TELEMETRY DATA COLLECTION
FROM OSCAR SATELLITE

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TABLE OF ACRONYMS AND ABBREVIATIONS

AFSK	Audio Frequency Shift Keying
AMSAT	a registered trademark of the Radio Amateur Satellite Corporation
ASCII	American Standard Code for Information Interchange
bps	bits per second
CW	Continuous Wave (Morse code)
dB	Decibels
dB$_{ic}$	Decibels relative to a circularly polarized antenna
DO-17	Digital Orbiting Voice Encoder(DOVE) OSCAR-17
FSK	Frequency Shift Keying
IC	Integrated Circuit
KCT	Kansas City Tracker
KCT/T	Kansas City Tracker and Tuner
LEO	Low Earth Orbit
LHCP	Left Hand Circular Polarization
NMSU	New Mexico State University
NORAD	North American Air Defense Command
OSCAR	Orbiting Satellite Carrying Amateur Radio
OU-11	UoSAT-OSCAR-11, AKA UoSAT-2, UoSAT-B
PSK	Phase Shift Keying
RF	Radio Frequency
RHCP	Right Hand Circular Polarization
RS-232	Recommend Standard-232 (port)
RTTY	Radio Teletype
SEU	Single Event Upset
SNR	Signal to Noise Ratio
TNC	Terminal Node Controller

UoSAT	identifier for amateur satellites built at the University of Surrey, England
UTC	Coordinated Universal Time
WARC	World Administrative Radio Conference
WOD	Whole Orbit Data

1 INTRODUCTION

This paper discusses the design, configuration, and operation of a satellite station built for the Center for Space Telemetering and Telecommunications Laboratory in the Klipsch School of Electrical and Computer Engineering Engineering at New Mexico State University (NMSU). This satellite station consists of a computer-controlled antenna tracking system, 2m/70cm transceiver, satellite tracking software, and a demodulator. The satellite station receives satellite telemetry, allows for voice communications, and will be used in future classes. Currently this satellite station is receiving telemetry from an amateur radio satellite, UoSAT-OSCAR-11. Amateur radio satellites are referred to as Orbiting Satellites Carrying Amateur Radio (OSCAR) satellites as discussed in the next section.

1.1 OSCAR SATELLITES

OSCAR satellites are designed and used by radio amateur operators to provide a valuable expansion in amateur radio communications. Just as importantly, they serve as an educational tool for anyone interested in satellites. This expanded communications ability provides for: vital communications during catastrophic events, scientific research and learning experience, experimentation, an opportunity to take advantage of the higher frequency bands offered by amateur radio, and also as recreational use by radio amateur operators. The first amateur satellite, OSCAR 1, was launched into space on December 12, 1961. OSCAR 1 consisted of a battery powered transmitter with a single monopole antenna that transmitted for three weeks until the batteries were depleted. During this time, the 2m very high frequency (VHF) beacon transmitter broadcasted in morse code (CW) HI-HI at a frequency related to the internal temperature of the satellite. Due to OSCAR 1's low altitude it reentered the earth's atmosphere just one day after its batteries were depleted. Since the advent of OSCAR 1, a nonprofit company, the radio amateur satellite corporation (AMSAT) has formed to support the amateur satellite program through design, construction, launching, and operation of these OSCAR satellites. OSCAR satellites have been allocated the following frequency use (Table 1-1) by the World Administrative Radio Conference (WARC) [2].

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Table 1-1 Frequency allocation for Amateur Satellites

Band(wavelength)	Frequency Range (MHz)	Band(frequency)
15 m	21.000- 21.450	21 MHz
10 m	28.000- 29.700	29 MHz
2 m	144.000- 146.000	145 MHz
70 m	435.000- 438.000	435 MHz
24 cm	1260- 1270	1270 MHz
13 cm	2400- 2450	2400 MHz

Satellite communications require the simultaneous use of two different frequencies during operation in order to provide two way communications to users. The uplink is referred to as the signal which is transmitted from the ground-station up to the satellite, whereas, the downlink is the signal transmitted by the satellite and received by the ground-station. Mode designations were assigned to identify the different combinations of uplink and downlink frequencies used by amateur satellites. The following mode designations (Table 1-2) provide a current listing of amateur modes and their corresponding frequency bands [2].

Table 1-2 Amateur Satellite Modes

Mode	Uplink	Downlink
A	2 m	10 m
B	70 cm	2 m
J	2 m	70 cm
JA	2 m	70 cm (Analog)
JD	2 m	70 cm (Digital)
JL	2 m & 23 cm	70 cm
K	15 m	10 m
KA	2 m & 15 m	10 m
KT	15 m	10 m & 2 m
L	23 cm	70 cm
S	70 cm	13 cm
T	15 m	2 m

Amateur satellite ground stations can be divided up into the following categories depending on the type of satellite work being done:

I) receive-only ground-stations (Telemetry gathering)

II) ground-stations to operate Low Earth Orbit (LEO) satellites with analog transponders

III) ground-stations to operate LEO digital store-and-forward satellites

IV) ground-stations to operate High Eccentric Orbit (HEO) satellites with analog transponders

This paper will be primarily concerned with ground-station type I satellite work in which received digital telemetry in the 2m and 70cm bands will be researched. This corresponds to modes B and J from Table 1-2. Appendix A contains a list of OSCAR satellites along with their operating modes and telemetry formats.

1.2   OSCAR TELEMETRY

Telemetry provides important information about the status and welfare of the satellite by monitoring its systems components, such as status, temperature, voltage, and current. This telemetry is transmitted from the satellite through a Radio Frequency (RF) channel data link to a ground station, where this information can be received, decoded, and analyzed. Once the telemetry is analyzed it can serve many useful purposes. It can be used as a diagnostics tool, as informative data which can be used in redesigning and building newer satellites, and as a monitoring instrument to see if a status should be changed onboard the satellite from the ground station through the uplink.

Current telemetry formats for OSCAR satellites include: digitized speech, morse-code (CW), RTTY, 1200 bits per second (bps) Audio-Frequency Shift Keying (AFSK) AX.25 packet, 1200 bps AFSK American National Standard Code for Information Interchange (ASCII), 1200 bps Phase Shift Keying (PSK) 8 bit packet, 400 bps PSK ASCII, and 9600 bps Frequency Shift Keying (FSK) ASCII. Originally for this project the 1200 bps AFSK AX.25 packet telemetry format was chosen as the format of telemetry to decode. The reason behind choosing this format was that beyond the receiver only a Terminal Node Controller (TNC) was required to decode the telemetry. DOVE-OSCAR-17 (DO-17), an amateur satellite, which used this format provided the

strongest 2m downlink signal among the OSCAR satellites. By choosing to initially decode telemetry from this satellite, a good foundation for a ground-station could be developed in order to provide telemetry data collection from other OSCAR satellites. Unfortunately, DO-17 suffered a severe software crash on the third week of March 1998, leaving the satellite inoperable for an indefinite period of time. With DO-17 being the only OSCAR satellite which currently uses the 1200 bps AFSK AX.25 packet modulation format, another OSCAR satellite had to be chosen which would have a modulation scheme which could be demodulated readily. The UoSAT-OSCAR-11 (UO-11) satellite uses a 1200 bps AFSK ASCII telemetry format, which can be demodulated using a slightly modified Bell Type 202 modem. Since the UO-11 satellite operates in mode B, which was compatible with the previously ordered hardware, UO-11 provided a suitable substitute for DO-17. Further discussion about the UO-11 satellite and the ground station will be discussed later in this report. Figure 1.2 shows an outline of the satellite ground station.

Figure 1.2 Outline of satellite ground station
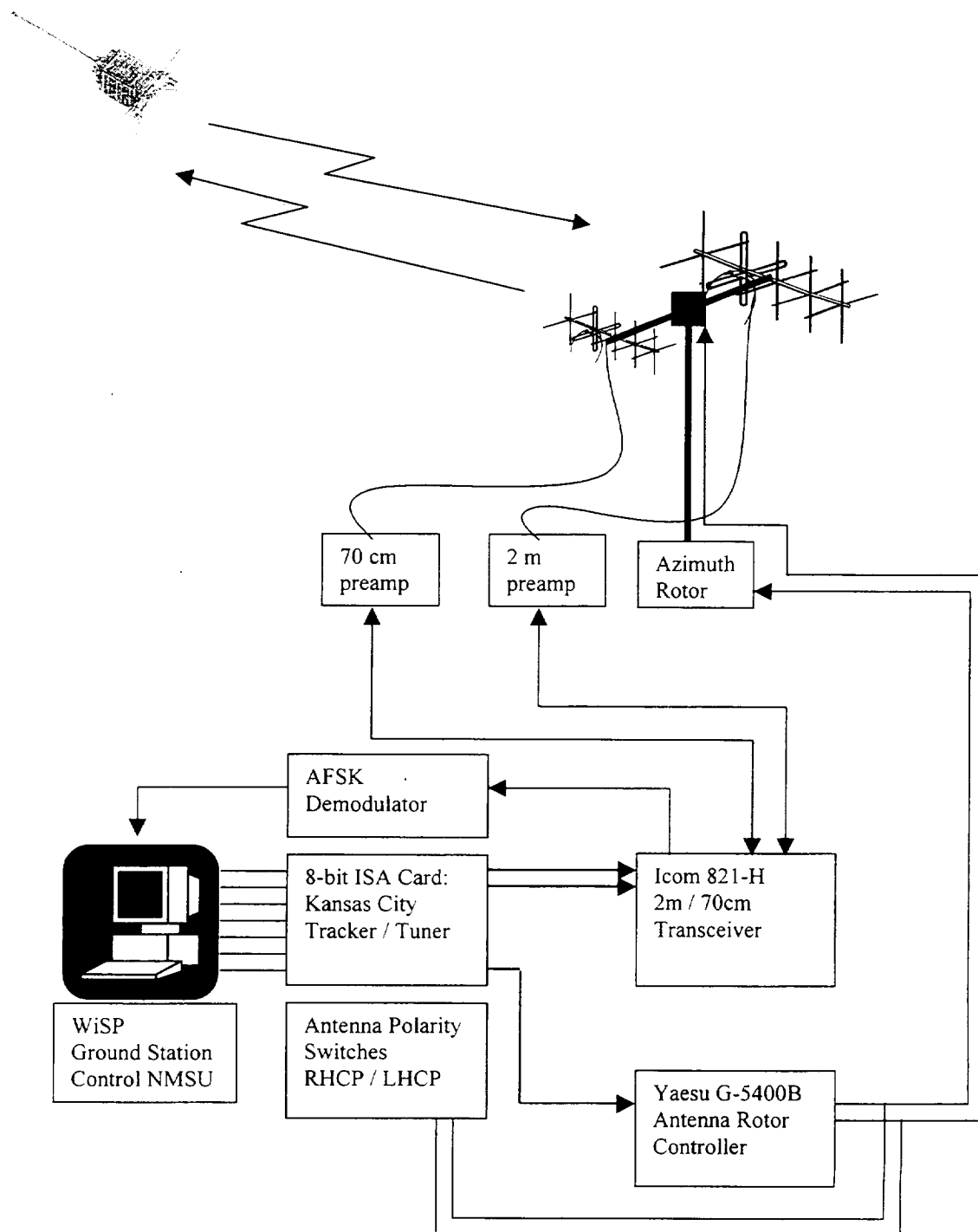
2 SATELLITE TRACKING

2.1 OSCAR SATELLITE ORBITS AND TRACKING

The majority of the OSCAR satellites are in a LEO, and have eccentricities very close to 0, where 0 corresponds to a perfectly circular orbit. This implies that the mean altitude of these satellites remains fairly constant as the satellite passes from its nearest point to earth (the perigee point) to its farthest point from earth (the apogee point). The orbital altitudes for the OSCAR satellites range from several hundred kilometers to a few thousand kilometers above the surface of the earth. The inclination angle for these satellites was chosen to provide a sun synchronous orbit, where the inclination angle is defined as the angle that the satellite makes with respect to the equator as it passes from the southern to northern hemisphere. The advantage to having a sun synchronous orbit is that the satellite will follow the illumination pattern provided by the sun maintaining a constant angle throughout the entire orbit. This provides a constant source of solar energy for the solar cells onboard the satellite for uninterrupted recharging of the batteries. A typical value of the inclination angle for this class of satellites is 98 degrees. Table 2-1 provides information about UO-11 and its orbit [1].

