Phased Array System Design that Incorporates Component Level Performance

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Using a Keysight SystemVue Workspace built around Analog Devices ADAR1000 X/Ku Analog Beam Former IC, this paper will show how device-level performance specifications such as Frequency Response, Noise Figure and Distortion, affect System Level Performance. A complete design will be presented that includes antenna, analog beam former, mixer and digital drive source. Simulated results will show system-level frequency response, beam patterns and the effect of part-to-part variations in the array. This will be a joint presentation between Keysight and Analog Devices.
ADAR1000 - 8 to 16 GHz, 4-Channel X/Ku Band Beamformer

- Half Duplex Solution for Pulse Doppler Radar
- 360° phase adjustment range, 2.8° phase resolution
- ≥31 dB gain adjustment range, ≤0.5 dB gain resolution
- Memory for 121 pre-stored beam positions
- Adjustable bias modes
- 4-wire SPI Interface
- Bias and control for external T/R Modules
- Four 30 dB power detectors
- Integrated temperature sensor
- Integrated 8-bit ADC for power detectors and temperature sensor

Modeled Circuitry
Goal of Simulation

- 8 Antenna Feeds per Transceiver
- Single Mixer for Up and Down Conversion
Keysight SystemVue Overview

Model-Based System Simulation Platform covering multiple domains and applications

- **Baseband**
  - Comms PHYs
  - Algorithms
  - DSP
  - Custom Code

- **Analog/RF**
  - TX/RX
  - ADC/DAC
  - Antenna Arrays

- **Environment**
  - Channels
  - Targets
  - Interference
Complete Rx or Tx Model Allows for Programmable Gain and Phase

Optional Title of the Presentation
Complete ADAR1000 Model

Rx or Tx Model and Attenuator are Selectable
Phase and Gain Variation Analysis
Frequency Sweep Analysis
The Main Control Panel

```matlab
% Array type
1 = 'Linear Array'
2 = 'URA'
3 = 'Circular'
4 = 'Rectangular Array with Triangle Grid'
5 = 'Hexagon'

% For linear Array Setup
NumLin = 16;

% For URA Array Setup
NumRow = 8;
NumCol = 16;

% For Circular Array Setup
Num_perCircle = [1,4,8,16,16];
Phase_perCircle = [0,0,0,0,0];
RadiCircle = [0,0.5,1,0.1,5.2,2];

% For Rectangular with Triangular Grid Array Setup
NumRowT = 16;
NumColT = 16;

% For Hexagonal Array Setup
NumBot = 5;
NumMid = 11;
num_per_row = [NumBot:NumMid,NumMid-1:-1:NumBot]
NumRowCol = 2*(NumMid - NumBot) + 1;

********** End User Inputs **********
```
Phased Array Hexagon Configuration - Rx
Array Configurations Supported
ADAR1000 TX Phased Array Design with real Radar Signal
ADTR1107 6-18 GHz 0.5 W T/R Module with Integrated RF Power Detector

- **Transmit**
  - Gain: 20 dB
  - $P_{\text{SAT}}$: 26 dBm
  - Bias: 5V/100 mA

- **Receive**
  - Gain: 19 dB
  - NF: 12.5 dB
  - PSAT: 18 dBm
  - $P_{\text{INMAX}}$: ≈ 23 dBm
  - Bias: 3.3V/90 mA

- **RF Detector**
  - Detection Range:
    - Glue-Less Control Interface from Core Chip to T/R Module

![Diagram of ADTR1107 T/R Module with integrated RF Power Detector]
ADAR1000 Evaluation Board and PC Control Software
Summary and Conclusions

- This Phased Array workspace allows simulation of system-level performance which is derived from component-level models.
- Beam patterns, RF Power Levels, SNR, Distortion and Flatness vs Frequency can be simulated.
- Signal chain can be expanded to include PAs and Amplifiers from ADI’s Sys-Parameter library.
- Radar Library and Phased Array SystemVue licenses are required to fully exercise the Workspace.
- This Workspace is available on request from Keysight Technologies or ADI.
Come Visit Us at Booth B585
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