• Noise
• Circuit insight
• SMT Lab
• Project Schedule
Announcements

• Tue 4/10 SMT Lab: 38-500 (last lecture)
• Tue 4/17 Student holiday
• Thu 4/19 Project presentation
  2:30 – 4:00pm
• Tue 4/24 Project presentation
  2:30 – 4:00pm
Question 2.1: A sharp (or may not so sharp) engineer, trying to saving costs, replaces Q1 and Q2 with a n-channel MOSFET with a gate to source threshold of 3v and driven by a 10v peak to peak signal. Will this circuit work?
SMT Manufacturing
SMT Lab

- Build a 1.4 watt class D amplifier
- Apply solder to surface mount pad
- Place components on resistors/capacitors on pcb using tweezers
- Place TPA2005 IC’s on pcb – **must be centered. Note orientation! Use microscope.**
- Note heatsink for TPA2005
- Reflow solder (oven)
- Solder audio jack, USB connector and terminal posts.
Applying Solder Paste

Use microscope
Note orientation
Apply solder paste to heatsink

Use microscope
Construction Sequence

Apply solder paste
Place 10uf cap
red line = + terminal

Apply solder paste . . .
Place (4) 1.2uf cap C1, C2 (red stripe)

Place (4) 30k resistors R1, R2

Place (2) .22uf cap (black stripe)

Place (2) TI chips – centered
Reflow Temperature Profile

en.wikipedia.org/wiki/Reflow_soldering#/media/File:RSS_Components_of_a_Profile1.svg
Understanding Noise

• Many applications deal with very small signals:
  – EEG (ElectroEncephaloGraphy): electrical activity of the brain 10uv -100uv
  – EMG (ElectroMyoGraphy): electrical activity by skeletal muscles 50uv – 30mv
  – ECG (ElectroCardioGraphy): electrical activity of the heart 2mv
  – New Horizon probe
New Horizon Signal

- Transmitter power 12 watts
- Transit time to earth 4.5 hours from Pluto
- Received signal strength $\sim 10^{-19}$ watts!

Noise vs Interference

• Interference
  – 60 Hz AC pickup
  – RF pick up (cell phones, cell phones, radio stations, WiFi, etc…)
  – Laptop, cell phone chargers
  – Power supply emissions, variation

• Noise
  – Characterized by density: rms noise in 1 Hz band. Units: $e_n = \frac{nv}{\sqrt{hz}}$
  – Noise spectra
    • white noise: $e_n$ constant over frequency
    • flicker or pink (1/f) noise: spectral density is inversely proportional to the frequency
Sources of Noise

• Johnson noise: thermal fluctuations generating noise voltage in a resistor.

\[ v_n = \sqrt{4kTRB} \]

10k resistor has a 1.3uV open circuit noise at 10kHz at room temperature

• Shot noise: fluctuations created by discrete nature of charges in steady current

At 1ma, 1.8nA at 10kHz

\[ i_n = \sqrt{2qi_{dc}} \quad A/\sqrt{Hz} \]

• Amplifier noise (BJT, JFETS)

• Signal to noise ratio SNR = 20 log\(_{10}\) \( \frac{v_s^2}{v_n^2} \)

• Amplifier Noise figure (in dB)
Figure 3.58. Noise voltage of three popular jellybeans, illustrating the poor low-frequency noise properties of MOSFETs.

* Art of Electronics, Horowitz, Hill 3rd edition p170
Eliminating Noise

• Ensure clean power supply; use a battery
• Use bypass capacitors - lots!
• Use shielded lines to avoid capacitive coupling
• Use twisted pair to reduce magnetic pickup
• Be aware of protoboards and cables. Protoboard capacitance between ~1pf
• Use ground plane for high frequencies
• Understand power supply and signal grounds
  — Within circuit
  — Between instruments
• Avoid long wires particularly with small signals
Digital/Analog Grounds

Connect the grounds at a single place
Gaining Circuit Insight

• Experience!
• Develop understanding without equations, google.
• Knowledge of key finger tip facts and ability to estimate results.
Schedule

• **Project Abstract** (today)
• **Project Proposal draft** (Thu 4/12)
• **Proposal Conference/design review with staff mentor**
  – Now to Fri 4/13
  – Order parts!
• **Project Design Presentation to class** (Thu/Tue 4/19 & 24)
  – Each group will make a 10-15 min electronic presentation (~10 slides) dividing presentation among team members
  – Submit PDF on-line, will be posted on website
  – Required attendance

*can be extended*
Schedule

- **Project Checkoff Checklist to staff** (Fri Apr 27)
  - Each group in discussion with mentor creates a checklist of deliverables (i.e., what we can expect each team member to demonstrate). Submit PDF on-line. Three groups:
    - **Commitment** – minimum goals; complexity 2x lab 4
      “Stuff we need in order to have not failed completely.”
    - **Expected** – needed for successful project
      “Stuff we need in order to succeed”
    - **Stretch goal** – stands out in complexity, innovation, risks
      “Stuff we need in order to be awesome”

- **Send out PCB (optional)**

- **Final Project Demo/Checkoff/Videotape** (TW May 8 & 9)
  - Videotaped and posted on-line with your permission

- **Final Project Report** (May 17 5pm)
  - Submit PDF on-line, will be posted on website
  - Sorry, no late reports will be accepted
Thu 4/19 2:30-3pm

- Lab and Labkit cleanup
- Sort, store and reuse components
  - 455khz transformer
  - 10-120pf trim caps
  - Power MOSFET
  - Inductor
  - BJT\textsc{s}, MOSFET\textsc{s}
  - PPG, supermatched pairs
  - Power resistors
  - Op-amps 353, 356
Review grades
• Follow on classes – Fall 2018
  – 6.025/6.525J Medical Device Design
  – 6.111 Introductory Digital Systems Laboratory
  – 6.131 Power Electronics Laboratory
  – 6.301 Solid-State Circuits