiring resistance or wiring failures; misreading's due to a meter connected to measure resistance or voltage at the input.

## NTC 10 kΩ (Type II)

| Temp. °F (°C) | Resistance [kΩ] | Terminal voltage [V] |
|---|---|---|
| -22 (-30) | 177 | 7.904 |
| -20.2 (-29) | 166.35 | 7.848 |
| -18.4 (-28) | 156.413 | 7.790 |
| -16.6 (-27) | 147.136 | 7.730 |
| -14.8 (-26) | 138.47 | 7.666 |
| -13 (-25) | 130.372 | 7.601 |
| -11.2 (-24) | 122.8 | 7.534 |
| -9.4 (-23) | 115.718 | 7.464 |
| -7.6 (-22) | 109.089 | 7.392 |
| -5.8 (-21) | 102.883 | 7.318 |
| -4 (-20) | 97.073 | 7.241 |
| -2.2 (-19) | 91.597 | 7.161 |
| -0.4 (-18) | 86.471 | 7.080 |
| 1.4 (-17) | 81.667 | 6.996 |
| 3.2 (-16) | 77.161 | 6.910 |
| 5 (-15) | 72.932 | 6.821 |
| 6.8 (-14) | 68.962 | 6.731 |
| 8.6 (-13) | 65.231 | 6.639 |
| 10.4 (-12) | 61.723 | 6.545 |
| 12.2 (-11) | 58.424 | 6.448 |
| 14 (-10) | 55.321 | 6.351 |
| 15.8 (-9) | 52.399 | 6.251 |
| 17.6 (-8) | 49.648 | 6.150 |
| 19.4 (-7) | 47.058 | 6.047 |
| 21.2 (-6) | 44.617 | 5.943 |
| 23 (-5) | 42.317 | 5.838 |
| 24.8 (-4) | 40.15 | 5.732 |
| 26.6 (-3) | 38.106 | 5.624 |
| 28.4 (-2) | 36.18 | 5.516 |
| 30.2 (-1) | 34.363 | 5.408 |
| 32 (0) | 32.65 | 5.299 |
| 33.8 (1) | 31.027 | 5.189 |
| 35.6 (2) | 29.494 | 5.079 |
| 37.4 (3) | 28.047 | 4.969 |
| 39.2 (4) | 26.68 | 4.859 |
| 41 (5) | 25.388 | 4.750 |
| 42.8 (6) | 24.166 | 4.641 |
| 44.6 (7) | 23.01 | 4.532 |
| 46.4 (8) | 21.916 | 4.423 |
| 48.2 (9) | 20.88 | 4.316 |
| 50 (10) | 19.898 | 4.209 |
| 51.8 (11) | 18.968 | 4.103 |
| 53.6 (12) | 18.087 | 3.998 |
| 55.4 (13) | 17.252 | 3.894 |
| 57.2 (14) | 16.46 | 3.792 |
| 59 (15) | 15.708 | 3.690 |
| 60.8 (16) | 14.995 | 3.591 |
| 62.6 (17) | 14.319 | 3.492 |
| 64.4 (18) | 13.678 | 3.396 |
| 66.2 (19) | 13.068 | 3.300 |
| 68 (20) | 12.49 | 3.207 |
| 69.8 (21) | 11.94 | 3.115 |
| 71.6 (22) | 11.418 | 3.025 |
| 73.4 (23) | 10.921 | 2.937 |
| 75.2 (24) | 10.449 | 2.850 |
| 77 (25) | 10 | 2.767 |
| 78.8 (26) | 9.572 | 2.684 |
| 80.6 (27) | 9.165 | 2.603 |
| 82.4 (28) | 8.777 | 2.524 |
| 84.2 (29) | 8.408 | 2.447 |
| 86 (30) | 8.057 | 2.372 |
| 87.8 (31) | 7.722 | 2.299 |
| 89.6 (32) | 7.402 | 2.228 |
| 91.4 (33) | 7.098 | 2.159 |
| 93.2 (34) | 6.808 | 2.091 |
| 95 (35) | 6.531 | 2.025 |
| 96.8 (36) | 6.267 | 1.962 |
| 98.6 (37) | 6.015 | 1.900 |
| 100.4 (38) | 5.775 | 1.840 |
| 102.2 (39) | 5.546 | 1.781 |
| 104 (40) | 5.327 | 1.724 |
| 105.8 (41) | 5.117 | 1.669 |
| 107.6 (42) | 4.917 | 1.616 |
| 109.4 (43) | 4.726 | 1.564 |
| 111.2 (44) | 4.543 | 1.514 |
| 113 (45) | 4.369 | 1.465 |
| 114.8 (46) | 4.202 | 1.418 |
| 116.6 (47) | 4.042 | 1.373 |
| 118.4 (48) | 3.889 | 1.329 |
| 120.2 (49) | 3.743 | 1.286 |
| 122 (50) | 3.603 | 1.244 |
| 123.8 (51) | 3.469 | 1.204 |
| 125.6 (52) | 3.34 | 1.166 |
| 127.4 (53) | 3.217 | 1.128 |
| 129.2 (54) | 3.099 | 1.092 |
| 131 (55) | 2.986 | 1.057 |
| 132.8 (56) | 2.878 | 1.023 |
| 134.6 (57) | 2.774 | 0.990 |
| 136.4 (58) | 2.675 | 0.959 |
| 138.2 (59) | 2.579 | 0.928 |
| 140 (60) | 2.488 | 0.898 |
| 141.8 (61) | 2.4 | 0.870 |
| 143.6 (62) | 2.316 | 0.842 |
| 145.4 (63) | 2.235 | 0.815 |
| 147.2 (64) | 2.158 | 0.790 |
| 149 (65) | 2.083 | 0.765 |
| 150.8 (66) | 2.011 | 0.740 |
| 152.6 (67) | 1.943 | 0.718 |
| 154.4 (68) | 1.877 | 0.695 |
| 156.2 (69) | 1.813 | 0.673 |
| 158 (70) | 1.752 | 0.652 |
| 159.8 (71) | 1.694 | 0.632 |
| 161.6 (72) | 1.637 | 0.612 |
| 163.4 (73) | 1.583 | 0.593 |
| 165.2 (74) | 1.531 | 0.575 |
| 167 (75) | 1.481 | 0.557 |
| 168.8 (76) | 1.433 | 0.541 |
| 170.6 (77) | 1.387 | 0.524 |
| 172.4 (78) | 1.342 | 0.508 |
| 174.2 (79) | 1.299 | 0.493 |
| 176 (80) | 1.258 | 0.478 |
| 177.8 (81) | 1.218 | 0.464 |
| 179.6 (82) | 1.179 | 0.450 |
