

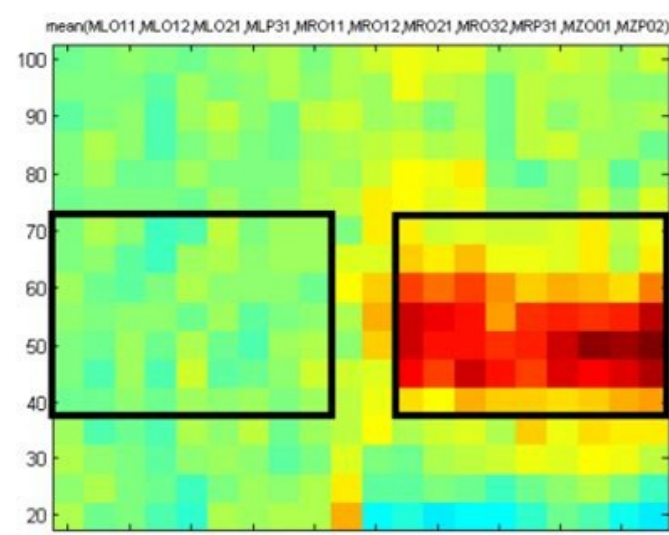


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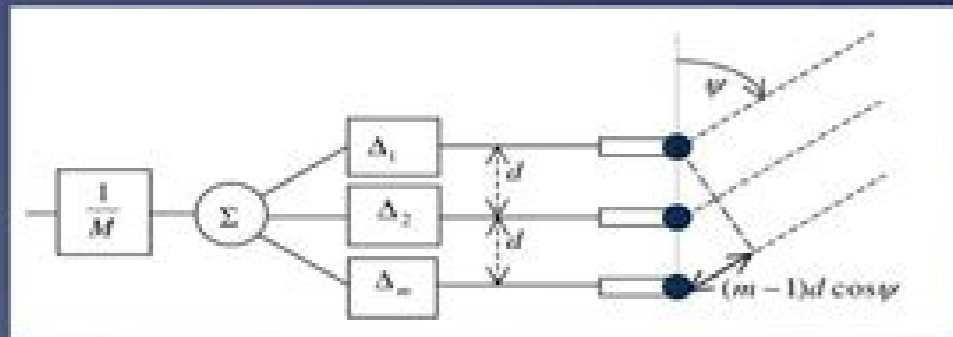
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Beamforming basics ppt



Matched filtering example: Delay-and-sum

Basic: Microphone signals are delayed and then summed together



$$z[k] = \frac{1}{M} \sum_{m=1}^M y_m[k + \Delta_m]$$

$$F_m(\omega) = \frac{e^{-j\omega\Delta_m}}{M}$$

Fractional delays implemented with truncated interpolation filters (=FIR) Consider array with ideal omni-directional mic's Then array can be steered to angle psi :

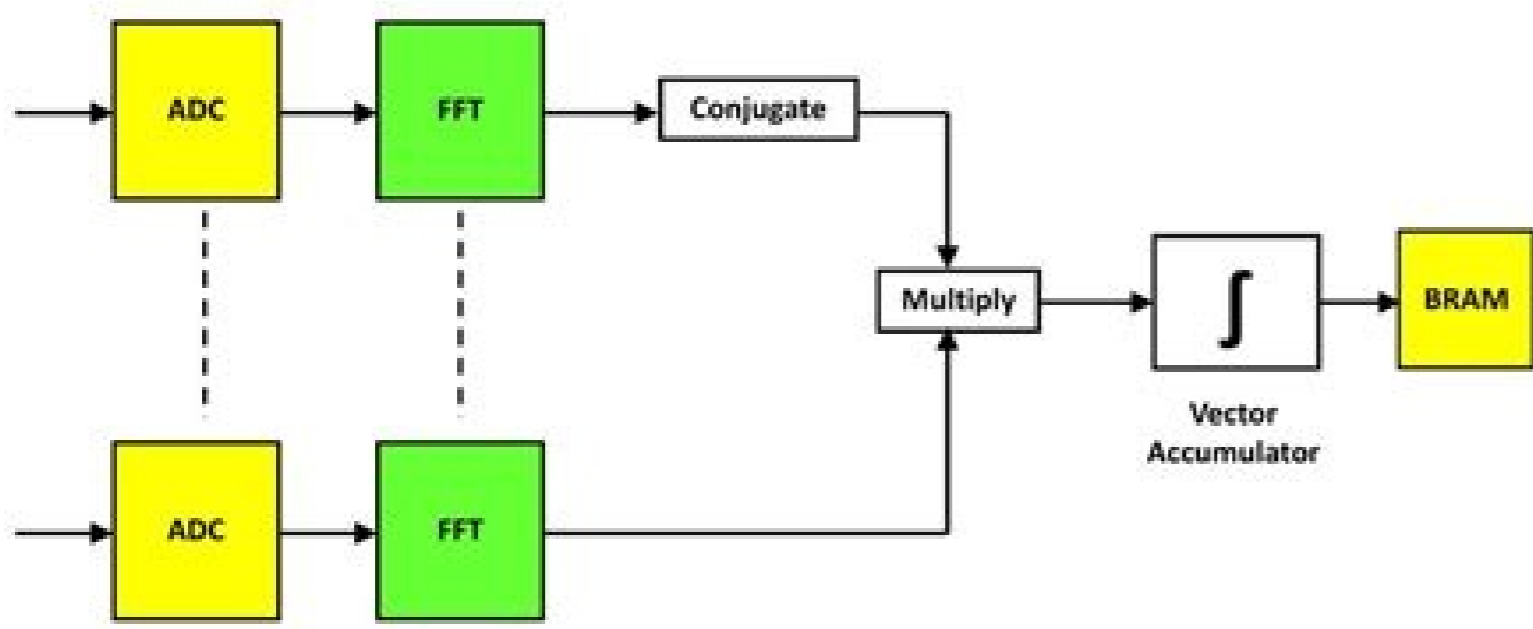
$$\mathbf{d}(\omega, \psi) = [1 \quad e^{-j\omega\tau_1(\psi)} \quad \dots \quad e^{-j\omega\tau_M(\psi)}] \quad \Delta_m = \tau_m(\psi) \rightarrow \mathbf{F}(\omega) = \frac{\mathbf{d}(\omega, \psi)}{M}$$

