Results of further hybrid simulations M.Raymond (7/12/00)

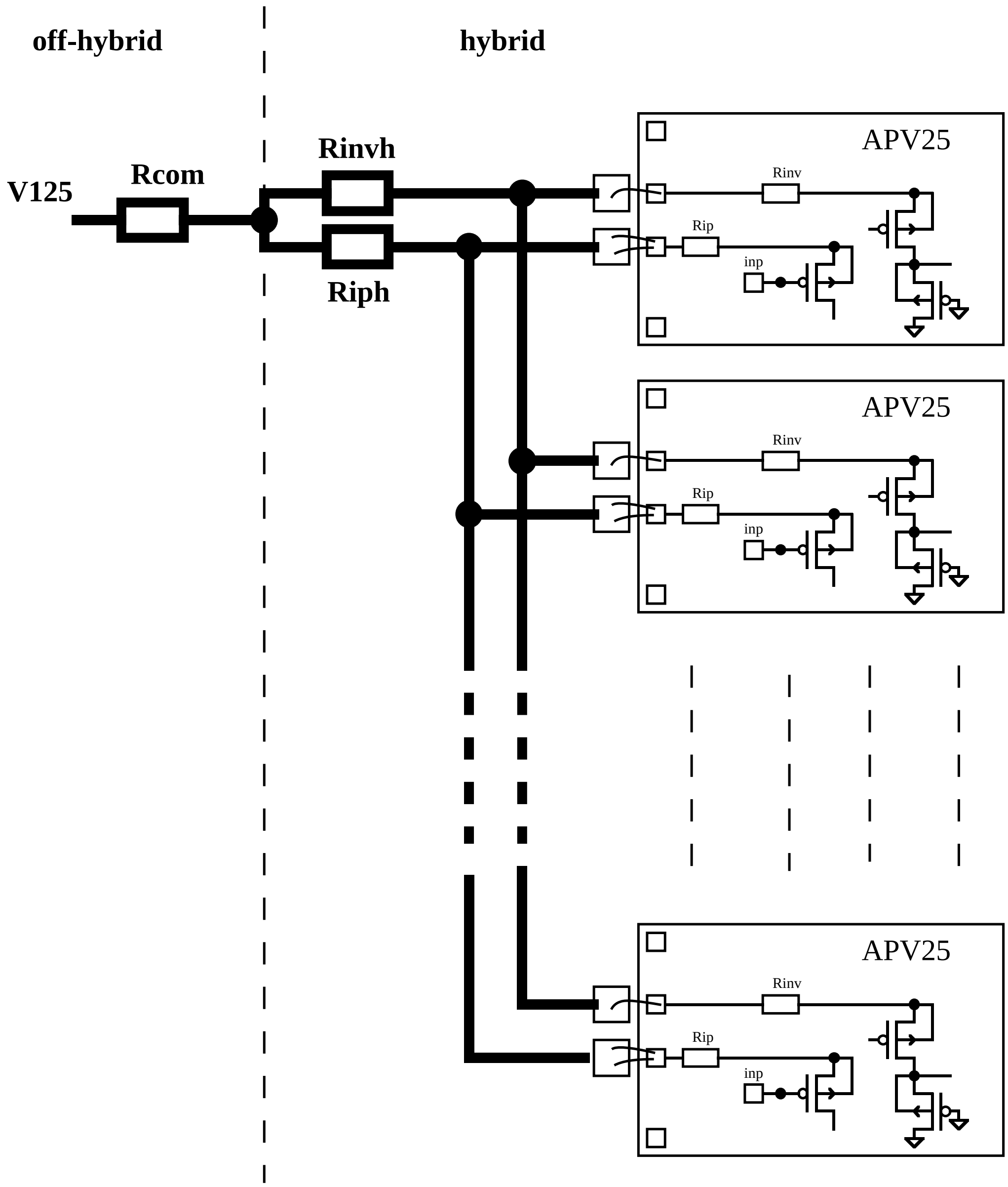
This note follows on from a previous one ("Preliminary results of hybrid simulations" (30/11/00)) where it was suggested that the multi-chip hybrid stability problem could be solved by segmenting (separating) the inverter and input device V125 connections on the hybrid, possibly through the connector as well, bringing them together at a low impedance point. Further simulations have been carried out to determine how low this impedance has to be, so that we can be confident that the APV/hybrid system can be operated reliably with realistic cable impedances. Values for realistic cable impedances have been taken here to be up to several Ω (for a single hybrid), to allow for the fact that many hybrids (up to 16?) may share the same power lines. This is probably pessimistic, since common mode effects which can trigger the instability will probably not be correlated on all hybrids sharing the same power bus (I assume not all will share the same detector bias line for example), and there is likely to be capacitance (either stray or added) in the power distribution system which will reduce impedances.