Table 2-1 UoSAT-OSCAR-11 Specifications

Name:	UO-11
Object #:	14781
Launch date:	March, 1 1984
Period:	99 minutes
Increment:	24.6 degrees west / orbit
Orbit:	Polar LEO
Altitude:	680 km (423 miles) average
Dimensions:	58.5 cm (23 in.) x 35.5 cm (14 in.) x 35.5 cm (14 in.)
Weight:	60 kg (132 lbs.)
Telemetry:	1200 baud Frequency Modulated (FM) AFSK
Downlinks:	145.825 MHz (2m)
	435.025 MHz (70cm)
	2401.5 MHz (S-Band)

In order to track the satellites from the ground station the exact location of the satellite relative to the ground station location needs to be known. The three parameters, which need to be coordinated in order to track a satellite, are: time, azimuth, and

elevation. The azimuth positions for north, east, south, and west are defined as 0, 90, 180, and 270 degrees respectively. Ground tracking provides a graphical representation of the satellite's orbit onto the earth's surface. From this, the satellite's location over geographical regions can be seen and the satellite's visibility and contact times can be determined. In order to provide satellite ground tracking, several computer programs were used throughout the project. These included Satellite Tool Kit 4.0, WinOrbit 3.4, and WiSP's GroundStation Control. Satellite Tool Kit 4.0 and WinOrbit 3.4 were used strictly for satellite orbital prediction and display, where the WiSP package is used currently in the project to provide additional support for interfacing with antenna rotor controllers. A typical orbit for UO-11 showing its ground track and coverage area can be seen in Figure 2-1. The computer packages used for ground tracking determine the satellite's position from the mean orbital elements. These elements contain the following information about the satellites orbit: inclination angle, eccentricity, right ascension of the ascending node, argument of perigee, mean anomaly, and the mean motion. The standard format for this information is given in the North American Air Defense Command (NORAD) 2 line element format, a similar format used by AMSAT is known as the Keplerian elements. Updated versions of these elements and more information about this format may be downloaded from the internet using the following address: http://www.amsat.org/amsat/keps/menu.html

Figure 2-1 Typical ground track for UoSAT OSCAR 11

AOS: 10.32 Az: 163 El: 11 Rg: 1990 Lat: +16°51' Lon: +101°47' Alt: 660 Dop: -2943
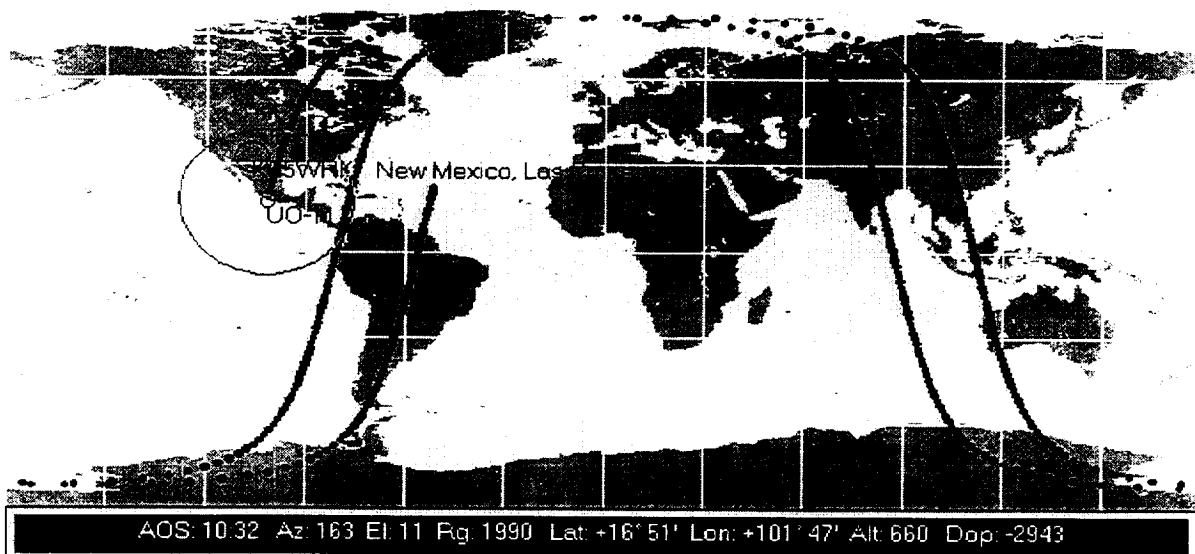
2.2   SATELLITE TRACKING USING WiSP

The WiSP GroundStation Control program is available for amateur radio use and must be registered with AMSAT. The location of the ground station is the first information needed in order to set up the ground station. The following parameters were entered under Setup and Station Setup for the location of NMSU located in Las Cruces, New Mexico as [10]:

Latitude = 32.31 North
Longitude = 106.78 West
Altitude = 1300 meters

Underneath the Database menu, the satellite database should be updated weekly with new Keplerian elements in order to provide for the most accurate tracking of the satellite. WiSP will automatically determine the correct time zone for the given ground station location in order to determine how much to lead or lag that of Coordinated Universal Time (UTC). UTC is based on a 24 hour format, which is related to the motion of the stars, the Sidereal Time, as determined from that of the earth based on the current local time of Greenwich, England [4]. During daylight savings, the ground station location at NMSU lags UTC by exactly 6 hours, otherwise lagging UTC by exactly 7 hours.

Underneath the Tracking menu, Graphic Track is selected to provide ground tracking for the satellite of interest. From the Graphic Track window, a list of satellites is provided from the database formed from the Keplerian elements. From the ground track, the coverage area of the satellite can be seen along with its next orbital period. The bottom of the screen provides the satellite's latitude, longitude, height, mean anomaly, and its next pass over the ground station. Also shown is the azimuth, elevation, and range of the satellite with respect to the ground station location.

2.3   COMPUTER AIDED SATELLITE TRACKING AND TUNING

Due to the visibility time of the typical OSCAR satellite in a LEO, the average time the satellite is visible from the ground station is approximately 15 minutes. Since these satellites move fairly quickly across the sky, the azimuth and elevation of the satellite relative to the ground station will change at a high rate. As will be discussed later in this report, the use of high gain antennas requires that the antennas track the satellite as it moves across the sky. In order to point the antennas at the satellite, the use

of azimuth and elevation rotors were used and will also be discussed later in this report. Interfacing the computer tracking program with the antennas requires that the computer tracking software know where the antennas are pointed, and has the ability to move the antennas to point at the satellites. Since we are using high-gain antennas with satellites, we are required to be able to move the antennas in both elevation and azimuth directions. The Kansas City Tracker (KCT) provides the proper interface between the computer tracking software and the antenna rotor controller. The Yaesu G-5400B rotor controller provides analog voltage values to show the current position of the antenna array. The KCT digitizes these values in order to keep track of the position of the antennas. The KCT also comes with a tuner function that can be used to help compensate for the Doppler shift due to the high velocities of the satellite. The amount of Doppler correction needed is calculated from the computer-tracking program. This information is then sent to the serial port of the transceiver via a shielded two conductor cable. Once a satellite pass is loaded on the computer-tracking program, the antenna tracking and Doppler correction is completely automated. This is most useful on LEO digital satellites where the satellite passes are short and require large amounts of antenna tracking and frequency tuning. Figure 2.3 shows the satellite ground station control center.

Figure 2.3 Satellite ground station control center

along with its controller meet all the above requirements. An external 8 pin DIN port
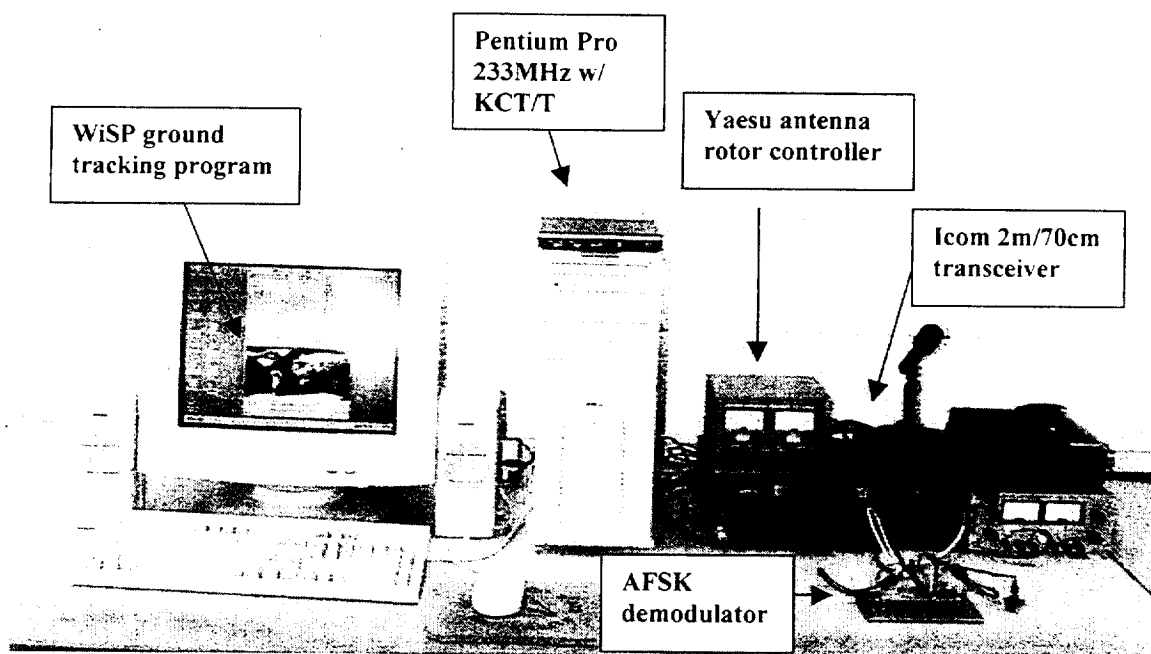
2.3.3 KANSAS CITY TUNER

The Kansas City Tuner contains added components on the KCT/T board which are used to control the radio transceiver to correct for Doppler shift. The amount of Doppler shift seen from a typical LEO satellite with a beacon frequency on the 2m band is approximately 10 kHz above that of carrier frequency during the beginning of the pass. At the end of the pass, there will be the same amount of Doppler shift, but this time it will be lower than the carrier frequency. Figure 2.3.3 shows the Doppler shift from UO-11 for both the 2m and 70 cm beacon frequencies. Appendix E contains the mathcad file for the Doppler shift calculations. The DB25 connector on back of the KCT/T board is interfaced to the CI-V serial interface on the Icom 821-H radio transceiver to provide the proper control signals to tune the frequency of the transceiver throughout the pass. The KCT/T comes equipped with RS-232 level converter ICs to provide RS-232 level operation on Ports A and B. The Icom transceiver serial interface requires non-inverting TTL level signals. Instead of purchasing Icom's CT-17 level converter for over $100, the RS-232 level converters onboard the KCT/T board were removed and replaced with header pins to supply the correct TTL signals for the Icom CI-V serial interface. This required the removal of IC 1488 and IC 1489 onboard the KCT/T. Pins 2 & 3 and pins 5 & 6 must be connected together on the empty 1488 socket, and pins 1 & 3 and pins 4 & 6 of the empty 1489 socket are connected together to convert both port A and B outputs to TTL levels. Figure 2.3.4 shows the KCT/T PC board with its modifications. The serial Icom CI-V interface consists of a 1/8 inch headphone jack located on back of the transceiver. Port A of the KCT/T was chosen to interface to the CI-V interface. Table 2.3.3 lists these connections.

Figure 2.3.3 Doppler Shift for UO-11

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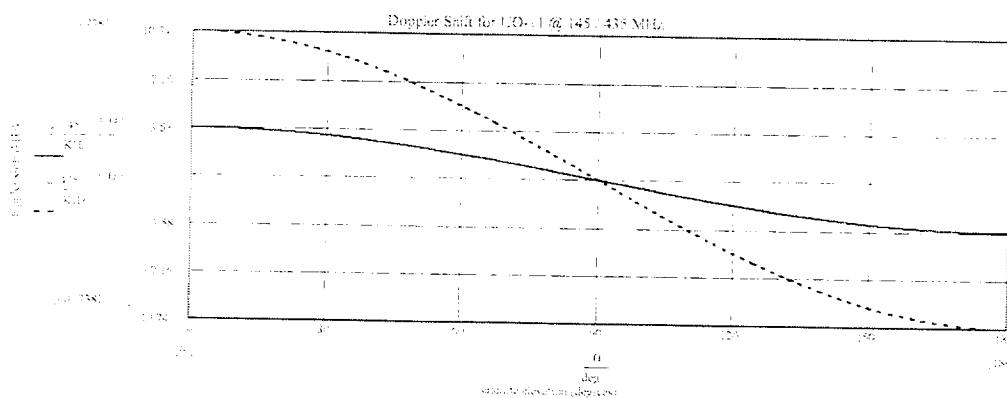
Table 2.3.3 Icom 821-H transceiver to KCT connections

ICOM 821-H	KCT:	Description
CI-V serial interface	pin # (DB25)	
center conductor	10	serial input to KCT/T Port A
center conductor	18	serial output to KCT/T Port A
outer conductor	15	ground

