A winner-take-all circuit with controllable soft max property

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A Winner-take-all Circuit with Controllable Soft Max Property

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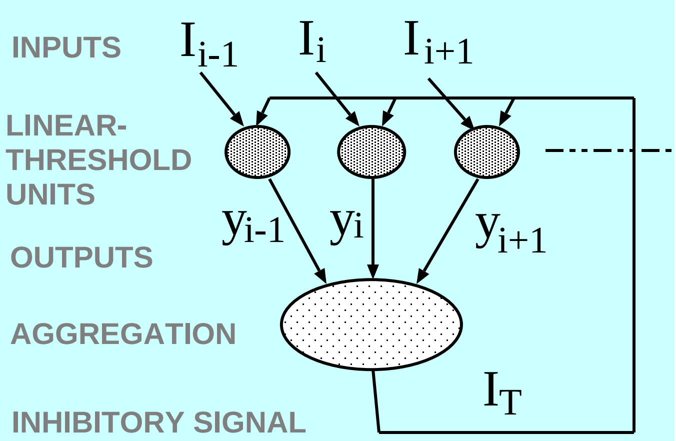
A network of N linear-threshold excitatory units and one global inhibitory unit can exhibit a winner-take-all (WTA) function. A hardware implementation of a hard WTA function was previously described by Lazzaro et al (1). The implementation described here can exhibit either a hard WTA or soft-max function with the addition of one transistor and a global bias.

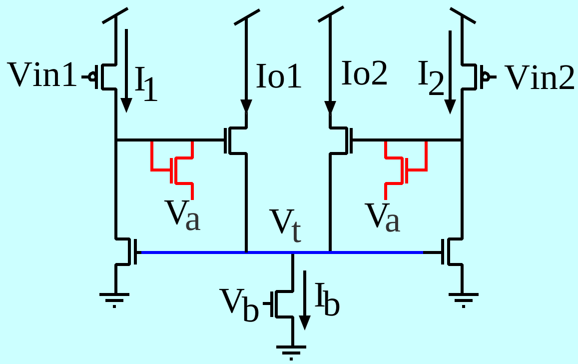
CIRCUIT ABSTRACTION



(1) "Winner-take-all networks of O(n) complexity", Lazzaro J., Ryckebusch, S., Mahowald M., and Mead C.A., Advances in Neural Information Processing Systems, Vol. 1, pp. 703-711, 1989.

CIRCUIT DIAGRAM

Soft-WTA circuit is same as Lazzaro's with addition of red transistors. Circuit below has 2 excitatory and 1 inhibitory unit. The parameter Va controls the soft-max property.Increasing Va reverts operation to hard WTA.



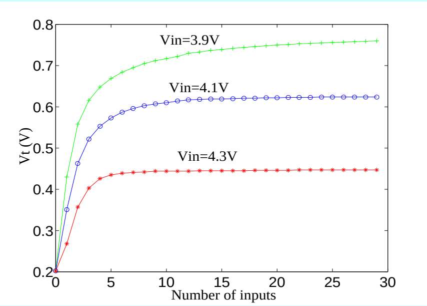
$$I_T = \frac{N I_i}{I_b / I_a + N}$$

$$I_T = I_0 e^{\frac{kV_t}{U_T}}$$

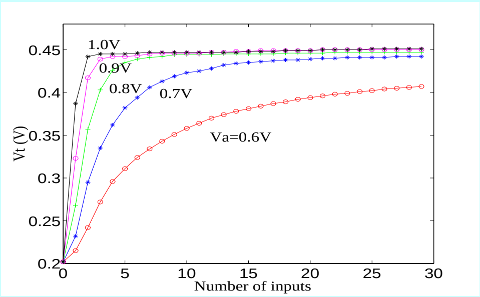
$$I_a = I_0 e^{\frac{kV_a}{U_T}}$$

CHIP DATA

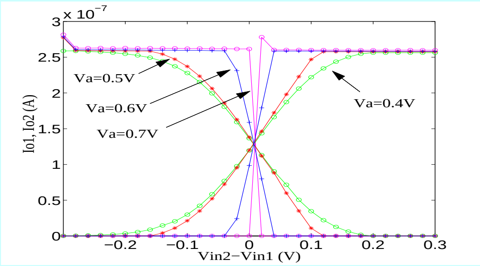
The common-node voltage, Vt, saturates with an increasing number of inputs and the saturation level increases with the level of input current.



The number of inputs at which the voltage saturates depends on Va and Vb. For a fixed Vb, we can change the saturating response of Vt by varying Va.



The two extremes of the network function are illustrated using a two-input network. From the plot of Io1 and Io2 against the differential input voltage, we see that the transition region decreases for increasing Va.



With two inputs that are almost equal in magnitude, the output currents, Io1 and Io2, depend on Va. The curves split apart as Va increases showing that the network acts as a hard WTA for a large Va.