Backscatter Journal

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THIS ISSUE OF THE TCS BACKSCATTER JOURNAL is Devoted Entirely to HF Communications and how it Could Become an Essential Tool in the Communications Toolbox for our Nation's Public Safety Agencies

THIS ISSUE

HF-SSB AND ITS ROLE IN PUBLIC SAFETY COMMUNICATIONS

Mention the terms High Frequency (HF) or Single-Sideband (SSB) to a group of Homeland Security managers, particularly those having a military background, and ears will perk up. The military has embraced HF communications for decades because of its ability to communicate over hundreds, if not thousands, of miles and essentially absent of multiple tower sites, phone lines and repeater stations. Utilizing the short wave frequency spectrum of 2-30MHz, simply-configured field base stations are able to maintain efficient, reliable and secure communications during the worst of conditions, often battlefield conditions.

So, why hasn't this media been used by the nation's public safety agencies. Well, the answer to that is simple…it wasn't allowed. At least not until a small maritime wireless shore station, ShipCom, petitioned the Federal Communications Commission (FCC) to allow public safety agencies to utilize their licensed facilities during emergencies. So, what is ShipCom and why is this important news now?

First, the maritime industry has historically embraced HF communications as a means for shipping operators to maintain contact and control of ocean-going vessels. The sinking of the Titanic brought to public view the true importance of reliable radio communications. Since that time, supportive maritime shore stations have offered first Morse and then later voice and now even electronic mail services with high frequency systems. Due to the life-safety nature of such communications, maritime shore stations have always been prohibited from providing services to other land-based field stations to ensure the highest availability to ships in distress.

Gradually, with the proliferation of geosynchronous satellites and affordable satellite earth stations designed for maritime use the role of HF shore stations has diminished. In the United States only one maritime carrier, ShipCom, continued to provide SSB voice services in addition to HF electronic mail and telex. And even then, HF-SSB serves as a backup to shipboard satellite systems.

Yet, there is a new and emerging role for HF-SSB in the landscape of public safety communications. The August 29th, 2005 landfall of Hurricane Katrina illustrated how vulnerable our nation's commercial as well as public safety systems are to widespread catastrophic natural events. In the affected areas along the Gulf Coast, from New Orleans to Mobile, many emergency operations and homeland security managers prayed to get urgent messages out to those in positions to assist, but were unable to do so. In fact, the first 72 hours after Katrina's landfall were a near-total communications disaster. Even the US Coast Guard's internal communication networks along the Gulf Coast were initially disabled, but not ShipCom's. In fact, ShipCom has never been off the air since it was established in 1948 simply because its mission is too critical and the stakes too high.

So, why shouldn't public safety have authorized access to such facilities during urgent times of need? Apparently the FCC believed such an endeavor was in the public's interest and has recently granted ShipCom the authority to now provide such services to cities, counties, states and federal agencies whose mission is ensuring the public's safety. Even supportive operations, such as hospitals and critical infrastructure providers, can avail themselves of this newly approved use of a well-proven service.

HF-Communications: How it Works

The object of either wired or radio communications is to relay information, reliably and clearly, between two or more people. Each facility has certain advantages. For example, wired communications are comparatively noise-free when compared to radio transactions. For the most part wired communications are secure from eavesdropping. And, due to the bandwidth inherent in copper or fiber facilities an enormous number of transactions can be undertaken using that media and its varied technologies.

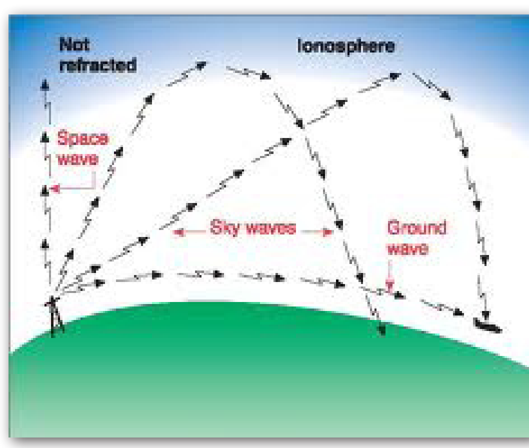
So, why bother with HF radio at all….well, what happens when the wires break, cables get cut and the facilities supporting that infrastructure get damaged, flooded or go dark?

