

## USING THE OPTIONAL TEMPERATURE COMPENSATION FEATURE

### SCOPE

All AT10.1 and AT30 Series microprocessor-controlled float battery chargers

### SUMMARY

The AT Series microprocessor-controlled stationary battery charger (AT10.1 single phase, or AT30 three phase) can use an optional battery temperature sensor (manufacturer's part number EJ5033-##) to compensate the dc output voltage for changes in temperature. This feature is referred to as "tempco".

### TEMPERATURE EFFECTS ON STORAGE BATTERIES

Storage batteries used in stationary applications are normally charged at a constant voltage ("float voltage"). The float current depends on electrochemical processes in the battery that vary with battery temperature. This causes the float current to change as the temperature changes. This is true especially for the two battery types most commonly used in industry, lead-acid and nickel-cadmium.

When storage batteries are charged at constant voltage, float current increases with increasing temperature. For a 10°C increase in temperature, the float current approximately doubles (but the change may be smaller for a nickel-cadmium battery). Expressed differently, float charge voltage required to maintain a constant float current decreases as temperature increases. Thus, we say that the battery float voltage has a negative temperature coefficient. In normal float operation, the float voltage is chosen so that the float current exactly compensates for internal self-discharge. Maintaining the balance between float current and self-discharge is an important element in realizing maximum battery life.

The AT series battery charger normally has a constant dc output (float) voltage. If the charger is connected to a battery that sees wide temperature fluctuations, the average float current may not be the optimum value. The AT charger can use an optional temperature probe, mounted on or near the battery, to monitor the battery temperature. The charger control circuit uses the information from the temperature probe to change the float voltage as temperature varies, with the goal of maintaining the float current at the correct value.

### WHEN TO USE TEMPERATURE COMPENSATION

If your battery is installed in a temperature-controlled room, you probably do not need a temperature-compensated charger, although you should adjust the float voltage correctly for the temperature in the battery room. However, you might consider adding temperature compensation to the charger if you have any of the following conditions:

- If the battery is in a temperature-controlled environment, but there is a risk of failure or disconnection of the environmental controls (e.g., air conditioning).
- If the battery is a VRLA (Valve-Regulated Lead Acid), and the battery room may see moderate temperature changes.
- If the battery is in a non-temperature-controlled environment.

To order tempco with a new charger, choose it (part number EJ5033-00) from the list of options on the order sheet, or specify it on your purchase order. To order it for field installation, order the tempco field retrofit kit suitable for your application from your sales representative. See also [www.ATSeries.net](http://www.ATSeries.net).

### INSTALLING TEMPERATURE COMPENSATION

A separate installation procedure ([JA5015-00](#)) is supplied with each tempco kit. It is the same for all AT Series battery chargers, and whether you have a new charger or are installing tempco into an existing unit. In most cases, you should follow the steps outlined in the AT Series battery charger *Operating and Service Instructions*, section 1.11. The steps outlined in the AT30 manual are reprinted at the end of this application note for convenience.

**ADJUSTING FLOAT & EQUALIZE VOLTAGES W/TEMPERATURE COMPENSATION**

Before setting the float and equalize voltages with the temperature compensation probe installed, it is a good idea to verify that the front panel voltmeter is calibrated, as described in the *Operating and Service Instructions*, section 2.3.7. To do this:

- Disconnect one wire from **TB8**. The error code **E 08** will appear on the front panel meter display. To get rid of the error, de-energize and restart the charger in Float mode.
- Connect a digital dc voltmeter to the dc output terminals of the charger.
- Press and hold the **UP** key, then press the **EQLZ MTHD** key. Release both keys. This places the charger in the Voltmeter calibration mode. The front panel meter displays the output float voltage.
- Press the **UP** or **DOWN** key repeatedly until the actual output voltage, measured by your external digital voltmeter, matches the float voltage shown by the charger's front panel meter. The output voltage increases or decreases by a small amount each time you press the key. You must press and release the key once for each increment in output voltage; pressing and holding the key does not cause the voltage to scroll.

