Sampler Circuit for Microwave In-Room Communications

Presented by

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Fachgebiet

Hochfrequenztechnik

an der

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Outline

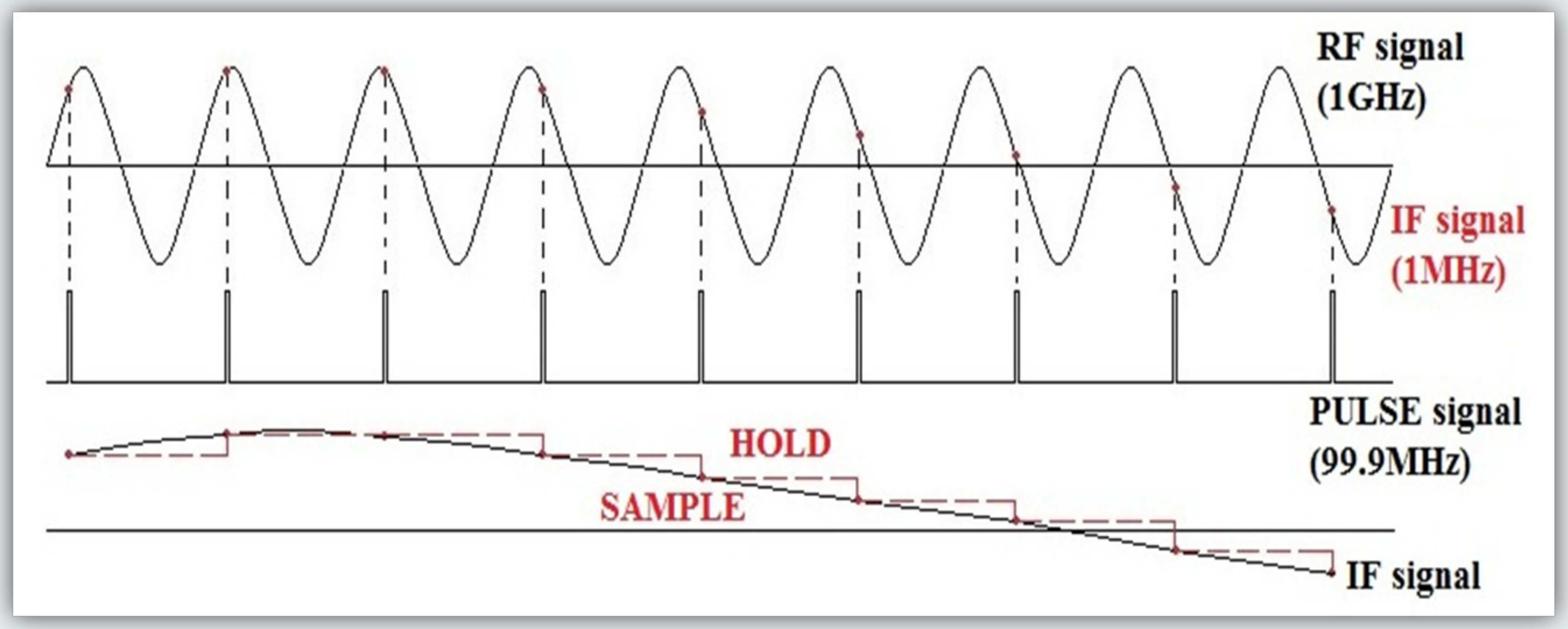
- Motivation
- Sampling
- Circuit Analysis
- Design Analysis
- Measurement Result

Motivation

- **To design a sampler circuit**
  - RF signals with frequency range of 1GHz to 4GHz
  - Harmonic sampling with low sampling frequency
  - SMD components

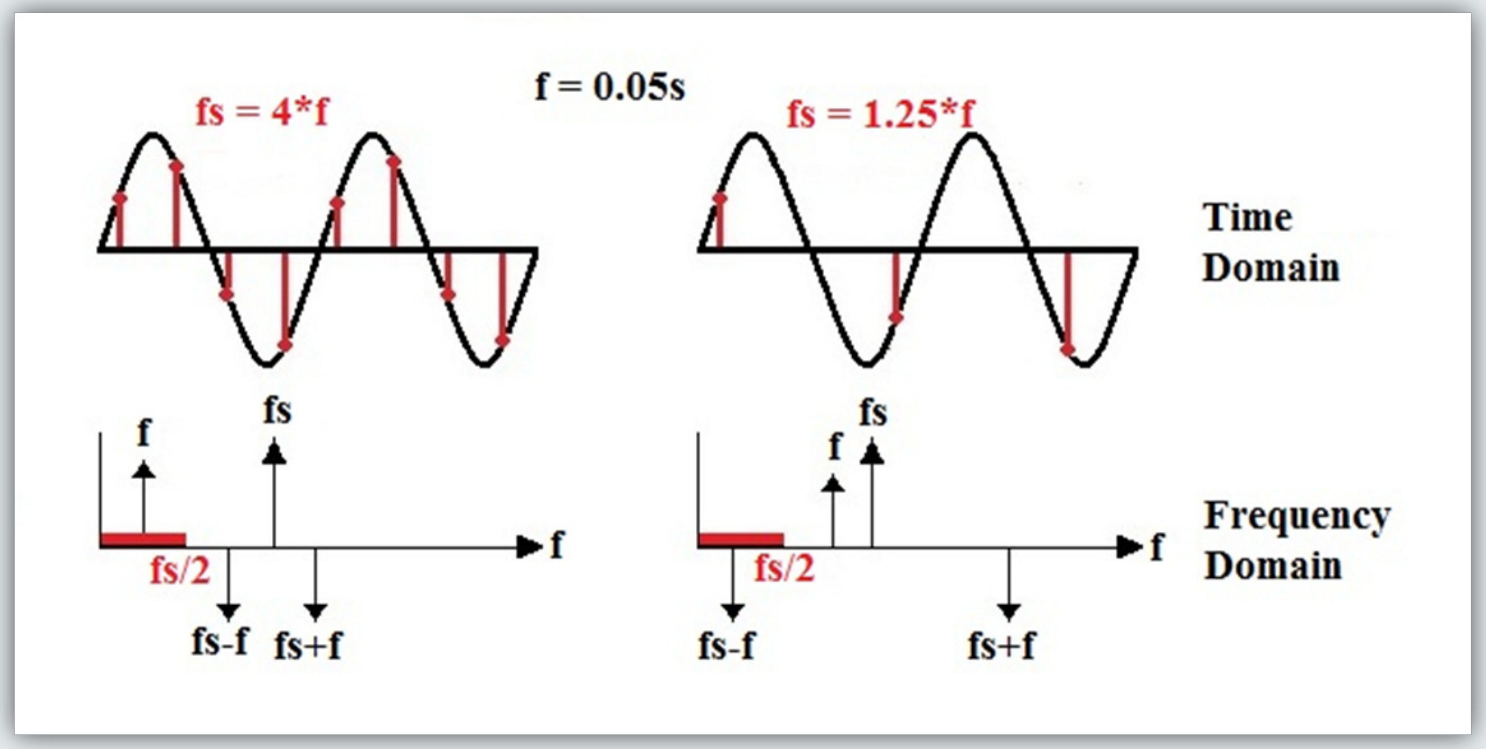
Sampling

- **What is sampling?**
  - Process of taking sample of an analog signal periodically

