AUSTRALIS-OSCAR 5 REPORT*

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PART 1 - 144.050 MHz RECEPTION

This section of our report is on our observation of the 144.050 MHz signals. We were primarily interested in the telemetry system and the magnetic attitude stabilization system (MASS) experiments. We will also comment on the propagation of the 144.050 MHz signals, although nothing new over the past Oscar experiments and our tracking on 136 MHz was observed.

The telemetry system was far superior to any of the past Oscar telemetry systems used and seemed to perform excellently. The telemetry could be decoded even in the final orbits when we had a poor signal-to-noise ratio due to weak signals from the satellite.

Our decoding system was an audio amplifier with dual inputs, one for the telemetry signal and the other for the audio signal from an audio generator. We used a null meter to determine "zero beat." Also, we could monitor the "zero beat" aurally on a speaker. We then measured the frequency of the audio generator and did not have to be concerned with receiver noise. The repeatability of the telemetry data indicated the system was working adequately well. We used WWV to calibrate the audio signal.

We did most of our data collecting during the early morning orbits so as to have a "cool and light" ionosphere to deal with. This gave us a stronger signal and a signal with less ionospheric upsets and made polarization measurements easier. In the early morning hours it was much easier to determine the terminator line, and also the sun and moon were more easily identified. By knowing the location of these three elements it was less work and it made identification of the three light sensors data more meaningful. Also, we could make better correlation of the sensor and polarization data.

The temperature stabilization system worked well. It was very interesting to watch the internal temperature climb and stabilize after launch. The internal temperature on orbit #1 was still about the same as that at the launch site, i.e., 24 degrees Centigrade. Orbit #4 showed 30 degrees; orbit #5, 32 degrees; orbit #6, 40 degrees; and by orbit #78 the temperature stabilized out to between 47 and 49 degrees Centigrade. The temperature remained very stable internally throughout the remaining active orbits of the 144.050 transmitter and telemetry system.

The internal skin temperature showed a wider variation, ranging from a low of 45 degrees to a high of 63 degrees Centigrade. During the night-time and early morning passes, on the south-bound node, it was interesting to watch the internal skin temperature drop as the satellite passed from daylight to Earth shadow. The temperature change was usually about 6 degrees Centigrade, but on some orbits it changed by as much as 12 degrees. During the day-time passes, when the satellite was in full sunlight, the internal skin temperature showed only a variation of about 3 degrees.

*Ed. note: This is the summary of a 43 page report received on March 26, 1970. It was one of the most complete and thorough reports received by AMSAT.

We did notice that the internal skin temperature and the "X" light sensor followed each other. When the "X" sensor was active, indicating sunlight, the internal skin temperature would be at its maximum. This was probably due to the internal skin temperature sensor being mounted on the same side of the satellite as the "X" light sensor.

During the early morning south-bound far-west passes, we did notice that the light sensors produced not a slowly changing or constant tone but a warble. This may have been due to the sun's rays being filtered through the mountain peaks in western Canada and the western United States. We did not notice this effect on the passes further to the east prior to this type of pass.

The light sensor system and the MASS experiment seemed to work. During the first few orbits the spin rate averaged 3.5 rpm. This was measured using the light sensor data and measuring the incoming polarization. We did our incoming wavefront polarization measurements on 144.050 MHz rather than on 29.450 MHz because of Faraday rotation. Faraday rotation made it very difficult to get any correlation between incoming wavefront polarization and light sensor data. By orbit #11 the spin rate had slowed to 3.3 rpm, orbit #19 was 2.8 rpm, orbit #36 was 0.75 rpm, orbit #69 was 0.6 rpm and by orbit #74 the spin rate was down to 0.2 rpm, giving an almost fade-free signal on 144.050 MHz. The fades were very shallow, about 5 dB, and the polarization of the 144.050 MHz signal was almost purely horizontal with a slight slant. As the satellite crossed North America, the 144.050 MHz antenna seemed to be parallel to the surface of the Earth with the antenna pointing in a north-south direction. The spin axis seemed to be on an oblique angle around the 144.050 MHz antenna, causing an orthogonal spin. All of the above conclusions were made using light sensor data and wavefront polarization measurements.

