A Differential Scanning Calorimeter for Teaching Labs
Abstract
AVR Contest Entry
A3688

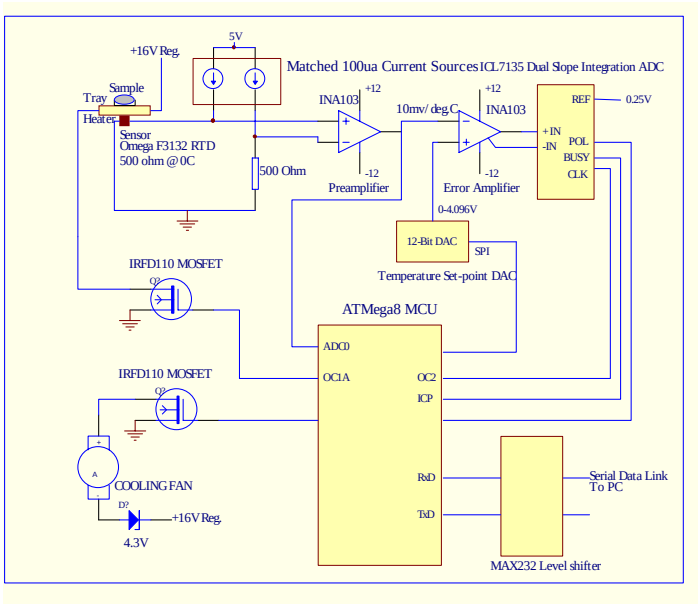
The old adage "A watched pot never boils" has some basis in fact. With a constant heat from the element, a pot of water will heat up towards 100°C (212°F) pretty steadily, but it will then take a lot of heat to make the water actually boil. This demonstrates a property of ***enthalpy***: as materials change temperature and go through a transition point such as melting, boiling etc., the amount of external energy required can be much greater than that needed to simply raise/lower the temperature by an equal amount at nearby temperatures. Actually, energy may be given off, not absorbed, at a transition temperature, depending upon the substance and the particular transition.

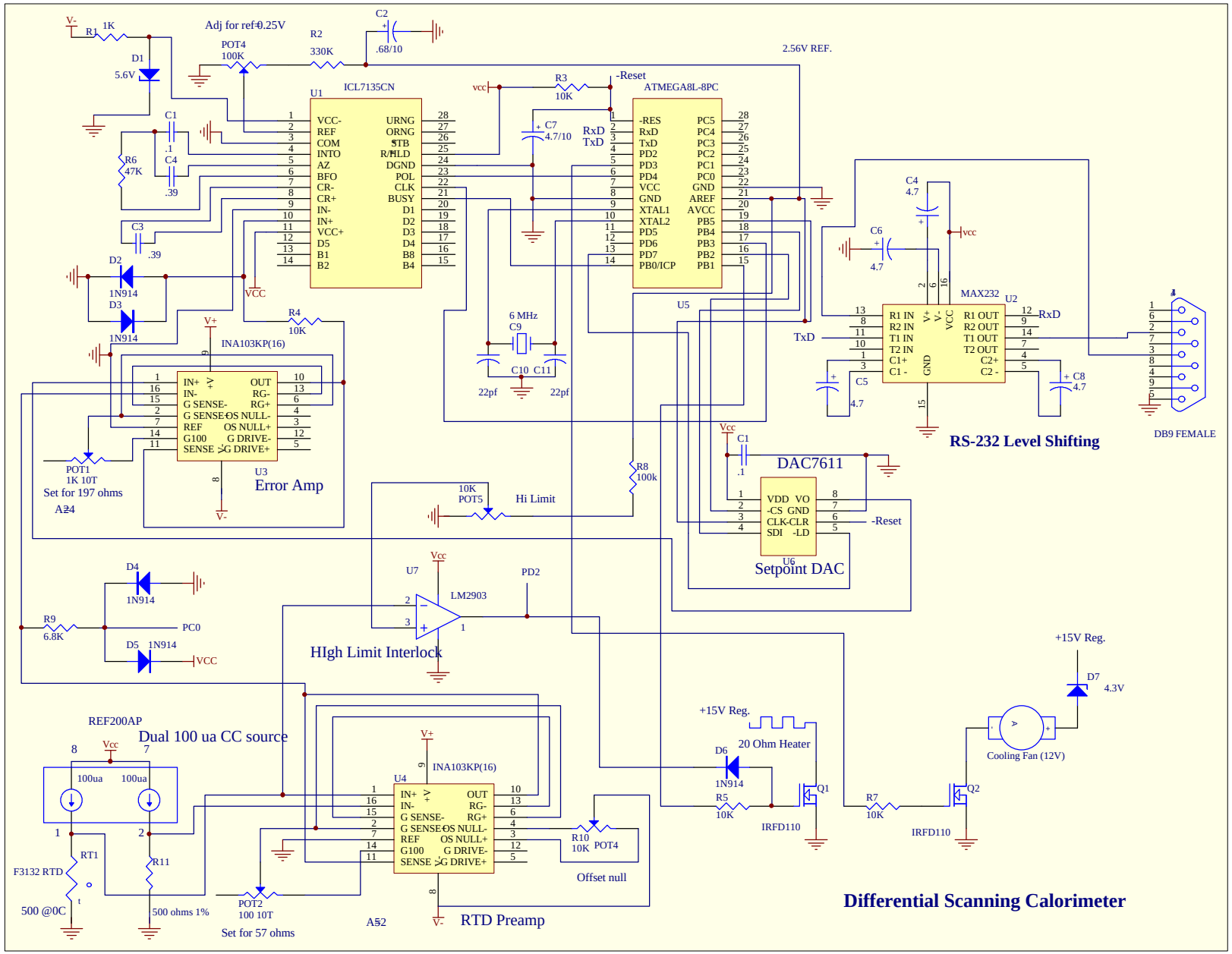
This property is very useful in the Material Science field. A common instrument to measure this is the Differential Scanning Calorimeter. These instruments are able to measure over a wide temperature range, with a very accurate temperature resolution. They also have a very high sensitivity with regards to measuring the enthalpy energy itself. Because of these features, these instruments cost upwards of $60,000 and are not really suited to the rigors of a university undergraduate teaching lab.