The unique characteristic of high frequency radio communication is its ability to project information over very long distances using only endpoint stations. Unlike VHF, UHF and 700/800MHz radio systems whose coverage is typically by ground wave and line-of-sight, HF communications is supported over very short distances by ground wave, longer distances via line-of-sight but over much greater distances by a physical property termed ionospheric ray bending.

The ionosphere is a region above the earth's surface is comprised of ionized gasses. These ionized gasses or clouds act as a partially reflective screen to radio frequency energy. But, this reflective property has some interesting limits. Generally speaking, frequencies above approximately 50MHz will pass through the ionosphere with little bending action. That is, they generally pass through this charged layer and are not bent back to earth. Frequencies below approximately 2MHz do not bend as readily as higher frequencies and tend to be absorbed within the ionosphere, itself. This effect is most pronounced during daytime hours as the ionosphere is most dense and low frequencies are more highly attenuated. At night, when the sun is no longer providing the energy necessary to maintain ionization, the clouds recombine, become thinner and higher in the earth's atmosphere. At these times, it is possible to communicate over longer distances because the reflective screen is located correspondingly higher above the earth's surface.

The many variables involved, such as the location of the sun, distance between stations, height of the ionospheric layers, layer density and angle of arrival of the incident radio wave front have a direct bearing in the distances covered and the most optimum frequency to use to support communications at any point in time. It is for that reason maritime HF shore stations are licensed to operate on frequencies in the 2, 4, 6, 8, 12, 16 and 20MHz regions.

For those interested in learning more about HF radio propagation, you are encouraged to research publications offered by the American Radio Relay League (ARRL) as amateur radio operators routinely utilize frequencies closely allied to those allocated to maritime shore stations such as ShipCom. An excellent book to add to the library is the ARRL's Radio Handbook.



What is Single-Sideband?

The concept of voiced radio communications is rooted in the ability of projecting information in a form analogous to speech. The process of adding that information to a radio frequency signal is termed modulation. Correspondingly, the process of converting a modulated radio signal back into speech energy at a remote location is termed demodulation.

In order for one to modulate or add voice energy to a radio frequency signal, it is necessary to instantaneously alter amplitude, frequency or phase in step with the voice source. Frequency Modulation is one having a very long history in public safety communications. This is the modulation form typically used for systems operable in VHF, UHF and often 800MHz radio systems. Analog FM offers excellent audio quality, however it requires a generally large bandwidth to project that information.

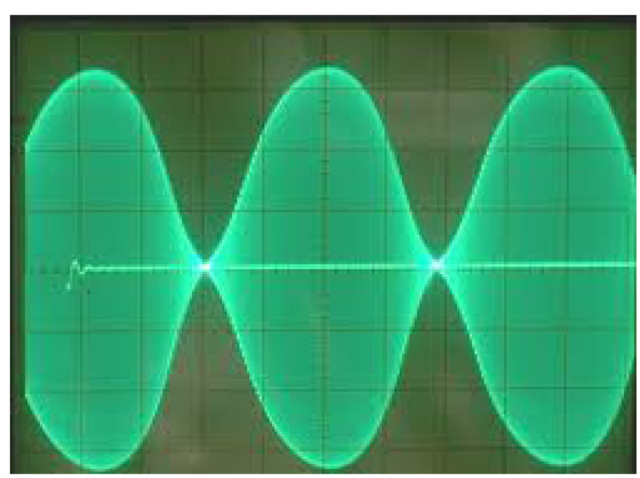
Amplitude modulation or AM is that used by commercial aircraft and broadcasting interests below 30MHz. The bandwidth of AM stations is nearly an order of magnitude less than FM, which has performance characteristics preferable to FM on these lower frequencies (selective fading, in particular, which would negate the noise immunity advantages of FM enjoyed by public safety users). In AM, the radiated signal consists of a carrier wave. On either side of the carrier wave, and in direct relationship to the frequency spectrum of the host voice information, reside two sidebands. The information contained in either sideband is identical, which gives a strong clue about why engineers sought to eliminate one!

