



Formulas Examples with Units

List of 17 Important CMOS Time Characteristics Formulas

1) Acceptable MTBF Formula

Formula

$$MTBF = \frac{1}{P_{fail}}$$

Example

$$2.5 = \frac{1}{0.4}$$

Evaluate Formula 

2) Aperture Time for Falling Input Formula

Formula

$$t_{af} = T_{setup0} + T_{hold1}$$

Example with Units

$$11.65\text{ ns} = 3.75\text{ ns} + 7.9\text{ ns}$$

Evaluate Formula 

3) Aperture Time for Rising Input Formula

Formula

$$t_{ar} = T_{setup1} + T_{hold0}$$

Example with Units

$$14\text{ ns} = 5\text{ ns} + 9\text{ ns}$$

Evaluate Formula 

4) Hold Time at High logic Formula

Formula

$$T_{hold1} = t_{af} - T_{setup0}$$

Example with Units

$$7.9\text{ ns} = 11.65\text{ ns} - 3.75\text{ ns}$$

Evaluate Formula 

5) Hold Time at Low logic Formula

Formula

$$T_{hold0} = t_{ar} - T_{setup1}$$

Example with Units

$$9\text{ ns} = 14\text{ ns} - 5\text{ ns}$$

Evaluate Formula 

6) Initial Voltage of Node A Formula

Formula

$$A_0 = V_m + a_0$$

Example with Units

$$18\text{ v} = 8\text{ v} + 10\text{ v}$$

Evaluate Formula 

7) Metastable Voltage Formula

Formula

$$V_m = A_0 - a_0$$

Example with Units

$$8\text{ v} = 18\text{ v} - 10\text{ v}$$

Evaluate Formula 



8) Phase Detector Average Voltage Formula

Formula

$$K_{pd} = \frac{i_{pd}}{\Phi_{err}}$$

Example with Units

$$3.08\text{v} = \frac{499.93\text{mA}}{9.30^\circ}$$

Evaluate Formula 

9) Probability of Synchronizer Failure Formula

Formula

$$P_{fail} = \frac{1}{MTBF}$$

Example

$$0.4 = \frac{1}{2.5}$$

Evaluate Formula 

10) Setup Time at High Logic Formula

Formula

$$T_{setup1} = t_{ar} - T_{hold0}$$

Example with Units

$$5\text{ns} = 14\text{ns} - 9\text{ns}$$

Evaluate Formula 

11) Setup Time at Low Logic Formula

Formula

$$T_{setup0} = t_{af} - T_{hold1}$$

Example with Units

$$3.75\text{ns} = 11.65\text{ns} - 7.9\text{ns}$$

Evaluate Formula 

12) Small Signal Offset Voltage Formula

Formula

$$a_0 = A_0 - V_m$$

Example with Units

$$10\text{v} = 18\text{v} - 8\text{v}$$

Evaluate Formula 

13) XOR Phase Detector Current Formula

Formula

$$i_{pd} = \Phi_{err} \cdot K_{pd}$$

Example with Units

$$499.9321\text{mA} = 9.30^\circ \cdot 3.08\text{v}$$

Evaluate Formula 

14) XOR Phase Detector Phase Formula

Formula

$$\Phi_{err} = \frac{V_{pd}}{K_{pd}}$$

Example with Units

$$9.3013^\circ = \frac{0.50\text{v}}{3.08\text{v}}$$

Evaluate Formula 

15) XOR Phase Detector Phase with reference to Detector Current Formula

Formula

$$\Phi_{err} = \frac{i_{pd}}{K_{pd}}$$

Example with Units

$$9.3^\circ = \frac{499.93\text{mA}}{3.08\text{v}}$$

Evaluate Formula 



16) XOR Phase Detector Voltage Formula

Formula

$$V_{pd} = \Phi_{err} \cdot K_{pd}$$

Example with Units

$$0.4999\text{v} = 9.30^\circ \cdot 3.08\text{v}$$

Evaluate Formula 

17) XOR Voltage NAND Gate Formula

Formula

$$V_x = \frac{C_y \cdot V_{bc}}{C_x + C_y}$$

Example with Units

$$0.882\text{v} = \frac{3.1\text{mF} \cdot 2.02\text{v}}{4\text{mF} + 3.1\text{mF}}$$

Evaluate Formula 



Variables used in list of CMOS Time Characteristics Formulas above









- a_0 Small Signal Offset Voltage (Volt)
- A_0 Initial Node Voltage (Volt)
- C_x Capacitance 1 (Millifarad)
- C_y Capacitance 2 (Millifarad)
- i_{pd} XOR Phase Detector Current (Milliampere)
- K_{pd} XOR Phase Detector Average Voltage (Volt)
- **MTBF** Acceptable MTBF
- P_{fail} Probability of Synchronizer Failure
- t_{af} Aperture Time for Falling Input (Nanosecond)
- t_{ar} Aperture Time for Rising Input (Nanosecond)
- T_{hold0} Hold Time at Low Logic (Nanosecond)
- T_{hold1} Hold Time at High Logic (Nanosecond)
- T_{setup0} Setup Time at Low Logic (Nanosecond)
- T_{setup1} Setup Time at High Logic (Nanosecond)
- V_{bc} Base Collector Voltage (Volt)
- V_m Metastable Voltage (Volt)
- V_{pd} XOR Phase Detector Voltage (Volt)
- V_x XOR Voltage Nand Gate (Volt)
- Φ_{err} XOR Phase Detector Phase (Degree)

Constants, Functions, Measurements used in list of CMOS Time Characteristics Formulas above

- **Measurement: Time** in Nanosecond (ns)
Time Unit Conversion ↻
- **Measurement: Electric Current** in Milliampere (mA)
Electric Current Unit Conversion ↻
- **Measurement: Angle** in Degree (°)
Angle Unit Conversion ↻
- **Measurement: Capacitance** in Millifarad (mF)
Capacitance Unit Conversion ↻
- **Measurement: Electric Potential** in Volt (V)
Electric Potential Unit Conversion ↻



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