Figure 2.3.4 KCT/T 8-bit ISA PC board

RS-232 level
converter ICs:
1488 / 1489
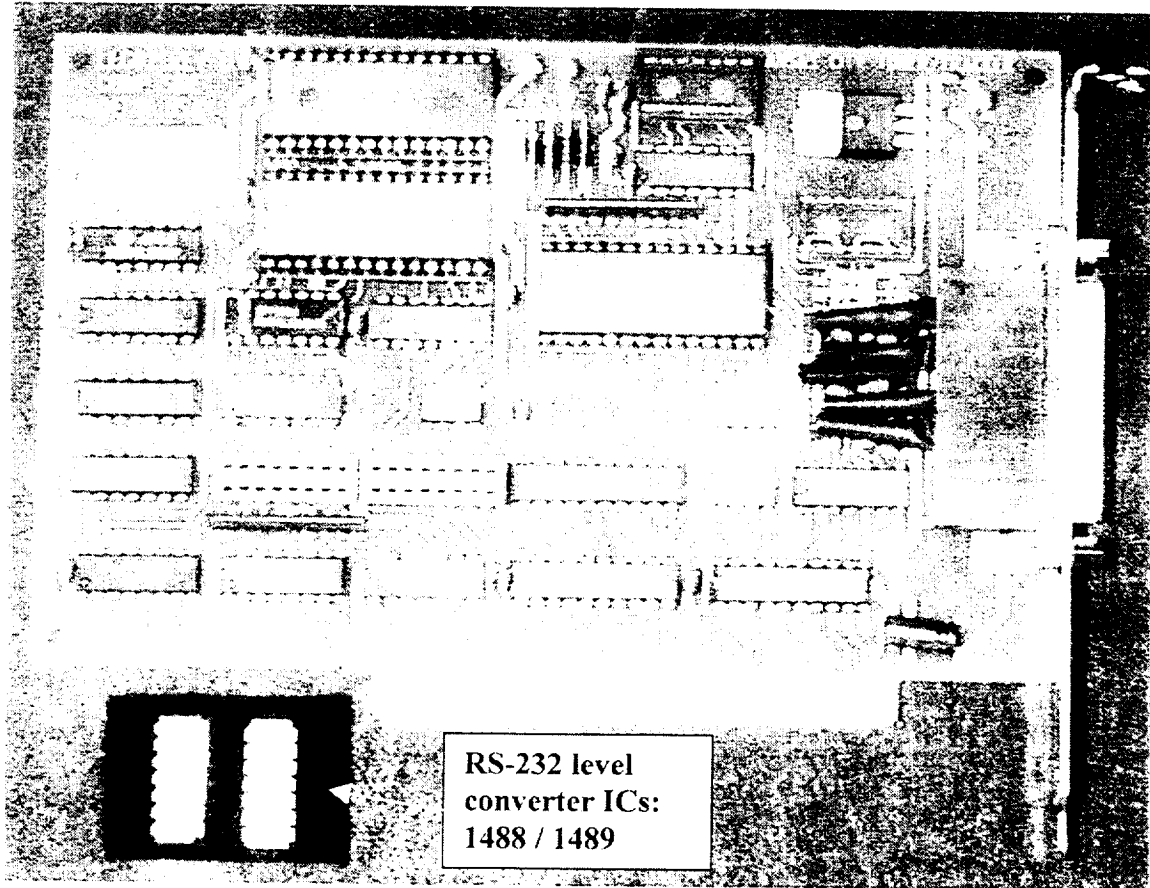
3   RECEIVING ANTENNAS

Initial attempts at trying to receive beacon signals from the OSCAR satellites were made using an omni-directional antenna and a quarter wave groundplane antenna that was built for 145 MHz. This groundplane antenna consists of 4 equidistant quarter wave ground radials at 135 degrees to the quarter wave vertical radiator providing a feed-point impedance of roughly 50 Ω as compared to that of 36 Ω if the ground radials were

at a 90 degree angle to the radiator [5]. With the use of a pre-amplifier the 2m beacon of Dove OSCAR-17 could be heard weakly as the satellite was at relatively low elevations.

With the signal reception from DO-17 being weak at best, the need for a higher gain antenna was clearly demonstrated since this satellite provides the strongest beacon among the OSCAR satellites. In order for an antenna to provide gain, the radiation power pattern of the antenna must become focused. The gain of an "ideal" omni-directional antenna being equal to 0 dB, has a radiation pattern that radiates in a full 4Π steradian area. Increasing the gain of an antenna reduces the beamwidth. It then becomes more critical to point the antenna at the satellite in order to keep it within its narrower beamwidth. The use of a directional antenna adds to the complexity of the project in several ways. These include: a location for mounting such antennas, increased cost, and the acquisition of required hardware needed in controlling the antennas. With the added complexity of having to track the satellites with the antenna during the pass, in addition to correcting for the Doppler-shift, the need for computer automation becomes more apparent.

3.1 ANTENNA POLARIZATION

The polarization of a plane wave is given as the outline that is traced out by the instantaneous electric field over time as seen from a fixed point of observation. Similarly, the polarization of an antenna is the polarization of the wave radiated in a given direction by the antenna when transmitting [6]. Due to the nature of satellites, the receiving ground stations often uses antennas that are circularly polarized. As RF waves propagate through the atmosphere the polarization of the waves become distorted due to atmospheric effects, such as that of the earth's magnetic fields. When radio waves travel large distances, such as, space communications, the earth's magnetic field can rotate the plane of polarization. This is commonly referred to as Faraday rotation. The extent of this rotation is dependent on many variables. These variables include: the strength of the magnetic field, the path length traveled in the magnetic field, the angular relationship to the magnetic field, and the frequency. As the frequency is increased, the effects from Faraday rotation are decreased, and for frequencies that are greater than 2.0 GHz the effects of Faraday rotation are minimal [1]. Due to Faraday rotation, the polarization of

the received wave will vary randomly with that of the receiving antenna causing fluctuations in the received signal power resulting from polarization mismatch losses. In order to eliminate the effects of Faraday rotation, circular polarization is used in which equal amounts of RF energy is placed into each plane. This provides an average received signal power that is greater using a linearly polarized antenna in which the random polarization mismatch losses would vary randomly. Circular polarization will however provide a received average power greater than that of linear polarization. If linear polarization was used, the resulting polarization of the received wave would be uncertain. The ground station antennas need to be able to switch between left-hand and right-hand circular polarization depending on the orientation of the received waves' polarization. Circular polarization in antennas is often achieved by using a helix antenna in which one turn corresponds to one wavelength, crossed Yagis in which two identical Yagis are mounted 90 degrees to each other, or by having a Yagi that uses phasing between its elements to achieve circular polarization. A helix antenna for the 2m band would mean that the diameter of the helix would be roughly equal to 2m. Due to the size requirement for the 2m antenna, the crossed Yagi-Uda was chosen. It is a popular, commercially-built antenna, which provides high gain and circular polarization.

3.2   CROSSED YAGI-UDA ANTENNAS

Many different commercially built Yadi-Uda antennas were researched as possible candidates for the reception of the satellite telemetry. These manufactures included Cushcraft, M-squared, Hy-Gain, and KLM. These antennas were compared according to their gain, polarization capabilities, beam-widths, size, wind-load, required mounting hardware, and cost. The desired gain of the antennas for both the 2m and 70 cm bands needed to be around 13 dB. The antennas made by M-squared provided only RHCP. All the other antennas provided the ability to switch between Left Hand Circular Polarization (LHCP) and RHCP. The KLM antennas were chosen based on their known high quality of hardware with all other things being relatively equal. The OSCAR series of antennas offered by KLM come in a small set and a large set. The KLM OSCAR set consists of a 2m and 70cm crossed Yagi-Uda antenna, polarity switches for both antennas, and a fiberglass cross-boom for mounting the two antennas. Due to the nature

of Yagi-Uda antennas, increasing the number of directors beyond 5 or 6 yields increases in gains that are small. For example, adding one director to a 3-director array gives a 1 dB gain while adding one director to a 9 director array provides only a 0.2 dB increase in gain [6]. The large set of OSCAR antennas by KLM provided an increase of 2 dB for the 2m band antenna and an increase of 3.2 dB for the 70cm band antenna at the cost of increasing the boom length by 6 ft. 4 in. and 7 ft. 3.5 in. respectively due to increase in the number of director elements. Since the mounting location for these antennas provided enough area for the full turning radius of the large set of KLM antennas, they were chosen over the smaller set. Table 3.1 provides the specifications for the large KLM OSCAR antennas. Figure 3.1 shows a picture of KLM OSCAR antennas after construction and mounting.

Table 3.1 KLM Antenna Specifications

	2M-22C	435-40CX
Bandwidth (spec.)	144-146 MHz	420-440 MHz
Bandwidth (usable)	144-148 MHz	410-450 MHz
Polarity	LHCP/RHCP	LHCP/RHCP
Gain	13 dBdC	15.2 dBdC
Beamwidth	34 degrees	25 degrees
Front/Back ratio	20 dB	20 dB
Front/Side ratio	25 dB	25 dB
Feed impedance	50 Ω, unbalanced	50 Ω, unbalanced
VSWR	< 1.5:1	< 1.5:1
Balun	4:1 RG-303 coax (2)	4:1 RG-303 coax (2)
Powerhandling	250 W w/ switcher	250 W w/switcher
Boom length	19'1"	14'7.5"
# driven elements	2 folded dipoles	2 folded dipoles
# parasitic elements	20 (10 vert, 10 horz)	38 (19 vert, 19 horz)
Wind load	1.85 sq. ft.	1.16 sq. ft.

Figure 3.1 KLM 2m / 70 cm Crossed Yagi-Uda Antennas

70 cm crossed
Yagi-Uda
antenna

2 m crossed
Yagi-Uda
antenna

Elevation rotor
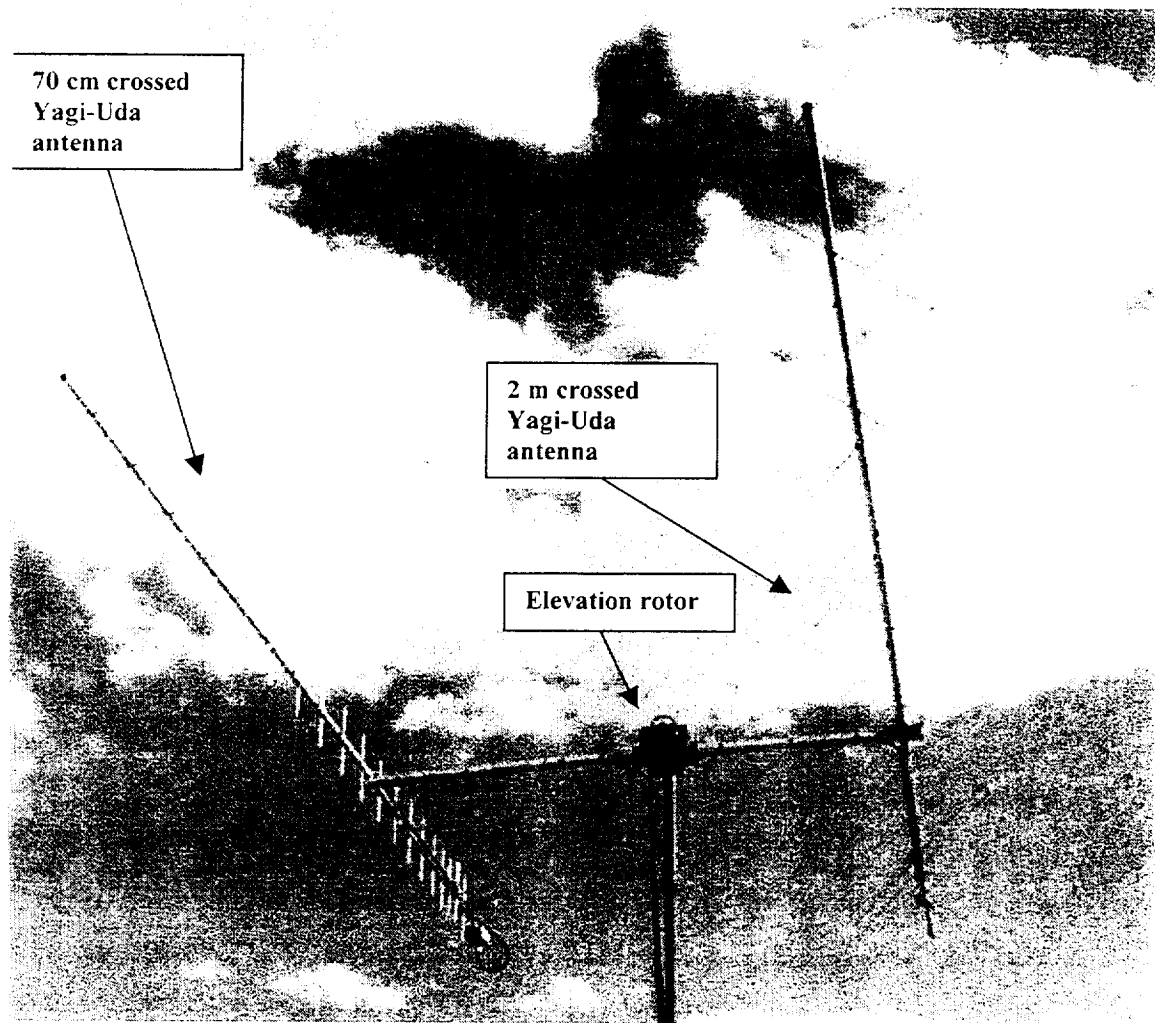
3.3   PREAMPLIFIERS

For this project 2 antenna preamplifiers were used, the Icom AG-25 for 2m and the Icom AG-35 for 70cm. By using these preamplifiers, we can expect to have greater receiver sensitivity, and improved Signal to Noise Ratio (SNR). The following specifications are given for these preamplifiers in Table 3.3

Table 3.3 Preamplifier Specifications

	AG-25	AG-35
Frequency range	144 – 148 MHz	430 – 450 MHz
Gain	> 15 dB	> 15 dB
Maximum RF power	100W	100W
Input / Output Impedance	50 Ω unbalanced	50 Ω unbalanced

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4 ANTENNA SUPPORT STRUCTURE / CABLE

The roof of the Thomas and Brown Electrical Engineering building at NMSU was selected for the antenna location. Since the Center for Space Telemetering and Telecommunications laboratory is located on the third floor, this location provided for access to the roof. On top of the building a previous antenna range had been setup for use by the electromagnetic group. Careful consideration had to be taken into account to prevent interference with the existing antenna range. A location suitable for the placement of the satellite antennas was determined with approval from the electromagnetic group. This corresponded to a location behind the electromagnetic's receiving antenna where reflections seen from the satellite antennas would not be received by the antenna. After approval by the electromagnetic's group, cable length requirements were measured and hardware requirements were researched into for mounting the antennas. The roof is flat and covered in small roofing rocks. Due to the high winds seen in southern New Mexico in the spring, careful consideration was given to the wind load handling capabilities of the antenna structure. The antenna mounting structure was designed to handle wind velocities up to 86 mph with a safety factor of 200%. Due to the fact that the roof was covered in rocks, the challenge of not having something physical to mount the antenna structure became apparent.

