



PACKET

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Tucson Amateur Packet Radio Corporation

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The (Vice)President's Corner

Another Dayton Hamvention has come and gone, and once again TAPR was present in force. We had lots of traffic at the booth, and lots of interest in both our old and our new products. The TAPR Digital Forum on Friday was well attended, and at the TAPR/MVFMA Packet*BASH on Friday evening nearly 100 attendees heard Commander Chas Richard, W4HFZ, give a tremendous presentation about his stint as captain of Naval Research Submarine NR-1 and how he used amateur radio technology to bring the Internet to the crew of this unique craft.

Changes at TAPR

I'll talk a little later about some of the exciting new products TAPR has in the works, but first I have some organizational news.

Greg Jones, WD5IVD, has decided to resign as President of TAPR, effective May 18, 2000. Greg has been President since 1992, and was a Board member and officer long before that. His positive influence on TAPR has been immense. TAPR has been fortunate in having tremendous leadership over the years, and Greg's hard work and dedication have been the driving force behind TAPR through the '90s. It's simply impossible to

Look for TAPR at these Upcoming Events

- | | |
|-------------------|--|
| Sept 22, 2000 | Annual Board of Directors Meeting, Orlando, FL. |
| Sept. 22-24, 2000 | ARRL & TAPR Digital Communication Conference
Orlando, Florida |
| Sept. 23, 2000 | Annual Membership Meeting; Orlando, Florida |

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President's Corner, continued...

overstate how much we owe him. Greg is finishing up his Ph.D dissertation, and is also getting married this summer. He's understandably decided that he needs to shift his attention from TAPR to concentrate on his real life for a while. Greg has agreed to remain on the Board, and we're all looking forward to his continuing support.

We normally elect TAPR's officers at the Annual Board Meeting, held each fall in conjunction with the Digital Communications Conference (see elsewhere in this issue for more details). Rather than elect an interim President now, the Board has decided to use the next few months to analyze our operations and decide on a distribution of the many tasks that Greg juggled.

As Vice President I'll be acting as TAPR's interim leader until this fall. Our Board members will all be chipping in to ensure we continue services to our members. In particular, Steve Bible, N7HPR, will be working with me to develop a plan for the Board to redesign TAPR's processes to better distribute the workload. Steve will also be taking on the overall project management function for our kits and projects. The TAPR office will continue to operate as normal; the phone number, address, and office hours will remain the same.

Volunteers Needed

Although many things are uncertain, one thing isn't: now more than ever, TAPR needs your support. We're looking for folks who want to get involved with the organization in a significant way. If you're interested in volunteering, we'd love to hear from you. The available jobs range from daunting (anyone interested in being TAPR's webmaster?) to more bite-sized.

Please contact me (n8ur@tapr.org) if you're interested in volunteering. And, the offer of the webmaster spot isn't a joke -- we're looking for someone with the skill, dedication, and time to make a huge contribution to the organization by managing www.tapr.org.

Project News

We're about to ship an exciting new kit -- the T-238, which is an APRS-capable weather station controller that uses the Dallas Semiconductor "I-Wire" network. This project, developed by Will Beals, N0XGA and Russ Chadwick KB0TVJ was a prize winner in Circuit Cellar magazine's recent design contest, and was featured on the cover of the May 2000 issue of that magazine.

The T-238 is a single-board kit that interfaces with various weather sensors available from Dallas Semiconductor and outputs weather data to an LCD display or to a computer. More interesting, it has a serial output that "speaks" APRS and can be plugged directly into a TNC. This provides the ability to put an APRS weather station on the air without needing a computer

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President	open
Vice President	John Ackermann, N8UR
Secretary	Bob Hansen, N2GDE
Treasurer	Jim Neely, WA5LHS

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Mel Whitten, K0PFX	2003	k0pfx@tapr.org

Date of expiration of term on Board of Directors.

The Tucson Amateur Packet Radio Corporation is a non-profit scientific research and development corporation [Section 501(c)(3) of the U.S. tax code]. Contributions are deductible to the extent allowed by U.S. tax laws. TAPR is chartered in the State of Arizona for the purpose of designing and developing new systems for digital radio communication in the Amateur Radio Service, and for disseminating information required during, and obtained from, such research.

Article submission deadlines for upcoming issues:

Fall 2000	September 15, 2000
Winter 2000	December 15, 2000
Spring 2001	March 15, 2001
Summer 2001	June 15, 2001

Submission Guidelines:

TAPR is always interested in receiving information and articles for publication. If you have an idea for an article you would like to see, or you, or someone you know, is doing something that would interest digital communicators, please contact the editor so that your work can be shared with the Amateur community.

The preferred format for articles is plain ASCII text; the preferred graphic formats are HPGL or PCX. However, we can accept many popular



attached -- the T-238, a TNC, and a radio are the only items needed.

The T-238 should be shipping by the time you read this, at a price of \$134.00 (\$120.60 for TAPR members). Check the TAPR web site for further updates. More information on the T-238 can be found at www.beals5.com/wx/ and www.tapr.org/tapr/html/Ft238.html.

Not quite as close at hand, but definitely on the way, is N7HPR's EasyTrak rotor interface. This is another PIC-based project, but it's perhaps the most advanced one we've seen yet. Steve has programmed a beefy PIC to provide all the functions of a computer-to-rotor interface that can control azimuth and elevation rotors as well as tune the radio. Steve will be presenting a paper and demonstrating the EasyTrak at September's DCC and the Annual AMSAT meeting in October.

In another example of the synergy between TAPR activities, the Sproul Brothers have already shown how WinAPRS can control the EasyTrak to aim antennas at an APRS object. You'll be able to click on a station in WinAPRS and have the antennas track it as it moves. Think about tracking a balloon launch with high-gain yagis... the GPS on the balloon transmits current position data via APRS, and WinAPRS uses that to feed the EasyTrak, which keeps the antenna trained on the balloon. That sure beats manually aiming a hand-held yagi for a few hours!

If HamVention is any evidence, TAPR's current products continue to be popular. The various GPS interface boards, TNC accessories, and publications all sold well. And, as more evidence of APRS's popularity, GPS antennas just about flew off the table.

The FHSS Radio Project

Perhaps the most frequently heard question around the TAPR booth at HamVention (apart from "How're you going to haul THAT home?") was "What's the status of the Spread Spectrum Radio project?" Although I wish I could tell you that we're just about ready to ship, unfortunately that's not the case. The bad news is that one of the component manufacturers discontinued virtually all of the chips, including some "nothing-else-does-this" ICs, on one of the two boards in the radio. That required a massive redesign and cost us months of progress.

The good news is that the redesign is now complete and the new prototype boards are getting ready for testing and debugging. Thanks to TAPR's agreement with The Dandin Group, we have the engineering talent and other

resources available to push the project ahead, and the team is optimistic that the worst is over. I hope that by the next PSR, we'll be able to report significant progress.

Thanking Another Jones

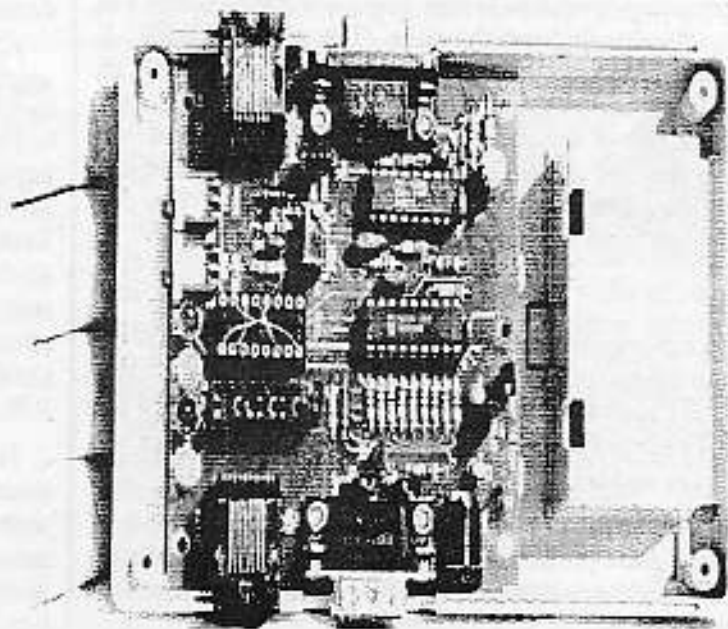
Greg isn't the only Jones responsible for TAPR's success over the last few years. I'd like to take a minute now to thank TAPR's unsung heroine, Dorothy Jones, KA5DWR. Dorothy runs the TAPR office and spends two exhausting weekends (and lots of preparation time before the events) each year making sure that we're ready for business at HamVention and the DCC. She is the telephone voice of TAPR, and she works harder behind the scenes than we have any right to expect. On behalf of the Board, I want to give her a big THANK YOU for all her dedication, and especially her good humor as she patiently deals with friendly callers, grumpy callers, uncooperative suppliers, and -- most difficult of all -- TAPR Board members. TAPR members appreciate her as well, as judged by the spontaneous applause she received when her name was mentioned at the '99 HamVention TAPR Digital Forum. Dorothy, we love you!

-- 73, John N8UR

An Enclosure for the TAPR PIC-E

Steven Bible, N7HPR
email: n7hpr@tapr.org

The TAPR PIC-E was designed to fit inside the Radio Shack project case with 9 volt battery compartment (RS 270-213). It is available at Radio Shack stores and it is not a special order item. The enclosure measures 3 5/8" x 5 3/4" x 1 1/8" and cost US\$5.39 (1999 Catalog). It



comes with a 9-volt battery clip. (The PIC-E can operate from a 9-volt battery)

The enclosure has three mounting holes that the PIC-E fits into. You will need to cut the sides of the enclosure to allow the RJ-45 and DB-9 connectors to protrude. I used a sharp X-acto knife. Take heed and do not cut yourself, make certain to cut away from your body!

Template

I've sketched a template and converted it to PDF format. [Available online at www.tapr.org/~n7hpr/pic-e/encl/index.html] When you print it out it may not be to scale. I put a 1" scale on the template. Use a ruler to check that the template did not expand or shrink. I'll attempt to draft a more accurate template and post it.

Wrap the template around the enclosure. Use the feet on the bottom half of the enclosure for reference. Then mark the cut out holes. If the template is not to scale, you can place your PIC-E in the bottom of the case and mark where the RJ-45 and DB-9 connectors meet the case. You can start cutting the case here and frequently check your work by test fitting the PIC-E in the case. When you finish the bottom case cut out, start on the top using the same procedure.

