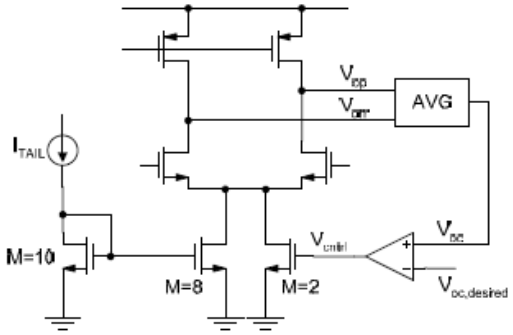
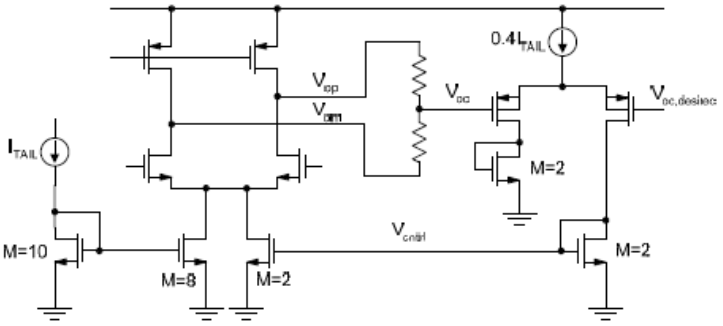
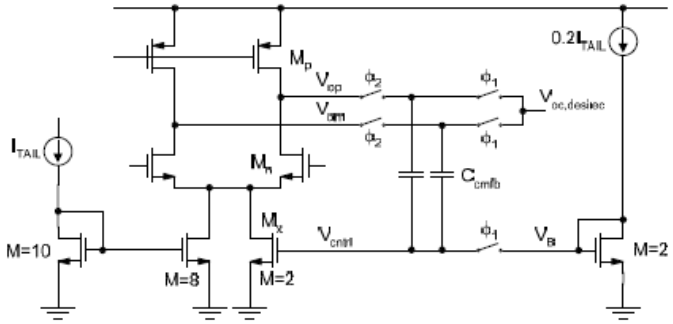
Common – Mode Feedback (CMFB)



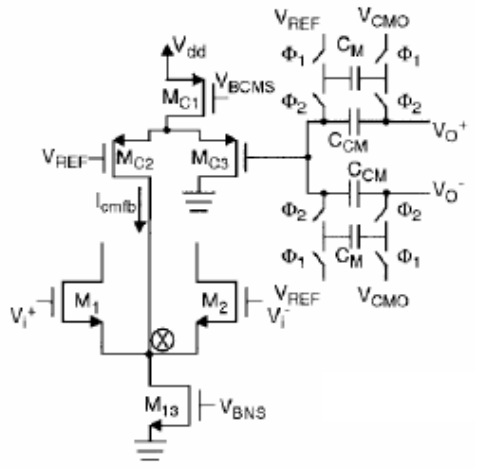
CMFB – principska šema



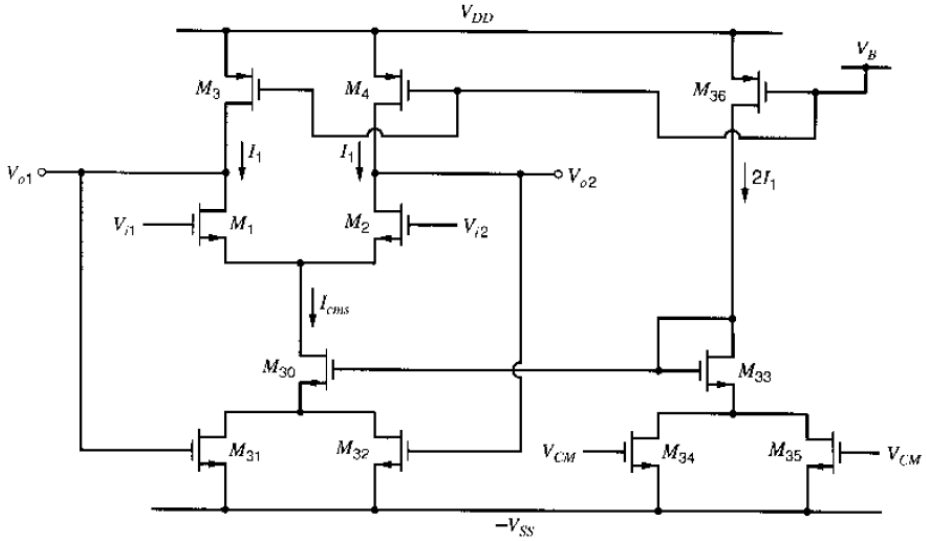
CMFB – realizacija sa otpornim razdelnikom



