IMPROVING WIRELESS MIMO WITH A DISPERSIVE SIGNAL GATHERING “LENS” OR REFLECTOR

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Abstract

With wireless MIMO spatial diversity, having more potential signal paths with spatial diversity means that a space can support more information transfer by using more signal streams, or RF paths. A signal interfering with other signals at a receive antenna element is actually a desired property. This is because the signals are mathematically separated by performing an inverse matrix comprised of complex transmission coefficient elements, assuming an inverse matrix can be computed. If the inverse solution cannot be computed, a matrix is singular. This idea is to make a radio-wave gathering parabolic lens to produce a large effective aperture and then locate a multi-element phased array at a point which is moved slightly from the focal point. This “blurring” causes spatially diverse signals to overlap. Blurring can also be enhanced by making the surface of the parabolic reflector slightly irregular.

In Fig. 1 three radio waves operating at the same frequency, at the same time, arrive from a far field. The radio waves are red, green, and blue. Ray tracing is used, but only 2 of unlimited rays are selected. The red. green, and blue rays intersect at a focal plane, as illustrated. The receive surface of the phased array is moved to the right from the focal plane. Note in Fig. 1 that the defocused red, green, and blue signals interfere with each other on the phased array.

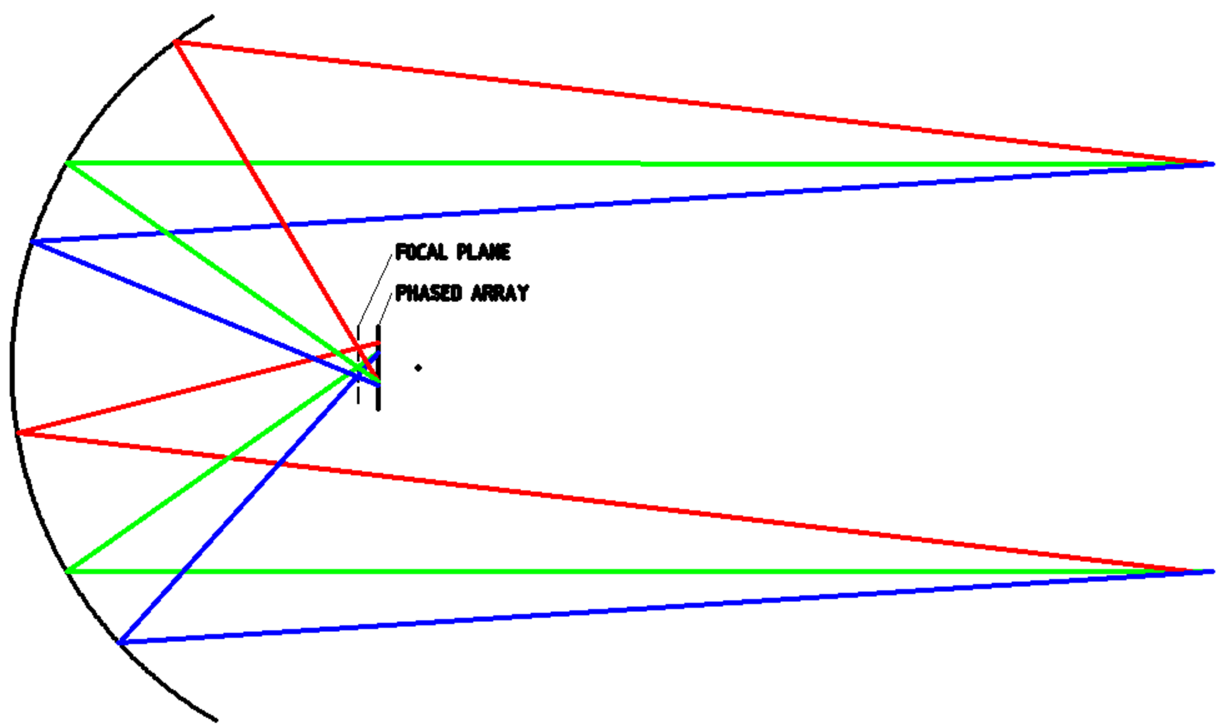


Fig. 1. Three far field signals arrive from different angles. The phased array is moved from the focal plane, causing the 3 signals to interfere with each other, which improve the chances at finding a good inverse matrix from channel responses. The inverse matrix allows signal separation.

