E151/3 F17 Lec 26 - op-amps (1)

| Slew rate | Final | LM 741 | Assessment |
|---|---|---|---|
| - wat? | - M | - inputs | |
| - why | | - identify | |
| - how observe | | | |

- Congratulations we made it
- Building op-amps like we promised

Lab 6
- 2 main focuses ~ DC coupling & stability
- Just get it hobbling along
- Beware slewing behavior & output clipping ~ try w/ $A_v = 2$ instead of unity

Final
- 9 AM Monday
- 2x crib sheets front & back
- In here — Office Hours
- Coverage

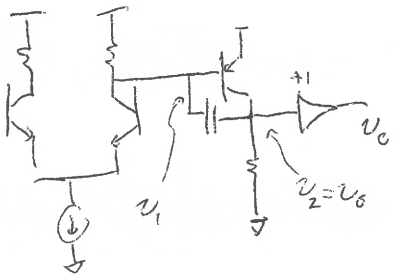
Dynamics
↳ caps in BJT Model
↳ Finding exact Xfer fn. from small signal
↳ Xfer fn. → step resp.
↳ Miller Effect
↳ OCTC & SCTC

Building blocks
↳ current mirrors — $V_{in}$, $V_{out,min}$, $\varepsilon$, $r_o$
↳ Active Loads — gain, biasing, diff → single
↳ diff stages — ½ ckt analysis, CMRR, PSRR
↳ Output stages — large-ish signal analysis
- class A, B, AB
↳ op-amp desing — 3 stages, compensation
↳ stability — phase margin
↳ references — sensitivity

## Slew rate

- on op-amp datasheets
- maximum change in output node per second: op-amp going as fast as it can
- set by discharging compensation cap: $SR = I_{tail}/C_c$
- or set by charging output cap: $SR = I_{bias,out}/C_L$
- slewing behavior

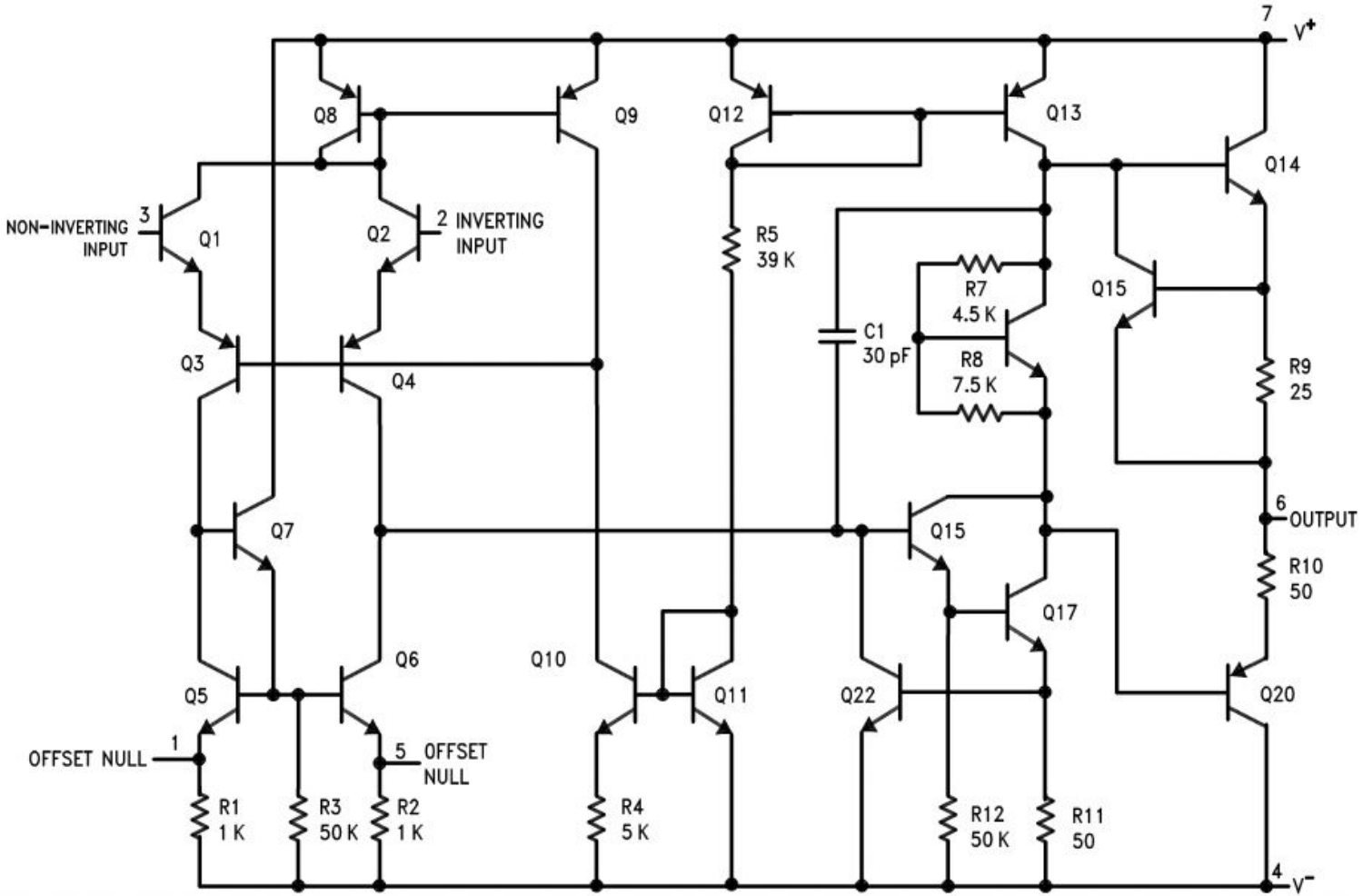
- straight lines (ramp) except where slope small

