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$\eta = k(T_A + T_{es}) = 2 \times 10^{-19}$ Watt/Hz

$f_m = 15$ kHz

$\beta = 5$

IF = 10,7 MHz

a. $\beta = \frac{\Delta f}{f_m} \rightarrow \Delta f = \beta . f_m = 5 . 15$ kHz $= 75$ kHz

$f_c = 100$ MHz

$f_{e1} = f_c - \Delta f = 100$ MHz $- 75$ kHz $= 99,925$ MHz

$f_{e2} = f_c + \Delta f = 100$ MHz $+ 75$ kHz $= 100,075$ MHz

IF $= f_{o1} - f_{e1}$

10,7 MHz $= f_{o1} - 99,925$ MHz

$f_{o1} = 110,625$ MHz

IF $= f_{o2} - f_{e2}$

10,7 MHz $= f_{o2} - 100,075$ MHz

$f_{o2} = 110,775$ MHz

b. $BW_{IF} = 2(\Delta f + f_m) = 2(75$ kHz $+ 15$ kHz$) = 180$ kHz

c. $\frac{S_o}{N_o} = 17$ dB $\rightarrow \frac{S_{in}}{\eta . BW_{IF}} = 50$

$S_{in} = 50 . 2 \times 10^{-19} . 180 \times 10^{3}$

$S_{in} = 1,8 \times 10^{-12}$ Watt $= 1,8 \times 10^{-9}$ mW

$S_{in} = 10 . \log (1,8 \times 10^{-9})$

$S_{in} = -87,45$ dBm

d. $\left(\frac{S}{N}\right)_o = 3\beta^3\left(\frac{S}{N}\right)_i$

$\left(\frac{S}{N}\right)_o = 3 \cdot 5^3 \cdot 17\ dB$

$\left(\frac{S}{N}\right)_o = 3 \cdot 75 \cdot 50$

$\left(\frac{S}{N}\right)_o = 11250$

$\left(\frac{S}{N}\right)_o = 40{,}51\ dB$