SPREAD SPECTRUM SCENE

Number 3

June, 1992

The PCN/PCS, Wireless Network and CDMA/TDMA Monthly Newsletter

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EDITORIAL

FCC Grants the Buaas Spread Spectrum STA on April 17!

The long awaited amateur radio SS request for Special Temporary Authority (STA) was finally granted in a letter from Ralph Hallcr, Chief, FCC Private Radio Bureau, to Mr. Robert A. Buaas, K6KGS, on April 17, 1992. While the STA did not grant everything Mr. Buaas asked for in his original filing -- it does provide relief from the restrictive regulations now in effect under the FCC's part 97 rules for amateur radio spread spectrum operation.

The STA is valid for one year and allows SS operations at 50-54, 144-148 and 222-225 MHz. The full text of the official FCC letter appears on page 5, in the Amateur Radio Spread Spectrum STA article. On the same page is Mr. Buaas' original request to the FCC. The direct result of this government action should be an opening up of possibilities for amateur experimentation in spread spectrum techniques. While we feel there will be no flood of enthusiasts unleashed, we do hope this action does not go unnoticed.

In related developments, this issue concludes a Technical Tricks column on Gold codes and an article on SS propagation. We are also including another installment of the forthcoming book *"Introduction to Spreud Spectrum"* in this issue. New features this month are three new columns: SS Networking Software by Kim Robinson, KM6OH; DSP Techniques for SS by Matthew Johnson, KI6WA; and a reader/advertiser services column by Koert Koelman, KC6WCI. Finally, for those of you with a practical eye, we start a new series of hands-on, construction articles for a simple SS transceiver for use under the new Amateur Radio Spread Spectrum STA (or look at it just to get a practical look at today's inexpensive SS circuitry). Called the STA-1, this new transceiver design can operate at 29 or 52.5 MHz using transmitted reference direct sequence spread spectrum (in short, TRDSSS). The design will be available in kit form by late summer, 1992. Though designed for ham radio applications, the STA-I is easily modified to cover other frequency ranges, data rates, etc. and can thus be used for part 15.247 or other commercial or industrial applications. Please write us if you or your company is interested in adapting the STA-1 design for applications that might bc of interest to our readers. The STA-I construction article starts on page 14.

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GOOD NEWS AND BAD NEWS

Watch for Spread Spectrum Legislation Soon!

Watch for US House and Senate action, very soon, on several bills introduced last year that may greatly affect the future of commercial spread spectrum on-the-air operations in the US. Senator Daniel Inouye (D-Hawaii) introduced S-218, the Emerging Telecommunications Technologies Act of 1991, last year -- it is again on the docket for Senate consideration. Last year's companion House Bill, sponsored by John Dingell (D-Michigan), Don Ritter (R-Pa.), Michael Oxley (R-Oh.) and Billy Tauzin (D-La.) is also due for action soon. All of this activity is the result of some significant pressure brought by Apple Com-

see Good/Bad, pg. 2

SPREAD SPECTRUM SCENE
is dedicated to the Spread Spectrum professional and is committed to being the primary source for the latest news and information about the growth, regulation and opportunities in this emerging science.

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Letters to the editor are welcome. Manuscripts submitted for publication should include a return envelope. We **will make every effort to publish items submitted to us if they are previously unpublished,** address our subject **area(s) and provide timely, general interest information.**

Good/Bad from pg. 1

-puter and the **joint actions** of the FCC, the Office of Telecommunications Policy (OTP) and the White House. The first version of the Emerging Telecommunication Technology Act was introduced to Congress in 1989 by Congressmen Dingell and Markey. This legislation package forms the basis of any future legislative package congress may adopt. The major reason that any action is being considered is that many professionals in radio and telecommunications feel that our frequency bands worldwide are becoming too congested. In the article *"Spread Spectrum goes commercial,"* by Donald L. Schilling, Raymond L. Pickholtz and Laurence B. Milstein, that appeared in the *IEEE Spectrum*, August, 1990, the problem was summarized:

"Spread-spectrum radio communications, long a favorite technology of the military because it resists jamming and is hard for an enemy to intercept, is now on the verge of potentially explosive commercial development. The reason: spread-spectrum signals, which are distributed over a wide range offrequencies and then collected onto their original frequency al the receiver, are so inconspicuous as to be 'transparent.' Just as they are unlikely to be intercepted by a military opponent, so are they unlikely to interfere with other signals intended for business and consumer users -- even ones transmitted on the same frequencies. Such an advantage opens up crowded frequency spectra to vastly expanded use.

"A case in point is a two-year demonstration project the Federal Communications Commission (FCC) authorized in May (1990) for Houston, Texas, and Orlando, Fla. In both places, a new spread spectrum personal communications network (PCN) will share the 1.85-1.90 gigahertz band with local electric and gas utilities. The FCC licensee, Millicom Inc. a New York City-based cellular telephone company, expects to enlist 45,000 subscribers.

"The demonstration is intended to show that spread-spectrum users can share a frequency band with conventional microwave radio users -- without one group interfering with the other -- thereby increasing the efficiency with which that band is used. "

Reader & Advertiser Services

Welcome to SSS, where you will find the latest on what's happening in the world of spread spectrum technology. With the tremendous progress in and integration of communication and information systems, the mission of SSS is to provide a unique forum which addresses all aspects of the field: spread spectrum hardware, software, R&D, legislation/FCC actions, spread spectrum applications, the integration of spread spectrum radio and information systems, user case studies, etc. We solicit reader and advertiser input on how we are succeeding in this mission. Just drop us a note at our El Granada address. Through this column, we will report on your feedback and suggestions if of interest to the majority of our readers. We also publish results of informal reader surveys we will conduct periodically. Additionally, this column will report on any future editorial, administrative and contents changes of SSS. We want this to be your newsletter! We look forward to serving you and are always open to your comments and suggestions.

Koert Koelman

Bit Errors

Corrections to issue h'umber 2, May **1,** 1992:

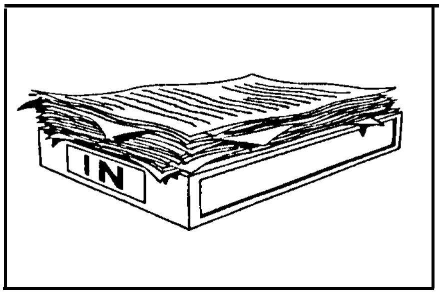
- Page 6: Halfway down, right column -- should read "... the figure above, taken from Andy's article".

- Page 7: **Two** thirds down, **left** column -- should read: "... bandwidth **as** wide as 20 to **254** times the". **With** this change, the page 7 inset and text agree.

- Page **11:** Top, right hand column -- Our political ad misspelled **Mr. Tenney's** first name. It should be: Glenn.

- Page 12: Data Conversion **Services** ad had Mr. **Gysbers first** name incorrect -- it should be Barry. **We also** had an incorrect 800 number for Data Conversion **Services** -- it should be: "USA: 800-327-0330".

Charter Subscription rates end soon! Subscribe now and save $10!



Letters & Comments

Welcome to the wacky world of publishing! I wish you good luck.

I have been fortunate enough to hold onto my position in amateur radio publishing -- despite the current economic situation. However, many of my friends -- like you -- have become "consultants." I had a bit of a scare when HAM RADIO magazine, which I had edited for almost four years, was sold to CQ Communications in Mny 1990. Fortunately, Richard Ross provided me with the chance of a lifetime when he gave me the opportunity to help him launch *Communications Quarterly*

I think you're off to a good start with Spread Spectrum Scene. The title is catchy, the layout is clean, and the editing is good. Your writing is informal and easy to read and I found myself breezing through the first issue. You managed to handle your lack of copy handily by explaining the purpose for each section of the publication.

Your deck head (The PCN/PCS, LAN/MAN/WAN and CDMA/TDMA Newsletter) is a bit wordy, but I'm not sure how you could abbreviate it.

It seems to me that a well-done newsletter can find a secure niche for itself. W5YI, for instance, is one that I rely on for information on amateur radio regulation, politicking, and local issues.

Keep up the good work and keep me posted on your progress. I'd like to read future issues of SSS.

Best regards,
Terry Northrup, KA1STC
Editor *Communications Quarterly*

Thanks for the kind words and nice wishes, Terry. We a/ways look forward to seeing your magazine, too!

Thanks for sharing with me a copy of the first issue of Spread Spectrum Scene. Good luck with it, certainly there's a need for more published material on CDMA.

I'm not qualified to comment on the technical content of the newsletter. However, since you've asked for comments I'll share two pet peeves of mine regarding newsletters.

Beginner's Box
SPREAD SPECTRUM GLOSSARY

AJ: Anti-Jam, designed to resist interference or jamming.

BPSK: Binary Phase Shift Keying -- Digital DSB suppressed carrier modulation.

CDMA: Code Division Multiple Access -- A way to increase channel capacity.

CHIP: The time It takes to transmit a bit or single symbol of a PN code.

CODE: A digital bit stream with noise-like characteristics.

CORRELATOR: The SS receiver component that demodulales a Spread Spectrum signal.

DE-SPREADING: The process used by a correlator to recover narrowband information from a spread spectrum signal.

DIVERSITY: Sharing a signal characteristic to allow more users In the same frequency band.

DPSK: Differential Pbase Shift Keying -- a simplified BPSK where only data transitions are trausmllted.

MULTIPLE A C''-A method for accommodating more users in the same frequency baud.

NARROWBAND: A signal whose bandwidth Is on the order of Its information bandwidth.

NOISE-LIKE: Having properties that cause the appearance of true random noise.

1. Separation of news from editorial content. There's nothing wrong with editorializing in a newsletter, most readers expect the editor to have a well-informed point of view. But it's important for the credibility of the newsletter to keep the news stories completely factual and to reserve comments for completely separate Columns clearly flagged as editorials. Some newsletters weaveunfoundedandunsupportablesuppositions into their news stories; it's not a good idea.

2. Spelling and grammar. Again, it's a question of credibility. These things communicate to the reader the degree of care that was taken in preparing the product.

73.
Sincerely,
David Sumner, K1ZZ
Executive Vice President
The American Radio Relay League

Thank you very much, David -- that advice and your compliments are certainly welcome. The ARRL does a great job in representing the USA's 500,000 or so Hams. David, you can expect that I will heed your suggestions.

Just returned from Dayton. Received a copy of *SSS* from your book seller friend. I'll get a chance to look it over as soon as we get settled from the trip -- lasted 11 days and we took all our computers and hardware from the business. Right now I'm sort of out of business until I get everything re-setup!

Sincerely,
Bob Myers W1XT
OSCAK *Satellite Report and Satellite Operator* Publications to support the Amateur Satellite Program

Bob published my article "Oscars, *Pacsats and Spread Spectrum"* in his May issue of Oscar Satellite Report to help build SSS circulation and the subscriber base.

We recently received the second issue of "Spread Spectrum Scene". Please find enclosed some information that we would like to submit to the "New Products" column. It regards the newest addition to our microwave generator line, the model 8002.

The main contribution of the 8002 is its small size, low price, and programmability. This is made possible by the new gallium arsenide MMIC technology and large scale, integrated silicon IC's.

