

Description

Radar systems have been using a hybrid of analog and digital beamforming (DBF). Sub-arrays of phase shifters are digitized at the sub-array output. Such systems suffer from limited bandwidth and produce only one beam at a time. DBF solves both problems. Frequency domain DBF is very efficient in resource, but inherently narrowband.

Time Delay Beamforming (TDBF), on the other hand, is natively wideband and allows a scalable number of simultaneous beams. With the advance of high density and low power FPGAs, TDBF is now possible. This reference design uses a very efficient and precise fractional delay algorithm to achieve sub-picosecond time delay. As a result, beamforming at a very fine angle can be achieved.

The design is implemented in Simulink® with Altera’s DSP Builder Advanced Blockset. To test the design in hardware, other support components such as chirp generator, target range emulation, RX noise emulation, aperture tapering, and pulse compression are also implemented.

Performance Examples	Spec. #1	Spec. #2	Spec. #3	Spec. #4
Sample Rate (MHz)	300	300	267	250
Signal Bandwidth (MHz)	200	200	200	200
Filter Length	6	8	12	16
Expected SNR (dB)	34	52	60	65
Multipliers (18x18)	416	544	800	1056
Logics (max 260k)	8140	8800	9300	10k
Block RAM	64	64	64	64
Compiled Fmax. (MHz)	310	304	284	284

Performance and resource shown is for 8 simultaneous beams driving 32 antennas with varying parameters including bandwidth and SNR

Features

- Highly parameterizable and efficient time delay algorithm to provide precision beam steering
- Altera’s System-in-the-Loop with MATLAB®
- Design includes chirp generator, target range emulation, rx noise emulation, and pulse compression in hardware
- Designed with Simulink/Advanced DSP Builder achieving 300MHz push button performance
- Arbitrary fine beam angle resolution
 - 0.02 degrees implemented
 - 6-8 beams of 32 antenna in a Stratix® V

Applications

- Active Electronically Scanned Array (AESA)
- Radar, Sonar
- Electronic Warfare and Software Defined Radio
- Phased Array Radio Telescope

Reference: C. Cheung, R. Shah, M. Parker, “Time Delay Digital Beamforming for Wideband Pulsed Radar Implementation”, in IEEE International Symposium on Phased Array Systems & Technology, p.448-455, October 2013

For additional information, please contact us at mil@altera.com or *contact your local Altera sales representative.*

Figure 1: System-in-the-loop Digital Time Delay Beamforming Reference Design

