

# A Brief Tutorial on Design of Experiments (DOE)

Agilent EEsof EDA  
MMIC Design



# DOE – A Brief Tutorial

Start by choosing variables that affect the response

Choose three variables with their +1 and -1:

Width of lines (W)

$$W = W_{\text{nom}} \pm .5 \text{ um}$$

Resistors (R)

$$R = R_{\text{nom}} \pm 5\%$$

Capacitors (C)

$$C = C_{\text{nom}} \pm 5\%$$

Example: For W

- 1 corresponds to 9.5 um
- +1 corresponds to 10.5 um
- 0 corresponds to nominal value, 10um

# Perform 8 Simulations (all combinations)

## Total # of experiments is $2^3=8$

W	R	C	Gain
0	0	0	13.80
-1	-1	-1	12.85
1	-1	-1	13.01
-1	1	-1	14.52
1	1	-1	14.71
-1	-1	1	12.93
1	-1	1	13.09
-1	1	1	14.61
1	1	1	14.81

# of variables

nominal Gain

# Main Effect of Capacitors, C on Gain

W	R	C	Gain
-1	-1	-1	12.85
1	-1	-1	13.01
-1	1	-1	14.52
1	1	-1	14.71
-1	-1	1	12.93
1	-1	1	13.09
-1	1	1	14.61
1	1	1	14.81

Average gain for C=-1  
13.7725 dB (yellow)

Average gain for C=1  
13.86 dB (blue)

Slope= .044

# Main Effect of Resistors, R on Gain

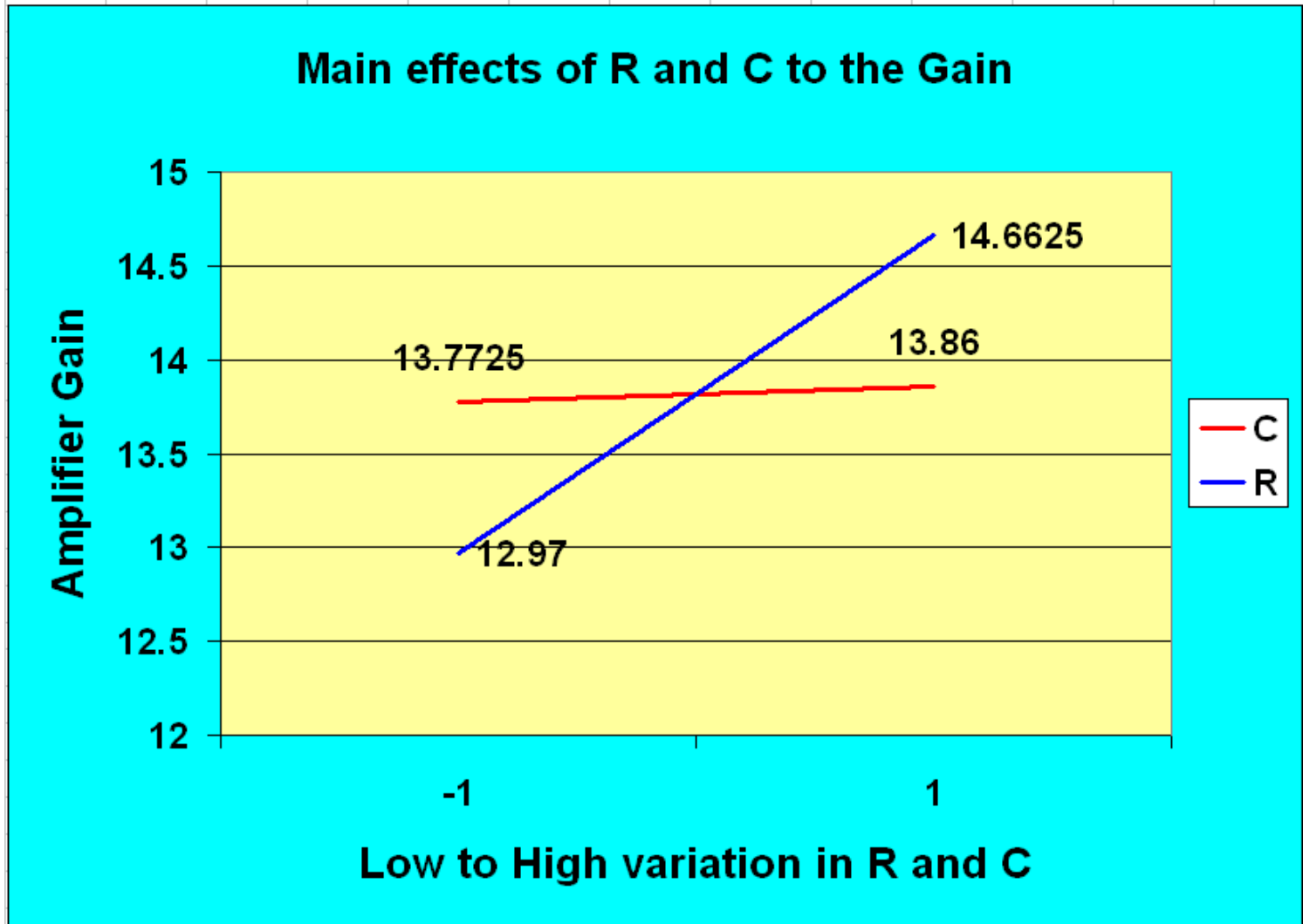
W	R	C	Gain
-1	-1	-1	12.85
1	-1	-1	13.01
-1	1	-1	14.52
1	1	-1	14.71
-1	-1	1	12.93
1	-1	1	13.09
-1	1	1	14.61
1	1	1	14.81