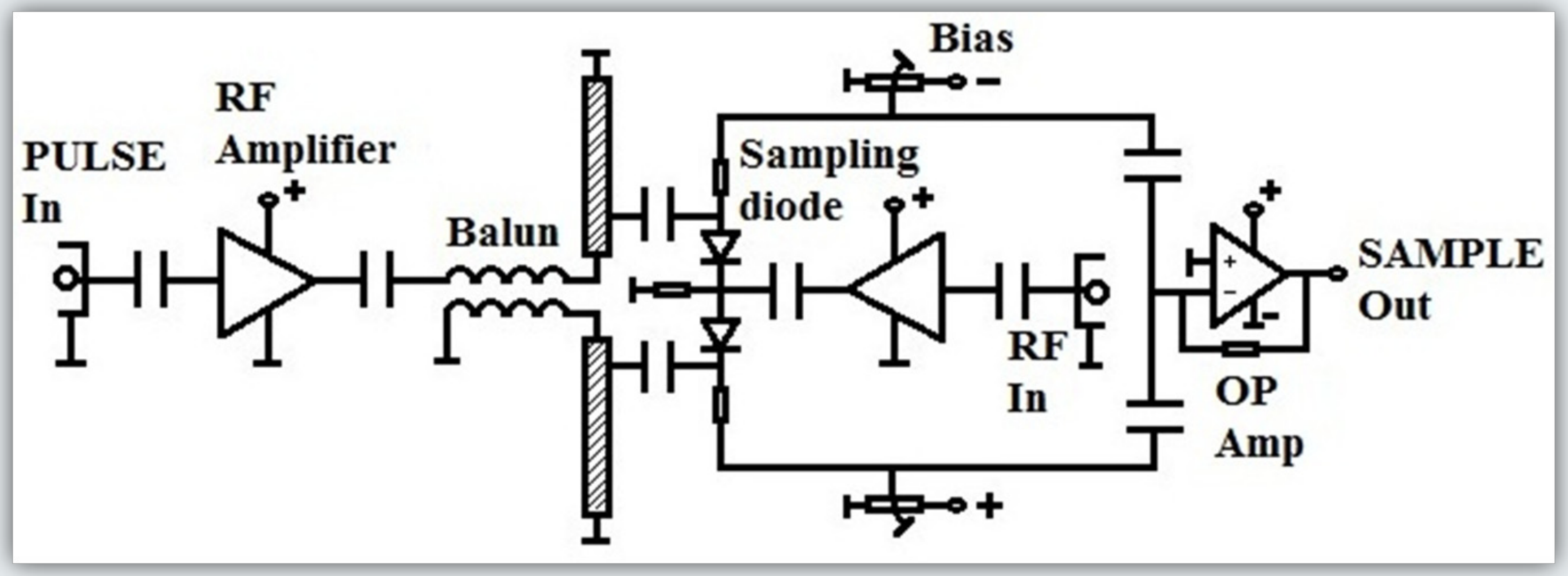


- **Rules of sampling**
  - Shannon's Information Theorem
  - Nyquist's Criteria

$$F_s \geq 2 * B$$



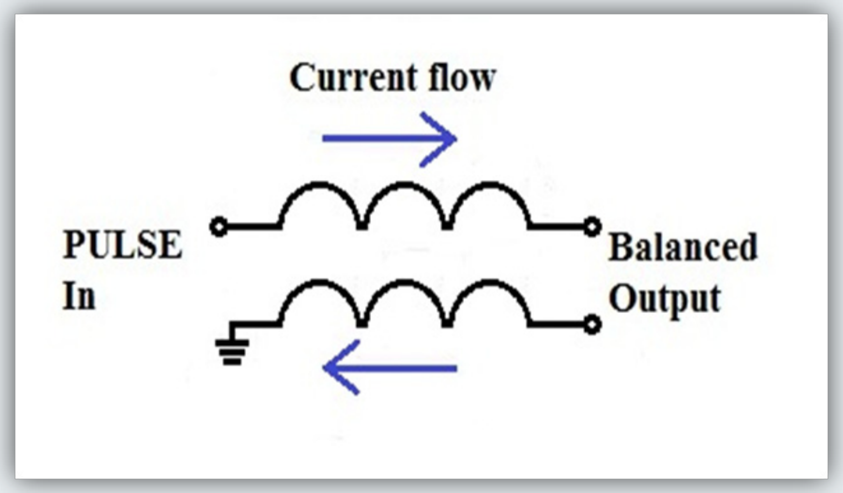
Circuit Analysis



- **Signal Generator**
  - DC Blocking

$$Xc = \frac{1}{2\pi f C}$$

  - Balanced Pulse Signals



  - Pulse Shaping

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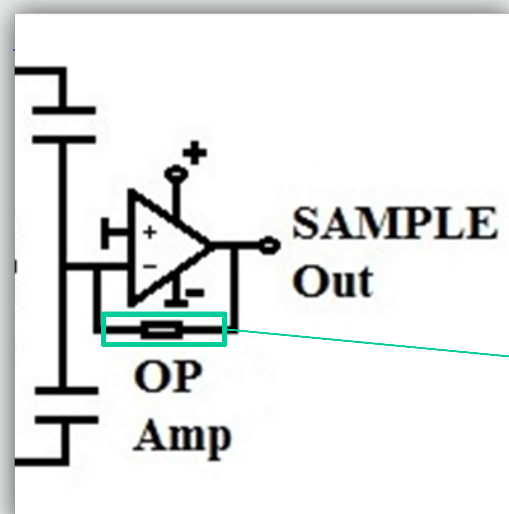
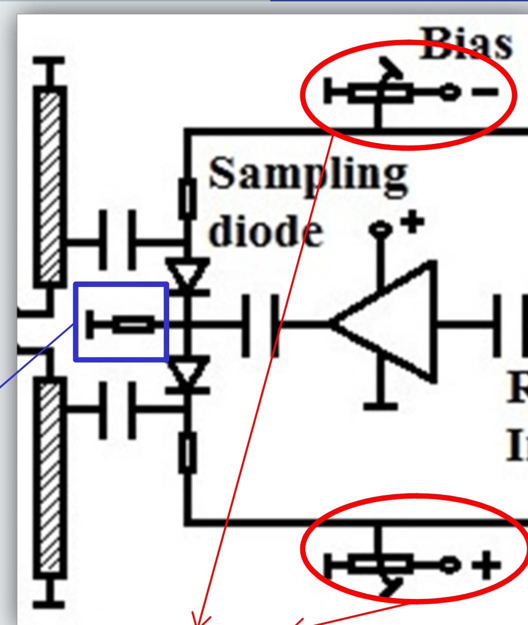
- **Two-diode Sampling Gate**
  - Switches
  - Balanced configuration

