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TABLE OF CONTENTS

COLUMNS

On the cover: Lawn sheep and other animals are now being joined by lawn radios, which are now sweeping the country. (NTØZ photo)

APRIL 1992 QEX ADVERTISING INDEX

Purpose of *QEX*:

1) provide a medium for the exchange of ideas and information between Amateur Radio experimenters
2) document advanced technical work in the Amateur Radio field
3) support efforts to advance the state of the Amateur Radio art

All correspondence concerning *QEX* should be addressed to the American Radio Relay League, 225 Main Street, Newington, CT 06111 USA. Envelopes containing manuscripts and correspondence for publication in *QEX* should be marked: Editor, *QEX*.

Both theoretical and practical technical articles are welcomed. Manuscripts should be typed and doubled spaced. Please use the standard ARRL abbreviations found in recent editions of *The ARRL Handbook*. Photos should be glossy, black and white positive prints of good definition and contrast, and should be the same size or larger than the size that is to appear in *QEX*.

Any opinions expressed in QEX are those of the authors, not necessarily those of the editor or the League. While we attempt to ensure that all articles are technically valid, authors are expected to defend their own material. Products mentioned in the text are included for your information; no endorsement is implied. The information is believed to be correct, but readers are cautioned to verify availability of the product before sending money to the vendor.

Empirically Speaking...

TAPR at Ten

In the fever of early packet activity, circa 1982, few took much notice of the small group of enthusiasts who formed Tucson Amateur Packet Radio. A lot of packet groups were being formed then, and there was little obvious difference between them. In the case of TAPR, which was formed for the express purpose of developing a low-cost terminal node controller (TNC), the difference would soon become obvious.

TAPR burst on the scene in early 1983 with their beta TNC, followed at the end of the year by the "production" TNC kits. Only a few years later, TAPR supplanted this design, which came to be called the TNC-1. with the lower-cost TNC-2. This later design remains the basis for many of the TNCs produced today, and these TAPR designs have influenced the design of almost all TNCs.

But "what have they done for us lately?" That might have been one of the themes for the tenth anniversary of TAPR, celebrated during the weekend of March 6-8 at the TAPR annual meeting in Tucson. The answer is: plenty. TAPR continues to do innovative work with the goal of jump starting areas of packet radio that need development.

The conference occupied all day Saturday and Sunday morning. It was attended by more than 120, an excellent turnout. For the first time, proceedings of the meeting were published. The availability of two new TAPR kits was announced at the meeting, and updates on two other projects were reported. The two new kits are a new 9600-baud modem board that is designed to plug into a TNC-2 or PK-232, and a satellite tracker box.

As explained by Lyle Johnson, WA7GXD, the 9600-baud modem is an upgrade of the older K9NG modem (which still is available from TAPR). The new design allows full-duplex operation, adjustment for nonlinearities in the radio, and optional bit regeneration for use in a full-duplex, 9600-baud packet repeater. It also shapes the modulation signal to produce a raised-cosine waveform, minimizing the transmitted bandwidth and implements an effective carrier-detect. A bit-error-rate output allows testing of link quality.

Lyle and Jack Davis, WA4EJR spoke about the TrakBox, a JAMSAT project being distributed by TAPR. It is a self-contained unit that provides the complete satellite tracking function: Keplerians in, antenna control out. An RS-232 port allows communication from a computer. The TrakBox optionally can support a 2-line, 16-character-wide LCD display, some switches and a potentiometer for front-panel control, eliminating the need for a computer (although one may still be used), except for loading the Keplerian elements and setting the internal battery-backed-up clock. The box also provides Doppler correction control of common radios that have an RS-232 interface. It also can be used for functions other than satellite tracking if and when software is developed for those applications.

One of the projects undergoing development is the TAPR deviation meter. This unit is almost in its final form, Lyle reports. One low-level amplifier stage remains to be tamed, at which point the project will be ready for final testing. This device will measure the deviation of 2-meter transmitters. What has this to do with packet radio? Simply this: One of the major problems encountered in packet networks is overdeviation. Radios adjusted for 5-kHz deviation, which is right for voice work, are overdeviating when a 1200-baud packet signal is sent. Since most amateurs can't mea-

continued on page 11

Demonstrating Celestial Mechanics Through Measured Doppler Shift

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ABSTRACT

Stable orbits (of natural and artificial satellites alike) require an equilibrium between gravitational and inertial forces. For a given satellite altitude, or orbital radius, there is but a single orbital velocity which affords such an equilibrium state. This paper shows how students at the Pennsylvania College of Technology utilize Doppler shift measurements of received satellite telemetry signals to accurately determine the orbital period of Amateur Radio communications satellites, and from it, their other orbital parameters.

FUNDAMENTAL ORBITAL MECHANICS

A stable orbit, whether of a satellite around a planet or a planet around a sun, requires that the inward pull of gravity and the outward pull of inertia be equal. Kepler tells us that all satellites orbit their primaries in an ellipse, and that orbital velocity changes throughout the elliptical orbit (fastest at perigee, slowest at apogee) in order to maintain equilibrium. For the present study, we will restrict ourselves to analyzing the behavior of satellites in roughly circular orbits (that is, orbital eccentricities near zero), so that the satellite's orbital velocity is essentially constant. Fortunately, the current generation of MicroSats fills the bill almost perfectly.

Newton's famous Inverse Square Law shows the force of the gravitational attraction between any two bodies to equal a fudge factor (the Universal Gravitational Constant), times the product of their masses, divided by the square of the distance between their centers of mass. Mathematically,

$$F = \frac{GMm}{r^2} \qquad \text{[Equation 1]}$$

where

M is the mass of the primary (in our case planet),
m is the mass of the secondary (satellite),
r is the distance between them (the orbital radius),
and
$G = 6.673 \times 10^{-11}$ Nt m^2 / kg^2, Newton's Universal Gravitational Constant.

We now consider the force of inertia pulling a satellite out, which (again according to Newton) equals:

$$F = mA \qquad \text{[Equation 2]}$$

where
m represents the mass of the satellite,
and
A is its acceleration, which in a circular orbit is found from:

$$A = \frac{v^2}{r} \qquad \text{[Equation 3]}$$

with
v representing the velocity of the satellite,
and
r the orbital radius, as defined above.

Combining Equations 2 and 3 gives us:

$$F = \frac{mv^2}{r} \qquad \text{[Equation 4]}$$

from which we could determine the inertial force acting on the satellite, given its mass and orbital velocity. Velocity is of course related to orbital period, which we will derive shortly from Doppler shift measurements.

Since our Amateur Radio satellites appear (thankfully) to be in stable orbits, we set Equations 1 and 4 equal to each other:

$$\frac{GMm}{r^2} = \frac{mv^2}{r} \qquad \text{[Equation 5]}$$

and then simplify:

$$\frac{GM}{r} = v^2 \qquad \text{[Equation 6]}$$

We can now solve Equation 6 for v:

$$v = \left(\frac{GM}{r}\right)^{1/2} \qquad \text{[Equation 7]}$$

or for r:

$$r = \frac{GM}{v^2} \qquad \text{[Equation 8]}$$

and we see that the velocity and orbital radius of our satellite are inexorably linked, by readily determined constants.

DETERMINING THE GM PRODUCT

At the Pennsylvania College of Technology, second year electronics students have recently come up with an independent estimate of the Earth's mass, based upon recovering echoes from radio signals bounced off the surface of the Moon. Their novel EME experiment, which involved observing the lunar orbit and solving Equation 6 above for M, has already been treated in the literature [Shuch, 1991]. Their published result for the mass of the Earth, 6.037×10^{24} kg, appears to be in error by about 1%.

Let's utilize a more widely accepted value for the mass of the Earth: 5.975×10^{24} kg. Now we've already stated that Newton's Universal Gravitational Constant, a fudge-factor for dimensional consistency, is equal to 6.673×10^{-11} Nt m^2 / kg^2. Thus we see that the GM product encountered in Equations 7 and 8 above is not a Chevy at all, but rather 4×10^{14} m^3/s^2, a constant which relates radius to velocity for any satellite orbiting the Earth.

DOPPLER, AND OTHER SHIFTY CHARACTERS

The change in frequency of electromagnetic waves as a function of relative motion is now known as the Doppler shift. The phenomenon was first described by Johann Christian Doppler, a mathematics professor at the State Technical Academy in Prague, in 1842, in a paper delivered to the Royal Bohemian Society of Learning titled "On the Colored Light of Double Stars and Some Other Heavenly Bodies" (Magnin, 1986). Doppler shift varies directly with both the transmitted frequency and the relative velocity between the transmitter and receiver, and inversely with the speed of light. It is utilized in fields as diverse as aircraft radar (Shuch, 1987), spacecraft navigation, remote sensing, biomedical imaging, and of course satellite orbital analysis (Davidoff, 1978).

