USING THE OPTIONAL TEMPERATURE COMPENSATION FEATURE

SCOPE

all single phase **AT10.1** and all three phase **AT30** microprocessor-controlled float battery chargers

SUMMARY

The AT Series battery charger can use an optional battery sensor (A10) to compensate dc output voltage for changes in temperature. This option (manufacturer's p/n EJ5033-##), also referred to as "TempCo", consists of a probe (or "puck") and an interconnection signal cable.

TEMPERATURE EFFECTS ON STORAGE BATTERIES

Storage batteries used in stationary applications are normally charged at a constant "float" voltage. The float ***current*** depends on electro-chemical 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 increases in ambient temperature. For a 10 °C increase in temperature, the float current approximately doubles (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 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 battery 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 Valve-Regulated Lead Acid (VRLA) type, and the battery room may see moderate temperature changes.
- If the battery is in a non-temperature-controlled environment.
- If a site requirement exists for **SCADA** system battery temperature monitoring. Refer to the AT Series Communications Module Operating Instruction (**JA0102-04**). See DNP3 Level 2 **Section 5.4.3** (Analog Input Point Index 9) or Modbus **Section 6.3.3** (Input Register 30010) for details.

To order TempCo (option p/n EJ5033-0#) with a new AT Series charger, choose it from the list 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.

INSTALLING TEMPERATURE COMPENSATION

A separate ***installation*** procedure (**JA5015-00**) is supplied with each TempCo kit. The procedure 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 may follow the steps outlined in the AT Series battery charger ***Operating and Service Instructions***, Section 1.11. The installation steps outlined in the AT30 manual are reprinted on Page 5 of ***this*** application note (**JD5003-00**) for convenience. Substitute "AT10.1" for "AT30" as needed.

ADJUSTING FLOAT & EQUALIZE VOLTAGES WITH TEMPCO

Before setting the float and equalize voltages with the remote TempCo 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 TempCo probe connected, working properly, under default factory settings, 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 adjusting the float and equalize voltages from the front panel, the displayed voltage is the value at 25°C. *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.

COMPENSATED VS. UNCOMPENSATED

AT Series battery chargers equipped with newer Main Control PC Boards (A1), utilizing firmware Version 6.53 or higher, feature the ability to use either temperature-compensated ***or*** un-compensated dc voltages in its operation and displays. Older boards may ***only*** use compensated voltages. Chargers with newer boards are normally shipped from the factory set for using compensated voltages. Utilize this feature as follows:

- Shut down the AT Series battery charger.
- Properly install the TempCo probe and cable as defined on Page 5 of this document.
- Set jumper (J30) on the Main Control PC Board (A1) to positions 2-3 to use ***compensated*** voltages.
  or
- Set jumper (J30) on the Main Control PC Board (A1) to positions 1-2 to use ***uncompensated*** voltages.
- Restart the AT Series battery charger per Section 2.1 of the ***Operating and Service Instructions***.
- The Main Control PC Board (A1) will detect the installed remote TempCo probe, and the display will flash **Pb** (or **nicd**).

Compensated (or firmware Version 6.52 or lower)

This is the default setting from the factory, and the only operation available on older units. If Jumper J30 is set at the 2-3 position, the charger will operate using compensated voltages. The front panel meter will display a dc voltage value modified for battery temperature. The displayed meter value will be different from the ***actual*** charger dc output voltage, unless the battery is at the nominal temperature of 25°C (77°F).

The software alarm points (HVDC and LVDC) will move with temperature. If the float voltage is set at 131.0 and the HVDC alarm is set to 136.0, the HVDC alarm will not trip unless the output is 5 volts above the float set-point. This means that if the actual charger dc output is at 135.0 due to temperature compensation, the HVDC alarm will not trip until 140.0 actual output.

The ***hardware*** Low DC Voltage alarm is not affected by temperature compensation, and will always trip at the same dc output voltage. This is the same as for the un-compensated setting.

If the remote TempCo probe circuit is shorted or opens while the charger is powered, an alarm code **E 08** will display on the front panel meter. If the probe circuit is open, and the charger is then shut down and re-energized, there will be no error code upon start-up. Also, temperature compensation will not be active.

If AT Series Forced Load Sharing, see ***Operating Instructions*** (**JA5054-00**), is being used, both chargers ***must*** have remote TempCo probes attached. The probe on the ***master*** (**LS-P**) charger will cause the output to be adjusted for temperature, while the probe on the ***slave*** (**LS-S**) charger will compensate the display and alarm set points. Both chargers must have jumper (J30) in the same position, or the displays and alarms will not match.

Uncompensated (available only on firmware Version 6.53 or higher)

If Jumper J30 is set at the 1-2 position, the charger will operate using ***un-compensated*** voltages. The front panel meter will display the ***actual*** charger dc output voltage. The displayed meter value will not be the same as the user-specified dc voltage ***set-point***, unless the battery is at the nominal temperature of 25°C (77°F).