Best regards,
Bill Chan, April Instrument, Sunnyvale, CA

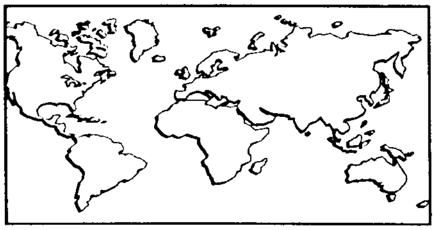
Look for April's new product announcement in this issue.

Why not send us your opinion, comment or note?

Wc want your feedback and will gladly publish it!

Beginner's Box
Learn a Little Japanese

ENGLISH	JAPANESE
Yes	Hai
No	Iie
Please	Dozo
Thank you	Arigato
You're welcome	Do itashimashite
Excuse me a moment	Chotto shitsurei shimasu
Excuse me shimashita.	Shitsurei
	Moshi moshi.
That's all right	Iin desu yo
My name is wa	Watashi no namae desu
May I have your name?	Anata no onamae wa?
Good morning	Ohayo
Good afternoon	Konnichiwa
Good evening	Konbanwa
Good night	Oyasuminasai
Good-bye	Sayonara
Mr., Mrs. or Miss	San
How do you do?	Hajimrmashite
How are you?	Gokigen ikagadesu ka?
Nice to meet you	Oai dekite ureshii
After you	Osaki ni dozo
Congratulations	Omedeto
Cheers!	[illegible]
I don't understand	Ossharu koto ga wakarimaen.
Pardon me? kudasai.	Mo ichido itte
Just a moment kudasai. please.	Chotto matte
Please speak more slowly.	Motto yukkuri itte kudasai.



International Scene

While the application of wireless LANs may know no geographical boundaries, international regulatory authorities certainly are aware of them. Some of the bureaucratic roadblocks that exist in the US for wireless LANs are also being seen overseas.

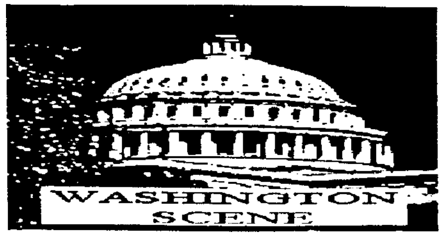
European standards for wireless LANs are set by the European Telecommunications Standards Institute (ETSI). ETSI's DECT was backed up by EEC Directive (91/287). This spec requires all members of the European Community to make the 1.88 to 1.90 GHz band available for use with DECT, this year. The DECT protocol allows individual users to demand a maximum of 1.1 Megabits per second at any instant. DECT's indoor RF range is typically 100 feet,

HiperLAN, is ETSI Sub-Technical Committee's new 20 Megabit system standard RES-IO. The spectrum allocation for HiperLAN favors 150 MHz of bandwidth at 5 GHz.

In Japan, the Ministry of Posts and Telecommunications (MPT) regulates wireless LAN technology. An MPT sub-committee (the Telecommunications Technology Council), is studying spectrum requirements for wireless LANs, as is an electronics industry organization funded by the Research and Development Center for Radio Systems (RCR). RCR likes the idea of a IO Megabits per second wireless LAN at the 2.4 to 2.5 and 18 to 19 GHz frequency ranges.

For More info see:

"Mobile Communications -- New components for GSH, PCN, DECT, GPS, etc. systems," Ludwig Scharf and Peter Hoffeins of Seimens AG, In the proceedings of RF expo WEST, March 18-20, 1992, pp.389-392.



ADT Pens $40 M Deal With DSC

While not really part of the Washington scene, the magnitude of the deal between ADT (The security systems company) and DSC makes banner headlines in my book. Mr. Don Hoke, president of Paramount Alarms, Inc., Las Vegas, Nevada told SSS that ADT was buying spread spectrum communications equipment from DSC for future use in ADT alarm systems. Mr. Hoke did not have all of the details at press time, however it seems that somebody finally has a mass market application for SS! Back to Washington, it seems that most of the action this month was covered by our front page "Good News & Bad News" story. We thought a little background information would help the reader better understand the issues involved with PCS and LAN regulation in the US at this point in time. Craig J. Mathias in the article "Wireless Lans: The Next Wave," ***Data Communications,*** March 2 l, 1992, pages 83-87, states:

"Although vendors would rather not contend for bandwidth licenses, there is an effort under way to get the FCC to alter some of its rules. Apple Computer Inc. (Cupertino, Calif.) has filed a petition asking the FCC to set aside 40 MHz of clear-channel space in the 1.85-to-1.99 GHz range for low-power, high-speed (nominally IO-Mbit/s) data transmission -- what Apple calls a 'Data-PCS' service, operating at a range of 50 meters and a power level of 1 watt. This petition piggybacks onto a proposal for a Personal Communications Service (PCS), which has the potential to replace current cellular telephony with an all-digital system. The wheels of bureaucracy turn slowly, however; resolution of Apple's petition is likely to take years."

FCC's SS STA Grant Letter

"Federal Communications Commission
WASHINGTON, D.C. 20554
April 17, 1992

IN REPLY REFER TO:
7230-A

"Mr. Robert A. Buaas
20271 Bancroft Circle
Huntington Beach, California 92646

"Dear Mr. Buaas:

"This is in response to your request for special temporary authority (STA) and waiver of the Commission's rules in order to permit certain amateur stations to conduct experiments involving Code Division Multiple Access (CDMA) spread spectrum (SS) emissions. Attached to your request are individual requests from the participating station Licensees.

"Your suggestion was presented to the Frequency Assignment Subcommittee of Interagency Radio Advisory Committee, which concurred with your proposal without objections. Accordingly, an STA is granted for a period of 365 days commencing with the date of this authorization for the amateur stations listed on the enclosure submitted with your letter of June 11, 1991, to the Chief. Private Radio Bureau. During this time, Section 97.305(c) of the Commission's Rules, 47 C.F.R. pp 97.305(c), is waived to the extent that these particular amateur stations are authorized to transmit SS emissions on frequencies in the bands 50 MHz to 54 MHz, 144 MHz to 148 MHz, and 222 MHz to 225 MHz; Section 97.311(c) of the Commission's Rules, 47 C.F.R. pp 97.311(c), is waived for these stations to the extent that the prohibition against hybrid SS emissions is lifted; and Section 97.311(d) is waived for these stations to use other spreading codes.

"The above authorization wiii also apply to any additional amateur stations joining the project during the period of the STA, provided you submit an amended list and individual requests to Robert II. McNamara, Chief of Special Services Division at:

"Federal Communications Commission
Private Radio Bureau
2025 M Street, N.W., Rm. 5322
Washington, D.C. 20554

Sincerely,

/signed/

Ralph A. Haller
Chief, Private Radio Bureau"

(Thanks to Mr. Dewayne Hendricks, President of Tetherless Access, Ltd., Fremont, California for sharing this letter.)

Amateur Radio Spread Spectrum STA

It took more than a year, a whale of a lot of work, patience, perseverance and sweat to accomplish, but here it is -- the official Special Temporary Authority from the FCC. Bob Buaas and Dewayne Hendricks are to be congratulated for the foresight and tenacity required to make this happen. Several other prominent hams also participated or at a minimum joined in the original request for the STA. Among these helpers are: Gwen Reedy, W1BEL of PacComm; congressional candidate Glenn Tenney, AA6ER; Paul Rinaldo, W4RI (*QST* Editor); Perry Williams, W1UED (ARRL Washington, D.C. staffer); Ben Kobb of ***Wireless World*** and Mike Chepponis, K3MC. As promised, the original text of the Buaas request for STA appears below (thanks again to Dewayne Hendricks):

"20271 Bancroft Circle
Huntington Beach, CA 92646
(date)

**"Mr. Ralph A. Haller, Chief
Private Radio Bureau
Federal Communications Commission
Washington DC 20554**

"Dear Mr. Haller:

"The commission is requested to grant special temporary authority (STA) to permit experimental data communications in the amateur service as detailed below. The application is made on behalf of, and with the consent of, the individuals named herein.

"NAMES AND ADDRESSES OF THE APPLICANTS

"The names, addresses and telephone numbers (day and night) of the proposed participants are given in Annex A. We request the ability to add participants upon specific prior coordination of the undersigned. A complete, updated list of participants will be mailed lo the designated Commission office monthly.

"BACKGROUND AND HISTORY

"The undersigned is a member of the Amateur Radio Research and Development Corporation (AMRAD) and participated in the 1984 STA granted to AMRAD which ultimately resulted in spread spectrum modulation being authorized in the Amateur Radio Service. At the time the rules were written, certain spreading sequence equations and specific procedures were specified. in the time since, Code Division Multiple Access (CDMA) has gained some favor for its potential for "coding gain." Custom designs for VLSI gate array integrated circuits have made inexpensive implementations possible for digital matched filters required in these systems. Also. recent inexpensive surface acoustic wave (SAW) matched filters are suitable for both generating and demodulating direct-sequence spread spectrum (DSSS) signals. This type of digital baseband VLSI DSSS component is capable of having spreading sequences loaded from an external supervisory processor.

"DESCRIPTION OF NEED

"An STA is needed to permit operation until such time that a permanent rule change becomes effective.

"TYPE OF OPERATIONS

"An m-sequence implemented as specified in paragraph

see STA pg. 17

Beginner's Box

PCN/PCS Providers:

GE/L. M. Ericsson: Mobidem wireless two-way data exchange for HP **95LX** Palmtop users.

McCaw-Oracle: A **newly announced 1.5 Megabit** per second (?) service to rival Ardis and other slower speed **mobile** data networks.

Millicom: FCC authorized field tests at several locations of **various** voice and data systems.

Motorola/IBM: The Ardis network now covers the major **metropolitan** areas of the USA. Ardis offers mobile data packrtized transmission and **reception** of documents.

NYNEX: Has installed test data system in Chicago Board of Trade. Doing field trials of representative systems.

ONTEL: Major player -- doing testing and evaluation. Uncertain status of any present market entry.

Qualcomm/Pacific Telesis: The most advanced and capable digital voice CDMA system available. Joint venture of both partners.

Southwestern Bell: **Major** player -- doing testing and **evaluation.** Uncertain status of any present market entry.

Telesis **Technology** Labs: FCC authorized field tests at several locations of various voice and data systems.

spread Spectrum Network Software

by Kim Robinson

Introductory Column

There is a diversity of software out there for hard wired local area networking. But for wireless networking, well that's a different story and a whole different ballgame. It's nothing like the wired networks that I am accustomed to such as ARCNET, and ETHERNET. The more I read about it the less I understand. Let's hope you are not quite as confused as I am. Thus, we come to the main reason for this column. We will try to examine what's available in SS networking software, what the major user and developer issues are and try to cast some light on ever popular issues like protocols and the IEEE 802.11 (and similar standards) committee recommendations. I welcome comments, criticism (constructive or otherwise) and shared opinions and input.

Most spread spectrum networking software today is bundled with the hardware that you buy. A good, functional example is the printer sharing and E-mail software that you get when you buy an O'Neill LAWN system. This inexpensive system works quite well, is moderately user friendly but it's awfully slow. Also it is not directly compatible with anything else.

