• *Two-Meter DX Via Satellite Translator.*

Communicating Through Oscar III

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Amateur space communications are due to begin this year, using the internationally allocated amateur space communications frequency assignment in the two-meter band. A new Oscar satellite, third in the series, is being readied for orbiting this fall. It will enable amateurs to establish two way contacts over distances of up to 2000 miles.

Oscar III

Oscar III is to be a radio-frequency translator. It will accept any number of input signals of any mode in a 50-kc.-wide channel (144.075 to 144.125 Mc.), and will retransmit these signals higher in the same band (145.925 to 145.875 Mc.). A signal entering the translator will be converted to a lower frequency (30 Mc.), amplified, passed through a 50-kc.-bandwidth filter, converted up to a frequency within the transmitting channel, amplified, and radiated from a dipole antenna. In this process, a signal entering the high-frequency end of the input channel will be reradiated at the low-frequency end of the output channel.

In addition to the translator, the Oscar III satellite package will contain two beacon transmitters. The first beacon (145.850 Mc.) will transmit the "HI" identifier. Three channels of telemetry will be transmitted, using the HI rate, as in Oscars I and II, plus two groups of variable-width pulses interspersed between the HIs. The second beacon (145.950 Mc.) will transmit a continuous carrier for special tracking purposes, such as for stations with phase-lock receivers For a more complete discussion of the Oscar III package, see the article by Art Walters, W6DKH, in an early issue of *QST*.

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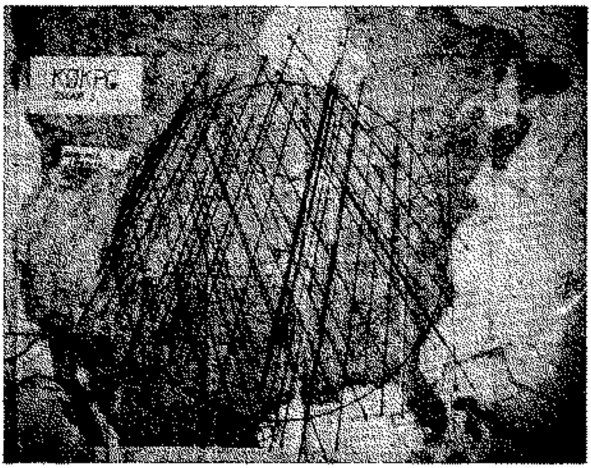
Doppler and Oscar III

The frequency inversion mentioned above is designed to reduce the total frequency shift observed by the receiving operator. A signal traveling from the ground to the satellite may shift as much as 8 kc. lower during a pass. If the inversion were not incorporated, the relayed signals would be shifted downward an additional amount between the satellite and the receiving station. The total Doppler shift could then be as much as 16 kc., but the inversion limits the shift to a maximum of 8 kc. The net frequency shift observed at the receiving station will be the satellite-to-receiver shift minus the transmitter-to-satellite shift. It will be possible to observe a net upward frequency shift for cases where the subsatellite track approaches closer to the transmitting than to the receiving station.

After they have been shifted by the Doppler effect, signals transmitted to the satellite must fall within the translator input channel frequency limits. There will be times when signals transmitted as much as 4 kc. outside the channel limits will be relayed through the satellite. At other times, signals transmitted as much as 4 kc. within the input channel limits will fall at the edge of or outside these limits. In the same fashion, signals relayed through the translator will be received at the ground at frequencies as much as 4 kc. above or below the frequency limits of the output channel.

Transmitting stations must transmit within the frequency range of 144.079 to 144.121 Mc. to be certain of entering the input channel of the translator for all relative positions of satellite and transmitter site. This is 8 kc. less than the width of the translator input channel. However, all or part of the frequencies from 144.071 to 144.079 Mc. may be used when the satellite is approaching the transmitting sta-



Oscar II data provides a means of observing the geographic coverage by a tracking station. This information forms the basis for evaluating possible operating range when the satellite carries an active communications repeater unit. (Courtesy KØKPG) tion. All or part of the frequencies from 144.121 to 144.129 Mc. may be used after the satellite has passed the p.c.a.,[1] and is going away from the transmitting station. At any instant, the usable channel width at a given ground location will be 50 kc. But, from all ground locations within range of the satellite, there may be stations transmitting over a 58-kc. range (144.071 to 144.129 Mc.).