Remember, it is the actual output voltage of the charger that changes when you press the **UP** or **DOWN** key, and the charger's front panel meter stays the same. After you have calibrated the meter, remove your digital voltmeter, de-energize the charger, reconnect the temperature probe wire to **TB8**, and restart the charger.

With the temperature compensation probe connected and working properly, the front panel meter always shows the float (or equalize) voltage for a 25°C (77°F) temperature. The actual output voltage of the charger varies with temperature, such that the actual dc output voltage will *almost never match* the front panel meter reading. The temperature probe should be installed in a location that is likely to produce a good indication of the average temperature of the battery.

When you adjust the float and equalize voltages from the front panel, the voltage that is displayed is the 25°C value. *The temperature probe determines the actual dc output voltage of the charger.* Be sure that the float and equalize voltages that you set agree with the battery manufacturer's recommendations for 25°C (77°F) ° operation.

If you know the probe temperature, you can adjust the float voltage for that exact temperature, using the graph at the end of this application note. Since the probe has a temperature tolerance of ±0.5°C, you may want to adjust the float and equalize voltages if they are more than about 1% off. Remember that any adjustment you make has to be for the average temperature of the entire battery. Changing the float or equalize voltage doesn't change the slope of the compensation; the change in dc output voltage vs. temperature will still be correct.

**NUTS & BOLTS**

- The temperature probe consists of a glass bead thermistor (temperature-dependent resistor) mounted in an epoxy puck, with double-faced adhesive tape for mounting on a dry surface. While the adhesive is compatible with a wide range of materials, it is optimized for high surface energy materials (most metals, for example). The probe should *not* be mounted on plastic surfaces, including most battery jars. It can be mounted on lead-plated or nickel-plated cell connectors, or on a battery rack, or enclosure wall. Inter-cell connectors are recommended as the best place for mounting the probe. In a battery room with little air movement, the connector will be closer to the actual battery internal temperature than the outside of a battery jar.

The thermistor used in current production has a nominal value of 10K Ohms at 25°C, and is interfaced with the charger microcontroller by an analog circuit, using a 5Vdc power supply. The maximum power dissipation of the thermistor is 0.6mW, and occurs at 25°C, which minimizes self-heating effects (less than 0.4°K). Because of the adhesive tape layer, the probe has a response time of one minute or longer.

Please note that only a shielded twisted pair cable should be used, such as the cable supplied with the probe. The shield should be grounded only at the battery charger end, as described in the installation instructions. Never run the cable in the same conduit or trough with power wiring. If possible, run the cable in its own dedicated conduit.

The thermistor manufacturer does not specify the dielectric strength. In factory tests, we have found that the probe and adhesive will withstand at least 500Vdc without damage. To be safe, do not use the probe in a dc system higher than 130Vdc (nominal).

- The thermistor resistance is measured by the battery charger control circuit, and that is converted to temperature using a linearizing calculation. The algorithm used has a maximum error of 1.0°C. Therefore, with the thermistor tolerance, self-heating effects, and algorithm accuracy, the temperature measurement is accurate to within ±2°C. The calculation is linearized only between 0°C and 50°C. These temperatures define lower and upper limits, respectively, on temperature compensation. That is, at temperatures below 0°C, the output voltage no longer changes, and at temperatures above 50°C, the output voltage no longer changes.

High dc voltage and low dc voltage alarms are not affected by temperature compensation. Therefore, if you anticipate large temperature excursions, you should adjust the HVDC and LVDC alarms so they are above the maximum and below the minimum output voltage, respectively.

- The compensation slopes chosen for lead-acid and nickel-cadmium batteries are typical values specified by battery manufacturers. Some manufacturers specify float voltage adjustments over a limited range (such as 10° - 40°C), and may choose to specify the "room temperature" as 20°C instead of 25°C. This does not change the slope. If you want to adjust the float and equalize voltages for the exact battery temperature as described above, you should consult the battery manufacturer's instructions to determine the correct float voltage value at 25°C.