Other commonly available SS hardware packages include X.25, AX.25, TCP/IP, or ***some*** proprietary networking software. One company, Tetherless Access, Ltd., Fremont, California seems to be on the "right track." They are designing a ***network*** using INTERNET and TCP/IP protocols that will ultimately run at 1.544 Megabits per second.

Please drop me a fax or note letting me know what your company is using or developing. I would also be very interested in what protocol you have chosen and why. **More next month**

Beginner's Box

More SS Terms Defined

Wireless LAN: Wireless Local Area Network -- a 1000 foot, or less, range computer to computerdatacommunications network_

PCN: Personal Communication Network. **PCNs** are usually short range **(100's** of feet to 1 mile or so) and involve cellular radio-type architecture. Services include digital voice, FAX, mobile data and national/international data communications.

PCS: Personal Communication System. **PCSs** are usually associated with cordlesstelephone-typedevices. Service is typically digital voice only.

PN: Pseudo Noise -- a digital signal with noise-like properties.

RF: Radio Frequcney -- generally a frequency from say **50 kHz** to around 3 **GHz. RF** is usually referred to whenever a signal is radiated through the air.

SS: Spread Spectrum, a **wideband** modulation which imparts noise-like characteristics to an RF signal.

SSS: Shorthand for Spread Spectrum Scene, this newsletter.

Wireless UAN: Universe Area Network -- a collection of wireless **MANs** or **WANs** that link together an entire nation or the world. **UANs** use very small aperture **(VSAT)** earth station gateway technology.

Beginner's Box

Selected Wireless LAN Manufacturers

California Microwave: Medium data rate (around 250 kBits/sec), frequency hopper at 915 MHz. Used in British point of sale applications, has built in antenna diversity, mature technology.

Cylink: Fractional T1 data rates (up to 500 kBits/sec), direct sequence radio/modem. High performance, mature technology.

GRE America: Just now introducing a direct sequence radio/modem capable of up to 128 kBit/sec. Low cost, mature technology. (Developed by author).

Metricomm: High volume, low cost, low speed (near 1 kBit per sec) radio/modem used by utility companies for meter reading and telemetry in vast quantities. Mature technology, robust, basic, solid performance.

Motorola Inc.. Altair Product Operations: Mature technology, Ethernet speed, networking system based on 18 GHz spread spectrum radios and directional antennas.

NCR Corp., Integrated Systems Group: PC plug-in circuit board radio/modem at 915 MHz, capable of 1.5 Megabits per second and 150 foot range. Good performance. mature technology, low throughput network technology.

O'Neill Communications: Low speed (up to 19.2 kBit/sec) async printer sharing and E-mail networking systems.

Proxim: Proxlink direct sequence radio modems for async or Mac/PC interfacing at rates to 242 kBits per second. Inexpensive. workhorse solutions for simple networks.

Senses Data Corporation: SAW-915 direct sequence, 915 MHz radio/modem. Up to 250 kBits/sec. Sync HDLC or async I/O. Newer technology, meets new FCC spread spectrum rules, X.25 capable. (Also developed by author).

DSP for Spread Spectrum

by Matthew Johnson

Since this is the first of this column in this Journal, we will not go into great depth on DSP just yet. However, I will give you a taste of things to come, as well as a summary of the direction I expect this column to take in the future, both near and far. My basic goal is to outline just what it is that really makes DSP interesting and useful, so that you can cut through all the Marketing HYPE more quickly and effortlessly.

To do all these things, I must first make clear to you, the reader, what DSP really is. The obvious answer, “Signal processing done by digital techniques”, may not sound very helpful, but is insightful, as I will show. After all, signal processing without digital techniques (i.e. relying on analog techniques) was so limited, and the methods for processes so diverse, that people did not see it as a cohesive whole, and almost never used the term “signal processing”. In those days, the prime examples of signal processing were filtering, amplification, modulation and demodulation.

There are other examples of analog signal processing, but fancy processing is expensive and cumbersome with analog components, so there is a wider variety of processing in the digital signal processing world. This wider variety includes not only the modulation/demodulation mentioned above, but also signal extraction, parameter estimation, pulse detection, frequency counting, source coding and spectral analysis. These types of processing are in turn used in scientific and engineering instrumentation, radar, sonar, alarm systems, audio, communications equipment, hi-fi equipment, etc. The list of applications for DSP is growing everyday, and every other issue of some of the computer/electronics industry’s trade journals seems to be trumpeting some new Digital Signal Processing (DSP) chip, or application or algorithm. Fortunately, there is more to this explosion than the investment in advertising; there really is a wide range of applications that have become more convenient/cheaper/practical thanks to these new technigues. This range includes both the esoteric, highly specialized applications like computer-aided tomography, radar and spectroscopy, and the more accessible, such as voice mail, telephone equipment, radios and real-time control systems. We will see more about these in this column in the future. In the next issue, we will see why it is that these really are more convenient, etc., and outline the basic “All Purpose” Digital Signal Processor. We will also take a brief look at HDTV as DSP (after all, isn’t HDTV sort of a spread spectrum signal)?

Beginner's Box

More Wireless LAN Manufacturers

Symbol Technologies: Low cost, medium data rate. hand held barcode reader, integrated palmtop computer and radio/ modem devices. Warehouse and Point of sale product emphasis -- not computer to computer LANs.

Tetherless Access. Ltd.: Has 1.544 Megabit per second Internet network in field tests in San Diego. Soon to expand network in Silicon Valley, all the way to Sacramento with 500 or so units. Newest most advanced hardware and networking technology on the market.

Technical Tricks

by Randy Roberts

More Info on Gold Codes

Last month we presented a basic introduction to Gold codes. This presentation included reasons for choosing Gold codes, Gold code advantages and disadvantages, as well as the start of a listing of one family of Gold codes of length 31 (5 bit shift register generator). This month we explain auto- and cross-correlation, give the cross-correlation characteristics of the 5 bit Gold code family and present an implementation of a Gold code generator (GCG) that you ran build.

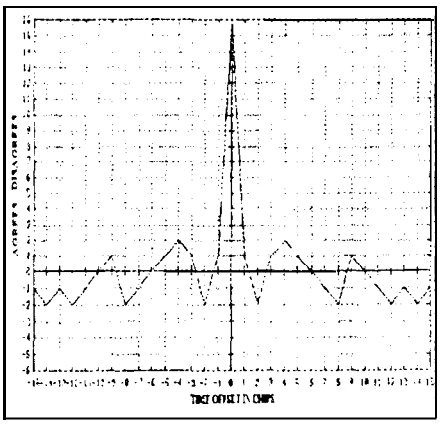


Figure 1: PN Autocorelation Function.

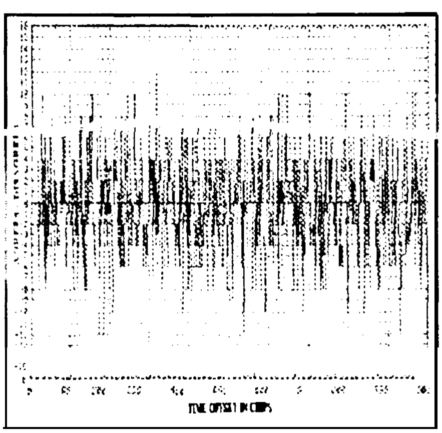
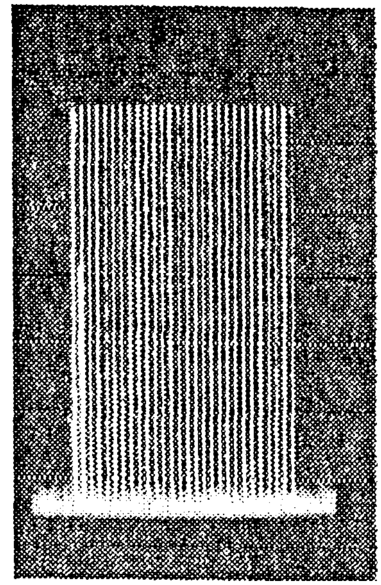


Figure 2: Cross-correlation of PN code with random datastream.

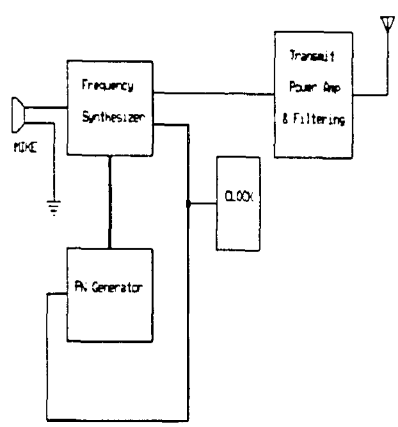
Gold codes are often used for CDMA systems because they possess controlled cross-correlation properties. In other words, one Gold code is not easily mistaken for another. The concept of correlation involves comparing two things for "likeness." While the mathematical definitions of auto- and cross-correlation are a little tedious, the concept of "likeness" and the generic idea of correlation are familiar to many people. Auto-correlation is the comparison of a signal with a time shifted replica of itself. Autocorrelation properties are used in DSSS to lock onto and track incoming signal and PN code fluctuations. As hinted at above, cross-correlation is used in DSSS systems to discriminate against un-wanted codes or noise. The DSSS receiver always uses some form of "cot-relator" to detect and demodulate the incoming "spread" signal. Figure I, at the left, shows a typical auto-correlation function for a PN code, Figure 2 shows the cross-correlation function for another PN code. Compare the two figures. If one sets a digital threshold at 13, 14 or 15 (Agrees - Disagrees), then the cot-relator discriminatesagainst random noise and <u>only</u> responds when the <u>correct</u> or (expected CDMA) code is present. DSSS systems inherently make use of the correlation properties of the PN codes that they utilize. Without correlation, DSSS systems probably would not exist. It is therefore, fundamental to fully understand all that the correlation properties of the PN code in-use possesses.

Back to building a GCG, see Table 1 on the facing page for the 33 Gold codes to program into the EPROM shown in the schematic of figure 3, also on the facing page. Gold code mux'ing is done 8 codes per EPROM byte. In other words, each byte of EPROM contents holds 1 bit of 8 different codes -- a dip switch selects which bit to output at each clocked address position. A full code is clocked out for each 31 clocks (address LSBs). The rest of the codes are stored modulo-32 and selected as higher order EPROM address bits.

Frequency Hop Signals: How to generate them and what they look like.



Frequency hop signals are easy to generate. Almost any frequency synthesized transceiver can be converted to frequency hopping. All that is needed is to add a PN generator to control the frequency commands to the radio's synthesizer. The above figure shows the expected output frequency spectrum of a frequency hop SS radio. The block diagram below shows how one might hook up a PN generator to a frequency synthesizer to generate a FH SS signal.



5 BIT GOLD CODE EPROM CONTENTS

The first two codes listed below are the "basis" codes for generating the codes listed. The output of the two "basis" codes are bit EXOR'd to generate all tbe other codes. Code 2 is the zero blt shift code, code 3 is the one blt shifted code, etc. The first blt out is the rightmost code bit. Store the code blts in an EPROM with MSB of tbe code (the last blt out) as the leftmost bit of this listing.

