E151 Lecture 26 – Review

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ENGR151

Disclaimer

These are notes for Prof. Spencer to give the lecture, they were not intended as a reference for students. Students asked for them anyway, so I'm putting them up as a courtesy. Remember that they are not intended as a substitute for attending lecture.

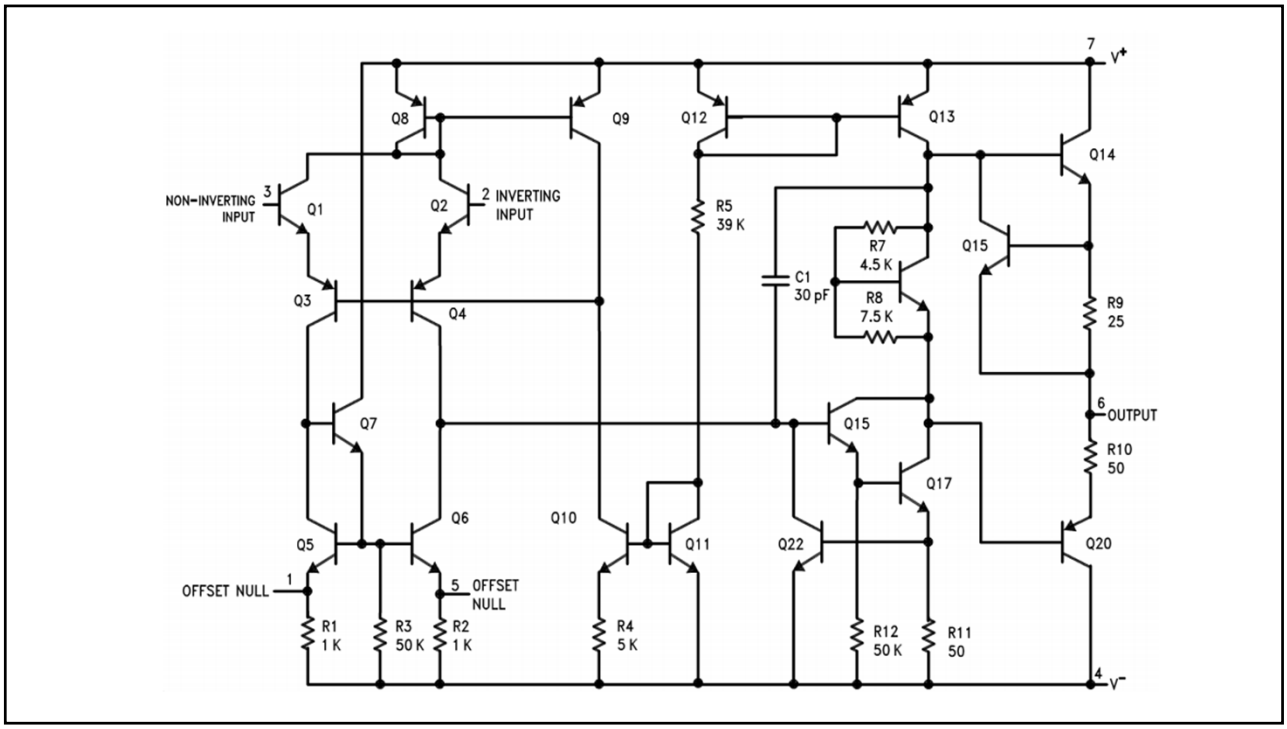
Topics Since the Midterm

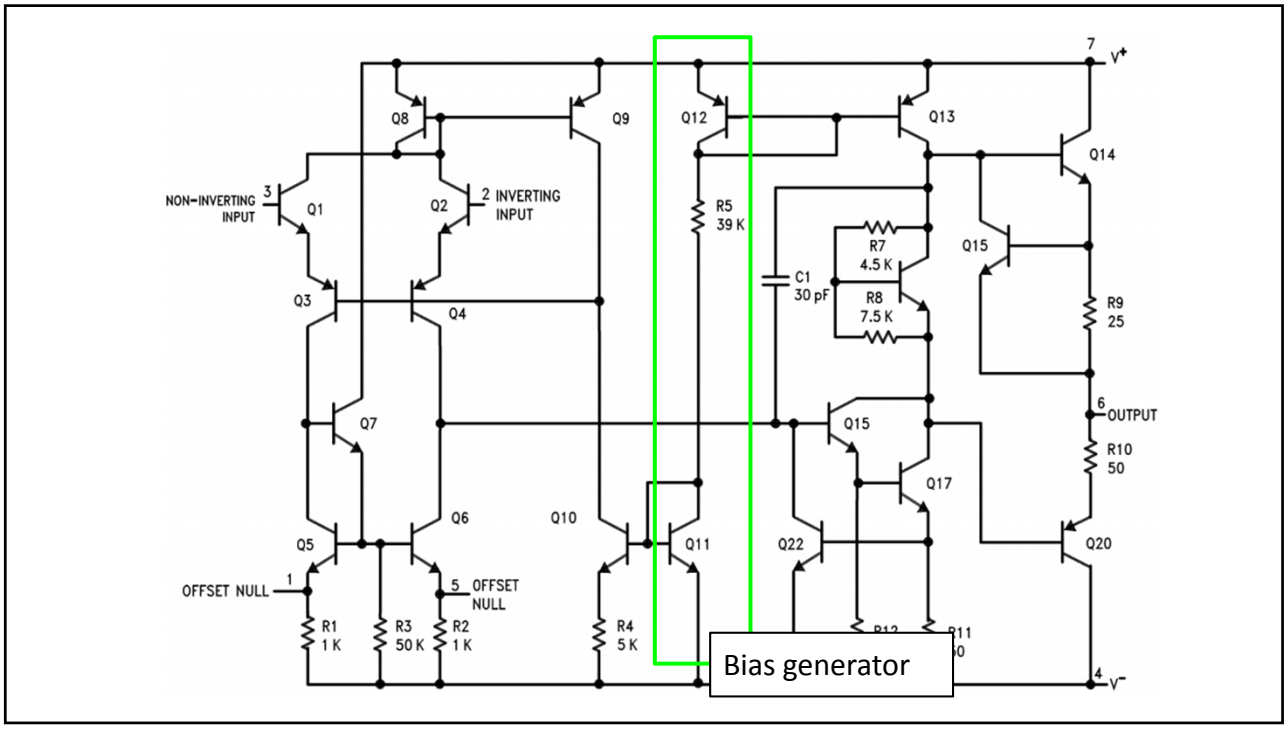
- Dynamics
  - Caps in BJT model
  - Exact CE Xfer function
  - Miller effect & approximation
  - OCTC & Cascodes
  - Step Responses
- Differential Analysis
  - CM and DM signals
  - CM and DM ½ Circuits
  - CMRR and PSRR
  - Offsets
- References
  - Sensitivity analysis
  - Examples
- Output Stages
  - Large signal analysis
  - Examples
- Op-amp design
  - Basics: 3 stages, etc.
  - Design specs: I_B, V_ICM, …
  - Compensation & Xfer fn.
- Stability & Feedback Effects

Topics before the Midterm (Digging Deep)

- Thevenin review and basics of dynamics
- Amplifier model and input/output impedance
- Diode and BJT equations, survey of physics, small signal models
- Going from small signal models to amplifier models
- Examples of single-stage amplifiers: CE, CB, EF, Cascode
- Multistage analysis, Current Mirrors, Active Loads

- All of this together lets us understand real op-amps!


