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Advanced Transistor Devices Formulas

Calculators! | Examples! | Conversions!

List of 20 Advanced Transistor Devices Formulas

Advanced Transistor Devices

FET

1) Drain Current of FET

Open Calculator

fx $$I_{d(fet)} = I_{dss(fet)} \cdot \left(1 - \frac{V_{ds(fet)}}{V_{cut\text{-}off(fet)}}\right)^2$$

ex $$0.301384\text{mA} = 0.69\text{mA} \cdot \left(1 - \frac{4.8\text{V}}{2.89\text{V}}\right)^2$$

2) Drain Source Voltage of FET

Open Calculator

fx $$V_{ds(fet)} = V_{dd(fet)} - I_{d(fet)} \cdot \left(R_{d(fet)} + R_{s(fet)}\right)$$

ex $$4.8407\text{V} = 5\text{V} - 0.3\text{mA} \cdot (0.32\text{k}\Omega + 0.211\text{k}\Omega)$$

3) Gate Drain Capacitance of FET

Open Calculator

fx $$C_{gd(fet)} = \frac{T_{gd\text{-}off(fet)}}{\left(1 - \frac{V_{gd(fet)}}{\Psi_{0(fet)}}\right)^{\frac{1}{3}}}$$

ex $$6.475557\text{F} = \frac{6.47\text{s}}{\left(1 - \frac{0.0128\text{V}}{4.976\text{V}}\right)^{\frac{1}{3}}}$$

4) Gate Source Capacitance of FET

Open Calculator

fx $$C_{gs(fet)} = \frac{T_{gs\text{-}off(fet)}}{\left(1 - \left(\frac{V_{ds(fet)}}{\Psi_{0(fet)}}\right)\right)^{\frac{1}{3}}}$$

ex $$6.805694\text{F} = \frac{2.234\text{s}}{\left(1 - \left(\frac{4.8\text{V}}{4.976\text{V}}\right)\right)^{\frac{1}{3}}}$$

5) Ohmic Region Drain Current of FET

Open Calculator

$$I_{d(fet)} = G_{o(fet)} \cdot \left(V_{ds(fet)} + \frac{3}{2} \cdot \frac{\left(\Psi_{0(fet)} + V_{ds(fet)} - V_{ds(fet)}\right)^{\frac{3}{2}} - \left(\Psi_{0(fet)} + V_{ds(fet)}\right)^{\frac{3}{2}}}{\left(\Psi_{0(fet)} + V_{off(fet)}\right)^{\frac{1}{2}}} \right)$$

ex $0.305501\text{mA} = 0.24\text{mS} \cdot \left(4.8\text{V} + \frac{3}{2} \cdot \frac{(4.976\text{V} + 4.8\text{V} - 4.8\text{V})^{\frac{3}{2}} - (4.976\text{V} + 4.8\text{V})^{\frac{3}{2}}}{(4.976\text{V} + 63.56\text{V})^{\frac{1}{2}}} \right)$

6) Pinch off Voltage of FET

Open Calculator

$$V_{off(fet)} = V_{ds\text{-}off(fet)} - V_{ds(fet)}$$

ex $63.36\text{V} = 68.16\text{V} - 4.8\text{V}$

7) Transconductance of FET

Open Calculator

$$G_{m(fet)} = \frac{2 \cdot I_{dss(fet)}}{V_{off(fet)}} \cdot \left(1 - \frac{V_{ds(fet)}}{V_{off(fet)}} \right)$$

ex $0.020072\text{mS} = \frac{2 \cdot 0.69\text{mA}}{63.56\text{V}} \cdot \left(1 - \frac{4.8\text{V}}{63.56\text{V}} \right)$

8) Voltage Gain of FET

Open Calculator

$$A_{v(fet)} = -G_{m(fet)} \cdot R_{d(fet)}$$

ex $-0.0064\text{V} = -0.02\text{mS} \cdot 0.32\text{k}\Omega$

IGBT

9) Breakdown Voltage of Forward Biased of IGBT

Open Calculator

$$BV_{soa(igbt)} = \frac{5.34 \cdot 10^{13}}{\left(N_{p(igbt)}\right)^{\frac{3}{4}}}$$

ex $37.53628\text{V} = \frac{5.34 \cdot 10^{13}}{(16\text{e}15\text{C})^{\frac{3}{4}}}$