| 181.4 (83) | 1.142 | 0.436 |
| 183.2 (84) | 1.107 | 0.423 |
| 185 (85) | 1.072 | 0.411 |
| 186.8 (86) | 1.039 | 0.399 |
| 188.6 (87) | 1.007 | 0.387 |
| 190.4 (88) | 0.976 | 0.375 |
| 192.2 (89) | 0.947 | 0.365 |
| 194 (90) | 0.918 | 0.354 |
| 195.8 (91) | 0.89 | 0.344 |
| 197.6 (92) | 0.863 | 0.334 |
| 199.4 (93) | 0.838 | 0.324 |
| 201.2 (94) | 0.813 | 0.315 |
| 203 (95) | 0.789 | 0.306 |
| 204.8 (96) | 0.765 | 0.297 |
| 206.6 (97) | 0.743 | 0.289 |
| 208.4 (98) | 0.721 | 0.280 |
| 210.2 (99) | 0.7 | 0.276 |
| 212 (100) | 0.68 | 0.265 |

## NTC 20 kΩ

| Temp. °F (°C) | Resistance [kΩ] | Terminal voltage [V] |
|---|---|---|
| -58 (-50) | 1659 | 8.78 |
| -56.2 (-49) | 1541 | 8.77 |
| -54.4 (-48) | 1432 | 8.76 |
| -52.6 (-47) | 1331 | 8.75 |
| -50.8 (-46) | 1239 | 8.74 |
| -49 (-45) | 1153 | 8.72 |
| -47.2 (-44) | 1073 | 8.71 |
| -45.4 (-43) | 1000 | 8.70 |
| -43.6 (-42) | 932 | 8.69 |
| -41.8 (-41) | 869 | 8.67 |
| -40 (-40) | 811 | 8.66 |
| -38.2 (-39) | 757 | 8.64 |
| -36.4 (-38) | 706 | 8.62 |
| -34.6 (-37) | 660 | 8.60 |
| -32.8 (-36) | 617 | 8.58 |
| -31 (-35) | 577 | 8.56 |
| -29.2 (-34) | 539 | 8.54 |
| -27.4 (-33) | 505 | 8.52 |
| -25.6 (-32) | 473 | 8.49 |
| -23.8 (-31) | 443 | 8.47 |
| -22 (-30) | 415 | 8.44 |
| -20.2 (-29) | 389 | 8.41 |
| -18.4 (-28) | 364 | 8.38 |
| -16.6 (-27) | 342 | 8.35 |
| -14.8 (-26) | 321 | 8.32 |
| -13 (-25) | 301 | 8.28 |
| -11.2 (-24) | 283 | 8.25 |
| -9.4 (-23) | 266 | 8.21 |
| -7.6 (-22) | 250 | 8.17 |
| -5.8 (-21) | 235 | 8.13 |
| -4 (-20) | 221 | 8.08 |
| -2.2 (-19) | 208 | 8.04 |
| -0.4 (-18) | 196 | 7.99 |
| 1.4 (-17) | 184 | 7.94 |
| 3.2 (-16) | 174 | 7.89 |
| 5 (-15) | 164 | 7.83 |
| 6.8 (-14) | 154 | 7.78 |
| 8.6 (-13) | 146 | 7.72 |
| 10.4 (-12) | 137 | 7.66 |
| 12.2 (-11) | 130 | 7.60 |
| 14 (-10) | 122 | 7.53 |
| 15.8 (-9) | 116 | 7.46 |
| 17.6 (-8) | 109 | 7.39 |
| 19.4 (-7) | 103 | 7.32 |
| 21.2 (-6) | 97.6 | 7.25 |
| 23 (-5) | 92.3 | 7.17 |
| 24.8 (-4) | 87.3 | 7.09 |
| 26.6 (-3) | 82.6 | 7.01 |
| 28.4 (-2) | 78.2 | 6.93 |
| 30.2 (-1) | 74.1 | 6.85 |
| 32 (0) | 70.2 | 6.76 |
| 33.8 (1) | 66.5 | 6.67 |
| 35.6 (2) | 63.0 | 6.58 |
| 37.4 (3) | 59.8 | 6.49 |
| 39.2 (4) | 56.7 | 6.40 |
| 41 (5) | 53.8 | 6.30 |
| 42.8 (6) | 51.1 | 6.20 |
| 44.6 (7) | 48.5 | 6.10 |
| 46.4 (8) | 46.0 | 6.00 |
| 48.2 (9) | 43.7 | 5.90 |
| 50 (10) | 41.6 | 5.80 |
| 51.8 (11) | 39.5 | 5.70 |
| 53.6 (12) | 37.6 | 5.59 |
| 55.4 (13) | 35.7 | 5.49 |
| 57.2 (14) | 34.0 | 5.38 |
| 59 (15) | 32.3 | 5.28 |
| 60.8 (16) | 30.8 | 5.17 |
| 62.6 (17) | 29.3 | 5.07 |
| 64.4 (18) | 27.9 | 4.96 |
| 66.2 (19) | 26.6 | 4.85 |
| 68 (20) | 25.3 | 4.75 |
| 69.8 (21) | 24.2 | 4.64 |
| 71.6 (22) | 23.0 | 4.53 |
| 73.4 (23) | 22.0 | 4.43 |
| 75.2 (24) | 21.0 | 4.32 |
| 77 (25) | 20.0 | 4.22 |
| 78.8 (26) | 19.1 | 4.12 |
| 80.6 (27) | 18.2 | 4.01 |
| 82.4 (28) | 17.4 | 3.91 |
| 84.2 (29) | 16.6 | 3.81 |
| 86 (30) | 15.9 | 3.71 |
| 87.8 (31) | 15.2 | 3.62 |
| 89.6 (32) | 14.5 | 3.52 |
| 91.4 (33) | 13.9 | 3.43 |
| 93.2 (34) | 13.3 | 3.33 |
| 95 (35) | 12.7 | 3.24 |
| 96.8 (36) | 12.1 | 3.15 |
| 98.6 (37) | 11.6 | 3.06 |
| 100.4 (38) | 11.1 | 2.97 |
| 102.2 (39) | 10.7 | 2.89 |
| 104 (40) | 10.2 | 2.81 |
| 105.8 (41) | 9.78 | 2.72 |
| 107.6 (42) | 9.37 | 2.64 |
| 109.4 (43) | 8.98 | 2.57 |
| 111.2 (44) | 8.61 | 2.49 |
| 113 (45) | 8.26 | 2.42 |
| 114.8 (46) | 7.92 | 2.34 |
| 116.6 (47) | 7.60 | 2.27 |
| 118.4 (48) | 7.29 | 2.20 |
| 120.2 (49) | 7.00 | 2.14 |
| 122 (50) | 6.72 | 2.07 |
| 123.8 (51) | 6.45 | 2.01 |
| 125.6 (52) | 6.19 | 1.94 |
| 127.4 (53) | 5.95 | 1.88 |
| 129.2 (54) | 5.72 | 1.82 |
| 131 (55) | 5.49 | 1.77 |
| 132.8 (56) | 5.28 | 1.71 |
| 134.6 (57) | 5.08 | 1.66 |