(0)	1100110100100001010111011000111	(17)	1001000011011010000100010011001
(1)	1011001110000110101001000101111	(19)	0111110000111011101110000010010
(2)	01010011100010000001111101000000	(19)	1010010111111000111010100000101
(3)	1111101010011111111001110100001	(20)	0001011001111110010011100101010
(4)	1019100010110000010101001100010	(21)	0111000101110011000001101110101
(5)	0000110011101111001100111100100	(22)	1011111101101001100101111001011
(6)	0100010001010001111111011101001	(21)	0010001101011100101101010110110
(7)	1101010100101100011000011110011	(24)	0001101100110110111100001001101
(9)	1111011111010111010110011000110	(25)	0110101111100010011110110111011
(9)	1011001000100001001010010101100	(26)	1000101001001011011011001010111
(10)	0011100111001101110010001111000	(27)	0100100100011001010000110001110
(11)	0010111000010100000010111010001	(29)	1100111110111101000111000111101
(12)	0000000110100111100011010000011	(29)	1100001011110101101000101011010
(13)	0101111011000000100000000100111	(30)	1101100001100100110111110010100
(14)	1110000000000111010011010101111	(31)	1110110101000110001001000001000
(15)	1001110110010010101011111111110	(32)	1000011100000011110100100110000
(16)	0110011010101010110001011011100		Initial states: PN1: 01001 -- PN2: 11011

The Minimum cross-correlation is: -9/31 -- Maximum is: 7/31
Worst cross-correiution sideiobe is -10.7 dB

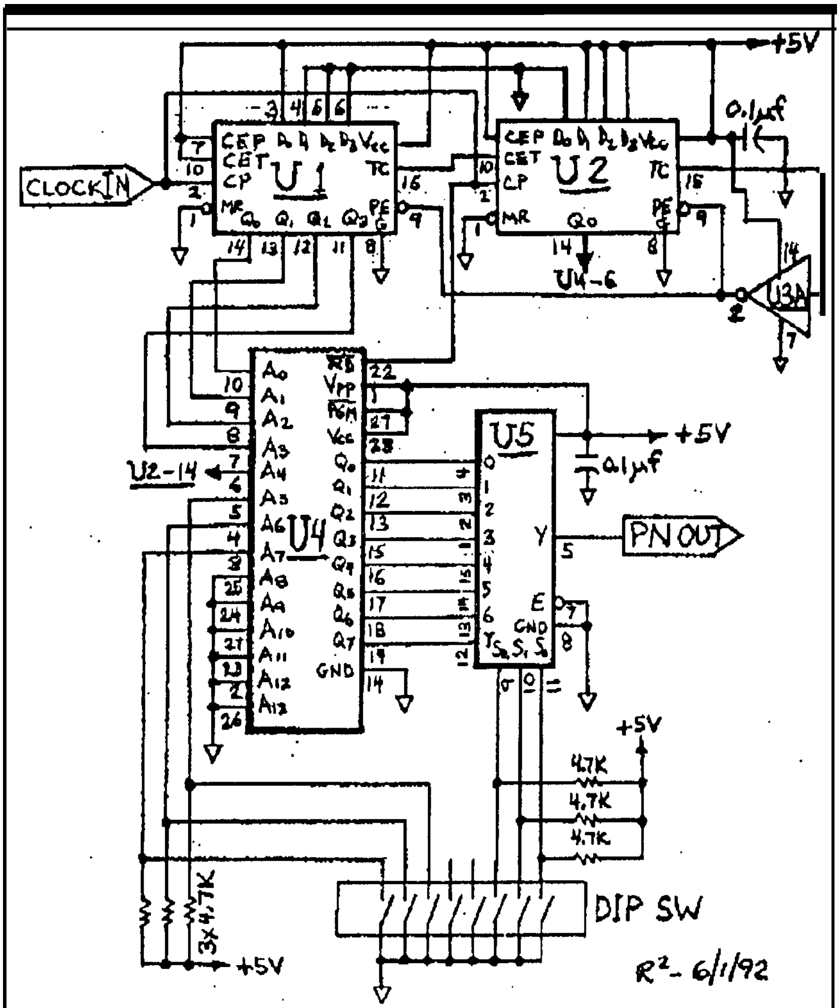


FIGURE 3: 5BIT GCG

U1,U2: 74HC 163N

U3: 74HC04N U 5: 74HC 151N

U4: 27C128 EPROM

Who is Randy Roberts Anyway?

Randy Roberts, the Editor and Publisher of SSS is an independent entrepreaeurtai engineer. He has over 27 years experience lo communications, electronics and spread spectrum system design. He graduated with a BSEE in 1970 from UC Irvine. He is currently the owner of RF/Spread Spectrum, a consulting, product development, publishing, strrteglc planning and training company. Randy Is an active amateur radio operator with tbe callsign: KC6YJY. He has been a ham off and on again since 1958 (his first call was WV6BFN) and then got his general Ucense, WA6BFN, at age 13 in 1959. His address is P. 0. Box 2199, El Granada, CA 94018-2199. He can be reached at 415-726 6235 or by FAX on 415-726-0118.

Spread Spectrum Propagation

by Randy Roberts

The art of reliably predicting radio propagation performance for spread spectrum links is clearly filled with problems. Some of these problems were mentioned last month. In this segment, we will concentrate on trying to establish a little more rigor in our propagation predictions. Many newer tools are available to help us in this ork. However, this non-exact science needs a good deal of painstaking and error or brute force perimentation to really succeed.

The problem neatly breaks down into two categories:

1 - Indoor propagation
2 - Outdoor propagation

We are using portable/mobile operation only in the outdoor sense. I really don't think you need or want your in-building LAN to work as someone carries around his/her laptop on a skateboard! Given that both indoor and outdoor environments are tough ones, a methodology for attacking each is presented in the adjacent sidebars.

As the sidebar at left points out, indoor propagation prediction is largely experimental in nature. I know of no computer based tools that really help in the indoor case. The best you can do seems to be: adopt an experimental mmdset, do some alpha and beta testing in various kinds of buildings and thoroughly train your field service and installation personnel.

Outdoor range and propagation prediction can be a bit more rigorous, time consuming and expensive, than indoor. Here is where many computer based tools and analytical aids can help -- don't entirely forget your experimental mindset, however. The final exam for all radio based signal propagation studies is the real world: does the link work reliably?

Three major steps are involved in outdoor propagation studies:

1 - Site selection, site/path surveys and identification of alternatives.

2 - Gather terrain data, path profiles and antenna height information/choices.

3 - Modeling and analysis of the path, terrain, obstacles and signal levels.

You are on your own in selecting sites and alternatives, but modem computer software can help with most of the other chores. The figures on page 11 are from a great article by Harry R. Anderson that appeared in February 199 1 *Communications*. The figures show very graphically what can be done today. Many simulation/modelling programs and terrain data bases are available. There are several consulting firms out there that do just this kind of work. Find them, use them if you can and finally, learn all you can from them. You'll need all the help you can get, when you have to make the link work.

Indoor SS Propagation Prediction Methodology

1 - Realize that siting and defied path analysis are **impossible.**

2 - Realize that the environment is far front benign and **suffers** front tremendous In-chip multipath.

3 - Allow for fade margins and signal levels **reminiscent** of Broadcast AM radio (10's or 100's of microvolts per meter signal strength.)

4 - Design or specify the equipment for coping with In-chip multipath.

5 - Run extensive tests in your planned **building** site(s) to **find** "live" and "dead" spots.

6 - Install passive repeaters (back to hack connected antennas) to carry signals front "live" spots to "dead" spots.

Outdoor/Mobile SS Propagation Prediction Methodology

1 - Unless you only need to connect a network of a very small number of units, adopt a cellular approach for system **connectivity.** Redundant paths and over-connected networks are mom reliable than **simple** point to point links. When propagation anomalies happen, redundant paths and voting receivers ensure that data **gets through.**

2 - Plan your MAN, WAN or **UAN** so that Individual units can automatically relay messages for other nearby units. This will **provide** even more path redundancy and reliability.

3 - Pick your sites and installation locations with care. Thoroughly identify alternatives and plan for back-up capability.

4 - Model and analyze both worse case and typical paths within your system. Do signal level mapping, **like** figure 1 on page II. Do terrain **modelling** and simulation -- evaluate alternative sites -- select the best sites for **primary** coverage. Install **secondary** or backup sites, if possible.

5 - Do as much **field** testing and at-site propagation **testing** as possible. Provide antennas and transmitter power levels **sufficient** to meet statistical fade margins that you can guarantee. Continue field tests into the Beta phase and If possible, well Into actual on-line system operations Be ready to change your system architecture and site locations if conditions later warrant it.

Want to see more on SS propagation?

Why not write up your experiences, your opinions or a short note -- **we'll** gladly publish them.

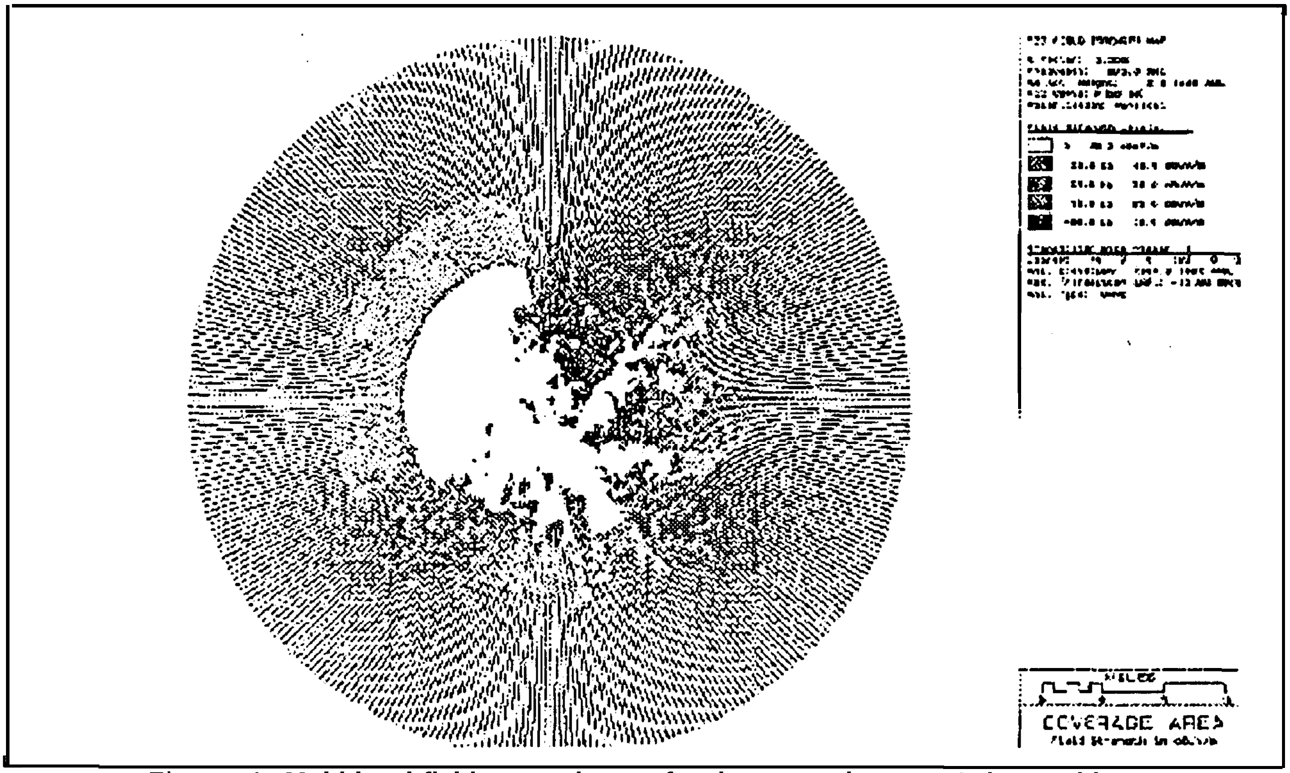


Figure 1: **Multi-level field strength map for the transmitter on Coburg Ridge.**