7
V+
Q8
Q9
Q12
Q13
Q14
NON-INVERTING INPUT
3
Q1
Q2
2 INVERTING INPUT
R5 39 K
R7 4.5 K
C1 30 pF
R8 7.5 K
Q15
R9 25
Q3
Q4
Q7
6
OUTPUT
Q15
R10 50
Q17
Q6
Q10
Q5
Q11
Q22
Q20
OFFSET NULL
1
5 OFFSET NULL
R1 1 K
R3 50 K
R2 1 K
R4 5 K
R12 50 K
R11 50
4
V-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Q20
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1
5 OFFSET NULL
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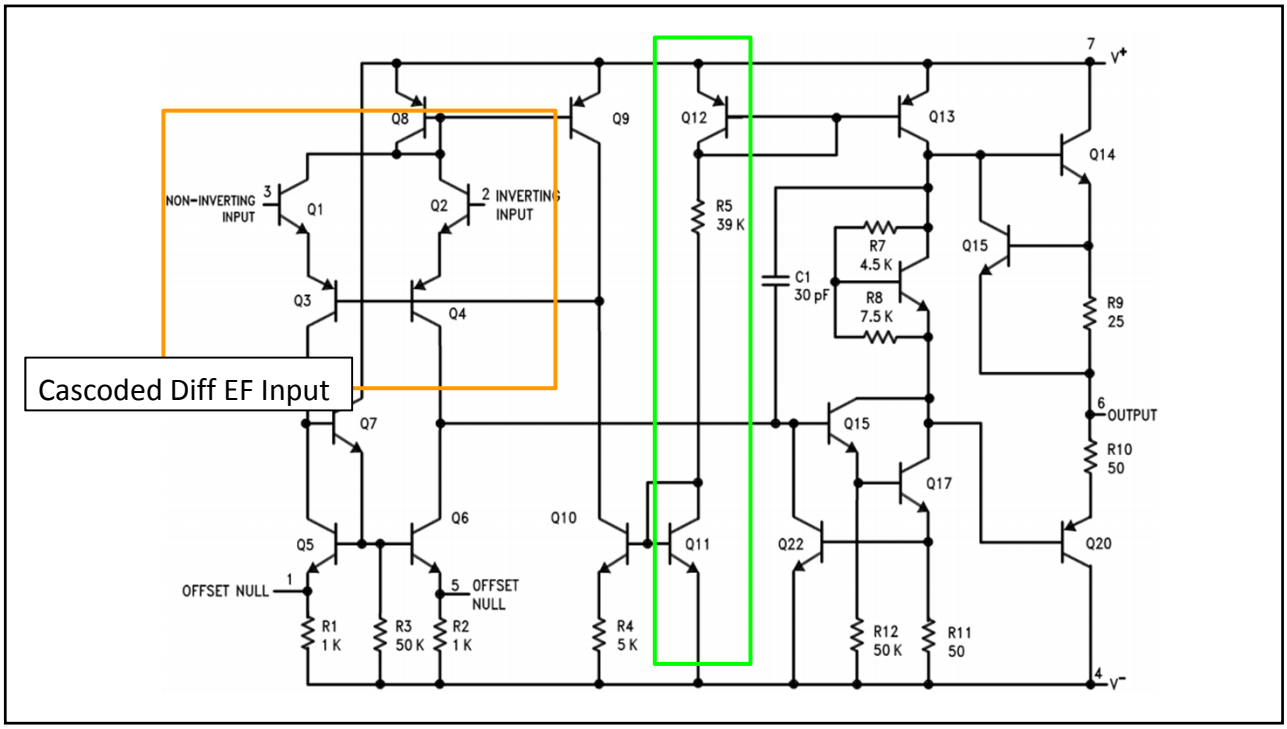
R3 50 K
R2 1 K
R4 5 K
Bias generator
4
V-