SC CMFB – 1

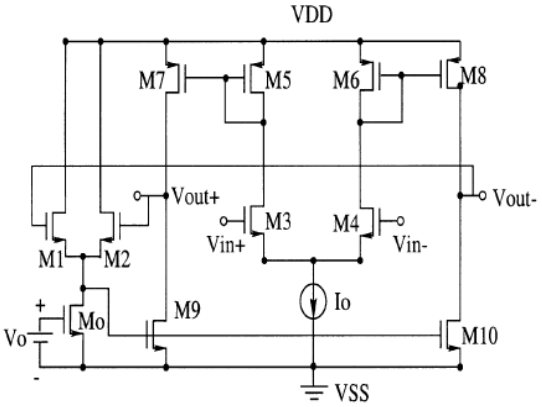


SC CMFB - 2

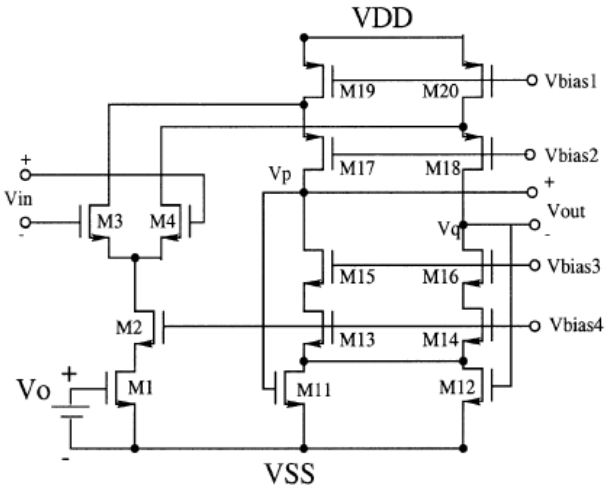


CMFB sa tranzistorima u triodnoj oblasti

$$v_{o1} = v_{o2} = v_{oc},\ i_{D3} = i_{D4} = i_1,\ i_{D36} = 2i_1 \Rightarrow$$
$$i_{D30} = i_{D33},\ (W/L)_{30-35} = W/L,\ v_{GS31} = v_{GS32} = v_{oc} \Rightarrow$$
$$v_{oc} = v_{CM}$$



Fully differential OTA sa CMFB realizovanim pomoću diferencijalnog para tranzistora (M1,M2)

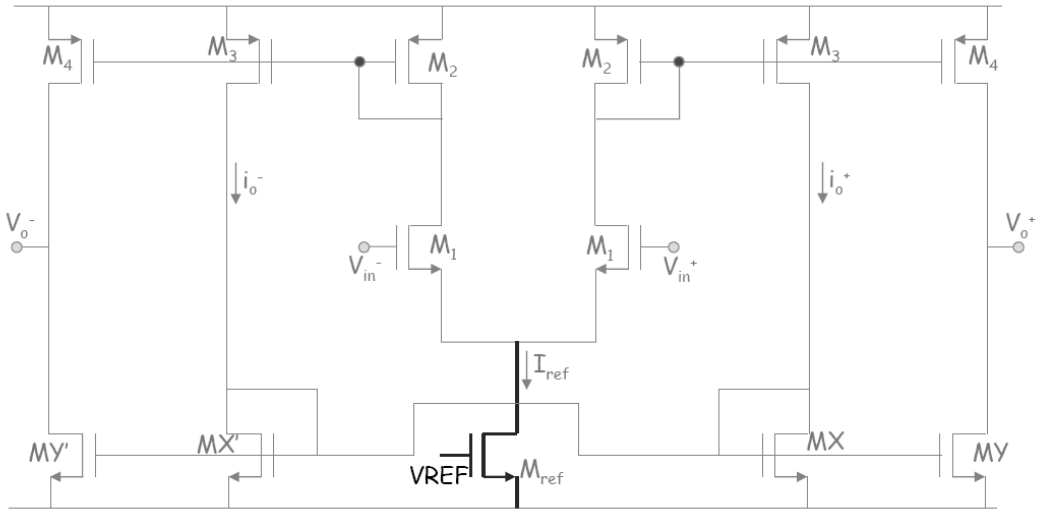


Fully differential folded cascode OTA sa CMFB sa tranzistorima u triodnoj oblasti