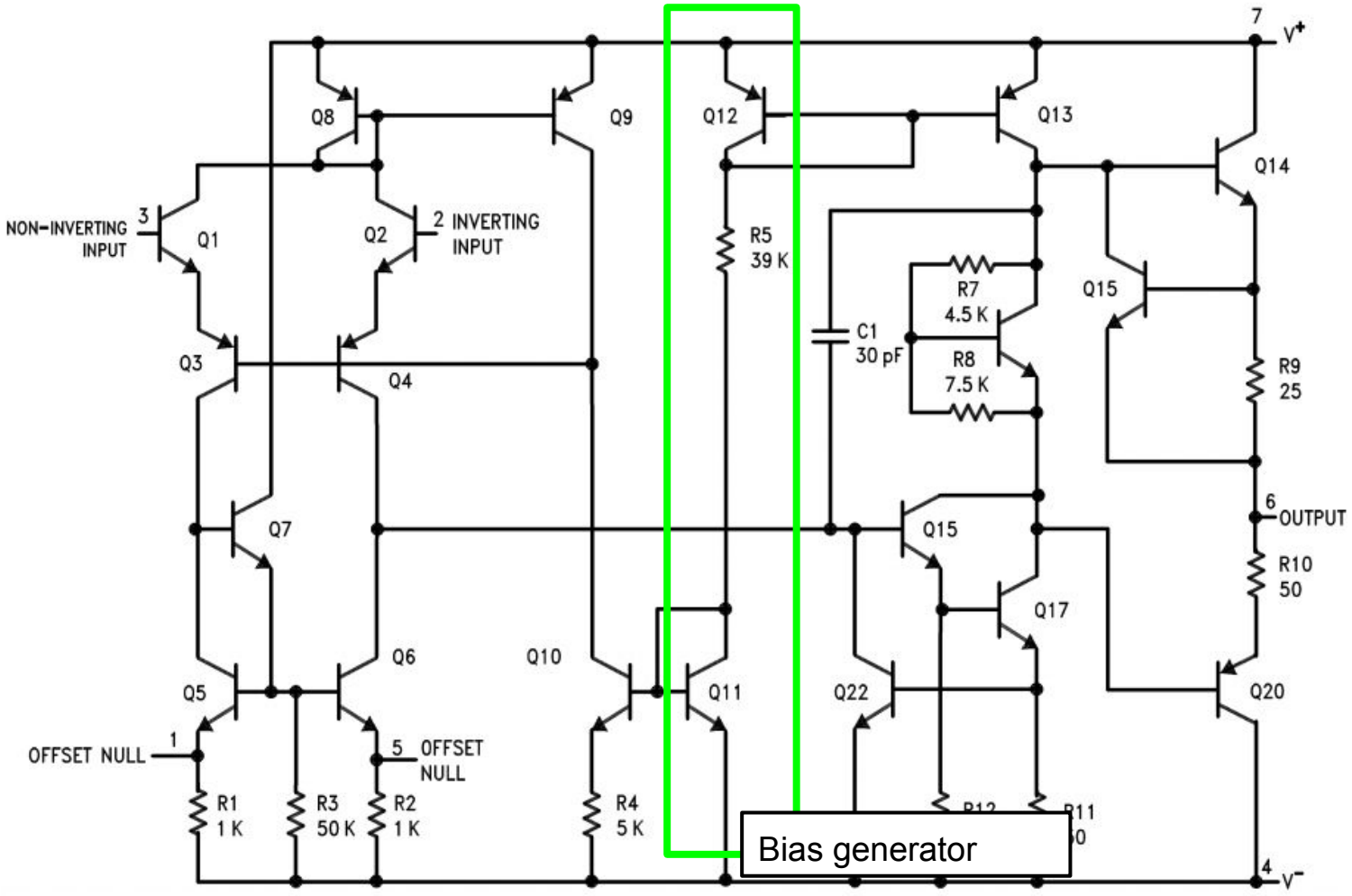


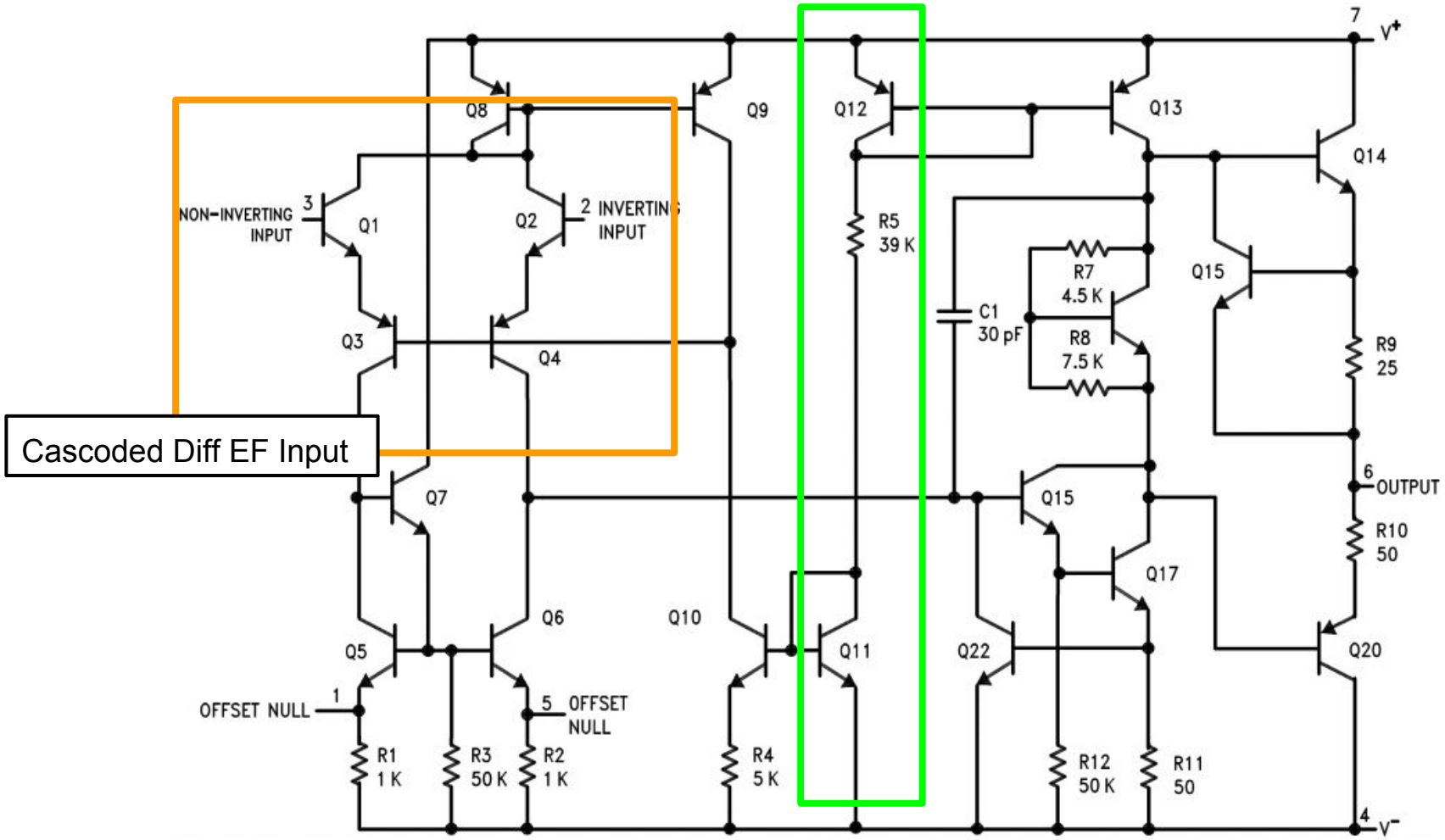

$\frac{dv_o}{dt} = \frac{dv_2}{dt} \Rightarrow v_2 = v_1 + \dot{C}Q \Rightarrow \frac{dQ}{dt} = I_t$ @ most

