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OPTIMUM GRARR ANTENNA POLARIZATION FOR OPERATION WITH IMP SATELLITES

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GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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INTRODUCTION

The IMP satellites are spin stabilized and do not enjoy the luxury of an earth oriented antenna system. They require an omnidirectional type antenna system such as the Canted Turnstile (Reference 1) since their aspect angle is continually changing as viewed from the earth. The canted turnstile has a standard IEEE antenna pattern. Its polarization is right hand circular when viewed from the bottom, left hand circular when viewed from the top, and linear when viewed near the center. Unfortunately this requires an adjusting in the polarization of the Goddard Range and Range Rate (GRARR) system (Reference 2) antennas to provide the best match to that of the received signal prior to each tracking mission.

A study was undertaken to investigate the possible existence of a correlation pattern between optimum polarization and orbit position. This pattern could be used as apriori information to eliminate the cumbersome requirement of actually measuring the signal level of all four possible configurations (left hand circular, right hand circular, parallel to X, and parallel to Y) prior to each interrogation.

TEST PROCEDURES

The signal level versus antenna polarization data presented here in graphical form was taken over a two-week period (from October 2 to 16, 1967) by the Carnarvon (C), Tananarive (T) and Rosman (R) stations. Each entry shows the variation in signal level over a one-minute sampling interval. Signal level measurements taken earlier by Santiago in connection with AIMP-D are also included as part of this study. Since the end result of this study was the determination of an a priori optimum antenna to orbit position correlation pattern, no adjustment was made for variations in signal level due to background noise, or for degradation of signal level (while in the linear modes) associated with the use of an X-Y type mount.

A measure of the variations in signal level from AIMP-E (as recorded by the GRARR system) was obtained as a result of a continuous orbit tracking mission carried out on September 25, 1967. The record is in terms of the variations in signal while using the optimum antenna polarization required for the tracking interrogations; and in terms of samplings using other polarizations taken during the non-interrogation intervals. All levels are measured in terms of the carrier AGC as shown on the system's Sanborn Recorder operating at a speed of 5 mm/sec.

RESULTS

The data shown in Figures 1 and 2 are for AIMP-D. Figure 1 shows the recorded variations in signal levels as a function of antenna polarization for one orbit. Figure 2 is a composite of the average received signal levels for all polarizations superimposed on each other, and is designed to show their relationship with orbit position. An examination of Figure 2 shows the nonexistence of an adequate a priori correlation between optimum antenna polarization and orbit position taken over a single orbit.

The data shown in Figures 3 and 4 are for IMP-F. Figure 3 shows the variation in signal levels as a function of antenna polarization for several orbits. Figure 4 is a composite of the average received signal levels for all polarizations superimposed on each other and is designed to show their relationship over several orbits. An examination of Figure 4 shows the nonexistence of an adequate a priori correlation function between optimum antenna polarization and orbit position taken over several orbits.

The data shown in Figures 5 and 6 are for AIMP-E. Figure 5 shows the variations in signal levels as a function of antenna polarization for portions of many orbits. Figure 6 is a composite of the average received signal levels for all polarizations superimposed on each other, and is designed to show their relationship over many orbits. An examination of Figure 6 shows the nonexistence of an adequate a priori correlation over many orbits.

The data presented in Figures 7 and 8 show the variation in signal level over an expanded portion of the AIMP-D orbit. Taken earlier by Santiago GRARR — Figure 7 shows the variation in signal level over a small part of the orbit as a function of antenna polarization on an hourly basis. Figure 8 is again a composite of the received signal levels for all polarizations designed to show their relationships as a function of position in the orbit.

The recordings taken during the continuous AIMP-E orbit were carefully analyzed. On the whole, the received signal was consistently adequate in both level and smoothness for ranging purposes. However variations in level due to unexplained glitches, atmospheric disturbances and changes in optimum antenna polarization were clearly evident. Typical examples are shown in the attached