$$I_{D19,20} = 2I_{D3,4}\,,\ (W/L)_1 = 2(W/L)_{11,12} \ \Rightarrow$$

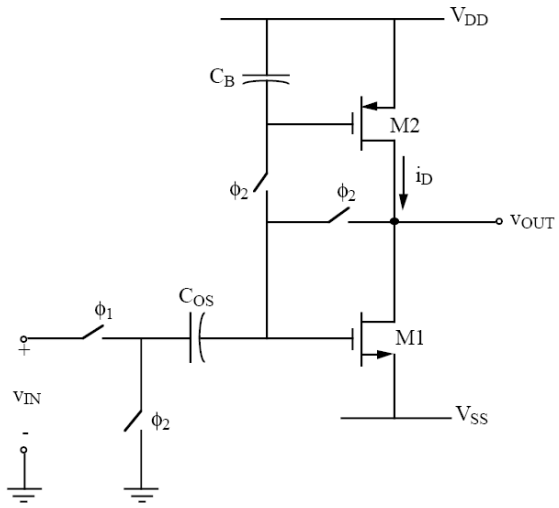
$$i_{D11} + i_{D12} = i_{D3} + i_{D4} = i_{D1} \ \Rightarrow\ v_{oc} = V_{SS} + V_0\,,\ v_{oc} = \frac{v_P + v_Q}{2}\,,$$

$$i_{D11} + i_{D12} \neq f\left(v_P - v_Q\right).$$

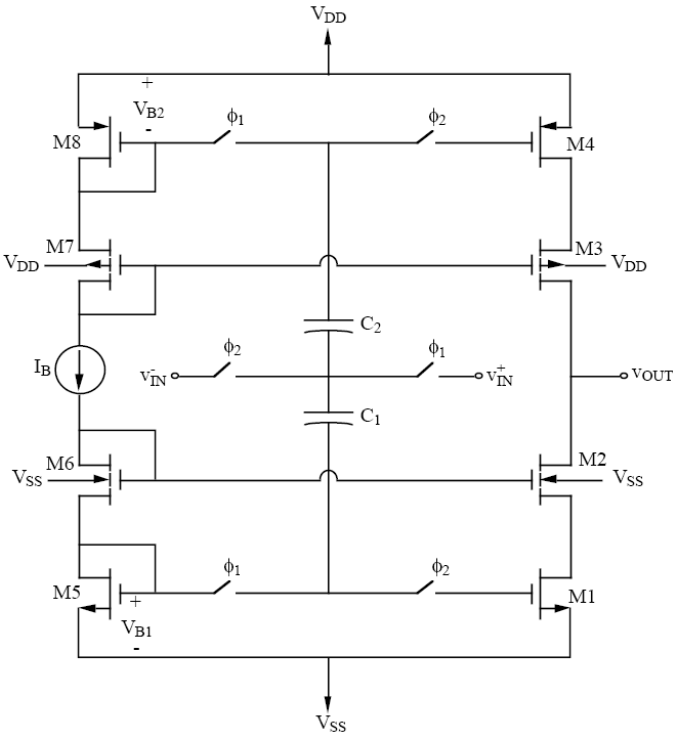


Fully differential OTA sa Common - mode Feedforward (current-mode)

