Important Advanced Transistor Devices Formulas PDF

Formulas
Examples
with Units

List of 20
Important Advanced Transistor Devices Formulas

1) FET Formulas

1.1) Drain Current of FET Formula

Evaluate Formula

Formula

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

Example with Units

$$0.3014\,\text{mA} = 0.69\,\text{mA} \cdot \left(1 - \frac{4.8\,\text{V}}{2.89\,\text{V}}\right)^2$$

1.2) Drain Source Voltage of FET Formula

Evaluate Formula

Formula

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

Example with Units

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

1.3) Gate Drain Capacitance of FET Formula

Evaluate Formula

Formula

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

Example with Units

$$6.4756\,\text{F} = \frac{6.47\,\text{s}}{\left(1 - \frac{0.0128\,\text{V}}{4.976\,\text{V}}\right)^{\frac{1}{3}}}$$

1.4) Gate Source Capacitance of FET Formula

Evaluate Formula

Formula

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

Example with Units

$$6.8057\,\text{F} = \frac{2.234\,\text{s}}{\left(1 - \left(\frac{4.8\,\text{V}}{4.976\,\text{V}}\right)\right)^{\frac{1}{3}}}$$

1.5) Ohmic Region Drain Current of FET Formula

Evaluate Formula

Formula

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

Example with Units

$$0.3055\,\text{mA} = 0.24\,\text{mS} \cdot \left(4.8\,\text{V} + \frac{3}{2} \cdot \frac{\left(4.976\,\text{V} + 4.8\,\text{V} - 4.8\,\text{V} \right)^{\frac{3}{2}} - \left(4.976\,\text{V} + 4.8\,\text{V} \right)^{\frac{3}{2}}}{\left(4.976\,\text{V} + 63.56\,\text{V} \right)^{\frac{1}{2}}} \right)$$

1.6) Pinch off Voltage of FET Formula

Evaluate Formula

Formula

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

Example with Units

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

1.7) Transconductance of FET Formula

Evaluate Formula

Formula

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

Example with Units

$$0.0201\,\text{mS} = \frac{2 \cdot 0.69\,\text{mA}}{63.56\,\text{V}} \cdot \left(1 - \frac{4.8\,\text{V}}{63.56\,\text{V}} \right)$$

1.8) Voltage Gain of FET Formula

Evaluate Formula

Formula

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

Example with Units

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

2) IGBT Formulas

2.1) Breakdown Voltage of Forward Biased of IGBT Formula

Evaluate Formula

Formula

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

Example with Units

$$37.5363\,\text{V} = \frac{5.34 \cdot 10^{13}}{\left(16e15\,\text{C} \right)^{\frac{3}{4}}}$$

2.2) Emitter Current of IGBT Formula

Evaluate Formula

Formula

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

Example with Units

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

2.3) IGBT Turn OFF Time Formula

Evaluate Formula

Formula

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

Example with Units

$$3.472\,s = 1.15\,s + 1.67\,s + 0.652\,s$$

2.4) Input Capacitance of IGBT Formula

Evaluate Formula

Formula

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

Example with Units

$$5.76\,F = 0.21\,F + 5.55\,F$$

2.5) Maximum Power Dissipation in IGBT Formula

Evaluate Formula

Formula

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

Example with Units

$$110.2597\,W = \frac{283\,°C}{289\,°}$$

2.6) Nominal Continuous Collector Current of IGBT Formula

Evaluate Formula

Formula

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

Example with Units

$$1.6916\,mA = \frac{-21.56\,V + \sqrt{\left(21.56\,V\right)^2 + 4 \cdot 12.546\,k\Omega \cdot \left(\frac{283\,°C - 250\,°C}{0.456\,k\Omega}\right)}}{2 \cdot 12.546\,k\Omega}$$

2.7) Saturation Voltage of IGBT Formula

Evaluate Formula

Formula

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

Example with Units

$$1222.25\,V = 2.15\,V + 105\,mA \cdot \left(1.03\,k\Omega + 10.59\,k\Omega\right)$$

2.8) Voltage Drop in IGBT in ON-State Formula

Evaluate Formula

Formula

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

Example with Units

$$20.2533\,V = 1.69\,mA \cdot 10.59\,k\Omega + 1.69\,mA \cdot 0.98\,k\Omega + 0.7\,V$$

3) TRIAC Formulas

3.1) Average Load Current of TRIAC Formula

Evaluate Formula

Formula

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

Example with Units

$$0.081\,\text{mA} = \frac{2 \cdot \sqrt{2} \cdot 0.09\,\text{mA}}{3.1416}$$

3.2) Maximum Junction Temperature of TRIAC Formula

Evaluate Formula

Formula

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

Example with Units

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

3.3) Power Dissipation of TRIAC Formula

Evaluate Formula

Formula

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

Example with Units

$$0.2942\,\text{mW} = 3.63\,\text{V} \cdot 0.081028\,\text{mA} + 0.0103\,\text{k}\Omega \cdot 0.09\,\text{mA}^{2}$$

3.4) RMS Load Current of TRIAC Formula

Evaluate Formula

Formula

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

Example with Units

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

Variables used in list of Advanced Transistor Devices Formulas above

- $A_{v(fet)}$ 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)*

Constants, Functions, Measurements used in list of Advanced Transistor Devices Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- Functions: **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*

- $R_{d(igbt)}$ 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)*
- $T_{gd-off(fet)}$ Gate Drain Capacitance Off Time FET *(Second)*
- $T_{gs-off(fet)}$ 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)*
- $V_{B-E(pnp)(igbt)}$ Base Emitter Voltage PNP IGBT *(Volt)*
- $V_{ce(igbt)}$ Total Voltage of Collector and Emitter (IGBT) *(Volt)*
- $V_{c-e(sat)(igbt)}$ Collector to Emitter Saturation Voltage (IGBT) *(Volt)*
- $V_{cut-off(fet)}$ Cutt-off Voltage FET *(Volt)*
- $V_{dd(fet)}$ Supply Voltage at Drain FET *(Volt)*
- $V_{ds(fet)}$ Drain Source Voltage FET *(Volt)*
- $V_{ds-off(fet)}$ 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)*

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