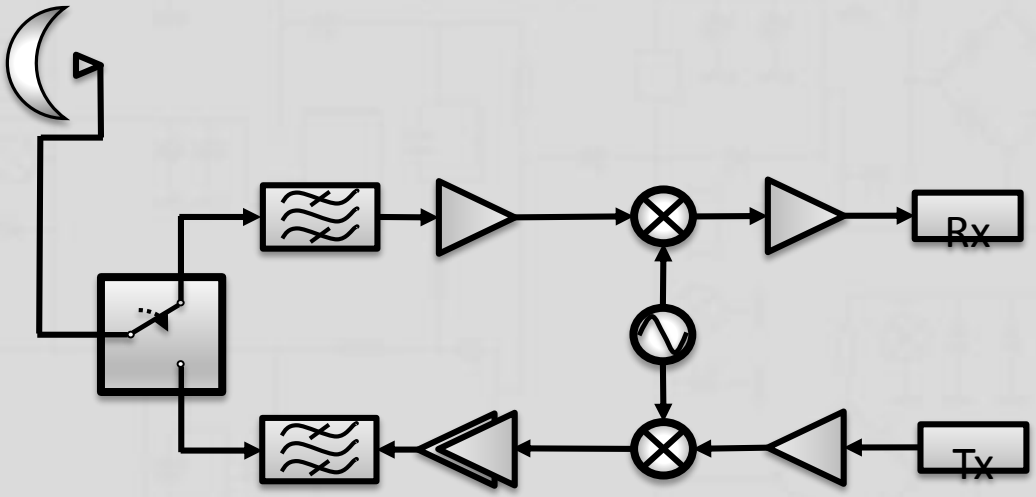
Radar Receivers

Short Course on Radar and Electronic Warfare

Kyle Davidson

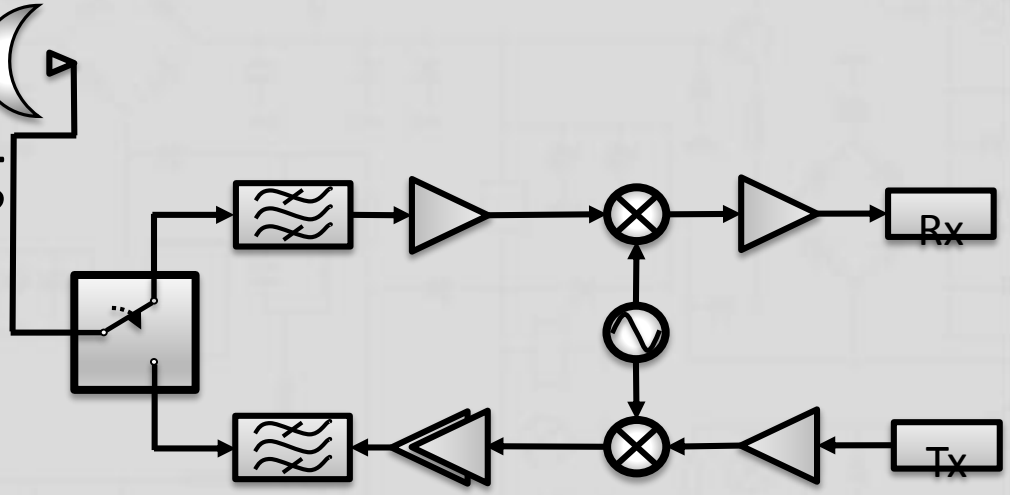
Overview

- Function of a receiver
- Noise in receivers
- Bandwidth
- Dynamic range
- Detection