Battery Power

You can power the PIC-E from a 9-volt battery. Solder the 9-volt battery clip that comes with the project box to B1 on the PIC-E. Pay attention to polarity, red is "+" and black is "-". Better yet, solder in place a polarized 2-conductor plug and jack so you can remove the PIC-E from the case if needed.

Switches

It is up to you to decide how you want the switches and LEDs to protrude from the case. The evaluation PIC-E came with mini-slide switches. The production PIC-E comes with mini-toggle switches. The toggle switches will stick out of the case. All you have to do is cut two slots in the end of the case. If you want to replace the mini-slide switches with mini-toggle switches, you can order them from Jameco (P/N 106067)

LEDs

You can mount the LEDs at a 90 degree angle and cut holes in the end of the case. Another possibility is to solder the LEDs such that they extend up through the top of the case. The benefit of this method is that you can easily see the LEDs and label their functions.

I am always investigating new and better ways to enclose TAPR projects. If you have an idea, or comment, please share them with the PIC SIG group or email me at n7hpr@tapr.org.

The Role of Amateur Radio in the New Century

Dale N. Hatfield (W0IFO)
Chief, Office on Engineering and Technology
Federal Communications Commission

[As Prepared for Delivery at AMRAD's 25th Anniversary Dinner, Falls Church, VA, June 17, 2000]

Thank you very much for the nice introduction.

I am very pleased to be able to speak to you this evening on the topic of the role of amateur radio in the new century. I am very pleased to be here for a number of reasons.

First, I am very pleased because it is both your 25th anniversary and your first anniversary dinner held in the new century. That seems like a particularly good time to reflect on the future of the amateur radio service and I am flattered that you have asked me to do so.

Second, I am very pleased because I have especially fond thoughts about the service because of the pivotal role that amateur radio and individual amateur operators -- hams -- played in my own career. As I will explain in more detail in a moment, I would not be in my current position if it had not been for the help of some hams back when I was a teenager about 50 years ago.

Third, I regard it as a particular honor to be asked to address an amateur radio group that emphasizes experimentation and the more technical aspects of amateur radio. Again, as I will indicate in more detail in a few minutes, I believe that experimentation and contributions to the state of the art in the radio field are a major part of the justification for maintaining spectrum allocations for the service in the face of increased demands by commercial and other interests.

I would like to divide the remainder of my remarks into five parts.

First, I will briefly -- very briefly -- talk about my personal involvement in amateur radio. Second, I will briefly describe the role of the Office on Engineering and Technology at the Federal Communications Commission so that you will have a better idea of the basis for my remarks. Third, speaking from that perspective, I will talk about the growing scarcity -- and hence economic value -- of the radio spectrum and how that growing scarcity will inevitably put pressure on amateur allocations.

Fourth, I will talk about the important role that the amateur radio service has played in the past and -- going to the basic topic I have been asked to address -- what the amateur service can do to in the future to justify its spectrum allocations on both a national and international basis.

Fifth, and finally, I will talk about a proceeding we recently launched at the Commission — a proceeding dealing with Software Defined Radios. Before I continue, I need to add the standard disclaimer that my remarks here this evening represent my own views and they may not necessarily reflect the views of the Commission, any individual Commissioner, or any other staff member.

Background in Amateur Radio

My own involvement in amateur radio began in my early teens, when my father bought me a used Hallicrafters S-38B shortwave receiver. He and his brother — my uncle — had tinkered with crystal sets when they were kids and he somehow sensed that I might find radio interesting as well. I connected that receiver to piece of antenna wire hung out of my bedroom window and soon I heard a ham radio operator in Morocco calling CQ in the 20 meter amateur band. From that moment I was hooked on radio communications.

Two local hams who lived near me — this was in Dayton, Ohio in the early 1950s — helped me get my first license (WN8NGG) and helped me build my first transmitter. These two hams were electrical engineers that were employed at Wright-Patterson Airforce Base near Dayton. It was their interest that led me into electrical engineering as a vocation and ultimately to a job at the government's old Central Radio Propagation Laboratory in Boulder, Colorado. I won't bore you with the details, but that first, entry-level job eventually led me to the position I hold today. Accordingly, I will forever be in the debt of those two hams who so unselfishly supported my passion for radio.

Role of the Office of Engineering and Technology

As most of you may know, the FCC is organized into Bureaus and Offices. Generally speaking, the bureaus — the Common Carrier Bureau, the Wireless Telecommunications Bureau, the Mass Media Bureau, the Cable Services Bureau, and the International Bureau — have the "line" or operating responsibility in terms of the Commission's regulation of particular segments of the telecommunications industry. For example, the Wireless Telecommunications Bureau — under the excellent leadership of my colleague, Tom Sugrue — has the responsibility for the Amateur Radio Service. The offices — such as the Office of the General Counsel and the Office of Plans and Policy — provide support and advice to the operating bureaus and to the five member Commission itself.

Reflecting that rough division, the office that I now head, the Office of Engineering and Technology, provides technical advice to other bureaus and offices and to the Chairman and other Commissioners. In addition, however, our office has the responsibility for

administering specific parts of the Commission's rules, namely, Parts 2, 5, 15, and 18. Part 2 of the rules contains the Table of Frequency Allocations. That is, while the individual bureaus have primary responsibility for developing and recommending specific service rules, we, in OET, have the responsibility for general allocation matters. We also issue experimental licenses under Part 5 of the Commission's rules. In addition, we administer Part 15 of the Commission's rules dealing with unlicensed devices as well as Part 18, which deals with certain industrial, scientific and medical equipment. Finally, we are responsible for the Commission's equipment authorization program. Much of that work is done at our laboratory facilities in Laurel, Maryland.

Growing Demand for Spectrum

The management of the radio spectrum resource is an extremely important part of telecommunications policy and regulation. As you all know so well, radio spectrum is an increasingly scarce natural resource. We simply do not have enough spectrum to give everyone all they want. This increasing demand is being propelled by a host of developments:

the growing shift of our economy towards the service sector, the increasing mobility of our workforce, the convenience and increased efficiency produced by mobile/portable communications the increasing performance and falling cost of wireless devices the increasing requirements for public safety and for national defense systems, and the dramatically growing interest in accessing the Internet on a wireless basis. Hence, the allocation of spectrum for particular uses and the development of specific technical and service rules governing those allocations is a crucial determinant of telecommunications industry structure and performance. Even more importantly, it is critical to the performance of our public institutions that are devoted to certain scientific pursuits, such as radio astronomy, to the safety of life and property, and to the national defense.

As the office at the Commission that has primary responsibility for spectrum allocation matters, we, in OET, are in a particularly good spot to judge — first hand — the increasing demand for spectrum. Our office is generally the first place people stop when they are seeking new spectrum. Hardly a week goes by without someone stopping in my office or filing a petition asking that spectrum be allocated for some new service or that additional spectrum be allocated to an existing service. While increased efficiency in the use of spectrum — through the use of digital compression techniques, more efficient modulation and greater frequency reuse, for example — can offset some of this increased demand, increased scarcity is a very real concern. This scarcity is exemplified by increasingly contentious debates over spectrum sharing arrangements and by the amounts bid

in auctions for radio licenses. The \$35 billion bid in the recent Third Generation Cellular auctions in the United Kingdom provides very clear evidence of the increasing value of spectrum.

Our Chairman -- FCC Chairman, Bill Kennard -- has recently called attention to the potential for a "spectrum drought", especially in the valuable range below about 3 GHz. Under the leadership of the Chairman, and with solid support of Commissioner Susan Ness -- who has always been intensely interested in spectrum issues, we have put forth a number of proposals and undertaken a number of initiatives that would allow more uses and users of this national and international resource. One of these initiatives relates to Software Defined Radios -- a topic which I will return to briefly near the end of my remarks. The point that I want to emphasize here, however, is that, in thinking about the role of Amateur Radio in the new century, we must think about it in the context of increasing pressure on the underlying spectrum resource.

Future of the Amateur Service

Turning now to the future, it seems to me that -- given the increased pressure on the underlying resource from commercial and other non-commercial uses -- the key issue for the amateur service is maintaining access to an adequate amount of spectrum. Let me make it absolutely clear that, in raising the spectrum issue, I am not suggesting that there is any immediate threat to existing amateur allocations. I am simply pointing out the reality of the situation. The rapidly growing demand for spectrum coupled with the increased visibility of its economic value due to auctions makes it almost inevitable that amateurs will be under a certain amount of pressure to justify their "free" use of this precious resource.

In the past, the amateur service has justified its spectrum allocations by, among other ways, (1) engaging in experimentation that has advanced the radio state-of-the-art, (2) providing emergency communications in times of natural or man-made disasters, (3) providing trained radio operators in times of national emergencies, (4) encouraging international cooperation and goodwill by allowing direct communications between and among people on an international basis and (5) as in my case, providing an important educational outlet for people interested in the more technical aspects of radio communications. While the relative importance of some of these ways has obviously changed because of marketplace, technological and other developments, they remain valid today. The important thing is that they actually be carried out. Or, to use a bit of slang, it seems to me that it will be even more important for all segments of the amateur community to "walk the walk" not just "talk the talk."

Another potentially important area deals with how efficiently one uses the spectrum. We could probably discuss at some length the proper measure of spectrum efficiency but for our purposes here this evening it might be simply the number of simultaneous conversations that can be accommodated in a given amount of spectrum in a particular geographic area. In the commercial sectors, where organizations pay for their use of the spectrum, there is a significant economic incentive to use the resource efficiently -- to spread costs over as many users as possible while maintaining good quality service. That is, there is a strong incentive to develop and adopt more spectrally efficient technology. For example, by adopting various digital techniques, commercial mobile radio service providers (e.g., cellular and PCS) have been able to dramatically increase their capacity compared to the original analog technology. Similarly, when the broadcast industry has completed its transition to digital television, we will be able to reclaim a substantial amount of spectrum for other uses.

I recognize that, in the past, hams have also adopted more spectrally efficient technologies -- for example, by migrating from double-sideband amplitude modulation to single-sideband modulation and, more recently, by shifting to more efficient modulation for text -- TTY -- modes. I would urge you to continue shifting towards more spectrally efficient communications techniques -- especially digital techniques. Such a shift has a number of benefits:

First of all, it demonstrates to policymakers and regulators that you are good stewards of the public's airwaves even without direct economic incentives. Second, by using what you have efficiently, it strengthens your case when you need to ask for additional spectrum. Third, by allowing more users to access the available allocations simultaneously, it improves the amateur experience and ultimately increases the attractiveness of the service to new and old users alike. Fourth, it provides the opportunity or "headroom" for increases in data rates to more closely match those available on wireline networks and, in the future, on commercial wireless networks as well. Fifth, as the rest of the telecommunications world makes the transition to digital techniques -- and there are very few exceptions to that trend -- the amateur service will look antiquated if it is not making progress in that direction as well. So looking to the future of the amateur radio service in the new century, I would urge you to continue your traditional role in public service by being prepared for and providing communications in times of emergencies, conducting experiments, providing training in radio communications, and encouraging international comity. But I would also urge you to focus particular attention -- for the reasons I just mentioned -- on experimentation with digital techniques that are capable of squeezing more "bits per

second per Hertz of bandwidth" out of the increasingly valuable radio spectrum resource.