| 136.4 (58) | 4.88 | 1.61 |
| 138.2 (59) | 4.69 | 1.56 |
| 140 (60) | 4.52 | 1.51 |
| 141.8 (61) | 4.35 | 1.46 |
| 143.6 (62) | 4.18 | 1.41 |
| 145.4 (63) | 4.03 | 1.37 |
| 147.2 (64) | 3.88 | 1.32 |
| 149 (65) | 3.73 | 1.28 |
| 150.8 (66) | 3.59 | 1.24 |
| 152.6 (67) | 3.46 | 1.20 |
| 154.4 (68) | 3.34 | 1.16 |
| 156.2 (69) | 3.21 | 1.13 |
| 158 (70) | 3.10 | 1.09 |
| 159.8 (71) | 2.99 | 1.06 |
| 161.6 (72) | 2.88 | 1.02 |
| 163.4 (73) | 2.78 | 0.991 |
| 165.2 (74) | 2.68 | 0.960 |
| 167 (75) | 2.58 | 0.929 |
| 168.8 (76) | 2.49 | 0.900 |
| 170.6 (77) | 2.41 | 0.872 |
| 172.4 (78) | 2.32 | 0.844 |
| 174.2 (79) | 2.24 | 0.818 |
| 176 (80) | 2.17 | 0.792 |
| 177.8 (81) | 2.09 | 0.767 |
| 179.6 (82) | 2.02 | 0.744 |
| 181.4 (83) | 1.95 | 0.720 |
| 183.2 (84) | 1.89 | 0.698 |
| 185 (85) | 1.82 | 0.676 |
| 186.8 (86) | 1.76 | 0.655 |
| 188.6 (87) | 1.70 | 0.635 |
| 190.4 (88) | 1.65 | 0.616 |
| 192.2 (89) | 1.59 | 0.597 |
| 194 (90) | 1.54 | 0.578 |
| 195.8 (91) | 1.49 | 0.561 |
| 197.6 (92) | 1.44 | 0.544 |
| 199.4 (93) | 1.40 | 0.527 |
| 201.2 (94) | 1.35 | 0.511 |
| 203 (95) | 1.31 | 0.496 |
| 204.8 (96) | 1.27 | 0.481 |
| 206.6 (97) | 1.23 | 0.466 |
| 208.4 (98) | 1.19 | 0.452 |
| 210.2 (99) | 1.15 | 0.439 |
| 212 (100) | 1.11 | 0.425 |
| 213.8 (101) | 1.08 | 0.413 |
| 215.6 (102) | 1.05 | 0.401 |
| 217.4 (103) | 1.01 | 0.389 |
| 219.2 (104) | 0.98 | 0.378 |
| 221 (105) | 0.95 | 0.367 |
| 222.8 (106) | 0.92 | 0.356 |
| 224.6 (107) | 0.90 | 0.346 |
| 226.4 (108) | 0.87 | 0.336 |
| 228.2 (109) | 0.84 | 0.326 |
| 230 (110) | 0.82 | 0.317 |
| 231.8 (111) | 0.79 | 0.308 |
| 233.6 (112) | 0.77 | 0.299 |
| 235.4 (113) | 0.75 | 0.290 |
| 237.2 (114) | 0.73 | 0.282 |
| 239 (115) | 0.70 | 0.274 |
| 240.8 (116) | 0.68 | 0.266 |
| 242.6 (117) | 0.66 | 0.259 |
| 244.4 (118) | 0.64 | 0.252 |
| 246.2 (119) | 0.63 | 0.245 |
| 248 (120) | 0.61 | 0.238 |
| 249.8 (121) | 0.59 | 0.231 |
| 251.6 (122) | 0.57 | 0.225 |
| 253.4 (123) | 0.56 | 0.219 |
| 255.2 (124) | 0.54 | 0.213 |
| 257 (125) | 0.53 | 0.207 |
| 258.8 (126) | 0.51 | 0.201 |
| 260.6 (127) | 0.50 | 0.196 |
| 262.4 (128) | 0.49 | 0.191 |
| 264.2 (129) | 0.47 | 0.186 |
| 266 (130) | 0.46 | 0.181 |
| 267.8 (131) | 0.45 | 0.176 |
| 269.6 (132) | 0.43 | 0.171 |
| 271.4 (133) | 0.42 | 0.167 |
| 273.2 (134) | 0.41 | 0.162 |
| 275 (135) | 0.40 | 0.158 |
| 276.8 (136) | 0.39 | 0.154 |
| 278.6 (137) | 0.38 | 0.150 |
| 280.4 (138) | 0.37 | 0.146 |
| 282.2 (139) | 0.36 | 0.142 |
| 284 (140) | 0.35 | 0.139 |
| 285.8 (141) | 0.34 | 0.135 |
| 287.6 (142) | 0.33 | 0.132 |
| 289.4 (143) | 0.32 | 0.128 |
| 291.2 (144) | 0.32 | 0.125 |
| 293 (145) | 0.31 | 0.122 |
| 294.8 (146) | 0.30 | 0.119 |
| 296.6 (147) | 0.29 | 0.116 |
| 298.4 (148) | 0.29 | 0.113 |
| 300.2 (149) | 0.28 | 0.110 |
| 302 (150) | 0.27 | 0.107 |

## PT 1000

| Temp. °F (°C) | Resistance [Ω] | Terminal voltage [V] |
|---|---|---|
| -58 (-50) | 803 | 0.312 |
| -56.2 (-49) | 807 | 0.314 |
| -54.4 (-48) | 811 | 0.315 |
| -52.6 (-47) | 815 | 0.317 |
| -50.8 (-46) | 819 | 0.318 |
| -49 (-45) | 823 | 0.320 |
| -47.2 (-44) | 827 | 0.321 |
| -45.4 (-43) | 831 | 0.323 |
| -43.6 (-42) | 835 | 0.324 |
| -41.8 (-41) | 839 | 0.326 |
| -40 (-40) | 843 | 0.327 |
| -38.2 (-39) | 847 | 0.329 |
| -36.4 (-38) | 851 | 0.330 |
| -34.6 (-37) | 855 | 0.332 |
| -32.8 (-36) | 859 | 0.333 |
| -31 (-35) | 862 | 0.335 |
| -29.2 (-34) | 866 | 0.336 |
| -27.4 (-33) | 870 | 0.338 |
| -25.6 (-32) | 874 | 0.339 |
| -23.8 (-31) | 878 | 0.341 |
| -22 (-30) | 882 | 0.342 |
| -20.2 (-29) | 886 | 0.344 |
| -18.4 (-28) | 890 | 0.345 |
| -16.6 (-27) | 894 | 0.347 |
| -14.8 (-26) | 898 | 0.348 |
| -13 (-25) | 902 | 0.350 |
