

So far, by applying the serial input, shunt output formalism and particularizing for the CFA base amplifier we got the expression of the equivalent open loop voltage gain of the CFA and the equivalent non inverting input impedance. We can now identify the G_{ij} parameters of the CFA base amplifier:

$$G_{21} = \frac{T(j\omega)}{R_o} \quad (12)$$

$$G_{11} = R_o \quad (13)$$

4. Discussion

Before starting, let's summarize what we got so far

- The serial input, shunt output feedback formalism worked for CFA
- For the CFA, the open loop voltage gain essentially depends on the feedback network
- The input impedance is frequency dependent, hence another reason for using an $\times 1$ input buffer - to isolate this impedance
- The input impedance also follows the serial input, shunt output feedback formalism and also depends on the feedback network

The big difference between the VFA and CFA is obvious if we consider the feedback network loading effect. Since G_{11} is small for CFAs, the input loading with $R_o \parallel R_F$ is important, and affects the G_{21} . Once again, we identified (this time from a two port formalism perspective) the property of open loop gain (G_{21}) depending on the feedback network.

If $T(j\omega)$ is "large" at low frequencies ("large" means $T \gg R_F$) then from (8) and (9) we immediately get the VFA closed loop non inverting gain

$$A_{u_{cl}} = \frac{1}{B} = 1 + \frac{R_F}{R_o} \quad (14)$$

Let's take a closer look at the frequency response of the CFA.

Assume the CFA transimpedance $T(j\omega)$ has a single pole, as much as a VFA open loop gain $A(j\omega)$ is characterized by a single dominant pole, a standard assumption. Thus, for a VFA we have successively:

$$A = \frac{A_0}{1 + j \frac{\omega}{\omega_0}} \quad (15)$$

$$A_{CL} = \frac{\frac{A_0}{1 + j \frac{\omega}{\omega_0}}}{1 + j \frac{\omega}{\omega_0} (1 + A_0 \beta)} \quad (16)$$

$$A_0' \triangleq \frac{A_0}{1 + \beta A_0} ; \quad \omega_0' \triangleq \omega_0 (1 + \beta A_0) \quad (17)$$

We immediately conclude the VFA closed loop bandwidth depends on β (also known as the "noise gain"). Also for a VFA, the loop gain is:

$$LG \triangleq A\beta = \frac{A_0}{1 + j \frac{\omega}{\omega_0}} \cdot \frac{R_G}{R_G + R_F} \quad (18)$$

So LG also depends on the noise gain.

If we use (8) to calculate the CFA loop gain we obtain:

$$LG \triangleq A\beta = \frac{T_0}{1 + j \frac{\omega}{\omega_0}} \cdot \frac{1}{R_F} \quad (19)$$

Interesting enough, the CFA loop gain does not depend on the noise gain, but only on R_F . Thus, the closed loop bandwidth of a CFA will only depend on R_F and not on the noise gain (which is also the closed loop gain at LF for a VFA). Under the circumstance, CFAs do not have a constant GBW product as the VFAs.

We just proved one of the essential properties of a CFA: closed loop gain and bandwidth are decoupled.

Question is, for what closed loop gain range? That's rather easy to estimate; as soon as $R_F \gg R_G$ (that is, for large closed loop gains the open loop gain in (8) becomes:

$$A \approx \frac{T(j\omega)}{R_G} = \frac{\frac{T_0}{1+j\frac{\omega}{\omega_0}}}{R_G} = \frac{T_0/R_G}{1+j\frac{\omega}{\omega_0}} = \frac{A_0'}{1+j\frac{\omega}{\omega_0}} \quad (20)$$

which shows that the CFA open loop gain degenerates to a VFA constant (at LF) and hence once again by changing R_F the bandwidth changes exactly as for a VFA. Finally let's take a quick look at how the standard CFA topology implements a CFA behaviour.

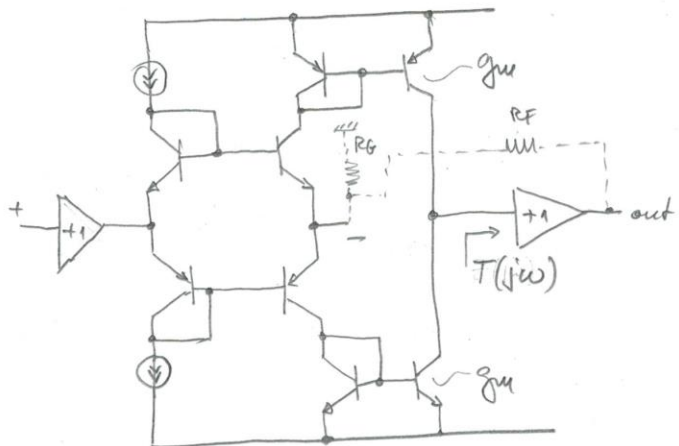


fig 8.

As discussed in Section 2, if according to the serial input, shunt output feedback analysis two port formalism, the driving input is loaded by $R_G \parallel R_F$ and the output by $R_G + R_F$. Thus, after breaking the loop, the open loop gain is, for a reasonable range of $R_G \parallel R_F$

$$A = \frac{T(j\omega)}{R_G \parallel R_F} \quad (21)$$

which is exactly a realisation of the theoretical (8)

5. Conclusions

Let's take a step back and see what we did;

- a) We have shown the two-port formalism for serial input, shunt output feedback analysis.
- b) Based on this formalism, we deduced the VFA properties.
- c) We successfully applied the same formalism to the generic CFA model. By identification, we determined the CFA two-port G_{ij} parameters.
- d) The G_{21} parameter (the open loop gain) resulted as depending on the feedback network (it is independent for a VFA).
- e) This G_{21} feedback network dependence explains the constant bandwidth (small signal) CFA property. The closed loop gains range for this property were estimated.
- f) It was shown how the standard CFA circuit topology implements the G_{21} model for a CFA.

Bottom line, all special small signal properties of a CFA can be mathematically deduced using the same two-port formalism feedback analysis used to calculate the VFA properties. The formalism is for serial input, shunt output feedback, also known as "voltage feedback". From a small signal properties, no other assumptions are required. Thus, CFAs are as much "voltage feedback" as the next longtail pair VFA.

By no means is this analysis intended to deny the existence of CFAs or their special small signal properties. It is intended only to show that CFAs don't define anything new or special from a feedback perspective, and because CFAs could be fully analysed using voltage feedback, the "CFA" naming is rather misleading (say, from an academic perspective).