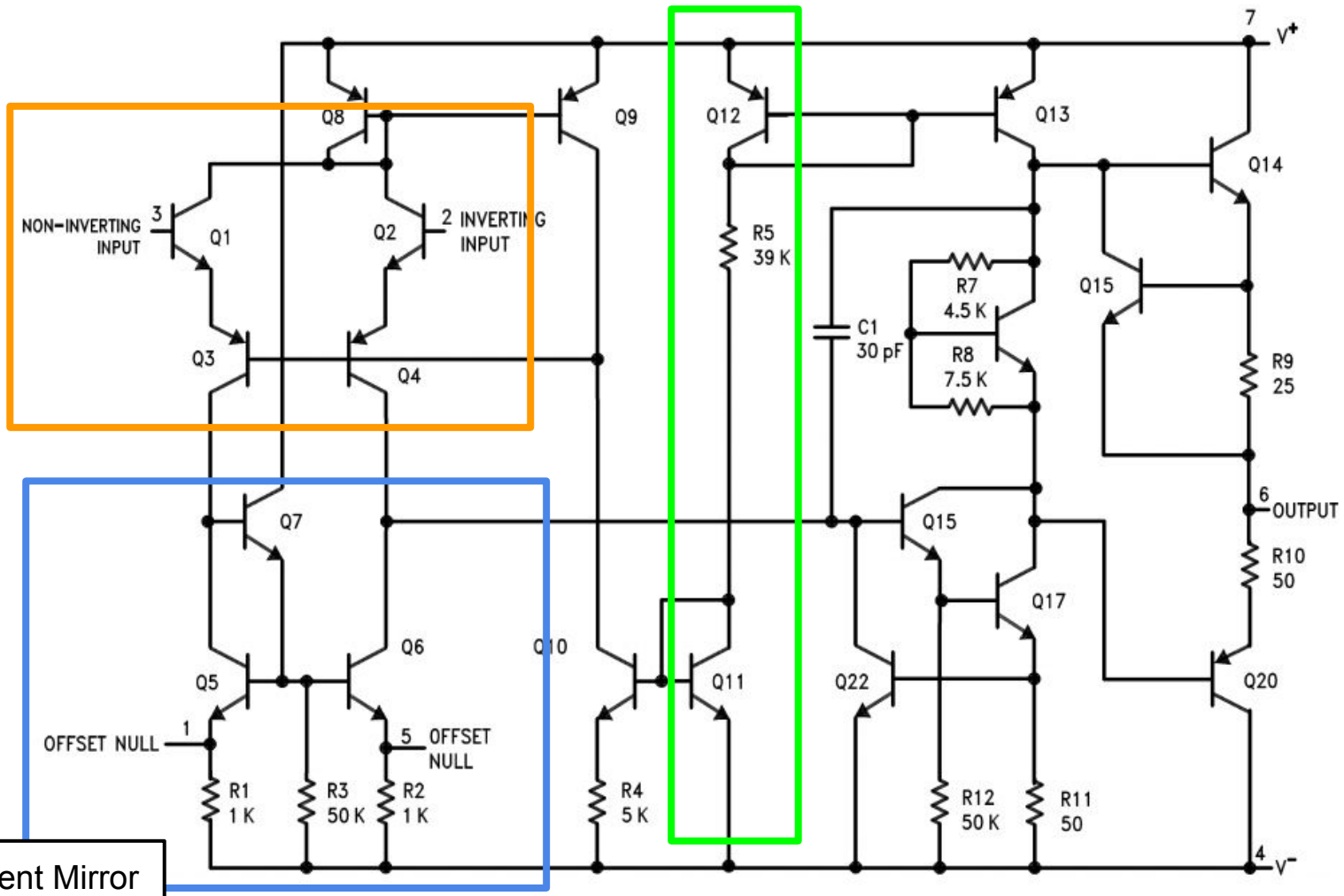
LM 741

- see slides
- inverting input
- Block ID

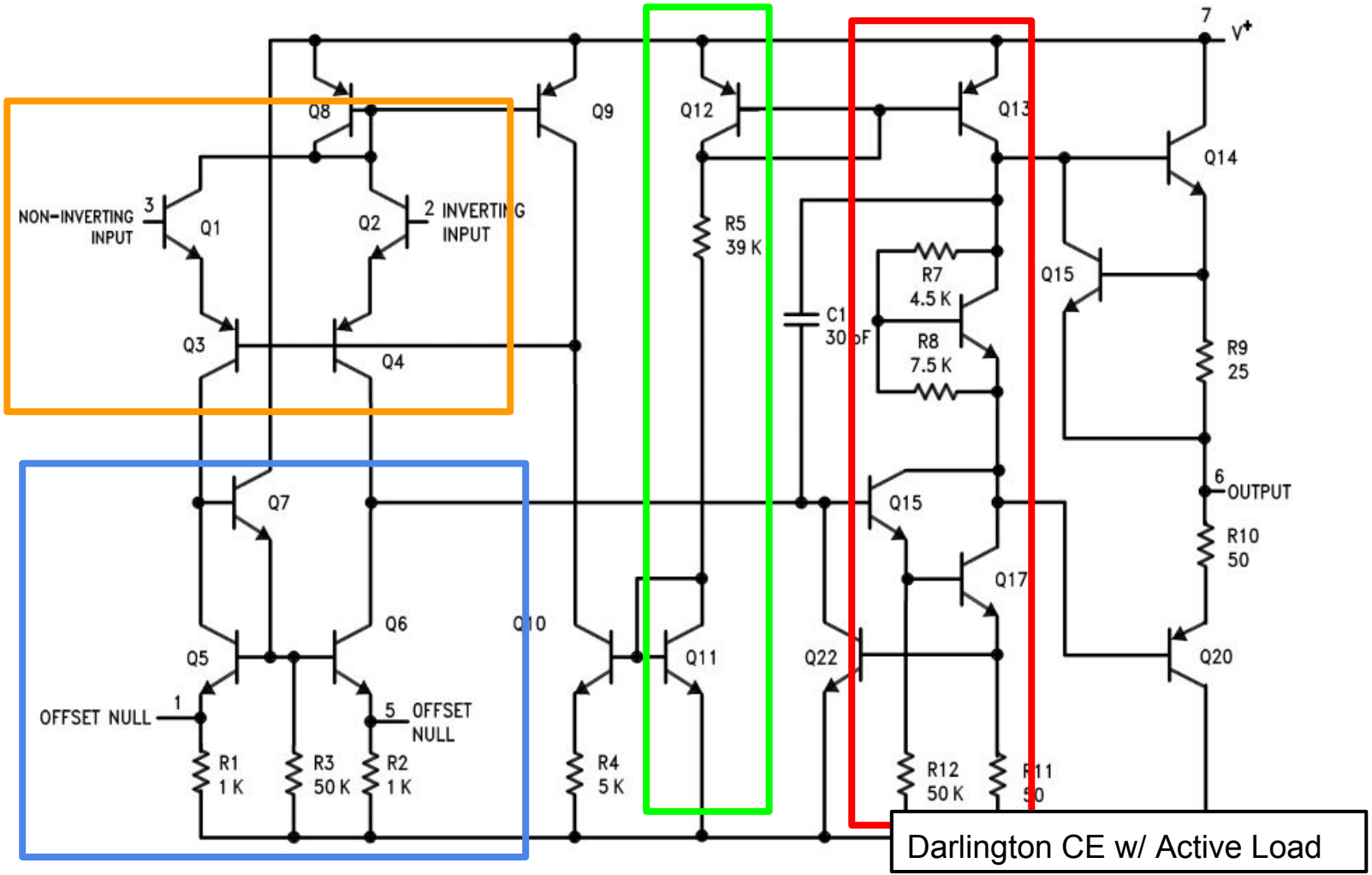

7
V+
Q8
Q9
Q12
Q13
Q14
NON-INVERTING
INPUT
3
Q1
Q2
2
INVERTING
INPUT
R5
39 K
R7
4.5 K
C1
30 pF
R8
7.5 K
Q15
R9
25
Q3
Q4
6
OUTPUT
Q7
Q15
R10
50
Q17
Q6
Q10
Q5
Q11
Q22
Q20
OFFSET NULL
1
5
OFFSET
NULL
R1
1 K
R3
50 K
R2
1 K
R4
5 K
R12
50 K
R11
50
4
V-

