University of British Columbia
Electrical and Computer Engineering
EECE281/EECE282

Project 1 – Reflow Oven Controller

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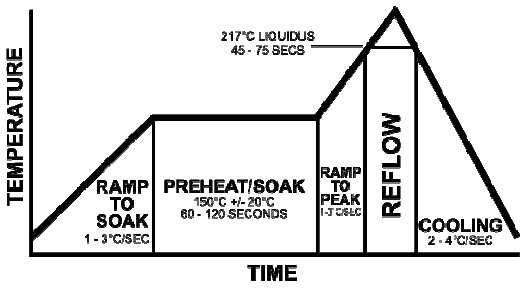
Objectives

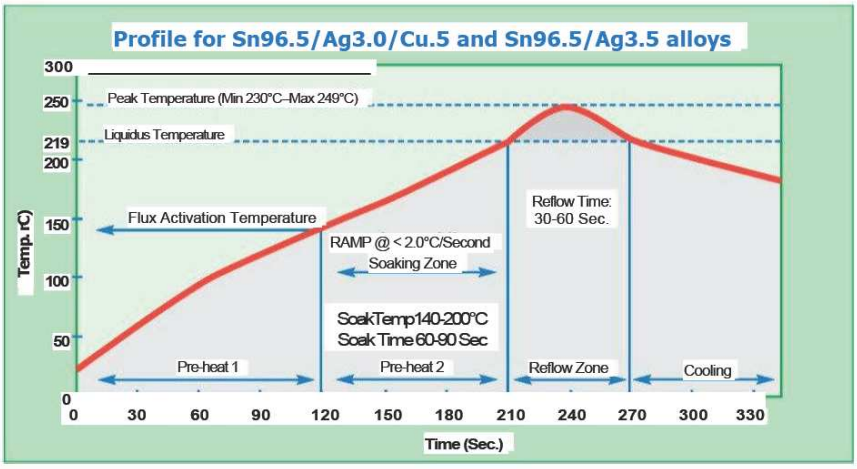
- Learn about reflow soldering thermal profiles.
- Understand the steps used in the assembling of PCBs with SMT components.
- Understand the components of a reflow oven controller.
- Measure temperature using a thermocouple.
- Control and AC load using a Solid State Relay.

Reflow Soldering Profile

http://en.wikipedia.org/wiki/Reflow_soldering

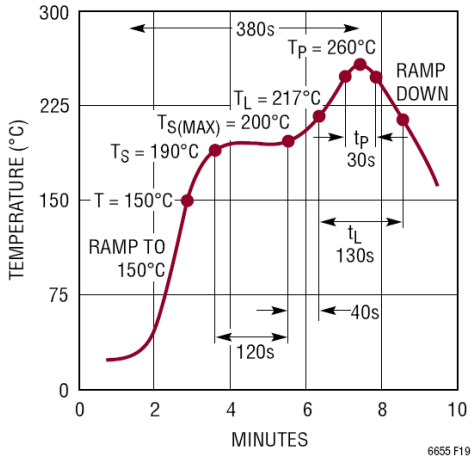


Solder Paste Profile (SAC305)