Cascoded Diff EF Input
NON-INVERTING INPUT
INVERTING INPUT
OFFSET NULL
OFFSET NULL
OUTPUT
V+
V-
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Q12
Q13
Q14
Q15
Q17
Q20
Q22
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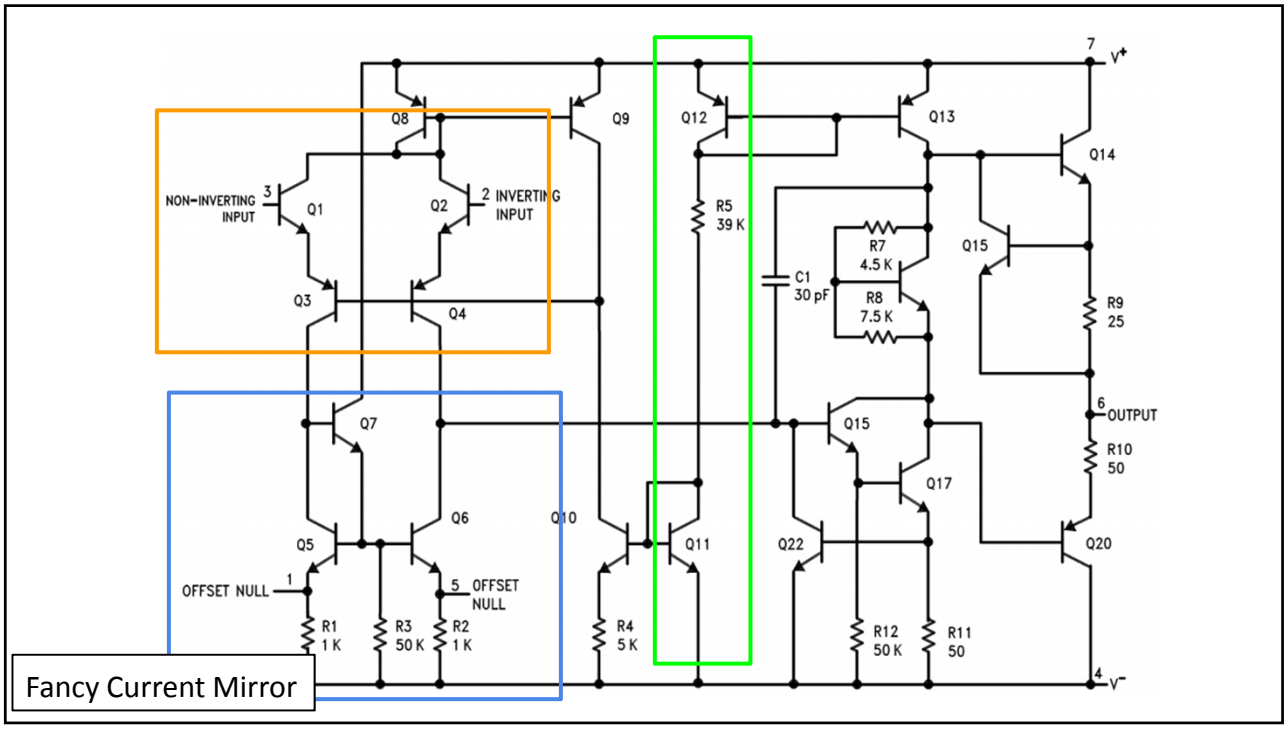
R9 25
R10 50
R11 50
R12 50 K
C1 30 pF