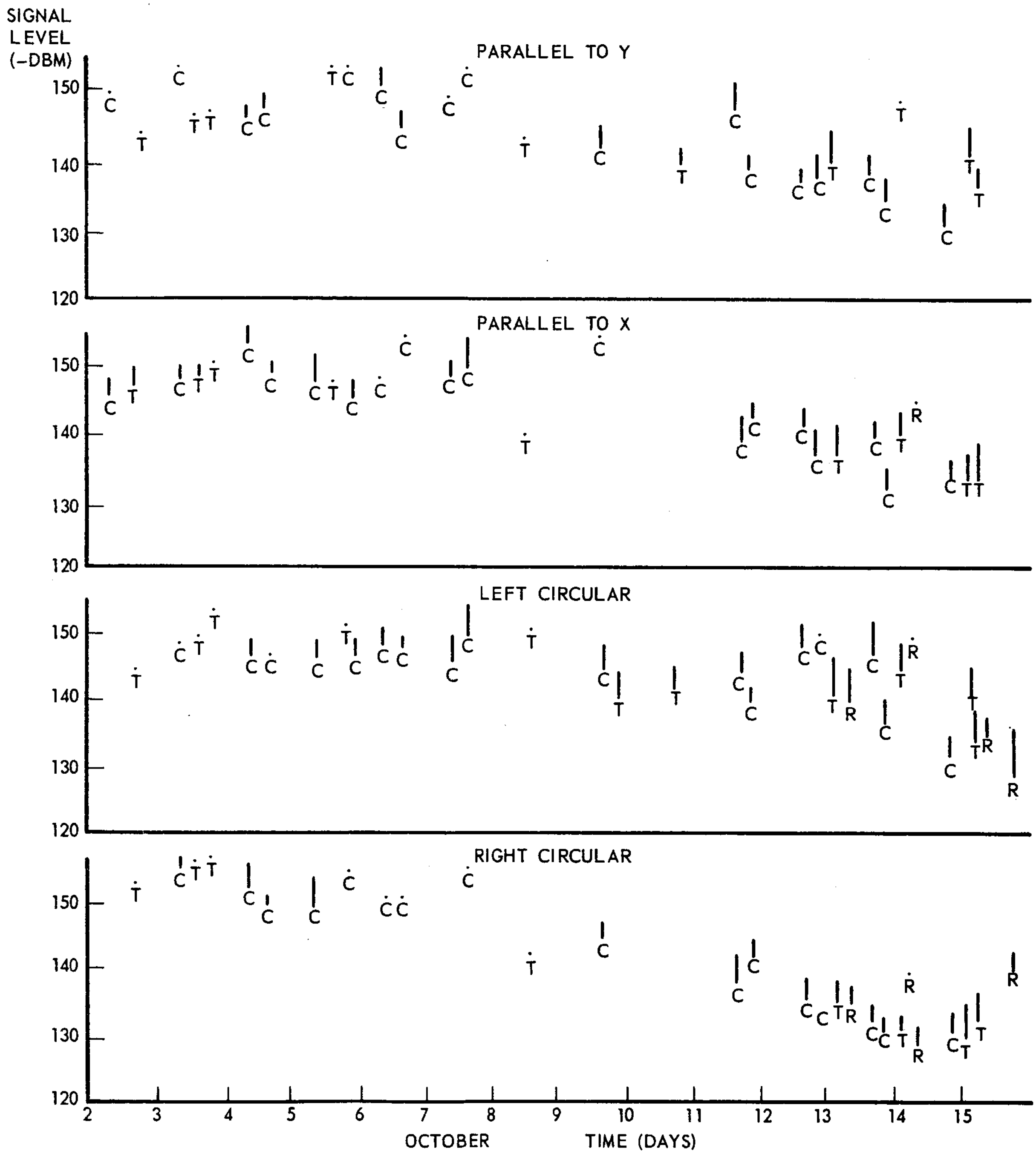


Figure 1. Received Signal Strength for Various Antenna Polarizations as a Function of Time for AIMP-D

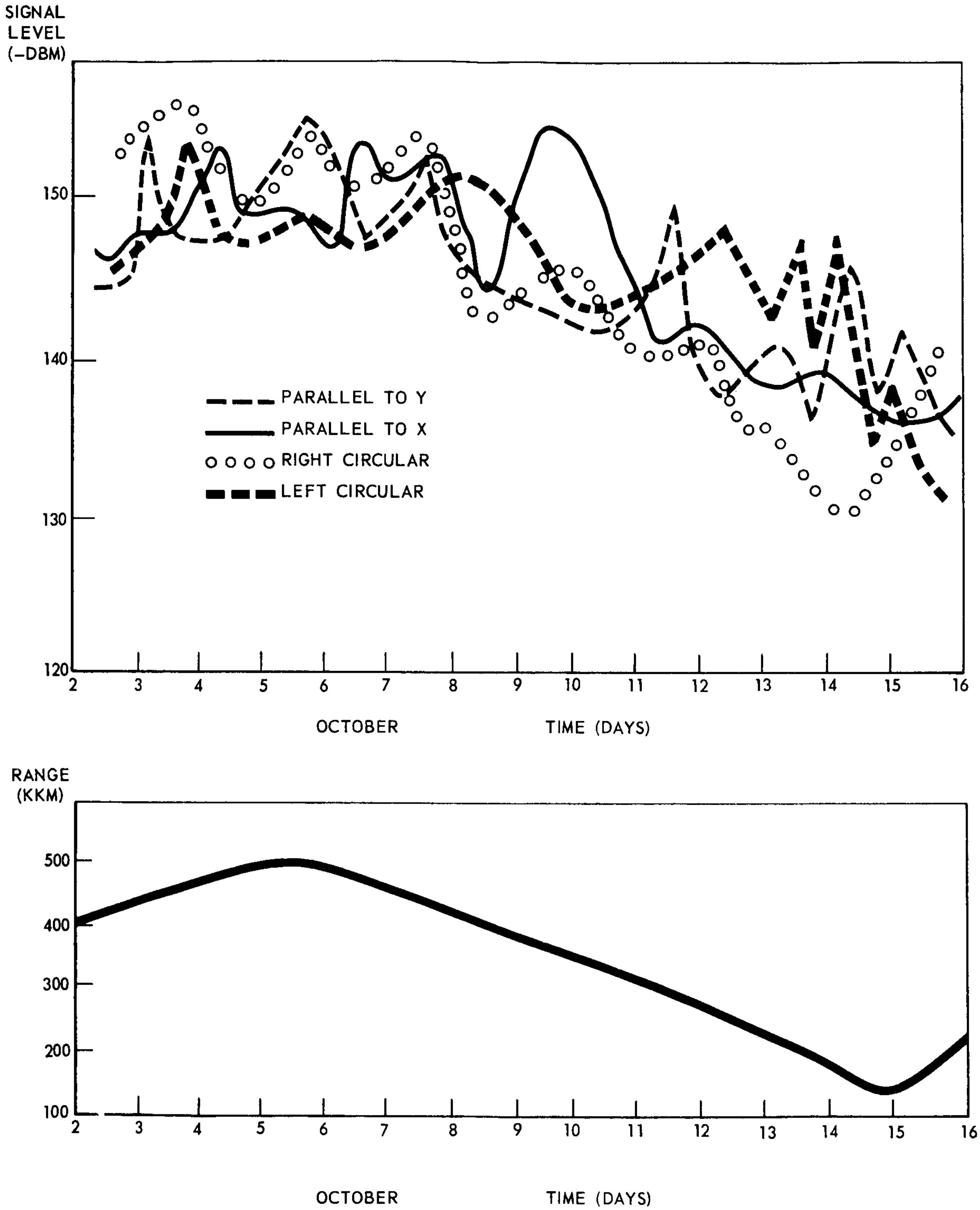


Figure 2. Received Signal Level (as a Function of Antenna Polarization) and Range vs Time for AIMP-D

