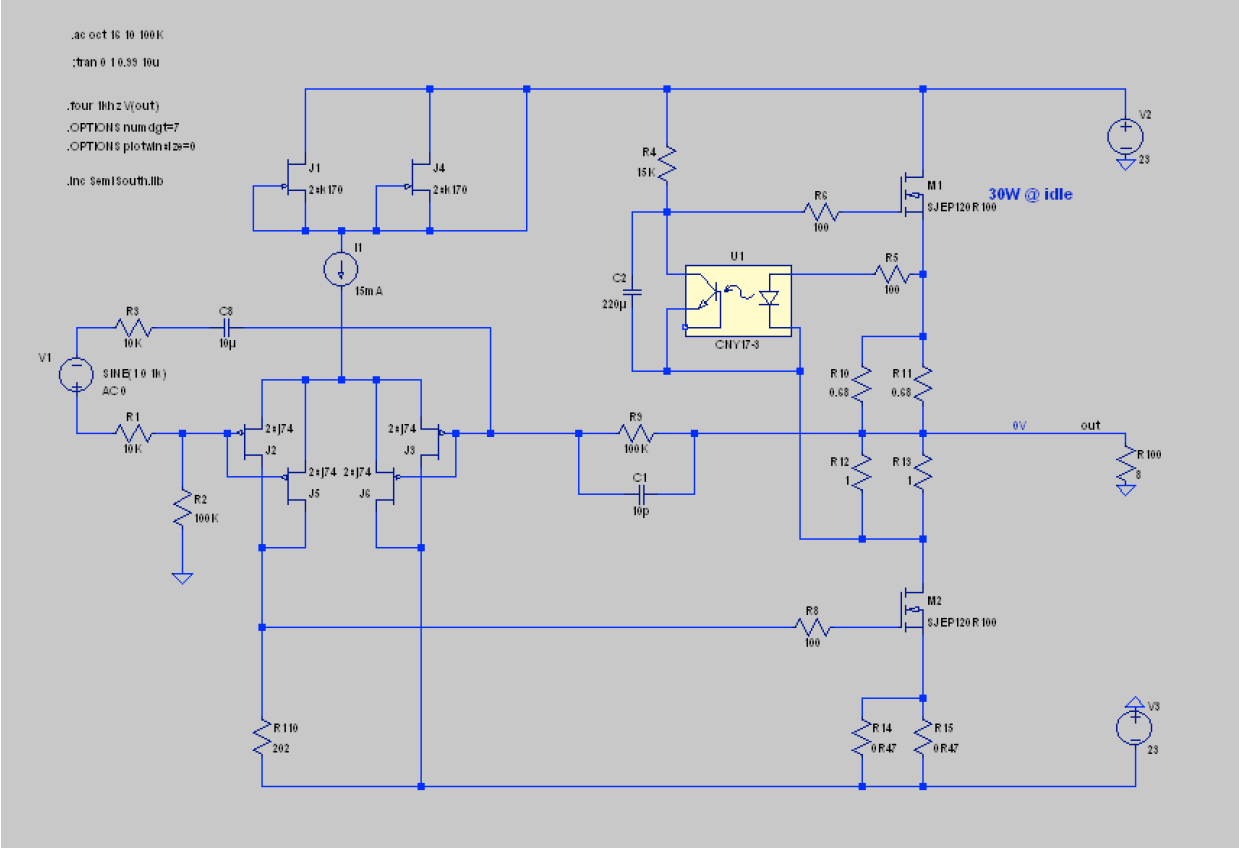
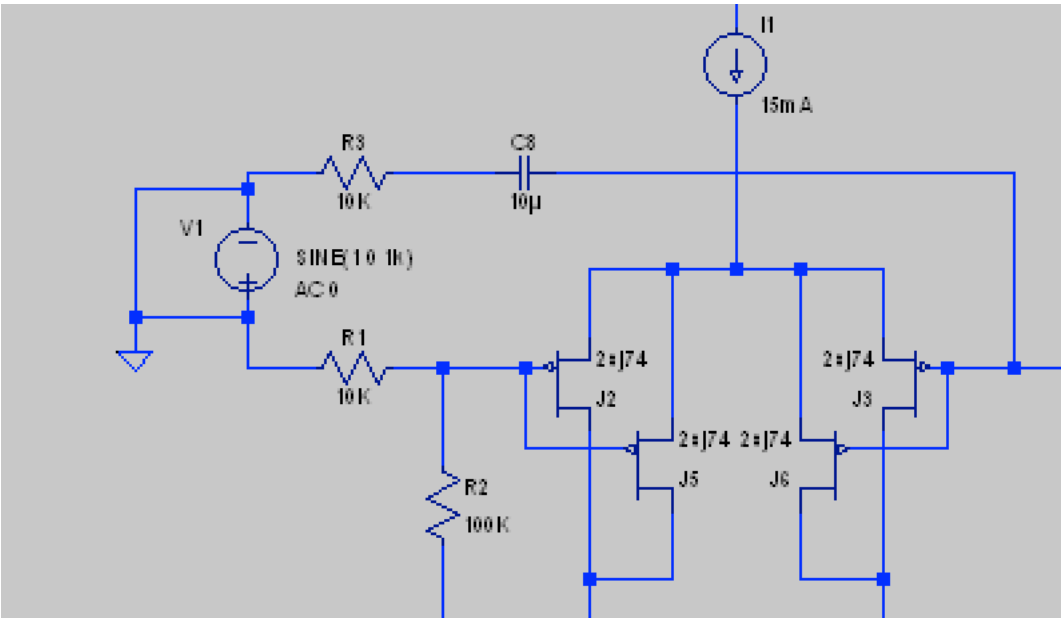
# Determining the LTP current “sweet spot” for a DIY J2 clone.