Software Defined Radios

I am rapidly running out of time but before I close I would like to talk about one additional topic that, as it turns out, may help enable some of the experimentation with digital techniques that I just advocated. The topic, as I mentioned at the outset of my remarks, is Software Defined Radios. Software defined radios -- or software radios or software programmable radios as they are sometimes called -- can be described as radios that are implemented in digital signal processors with functions defined in software. In other words the signals are generated in -- or converted to -- the digital format and the necessary processing -- for example, modulation and demodulation -- is done in software on a common platform.

From what I have been told, such radios could have a host of advantages:

One, they would allow a common radio to accommodate a host of different standards and thereby help alleviate some of the problems that we have had with the creation of different standards in the wireless field.

Two, they would facilitate interoperability among different types of radio systems, when for example, a large number of different emergency groups arrive at the scene of a major disaster.

Three, they would allow a manufacturer to develop different radios but on a common hardware platform. In other words, rather than manufacture and carry in inventory several different radios, the manufacturer could achieve economies of scale in the production of a common hardware platform, but wait until the product is about to be shipped before loading the software to create a specific type of device.

Four, they would allow the end user to update his or her radio simply by getting a software update -- just like an end user gets updated software for a Personal Computer today. In fact, one could even envision a situation where one could get software updates right off of the Internet or over-the-air.

Five, it is possible that a manufacturer could sell a bare-bones hardware platform to which third party providers or end users -- including hams -- could supply software to create custom radio systems. Certainly we have seen similar developments in the computer field and in other sectors of the telecommunications industry.

Six, it is even possible to imagine a radio that could adapt its characteristics to fit the interference environment and user needs on a more-or-less real time basis. For example, the radio could maximize its use of bandwidth in areas where the spectrum is not congested while conserving bandwidth or going to more robust modulation in areas where

interference is heavy, and/or propagation conditions are particularly difficult.

Indeed, if we can solve some of the difficult regulatory issues involved, it is even possible to envision Software Defined Radios as a means of facilitating a new era of amateur experimentation. One intriguing possibility is that it could enable hams without skills and/or interest in hardware construction to build and experiment with new systems by writing new code. It might also allow the rapid sharing of new modulation techniques and receiver designs through electronic publication of the implementing software. This could stimulate a whole new generation of amateur innovation that not only includes the more spectrally efficient systems I mentioned earlier, but also radios that could adapt to their environment as well.

In many ways, Software Defined Radios represent a final merger of the radio communications and computer fields. Viewed from that perspective, this technological development even has the potential of attracting back to the hobby some of the people who have shifted their interest to computer technology. Because of this potential to advance the service in fundamental ways, I would urge amateur groups to participate actively in our proceeding.

Concluding Thoughts

Let me conclude by saying that I believe that the future of the amateur service is a bright one. It is one where technological advances such as Software Defined Radios can enable the ham community to continue its proud tradition of innovation while demonstrating its commitment to the efficient use of the spectrum resource. Certainly your organization -- AMRAD -- is in a particular good position to encourage the experimentation that will lead to such innovations and I strongly commend you for your leadership efforts in that direction in the past.

Thank you very much.

TAPR Board of Directors Online Meeting Minutes - Quarter 1, 2000

[The TAPR Board of Directors holds a continuous meeting on a private mailing list. This is a summary of the discussions in that forum.]

TAPR Secretary

Due to the lack of meeting minutes from the last several Board meetings, a motion was made to remove Steve Stroh as Secretary of TAPR. The motion was seconded and passed. Almost simultaneous to the voting, Steve submitted his formal resignation. Bob Hansen was elected as the new Secretary.

Member Communications

In order to improve communications with TAPR members, the Board decided to create the "tapr-org" mailing list. This list can be used to discuss issues concerning the organization and as an open forum between the members and the Board. It was also decided to post the bylaws on the web site.

Group Deals

Some discussion was held on how to initiate and manage group purchases of equipment (specifically spread-spectrum radios).

Every group deal done has been a one of a kind type thing. TAPR found itself at the right place at the right time. The deals we have gone looking for typically haven't worked out. No one is authorized to 'deal' on these sorts of things besides the Board and officers.

The TAPR Board decided not to pursue a group purchase on spread-spectrum equipment because 1) there's no consensus on which product to go after, 2) at least two manufacturers approached in the past have been reluctant to deal with TAPR, causing a lot of effort to be wasted, and 3) we're not convinced, on the basis of past history, sufficient numbers of orders could be generated to make the effort worthwhile. We're still prepared to consider something if a good deal (e.g., discontinued product) can be identified.

-Submitted July 27, 2000, Bob Hansen, Secretary.

TAPR Board of Directors Meeting Minutes 5/18/00 Dayton, OH

Meeting called to order at 19:25.

Board Members Present:

Greg Jones, WD5IVD, President
John Ackermann, N8UR, Vice President
Mel Whitten, K0PFX
John Koster, W9DDD
Bob Hansen, N2GDE
Steve Bible, N7HPR
Barry McLarnon, VE3JF
Doug McKinney, KC3RL
Steve Dimse, K4HG

Not Present:

Jim Neely, WA5LHS, Treasurer

Guests:

Steve Stroh, N8GNJ
Phil Karn, KA9Q
Tom McDermott, N5EG

Reports

President

Greg Jones officially submitted his resignation as President of TAPR. A motion was made to officially thank Greg for his service as President; the motion was seconded and carried (one abstention).

John Ackermann will act as interim president until a new one is elected at the annual Board meeting at the DCC.

Secretary

Recent on-line Board discussions were reviewed.

Treasurer

The report concerning the financial status of the organization was posted online prior to the meeting. The report was accepted.

Project Reports

The following project reports were covered:

HamIUD

This is a project started by Steve Bragg which provides a mini TNC with scrollable LCD display. No Board action required at this point.

T238

This is a mini weather station using Dallas Semiconductor 1-wire sensors. It appeared in the May 2000 issue of Circuit Cellar magazine. A new discussion list (wxsig) was created to support the kit.

Rotor Controller

Prototypes in progress. This kit is not just for satellites, but can be used for applications such as balloon tracking.

SS Radio

This project had suffered a setback when all the major components (except one) had been discontinued by the manufacturer.

Kits and Publications

Most of the work on the new CDs is complete; most of the remaining work is for the PSR CDs.

The TCP/IP book is still in progress.

New Business

Downlink Receiver Project

Phil Karn presented an idea for a satellite downlink receiver project. A motion was made to support Phil on this project and the motion was approved.

Meeting was adjourned at 20:45.

-Submitted July 27, 2000, Bob Hansen, Secretary.

Correlation for Direct Sequence Spread Spectrum—The design of a simple data extraction circuit, using serial acquisition in conjunction with a Delay–Lock tracking loop.

Panagiotis Gavalas.

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A .pdf file of this paper can be retrieved at: <http://wireless.net/PanosDSSS>

Keywords: Direct Sequence Spread Spectrum, Correlation, Acquisition, Delay-Lock Loop, De-spreading.

Introduction

Spread Spectrum systems have become very 'trendy toys' in the areas of radio engineers and enthusiasts. Not only they provide privacy to the user, as an extend the ingenious channel encoding techniques involved make such systems very challenging for communications engineers and radio enthusiasts. Direct Sequence systems are the most preferred as they are the easiest to play with.

Sadly, among the articles and textbooks written on Spread Spectrum there are not many examples provided to the amateur radio enthusiasts. The concepts behind SS applications tend to be rather difficult to grasp and thus put the radio enthusiast in a very difficult position in terms of understanding and designing of such a system.

As an extend, some already available examples demand the use of complicated circuitry and expensive ICs. Thus, amateur radio enthusiasts are put in the risk of loosing valuable time and money in case of failure or possible damage of expensive components due to the idiosyncrasies of such ICs. Thus an easy and cheap solution is necessary.

This article is written in order to explain the concept of correlation in the simplest possible way to the amateur radio enthusiast and thus provide a simple solution concerning the heart of the system, i.e. the circuit that performs the de-spreading. It could be used as reference or a manual and the circuit described has the potential to be adjusted to any Direct Sequence SS system used for digital data transmission.

Demodulation and de-spreading for DS SS systems

At this early stage, the best way to understand correlation strictly speaking in terms of DS is to visualise the DS SS signal as a digital data stream with two types of modulation imposed onto it. At the transmitting side the following two actions are necessary.

- Spreading modulation, which 'spreads' the digital signal. It is used for channel coding purposes.
- RF modulation, which is the conventional part of modulation used for transmission.

Consequently at the receiving side of the system the exact opposite actions will have to be taken, in order to recover the data.

- RF demodulation, which 'cleans up' the spread signal from the radio frequency used for transmission. What is left after this action is the digital data stream 'carrying' the spreading code onto it.
- Demodulation of the spreading code. This is by far the trickiest part of the task and it is the ultimate recovery stage of the receiving system. It gives back the spread or 'hidden' data stream for the next stages of digital signal processing.

This article is solely concerned with the second stage of demodulation described above for DS SS systems. It is assumed that a spreading code cycle is used for each data bit.