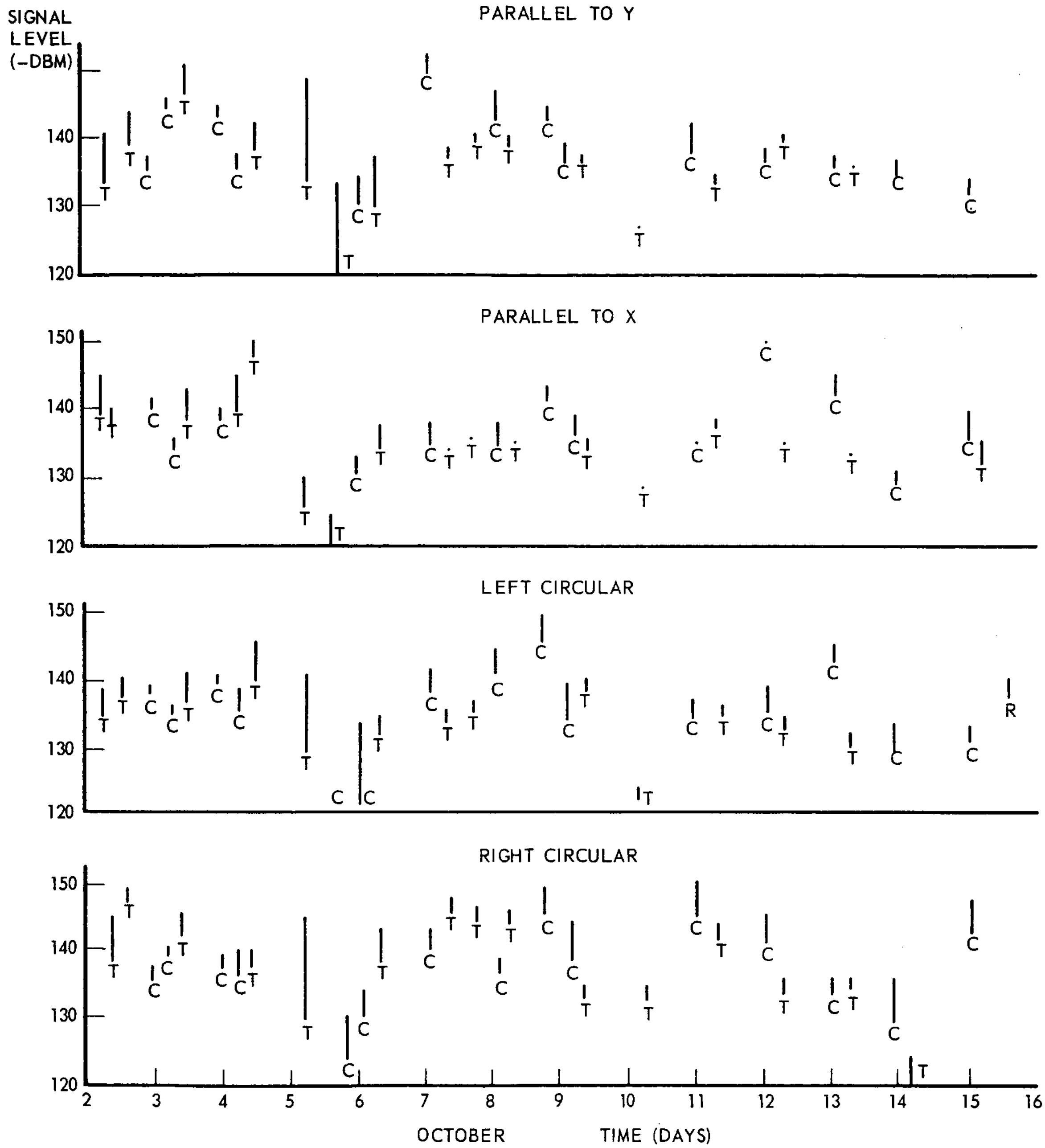


Figure 3. Received Signal Strength for Various Antenna Polarizations as a Function of Time for IMP-F

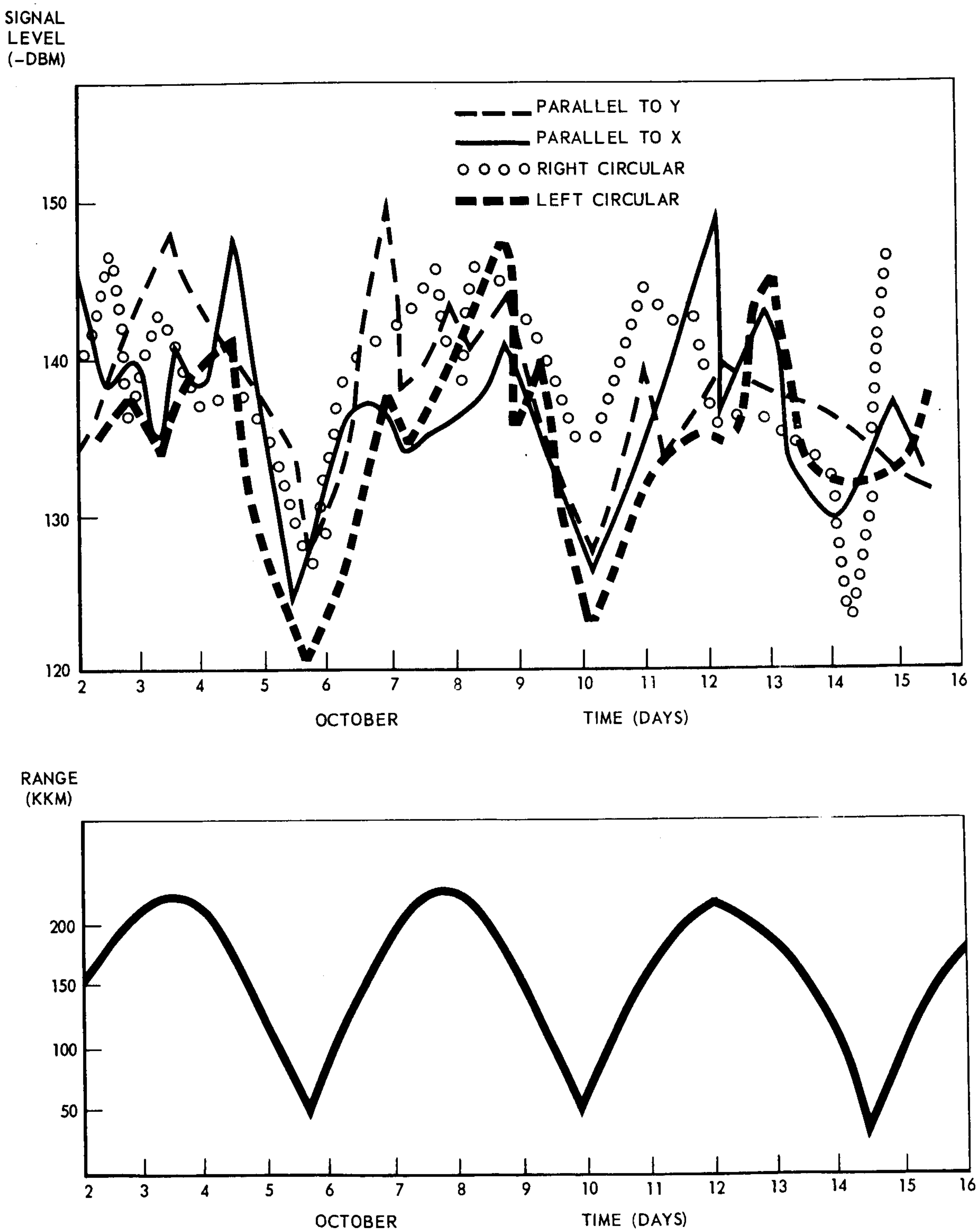


Figure 4. Received Signal Level (as a Function of Antenna Polarization) and Range vs Time for IMP-F