The software alarm points (HVDC and LVDC) will ***not*** move with temperature. The alarm set-points will need to be raised or lowered sufficiently to allow for dc output voltage variations, due to temperature compensation. **NOTICE** Using this feature, the default **equalize** setting of 139.0 will trip the default HVDC alarm point of 144.0 when the temperature goes below 48°F on a lead-acid battery.

The ***hardware*** Low DC Voltage alarm is not affected by temperature compensation, and will always trip at the same dc output voltage. This is the same as the compensated setting, or earlier firmware versions.

If the remote TempCo probe circuit is shorted or opens while the charger is powered, an alarm code **E 08** will display on the front panel meter. This code will replace the indicator for temperature compensation (**Pb** or **nicd**). If the probe circuit is open, and the charger is then shut down and re-energized, there will be no error code upon start-up. Also, temperature compensation will not be active.

If AT Series Forced Load Sharing, see ***Operating Instructions*** (**JA5054-00**), is being used, both chargers ***must*** have remote TempCo probes attached. The probe on the ***master*** (**LS-P**) charger will cause the output to be adjusted for temperature, while the probe on the ***slave*** (**LS-S**) charger will compensate the display and alarm points. The temperature compensation indicator (**Pb** or **nicd**) will alternate with the load share indicator (**LS-S** or **LS-P**). Both chargers must have jumper (J30) in the same position, or the displays and alarms will not match.

TEMPCO 'NUTS & BOLTS'

- The temperature probe consists of a glass bead thermistor (temperature-dependent resistor) mounted in an epoxy puck, with double-faced 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, a battery rack, or enclosure wall. Inter-cell connectors are recommended as the best place for probe-mounting. In a battery room with little air movement, the inter-cell 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 linear-izing 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.

  Temperature compensation affects high and low dc voltage alarm set points differently, dependent upon utilizing compensated or uncompensated voltages. Refer to the two sections describing these differences, starting on Page 3 of 8. If you anticipate large temperature excursions, you may need to adjust the HVDC and LVDC alarms accordingly.

- 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.

  There are two (2) temperature compensation slopes for the AT Series microprocessor-controlled battery charger, which are linear between 0° and 50°C:

  1) Lead Acid: **-2.5mV/V/°C** (**-1.4mV/V/°F**) ***or***
  -6.0mV/cell/°C (**-3.3mV/cell/°F**) at **2.4VPC** (Volts per cell)
  2) Nickel Cadmium: **-1.9mV/V/°C** (**-1.1mV/V/°F**) ***or***
  -2.7mV/cell/°C (**-1.5mV/cell/°F**) at **1.4VPC** (Volts per cell)

  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).

INSTALLATION INSTRUCTIONS

*(reprinted from **AT30 Operating and Service Instructions**, Section 1.11, Page 20)*

The remote TempCo probe contains a temperature-dependent resistor in an epoxy module that you install near your battery. There are three (3) 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 AT30.

The actual temperature compensation probe (A10), or puck, 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) for further user details. 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 enclosure. 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. The end of the cable with two stripped wires and a quick-connect terminal will be installed inside the AT30.
   - Leave 30in / 762mm of cable inside the enclosure, and route the other end to the probe at the battery.

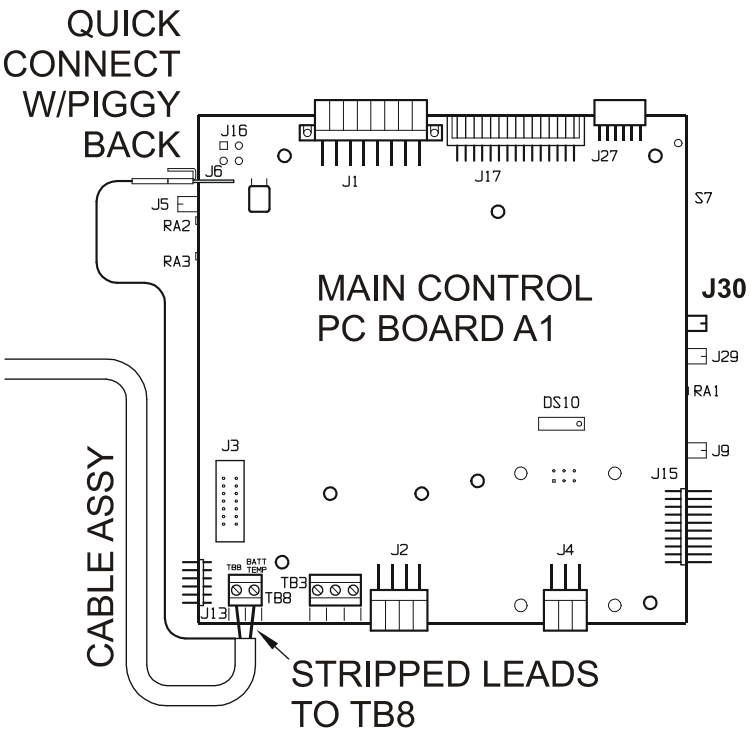
- Run the cable though a conduit if possible, but not through a conduit containing any power wiring.
- Route the other end to the probe at the battery and coil up excess cable.