To understand the Doppler shift for electromagnetic waves, imagine the headlight on the front of an approaching train, which is traveling at a substantial velocity—let's say, mach 100,000, a tenth the speed of light. Now we know the radiation leaves the headlight at the speed of light, 3×10^8 meters per second. Since it appears that the train is adding its forward velocity to that of the light beam, we would naively expect the light from the moving train to reach us at a speed 10% greater than that at which it left the bulb, or 3.3×10^8 m/s.

But of course it can't. Einstein tells us that the speed of light in free space, whether measured at the point of transmission, the point of reception, or some point in between, will *always* equal exactly the same value, 300 million meters per second. The wave *cannot* change speed, regardless of relative motion between the observers. Yet the presumed additional velocity which we had expected the train's motion to impart to the wave has to go somewhere. And since it can't manifest itself in a speed variation, it instead varies the *frequency* of the wave.

The Doppler shift is remarkably symmetrical. It cares not whether the source of relative motion is the transmitter, the receiver, or some combination of the two. And the magnitude of the frequency shift is the same whether the length of the transmission path is increasing or decreasing, though of course its direction varies. Moving closer together, blue shift, increasing frequency. And moving farther apart, red shift, a decrease in frequency.

Radio amateurs have been aware of the Doppler shift within the context of space communications, ever since they began bouncing signals off the surface of the Moon nearly forty years ago. As the Moon is rising, moving toward us (or more properly, as we are rotating toward it), our echoes come back higher in frequency than the transmitted signal. The setting Moon (moving away from us, or more properly us away from it) gives us the opposite effect, down Doppler, decreasing frequency.

The phenomenon was spectacularly evident to those space communications pioneers who first recovered Sputnik I's 20-MHz beeps on October 4, 1957.[1] However, the Sputnik signals had so much chirp on them that more than one observer overlooked the Doppler shift as yet another manifestation of an instable transmitter. Today we often design the transponders of communications satellites with frequency inverting passbands, in an effort to partially cancel this ever-present "designed-in drift."

The easiest way to quantify the Doppler shift is to think of it as a simple ratio. The Doppler change in frequency f_d, is to the transmitted frequency (f_o) as the relative velocity (v) is to the velocity of the transmitted wave (which we know to equal c, the speed of light). We formalize this relationship as:

$$\frac{f_d}{f_o} = \frac{v}{c} \qquad \text{[Equation 9]}$$

The equation can also be solved for the relative velocity between the points of transmission and reception:

$$v = \frac{c \times f_d}{f_o} \qquad \text{[Equation 10]}$$

[1]Notes appear on page 7

which will enable us to determine the orbital velocity of a communications satellite, from the maximum Doppler shift observed on its telemetry beacon, or other transmitted signal.

SATELLITE SLEUTHING

This avocation has been raised to the level of high artform by Geoff Perry and others of the legendary Kettering Group in England, and the techniques discussed here should certainly be attributed to them (Davidoff, 1990, 14-12 to 14-17). The key to determining the orbital characteristics of an "unknown" satellite is to observe Doppler-induced changes in its apparent frequency, and to graph them over time. If we can accurately observe Time of Closest Approach (TCA), along with Acquisition of Signal (AOS) and Loss of Signal (LOS) times, then we can estimate the satellite's orbital period. From that we can compute altitude and velocity, thence estimate AOS, LOS and TCA for future orbits.

The dedicated satellite sleuth relies upon not only direct observation, but past experience in determining orbital parameters. A thorough database of the characteristics of known satellites is built up, to which a newcomer can be compared in trying to determine its general orbit, and speculate as to its mission.

SELECTING A SATELLITE

The true satellite sleuth delights in "discovering" new satellites, and working out as many of their orbital characteristics as possible, armed with little more than a receiver with which to recover their signals. The purpose of the present exercise is somewhat different: to demonstrate to the student the relationships between the orbital parameters of a satellite, and to illustrate how a balance of forces defines the orbit. Thus a truly "unknown" satellite is hardly a requisite. In fact, the exercise has even more instructional validity if the measurements are made on a satellite of known orbital characteristics, against which the student's results can be compared. Let us consider, for example, analyzing the 70-cm CW signals from the LUSAT-OSCAR 19 (MicroSat D).

This particular signal is chosen for my students' first exercise in orbital analysis for a number of reasons. The 437.127-MHz frequency is high enough to provide ample, easily observed Doppler shift (remember, f_d varies directly with frequency). The 750-mW beacon signal is strong enough to be readily received on relatively simple equipment. CW is the preferred modulation mode for accurate Doppler measurements, because the signal can be zero-beat on a receiver with direct digital frequency readout. Finally (and this is cheating), the orbits of low-altitude, circular, sun-synchronous, near-polar satellites such as all four of the 1990 MicroSats are especially well suited to the type of measurements required. In other words, if you pick a satellite with the right orbital parameters, it's easy to determine its orbital parameters![2]

CONDUCTING THE EXPERIMENT

We begin much as the satellite sleuth begins, measuring Doppler shift over successive orbits and displaying it graphically. The procedure, well documented in the literature (Talcott Mountain Science Center, 1975), is repeated here for the benefit of those who might not have seen it in its entirety.

Once able to successfully (and consistently) receive the telemetry beacon from OSCAR 19, the student is asked simply to measure, as accurately as possible, the received signal frequency, at one minute intervals all the way from AOS to LOS. This is done initially for two successive orbits. The TCA of the satellite to the observer is indicated by the maximum slope of the plotted Doppler curves, as illustrated in Figs 1 and 2. These are of course the familiar Doppler S-curves, which we've used since the days of OSCAR VI. Their continuously varying slope (rate of change, or first derivative) holds the key to evaluating the satellite's orbit.

The time difference between two successive TCAs is a first order approximation of the satellite's orbital period. It is *only* an approximation, since the effect we are actually measuring involves not only the satellite's orbital motion, but also the eastward rotation of the Earth. For a more precise measurement, we determine the elapsed

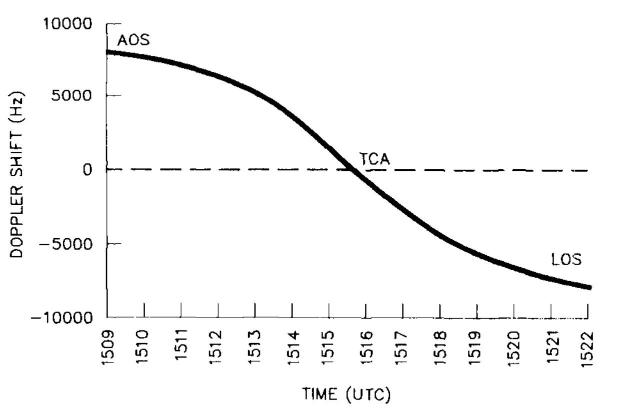

Figure 1—LO-19, 22 Aug 91

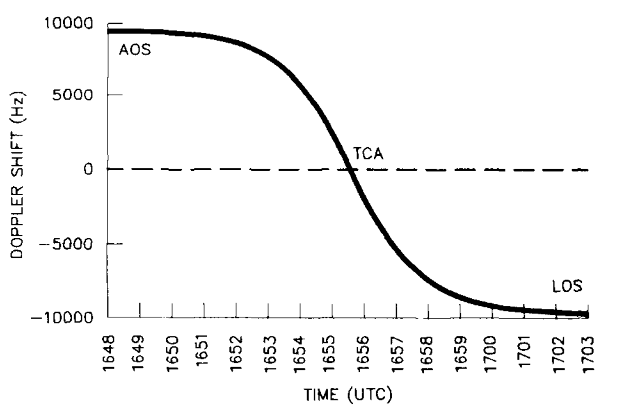

Figure 2—LO-19, 22 Aug 91

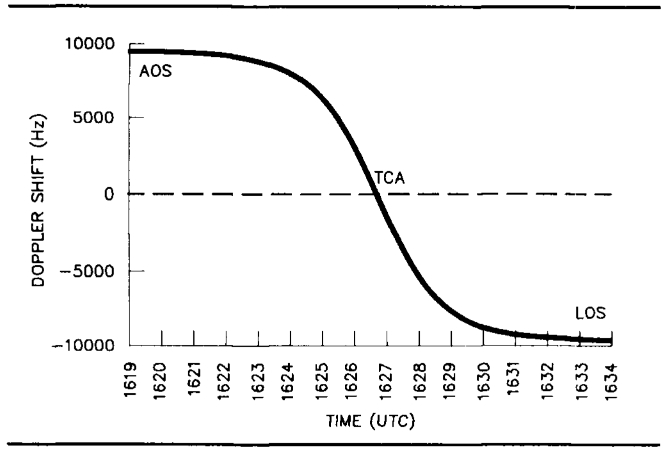

Figure 3—LO-19, 23 Aug 91

time between successive overhead passes. If the satellite is monitored for an extended period, eventually an orbit is encountered which closely approximates a direct overhead pass. This is evidenced by a maximum period of visibility (the difference between LOS and AOS), strongest signals at TCA, most rapid rate of frequency change around TCA, and maximum observed Doppler shift just at AOS and LOS. For the LUSAT-OSCAR 19 spacecraft, Fig 2 represents just such an orbit.