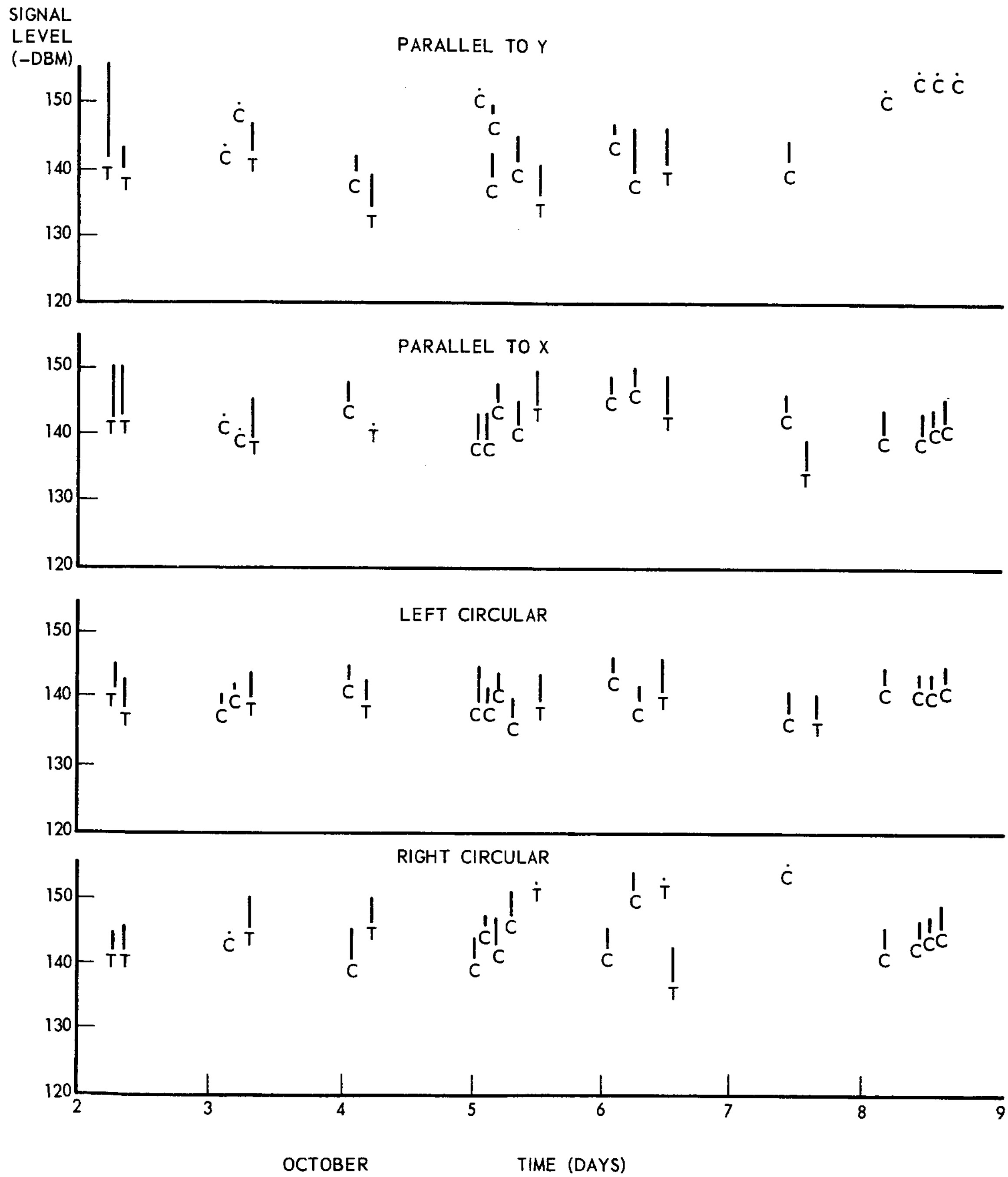
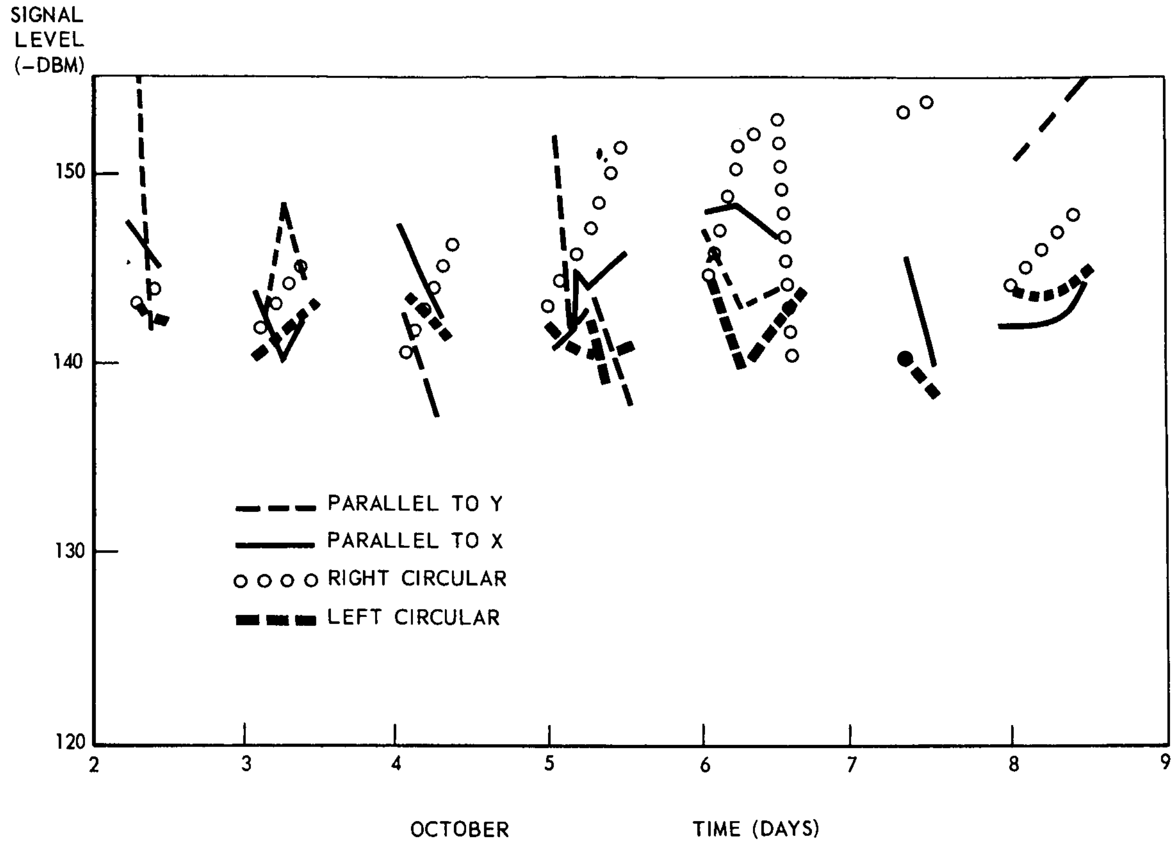