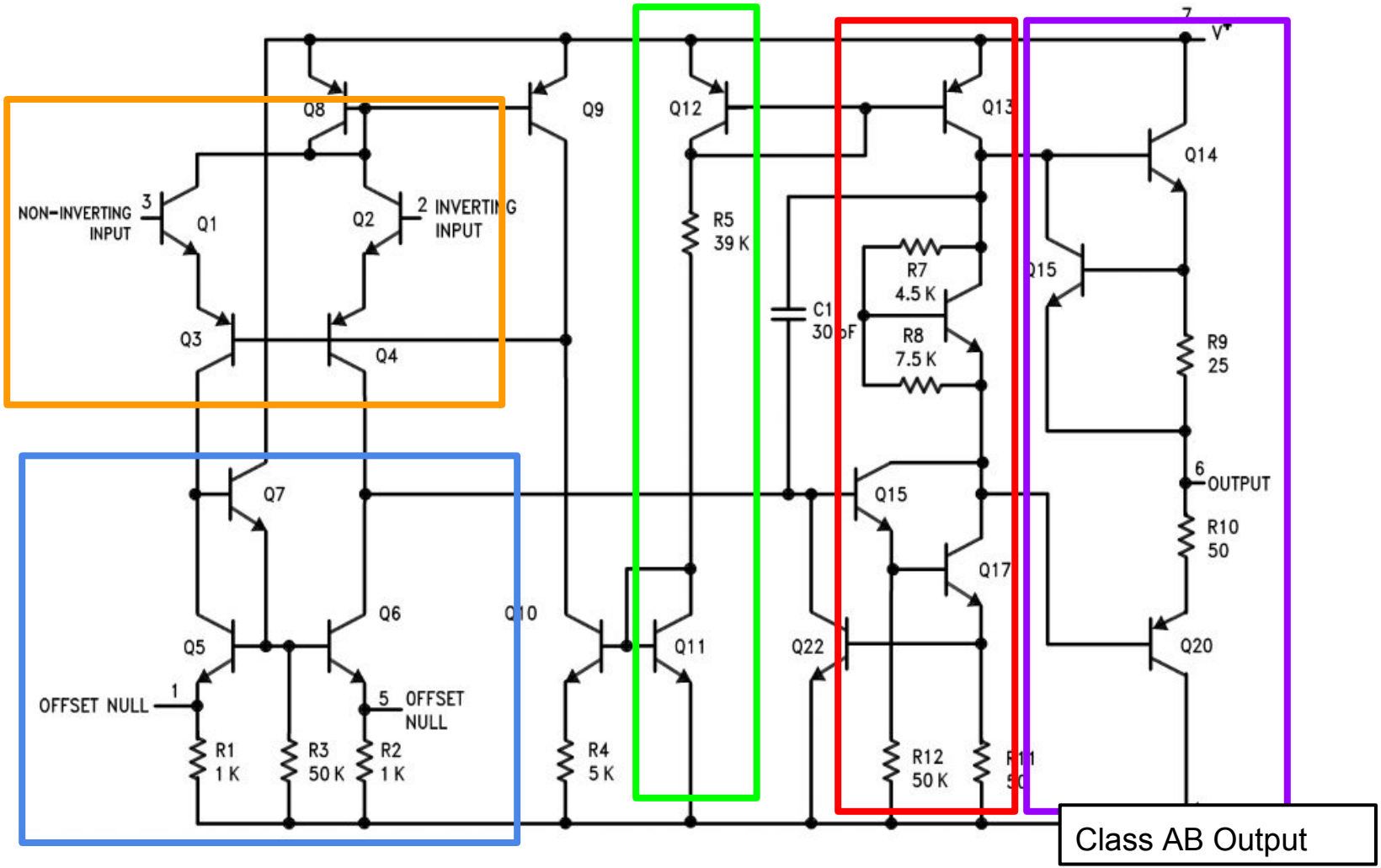

7
V+
Q8
Q9
Q12
Q13
Q14
NON-INVERTING
INPUT
3
Q1
Q2
2
INVERTING
INPUT
R5
39 K
R7
4.5 K
Q15
C1
30 pF
R8
7.5 K
R9
25
Q3
Q4
6
OUTPUT
Q7
Q15
R10
50
Q17
Q6
Q10
Q11
Q22
Q20
Q5
1
OFFSET NULL
5
OFFSET
NULL
R1
1 K
R3
50 K
R2
1 K
R4
5 K
R11
Bias generator
4
V-