- **Operational Amplifier**
  - Isolation



Feedback resistor

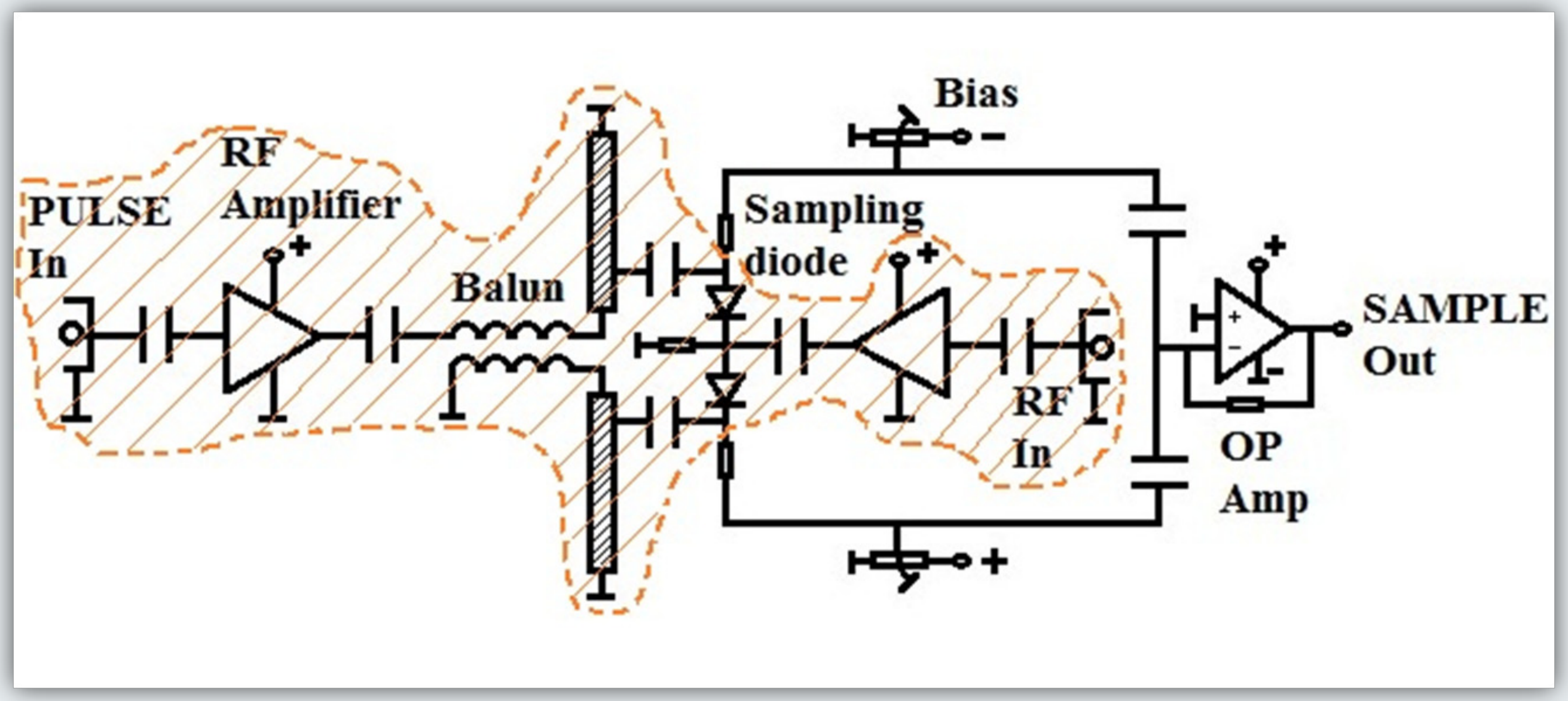


50ohm matching impedance

DC voltage applied to back bias the diode

Design Analysis

- **Transmission Line**



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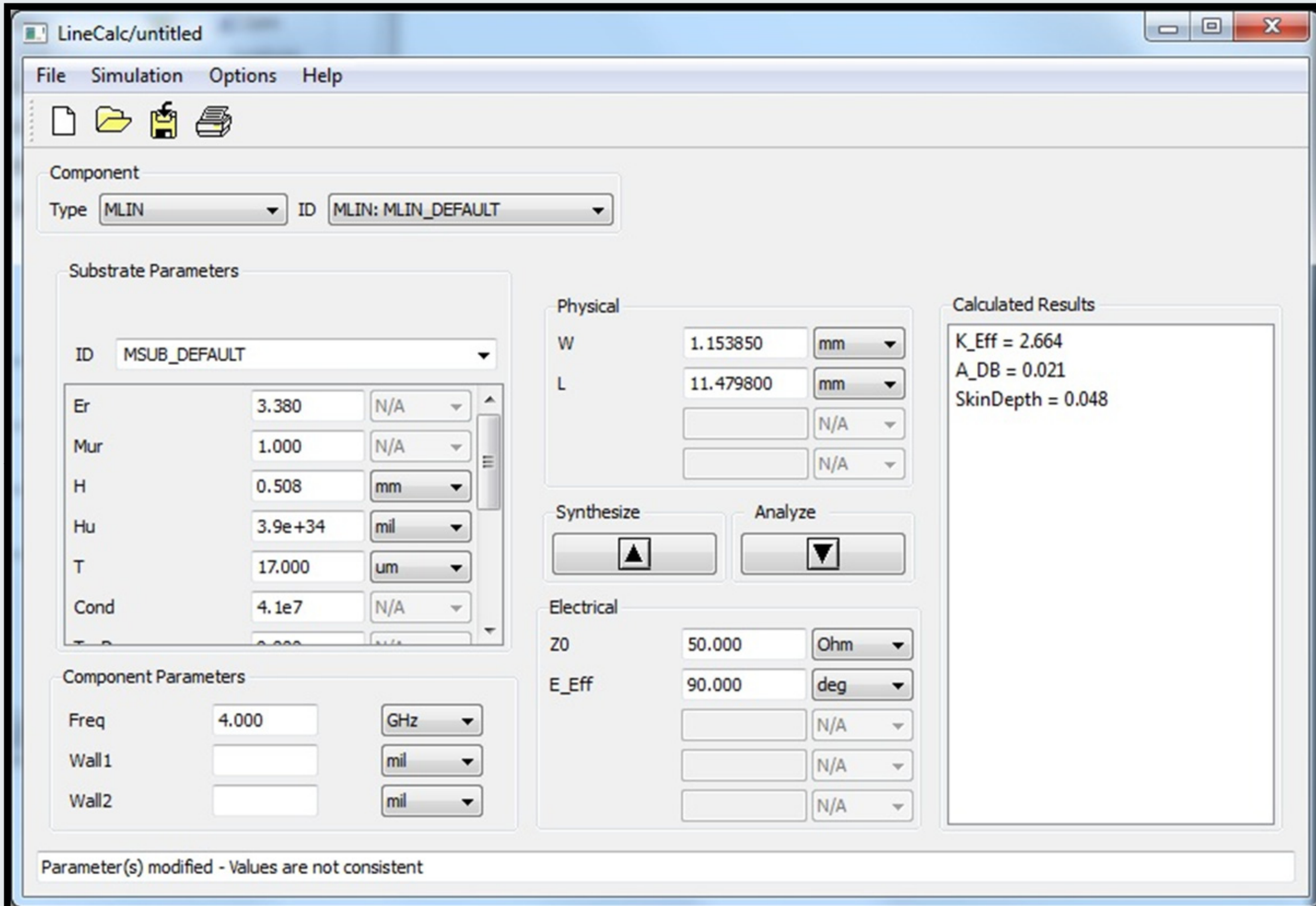
LineCalc/untitled
File Simulation Options Help
Component
Type MLIN
ID MLIN: MLIN_DEFAULT
Substrate Parameters
ID MSUB_DEFAULT
Er 3.380 N/A
Mur 1.000 N/A
H 0.508 mm
Hu 3.9e+34 mil
T 17.000 um
Cond 4.1e7 N/A
Component Parameters
Freq 4.000 GHz
Wall1 mil
Wall2 mil
Physical
W 1.153850 mm
L 11.479800 mm
Synthesize
Analyze
Electrical
Z0 50.000 Ohm
E_Eff 90.000 deg
Calculated Results
K_Eff = 2.664
A_DB = 0.021
SkinDepth = 0.048
Parameter(s) modified - Values are not consistent

- **SMD Components**
  - DC Blocking Capacitor
    - Resonant frequency – S-parameters
    - 0603
    - 100pF and 3.3pF
  - Microwave Amplifier
    - GALI-6+
    - Frequency range of DC to 4GHz
    - Gain of 10dB to 12.3dB
  - Balun
    - TC1-1-43+
    - Ratio 1:1
    - Operating frequency range of 650 to 4000MHz