| -11.2 (-24) | 906 | 0.351 |
| -9.4 (-23) | 910 | 0.353 |
| -7.6 (-22) | 914 | 0.354 |
| -5.8 (-21) | 918 | 0.356 |
| -4 (-20) | 922 | 0.357 |
| -2.2 (-19) | 926 | 0.359 |
| -0.4 (-18) | 929 | 0.360 |
| 1.4 (-17) | 933 | 0.361 |
| 3.2 (-16) | 937 | 0.363 |
| 5 (-15) | 941 | 0.364 |
| 6.8 (-14) | 945 | 0.366 |
| 8.6 (-13) | 949 | 0.367 |
| 10.4 (-12) | 953 | 0.369 |
| 12.2 (-11) | 957 | 0.370 |
| 14 (-10) | 961 | 0.372 |
| 15.8 (-9) | 965 | 0.373 |
| 17.6 (-8) | 969 | 0.375 |
| 19.4 (-7) | 973 | 0.376 |
| 21.2 (-6) | 977 | 0.378 |
| 23 (-5) | 980 | 0.379 |
| 24.8 (-4) | 984 | 0.380 |
| 26.6 (-3) | 988 | 0.382 |
| 28.4 (-2) | 992 | 0.383 |
| 30.2 (-1) | 996 | 0.385 |
| 32 (0) | 1000 | 0.386 |
| 33.8 (1) | 1004 | 0.388 |
| 35.6 (2) | 1008 | 0.389 |
| 37.4 (3) | 1012 | 0.391 |
| 39.2 (4) | 1016 | 0.392 |
| 41 (5) | 1020 | 0.394 |
| 42.8 (6) | 1023 | 0.395 |
| 44.6 (7) | 1027 | 0.396 |
| 46.4 (8) | 1031 | 0.398 |
| 48.2 (9) | 1035 | 0.399 |
| 50 (10) | 1039 | 0.401 |
| 51.8 (11) | 1043 | 0.402 |
| 53.6 (12) | 1047 | 0.404 |
| 55.4 (13) | 1051 | 0.405 |
| 57.2 (14) | 1055 | 0.406 |
| 59 (15) | 1058 | 0.408 |
| 60.8 (16) | 1062 | 0.409 |
| 62.6 (17) | 1066 | 0.411 |
| 64.4 (18) | 1070 | 0.412 |
| 66.2 (19) | 1074 | 0.413 |
| 68 (20) | 1078 | 0.415 |
| 69.8 (21) | 1082 | 0.416 |
| 71.6 (22) | 1086 | 0.418 |
| 73.4 (23) | 1090 | 0.419 |
| 75.2 (24) | 1093 | 0.420 |
| 77 (25) | 1097 | 0.422 |
| 78.8 (26) | 1101 | 0.423 |
| 80.6 (27) | 1105 | 0.425 |
| 82.4 (28) | 1109 | 0.426 |
| 84.2 (29) | 1113 | 0.428 |
| 86 (30) | 1117 | 0.429 |
| 87.8 (31) | 1121 | 0.431 |
| 89.6 (32) | 1124 | 0.432 |
| 91.4 (33) | 1128 | 0.433 |
| 93.2 (34) | 1132 | 0.435 |
| 95 (35) | 1136 | 0.436 |
| 96.8 (36) | 1140 | 0.438 |
| 98.6 (37) | 1144 | 0.439 |
| 100.4 (38) | 1148 | 0.441 |
| 102.2 (39) | 1152 | 0.442 |
| 104 (40) | 1155 | 0.443 |
| 105.8 (41) | 1159 | 0.445 |
| 107.6 (42) | 1163 | 0.446 |
| 109.4 (43) | 1167 | 0.448 |
| 111.2 (44) | 1171 | 0.449 |
| 113 (45) | 1175 | 0.451 |
| 114.8 (46) | 1179 | 0.452 |
| 116.6 (47) | 1182 | 0.453 |
| 118.4 (48) | 1186 | 0.455 |
| 120.2 (49) | 1190 | 0.456 |
| 122 (50) | 1194 | 0.458 |
| 123.8 (51) | 1198 | 0.459 |
| 125.6 (52) | 1202 | 0.461 |
| 127.4 (53) | 1205 | 0.462 |
| 129.2 (54) | 1209 | 0.463 |
| 131 (55) | 1213 | 0.465 |
| 132.8 (56) | 1217 | 0.466 |
| 134.6 (57) | 1221 | 0.467 |
| 136.4 (58) | 1225 | 0.469 |
| 138.2 (59) | 1229 | 0.470 |
| 140 (60) | 1232 | 0.471 |
| 141.8 (61) | 1236 | 0.473 |
| 143.6 (62) | 1240 | 0.474 |
| 145.4 (63) | 1244 | 0.476 |
| 147.2 (64) | 1248 | 0.477 |
| 149 (65) | 1252 | 0.479 |
| 150.8 (66) | 1255 | 0.480 |
| 152.6 (67) | 1259 | 0.481 |
| 154.4 (68) | 1263 | 0.483 |
| 156.2 (69) | 1267 | 0.484 |
| 158 (70) | 1271 | 0.486 |
| 159.8 (71) | 1275 | 0.487 |
| 161.6 (72) | 1278 | 0.488 |
| 163.4 (73) | 1282 | 0.490 |
| 165.2 (74) | 1286 | 0.491 |
| 167 (75) | 1290 | 0.493 |
| 168.8 (76) | 1294 | 0.494 |
| 170.6 (77) | 1297 | 0.495 |
| 172.4 (78) | 1301 | 0.497 |
| 174.2 (79) | 1305 | 0.498 |
| 176 (80) | 1309 | 0.499 |
| 177.8 (81) | 1313 | 0.501 |
| 179.6 (82) | 1317 | 0.502 |
| 181.4 (83) | 1320 | 0.503 |
| 183.2 (84) | 1324 | 0.505 |
| 185 (85) | 1328 | 0.506 |
| 186.8 (86) | 1332 | 0.508 |
| 188.6 (87) | 1336 | 0.509 |
| 190.4 (88) | 1339 | 0.510 |
| 192.2 (89) | 1343 | 0.512 |
| 194 (90) | 1347 | 0.513 |
| 195.8 (91) | 1351 | 0.515 |
| 197.6 (92) | 1355 | 0.516 |
| 199.4 (93) | 1358 | 0.517 |
| 201.2 (94) | 1362 | 0.519 |
| 203 (95) | 1366 | 0.520 |
| 204.8 (96) | 1370 | 0.522 |
| 206.6 (97) | 1374 | 0.523 |
| 208.4 (98) | 1377 | 0.524 |
| 210.2 (99) | 1381 | 0.525 |
| 212 (100) | 1385 | 0.527 |
| 213.8 (101) | 1389 | 0.528 |
