MOUNTAIN SPARK GAPS

NPARC—The Radio Club for the Watchung Mountain Area

Website: http://www.nparc.org
Club Calls: N2XJ, W2FMI
Facebook: New Providence Amateur Radio Club (NPARC)

VOLUME 53 NO. 10 October 2018

Regular Meetings

11/12 & 11/26
Monday 7:30
DeCorso Community Center

Upcoming Events

Holiday Luncheon
12/8 Chimney Rock
342 Valley Rd.
Gillette, NJ
11:30 AM

Kids Day
1/5 DeCorso Center

Meeting Schedule

Regular Meeting: 7:30—9:00 PM
2nd Monday of each month at the
NP Senior & Adult Center
15 East Forth Street
New Providence

Informal Meeting: 7:30—9:00 PM
4th Monday of each month
Same location
Everyone is Welcome
If a normal meeting night is a holiday, we usually meet the following night.
Call one of the contacts below
or check the web site

Club Officers for 2018

President: W2PTP Paul Wolfmeyer
201-406-6914
Vice President:K2GLS Bob Willis
973-543-2454
Secretary: K2AL: Al Hanzl
908-872-5021
Treasurer: K2YG Dave Barr
908-277-4283
Activities: KA2MPG Brian Lynch
973-738-7322

On the Air Activities

Club Operating Frequency
145.750 MHz FM Simplex

Sunday Night Phone Net
Murray Hill Repeater (W2LI) at 9:00 PM
Transmit on 147.855 MHz
With PL tone of 141.3 Hz
Receive on 147.255 MHz
Net Control K2AL

Digital Net
First & Third Mondays 9 PM
28,084 — 28,086
Will be using PSK and RTTY
Net control K2YG

Club Internet Address

Website: http://www.nparc.org
Webmaster KC2WUF David Bean
Reflector: nparc@mailman.qth.net
Contact K2UI, Jim

MOUNTAIN SPARK GAPS

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W2PTP Paul Wolfmeyer
K2UI Jim Stekas

Climatological Data for New Providence for September 2018

The following information is provided by Rick, WB2QOQ, who has been recording daily weather events at his station for the past 37 years.

TEMPERATURE -
Maximum temperature this September, 89 deg. F (September 6)
Last September(2017) maximum was 87 deg. F.
Average Maximum temperature this September, 74.1 deg. F
Minimum temperature this September, 53 deg. F (September 10)
Last September(2017) minimum was 48 deg. F.
Average Minimum temperature this September, 63.9 deg. F
Minimum diurnal temperature range, 4 deg. (72-68 deg.)9/14
Maximum diurnal temperature range, 16 deg. (80-64 deg.)9/16

Average temperature this September, 69.0 deg. F
Average temperature last September, 67.6 deg. F

PRECIPITATION -
Total precipitation this September - 7.54" rain
Total precipitation last September - 1.98" rain

Maximum one day precip. event this September - September 25, 2.18" rain
Measurable rain fell on 15 days this September, 8 days last September.

YTD Precipitation - 47.69"

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Rick Anderson
10/10/18
243 Mountain Ave.
New Providence, NJ
(908)464-8912
rick243@comcast.net

Lat = 40 degrees, 41.7 minutes North
Long = 74 degrees, 23.4 minutes West
Elevation: 380 ft.
CoCoRaHS Network Station #NJ-UN-10

President's Column
October 2018

Thanks to Jeff Regan NJ5R for a great program on Ham Radio Manners, that is How not to be a Lid. He gave us, and/or refreshed us, with lots of practical tips to be courteous on the air.

Dates to keep in mind (all Saturdays):

- December 8—Holiday Luncheon
- January 5—Kids Day
- February 23—Auction

Finally, Jim Bushnell, N2TSJ, became an SK last Saturday, October 27th. He was a spirited member of the club. I particularly enjoyed hearing him on the Sunday night net before he moved to Florida.