10) Emitter Current of IGBT

Open Calculator

fx $I_{e(igbt)} = I_{h(igbt)} + i_{e(igbt)}$

ex $12.523\text{mA} = 12.2\text{mA} + 0.323\text{mA}$

11) IGBT Turn OFF Time

Open Calculator

fx $T_{off(igbt)} = T_{dl(igbt)} + t_{f1(igbt)} + t_{f2(igbt)}$

ex $3.472\text{s} = 1.15\text{s} + 1.67\text{s} + 0.652\text{s}$

12) Input Capacitance of IGBT

Open Calculator

fx $C_{in(igbt)} = C_{(g\text{-}e)(igbt)} + C_{(g\text{-}c)(igbt)}$

ex $5.76\text{F} = 0.21\text{F} + 5.55\text{F}$

13) Maximum Power Dissipation in IGBT

Open Calculator

fx $P_{max(igbt)} = \frac{T_{jmax(igbt)}}{\theta_{j\text{-}c(igbt)}}$

ex $110.2597\text{W} = \frac{283^\circ\text{C}}{289^\circ}$

14) Nominal Continuous Collector Current of IGBT

Open Calculator

fx $i_{f(igbt)} = \frac{-V_{ce(igbt)} + \sqrt{\left(V_{ce(igbt)}\right)^2 + 4 \cdot R_{ce(igbt)} \cdot \left(\frac{T_{jmax(igbt)} - T_{c(igbt)}}{R_{th(jc)(igbt)}}\right)}}{2 \cdot R_{ce(igbt)}}$

ex $1.691553\text{mA} = \frac{-21.56\text{V} + \sqrt{(21.56\text{V})^2 + 4 \cdot 12.546\text{k}\Omega \cdot \left(\frac{283^\circ\text{C} - 250^\circ\text{C}}{0.456\text{k}\Omega}\right)}}{2 \cdot 12.546\text{k}\Omega}$

15) Saturation Voltage of IGBT

Open Calculator

fx $V_{c\text{-}e(sat)(igbt)} = V_{B\text{-}E(pnp)(igbt)} + I_{d(igbt)} \cdot \left(R_{s(igbt)} + R_{ch(igbt)}\right)$

ex $1222.25\text{V} = 2.15\text{V} + 105\text{mA} \cdot (1.03\text{k}\Omega + 10.59\text{k}\Omega)$

16) Voltage Drop in IGBT in ON-State

Open Calculator

fx $V_{ON(igbt)} = i_{f(igbt)} \cdot R_{ch(igbt)} + i_{f(igbt)} \cdot R_{d(igbt)} + V_{j1(igbt)}$

ex $20.2533\text{V} = 1.69\text{mA} \cdot 10.59\text{k}\Omega + 1.69\text{mA} \cdot 0.98\text{k}\Omega + 0.7\text{V}$

TRIAC

17) Average Load Current of TRIAC

Open Calculator

fx $I_{avg(triac)} = \frac{2 \cdot \sqrt{2} \cdot I_{rms(triac)}}{\pi}$

ex $0.081028\text{mA} = \frac{2 \cdot \sqrt{2} \cdot 0.09\text{mA}}{\pi}$

18) Maximum Junction Temperature of TRIAC

Open Calculator

fx $T_{jmax(triac)} = T_{a(triac)} + P_{(triac)} \cdot R_{th(j\text{-}a)(triac)}$

ex $196.12^\circ\text{C} = 102.4^\circ\text{C} + 0.66\text{W} \cdot 0.142\text{k}\Omega$

19) Power Dissipation of TRIAC

Open Calculator

fx $P_{max(triac)} = V_{knee(triac)} \cdot I_{avg(triac)} + R_{s(triac)} \cdot I^2_{rms(triac)}$

ex $0.294215\text{mW} = 3.63\text{V} \cdot 0.081028\text{mA} + 0.0103\text{k}\Omega \cdot (0.09\text{mA})^2$

20) RMS Load Current of TRIAC

Open Calculator

fx $I_{rms(triac)} = \frac{I_{peak(triac)}}{2}$

ex $0.09\text{mA} = \frac{0.18\text{mA}}{2}$

Variables Used

- $A_{v(fet)}$ Voltage Gain FET *(Volt)*
- $BV_{soa(igbt)}$ Breakdown Voltage SOA IGBT *(Volt)*
- $C_{(g-c)(igbt)}$ Gate to Collector Capacitance (IGBT) *(Farad)*
- $C_{(g-e)(igbt)}$ Gate to Emitter Capacitance (IGBT) *(Farad)*
- $C_{gd(fet)}$ Gate Drain Capacitance FET *(Farad)*
- $C_{gs(fet)}$ Gate Source Capacitance FET *(Farad)*
- $C_{in(igbt)}$ Input Capacitance (IGBT) *(Farad)*
- $G_{m(fet)}$ Forward Transconductance FET *(Millisiemens)*
- $G_{o(fet)}$ Channel Conductance FET *(Millisiemens)*
- $I_{avg(triac)}$ Average Load Current TRIAC *(Milliampere)*
- $I_{d(fet)}$ Drain Current FET *(Milliampere)*
- $I_{d(igbt)}$ Drain Current (IGBT) *(Milliampere)*
- $I_{dss(fet)}$ Zero Bias Drain Current *(Milliampere)*
- $i_{e(igbt)}$ Electronic Current (IGBT) *(Milliampere)*
- $I_{e(igbt)}$ Emitter Current (IGBT) *(Milliampere)*
- $i_{f(igbt)}$ Forward Current (IGBT) *(Milliampere)*
- $I_{h(igbt)}$ Hole Current (IGBT) *(Milliampere)*
- $I_{peak(triac)}$ Peak Current TRIAC *(Milliampere)*
- $I_{rms(triac)}$ RMS Current TRIAC *(Milliampere)*
- $N_{p(igbt)}$ Net Positive Charge (IGBT) *(Coulomb)*
- $P_{(triac)}$ Dissipation Power TRIAC *(Watt)*
- $P_{max(igbt)}$ Maximum Power Dissipation (IGBT) *(Watt)*
- $P_{max(triac)}$ Maximum Power Dissipation TRIAC *(Milliwatt)*
- $R_{ce(igbt)}$ Resistance of Collector and Emitter (IGBT) *(Kilohm)*
- $R_{ch(igbt)}$ N Channel Resistance (IGBT) *(Kilohm)*
- $R_{d(fet)}$ Drain Resistance FET *(Kilohm)*
- $R_{d(igbt)}$ Drift Resistance (IGBT) *(Kilohm)*
- $R_{s(fet)}$ Source Resistance FET *(Kilohm)*
- $R_{s(igbt)}$ Conductivity Resistance IGBT *(Kilohm)*
- $R_{s(triac)}$ Conductivity Resistance TRIAC *(Kilohm)*
- $R_{th(j-a)(triac)}$ Junction to Ambient Thermal Resistance TRIAC *(Kilohm)*

