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CODAR CURRENTS

CODAR OCEAN SENSORS

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Links to the latest SeaSonde software below:

Current Radial Software available:
SSRadialSuiteCD_10R4SeaSonde10R4/

Current Combine Software available:
SSCombineSuiteCD_10R3SeaSondeR3u3/

Note: You will be required to enter the standard user name and password to enter the customer section of SeaSonde.com

"The Sound of MUSIC" Heard by SeaSondes

by Dr. Don Barrick

Everyone who has scratched beneath the surface of SeaSonde usage perhaps wondered at the statement "SeaSonde bearings are determined using MUSIC". Or maybe one hears about MUSIC parameters used in the Setup and Preferences files. We explore what this is all about, and try to remove some of the "mystery of MUSIC".

• History of MUSIC

Believe it or not, MUSIC (MUltiple SIgnal Classification) was devised by a very bright Stanford researcher working for the CIA back during the Vietnam War [R.O. Schmidt -- check our website to get his 1986 IEEE reprint]. They wanted to put flush-mounted receive antennas on different parts of the skin of surveillance aircraft. Receiving radio signals from enemy transmitters in the jungle below, the goal was to find the direction of the source while flying by. This is called "direction finding" (or DF). Conceptually, if one receives the same signal on antennas at different locations, it ought to be possible to estimate its direction, just as you or an animal turns its head and uses its brain to locate the direction of a sound picked up by our ears. But what is the optimum algorithm to do this? Others are available, but MUSIC is one of the best.

• How It Works in Two Paragraphs

Think of what is received on a given frequency as comprised of several possible candidates: desired signal(s) and noise, the latter always being present. E.g., let there be two signals and noise present, heard on three antennas. Wouldn't it be nice if one could devise some kind of "mathematical space" where signals and noise were totally separated from each other? And where these clusters of two signals and noise could be made to have identifiable properties when their directions of arrival were properly chosen? Well, that's what MUSIC does.

The same signal heard on three antennas is not totally different. When mixed up with the other signals and noise, however, it is hard to separate them, much less determine their directions. That's what a matrix-based mathematical procedure called "eigenfunction analysis" (a dreaded bane to graduate students in the physical sciences) does for you. It creates three new "signals" -- called eigenvectors -- that are mutually perpendicular to each other, when you get their directions correct. Each antenna has its own response vs. signal angle-of-arrival. With SeaSondes we measure these with a transponder rather than naively relying on textbook predictions which are rarely correct in the real world. Using these antenna responses in matrix form, we step through direction-of-arrival angles until the signal eigenvectors are perpendicular to the noise eigenvector. When we have chosen the correct angles so that this happens, vector products become zero, which is an easy algorithmic test to carry out.

• Why MUSIC and Direction Finding with SeaSondes?

We at CODAR are the first to use MUSIC (or any direction finding) with radar. Normally one forms and scans narrow beams to determine direction, like finding an object in the dark with a flashlight. At HF, however, the size of antennas required to do this (called phased arrays) is huge because of the long wavelength. After a few early tests in the 60s, we decided this could not lead to a cost-effective easy-to-use affordable system that people wanted. So we abandoned this (while others did not), and CODAR was born. DF allows low-cost, inefficient tiny antennas to be used in place of the massive antenna farms of yore, with no penalty in performance.

Direction or bearing angle is determined for each current radial velocity that is outputted from our Doppler analysis, because each velocity/Doppler bin is an individual radio signal pulled out by the spectral processing. In our early algorithms, we used a "least-squares" algorithm instead of MUSIC for DF. But MUSIC had too many advantages to ignore. In fact, MUSIC DF was found to be more accurate even for long phased array antennas than beam forming/scanning [K. Laws, PhD Thesis, UCSC, 2001, available as PDF from our website]. Note that MUSIC is not used in wave directional information processing with SeaSondes, only for current mapping; relevant wave algorithms are described elsewhere.

• Setup Choices, Decisions, and the Tradeoffs

Decisions must be made in MUSIC DF processing. The important one is: how many directions are we actually receiving echoes from -- for the same Doppler (or radial velocity) over a given circular range cell? Oceanographically, two is a realistic upper limit, based on the resolution offered by HF radars in current mapping. But the answer could be one. How to decide? If we guess wrong, the answer(s) will be in error. That's where our "MUSIC parameters" come in. We start off assuming both single and dual-angle situations, determine the respective angles as described above, then run hypothesis tests to pick which situation best fits the data: single or dual. You can read mathematical details of this procedure in our patent [Barrick and Lipa, 1999, PDF on our website]; there is no attempt to keep this hidden as in a "black box". To contrast two examples that have been used, [10 5 8] are three parameters that favor single-angle , while [80 40 1] are a set of parameters at the other extreme that favor the dual-angle solution outcome.