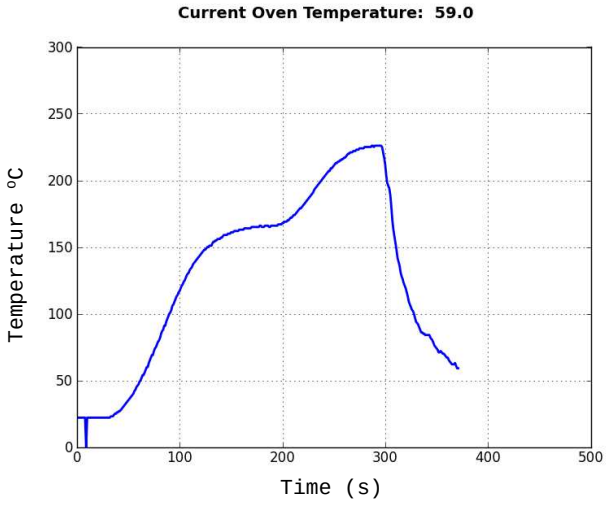


SMT Component Thermal Profile

Figure is from LTC6655 datasheet



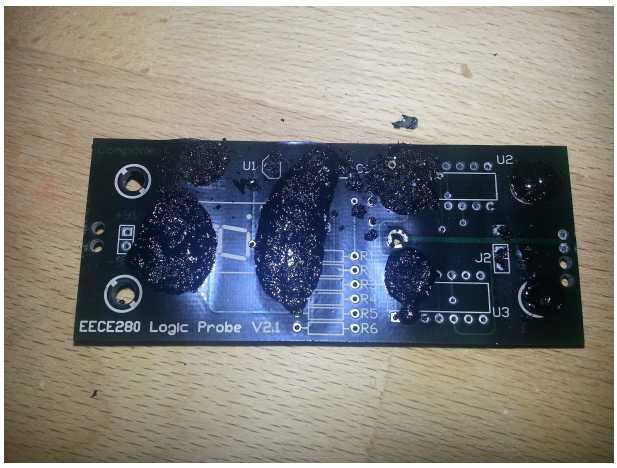
My tests thermal profile



Warnings:

- Don’t let your reflow time be more than 45s or the silk screen will darken.
- Don’t let your reflow max temperature climb over 235 ºC or your PCB may burn: lots of smelly smoke!

PCB Burnt in Reflow Oven



Steps Assembling a PCB with SMT components.

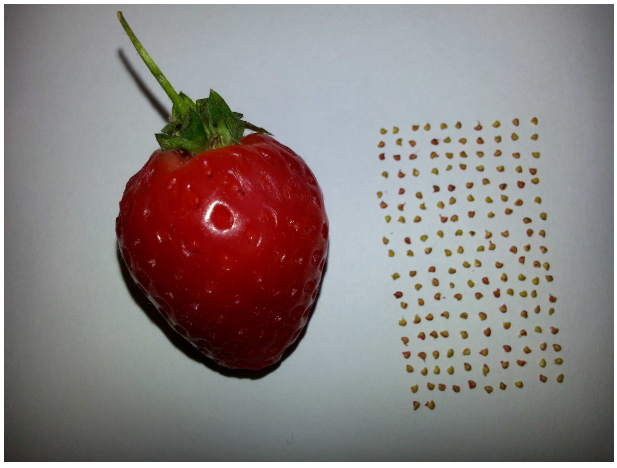
- Step 1: Apply solder paste to the PCB. You will use a Mylar stencil. (I personally believe this is the most critical step in the whole process!)
- Step 2: Place the SMT components into the PCB.
- Step 3: Reflow soldering. You will be using a toaster oven with a controller of your own design.
- Step 4: Hand soldering of TH (thru hole) components.

Steps Assembling a PCB with SMT components.

- Video 1 shows how I applied solder paste and placed the components by hand using tweezers.
  http://courses.ece.ubc.ca/281/2014/20131004_131829.mp4
- Video 2 shows how I reflow soldered the SMT components using a toaster oven.
  http://courses.ece.ubc.ca/281/2014/20131004_133308.mp4
- Video 3 shows how I soldered the TH components.
  http://courses.ece.ubc.ca/281/2014/20131004_140421.mp4

Mastering the Tweezers and Loupe, Step 1: find tools and materials

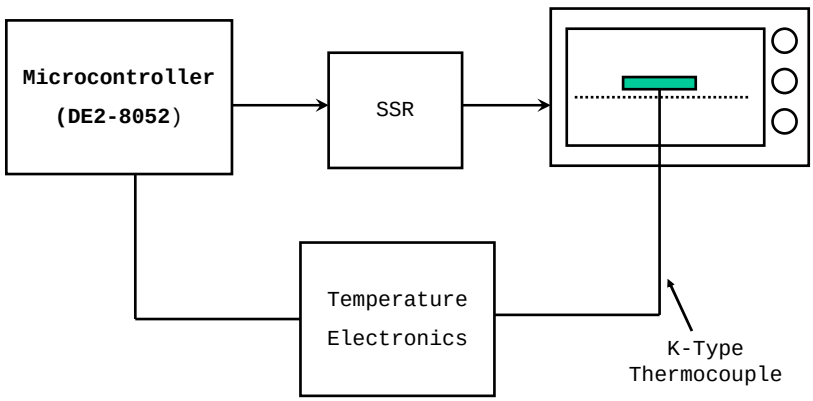
Mastering the Tweezers and Loupe, Step 2: remove seeds!



172 seeds!

Tweezers Wizard level: Put the seeds back!