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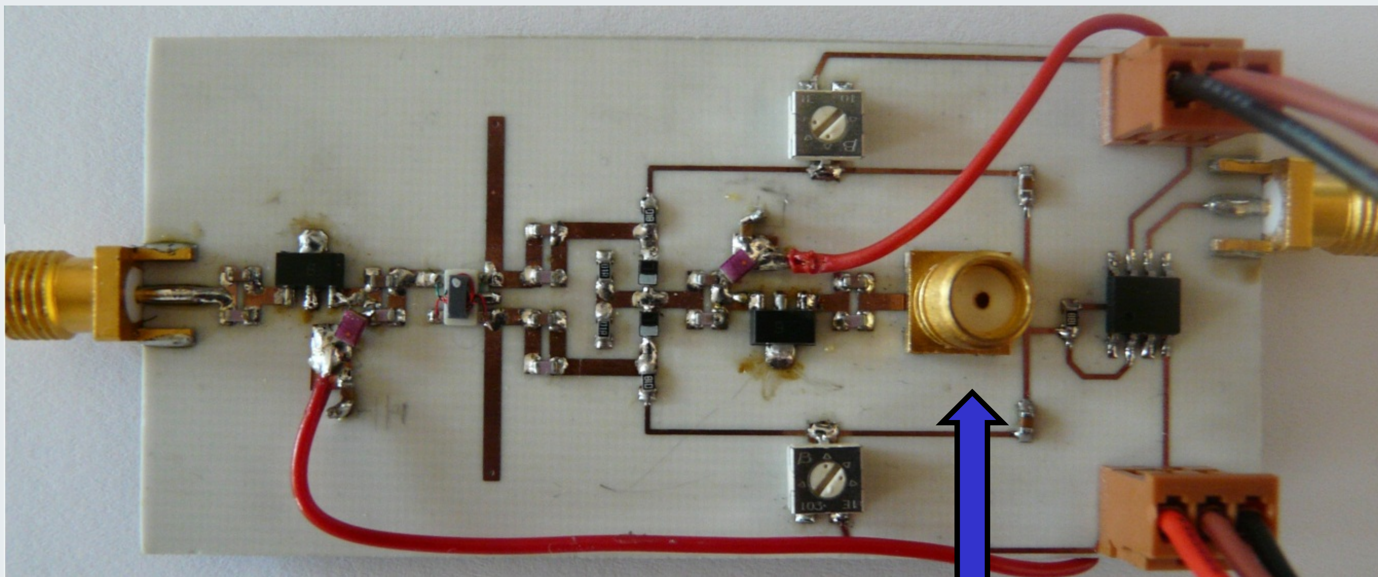
- Schottky Diode
  - Schottky diode BAT62-03W
  - Fast switching and low forward voltage drop
- Matching Impedance
  - 100Ohm
  - Resonant frequency
  - 0603
- High Pass Filter
  - RC filter
  - Block unused DC product
  - 1kOhm and 10nF
- Trimmer
  - 10kOhm
- Operational Amplifier
  - UA741
  - Feedback resistance = 1.5kOhm

Measurement Result

- **Setup**

Pulse signal (LO)



Output signal (IF)

RF signal

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Conversion Gain and Bandwidth

$$Conversion\ gain\ (dB) = IF\ power\ level\ (dBm) - RF\ power\ level\ (dBm)$$

Case	RF frequency, F	RF input power, P_{in}	IF frequency, F_{IF}	Sampling frequency, Fs
1	Fixed, 1GHz	Fixed, -10dBm	Varied	Varied
2	Varied	Fixed, -10dBm	Varied	Fixed, 250MHz
3	Fixed, 1GHz	Varied	Varied	Fixed, 250MHz

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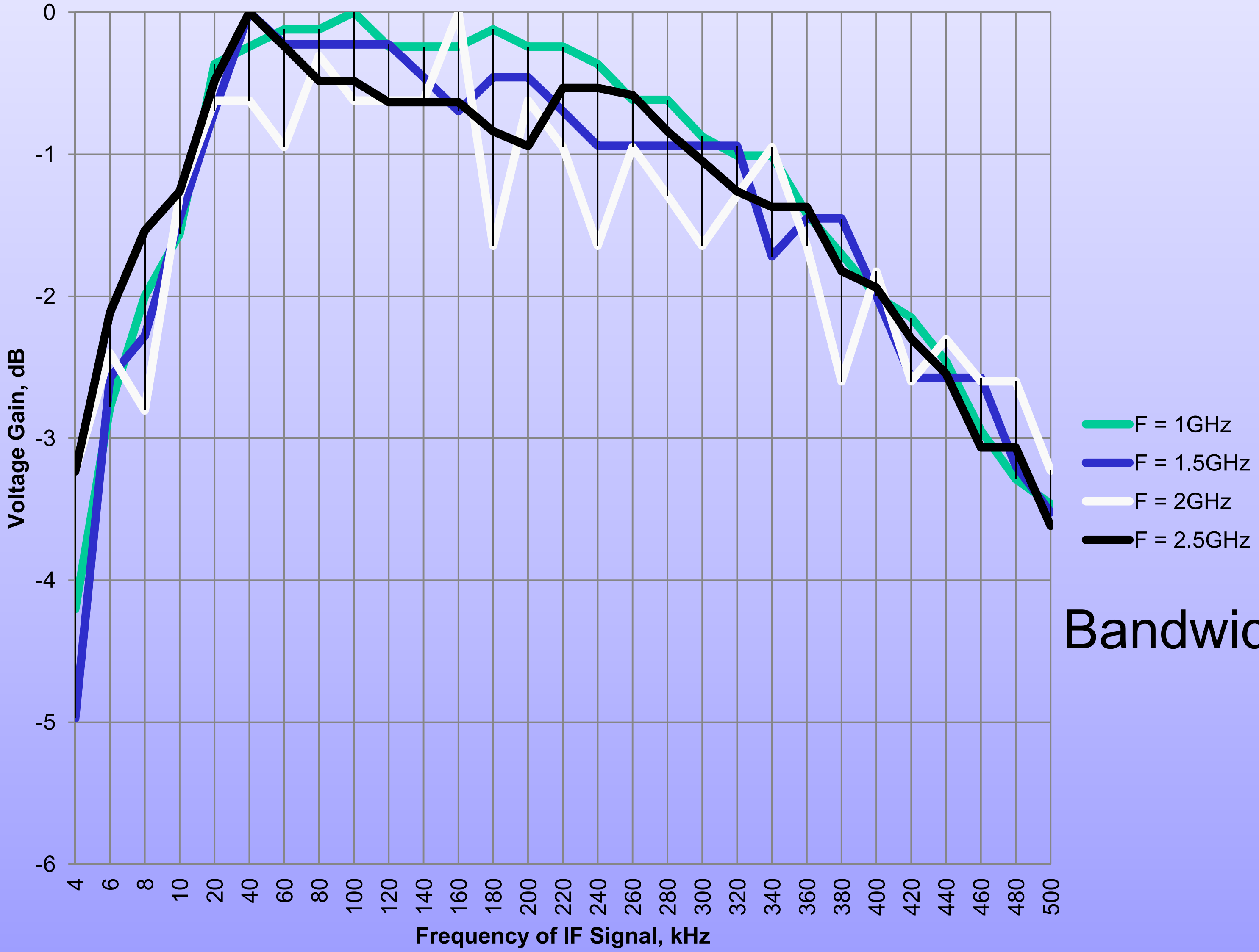