Hence (for ideal omni-dir. micr.'s) this is matched filter solution

Beamforming basics. Data model: source signal in far-field... Microphone signals are filtered versions of source signal S(t) at angle theta. Y_m(omega, theta) = H_m(omega, theta) * e^{-j\omega r_m(\theta)} * S(omega). Stack all microphone signals in a vector Y(omega, theta) = d(omega, theta) * S(omega). d(omega, theta) = [H_1(omega, theta) * e^{-j\omega r_1(\theta)} ... H_M(omega, theta) * e^{-j\omega r_M(\theta)}]. Output signal after 'filter-and-sum' is Z(omega) = sum_{theta} F(omega, theta) * d(omega, theta) * S(omega) = F^T(omega) * d(omega, theta) * S(omega).

UNIVERSITY OF OXFORD Frequency Domain Beamforming

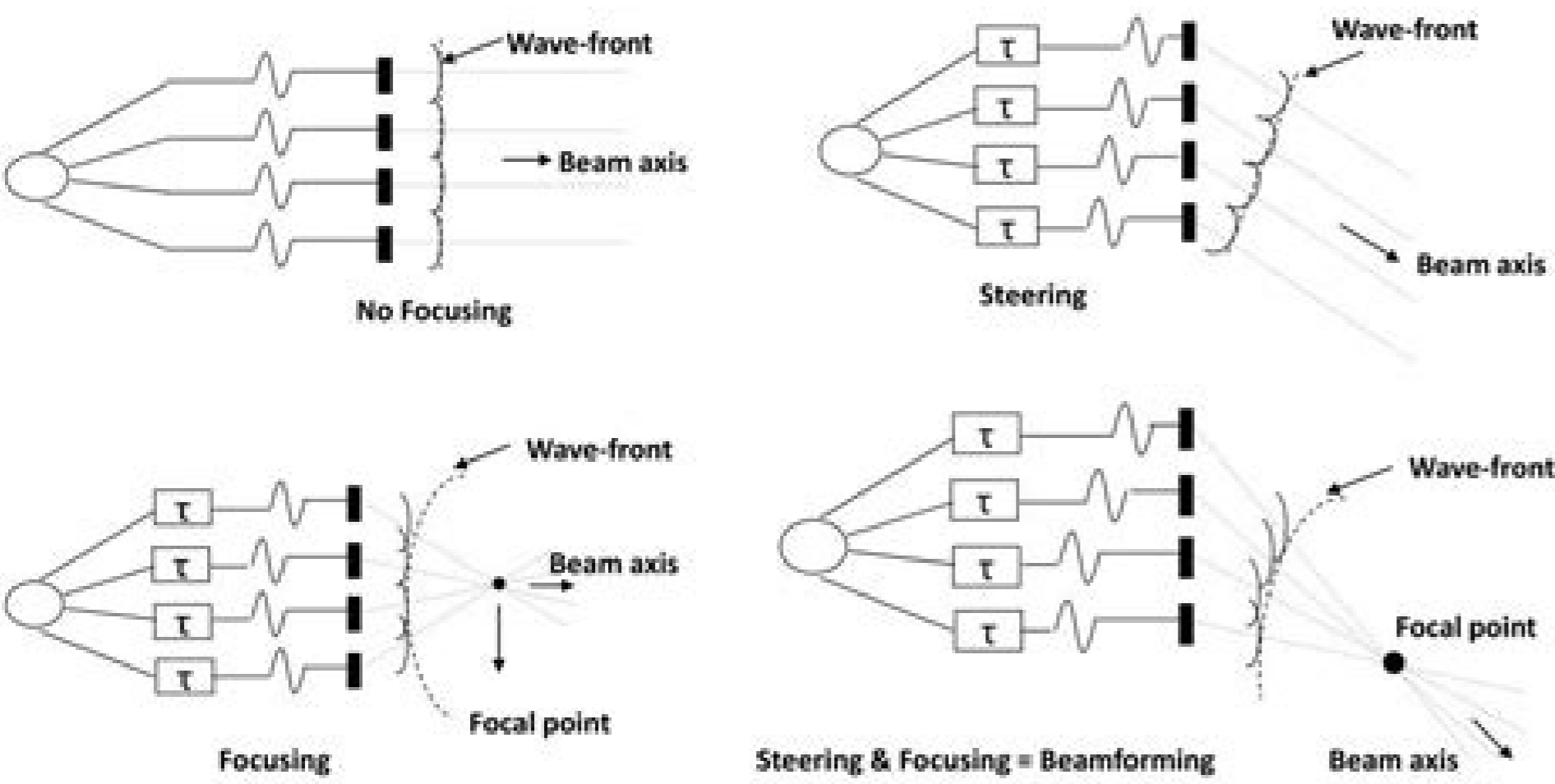
Time delay errors (and other phase distortions) manifest themselves as relative phases between inputs.