In the AT Series microprocessor-controlled battery charger, the temperature compensation slope for lead-acid batteries is **-2.5mV/V/°C**, or **-3.3mV/cell/°F** at **2.4VPC** (Volts per cell). Note that this is linearized between 0° and 50°C. For nickel-cadmium batteries, the slope is **-1.9mV/V/°C**, or **-1.5mV/cell/°F**.

If you want to perform manual temperature compensation, you should first have a good temperature-controlled environment. You may use the slopes (in the graph featured at the end of this application note) to calculate the correct float voltage for any battery temperature.

- This application note primarily covers tempco use with float voltage. The same considerations apply to equalize voltage. If you are using temperature compensation because of environmental requirements, never try to equalize the battery without the temperature compensation active. This is especially true for VRLA batteries, since thermal runaway, and consequent permanent battery damage, are possible when equalizing at elevated temperatures.
- A major goal of temperature compensation is to minimize "excess Ampere-hours" delivered to the battery at elevated temperatures. Excess charge Ampere-hours translates to increased electrolyte loss and grid corrosion, resulting in a reduction of battery life. Since temperature compensation does not adjust the output voltage for temperatures over 50°C, never operate a battery in an environment warmer than 50°C (122°F). Most VRLA manufacturers recommend the battery temperature never exceed 40°C (105°F).

**SUPPLEMENTAL DOCUMENTATION**

Supplemental documents may be used in conjunction with this application note:

Doc. No.	Online Hyperlink	Description
JA5015-00	<a href="http://www.ATSeries.net/PDFs/JA5015-00.pdf">http://www.ATSeries.net/PDFs/JA5015-00.pdf</a>	AT TempCo Probe Acy. Install Instructions
JD5003-00	<a href="http://www.ATSeries.net/PDFs/JD5003-00.pdf">http://www.ATSeries.net/PDFs/JD5003-00.pdf</a>	AT Tempco Probe Application Note (this doc.)

**INSTALLATION INSTRUCTIONS**

(reprinted from **AT30** *Operating and Service Instructions*, section 1.11, page 20)

The temperature compensation probe contains a temperature-dependent resistor in an epoxy module that you install near your battery. There are three steps in installing the assembly:

1. Mounting the probe assembly near the battery.
2. Installing an interconnection cable from the probe assembly to the AT30.
3. Wiring the charger end of the cable to a terminal block on the main control circuit board.

The actual tempco probe is the same for all battery types and all output voltages of the AT30. The accessory part numbers differ depending on cable length ordered. See the tables in Appendix B on page 65 for ordering information. Each kit contains detailed installation instructions ([JA5015-00](#)). The main elements of the installation are outlined below:

**WARNING**

*High voltages appear at several points inside the AT30. Use extreme caution when working inside the unit. Do not attempt to work inside the AT30 unless you are a qualified technician or electrician.*

*Disconnect and lock out all power from the AT30 before starting to remove or replace any components. Turn the ac power off at the distribution panel upstream from the charger. Disconnect the battery from the AT30 output terminals TB1(+/-).*

