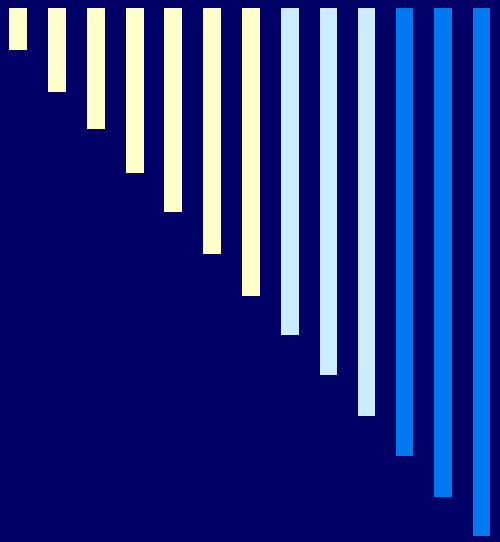


RF Communication System

EE 172

Systems Group Presentation

RF System Outline

- Transmitter Components
- Receiver Components
- Noise Figure
- Link Budget
- Test Equipment
- System Success
- Design Remedy

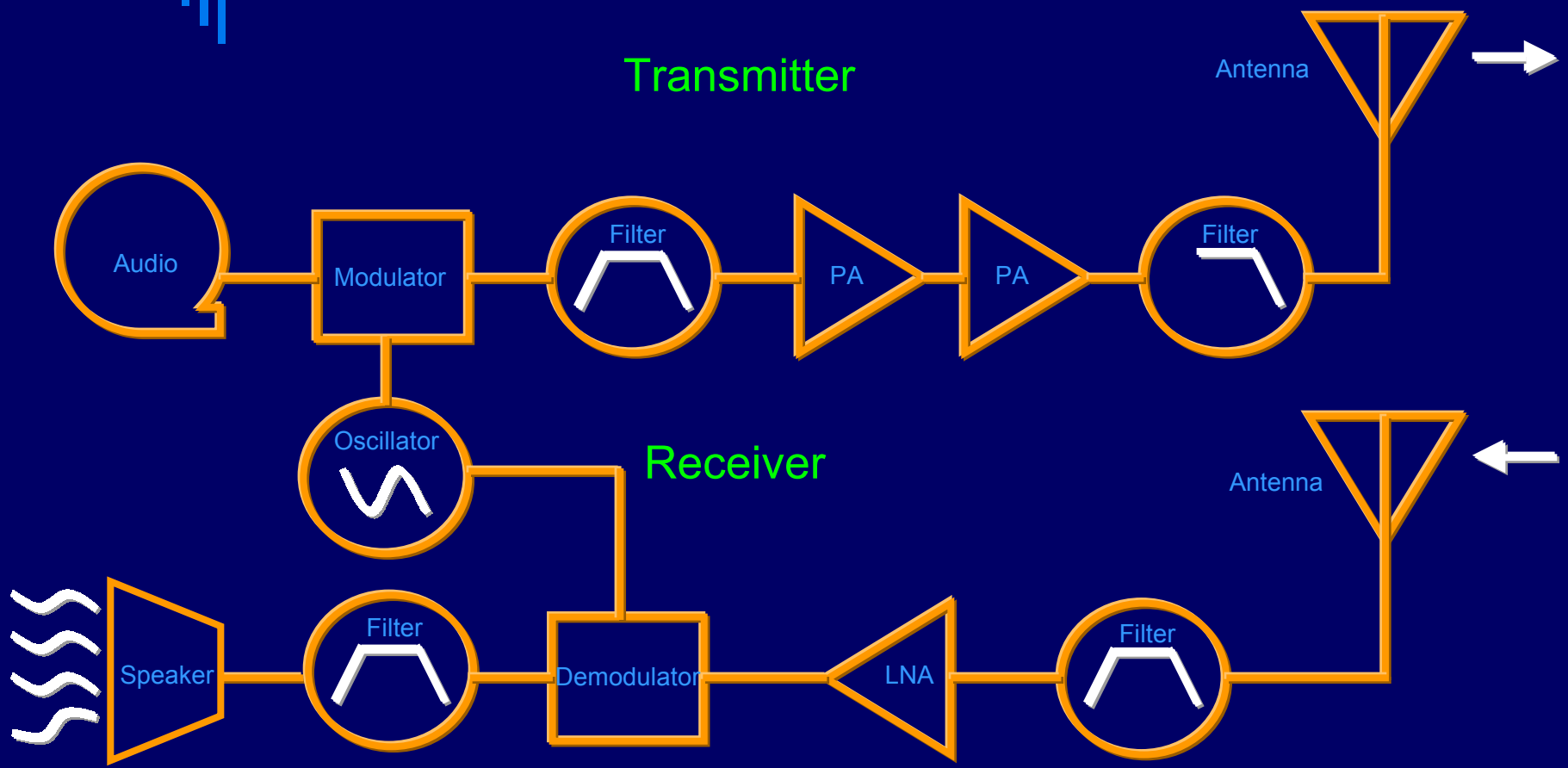
Transmitter Components

- Audio Transducer
- Oscillator
- Modulator
- Band Pass Filter
- Power Amplifier
- Low Pass Filter
- Antenna

Receiver Components

- Antenna
- Evanescent Mode Filter
- Low Noise Amplifier
- Oscillator
- Demodulator
- Band Pass Filter
- Speaker

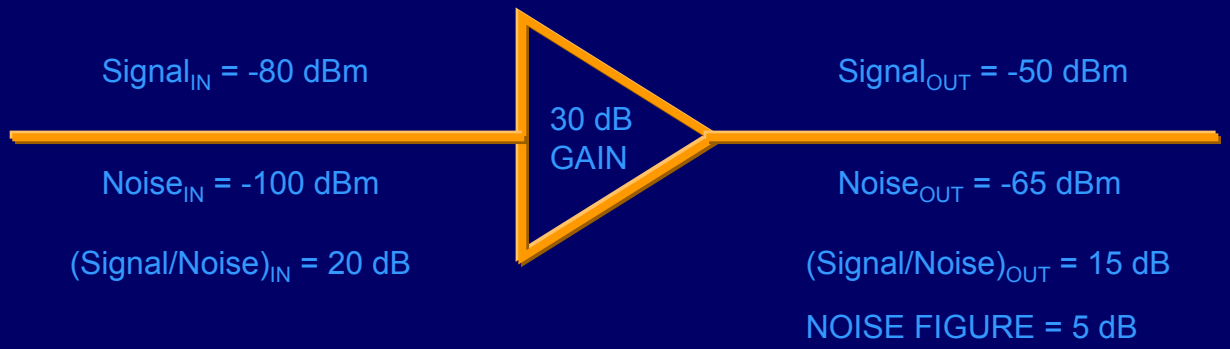
System Block Diagram



Noise Figure

- The Noise Figure (NF) is the increase of noise power from the input to the output of a network
- “White noise”, or noise power, is constant in RF and microwave frequencies
- Noise is mainly important on the receiver end due to the low signal strength

Noise Figure (LNA example)



- Noise Figure is the ratio of the signal to noise power going into a device compared to the signal to noise ratio coming out
- Noise Figure of a passive device, such as a filter, is equal to its attenuation

Link Budget - Expected

P_T = Transmitter power (dBm)	30 dBm
G_T = Transmitter antenna gain (dB)	3 dB
G_R = Receiver antenna gain (dB)	10 dB
P_L = Path Loss (dB)	-154 dB
$T_P = P_T + G_T + G_R + P_L$	-111 dBm

*Path loss is an estimated value. Propagation engineers would be responsible for this value.