4.1 ANTENNA TOWER

A tower that would support the vertical mast for the antennas was purchased from Glenn Martin Engineering. The legs of the tower are bolted to (4) 2" x 2" x 1/8" x 10' angle iron that runs out radially from the base of the tower. Cement blocks placed on top of the angle iron provided the needed amount of down force required to prevent the antenna structure from being blown over. Figure 4.1 shows the antenna tower with the angle iron support base and cement blocks. A separation kit was installed to the Yaesu G-5400B rotors that allowed for the separation of the azimuth and elevation components of the rotor. This provided the advantage of placing the azimuth rotor inside the base of the tower, and the elevation rotor on top of the vertical mast. This also provided a lower center of gravity for the antenna structure eliminating 10 pounds from the top of the structure. A thrust bearing was installed that supports the vertical mast at the top of the

tower. This particular component provides extra support and extends the life of the azimuth rotor. Figure 4.2 shows the location of the thrust bearing, azimuth rotor, and preamplifiers.

Figure 4.1 Antenna tower and support base

Figure 4.2 Close-up of antenna tower

Labels in figure: Thrust bearing, Preamplifiers, Azimuth rotor
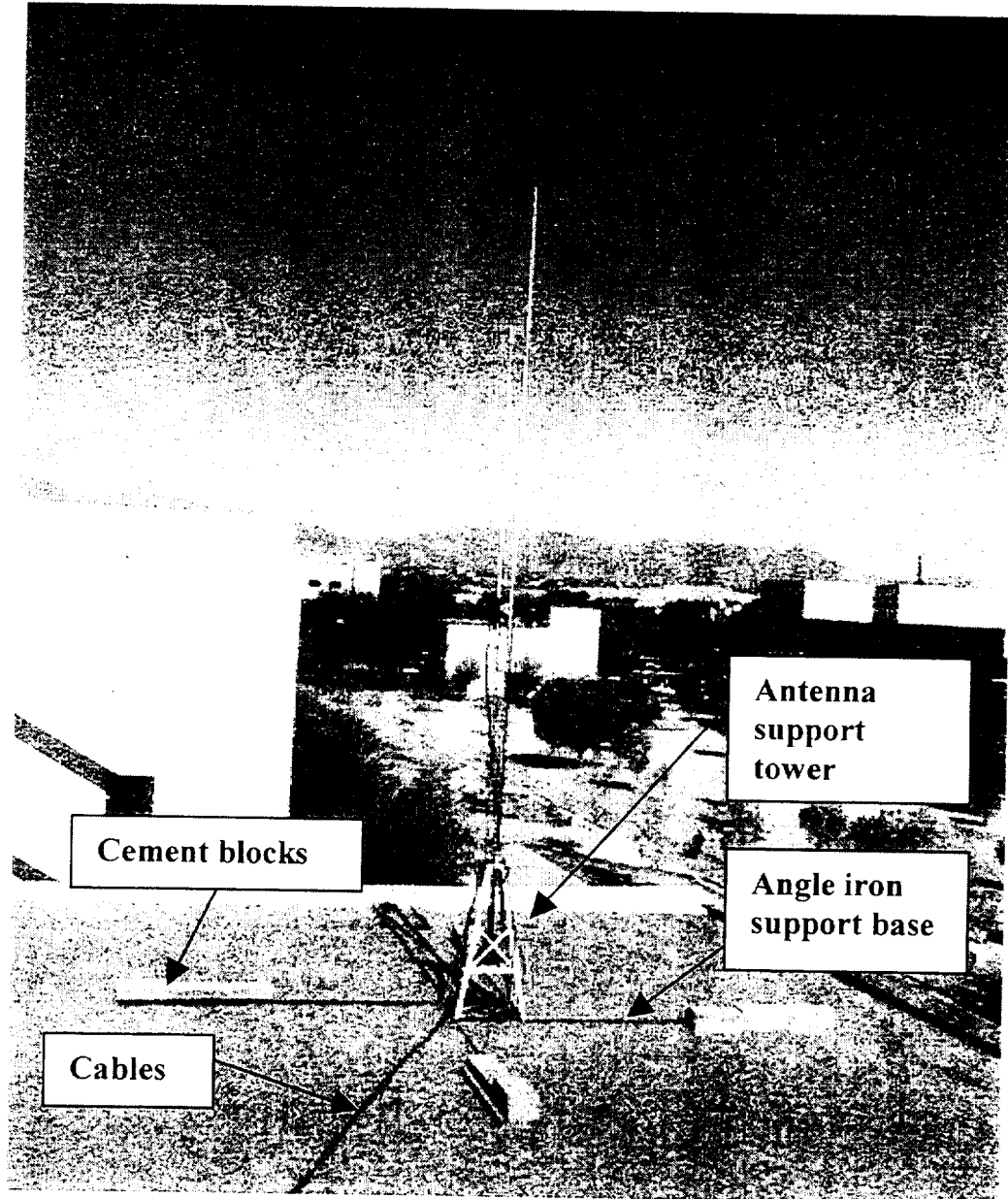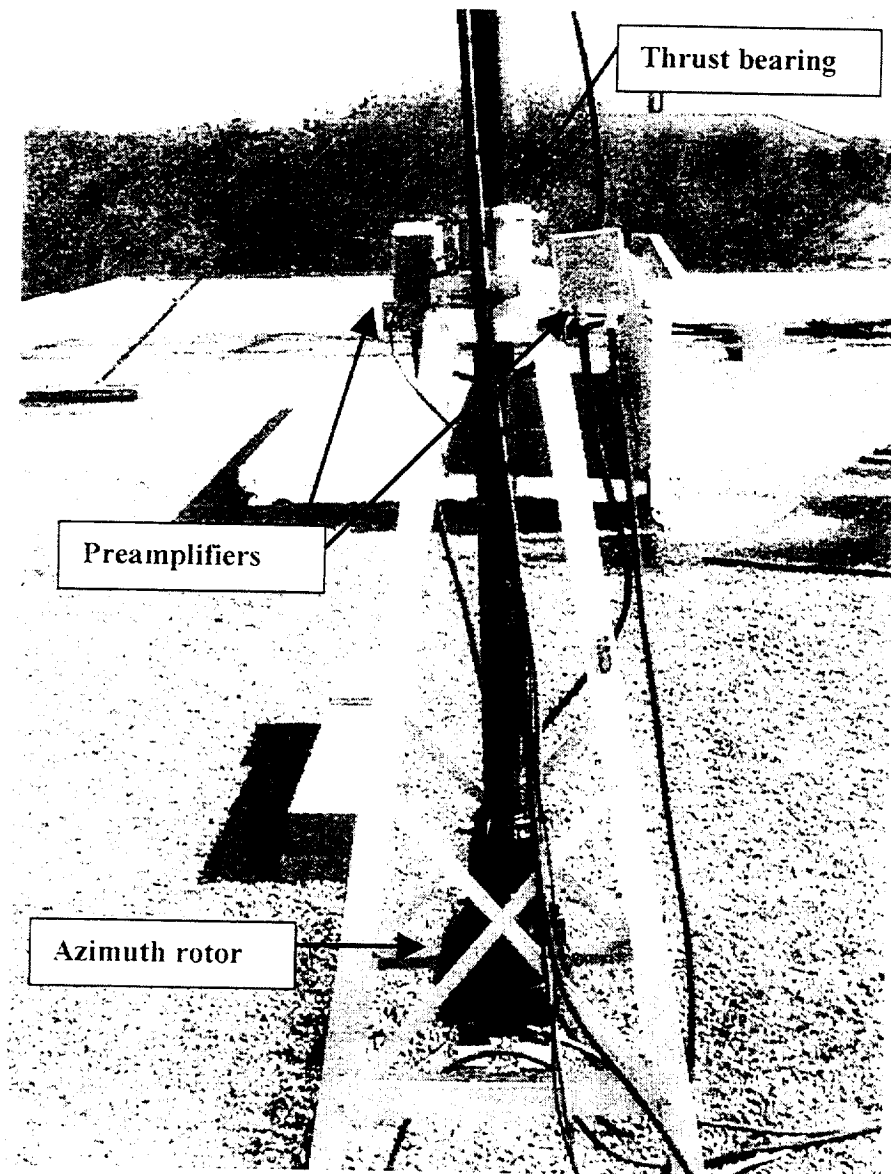
4.2   WIND LOAD CALCULATIONS

The Yaesu G-5400B rotor has a specified a maximum antenna wind load of 8.6 sq. ft. The two Yagi-Uda antennas have a wind load of 1.85 sq. ft. and 1.16 sq. ft., for a total combined wind load of 3.01 sq. ft. From a wind load standpoint of view, this antenna rotor provides a safety factor of 286 %.

4.2.1 ROTORS K-FACTOR

The K-Factor is a specification used by Yaesu for their antenna rotors to determine if the desired rotor is strong enough to handle a given antenna. The K-Factor is determined by multiplying the weight (lbs.) of the antenna by its turning radius (ft). When multiple antennas are used with one rotor the K-Factor from each antenna may be added together to give the total system K-Factor. The rotor is considered acceptable as long as the specified K-Factor for the rotor is greater than the total system K-Factors for the antennas. The Yaesu G-5400B antenna rotor is specified as having a K-Factor of 578 ft. lbs., where both of the crossed Yagi-Uda antennas added together give a K-Factor of 230.5 ft. lbs. This calculation show a 250% safety factor for this antenna / rotor combination. See Appendix C for calculations

4.2.2 TOWER WIND LOAD

The Glen Martin Engineering RT-424 antenna tower has the following specifications:

Maximum Antenna Wind Load

87 mph	100mph	112mph
6 sq. ft.	4.5 sq. ft.	3.6 sq.

With all other wind load calculations being specified at 87 mph the antenna tower has a safety factor of 199%.

4.3 RF CABLE

For this project, the RF coaxial cable chosen was the Belden 9913F. The 9913F cable has a characteristic impedance of 50 Ω, provides flexibility, and low loss. This cable is more flexible than the RG-8 cable or Beldens 9913 cable. The increased flexibility is due to the fact that the center conductor is stranded as opposed to being solid. Table 4.3 lists the specifications for the Belden 9913F.

Table 4.3 Belden 9913F Coaxial Cable Specifications

Electrical Characteristics

Nominal Impedance:	50 Ω
Nominal Inductance:	59 pico Henry/ft.
Nominal Conductance:	24.6 pico Farad/ft.
Nominal velocity of propagation:	84%
Nominal Attenuation:	1.5 dB/100 ft. @ 100 MHz
	2.0 dB/100 ft. @ 200 MHz
	2.8 dB/100 ft. @ 400 MHz

Table 4.3 Belden 9913F Coaxial Cable Specifications (continued)

Physical Characteristics

Overall diameter:	0.405 in.
Minimum bending radius	6 in.
Maximum pulling tension	210 lbs.
Insulation material, diameter	foam high density PE, 0.285 in.
Shielding, % coverage 1st layer:	DouBond II, 100%
2nd layer:	tinned copper braid, 90 %

Access to the roof is provided in discrete locations through access ports running up through the roof. Since the satellite communication link will be set up for full duplex, two separate coaxial cables were required. If the ground station was going to be setup for simplex operation, a remote transmit/receive switch could have been used along with a single run of RF cable. The measured length for the cable was 120 ft. For the 9913F coaxial cable, a 250 ft. roll of cable was purchased and cut in 2 equal lengths of cable providing 125 ft. of cable per antenna. The calculated loss for the 2m / 70cm cable was calculated as 2.16 dB / 3.68 dB respectively. See Appendix D for calculations. Due to the flexibility of the 9913F Belden cable, this cable could also be used for the connection of the rotating antennas to the preamplifiers mounted on the antenna tower. The length of these cables were kept as short as possible due to their high sensitivity to the overall noise figure of the receiving system. This length was chosen so that it would insure minimal loss while providing slack for the full range rotation of the antennas. A great amount of detail was given to the connectors, cable lengths, and preamplifiers in order to provide the best possible noise figures. During the initial setup, the RF coaxial cable was

suspended from the antenna feed points to the tower mounted preamplifiers. By letting the RF cable suspend from the rear of the antennas, this provided a good way to feed the antennas without having a large impact on the antenna field patterns. After initially running the ground station in this configuration, it was evident that there was a great deal of stress on the coaxial cable occurring at the feed point. This was due to the fact that the weight of coaxial cable was being suspended from its feed point and during the movement of the antennas a larger amount of stress was occurring at the feed points. Due to concern for the longevity and reliability of the RF cable another method for suspending the RF cable from the antennas was chosen. By routing the RF cable along the length of the antenna's aluminum boom, the cable could then be routed to the fiberglass cross-boom and suspended to the preamplifiers from the center of the cross-boom along with the rotor control cable used for the elevation rotor. The drawback from routing the RF cable in this manner is that there will be a small perturbation in antenna's field pattern due to the coaxial cables metal content. The 2 m crossed Yagi-Uda antenna was positioned so that there was a 45 degree angle between the of director elements and the coaxial cable coming off of the antennas boom to the fiberglass cross-boom. This allows the RF cable to come off the antenna in such a way to minimize its effects to the field patterns. Due to the physical mounting structure for the 70 cm crossed Yagi-Uda antenna, it can not be rotated in the same manner as described above. No degradation in the quality of the received signal was observed after these changes. Figure 4.3 shows the cable routing and connections for the 70 cm antenna.