Oven Controller Typical Block Diagram

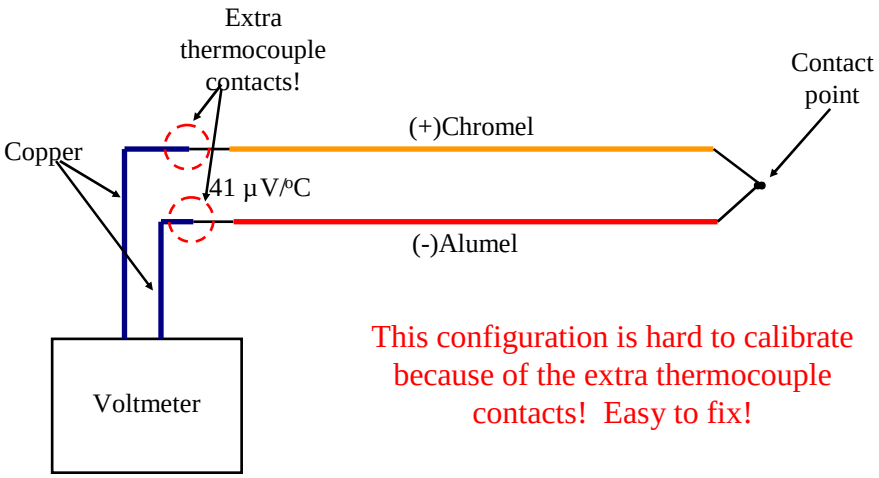


K-Type Thermocouple

- Has two wires: Yellow (+) and Red (-).
- About 41 µV/ºC. You'll need and amplifier!
- Very accurate calibration table provide by the National Institute of Standards and Technology (USA):

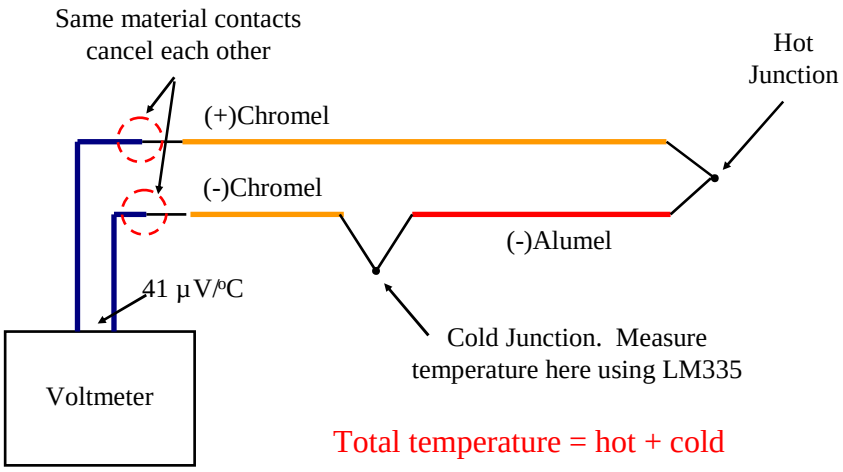
  http://srdata.nist.gov/its90/download/type_k.tab

Using a K-type Thermocouple



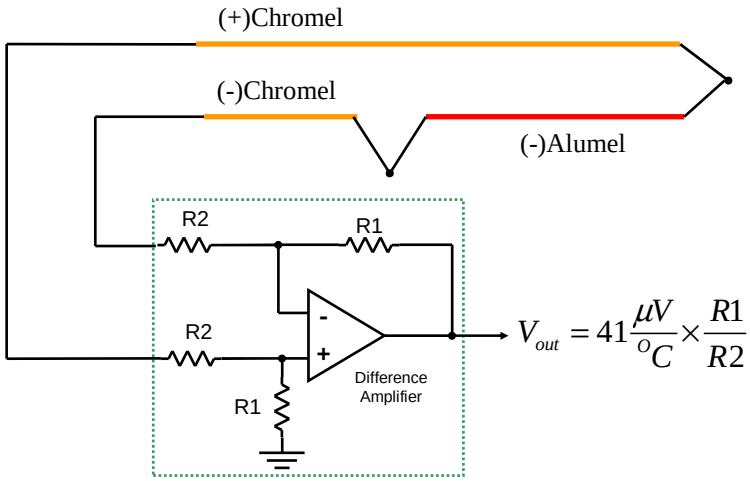
This configuration is hard to calibrate because of the extra thermocouple contacts! Easy to fix!