(Figure from: *"Using Your* **PC for Signal Propagation Prediction," by Harry R. Anderson, Feb. 1991,** ***Communications*****)**

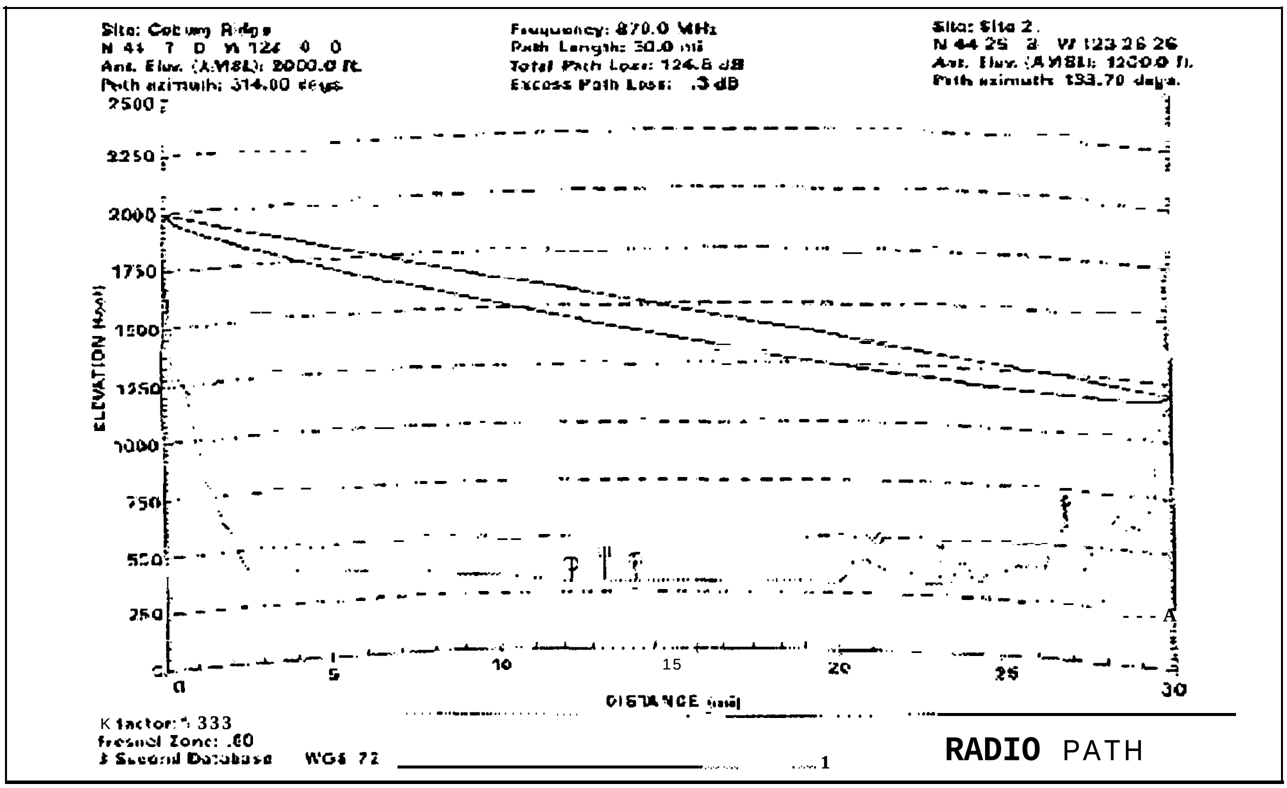


Figure 2: Terrain profile with radio path and 0.6 Fresnel zone.

(Figure from: "Using Your PC for Signal Propagation Prediction," by Harry Ft. Anderson, Feb. 1991, ***Communications*****)**

INTRODUCTION TO SPREAD SPECTRUM

by R. H. Roberts

Second installment of a forthcoming book by the SSS publisher.

Chapter 1 -- Basics /Continued)

Chirp systems -- Chirp systems are the only spread spectrum systems that do not always employ a code sequence to control their output signal spectra. Instead, a chirp signal is generated by shifting the carrier over a range of frequencies from fl to f2 as shown in figure 1, in a linear (or some other known manner) during a fixed pulse period. This results in a pulsed FM signal whose bandwidth is limited only by a transmitter's physical ability to shift a carrier frequency and by the ability of a receiver to demodulate it.

The idea behind chirp signals is that the receiver can employ a matched filter of a relatively simple design to reassemble the time dispersed signal in such a way that ii adds coherently and thus provides an improvement in signal to noise ratio.

Hybrid systems -- Spread spectrum systems made up of combinations of the direct sequence, frequency hopping, and chirp systems are also practical and have been used in various configurations to exploit the properties available. Time division multiplexing, or time hopping, is also applied in spread spectrum systems to great advantage where a number of users must access a single link.

Advantages of Spread Spectrum Techniques -- Spread spectrum signalling techniques offer a combination of advantages not available in any other way of communicating:

- Selective addressing capability
- Code division multiplexing
- Low density output signals
- Inherent message privacy/security
- High resolution range measurement
- Interference rejection

Selective addressing is possible through use of the modulating code sequences to recognize a particular signal. Assignment of a particular code to a given receiver would allow it to be contacted only by a transmitter which is using that code to modulate its signal. With different codes assigned to all of the receivers in a network, a transmitter can select any one receiver for communication by simply transmitting that receiver's code; only that receiver will receive the message.

Code division multiplexing is similar, in that a number of transmitters and receivers can operate on the same frequency at the same time by employing different codes. Either continuous transmission or time division is facilitated, since the synchronization inherent to transmission and reception of spread spectrum signals provides an excellent time base for on and off timing.

Low spectral power density transmitted signals are advantageous for prevention of interference to other systems as well as to provide a low probability of intercept. The low spectral power density of spread spectrum signals is an inherent property which exists because of the bandwidth expansion. In a direct sequence system, for instance, where the spectrum spreading code is at a 20 Mbps rate, the transmitted output is at least 24 MHz wide (at the 3 dB points) and the transmitter's power is spread over this bandwidth. In that 24 MHz

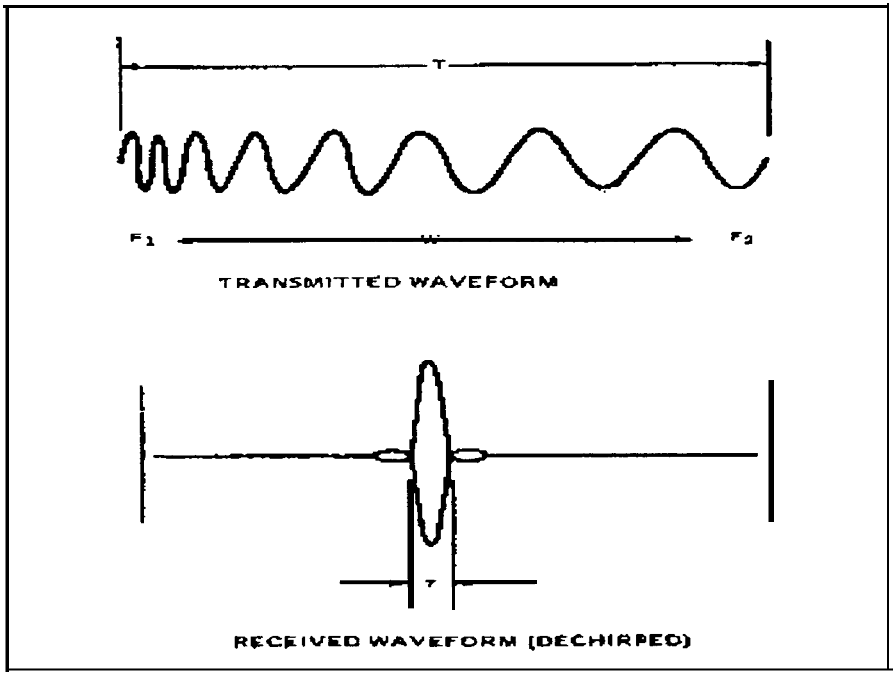


Figure 1: Chirp Spread Spectrum Signals. Chirp SS may not use a spreading code as such, it typically uses a pre-determined non-random chirp pattern, however.

band, a 1 W transmitter could output a spectral power density of approximately .416 uW per Hertz. To a narrow band receiver with a 50 kHz bandwidth, this 1 W signal would have less effect than a 20 mW transmitter of anything less than 50 kHz bandwidth. In addition, a spread spectrum output signal appears to be incoherent and is therefore often less objectionable, than a narrow band signal.

Message privacy is inherent in spread spectrum signals because of their coded transmission format. Of course, the degree of privacy, or security, is a function of the codes used. Spread spectrum systems have been constructed to employ every kind of code from the relatively simple linear maximal length shift registers to the truly secure nonlinear encryption types.

Spread spectrum signals of the direct sequence type excel in their capability to provide high resolution range measurements. Again, this property is due to the high speed codes used for modulation. Since synchronizing a spread spectrum receiver depends on the receiver matching its code reference to the signal it receives to within one bit (typically, a spread spectrum receiver's code will be matched to the incoming signal's code to within one tenth or less of a bit), then the intrinsic resolution capability of the signal is not worse than the range which corresponds to a bit period. Given that same system with a 10 megabits per second code, the range between transmitter and receiver can easily be measured to within 100 nanoseconds, or 100 feet, and little difficulty is found in narrowing the resolution to 10 feet or less. An added advantage of spread spectrum systems in the range area is that their range resolution is minimally affected by range. That is, a spread spectrum ranging system that provides 25 feet basic resolution capability at 7 miles will also provide that same resolution capability at 150 miles. Direct sequence ranging techniques have been more than proven on deep space probes, where they provide accurate tracking for space probes millions of miles away. In addition, spread spectrum ranging has been employed in high performance aircraft where accurate tracking has been demonstrated at several hundred mile ranges with a 2 watt transmitter power level.

Spread spectrum systems provide an interference rejection capability that cannot be matched in any other way. Both deliberate and unintentional interference are rejected by a spread spectrum receiver, up to some maximum which is known as the "jamming margin" for that receiver. This jamming margin is also a function of the code sequence rate (in a direct sequence system) or the number of frequency channels available (in a frequency hopper). A chirp system's jamming margin is set by the frequency band it covers during its pulse time, or may be better expressed by its compression ratio. Chirp systems have received a great deal more attention in radar systems, to provide better transmitter power efficiency and range resolution, than in communications systems for interference rejection.