**PROCEDURE**

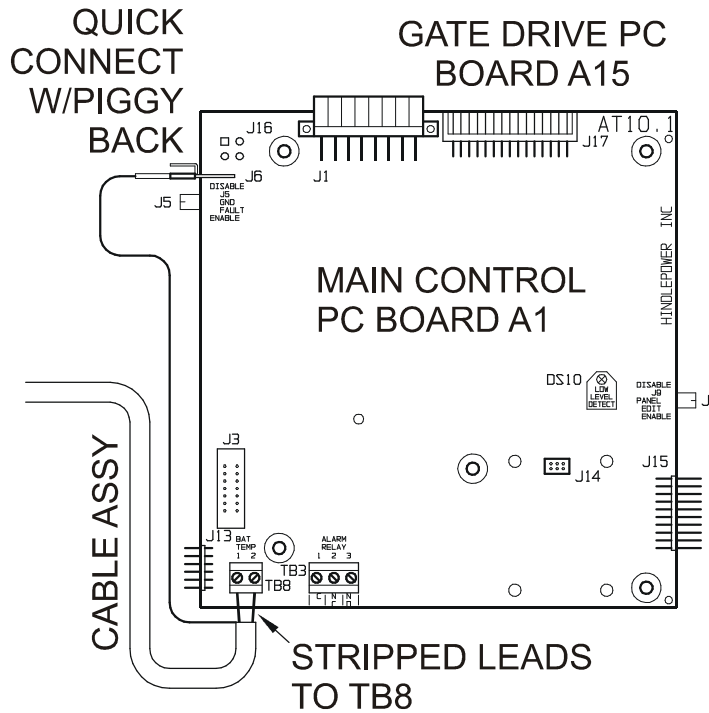
1. De-energize and lock out all ac and dc voltage sources to the AT30, and check with a voltmeter before proceeding.
2. Mount the probe on a clean, dry surface, as close to the battery as possible, such as the battery rack. **DO NOT** mount the probe:
  - on the battery itself
  - on unpainted wood, or bare galvanized metal.
  - on plastic surfaces
3. To apply the probe, clean the mounting surface with isopropyl alcohol, and allow to dry thoroughly. Remove the protective backing from the double-faced adhesive tape on the probe, and securely press it onto the surface.
4. Install the cable supplied with the temperature compensation probe kit:
  - Start at the AT30 charger. The end of the cable with two stripped wires and one lead with a quick-connect terminal will be connected inside the AT30. Leave 30in / 762mm of cable inside the enclosure, and route the other end to the probe at the battery.

- Run the cable though a conduit if possible, but not through a conduit containing any power wiring.
- Route the other end to the probe at the battery and coil up excess cable.

*NOTE: If the standard (25ft / 7.6m) cable is not long enough, longer cable assemblies are available in lengths of 50, 100 & 200ft / 15.2, 30.5 & 61.0m. See Appendix B on page **Error! Bookmark not defined.** for ordering information.*

- Be sure your wiring conforms to the NEC and your facility requirements.
5. Attach the interconnection cable to the AT30 as shown in the figure below:

- Route the cable within the AT30 enclosure so it runs with the wire harness to the back of the front panel, and easily reaches the main control circuit board.
- At the main control circuit board, insert one of the bare wires from the cable into each terminal of TB8. Polarity is not important.



- Plug the connector at the end of the nylon-shielded wire of the cable assembly onto J6.
  - Using plastic wire ties, fasten the interconnection cable loosely to the existing wire harness. Make sure that the cable conforms to the service loop at the hinge end of the door.
6. At the battery, connect the quick-connect terminals to the temperature compensation probe. Polarity is not important. Coil up any excess wire and tape or tie it together to prevent damage:
7. Check your work. Be sure that:
- All connections are secure.
  - The shield is connected to ground at the charger end only (on the main circuit board).
  - The cable is connected to TB8 on the circuit board. Other terminal blocks may look similar.

8. Restart the AT30 using the startup procedure in Section 2.1. During startup, the AT30 displays **LEAD** on the front panel, indicating that the temperature compensation is set up for lead-acid batteries. While this is being displayed, you can press any front panel key to change the display to read **NICD**, to change the temperature compensation setup for nickel cadmium batteries. The choice you make is saved internally, and will be used again by the AT30 the next time it starts.
9. Adjust the output float and equalize voltages to the battery manufacturer's recommended values, using the AT30 front panel meter, as described in Section 2.3.2.

*NOTE: If the temperature compensation probe, or the wiring from the probe to the AT30, is damaged and becomes an open circuit, the AT30 detects the damage and displays **E 08** on the display. The charger then reverts to normal non-temperature-compensated operation until the probe or wiring is repaired. Once the probe is repaired, you must restart the AT30 to activate the probe, as described in Section 2.1.*

### **Using temperature compensation**

When an electric storage battery is being charged, the terminal voltage of the battery changes a small amount whenever the battery temperature changes. As the battery temperature increases, its terminal voltage decreases. When a battery is charged by a float type charger with a constant output voltage, float current increases when the temperature increases. This results in overcharging the battery, which can result in damage to the materials, or at least the need for more frequent maintenance.