| 215.6 (102) | 1393 | 0.530 |
| 217.4 (103) | 1396 | 0.531 |
| 219.2 (104) | 1400 | 0.532 |
| 221 (105) | 1404 | 0.534 |
| 222.8 (106) | 1408 | 0.535 |
| 224.6 (107) | 1412 | 0.537 |
| 226.4 (108) | 1415 | 0.538 |
| 228.2 (109) | 1419 | 0.539 |
| 230 (110) | 1423 | 0.541 |
| 231.8 (111) | 1427 | 0.542 |
| 233.6 (112) | 1430 | 0.543 |
| 235.4 (113) | 1434 | 0.545 |
| 237.2 (114) | 1438 | 0.546 |
| 239 (115) | 1442 | 0.547 |
| 240.8 (116) | 1446 | 0.549 |
| 242.6 (117) | 1449 | 0.550 |
| 244.4 (118) | 1453 | 0.551 |
| 246.2 (119) | 1457 | 0.553 |
| 248 (120) | 1461 | 0.554 |
| 249.8 (121) | 1464 | 0.555 |
| 251.6 (122) | 1468 | 0.557 |
| 253.4 (123) | 1472 | 0.558 |
| 255.2 (124) | 1476 | 0.560 |
| 257 (125) | 1479 | 0.561 |
| 258.8 (126) | 1483 | 0.562 |
| 260.6 (127) | 1487 | 0.564 |
| 262.4 (128) | 1491 | 0.565 |
| 264.2 (129) | 1494 | 0.566 |
| 266 (130) | 1498 | 0.567 |
| 267.8 (131) | 1502 | 0.569 |
| 269.6 (132) | 1506 | 0.570 |
| 271.4 (133) | 1510 | 0.572 |
| 273.2 (134) | 1513 | 0.573 |
| 275 (135) | 1517 | 0.574 |
| 276.8 (136) | 1521 | 0.576 |
| 278.6 (137) | 1525 | 0.577 |
| 280.4 (138) | 1528 | 0.578 |
| 282.2 (139) | 1532 | 0.580 |
| 284 (140) | 1536 | 0.581 |
| 285.8 (141) | 1539 | 0.582 |
| 287.6 (142) | 1543 | 0.584 |
| 289.4 (143) | 1547 | 0.585 |
| 291.2 (144) | 1551 | 0.586 |
| 293 (145) | 1554 | 0.587 |
| 294.8 (146) | 1558 | 0.589 |
| 296.6 (147) | 1562 | 0.590 |
| 298.4 (148) | 1566 | 0.592 |
| 300.2 (149) | 1569 | 0.593 |
| 302 (150) | 1573 | 0.594 |
| 303.8 (151) | 1577 | 0.596 |
| 305.6 (152) | 1581 | 0.597 |
| 307.4 (153) | 1584 | 0.598 |
| 309.2 (154) | 1588 | 0.600 |
| 311 (155) | 1592 | 0.601 |
| 312.8 (156) | 1596 | 0.602 |
| 314.6 (157) | 1599 | 0.603 |
| 316.4 (158) | 1603 | 0.605 |
| 318.2 (159) | 1607 | 0.606 |
| 320 (160) | 1610 | 0.607 |
| 321.8 (161) | 1614 | 0.609 |
| 323.6 (162) | 1618 | 0.610 |
| 325.4 (163) | 1622 | 0.612 |
| 327.2 (164) | 1625 | 0.613 |
| 329 (165) | 1629 | 0.614 |
| 330.8 (166) | 1633 | 0.615 |
| 332.6 (167) | 1636 | 0.617 |
| 334.4 (168) | 1640 | 0.618 |
| 336.2 (169) | 1644 | 0.619 |
| 338 (170) | 1648 | 0.621 |
| 339.8 (171) | 1651 | 0.622 |
| 341.6 (172) | 1655 | 0.623 |
| 343.4 (173) | 1659 | 0.625 |
| 345.2 (174) | 1662 | 0.626 |
| 347 (175) | 1666 | 0.627 |
| 348.8 (176) | 1670 | 0.629 |
| 350.6 (177) | 1674 | 0.630 |
| 352.4 (178) | 1677 | 0.631 |
| 354.2 (179) | 1681 | 0.632 |
| 356 (180) | 1685 | 0.634 |
| 357.8 (181) | 1688 | 0.635 |
| 359.6 (182) | 1692 | 0.636 |
| 361.4 (183) | 1696 | 0.638 |
| 363.2 (184) | 1699 | 0.639 |
| 365 (185) | 1703 | 0.640 |
| 366.8 (186) | 1707 | 0.642 |
| 368.6 (187) | 1711 | 0.643 |
| 370.4 (188) | 1714 | 0.644 |
| 372.2 (189) | 1718 | 0.645 |

| Temp. °F (°C) | Resistance [Ω] | Terminal voltage [V] |
|---|---|---|
| 374 (190) | 1722 | 0.647 |
| 375.8 (191) | 1725 | 0.648 |
| 377.6 (192) | 1729 | 0.649 |
| 379.4 (193) | 1733 | 0.651 |
| 381.2 (194) | 1736 | 0.652 |
| 383 (195) | 1740 | 0.653 |
| 384.8 (196) | 1744 | 0.655 |
| 386.6 (197) | 1747 | 0.656 |
| 388.4 (198) | 1751 | 0.657 |
| 390.2 (199) | 1755 | 0.658 |
| 392 (200) | 1758 | 0.659 |
| 393.8 (201) | 1762 | 0.661 |
| 395.6 (202) | 1766 | 0.662 |
| 397.4 (203) | 1769 | 0.663 |
| 399.2 (204) | 1773 | 0.665 |
| 401 (205) | 1777 | 0.666 |
| 402.8 (206) | 1780 | 0.667 |
| 404.6 (207) | 1784 | 0.669 |
| 406.4 (208) | 1788 | 0.670 |
| 408.2 (209) | 1791 | 0.671 |
| 410 (210) | 1795 | 0.672 |
| 411.8 (211) | 1799 | 0.674 |
| 413.6 (212) | 1802 | 0.675 |
| 415.4 (213) | 1806 | 0.676 |
| 417.2 (214) | 1810 | 0.678 |
| 419 (215) | 1813 | 0.679 |
| 420.8 (216) | 1817 | 0.680 |
| 422.6 (217) | 1821 | 0.681 |
| 424.4 (218) | 1824 | 0.683 |
