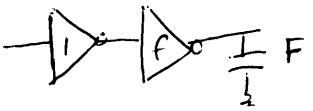
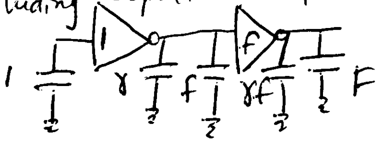
Transistor sizing for min energy

For  recall $t_p = t_{p0}\left(\left(1+\frac{f}{\gamma}\right)+\left(1+\frac{F}{\gamma f}\right)\right)$; $t_{p0} \propto \frac{V_{DD}}{V_{DD}-V_{TE}}$

where $V_{TE} = V_T + V_{DSAT}/2$ and $C_{int} = \gamma C_{gin}$

Also including capacitance of buffers



$$E = V_{DD}^2 C_{gin}\left((1+\gamma)(1+f)+F\right)$$

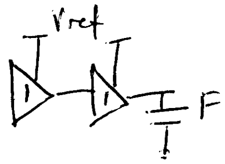
Reference Implementation $V_{DD} = V_{ref}$, $\gamma = 1$, $f = 1$

$$t_{pref} = t_{poref}\,(3+F) \qquad t_{poref} \propto \frac{V_{ref}}{V_{ref}-V_{TE}}$$

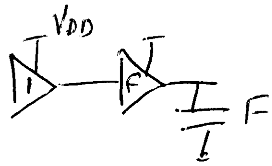
$$E_{ref} = V_{ref}^2 C_{gin}(4+F)$$

Trick: by varying V_{DD} & f, we can change t_p and E.

Suppose we want



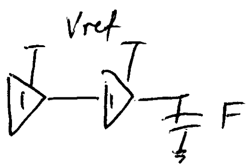
speed =



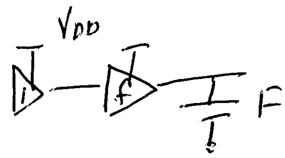
$$\frac{t_p}{t_{pref}} = 1 \Rightarrow \frac{t_{p0}(2+f+F/f)}{t_{poref}\,(3+F)} = 1$$

$$\Rightarrow \frac{V_{DD}}{V_{ref}}\;\frac{V_{ref}-V_{TE}}{V_{DD}-V_{TE}}\;\frac{(2+f+F/f)}{3+F} = 1$$

Suppose we want



Energy =



$$\frac{E}{E_{ref}} = 1 \Rightarrow \frac{V_{DD}^2}{V_{ref}^2}\left(\frac{2+2f+F}{4+F}\right) = 1$$

TRANSISTOR DRAIN CURRENT SPREADSHEET

VDD 2.5 V

NMOS Parameters				**PMOS Parameters**			
VT0	0.43	Volts		VT0	-0.4	Volts	
GAMMA	0.4	V^0.5		GAMMA	-0.4	V^0.5	
VDSAT	0.63	V		VDSAT	-1	V	
k'	115	uA/V2		k'	-30	uA/V2	
LAMBDA	0.05	V^-1		LAMBDA	-0.1	V^-1	
PHIF	0.45	V		PHIF	0.3	V	
VT	0.43			VT	-0.4		
VGT	2.07	V		VGT	-2.1	V	
Vmin	0.63	V		Vmin	-1	V	
W/L	1			W/L	1		
k'W/L	115	uA/V2		k'W/L	-30	uA/V2	
ID(no lambda)	127.14975	uA		ID(no lambda)	-48	uA	
ID (w lambda)	143.0434688	uA		ID (w lambda)	-60	uA	
IDSAT	127.14975	uA		IDSAT	-48	uA	
				BETA (Wp/Wn)	**1**		
W	**0.25**	**um**		**W**	**0.25**	**um**	
L	**0.25**	**um**		**L**	**0.25**	**um**	
VGS	**2.5**	**V**		**VGS**	**-2.5**	**V**	
VDS	**2.5**	**V**		**VDS**	**-2.5**	**V**	
VSB	0	**V**		**VSB**	0	**V**	
ID	**143.0434688**	**uA**	**VELSAT**	**ID**	**-60**	**uA**	**VELSAT**
Req	**13312.7146**	**ohms**		**Req**	**31467.0139**	**ohms**	