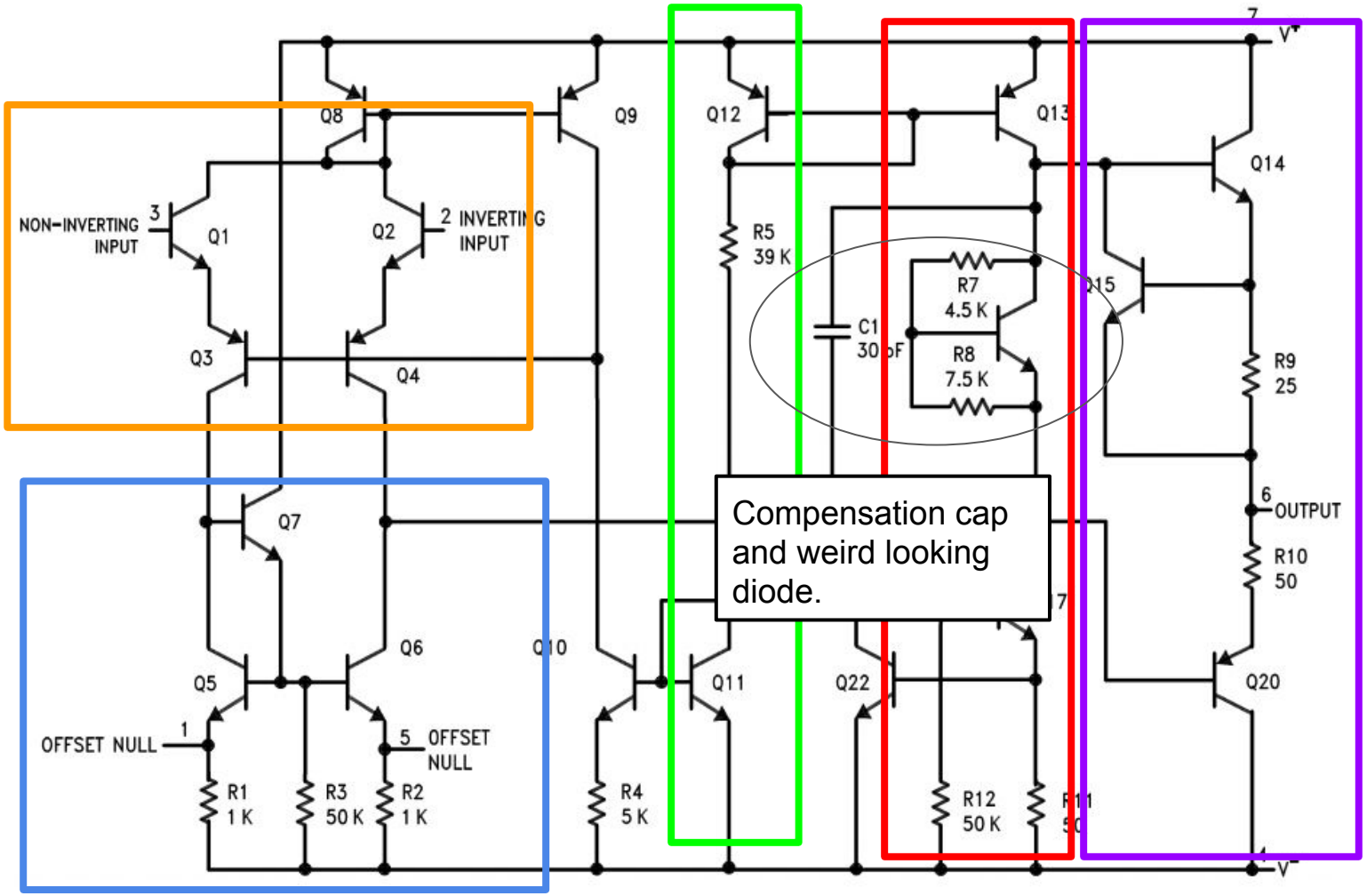

Cascoded Diff EF Input
NON-INVERTING INPUT
3
Q1
Q2
2
INVERTING INPUT
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Q12
Q13
Q14
Q15
Q17
Q20
Q22
OFFSET NULL
1
5
OFFSET NULL
R1 1 K
R3 50 K
R2 1 K
R4 5 K
R5 39 K
R7 4.5 K
R8 7.5 K
C1 30 pF
R9 25
R10 50
R12 50 K
R11 50
7
V+
6
OUTPUT
4
V−

