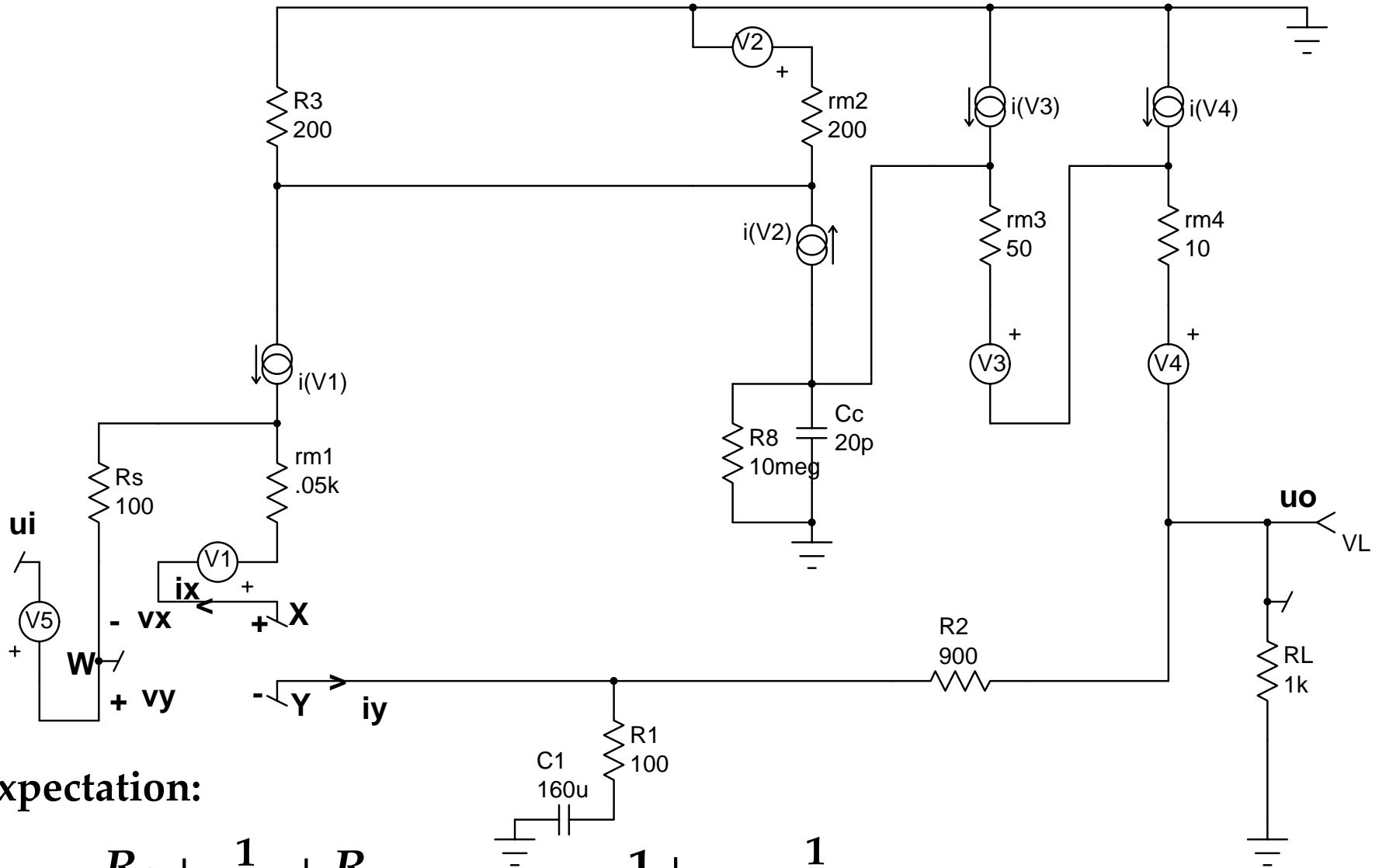


## EXAMPLE

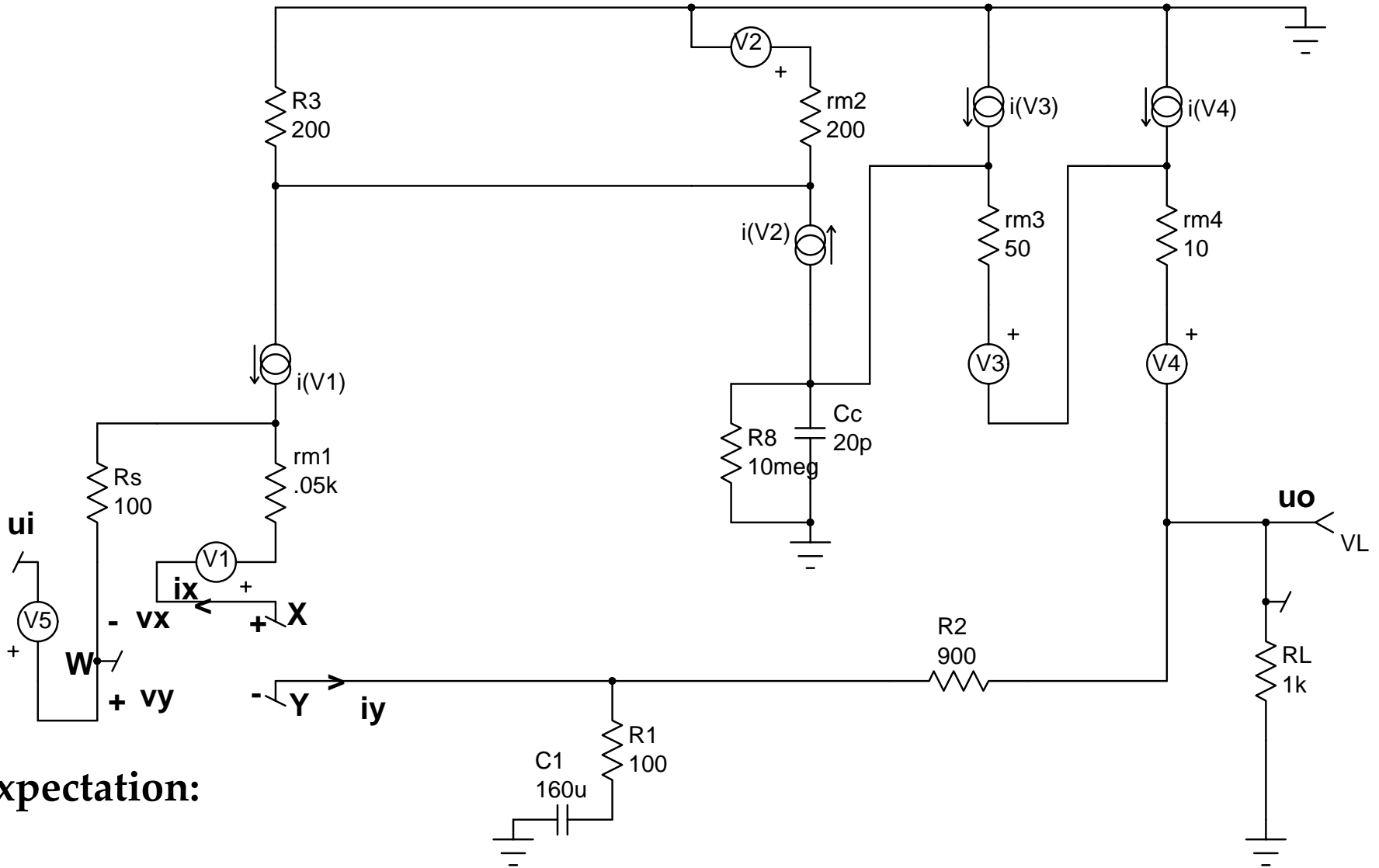
# 15. A REALISTIC IC FEEDBACK AMPLIFIER

# Example 1: Noninverting Amplifier with nonflat $H_\infty$



