

## Auto-Autocalibration Reduces Analog I/O Errors

Every analog circuit exhibits fluctuations in performance due to changes in temperature. Today's complex A/D circuits, containing input multiplexor chips, a programmable gain circuit, a unipolar / bipolar shifting circuit, a single-ended / differential switching circuit, a voltage reference, and finally an A/D chip, may exhibit errors that become significant in comparison to the signal being measured. The problem becomes even worse with products which are rated for operation over a range of -40°C to +85°C.

The A/D circuit must have some method to compensate for these built-in errors, or the A/D reading will become unreliable. It is not uncommon for an A/D board with a 16-bit A/D converter to yield measurements with only 9-bit or 10-bit accuracy.

### CALIBRATION METHODS

**Analog potentiometers** are used to calibrate the analog circuitry on low-cost A/D boards. This method works well at a fixed temperature, typically room temperature, at which the board was initially calibrated. As the temperature changes, error is induced. Re-calibrating the board requires physical access to the potentiometers, which usually means disassembling the system, an inconvenient and time-consuming process.

**Autocalibration** solves these problems by enabling the board to be calibrated under software control at any time. No physical access is required, so the process can be done as often as desired, limiting any effects of temperature changes on the system. However, autocalibration requires direct involvement of the application program to initiate the calibration process. Diamond Systems' Universal Driver software, included free with all our A/D boards, provides built-in autocalibration code to simplify the task. A simple function call is all that is required to initiate autocalibration.

**Auto-autocalibration** takes this process one step further by eliminating the need for application software intervention. With Diamond Systems

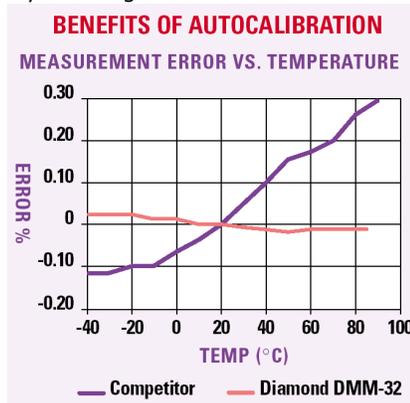
patented approach, the A/D board contains a built-in temperature sensor and microcontroller. The microcontroller continuously monitors the temperature sensor. When the board's temperature changes by a specified amount, the microcontroller will initiate and control the autocalibration process automatically, without any need for involvement by the application software.

### AUTO-AUTOCALIBRATION TRADE-OFFS

Since the analog error is directly proportional to temperature change, reducing the size of the temperature change that triggers autocalibration will result in lower maximum error. This threshold may be set using the Universal Driver software.

However, the auto-autocalibration process lasts about 1/2 second. In order to prevent the process from interrupting a time-sensitive data acquisition sequence, auto-autocalibration can be disabled via the Universal Driver software. Once the sensitive operation is complete, the auto-autocalibration feature can be re-enabled. If calibration is then required it will begin immediately. Calibration can also be terminated mid-process if needed, and the board will automatically return to its previous state.

### ILLUSTRATION OF THE BENEFITS



The chart shows the total error of two commercially available PC/104 A/D boards, both of which have an operating temperature range of -40 to +85°C. The blue line shows the error for an A/D board with manual calibration, and the red line shows a Diamond Systems board with auto-autocalibration.

Note that the maximum error of the blue line (manual calibration board) is 0.3%. For a 16-bit A/D converter, this error amounts to 197 A/D counts, reducing the accuracy to between 8 and 9 bits. In comparison, the red line (auto-autocalibration board) shows a maximum error of only .014%, or 9 A/D counts. This represents a 20x reduction in measurement error.

## DIAMOND SYSTEMS BOARDS WITH AUTOCALIBRATION OR AUTO-AUTOCALIBRATION

### Boards with Autocalibration

- Hercules
- Athena
- Diamond-MM-16-AT
- Diamond-MM-AT

### Boards with Auto-autocalibration

- Diamond-MM-32X-AT