| 426.2 (219) | 1828 | 0.684 |
| 428 (220) | 1832 | 0.685 |
| 429.8 (221) | 1835 | 0.686 |
| 431.6 (222) | 1839 | 0.688 |
| 433.4 (223) | 1843 | 0.689 |
| 435.2 (224) | 1846 | 0.690 |
| 437 (225) | 1850 | 0.692 |
| 438.8 (226) | 1854 | 0.693 |
| 440.6 (227) | 1857 | 0.694 |
| 442.4 (228) | 1861 | 0.695 |
| 444.2 (229) | 1865 | 0.697 |
| 446 (230) | 1868 | 0.698 |
| 447.8 (231) | 1872 | 0.699 |
| 449.6 (232) | 1875 | 0.700 |
| 451.4 (233) | 1879 | 0.702 |
| 453.2 (234) | 1883 | 0.703 |
| 455 (235) | 1886 | 0.704 |
| 456.8 (236) | 1890 | 0.705 |
| 458.6 (237) | 1894 | 0.707 |
| 460.4 (238) | 1897 | 0.708 |
| 462.2 (239) | 1901 | 0.709 |
| 464 (240) | 1905 | 0.711 |
| 465.8 (241) | 1908 | 0.712 |
| 467.6 (242) | 1912 | 0.713 |
| 469.4 (243) | 1915 | 0.714 |
| 471.2 (244) | 1919 | 0.716 |
| 473 (245) | 1923 | 0.717 |
| 474.8 (246) | 1926 | 0.718 |
| 476.6 (247) | 1930 | 0.719 |
| 478.4 (248) | 1934 | 0.721 |
| 480.2 (249) | 1937 | 0.722 |
| 482 (250) | 1941 | 0.723 |
| 483.8 (251) | 1944 | 0.724 |
| 485.6 (252) | 1948 | 0.726 |

| Temp. °F (°C) | Resistance [Ω] | Terminal voltage [V] |
|---|---|---|
| 487.4 (253) | 1952 | 0.727 |
| 489.2 (254) | 1955 | 0.728 |
| 491 (255) | 1959 | 0.729 |
| 492.8 (256) | 1962 | 0.730 |
| 494.6 (257) | 1966 | 0.732 |
| 496.4 (258) | 1970 | 0.733 |
| 498.2 (259) | 1973 | 0.734 |
| 500 (260) | 1977 | 0.736 |
| 501.8 (261) | 1980 | 0.737 |
| 503.6 (262) | 1984 | 0.738 |
| 505.4 (263) | 1988 | 0.739 |
| 507.2 (264) | 1991 | 0.740 |
| 509 (265) | 1995 | 0.742 |
| 510.8 (266) | 1998 | 0.743 |
| 512.6 (267) | 2002 | 0.744 |
| 514.4 (268) | 2006 | 0.746 |
| 516.2 (269) | 2009 | 0.747 |
| 518 (270) | 2013 | 0.748 |
| 519.8 (271) | 2016 | 0.749 |
| 521.6 (272) | 2020 | 0.750 |
| 523.4 (273) | 2024 | 0.752 |
| 525.2 (274) | 2027 | 0.753 |
| 527 (275) | 2031 | 0.754 |
| 528.8 (276) | 2034 | 0.755 |
| 530.6 (277) | 2038 | 0.757 |
| 532.4 (278) | 2042 | 0.758 |
| 534.2 (279) | 2045 | 0.759 |
| 536 (280) | 2049 | 0.760 |
| 537.8 (281) | 2052 | 0.761 |
| 539.6 (282) | 2056 | 0.763 |
| 541.4 (283) | 2060 | 0.764 |
| 543.2 (284) | 2063 | 0.765 |
| 545 (285) | 2067 | 0.766 |
| 546.8 (286) | 2070 | 0.768 |
| 548.6 (287) | 2074 | 0.769 |
| 550.4 (288) | 2077 | 0.770 |
| 552.2 (289) | 2081 | 0.771 |
| 554 (290) | 2085 | 0.773 |
| 555.8 (291) | 2088 | 0.774 |
| 557.6 (292) | 2092 | 0.775 |
| 559.4 (293) | 2095 | 0.776 |
| 561.2 (294) | 2099 | 0.777 |
| 563 (295) | 2102 | 0.778 |
| 564.8 (296) | 2106 | 0.780 |
| 566.6 (297) | 2110 | 0.781 |
| 568.4 (298) | 2113 | 0.782 |
| 570.2 (299) | 2117 | 0.784 |
| 572 (300) | 2120 | 0.785 |
| 573.8 (301) | 2124 | 0.786 |
| 575.6 (302) | 2127 | 0.787 |
| 577.4 (303) | 2131 | 0.788 |
| 579.2 (304) | 2134 | 0.789 |
| 581 (305) | 2138 | 0.791 |
| 582.8 (306) | 2142 | 0.792 |
| 584.6 (307) | 2145 | 0.793 |
| 586.4 (308) | 2149 | 0.794 |
| 588.2 (309) | 2152 | 0.796 |
| 590 (310) | 2156 | 0.797 |
| 591.8 (311) | 2159 | 0.798 |
| 593.6 (312) | 2163 | 0.799 |
| 595.4 (313) | 2166 | 0.800 |
| 597.2 (314) | 2170 | 0.802 |
| 599 (315) | 2173 | 0.803 |

| Temp. °F (°C) | Resistance [Ω] | Terminal voltage [V] |
|---|---|---|
| 600.8 (316) | 2177 | 0.804 |
| 602.6 (317) | 2181 | 0.805 |
| 604.4 (318) | 2184 | 0.806 |
| 606.2 (319) | 2188 | 0.808 |
| 608 (320) | 2191 | 0.809 |
| 609.8 (321) | 2195 | 0.810 |
| 611.6 (322) | 2198 | 0.811 |
| 613.4 (323) | 2202 | 0.812 |
| 615.2 (324) | 2205 | 0.814 |
| 617 (325) | 2209 | 0.815 |
| 618.8 (326) | 2212 | 0.816 |
| 620.6 (327) | 2216 | 0.817 |
| 622.4 (328) | 2219 | 0.818 |
| 624.2 (329) | 2223 | 0.820 |
| 626 (330) | 2226 | 0.821 |
| 627.8 (331) | 2230 | 0.822 |
| 629.6 (332) | 2234 | 0.823 |
| 631.4 (333) | 2237 | 0.824 |