Link Budget - Calculations

Parameters & Calculations	Transmitter				
	Modulator (oscillator terminated)	Modulator (audio terminated)	Band Pass Filter	Amplifier (Systems)	Low Pass Filter
S11 (dB)	-6.01	-4.76	-5.50	-7.40	-5.08
S12 (dB)	-39.50	-17.24	-60.00	-20.20	-7.06
S21 (dB)	-40.30	-17.22	-60.00	-20.20	-7.06
S22 (dB)	-2.48	-3.93	-4.30	-5.50	-6.65
ρ	0.50	0.58	0.53	0.43	0.56
Return Loss (dB)	-6.01	-4.76	-5.50	-7.40	-5.08
Insertion Loss (dB)	-39.50	-17.24	-60.00	-20.20	-7.06
SWR	3.00	3.74	3.26	2.49	3.52
P reflected	25%	33%	28%	18%	31%
P transmitted	75%	67%	72%	82%	69%

Link Budget - Calculations

Parameters & Calculations	Receiver			
	Amplifier	Evanescent Mode Filter	Demodulator	Band Pass Filter
S11 (dB)	-11.10	-4.70	-7.00	-15.00
S12 (dB)	-47.00	-27.00	-23.50	-11.60
S21 (dB)	-47.00	-27.00	-23.50	-11.60
S22 (dB)	-4.70	-3.80	-5.70	-8.80
ρ	0.28	0.58	0.45	0.18
Return Loss (dB)	-11.10	-4.70	-7.00	-15.00
Insertion Loss (dB)	-47.00	-27.00	-23.50	-11.60
SWR	1.77	3.79	2.61	1.43
P reflected	8%	34%	20%	3%
P transmitted	92%	66%	80%	97%

Link Budget - Actual

Transmitter power:	16 dBm
Transmitter antenna gain:	6 dB
Free space path loss:	-71 dB
Obstacle loss:	-20 dB
Multipath loss:	-20 dB
Receiver antenna gain:	10 dB
Received carrier power:	-79 dB
Thermal noise in 1 MHz	-114 dBm
30 kHz bandwidth correction	-15 dB
Receiver noise figure:	-6 dB
Noise floor:	-123 dB
Carrier to noise ratio:	32 dB

Test Equipment

- Network Analyzer
  - to retrieve S-parameters for reflection calculations
- Spectrum Analyzer
  - to determine gain, bandwidth, and frequency measurements from components
- Power Supply
  - power up subsystems as needed

System Success

- The RF Communications System did… not work ☹
- Major factors for measuring our success includes:
  - power loss across all subsystems
  - gain was nominal versus loss
  - missing components vital for success
  - test yields were astray from specs

System Success

- Overall subsystems are lossy as opposed to ideal conditions
- Amplifier gain was 6 dB versus 15 dB as specs had stated and were missing 2 out of 3 of them.
- The Low Pass Filter had a tested cutoff frequency of 850 MHz versus 940 MHz as specs had stated.
- Demodulator tests showed that the carrier frequency was not removed.
- Systems attempted some remedial tactics.