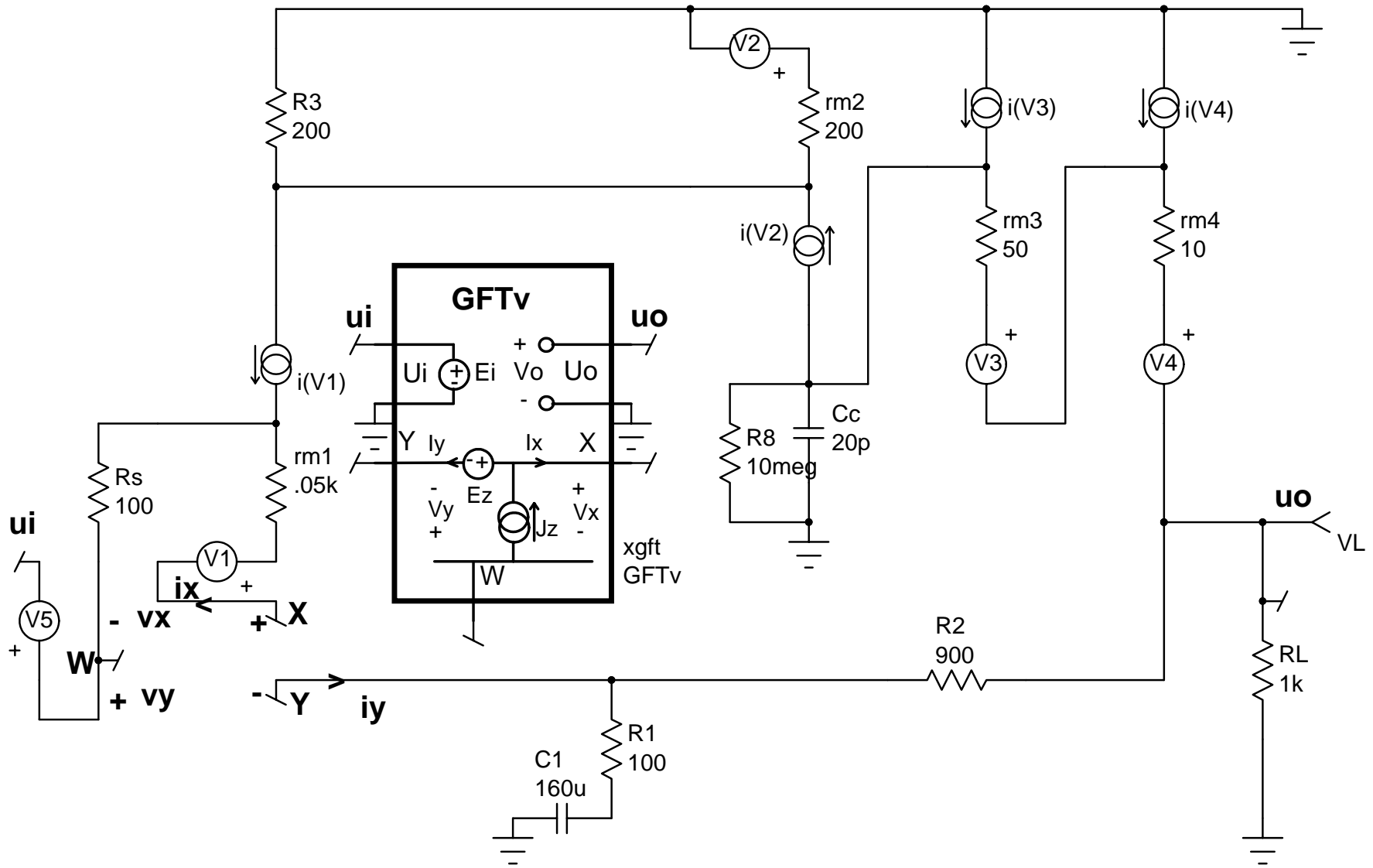
Expectation:

$$H_\infty = \frac{R_1 + \frac{1}{sC_1} + R_2}{R_1 + \frac{1}{sC_1}} = \frac{R_1 + R_2}{R_1} \frac{1 + \frac{1}{sC_1(R_1 + R_2)}}{1 + \frac{1}{sC_1R_1}}$$