Our objective now is to produce a Doppler S-curve for the *next* overhead pass. With sun-synchronous satellites (and this is precisely why we chose one), the orbit tends to trace out identical ground tracks at one or two day intervals. So if we're persistent, within the next couple of days we'll see an S-curve which looks very much like Fig 2. In this example, we see the result in Fig 3.

The only thing we have to watch out for is that the two successive overhead passes must, as nearly as possible, be *identical* in relative motion. If the first observation (say, Fig 2) was made with the satellite ascending (moving from South to North), we don't want to use as our next orbit a pass in which the satellite is descending (moving from North to South). Directional beams should help to verify that both observations were made with the satellite traveling overhead in the same general direction.

Our Doppler S-curves (Figs 1 through 3) now contain all the information we require to determine orbital period, and from it, various other characteristics of the satellite and its orbit.

ESTIMATING ORBITAL PERIOD

The Doppler S-curves shown in Figs 1 through 3 depict received frequency over time, for 70-cm telemetry signals from the LO-19 satellite. Figs 1 and 2 represent two successive orbits, while the data for Figs 2 and 3 were taken one day apart. We will use the first pair of Figures to roughly estimate the orbital period of LO-19, and the second pair to refine our estimate.

Note in Fig 1 that the closest approach of the satellite to the observer (as indicated by the greatest slope of the Doppler S-curve) occurred at roughly 15 hours, 15 minutes, 36 seconds UTC. TCA for the successive orbit is noted from Fig 2 as 16:55:42, or about 100.1 minutes later. We thus have a rough estimate of orbital period, which contains an assumed error related to the Earth's rotation.

To correct the error, we note the TCAs for two successive overhead descending passes (Figs 2 and 3), which are seen to occur at 16:55:42 on one day, and then 16:26:48 the next. The elapsed time between these two overhead TCAs is thus 23:31:06 (1411.1 minutes), which must be nP, an integer multiple of the satellite's nodal orbital period.

But before we can accurately calculate P, we must have a value for the integer n. This we can determine by dividing the elapsed time between successive overhead passes, by the *estimated* orbital period. Mathematically,

$$n = \text{int}\left(\frac{nP}{P_{est}}\right) \qquad \text{[Equation 11]}$$

$$= \text{int}\left(\frac{1411.1}{100.1}\right) = 14$$

If two successive overhead TCAs are indeed separated by precisely (n = 14) orbits, then the exact orbital period must be that elapsed time divided by fourteen, or P = 100.793 minutes. Relative to this refined estimate, we see that our original estimate of orbital period, based upon two successive orbits, was off by about 0.7%. If we now compare our more exact measured value to that published for LO-19's orbital period [see Table 1], we see that we have reduced our error by roughly a factor of a hundred.

ESTIMATING OTHER ORBITAL PARAMETERS

It turns out that, for a circular sun-synchronous orbit, nearly all the important orbital parameters can be derived from the satellite's nodal period. This, after all, is why we picked this particular satellite for our experiment to begin with. I'll spare you the algebra and trig derivations; the pertinent equations are listed in the Appendix. With them, we calculate altitude, velocity, orbital increment, visibility angle, terrestrial range, access time, and Doppler shift for the LO-19 satellite.

Table 1 summarizes our results. Our "observed" values listed are either the results of direct student observation in the Penn College Telecommunications Lab, or values mathematically derived from those measured parameters. Similarly, the "theoretical" values shown are either published parameters for the LO-12 satellite given in Davidoff (1990, Appendices A and B), or values mathematically derived from those published parameters.

Note that the difference between observed and theoretical values[3] seldom exceeds a fraction of a percent. Does this mean that my students are uncannily precise? Hardly! Rather, we conclude that the experiment is structured to be forgiving of observational imprecision. We derived period, after all, by averaging elapsed time over

TABLE 1
ANALYSIS OF RESULTS

Parameter	*Units*	*Observed*	*Theoretical*	*Error*
Period	min	100.793	100.8	0.007%
Mean Altitude	km	803.9	796.4	0.9%
Velocity	m/s	7454	7458	0.1%
Increment	°W/orbit	25.2	25.3	0.4%
Max. Doppler	kHz	10	10.3	2.9%
Max. Range	km	3045	3038	0.2%
Max. LOS-AOS	min:sec	15:00	15:20	2.2%

fourteen orbits. Should this not reduce observational error by a factor of fourteen? Similarly, our Doppler S-curves depended not on *absolute* frequency measurement (always suspect), but rather on reasonably precise measurements of frequency *drift.* Even given dial calibration errors of several kilohertz (the rule rather than the exception at UHF), we can still precisely estimate the rate of frequency *change.*

CONCLUSIONS

Since their inception in 1961, Amateur Radio satellites have significantly expanded our communications horizons. They have also proved an invaluable aid in the teaching of celestial mechanics, the study of how heavenly bodies interact. If there is truly an underlying order to the Universe, it is ham satellites which may best enable our students to glimpse it. As an instructional tool, the satellite may well rank in importance second only to the chalkboard.

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Notes

[1]The word "beep" really is appropriate here, as the keyed signal was too long for a Morse "dit," and too short for a "dah."

[2]There is a direct analog here to successful moonbounce communication (or any other exotic DX mode, for that matter): If you know in advance the other station's call, it's about 3 dB easier to pick his call out of the noise!

[3]To motivate my students, I hesitate to call them "errors," just "differences of opinion."

Appendix

Pertinent Constants and Equations

Inertia: $F = mA$

Acceleration: $A = \frac{v^2}{r}$

Gravity: $F = \frac{GMm}{r^2}$

Velocity: $v = \left(\frac{GM}{r}\right)^{1/2}$

Period: $P = 2\,\text{pi} \times \left(\frac{r^3}{GM}\right)^{1/2}$

Increment: $^{o}W = \frac{P(\text{mins})}{4}$ [± Precession]

Gravitational Constant: $G = 6.673 \times 10^{-11}\ \frac{\text{Nt m}^2}{\text{kg}^2}$

Mass of the Earth: $M = 5.975 \times 10^{24}\,\text{kg}$

GM Product: $GM = 3.987 \times 10^{14}\ \frac{m^3}{s^2}$

Mean Radius of the Earth: $R_E = 6.371 \times 10^6$ m

Doppler Shift: $f_d = \frac{f_o v}{c}$

Visibility Half-Angle: $\theta = \cos^{-1}\left(\frac{R_E}{R_E + h}\right)$

Max. Visibility Time: $t_{max} = \text{Period} \times \left(\frac{2\,\theta}{360\ \text{deg}}\right)$

Meteor Scatter Experiments Using Packet at 144 MHz

By: Giuseppe Zollo, I2KFX

Translated by Domenic Mallozzi, N1DM, from the February 1990 issue of Radio Rivista *Packet Column.*

Described here are experiments carried out between IØVUQ and I2KDX on meteor scatter (MS) using 1200-baud packet with biphase PSK (phase shift keyed) modulation techniques. The use of digital technologies for MS communications has been used for many years in military and civilian systems to broadcast brief messages over large geographical areas.

The coming of age of packet radio has made it practical to expand these techniques for use by amateurs with the minimum equipment to engage in this passionate activity previously reserved only for more powerful stations and with very patient operators.

Because the AX.25 protocol was not developed for MS activity it was necessary to adjust and modify the frames so that they could interact with the meteor streams and be reflected back to Earth. With this idea in mind, last year I set about to write a program for a PC which could use a KISS TNC to establish a protocol more suitable for use in MS activities.

To understand the changes required, it is necessary to explain how meteor scatter works. I'll give a brief explanation mostly to those among you more oriented to digital technology than to RF. This explanation will also demonstrate how the union between the two disciplines could bring advantages in operation to both technologies.

The Earth is bombarded daily by tons of debris of various dimensions that comes from outer space. When they enter the Earth's atmosphere, this debris terminates their own existence in a flash of light. They disintegrate due to friction of rarefied gas in the stratosphere. This disintegration generates a cylinder of ionized air around their trajectory. The cylinder of ionized air unfortunately lasts only a very short period varying from a few thousandths of a second to almost a minute for larger meteors.

The ionized air is the very mirror which is required for the reflection of the radio waves but the arrival of one meteor in the right position is only approximately foreseeable. We will discuss this further later. The frequencies that are better reflected by our cylinders of ionized air vary from the shortwave (28 MHz) to the VHF (144 MHz) with peak performance around 50 MHz.

Because we like to try difficult things, we used VHF for the MS experiment: In particular, IØVUQ and I have selected 144.160. Therefore, if you hear strange noises on this frequency, don't get scared. Do not interfere or telephone asking for explanations. Right at that moment the right meteor we were waiting for could be passing.

The altitude at which the ionized cylinders form vary from the 80 and the 110 km. Because of the curvature of the Earth, this system permits QSO up to 2000 km.