Fancy Current Mirror
NON-INVERTING INPUT
INVERTING INPUT
OFFSET NULL
OFFSET NULL
OUTPUT
V+
V-
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Q12
Q13
Q14
Q15
Q17
Q20
Q22
R1 1 K
R2 1 K
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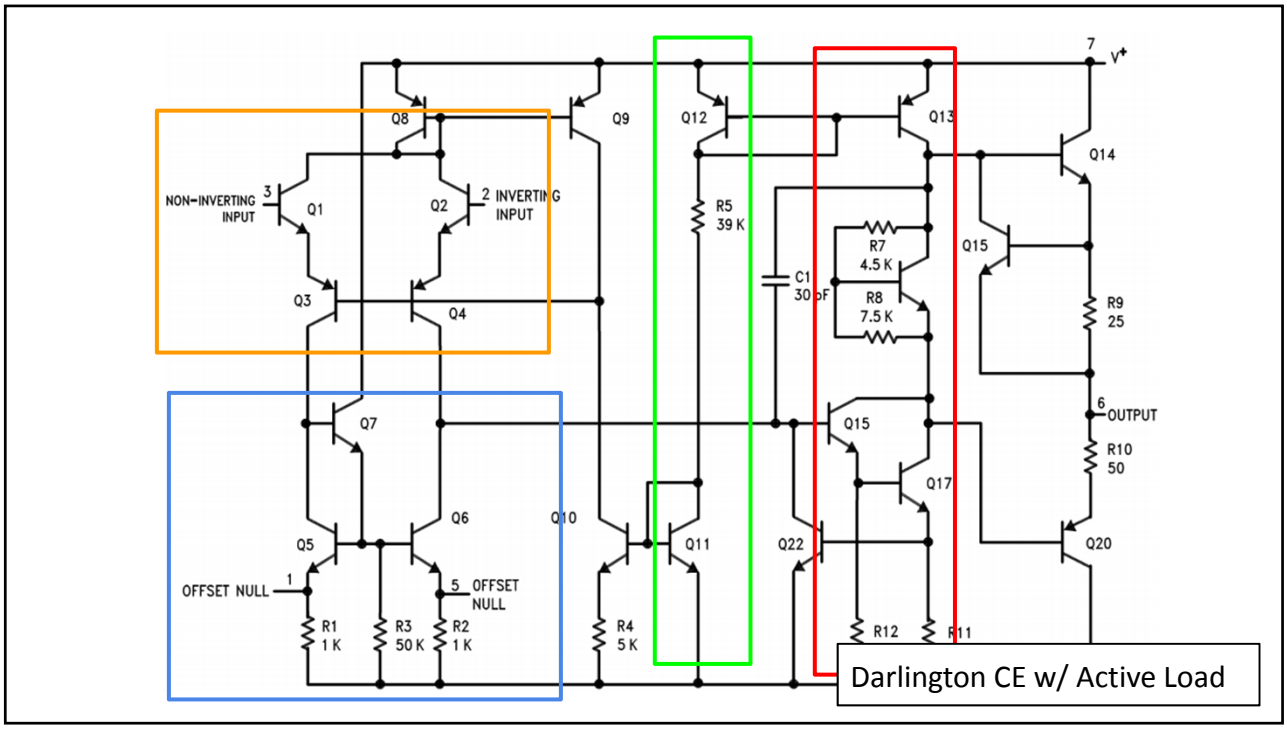
C1 30 pF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Q4
