D. Langford, et al. "A Bi-CMOS AFE for ADSL"

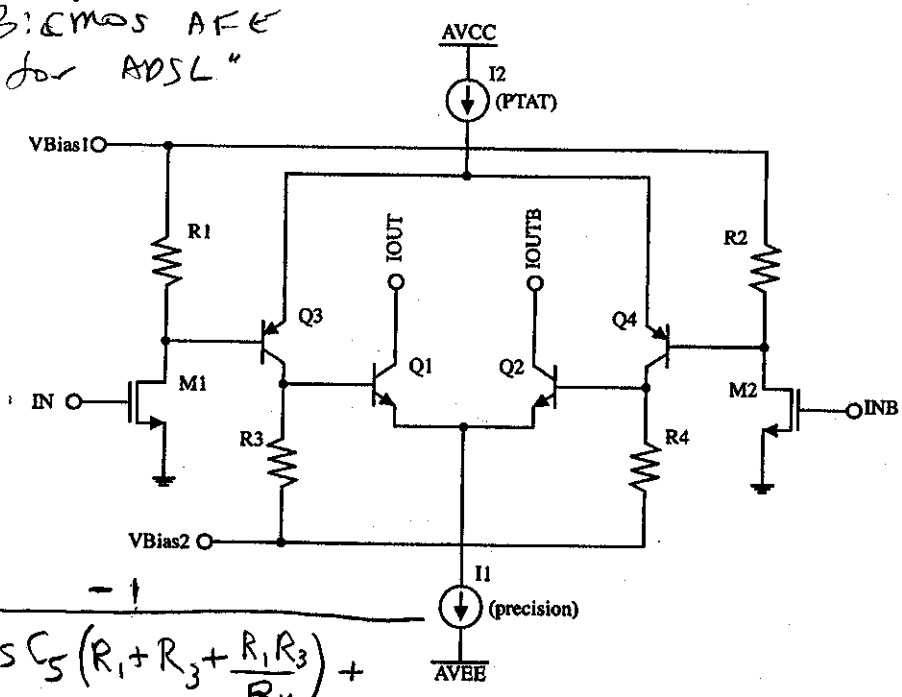

Fig. 9. D/A CMOS/CML level translator.

$$\frac{V_O}{V_I} = -\left[\frac{R_1}{R_4} + sC_5\left(R_1 + R_3 + \frac{R_1 R_3}{R_4}\right) + s^2 R_1 R_3 C_2 C_5\right]$$

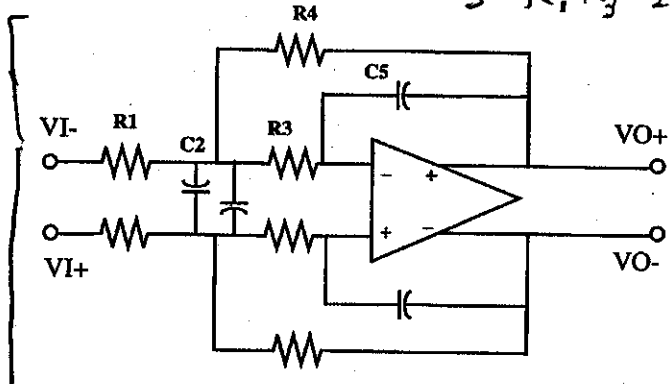

Fig. 10. Rauch biquad.

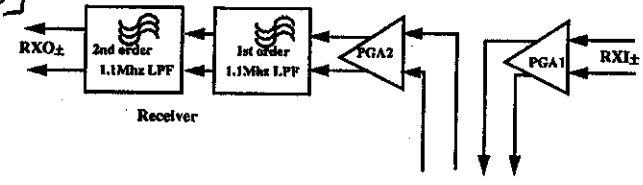

Fig. 11. RX chain.

that the "high" voltage at the base of $Q1$ or $Q2$ is always 1.5 V. This helps to maximize VCE of $Q1, Q2$ and the BJT in precision current source $I1$ over the operating temperature range of the chip. Input devices $M1$ and $M2$ are sized as small as possible to minimize capacitive coupling of the 0–5 and 5–0 V input swings to the bases of $Q3$ and $Q4$ while maintaining a ±0.25 V minimum differential output voltage swing. As in the 100-MHz version, current source $I2$ is proportional to absolute temperature (PTAT) in order to eliminate the temperature dependence of the I_{OUT}/I_{OUTB} ratio, thereby giving the least possible glitch energy over temperature [7]. Finally, the value of resistors $R1$–$R4$ has been chosen to minimize power dissipation while maintaining adequate switching speed for 5-MHz operation.

C. Reconstruction Filters

The current output of the D/A is converted to a voltage by a third-order active R-C Chebyshev filter. This filter acts to reconstruct the sample and held signal of the D/A. The filter cutoff frequency and gain are trimmed by using NiCr links for the resistive sections of the filter network. The third-order filter is constructed of a single-order section and a biquad. This third-order configuration allows independent setting of the gain and frequency response. The second order section is a Rauch biquad, shown in Fig. 10, utilizing only one amplifier with no positive feedback thus minimizing the required gain bandwidth product. The amplifier used for these filter sections is described below. The Rauch topology minimizes the number of opamps in the transmit chain thus lowering the power and reducing the noise and distortion contributors. The first-order section can be reconfigured into a second-order section with a limited number of mask changes to achieve a fourth-order response. The filter cutoff frequency is trimmed to within ±4% of the theoretical value.

D. TX Power Control

The final stage of the TX chain is a programmable attenuator (−12 to 0 dB) that is capable of driving a 220-ohm differential load at 12 $V_{p\text{-}p}$ diff. This attenuator is used to adjust the TX power levels depending on the line length and FCC transmission requirements.

IV. Receive (RX) Chain

The RX path contains programmable gain and attenuation and an anti-aliasing filter. The gain and attenuation are programmed to achieve maximum SNR while meeting the