*First we need to measure the open-loop gain so that we can do our distortion measurements with the same amount of feedback.*

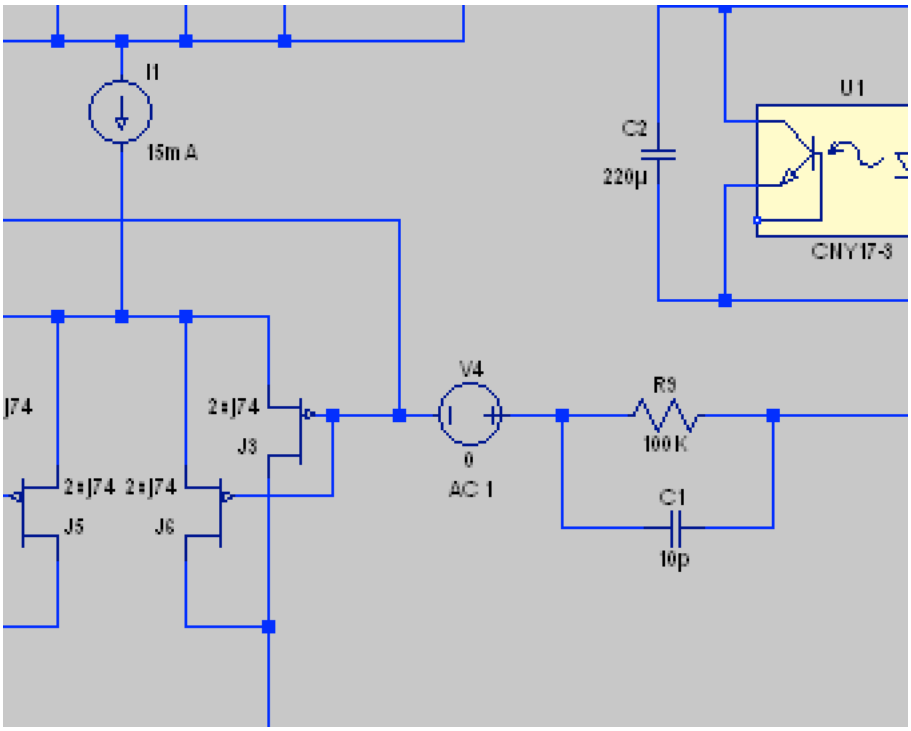
1. Add a SPICE current source between the CCS and the LTP (just to make it easier to set):