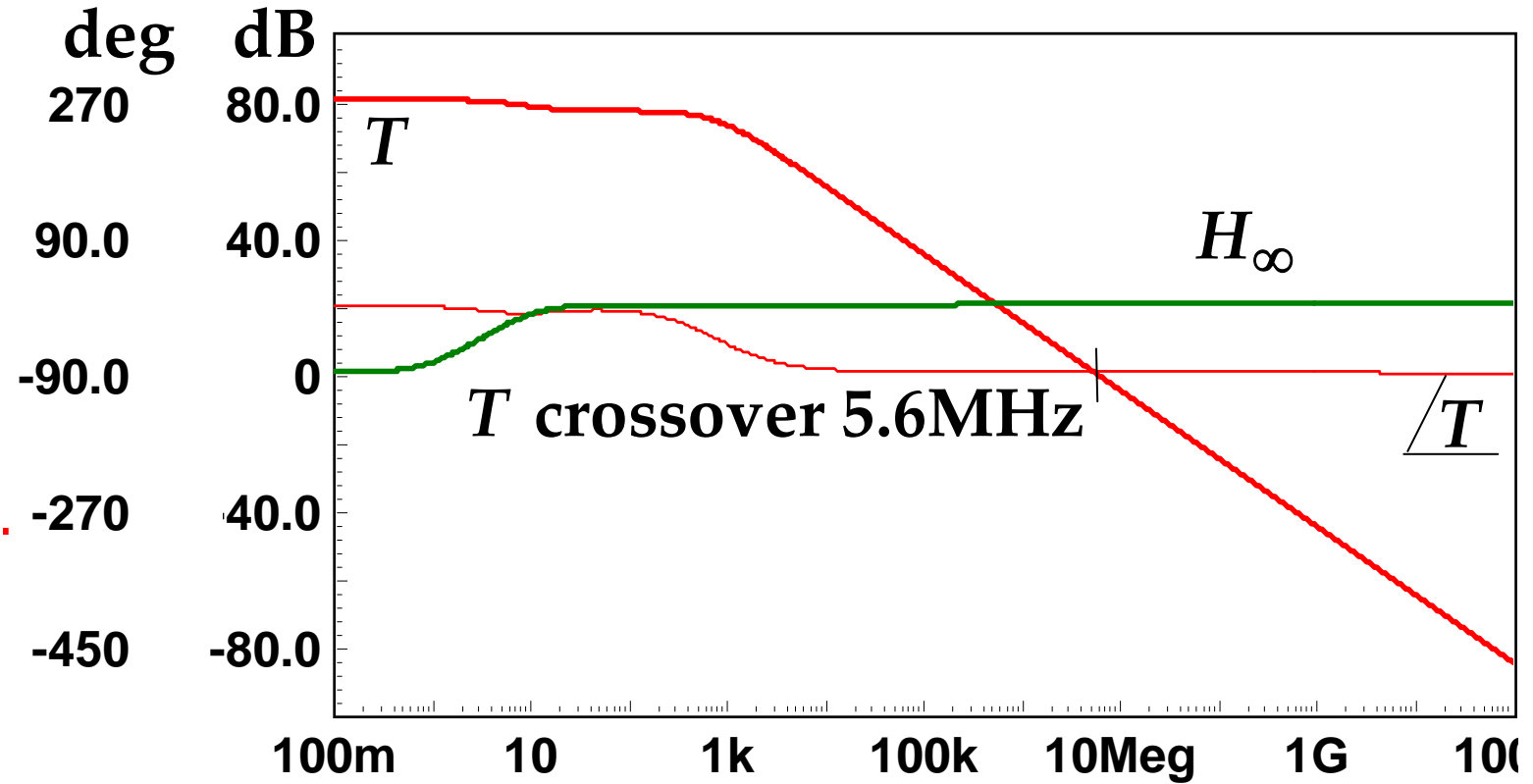
**Expectation:**

**$T$  should be flat at low frequencies, with a small shelf due to  $C_1$ , plus a dominant pole due to  $C_c$ .**

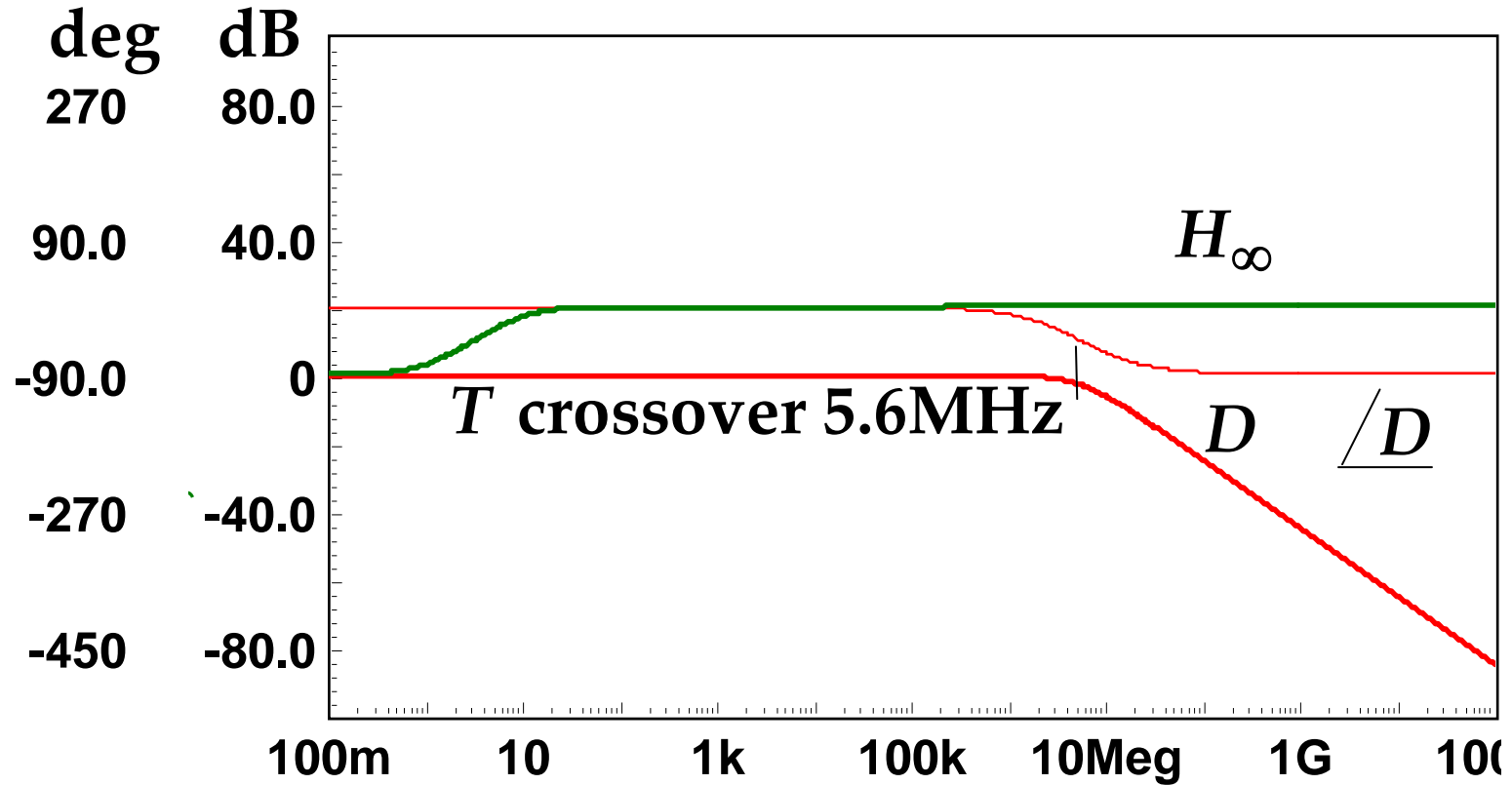


**This Test Signal Injection Configuration meets the two requirements**

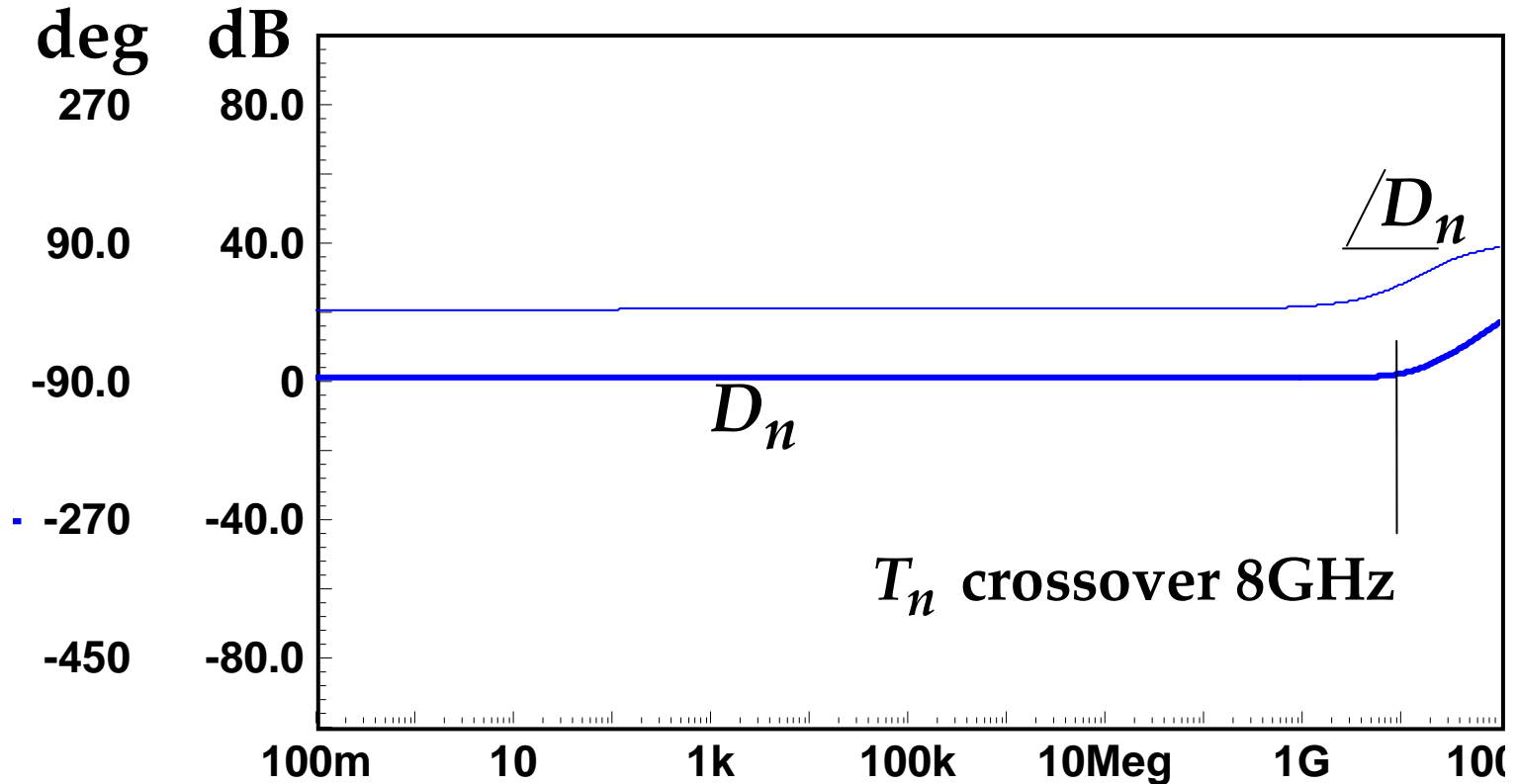
The expectations are borne out:



The discrepancy factor  $D$  should be flat at 0dB at low frequencies, with a dominant pole at the  $T$  crossover frequency, beyond which  $T = D$  :



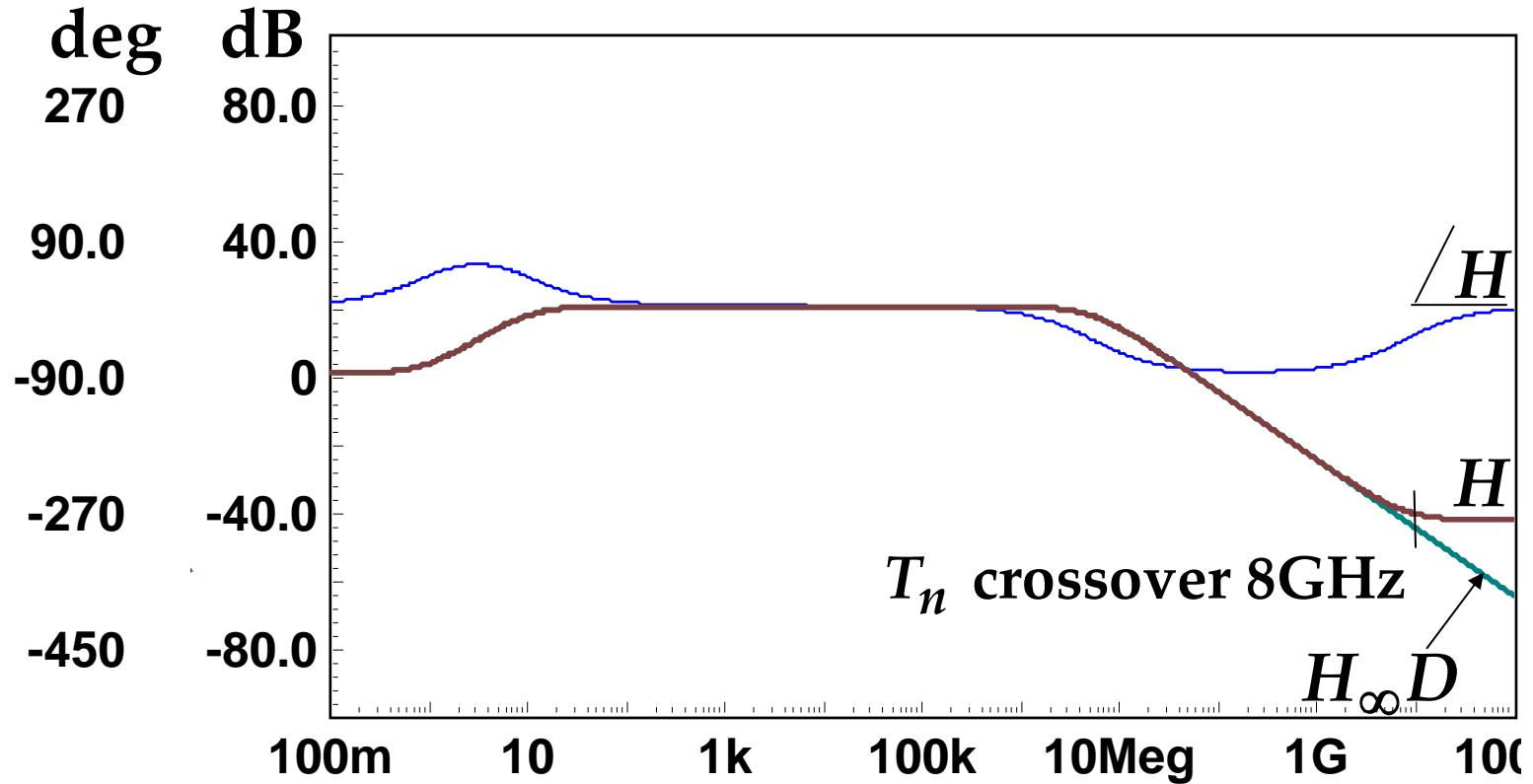
The null discrepancy factor  $D_n$  would be 0dB at all frequencies,



but the nonideality direct forward transmission through the feedback path causes  $D_n$ , above the  $T_n$  crossover frequency, to rise.

## Assembled results:

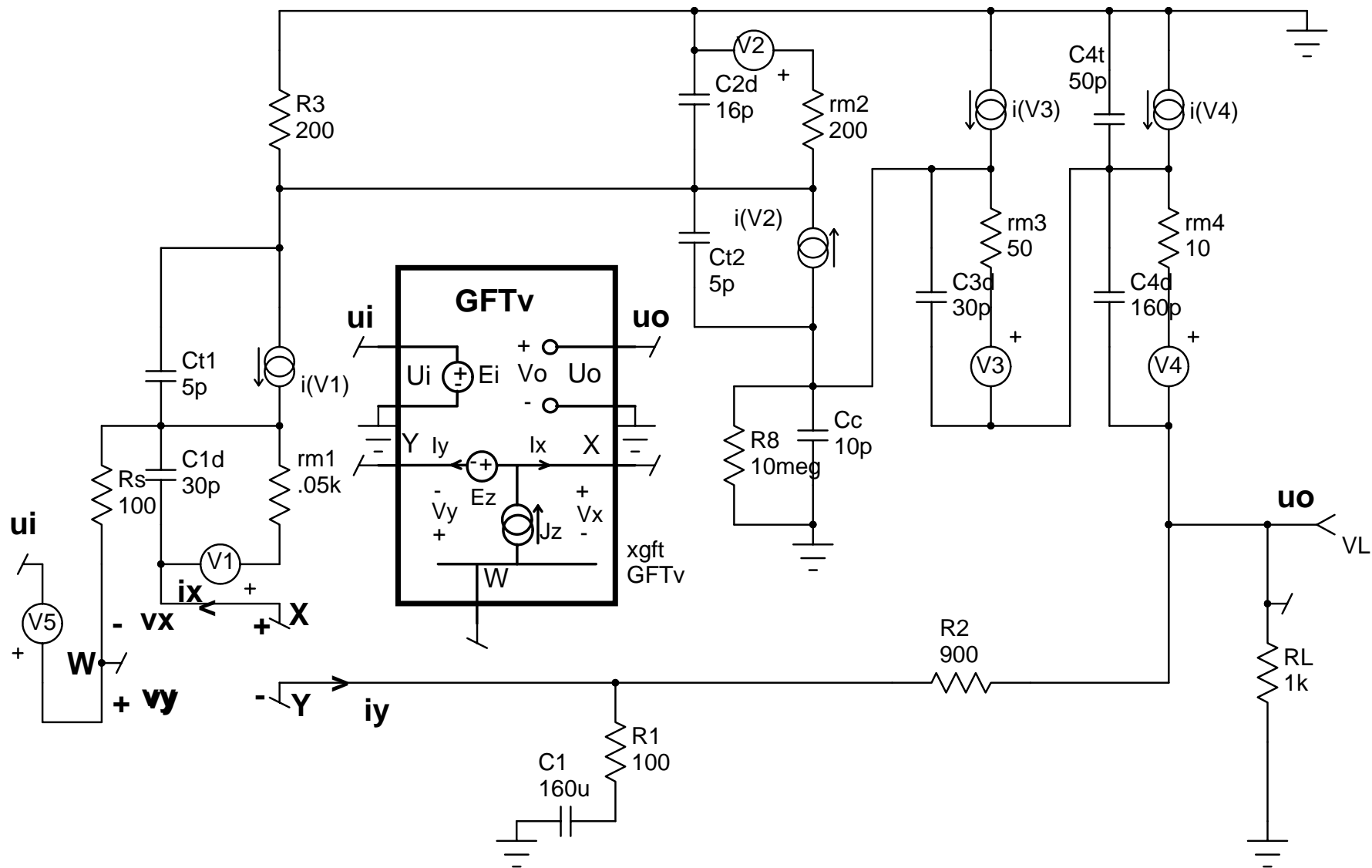
The closed-loop gain  $H$  follows  $H_\infty$  up to  $T$  crossover, then falls with  $D$ . However,  $H$  levels off above  $T_n$  crossover:



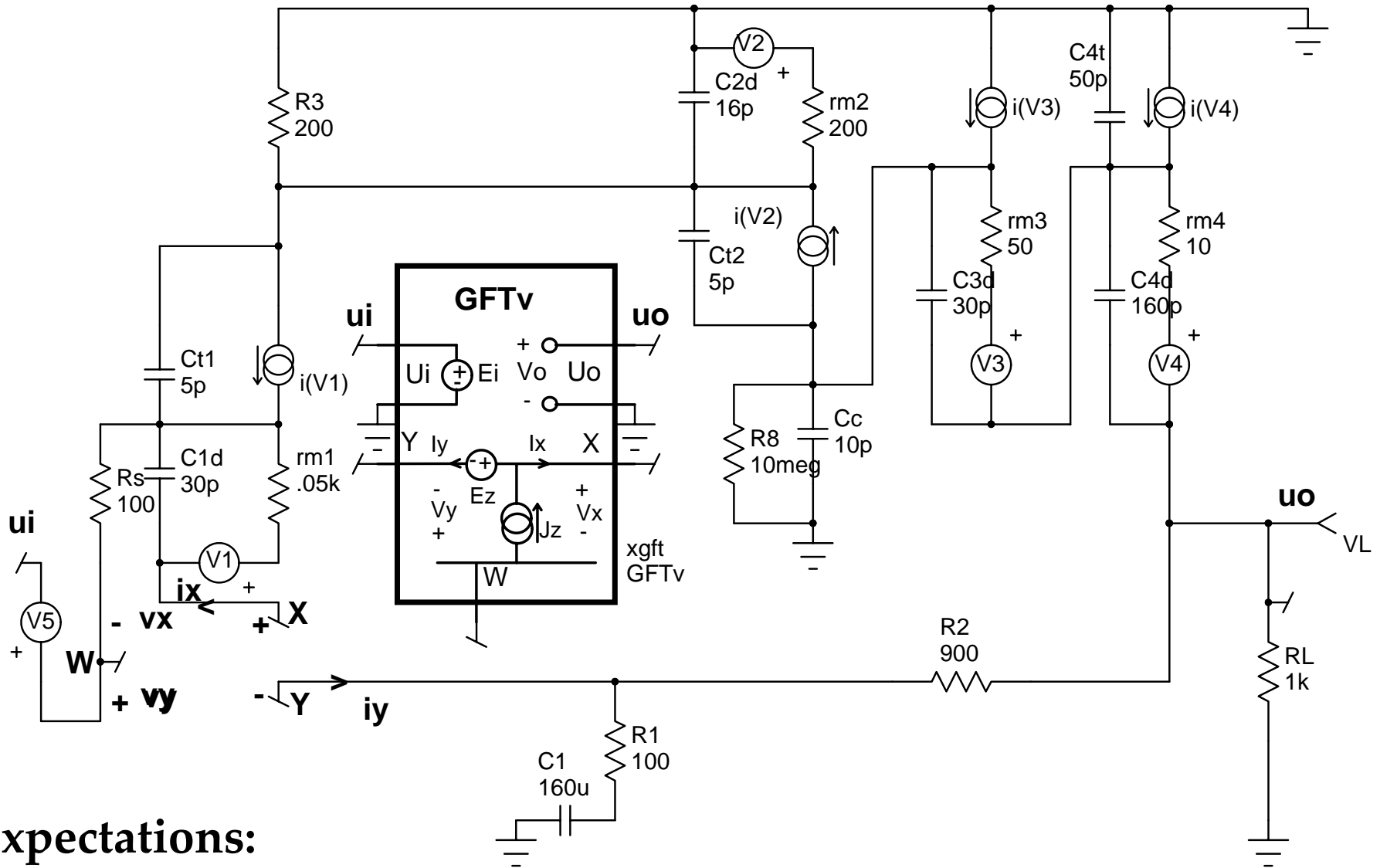
The nonideality is negligible.



# Same basic circuit, but many device capacitances included:

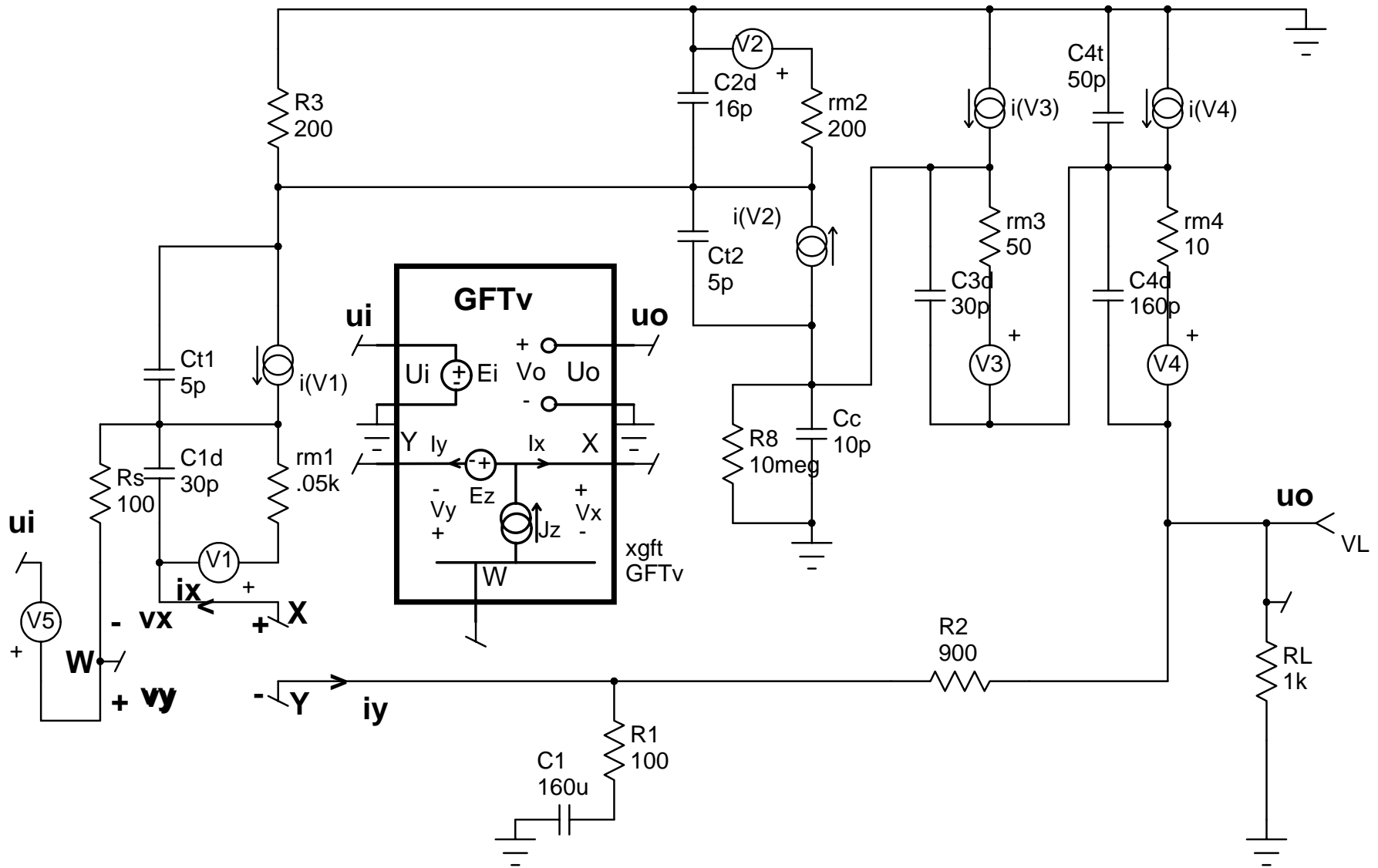


These cause additional nonidealities: reverse transmission in the forward path, and nonzero reverse loop gain.