Figure 4.3 Cable routing and connections for the 70 cm antenna
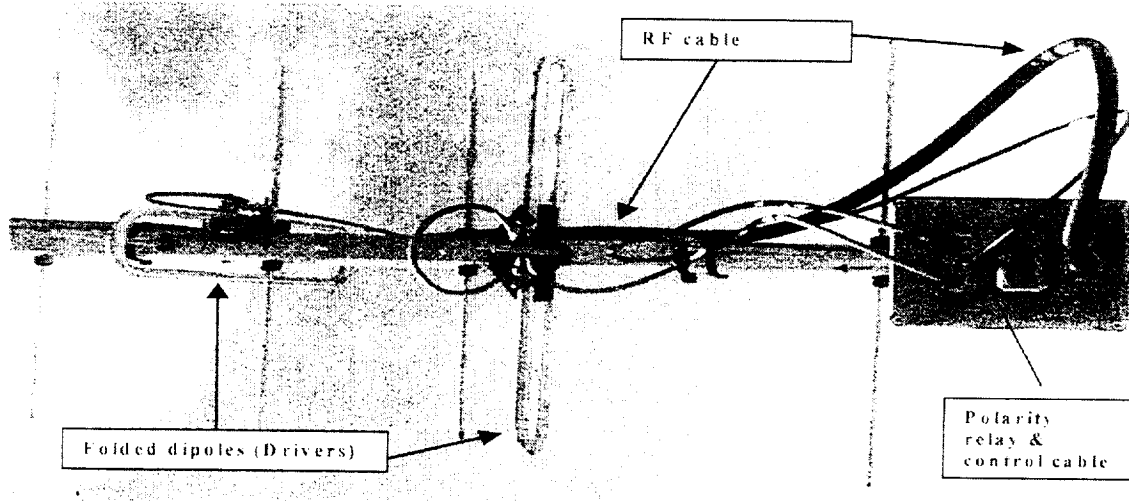
4.4   ROTOR CONTROLLER / POLARITY SWITCHING CABLES

The Yaesu G-5400B azimuth/elevation rotor required a 6 conductor wire for full operation. The Belden 9405 cable was chosen for this task due to the fact that it contained six 18 AWG conductors, and two 16 AWG conductors. Special consideration was given to the conductor size due to the length of the required cable run. The extra two conductors in the cable bundle were needed in order to provide the + 12 VDC used for polarity switching of the antennas. An external power supply at +12 VDC was connected to two toggle switches that provide the needed voltage to energize the polarity switches and to change polarity from RHCP to LHCP.

5   DECODING UoSAT-OSCAR-11 TELEMETRY

The UoSAT-OSCAR-11 satellite uses 1200 baud Audio Frequency-Shift Keying (AFSK) modulation with tones of 1200 and 2400 Hz on its 145.825 MHz beacon for telemetry. This modulation data type may be demodulated with a slightly modified Hamtronics DE-202 demodulator. This demodulator is based on the Exar XR-2211 FSK demodulator / tone decoder. The modifications were necessary since the demodulator was designed to operate using tones of 1200 and 2200 Hz. The phase locked loop center frequency was changed from 1700 Hz to 1800 Hz and the resistor value between pins 12 and 11 was changed to 10.8 kΩ to allow for the larger bandwidth. Other suitable demodulators include a modified Bell Type 202 modem, a BAYCOM type modem, or the popular G3RUH demodulator designed by James Miller [7],[8]. The Bell Type 202 modems require that the data bits be inverted before sending them to the computer's RS-232 port. The operating schedule for the 2m beacon onboard the UO-11 is shown in Table 5 [9].

Table 5: Operating schedule of UO-11

Format	Time Duration
ASCII status	210 seconds
ASCII bulletin	60 seconds
BINARY single event upset	30 seconds
ASCII telemetry (TLM)	90 seconds
ASCII Whole Orbit Data (WOD)	120 seconds
ASCII bulletin	60 seconds
BINARY engineering	30 seconds

* status blocks are inserted between the ASCII bulletins, WOD, and ASCII TLM.

5.1 DEMODULATING 1200 BAUD AFSK

The AFSK demodulator uses the audio output of the receiver as its input. The Hamtronics DE-202 requires a minimum audio level of 80 mV p-p in order to work properly. The AFSK output from the receiver was taken from the ACC connector (pin 4) on the rear of the Icom 821-H transceiver. The audio output is taken directly from the detector in order to avoid added distortion from the audio amplifier.

Standard convention used in Bell Type 202 modems
"space" 1200 Hz = high
"mark" 2200 Hz = low

Modified Type 202 Bell Standard / Hamtronics DE-202 Demodulator

Command	Audio Frequency	(RS-232 / TTL) Outputs
On	1200 Hz "space"	+12VDC / Lo
Off	2200 Hz "mark"	-12 DC / Hi

DB-9	DE-202	Description
1	E3	Receive Carrier Detect (RCD)
2	E1	Receive Data
5	E6	Signal Ground
	E7	Audio Input (from Pin 4 of ACC)
	E2	-12VDC
	E6	Ground
	E8	+12VDC

For the ASCII data formats used in the telemetry, bulletins, and WOD the computers RS-232 port should be setup to receive data with the following parameters:

RS-232 Port Parameters – For ASCII data formats
1200 baud - data rate
1 – start bit
7 – data bits
1 – even parity bit
2 – stop bits

The experimental, operational, and diary data are sent as hexadecimal values using an 8 bit format that is not compatible with that of the 7 bit ASCII data formats. Even though this data is not of interest to the current project, its parameters are given here for reference.

RS-232 Port Parameters – For hexadecimal formats
1200 baud – data rate
1 – start bit
8 – data bits
N – no parity
1 – stop bits

5.2   GATHERING UoSAT-OSCAR-11 TELEMETRY

In order for a satellite pass to be acknowledged by WiSP, the satellite must be set up in the satellite database. Underneath the Setup menu Satellite Setup is selected. From here, a new satellite may be added for tracking, or a previously entered satellite may be edited. The name of the satellite chosen for tracking will be prompted for, where the name of the satellite is entered as it appears in the Keplerian elements, for example, UO-11. Track and display, should be selected and a priority level given to run that satellite's passes. Next, the uplink and downlink frequencies along with each mode are entered. For telemetry purposes, we are only concerned with the downlink frequency, but the uplink may also be entered for communication purposes. Here, the downlink frequency is setup for 145.825 MHz FM. Once the satellite is setup underneath the Setup menu, Scheduling is checked underneath the Tracking menu in order for WiSP to track any satellites. If Scheduling is not checked, the rotors and radio will not be accessed during the pass. This should only be selected when you wish to run a given satellite pass. Once everything is setup with WiSP a message will appear 3 minutes before the pass to alert the user to an approaching satellite pass. The radio, antenna rotor controller, antenna preamplifiers, and demodulator should be powered on by this time. The antenna rotor controller will not be accessed by the computer until 30 seconds before the pass. In order to capture the data from the demodulator, HyperTerminal is being used as supplied within Windows 95. The terminal program's RS-232 port parameters are setup as described in Section 5.2. Once the satellites elevation is above the horizon, the satellite's beacon should easily be heard and data should be scrolling across the HyperTerminal window. To start saving the telemetry, Capture Text underneath the Transfer menu in HyperTerminal is selected, and a name given to the telemetry file. Once the satellite pass has ended, Stop is selected from the Capture Text selection. This data file is now ready

to run through the filter program that will remove unwanted characters from the telemetry file. Thus enabling it to be used for a telemetry decoding program. The filter program prompts for the input telemetry filename, and a name to provide for the output. The telemetry data is now ready to be decoded by hand or by a telemetry decoding program. Appendix F provides an operations checklist that should be used when operating the satellite station. Due to the effects of multipath for satellites at low elevations, the telemetry data will have a high bit error rate until the satellite's elevation exceeds that of approximately 10 degrees. Other sources of multipath exist due to the large metal structure used to support an existing large parabolic dish antenna. This multipath can be observed when the satellite passes over the parabolic dish structure.

5.3   DECODING UoSAT-OSCAR-11 TELEMETRY

Appendix I shows the data collected during a single pass from UoSAT-OSCAR-11 on 4-21-98. The data file begins with the ASCII status. Shown below (Figure 5.3) is an ASCII telemetry frame taken from the pass mentioned above.

Figure 5.3 UoSAT-OSCAR-11 ASCII telemetry frame

```
UOSAT-2              9804232225040

0025700133320224730344120404000502BF06014307039D08034F09027C
10499511308B1200031305341416131558ID16183D17431018433D19488C
2049782122122264572300012400062500072608592744C28461929455F
3049973102663227513357023400073522533627883739IF38431D39462A
40737741095942628A43055744153745000146000247443048461F494292
50517651117352631353271254668955579B5617055745125838BE59452F
60A2A4615FC162414563335064440265IE0C6607E967F00E68000E69000F
```

The header states the satellite's name and time which the telemetry frame transmitted. UoSAT-11 is also known as UoSAT-2 and UoSAT-B since it was the second amateur satellite built from the University of Surrey. The time stamp 9804232225040 may be decoded to give the date and time of transmission as:

Date: 04-23-98

Day: 2 = Tuesday

Time: 22:50:40 UTC

Each major frame contains 70 channels of data. The first 59 contain analog data while the remaining 11 channels contain the reporting of 96 status points. Taking the first line of telemetry data in Figure 5.3 we have:

<u>00</u>2570<u>01</u>3332<u>02</u>2473<u>03</u>4412<u>04</u>0400<u>05</u>028F<u>06</u>0143<u>07</u>039D<u>08</u>034F<u>09</u>027C

The above minor frame shows analog channels 00 through 09 in which the channel numbers are underlined, along with their hex data values which are in bold typeface. The value following hex data is the checksum. To verify that the hex data value of 257 for channel 00 was most likely received correctly we will exclusive-OR (XOR) the data value with 0 hex as illustrated below to verify that the result equals that of the checksum value, 0 hex.

257 (hex) = 0010 0101 0111 (binary)

0000 XOR 0010 → 0010

0010 XOR 0101 → 0111

0111 XOR 0111 → 0000 = checksum value

The checksum value here of 0 hex is equal to the checksum provided in the telemetry data for channel 00. The data received for channel 00 was most likely received properly.

Decoding channel 00: Y – directed solar array current

      Hex data: 257

      Checksum: 0

      From Appendix H: $I = 1.9(516 - N)mA$

                       $I = 1.9(516 - 257)mA = 492.1 \text{ mA}$

Decoding channel 35: 145 MHz RF power output

      Hex data: 225

      Checksum: 3

      From Appendix H: $P = (2.5*N - 275) \text{ mW}$

                       $P = (2.5*225 - 275) \text{ mW} = 287.5 \text{ mW}$

Decoding channel 36: 145 MHz beacon current

     Hex data: 278

     Checksum: 8

     From Appendix H: $I = (0.22 * N) \text{ mA}$

                           $I = (0.22 * 278) \text{ mA} = 61.16 \text{ mA}$

Decoding channel 60 Bit 1:   145 MHz beacon power

     Hex data: A2A = 1010 0010 1010

     Checksum: 4

     From Appendix H: Bit 1(MSB) (1 = ON) (0 = OFF)

                           Bit 1 = 1 (therefore beacon power is ON)

Decoding these channels by hand is a good exercise, but the use of programs written to decode this telemetry is much more time efficient. Programs such as TLM2.EXE by Craig Underwood of the University of Surrey, and U2TM which is coded in BBC basic, can be used to decode the ASCII telemetry from UoSAT-11. Currently U2TM is being used to decode the telemetry. Telemetry decoding programs and further information on UO-11 can be found at G3CWV amateur radio and satellites home page [11].

6   Summary

The satellite ground station is currently in full operation. Satellite passes from UO-11 have been successfully received several times per day collecting telemetry on each pass. The operation of both the station's software and hardware have been extremely reliably. Due to the fact that the satellite station is fully automated, collecting telemetry is easily managed. Although the satellite station is currently gathering telemetry from UO-11, with the addition of a DSP modem all of the OSCAR satellites could be decoded. With the DSP modem, demodulation becomes a matter of software rather than physical hardware. The availability of the AEA 2232 DSP modem manufactured by Timewave Technology Inc. was delayed due to the company's backorder time of several months. By mid summer 1998 a new AEA DSP modem, model number 2232 ZX, is to be released with increased capabilities. Furthermore, this

satellite ground station should not be limited to that of OSCAR satellites. Any satellite that operates in the 2m or 70 cm frequency band limits as given in Table 1-1 may be received.