Figure 5. Received Signal Strength for Various Antenna Polarizations as a Function of Time for AIMP-E



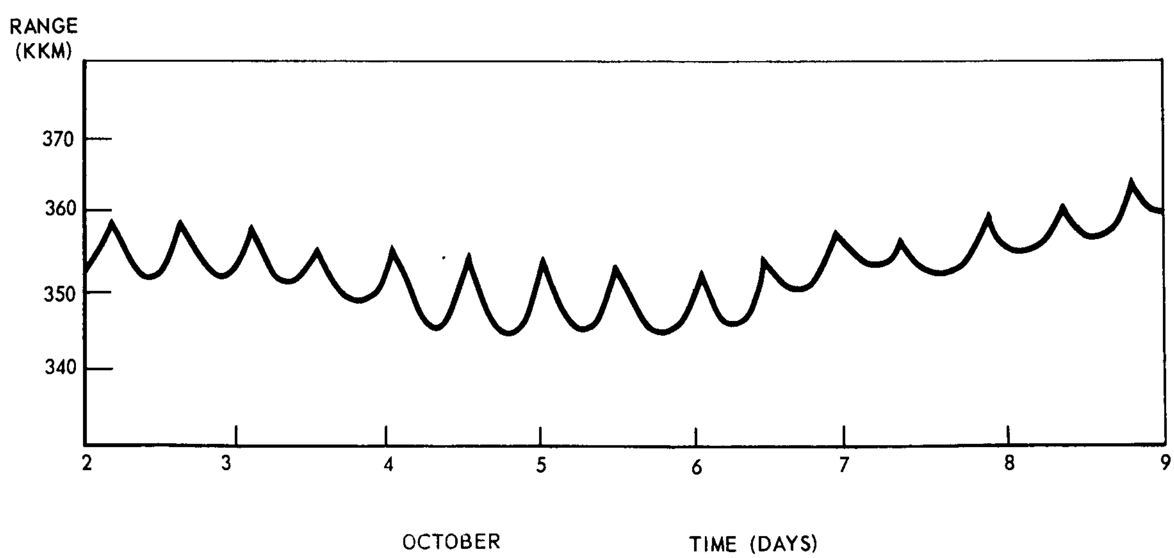


Figure 6. Received Signal Level (as a Function of Antenna Polarization) and Range vs Time for AIMP-E

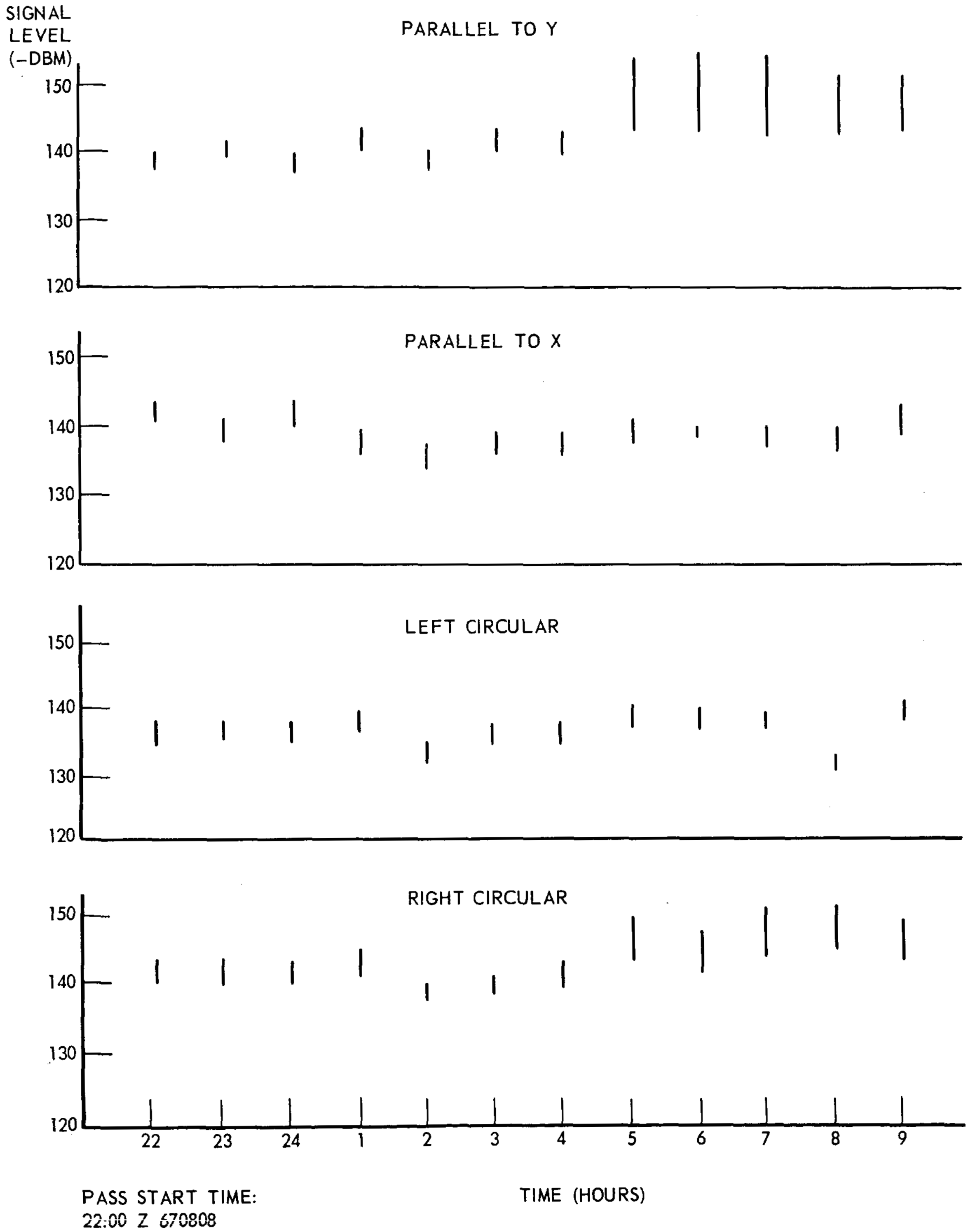


Figure 7. Received Signal Strength for Various Antenna Polarizations as a Function of Time for AIMP-D (Taken Over an Eleven Hour Period)