The same considerations will apply to the translator output channel. Signals may be received from the satellite over the frequency range from 145.871 to 145.929 Mc. over a period of time, although, at any instant, the received band will be 50 kc. wide.

Ground Stations

The design of the Oscar III package involved a tradeoff between operating life, range of communication, and package weight. These factors established one watt as the average power output. The link calculations from the ground to the satellite were based upon 1 kw. e.r.p. (effective radiated power). One hundred watts into an antenna with 10 db. forward gain should do the job. It has been possible to obtain a transfer gain of 110 db. through the translator, which will make it possible for 1 kw. e.r.p. to drive the translator to one full watt of output at a range of 1000 miles. If one signal, or a combination of signals, exceeds 10^{-11} watts (110 db. below 1 watt), the a.l.c. system will limit the output to one watt by reducing the over-all gain of the translator.

When the translator is operating at maximum gain, the ground station transmitting power can be far less than one kw. e.r.p. At 1000 miles, 10 watts into a 10-db.-gain antenna would appear at the translator output at a power level equal to that of the Oscar II beacon transmitter. The same translator output can be obtained at the p.c.a. of an overhead pass with one watt into a horizontal dipole antenna.

Satellite Tracking

Here is where the tracking experience gained from Oscars I and II will pay off. Before an operator can communicate via any satellite, he must be able to acquire and track it. The most efficient use of Oscar II will be made by those operators who have the best prediction and tracking techniques, and who are, at all times during a pass, able to visualize the relative positions of the satellite and the station they are contacting.

Some idea of the possible area of coverage may be obtained by mapping observations from the earlier satellites, as was done for the Oscar II reports submitted by KØKPG (see map, left). His operating range to the subsatellite track is about 1200 miles in nearly all directions, although there seems to be a zone between 270 and 315 degrees where it is limited to about 1000 miles. This is still very good performance, considering that the median range limit for all reporting stations was 1000 miles. For those stations that submitted Oscar II reports (including latitude and longitude), the Project Oscar Association can, on request, provide the information needed to map their observations.

[1] Point of Closest Approach. A glossary of terms used in this article appears on this page.

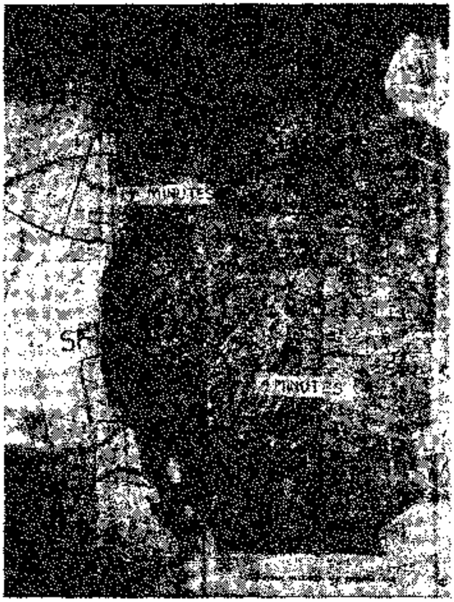


Fig. 1—The overlapping areas of 1000-mile range arcs around San Francisco (SF), Juneau (J), and Dallas (D) shows the zones where inter-city contacts are possible by way of a repeater satellite.

Once the Oscar II reports have been mapped, the pattern can be extended radially about 1000 miles to show the normal coverage which may be expected for Oscar III. Lacking this, a circle of 2000 miles' radius should cover the normal communication range. A 1000-mile-radius circle will define the area over which the satellite must pass before any communication would be possible. The nearer the target is to the 2000-mile circle, the fewer contact opportunities will occur, and the shorter will be their durations. The great circle direction between the stations will also

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GLOSSARY OF TERMS

Subsatellite Point: The point where a line joining a satellite with the center of the earth would intercept the surface of the earth.

