COMPREHENSIVE DIODE CIRCUIT FORMULA LIST

1. BASIC VOLTAGE RELATIONSHIPS

- Peak Voltage: $V_m = V_{rms} \times \sqrt{2}$
- RMS Voltage: $V_{rms} = V_m/\sqrt{2}$
- Input AC: $V_{rms} = V_m/\sqrt{2}$

2. FIRST APPROXIMATION (IDEAL DIODE)

Forward Bias:

- Voltage Drop = 0V
- Resistance = 0Ω
- Current = V_{in}/R_L
- Power Loss = 0W

Reverse Bias:

- Current = 0A
- Resistance = ∞
- Voltage = V_{in}
- Power = 0W

3. SECOND APPROXIMATION (CONSTANT VOLTAGE DROP)

Forward Bias:

- Silicon: $V_d = 0.7V$
- Germanium: $V_d = 0.3V$
- Current = $(V_{in} - V_d)/R_L$
- Power Loss = $V_d \times I$

Reverse Bias:

- Current = 0A
- Resistance = ∞
- Voltage = V_{in}
- Power = 0W

4. HALF-WAVE RECTIFIER

First Approximation:
- DC Voltage: Vdc = Vm/π
- RMS Voltage: Vrms = Vm/2
- DC Current: Idc = Im/π
- RMS Current: Irms = Im/2
- PIV = Vm
- Ripple Factor = 1.21 = 1/2*root3*f*L*r

Second Approximation:
- DC Voltage: Vdc = (Vm - Vd)/π
- RMS Voltage: Vrms = (Vm - Vd)/2
- DC Current: Idc = (Im - Id)/π
- RMS Current: Irms = (Im - Id)/2
- PIV = Vm
- Efficiency = [2/π][1 - Vd/Vm] × 100%
- TUF = 0.287

5. FULL-WAVE RECTIFIER

First Approximation:
- DC Voltage: Vdc = 2Vm/π
- RMS Voltage: Vrms = Vm/√2
- DC Current: Idc = 2Im/π
- RMS Current: Irms = Im/√2
- PIV = 2Vm
- Form Factor = 1.11
- Ripple Factor = 0.482

Second Approximation:
- DC Voltage: Vdc = 2(Vm - Vd)/π
- RMS Voltage: Vrms = (Vm - Vd)/√2
- DC Current: Idc = 2(Im - Id)/π
- RMS Current: Irms = (Im - Id)/√2
- PIV = 2Vm
- Efficiency = [4/π][1 - Vd/Vm] × 100%
- TUF = 0.693

6. BRIDGE RECTIFIER

First Approximation:

- DC Voltage: $V_{dc} = 2V_m/\pi$
- RMS Voltage: $V_{rms} = V_m/\sqrt{2}$
- PIV = Vm
- TUF = 0.812

Second Approximation:

- DC Voltage: $V_{dc} = 2(V_m - 2V_d)/\pi$
- RMS Voltage: $V_{rms} = (V_m - 2V_d)/\sqrt{2}$
- PIV = Vm
- Efficiency = $[4/\pi][1 - 2V_d/V_m] \times 100\%$

7. RIPPLE CALCULATIONS

Without Filter:

- Half-Wave: $\gamma = 1.21$
- Full-Wave: $\gamma = 0.482$

With Capacitor Filter:

- Ripple Voltage: $V_r = I_{dc}/2fC$
- Ripple Factor: $\gamma = V_r/V_{dc}$
- Capacitance: $C = I_{dc}/2fV_r$

8. EFFICIENCY CALCULATIONS

Power Efficiency:

- $\eta = (P_{out}/P_{in}) \times 100\%$
- $\eta = (V_{dc}I_{dc})/(V_{rms}I_{rms}) \times 100\%$

Rectification Efficiency:

- Half-Wave: $\eta = [2/\pi][1 - V_d/V_m] \times 100\%$
- Full-Wave: $\eta = [4/\pi][1 - V_d/V_m] \times 100\%$
- Bridge: $\eta = [4/\pi][1 - 2V_d/V_m] \times 100\%$