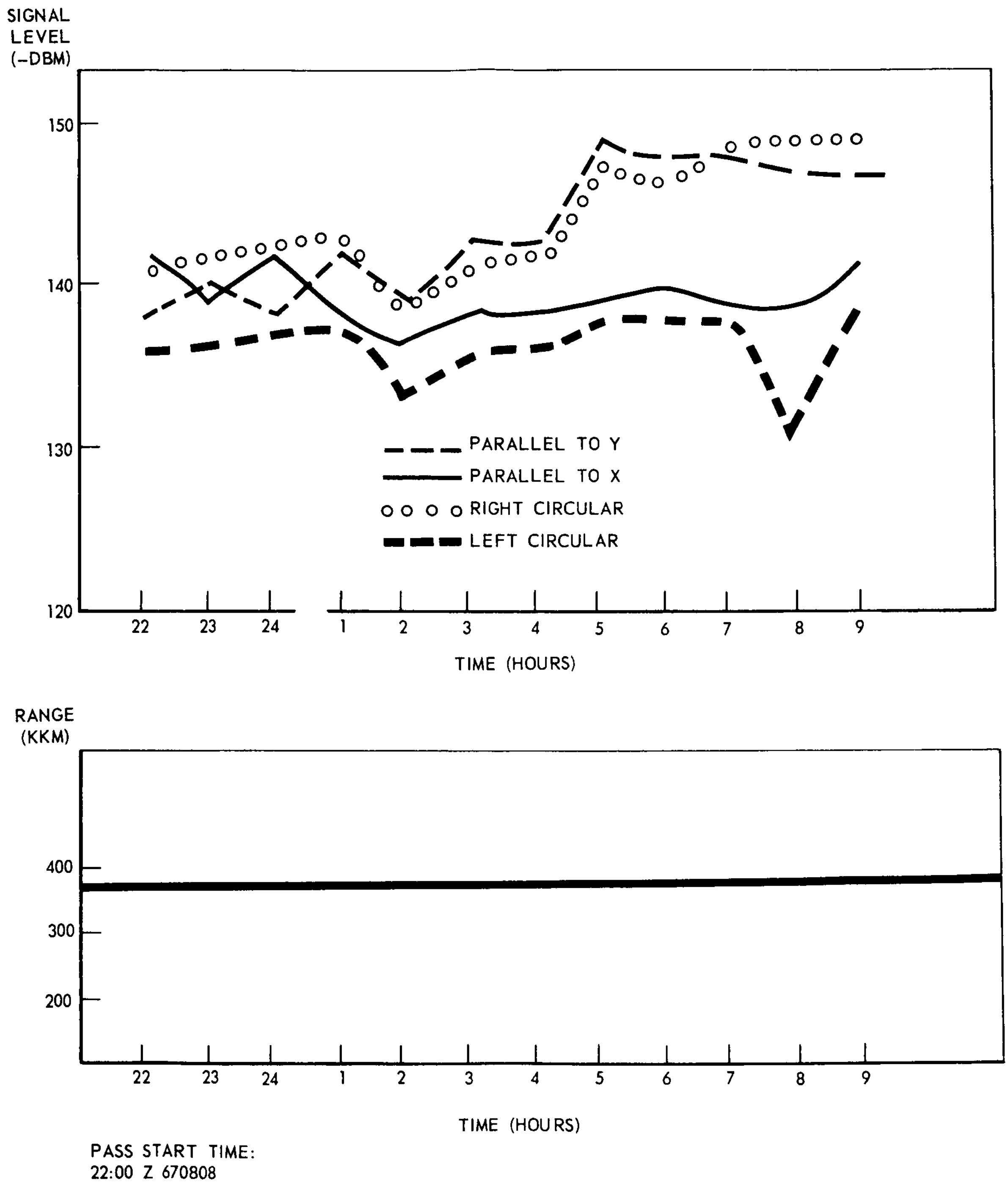


Figure 8. Received Signal Level (as a Function of Antenna Polarization) and Range vs Time for AIMP-D (Taken Over an Eleven Hour Period)

reproduction of the AGC records. Those shown in Figure 9 were taken during the actual spacecraft interrogations; those in Figures 10 and 11 were taken during the monitoring periods. All times of observation are referenced to the start of the nearest interrogation interval.

The effects of glitches and atmospheric disturbances on the received signal occurring during a spacecraft interrogation are shown in Figure 9. None of these shown was of sufficient magnitude or duration to unlock the ranging system. A short 14 db drop in signal level is shown in the upper chart; a longer 5 db drop is shown in the middle chart; and an atmospheric-disturbance which blanked the signal for 13 seconds is shown in the lower chart.

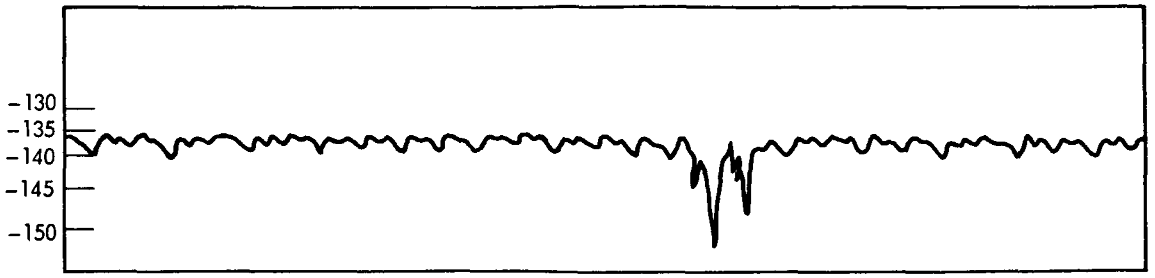
Variations in signal level as a function of antenna polarization of the GRARR system are shown in Figure 10. These recordings were taken at Santiago which, although limited to linear polarization, had the antenna switching capability necessary to show these effects. At certain positions of the orbit changes in antenna polarization did not affect the level or nature of the received signal as shown in the top chart. At other positions, changes in antenna polarization strongly influenced the level and nature of the received signal.

Note on the middle chart that the received signal for linear to X polarization is about 13 db stronger and much more quiet than that for linear to Y polarization. On the bottom chart, the opposite is true; the signal for linear to Y is about 15 db stronger and much more quiet than for linear to X.

