From ②,

$$I_{DS1} + I_{DS2} - 2\sqrt{I_{DS1}\cdot I_{DS2}} = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS1}-V_{GS2})^2$$

$$\therefore 2\sqrt{I_{DS1}\cdot I_{DS2}} = 2I_{DS} - \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS1}-V_{GS2})^2 \quad — ③$$

apply

From ①,

$$(I_{DS1}-I_{DS2})^2 = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS1}-V_{GS2})^2\left(2I_{DS} + 2\sqrt{I_{DS1}\cdot I_{DS2}}\right)$$

$$= 2I_{DS}\mu_n C_{ox}\frac{W}{L}(V_{GS1}-V_{GS2})^2 - \frac{1}{4}\left(\mu_n C_{ox}\frac{W}{L}\right)^2(V_{GS1}-V_{GS2})^4$$

$$\therefore I_{DS1}-I_{DS2} = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS1}-V_{GS2})\sqrt{\frac{8I_D}{\mu_n C_{ox}\frac{W}{L}} - (V_{GS1}-V_{GS2})^2} \quad — ④$$

From ④, $I_{DS1}-I_{DS2} = i_o$

$V_{GS1}-V_{GS2} = v_{in}$

$$\therefore i_o = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}v_{in}\sqrt{\frac{8I_D}{\mu_n C_{ox}\frac{W}{L}} - v_{in}^2} \quad — ⑤$$

$$\therefore \text{overall } G_m = \left(\frac{\partial i_o}{\partial v_{in}}\right)_{v_{in}=0}$$

$$= \left(\frac{1}{2}\mu_n C_{ox}\frac{W}{L}\frac{\frac{8I_D}{\mu_n C_{ox}\frac{W}{L}} - 2v_{in}^2}{\sqrt{\frac{8I_D}{\mu_n C_{ox}\frac{W}{L}} - v_{in}^2}}\right)_{v_{in}=0}$$

$$= \sqrt{\mu_n C_{ox}\frac{W}{L}\cdot 2I_D}$$