High Frequency Electronics, 2018, Heikki Valmu

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The synthesizer at page 8 of the document HFele amps synths.pptx. :

1. Calculate the output frequency of the synthesizer if the reference frequency is 10 MHz, the multiplier of the frequency multiplier (M) is 10 and the prescaler values are: N_6=10, N_5=2, N_4=3, N_3=10, N_2=2, N_1=10.

   The prescaler values are digitally controlled. If you want to decrease the frequency by 1 MHz by changing one of the values, which prescaler value you have to increase or decrease by 1? What if you want to increase the value by 500 MHz?

   $$f_O = \left[M\left(\frac{N_6}{N_5}+\frac{N_4}{N_3}\right)+\frac{N_2}{N_1}\right]f_{ref} = \left[10\times\left(\frac{10}{2}+\frac{3}{10}\right)+\frac{2}{10}\right]\times 10^7 = 532MHz$$

   If

   $$f_O = \left[M\left(\frac{N_6}{N_5}+\frac{N_4}{N_3}\right)+\frac{N_2}{N_1}\right]f_{ref} = 531MHz$$

   We should change $N_2 = 1$

   So,

   $$f_O = \left[M\left(\frac{N_6}{N_5}+\frac{N_4}{N_3}\right)+\frac{N_2}{N_1}\right]f_{ref} = \left[10\times\left(\frac{10}{2}+\frac{3}{10}\right)+\frac{1}{10}\right]\times 10^7 = 531MHz$$

   If

   $$f_O = \left[M\left(\frac{N_6}{N_5}+\frac{N_4}{N_3}\right)+\frac{N_2}{N_1}\right]f_{ref} = 32MHz$$

   We should change $N_6 = 20$

   So,

   $$f_O = \left[M\left(\frac{N_6}{N_5}+\frac{N_4}{N_3}\right)+\frac{N_2}{N_1}\right]f_{ref} = \left[10\times\left(\frac{20}{2}+\frac{3}{10}\right)+\frac{1}{10}\right]\times 10^7 = 1.032GHz$$

2. Rename the multiplication factor of the frequency multiplier as M_2 (previously M) and place as well a frequency multiplier with a multiplication factor of M_1 before / below the previous mixer.

   Redraw the circuit.

   Derive an equation for its output frequency (as a function of f_{REF} and the factors N_i and M_i).

   Please find answer in page 2.

$$\frac{f_{ref}}{N_5} = \frac{f_2}{N_6} \rightarrow f_2 = \frac{N_6}{N_5} f_{ref}$$

$$\frac{f_{ref}}{N_3} = \frac{f_1 - M_1 f_2}{N_4} \rightarrow f_1 = \left(\frac{N_4}{N_3} + M_1 \cdot \frac{N_6}{N_5}\right) f_{ref}$$

$$\frac{f_{ref}}{N_1} = \frac{f_O - M_2 f_1}{N_2} \rightarrow f_O = \left(\frac{N_2}{N_1} + M_2 \left(\frac{N_4}{N_3} + M_1 \cdot \frac{N_6}{N_5}\right)\right) f_{ref}$$