BAND WIDTH AND SLEW RATE CALCULATION

$$\text{BAND WIDTH} = \frac{0.35}{\text{RISE TIME}}$$

$$\text{OUT PUT VOLTAGE} = \frac{\text{VOLTAGE GAIN}}{2} \times \text{I/P VOLTAGE (P-P)}$$

$$\text{\% CHANGE IN OUT PUT VOLTAGE} = (\%2 - \%1) \times \text{O/P VOLTAGE} = \text{RISE IN VOLTAGE}$$

$$\text{SLEW RATE} = \frac{\text{RISE IN VOLTAGE}}{\text{RISE TIME INCREASED TO NEW VALUE}}$$

$$\text{GAIN BANDWIDTH PRODUCT (GBWP)} = \frac{\text{VOLTAGE GAIN}}{2} \times \text{BANDWIDTH}$$

$$\text{RISE TIME DUE TO SLEW RATE} = \frac{(\%2 - \%1) \times \frac{\text{GAIN}}{2} \times V_i}{\text{SLEW RATE}}$$

$$\text{NEW RISE TIME} = \frac{0.35}{\frac{\text{GBWP}}{\text{GAIN}}}$$

Pb

A NON INVERTING AMPLIFIER HAS A VOLTAGE GAIN OF 20

WHEN THE INPUT IS 10mV P-P SQUARE WAVE, THE 10% → 90% RISE TIME WAS 3.5 μs

WHEN THE INPUT WASE INCREASED TO 1V, THE OUTPUT 10% → 90% RISE TIME INCREASED TO 12.8 μs.

CALCULATE

(a) THE SMALL SIGNAL BANDWIDTH

(b) THE SLEW RATE

(c) THE GAIN BANDWIDTH PRODUCT OF THE AMPLIFIER

(d) THE P-P SQUARE WAVE INPUT VOLTAGE WHEN THE 10% → 90% RISE TIME DUE TO SLEW RATE IS EQUAL TO 10% → 90% RISE TIME DUE TO THE BANDWIDTH LIMITATION

(e) THE NEW SMALL SIGNAL RISE TIME IF THE GAIN IS ADJUSTED TO 5.5

(a) $BW = \dfrac{0.35}{\text{RISE TIME}} = \dfrac{0.35}{3.5 \times 10^{-6}} = 100{,}000 = 100\ \text{KHz}$

(b) $\text{SLEW RATE} = \dfrac{\text{RISE IN VOLTAGE}}{\text{RISE TIME INCREASED TO NEW VALUE}} = \dfrac{(\%2 - \%1) \times \text{OUTPUT VOLTAGE}}{12.8\ \mu s}$

$\%2 = 90\%$

$\%1 = 10\%$

, $\text{OUTPUT VOLTAGE} = \dfrac{\text{VOLTAGE GAIN}}{2} \times \text{I/P VOLTAGE (P-P)}$

$= \dfrac{20}{2} \times 10 \times 10^{-3}$

$= 10 \times 10 \times 10^{-3}$

$\Rightarrow = \dfrac{\frac{(90-10)}{100} \times 10 \times 10 \times 10^{-3}}{12.8\ \mu s}$

SLEW RATE = 0.625 V/μs

=

(c) $GBWP = \dfrac{\text{VOLTAGE GAIN}}{2} \times BW$

$= \dfrac{20}{2} \times 100\ \text{kHz}$

$= 10 \times 100\ \text{kHz}$

$= 1000\ \text{kHz} = 1\ \text{MHz}$

(d) RISE TIME DUE TO SLEW RATE $= \dfrac{(\%2 - \%1) \times \frac{\text{GAIN}}{2} \times v_i}{\text{SLEW RATE}}$

$3.5 = \dfrac{\left(\frac{90 - 10}{100}\right) \times \frac{20}{2} \times v_i}{0.625\ \text{V}/\mu\text{s}}$

$\cancel{10^{-6}} \times 3.5 = \dfrac{0.8 \times 10 \times v_i}{0.625} \times \cancel{10^{-6}}$

$v_i = \dfrac{0.625 \times 3.5}{8} = 273\ \text{mV}_{p\text{-}p}$

(c)

$$\text{NEW RISE TIME} = \frac{0.35}{\frac{GBWP}{GAIN}}$$

$$= \frac{0.35}{\frac{1\,MHz}{5.5}}$$

$$= \frac{0.35}{\frac{1 \times 10^6}{5.5}}$$

$$= 1.9\ \mu s$$

SUMMARY

- DUE TO STRAY CAPACITANCE, THE MAGNITUDE OF FREQUENCY RESPONSE IN OPEN LOOP DECREASES WITH FREQUENCY PHASE SHIFT GOES MORE NEGATIVE

- SIGNAL PHASE $\leq -180^\circ$

  AMPLIFIER IS UNSTABLE

  OSCILLATE

- PHASE MARGIN IS ABOVE 45°

  FREQUENCY RESPONSE IS NEARLY FLAT

FOR STABLE AMPLIFIER 3dB IS CUT OFF FREQUENCY

TO STABLIZE NFB (NEGATIVE FEED BACK) AMPLIFIER,

REDUCE THE SIGNAL GAIN

FREQUENCY COMPENSATION IS UTILIZED TO STABILIZE NFB AMPLIFIER

FREQUENCY COMPENSATION
- SINGLE CAPACITOR
- TWO CAPACITORS
- FEED FORWARD

$$\text{GAIN BANDWIDTH PRODUCT} \propto \frac{1}{\text{VALUE OF COMPENSATION CAPACITOR}}$$

$$\text{SLEWRATE} \propto \frac{1}{\text{VALUE OF COMPENSATION CAPACITOR}}$$