This is exactly where the concept of **correlation** jumps in. The receiver must generate a replica of the exact same code used at the transmitter and modulo-2 add it (which is an equivalent mathematical operation to the XOR logic operation) with the received code signal. At this stage the received code signal is the code itself, either inverted or not corresponding to data bits '1' or '0' being received respectively. This is shown below, in Figure 1. [1]

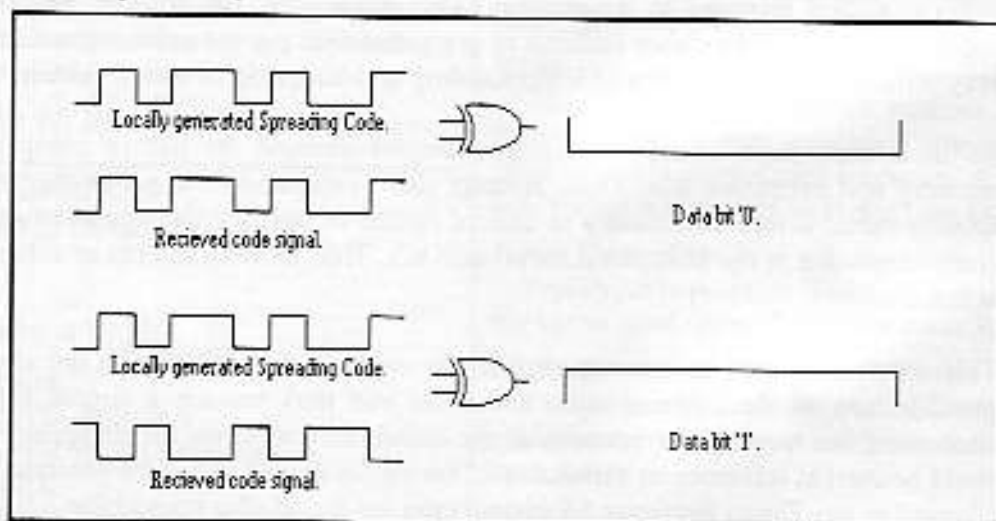


Figure 1 - Data De-Spreading in DS SS

Correlation versus time offset effects

A definition for correlation in DS SS should be given initially: "Correlation is the fundamental process for DS SS systems and is the action of measuring the similarity of the locally generated code, with the received code signal." The aim of this action as explained above is the completion of the digital data recovery.

In the previous paragraph it was assumed that the locally generated code and the received code signal were perfectly time-aligned. This case slightly departs from what the engineer will face in reality.

Due to uncertainties in the distance between the transmitter and the receiver, which may vary depending on how far the user may want to transmit or how far can the system transmit, propagation delays are caused. In addition to this, relative clock instabilities between the transmitter and the receiver spreading code generators will result into phase differences between the locally generated code and the received code signal. Note that it is assumed that the receiver and the transmitter spreading code generators are not synchronised with each other.

Thus, it is almost a certainty that when the signal will be received the locally generated code and the received code signal will not be in perfect time alignment. This is illustrated below in Figure 2. At a random time instant the locally generated code and the received code signal are modulo-2 added, i.e. XORed. Data cannot be recovered, as the two correlated signals are not time aligned.

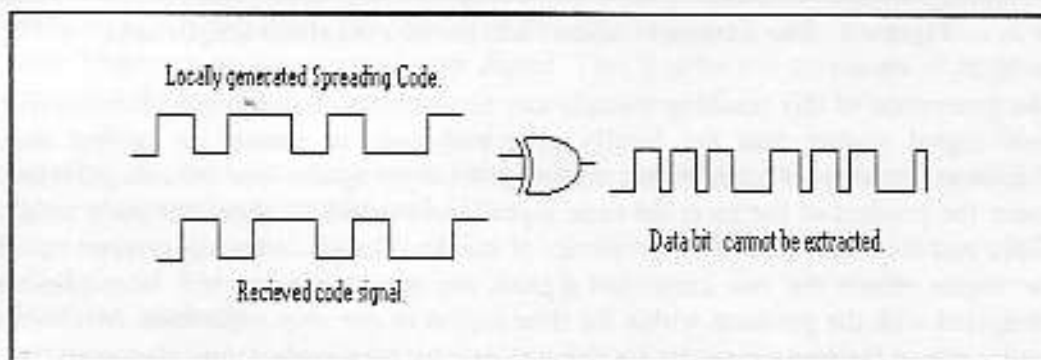


Figure 2 - Despreading without the locally generated code being time aligned with the received code signal.

Mathematically, considering the locally generated code as a time varying function $f(t)$ and the received code signal as $g(t)$, correlation is defined with the integral below:

$$\psi(t) = \int_{-\infty}^{+\infty} f(t)g(t)dt$$

Consider the case were a data bit '0' was transmitted. This effectively means that a non-inverted code cycle was received. The receiver will now have to time align the received code with the locally generated code. Thus mathematically the received code signal can now be re-expressed as a time shifted version of the spreading code. Therefore: $g(t)=f(t-\tau)$, and the correlation integral can be expressed as:

$$\psi(t) = \int_{-\infty}^{+\infty} f(t)f(t-\tau)dt$$

where τ is the time shift

This is the auto-correlation integral. Due to the properties of a well behaved maximal length code like the one that was used for the circuit described later, the correlation integral gives the triangle function as presented below in Figure 3.

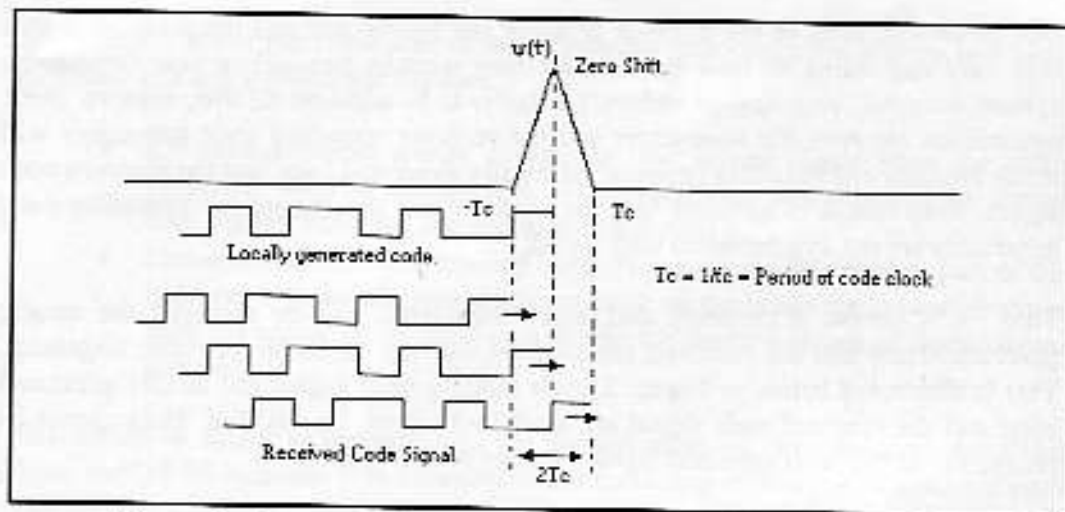


Figure 3 - The autocorrelation function of a maximal length code

The generation of this resulting triangle can be visualised by imagining the received code signal sliding past the locally generated code in search for perfect time alignment. In terms of mathematics the integral simply symbolises the area generated under the product of the received code signal and the locally generated code as one slides past the other. Due to the properties of maximal length codes any product out of the region where the two correlated signals are one chip apart will be negligible compared with the products within the time region of one chip separation. Maximum output occurs for zero time shift, i.e. for $\tau=0$, or otherwise perfect time alignment.

The use of maximal length codes is strongly recommended as their correlation integral produces a single triangle making de-spreading an easier task.

If a data bit '1' was transmitted then the case is quite similar except for the fact that the correlation triangle would appear with 'pointing' downwards. [1]

Acquisition

This section deals with the ideas and considerations of how to bring the locally generated code and the received code signal into perfect time-alignment. This process is known as acquisition.

The device designed to perform acquisition must be able to produce a voltage output proportional to the similarity between the two correlated signals. This voltage then, will have to be compared with a threshold, set to statistically decide whether the two signals are perfectly time aligned or not. If they are not perfectly time aligned, the acquisition circuit must then decide to perform a systematic search through the time and phase uncertainty region between the two signals and thus find the exact time instant when the two signals are perfectly time aligned.

Acquisition can be performed serially or in parallel. The cheapest solution is provided by a serial search, which is the technique used for the circuit that will be described later. [1]

The frequency uncertainty problem

Suppose that perfect time-alignment, between the locally generated code and the received code signal has been accomplished. One could say it is obvious that data could be extracted from that point. This is not the real case.

Due to minimal, but not negligible relative frequency offsets between the receiver's clock and the transmitter's clock the received code signal will arrive at a slight different frequency compared to the locally generated code. As a consequence, when synchronisation has been achieved the two signals will try to drift apart from each other resulting loss of synchronisation. Again, it is assumed that the receiver's and the transmitter's code generators are not synchronised with respect to each other.

This is another problem that the designer must overcome. It is of major importance to maintain synchronisation. The idea is to force the receiver's code clock to run at the same frequency as the received code signal. This is achieved by means of feedback loops and the process is called tracking.

Tracking is used in conjunction with acquisition must be initiated right after synchronisation has been achieved. [1]

Tracking methods

The two methods used are the delay lock loop and the tau dither loop. The delay lock loop is presented in Figure 4 below. The received code signal is split into three different channels and is mixed with three replicas of the spreading code. Two of the replicas have the same time offset with respect to the third. One is advanced by a fraction of one chip time duration and the other is retarded by the same fraction of one chip time duration.

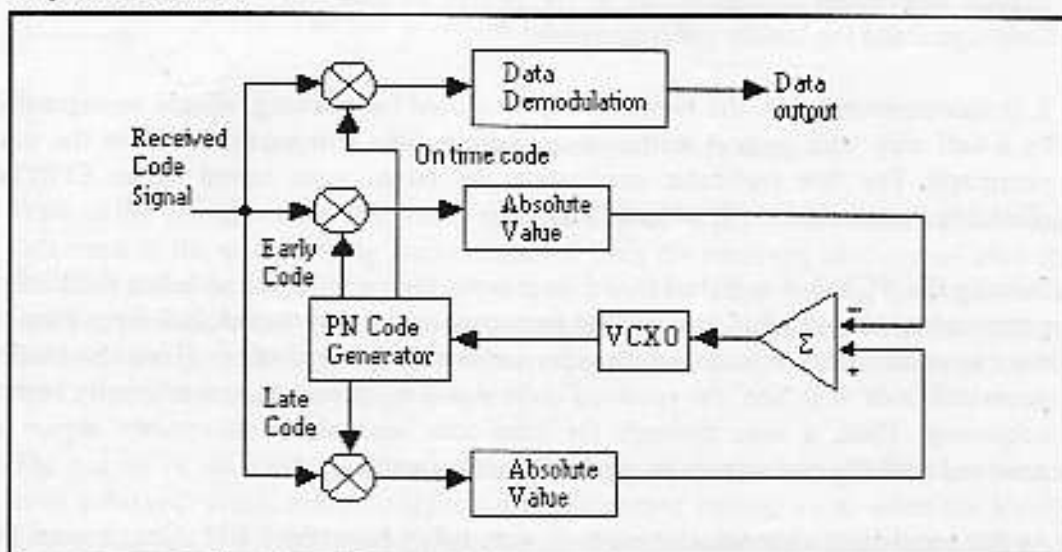


Figure 4 - The Delay Lock loop for DS spread spectrum signals

These two replicas are used for the delay lock loop whereas the third is used at a separate channel to perform acquisition. Thus the names 'early' and 'late', with

respect to the 'on-time' code. Due to the fact that both of the codes have the same time offset with respect to the on-time channel, when perfect time alignment is achieved at the on-time channel, their mixing stage outputs are made equal with the aid of absolute value circuits independent of whether a data bit '1' or '0' was recovered. Thus solely the degree of matching is converted to DC levels.