Bandwidth = 400kHz

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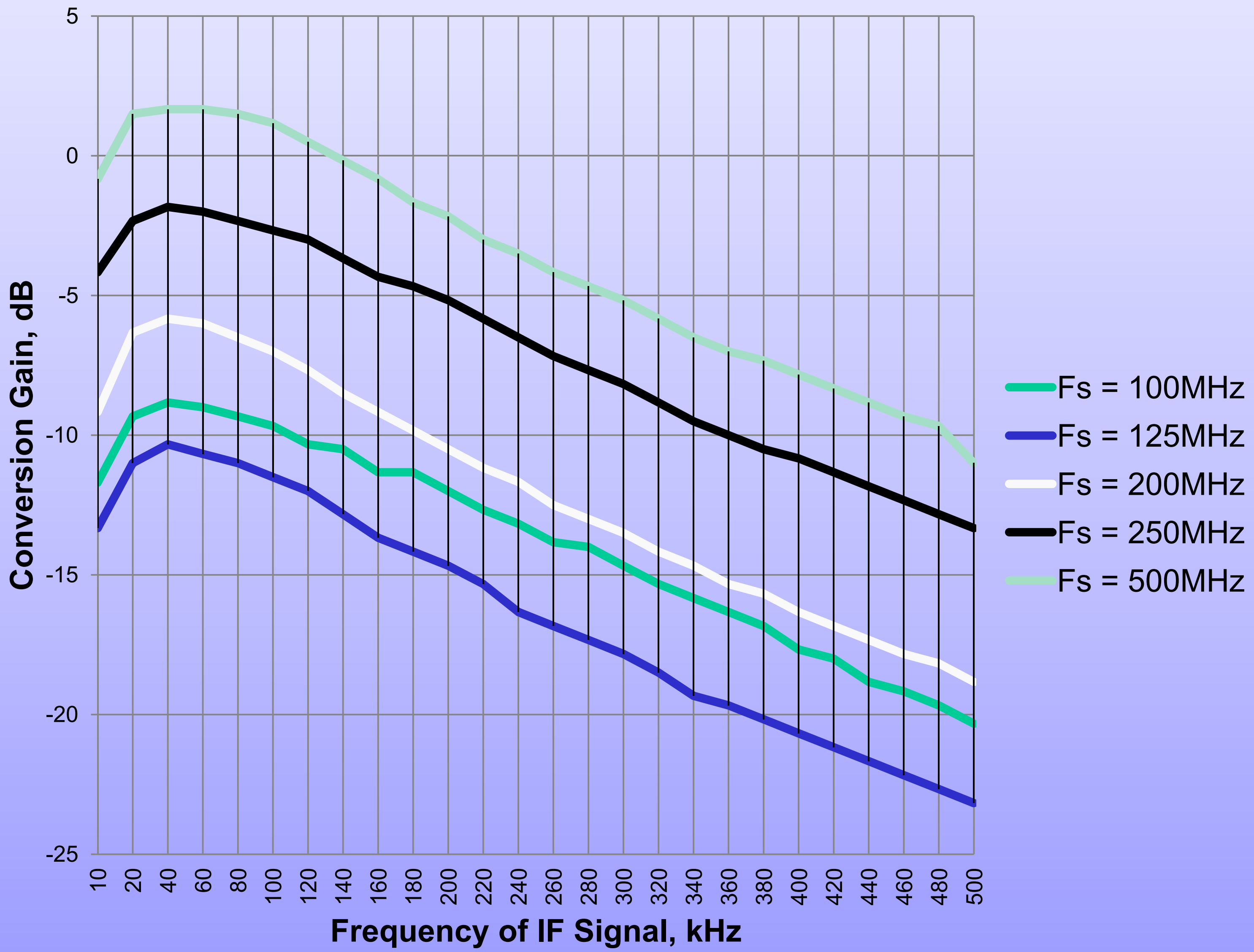
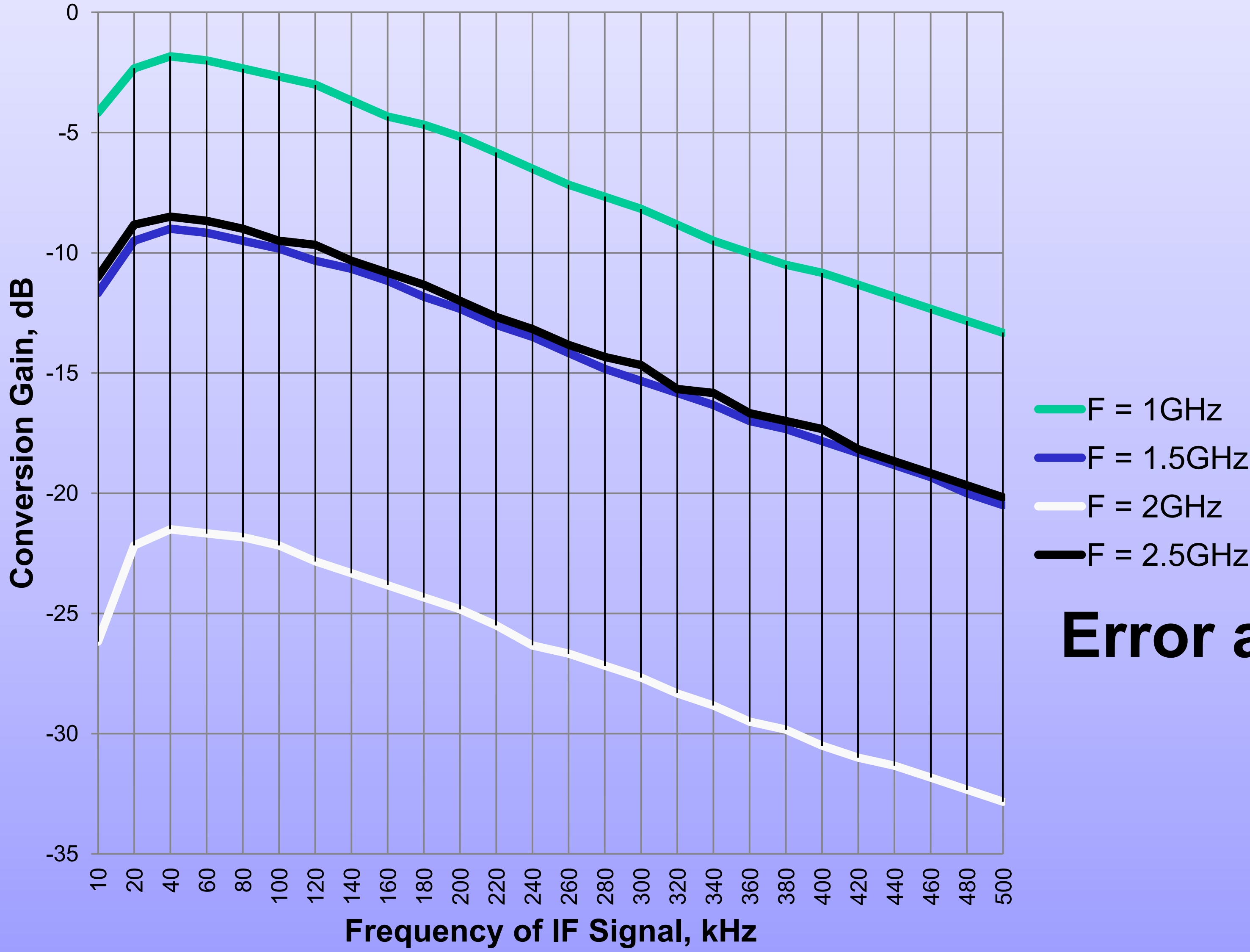
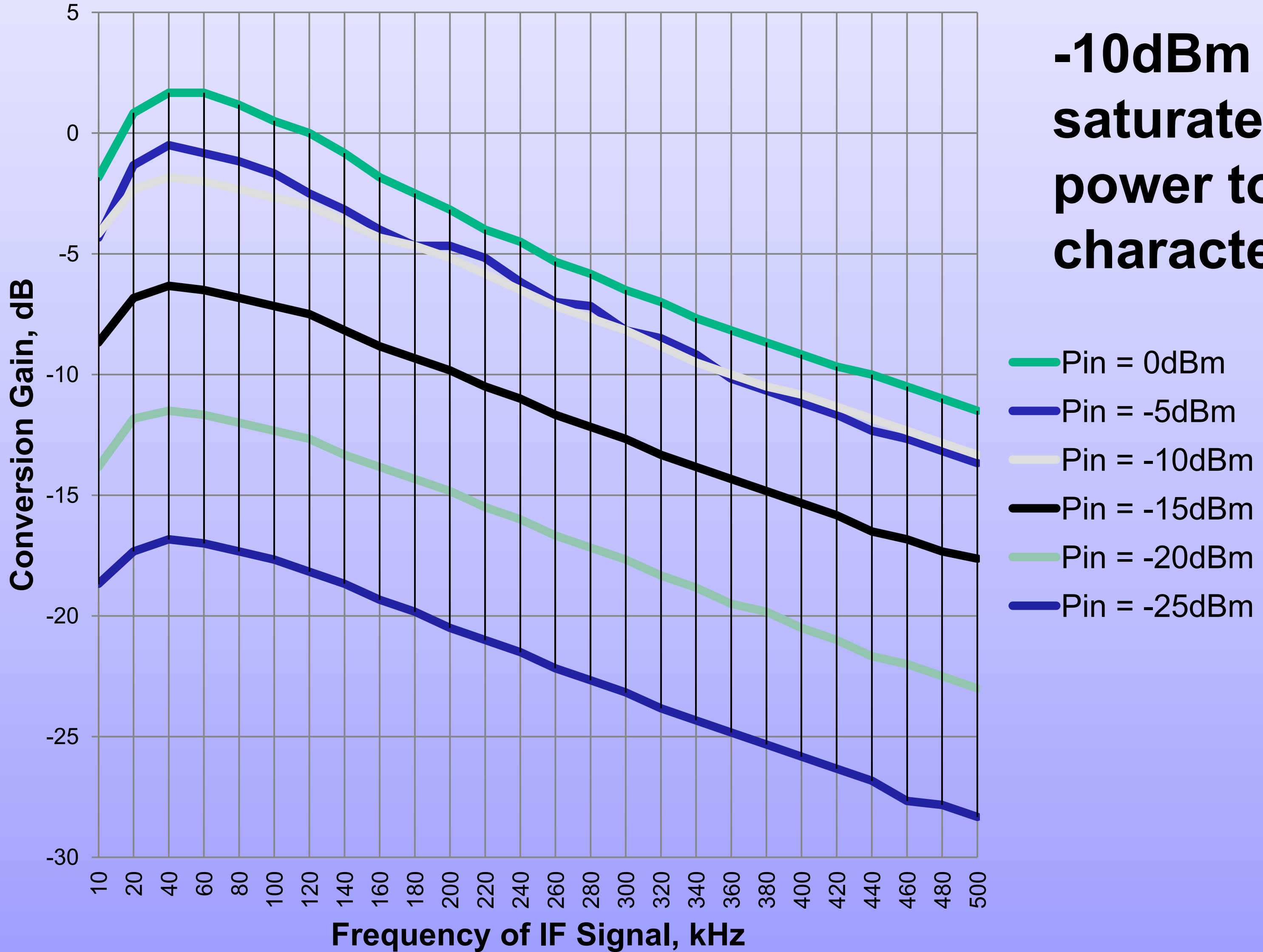