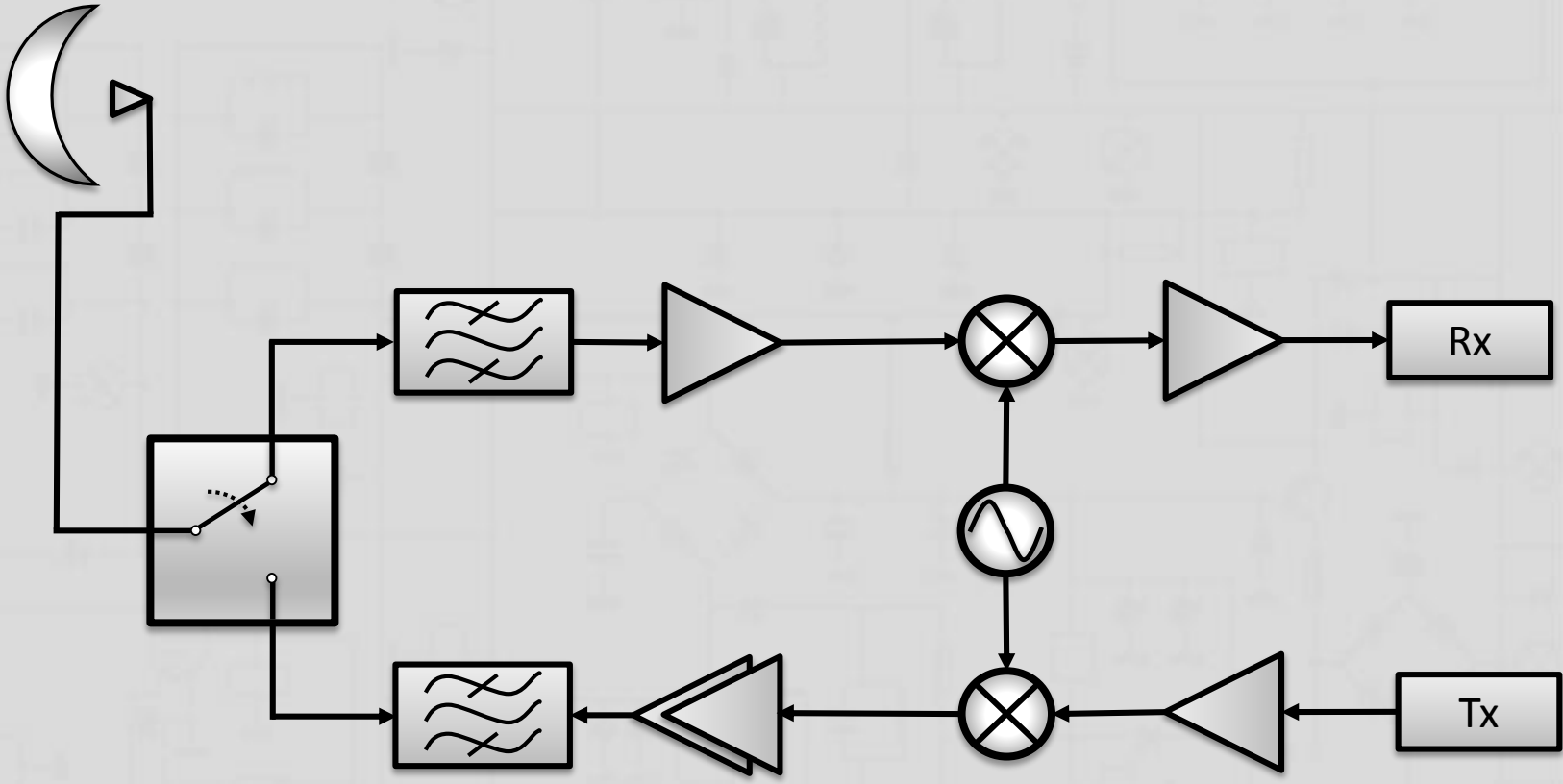


What does a receiver do?

- Turn EM waves into electric currents
- Amplify signals
- Frequency conversion
- Filtering
- Signal Processing
- Detection