Suppose you push toward single angle when the actual current pattern is dual-angle? Then you will get angle gaps in your radial map coverage. That's not good. Gaps are especially aggravated if the measured antenna patterns are very distorted from ideal, or if the receive channel amplitude or phase balances drift over time and are not accounted for. On the other hand, if dual-angle is obtained when the situation demands single-angle, these wrong answers will bias the mapped results.

- **How Did We Arrive at Default Values - When Might One Change Them?**

Two methods were used over the years: (i) Extensive simulations; (ii) Comparisons of SeaSonde outputs with independent measurements like ADCPs. With simulations, you know the answer going in, and you devise input flow patterns to resemble realistic circulation features commonly seen. But there's nothing like independent comparisons in the real world. Many studies of both simulations as well as comparisons have been done by our customers, lending greater credibility to our recommended MUSIC parameters. It's always good to have outside studies like this rather than trust the manufacturer for everything, isn't it? After all, scientific claims should be reproducible by others if they are to be credible.

Right now, based on our experience, we recommend as default MUSIC parameters [40 20 2]. If you want to study differences between two parameter sets on you own data, you can re-process offline both ways. Contact us so we can advise how to set this up and what parameters to try. And let us know if you want to learn more of what others have done on this subject.

Tech’s Corner

Protecting Your SeaSondes® With a "Smart" UPS Configuration

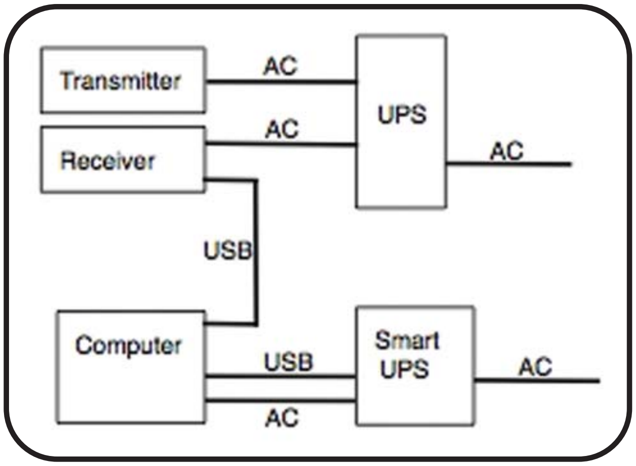
by Chad Whelan, Sr. Field Engineer

What is a UPS and why do I need one?

As all of us who work with high-tech equipment know, a stable supply of power is of paramount importance to reliable, uninterrupted data collection. UPS is an acronym for Uninterruptible Power Supply. By using a UPS, you give your equipment a reserve of power from a backup source that filters the incoming power and allows for controlled shutdowns in the event of an extended outage. The amount of time a piece of equipment can run on a UPS during a power outage depends on the size of the UPS battery and the power consumption or draw of the equipment. The Transmitter and Receiver chassis have somewhat different requirements of a UPS than the computer.

Transmitter and Receiver

While they have been designed to withstand some power line fluctuation, both the transmitter and the receiver are sophisticated pieces of equipment and should be afforded additional protection. There are a number of power-related circumstances that can cause damage, wear or undesirable performance. Brownouts, power surges, voltage spikes and short, momentary power outages are the most common types of damaging power issues. Since the transmitter is a constant power device, if the voltage drops to a low, non-zero value (a brownout) or it ramps down to zero volts slowly, the transmitter will try and compensate by drawing more current.



This can blow out the fuse that protects its internal components. Unfortunately, when this happens, someone needs to visit the site and replace the fuse manually. Frequent momentary losses of power are another concern as they can cause the internal modules to restart repeatedly and behave in unexpected ways. Things like USB communications between computer and receiver have been known to be affected by frequent module restarts. Power surges and spikes, if strong enough, can also cause data loss if they blow fuses or damage components.

Computer

The computer is the interface between the user and the electronics and in addition to collecting and processing data, it can be used for diagnostics and monitoring performance. During a long power outage, it may be desirable to keep the computer active even if the transmitter and receiver have drained their UPS. It provides the user much more information to be able to log on and see that the UPS is not receiving power rather than not being able to access the computer at all. Computers also do not typically respond well to losing power frequently, sometimes even failing to reboot when power is restored. It has been reported that in some cases, cutting power to the computer has caused the clock to reset and lose the current time. A controlled shutdown is always a better solution than just cutting power. By monitoring the UPS storage, a computer can shut itself down to protect itself, but also to conserve power and set a reboot time.