After about seven days in orbit it would take over three complete telemetry sequences for one light sensor to make a complete scan. The "X", "Y" and "Z" light sensors were sequential in their scanning. After 14 days in orbit the passes were not long enough for the satellite to make one complete revolution and give a complete light sensor data pattern. After the satellite had stabilized we found that horizontal polarization seemed to work well for receiving the satellite on 144.050 MHz. We did lose the signal when we would switch to vertical polarization. The drop in signal level was around 35 dB. The 29.450 MHz antenna seemed to be spinning in a vertical position. We did get some excellent antenna-tip nulls when the satellite was passing in or near zenith. We also had a lot of sun and moon pick-ups by the light sensors.

The propagation of signals on 144.050 MHz was the same as seen on the previous Oscar satellites and on 136 MHz tracking. We had a rather quiet ionosphere during the active time of the 144.050 MHz transmitter. The signals were always good on all portions of the orbit below 65 degrees latitude. As expected, when in the far northern latitudes, the 144.050 MHz signal was disturbed by the heavy ion and electron concentration around the magnetic poles. On a north-bound pass, 45 seconds prior to full acquisition of the 144.050 MHz signal, we would make a very short acquisition, sometimes only 3 to 5 seconds long. The signal at acquisition was usually quite good. When the satellite signal propagation was making the transition from full refraction to line-of-sight, the Doppler shift was quite large. After this period, signal propagation was very predictable. We did encounter some trouble with the daytime passes due to the heavy ionosphere. Signals were generally weaker and the polarization measurements were not as smooth as during the early morning and night-time passes. When the satellite, on the north-bound node, passed through the polar region the signals would become badly disturbed with a wide variation in signal levels and polarization. After passing through the polar refractive period the signal would surge upward in level as propagation went to true refraction. Signal loss would occur about 50 seconds after going to true refraction. This whole process would be reversed for a south-bound node, except we would not have the heavy ionosphere to deal with, as the south-bound nodes occurred during the night and early morning.

To summarize the reception at 144.050 MHz, the signal level seemed adequate and the telemetry was excellent. Signal propagation was normal and predictable.

PART 2 - 29.450 MHz RECEPTION

This portion of the report deals with our observations of the 29.450 MHz beacon and discusses signal levels, north-bound vs. south-bound orbits, 29.450 MHz vs. 144.050 MHz reception, effects of the solar eclipse on propagation, and the final orbits of Australis-Oscar 5.

Our antenna system for 29.450 MHz reception was a simple ground plane. We had planned to make our greatest effort for the Australis-Oscar 5 experiment on 144.050 MHz so the 29.450 MHz beacon did not immediately receive much attention. After the end-of-life of the 144.050 MHz signal, we decided to make a propagation study of the 29.450 MHz beacon and were very interested in some of our findings vs. those known about the 144 MHz propagation.

We were a little skeptical as to whether we would be able to receive enough signal with the ground plane antenna. As it turned out, we were able to receive adequate signal. It was also convenient not to have to rotate a beam, and with the 45 degree radiation angle it worked out quite well on the close-in passes when the satellite was at or near zenith.

The signal levels received on 29.450 MHz averaged about 42 dB above noise on a close-in crossing during the night-time. The daytime north-bound passes did have some attenuation of the signal, with most daytime passes giving a signal level 15 dB above noise. As time progressed, the signal level showed a gradual decay up to the last two days, when the signal level dropped off rapidly. The last orbit received here on 29.450 MHz was orbit #581. The signal level on orbit #581 was only about 1 to 2 dB above the noise on peaks. On orbit #581 we were using a high-gain preamplifier and a 2.5 Hz bandpass on the tracking filter.

