Decades of successful microelectronics development are based on the known transistor paradigm offering a broad band current gain $\beta$ up to the transit frequency $f_T$

$$\beta = \beta_0/[1 + j(f/f_T)]$$  \hspace{1cm} (1)

For very high frequencies $f >> f_T/\beta_0$, Eq. (1) simplifies to

$$\beta \approx -j(f_T/f)$$  \hspace{1cm} (2)

which shows the phase delay ($\pi/2$) of the output current as well as the amplitude decrease to $\beta = 1$ when operation frequency $f$ reaches $f_T$. In the usual logarithmic plot of gain $\beta$ vs. frequency $f$ one will find a 20 dB gain decay per frequency decade.

Consequently, device engineers worked hard to reduce phase delays and to recover current gains at high $f$. With device dimensions approaching 100 nm and vertical hetero-structures, impressive results in III-V and SiGe/Si were obtained, e.g. 350 GHz $f_T$ for a SiGe-HBT.\(^1\)

But remember early knowledge of networks which states that a specific value ($\pi$) of phase delay between voltage and current (negative differential resistance) is valuable for amplification and oscillation. This large phase delay may be utilized to operate transistors at a resonance frequency (Fig. 1) beyond the transit frequency.\(^2\)

Our first experimental results with a SiGe-HBT as injector and a silicon depletion layer as drift region seem to confirm the concept. The phase delay is composed of the contributions from coherent transport\(^3\) through the depletion region. Possible injection mechanisms for oscillators up to the THz regime will be discussed.

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