Design Remedy

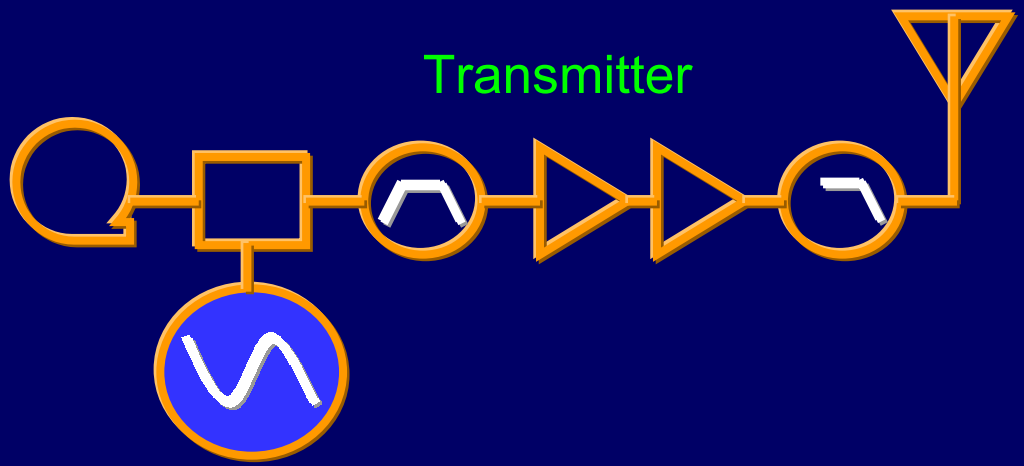
- New amplifier was designed that yielded better gain. (with help of Elena from Oscillator group)
- Attempted to design a new low pass filter to remedy cutoff frequency
- Furthermore, the systems group recommends that all the subsystems be matched for the least reflections and loss.

Systems Analysis Team

- Sahel Jalal
- Rizwan Khalid
- Kartik Patel
- Gurvinder Dilawari
- Ankush Mohan

Questions and Answers…

Oscillator



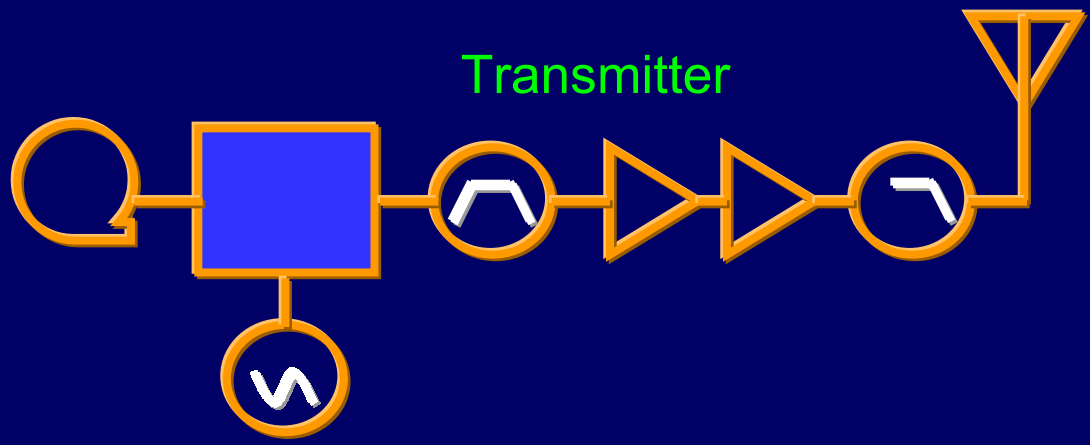
Specifications

Frequency: 915 MHz Amplitude: 0 dBm Phase Noise:

Actual Measurements

Frequency: 915.2 MHz Amplitude: 1.8 dBm Phase Noise:

Modulator



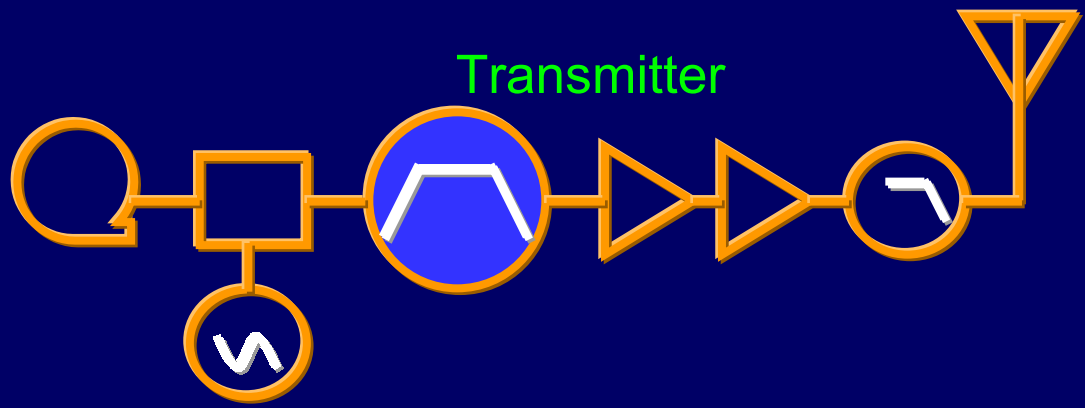
Specifications

Conversion Loss: 10 dB Spurious: None

Actual Measurements

Conversion Loss: 17 dB Spurious: 872 MHz, 924 MHz

Band Pass Filter



Specifications

Center Frequency: 915 MHz Bandwidth: 915 MHz +/- 15%

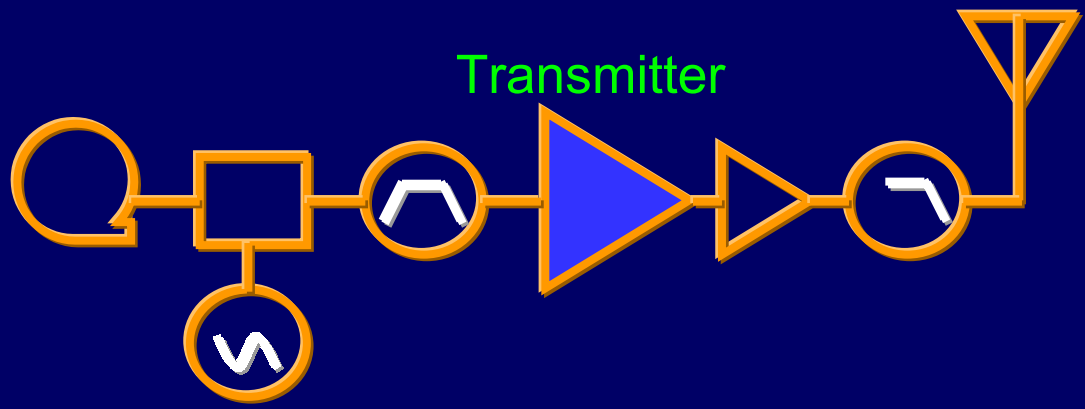
Insertion Loss: 10 dB

Actual Measurements

Center Frequency: 1.2 GHz Bandwidth: 200 Mhz

Insertion Loss: 46 dB @ 915 MHz

Power Amplifier



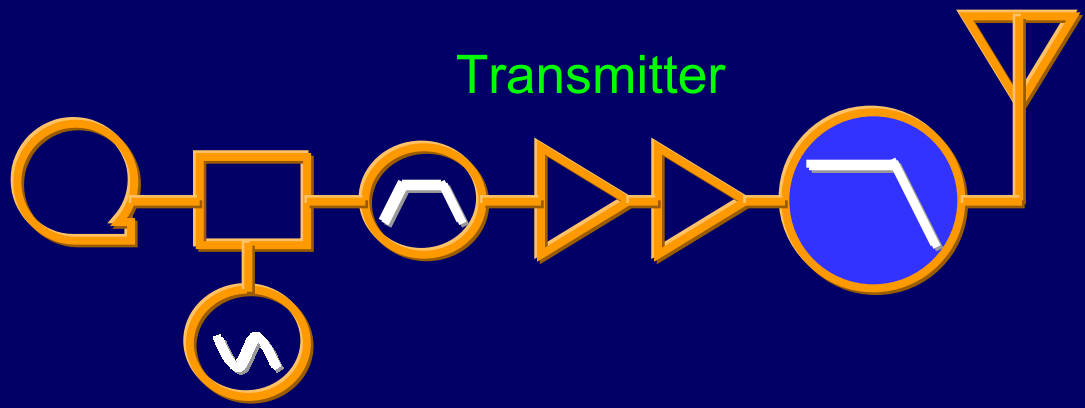
Specifications