REFERENCES

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[9] *AMSAT News Service*, http://www.amsat.org/amsat/news/ans.htm#uo-11

[10] *NMSU Monitored Climate Stations*, http://www.weather-mirror.nmsu.edu/stations

[11] *G3CWV Home Page*, http://www.users.zetnet.co.uk/clivew/oscar11.htm

Appendix A: Telemetry Beacons for OSCAR Satellites

Satellite	Modes	Telemetry Format	Frequency
AO-16	J	1200 bps PSK AX.25 (SSB)	437.025
	J	1200 bps PSK AX.25 (SSB) [1]	437.050
AO-21	B	1200 bps BPSK AX.25 (SSB) [1]	145.983
	B	1200 bps BPSK AX.25 (SSB) [2]	145.800
	B	1100 bps BPSK (FM) [1]	145.952
	B	1100 bps BPSK (FM) [2]	145.838
	B	CW [1]	145.822
	B	CW [2]	145.848
DO-17	B	1200 bps AFSK AX.25 (FM)	145.825
LO-19	J	1200 bps PSK AX.25 (SSB) [1]	437.150
	J	1200 bps PSK AX.25 (SSB) [2]	437.125
	J	CW	437.125
RS-10	KA,K,A	CW	29.360
	KA,K,A	CW	29.403
	T	CW	145.857
	KT	CW	145.903
RS-11	K	CW	29.407
	KA,K,A	CW	29.453
	T	CW	145.907
	T	CW	145.953
RS-12	KA,K,A	CW	29.4081
	KA,K,A	CW	29.4543
	KT,T	CW	145.9125
	KT,T	CW	145.9587
RS-13	KA,K,A	CW	29.4582
	KA,K,A	CW	29.5043
	KT,T	CW	145.8622
	KT,T	CW	145.9083
UO-11	B	1200 bps AFSK ASCII (FM)	145.825
	J	1200/4800 bps AFSK ASCII (FM)	435.025
UO-14	J	9600 bps FSK ASCII (FM)	437.025
WO-18	J	1200 bps PSK AX.25 (SSB) [1]	437.100
	J	1200 bps PSK AX.25 (SSB) [2]	437.075

Appendix B: Kansas City Tracker / Tuner DB25 pinout description

Pin #	Description
1	ground
2	n/c
3	control output (Up)
4	n/c
5	control output (Down)
6	ground
7	control output (Right)
8	azimuth brake release
9	control output (Left)
10	serial input (Port A)
11	analog input (Vertical)
12	serial input (Port B)
13	analog input (Horizontal)
14	– 12 VDC (regulated)
15	ground
16	ground
17	ground
18	serial output (Port A)
19	+ 5 VDC (regulated)
20	serial output (Port B)
21	+ 12 VDC (regulated)
22	click-down (Port C)
23	click-up (Port C)
24	click-down (Port D)
25	click-up (Port D)

Appendix C: K-Factor calculations

Turn_{radius_2m} $13 \cdot ft$ Turning radius for 2m crossed Yagi-Uda

$\text{Turn}_{radius\_70cm}$ $8.75 \cdot ft$ Turning radius for 70cm crossed Yagi-Uda

Weight_{2m} $11 \cdot lb$ Weight of 2m crossed Yagi-Uda

Weight_{70cm} $10 \cdot lb$ Weight of 70cm crossed Yagi-Uda

K_{factor_2m} $\text{Turn}_{radius\_2m} \cdot \text{Weight}_{2m}$

K_{factor_70cm} $\text{Turn}_{radius\_70cm} \cdot \text{Weight}_{70cm}$

$K_{factor\_2m} = 143 \cdot ft \cdot lb$ K-Factor for 2m crossed Yagi-Uda

$K_{factor\_70cm} = 87.5 \cdot ft \cdot lb$ K-Factor for 70cm crossed Yagi-Uda

K_{tot} $K_{factor\_2m} \cdot K_{factor\_70cm}$

$K_{tot} = 230.5 \cdot ft \cdot lb$ Total system K-Factor for antennas

For the Yaesu G-5400B rotor the K-Factor is specified as being:

K_{rotor} $578 \cdot ft \cdot lb$

$\dfrac{K_{rotor}}{K_{tot}} = 2.508$

therefore, the Yaesu G-5400B antenna rotor has a 250% safety factor when using the large set of KLM OSCAR antennas

Appendix D: Belden 9913F Coaxial Cable Attenuation Calculations

i 1.. 10

Specifications from Belden:

freq(MHz)	attenuation (dB/100ft)
freq	dB
1	0.2
10	0.6
50	1.1
100	1.5
200	2.0
400	2.8
700	3.9
900	4.4
1000	4.8
4000	11.0

interpolate for attenuation for 2m band:

f_{2m} 145 MHz

f_{dB_2m} linterp freq.dB.f_{2m}

f_{dB_2m} 1.725 dB / 100 ft   (attenuation)

interpolate for attenuation for 70cm band:

f_{70cm} 440 MHz

f_{dB_70cm} linterp freq.dB.f_{70cm}

f_{dB_70cm} 2.947 dB / 100 ft   (attenuation)

attenuation for 125 ft length of 9913F coaxial cable:

$f_{dB\_2m}(1.25) = 2.16$ dB (total attenuation for 125 ft. length @ 150 MHz)

$f_{dB\_70cm}(1.25) = 3.68$ dB (total attenuation for 125 ft. length @ 428 MHz)

attenuation for 15 ft length of 9913F coaxial cable:

$f_{dB\_2m}(0.15) = 0.26$ dB (total attenuation for 125 ft. length @ 150 MHz)

$f_{dB\_70cm}(0.15) = 0.44$ dB (total attenuation for 125 ft. length @ 428 MHz)

Appendix E: Doppler shift caculations

$$f_d = \frac{v}{c} \cdot \cos(\theta)$$

equation for doppler shift

$$v \quad 7.406 \cdot \frac{km}{sec}$$

velocity of satellite

$$c \quad 3.0 \cdot 10^8 \cdot \frac{m}{sec}$$

speed of light

$$f_1 \quad 145 \cdot MHz$$

2 m beacon frequency

$$f_2 \quad 435 \cdot MHz$$

70 cm beacon frequency

$$f_{d\_145}(\theta) \quad \frac{v}{c} \cdot \cos(\theta) \cdot f_1$$

Doppler shift @ f = 145 MHz

$$f_{d\_435}(\theta) \quad \frac{v}{c} \cdot \cos(\theta) \cdot f_2$$

Doppler shift @ f = 435 MHz

$$\theta \quad 0, 0.1 \cdot deg .. 180 \cdot deg$$

angle of satellite relative to ground station

Doppler Shift for UO-11 @ 145 / 435 MHz

satellite elevation (degrees)

39
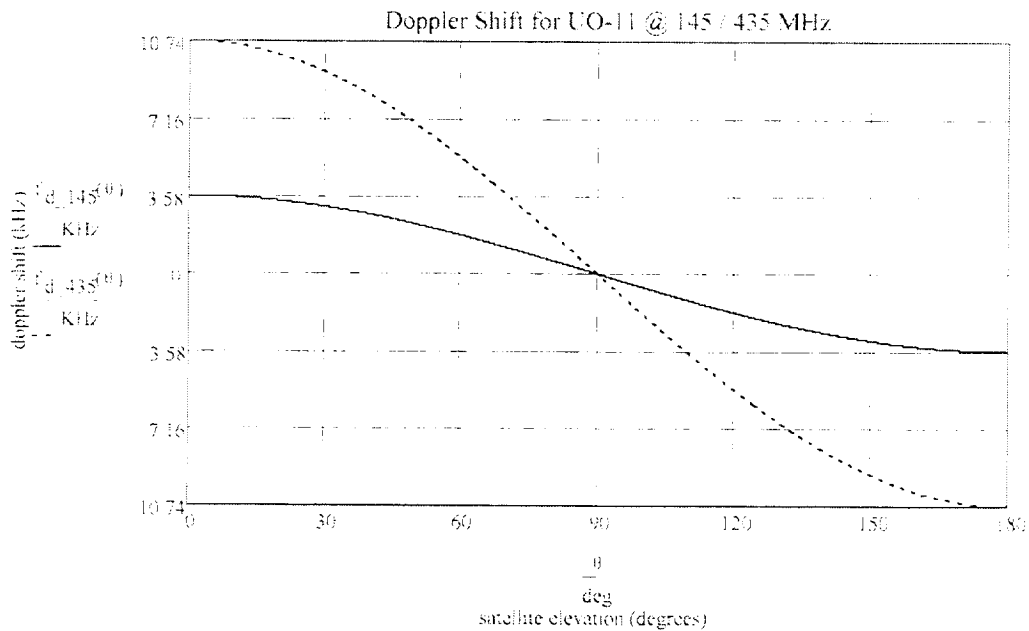
Appendix F: Operations procedure for satellite station

1. Visibly inspect the integrity of the antennas and support structure on top of roof before powering up the antenna rotor controller after extended periods of inactivity or after a severe weather condition.

2. Verify the time of the satellite pass through the computers WiSP ground tracking program.

3. Power on the transceiver, rotor controller, demodulator, and the antenna preamplifiers via the front panel switch located on the Icom 821-H.

4. Select Scheduling from underneath the Tracking menu in WiSP.

5. Select run when prompted from WiSP for the three minute alert of the satellite pass.

6. HyperTerminal should be opened and a filename given for the telemetry data. Once the satellite has come over the horizon, Capture text should selected.

7. The antennas and transceiver will automatically be controlled during the satellite pass. After the satellite pass has been completed the antennas will be parked at a azimuth value of 0 degrees, and a elevation value of 90 degrees.

8. After the completion of the satellite pass, the capture text function on HyperTerminal should be stopped. The telemetry data file is now ready to be filtered and analyzed by a telemetry decoding program.

9. After the antenna rotor controller meters verify that the antennas have been parked to these values the satellite station may be powered down.

Appendix G: Rotor Calibration

The Azimuth and Elevation rotors need to be calibrated to both the controller box and the computer. This is best carried out with the aid of a second person. The use of a two-way communication link should be used between one person located on the roof while the other person operates the control station. The exact position of each rotor must be known in order to obtain the strongest possible downlink signal. The controller box has three adjustments per rotor that should be calibrated. These adjustments include: a meter calibration, a full-scale potentiometer, and an output voltage potentiometer. The first adjustment is to zero both the azimuth and elevation meters to readings to 180 degrees left and 0 degrees down respectively. This is accomplished via a small adjustment screw located below the meters. Once this adjustment is made, the full range of output for each rotor should be determined. For the azimuth rotor, the exact position of the rotor needs to be marked for the –180 degrees. Once the rotor position is marked, the rotor needs to rotated 360 degrees to +180 degrees . The rotor position should be determined from the actual rotor position of the antennas and not by the meter reading. After the rotor is positioned to exactly +180 azimuth, the potentiometer on the back of the control box for the azimuth controls should be adjusted so that the meter reads +180 azimuth.

Next, the same procedure is carried out for the elevation rotor. The elevation rotor needs to be marked at the 0 degree position and then rotated 180 degrees and adjusted in the same manner as described above. After both the azimuth and elevation rotors have been calibrated to their controller box for their full range of movement, the rotors must be aligned geographically. The azimuth rotor should be aligned first. It should be aligned to true North. True North is determined by finding the magnetic deviation in the area and subtracting its value from the compass reading. For the Las Cruces area, the magnetic deviation is 13 degrees. This corresponds to a true North reading of 347 degrees West. With the azimuth rotor positioned for 0 degrees North, the azimuth's rotor mast support clamp should be loosened and the antenna array pointed to that of true North. This was accomplished by finding a distant landmark located at true North and then aligning the antenna boom's to point to that landmark. Once the azimuth

rotor is aligned the bottom mast supporting clamp should be tightened. Now, the elevation rotor should be aligned. The 0 degree elevation position corresponds the antenna booms being parallel to the horizon. This adjustment was made with the help of a level. Once the mast is aligned parallel to the horizon, 90 degrees corresponds to the vertical position, where the antennas are pointing at the zenith. At 180 degrees, the antennas should once again be parallel to the horizon put pointed in the opposite direction.

Finally, the rotors need to be calibrated in the WiSP GroundStation control program. This procedure can be found underneath the Setup, Station Setup, Rotator, Setup menu. From here calibrate rotor is selected. The procedure will ask to rotate the rotors to their full extents, and to make adjustments to the voltage output potentiometers located on the rear of the antenna rotor controller. It is important to determine the rotor positions according to their physical locations rather than the meter readings.

Appendix H: Analog Telemetry Channel Calibration Equations for UoSAT OSCAR 11

Channel	Parameter	Equation
00	Solar array current −Y	$I = 1.9(516 - N)$ ma
01	Nav mag X axis	$H = (0.1485N - 68)\ \mu T$
02	Nav mag Z axis	$H = (0.1523N - 69.3)\ \mu T$
03	Nav mag Y axis	$H = (0.1507N - 69)\ \mu T$
04	Sun sensor 1	N uncalibrated
05	Sun sensor 2	N uncalibrated
06	Sun sensor 3	N uncalibrated
07	Sun sensor 4	N uncalibrated
08	Sun sensor 5	N uncalibrated
09	Sun sensor 6	N uncalibrated
10	Solar array current +Y	$I = 1.9(516 - N)$ mA
11	Nav mag (Wing) temp	$T = (330 - N)/3.45$ C
12	Horizon sensor	N uncalibrated
13	435 MHz Beacon VCO control	$V = N/200$ V
14	DCE RAMUNIT current	$I = (N - 70.4)/6.7$ mA
15	DCE CPU current	$I = (N - 187.1)/2.0$ mA
16	DCE GMEM current	$I = (N - 121.3)/2.1$ mA
17	Facet temp +X	$T = (480 - N)/5$ C
18	Facet temp +Y	$T = (480 - N)/5$ C
19	Facet temp +Z	$T = (480 - N)/5$ C
20	Solar array current −X	$I = 1.9(516 - N)$ mA
21	+ 10 V line current	$I = 0.97N$ mA
22	PCM voltage + 10V	$V = 0.015N$ V
23	P/W logic current (+ 5V)	$I = 0.14$ mA (N<=500)
24	P/W Geiger current (+ 14V)	$I = 0.21N$ mA
25	P/W Elec sp. Curr (+ 10V)	$I = 0.096N$ mA
26	P/W Elect sp. Curr (- 10V)	$I = 0.093$ mA
27	Facet temp −X	$T = (480 - N)/5$ C
28	Facet temp −Y	$T = (480 - N)/5$ C
29	Facet temp −Z	$T = (480 - N)/5$ C
30	Solar array current +X	$I = 1.9(516 - N)$ mA
31	- 10V line current	$I = 0.48N$ mA
32	PCM voltage −10V	$V = -0.036N$ V
33	1802 comp curr (+ 10V)	$I = 0.21N$ mA
34	Digitalker current (+ 5V)	$I = 0.13N$ mA (N<=500)
35	145 MHz beacon power O/P	$P = (2.5N - 275)$ mW (N>200)
36	145 MHz beacon current	$I = 0.22N$ mA
37	145 MHz beacon temperature	$T = (480 - N)/5$ C
38	Command decoder temperature	$T = (480 - N)/5$ C
39	Telemetry temp (+X)	$T = (480 - N)/5$ C