We found no malfunctions of the 29.450 MHz beacon except for the low-level modulation. It would have been of great help in our study of the propagation if the telemetry would have been usable on the 29.450 MHz beacon to help us determine the fade rate and attitude of the satellite.

In comparing the 144.050 MHz and 29.450 MHz propagation, there was a great difference between the two frequencies. The first major difference was the large amount of Faraday rotation of the 29.450 MHz signal which was not too pronounced at 144.050 MHz. Secondly, the refractive process of the two frequencies differed greatly. The only time that the 144.050 MHz signal was propagated by refraction was for a short period of time at acquisition of signal (AOS) and again just prior to loss of signal (LOS). The 29.450 MHz signal,on the other hand, seemed to be refracted at all times. On 144.050 MHz, the signal usually had no trouble penetrating the ionosphere except when in the polar region and occasionally on a daytime pass when the ionosphere was agitated by high solar activity. The only time that we can say that the 144.050 MHz signal was propagated by refraction was when it was below the horizon. This refractive period lasted only for a short time, usually about 60 seconds. It was always quite easy to tell the 144.050 MHz refractive period, as the signal level would fluctuate at random and we would always have trouble measuring the polarization. About 60 seconds prior to LOS the signal would take a large upward surge and then would fluctuate at random and gradually fade out. This was true for both the north- and south-bound passes. It was sometimes difficult to determine the refractive period on the north-bound nodes, as the signal had to travel through the heavy polar region and this region always caused a major amount of disturbance to the signal.

The only correlation found between the 144.050 MHz and the 29.450 MHz signals was when the two signals had to travel through the polar region. This region, with its heavy electron content, disturbed the signals at both frequencies causing large signal amplitude changes and a rapid change in the polarization.

The 29.450 MHz signal differed greatly from that at 144.050 MHz. This is due to the signal being refracted all of the time. The inability of the 29.450 MHz signal to easily penetrate the ionosphere was also characterized by Faraday rotation of the signal. The amount and rate of Faraday rotation depends on several factors, including the angle of incidence at which the signal passes through the magnetic lines of force of the Earth, the electron content of the signal path, the spin rate of the satellite and the type of transmitting antenna of the satellite. The spin rate and type of transmitting antenna will only have an effect on the observed Faraday rotation.

We will now apply some of our observations to the above known facts. We will use mostly north-bound nodes, as the south-bound nodes are more complex due to the polar disturbance. We have found that the closer to the horizon and the further away from the satellite, the greater the amount of Faraday rotation. On the passes when the equatorial crossing was between 45 and 50 degrees at AOS the Faraday rotation would be very rapid, usually about 0.2 seconds per fade. This probably was due to the low angle of incidence and the low angle of elevation, on the horizon, causing the signal to travel along a path that would have the greatest electron content. As the satellite progressed north, the Faraday rotation fade rate would decrease. This was due to the elevation angle increasing, giving a signal path with less electron content, and also the angle of incidence was increasing. The fade rate would continue to decrease until the signal was passing at 90 degrees, or perpendicular to the magnetic lines of force. The fade rate at this time was about 20 to 22 seconds long. Shortly after passing this point, the signal would enter the polar region and become disturbed. It was impossible to tell if the fade rate was increasing, as the fade rates would be very irregular, making accurate measurements impossible. As the equatorial crossing moved to the west, bringing the satellite crossing closer to us, the fade rate at acquisition would be decreasing. For an overhead pass equatorial crossing the fade rate at acquisition was usually about 2 seconds in length. When the satellite was at zenith, the fade rate was about 20 to 22 seconds per fade.