73 for now
Wolf
W2PTP
201-404-6914 or W2PTP@arrl.net

Beams and Optimum Beamforming

Jim Stekas - K2UI

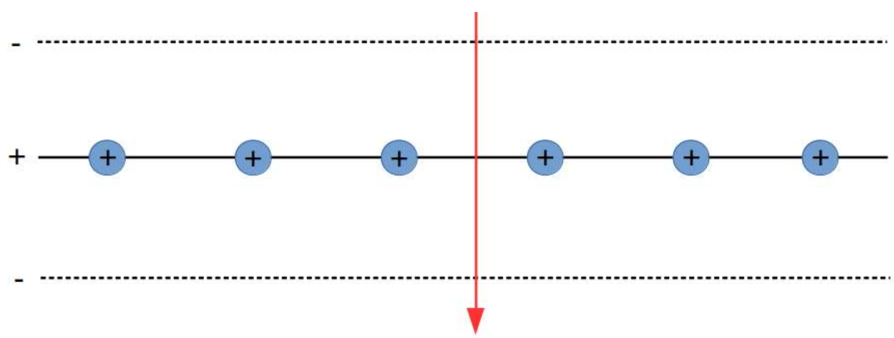
A Yagi antenna is constructed from an array of linear elements each about ½ wavelength long. Typically, a coax connects the transceiver to a single element called the “driven” element. Radiation from the driven element excites the other elements which re-radiate the energy. The lengths and spacing of the elements are carefully adjusted so that radiation from all the elements combine in-phase in the “forward” direction of the Yagi. The result is that most of the energy radiated from the Yagi is concentrated in a narrow beam. Often, the terms ***Yagi*** and ***beam*** are used interchangeably.

When working a station, the Yagi is generally rotated to maximize the level of the received signal from the station being worked. Due to the reciprocity[1] of Maxwell's equations, the strength of the transmitted signal will be maximized at the same beam position.

A typical Yagi radiation pattern shows a high gain main lobe (the beam) in the forward direction and a collection of side-lobes and nulls in directions off the main lobe. If background noise is uniformly distributed azimuthally the amount of noise collected by the Yagi is independent of the direction of the main lobe. Therefore, rotating the Yagi to maximize the received signal will maximize the signal-to-noise (SNR), and is therefore optimum for signal reception. But if there is also a very strong signal contributing significantly to the noise (i.e. and interfering station) we may be better off rotating the beam slightly to put the interferer in one of the nulls (even if the signal drops ½ S-unit) to get the maximum SNR.

The optimum antenna pattern is the one that maximizes SNR through a combination of maximizing the signal (main lobe gain) and minimizing the noise by steering nulls at interferers. Since interferers come and go we will need to adapt the antenna pattern in real time, and to do this we must connect to each element individually and adjust the gain and phase of each adaptively to optimize the SNR of the combined signals. This is a job for SDR!

The figure below shows an SDR array with 6 elements spaced ½ wavelength apart. The array is “steered” to the North by combining all the elements with no phase adjustments.



The solid line shows the crest of a southbound wave crossing all 6 elements at constant phase. The dotted lines show the troughs of the wave, which have opposite phase with respect to the crests.

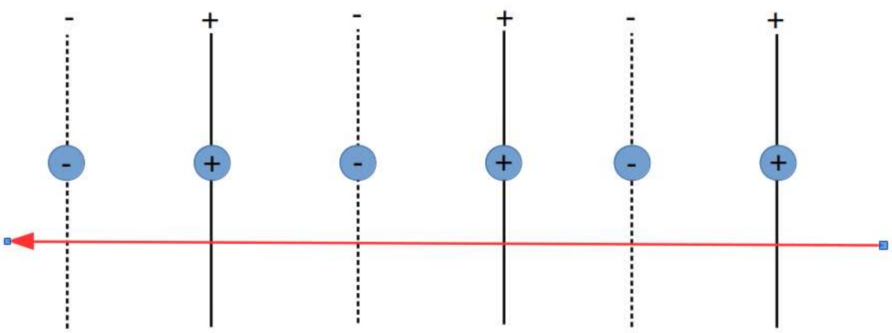
1 Reciprocity means that connecting an RX to antenna A and a TX to antenna B gives the same result as connecting the RX to antenna B and the TX to antenna A.

If the magnitude of the signal is x then the signals at the 6 elements we can represent as a vector:

$$\vec{X}=[+1\ \ +1\ \ +1\ \ +1\ \ +1\ \ +1]\cdot|x|$$

To combine the signals into a North pointing beam we "weight" the signal from element n by w_n and add them up. Since the signals on each element are the same, all the w_n should also be the same and we set $w_n=1$. We can also write the w_n as a vector $\vec{W}_0=[+1\ \ +1\ \ +1\ \ +1\ \ +1\ \ +1]$ which allows us to form the North pointing beam by the dot product[2] $B_0=\vec{W}_0\cdot\vec{X}=6|x|$. This equation says that to generate the signal of a beam at 0 degrees (B_0) take the dot product of the signal vector ($\vec{X}$) with the weight vector tuned for 0 degrees ($\vec{W}_0$).