40	Solar array voltage (+ 30V)	$V = (0.1N - 51.6)$ V
41	+ 5V line current	$I = 0.97N$ mA
42	PCM voltage + 5V	$V = 0.0084N$ V
43	DSR current (+ 5V)	$I = 0.21N$ mA (N<=500)
44	Command RX current	$I = 0.92N$ mA
45	435 MHz beacon power O/P	$P = (2.5N - 200)$ mW (N>175)
46	435 MHz beacon current	$I = 0.44N$ mA
47	435 MHz beacon temperature	$T = (480 - N)/5$ C
48	P/W temperature (-X)	$T = (480 - N)/5$ C
49	BCR temperature (-Y)	$T = (480 - N)/5$ C
50	Battery charge/discharge current	$I = 8.8 (N - 513)$ mA
51	+ 14V line current	$I = 5N$ mA
52	Battery voltage (+ 14V)	$V = 0.021N$ V
53	Battery cell volts (MUX)	$V = N$ uncalibrated
54	Telemetry current (+ 10V)	$I = 0.02N$ mA
55	2.4 GHz beacon power O/P	$P = ((N + 50)^2)/480$ mW
56	2.4 GHz beacon current	$I = 0.45N$ mA
57	Battery temperature	$T = (480 - N)/5$ C
58	2.4 GHz beacon temperature	$T = (480 - N)/5$ C
59	CCD imager temperature	$T = (480 - N)/5$ C

Analog Telemetry Channel Conversion Equations for UoSAT OSCAR 11

Channel	Bit	Function	0 /1
60(MSB)	1	145 MHz general beacon power	OFF/ON
	2	435 MHz engineering beacon power	OFF/ON
	3	2401 MHz engineering beacon power	OFF/ON
	4	Telemetry channel mode select	Run/Dwell
	5	Telemetry channel dwell address load	OFF/ON
	6	Telemetry channel dwell address source	Gnd/Computer
	7	Primary spacecraft computer power	OFF/ON
	8	Primary spacecraft computer error count	Bit 1
	9	Primary spacecraft computer error count	Bit 2
	10	Primary spacecraft computer bootstrap	UART/PROM
	11	Primary spacecraft computer error count	Bit 3
(LSB)	12	Primary spacecraft computer bootstrap	A/B
61(MSB)	13	Gravity gradient boom deployment pyros	Safe/Arm
	14	Gravity gradient boom deployment pyros	Fire/Hold
	15	Gravity gradient boom deployment	Safe/Arm
	16	Gravity gradient boom deployment	Deploy/Hold
	17	Gravity gradient boom deployment	Extend/Retract
	18	Attitude Control Magetorquers	Safe/Arm
	19	Attitude Control Magetorquers –X	ON/OFF
	20	Attitude Control Magetorquers –Y	ON/OFF
	21	Attitude Control Magetorquers –Z	ON/OFF
	22	Attitude Control Magetorquers	Reverse/Forward

	23	435 MHz PSK Mode	NRZI/NRZIC
61(LSB)	24	2401 MHz PSK Mode	NRZI/NRZIC
62(MSB)	25	Attitude Control Magetorquers	High/Low Power
	26	Digitalker experiment power	ON/OFF
	27	CCD camera experiment power	OFF/ON
	28	CCD camera exper. integration period	Bit 0
	29	CCD camara exper. integration period	Bit 1
	30	CCD camera exper. video amp gain	Bit 0
	31	CCD camera exper. video amp gain	Bit 1
	32	DSR power	OFF/ON
	33	DSR mode	Read/Write
	34	DSR mode	Run/Reset
	35	Radiation detectors Geiger-A EHT power	OFF/ON
	36	Radiation detectors Geiger-B EHT power	OFF/ON
	37	Radiation detectors Geiger-C EHT power	OFF/ON
	38	Electron Spectrometer sensor EHT power	OFF/ON
	39	DCE experiment power	OFF/ON
	40	DCE experiment	Reset/Run
	41	DCE experiment PROM select	A/B
	42	DCE experiment CPU clock rate select	0.9/1.8 MHz
	43	Navigation Magnetometer power	OFF/ON
	44	Space Dust experiment power	OFF/ON
	45	Status calibrate	
	46	BCR status	A/B
	47	435 MHz beacon modulation select	AFSK/PSK
63(LSB)	48	2401 MHz beacon modulation select	AFSK/PSK
64(MSB)	49	Engineering data	Bit 1
	50	Engineering data	Bit 2
	51	Engineering data	Bit 3
	52	Engineering data	Bit 4
	53	Engineering data	Bit 5
	54	Command Watchdog	Disable/Enable
	55	Command Watchdog reset	Run/Reset
	56	145 MHz beacon data select	A
	57	145 MHz beacon data select	B
	58	145 MHz beacon data select	C
	59	145 MHz beacon data select	D
	60	145 MHz beacon data select	E
	61	145 MHz beacon data select	F
	62	145 MHz beacon data rate	A
	63	145 MHz beacon data rate	B
	64	435 MHz beacon data rate	A
	65	435 MHz beacon data rate	B
	66	435 MHz beacon data rate	C
	67	Particle / Wavecounter control	Count/Reset
	68	VHF/UHF beacon lockout protection	Disable/Enable

	69	Engineering data	Bit 6
	70	Engineering data	Bit 7
	71	Engineering data	Bit 8
65(LSB)	72	Engineering data	Bit 9
66(MSB)	73	P/W channel plate control	Bit 2
	74	P/W channel plate control	Bit 1
	75	P/W channel plate control	Bit 0
	76	Space Dust (MSB)	
	77	Space Dust	
	78	Space Dust	
	79	Space Dust	
	80	Space Dust	
	81	Space Dust	
	82	Space Dust	
	83	Space Dust (LSB)	
66(LSB)	84	DSR write cycle complete	NO/YES
67(MSB)	85	1802 CWO output	
	86	1802 Telemetry port (MSB)	
	87	1802 Telemetry port	
	88	1802 Telemetry port	
	89	1802 Telemetry port	
	90	1802 Telemetry port	
	91	1802 Telemetry port	
	92	1802 Telemetry port	
	93	1802 Telemetry port	
	94	1802 Telemetry port	
	95	1802 Telemetry port	
67(LSB)	96	1802 Telemetry port (LSB)	

Appendix I: Telemetry data file collected on 4/21/98

```
** UoSAT-OSCAR-11 OBC **
Diary Operating System V3.7

 Date: 21 /4 /98   (Tuesday)
 Time: 22 :37 :48 UTC
 Auto Mode is selected
 Spin Period: - 358!
 Z Mag firings:  362
 + SPIN firings: 3
 - SPIN firings: 128
 SEU count        -9077
 RAM WASH pointer at 3B51
 WOD commenced 19 /3 /98 at 16 :0 :5
 with channels 1 ,2 ,3 ,61 ,
 Last Command: 109 to 0 , 0
 Attitude control initiated, mode 3




** UoSAT-OSCAR-11 OBC **
Diary Operating System V3.7

 Date: 21 /4 /98   (Tuesday)
 Time: 22 :37 :57 UTC
 Auto Mode is selected
 Spin Period: - 358
 Z Mag firings:  362
 + SPIN firings: 3
 - SPIN firings: 128
 SEU count        -9077
 RAM WASH pointer at 817B
 WOD commenced 19 /3 /98 at 16 :0 :5
 with channels 1 ,2 ,3 ,61 ,
 Last Command: 109 to 0 , 0
 Attitude control initiated, mode 3




** UoSAT-OSCAR-11 OBC **
Diary Operating System V3.7

 Date: 21 /4 /98   (Tuesday)
 Time: 22 :38 :12 UTC
 Auto Mode is selected
 Spin Period: - 358
 Z Mag firings:  362
 + SPIN firings: 3
 - SPIN firings: 128
 SEU count        -9077
 RAM WASH pointer at 8584
 WOD commenced 19 /3 /98 at 16 :0 :5
 with channels 1 ,2 ,3 ,61 ,
 Last Command: 109 to 0 , 0
```

Attitude control initiatee,@mode 3

        ** UoSAT-OSCAR-11 OBC **
        Diary Operating System V3.7

         Date: 21 /4 /98 (Tuesday)
         Time: 22 :38 :21 UTC
         Auto Mode is selected
         Spin Period: - 358
         Z Mag firings: 362
         + SPIN firings: 3
         - SPIN firings: 128
         SEU count   -9077
         RAM WASH pointer at 8992
         WOD commenced 19 /3 /98 at 16 :0 :5
         with channels 1 ,2 ,3 ,61 ,
         Last Command: 109 to 0 , 0
         Attitude control initiated, mode 3

        ** UoSAT-OSCAR-11 OBC **
        Diary Operating System V3.7

         Date: 21 /4 /98 (Tuesday)
         Time: 22 :38 :31 UTC
         Auto Mode is selected
         Spin Period: - 358
         Z Mag firings: 362
         + SPINfirings: 3
         - SPIN firings: 128
         SEU count   -9077
         RAM WASH pointer at 8EC7
         WOD commenced 19 /3 /98 at 16 :0 :5
         with channels 1 ,2 ,3 ,61 ,
         Last Command: 109 to 0 , 0
         Attitude control initiated, mode 3

        ** UoSAT-OSCAR-11 OBC **
        Diary Operating System V3.7

         Date: 21 /4 /98 (Tuesday)
         Time: 22 :38 :43 UTC
         Auto Mode is selected
         Spin Period: - 358
         Z Mag firings: 362
         + SPIN firings: 3
         - SPIN firings: 128
         SEU count   -9077
         RAM WASH pointer at 92D2
         WOD commenced 19 /3 /98 at 16 :0 :5
         with channels 1 ,2 ,3 ,61 ,
         Last Command: 109 to 0 , 0

Attitude control initiated, mode 3

** UoSAT-OS@AR-11 OBC **
Diary Operating System V3.7

Date: 21 /4 /98 (Tuesday)
Time: 22 :38 :52 UTC
Auto Mode is selected
Spin Period: - 358
Z Mag firings: 362
+ SPIN firings: 3
- SPIN firings: 128
SEU count   -9077
RAM WASH pointer at 96D5
WOD commenced 19 /3 /98 at @16 :0 :5
with channels 1 ,2 ,3 ,61 ,
Last Command: 109 to 0 , 0
Attitude control initiated, mode 3

** UoSAT-OSCAR-11 OBC **
Diary Operating System V3.7

Date: 21 /4 /98 (Tuesday)
Time: 22 :39 :7 UTC
Auto Mode is selected
Spin Period: - 358
Z Mag firings: 362
+ SPIN firings: 3
- SPIN firings: 128
SEU count   -9077
RAM WASH pointer at 9D0D
WOD commenced 19 /3 /98 at 16 :0 :5
with channels 1 ,2 ,3 ,61 ,
Last Command: 109 to 0 , 0
Attitude control initiated, mode 3

** UoSAT-OSCAR-11 OBC **
Diary Operating System V3.7

Date: 21 /4 /98 (Tuesday)
Time: 22 :39 :17 UTC
Auto Mode is selected
Spin Period: - 358
Z Mag firings: 362
+ SPIN firings: 3
- SPIN firings: 128
SEU count   -9077
RAM WASH pointer at A11F
WOD commenced 19 /3 /98 at 16 :0 :5
with channels 1 ,2 ,3 ,61 ,
Last Command: 109 to 0 , 0

Attitude control initiated, mode 3

** UoSAT-OSCAR-11 OBC **
Diary Operating System V3.7

 Date: 21 /4 /98 (Tuesday)
 Time: 22 :39 :26 UTC
 Auto Mode is selected
 Spin Period: - 358
 Z Mag firings: 362
 + SPIN firings: 3
 - SPIN firings: 128
 SEU count   -9077
 RAM WASH pointer at A53A
 WOD commenced 19 /3 /98 at 16 :0 :5
 with channels 1 ,2 ,3 ,61 ,
 Last Command: 109 to 0 , 0
 Attitude control initiated, mode 3

** UoSAT-OSCAR-11 OBC **
Diary Operating System V3.7

 Date: 21 /4 /98 (Tuesday)
 Time: 22 :39 :36 UTC
 Auto Mode is selected
 Spin Period: - 358
 Z Mag firings: 362
 + SPIN firings: 3
 - SPIN firings: 128
 SEU count   -9077
 RAM WASH pointer at A953
 WOD commenced 19 /3 /98 at 16 :0 :5
 with channels 1 ,2 ,3 ,61 ,
 Last Command: 109 to 0 , 0
 Attitude control initiated, mode 3

** UoSAT-OSCAR-11 OBC **
Diary Operating System V3.7

 Date: 21 /4 /98 (Tuesday)
 Time: 22 :39 :45 UTC
 Auto Mode is selected
 Spin Period: - 358
 Z Mag firings: 362
 + SPIN firings: 3
 - SPIN firings: 128
 SEU count   -9077
 RAM WASH pointer at AD67
 WOD commenced 19 /3 /98 at 16":0 :5
 with channels 1 ,2 ,3 ,61 ,
 Last Command: 109 to 0 , 0