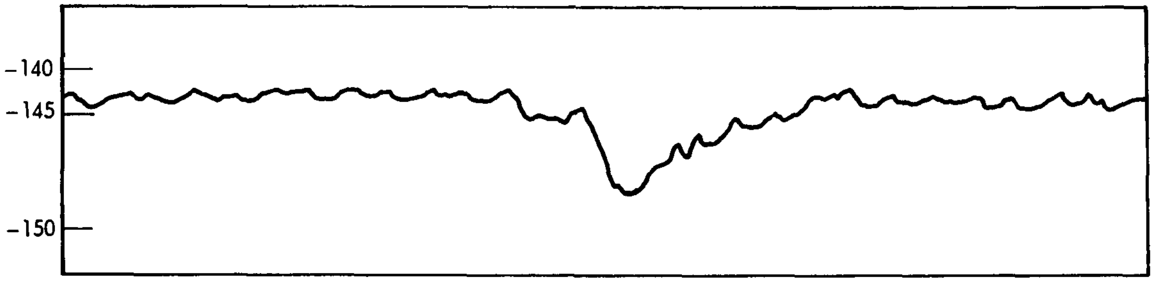
An interesting variation in signal level that occurred over a three-minute interval is shown in Figure 11, starting with the right side of the upper chart and progressing to the left side of the bottom chart. As shown in the top chart, the signal for linear to Y was stronger and much smoother than the signal for linear to X polarization. Then the received signal for both linear to X and linear to Y appeared equally noisy, as shown in the middle chart. Finally, the signal for linear to Y appeared to increase slightly and to become smoother.

SUMMARY

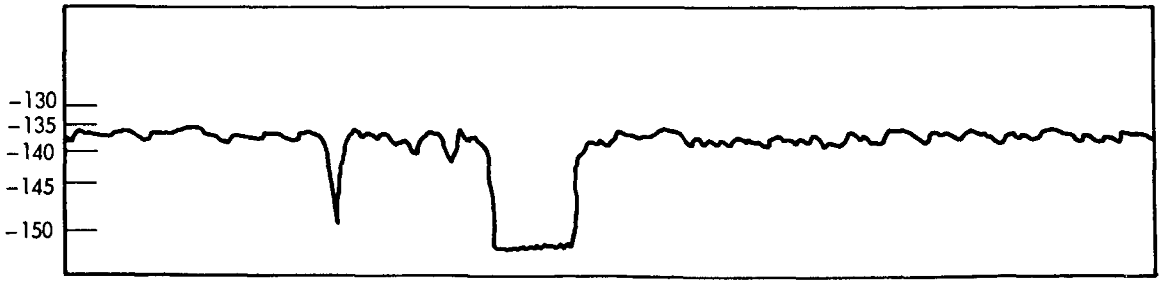
The results of this study show that there is no consistent correlation pattern between optimum GRARR antenna polarization and orbit position existing for presently orbiting IMP satellites. The optimum undergoes both gradual and rapid changes from one polarization to another. There is evidence of sharp and gradual changes in received signal level existing in all polarizations.



