- The ***simplified circuit*** can be easily identified as the ***three-legged creature***, and using the ***ZVTC technique***:

$$R_C^0 = R' + R'' + G_{m2}R'R'' = 1.27\ G\Omega$$

- Now, to get an estimate of the ***DPF*** f_d, we assume that the ***open-loop gain*** is exactly 100 dB, and the ***first pole*** of the ***uncompensated op-amp*** is ***exactly 1 MHz***

$$\Rightarrow f_d = 10\ \text{Hz}$$

- Also, $f_d = \omega_d/(2\pi)$, with $\omega_d = 1/\tau$, and

$$\tau = R_C^0 C_C$$

- Thus:

$$C_C = \tau / R_C^0 = 12.5 \text{ pF}$$

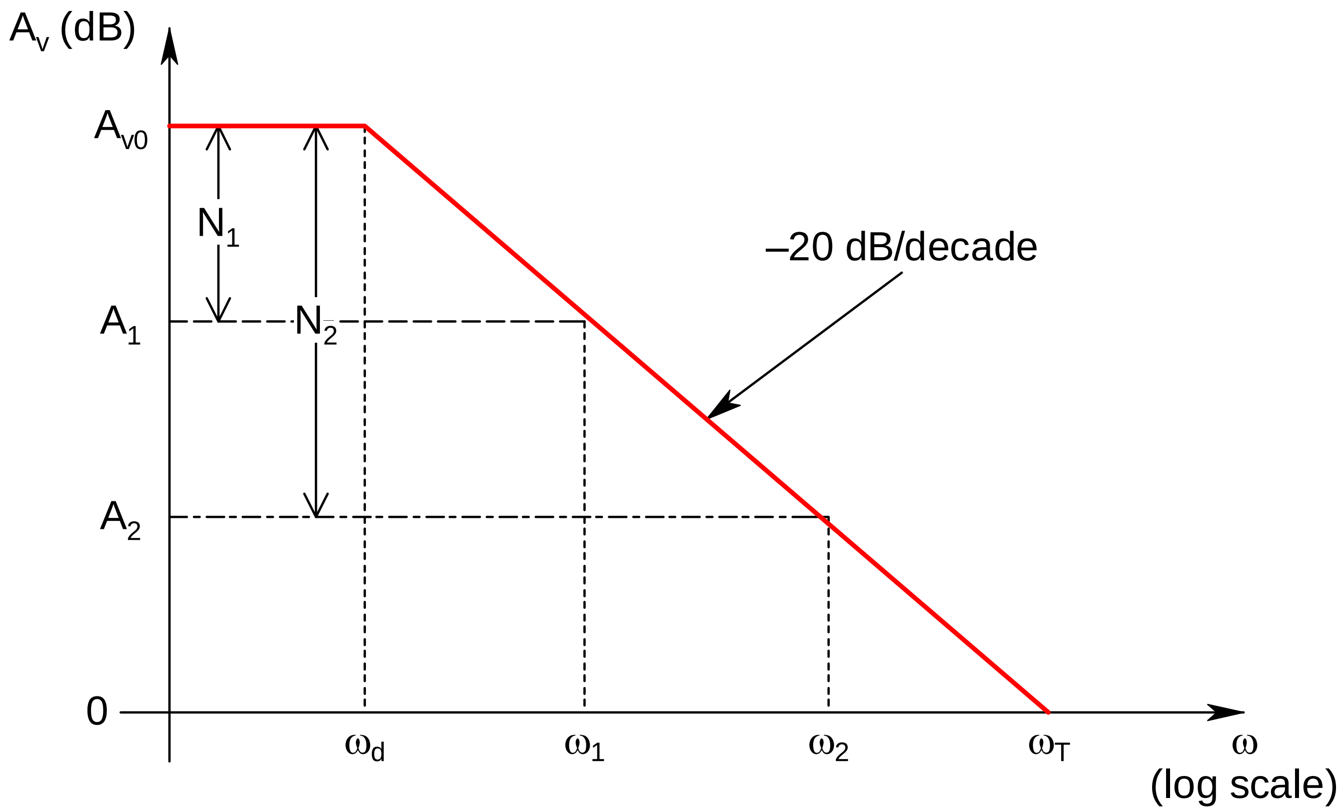
- Note that with this ***compensation scheme***, the ***open-loop bandwidth*** of the ***compensated op-amp*** drops all the way down to ***10 Hz*** from ***1 MHz***