| 633.2 (334) | 2241 | 0.826 |
| 635 (335) | 2244 | 0.827 |
| 636.8 (336) | 2248 | 0.828 |
| 638.6 (337) | 2251 | 0.829 |
| 640.4 (338) | 2255 | 0.830 |
| 642.2 (339) | 2258 | 0.831 |
| 644 (340) | 2262 | 0.833 |
| 645.8 (341) | 2265 | 0.834 |
| 647.6 (342) | 2269 | 0.835 |
| 649.4 (343) | 2272 | 0.836 |
| 651.2 (344) | 2276 | 0.838 |
| 653 (345) | 2279 | 0.839 |
| 654.8 (346) | 2283 | 0.840 |
| 656.6 (347) | 2286 | 0.841 |
| 658.4 (348) | 2290 | 0.842 |
| 660.2 (349) | 2293 | 0.843 |
| 662 (350) | 2297 | 0.845 |
| 663.8 (351) | 2300 | 0.846 |
| 665.6 (352) | 2304 | 0.847 |
| 667.4 (353) | 2307 | 0.848 |
| 669.2 (354) | 2311 | 0.849 |
| 671 (355) | 2314 | 0.850 |
| 672.8 (356) | 2318 | 0.852 |
| 674.6 (357) | 2321 | 0.853 |
| 676.4 (358) | 2325 | 0.854 |
| 678.2 (359) | 2328 | 0.855 |
| 680 (360) | 2332 | 0.856 |
| 681.8 (361) | 2335 | 0.857 |
| 683.6 (362) | 2339 | 0.859 |
| 685.4 (363) | 2342 | 0.860 |
| 687.2 (364) | 2346 | 0.861 |
| 689 (365) | 2349 | 0.862 |
| 690.8 (366) | 2353 | 0.863 |
| 692.6 (367) | 2356 | 0.864 |
| 694.4 (368) | 2360 | 0.866 |
| 696.2 (369) | 2363 | 0.867 |
| 698 (370) | 2367 | 0.868 |
| 699.8 (371) | 2370 | 0.869 |
| 701.6 (372) | 2373 | 0.870 |
| 703.4 (373) | 2377 | 0.871 |
| 705.2 (374) | 2380 | 0.872 |
| 707 (375) | 2384 | 0.874 |
| 708.8 (376) | 2387 | 0.875 |
| 710.6 (377) | 2391 | 0.876 |
| 712.4 (378) | 2394 | 0.877 |

| Temp. °F (°C) | Resistance [Ω] | Terminal voltage [V] |
|---|---|---|
| 714.2 (379) | 2398 | 0.878 |
| 716 (380) | 2401 | 0.879 |
| 717.8 (381) | 2405 | 0.881 |
| 719.6 (382) | 2408 | 0.882 |
| 721.4 (383) | 2412 | 0.883 |
| 723.2 (384) | 2415 | 0.884 |
| 725 (385) | 2419 | 0.885 |
| 726.8 (386) | 2422 | 0.886 |
| 728.6 (387) | 2426 | 0.888 |
| 730.4 (388) | 2429 | 0.889 |
| 732.2 (389) | 2432 | 0.890 |
| 734 (390) | 2436 | 0.891 |
| 735.8 (391) | 2439 | 0.892 |
| 737.6 (392) | 2443 | 0.893 |
| 739.4 (393) | 2446 | 0.894 |
| 741.2 (394) | 2450 | 0.896 |
| 743 (395) | 2453 | 0.897 |
| 744.8 (396) | 2457 | 0.898 |
| 746.6 (397) | 2460 | 0.899 |
| 748.4 (398) | 2463 | 0.900 |
| 750.2 (399) | 2467 | 0.901 |
| 752 (400) | 2470 | 0.902 |

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| Temp. °F (°C) | Resistance [Ω] | Terminal voltage [V] |
|---|---|---|
| -22 (-30) | 871.7 | 0.338 |
| -20.2 (-29) | 875.8 | 0.340 |
| -18.4 (-28) | 880 | 0.341 |
| -16.6 (-27) | 884.1 | 0.343 |
| -14.8 (-26) | 888.3 | 0.344 |
| -13 (-25) | 892.5 | 0.346 |
| -11.2 (-24) | 896.7 | 0.348 |
| -9.4 (-23) | 900.8 | 0.349 |
| -7.6 (-22) | 905.1 | 0.351 |
| -5.8 (-21) | 909.3 | 0.352 |
| -4 (-20) | 913.5 | 0.354 |
| -2.2 (-19) | 917.7 | 0.355 |
| -0.4 (-18) | 922 | 0.357 |
| 1.4 (-17) | 926.2 | 0.359 |
| 3.2 (-16) | 930.5 | 0.360 |
| 5 (-15) | 934.7 | 0.362 |
| 6.8 (-14) | 939 | 0.363 |
| 8.6 (-13) | 943.3 | 0.365 |
| 10.4 (-12) | 947.6 | 0.367 |
| 12.2 (-11) | 951.9 | 0.368 |
| 14 (-10) | 956.2 | 0.370 |
| 15.8 (-9) | 960.6 | 0.371 |
| 17.6 (-8) | 964.9 | 0.373 |
| 19.4 (-7) | 969.3 | 0.375 |
| 21.2 (-6) | 973.6 | 0.376 |
| 23 (-5) | 978 | 0.378 |
| 24.8 (-4) | 982.4 | 0.380 |
| 26.6 (-3) | 986.7 | 0.381 |
| 28.4 (-2) | 991.2 | 0.383 |
| 30.2 (-1) | 995.6 | 0.384 |
| 32 (0) | 1000 | 0.386 |
| 33.8 (1) | 1004.4 | 0.388 |
| 35.6 (2) | 1008.9 | 0.389 |
| 37.4 (3) | 1013.3 | 0.391 |
| 39.2 (4) | 1017.8 | 0.393 |
| 41 (5) | 1022.3 | 0.394 |
| 42.8 (6) | 1026.7 | 0.396 |
| 44.6 (7) | 1031.2 | 0.398 |
| 46.4 (8) | 1035.8 | 0.399 |
| 48.2 (9) | 1040.3 | 0.401 |
| 50 (10) | 1044.8 | 0.403 |
| 51.8 (11) | 1049.3 | 0.404 |
| 53.6 (12) | 1053.9 | 0.406 |
| 55.4 (13) | 1058.4 | 0.408 |
| 57.2 (14) | 1063 | 0.409 |
| 59 (15) | 1067.6 | 0.411 |
| 60.8 (16) | 1072.2 | 0.413 |