Dinamička polarizacija CMOS pojačavača

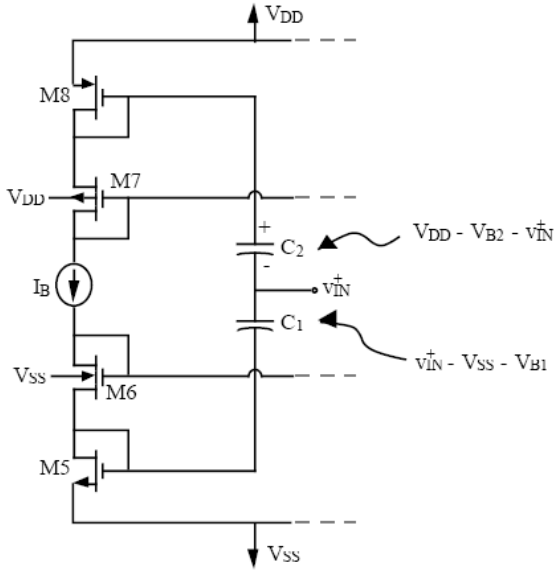


Dinamička polarizacija CMOS invertora



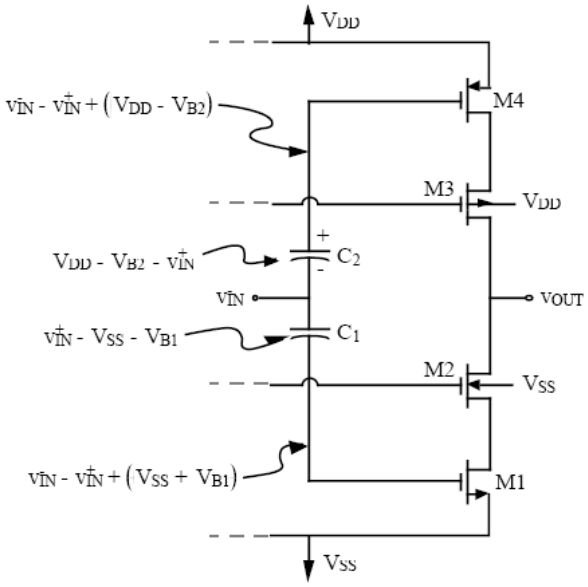
Dinamička polarizacija Push – pull Cascode Op Amp-a

