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# Non Linear Circuits Formulas

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# List of 16 Non Linear Circuits Formulas

## Non Linear Circuits

### 1) Amplifier Gain of Tunnel Diode

$$fx \quad A_v = \frac{R_n}{R_n - R_L}$$

[Open Calculator !\[\]\(a870788d6ed9b8fd294b7654a8c8526b\_img.jpg\)](#)

$$ex \quad 1.062069dB = \frac{77\Omega}{77\Omega - 4.5\Omega}$$

### 2) Average Diode Temperature using Single Side Band Noise

$$fx \quad T_d = (F_{ssb} - 2) \cdot \left( \frac{R_g \cdot T_0}{2 \cdot R_d} \right)$$

[Open Calculator !\[\]\(c50c8b7b2cc2cf9ff925edec0ee94c0d\_img.jpg\)](#)

$$ex \quad 289.9286K = (14.3dB - 2) \cdot \left( \frac{33\Omega \cdot 300K}{2 \cdot 210\Omega} \right)$$


### 3) Bandwidth using Dynamic Quality Factor

$$fx \quad S = \frac{Q_d}{\omega \cdot R_s}$$

[Open Calculator !\[\]\(f60b7a900783ac3fd531bfd9c111be6d\_img.jpg\)](#)

$$ex \quad 0.003794Hz = \frac{0.012}{5.75rad/s \cdot 0.55\Omega}$$



4) Dynamic Q Factor 

$$fx \quad Q_d = \frac{S}{\omega \cdot R_s}$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235\_img.jpg\)](#)


$$ex \quad 0.012648 = \frac{0.04Hz}{5.75rad/s \cdot 0.55\Omega}$$

5) Magnitude of Negative Resistance 

$$fx \quad R_n = \frac{1}{g_m}$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0\_img.jpg\)](#)

$$ex \quad 76.92308\Omega = \frac{1}{0.013S}$$

6) Maximum Applied Current across Diode 

$$fx \quad I_m = \frac{V_m}{X_c}$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f\_img.jpg\)](#)

$$ex \quad 0.014A = \frac{77mV}{5.5H}$$


7) Maximum Applied Voltage across Diode 

$$fx \quad V_m = E_m \cdot L_{depl}$$

[Open Calculator !\[\]\(b64b40baaee5acddc1eab8538ba84754\_img.jpg\)](#)

$$ex \quad 77mV = 100V/m \cdot 0.77mm$$



8) Negative Conductance of Tunnel Diode 

$$\text{fx } g_m = \frac{1}{R_n}$$

[Open Calculator !\[\]\(e78f798d4ea5c530c9db49e7d26e6b95\_img.jpg\)](#)


$$\text{ex } 0.012987\text{S} = \frac{1}{77\Omega}$$

9) Noise Figure of Double Side Band 

$$\text{fx } F_{\text{dsb}} = 1 + \left( \frac{T_d \cdot R_d}{R_g \cdot T_0} \right)$$

[Open Calculator !\[\]\(05be7c7a8995decd503647c99211f7c2\_img.jpg\)](#)

$$\text{ex } 7.151515\text{dB} = 1 + \left( \frac{290\text{K} \cdot 210\Omega}{33\Omega \cdot 300\text{K}} \right)$$

10) Noise Figure of Single Side Band 

$$\text{fx } F_{\text{ssb}} = 2 + \left( \frac{2 \cdot T_d \cdot R_d}{R_g \cdot T_0} \right)$$

[Open Calculator !\[\]\(fe3aebe81acea8d45108cd2768939da7\_img.jpg\)](#)

$$\text{ex } 14.30303\text{dB} = 2 + \left( \frac{2 \cdot 290\text{K} \cdot 210\Omega}{33\Omega \cdot 300\text{K}} \right)$$

11) Power Gain of Tunnel Diode 

$$\text{fx } \text{gain} = \Gamma^2$$

[Open Calculator !\[\]\(899d8b7697d64725bf017d3296cfcf1b\_img.jpg\)](#)

$$\text{ex } 0.0169\text{dB} = (0.13)^2$$



12) Ratio Negative Resistance to Series Resistance 

$$\text{fx } \alpha = \frac{R_{\text{eq}}}{R_{\text{Ti}}}$$

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a\_img.jpg\)](#)

$$\text{ex } 9 = \frac{90\Omega}{10\Omega}$$

13) Reactive Impedence 

$$\text{fx } X_c = \frac{V_m}{I_m}$$

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021\_img.jpg\)](#)

$$\text{ex } 5.5\text{H} = \frac{77\text{mV}}{0.014\text{A}}$$

14) Room Temperature 

$$\text{fx } T_0 = \frac{2 \cdot T_d \cdot \left( \left( \frac{1}{\gamma \cdot Q} \right) + \left( \frac{1}{(\gamma \cdot Q)^2} \right) \right)}{F - 1}$$