NOTICE

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 65 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 PC Board (A1).
   - At the Main Control PC Board (A1), insert one of the bare wires from the cable into each terminal of TB8. Polarity is not vital.



   - 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 (A10), or puck. Polarity is not important. Coil up any excess wire and tape or tie it together to prevent damage.
7. Set jumper (J30) on the Main Control PC Board (A1) to positions 2-3 to use ***compensated*** voltages, or to positions 1-2 to use ***uncompensated*** voltages.

8. Check your work. Be sure that:
   - All connections are secure.
   - The shield is connected to ground at the ***charger end only*** (A1-J6).
   - The cable is connected to the 2-position terminal block (TB8) on the Main Control PC Board (A1). Other terminal blocks may look similar.
9. Restart the AT30 using the startup procedure in Section 2.1. During startup, the AT30 displays **Pb** on the front panel meter, indicating that the temperature compensation is set up for lead-acid battery types. 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.
10. Adjust the float and equalize voltage settings to the battery manufacturer's recommended values, as described in the AT30 ***Operating and Service Instructions***, Section 2.3.2.

NOTICE

*If the TempCo probe, or the probe wiring, is damaged and becomes an open circuit, the AT30 detects the damage and displays **E 08** on the front panel meter. The AT30 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

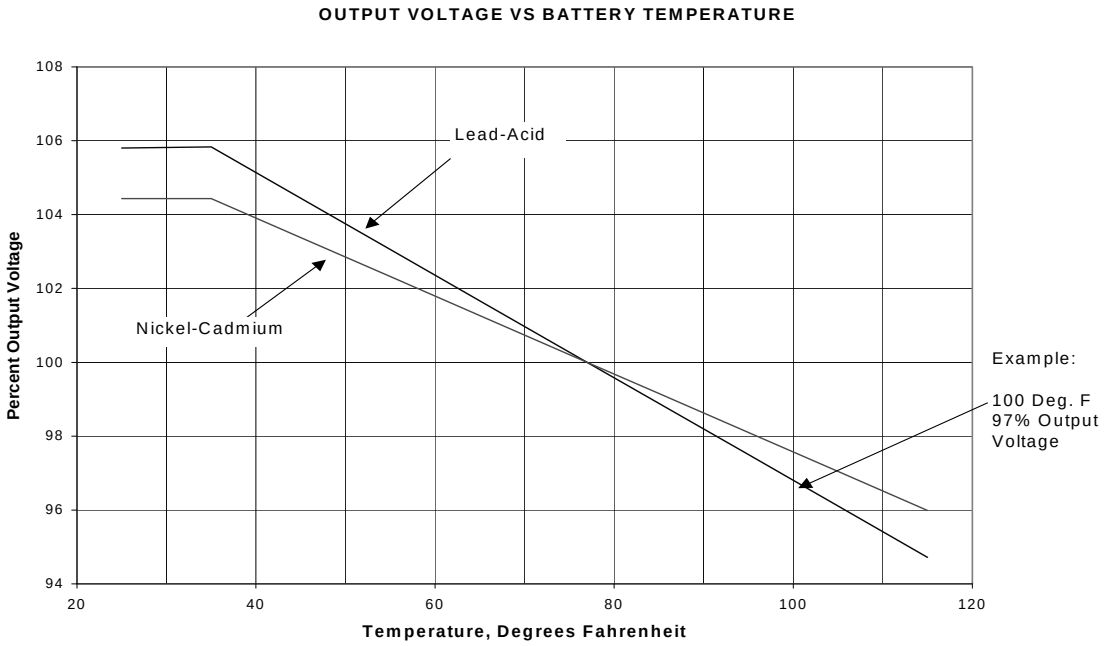
When an electric storage battery is being charged, the terminal voltage of the battery changes a small amount whenever the battery temperature changes. As the battery temperature increases, its terminal voltage decreases. When a constant output voltage float type rectifier charges a battery, float current 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 remote TempCo 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 remote TempCo probe is utilized, temporarily disconnect the probe and refer to 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 displays 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 displayed 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 dc output voltage of the AT30. If you know the temperature at the remote TempCo 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.



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 x 0.97 = **128 Vdc**

SUPPLEMENTAL DOCUMENTATION

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

Doc. No.	Online Hyperlink	Description
JA5015-00	http://www.ATSeries.net/PDFs/JA5015-00.pdf	AT TempCo Probe Accessory Install Instructions
JD5003-00	http://www.ATSeries.net/PDFs/JD5003-00.pdf	AT Tempco Probe Application Note (*this document*)