| 62.6 (17) | 1076.8 | 0.415 |
| 64.4 (18) | 1081.4 | 0.416 |
| 66.2 (19) | 1086 | 0.418 |
| 68 (20) | 1090.7 | 0.420 |
| 69.8 (21) | 1095.3 | 0.421 |
| 71.6 (22) | 1100 | 0.423 |
| 73.4 (23) | 1104.6 | 0.425 |
| 75.2 (24) | 1109.3 | 0.427 |
| 77 (25) | 1114 | 0.428 |
| 78.8 (26) | 1118.7 | 0.430 |
| 80.6 (27) | 1123.4 | 0.432 |
| 82.4 (28) | 1128.1 | 0.433 |
| 84.2 (29) | 1132.9 | 0.435 |
| 86 (30) | 1137.6 | 0.437 |
| 87.8 (31) | 1142.4 | 0.439 |
| 89.6 (32) | 1147.1 | 0.440 |
| 91.4 (33) | 1151.9 | 0.442 |
| 93.2 (34) | 1156.7 | 0.444 |
| 95 (35) | 1161.5 | 0.446 |
| 96.8 (36) | 1166.3 | 0.447 |
| 98.6 (37) | 1171.2 | 0.449 |
| 100.4 (38) | 1176 | 0.451 |
| 102.2 (39) | 1180.9 | 0.453 |
| 104 (40) | 1185.7 | 0.455 |
| 105.8 (41) | 1190.6 | 0.456 |
| 107.6 (42) | 1195.5 | 0.458 |
| 109.4 (43) | 1200.4 | 0.460 |
| 111.2 (44) | 1205.3 | 0.462 |
| 113 (45) | 1210.2 | 0.463 |
| 114.8 (46) | 1215.1 | 0.465 |
| 116.6 (47) | 1220.1 | 0.467 |
| 118.4 (48) | 1225 | 0.469 |
| 120.2 (49) | 1230 | 0.471 |
| 122 (50) | 1235 | 0.473 |
| 123.8 (51) | 1240 | 0.474 |
| 125.6 (52) | 1245 | 0.476 |
| 127.4 (53) | 1250 | 0.478 |
| 129.2 (54) | 1255 | 0.480 |
| 131 (55) | 1260.1 | 0.482 |
| 132.8 (56) | 1265.1 | 0.484 |
| 134.6 (57) | 1270.2 | 0.485 |
| 136.4 (58) | 1275.3 | 0.487 |
| 138.2 (59) | 1280.3 | 0.489 |
| 140 (60) | 1285.4 | 0.491 |
| 141.8 (61) | 1290.6 | 0.493 |
| 143.6 (62) | 1295.7 | 0.495 |
| 145.4 (63) | 1300.8 | 0.496 |
| 147.2 (64) | 1306 | 0.498 |
| 149 (65) | 1311.1 | 0.500 |
| 150.8 (66) | 1316.3 | 0.502 |
| 152.6 (67) | 1321.5 | 0.504 |
| 154.4 (68) | 1326.7 | 0.506 |
| 156.2 (69) | 1331.9 | 0.508 |
| 158 (70) | 1337.1 | 0.510 |
| 159.8 (71) | 1342.4 | 0.512 |
| 161.6 (72) | 1347.6 | 0.513 |
| 163.4 (73) | 1352.9 | 0.515 |
| 165.2 (74) | 1358.2 | 0.517 |
| 167 (75) | 1363.5 | 0.519 |
| 168.8 (76) | 1368.8 | 0.521 |
| 170.6 (77) | 1374.1 | 0.523 |
| 172.4 (78) | 1379.4 | 0.525 |
| 174.2 (79) | 1384.8 | 0.527 |
| 176 (80) | 1390.1 | 0.529 |
| 177.8 (81) | 1395.5 | 0.531 |
| 179.6 (82) | 1400.9 | 0.533 |
| 181.4 (83) | 1406.3 | 0.535 |
| 183.2 (84) | 1411.7 | 0.537 |
| 185 (85) | 1417.1 | 0.538 |
| 186.8 (86) | 1422.5 | 0.540 |
| 188.6 (87) | 1428 | 0.542 |
| 190.4 (88) | 1433.4 | 0.544 |
| 192.2 (89) | 1438.9 | 0.546 |
| 194 (90) | 1444.4 | 0.548 |
| 195.8 (91) | 1449.9 | 0.550 |
| 197.6 (92) | 1455.4 | 0.552 |
| 199.4 (93) | 1460.9 | 0.554 |
| 201.2 (94) | 1466.5 | 0.556 |
| 203 (95) | 1472 | 0.558 |
| 204.8 (96) | 1477.6 | 0.560 |
| 206.6 (97) | 1483.2 | 0.562 |
| 208.4 (98) | 1488.8 | 0.564 |
| 210.2 (99) | 1494.4 | 0.566 |
| 212 (100) | 1500 | 0.568 |
| 213.8 (101) | 1505.6 | 0.570 |
| 215.6 (102) | 1511.3 | 0.572 |
| 217.4 (103) | 1517 | 0.574 |
| 219.2 (104) | 1522.6 | 0.576 |
| 221 (105) | 1528.3 | 0.578 |
| 222.8 (106) | 1534 | 0.580 |
| 224.6 (107) | 1539.7 | 0.582 |
| 226.4 (108) | 1545.5 | 0.584 |
| 228.2 (109) | 1551.2 | 0.586 |
| 230 (110) | 1557 | 0.589 |
| 231.8 (111) | 1562.8 | 0.591 |
| 233.6 (112) | 1568.5 | 0.593 |
| 235.4 (113) | 1574.4 | 0.595 |
| 237.2 (114) | 1580.2 | 0.597 |
| 239 (115) | 1586 | 0.599 |
| 240.8 (116) | 1591.8 | 0.601 |
| 242.6 (117) | 1597.7 | 0.603 |
| 244.4 (118) | 1603.6 | 0.605 |
| 246.2 (119) | 1609.5 | 0.607 |
| 248 (120) | 1615.4 | 0.609 |
| 249.8 (121) | 1621.3 | 0.611 |
| 251.6 (122) | 1627.2 | 0.613 |
| 253.4 (123) | 1633.2 | 0.616 |
| 255.2 (124) | 1639.1 | 0.618 |
| 257 (125) | 1645.1 | 0.620 |
| 258.8 (126) | 1651.1 | 0.622 |
| 260.6 (127) | 1657.1 | 0.624 |
| 262.4 (128) | 1663.1 | 0.626 |
| 264.2 (129) | 1669.1 | 0.628 |
| 266 (130) | 1675.2 | 0.630 |

**Trademark Information**

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