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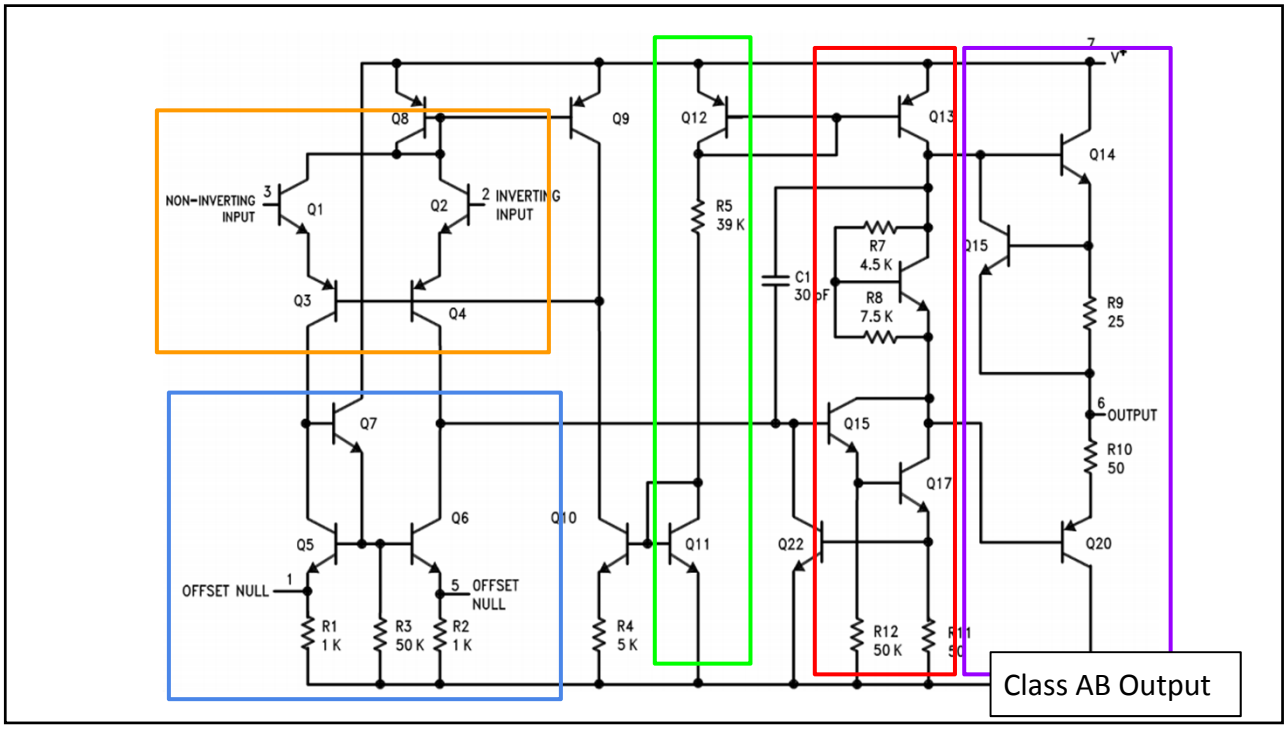
R10 50
Q17
Q6
Q10
Q5
Q11
Q22
Q20
OFFSET NULL
1
5 OFFSET NULL
R1 1 K
R3 50 K
R2 1 K
R4 5 K
R12
R11
Darlington CE w/ Active Load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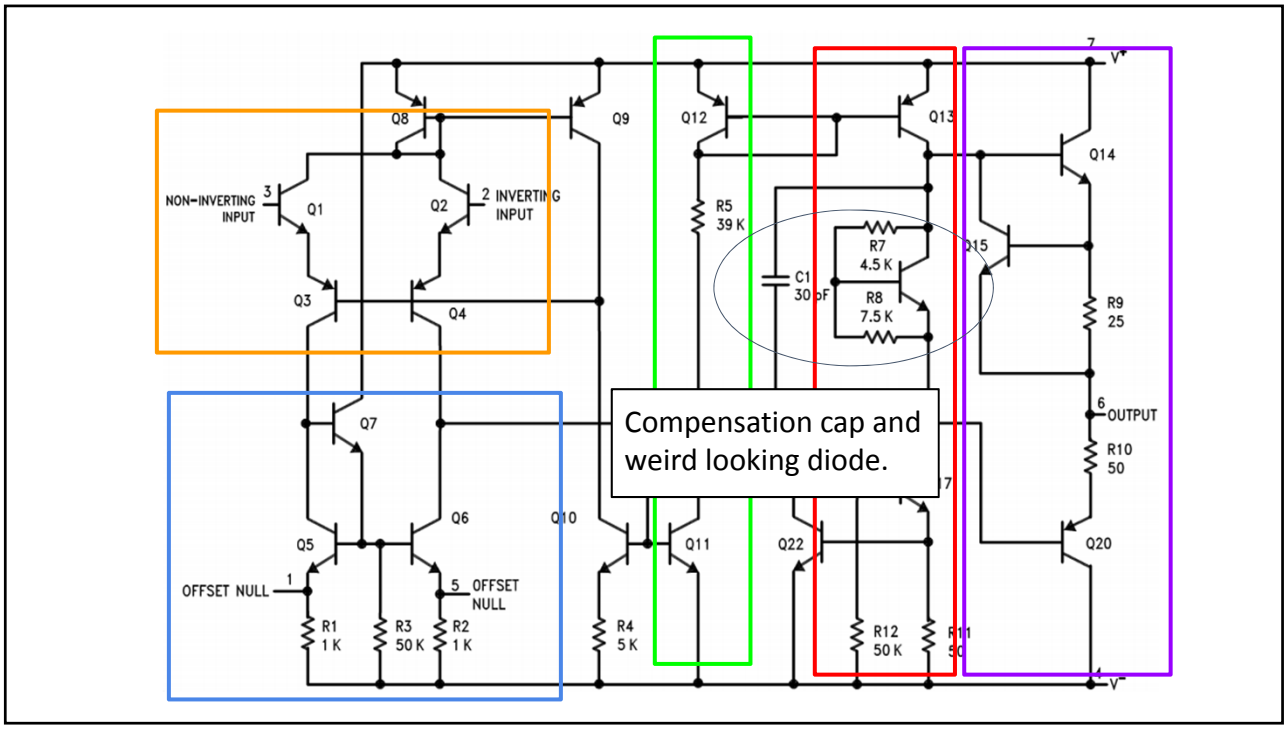
R10 50
Q17
Q6
Q10
Q5
Q11
Q22
Q20
OFFSET NULL
1
5 OFFSET NULL
R1 1 K
R3 50 K
R2 1 K
R4 5 K
R12 50 K
Class AB Output