We were saying that the meteors arrive by surprise, but something is known about arrival periods of major groups. Hundreds of major streams have been cataloged by astronomers and they have identified the point in the sky from which the stream appears to come from (ascent line and declination are found in *Dubus,* for example). The period of days in which these streams encounter the Earth is also known.

DL5MCG has written a suitable BASIC program for determining the optimal period for a MS QSO between two stations. In such periods the meteors arrive almost perpendicular to the point between the two stations.

To make a QSO occur, I transmit continuously hoping that the meteors arrive and make the message arrive at its destination. To do so I have written a program in Turbo Pascal which manages all the operations. Details of the program can be found in *Radio Rivista,* October 1988. Essentially, the program sets the TNC to transmit the same message as many times as possible in the period of the transmitting window. In practice we use windows of 15 seconds. One station transmits the first 15 seconds of the minute, then switches to receive for the next 15 seconds. Obviously, the other station in the QSO listens the first 15 seconds and transmits in the next 15-second window.

The Experiments

From the middle of May, 1989, IØVUQ and I started to execute a series of tests to verify the possibility of utilization of the small meteor streams for communication by packet radio.

In the following I'll try to explain the state of the experiments, the success and difficulties encountered, and also the prospective of future developments of this speciality that searches to realize the synergy between digital technologies and VHF DX activity.

Following the publication in *Radio Rivista* and in *Dubus* of my article presenting the MS program for PC, there have been many hams interested in performing the first experiments.

The first station to equip itself with a PC, TNC and PSK modem was that of Alessandro, IØVUQ, at S. Maria LeMole (JN61hs) to the south of Rome.

Alessandro's station is composed of a PC, a TNC2 with EPROM1,1,6 with KISS, an external PSK modem, an ICOM IC202 is used as a transmitter to drive a 50-watt linear using a QQEO6/40 tube (similar to a 5894). For reception he uses a TS820 with a Datong UC/1 converter. The antenna is one 9 × 9 crossed elements (used for OSCAR 13).

My station at Monza (JN45po) is made up of an IBM PS2/30 computer, an AEA PK80 with EPROM1.11.4e loader for KISS, an external PSK modem, an FT201 transceiver feeds a home-brew transmit converter which then drives a Fisher 150-watt linear (but with only 80-W effective output due to a weak 4 × 250 output tube). The receiving equipment is a GaAs FET converter with a 0.9-dB noise figure preamp that feeds a Drake R4B receiver. Two 9-element antennas are fed to produce right-hand circular polarization.

The distance between our stations is 507 km. This is considered small by the traditional meteor scatter experts. However, theory says that a minimum distance exists. On the contrary, a maximum distance exists, around 2000 km, which depends on the geometry of the reflections.

Before we initiated tests on 144-MHz MS, we wanted to make sure that all the hardware, especially the PSK modems, was working properly. We performed test QSOs of 20- to 40-minute durations (the longer periods are used when propagation over 20 minutes is not suitable).

PSK modulation has demonstrated excellent performance in QRM between collisions in QSOs of up to 40 minutes.

After verifying that everything was going well, but doubting the ability to make a MS QSO with only 50 W, Alessandro moved his digital equipment to the house of his friend, IØNLK. IØNLK is equipped for EME with an array of four 20-element Yagis and 500 W. And so we made the first test. That day we felt very good. There was tropo propagation and IØVUQ managed to decode a packet for the first time. In fact, we were even able to have a voice QSO.

After that we have always operated from the same stations and we have never again had a tropo opening. In the meantime I had problems with my old frequency meter which is configured to use an external time base frequency locked to RAI, the Italian broadcast authority.

The major difficulty I had encountered from the beginning of the experiments was measuring the frequency output exactly. The PSK modem has a requirement to maintain the tones within ± 100 Hz. However, if the signals are weak it requires more precision...let us say ± 30 Hz.

We also must take into account the fact that the other station in the system has the same requirement. Having such precision and stability at 144 MHz is not easy. First of all, it's required to measure the frequency of the actual output not the 1600 Hz inserted into the mic input of the transmitter.

The frequency meter (frequency counter) has to have a precision time base to meet these requirements. I was unable to arrange the professional grade instrument required, so I phase locked the external time-base input of my frequency meter to the AM carrier of the local (RAI) television station. This was used because the RAI network is phase locked to a cesium beam standard. (In the US, because of the fact that a significant amount of programming is not tied to the "network" source it may be more appropriate to phase lock to WWV, WWVH, CHU, WWVB or the LORAN-C radionavigation system. *Ed.*) It is also necessary to consider the drift of one's own equipment. It is therefore necessary to warm up your equipment for about an hour so that it becomes temperature stable, and then check the frequency and recheck it at least every half hour to correct for random frequency fluctuations.

So now we come to a true and proper test...on the air. After having missed several chances at major meteor showers due to other commitments, on Saturday, May 13th, we finally succeeded in making a test during the Nu Piscidis. The Nu Piscidis in this case occur during the middle of the day which is convenient. Unfortunately the conditions were poor. But, we proceeded with the test anyway.

Within about an hour of beginning the experiment we began to get discouraged. Nothing could be heard. We exchanged a telephone call. "Have you heard anything?" "Not me, and you?" "Very well, let's continue for one more hour."

After about a minute, not knowing what to do while the PC continued to transmit every 15 seconds, I went near the receiver and heard a strange noise at the fluctuating in the noise...it reminded me of a car at the racetrack: voom..voom..what could it be? I tried moving the tuning dial of the Drake receiver back and forth and suddenly the LED indicators on the demodulator showed phase lock. Immediately I heard the printer starting and after a little more tuning I got more printed lines.

You can imagine the joy! The first message:

IØVUQ=>12KFX UI
Odd 8<240>:cqms

It was 11:01. I grabbed the telephone and called Alessandro and read him the message.

While we were talking the printer does another streak of printing. At this point there's need to finish the QSO. It happened that even IØVUQ received my messages.

We continued again for a while but nothing, even after resetting the transmit frequency to that of the receiver. I then discovered I was 140 Hz lower than planned.

Later on while discussing the event we discovered that Alessandro's meter (an HP) had not been calibrated for quite some time and therefore was giving the wrong readings, sufficient to be out of tune.

Since that day we tried other times: the 20 and the 21st of May on the Omicron Centidis and the 4th of June on the Arietidi. In all these tries I received an abundance of frames but none of my frames were received in Rome.

Seeing this asymmetrical (one way) behavior we began to investigate the phenomenon. However, in the first tests IØVUQ did not have a preamplifier in line for reception. The signals received by me did not reach S1, therefore we were at the limits of the sensitivity of my station. Also we considered the path geometry. IØVUQ has to point his antenna towards the city of Rome with all its electronic noises. From Monza, I point my antennas to the east of Milano and therefore don't encounter this problem. During the attempt on the 4th of June, Alessandro mounted a preamplifier of unknown noise figure, and has also modified the connection between the horizontal and vertical antennas utilizing a hybrid ring in place of the T connection.

Even with these improvements and even through having the first message at 10:30 on the 4th of June, IØVUQ wasn't able to decode any packets.

The 11th of June, we tried one more test from 11:30 in the morning and also on the 16th of June trying to make use of either the Arietidi or Z Perseidis. We began to have success.

At the beginning we decoded one or two frames, then bunches. One swarm at 12:41 had 88 frames with the message "CQMSPSK." Unfortunately nothing yet from the direction of Monza-Rome despite IØVUQ increasing his power output from 40 to 100 W. He also used a new preamplifier mounted in a housing at the bottom of the tower.

While continuing with the investigation to discover the cause of Alessandro's lack of reception, I began to make a little modification to the PACKET MS program.

The first version of MS was written in Turbo Pascal 3.0. Right after having initiated the experiment, I acquired the 5.0 version of Turbo Pascal.

The conversion from version 3.0 to 5.0 was long and painful, because of several variations between the two compliers. The on-the-air testing pointed out the necessity of displaying the received frames on both the computer display and the printer; version 2.0 of MS includes these additions.

In the meantime, JPI came out with his own complete Module 2 compiler at a reasonable price and with really interesting characteristics. The principal characteristic which distinguishes Module 2 from Pascal is that the syntax is more fluid, and the presence of the "Coroutine" which permits the implantation multitasking programs. In a multitasking program more "procedures" can run virtually simultaneously (based on prioritization standards). This makes it possible to exchange synchronization signals.

This language was much more appropriate for a program like MS where multiple functions must be carried out simultaneously. The major three functions being:

- reception and decoding of the frames
- editing of the messages
- the clock function that sequences the transmission

As soon as I received the compiler from the US, I began to learn it and how it could be applied to another version of MS. After examining the compiler I began a complete rewrite of MS using a new structure.

The rewriting of MS has been informative. A lot of improvements have been made, for example the handling of the data into the serial port and its handling in the Module-2 program. Other improvements include a new clock pulse routine (in the Pascal version the clock was one TSR), and allowing the editing of protocols during the transmission sequence.

The "features" added also include the ability to set the computer clock to the second and to mark every frame to the second as received. This assists in analyzing the distribution of messages received in each time interval during a particular window of reception.