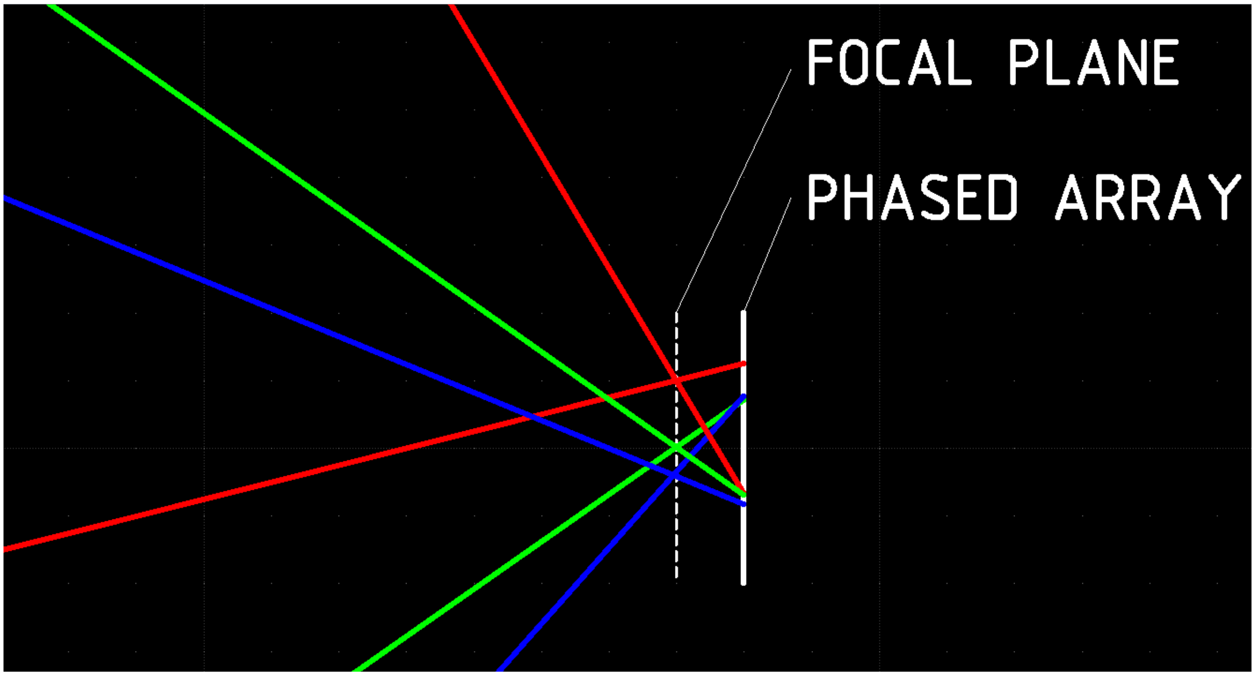
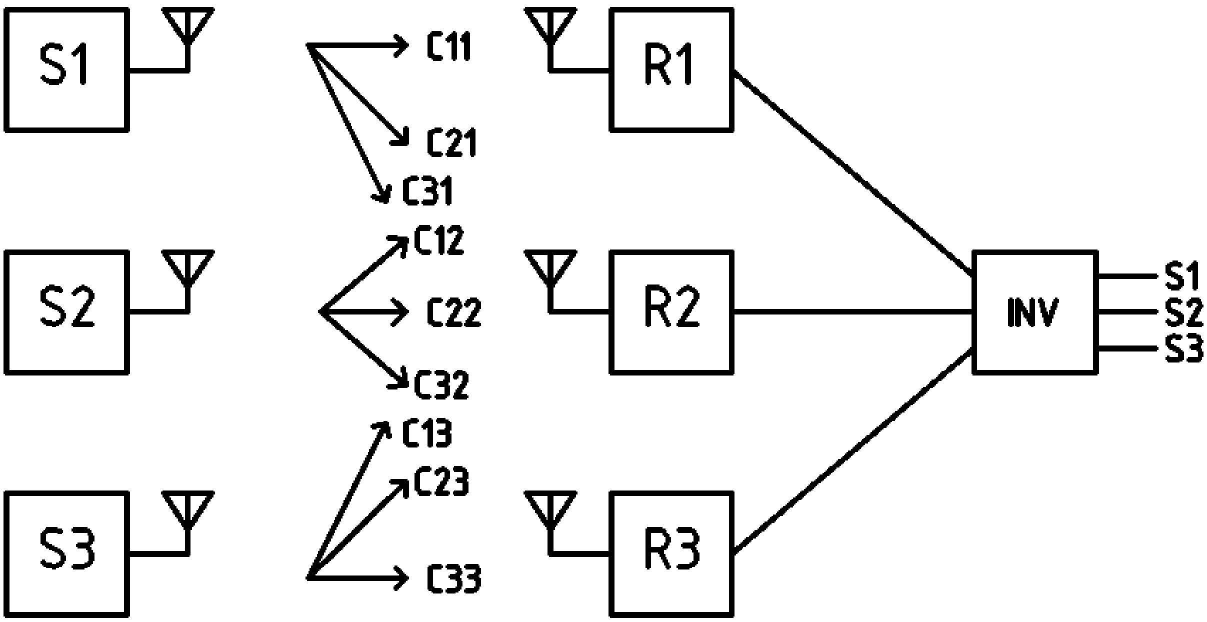