Frequency: 915 MHz Gain: 15 dB Saturation: 28 V

Actual Measurements

Frequency: 915 MHz Gain: 6 dB Saturation: 22 V

Low Pass Filter



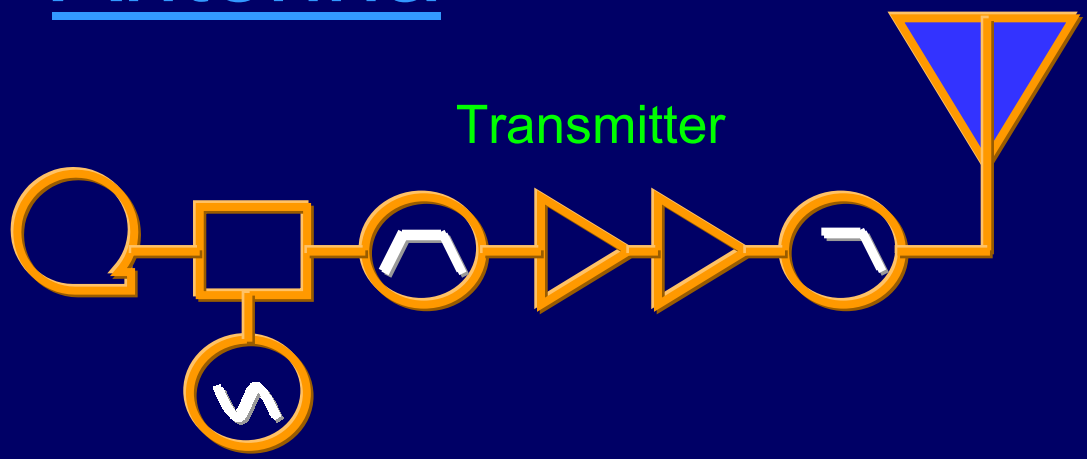
Specifications

Cutoff Frequency: 940 MHz Insertion Loss: 10 dB

Actual Measurements

Cutoff Frequency: 850 MHz Insertion Loss: 4.7 dB

Antenna



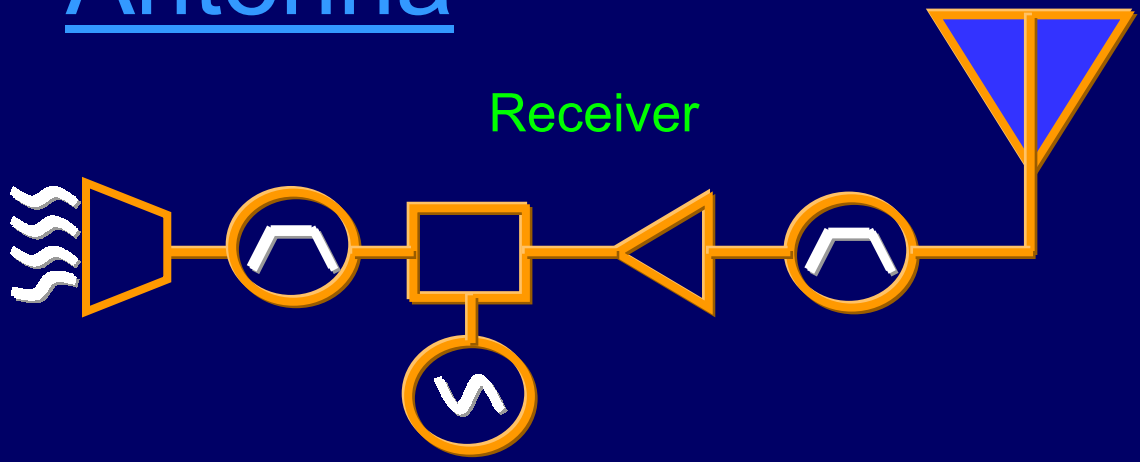
Specifications

Gain: 3 dB Frequency Range: 910 MHz to 920 MHz

Actual Measurements

Gain: 6 dB Frequency Range: 910 MHz to 920 MHz