Phase 1 Clock Period

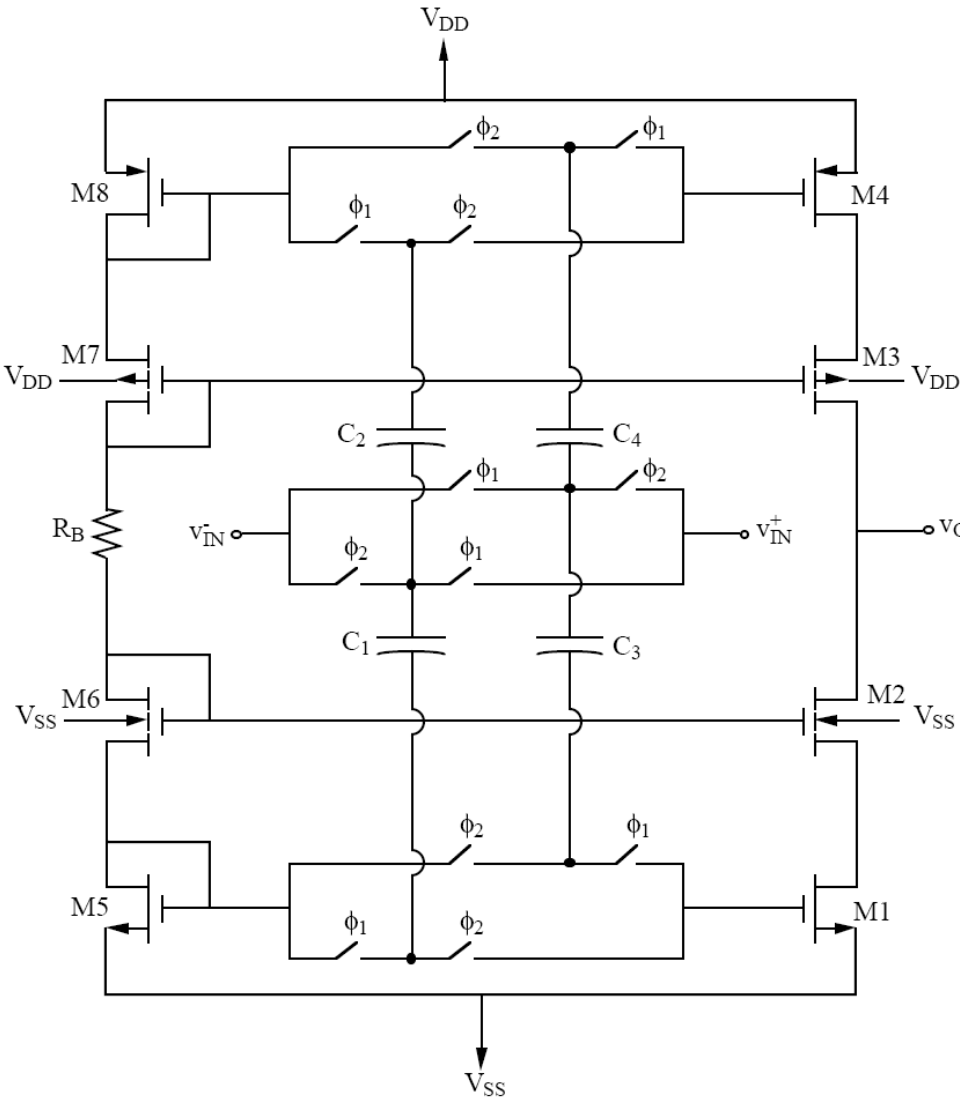


Dinamička polarizacija Push – pull Cascode Op Amp-a

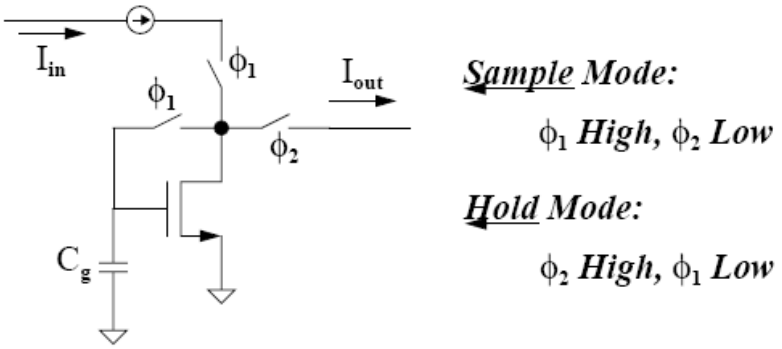
Phase 2 Clock Period



Dinamička polarizacija Push – pull Cascode Op Amp-a

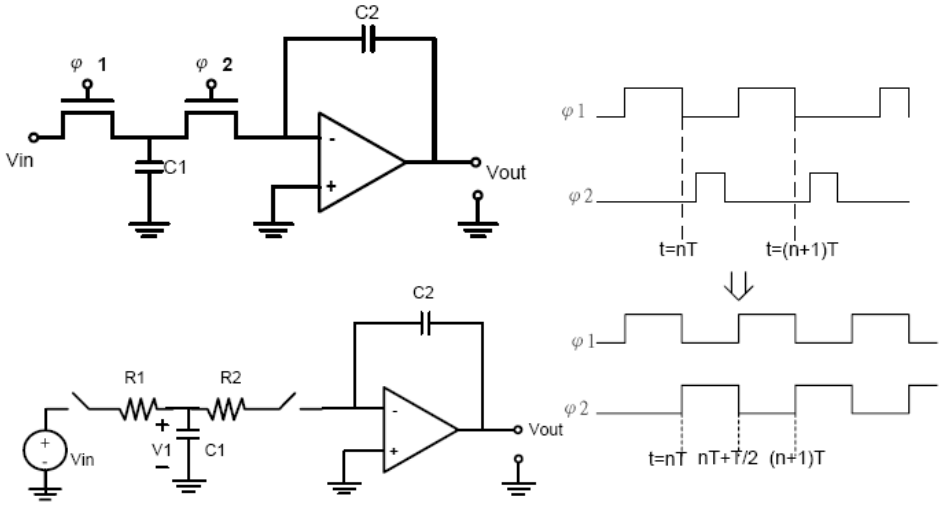


Dinamička polarizacija Op Amp-a koji radi za vreme obe faze Clock-a
(GB=130MHz (CL=2.2pF), 1,6 mW dissipation)



Current-Mode Sample and Hold Circuit

Uticaj neidealnosti u SC kolima



Uticaj otpornosti prekidača u jednom SC pojačavaču

$$t = nT : V_1(nT) = V_{in}(nT)\left(1 - e^{\frac{-T/2}{R_1 C_1}}\right)$$

$$\Delta Q(nT + T/2) = C_1 V_1(nT)\left(1 - e^{\frac{-T/2}{R_2 C_1}}\right) = C_2\left[V_{out}(nT + T) - V_{out}(nT)\right],\ R_1 = R_2 = R$$