When the AT30 is equipped with a temperature compensation probe, it is able to adjust the output voltage applied to the battery to keep the float current constant, thereby avoiding overcharging. The probe senses the ambient temperature at the battery, and adjusts the output float/equalize voltages to compensate for variations in temperature. If the ambient temperature increases, the AT30 output voltage decreases.

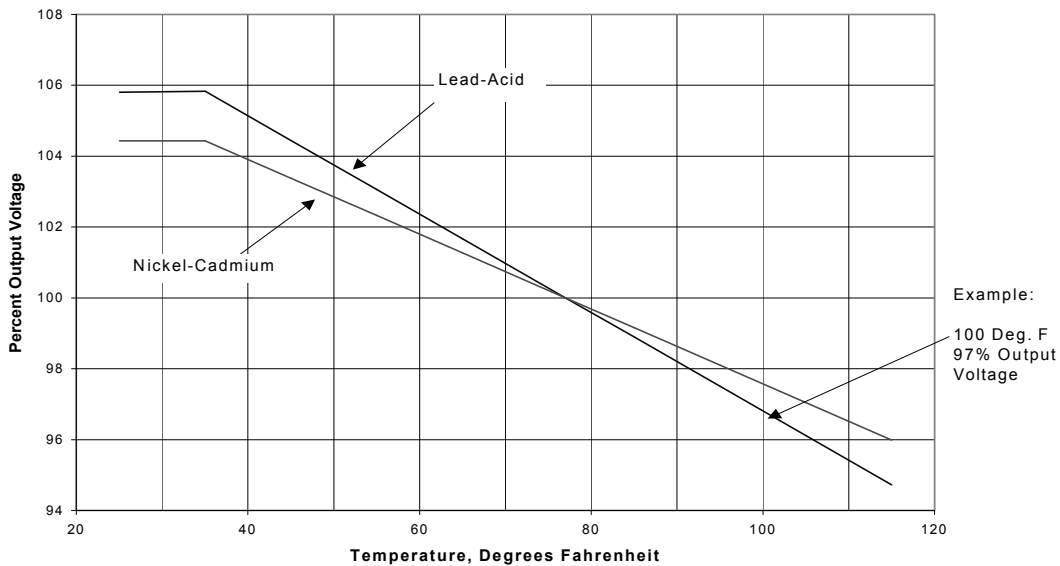
If you are experiencing any inconsistencies in the AT30 when the temperature compensation probe is utilized, temporarily disconnect the probe, and refer to the earlier sections of this application note ([JD5003-00](#)) for further details.

Note the following:

- You should set the Float and Equalize voltages to the values recommended by your battery manufacturer for 77° F (25° C).
- When you enter the Edit mode to adjust the Float or Equalize voltage (see Section 2.3.2), the front panel meter shows the 77° F (25° C) value for the Float or Equalize voltage, even if the battery is warmer or cooler than 77° F (25° C).

- The actual output voltage of the AT30 may be different from the value shown on the front panel meter, if the battery is warmer or cooler than 77° F (25° C).
- Use a digital meter to measure the actual output voltage of the AT30. If you know the temperature at the temperature compensation probe, you can use the graph below to determine that the output voltage is correct.
- If the battery temperature goes below 32° F (0° C), there will be no further increase in charger output voltage. Likewise, if the battery temperature goes above 122° F (50° C), there is no further decrease in output voltage.

OUTPUT VOLTAGE VS BATTERY TEMPERATURE



**EXAMPLE:** Suppose you have a lead-acid battery whose temperature is 100° F / 37.8° C. As shown on the graph, the output voltage should be approximately 97% of the 77° F voltage. If the float voltage is set on the front panel to 132 Vdc, the actual output voltage will be:

$$132 \times 0.97 = 128 \text{ Vdc}$$

**JD5003-00**

AT10.1/AT30 Series Battery Charger  
***Application Note***