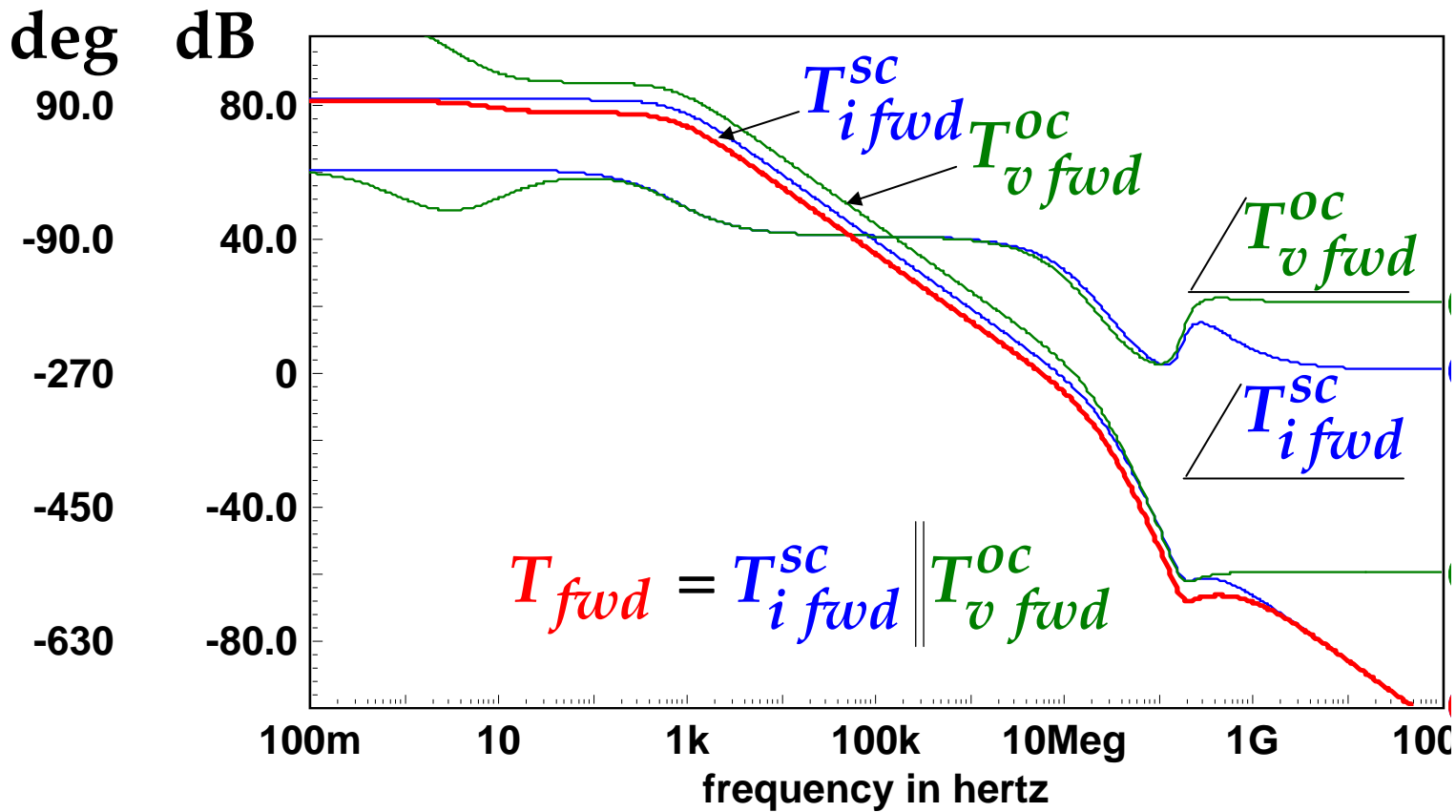


**Expectations:**

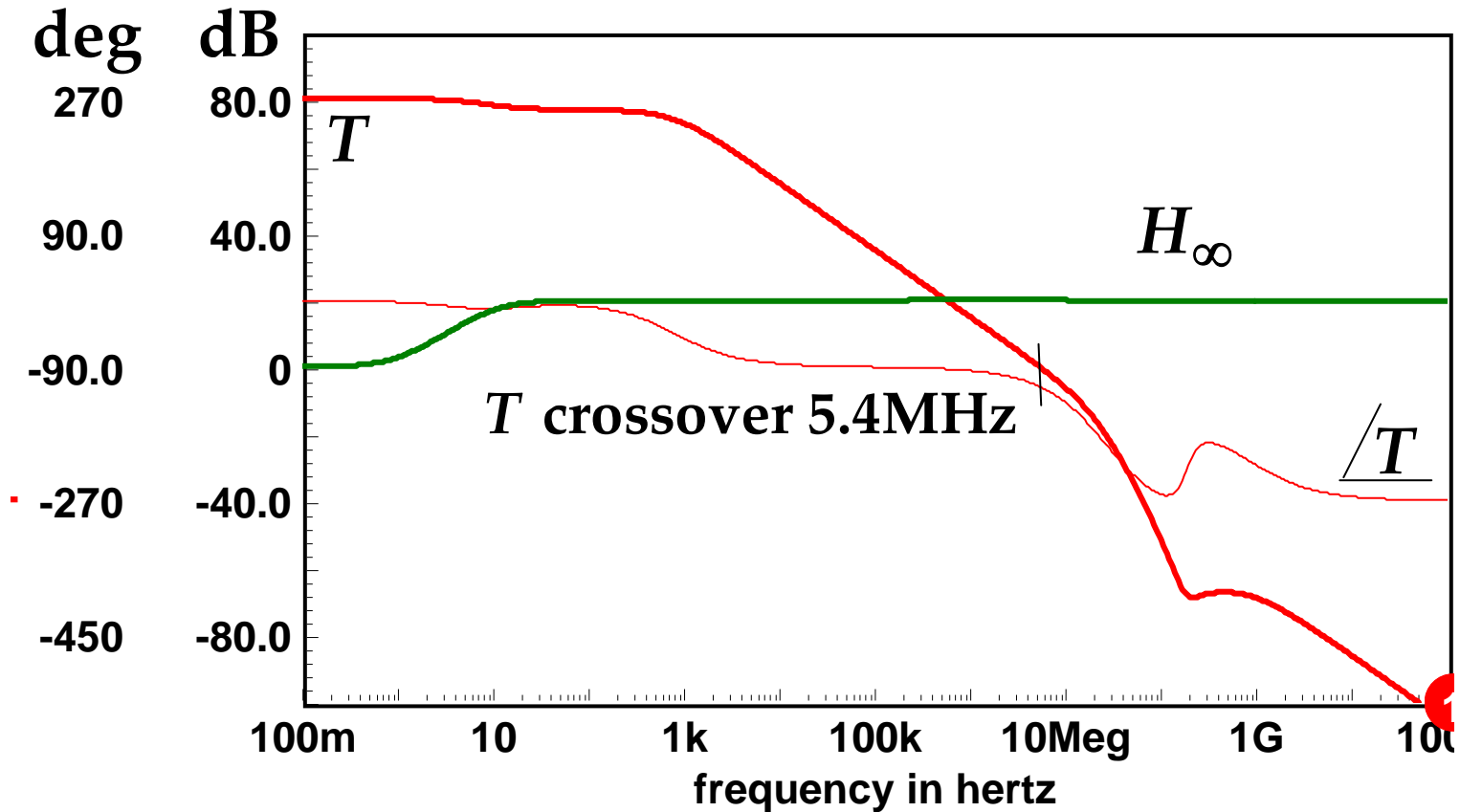
**$T$  crossover is lowered ; high-frequency  $T$  is more complicated;  
 phase margin is lowered**