Antenna



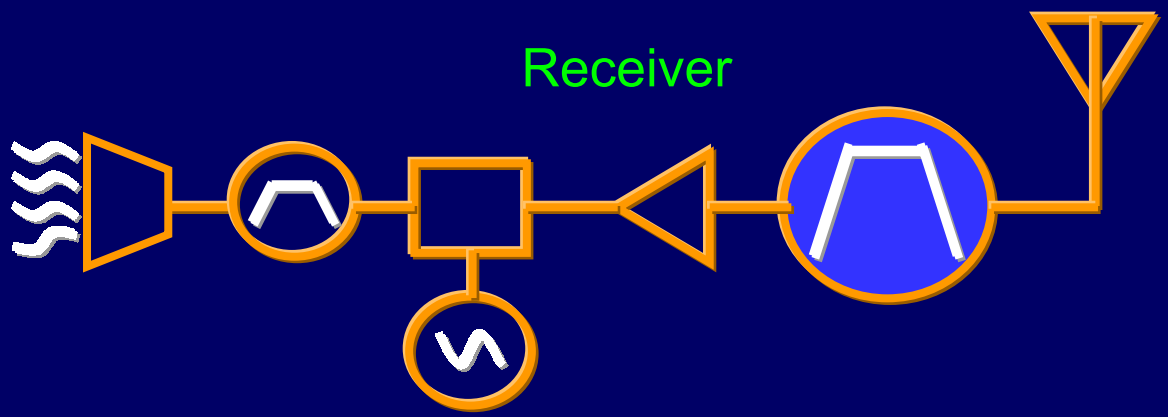
Specifications

Gain: 10 dB Frequency Range: 910 MHz to 920 MHz

Actual Measurements

Gain: 9-12 dB Frequency Range: 910 MHz to 920 MHz

Evanescent Mode Filter



Specifications

Center Frequency: 915 MHz Bandwidth: 140 MHz

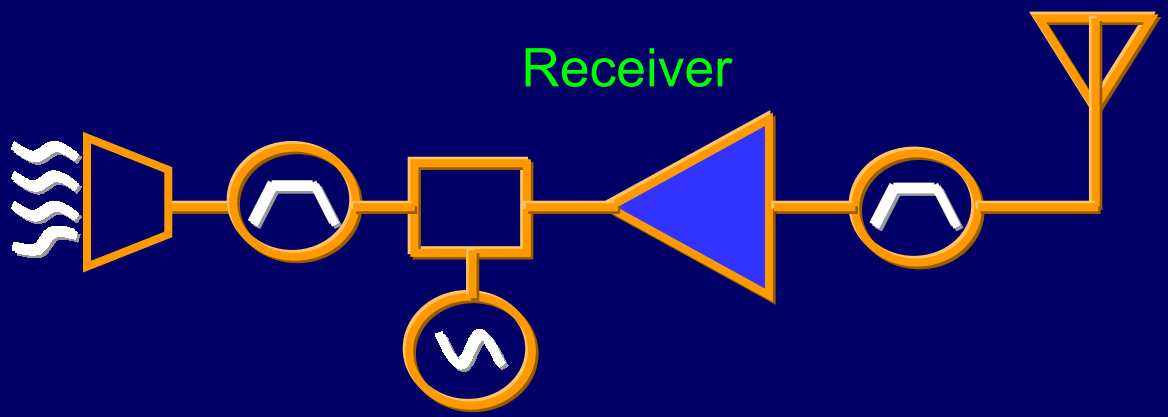
Insertion Loss: 10 dB

Actual Measurements

Center Frequency: 915 MHz Bandwidth: 140 MHz

Insertion Loss: 14 dB

Low Noise Amplifier



Specifications

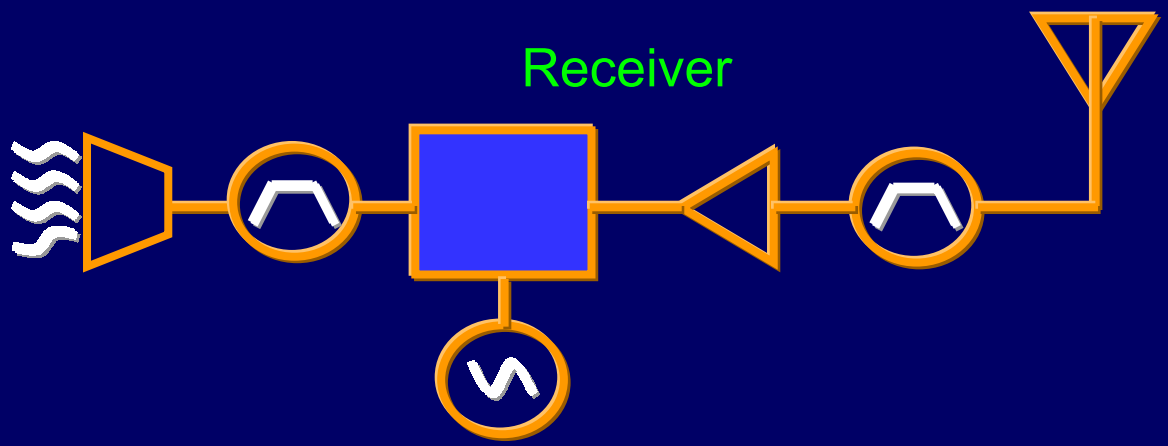