I'll reserve a detailed description of the program for a future article dedicated to whomever wants to examine the techniques used. But let us return to the activity on the air.

In examining the reasons for the lack of reception at IØVUQ we considered the possibility of a problem with the PSK demodulator. Taking advantage of a journey by Alessandro up north, he took his demodulator with him to compare with mine. Putting one next to the other and using a calibrated weak signal, mine appeared to be much more sensitive. A subsequent investigation detected some anomalous behavior of the fixed circuit, the heart of the demodulator. Another problem at Alessandro's station was interference from spurious RF signals from stations in Monte Cavo and Ciampino. This was corrected by limiting the spurious signals by RF filtering. This resolved the question of relative station performance.

Meanwhile, the holidays came and the Perseids went by while Alessandro was sailing in Greece and I was sunning myself in Liguria.

Other commitments prevented us from making tests until Sunday the 22nd of October 1989. It was the period of the Orions, of small bands but with the good intentions to arrive at 6 in the morning in unison with the maximum variable at the bottom of the meteors (see the article by Jay A. Weitzen, "Communicating Via Meteor Burst On Short Ranges" in *Transactions on Communications* of the IEEE, November 11, 1987, as well as the fundamental article by George R. Sugar, "Radio Propagation by Reflection from Meteor Trail" in the *Proceedings of the IEEE*, Volume 52, February 1964).

For science you even get up early. Therefore, we got up at four in the morning to begin to warm up the equipment so that the VFO in the radio came to thermal stability, and then after an hour checking the calibration of the receiver and transmitter. Finally we got to transmitting using the usual procedure: a window of 15 seconds, IØVUQ on the odd window and I on the even. Not much time went by when at 4:48:04 UTC I received the first correct frames. The printer was disabled so as not to make noise but the reception on the CRT worked well.

This is the first message received by IØVUQ:

4:40:55 EvenI2KFX=>IØVUQ uil<FO.73 Alex

And this is the first message received by me:

4@:48:4@Odd IØVUQ=>I2KFX U11<FO@>r73 alex

At 8:24:11 I received the last frame, when the transformer of my linear decided to become short circuited between the high voltage and grid windings (sounds familiar. *Ed.*).

The QSO is done!! But, what was there different from past attempts?

Certainly on Sunday morning the noise produced from Rome was a lot lower than on the weekdays. In fact, conditions were so much more suitable that it was possible to operate even with the minimal amount of individual meteors that the Earth encounters every day.

A reason can be deduced by reviewing one burst of a successful sequence:

5:6:37 Odd IØVUQ=>I2KFX UI 1 <FO> tnx fer "bel qso"
5:6:37 Odd IØVUQ=>I2KFX UI 1 <FO> tnx fer "bel qso"
5:6:37 Odd IØVUQ=>I2KFX UI 1 <FO> tnx fer "bel qso"
5:6:37 Odd IØVUQ=>I2KFX UI 1 <FO> tnx fer "bel qso"
5:6:38 Odd IØVUQ=>I2KFX UI 1 <FO> tnx fer "bel qso"
5:6:38 Odd I0/VUQ=>I2KFX UI 1 <FO> tnx fer "bel qso"
5:6:38 Odd IØVUQ=>I2KFX UI 1 <FO> tnx fer "bel qso"
5:6:39 Odd IØVUQ=>I2KFX UI 1 <FO> tnx fer "bel qso"

Notice the distribution of the messages in time: 4 in the 37th second and three in the 38th second, with an average of six lines a second sent. This shows that the method of sending multiple times in each block with each line being approximately 1/6th of a second long matches the brief openings found in meteor scatter work.

I hope we have attracted your interest in this technique of communication. I invite you to join us in further experiments.

Empirically Speaking...

continued from page 2

sure deviation, they can't adjust it properly. This problem continues to plague packet networks. TAPR wants to change that.

The other ongoing project that was much discussed was the DSP-1 board. This board, currently in beta test, is an IBM-PC plug-in card that carries a Texas Instruments TMS320C25 digital signal processor and associated circuitry. A joint TAPR/AMSAT project, this board is intended to eliminate the need for the "modem stack" presently necessary to operate all of the various terrestrial and satellite packet systems. Jon Bloom, KE3Z, (ARRL Laboratory Supervisor) reported on and demonstrated software for the DSP-1 beta board (a RTTY/AMTOR modem and a 1200-baud, Bell 202 packet modem, along with an audio filter written by Dave Hershberger, W9GR). With the advent of working software for the board, interest (and, more important, activity) has been rekindled. Because of a few errors in the existing design and a couple of other desired changes, one more revision of the board is required. Work continues on this project.

Other presentations at the TAPR meeting included:

- "Use of Spread Spectrum (CDMA) in the Amateur Service," by Dewayne Hendricks, WA8DZP
- "General Purpose Signal Processing Software for a Radio Workstation," by Dr. Michael Parker, KT7D

Presentations on 9600-baud packet network implementation were given by Mel Whitten, KØPFX, and Mike Curtis, WD6EHR. Dr. Tom Clark, W3IWI spoke on the use of surplus 900-MHz cell-site equipment for packet backbones, AMSAT's Phase III-D satellite efforts, and connection of widely separated packet networks via Internet IP encapsulation. Mark Oppenheim, KD6KQ, of VITA, gave a slide presentation about the efforts of that organization. Bill Henry, K9GWT, of HAL Communications Corp, gave a detailed talk about Clover II, the HF communications system being developed by Ray Petit, W7GHM.

Chuck Green, NØADI, long-time TAPR prototype builder, schematic checker and all-around stalwart received an award of appreciation from the organization.

So, TAPR is alive and well and *still* contributing to the development of packet radio. You can help develop packet radio, or just keep abreast of the exciting work being done, by joining TAPR. Contact them at PO Box 12925, Tucson, AZ 85732. The small group of amateurs who have done most of the work have contributed to Amateur Radio well out of proportion to their numbers. TAPR stands as the clearest example of what can be accomplished by committed amateurs working together, and its continued success is to be devoutly wished by all amateurs who hope to see amateur digital communications continue to advance.—*KE3Z*

Conducted by: Stan Horzepa, WA1LOU
75 Kreger Drive
Wolcott, CT 06716-2702

DEVELOPMENT OF CALIFORNIA STATE PACKET RADIO NETWORK CONTINUES

Tetherless Access is responsible for the Macintosh version of amateur packet-radio TCP/IP software called NET/Mac. *The following describes Tetherless's current Macintosh networking efforts and its subsequent application to "pure" Amateur Radio use. The following describes the results of public grants (although IBM provided some funding), technology based on Amateur Radio operations (spread spectrum) and does not promote the direct commercial operations of any entity.*

This year will see dramatic evidence of the return-on-investment from research and development in the California State Library Packet Radio Project undertaken during the mid- and late 1980s. IBM, the Council on Library Resources, and the California State Library made grants to the University of California where Dr. Edwin Brownrigg was the principal investigator in a series of projects that explored the potential for packet radio — wireless, high-speed digital communications — among libraries.

While the early goals of the research and development were to prove technological feasibility and to adapt extant FCC rules to packet-radio technology among libraries, the actual outcome was the need for a fresh approach. The project showed that the conventional radio technology and the standard digital encoding techniques of the time were becoming arcane approaches to achieving the research and development goals. The FCC was just then introducing into its rules (Title 47 of the Federal Code of Regulations) a new Part, 15.247, which allowed an exotic method of digitizing a radio wave, and that held promise for packet radio. The new FCC rules were a welcomed alternative to the politics of recycling Instructional Television spectrum for packet radio.

Called spread spectrum, this new method of using radio to convey digital information under Part 15.247 presented several advantages for libraries and other civilian users, as well as large technological challenges to the telecommunications industry. The major advantages were that multiple users could share the same radio spectrum simultaneously, and that, within prescribed transmitter power, the FCC would require no user license.

The challenges were to transfer spread spectrum technology from the military sector, which perfected it as a means of secure communication, into the FCC regulated civilian sector at a reasonable price.

Research and development now under way involve a convergence of interests in California among The Memex Research Institute, Tetherless Access, Ltd and special-interest user groups. Among the latter is the City of San Diego Public Library, which is using packet radio for a 1.54-Mbit/s link among the central and branch libraries and San Diego State University where the public library subnetwork gateways to the Internet.

The Council on Library Resources and Apple Computer, Inc are the sponsors of the San Diego Packet Radio Project. One project objective was to prove that FCC Part 15.247 rules will work for libraries. Dr. Edwin Brownrigg of the Memex Research Institute and Richard Goodram of San Diego State University are the principal investigators.

Tetherless Access, Ltd and the Memex Research Institute now seek funding to deploy a network of 600 packet radios in the San Francisco Bay Area. These will be used by civilian groups including libraries. This network will extend as far south as San Jose and northeast to Roseville. The network's radios will comply with FCC Part 15.247 as well as with an authorization from the FCC allowing Tetherless Access, Ltd to apply FCC Part 97 rules (Amateur Radio) for the network backbone.

