Synapse as difference of 2 exponentials:

$$g(t) = \bar{g}\alpha(t, t_0, \tau_d, \tau_r) \tag{1}$$

$$\alpha = \frac{e^{-\frac{t-t_0}{\tau_d}} - e^{-\frac{t-t_0}{\tau_r}}}{(e^{-\frac{t_0-\theta}{\tau_d}} - e^{-\frac{t_0-\theta}{\tau_r}})} \tag{2}$$

$$\theta = t_0 + \frac{\tau_r \tau_d}{\tau_d - \tau_r} log(\frac{\tau_d}{\tau_r}) \tag{3}$$

where θ is time to peak
α is the normalization function
τ_d and τ_r are decay and rise times.

$$g_e(t) = \bar{g}_{AMPA}\alpha_e(t, 0, \tau_{e_d}, \tau_{e_r}) \tag{4}$$

$$g_i(t) = \bar{g}_{GABA}\alpha_i(t, \delta, \tau_{i_d}, \tau_{i_r}) \tag{5}$$

δ is delay between excitation and inhibition onsets

Total conductance equation due to AMPA and GABA:

$$I_{syn}(t) = (E_{AMPA} - V_m)g_e(t) + (E_{GABA} - V_m)g_i(t) \tag{6}$$

Correspoding PSP equation:

$$\frac{dV_m}{dt} = \frac{1}{C_m}[(E_{leak} - V_m(t))g_{leak} + I_{syn}(t)] \tag{7}$$

At inflextion points, $\frac{dV_m}{dt} = 0$. Therefore,

$$(E_{leak} - V_m(t^*))g_{leak} + I_{syn}(t^*) = 0 \tag{8}$$

$$(E_{leak} - V_m(t^*))g_{leak} + (E_{AMPA} - V_m(t^*))g_e(t^*) + (E_{GABA} - V_m(t^*))g_i(t^*) = 0 \tag{9}$$

Using equations (4) and (5) in (9), and renaming $V_m(t^*)$ as V_m^* and E_{AMPA} and E_{AMPA} as E_e and E_i respectively and rearranging,

$$V_m^* = -\left[\frac{I_{leak} + \bar{I_e}\alpha_e(t^*, 0, \tau_{e_d}, \tau_{e_r}) + \bar{I_i}\alpha_i(t^*, \delta, \tau_{i_d}, \tau_{i_r})}{g_{leak} + \bar{g_e}\alpha_e(t^*, 0, \tau_{e_d}, \tau_{e_r}) + \bar{g_i}\alpha_i(t^*, \delta, \tau_{i_d}, \tau_{i_r})}\right] \tag{10}$$

When Gabazine is put in the bath, the inhibitory component of this equation is lost.

$$V_m^*(e) = -\left[\frac{I_{leak} + \bar{I_e}\alpha_e(t^*, 0, \tau_{e_d}, \tau_{e_r})}{g_{leak} + \bar{g_e}\alpha_e(t^*, 0, \tau_{e_d}, \tau_{e_r})}\right] \tag{11}$$

Now, for divisive normalization,

$$V_m^* = \frac{1}{f(e)}V_m^*(e) \tag{12}$$

where $f(E)$ is linear in E.

Or, $\frac{V_m^*(e)}{V_m^*} = f(e)$

From 7,8 and 9,

$$f(e) = \left[\frac{1 + \frac{\bar{g}_i \alpha_i}{g_{leak} + \bar{g}_e \alpha_e}}{1 + \frac{\bar{I}_i \alpha_i}{I_{leak} + \bar{I}_e \alpha_e}}\right] \tag{13}$$

The above equation is of the form $\frac{1+y}{1+x}$ and must increase linearly in E,

1. It must be of the form $y = f(e)x + (f(e) - 1)$