As the received code signal and the locally generated code tend to drift apart from each other, the absolute value outputs will differ. Their difference is used to steer the voltage control crystal oscillator (VCXO) that drives the code generator. Thus the locally generated code can be forced to catch up in frequency with the received code signal. Consequently perfect time alignment between the locally generated code and the received code signal is maintained and data can be continuously extracted.

The tau dither loop does not provide the engineer with the same flexibility in terms of steering as the delay lock loop and will not be examined. [1]

The de-spreading circuit's block diagram

This circuit was designed for a DS SS system with a digital data stream at 9600 kbps. A maximal length code of 255 chips was used.

The received code signal is split into three channels, one performing serial sliding acquisition and data extraction, while the other two are used for the delay lock loop as presented in Figure 5.

In an earlier part of this report the de-spreading concept was explained with the aid of XOR gates for simplicity. Double balanced mixers substitute the XOR gates for this application. The double balanced mixers are configured in such a way to give output voltage amplitudes corresponding to the degree of matching between the received code signal and the locally generated code.

It is recommended that, the two code replicas used for tracking, should be separated by a half chip with respect to the on-time code. This will be explained in the next paragraph. For this particular application the codes were stored in an EPROM (Erasable Programmable Read Only Memory).

Initially the VCXO is switched to a certain input tuning voltage and hence the locally generated code is clocked at a smaller frequency compared to the clock frequency of the transmitter. This effectively provides serial sliding acquisition. Thus the locally generated code will 'see' the received code signal slide past it, at a relatively higher frequency. Thus, a scan through the total time and phase uncertainty region is achieved until the two signals are perfectly time aligned.

At the acquisition channel, two outputs were taken from the DBM. One is used for data extraction whereas the other is used to indicate, whether synchronisation has been achieved or not and thus turn the delay lock loop on.

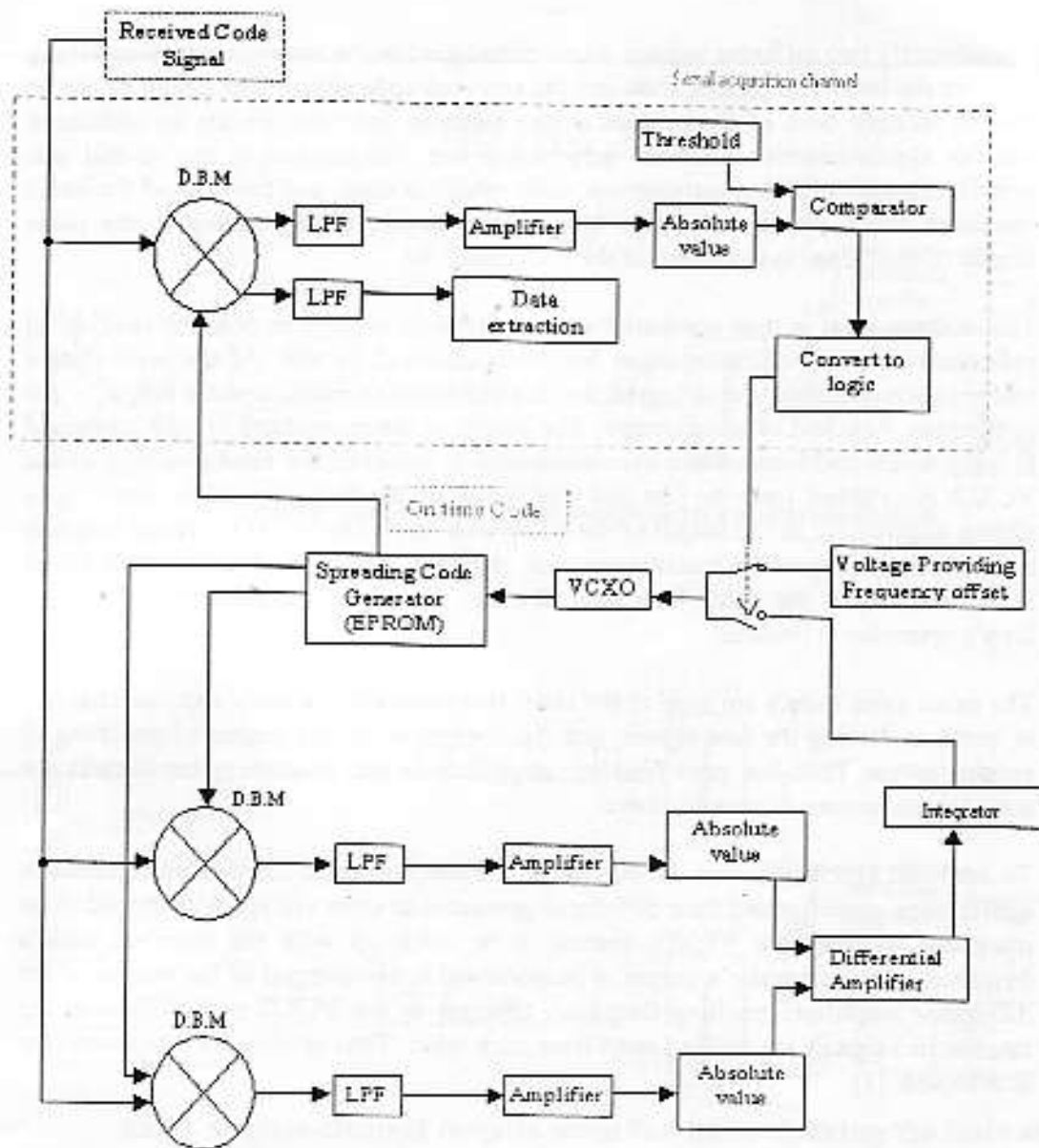


Figure 5 – De-spreading circuit block diagram

Both of the outputs of the DBM are low pass filtered to get rid of the unwanted noise delivered to the de-spreading circuit together with the received code signal after the RF demodulation stage. The second output after low pass filtering is amplified in order to provide larger voltage levels corresponding to the degree of matching. Here, the aim is to provide a dc indication corresponding to how well the two signals are time aligned with respect to each other.

The output of the DBM used to provide an indication whether synchronisation has been achieved or not, gives its highest possible output voltage value when the locally generated code is perfectly time aligned with the received code signal being the code inverted corresponding to a data bit '1' transmitted. The lowest possible voltage value is output when the locally generated code is synchronised with the received code signal being the code non-inverted corresponding to data bits '0' transmitted.

Consequently two different voltage levels correspond to the same degree of matching between the locally generated code and the received code signal. The circuit has to be able to identify both of these cases as the same in order to provide an indication whether synchronisation has been achieved or not, independent of the bit that was initially transmitted. Thus an absolute value circuit is used, and for both of the cases described above the same voltage levels were output, corresponding to the same degree of matching, independent of the transmitted bit.

This voltage level is then compared with a threshold voltage in order to provide an indication whether synchronisation has been achieved or not. At the time instant where synchronisation was achieved the threshold was exceeded and the output of the comparator switched to its maximum. The output of the comparator is then converted to logic levels and hence when synchronisation is achieved the tuning voltage of the VCXO, is switched from the one that was providing the frequency offset resulting to sliding acquisition, to the output of the delay lock loop. The VCXO is tuned to run at the same frequency of the transmitters code generator frequency when no error signal is delivered from the delay lock loop. By this switching operation the delay lock loop's operation is initiated.

The exact same tactics are used at the other two channels, the early and late channel, in terms of mixing the two signals and the conversion of the degree of matching to voltage levels. Thus low pass filtering, amplification and absolute value circuits are used for the reasons explained above.

To maintain synchronisation the outputs of the absolute value circuits are summed in a difference amplifier and their difference generates an error voltage with the aid of an integrator to steer the VCXO, forcing it to catch up with the received code's frequency. The integrator's output is proportional to the integral of the output of the difference amplifier, resulting frequency changes to the VCXO proportional to the rate the two signals are drifting apart from each other. Thus continuous data extraction is achieved. [1]

Half chip separation of the early and late with respect to the on time code

This part presents a simple explanation why a half chip separation should be preferred for the late and early spreading codes with respect to the on time code. Note that here the XOR de-spreading concept is employed again. Figure 6.

Suppose that the received code signal and the locally generated code are synchronised. At this certain time instant due to the half chip separation, the outputs of the XOR gates at the early and late channel are exactly the same. If they are both integrated, then the outputs of the integrators will be voltage levels proportional to the areas under the outputs of the XOR gates. (i.e. the integral of the XOR outputs.)

Supposing that at this time instant the locally generated code is driven by the VCXO at a higher frequency compared to the frequency of the received code. The outputs of the XOR gates will differ as presented in Figure 6.