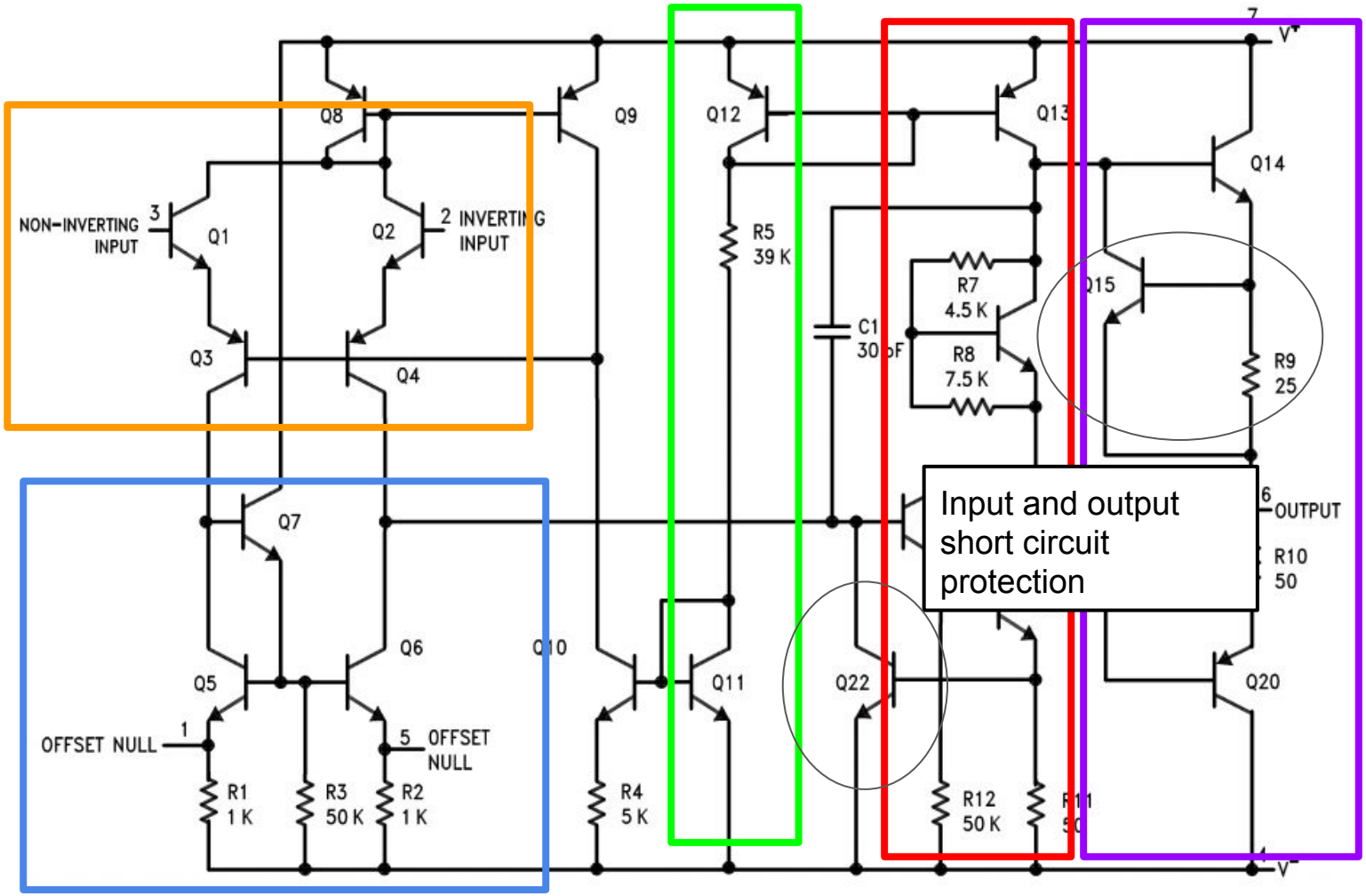



Fancy Current Mirror


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


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


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


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