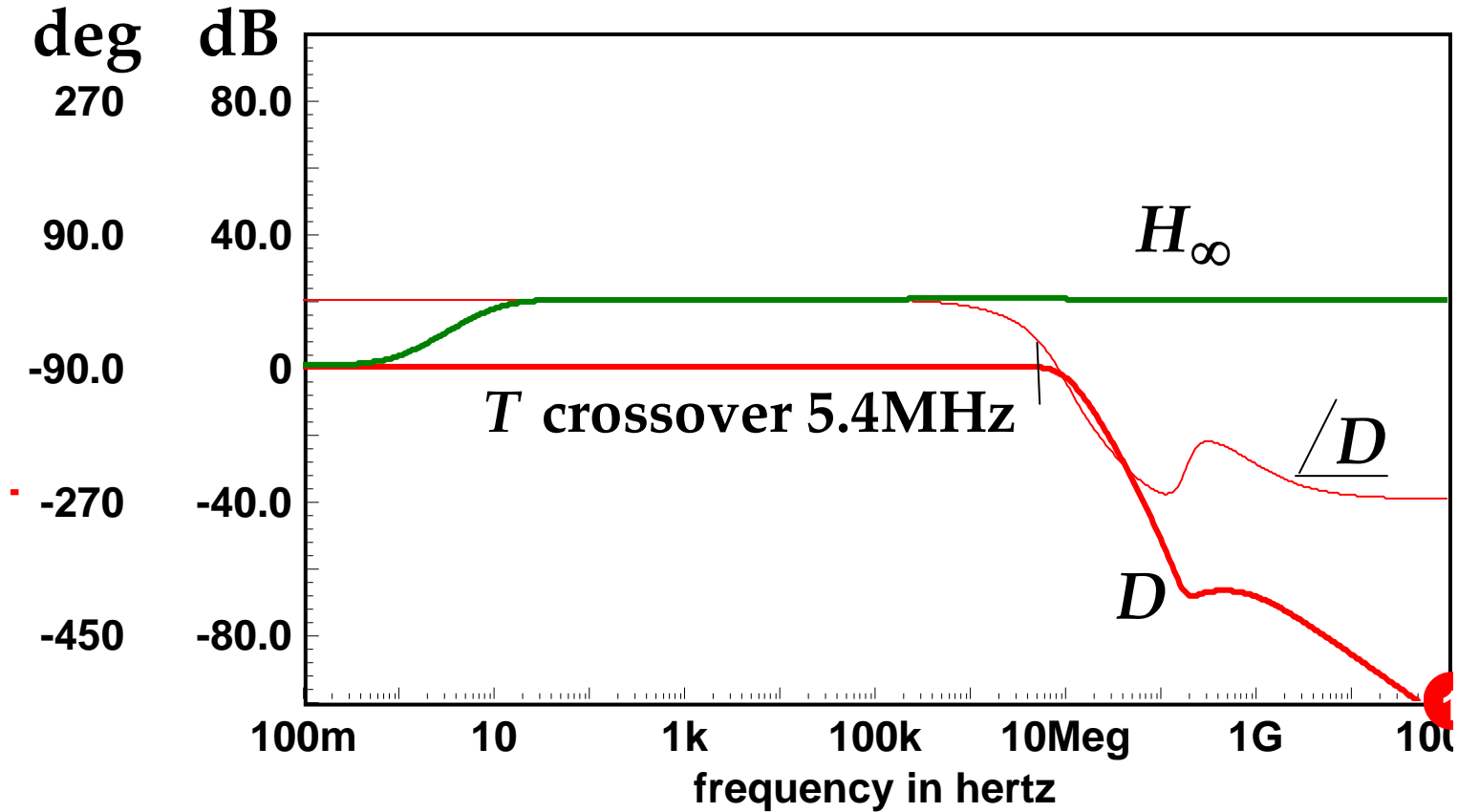
To retain about the same crossover frequency of 5.6MHz,  $C_c$  has been lowered from 20pF to 10pF.



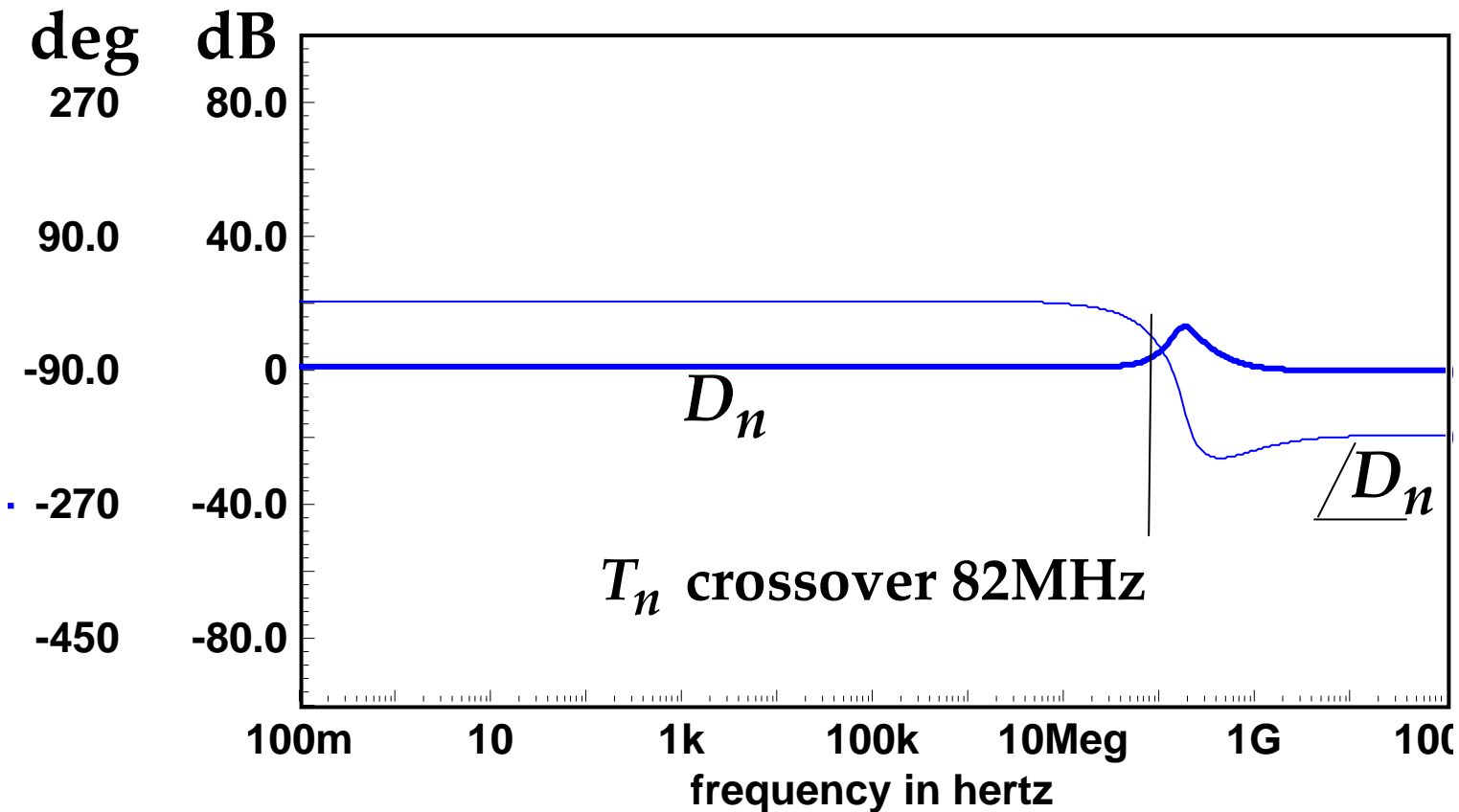
The expectations are borne out:



Beyond  $T$  crossover,  $D = T$  and therefore is also more complicated:

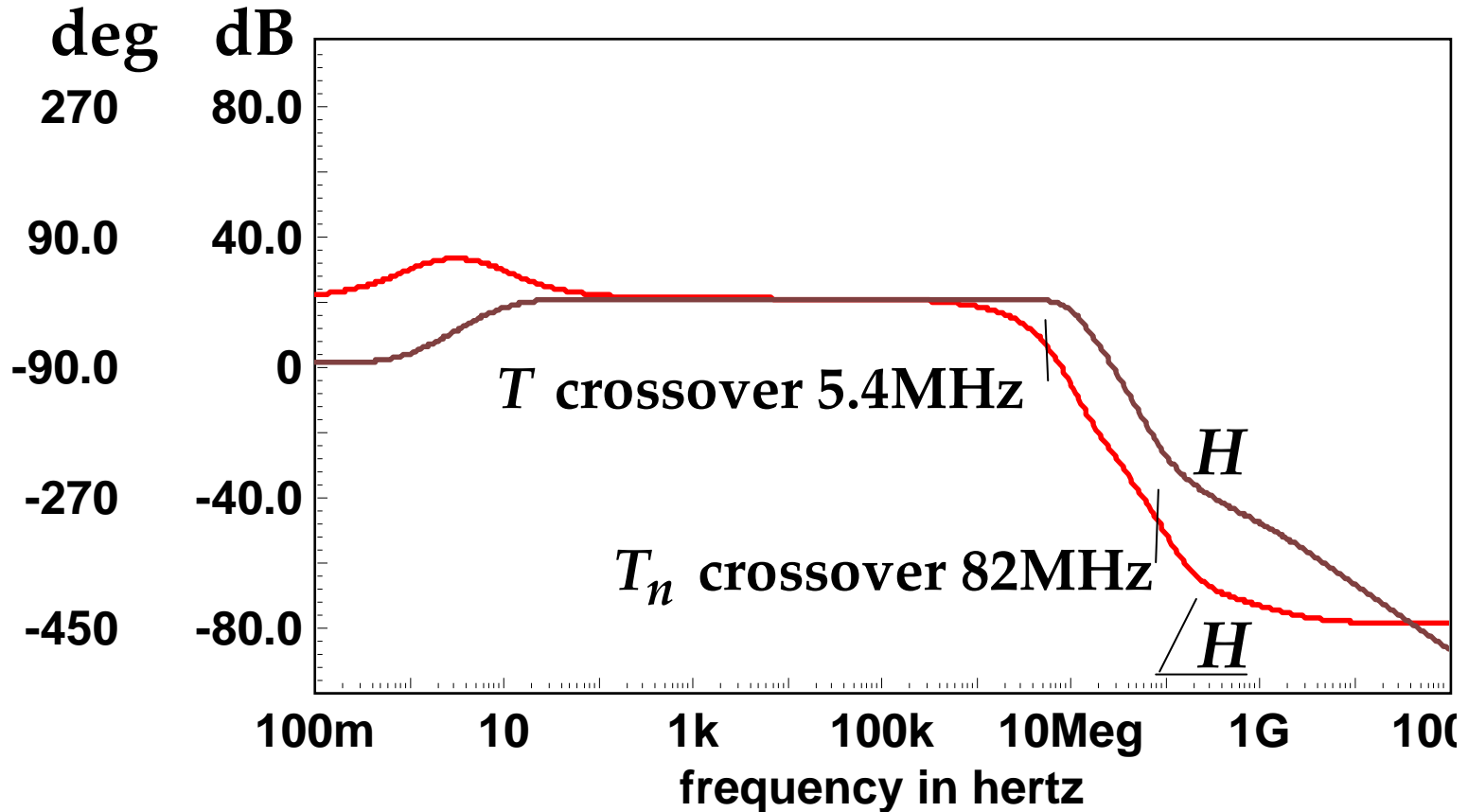


The  $T_n$  crossover is drastically lowered from 16GHz to 82MHz:



Even though  $D_n$  is approximately 0dB at both low and high frequencies, it undergoes a complete phase reversal

The major effect of the additional nonidealities is to cause  $\underline{H}$  to fall off much more rapidly,

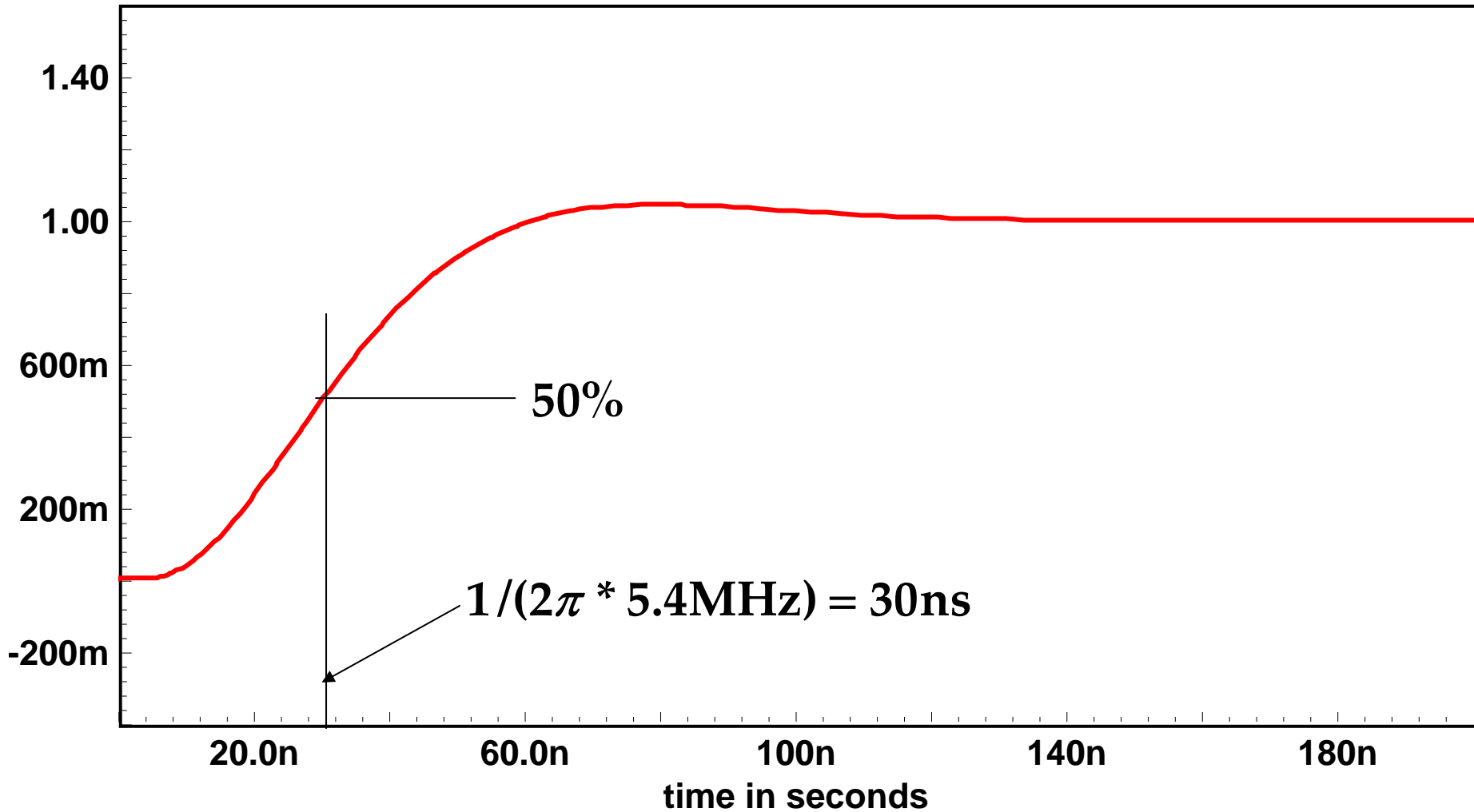


and it is now asymptotic to  $-450^\circ$  instead of to  $0^\circ$ !

The transient response is therefore strongly degraded.



# Step response:



# Add step response with $C_c$ only:

