Small-aperture, high-resolution beam-scanning antenna array using nonlinear signal processing

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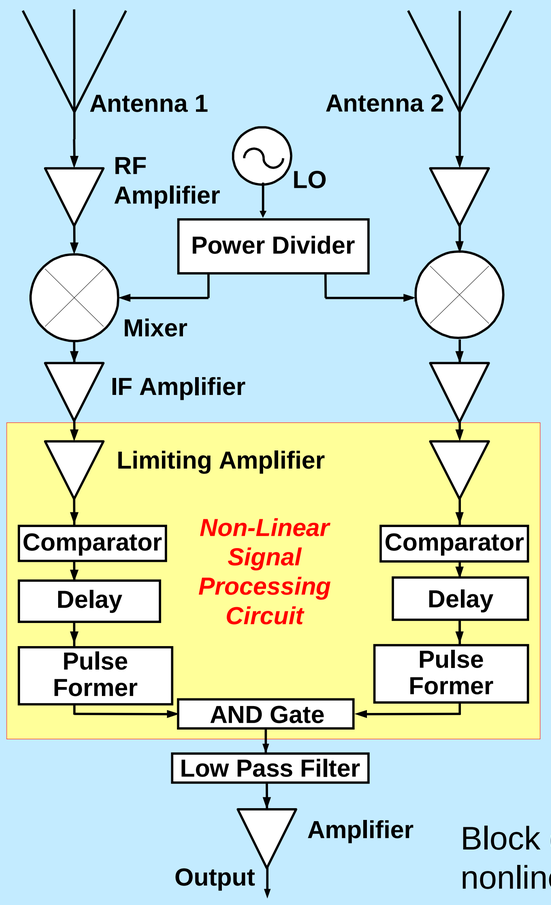
Nonlinear receiver array

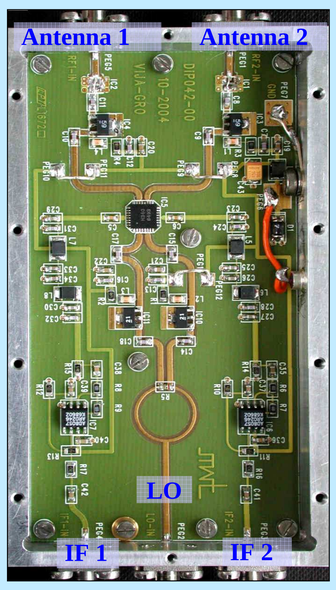
If there is only a single incident wave, it is possible to determine the direction of arrival by measuring the phase difference between two neighboring antennas, even if these are closely spaced. Recently, a nonlinear method had been proposed (Z. Popovic et al., IEEE Int. Microwave Symp. 2004) which is extended here.

Down conversion:

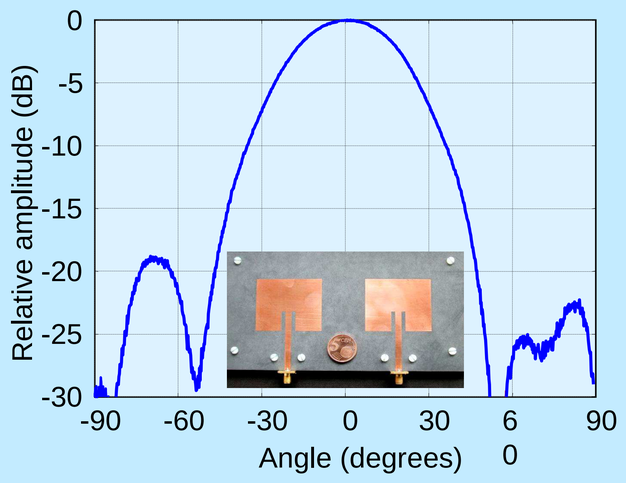
- Phase differences are maintained. In time domain, this can equally be interpreted as an extension of delay time
- At low IF frequencies, standard digital circuits can be employed to do the nonlinear signal processing.
- "Beam scanning" is performed by delay circuits in the two IF channels.



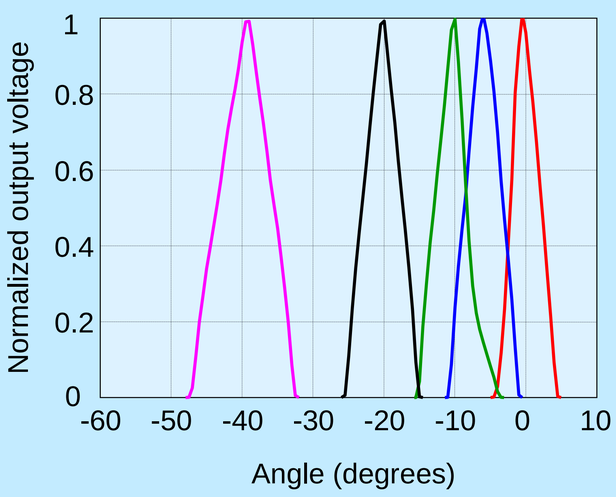
Block diagram of the nonlinear receiver



Photograph of the linear part of the receiver



Radiation diagram of the two antenna elements alone (distance between the two patches is 3/4λ)

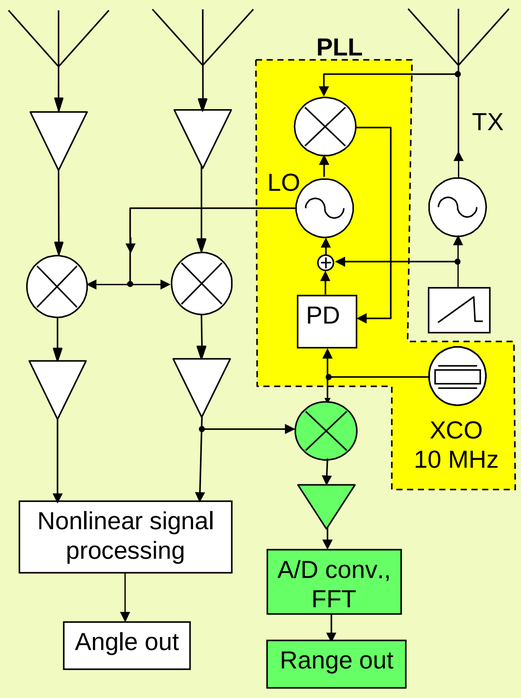


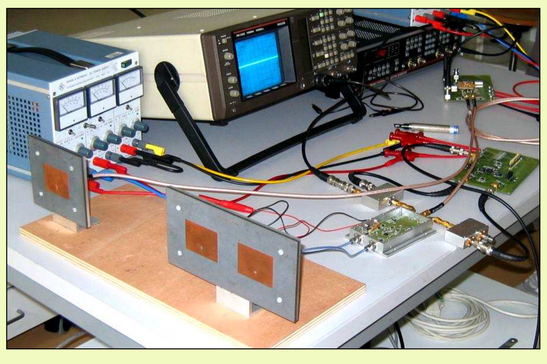
Output voltage of the nonlinear receiver circuit as a function of angle for the incident wave for different delay values.

Test setup was at a RF frequency of 2.45 GHz and an IF frequency of 10 MHz

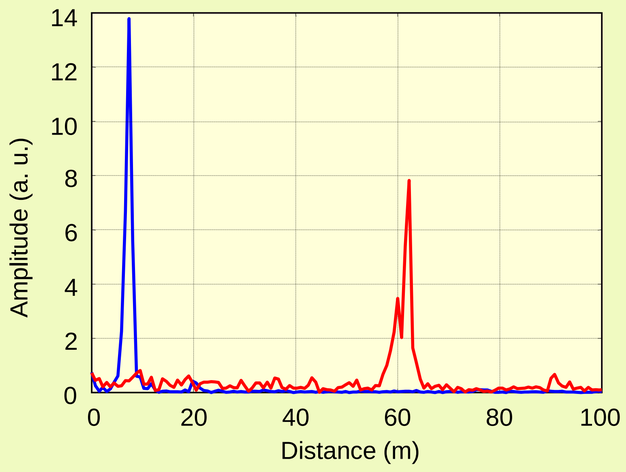
Extension to a simple radar module

- FM-CW modulation of the transmitter
- PLL to lock TX and LO for constant IF frequency

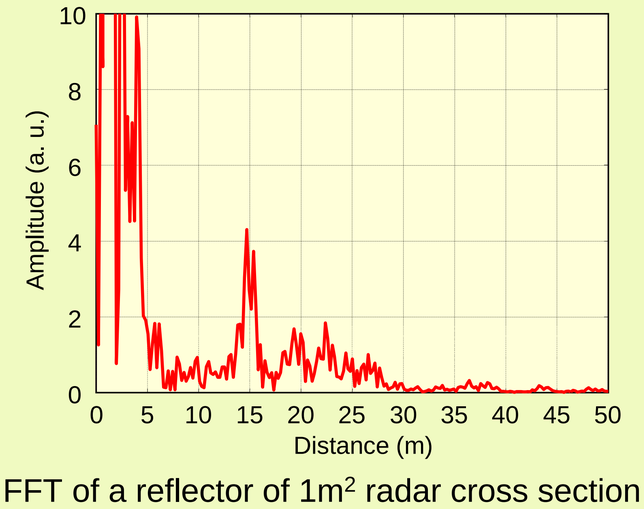




Block diagram of the radar setup and photograph of the measurement setup



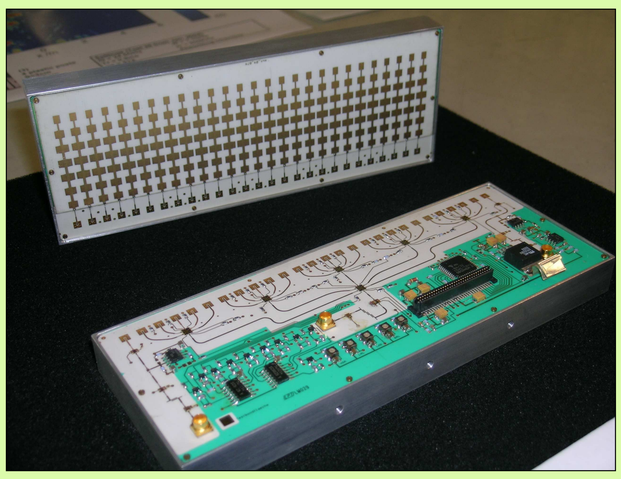
FFT of the test measurements of two cables of 15 m and 110 m electrical lengths



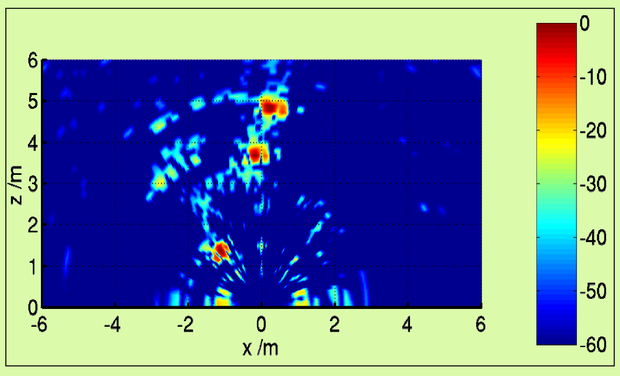
FFT of a reflector of 1m² radar cross section at a distance of 15 m (no range filtering)

Experiment with a 24 GHz sensor

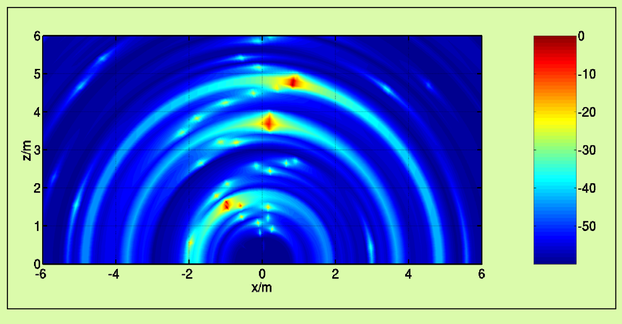
(using two neighboring antennas only)



Photograph of a 24 GHz sensor with switched synthetic aperture (W. Mayer, S. Buntz, H. Leier, W. Menzel, EuRAD 2004, Amsterdam)



Radar image of a scene with three targets recorded with the full aperture of the sensor



Radar image of a scene with three targets using only two adjacent antenna elements of the sensor and nonlinear signal processing