Compensation cap and weird looking diode.
NON-INVERTING INPUT
INVERTING INPUT
OFFSET NULL
OFFSET NULL
OUTPUT
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Q12
Q13
Q14
Q15
Q20
Q22
R1 1 K
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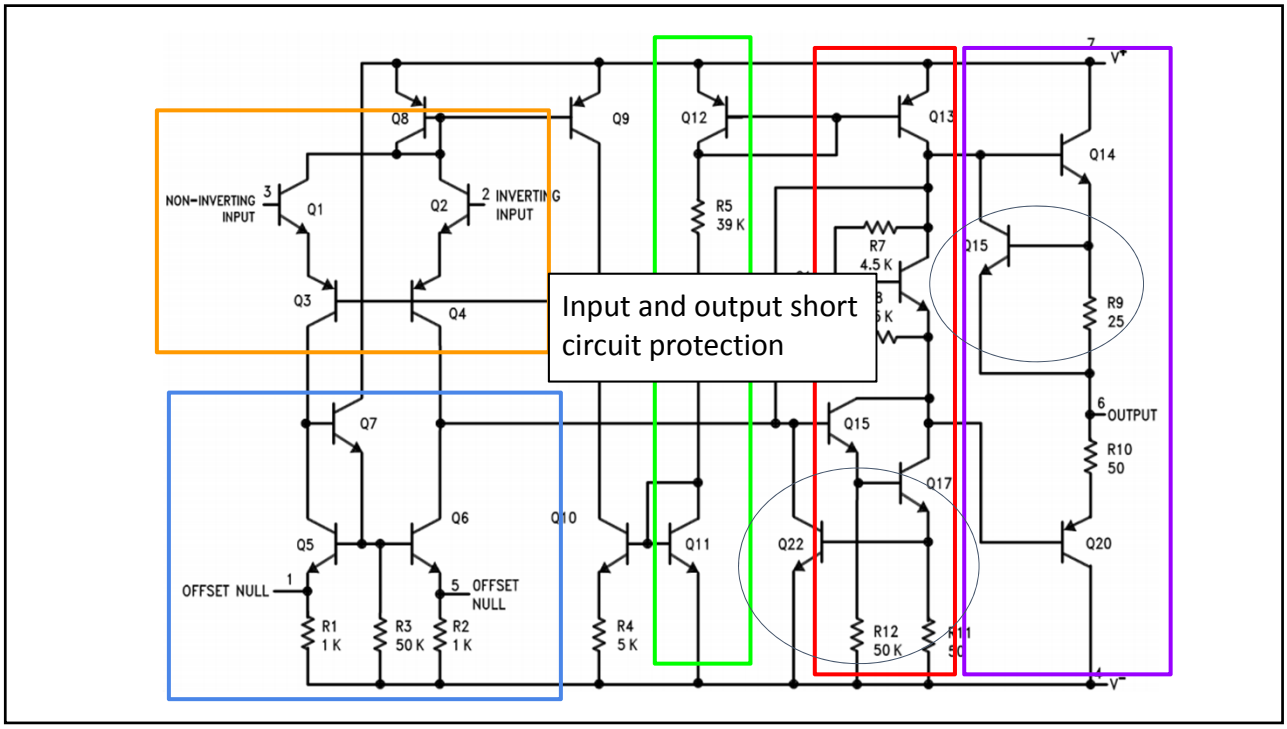
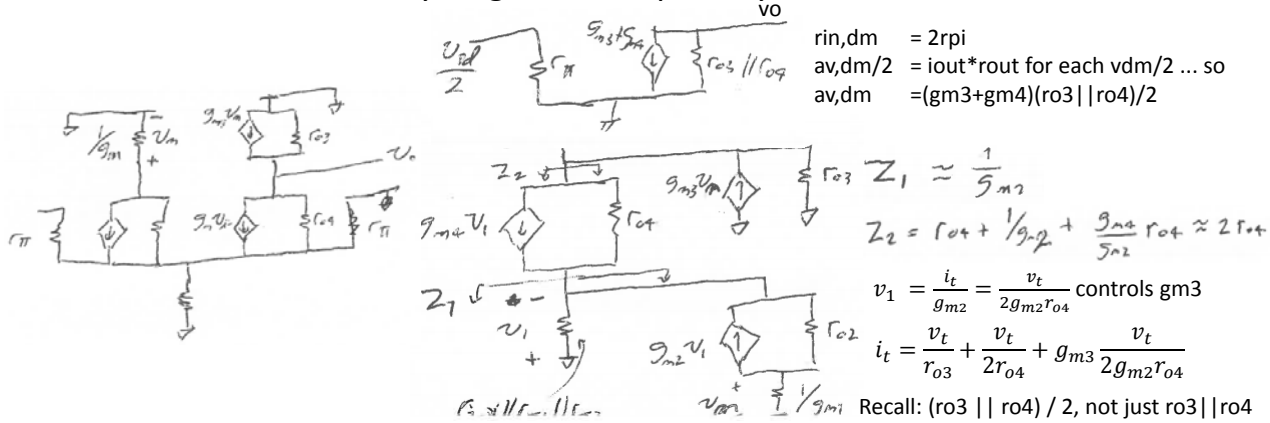
R8 7.5 K
R9 25
R10 50
R12 50 K
C1 30 pF