For the night-time passes, when the satellite was south-bound, there was some difference in the Faraday rotation. This was probably the result of the lighter and cooler ionosphere. From AOS until the satellite crossed 60 degrees North latitude, the signal would be badly disturbed by the polar region. We found no difference in the daytime or night-time polar region disturbance. After the satellite had traversed the polar region, the signal would smooth out and have a fade rate of about 3 seconds, lengthening to about 22 seconds at closest approach. As the satellite moved south, the fade rate would increase to 2 seconds per fade prior to LOS. About 3 minutes prior to LOS the signal on south-bound passes would go through a short period of disturbance and the apparent frequency of the satellite would shift from 25 to 100 Hz. This happened on just about all south-bound passes except during the final days of the satellite's life when we went through a major solar disturbance. Also, this observation was only noticed on passes that crossed slightly east, overhead, or slightly west of us. This sudden apparent frequency change was probably due to the satellite going from line-of-sight refraction to below-the-horizon refraction. As the signal would make this path transition, the signal would have a rapid change in velocity of propagation, causing the sudden change in frequency.

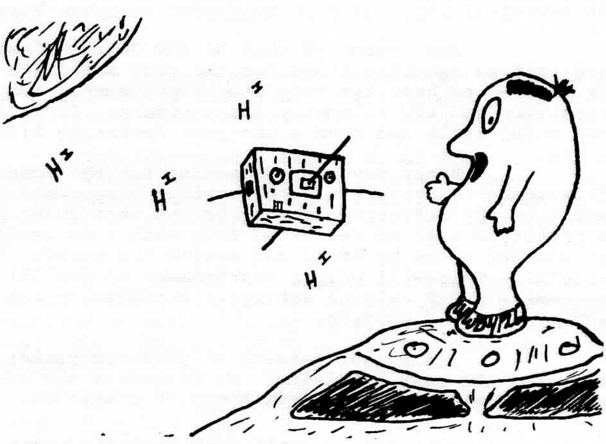
The length of time for a pass averaged around 20 minutes for a close-in pass. We did have several instances of prolonged signal reception. The longest pass received was orbit #368 lasting for 53 minutes. Orbit #368 was a daytime north-bound pass. The signal after passing through the polar region was weak, with periods of higher signal level. This prolonged reception was probably the result of ducting.

We were fortunate to have the satellite pass in conjunction with a solar eclipse on March 7th on orbit #542. What we were expecting to observe when the satellite passed through the umbra or region where the umbra had passed was a change or departure from the normal Faraday rotation as observed on orbits of similar equatorial crossings. In preparation for orbit #542 we took several orbits with comparable equatorial crossings and plotted the fade rate versus time from AOS to the polar region disturbance. We then plotted these passes graphically. On orbit #542 we also plotted the Faraday rotation fade rate. From the plots and our observation of orbit #542 we found no change in the propagation during the solar eclipse. About 10 minutes following LOS of orbit #542, the signals on the ten-meter band started to fade out. The W4's were the first to fade out, although prior to this time they were very strong. The band became very quiet except for a couple of W7's and a few W6's. The band remained quiet for about 54 minutes.

After this length of time the band returned to normal with the W4's coming in very strong. The direction and length of the "blackout" could indicate a possible connection with the solar eclipse. The W4's being affected first gave us the proper direction, and the length of time of the blackout would be the amount of time it would take us to rotate under and clear the area of the solar eclipse umbra. It is possible that it would take a period of time for the ionosphere to react to the loss of sunlight. It is also possible that a solar flare occurred during this time, as the sun was very active and several large sunspots had been observed. We checked with the National Bureau of Standards and they said that no solar flare occurred during this time.

To conclude our observations of orbit #542 during the solar eclipse, no departure from the normal was seen but a blackout was observed on the ten-meter band following the solar eclipse.

The final active orbits of Australis-Oscar 5 received at this station showed a rapid decay in signal strength during the last two days. The first poor pass that we received was orbit #578. This pass was usually quite disturbed but of good signal level. On this pass we only received the signal for 11 seconds and the signal was very weak. Orbit #581 was the next pass received. This was a near overhead pass and should have been quite strong. However, the signal was very weak, only about 1 or 2 dB above noise. This was the last orbit of Australis-Oscar 5 received at this station. We did attempt to receive orbit #587, 588, 600, 611, 623 and 624, but nothing further was heard.



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"Hi to you too, little fellow!"