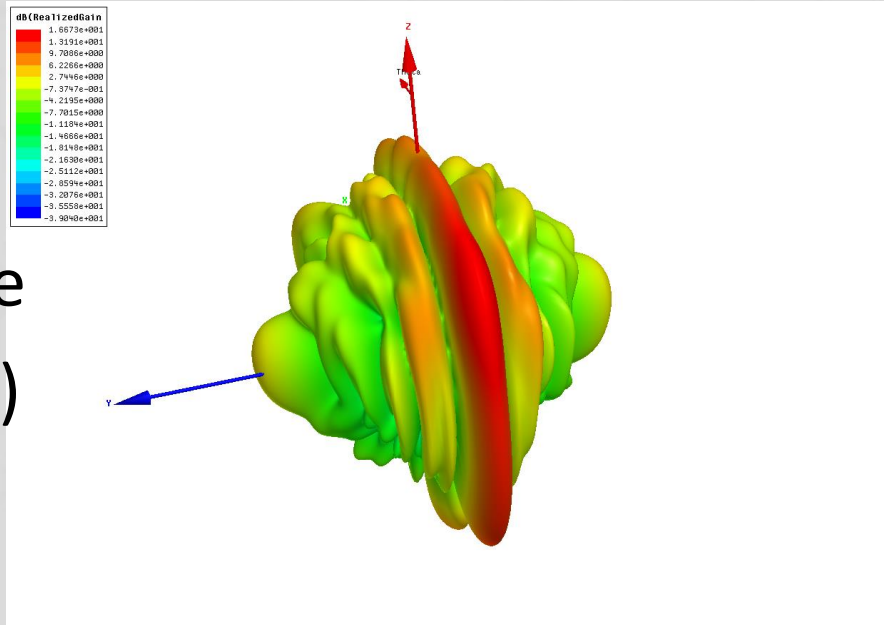


Radar Receiver



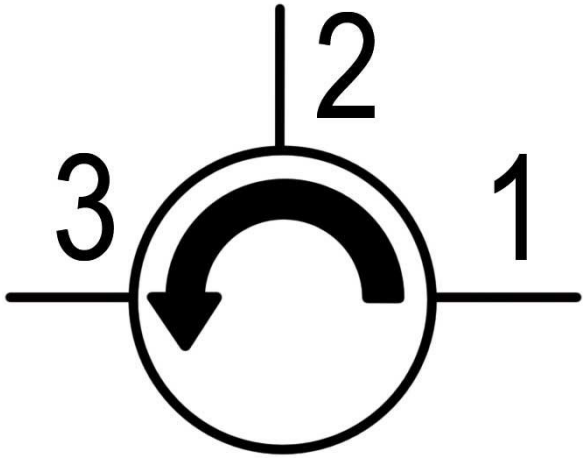
Receiver Antenna

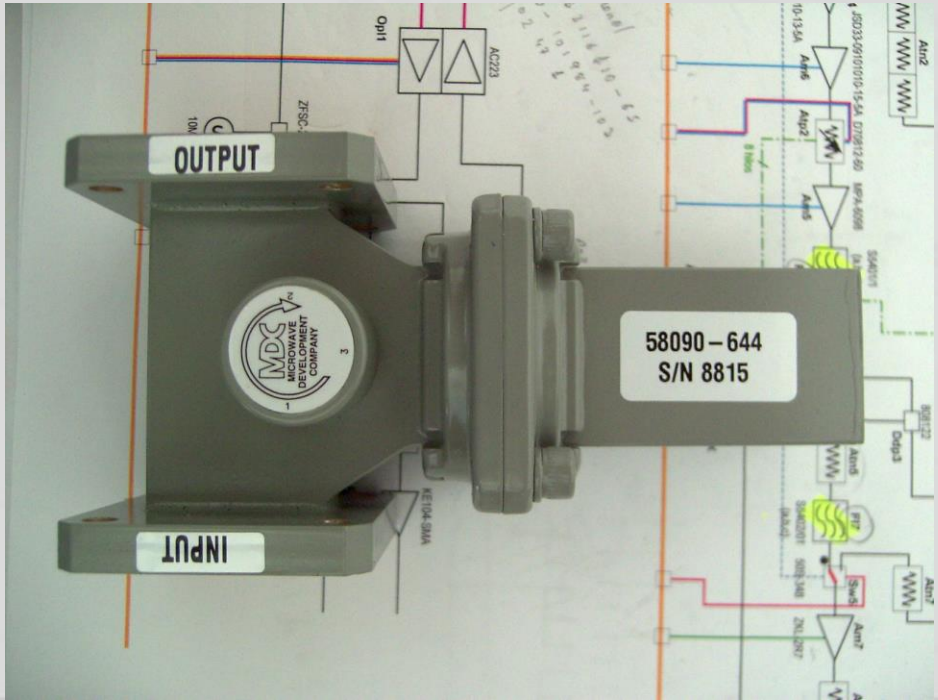
- May de a separate AESA from the transmitter AESA – common on CW
- Characteristics:
  - Gain
  - Antenna temperature
  - Side Lobe Levels (SLL)
- Monostatic
- Bistatic