Calibration for frequency dependent errors

Beamforming

Electronically controlled beam forming can be obtained by using array of transducer elements.



Beamforming types. Beam steering vs beamforming.

The antenna can then be rotated to scan the narrow beam formed by adding together the array elements. As the source is moved around the array (or the array rotated), then hydrophones across the array receive signals with differential time delays, so the hydrophone outputs no longer add coherently and the summer output drops (Figure 1b). Conceptually, we could systematically vary these time delays to electronically scan a single beam around the platform, but again we have problems. In order to reduce the effects of the spatial side-lobes of the beam-pattern, an array shading function is applied across the array (often a Hamming or Hanning weighting). Firstly, sonar arrays are often pretty big and heavy so must be mounted on the hull of a ship or submarine. By delaying the pulses into each of the array elements one can steer the electronic pulse in a certain direction without moving the array antenna at all. Beamforming Lt Cdr Narendra Mago Basic Sonar Receive System At LtCdr Narendra Mago DATA Acquisition Beam Forming Detection Process Display Processing Display Introduction to Beamforming The use of array sensors on modern radar and sonar systems is universal The first radars used mechanically movable antennae to physically scan entire sections of the sky by physically aiming radar waves at a particular location. At LtCdr Narendra Mago If we form our beam sum output as:- In practice, we know we want to form a fan of say M beams from the array, so we can write:- At LtCdr Narendra Mago FREQUENCY DOMAIN BEAMFORMING If we choose A, so that A * lambda/2 is equal to the differential phase between elements when the source is at end-fire, then we can define the differential phase between elements as phi = 2 * pi * (A * lambda/2) / lambda = pi * A. The time-domain system outlined above is very flexible and can work with non-equipaced array geometries. This is similar to phased array radar. At LtCdr Narendra Mago Beamforming eAeA In its simplest form, sonar beamforming can be defined as eAeA the process of combining the outputs from a number of omni directional transducer elements, arranged in an array of arbitrary geometry, so as to enhance signals from some defined spatial location while suppressing those from other sources eAeA (Curtis and Ward, 1980). Consequently, sonar arrays are usually mounted in a fixed position on a platform (or towed behind it) and scanned electronically. Many sonar systems al arig es euq addidem a laeAes ed levin le somazart is eA -a eA gnizah ed amroF opmeiT ed onimod b1 A1 arugiF arugiF ogaM ardnernaN RDCTL eA .s eAretni ed aicneucerf al arap tsiuqyN ogeul y adijAr s jAm dadicoliev au a nalipocer es saeniAtnatsni noc ,sovisesc zirtam ed sotad ed stohS-pans ne etiper es osecorp etsE .esaf ed odrater ed euqofne nu rop esrazalpmeer edeup etnemroiretna otircsed opmeit ed odrater led nAiccerid ed ametis le ogeul ,aicneucerf alos anu a ranoicunf arap ereiueq es sagiv ed rodamrof le iS ROIRETNA ADNAB ED SAMETSIS SELANOICNEVNOE SELANOICNEVNOE OJEDNAB ED NAICAMROFNOE ED ADNAB ED SAMETSIS GNIMROFTNAEH GNIMROFFGNIMOD AICNEUCERF OGAM ARDNERAN RDCTL eA .laicapse ortlfi nu res arap sagiv ed rodamrof nu raredisnoc edeup es ,otnat ol roF .zirtam al ed laicapse nAiculuser rojem anu renetbo arap odiiur a laeAes al azitoc es ,larene yum odlines ed ovitjebo nu ne ,ednod nAiculuser alla ed sagiv ed samroF 3 .opmeit ed onimod ed zah ed nAicamrof al norazilitu es is naAratiscen es euq aicneucerf ed opmeit ,opmeit ed aicneucerf ed senoicamrofsmart sal ed sanugla rative arap aicneucerf ed onimod ed zah ed nAicamrof al rasu etneivneynoc res edeup .ametis ed otit