5
0
-5
-10
-15
-20
-25
Conversion Gain, dB
10
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
Frequency of IF Signal, kHz
Fs = 100MHz
Fs = 125MHz
Fs = 200MHz
Fs = 250MHz
Fs = 500MHz



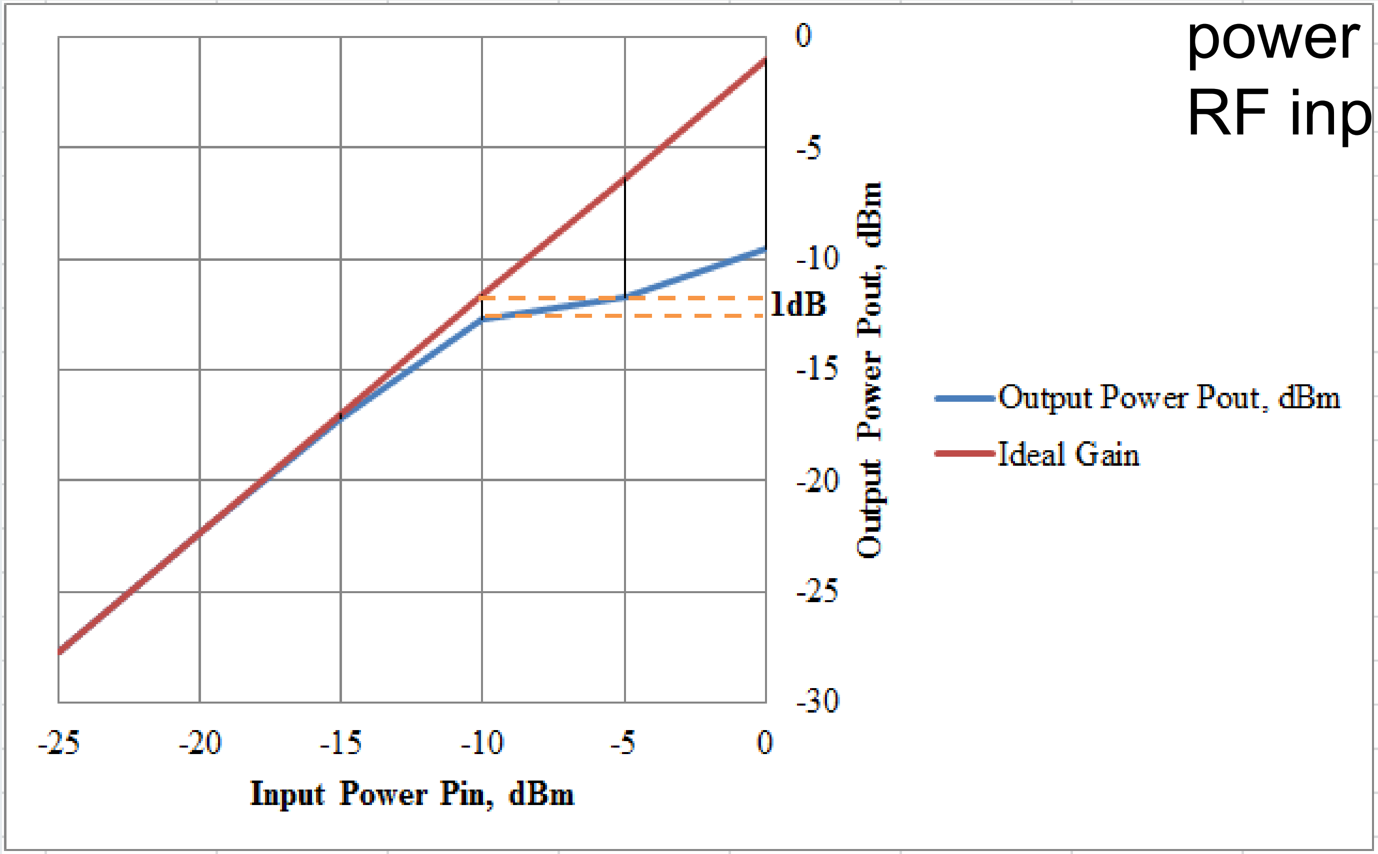
Error at 2GHz!!!