First idea

Figure 1 shows schematically a possible segmented V125 scenario. The resistors **Rinvh** and **Riph** can represent just track resistance or could be added resistors for extra stability. **Rcom** represents common resistance to the low impedance V125 node which could be the power supply itself. It can be seen that the ratio of **Rinvh** to **Rcom** determines the positive feedback fraction via the input devices V125 line. For a fixed value of **Rcom** it is desirable to maximise **Rinvh** to minimise this undesirable feedback, which can be achieved with added resistance. Some increase in "V125" is needed to compensate for voltage drops across the resistor and another resistor (**Riph** = 0.25 x **Rinvh**) has to added to equalise the values of the individual V125 values at the chips.

A scheme such as figure 1 has been simulated and can result in stability for limited values of **Rcom**. A disadvantage is that better stability is achieved for bigger resistor values which give rise to larger "IR" drops and consequently increased power consumption on the hybrid. A better solution has been discovered and will now be proposed.

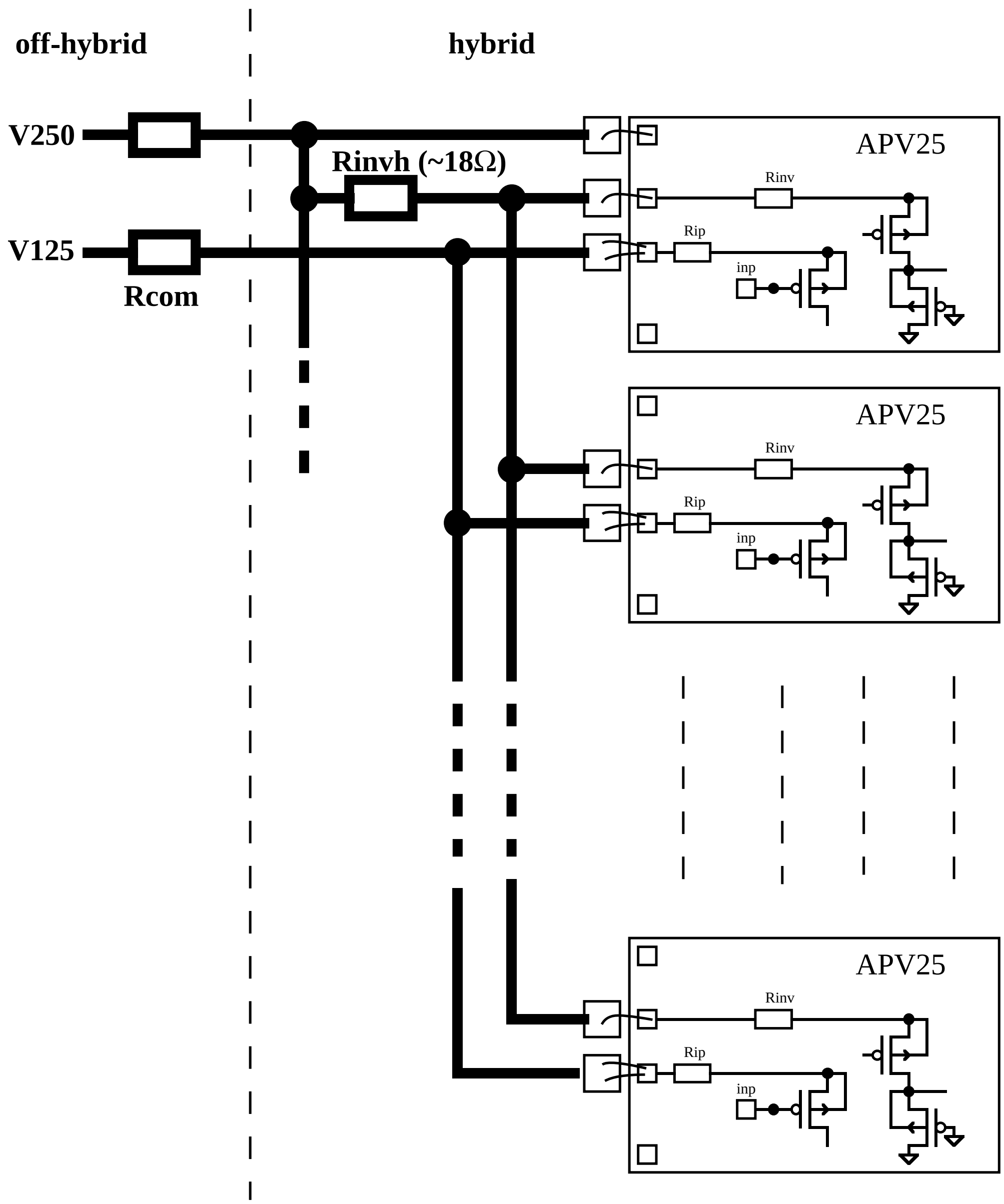
Figure 1. First idea



Second idea - proposed solution

Figure 2 shows a better method of achieving stability on the hybrid. The inverter V125 lines are fed from the V250 supply via an added resistor on the hybrid. The input device V125 lines connect directly to the normal V125 supply to the hybrid. The solution guarantees stability as the feedback loop around the preamplifier is broken by the power supplies themselves. A minor drawback is the power dissipated in the resistor (96 mW total for a 6 chip hybrid) but this seems a small price to pay for such a robust solution. The operating