Subsatellite Track: An imaginary line described on the surface of the earth by the motion of the subsatellite point.

PCA: The Point of Closest Approach is the location along an orbit where a satellite is at its nearest to an observing station.

TCA: The Time of Closest Approach is the time during a pass when the satellite is at its p.c.a. Also the time when Doppler shift of signals between satellite and observer is zero.

Acquire: The initial reception of signals from a satellite on a given pass.

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control the regularity and duration of contacts, as will be illustrated by the following example.

Arcs representing 1000-mile working radii were drawn on a map around San Francisco, Juneau, and Dallas (see Fig. 1). The overlapping area of the San Francisco and Juneau arcs represents the zone of normal contacts between these two cities via the satellite. The dashed line shows a subsatellite track for a north-to-south pass over these two cities. It takes about 90 seconds for the satellite to cross the widest part of this zone. On the other hand, the pattern spreads across more than 25 degrees of longitude, so that at least one, and occasionally two, north-to-south passes each day will pass through this zone.

The San Francisco-Dallas arcs on the same map show the other extreme, a south-to-north pass traveling the length of the overlapping area. This type of pass would last for about 4 minutes, but it can be readily seen that this will be a rare event. The subsatellite track would only have to shift about 5 degrees east or west to completely miss the pattern.

Operating Tactics

Maximum usage of the translator will be achieved when all stations within a few hundred miles of the satellite restrict their operating power to the minimum value necessary to maintain communications. By holding the a.l.c. action down, more stations will be able to use the satellite, and the 2000-mile-plus stations will have a better chance of being heard.

Stations in locations where little or no two-meter activity exists may be able to make some DX contacts by transmitting a signal through the satellite even though no other stations are heard. Again, overdriving the translator is not desirable, because it would limit the translator gain and reduce the sensitivity to possible replies. This is particularly true if full duplex is possible, or if one operator listens while another station is transmitting to the satellite. It will be particularly valuable if African, South American, and mid-Pacific stations can keep the translator active whenever it is passing over their areas.

The Doppler shift of signals entering the input channel may be used to advantage during contacts over north-to-south paths, such as the Juneau-to-San Francisco path shown on the map. During the southbound pass illustrated, the Alaska station can enter the satellite input channel by transmitting on a frequency 2 kc. above the nominal upper band limit, while the California station can respond by transmitting on a frequency 2 kc. below the nominal lower band limit. Throughout the possible contact zone, the satellite is traveling away from the Alaska station, and lowering his transmitting frequency as seen by the translator. As the satellite approaches the California station, it raises his frequency as seen at the translator input. By the time the frequency of the California station drops out of the input band of the translator, the contact would have been terminated by the satellite going out of range of the Alaska station.

Information Reporting

Communication operations may be reported to Project Oscar, P.O. Box 183, Sunnyvale, California, in the form of extracts from the station log, with particular emphasis on precise times of starting and ending contacts, and accurate notations of the transmitting frequency used. All calls made, successful or not, should be recorded so that listener reports may be cross-checked. To supplement the log, a summary of the station equipment — transmitter power, receiver noise figure, antenna gain and polarization — would be appreciated. Also, please give station latitude, longitude, and altitude above sea level, and describe any special site characteristics, such as unusual noise conditions, horizon-masking directions, etc. At all events, *do not* send your original log.

The following articles are suggested review reading for those who wish further information on satellite tracking techniques.

Giro, "Planning Oscar's Orbit with Ease," *CQ*, June, 1962.

Hilton, "Making Your Own Orbital Predictions," *QST*, March, 1962.

Walters, Wells, and Hillesland, "Project Oscar Measurements and Tracking," *QST*, July, 1961. QST

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