The bandwidth of an AM signal is equal to the highest speech signal to be transmitted, times two since there are two sidebands. So, if the highest voice frequency was 3,500Hz, then the bandwidth of the transmitted AM signal would be 7KHz. As the use of radio grew in the 1930s and 40s, so did the instances of interference. One way to combat interference is to make signals narrow, which brought attention to the redundant sideband. And, while you're at it, why not figure out a way to remove the carrier wave as well? To do so would make for a much more bandwidth and energy-efficient system.

Removing the carrier wave and re-introducing it at the receiver was a straight-forward process and brought about an immediate efficiency improvement since 2/3rds of an AM transmitter's power is allocated to the carrier wave. While certainly advantageous, this did nothing to improve the main deficiency, occupied bandwidth, as absent the carrier wave the modulated signal still occupied a bandwidth twice that of the highest voice frequency. Thus ushered in a number of attempts and systems aimed at eliminating one sideband. Today, single sideband signals are generated using processes that inherently cancel out an unwanted sideband (termed the phasing method) or a more brute force approach using a band pass filter whose characteristics block passage of the unwanted information.

Since the mid 1950's, single-sideband has been a communications mainstay of the armed forces and maritime interests, but it also exists in our long distance telephone networks and some forms of data communications. Operationally, a single-sideband radio system has a 12db advantage compared to normal AM operations. That is, to achieve the same communications effectiveness of a 100-watt SSB system, the corresponding AM system would require transmitted power level in the order of 1,600-watts.

In summary, single-sideband occupies less bandwidth and consumes less power than other modulation schemes. Its narrow bandwidth allows it to perform better in fading environments as compared to either AM or FM. And, since a single sideband transmitter's average power follow that of speech energy (15%) these systems lend themselves well to battery and solar-powered applications.



HF Station Basics

If you are ex-military and remember the racks of equipment, glowing vacuum tubes and zillions of meters and dials associated with fixed stations or the 300-pound "boatanchor" radio in the back of your Jeep….well, put those thoughts aside! Using present-day technology the typical 100-watt SSB transceiver takes up very little space, weighs far less than thirty pounds and has few knobs to befuddle your emergency operators.

In fact, because of ShipCom's channelized operations, finding the right frequency to use is as easy as picking a station on your car's FM radio. The key operational parameters of your transceiver and antenna system will be pre-configured by your consultant and HF radio supplier. While there are user decisions that must be made each time you contact ShipCom via radio, these are commonsense procedures that become second nature with occasional practice and use.

So, what do you need? If your intention is a station equipped for voice operations only, an HF-SSB transceiver FCC type-approved for operation on marine frequencies (FCC Part 80) is required. These are available from a number of manufacturers and in various price ranges depending upon features. In a typical case a 100-watt SSB transceiver, microphone and power supply would cost in the range of $1,500 to $3,000. An antenna is, of course, necessary and this should be custom designed for the specific setting and optimized for the distance between the fixed site and nearest ShipCom facility (Mobile, AL or West Coast).

ALWAYS select an HF transceiver with a built-in noise blanker as electrical noise is evident at low frequencies. Better yet, choose one with adaptive digital signal processing that can help reduce atmospheric noise as is typically high during the summer months. Digital signal processing has made the use of single sideband equipment much more enjoyable and less fatiguing than what was the norm in SSB's early days.