point for the inverter is self adjusting, which means that the external resistor value is not critical but should be about 100Ω/chip to achieve an inverter current of 100μA/channel, i.e. a value of 18Ω for a six chip hybrid. This solution has been simulated with no loss of stability with power line resistances of 10Ω, with no added decoupling capacitance. In addition the solution has been verified in practice (using 100Ω for the "on-hybrid" external resistor) on an APV25s1 single chip test board.

Figure 2. Proposed solution



Third idea - possibly interesting?

Figure 3 shows a schematic which is basically an extension of figure 1, but instead of connecting the junction of **Rinvh** and **Riph** to a separate supply, it is connected directly to V250. This allows the resistor values to be made relatively large (~18Ω and ~4Ω respectively), giving some robustness against power supply resistance. A significant drawback is the increase in power dissipated on the hybrid which would be an extra 0.5W for a 6-chips, corresponding to a 25% increase overall (considering the APV power consumption alone). A significant advantage is that the hybrid power supply is simplified, being now 2 instead of 3 rails, and the currents in the rails are balanced. The tracker power supply and cabling could be significantly simplified.

Conclusions

The proposed solution is that shown in figure 2. There are no simulation results included here, but I think it can be seen that the solution is "stable by design".

The solution shown in figure 3 is not stable for all values of **Rcom** and more work (simulation and experimental) is required here to quantify the stability, and to assess the other possible advantages/disadvantages throughout the system.

Figure 3. Possibly interesting?