Together, the San Diego and Bay Area networks will prove several technical features of packet-radio: wireless wide area telecommunications, high data rates, last-mile access to the Internet, and communication between such wireless networks through the Internet. They also will demonstrate two precedent-setting public policy features of packet radio: common carrier by-pass for public benefit; and, use of the electromagnetic spectrum, a public good, in support of library service, also a public good.

Accordingly, the Memex Research Institute is seeking the voluntary participation of Bay Area libraries as nodes in the grant-supported wireless wide-area network. A single packet radio at a library will serve a local-area network within the library and gateway it to the wireless wide-area network extending to the Internet.

—from Ned Kroeker, N1EWB

MIR/SAREX NEWS

On March 17th at 1022 UTC, German astronaut Klaus-Dietrich Flade, DP1MIR, and two Russian cosmonauts—Alexander Kaleri, U8MIR and Alexander Viktorenko, U9MIR—blasted off from Baikonur, Kazakhstan. They successfully docked with the *Mir* space station 48 hours later.

Between mission assignments, Flade was active on 2-meter FM. Flade also assisted in setting up a digital speech system which will act as a simplex "repeater."

When active, the repeater will listen for one minute and then retransmit the received audio for one minute.

On March 25th, Flade returned to earth along with Sergei Kirkalev, U5MIR and Alexander Volkov, U4MIR. During their last few months in orbit, Sergei and Alexander became media celebrities. They were often portrayed as lonely, abandoned cosmonauts. Their "plight" even attracted the attention of the rock band *U2*, who attempted to uplink the audio from one of their concerts via a commercial satellite.

The new *Mir* crew intends to maintain Amateur Radio activity from the space station. FM phone and packet contacts with U8MIR and U9MIR will continue to take place on 145.55 MHz.

American hams have also been active in space. The recent S*TS-45 Atlantis*/SAREX mission utilized a 57-degree inclination orbit. This provided an excellent opportunity to make scheduled contacts with schoolchildren throughout the world. Many earthbound amateurs also enjoyed shuttle contacts on a random basis.

DOVE TELEMETRY STUDIED IN CLASSROOMS

Many schools have collected and decoded telemetry, monitored the health and studied the properties of the tiny spacecraft known throughout the world as DOVE (DO-17). Physics students at Chaminade Preparatory School in West Hills, California, have gone one step further by making detailed studies of DOVE when its telemetry has been available. Under the leadership of school teacher Dave Reeves, KF6PJ, these students have been closely following DOVE's spin rate. They often share their results with MicroSat Command Station, Jim White, WDØE.

Jim recently suggested that their spin rate studies might be greatly aided if he commanded DOVE to collect telemetry at different sample rates, both faster and slower than the current 16 or 17 "seconds-between-samples." DOVE's current spin rate is around 3 RPM. As Jim states, "By collecting and analyzing telemetry sampled at different intervals, students will be able to investigate the relationship between sample rate and apparent spin rate. If the sample rate isn't fast enough, incorrect conclusions may be drawn about both spin rate and direction. I will set the DOVE telemetry sample rate according to their direction."

This satellite, with its standard FM packet-radio transmissions, provides a unique opportunity for doing this kind of experimentation. Special thanks go to WDØE for his active involvement in educational efforts. Jim will be working closely with Bob McGwier, N4HY, and Harold Price, NK6K, who continue in their voice software development and testing for DOVE.

Watch for updates in the DOVE telemetry beacon transmissions on 145.825 MHz.

—from AMSAT News Service

MODIFYING COMMERCIAL RADIOS FOR SPEED

I have been doing some work converting used mobile radios to 9600 bit/s and higher for backbone link service. I would like to share the following learned information with the rest of the amateur packet-radio community.

Redicomm UHF Front Mount Mobiles at 9600 bit/s

Note: This Redicomm radio was marketed under the many names

Receiver Modification

The basic problem is that the receiver IF filtering is too narrow to accept the signal from the G3RUH modem. Add nominal frequency drifts, particularly at a cold hilltop site, and the link fails.

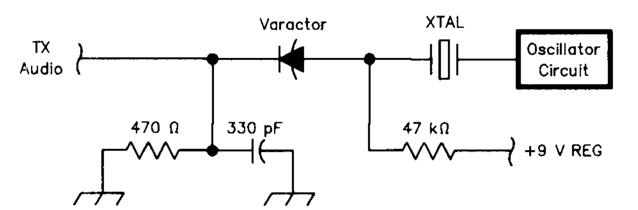
The solution is to widen the I, by removing the first ("E" bandwidth) ceramic filter, moving the second ("C" bandwidth) ceramic filter to the first's position and jumper the vacant position of the second filter with a 0.001 μF capacitor.

The "E" filter has a nominal 6-dB bandwidth of 15 kHz, while the "C" filter has 25 kHz. The occupied bandwidth of the 9600-bit/s signal is 20 kHz. The receiver eye pattern greatly improves and moderate drift is no longer a problem.

Transmitter Modification

Modify the transmitter for direct FM by replacing the frequency trimmer and parallel fixed capacitors with a varactor capacitor. I have been using KV2202 Hyper-Abrupt varactors with good results. The varactor equals the mid-range capacitance of the trimmer and fixed padder when biased to 9 volts. Use the series inductor on the oscillator side of the crystal for frequency adjustment.

The modulation circuit is as follows:



Motorola MOCOM-35 for 19,200 bit/s

This effort started out as a 9600-bits/s modification and then I realized that wider bandwidths and higher data rates could be achieved.

Receiver Modification

Again the receiver is too narrow for even 9600 bits/s, so you must widen the narrow 455-kHz filter. A discrete lattice filter is used in this receiver at 455 kHz. Remove the four ceramic "Tombstone" resonators and the capacitors that parallel two of them. Add a 47-pF coupling capacitor from the top of the input tank (of what was the lattice filter) to the top of the intermediate tank. Likewise, add a second 47-pF capacitor from the top of the intermediate tank to the output tank circuit. The three poles can now be aligned to form a fairly flat 50-kHz wide band-pass filter with a linear phase response. With no further modification, the receiver will operate at 9600 bits/s. However, if you widen the 10.7-MHz first IF filter, much higher data rates can be used. Either convert the existing matching circuitry to the cascaded crystal filter elements to a wide L-C filter, as was done to the 455-kHz filter, or replace the filter elements with FM broadcast receiver ceramic filters.

Transmitter Modification

Modify the transmitter for direct FM using the same circuitry as for the Redicomm radios. However, I found that the internal 9.6-volt source wandered enough with external supply and temperature variations to cause frequency drift problems. A small three terminal regulator solved the problem.

The use of slightly wider IF filters may be the key to successful 9600 operation. None of the better quality voice radios, in particular Motorola's commercial two-way products, appear to operate due to the extremely narrow filters needed to survive in a crowded urban RF environment. Currently, the amateur bands permit wider channel spacing and poorer filter skirts in the band segments set aside for node linking.

A large number of these high speed links are currently being installed in the EastNet backbone network, which serves the New Jersey, New York City, Long Island and Southwestern Connecticut area. The current overloaded condition of this network will be greatly alleviated by Spring 1992.

—from John C. Papson, WB2CIK

STATION AUTOMATION IMPROVED BY NEW *PB* AND *PG*

Jeff Ward, GØK8KA, reports that bugs in the first release (December 1991) of the "new version" of *PB* have been fixed. In addition, some new features for automated station operation have been added. These features involve using batch files and batch processing.

A new utility called *PFH_VAL.EXE* helps you create batch files. It returns as an error level the first byte of data from a PACSAT File Header item that you select. DOS batch commands are not particularly complicated or comprehensive, but a good system can be assembled using the hooks provided.

PG has been stripped of all functions other than uploading. It is also possible to have *PG* upload waiting messages and exit without human (keyboard) intervention. This should really clear the decks for fully automated stations based on *PG* and *PB.*

The software is now available on UO-22 for downloading.

—from AMSAT News Service

THE LOW DOWN ON AMSAT BULLETIN DISTRIBUTION

Tom Clark, W3IWI, provides the following information on the worldwide distribution of AMSAT bulletins primarily for the benefit of PBBS SYSOPs.

I receive a lot of inquiries about how these bulletins are generated and distributed and how they interact with the packet-radio system. First, the bulletins are generated by people based on the inputs they receive. Dick Campbell, N3FKV, collects and formats the weekly Keplerian elements. Dave Cowdin, WDØHHU, prepares the weekly AMSAT News Service (ANS) bulletins. The @AMSAT distribution channel also handles the independent SpaceNews that John Magliacane, KD2BD, originates. All three of these sources prepare material that is usually distributed on the weekends for posting on local PBBSs and for reading on various nets around the world.

