1.0 **Introduction:**

The lateral pnp transistor is shown below. It consists of base diffusions (green) which define the emitter and collector (ring, in green) and the epi layer, the base. It is difficult to model these for quick simulations. In this description a method is provided to do this and get approximate results that may be good enough as starting points for more rigorous modeling. In this process the base diffusion junction depth is 2.5 um. (Other process parameters are defined further along in this paper. The outside dimensions are shown for purposes of comparison. This is an older SBC (standard buried collector process).
In the following a model will be developed for this transistor.

2.0 **Assumptions: (Refer to figure 2.0 below)**

2.1 The injection efficiency is assumed to be unity
2.2 The injected carriers are confined to the surface and half the junction depth of the emitter and collector regions.
2.3 The effective sidewall emitter area is $A_e$ and the parasitic emitter area is $A_p$
2.4 The length of the emitter diffusion is $L$
2.5 The width of the emitter diffusion is $W$
2.6 The effective parasitic emitter area is the surface area of the emitter.
2.7 The effective base width of the injected carriers is the emitter to collector spacing.
2.8 The diffusion length for minority carriers in epi is $L_p$
2.9 Depletion regions are neglected.

3.0 **Modeling:**

Definitions:

- $w_l$ = effective base width
- $w_v$ = base width for other carriers
- $x_{jc}$ = collector/emitter junction depth
- $x_{js}$ = substrate junction depth

Then the transport factor is:

$$B_l = 1 - \{ (w_l)^2 / 2L_p^2 \}$$  (1.0)

For the parasitic pnp it is:

$$B_v = 1 / \{ 1.0 + (x_{js} - x_{jc})^2 / (2L_p^2) \}$$  (2.0)

The BETA (common emitter current gain) is defined as the ratio of the collector current to the base current when both collector and substrate are reverse biased. This can be shown to be:

$$BETA = [A_e/A_p] \times (B_l \times (1 + w_v^2) / (2L_p^2))^* \times (2L_p^2) / w_v^2$$  (3.0)

In practice

$w_l << L_p$ thus BETA becomes,
BETA ~ \[\frac{Ae}{Ap} \{1.0 + (2Lp^2/wv^2)\} \]  

It is clear that the BETA of the lateral pnp is dependent on the ratio:

\[\frac{Ae}{Ap} = \frac{(1.0 + W/L)}{\{2.0 + (W/xjc)\}}\]  

A rule of thumb should be. To design a lateral pnp, keep W as small as possible and choose L = 10W approximately.

**Figure 2.0. Equivalent circuit the lateral pnp**

**4.0 Other parameters:**

Lp is the minority carrier diffusion length. It is defined as follows:

\[L_p = \sqrt{D_p \tau_p}\]  

Where,

\[\tau_p\] the hole lifetime ,  
\[D_p = \text{diffusion constant for holes}\]

Similar definitions are valid for electrons.

It is difficult to analytically calculate diffusion lengths. In this paper it is simply presented in graphical form. A result of measurements. These graphs are shown below.
Figure 3.0 Diffusion length and lifetime for holes
Figure 4.0 Diffusion length and lifetime for electrons