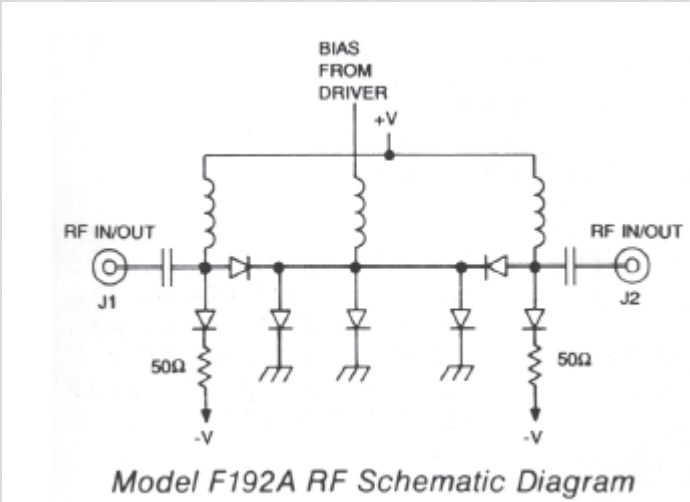


Switches and Circulators

- Switch
- Circulator
- Bistatic



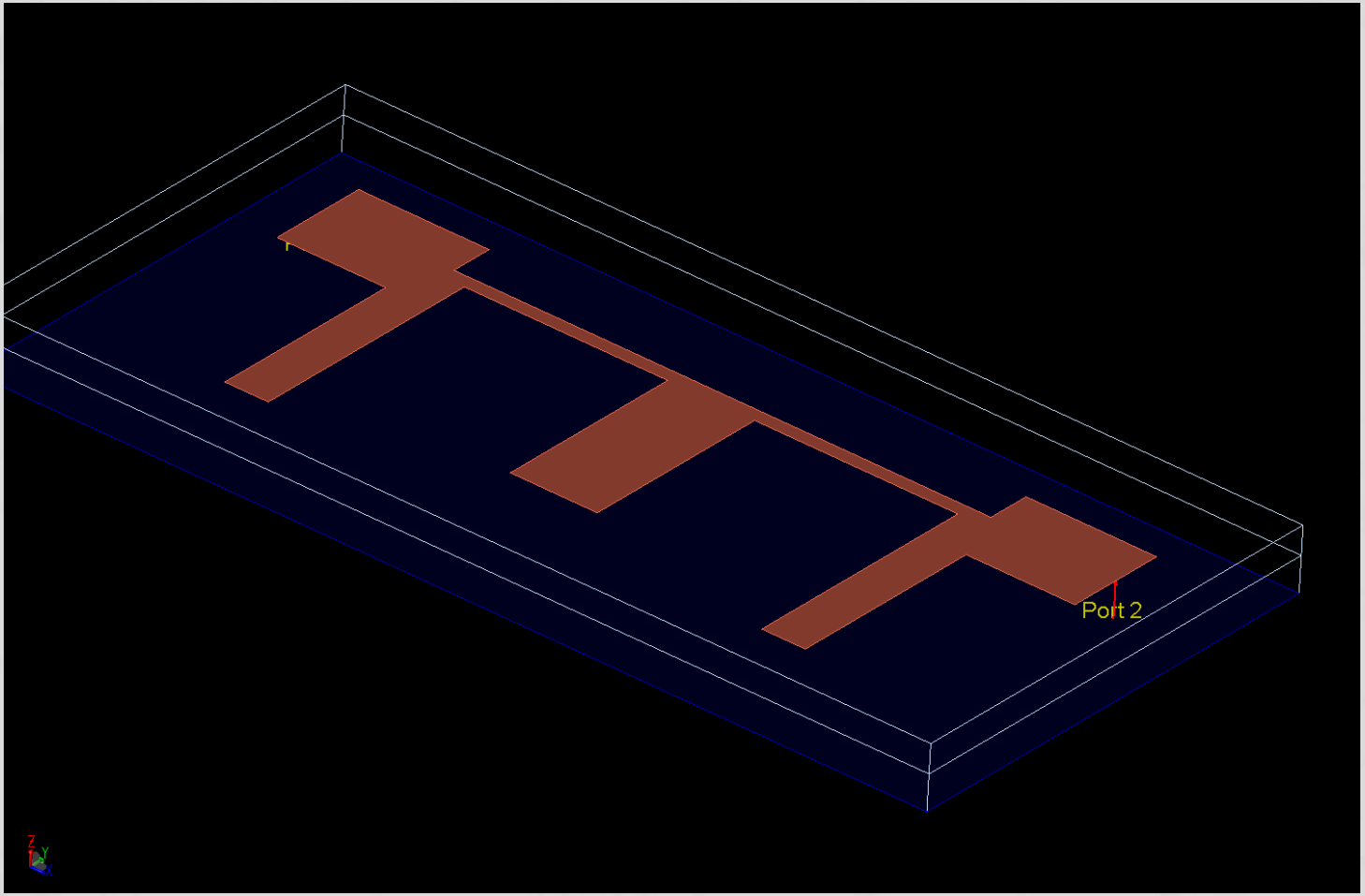




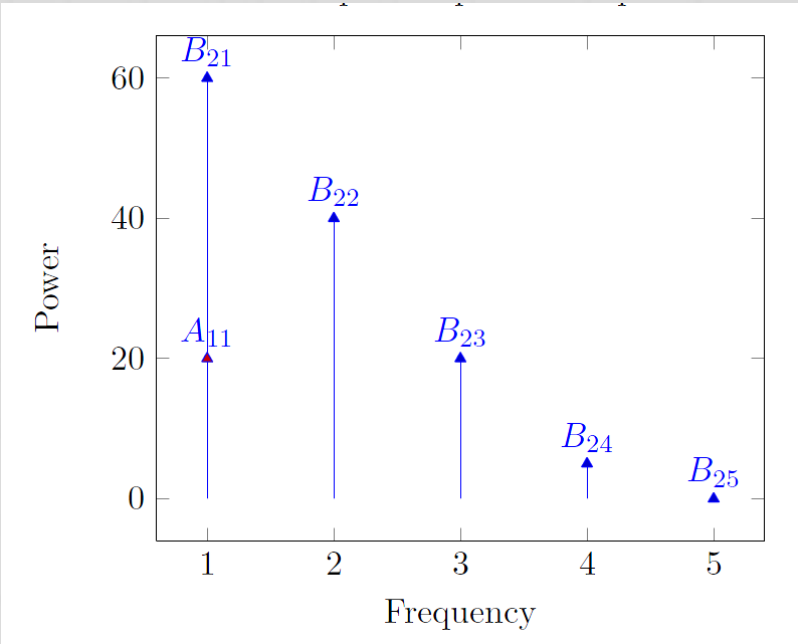
Model F192A RF Schematic Diagram

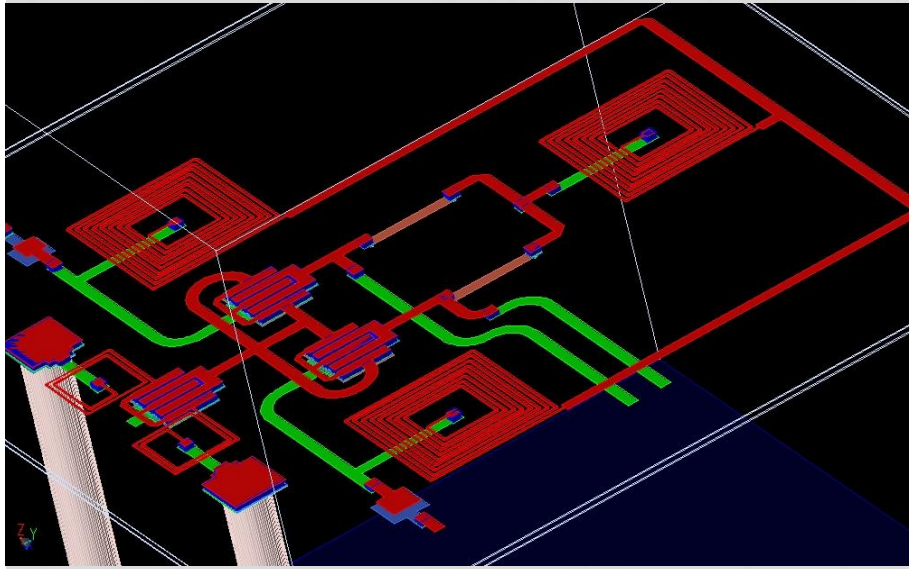
Low Noise Amplifier

Filters

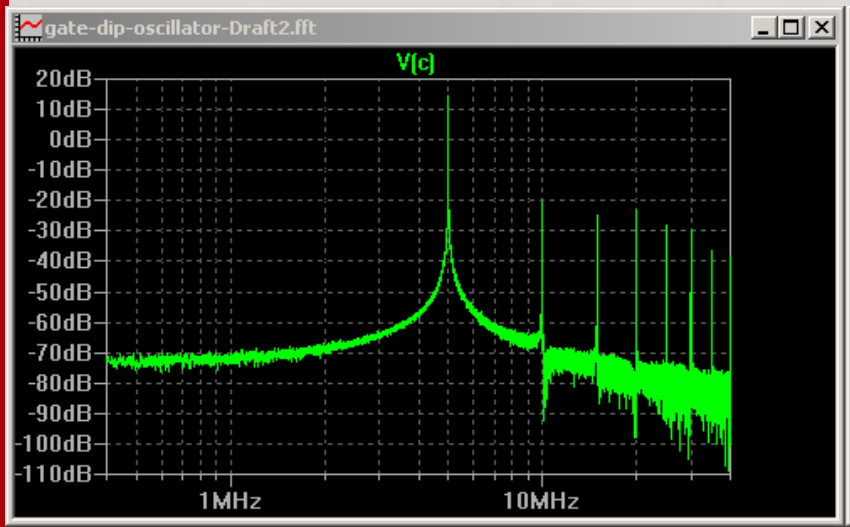


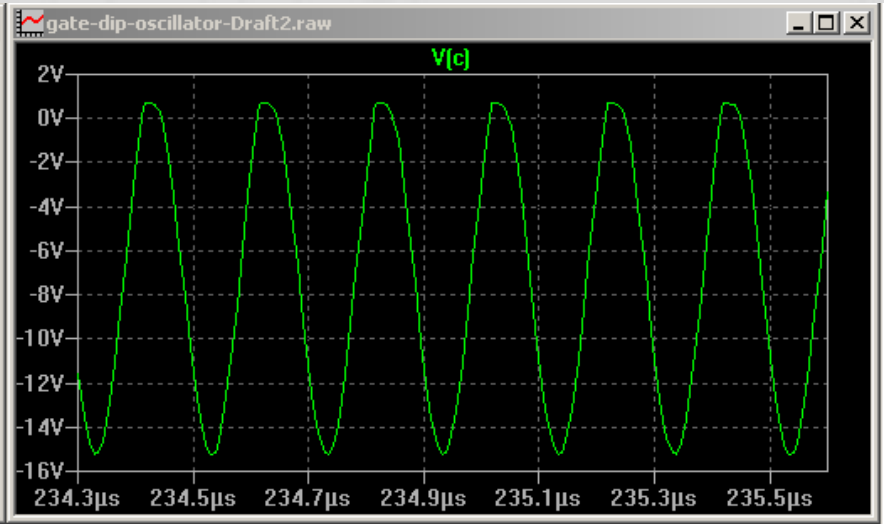
Frequency Conversion

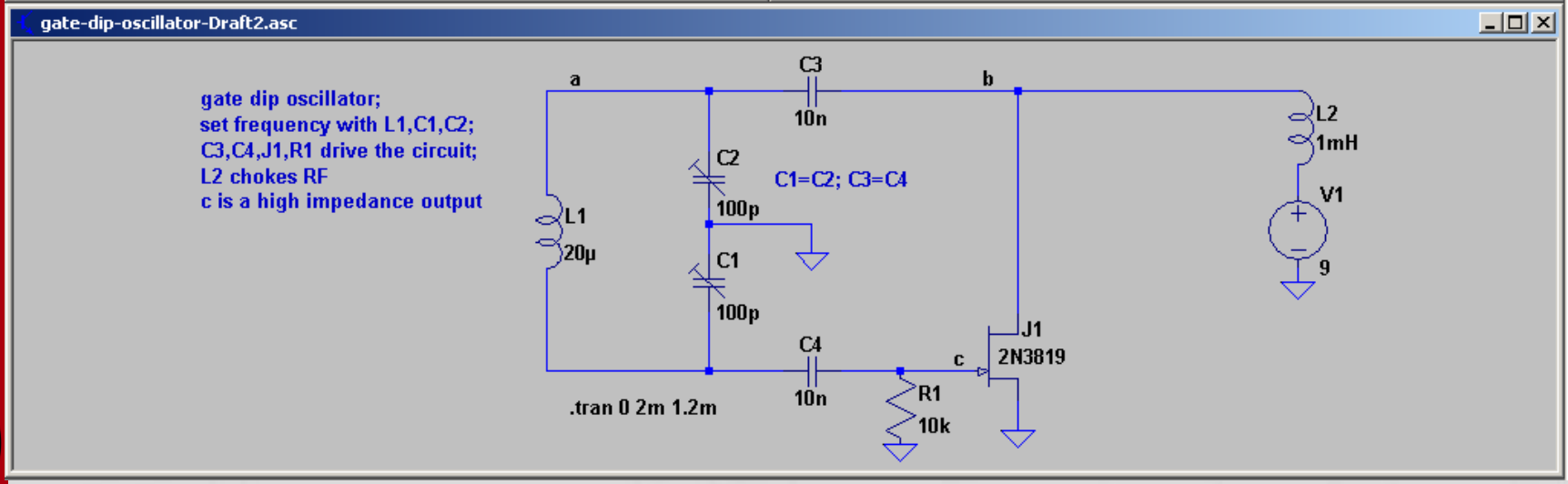




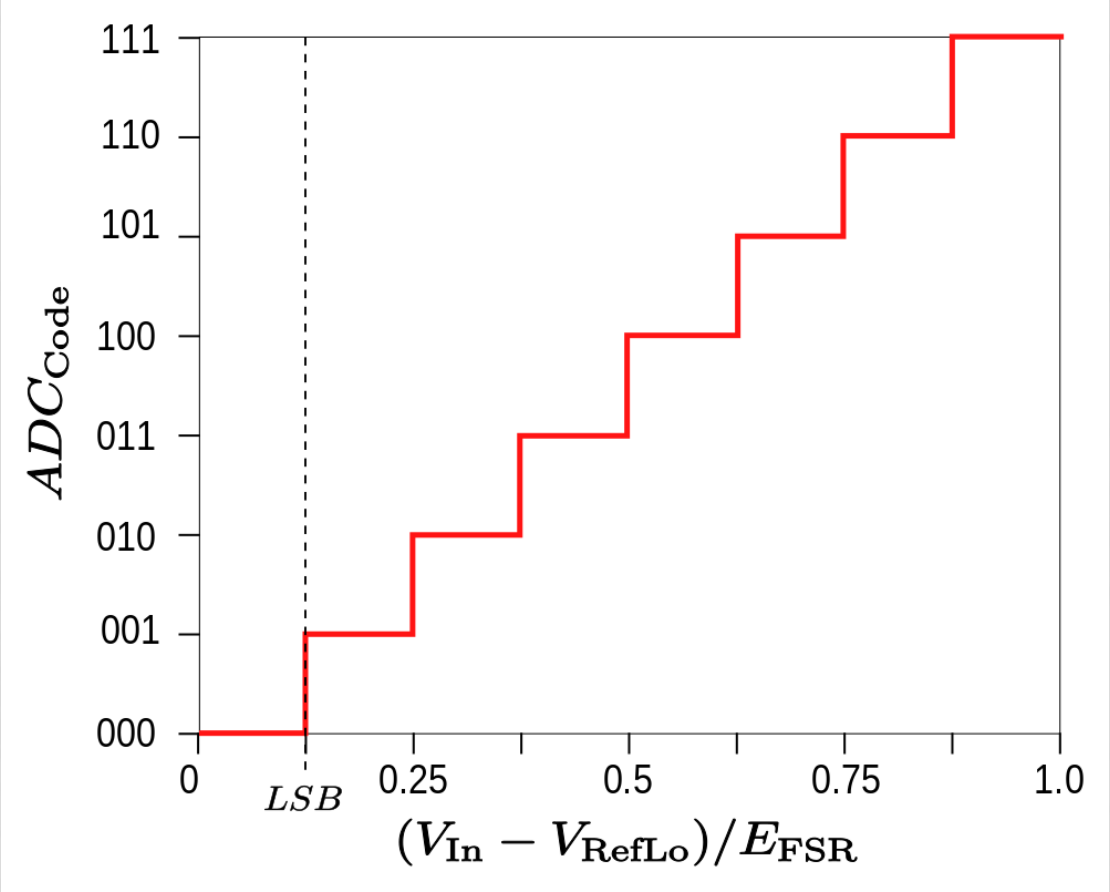
Oscillator

