

Fig 4 is useful for understanding the 'breaking the feedback loop' concept. As usual, to break the loop, we have to passivate the feedback network ( $h_{12}=0$ ) and consider the base amplifier 'loading' by the feedback network. It is easy to observe that the loading effect is  $h_{11}$  in series with  $G_{11}$  and  $h_{22}$  in parallel with  $G_{22}$ . What's left, we have to particularize  $h_{11}$ ,  $h_{12}$  and  $h_{22}$  for the canonical series shunt network. Please note that  $h_{12}v_2$  is the 'error signal'.

A little bit of elementary algebra and Thevenin/Norton transformations shows the fig. 5 loads the input with  $R_1 || R_F$  while the output is loaded by  $R_1 + R_F$ . Once we determined the base amplifier loading we can determine the loop gain and the closed loop gain of the feedback amplifier and also the closed loop input and output impedances. By adopting the standard notation of  $A(j\omega)$  for the open loop <sup>midband</sup> gain and noting that

$$h_{12} = \frac{R_1}{R_1 + R_F} \triangleq \beta \quad (1)$$

$$G_{21} = A(j\omega) \cdot G_{22} \quad (2)$$

$$R_{11} = \frac{1}{G_{11}} = r_i \quad (3)$$

we immediately find the classic results:

$$Z_I = (1 + A\beta) r_i \quad (4)$$

$$Z_O = \frac{z_o}{1 + A\beta} \quad (5)$$

$$A_{cl} = \frac{A}{1 + A\beta} \quad (6)$$

Please note that we made absolutely no assumptions regarding the topology of the base amplifier; we only modelled the base amp as a VCVS, using the canonical  $b_{ij}$  representation.

### 3. The CFA model analysis.

Let's start from the universally accepted CFA model in fig. 6.

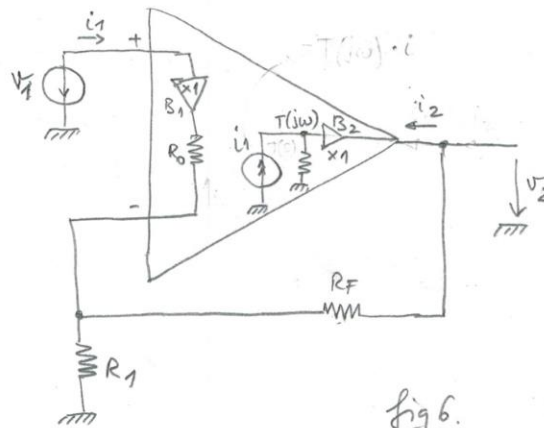


fig. 6.

We are now very specific on the structure of the base amplifier. Since for the purpose of this analysis the B1 buffer is irrelevant (we don't care about what the external world will care about the non-inverting input impedance, and B1 is not in the feedback loop). Therefore we can simplify the CFA model as in Fig 7

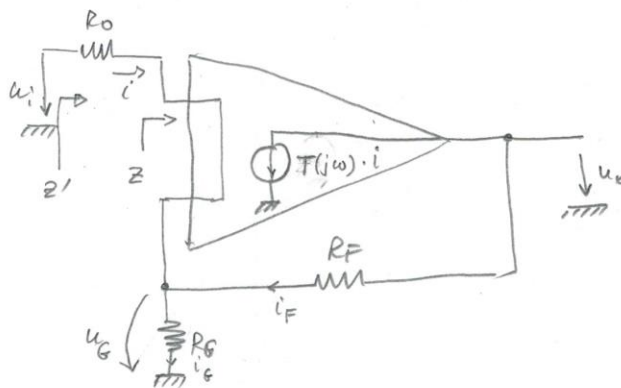


fig 7

We can recognize immediately that the feedback network has the same topology as in the VFA case in section 2. Since no assumptions were made about the base amp in section 2, and the gain  $u_0/u_i$  is a voltage gain, the same formalism will apply. However, due to the specifics of the base amplifier in fig. 7, the  $G_{ij}$  parameters will be different in expressions.

To determine the  $G_{ij}$  parameters expressions, and the closed loop gain and input impedance, we can use an identification method that is, calculate the closed loop gain without breaking the loop, considering feedback network loading, etc... then identify (if possible) with the general expression for the closed loop gain and input impedance. Some algebra leads to the core result in fig 7.

$$\frac{u_o}{u_i} = \frac{\frac{T(j\omega)}{R_F \parallel R_G}}{1 + \frac{T(j\omega)}{R_F \parallel R_G} \cdot \frac{R_G}{R_F + R_G}} \stackrel{\Delta}{=} \frac{A}{1 + \beta A} \quad (7)$$

Identification with the general expression of serial input, shunt output closed loop gain (1) and (6)

$$A = \frac{T(j\omega)}{R_F \parallel R_G} [V/V] \quad (8)$$

$$\beta = \frac{R_G}{R_F + R_G} \quad (9)$$

As expected, since the feedback network is identical,  $\beta$  for the CFA is the same. However, the open loop gain is completely different. Remarkable, it is no longer depending only on the base amplifier transconductance gain  $T(j\omega)$  but also on the feedback network! The closed loop input impedance results, after the same identification process

$$Z_i = R_0 + \beta (Z(j\omega) + R_F) \quad (10)$$

$$Z_i = R_0 + (1 + \beta A) R_F \parallel R_G \stackrel{\Delta}{=} R_0 + Z (1 + \beta A) \quad (11)$$

where  $A$  and  $\beta$  are defined in (8) and (9)