Process Gain -- Interference rejection, selective addressing, and code division multiplexing occur as a result of the spectrum spreading and consequent despreading necessary to the operation of a spread spectrum receiver. In a particular system, the ratio of the spread or transmitted band width to the bandwidth of the information sent is called the "process gain" of that system. For a system in which the transmitted signal bandwidth is 20 MHz and the baseband is 10 kHz, process gain would be 10 log $((2 \times 10^7)/10^4\}=33$ dB. This system would offer a 33 dB improvement in the signal to noise ratio between its receiver's RF input and its baseband output, less whatever might be lost in imperfect implementation.

Jamming Margin -- Jamming margin is determined by a system's process gain acceptable output signal to noise ratio, and implementation losses. This margin, called J/S margin, is the amount of interference that a receiver can withstand while operating and producing an acceptable output signal to noise ratio. For the above system, which has a 33 dB process gain, if the minimum acceptable output signal to noise ratio is 10 dB and implementation losses are 2 dB, then the jamming margin is 33-12 = 21 dB.

A 21 dB jamming margin would permit a receiver to operate in an environment in which its desired signal is 121 times smaller than the interference at its input. Expressed another way, an interfering transmitter can have 121 times more power output than the desired signal's transmitter before it affects the receiver's operation.

The security, anti-interference, multiple access, and high range resolution capabilities of direct sequence spread spectrum (DSSS) signals and systems make their use almost mandatory for today's demanding digital communications systems that must operate in an extremely crowded and interference ridden RF environment.

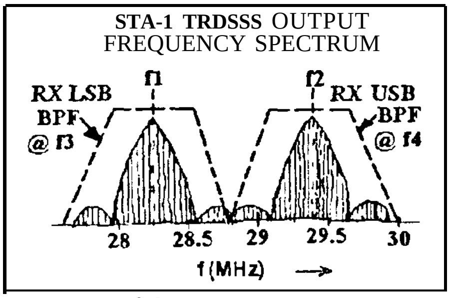
Build Your Own SS STA Transceiver (Part 1)

How would you like to get your hands on a Direct Sequence Spread Spectrum transceiver designed to operate under the new amateur radio Spread Spectrum STA from the FCC? Here's your chance. In this series of articles we will present a new and original design of a small light weight, low power, simple transceiver that operates on 6 meters at the 100 milliwatt power level or on 10 meters at a 10 milliwatt power level for use with VHF/UHF transverters.

This new design designated STA-I will be available in kit form on 2 or 3 small (about 2" by 5") PC boards. The design is currently in the breadboard and de-bug stages. It will be prototyped, tested and ready for you to start assembly and operation on SS by the middle of summer.

Looking at figures 1 and 2 on the next page gives you a general idea of the simplicity involved in this design. We are keeping it absolutely as simple as possible. However, the transceiver will be able to operate with digital data at serial, RS-232 baud rates of 1200, 9600 and 19200. It will also be capable of narrowband FM audio (for ID'ing, as required by the FCC) as well as spread spectrum over analog FM. Another voice mode option will be digital continuously variable slope delta modulation (CVSD). Finally, higher speed TCP/IP at HDLC speeds of 38.4 kBits per second will be included with the basic transceiver capabilities.

In the digital modes of operation the STA-I will normally be used with an outboard terminal node controller (TNC) -- this is not absolutely necessary, however. The radio will be capable of direct connection to a serial port of a PC or laptop and can be used with external software like Procomm and whatever data protocols the user may want to experiment with. Given this short introduction to the STA-I, we now describe how the unit will operate.



Drawing of the STA-1 output **spectrum**.

The sketch above shows the expected output frequency spectrum of the STA-1 transceiver. After a lot of thought, experimentation and soul searching by the author, transmitted reference direct sequence spread spectrum was selected as the simplest, cheapest and most efficient modulation for this application. Other SS modulation types make better use of transmit power or receiver signal to noise ratio -- but all of them require much more complication in receiver and transmitter circuitry. When you send two PN coded signals, simultaneously using one carrier just to send the PN code and the other carrier for the data EXOR'ed with the PN code, the result is called transmitted reference. This approach is "self-synchronizing" -- that is, no special correlator or matched filter or expensive custom ASIC chip is required to de-spread the received signal. PN demodulation is achieved instantly with transmitted reference, because both the data signal and PN reference signal are available all the time and undergo almost identical RF channel disturbances.

Transmitted reference spread spectrum has been used, in different form, in the past by hams -- see the ARRL ***Spread Spectrum Sourcebook***, where a local broadcast station was used as the timing reference for an SS link. The new twist used here is that you split your radiated power in half, by frequency multiplexing the two signal components. Half of your power is used to send the PN and data signal. The other half of your transmitted power is "wasted" sending the synchronizing information on the PN only reference channel. The "waste" of half your transmit energy is what so greatly simplifies the SS receiver circuitry in the STA-1.

The STA-I design shown on the facing pages in block diagram form will use an embedded control microprocessor for all of the required control functions. The microprocessor and the control lines are not shown in these functional block diagrams, to simplify the presentation of new ideas. Much more complete details including schematics, parts lists and photographs of working hardware will be available next month.

Table 1 below highlights some of the detailed information about the STA-I design. Remember that the STA-I will be available in two versions: one for 10 meter output for use with VHF or UHF transverters and another version for direct output at 6 meters. By using common circuitry for both STA-1 versions, we are able to greatly simplify circuit board layout and keep kit costs low. Continued on Page 18

TABLE 1

STA-1 Optional Frequencies and Parameters

(refer to pg. 15 -- Figs. 1 and 2)

Transmitter

Version	F1	F2
6 Meters	52.5 MHz	53.75 MHz
10 Meters	28.25 MHz	29.5 MHz

Receiver

Version	F LO
6 Meters	48 MHz
10 Meters	24 MHz

Version	F3	F4
6 Meters	4.5 MHz	5.75 MHz
10 Meters	4.25 MHz	5.5 MHz

System

Data Rate	F PN (kHz)	PG (dB)
1200	308	24
9600	296	14.9
19200	288	11.8
38400	268	8.5

Exact prices **have not** been set for the **kits yet** -- we hope to offer the complete kit for **less** than $250.00.

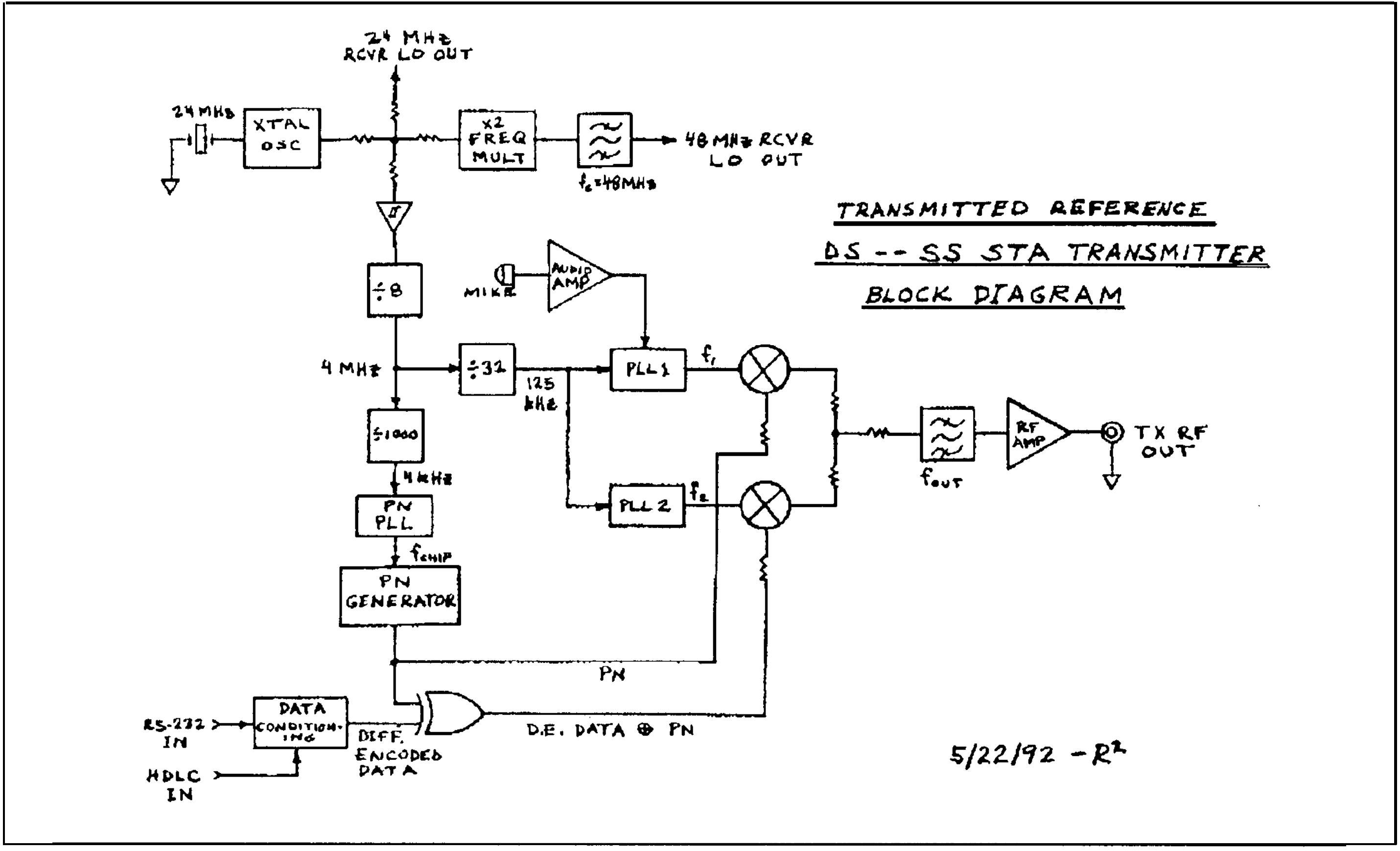


Figure 1: SS STA Transceiver -- TX Section Functional Block Diagram. This transmitter section generates the waveform shown on page 14.