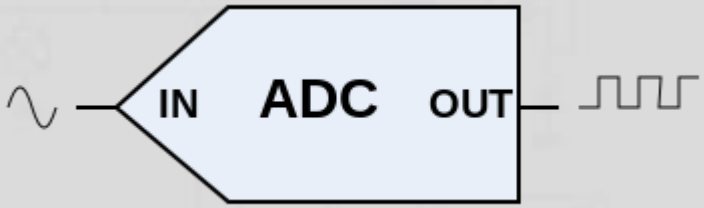

gate-dip-oscillator-Draft2.fft
V(c)
20dB
10dB
0dB
-10dB
-20dB
-30dB
-40dB
-50dB
-60dB
-70dB
-80dB
-90dB
-100dB
-110dB
1MHz
10MHz


gate-dip-oscillator-Draft2.raw
V(c)
2V
0V
-2V
-4V
-6V
-8V
-10V
-12V
-14V
-16V
234.3µs
234.5µs
234.7µs
234.9µs
235.1µs
235.3µs
235.5µs

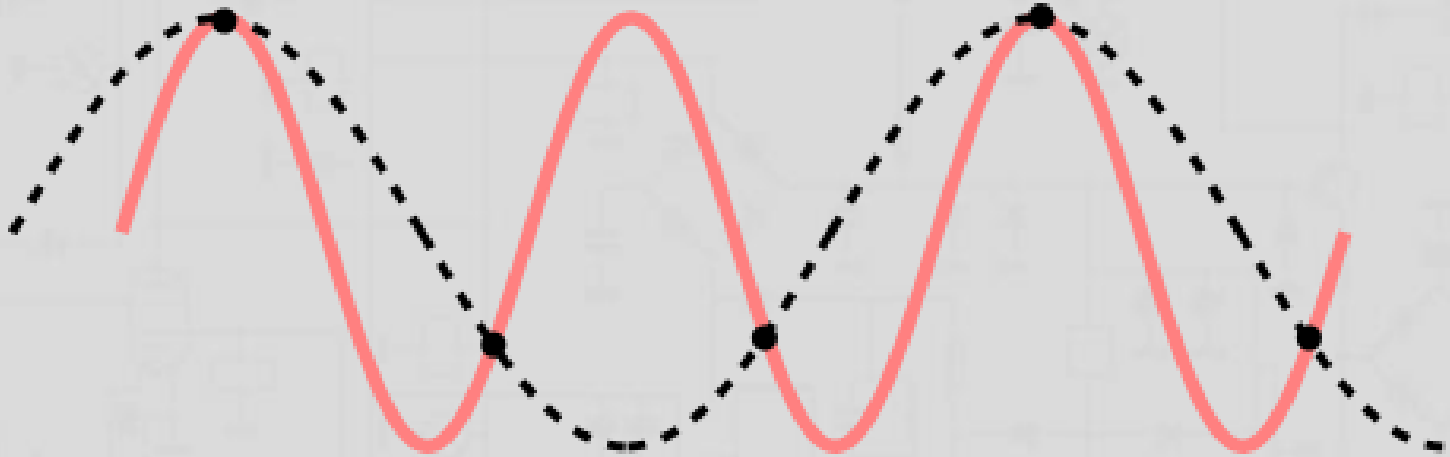

gate-dip-oscillator-Draft2.asc
gate dip oscillator;
set frequency with L1,C1,C2;
C3,C4,J1,R1 drive the circuit;
L2 chokes RF
c is a high impedance output
a
b
C3
10n
C2
100p
C1=C2; C3=C4
L1
20µ
C1
100p
L2
1mH
V1
9
J1
2N3819
c
C4
10n
R1
10k
.tran 0 2m 1.2m

Analog to Digital Convertor





Nyquist Theorem



Receiver Noise Power

- Received radar signals are usually very low powered (< -100 dBm)
- Noise comes from a variety of sources, but most is due to thermal activity (we're ignoring the rest)
- The received signal must compete with the noise power:

$$P_n = kTBF$$

- $k = 1.38 \times 10^{-23} \frac{J}{K}$
- $T =$ temperature (290 K)
- $B =$ bandwidth (Hz)
- $F =$ Noise Figure