Proposed Setup

Because of their different needs, one possible solution is to use one UPS for the SeaSonde® electronics and a separate one for the computer. The UPS for the electronics should be of at least 1 kVA but preferably 1.5 - 2 kVA and does not need to have a USB interface. With AC power, 1.25 kVA is approximately 1 kW. UPS's are typically rated in kVA. The UPS for the computer does not need to have as high capacity, but should have enough storage to last the computer for several hours. It should also have a USB interface that is compatible with OS X, like the APC SmartUPS® line of products. This configuration will provide the electronics with stable power through outages and power line fluctuations as well as a clean voltage drop to zero volts when the UPS storage has been spent. It will also provide the computer with stable power and controlled shutdowns before power is removed. We have developed a script that will monitor the UPS and shutdown the computer periodically to conserve power as well as prevent an immediate power loss while the OS and software are running. When AC power is gone and the UPS storage reaches a user-defined power reserve, the script will schedule a startup at a user-defined time or interval and then shutdown properly. When the system starts up again, it will determine whether AC power has returned. If power has not returned, the computer will remain on for a user-defined interval and then go through the process again. It will continue this way until AC power has returned or the UPS has reached another user-defined threshold reserve, below which it will remain off until power is restored. If a communication device, like a router, is also on UPS power, it will allow the user to log in during one of these reboots to check on the system. Please contact CODAR Ocean Sensors Support <support@codaros.com> to find out more about this or other UPS options.

More from **Tech's Corner**

Important Message for GPIB equipped SeaSonde users! USB Upgrades Available for GPIB Systems!

CODAR Ocean Sensors (COS) will be phasing out all support for SeaSondes using the obsolete GPIB (General Purpose Interface Bus) over the next six months. The good news is that COS will be offering specially priced USB upgrades to encourage the few remaining GPIB system owners to make the leap to the USB interface which is now an industry standard.

Two specially priced upgrade packages will be available through June 30, 2006. One is a basic upgrade to the USB bus. This will allow older SeaSondes to take advantage of all of our new OS X based software. A second upgrade option includes the addition of a GPS timing module and built-in wattmeter. The GPS timing module allows multiple SeaSondes to operate simultaneously while sharing the same frequency. This upgrade option also provides remote monitoring of output power.

If you are one of the half-dozen or so remaining "loyal" GPIB system owners and are interested in adding years more life to your system along with a one year warranty renewal, please contact support@codaros.com for pricing information.

Help is Available if You Ask

CODAR has a dedicated and experienced Support team available to help customers with potential problems, and can provide instant feedback if you suspect something is not right with your data.

Examples of situations that might precipitate contacting our support staff: (1) Significant variations in maximum coverage, e.g., radial map patterns fluctuate by 40% over a 24 hour period.
(2) Noticeable, regular gap regions appear in specific positions on your maps. (3) Wild vectors occasionally are spotted in circular bands at ranges from one or the other site from 100-130 km (for Long-Range systems).

Any change from data outputs that you had been getting, or from what you expected, can probably be remedied ... But we need to know what you are seeing that you don't like! We will then swing into action, diagnose your problem, fix it, and educate you as to what happened.

At the lower operating frequency bands, late-afternoon and nighttime radio interference is known to occur, even in systems that had not been seeing this before. Nighttime is when radio broadcasters use the lower HF band, and usually for only a few hours. Such interference appears as noise to our processor. Maximum range will decrease during these periods, even though vectors closer in are perfectly valid. Remedies are to shift positions within your present authorized frequency band, or move to another frequency that you were granted. We can diagnose this immediately, and teach you how to do it also.

PLEASE NOTIFY US OF ANY PLANNED CHANGES BEFORE OR WHEN YOU MAKE THEM

Often a customer will change frequency bands, move one of the antennas, or rotate the receive antenna, perhaps for a very good reason. We can often advise you before such a change what kind of "domino effect" this could result in. Also, immediately after the change, we can monitor your system to verify that it is operating correctly, or make recommendations for additional modifications. Again, we will keep you informed as to what we find. Nearly 85% of problems happen as a result of a change to system settings (software or hardware) that we are unaware of. We only want your systems to be producing the best possible data for you. When that happens, we both look good. But we can only do that with input from you.

Don't hold back!

Are You Up To Date?

SeaSonde10 users should be running:
SeaSondeRadialSuite10 Release 3 with Updater3 installed
SeaSondeCombineSuite10 Release 3 with Updater3 installed
Mac OSX 10.3.9
Timbuktu 7.0.4 (required for latest Timbuktu scripting)

OS9 SeaSonde users should be running 4.4f6 Mac OS 9.2.2

If you have any questions please email us:
support@codaros.com

Links to the latest SeaSonde software below:

Current Radial Software available:
SSRadialSuiteCD_10R4SeaSonde10R4/

Current Combine Software available:
SSCombineSuiteCD_10R3SeaSondeR3u3/

Note: You will be required to enter the standard user name and password to enter the customer section of SeaSonde.com

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