10. SHOCKLEY EQUATION

- $I = I_s(e^{(V/nV_T)} - 1)$
- $V_T = kT/q \approx 26mV$ at 300K
- Dynamic Resistance: $r_d = nV_T/I_D$

11. POWER CALCULATIONS

- AC Power: $P_{ac} = V_{rms}I_{rms}$
- DC Power: $P_{dc} = V_{dc}I_{dc}$
- Diode Power: $P_d = V_dI_d$
- Power Loss: $P_{loss} = P_{in} - P_{out}$

13. TEMPERATURE EFFECTS

- $V_T = kT/q$
- I_s doubles for every 10°C rise
- V_d decreases by 2mV/°C

14. FILTER DESIGN

- Capacitor: $C = I_{dc}/2fV_r$
- Inductor: $L = R_L/2\pi f$
- RC Time Constant: $\tau = RC$

15. RECTIFIERS

A. Half-Wave Rectifier

- $V_{dc} = V_m/\pi$ (First Approx)
- $V_{dc} = (V_m-V_d)/\pi$ (Second Approx)
- $I_{rms} = I_m/2$
- Form Factor = 1.57
- Ripple Factor = 1.21
- PIV = V_m
- Efficiency = $(2/\pi)(1-V_d/V_m) \times 100\%$

B. Full-Wave Rectifier

- $V_{dc} = 2V_m/\pi$
- $V_{dc} = 2(V_m-V_d)/\pi$
- $I_{rms} = I_m/\sqrt{2}$
- Form Factor = 1.11

- Ripple Factor = 0.482
- PIV = 2Vm-Vk
- Efficiency = $(4/\pi)(1-Vd/Vm) \times 100\%$

C. Bridge Rectifier
- Vdc = $2Vm/\pi$
- Vdc = $2(Vm-2Vd)/\pi$
- PIV = Vm - 2Vk
- Efficiency = $(4/\pi)(1-2Vd/Vm) \times 100\%$

16. FILTERS

A. Shunt Capacitor Filter
- Ripple Voltage: Vr = Idc/2fC
- Capacitance: C = Idc/2fVr
- Peak-to-Peak Ripple: Vr(p-p) = Idc/fC
- Ripple Factor: γ = Vr/Vdc
- Time Constant: τ = RC

17. ZENER DIODE APPLICATIONS

A. Voltage Regulator
- Series Resistor: Rs = (Vin-Vz)/Iz
- Power Rating: Pz = VzIz
- Load Current: IL = (Vin-Vz)/RL
- Regulation: %Reg = [(VNL-VFL)/VFL] × 100%

B. Different Cases:
Case 1: Normal Operation
- Iz = (Vin-Vz)/Rs - IL
- Vout = Vz

Case 2: Below Knee
- Iz $\approxeq$ 0
- Vout < Vz

Case 3: Maximum Power

- $P_{z(max)} = V_z I_{z(max)}$
- $R_{s(min)} = (V_{in(max)} - V_z)/I_{z(max)}$

19. RIPPLE FACTOR CALCULATIONS

A. Without Filter
- Half-Wave: $\gamma = 1.21$
- Full-Wave: $\gamma = 0.482$
- Bridge: $\gamma = 0.482$

B. With Capacitor Filter
- $\gamma = 1/2\sqrt{3}fCR_L$
- $\%Ripple = (V_r/V_{dc}) \times 100\%$

21. VOLTAGE REGULATION

A. Line Regulation
- $\%LR = [(V_{out1} - V_{out2})/V_{out(nom)}] \times 100\%$

B. Load Regulation
- $\%LR = [(V_{NL} - V_{FL})/V_{FL}] \times 100\%$

22. TEMPERATURE EFFECTS

A. Zener Voltage
- Temperature Coefficient = $\Delta V_z/\Delta T$

B. Forward Voltage
- $\Delta V_F = -2mV/°C$