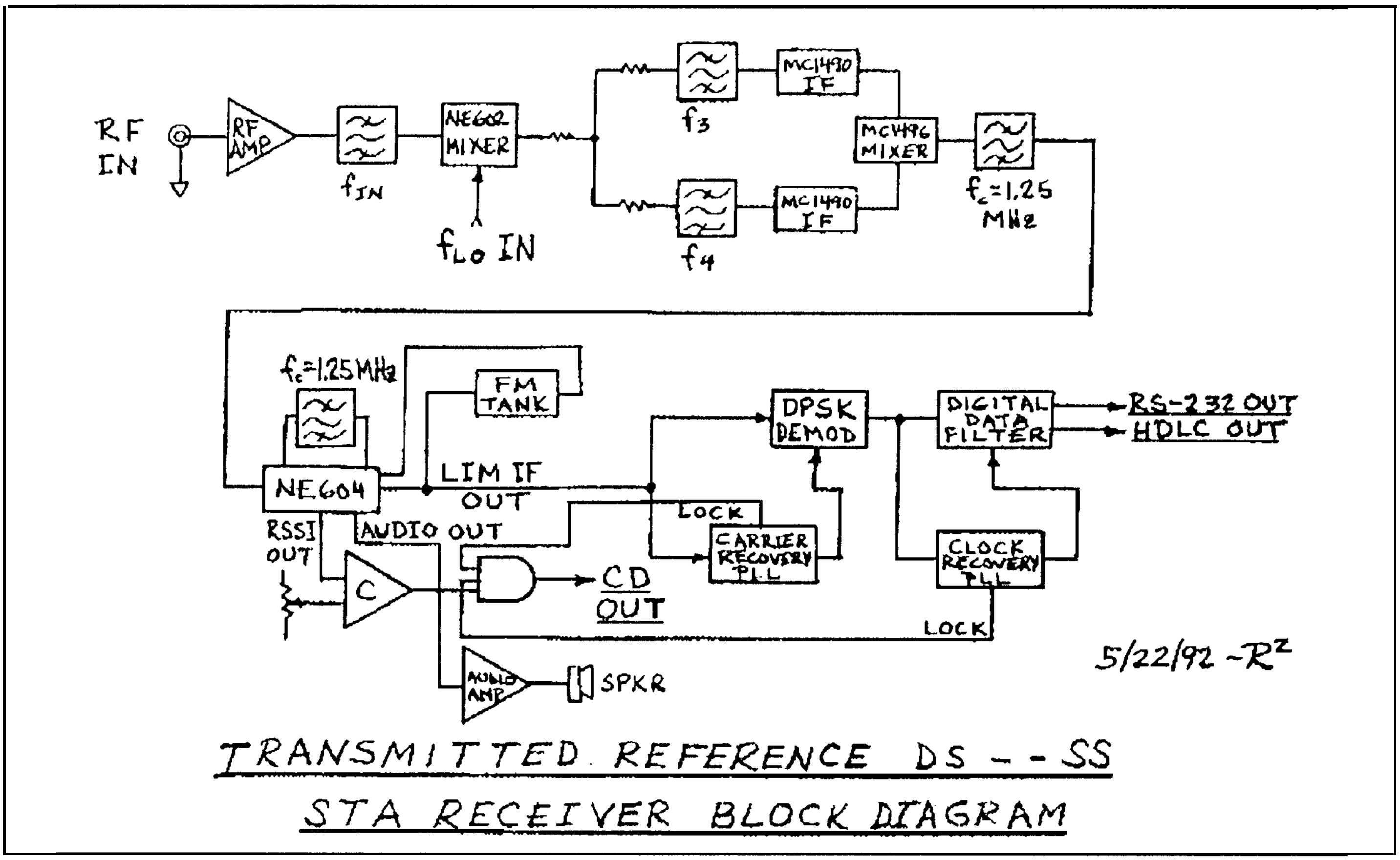
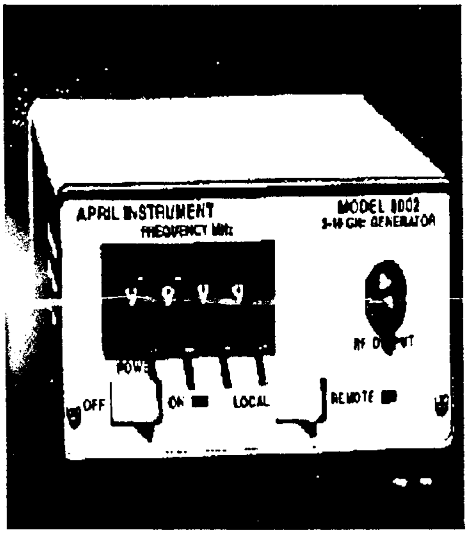


Figure 2: SS STA Transceiver -- Receiver Section Functional Block Diagram. This receiver demodulates the waveform of page 14.

New Products



April Instruments 8002 Signal Generator

c model 8002 from April nstrument is a handheld, programmable, microwave signal generator. The unit covers 2-10 GHz in 1 MHz increments with a guaranteed output power of +10 dBm. Phase noise at a 20 KHz offset from the carrier is -80 dBc with -90 dBc typical. An FM modulation input allows FM rates from DC to 200 KHz and deviations from 0 to 20 MHz. Spurious output is typically less than -60 dBc.

Programming is via a TTL compatible, parallel BCD data bus. Full band switching speed may be set to 350 or 25 milliseconds; the slower speed providing better phase noise rformance. The 8002 requires less an 10 watts AC power. It measures ly 2.52” H by 5.57” W by 7.45” L and weighs 2.6 lbs. Price is $3,995 and availability is 30 days. For additional information, contact April Instrument, PO Box 62046, Sunnyvale, CA 94088, TEL (415) 964-8379, FAX (415) 965-3711.

SIGNAL TECHNOLOGY CORPORATION ACQUIRES KELTEC FLORIDA

Wevmouth. MA (April 15, 1992) -- Signal Technology Corporation of Weymouth, MA and Sunnyvale, CA, has acquired the business and substantially all of the assets of Keltec Florida, Inc., a subsidiary of Amstar Corporation, located in Fort Walton Beach, Florida, as announced today by Signal Technology’s CEO, Dale L. Peterson. The acquisition was made by a subsidiary of Signal Technology which will operate under the name ST Keltec Corp. and will remain in Fort Walton Beach.

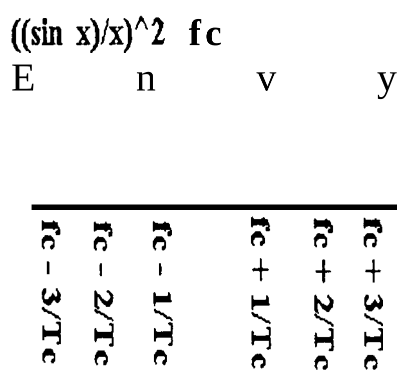
Keltec Florida is a leading manufacturer of custom-built electronic products for the defense industry. These include power supplies for surveillance, display and electronics countermeasures systems, plus TWT amplifiers for instrumentation and satellite applications. Keltec manufactures electronics which are employed in airborne, shipboard, satellite support, and ground-based environments throughout the world.

Signal Technology companies are leading producers of radio frequency and microwave components and subsystems for defense, international and commercial applications which require precision frequency management. The other Signal Technology companies are ST Olektron Corp. of Beverly, MA, ST Microsonics Corp. of Weymouth, MA, ST Microwave Corp., Arizona Operations, located in Chandler, Arizona and ST Microwave Corp., California Operations, located in Sunnyvale, California.

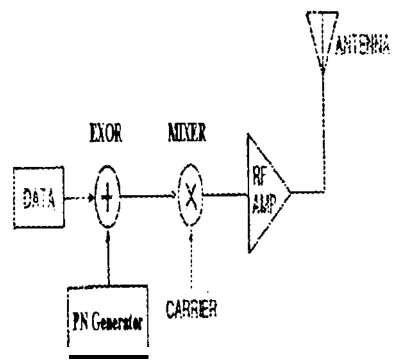
Contact: Robert E. Sliney, Jr., Signal Technology Corp. at (617) 3378823.

Beginner's Box

Direct Sequence Spread Spectrum Basics



The figure above shows the spectral shape of a direct sequence SS signal. The basic spectrum shape is called (SIN(r) /x)^2. There are actually lines in the spectrum at a spacing equal to the data rate. Only the signal’s envelope is shown here. The width of the spectrum is directly related to the “CHIP” rate, Tc, (1 over the PN Clock frequency). The first sidelobes are 13 dB down compared to the main lobe. The block diagram below shows a very simple direct sequence transmitter.



STA. from pg. 5

"97.311(d)(1) will be used as a 'generating function. Spreading codes will be selected from continuous segments of bits produced in the output of the generating function based on their suitability to provide uniformly distributed spectral density, code orthagonality and maximal coding gain. Each spreading code will represent one symbol in the data to be transmitted. Only the selected spreading codes will be transmitted, and each will be transmitted in its entirety.

"DSSS generators using SAW devices with fixed spreading codes not related to the m-sequences specified in paragraph 97.3 1 l(d)(l) will also be used.

"Frequencyhoppingmay be evaluated as a means for further distributing the transmitted energy.

"Frequency synthesized homodyne and single heterodyne transceivers will be evaluated on each of the frequency bands proposed, time and resources permitting. Test units will also be made available for FCC monitoring if so requested.

"Purpose:

"The purpose of the tests is to experiment with spread spectrum transmission, reception and processing techniques.

"Objectives:

"Specific objectives of the STA are to:

"(1) assess the strengths and weaknesses of the proposed systems;

"(2) evaluate the potential of spread spectrum overlay on conventional FM systems;

"(3) determine interference impact, if any, to existing users;

"(4) evaluate immunity to intersymbol interference due to multipath propagation;

"(5) evaluate potential for improved spectrum utilization;

"(6) evaluate performance improvement claimed for CDMA; and

"(7) gain operational experience.

"DATES AND TIMES OF OPERATION

"The applicants request that operation under the STA commence immediately upon the granting of authority by the Commission, and that such authority be pennitted for one year, with leave to renew the STA.

"CLASS OF STATIONS AND RADIO SERVICE

"All stations are licensed in the amateur service, and all licensees hold a minimum of a Technician class license.

"LOCATIONS

"The locations of the stations shall be from the fixed station location listed in the station licenses of the applicants, plus any such portable operation as would be permitted under ordinary amateur operation.

"NUMBER OF TRANSMITTERS

"Each station will use one transmitter per frequency band in use.

"OPERATING FREQUENCIES

"Operating frequencies will be as follows: SO-54 MHz, 144-148 MHz, 222-225 MHz, 420-450 MHz, 902-928 MHz, 1240-1300 MHz and 2390-2450 MHz.

"OUTPUT POWER OF TRANSMITTERS

"The maximum power will not exceed 100 watts.

"TYPE OF EMISSION

"Spread spectrum emissions are to be used.

"DESCRIPTION OF ANTENNA

"No special waiver of rules is required. Antennas expected to be used are dipoles, collinear arrays and Yagi arrays with gains of 0 to 12 dBi, at heights up to 30 meters above ground.

"WAIVERS REQUESTED

"Waivers of the following sections of the rules are requested:

"97.305(c) Column entitled "Emission types authorized' is requested to be waived in order to transmit emission type SS in the bands 6 m, 2 m and 1.25 m.

"97.3 1 l(c) is requested to be waived to lilt the prohibition against hybrid SS transmissions.

"97.3 1 l(d) is requested to be waived to permit the use of other spreading codes.

"SUMMARY

"The undersigned on behalf of the group of experimenters respectfully requests that the Commission grant this request for special temporary authority. If you have any questions or need additional information, please contact the undersigned.

"Sincerely

/ signed /
Robert A. Buaas, K6KGS

"ANNEX

"Declaration of Participant

"I desire to participate in the spread spectrum temporary authority described herein:

"Name:
"Call sign:
"License class:
"Address:
"Daytime telephone:
"Evening telephone:
"Signature: "

If you want to participate in any way in this STA you must send Mr. Buaas a facsimile of the declaration above with the information requested and your signature. Bob also requests that each participant include a short description of the experiment(s) proposed, resuilts expected and ID'ing method to be used. Please use a format similar to the paragraph headings of the STA request itself. The major obligation of each participant is to provide Mr. Buaas and the FCC a final report at the end of the STA's year of operation. Bob has promised to update the list of STA participants to the FCC monthly. Remember, if you want to build the STA-1 kit and operate it on the ham bands of 6M. 2M or 11/4 M you must first get official FCC recognition as an STA participant. ***Lust minute note: Bob Buaas, K6KGS says the STA grunts everything they asked for!***

Want to Get on the air using Spread Spectrum?

Then, please turn buck to page 14 -- you'll see how to build the STA-1 Ham SS STA Transceiver.

The complete STA-1 kit will be available mid-summer, 1992. In the meantime look for complete construction details in the pages of SSS in coming months.

Build Your Own SS STA Xcvr from page 14

TRDSSS Fundamentals

Many readers may not be as familiar as they'd like with the fundamentals of transmitted reference direct sequence spread spectrum, let alone spread spectrum in general, so the following short background information is provided.

If you look at the text and figure box on page 16, entitled "Beginner's Box -- Direct Sequence Spread Spectrum Basics," you will see a graphical introduction to direct sequence. Direct sequence spread spectrum differs from frequency hop spread spectrum (which most people seem to intuitively understand) in a very fundamental way. Frequency hop modulation accommodates <u>any</u> form of baseband data or voice modulation. The frequency hop process is an indirect fonn of modulation -- only the transmitted carrier center frequency is changed by the frequency hop modulation process. Frequency hop (FH) <u>does not</u> alter the modulation waveform of the signal in any way!

Direct sequence (DS), on the other hand, radically alters the spread spectrum signal's apparent modulation -- it seeks to obliterate it! This DS modulation covering process is the actual mechanism for "spreading" the DS signal. Most DS modulations use digital forms of baseband modulation (data, voice or other information to be transmitted by DS is converted to simple "1's" and "O's"). The use of digital baseband (low frequency -- unmodulated -- what you see on a low frequency scope when you view the RS-232 input to a modem) data enables a direct sequence spread spectrum radio/modem to simply EXOR incoming data with a higher speed PN (Pseudo Noise) code. The EXOR process is what actually "spreads" (and tends to hide the baseband infonnation) the signal to its wideband form.

The higher the ratio of PN generator's clock frequency to the digital data (sampling) clock, the more spread spectrum processing gain the DS signal has and the more hidden is the baseband information. The "art" of hiding the baseband information requires several things -- long, very random PN codes; data bit scrambling to eliminate discrete spectral lines when the information contains long strings of" l's", "O's" or other repetitive patterns; and careful signal and modulation filtering. It is not our purpose, here, to dwell *on* LPI (low probability of intercept) wavefonn design, we just want to point out what can be done. A "spread" signal is <u>not only</u> hidden, it is has a lower spectral power density, in watts per hertz of transmitted bandwidth than the original information signal. Lower power density makes a signal less likely to interfere with narrowband signals and less likely to be detected by an unintended receiver.

DS signals seem to have some interesting and unique properties -- they were designed to be that way. DS modulation of the carrier frequency is easily accomplished in a balanced mixer or an EXOR where the transmitted carrier frequency is "multiplied" by the composite [PN EXOR Data] signal. The output of this mixing operation produces double sideband suppressed carrier (DSB-SC) AM of the RF carrier -- also called digital Binary Phase Shift Keying (BPSK), because the PN signal causes 180 degree phase changes of the data bits with every transition of the PN stream. Since both the data and PN bit streams are digital it is easy to synthronize the PN and data clocks in a DS transmitter. It is generally assumed that there is a simple integer number of PN bits (called PN "chips" -- as opposed to data "bits") for every single data bit transmitted by a DS transmitter. This PN and data clock synchronization makes it easier for the receiver to lock onto and track the DS signals it receives in the most efficient (coherently or synchronously processed) way. If the receiver did not use the synchronization of PN and data clocks, signal processing losses of several dB can be incurred and <u>many be the pr[illegible]rties of DS can not explo[illegible]</u>

So much for regular direct sequence, you may now ask what the heck is TRDSSS anyway? Robert C. Dixon, in his text <u>&read Spectrum **Systems**</u>, describes transmitted reference direct sequence spread spectrum very succinctly:

"Transmitted-Reference Methods

"When a receiving system must be the simplest possible, a transmitted reference may be used for initial synch acquisition, tracking, or both. Transmitted reference receivers employ no code sequence or other local reference generator. Instead the coded reference is generated at the transmitter and transmitted at the same time as the intended information bearing signal. Both frequency hopping and direct sequence systems are amenable to transmitted reference methods.

. . .

" The operation of a transmitted reference receiver is precisely the same as that of any other receiver using an offset local reference signal. The difference is that the local reference is generated in the transmitter and sent to the receiver along with the signal to be demodulated. Their carrier frequencies are offset by an amount equal to the first IF in the receiver. and when mixed, a correlated IF signal is produced.

" Transmitting the reference is obviously advantageous when the receiver must be limited in cost, wright, or size because there is no need for a code sequence generator. search or tracking circuits, or any of the code-related mechanisms. Of course, if the reference is transmitted only to achieve rapid synch acquisition with a subsequent switch to normal direct sequence or frequency hopping demodulation, we must also still include these subsystems.

" If the transmitted reference technique is to be employed when interference or active jamming is a threat, some other synch provision may be necessary. Otherwise any two identical signals offset by the amount of the IF would produce false synchronization in the post correlation circuits. One method of protecting the IF in this situation would be lo frequency hop one of the signals transmitted, which would require the receiver IF to hop with the same frequency pattern, or a frequency hopping local oscillator would be needed to act as a local reference for the 'frequency hopping subsignal'. In either case the synchronization time would be increased to

Call for Technical Articles

SSS needs material for future publication relating to SS, RF, *antennas or software*. Drop *us* a note if you can help with some new material.

account for frequency hop synch acquisition.

" One other disadvantage exists, and this is that noise introduced in the reference due to being transmitted through the link (rather than locally generated) degrades the receiving system. When interference appears at both desired and reference-signal frequencies, correlator output products are produced which fall into the IF baud, thus also degrading signal demodulation."

So TRDSSS is not without warts! The STA-I, however, provides a simple, inexpensive introductory vehicle to getting on the air with some form of spread spectrum. After the reader has built, tested and operated the STA-I for a while he can think about upgrading its circuitry to do "real" direct sequence.

We think a lot can be learned from the STA-I. For anyone who needs an introduction to modem digital data communications, the STA-1 provides the equivalent of a one semester lab course in hands-on learning. The operation of the STA-1 on the air (or even into attenuators/dummy loads, to keep from radiating, if you don't have a Ham license) provides insight into the performance of SS.

If there is sufficient reader interest we will publish suggestions for improvements, suggested experiments with and even plans for enhancement of the basic STA-I design. We hope that our readers enjoy this series of construction articles whether they build an STA-I kit or not. If Ham radio is to survive into the 21 st century, hams must not only upgrade their skills -- they must join up with today's technology. Forget your 1970's 1200 Bps Packet, narrow band FM radio -- if you don't, some commercial entity (probably using SS) will most likely take over your favorite repeater frequency, packet BBS or your whole favorite band. What will you do -- try SS and join the 2 l st century or what?

Please let us know what You think about the STA-1 construction project.

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1. <u>**RF** Transceiver **Engineer**</u> -- To be involved iu the **design/development** of wireless **communications** systems, utilizing spread spectrum **technology** for PCN. **Requires** previous RF/Microwave **Component/Subsystem** design experience to **include** low cost amps, oscillators, **up/downconverters,** synthesizers, LO and RF chains.

2. <u>**Digital/Data Communications Engineer**</u> -- **Will** design communications interface for wireless LANS. Knowledge of micro controllers **(8061** or related) serial **communications** controllers, RS 485, synchronous/asynchronous communications and ethernet knowledge preferred.

3. <u>**Data** Communications Software Engineer</u> -- Knowledge of Intel **80C51,** 152, 186 **micros, synchronous, asyncronous communications** for wireless **PCNs.**

4. <u>**Analog/Digital Design Engineer**</u> -- Involved **in** design of digital ECL, TTL, Logic, **PLDs, PALs, PLLs** and clock recovery circuits and microprocessor-based **circuitry** for digital microwave radio.

<u>**SOUTHERN CALIFORNIA** AREA</u>

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2. <u>**Spread Spectrum** Systems **Engineer**</u> -- **Utilize** your knowledge of spread spectrum communications systems theory, **TDMA, CDMA, FDMA,** digital **cellular** and DSP in the design of wireless PCN.

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There is no space limit for Help Wanted ads. All help wanted ads are provided as a public service -- they are published at <u>no cost</u> to the prospective employer. Help Wuntcd ads <u>must include the name and phone number of a hiring manager and involve SS, RF, communications. systems, networking or related skills, in some way.</u> Help wuntcd ads with only a rcfcrcncc to the Human Rcsourccs or pcrsonnct departments are not acceptable for publication.

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A fast growing "News **Magazette", as we** will **start** calling **ourselves in July, needs two talented volunteer staff** members **to** help, part time with publication duties.

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July SSS Preview

Special: Third installment of ***Introduction to Spread Spectrum.***

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Date:

To: Mr. Robert A. Buaas
20271 Bancroft Circle
Huntington Beach, CA 92646

Re: The Amateur Radio STA Permitting Spread Spectrum Operations

Declaration of Participant

I desire to participate in the spread spectrum temporary authority described herein:

Name:

Call sign:

License class:

Address:

Daytime telephone:

Evening telephone:

Signature:

Fill in the above declaration, the backside of this page and mail the page to Mr. Buaas, if you want to participate in the new amateur radio Spread Spectrum Special Temporary Authority from the FCC. Do it soon or you may not get listed in time to fire up your own STA-1 transceiver!

DESCRIPTION OF PLANNED EXPERIMENT(S):

TYPE OF OPERATIONS:

Purpose:

Objectives:

(1)

(2)

(3)

(4)

(5)

(6)

(7) gain operational experience.

DATES AND TIMES OF OPERATION:

CLASS OF STATIONS AND RADIO SERVICE:

LOCATIONS:

NUMBER OF TRANSMITTERS: This station will use one transmitter per frequency band in use.

OPERATING FREQUENCIES:

OUTPUT POWER OF TRANSMITTER: The maximum power will not exceed 100 watts.

TYPE OF EMISSION: Spread spectrum emissions are to be used.

DESCRIPTION OF ANTENNA: Antennas to be used are dipoles, collinear arrays and Yagi arrays with gains of 0 to 12 dBi, at heights up to 30 meters above ground.

SUMMARY: The undersigned experimenter respectfully requests that the Commission grant this request for special temporary authority. If you have any questions or need ● dditionnl information, please contact the undersigned.

Sincerely

Signature, Callsign

Instructions: Fill in all the information you can, under each heading. Submit completed form, both sides to Bob Buaas at address on flip side of this page.