[Open Calculator !\[\]\(bd3b31712ad9bab5a241210fa6925cdd\_img.jpg\)](#)

$$\text{ex } 300.2532\text{K} = \frac{2 \cdot 290\text{K} \cdot \left( \left( \frac{1}{0.19 \cdot 12.72} \right) + \left( \frac{1}{(0.19 \cdot 12.72)^2} \right) \right)}{2.13\text{dB} - 1}$$

15) Tunnel Diode Output Power 

$$\text{fx } P_o = \frac{V_{\text{dc}} \cdot I_{\text{dc}}}{2 \cdot \pi}$$

[Open Calculator !\[\]\(7bc43b319a082987e20f7bf78f4bab80\_img.jpg\)](#)

$$\text{ex } 30.63733\text{W} = \frac{35\text{V} \cdot 5.5\text{A}}{2 \cdot \pi}$$



## 16) Voltage Reflection Coefficient of Tunnel Diode

[Open Calculator !\[\]\(eafc244b53721dd1ec133f0772f70fc7\_img.jpg\)](#)

$$\text{fx } \Gamma = \frac{Z_d - Z_o}{Z_d + Z_o}$$

$$\text{ex } 0.130435 = \frac{65\Omega - 50\Omega}{65\Omega + 50\Omega}$$



## Variables Used

- $A_v$  Amplifier Gain of Tunnel Diode (Decibel)
- $E_m$  Maximum Electric Field (Volt per Meter)
- $F$  Noise Figure of Up-Converter (Decibel)
- $F_{dsb}$  Noise Figure of Double Side Band (Decibel)
- $F_{ssb}$  Noise Figure of Single Side Band (Decibel)
- $g_m$  Negative Conductance Tunnel Diode (Siemens)
- **gain** Power Gain of Tunnel Diode (Decibel)
- $I_{dc}$  Current Tunnel Diode (Ampere)
- $I_m$  Maximum Applied Current (Ampere)
- $L_{depl}$  Depletion Length (Millimeter)
- $P_o$  Output Power of Tunnel Diode (Watt)
- $Q$  Q Factor
- $Q_d$  Dynamic Q-Factor
- $R_d$  Diode Resistance (Ohm)
- $R_{eq}$  Equivalent Negative Resistance (Ohm)
- $R_g$  Output Resistance of Signal Generator (Ohm)
- $R_L$  Load Resistance (Ohm)
- $R_n$  Negative Resistance in Tunnel Diode (Ohm)
- $R_s$  Series Resistance of Diode (Ohm)
- $R_{Ti}$  Total Series Resistance at Idler Frequency (Ohm)
- $S$  Bandwidth (Hertz)















- $T_0$  Ambient Temperature (Kelvin)
- $T_d$  Diode Temperature (Kelvin)
- $V_{dc}$  Voltage Tunnel Diode (Volt)
- $V_m$  Maximum Applied Voltage (Millivolt)
- $X_c$  Reactive Impedence (Henry)
- $Z_d$  Impedance Tunnel Diode (Ohm)
- $Z_o$  Characteristic Impedance (Ohm)
- $\alpha$  Ratio Negative Resistance to Series Resistance
- $\gamma$  Coupling Coefficient
- $\Gamma$  Voltage Reflection Coefficient
- $\omega$  Angular Frequency (Radian per Second)






## Constants, Functions, Measurements used

- **Constant:** **pi**, 3.14159265358979323846264338327950288  
*Archimedes' constant*
- **Measurement:** **Length** in Millimeter (mm)  
*Length Unit Conversion* 
- **Measurement:** **Electric Current** in Ampere (A)  
*Electric Current Unit Conversion* 
- **Measurement:** **Temperature** in Kelvin (K)  
*Temperature Unit Conversion* 
- **Measurement:** **Power** in Watt (W)  
*Power Unit Conversion* 
- **Measurement:** **Noise** in Decibel (dB)  
*Noise Unit Conversion* 
- **Measurement:** **Frequency** in Hertz (Hz)  
*Frequency Unit Conversion* 
- **Measurement:** **Electric Resistance** in Ohm ( $\Omega$ )  
*Electric Resistance Unit Conversion* 
- **Measurement:** **Electric Conductance** in Siemens (S)  
*Electric Conductance Unit Conversion* 
- **Measurement:** **Inductance** in Henry (H)  
*Inductance Unit Conversion* 
- **Measurement:** **Electric Field Strength** in Volt per Meter (V/m)  
*Electric Field Strength Unit Conversion* 
- **Measurement:** **Electric Potential** in Millivolt (mV), Volt (V)  
*Electric Potential Unit Conversion* 
- **Measurement:** **Sound** in Decibel (dB)  
*Sound Unit Conversion* 



- **Measurement: Angular Frequency** in Radian per Second (rad/s)  
*Angular Frequency Unit Conversion* 



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