Input and output short circuit protection
NON-INVERTING INPUT
INVERTING INPUT
OFFSET NULL
OFFSET NULL
OUTPUT
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Q12
Q13
Q14
Q15
Q17
Q20
Q22
R1 1 K
R2 1 K
R3 50 K
R4 5 K
R5 39 K
R7 4.5 K
R9 25
R10 50
R12 50 K

Analyze Mirror Loaded Emitter Coupled Pair

- rin,dm unaffected by load, whew. Both sides help av,dm.
- ro is a fundamentally single ended quantity … involved. Anecdote.



rin,dm = 2rpi

av,dm/2 = iout*rout for each vdm/2 ... so

av,dm =(gm3+gm4)(ro3||ro4)/2

$Z_1 \simeq \frac{1}{g_{m2}}$

$Z_2 = r_{o4} + \frac{1}{g_{m2}} + \frac{g_{m4}}{g_{m2}} r_{o4} \approx 2 r_{o4}$

$v_1 = \frac{i_t}{g_{m2}} = \frac{v_t}{2 g_{m2} r_{o4}}$ controls gm3

$i_t = \frac{v_t}{r_{o3}} + \frac{v_t}{2 r_{o4}} + g_{m3} \frac{v_t}{2 g_{m2} r_{o4}}$

Recall: (ro3 || ro4) / 2, not just ro3||ro4