-10dBm is the saturated input power to have linear characteristic

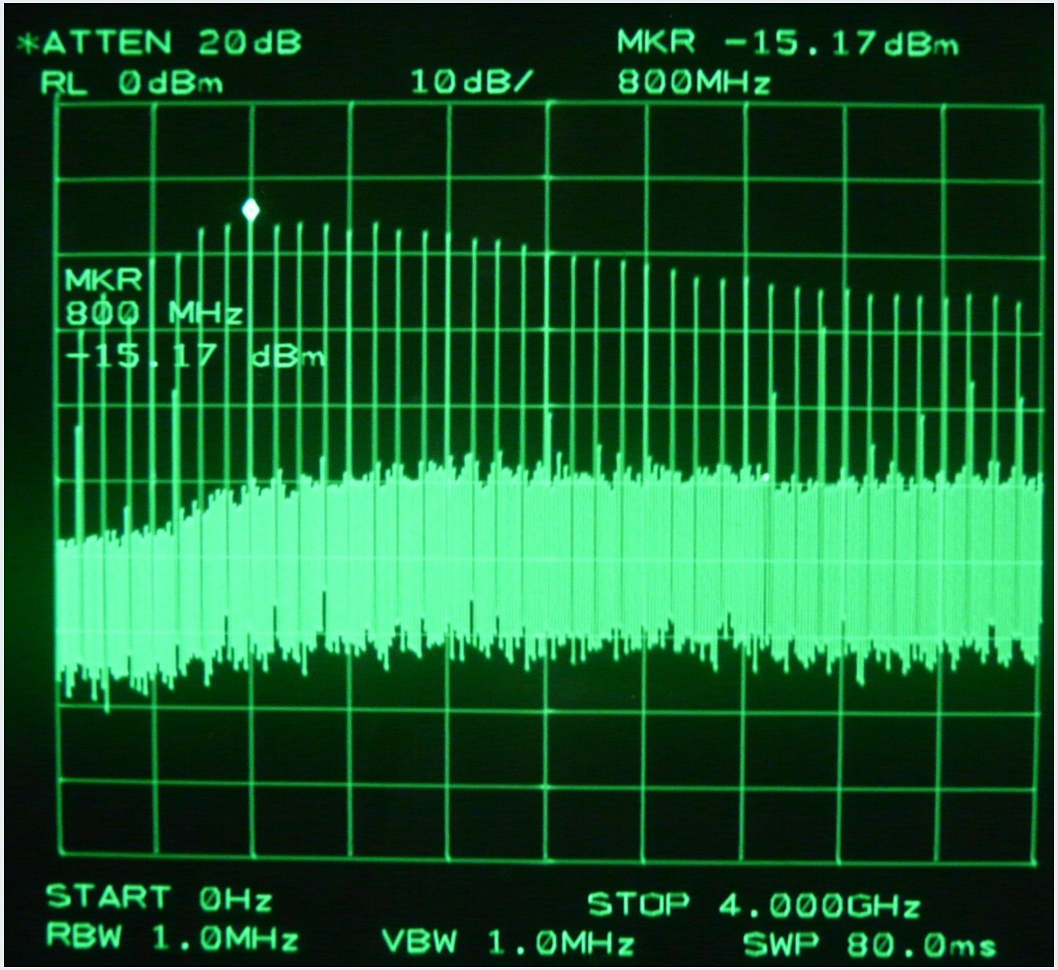
- **1dB Compression**

Indicates the upper limit of the power level of the RF input signal.



Amount of power leakage that leaks from one port to another

- **Isolation**
  - RF-LO isolation = 30dB
    - decreased with increasing sampling frequency
  - IF-LO isolation = 25dB
    - System imbalance



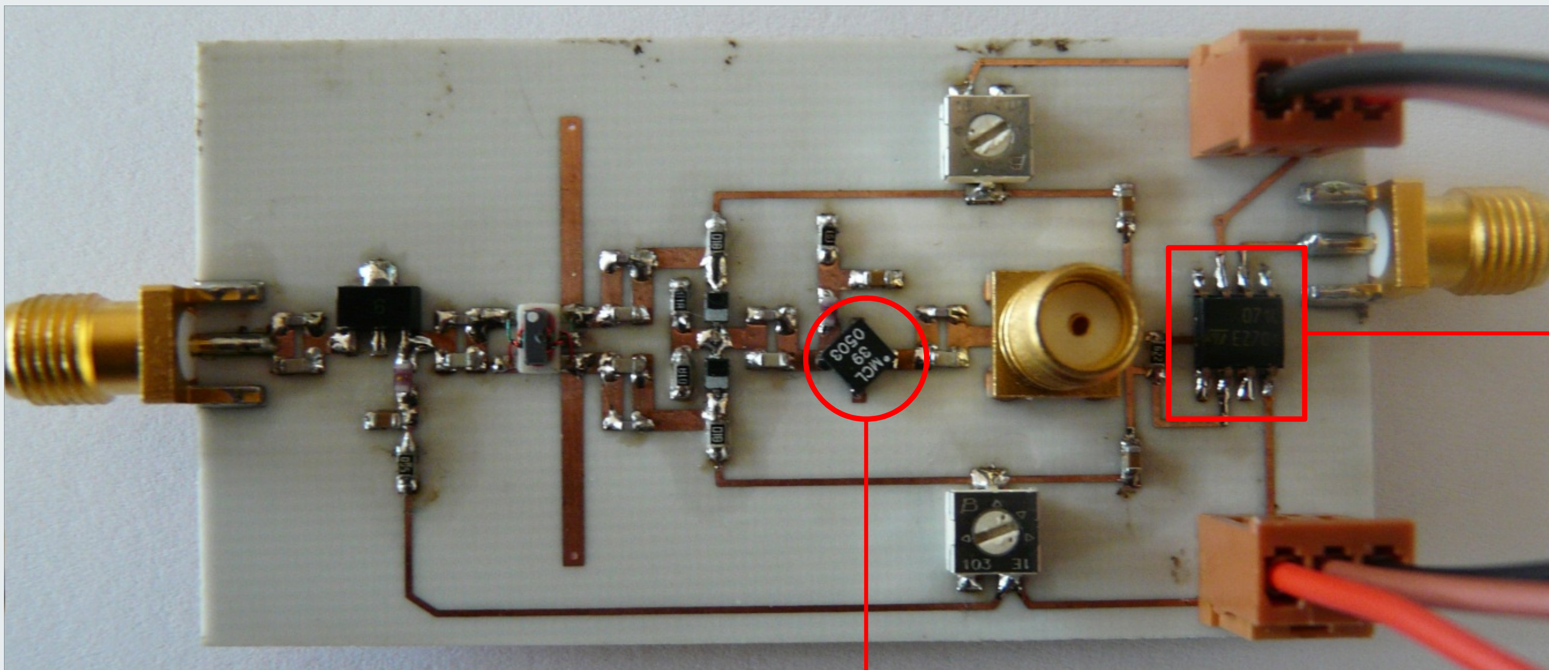
Frequency domain of pulse signals----uniform!