All three sources generate material suitable for the packet-radio network by pre-assigning a Bulletin ID (BID) to prevent duplicates. As the bulletins originate, the BIDs are of the form:

ANS Bulletins:	$ANS-xxx.yy
Keplerian elements:	$ORBS-xxx.z
SpaceNews:	$SPCmmdd

where xxx is the day-of-the-year (for example, "039" represents February 8), yy is a two-digit serial number (for example, 07), z is a single letter (like O for the analog OSCAR satellites, D for the digital MicroSats, M for manned and miscellaneous, N for the two-line NASA format data) and mmdd is the month and day (for example, 0210).

Each weekend the bulletins are distributed to a list of more than 100 subscribers in over 20 countries on all six continents using electronic mail (Internet, CompuServe, etc.) and within hours they have flooded the world.

Greg Jones at the University of Surrey has begun using the @AMSAT distribution to send weekly UoSAT status reports (which appear with BIDs like $USR0205.0x)

Occasionally it is necessary to distribute special bulletins mid-week. These will usually have special BIDs, for example, a bulletin concerning a major change in the UoSAT operating schedule had the non-standard BID of $UOSAT_CHANGE.

We hear complaints about duplicate @AMSAT bulletins circulating with BIDs or @AMSAT addresses that have been changed. We ask PBBS SYSOPs not to change the @AMSAT address or the BID to prevent duplication. The "official" @AMSAT material always has BIDs as described above. When people ask me why duplicates with BIDs like $12345_W3IWI are appearing, my stock answer is, "It ain't my fault!" Also, we urge PBBS SYSOPs to be sure that their systems will not drop or create new BIDs on such bulletins.

We ask packet-radio users not to use @AMSAT as an address for bulletins they originate. A seemingly harmless bulletin sent to @AMSAT asking about *MIR* passes in your local area will be relayed to over 2000 PBBSs around the world.

—from AMSAT News Service

EVERYTHING YOU ALWAYS WANTED TO KNOW ABOUT SATELLITE FREQUENCIES

Ruben Omar Ferreiro, LU6DYD, compiled the following list of operating frequencies for the Amateur Radio satellite fleet.

AMSAT-OSCAR 10

General beacon	145.809 MHz (unmodulated carrier)
Engineering beacon	145.987 MHz (switched off)
Mode B uplink	435.030-435.180 MHz (SSB, CW)
Mode B downlink	145.825-145.975 MHz (SSB, CW, inverting)

UOSAT-OSCAR 11

Beacon	145.826 MHz (AFSK/FM)
Beacon	435.025 MHz (AFSK/FM)
Beacon	2401.500 MHz (AFSK/FM)

RADIO SPUTNIK 10

Beacon/robot	29.357 MHz (CW)
Beacon/robot	29.403 MHz (CW)
Mode A uplink	145.860-145.900 MHz (SSB, CW)
Mode A downlink	29.360-29.400 MHz (SSB, CW)
Robot A uplink	145.820 MHz (CW)
Robot A downlink	29.357 or 29.403 MHz (CW)
Beacon/robot	29.357 MHz (CW)
Beacon/robot	29.403 MHz (CW)
Mode K uplink	21.160-21.200 MHz (SSB, CW)
Mode K downlink	29.360-29.400 MHz (SSB, CW)
Robot K uplink	21.120 MHz (CW)
Robot K downlink	29.357 or 29.403 MHz (CW)
Beacon/robot	145.857 MHz (CW)
Beacon/robot	145.903 MHz (CW)
Mode T uplink	21.160-21.200 MHz (SSB, CW)
Mode T downlink	145.860-145.900 MHz (SSB, CW)
Robot T uplink	21.120 MHz (CW)
Robot T downlink	145.857 or 145.903 MHz (CW)

RADIO SPUTNIK 11

Beacon/robot	29.407 MHz (CW)
Beacon/robot	29.453 MHz (CW)
Mode A uplink	145.910-145.950 MHz (SSB, CW)
Mode A downlink	29.410-29.450 MHz (SSB, CW)
Robot A uplink	145.830 MHz (CW)
Robot A downlink	29.407 or 29.453 MHz (CW)
Beacon/robot	29.407 MHz (CW)

Radio Sputnik 11, continued

Beacon/robot	29.453 MHz (CW)
Mode K uplink	21.210-21.250 MHz (SSB, CW)
Mode K downlink	29.410-29.450 MHz (SSB, CW)
Robot K uplink	21.130 MHz (CW)
Robot K downlink	29.407 or 29.453 MHz (CW)
Beacon/robot	145.907 MHz (CW)
Beacon/robot	145.953 MHz (CW)
Mode T uplink	21.210-21.250 MHz (SSB, CW)
Mode T downlink	145.910-145.950 MHz (SSB, CW)
Robot T uplink	21.130 MHz (CW)
Robot T downlink	145.907 or 145.953 MHz (CW)

AMSAT-OSCAR 13

General beacon	145.812 MHz (PSK, CW, RTTY)
Engineering beacon	145.985 MHz (PSK, CW, RTTY)
Mode B uplink	435.423-435.573 MHz (SSB, CW)
Mode B downlink	145.825-145.975 MHz (SSB, CW, inverting)
General beacon	435.651 MHz (PSK, RTTY)
Engineering beacon	435.677 MHz (PSK, RTTY)
Mode I uplink	1269.351-1269.641 MHz (SSB, CW)
Mode I downlink	435.715-436.005 MHz (SSB, CW, inverting)
Mode J uplink	144.423-144.473 MHz (SSB, CW)
Mode J downlink	435.940-435.990 MHz (SSB, CW, inverting)
Beacon	2400.325 MHz (PSK, RTTY)
Beacon	2400.664 MHz (PSK, RTTY)
Mode S uplink	435.603-435.639 MHz (SSB, CW, FM)
Mode S downlink	2400.711-2400.747 MHz (SSB, CW, FM)
RUDAK uplink	1269.710 MHz (inoperative)
RUDAK downlink	435.677 MHz (inoperative)

UoSAT-OSCAR 14

Uplink	145.975 MHz (FSK/FM)
Downlink 1	435.070 MHz (FSK/FM)
Downlink 2	435.070 MHz (AFSK/FM)

AMSAT-OSCAR 16

Uplinks	145.900, 145.920, 145.940, 145.960 MHz (AFSK/FM)
Downlink (PSK)	437.02625 MHz (BPSK/SSB)
Downlink (RC)	437.05130 MHz (BPSK/SSB)
Downlink S	2401.1428 MHz (BPSK/SSB)

DOVE-OSCAR 17

Beacon 1	145.82516 MHz (AFSK/FM, digital voice/FM)
Beacon 2	145.82438 MHz (AFSK/FM, digital voice/FM)
Beacon 3	2401.2205 MHz (BPSK/SSB)

WEBERSAT-OSCAR 18

Downlink (PSK)	437.0751 MHz (BPSK/SSB)
Downlink (RC)	437.1020 MHz (BPSK/SSB)
Uplink ATV (NTSC)	1265.000 MHz (TV/AM)

LUSAT-OSCAR 19

Uplinks	145.840, 145.860, 145.880, 145.900 MHz (AFSK/FM)
Downlink (PSK)	437.15355 MHz (BPSK/SSB)
Downlink (RC)	437.12580 MHz (BPSK/SSB)
CW beacon	437.125 MHz (CW)

FUJI-OSCAR 20

Beacon	435.795 MHz (CW)
Mode JA uplink	145.900-146.000 MHz (SSB, CW)
Mode JA downlink	435.800-435.900 MHz (SSB, CW, inverting)
Mode JD uplinks	145.850, 145.870, 145.890, 145.910 MHz (AFSK/FM)
Mode JD downlink	435.910 MHz (BPSK/SSB)

AMSAT-OSCAR 21

Beacon	145.822 MHz (CW)
Beacon	145.952 MHz (BPSK/FM)
Beacon	145.983 MHz (BPSK/SSB)
Mode B uplink 1	435.022-435.102 MHz (SSB, CW)
Mode B downlink 1	145.852-145.932 MHz (SSB, CW, inverting)
RUDAK 2 uplink 1	435.016 MHz (AFSK/FM)
RUDAK 2 uplink 2	435.155 MHz (BPSK/FM)
RUDAK 2 uplink 3	435.193 MHz (BPSK/FM)
RUDAK 2 uplink 4	435.041 MHz (various modes)
RUDAK 2 downlink	145.983 MHz (various modes)
Beacon	145.948 MHz (CW)
Beacon	145.838 MHz (BPSK/FM)
Beacon	145.800 MHz (BPSK/FM)
Mode B uplink 2	435.043-435.123 MHz (SSB, CW)
Mode B downlink 2	145.866-145.946 MHz (SSB, CW, inverting)

RADIO SPUTNIK 12

Beacon/robot	29.408 MHz (CW)
Beacon/robot	29.454 MHz (CW)
Mode A uplink	145.910-145.950 MHz (SSB, CW)
Mode A downlink	29.410-29.450 MHz (SSB, CW)
Robot A uplink	145.831 MHz (CW)
Robot A downlink	29.408 or 29.454 MHz (CW)
Beacon/robot	29.408 MHz (CW)
Beacon/robot	29.454 MHz (CW)
Mode K uplink	21.210-21.250 MHz (SSB, CW)
Mode K downlink	29.410-29.450 MHz (SSB, CW)
Robot K uplink	21.129 MHz (CW)
Robot K downlink	29.408 or 29.454 MHz (CW)