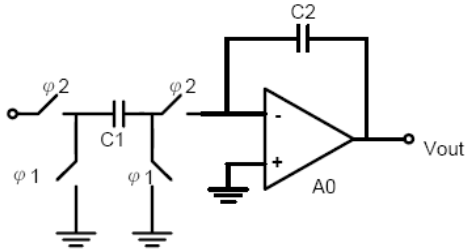
$$H(z) = -\frac{C_1/C_2}{z-1}\left(1 - e^{\frac{-T/2}{RC_1}}\right)^2 = H_i(z)\left(1 - e^{\frac{-T/2}{RC_1}}\right)^2$$

$$\varepsilon = \frac{H_i(z) - H(z)}{H_i(z)} = 1 - \frac{H(z)}{H_i(z)} = 1 - \left(1 - e^{\frac{-T/2}{RC_1}}\right)^2 \approx 2e^{\frac{-T/2}{RC_1}}$$

$$\varepsilon \le 0{,}1\% \ \Rightarrow\ 2e^{\frac{-T/2}{RC_1}} \le 10^{-4} \ \Rightarrow\ \frac{RC_1}{T} \le 5\cdot 10^{-2} \ \Rightarrow\ RC_1 \le \frac{T}{20},$$

$$f_{clock} = 1/T = 1\,\text{MHz},\ C_1 = 5\,\text{pF} \ \Rightarrow\ R \le 10\,\text{k}\Omega,$$

$$f_{clock} = 1/T = 100\,\text{MHz},\ C_1 = 1\,\text{pF} \ \Rightarrow\ R \le 500\,\Omega.$$



Uticaj konačnog pojačanja operacionog pojačavača u jednom SC integratoru

$$t = nT : V_{out}(nT) = V_{C2}(nT) - \frac{V_{out}(nT)}{A_0},$$

$$C_2\left[V_{C2}(nT)-V_{C2}(nT-T)\right]+C_1\left[V_{in}(nT)+\frac{V_{out}(nT)}{A_0}\right]=0 \Rightarrow$$

$$H(z)=\frac{V_{out}(z)}{V_{in}(z)}=\frac{-\frac{C_1}{C_2}\left[1+\frac{1+C_1/C_2}{A_0}\right]^{-1}z}{z-\frac{1+1/A_0}{1+\frac{1+C_1/C_2}{A_0}}},$$

$$H\left(e^{j\omega T}\right)=H_i\left(e^{j\omega T}\right)F(\omega),\ F(\omega)=\frac{1}{1-m(\omega)+j\theta(\omega)},$$

$$m(\omega)=-\frac{1+\frac{C_1}{2C_2}}{A_0},\ \theta(\omega)=\frac{C_1/C_2}{2A_0\tan(\omega T/2)}\approx\frac{C_1}{C_2}\frac{1}{A_0\omega T} \Rightarrow$$

$$\left|F(\omega)\right|=\frac{1}{\sqrt{\left(1-m(\omega)\right)^2+\left(\theta(\omega)\right)^2}}\approx\frac{1}{1-m(\omega)}\approx 1+m(\omega) \Rightarrow$$

$$A_0>1000 \Rightarrow \varepsilon_m<0{,}1\%,\ A_0>100 \Rightarrow \varepsilon_m<1\%$$

$$\arg\left(F(\omega)\right)=-\arctan\frac{-\theta(\omega)}{1-m(\omega)}\approx\arctan\left(\theta(\omega)\right)\approx\theta(\omega) \Rightarrow$$

$$\varepsilon_\theta\approx 0,\ A_0\omega T\gg 1.$$

$$A(s)=\frac{A_0}{1+\frac{s}{\omega_P}}=\frac{1}{\frac{1}{A_0}+\frac{s}{\omega_T}} \Rightarrow m(\omega)=-e^{-k_1}\left[1-k\cos(\omega T)\right],$$

$$k=\frac{C_1}{C_1+C_2},\ k_1=\frac{k\omega_T T}{2},\ \theta(\omega)=-e^{-k_1}k\sin(\omega T)$$

$$\frac{\omega_T T}{2}=\pi\frac{\omega_T}{\omega_{clock}}\gg 1\ (\omega_T>5\omega_{clock}) \Rightarrow m(\omega)\to 0 \text{ і } \theta(\omega)\to 0.$$