High power, 1000-watt amplifiers are available to complement you transceiver. Our advice is to save your money. ShipCom has a twenty-acre field loaded with receive antennas of all types, for all assigned channels and oriented at 60-degree azimuths. Likewise they have an 80-acre remote transmitter site and one-hundred 5,000-watt transmitters. These systems have been optimized to communicate with low-powered, HF-equipped sailboats. Let ShipCom's antennas do the heavy lifting and perhaps spend that spare $9,000 planned for an automatic power amplifier on an HF email system instead.

Speaking of suitable antennas, in most instances a viable user-end antenna system does not require tall towers and in settings along the Gulf Coast tall antennas may actually provide inadequate coverage…unless your goal is to talk reliably to counterparts in Europe!

Generally speaking, a viable antenna can be constructed for less than $1,000. But, bear in mind that HF antennas can be damaged by high winds, so always have your installation contractor provide both an operational antenna and as well as a replacement that can be quickly installed when necessary. Properly designed and pre-constructed, a fallback antenna can be installed as easily and safely as a replacement clothesline.

Typical HF SSB Transceiver

HF Antenna Considerations for Gulf Coast Operations

Antenna systems make or break an HF radio system. And the selection of the proper antenna type and frequency of operation is surely necessary to ensure the highest signal to noise ratio (SNR). Higher SNR translates into best quality communications, fewer repeats and less operator fatigue.

Looking at those operations probable along the Gulf Coast, the majority of path distances to ShipCom's Mobile, Alabama facilities would fall within a 600-mile radius. During nighttime hours, frequencies between 4-6MHz would provide the best communications. Likewise, during the daylight hours 6-8MHz would provide good to excellent service. For those locations within 300 miles of Mobile, the choice is clear: 4MHz for nighttime operations and 6-8MHz during the day.

With the frequency issue settled, what is the best sort of antenna to use? First, vertical antennas should not be used in this case and for two reasons. Vertical antennas when properly installed have a very low take-off angle. This means that most of the transmitted or received energy will be present at angle of 20-degrees or less off the horizon. Vertical antennas provide far less effectiveness at higher take-off angles and these are the ones most needed for close-in communications.

To be electrically effective, vertical antennas require a substantial radial/counterpoise system that is physically large (65ft circular area about the antenna feed point) and costly to install. Short cuts taken in fielding the necessary radial counterpoise for a vertical antenna system results in a horribly inefficient antenna and degraded SNR. Unfortunately, many underestimate the important contribution made by the radial system, install very few (at least 45 are recommended with 120 being optimum) and settle for a vertical antenna, no radials, with a couple of ground rods thrown in for lightning protection. The owner is justly "rewarded" with an antenna whose radiation efficiency is 15%, at best and wonders why he can't be heard. Oh well…

Conversely, horizontally oriented antennas principally radiate outward along the length of the antenna, with a take-off angle highly dependent upon the antenna's height above ground level. The higher the horizontal antenna with respect to frequency, the lower the antenna's take-off angle. There is very little radiation, comparatively speaking, off the ends of a horizontal antenna. So, when selecting potential antenna sights for a horizontal antenna find those where the distant station (i.e. Mobile, Alabama) is oriented broadside to the axis of the horizontal element. By so doing, the distant site would receive the antenna's best radiation characteristic. But, there is more!

It has been found that horizontally-mounted antennas, when oriented near the ground, will have their radiation patterns altered to where most of the antenna's radiation is at very high angles…as high as 90-degrees or straight up. This phenomenon is particularly useful for stations within several hundred miles of a receiving station. Remember, ground-mounted vertical antennas and horizontal antennas elevated above ground (at least one-half wavelength of the operating frequency) exhibit low take-off angles in the order of 35-degrees. A low take-off angle is good for distant communications (those beyond 1,200 miles) but close-in communications suffers by as much as 10db (10:1 effective radiated power difference).

