

Reconciling VFAs and CFAs

1. Introduction

There is much literature around CFAs and their magic properties. While nobody would want to deny these properties (namely the small signal bandwidth invariance to the closed loop gain, and the large signal slew rate (as a result of the "current on demand" behaviour) what is sometimes under debate is the entire "current feedback" concept. Black defined "current feedback" as output amplifier current sampling, while the literature since the introduction of the integrated version of the CFA (1982, Canlineau) is centered around current injection in the inverting node, which allegedly controls the CFA closed loop behaviour.

Based on their special properties, a large gap was drawn between CFAs and VFAs (such as standard op amps). While from an application perspective this gap is totally justified, the two types of amplifiers addressing different segments (speed and bandwidth invariance vs. precision and low noise) from a theoretical perspective the gap is still deep and led to a significant division among engineers and even academics. The application notes and data sheets all use an analysis methodology based on current running at the CFA inverting input which, according to the proponents of this approach, justifies the "CFA" naming. On the other side, some maintain that CFAs actually don't exist, and "CFA" is just a marketing brand applied to a concept that is 80 years old. Both teams have their own arguments and the debate, occasionally raging, is a good example of a war that cannot be won.

It is in our intention to somehow harmonize these rather extreme views. We will prove, using the standard two-pole formalism for analysing feedback circuits that, in fact, we can describe the

known CFA small signal special properties by analyzing a CFA standard model using the same mathematical description used for the standard VFA model. Following this methodology we will show that the CFA vs. VFA debate is in fact false; the debate is not about "feedback" but about the topology of the base amplifier (before closing the feedback loop). We will show that it is actually the CFA base amplifier circuit topology that delivers the CFA remarkable properties, and not the feedback network or the way feedback is applied.

2. A short VFA two port analysis primer

Since the classic VFA (standard op amp with negative feedback in non inverting and inverting configurations) is described in detail in all EE undergraduate manuals and notes, we won't insist much. We would though like to remind the reader the basic blocks of the VFA, as seen from a two-port analysis formalism.

The VFA base amplifier is modelled as a Voltage Controlled Voltage Source (VCVS) with a frequency dependent gain. For the simplicity we will consider herein the gain as having a single dominant pole, which is very common in integrated circuits.

Let's consider the two port serial input shunt output feedback topology.

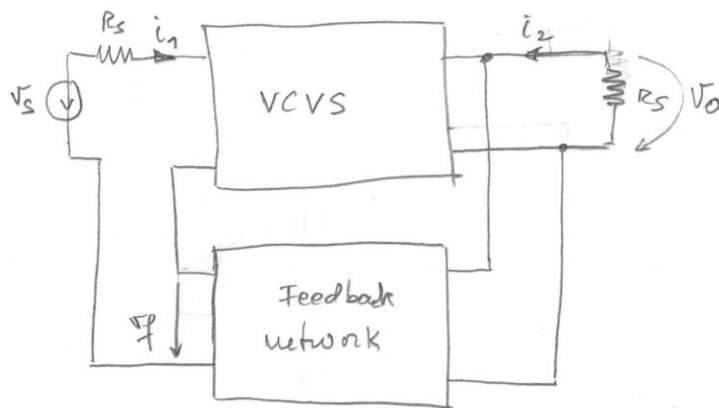


Fig. 1

Since the base amplifier is a VCVS, the pertinent two-pole description is using the hybrid h_{ij} parameters. Using the h_{ij} parameters, the canonical model for the feedback network is:

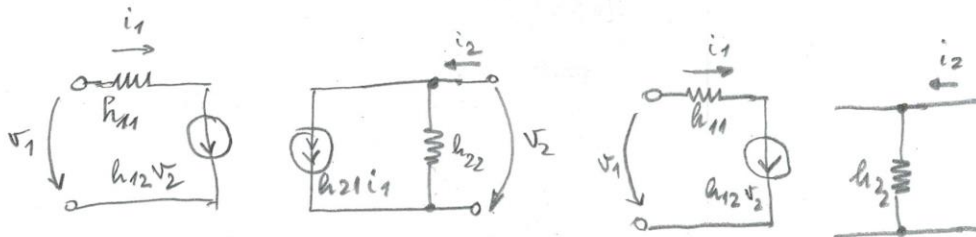


fig 2a

fig 2b

(fig 2b shows the usual simplification), while the base amplifier two port model is:

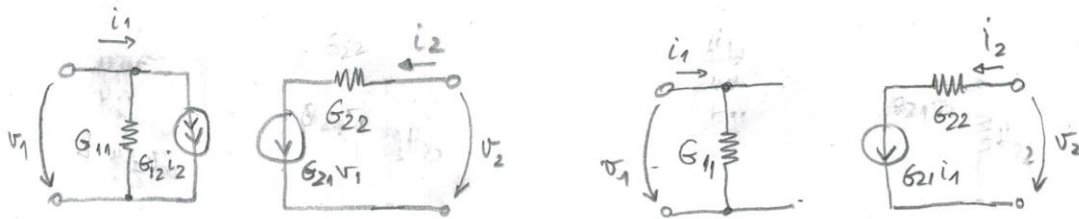


fig 3a

fig 3b.

Once again, fig 3b shows the simplified base amp model. Both fig 2b and fig 3b simplification that assume zero reverse transmission $h_{12} = H_{12} = 0$. $H_{21} = H_{21}(j\omega)$ is the base amplifier gain, and is a voltage gain. Now we have to put together fig 2b and 3b, as in fig 1.

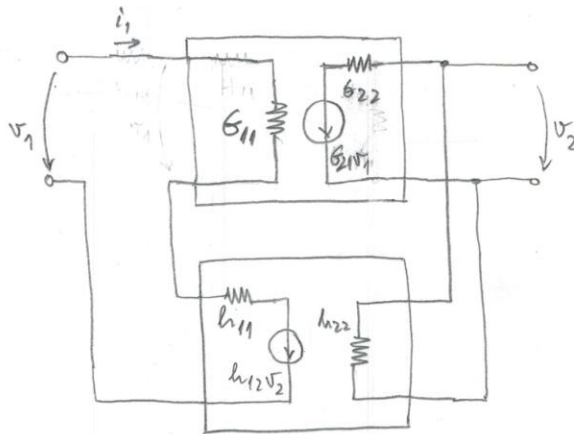


fig 4

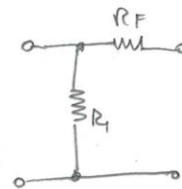


fig 5