I set out to design a Differential Scanning Calorimeter which would handle the measurements needed to demonstrate the concepts, from a teaching point of view. Its temperature range, accuracy and enthalpy energy resolution don't match those of a research-grade instruments, but it handles teaching measurements easily and costs only a few hundred dollars to build. Because students are often careless with lab instruments, I designed the actual measurement "head" in such a way that it is easy to replace if destroyed, at a cost of about $40. In contrast, the Perkin-Elmer commercial DSC "head" costs about $10,000 to replace, (as we've unfortunately discovered in one of our research labs)

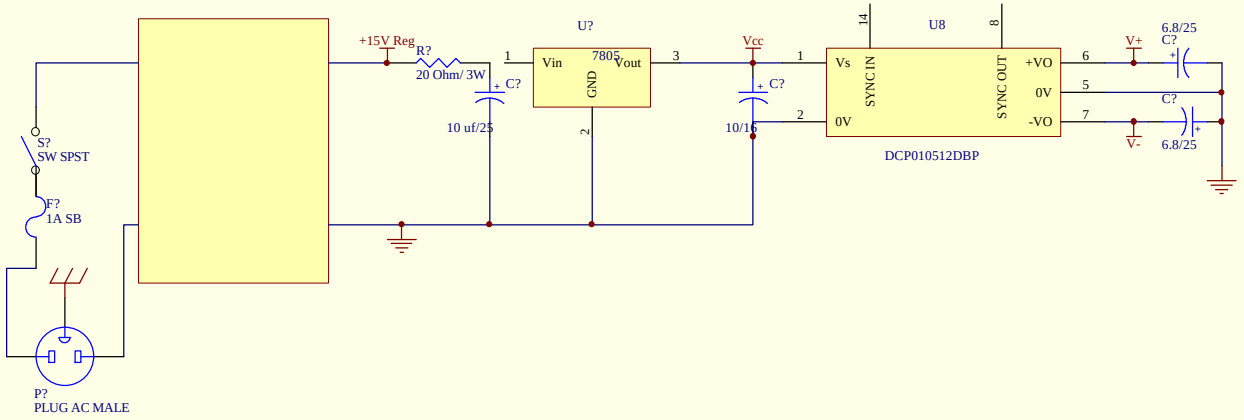
Since today's students are very comfortable using computers, I settled on an inexpensive PC computer as the user interface/ display part of the project, rather than designing a "free-standing" instrument. This drastically reduced the cost of the instrument, since PCs are already present in the lab for use with other instruments. All the temperature control and measurement functions in my DSC are performed by an Atmel ATmega8 MCU: the "smallest" member of the ATmega family.

Block Diagram of the Differential Scanning Calorimeter




Differential Scanning Calorimeter
RS-232 Level Shifting
Setpoint DAC
Error Amp
RTD Preamp
HIgh Limit Interlock
Dual 100 ua CC source
Adj for ref=0.25V
2.56V REF.
ICL7135CN
ATMEGA8L-8PC
MAX232
INA103KP(16)
DAC7611
LM2903
REF200AP
20 Ohm Heater
Cooling Fan (12V)
DB9 FEMALE
Hi Limit
Offset null
Set for 197 ohms
Set for 57 ohms
F3132 RTD
500 @0C
500 ohms 1%
+15V Reg.
-Reset
RxD
TxD
IRFD110
1N914
4.3V

Condor 15V 0.9A Linear Power Supply



Power Supply