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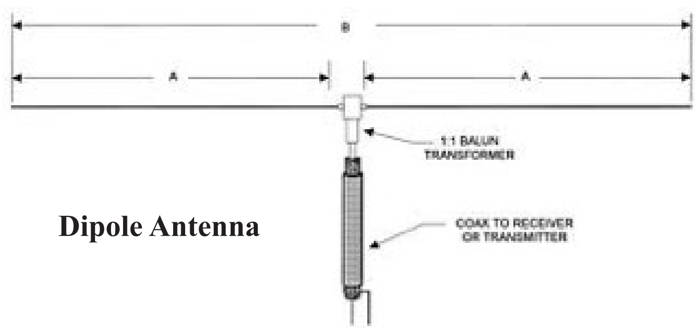
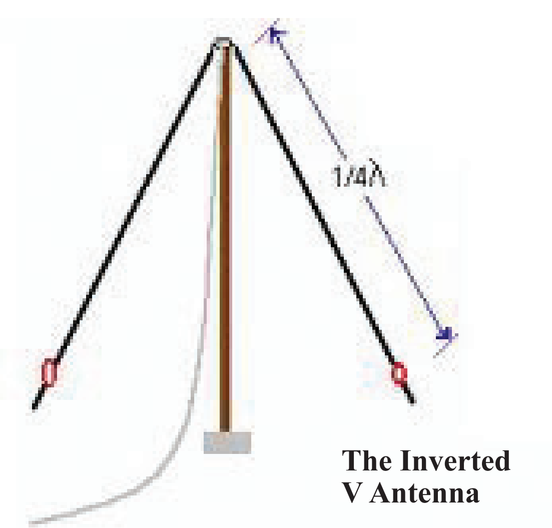


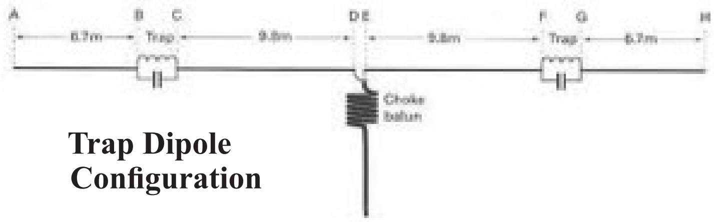
Dipole Antenna



The Inverted V Antenna

So, how about some real-world antenna examples? Okay. For a system to be located in Covington, LA a viable configuration would be a horizontal, dual band (4-8MHz) dipole or loop antenna located not more than 30ft above ground level. This antenna, if a dipole, should be located with it ends oriented North/South thereby providing the highest radiation in the easterly/westerly directions.

In the case of coverage from, perhaps, Miami, a tri-band 4-8-16MHz dipole or inverted Vee antenna at an elevation of 60-feet would be appropriate. The three bands could be made operationally viable using traps for 8MHz and 16MHz (see ARRL Handbook for examples of trapped antennas). The antenna should be oriented along an azimuth of approximately 45-degrees, which would support 4-8MHz operations with ShipCom-Mobile and 16MHz low-angle coverage to either of the two ShipCom west coast facilities as a fall-back.



Trap Dipole Configuration

Taking the Mystery Out of HF Communications

With so many variables involved with HF propagation, i.e., ionization levels, sunspots, time of day and plethora of available frequencies, how can non-technical users realistically expect to communicate via Ship Com? In short, the answer is a technique termed automatic link establishment or ALE.

The armed forces faced these same system-resource management issues…how to make HF-SSB communications easily deployed and established during battle field conditions. In the end a software-dr iven process, ALE, took the guesswork out of HF point-to-point HF communications. ALE is the process whereby a radio network automatically determines the most appropriate frequency to support voice or data communications. ALE can be accomplished using a variety of methods. For example, a fixed base station site might transmit a polling signal that triggers an automatic response from a distant field unit. If the fixed base station polls its pre-programmed channels in ascending order while the distant field unit, using the same channel list, monitors in descending order eventually the two will converge. Once the two meet and automatically verify communications is possible, the users are so alerted and actual communications may commence.