Gain: 15 dB Frequency: 915 MHz

Actual Measurements

Missing originally, systems designed

Gain: 20 dB Frequency: 915 MHz

Demodulator



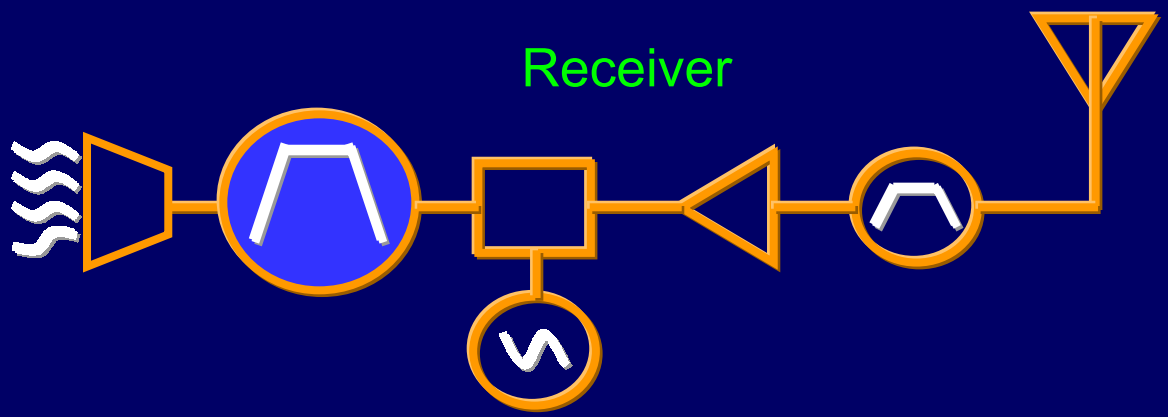
Specifications

Conversion Loss: 10 dB Spurious: None

Actual Measurements

Conversion Loss: 17 dB Spurious: 875 MHz, 928 MHz

Band Pass Filter



Specifications

Conversion Loss: 10 dB Bandwidth: 915 MHz +/-15%
Spurious: None

Actual Measurements

Conversion Loss: 8.1 dB Bandwidth: 873 MHz to 960 MHz
Spurious: None