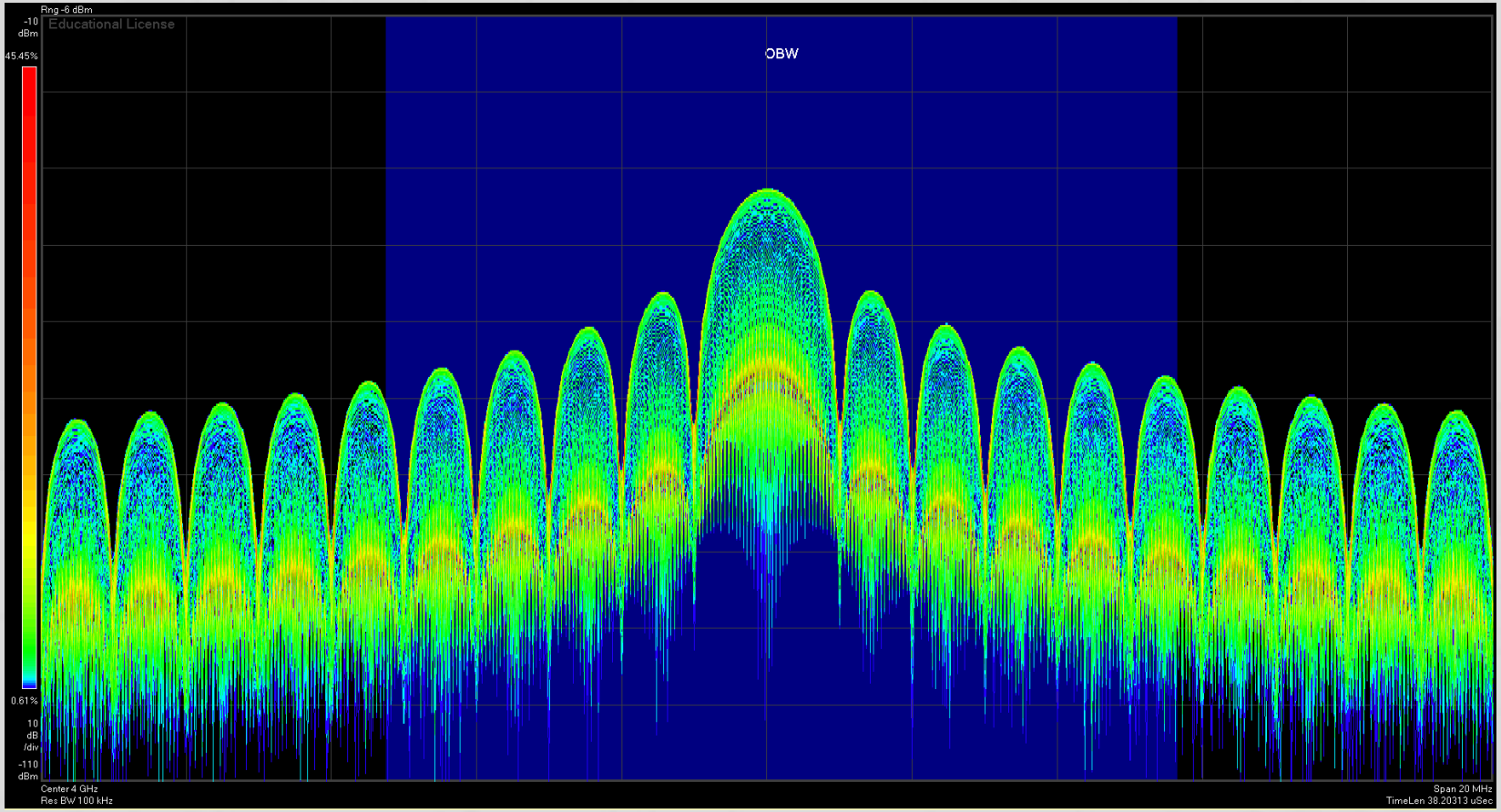
Receiver Bandwidth

- More bandwidth = more noise!
- Rectangular pulses have a Reyleigh bandwidth of

$$B = 1/\tau$$

- Other waveforms very, but we want the bandwidth to contain 99 % of the signal power
- Need to consider Doppler shift

