The Signal Path Blog

http://www.TheSignalPath.com

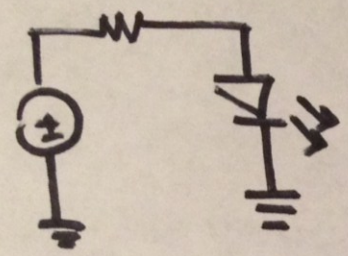
Cryogenic Experiments on Passive and Active Electronic Components

Resistor

$$\rho(T) = \rho_0 (1 + \alpha(\Delta T)) \Rightarrow T\downarrow \rightarrow R\downarrow$$

DUT	T = 25c	T = -195c	ΔR	% ΔR
R (Carbon)	13.1K	21.5K	8.3K	63%
R	10K	10.8K	800Ω	8%
R (T. Film)	9.5K	9.59K	82Ω	0.8%

LED



Green = $500 < \lambda < 570$ (nm) [InGaN, AlGaInP]

RED = $610 < \lambda < 780$ (nm) "

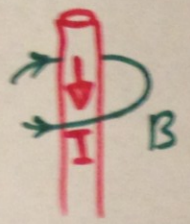
$$\lambda = \frac{hc}{E}$$

$E \propto T$, $E \propto$ Material

Typically $T \downarrow \rightarrow E \uparrow$

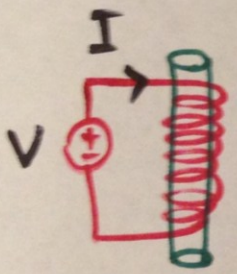
T = 25C	T = -195C
Green	Orange

Electromagnet



$$\oint B \cdot dl = \mu_0 I$$

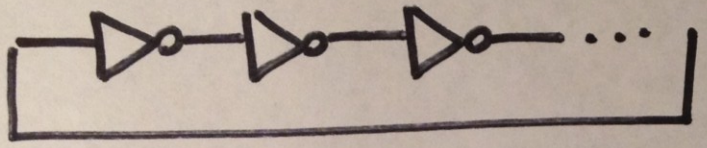
Solenoid $\approx$ $B = \mu n I$



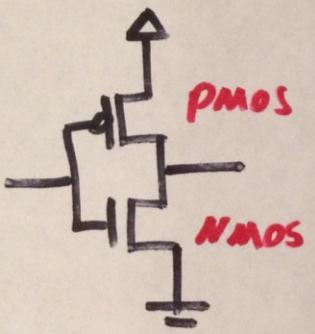
$I = V/R$, $T\downarrow \rightarrow R\downarrow \rightarrow I\uparrow \rightarrow B\uparrow$

P	R T=25C°	R T=-195	B T=25C°	B T=-195°
1 W	480Ω		0.22 (50mA)	
1 W	59Ω ↗		61m (134mA) ↗	

CMOS Ring Oscillator



$$f = 1/T = \frac{1}{2n\tau_D}$$



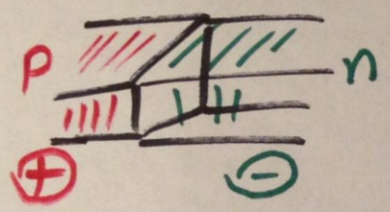
$$\tau_D \approx 0.69 R_{eq} C_L$$

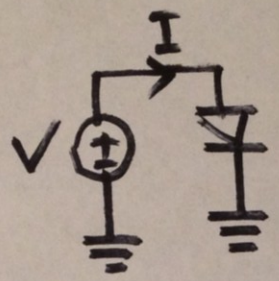
$$R_{eq} \approx \frac{2.5}{\mu_n C_{ox} (W/L)(V_{DD} - V_{tn})}$$

$T \downarrow \rightarrow (\mu_n \uparrow, V_{tn} \downarrow) \rightarrow R_{eq} \downarrow \rightarrow \tau_D \downarrow \rightarrow f \uparrow$

T = 25C°	T = −195C°
27MHz	58MHz
19mA	50mA (15.8Vpp)
(8Vpp)	

PN-Junction





$$I = I_s\left(e^{V/nV_T} - 1\right)$$

$$\approx I_s e^{V/nV_T}$$

$$V = nV_T \ln\left(I/I_s\right)$$

$$V_T = \frac{KT}{q}$$

$V_T \propto T$ But I_s is a strong $\propto T$!!

$T \downarrow \rightarrow (V_T \downarrow, I_s \uparrow\uparrow) \rightarrow V \uparrow$ (2mV/C)

$T = 25C$	$T = -195C$
$0.661\,V$	$1.053\,V$

@ $I = 1mA$