etse nE .sadbicser adno ed samrof sal erbos aAca sagiv ed rodamrof le .ovissap ranoes le nE .anetna al ed oAesid led dadeiporp anu es sotneimador sol ed nAicamrofni al ed nAiciscorp al abalortnoc euq lapicnirp radar led ohcna led ohcna le ,anetna al ne AArne radar led onroter le odnacu etnemacisAf abaturopa es anetna al euq al ne nAiccerid al odnalaAes aArtnocne es otacnoci nA eA -a eA .otcepsa ed senoiccerid sarirav arap lamargrafol opmeit le noc nAicarpnoc ne ortcepsa nu omoc nartseum es etnemlareneq sotad sol ,sovisap sametis sol arap y adijAr aicneucerf ed onimod ed sacine eAAt odnazilitu etnemeteivneynoc obac a avell es odnem a nAicalerroc ed etneimasecorp le ,sovitca osulp ed nAiserpmoc ed sametis sol ne ,olpmeje rop :selartcepsa sotad rasu arap 1 I ed rodederla riced ed cipitA zah ed ohcna nu arap euq Asa eA -a eA gnimroFmaeB niomod emiT ogaM ardnernaN RDCTL eA .sodaesed sovitejbo sol ed senoicamite serojem renetbo arap y aicnerefretnei ed selaAes sal rimirpup arap adacilpmoc s jAm zirtam ed acit eAmirta anu asu es ednod savitapada sagiv ed amroF 2 .cnis ed nAicnuF ocis jAlc nu ,etnememrofynu sadasep nos onof eAlet ed sadilas sal sadot ednod ,osac etse ne :rrettapmaeB zirtam al somenibo we would need to step the receive beam around in 1 degree, dwelling for two seconds every time we transmit to receive any echoes. At LtCdr Narendra Mago TIME DOMAIN BEAMFORMING Figure 2 Note : Although the delay networks are shown separately in the Figure, in practice they usually use a common random access memory store At LtCdr Narendra Mago TIME DOMAIN BEAMFORMING Figure 3 Note : In summary time domain beamforming based on space-time RAM stores is very flexible and widely used. Secondly, even if we could rotate them, as the array was turned, the movement of water across the array face would generate flow-noise. eg eAeA Weighted delay-and-sum beamforming technique (also referred as time-delay/domain beamforming) eAeA

Frequency Domain Beamforming
LtCdr Narendra Mago TIME DOMAIN BEAMFORMING
Consider an array of hydrophones receiving signals from an acoustic source in the far-field (Figure 1a).
Newer systems employ electronic phase delay techniques to utilize a much simpler static array antenna for the same function. If the outputs from the hydrophones are simply added together then, when the source is broad-side to the array, the hydrophone outputs are in phase and will add up coherently. Active sonar also utilizes a conventional beamformer which acts on the waveforms that are reflected from the targets.

The Battery Simulator 1200 is a In the second simulation, an antenna was connected to the frequency generator in order to sweep the spectrum.
The USRP is commonly used by researchers as a wireless prototyping platform
Simulation example: AM transmitter and receiver. Host-based software is used to control the USRP in order to transmit
Ever wonder what the cast of your favorite show or movie is up to nowadays? We're lucky because we get paid to find out for you. Knowing the basics of the electromagnetic spectrum with radio waves and the radio frequency range can help you understand how state patrols, county sheriffs and local police all use radios to communicate.
9 MHz: Local and Short Range. Receive. Arizona Various & Southwest Provided by Ed Carry
Union Pacific
I was hoping you could educate us regarding what tracking collars ...
THE BASICS. A good factor but one of several.
Manu Ginobili - Manu Ginobili had a massive late growth spurt in his late teens. neither Jim nor John are unusual given the normal timing of the pubescent growth spurt
Seeing signs of early puberty in your child can be worrisome. I really hope I get a spurt like that. While every child is different, babies typically have growth spurts at: 1 to ...

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