2. Ground the inputs:



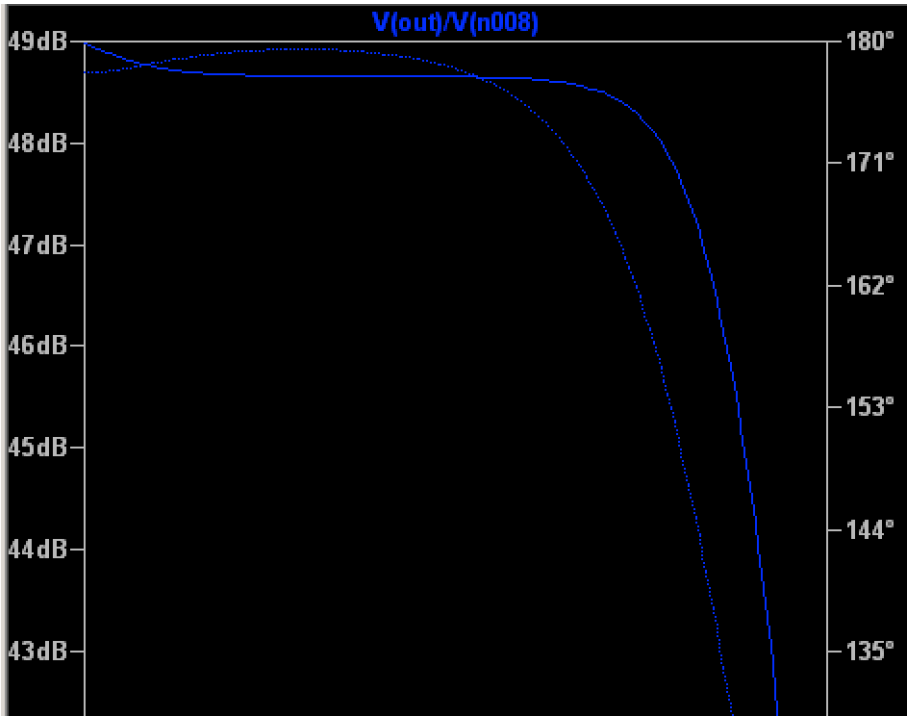
3. Inject some AC into the feedback loop:




4. Run AC analysis simulations with various LTP currents. Adjust the LTP tail resistor each time to zero out the offset.

```
.ac oct 16 10 100K

;tran 0 1 0.99 10u


.four 1khz V(out)

.OPTIONS numdgt=7
.OPTIONS plotwinsize=0

.inc SemiSouth.lib
```