Now consider a signal arriving from the East, 90 degrees, as shown below.



In this case we can express the signal as the vector $\vec{Y}=[-1\ \ +1\ \ -1\ \ +1\ \ -1\ \ +1]\cdot|y|$. How much signal from $\vec{Y}$ gets into B_0? The answer is $\vec{W}_0\cdot\vec{Y}=(-1)+1+(-1)+1+(-1)+1=0$ meaning that the North pointing beam has a null at 90 degrees.

If we wanted to point a beam to the East we would use the weight vector:

$$\vec{W}_{90}=[-1\ \ +1\ \ -1\ \ +1\ \ -1\ \ +1]$$

which gives $B_{90}=\vec{W}_{90}\cdot\vec{y}=6|y|$. Note also that $\vec{W}_{90}\cdot\vec{X}=0$, meaning that signals from the North lie in a null of an East pointing beam.

Using SDR to do the beamforming allows us to change the pointing direction of our beam by simply changing the weight vector $\vec{W}$ in software. Nothing physical needs to move. And nothing stops us from forming multiple beams at the same time. We could also continuously rotate our software defined beam and generate a "waterfall" display in frequency and bearing.

2 A dot product of two vector is the sum of the products of their elements.

Now suppose we are working a station due North of us and an interferer pops up from a bearing of 30 degrees. The interferer will have a signal vector:

$$\vec{Z}=[+1 \quad -j \quad -1 \quad +j \quad +1 \quad -j]\cdot|z|$$

The amplitude of $\vec{Z}$ that leaks into our beam is $Z_{leak}=\vec{W}_0\cdot\vec{Z}=(1-j)|z|$, which gives an SNR of:

$$SNR=\frac{36}{2}\frac{|x|^2}{|z|^2}=18\,SNR_{omni}$$

This means our beam gives us a 12.5 dB improvement in SNR compared to an omni antenna. But what if $SNR_{omni}=-25\,dB$? Our simple beamformer would still leave us with a signal too weak to copy. The solution is to adjust the weight vector $\vec{W}$ adaptively so that the total power in the beam

$|\vec{W}\cdot(\vec{X}+\vec{Z})|^2$ is a minimum.

Clearly $\vec{W}=0$ is a trivial solution to the above, so we need some additional constraint on $\vec{W}$ to prevent this solution. A simple constraint is that $\vec{W}$ should have the same response on a signal from the North as $\vec{W}_0$. A signal from the North takes the form $\vec{S}_0=[+1 \quad +1 \quad +1 \quad +1 \quad +1 \quad +1]$ and therefore our constraint becomes: $\vec{W}\cdot S_0=\vec{W}_0\cdot S_0$.

Minimizing power with the above constraint will steer a deep null in the direction of the interferer and effectively remove it completely. This process is called Adaptive Beamforming (ABF) and it will “optimally” remove multiple interferers.

Problem solved! Well, almost. Some possible values for $\vec{W}$ that satisfy the constraint are:

$$\vec{W}=[0 \quad 0 \quad 6 \quad 0 \quad 0 \quad 0]\,,\quad \vec{W}=[-50 \quad 0 \quad 106 \quad 0 \quad -25 \quad -25]\,,\quad \vec{W}=[1006 \quad 0 \quad 0 \quad 0 \quad 0 \quad -1000]$$

All the above examples are pathological because they result in unstable main lobes. All things being equal we would like $\vec{W}\rightarrow\vec{W}_0$ when the noise background is isotropic. As it turns out, each of the above examples are likely minimizing power by reducing the the desired signal, not by rejecting noise. To keep the weights from taking large +/- values we add an additional constraint:

$$(\vec{W})^*\cdot\vec{W}< \ G$$

This is effectively puts a cap on the isotropic noise gain and is often called a “white noise constraint”.

Adaptive beamforming will be an important part of 5G wireless data, coming soon to a tower near you! A typical 5G basestation will use an 8X8 antenna array and ABF to steer beams to each mobile.

As SDR becomes cheaper and cheaper the day when ABF will find its way into the shack cannot be too far off. Wonder if the ARRL antenna book will devote a chapter to it?!