Average gain for R=-1  
12.97 dB (blue)

Average gain for R=1  
14.6625 dB (green)

Slope = .85

# Plotting Main Effects of C and R





# Interaction Effect of (W and R) on Gain

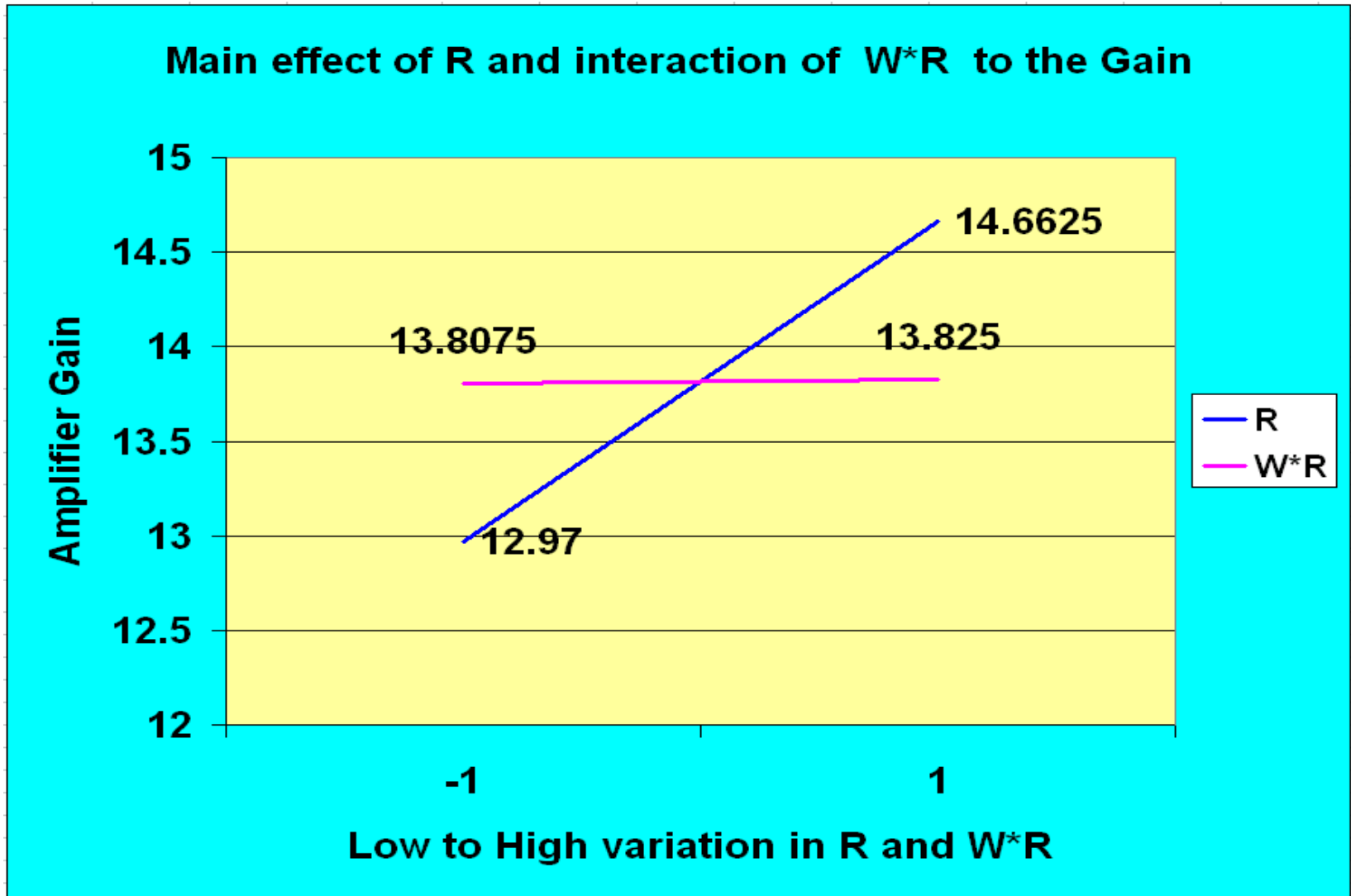
W	R	C	Gain
-1	-1	-1	12.85
1	-1	-1	13.01
-1	1	-1	14.52
1	1	-1	14.71
-1	-1	1	12.93
1	-1	1	13.09
-1	1	1	14.61
1	1	1	14.81

Average gain for  $W \cdot R = -1$   
13.8075 dB (blue)

Average gain for  $W \cdot R = 1$   
13.825 dB (pink)

Slope = .0088

# Plotting Interaction Effects of W and R







# Obtaining the Rest of the Coefficients

<u>Term</u>	<u>Coefficient</u>
Constant (nominal gain)	13.8
W	.09
R	.85
C	.044
W*R	.0088
W*C	.0013
R*C	.0050
W*R*C	0.0025

We calculated these three coefficients in the previous slides



Construct a linear equation to represent the experiment results.

$$\text{Gain} = 13.8 + .09W + .85R + .044C + .0088WR + \dots \text{etc.}$$

# Display All Effects on a Pareto Chart

