

RC Mismatch: Monte-Carlo Simulation

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I. GENERAL APPROACH

For this activity, a .MEAS command is used to get t_d . The SPICE software outputs a file that contains all values t_d of each run. Python is then used for the statistical processing of the obtained data.

II. NETLIST

```
.title RC Mismatch
*edited spice file from sir Louis Alarcon

.options savecurrents seed=random

* Polysilicon resistor models
.model rpoly_n R rsh=100 tcl=-800u tnom=27C
.model rpoly_p R rsh=180 tcl=200u tnom=27C

* MOM capacitor model
.model cmom C cj=50m tcl=30u tnom=27C
.model cmsub C cj=30m tcl=25u tnom=27C

* Capacitor with bottom-plate parasitic capacitance
.subckt cm top bottom sub w=1000u l=2000u
C1          top bottom      cmom w={w} l={l}
Csub        bottom sub      cmsub w={w} l={l}
.ends

R1           in out          rpoly_n w=2u l=20u
X1           out 0 0          cm w=1000u l=2000u

Vs           in 0             pulse(0 1)

.control

let mc_runs = 1000
let run = 1

define gauss(nom, var) (nom + nom*var * sgauss(0))

dowhile run <= mc_runs

* mismatch
alter @R1[l] = gauss(20u, 0.01)
alter @R1[w] = gauss(2u, 0.01)

let l1 = gauss(2000u, 0.01)
alter @c.x1.cl[l] = l1
alter @c.x1.csub[l] = l1

let l2 = gauss(1000u, 0.01)
alter @c.x1.cl[w] = l2
alter @c.x1.csub[w] = l2

* process
altermod @rpoly_n[rsh] = gauss(100, 0.01)
altermod @cmom[cj] = gauss(50m, 0.01)
altermod @cmsub[cj] = gauss(30m, 0.01)
```

```
tran 10u 1m
echo {$run}
meas TRAN t_d FIND time WHEN v(out) = 0.5

let R1 = @r1[r]
let C1 = @c.x1.cl[cap]
set run = "$&run"

echo {$t_d} >> mc_RC.dat

let run = run + 1

end
.endc

.end
```

III. PYTHON SCRIPT

```
import numpy as np
import matplotlib.pyplot as plt
import statistics as stat

td = np.loadtxt('mc_RC.dat')
mean = np.mean(td)
std = stat.stdev(td)

mu = np.format_float_scientific(mean, precision=3)
sigma = np.format_float_scientific(std, precision=3)

plt.hist(td, bins=20, rwidth=0.85)
plt.title(f'$t_d$ ($\mu$={mu}, $\sigma$={sigma})')
plt.xlabel('Time Delay [s]')
plt.ylabel('Occurrence')
plt.grid(linestyle='--')
plt.show()
```

IV. HISTOGRAM

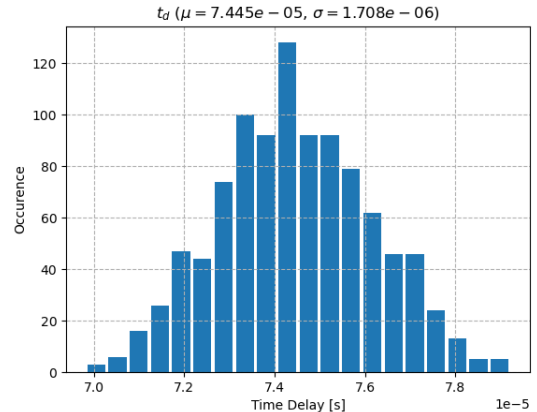


Fig. 1. Generated histogram, $N = 1000$