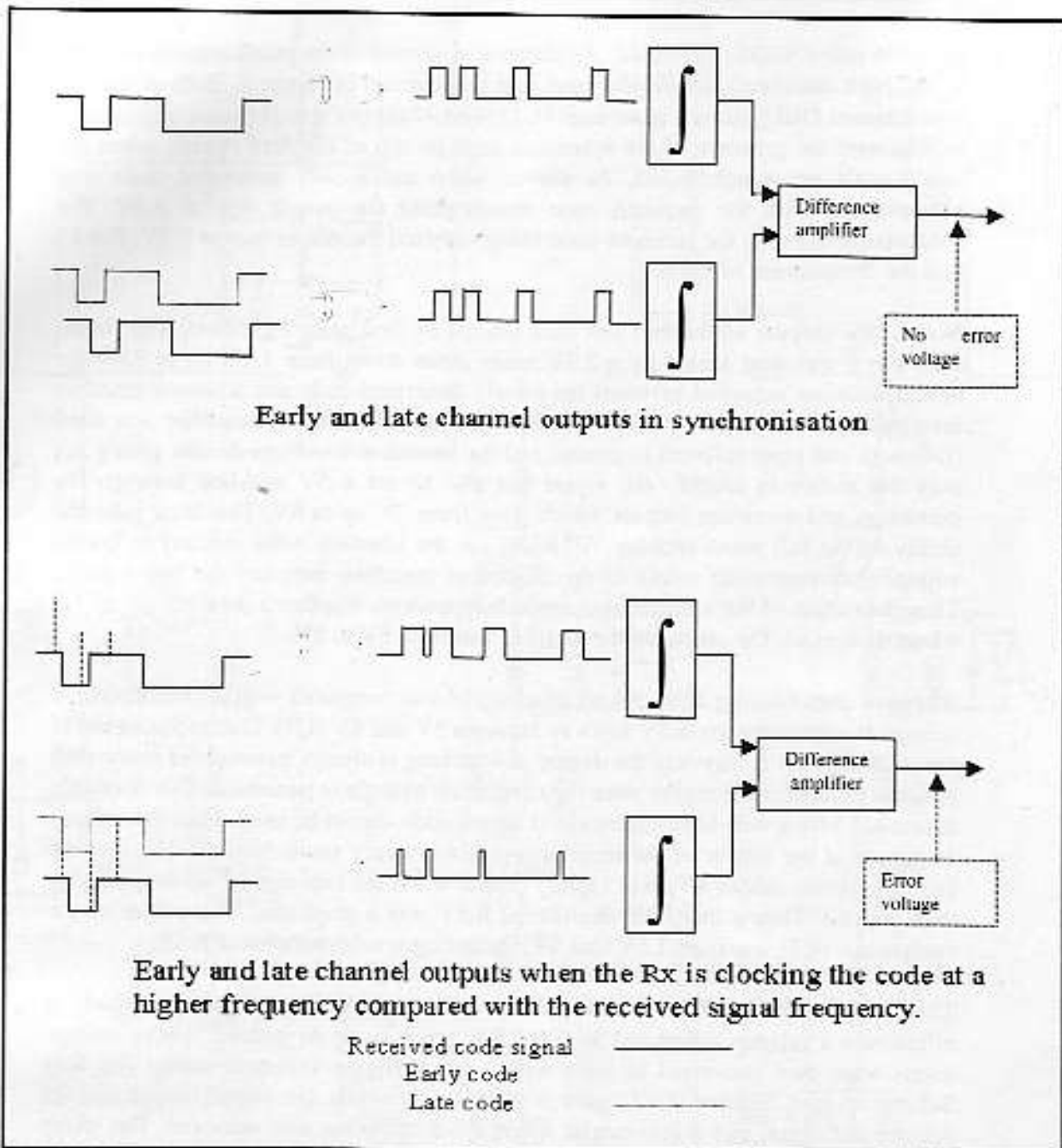


Figure 6 – The effect of a half chip separation between the early and late codes with respect to the on time code as the two signals drift apart from each other.

As a result the integrators will deliver different voltages at their outputs, as the area under the outputs of the XOR gates is different.

But it is the rate of change between the outputs of the integrators, which causes the VCXO to catch up with the received code signal's frequency. The smaller the time distance between the early and late codes with respect to the on-time code the larger the rate of change at the output of the difference amplifier. [1]

Detailed analysis of the de-spreading circuit

MC1496 active DBMs were used. An alternative version of the product detector (refer to MC1496 datasheet) circuit was used, and is presented in Figure 7. Both of the on-time channel DBM outputs were used (U1). The 47k Ω pot's wiper must be centered to eliminate the presence of the spreading code on top of the data stream, when the two signals are synchronised. At pin 6, when the locally generated code was synchronised with the received code non-inverted the output was at 6.4V. For synchronisation with the received code being inverted the output was at 9.8V. Pin 12 was the complement of pin 6.

Both of the outputs were then low pass filtered by first order RC filters. The output from pin 6 was then scaled by a 2.2V zener diode down from 4.2V up to 7.6V for synchronisation achieved between the locally generated code and a non-inverted or inverted received code respectively. After low pass filtering an amplifier was used (U4) with one input referred to ground and the second to a voltage divider giving not only the ability to amplify the signal but also to set a 5V mid-line between the maximum and minimum outputs which were from 2V up to 8V. This trick gave the ability to the full wave rectifier (U5&U6, i.e. the absolute value circuit) to output voltages corresponding solely to the degree of matching between the two signals. Thus the output of the rectifier was made independent, whether a data bits '0' or '1' were de-spread. The output of the rectifier was from 5V to 8V.

After low pass filtering again the rectified signal was compared with a fixed threshold voltage at approximately 6.5V halfway between 5V and 8V (U7). Due to the nature of the code used for this system the degree of matching is always minimal for every shift position except for the region where the correlation triangle is generated. This is mainly the reason why a well-behaved maximal length code should be used. Thus the voltage amplitude at the output of the rectifier was always very small (about 5.1V) and the largest possible (about 8V) was rapidly output when the two signals were perfectly time aligned. Thus a threshold decision at 6.5V was a good one. The output of the comparator (U7) was from 1.5V to 8.5V, indicating synchronisation at 8.5V.

This output was then scaled down from 1.5V to 4.6V by a regulator, which is effectively a resistor connected with a 3.9V zener diode to ground. These voltage levels were then converted to logic with Schmitt trigger inverters twice. The first Schmitt trigger inverter (U17) gave a high output while the circuit was trying to acquire the signal and a low output when synchronisation was achieved. The other Schmitt trigger inverter (U19) gave the opposite voltage levels under the same conditions.

Pin 12 output of the DBM was used for data extraction. After low pass filtering again the output was compared with a fixed voltage set at 8.1V, right at the middle between the minimum and maximum output voltages. The output of the comparator (U8) was scaled down and regulated as above, converted to logic using a Schmitt trigger inverter (U18) and low pass filtered.

This inverter's (U18) output, was effectively the data when the locally generated code was synchronised with the received code. The output of the second inverter (U19) described above was then input to an AND gate (U21) together with the data. By this

U1-U3: MC1496 Active DBM
 U4-U16: Op-Amps must be carefully selected
 depending on the system's specifications.
 U17-U20: 74HC14 Schmitt trigger
 U21: 74HC08 AND gate

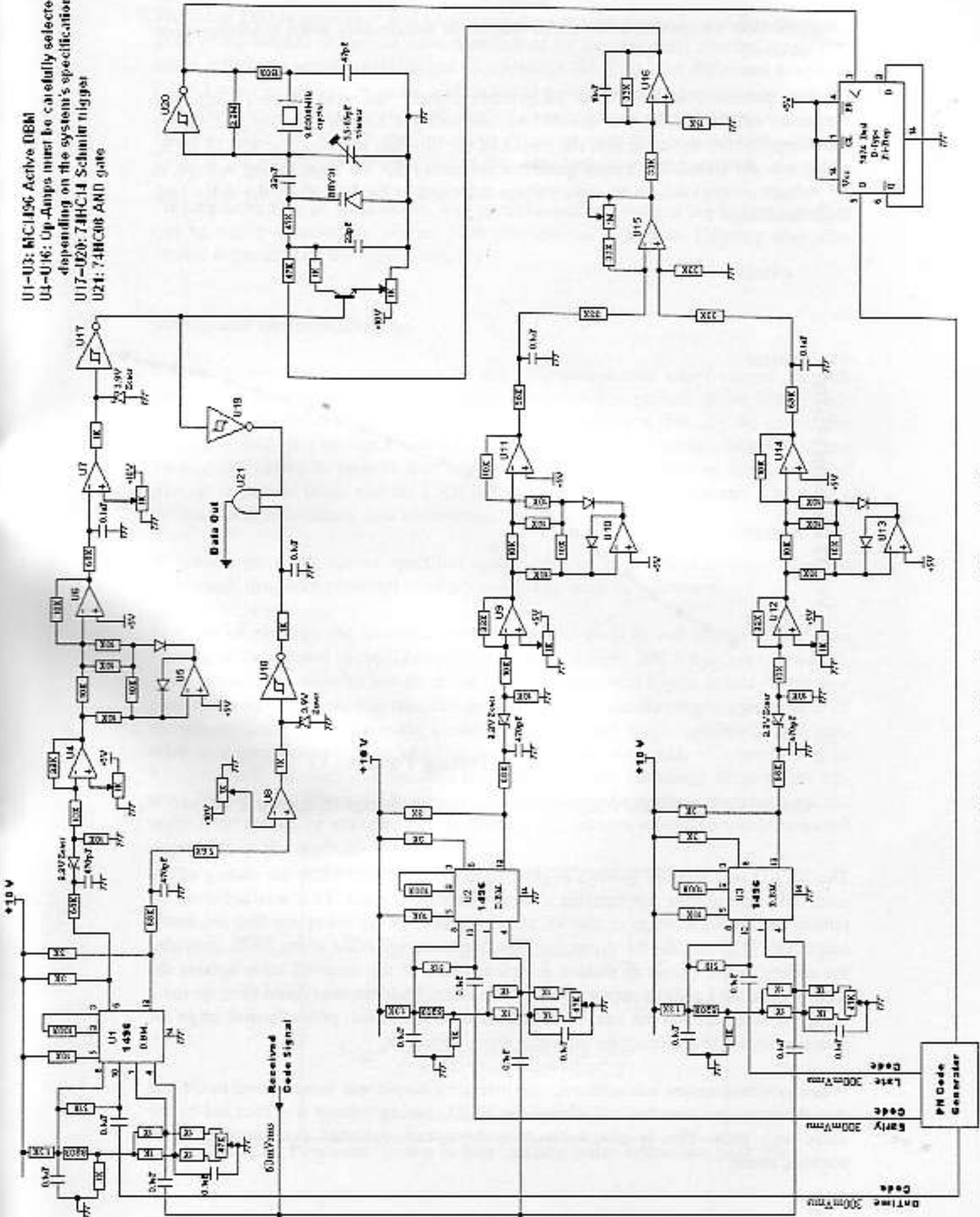
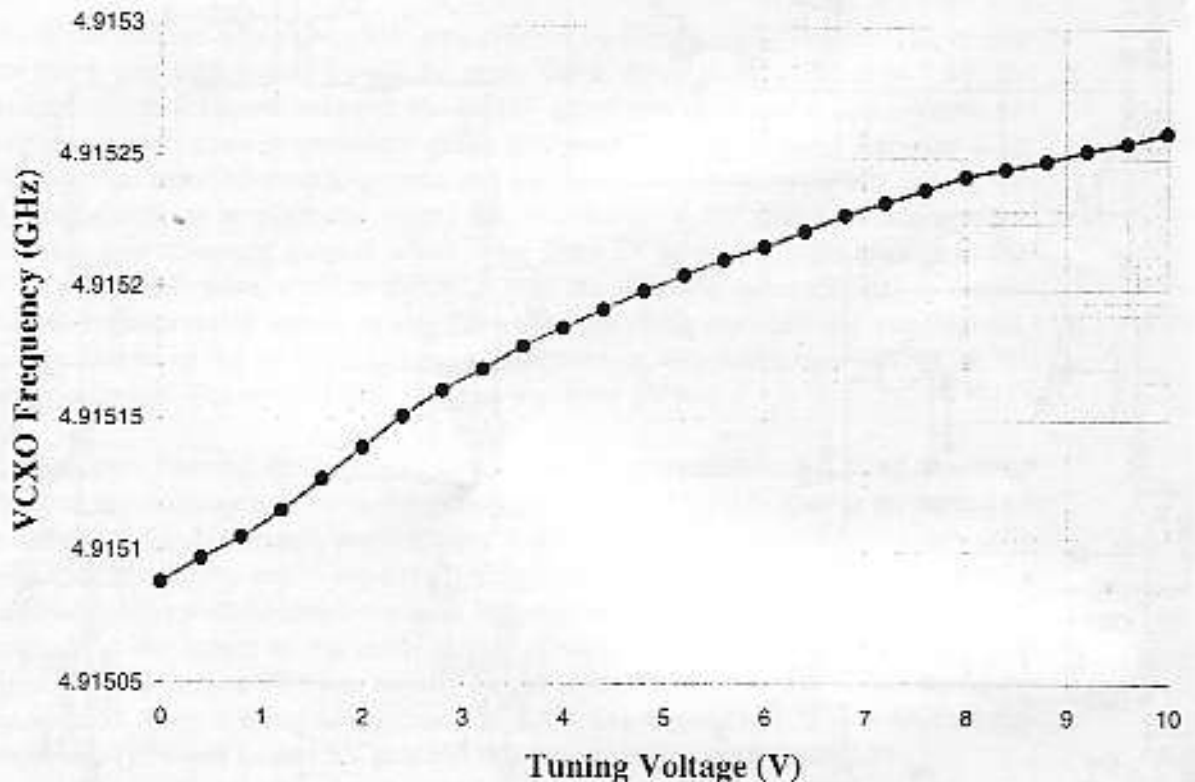