- $R_{th(jc)(igbt)}$ Thermal Resistance (IGBT) *(Kilohm)*
- $T_{a(triac)}$ Ambient Temperature TRIAC *(Celsius)*
- $T_{c(igbt)}$ Case Temperature IGBT *(Celsius)*
- $T_{dl(igbt)}$ Delay Time (IGBT) *(Second)*
- $t_{f1(igbt)}$ Initial Fall Time (IGBT) *(Second)*
- $t_{f2(igbt)}$ Final Fall Time (IGBT) *(Second)*
- $T_{gd\text{-}off(fet)}$ Gate Drain Capacitance Off Time FET *(Second)*
- $T_{gs\text{-}off(fet)}$ Gate Source Capacitance Off Time FET *(Second)*
- $T_{jmax(igbt)}$ Maximum Operating Junction (IGBT) *(Celsius)*
- $T_{jmax(triac)}$ Maximum Operating Junction TRIAC *(Celsius)*
- $T_{off(igbt)}$ Turn OFF Time (IGBT) *(Second)*
- $V_{B\text{-}E(pnp)(igbt)}$ Base Emitter Voltage PNP IGBT *(Volt)*
- $V_{ce(igbt)}$ Total Voltage of Collector and Emitter (IGBT) *(Volt)*
- $V_{c\text{-}e(sat)(igbt)}$ Collector to Emitter Saturation Voltage (IGBT) *(Volt)*
- $V_{cut\text{-}off(fet)}$ Cutt-off Voltage FET *(Volt)*
- $V_{dd(fet)}$ Supply Voltage at Drain FET *(Volt)*
- $V_{ds(fet)}$ Drain Source Voltage FET *(Volt)*
- $V_{ds\text{-}off(fet)}$ Pinch OFF Drain Source Voltage FET *(Volt)*
- $V_{gd(fet)}$ Gate to Drain Voltage FET *(Volt)*
- $V_{j1(igbt)}$ Voltage Pn Junction 1 (IGBT) *(Volt)*
- $V_{knee(triac)}$ Knee Voltage TRIAC *(Volt)*
- $V_{off(fet)}$ Pinch OFF Voltage *(Volt)*
- $V_{ON(igbt)}$ Voltage Drop ON Stage (IGBT) *(Volt)*
- $\theta_{j\text{-}c(igbt)}$ Junction to Case Angle (IGBT) *(Degree)*
- $\Psi_{0(fet)}$ Surface Potential FET *(Volt)*

Constants, Functions, Measurements used

- Constant: **pi**, 3.14159265358979323846264338327950288
  Archimedes' constant
- Function: **sqrt**, sqrt(Number)
  A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- Measurement: **Time** in Second (s)
  Time Unit Conversion
- Measurement: **Electric Current** in Milliampere (mA)
  Electric Current Unit Conversion
- Measurement: **Temperature** in Celsius (°C)
  Temperature Unit Conversion
- Measurement: **Electric Charge** in Coulomb (C)
  Electric Charge Unit Conversion
- Measurement: **Power** in Watt (W), Milliwatt (mW)
  Power Unit Conversion
- Measurement: **Angle** in Degree (°)
  Angle Unit Conversion
- Measurement: **Capacitance** in Farad (F)
  Capacitance Unit Conversion
- Measurement: **Electric Resistance** in Kilohm (kΩ)
  Electric Resistance Unit Conversion
- Measurement: **Electric Conductance** in Millisiemens (mS)
  Electric Conductance Unit Conversion
- Measurement: **Electric Potential** in Volt (V)
  Electric Potential Unit Conversion

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