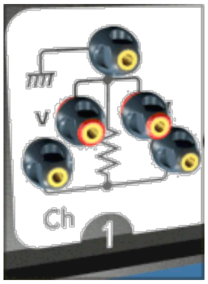


microK Blog

A Few Words From The microK Design Team

Paul Bramley - microK Project Manager: Entry 1 - June 2006

When we were tasked with designing the microK product in 2004, the brief was to produce a precision thermometer that measures at the sub-mK performance level and is simply the best in its class… the microK was to have the best performance (on all parameters!) and have the most comprehensive range of features. Two years on and with the microK in production, we look back on a project which has brought a lot of professional satisfaction to the team as we have pushed the performance boundaries (and ourselves) to achieve that goal. I thought it would be useful to set down some of the technical background to the microK instrument in order to shows what sets it apart.

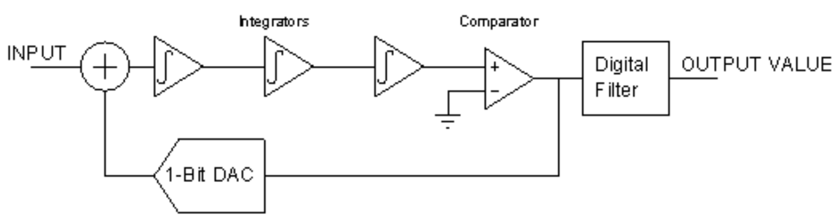
Accuracy

Measurement uncertainty is a key parameter for any temperature metrologist. We wanted the accuracy of the microK to contribute the minimum uncertainty possible.

Other instrument working at or below 1mK uncertainty use either a DC (actually chopped DC) potentiometric measuring technique or are AC resistance bridges. We wanted the microK to work with thermocouples as well as PRTs and thermistors, so the AC bridge technique, with its excellent measuring performance, was not an option. One problem with DC instruments lies in the ADC – typically they use an integrating ADC whose linearity is fundamentally limited to a few ppm by dielectric absorption effects and the limitations of the analog circuits. The best commercially available integrating ADCs (produced by Thaler) have a linearity of 3ppm (very good, but not good enough for us) Some DC instruments use these ADCs and then 'linearize' the instrument in order to correct for the limitations of their ADC. But with our sights set on being the best, such an approach wasn't acceptable - so we decided to design our own ADC. The new ADC had to have a linearity of better than 0.5ppm since it is the "measurement engine" for any instrument and we were determined not to leave the microK 'underpowered'.

The ADC used in the microK is a unique adaptation of the established sigma-delta technique in which the analog signal is balanced again a modulated waveform that has only two states (a 1-bit DAC). A control loop controls this DAC and ensures that the average value of the modulated waveform equals that of the analogue signal. The average value of the modulated waveform, determined using digital-signal-processing (DSP), is the output from the ADC.

Conventional Sigma-Delta ADC



Sigma-delta ADCs are readily available as single integrated circuits and provide phenomenal resolution. However, their linearity is significantly more limited than their resolution and the converted signal is inevitably quite noisy (since they rely on taking a very noise, binary signal and filtering it heavily using DSP). The microK ADC is different in that it uses a 5-bit DAC in place of the 1-bit DAC in the control loop. This would not normally be feasible, since the DAC would 'carry' the full accuracy burden of the measurement. However, the microK ADC uses pulse-width-modulation (PWM) to generate the 5-bit signal thereby converting the analog signal requirement into one of timing. This in itself presented some interesting challenges; our sigma-delta control loop works at 100kHz in order to achieve our required 0.1s conversion time, so 0.5ppm corresponds to a timing accuracy of 5ps, or to put it in perspective, about the time it takes light/electrical signals to travel 1.5mm!. In actual fact we have been able to do better than our 0.5ppm target.

A fundamental benefit of the new ADC is its low noise. The 5-bit PWM DAC immediately reduces the noise by a factor of 32 compared with the conventional 1-bit sigma-delta approach. The new ADC therefore gave us exceptional linearity and extremely low noise… both of which are key to achieving