Radio Sputnik 12, continued

Beacon/robot	145.912 MHz (CW)
Beacon/robot	145.959 MHz (CW)
Mode T uplink	21.210-21.250 MHz (SSB, CW)
Mode T downlink	145.910-145.950 MHz (SSB, CW)
Robot T uplink	21.129 MHz (CW)
Robot T downlink	145.912 or 145.959 MHz (CW)

RADIO SPUTNIK 13

Beacon/robot	29.458 MHz (CW)
Beacon/robot	29.504 MHz (CW)
Mode A uplink	145.960-146.000 MHz (SSB, CW)
Mode A downlink	29.460-29.500 MHz (SSB, CW)
Robot A uplink	145.840 MHz (CW)
Robot A downlink	29.458 or 29.504 MHz (CW)
Beacon/robot	29.458 MHz (CW)
Beacon/robot	29.504 MHz (CW)
Mode K uplink	21.260-21.300 MHz (SSB, CW)
Mode K downlink	29.460-29.500 MHz (SSB, CW)
Robot K uplink	21.138 MHz (CW)
Robot K downlink	29.458 or 29.504 MHz (CW)
Beacon/robot	145.862 MHz (CW)
Beacon/robot	145.908 MHz (CW)
Mode T uplink	21.260-21.300 MHz (SSB, CW)
Mode T downlink	145.960-146.000 MHz (SSB, CW)
Robot T uplink	21.138 MHz (CW)
Robot downlink	145.862 or 145.908 MHz (CW)

ROSE DIRECTORY IN THE WORKS

The Radio Amateur Telecommunications Society (RATS) is producing a directory of all RATS Open Systems Environment (ROSE) facilities operating throughout the world. If you or your organization operates one or more ROSE X.25 Packet Switches or ROSErver/PRMBS PBBSs, please let RATS know. They would like to include your system(s) in their directory. (Everyone included in the directory will receive a copy.)

The information they are requesting for ROSE Switches is: call sign, ROSE address, location, user (only) frequency, data rate. For ROSErver and PRMBS PBBSs: call sign, ROSE address (if any), location, user frequency(s) and data rate(s)

Please include information on the sponsoring organization and individual(s) including packet radio, other data and postal addresses; voice, fax, and data telephone number(s); etc.

Send directory information to:
RATS
PO Box 93
Park Ridge, NJ 076556

—from Andrew Funk, KB7UV

DO YOU RECEIVE UOSAT-OSCAR-11 BULLETINS?

If you are receiving UO-11 bulletins, please drop a postcard to UoSAT. They are very interested in hearing from folks using the satellite. If you are using the satellite for educational purposes, please send along what you are doing. UoSAT will post information in future UO-11 bulletins concerning arrived postcards. Send postcards to:

Greg Jones GØ/WD5IVD
UoSAT
Elec. Eng.
Univ. of Surrey
Guildford, Surrey
GU2 5XH, England.

—from AMSAT News Service

GATEWAY CONTRIBUTIONS

Submissions for publication in Gateway are welcome. You may submit material via the US mail to 75 Kreger Dr, Wolcott, CT 06716, or electronically, via CompuServe to user ID 70645,247, or via Internet to horzepa@evax.gdc.com. Via telephone, your editor can be reached on evenings and weekends at 203-879-1348 and he can switch a modem on line to receive text at 300, 1200 or 2400 bit/s. (Personal messages may be sent to your Gateway editor via packet radio to WA1LOU@N1DCS or IP address 44.88.0.14.)

The deadline for each installment of Gateway is the tenth day of the month preceding the issue date of *QEX*.

SURVEY FOR NEW PACKET-RADIO SATELLITE

The Naval Postgraduate School space systems department, consisting of graduate engineering students, is developing a small low-orbit spread spectrum packet-radio communications satellite due to be launched in 1993 for use by the United States Amateur Radio community. Essentially, it will be a PBBS that will fly by periodically. To obtain a good estimate of the size of the potential user base among ham radio operators and by geographic location (to make the appropriate design and protocol decisions), please answer the following survey (answer only one question per line in your responses). Send your replies to 7996p@cc.nps.

1. (Optional) What is your name, call sign and email or home PBBS address (if you have one)?
2. (a) In what state do you live ?
   (b) What major city is the nearest to your residence?
   (c) What is your postal mail ZIP Code?
   (d) If you conduct operations from a station besides your residence, what is the ZIP Code of this site? If you don't, please enter 00000.
3. Do you currently conduct packet-radio communications with your system?
4. Do you currently conduct satellite packet-radio communications?
5. If you are not involved with the fields of Amateur Radio communications enumerated in questions 3 and 4, within the next 2-4 years are you planning on investing the money to be able to add a packet-radio capability to your system?
6. Over the next 2-4 years, how much money are you willing to spend on hardware and software for the ham radio station you operate?
   (1) 0-$500 (2) $500-1000 (3) $1000-2000
   (4) $2000-4000 (5) $4000-6000 (6) over $6000
7. In the past two or three years, how much money have you spent on the hardware and software for the ham radio station you operate?
   (1) 0-$500 (2) $500-1000 (3) $1000-2000
   (4) $2000-4000 (5) $4000-6000 (6) over $6000
8. Do you currently conduct direct sequence spread spectrum communications? (By spread-spectrum, we mean utilization of pseudonoise random spreading code in transmissions.)
9. Which of the following best describes your level of interest in expanding your communications suite to include the capability to conduct spread spectrum packet-radio satellite communications?
   (1) I am not interested at all.
   (2) I am not interested, but would like to hear feedback from those who do become subscribers.
   (3) I am interested, but would like to hear feedback from those who become subscribers before me.
   (4) I am most interested. Send me any designs, prints and protocol information as soon as they become available.

Bits

FCC Streamlines Experimental License Procedures

The FCC's Office of Engineering and Technology announced today that it intends to adopt new procedures to speed up the processing of applications to conduct experiments pursuant to Part 5 of the Commission's Rules. Activities permitted under Part 5 range from the development of telecommunications equipment to the test marketing of new technologies and services.

Each year, the Commission receives between 800 and 900 applications under Part 5 and recently, the number has been growing. Since July, 1989, for instance, the Commission has received 139 applications to perform experiments relating to the new field of Personal Communications Services (PCS). In addition, data generated from experiments are expected to play a significant role in decisions to grant licensing guarantees for innovators of new technologies or services under the Commission's pioneer's preference policy adopted in April of 1991.

At the present time, the processing time for most routine Part 5 applications is about 60 days. It is anticipated that this number can be greatly decreased by treating many renewal applications on a fast track and reducing the time required to coordinate applications with the Commission's licensing bureaus. The Office of Engineering and Technology anticipates that under its new procedures, most renewal applications can be processed within a week of receipt at the Commission, and most routine applications to perform new experiments can be processed within a week of receipt at the Commission, and most routine applications to perform new experiments can be processed within 30 days.

Bits

18th Annual Eastern VHF/UHF/SHF Conference

The 18th Annual Eastern VHF/UHF/SHF Conference will be held May 22-24, 1992 at the University of Hartford. The University of Hartford campus is located off US Route 44 a short distance west of downtown Hartford, Connecticut.

Friday night will feature an informal social gathering at a location to be announced. All day Saturday there will be technical talks by well-known VHFers and "rap sessions" for each of the VHF/UHF bands. A noise-figure clinic and contest will be held on Saturday afternoon.

On Saturday evening there will be a catered banquet, followed by the popular "VHF Trivia" quiz and additional informal social activities. Sunday morning there will be antenna gain measurements (222 MHz through 2304 MHz, weather permitting) and an informal swap-fest.

The conference registration fee this year is $24.00 prior to May 15, which includes annual membership in the Eastern VHF Society and printed conference proceedings. Registration at the door will be $30.00, so it pays to send in your money in advance! The Saturday night banquet will cost $22.00, also payable in advance.

The registration chairman is David Knight, KA1DT, 15 Oakdale Ave., Nashua, NH 03062. Those who have attended in recent years will receive a preregistration packet. Otherwise, please contact W1EJ, KA1DT, or W1GXT for a registration form (A self-addressed, stamped envelope is appreciated!)

Housing will be available in dormitory rooms at the University. The room rates per night are $30.00 per person, payable by May 15. There are numerous hotels and motels nearby for those wishing to make their own arrangements. Many have special weekend rates, if you ask when making reservations. A list will be included with your registration materials.

Papers for the conference are being solicited for publication in the proceedings. Contact conference chairman Tom Kirby, W1EJ, PO Box 455 Pelham, NH 03076 for details.

The conference is sponsored by the Eastern VHF Society and the NEVHF Association with assistance from volunteers from the New England VHF community and the Hamden County Radio Association.