file: g:/coursesS19/303/OTA_QvsM.mcd 03/02/19

Mathdad program to compare BJT vs MOS OTA response. Only 1st quadrant given as output current Io is symmetric in differential input voltage v.

bias voltages: $VPlus := 5$ $Vminus := VPlus$

$IT := 5 \cdot 10^{-3}$ $VT := 26 \cdot 10^{-3}$ $k := 4 \cdot 10^{-3}$ k=KP.*W/(2L) for MOS

BJT output current = IoBJT(v); v = differential input voltage

$$IoBJT(v) := IT \cdot \tanh\left(\frac{v}{2 \cdot VT}\right)$$

VB=MOS break V to IT $VB := \sqrt{\frac{IT}{k}}$ $VB = 1.118$

$$Vscale := \sqrt{\frac{k}{2 \cdot IT}} \qquad Vscale = 0.632$$

$MOS(v) := v \cdot Vscale$

MOS output current = IoMOS(v); Φ(.)=unit step function; scale factor on v is Vscale

$$IoMOS(v) := 2 \cdot IT \cdot MOS(v) \cdot \left[\sqrt{\left(1 - MOS(v)^2\right)}\right] \cdot \Phi(VB - v) + IT \cdot \Phi(v - VB)$$

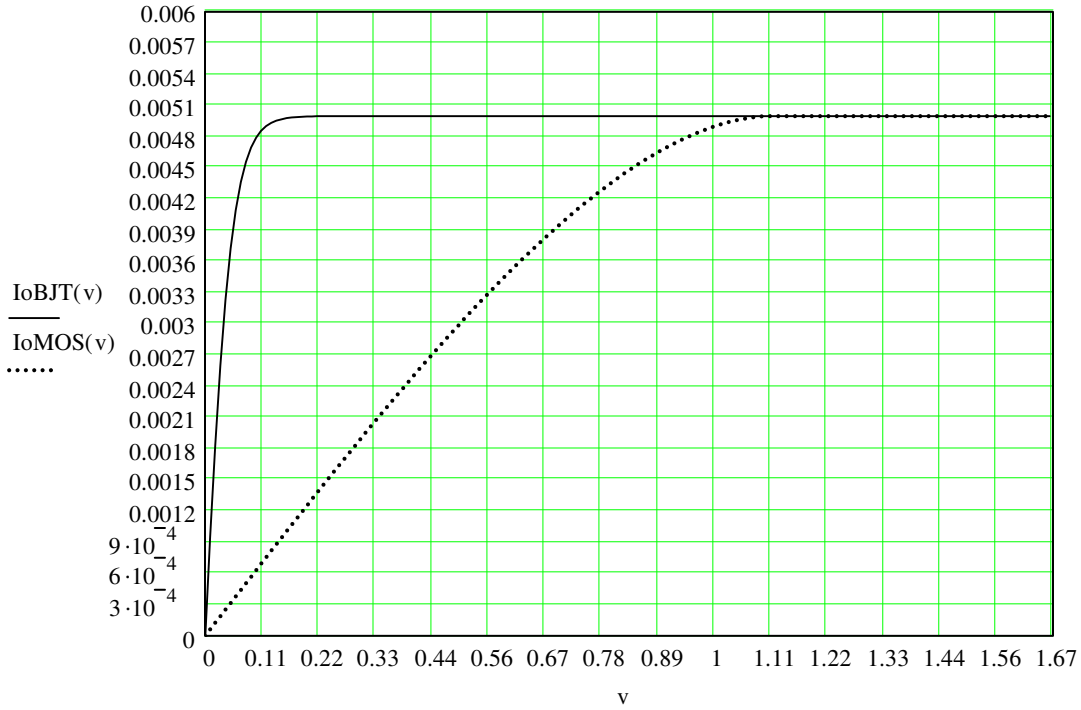
ChecjVB works in both terms

$$Icheck(v) := 2 \cdot IT \cdot MOS(v) \cdot \left[\sqrt{\left(1 - MOS(v)^2\right)}\right] \qquad Icheck(VB) = 5 \times 10^{-3}$$

Plot both Iouts:

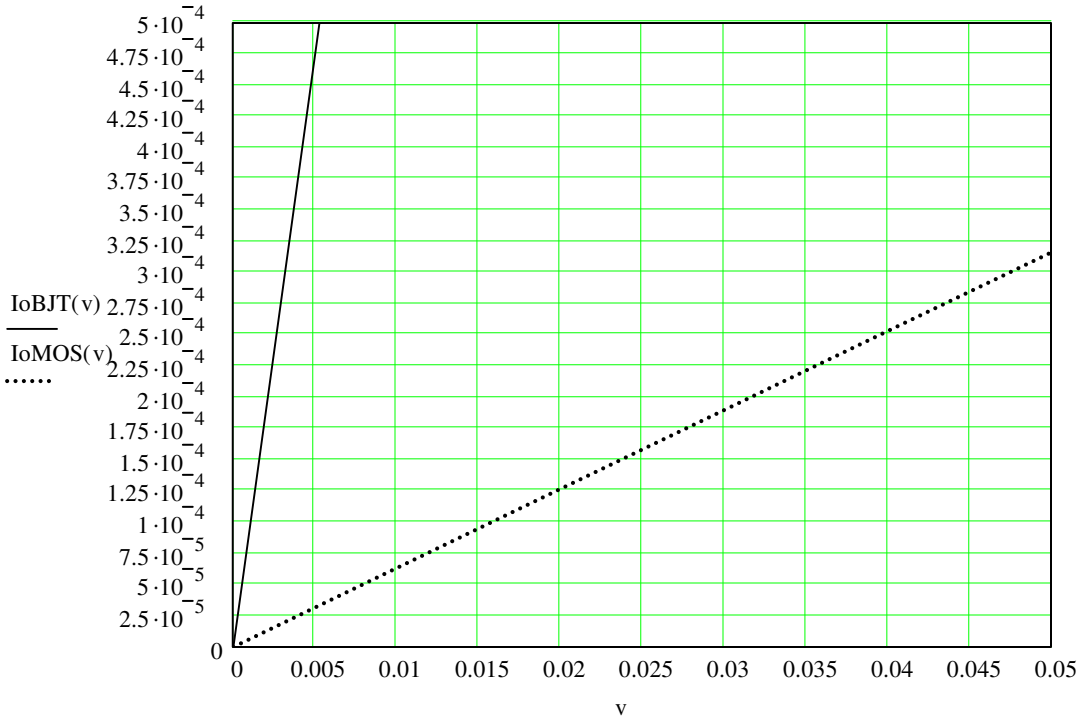
$vmin := 0$ $vmax := \frac{VPlus}{3}$ $dv := 0.01$ $Imax := IT \cdot \frac{6}{5}$

$v := vmin, vmin + dv .. vmax$



Rescale: x axis to look near origin

$$vmax := \frac{VPlus}{100} \qquad dv := 0.001 \qquad Imax := \frac{IT}{10}$$




Redesign MOS so both MOS and BJT have same gm at v=0 by varying IT as function of k:

Derivatives at the origin: BJT=IT/(2VT) for MOS=2ITVscale, Vscale=sqrt(k/(2IT))
setting them equal 1=4VTsqrt(k/(2IT)) or k=2IT/16(VT^2))

$$keq(IT) := \frac{IT}{8 \cdot VT^2} \qquad keq(IT) = 0.925$$

$$ITeq(k) := 8 \cdot k \cdot VT^2 \qquad ITeq(k) = 2.163 \times 10^{-5}$$

$$MOS(v,k) := \left[\sqrt{\left(\frac{k}{2 \cdot ITeq(k)}\right)}\right] \cdot v \qquad VB(k) := \sqrt{\frac{ITeq(k)}{k}} \qquad VB(k) = 0.074$$

Redefine IoMOS to include function of k:

$$IoMOS(v,k) := 2 \cdot IT \cdot MOS(v,k) \cdot \left[\sqrt{\left(1 - MOS(v,k)^2\right)}\right] \cdot \Phi(VB(k) - v) + IT \cdot \Phi(v - VB(k))$$

Replot to show the equal gm and comparison for non-small input v:

$$vmax := \frac{VPlus}{40} \qquad dv := 0.01 \qquad Imax(k) := ITeq(k) \cdot \frac{1000}{4}$$