Fig. 1 Expanded. 3 colored beams converge on focal plane, but reception plane is moved out of focus. Note on phased array surface, at one point red, green and blue overlap. At another point blue and green overlap.

Matlab example:



3 X 3 MIMO EXAMPLE

#Let C be a 3x3 transmission matrix with each C_{ij} coefficient being determined from training signals.

#C = [C11 C12 C31 ; C21 C22 C23 ; C31 C32 C33]

C = [1+0i 2-1i 2+1i ; 8-4i -6+4i I ; 5.4-4i 9i 7-1i]

#Let S be three OFDM(A) subcarriers from 3 sources.

#S= [S1 ; S2 ; S3]

S = [4; 5i; -6]

#The received signals will be R

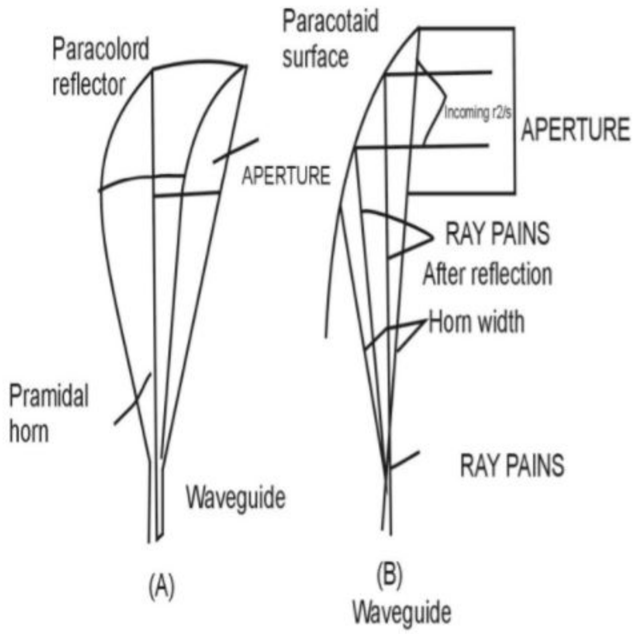
R=C*S

#Compute an inverse of C if you can

iA = inv(A)

#Signals are separated with inverse matrix

iA * R



Hoghorn antenna. (A) Perspective view (b) ray paths.

Fig. 3 Also known as a cornucopia antenna, a MIMO array can be placed at the waveguide connection. The reflector can be made irregular or out of focus to mix off-axis signals.

Topics:

1. Phased array may be rectangular when remote transmitters are disposed in a horizontal direction.
2. Works for sectors on a wireless tower.
3. Works with MM wave RF
4. To avoid too many MIMO streams (because of DSP processing energy required) the field of view (FOV) of parabolic reflector can be segmented into multiple physical sectors each with its own phased array.
5. Effect of big aperture is to gather more signal, improving signal-to-noise ratio (SNR). This allows transmitters to use lower RF energy transmitters, improving battery life.
6. Parabolic reflector does not have a smooth surface to increase de-focusing.
7. This works for lenses where the radio waves go thru the lens, such as a Styrofoam lens.
8. Matrix can be overdetermined. That is, you have more equations than unknowns. This additional information can be used to reduce noise and improve sensitivity, eliminate one or more interferers, or improve the chance of finding an inverse
9. This idea works in reverse where a programmed phased array can transmit instead of receive.

Optics & Photonics News, July/August 2021, Losing the Lens by Nick Antipa, pp 26-33

Note that complex signal addition happens, whereas optical sensors, such as a CMOS or CCD arrays produce scalar addition.