Figure 7 - The de-spreading circuit

action the data was passed to the audio side of the system only when synchronisation was achieved.

For this particular application a 9.8304MHz crystal was used at the VCXO. The frequency of the VCXO was divided by two using a D-type flip-flop. By slowly adjusting the trimmer capacitor, the output of the flip-flop was tuned at 4.9152 MHz, which was the transmitter's code generator frequency, for 5V input tuning voltage. A 5V voltage corresponds to no error voltage delivered to the VCXO by the delay lock loop. See Graph 1.



Graph 1 - The VCXO frequency vs. the tuning voltage (after the /2 stage)

The VCXO was initially given a slight frequency offset providing the sliding of the received code against the receiver's locally generated code. This was achieved by pulling the tuning voltage of the VCXO down to 2.4V by using the first inverter's output (U17) to turn the transistor on. This frequency offset, of about 50Hz, provided the ability to the circuit to slide a complete cycle of the received code against the locally generated code at approximately 4 seconds. Thus the maximum time, to run a complete scan through the total time uncertainty region time, perfectly time align the two signals and thus extract the data was about 4 seconds.

When synchronisation was achieved, the inverter's output was turned down to 0V and thus the transistor switched off. Hence the VCXO tuning voltage was then fed by the delay lock loop. This is effectively how the circuit switched from acquisition to tracking mode.

The same DBMs amplifiers and rectifiers were used for the early and late channels. Both of the outputs of the full wave rectifiers of the late and early channel are passed into a difference amplifier (U16) and an integrator (U18). At the difference amplifier a 1M Ω variable resistor in series with a 33K Ω resistor was used in order to vary the amplifier's gain. Consequently, the rate of change of the error voltage was made variable. Thus the VCXO was forced to catch up with the received code signal's frequency at a faster rate and stability of the delay lock loop was improved.

This could be used as an example. Any crystal could be used and the frequency offset can be easily adjusted by playing with the trimmer capacitor. Filtering may also change depending on the application. [1]

Results and recommendations

The circuit was able to re-construct the data. Exhaustive tests were carried out with the circuit's early late and on time channels constructed on printed circuit board while the VCXO and the code generator were still on breadboards. Initially the circuit did manage to lock and extract the data even with 60dBs of attenuation. In order to test the circuit's ability to recover data under the worst signal conditions the attenuation was set to exceed 60dB and the LNB was set not facing the transmitter. The circuit did not manage to extract data under those conditions.

In reality, for a DS spread spectrum system that is to be tested in environmental conditions, this would turn out to be a problem that must be overcome.

In terms of circuitry the first and obvious thing to do is to use improved low pass filtering at the outputs of the DBMs. A filter with a sharper 3dB frequency is required. Thus it would be wiser to use an active low pass filter of a higher order. Active low pass filters use op-amps and thus the designer should take the frequency response of the op-amp itself into account. As a solution a 'Sallen and Key' second order low pass filter is shown below with a 3dB frequency of around 4.650kHz (Corresponding to 9.7kbps). It is assumed that the 3dB frequency is in the frequency range of the op-amp. Higher order filters can be used, providing sharper 3dB frequencies but a second order filter should be enough. The capacitor's and resistor values should be selected depending on the application.

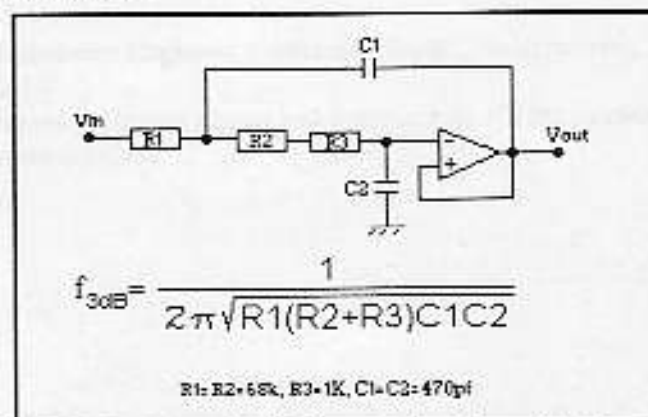


Figure 8 - Proposed 'Sallen & Key' second order active low pass filter

As a second priority, a smaller acquisition time must be provided. The acquisition time of the circuit presented in Figure 7 was about 4 seconds. This is a problem when the user is trying to align the receiver with the transmitter for line of sight transmission. Thus rapid acquisition is essential. In order to achieve this, a larger frequency offset should be provided. But first it must be ensured that the frequency offset is within the delay lock loop's capture range. For the circuit configuration presented in Figure 7, the 50Hz frequency offset was the maximum within the loop's capture range and it was worked out using a trial and error approach.

By substituting the 22pF capacitor between the 470k Ω resistor and the 9.8304MHz crystal, with a larger capacitor the VCXO's frequency deviation for a range of tuning voltages from 0V to 10V will be larger. For the 22pF capacitor the frequency deviation was about 175Hz. It was found that for a 33pF capacitor the deviation was 225Hz and for a 56pF capacitor 260Hz. For every capacitor used it was ensured that a tuning voltage of 5V corresponded to about 4.9152MHz. (i.e. the transmitter code generator's frequency). This was accomplished by adjusting the 5.5-65pF trimmer capacitor.

In order to keep the desired frequency offset within the loop's capture range, the time constant of the 1k Ω resistor and 22pF capacitor RC circuit, connected from the collector of the transistor to ground, must be made smaller. By reducing the time constant of the RC circuit the VCXO will switch from its acquisition mode to tracking mode faster. Thus by trial and error again the right resistor and capacitor values can be worked out and consequently the acquisition time can be minimised.

With the current circuit configuration, when the transmitted signal is corrupted, or lost for a short time period, the circuit will switch back to acquisition mode from tracking mode until the data is de-spread again. Extra circuitry could be added in order to keep the circuit on tracking mode for a short time period, before switching back to acquisition mode when the signal is lost. Thus if the lost signal appears again within this time period the circuit will not have to try and de-spread the data again. Such an idea will involve complicated circuitry and it may not be necessary if the acquisition time was made quite small (i.e. a fraction of a second). When the signal is lost, the circuit may switch back to acquisition mode, but when the signal appears at the receiver again the acquisition time will be quite small and data will be extracted again rapidly. [1]

References

[1] GAVALAS P. - MAY C. M. A. - PROCTOR, M. D. - WINKLE, J. L.: 'The design of a simple Spread Spectrum system at 10GHz', (The University of Sheffield UK, Department of Electronic and Electrical Engineering, 2000)

Recommended Reading

- 1 SKLAR B.: 'Digital Communications: Fundamentals and Applications', (Prentice Hall, 1988), pp. 561-570
Comments: A great introduction.
- 2 DIXON, R. C.: 'Spread Spectrum Systems', (Wiley-Interscience, June 1984), pp. 120-260
Comments: This is a 'must read' book on Spread Spectrum.
- 3 'The ARRL Spread Spectrum Sourcebook', (American Radio Relay League Inc, 1997), Chap. 8
Comments: This is the kind of book I was praying to get my hands on. It helped me a great deal. It covers everything one needs to know on Spread Spectrum. Practical solutions and examples are provided.
- 4 AGARD (Advisory Group for Aerospace Research and Development): 'AGARD lecture Series No. 58 on Spread Spectrum Communications', (NATO, 1973), Chaps. 4-5
Comments: This is a tough one. All aspects are explained in the greatest possible theoretical detail. Be very patient while reading this one and take notes.
- 5 DIXON, R. C.: 'Spread Spectrum Techniques', (IEEE Press, 1976), Part V
Comments: A good theoretical reference. Presents articles written on Spread Spectrum.
- 6 COOPER R. G., MCGILLEN C. D.: 'Modern Communications and Spread Spectrum', (McGraw-Hill, 1986), pp. 296-356
Comments: Another 'must read' book.
- 7 MAZDA F. F.: 'Electronics Engineer's reference book', (Butterworths, 5th edition), pp. '39/12-14'
Comments: Good solutions for circuit design and construction. All the considerations that can be easily forgotten are there.

ARRL and TAPR 1st Annual

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Information

Mark your calendar and start making plans to attend the year's premier event in digital communications. The 19th Annual ARRL and TAPR Digital Communications Conference will be held September 22-24, 2000, in Orlando, Florida - just minutes from the Orlando International Airport.

The ARRL and TAPR Digital Communications Conference is an international forum for radio amateurs in digital communications, networking, and related technologies to meet, publish their work, and present new ideas and techniques for discussion. Presenters and attendees will have the opportunity to exchange ideas and learn about recent hardware and software advances, theories, experimental results, and practical applications. The Digital Communications Conference is not just for the digital expert, but also for digitally oriented amateurs of all levels of experience.