- **Noise Figure**

$$Noise\ Factor\ (F) = \frac{\frac{S_{in}}{kT_0B}}{\frac{S_{out}}{N_{out}}}$$

$\frac{S_{out}}{N_{in}}$	S_{in}	N_{in}	Noise figure, F
10dB	-57dBm	-124dBm	57dB
20dB	-77dBm	-124dBm	56dB

- **New Circuit**



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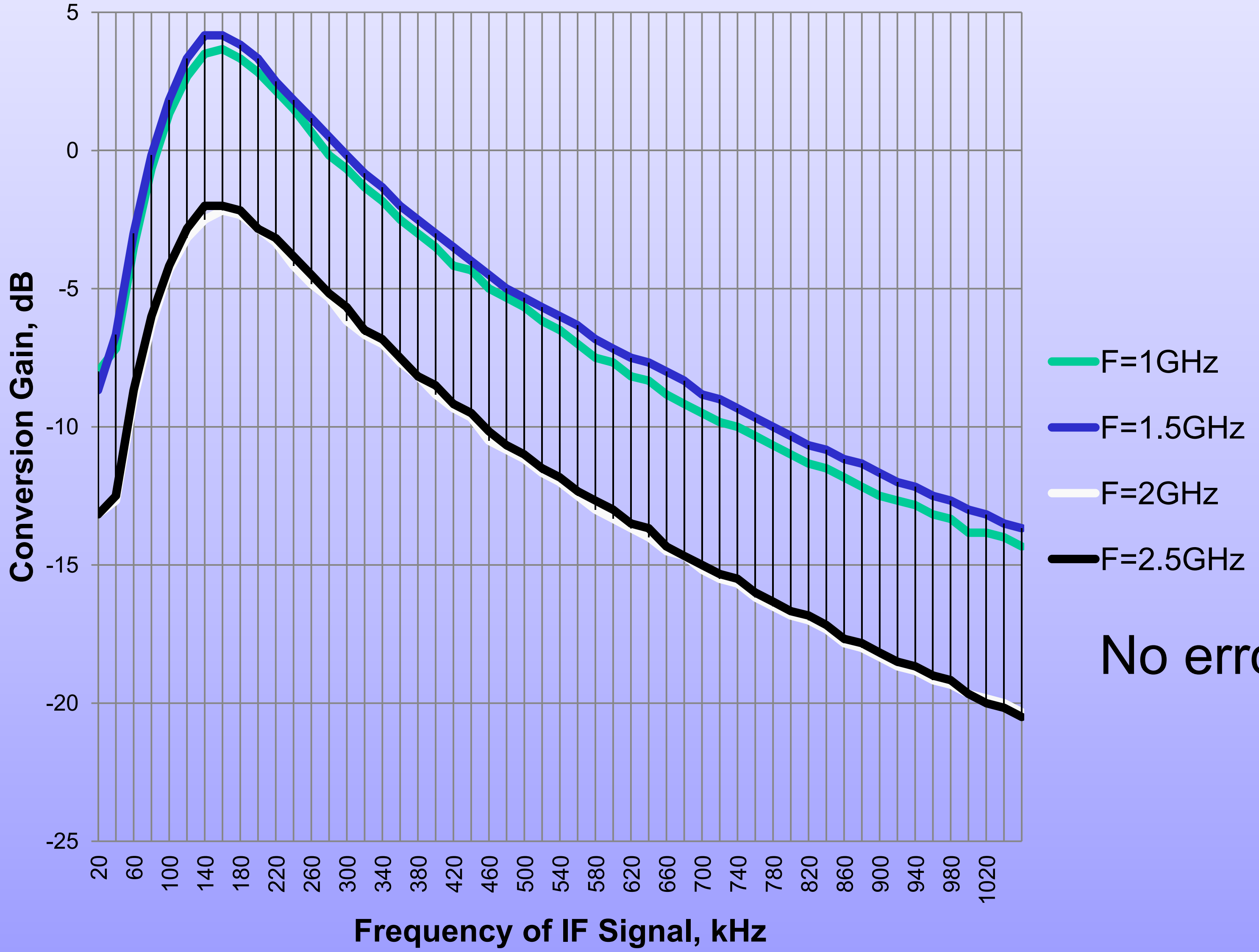
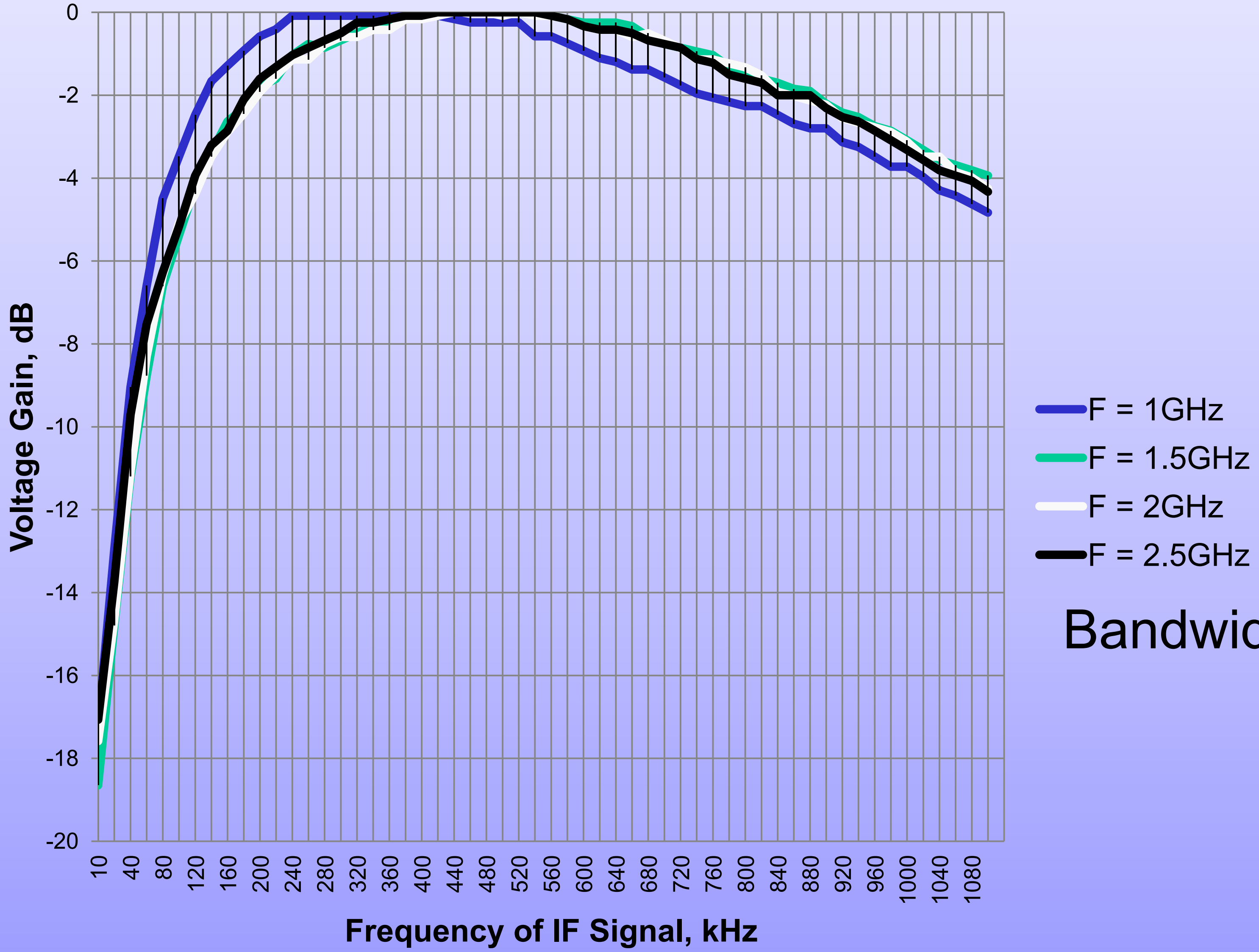


No error at 2GHz!!



Bandwidth = 900kHz

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Thank you for your attention!!!

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