- However, this is not really a ***limitation***, since the ***open-loop gain*** is ***so high***, that even with ***negative feedback***, ***sufficiently high values of gain can be achieved***

➢ ***Unity-Gain Bandwidth (f_T)***:

- ***Product*** of the ***dominant pole frequency*** and the ***open-loop gain***
- This is also the ***bandwidth*** of the system when the ***gain is unity*** (hence the name!)
- Also known as the ***gain-bandwidth product*** (GBP)
- It is ***1 MHz*** for this case
- Note that under ***DPC***, it's also the ***first pole*** of ***uncompensated system***
- With ***negative feedback***, the ***GBP remains constant***

  $\Rightarrow$ ***As gain↓, bandwidth↑, and vice-versa***



A_{v0}: Midband Gain, ω_d: Compensated Bandwidth, ω_T: Unity-Gain Bandwidth

N_1 and ω_1, N_2 and ω_2: Amount of Feedback and Corresponding Bandwidth

A_1, A_2: Gain With Feedback N_1, N_2

$$A_{v0}\omega_d = A_1\omega_1 = A_2\omega_2 = \omega_T$$

- ***Protection Circuits***:
  - Q_{15}-R_6: ***Overload protection circuit*** for Q_{14}
  - Similar to that discussed in the chapter on ***Output Stages***
  - R_6 ***senses*** the ***current*** being ***sourced*** by Q_{14} to ***load***
  - When the ***drop*** across R_6 ***approaches*** V_γ of Q_{15}, it starts to ***bypass*** the ***base current*** of Q_{14}

    $\Rightarrow$ ***The current does not increase indefinitely***
  - ***Protection scheme of Q_{20} is slightly different***

- For the ***previous case*** of Q_{14}, the ***load current*** was ***flowing out*** of the circuit
- However, for Q_{20}, the ***load current*** is ***flowing into*** the circuit
- Thus, the circuit should be ***protected*** by ***limiting*** the amount of this ***current***
- Here, R_7 ***senses*** the ***current*** being ***sunk*** by Q_{20}
- As soon as the ***drop*** across R_7 ***approaches*** V_γ of Q_{21}, it ***turns on*** and starts to ***bypass*** the ***current*** through Q_{20}

- ***Values of R_6 and R_7 are slightly different to account for the difference in V_γ for npn and pnp BJTs***
- Initially, this ***shunted current*** starts to ***flow*** through the ***unnumbered*** 50 kΩ resistor to $-V_{CC}$
- When the ***drop*** across this 50 kΩ resistor ***approaches*** V_γ of Q_{24}, it starts to ***turn on***, which makes Q_{22} to ***turn on*** too (note that Q_{22} and Q_{24} form a ***mirror***)
- Now, the ***collector*** of Q_{22} is ***connected*** to the ***base*** of Q_{16}

- Thus, Q_{16} starts to ***lose*** its ***base drive***, since a ***part of it*** is ***shunted away*** by Q_{22}
- Hence, Q_{16} ***conducts less***, and produces a ***chain reaction***, which ***limits*** the ***current sinking capability*** of the ***output stage***
- Thus, the ***circuit gets protected***
- Now, about the ***role played by Q_{23B}***
- ***Note***: $V_{B16} = V_{E23B}$, and $V_{C17} = V_{B23B}$

  $\Rightarrow V_{EB23B} = V_{B16} - V_{C17}$
- Also, $V_{C17} = V_{B17} + V_{CB17}$

- Noting that $V_{B17} = V_{E16}$:

  $V_{EB23B} = V_{B16} - V_{E16} - V_{CB17} = V_{BE16} - V_{CB17}$
- Under ***normal operating condition***, $V_{BE16} \sim 0.7$ V
- If Q_{17} also is in the ***FA mode***, which is the ***desired mode of operation***, then the ***CB junction*** of Q_{17} will be ***reverse biased***

  $\Rightarrow V_{CB17}$ is ***positive***

  $\Rightarrow V_{EB23B} < V_{BE16}$, and Q_{23B} would ***remain off***
- Now, if ***for any reason whatsoever***, Q_{17} ***moves towards saturation***, then V_{CB17} would ***decrease***