A Conference for the Beginner as well

The conference is not just for the digital expert. As in years past an entire session strand with beginning, intermediate, and advanced presentations on selected topics in digital communications will be offered. Some of the topics will include: APRS, Satellite Communications, TCP/IP, Digital Radio, Spread Spectrum and other introductory topics. Come to the conference and hear these topics presented by the experts!

Symposia, Seminars, and

Three symposia/seminars will be held which allow those with additional time and interest to make the most of the Conference. For those who may have interest in just one symposium or seminar, registration for the conference is not required to attend these activities. This allows maximum flexibility for those who may want to participate during the Digital Communications Conference, but do not have an entire weekend to devote to the event.

The Fourth APRS National Symposium will be held on Friday and will be moderated by Steve Dimse, K4IIG (the developer of javAPRS). It will likely include many APRS software authors, such as Bob Bruninga, WB4APR (the father of APRS), Keith Sproul, WU2Z, Mark Sproul, KB2ICI (the developers of MacAPRS and WinAPRS), Brent Hildebrand, KH2Z (the developer of APRSPUS), Mike Musick, N0QBF (developer of PocketAPRS), and other nationally-known APRS leaders. Join this group for the afternoon and evening for in-depth discussions and presentations on the current and future status of APRS. This is a unique opportunity to gain insight into this fast-growing digital aspect of amateur operations that combines computers, packet radio, and GPS (Global Positioning System).

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The 2000 ARRL and TAPR Digital Communications Conference local co-hosts will be the Lake Monroe Amateur Radio Society (<http://www.qsl.net/lmars/>), Orange County ARES/RACES, Seminole County ARES/RACES, and the Orlando Amateur Radio Club (<http://www.oarc.org/>).

International Co-Hosts

PRUG (Packet Radio User Group of Japan) will be the International co-host for a third year running. PRUG will be hosting an informal social Friday evening before their seminar and symposium is held. Visit <http://www.prug.or.jp> for more information about PRUG.

Call for Papers

Anyone interested in digital communications is invited to submit a paper for publication in the Conference Proceedings. Presentation at the Conference is not required for publication. Papers are due by August 7th, 2000, and should be submitted to

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or via the Internet to

lweinberg@arrl.org

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<http://www.tapr.org/dcc>

Banquet

On Saturday night the DCC Banquet will be held. A guest speaker will talk after the banquet and a prize drawing will top the evening. The Sunday morning seminar will be focused on PIC development, design, and programming. This five-and-a-half hour seminar will focus on the things you need to know now in order to understand and begin to participate in PIC development.

Hotel

Conference presentations, meetings, and seminars will be held at the Orlando Airport Marriott. Special DCC room rates are **\$89/single** and **\$89/double** per night. When making reservations with the hotel, be sure to indicate you are attending the ARRL and TAPR DCC in order to get the discount. It is highly recommended that you book your room prior to arriving. **A block of 50 rooms is reserved until September 1, 2000.** After the 50 rooms are booked, rooms will only be available in nearby hotels, so be sure to book your rooms early! The hotel provides transportation to and from the Orlando International Airport. Please contact the hotel to arrange specific transportation needs.

Orlando Airport Marriott (conference hotel)

7499 Augusta Drive

Orlando, FL 32822

Phone 407-851-9000, Fax 407-857-6211

(<http://marriotthotels.com/MCOAP/>)

What you can expect in 2000!

- A full day of papers and breakouts for the beginner to the advanced
- Three seminars/symposiums
- The fifth annual Student Paper session.
- A banquet with Special Guest Speaker.
- Informal get-togethers throughout the weekend.
- TAPR Membership Meeting
- An event at which the most important new developments in amateur digital communications are announced.
- Digital 'movers and shakers' from all over the world in attendance.

Conclusion

There are few activities where your participation can be **so much fun and important!** What a great way to share and renew your enthusiasm for digital amateur radio! A get-together with colleagues and bringing each other up to date on your latest work -- all this, and more, for an unforgettable weekend of amateur radio and digital communications. We hope to see you at the ARRL and TAPR Digital Communications Conference on September 22-24, 2000!

Full information on the conference and hotel information can be obtained by contacting:

Tucson Amateur Packet Radio

Phone: (940) 383-0000.

Fax: (940) 566-2544

Email: tapr@tapr.org

Web: <http://www.tapr.org>

Registration Form

Contact the TAPR office by Phone 940-383-0000, Fax 940-566-2544, or Internet: <http://www.tapr.org> and tapr@tapr.org to register or for additional information.

Conference Registration includes:

Conference Proceedings, Sessions, Meetings, and Lunch on Saturday.

- Pre-Registration (before Sept 1st)

\$45.00 _____

- Registration (after Sept 1) or at door

\$55.00 _____

- Saturday Evening Dinner (Limited Space)

Dinner with Guest Speaker
Prize Drawing

\$30.00 _____

Symposia/Seminars

- 4th Annual APRS National Symposium

Friday, 1pm - 7pm. \$25.00 _____

- Sunday Seminar

PIC Design, Development,
and Programming

Sunday, 8:30 am - 2 pm. \$20.00 _____

TOTAL _____

Name/Call: _____

Street Address: _____

City/State/Zip: _____

Country: _____

Phone Number: _____

Email: _____

Charge my credit card (circle one):

VISA MasterCard

Acct: _____

Expiration Date: _____

Signature on card: _____

Mail completed registration form with check to:

TAPR

8987-309 E Tanque Verde Rd #3378

Tucson, AZ 85749-9399

Or check <http://www.tapr.org/dcc> for an on-line registration form.

A registration packet will be mailed in September upon receipt of registration form and payment.



Tucson Amateur Packet Radio
 8987-309 E. Tanque Verde Rd #337
 Tucson, Arizona • 85749-9399
 Office: (940) 383-0000 • Fax: (940) 566-2544
 Internet: TAPR@TAPR.ORG • www.tapr.org
 Non-Profit Research and Development Corporation

May 2000

www.tapr.org • ftp.tapr.org • tapr@tapr.org
 Office Hours: Tue-Fri 9am-12pm, 3pm-5pm CT

Membership	Price	Number of Years	Total
United States	\$20.00		
Canada/Mexico	\$20.00		
International	\$25.00		

New Member Renewal

SubTotal _____

Membership 10% Discount

Member #: _____ (Place new if joining)

Total Sales (Subtotal minus discount)

Texas Residents (7.75% tax)

Membership (New or Renewal)

Shipping and Handling

For Total Kit Codes Between

1 - 7	8 - 15	16 - 27	28 - 55
Add \$5	Add \$6	Add \$7	Add \$8

Kit Codes above 55 or International orders must contact TAPR for amount

TOTAL Order Amount _____

Charge my credit card (check one):

VISA MasterCard

Exp. Date: _____

Signature or card: _____

Name / Call: _____

Street Address: _____

City / State / Zip: _____

Country: _____ Phone Number: _____

Internet E-mail: _____



Subtotal: _____ Added Total Kit Codes _____

Kit	Price	Qty	Total	Kit Code	Information
PIC-Etmcoder	\$45.00			8	
ComputerFlash Card Adapter	\$39.00			5	
Motorola EVM56002 Interface	\$150.00			16	
TAPR APRS - MIC-Etmcoder*	\$149.00			28	
TAC-2 (Totally Accurate Clock)	\$139.00			10	
Differential GPS (Member Price)	\$179.00			16	
DAS-DTDPF Accessory (Signal)	\$68.00			3	
TAPR 96000 Eps Modem	\$85.00			6	
Dig Regenerator	\$10.00			1	
Clock Option	\$5.00			1	
PR-212 Modem Disconnect	\$35.00			2	
PR-212MBX Installation Kit	\$35.00			2	
XR2111 DCD Mod.	\$35.00			2	
State Machine DCD Mod.	\$35.00			2	
State Machine DCD w/in Clock	\$35.00			2	
FIRMWARE					
32K RAM w/ TNC-2 update docs	\$20.00			2	
TNC-2 1.1.9 w/ KISS EPR0M	\$15.00			4	
L1.9 Comanda Booklet (only)	\$8.00			4	
TNC-2 WASHDED EPR0M	\$12.00			2	
TNC-1 WASHDED EPR0M	\$12.00			2	
TNC-2 KISS EPR0M	\$12.00			2	
TNC-1 KISS EPR0M	\$12.00			2	
PR-87 WASHDED EPR0M	\$12.00			2	
Trackbox	\$15.00			2	
Publications					
TAPR Sprint Spectrum Update	\$18.00			8	
2000 TAPR Software Library	\$30.00			4	
1997/1998 TAPR CD-ROM	\$10.00			4	
Wireless Dharma Communications	\$39.99			8	
Packet Radio: What's Who? How?	\$12.00			5	
BBS Sysop Guide	\$9.00			4	
NOSHimo, Intro to KASQ NIOS	\$23.00			8	
TAPR's 96 Annual Proceedings	\$7.00			4	
TAPR's 95 Annual Proceedings	\$7.00			4	
PSR Set Vol 1 (91 - 917 - 85)	\$20.00			8	
PSR Set Vol 2 (918 - 916 - 86 - 89)	\$20.00			8	
PSR Set Vol 3 (931 - 932 - 90 - 93)	\$20.00			8	
PSR Set Vol 4 (951 - 958 - 94 - 97)	\$35.00			16	
ARRL/TAPR 1999 DCC	\$15.00			4	
ARRL/TAPR 1998 DCC	\$15.00			4	
ARRL DCC Proceedings 1st - 16th Issue Set ARRL DCC 1st - 16th	\$125.00			144	
Other					
TAPR 11oz Coffee Mug Logo	\$11.00			4	
TAPR Badge	\$10.00			0	
TAPR Shirt - 4 styles				0	
GPS					
TAC-32 Software Registration	\$55.00			0	
Garmin GPS-23	\$130.00			28	
Garmin GPS-20/25 Interface Kit	\$40.00			8	
Garmin GPS-20/25 23 Data Cable	\$15.00			2	
Garmin GA-27 GPS Antenna	\$75.00			8	
Oncore LT+ GPS	\$260.00			28	
Oncore YF Interface/Power Kit	\$40.00			8	
Oncore GT+ GPS	\$189.00			28	
Motorola Antenna 97	\$65.00			8	
MECX Ri-Adap Connector w/cable pigtail	\$15.00			2	

All prices subject to change without notice and are payable in U.S. funds. Members receive 10% off on Kits and Publications. Please allow six to eight weeks for your order to be shipped. For specific information on kits, see Product Description flyer.