5. Measure the open loop gain by plotting V(out) / V(ltp-negative-input):

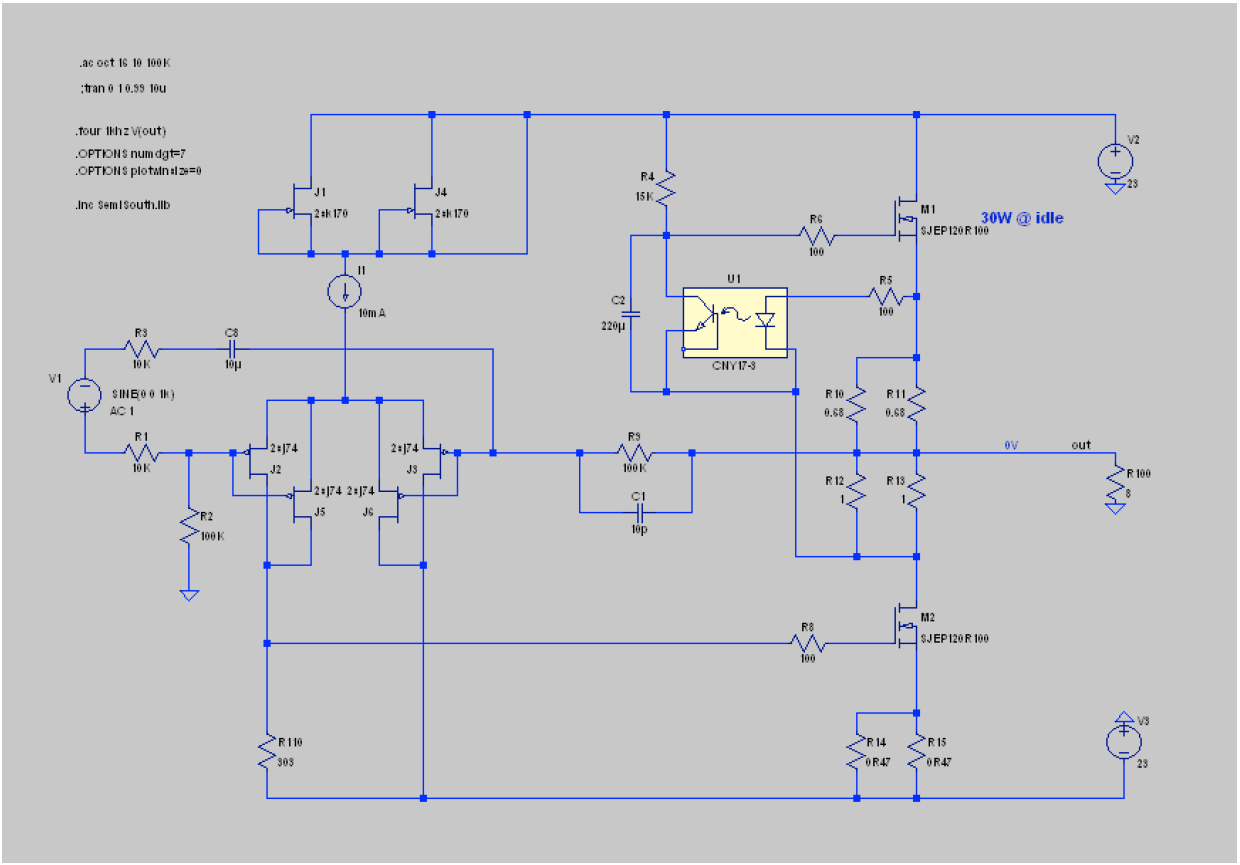



6. My results:

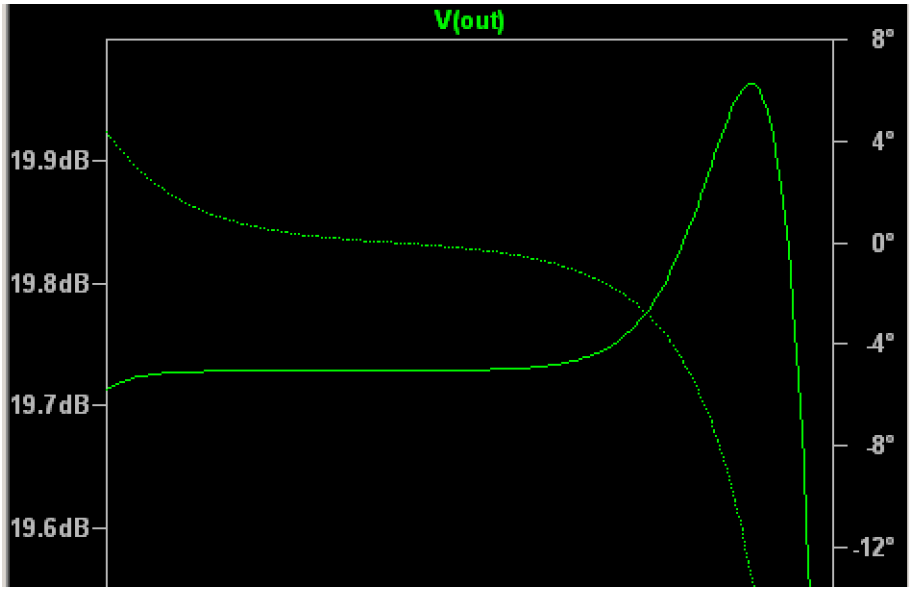
| LTP current | Open loop gain |
|---|---|
| 6mA | 53.5dB |
| 8mA | 52dB |
| 10mA | 51dB |
| 12mA | 50dB |
| 15mA | 49dB |

*Now we want to determine the feedback resistors required for a constant level of feedback.*