Using a K-type Thermocouple

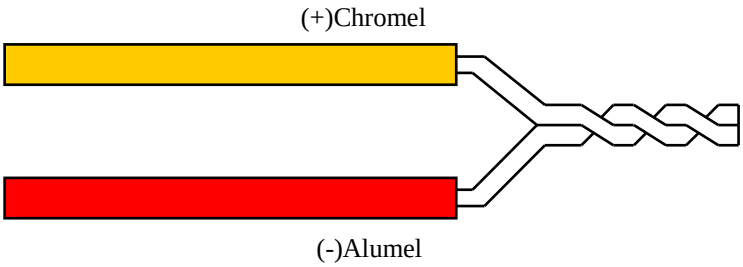


Total temperature = hot + cold

Amplifying the Thermocouple Voltage



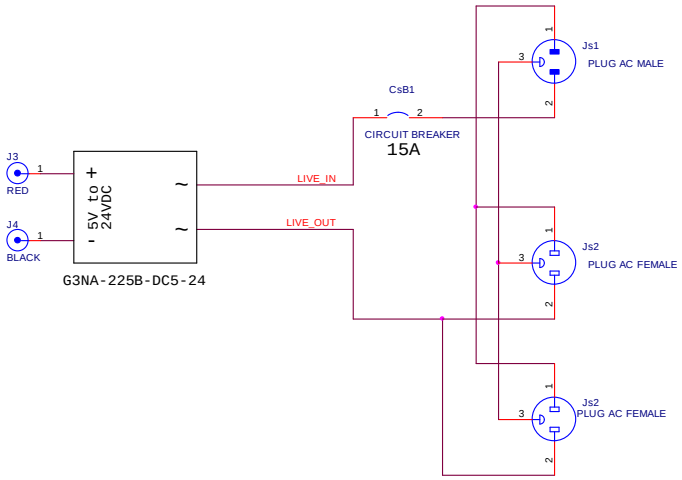
Making the Junctions



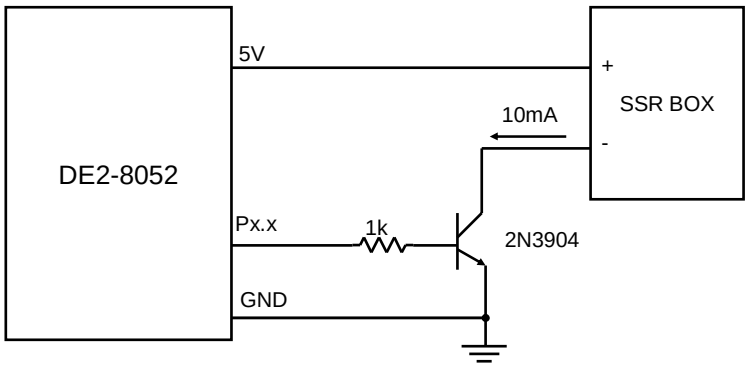
Opamp

- Must have very small input offset voltage, or offset null circuit.
- OP07 provided in the kit has a typical offset voltage of 50µV.
- OP07 needs dual power supplies, for example +5V and -5V. ICL7660 (or equivalent) can be used to produce -5V from +5V.
- Choose the gain wisely!

SSR box block diagram



3.3V to 5V



Using the SSR box

- Connect a power cord cable to the male AC connector. The power cord cable must be rated for the type of load to be connected. If the SSR box would be used to power a 1500W toaster oven, the power cord cable must be rated for at least 13A.
- Connect the AC load to one of the available AC plugs.
- Apply a DC voltage from 5V to 24V to the control banana plugs.

Using the SSR box

- Do not operate the SSR box for more than 30 minutes at the maximum rated current of 15A.
- The SSR box is designed for resistive loads only. Do not plug inductive loads (such as motors) to the SSR box.
- Do not operate the SSR box if the ambient temperature is above 40^{o}C.
- The SSR box may become warm to the touch after using it for several minutes at maximum rated capacity. If you suspect that the case temperature is over 40^{o}C discontinue using the SSR box immediately.
- Only apply a DC voltage from 5V to 24V to the control pins. Do not apply negative DC voltages of ANY magnitude.
- Do not disassemble the SSR box.
- If the protection breaker is tripped, find and correct the cause of the fault before resetting the breaker to normal operating mode.