In the case of ShipCom and inexpensive HF non-ALE radios, a manual process is used. On each of ShipCom's outbound voice channel pairs, a marker signal is transmitted. This is actually a continuously transmitted mark/space Teletype signal that, when using a HF-SSB radio in the voice mode sounds like a repetitive string of "weebles." This "weeble" sound is the audible demodulation of alternating binary 1's and 0's or mark/space signals using frequency shift keying (FSK), which is an early modulation scheme developed for the transmission of Baudot telex data.

For the emergency responder service, this channel marker provides a key operational feature to voice users: if a distant field unit can reliably detect the marker on a ShipCom channel, then that channel is good from a signal propagation standpoint. Furthermore, the marker is sent only when a channel is in the idle mode, so the issue of interference with an in-progress call is addressed. Of course, for those systems configured for electronic mail delivery, the installed radios/data modems complete this link establishment automatically and silently in the background. It should be noted that ShipCom transmits its marker signals at medium power levels (in the order of 250 watts), but assumes full power (5,000 watts) when supporting voice or data traffic. Should an emergency response user attempt communications after identifying an idle channel, ShipCom's elaborate antenna farm is there to do the heavy lifting.

ShipCom's voice radio network has been optimized to make operation on the user's end as simple and transparent as possible. Make no mistake, an emergency event is a troubled time and, frankly, network reliability on the field user's side requires simplicity with the fewest number of operational decisions. During emergency events there is no time to study propagation charts or conduct "do you hear me now" coverage tests. If a user can simply hear the "weeble" tones on a selected channel, then life-safety communications with a skilled ShipCom radio dispatcher is only a push-to-talk away.

ShipCom and Amateur Radio

AN HF OPTIMUM EMERGENCY RESPONSE SOLUTION

The Amateur Radio Service has a long, distinguished history of providing supportive radio communications during emergency events. These communications generally involve health and welfare traffic that provides comfort and relief to family members of others who may be missing or unable to communicate from affected areas. Yet, as our nation's public safety radio networks have been much more sophisticated in terms of security, capacity and coverage so too has their reliance on vulnerable broadband networks and commercial electrical power. If during an emergency those support services become disrupted or unavailable, the need for alternative communication solutions and trained radio operators becomes most acute.

The Amateur Radio Service has gained the respect of public safety professionals in that it has the capacity to provide a reservoir of skilled volunteer radio operators as well as a communications medium that does not rely on fixed infrastructure assets in the affected area. And while the attractiveness of Amateur communications is its volunteer nature, availability is not instantaneous. It takes time for volunteers to assemble and travel to affected areas…particularly those areas that are under strict evacuation orders. Additionally, the radio spectrum available to amateur operations is shared and, at times, could be vulnerable to harmful interference. So, what's the best solution to such a vexing set of problems?

ShipCom is an HF commercial maritime service that must, by condition of FCC license, be operable 24/7/365. There is never a period where assigned maritime channels are not monitored by one of several locations so when disaster strikes an HF radio response is immediate. And, its licensed channels are exclusive to the service.

By making the service and its allied user equipment simple by design and easy to use, highly skilled operators on the user's end are not necessary to project urgent life-safety messages to distant locations and resources…particularly so within those fearful first 48-hours. ShipCom's radio dispatchers have the experience to guide even the radio neophyte in those most difficult of times. Yet, when field operations are supported by resourceful Amateur Radio volunteers, the power of HF single-sideband communications and the ShipCom network could become an essential, complementary resource during wide-area emergency events.

TCS Hall of Shame: Can Someone Spare a Ty-Wrap??

No issue of the Backscatter Journal is complete without an entry to our long running Hall of Shame. Today we view a splendid example of workmanship of the lowest order. Sadly, this system is supposedly "covered" by a maintenance contract. Are you ready to sign up for one?

It Speaks for itself