7. Run an AC analysis of the middle LTP current without all the open-loop gain stuff:




8. Measure the closed loop gain by plotting V(out):




9. We'll call that 20dB, which gives us a baseline of 31dB feedback.

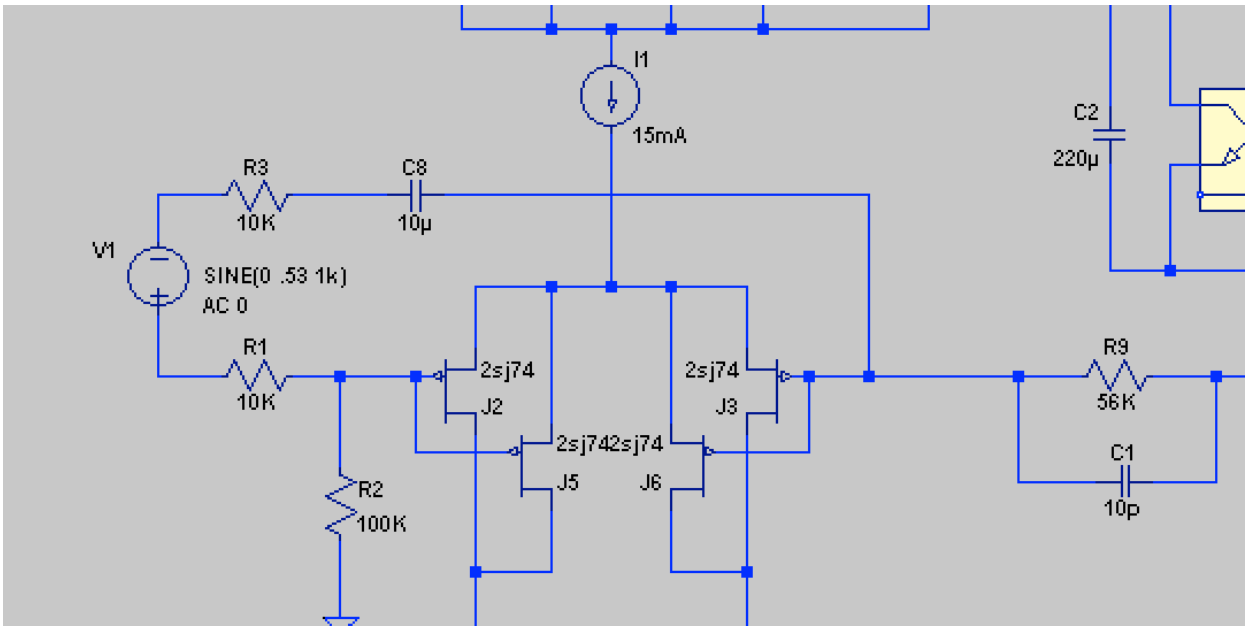
10. Run through the various LTP currents, adjusting the feedback resistor to get a closed loop gain of that current's open loop gain (from table 6) minus 31dB. (Adjust the LTP tail resistor as well for each current to zero the offset.)

11. My results:

| LTP current | Open loop gain | Feedback resistor required for 31dB of feedback |
|---|---|---|
| 6mA | 53.5dB | 180K |
| 8mA | 52dB | 130K |
| 10mA | 51dB | 100K (baseline) |
| 12mA | 50dB | 82K |
| 15mA | 49dB | 68K |

*Now we can determine the distortion of the various solutions.*

12. Run a transient analysis on each current solution to find the input voltage which produces 1w RMS at the output:




13. Examine the SPICE error log to get the distortion figures:

```
Fourier components of V(out)
DC component:-0.00135224

Harmonic             Frequency            Fourier              Normalized
 Number                [Hz]               Component             Component
    1                1.000e+03            3.998e+00            1.000e+00
    2                2.000e+03            8.985e-04            2.248e-04
    3                3.000e+03            8.423e-05            2.107e-05
    4                4.000e+03            2.587e-06            6.471e-07
    5                5.000e+03            8.372e-07            2.094e-07
    6                6.000e+03            6.201e-07            1.551e-07
    7                7.000e+03            5.579e-07            1.396e-07
    8                8.000e+03            6.122e-07            1.531e-07
    9                9.000e+03            6.398e-07            1.600e-07
Total Harmonic Distortion: 0.022574%(0.026167%)
```

14. My results:

| LTP current | Open loop gain | Feedback resistor | Input voltage | THD @ 1W |
|---|---|---|---|---|
| 6mA | 53.5dB | 180K | 0.30V | 0.010% |
| 8mA | 52dB | 130K | 0.37V | 0.009% |
| 10mA | 51dB | 100K (baseline) | 0.42V | 0.010% |
| 12mA | 50dB | 82K | 0.46V | 0.013% |
| 15mA | 49dB | 68K | 0.49V | 0.017% |

15. One more data point to determine which side of 8mA the minima is on:

| LTP current | Open loop gain | Feedback resistor | Input voltage | THD @ 1W |
|---|---|---|---|---|
| 6mA | 53.5dB | 180K | 0.30V | 0.010% |
| 8mA | 52dB | 130K | 0.37V | 0.009% |
| 9mA | 51.5dB | 110K | 0.40V | 0.009% |
| 10mA | 51dB | 100K (baseline) | 0.42V | 0.010% |
| 12mA | 50dB | 82K | 0.46V | 0.013% |
| 15mA | 49dB | 68K | 0.49V | 0.017% |

16. Result: target is 8.5mA.

*Note that 6mA is likely to run out of room on the 500ohm tail potentiometer, so I'd suggest using 8mA to 10mA (or even 12mA).*

*Caveats: This is DIY. I'm an amateur. The methodology presented here (and the results) may be wrong. (If it is wrong, please let me know.)*

*Jeff Young, Sept 14, 2019*