EXAMPLE OF SHORT GLITCH IN NORMAL SIGNAL LEVEL PST 11:01 SANTIAGO

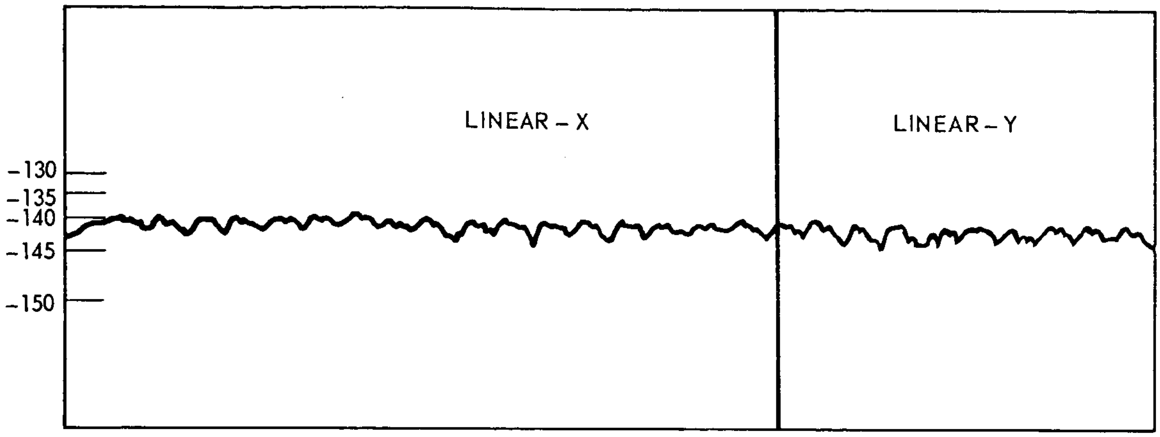


EXAMPLE OF LONG GLITCH IN NORMAL SIGNAL LEVEL PST 14:16 ROSMAN

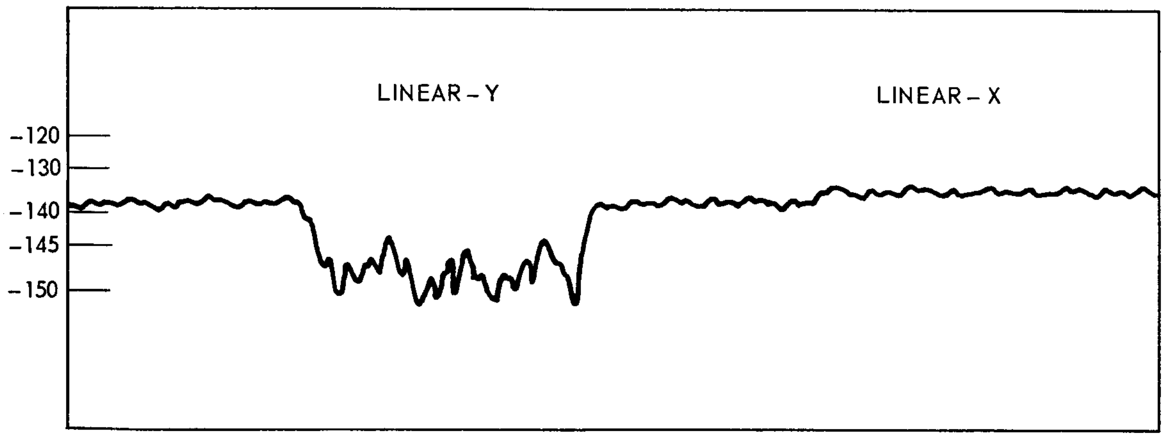


EXAMPLE OF ATMOSPHERIC DISTURBANCE (NO RFI DETECTED AT THIS TIME)
PST 05:29 SANTIAGO

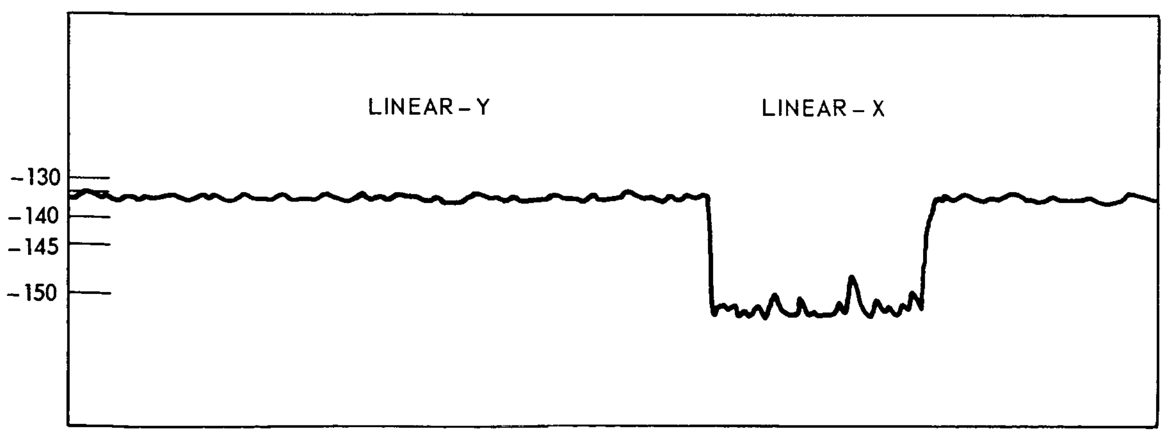
Figure 9. Examples of Disturbances in Normal Received Signal Level



SIGNAL LEVEL USING LINEAR X EQUAL TO SIGNAL LEVEL USING LINEAR Y
PST 05:29



SIGNAL LEVEL USING LINEAR X GREATER THAN SIGNAL LEVEL USING LINEAR Y
PST 09:51



SIGNAL LEVEL USING LINEAR Y GREATER THAN SIGNAL LEVEL USING LINEAR X
PST 08:57

Figure 10. Examples of Variations in Received Signal Level as a Function of Linear Antenna Polarization (Taken by Santiago)

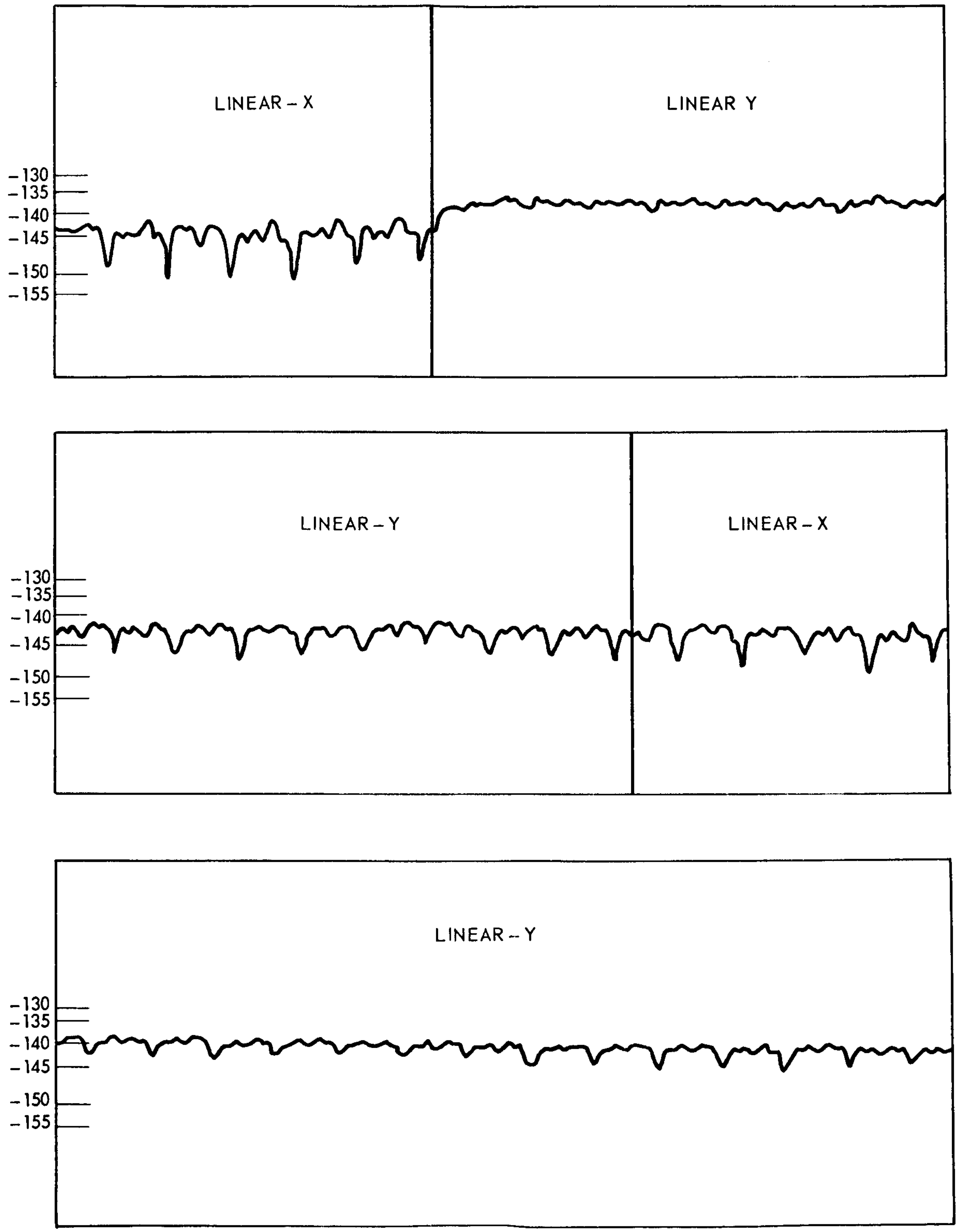


Figure 11. Example of Variation in Received Signal as a Function of Linear Polarization Over a Three Minute Interval (Taken by Santiago PST 06:05)

There are indications and trends apparent however that could be used to define a correlation pattern if a non optimum signal were acceptable. The pattern would have to be derived after the acceptable signal level was established.

REFERENCES

1. "The Canted Turnstile as an Omnidirectional Spacecraft Antenna System," by R. B. Jackson, September 1967, X-712-67-441.

2. "The Goddard Range and Range Rate Tracking System: Concept, Design and Performance," by G. C. Kronmiller, Jr., and E. J. Baghdady, October 1965, X-531-65-403.