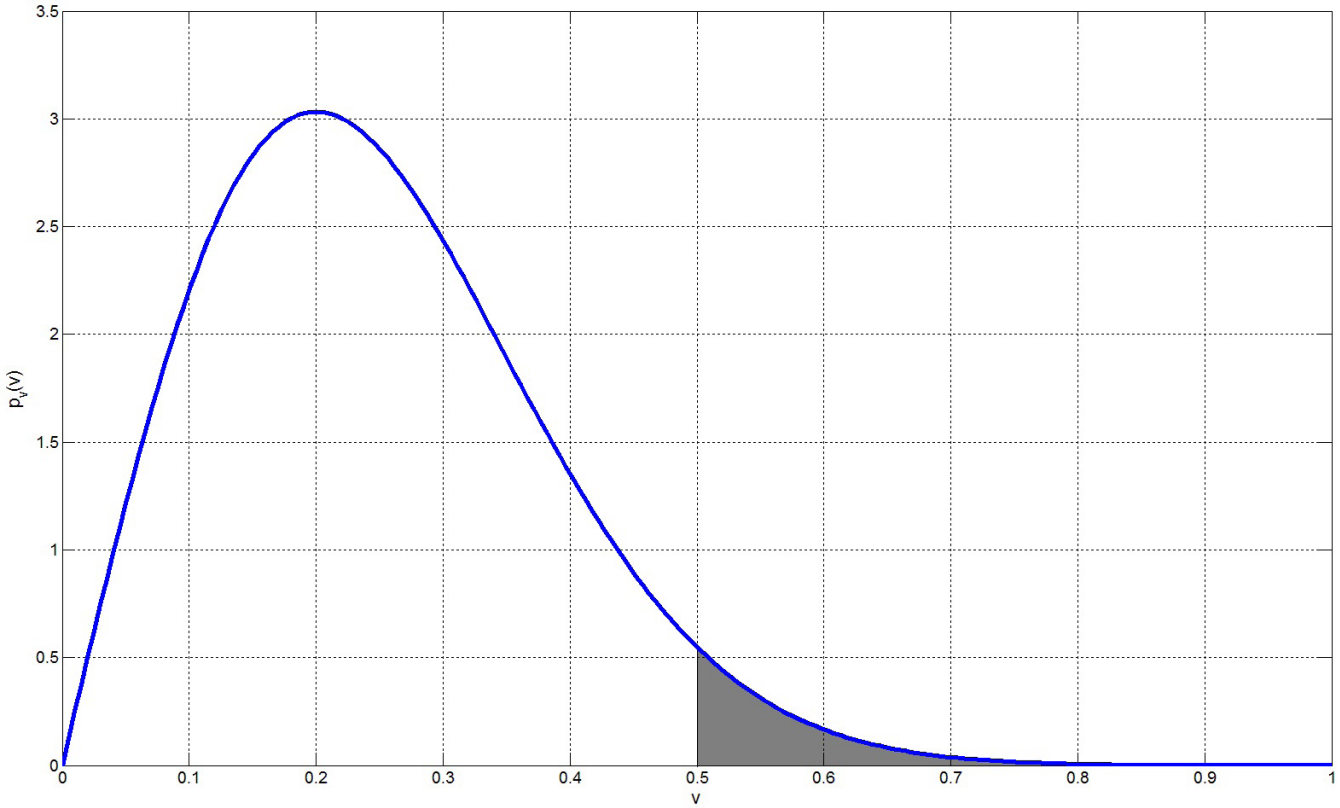
1 µs pulse


Rng -6 dBm
-10
dBm
Educational License
OBW
45.45%
0.61%
10
dB
/div
-110
dBm
Center 4 GHz
Res BW 100 kHz
Span 20 MHz
TimeLen 38.20313 uSec

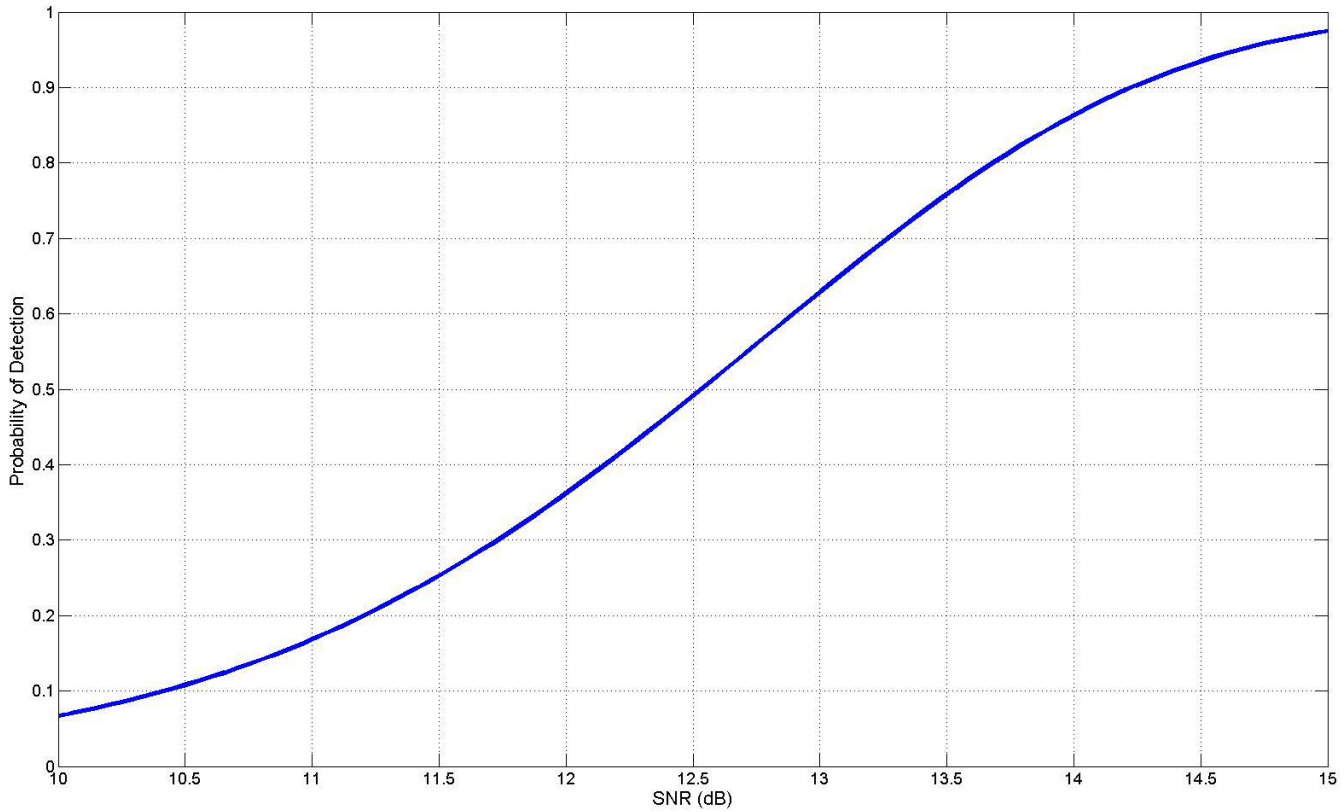
Dynamic Range

- Difference between largest and smallest signal the receiver can detect
- DR limited by RF
- DR limited by ADC
- Often requires automatic gain control

Detection Threshold



Probability of Detection



Probability of False Alarm