Attitude control initiated, mode 3

Attitude control initiated, mode 3


```
** UoSAT-OSCAR-11 OBC **
Diary Operating System V3.7

 Date: 21 /4 /98  (Tuesday)
 Time: 22 :40 :29 UTC
 Auto Mode is selected
 Spin Period: - 358
 Z Mag firings:  362
 + SPIN firings: 3
 - SPIN firings: 128
 SEU count        -9077
 RAM WASH pointer at C0F7
 WOD commenced 19 /3 /98 at 16 :0 :5
 with channels 1 ,2 ,3 ,61 ,
 Last Command: 109 to 0 , 0
 Attitude control initiated, mode 3
```

UoSat-Oscar-11 Information Bulletin from Amsat-UK and UOSAT
===

Satellite		Uplink	Downlink	Beacons	Notes
AO-10		435.025-175	145.83-98	145.81/987	
UO-11				145.825/435.025	also 2.401 GHz
OSCAR 16		145.90-96	437.026	437.026/051	Also 2401.143
OSCAR 17				145.825	Also 2401.221
OSCAR 18				437.102	
OSCAR 19		145.84-90	437.154	437.126/154	cw on 437.127
OSCAR 20		1a5.9-146	435.8-.9	435.797/91	.797=cw, .910=packet
RS 10	(mode A)	145.86-90	29.36-40	29.357/403	Robot up 145.820
	(mode K)	21.16-20	29.36-40	29.357/403	Robot up 21.120
	(mode T)	21.16-20	145.86-90	145.857/903	modes KA & KT
also					
RS 11	(mode A)	145.91-95	29.41-45	29.407/453	Robot up 145.830
	(mode K)	21.21-25	069.41-45	29.407/453	Robot up 21.130
	(mode T)	21.21-25	145.91-95	145.907/953	modes KA & KT
also					
RS 12	(mode A)	145.91-95	29.41-45	29.408/454	Robot up 145.831
	(mode K)	21.21-25	29.41-45	29.408/454	Robot up 21.129
	(mode T)	21.21-25	145.91-95	145.912/959	modes KA & KT
also					
RS 13	(mode A)	145.96-146	29.46-50	29.458/504	Robot up 145.840
	(mode K)	21.26-30	29.46-50	29.458/504	Robot up 21.138
	(mode T)	21.26-30	145.96-146	145.862/908	modes KA & KT
also					
OSCAR 22		145.900/975	435.120	435.120	
OSCAR 23		145.850/900	435.175	435.175	
OSCAR 25		145.980	436.500	436.500	
OSCAR 27		145.850	436.795	436.795	FM. Timed operations
OSCAR 29		145.9-146	435.8-.9	435.797/91	.797=cw, .910=packet

Satellite transponders are usually specified by a mode type i.e. mode-A etc
and a list of the differences, mostly of frequency, follows:

Mode A Uplink 2m, downlink 10m
Mode B Uplink 70cm, downlink 2m
Mode J Uplink 2m, downlink 70cm
Mode JL Uplinks 23cm & 2m combined to downlink 70cm
Mode K Uplink 15m, downlink 10m
Mode L Uplink 23cm, downlink 70cm
Mode S Uplink 50cm, downlink 12cm
Mode T Uplink 15m, downlink 2m

* Feedback Requested *
We are always interested in YOUR comments on the service but few people ell
us. What would you like to see included ?
NB each bulletin is limited to 3000 bytes.

Please reply to:
UoSAT Command & Control Centre
Centre for Satellite Engineering Research
University of Surrey
Guildford, Surrey GU2 5XH
United Kingdom
email: C.Jackson@ee.surrey.ac.uk

or send a message to G3RWL via Internet at g3rwl@amsat.org or via terrestrial
packet radio (@ GB7HSN.#32.GBR.EU) or on Oscars 16/19/22/23/25

If you place this bulletin n a terrestrial packet nepwo9k, please jse the
*bulletin idew4afier $BID UO1l.114

73 de Richard G3RWL for Amsat-UK and UOSAT

** UoSAT-OSCAR-11 OBC **
Diary Operating System V3.7

 Date: 21 /4 /98 (Tuesdax)
 Timd: 22 :41 @:@8 UTC
 !Aqto@`M;>Y@qs sa1 #+#8`@
 S`mf PLphgd;Z A@x<89Q`Oh@t `>@8"vBz{!LO^Hpg@1V0'D?;qL
X80`@!"'~G4S|f$@/0FA08b
$,"1@?tFdB@$XJfB@4Cl?<C.n[\@&&pod!|!!:L40|{`Bzb@FICppq%mx07+0xsH/\H0dDu
@J pk@~tuz '8`@ DD0IFD$
W_PCnmMdxc+ 19   3 O98 iu @06 @:0`:5
`_wit` ch`nnels 1 ,2@ @@@|3@ ,@62 @,,A
R lxst Co}mqnd8   @
p~nFD>@@TtHBL@D@0AP`@< ,y^ zp%@(bA<!&p@N$
"#k+wp#@fNhnPhn$x;`dTb?gK@OPh|@u[sDPn5~$]_x.X8@pAlpL0Fx"lol0@P_ xz78$H
<CPn@1[@}]#p!+_`b@B |D8xFF1J9=Nt`vK83bpNs>AL
X0@`bbG>",~d0ph.S?0yd$fL@Rq|9pP`d>>@xxDQ}@rAaaG!p3bH%>@100$AFH`hC880Mr`

53

7LFDh@54N08'Y $p@AA2txx*|4d
:b<c@@>Fb.lPEWpXsxP<ZhpF<9o<<n8pzI+d
`vF&8Nb0fq2@C#/@vo<y$'7aQ`
@z00#]|z"tA~b7oNp{p!~@i`?@|Cq$fr4|0|`AO$@8x@q@ g?0
!?Wz0dY`qrjn~vA```'2e{Rj>|x@LA`_xd04^pr`Y @@LQ+N@lK7o4Rw{D! x@
XJtbpp0>(;>LsV4@b6do8%0Y8PGHyrf@ ~qd?R<xE\<t(Pjhp2@lU
0`E@a.G`%?p`@8$>F`yZDXphO@(O&T90H8!b|xy|DO|T@1to
A|b;z1d<B\]0B$OA1[@x9K@tLh~n%dP"~x`i
n?`Fadb2h]PPAK109@\66kL^@^0@`D18`>N<GF&L?Ay@4=rc+Gho=p`e{#dK/^<mO_yp-)#
HHB@@r<.XNhvO;L@?qG3|3oupdq:|IF'V^>pHAG_#y2++2n3p-10x= @*`bbb<?d`
2=d<w@OLt@Ro8bsp4bW5sOLQOTh$ ncluded ?
NB each bulletin is limited to 3000 bytes.

Please reply to:
UoSAT Command & Control Centre
Centre for Satellate Enginee`ing Research
Univeb#itx of Strr%yC
Guildford, qrrau G0 5XH
5bated ki]>YWY@@6[HB|zK(Jagk PYu@ kc,3klp0`lHsa~ c@+gd p' g3
=SPviaM7Yn[&]@c@v[n7lPalsat:rg Or via hdpre{trial
pac,+#&#K{2$h3Pj'.#32.GBR.EU) or on Oscars 16/19/22/23/25

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the
bulletin identifier $BID UO11.114

73 de Richard G3RWL for Amsat-UK and UOSAT
PA7A"!771\"!771\B""!771\0"!771\
D7"!771\3!WW\L7!771bPA6A"!'!!nn;\0!!771\87!!771\E!!771\9R!!771\"!771\A"
!SPAEA"!\M4D!771\NR!771\O5Y!771\P!771\Q7!771\R"!771\S8)<PAEA"!!771\T7!7
71\U9D!771\VR!771\WAY!771\X!771\YB!yPAFA"!71\Z"!771\[D)!771\\7!771\]ED!
771\^R!771_FY!771\`JPAGA"!!!771\aH!!771\b""!771\cI)!!771\d
7!!771\eB!!ss#\fPD!!&PAHA"!771\g!R!!771\hRY!!771\i#!771\jU!QQw\kS!771\l
C!??DrrPAIA"!\mS"!771\nU)!771\o%7!771\pVD!771\q'R!771\rWY!771\s(PAPA"!
!771\tY !771\u0" !771\v0 !771\w27 !771\xB !kk+\yE !zPAPA"!71\z4R
!771\{%U
!@@o\|!!771\}5!!771\~!!771\7"!!771\rrPAQA"!'!!nn;\0!!771\87!!771\E!!771
\9R!!771\"!771\A"!nPARA"!771\"!771\B""!771\0"!771\
D7"!771\3!WW\L7!771}PASA"!\M4D!771\NR!771\O5Y!771\P!771\Q7!771\R"!771\S
8)JPATA"!!771\T7!771\U9D!771\VR!771\WAY!771\X!771\YB!PATA"!71\Z"!771\[D
)!771\\7!771\]ED!771\^R!771_FY!771\`XPAUA"!!!771\aH!!771\b""!!771\cI)!
!771\d
7!!771\eB!!ss#\fPD!!4PAVA"!771\g!R!!771\hRY!!771\i#!771\jU!QQw\kS!771\l
C!??DPAWA"!\m$"!771\nU)!771\o%7!771\pVD!771\q'R!771\rWY!771\s(PAXA"!
!771\tY !771\u0" !771\v0 !771\w27 !771\xB !kk+\yE !PAYA"!71\z4R
!771\{%U
!@@o\|!!771\}5!!771\~!!771\7"!!771\{{PAYA"!'!!nn;\0!!771\87!!771\E!!771
\9R!!771\"!771\A"!vPAB"!771\"!771\B""!771\0"!771\
.D7"!771\3!WW\L7!771-
PAB"!\M4D!771\NR!771\O5Y!771\P!771\Q7!771\R"!771\S8){PAB"!!771\T7!771\U
9D!771\VR!771\WAY!771\X!771\YB!9PAB"!71\Z"!771\[D)!771\\7!771\]ED!771\^
R!771_FY!771\`
PAB"!!!771\aH!!771\b""!!771\cI)!!771\d
7!!771\eB!!ss#\fPD!!fPAB"!771\g!R!!771\hRY8|
UOSAT-2   9804232225035

0025700132990225270343260404000502 8F06014307039D08034F09027C

104995113089120003130534141675155583A16183D17432318432C19489D
204987212203226457230001240006250007260859274449C28461929455F
30492C3102663227513357643400073522603627993739IF38431D39462A
40737741095942628A430546441540450001460002474430484461F494292
505198511180526320536374546766555579B56170557451258388E59452F
60A2A4615FC1624145633350644402651E0C661F2C67F00E68000E69000F
UOSAT-2   9804232225040

00257001333202247303441204040005028F06014307039D08034F09027C
104995113089120003130534141613155584D16183D17431018433D19488C
2049782122122264572300012400062500072608592744C28461929455F
30499731026663227513357023400073522533627883739IF38431D39462A
4073774109594262SA430557441537450001460002474430484461F494292
50517651117352631353271254668955579B56170557451258388E59452F
60A2A4615FC1624145633350644402651E0C6607E967F00E68000E69000F
UOSAT-2   9804232225045

00261501322202254103449A04040005028F06014307039D08034F09027C
104995113074120003130534141523155584D16183D17429918435B19488C
20495A21220322645723000124000625000726085927450428460829455F
30502431026663227513357133400073522423627773739IF38431D39462A
4073774109594262SA430557441537450001460002474430484461F494292
50517651117352630253263154668955579B56170557451258388E59452F
60A2A4615FC1624145633350644402651E0C6607E967F00E68000E69000F
JOSAT-2   9804232225050

00259E01318B022550034667040400005028F06014307039D08034F09027C
104995113074120003130525141788155584D16183D17428818436819488C
20491E2121992264572300012400062500072608592745042846082945SF
3050353102663227513357133400073522423627773739IF38431D39462A
4073774109594262SA430557441537450001460002474430484461F494292
50517651117352630253243354664555579B56170557451258388E59452F
60A2A4615FC1624145633350644402651E0C661CA767F00E68000E69000F
UOSAT-2   9804232225055

00269D013255022490034676040400005028F06014307039D08034F09027C
104995113074120003130525141433155585C16183D174277184386194873
20473221220322645723000124000625000726085927450428460829455F
30502431027732275133357463400073522423627773739IF38431D39462A
4073774109594262SA430557441537450001460002474430484461F494292
50525751118C5263025325235466455579B56170557451258388E59452F
60A2A4615FC1624145633350644402651E0C66088067F00E68000E69000F
UOSAT-2   9804232225100

00270501338902240034799040400005028F06014307039D08034F09027C
104984113074120003130534141499155585C16184A174266184397194873
20441321221222645723000124000625000726085927451528459229455F
30502431027732275133357203400073522533627773739IF38431D39462A
40738841095942628A430557441537450001460002474430484461F494292
5053035111805263135325455466455579B56170557451258388E59451C
60A2A4615FC1624145633350644402651E0C660BA167F00E68000E69000F
UOSAT-2   9804232225104

00280A01338902240034887040400005028F06014307039D08034F09027C
104984113074120003130534141631155584D16183D174266184418194873
20428C21220322645723000124000625000726085927451528459229454E
3050353102773227513357133400073522533627883739IF38431D39462A

40738841095942628A430520441537450001460002474430484 61F494292
50529B51118C5263205328485466015557 9B5617055745 1258388E59451C
60A2A4615FC16241456333506444026 51E0C661CA767F00E68000E69000F
UOSAT-2   9804232225109

00289301332302246203499704040005028F06014307039D08034F09027C
10498411307412000313053414183F15584D16184A17425518442B194862
20418F2121992264572300012400006250007260859274526284 58329454E
3050353102773227513357573400073522 6036279937391F38431D39462A
40738841095942628A430520441537450001460002474430484 61F494292
505321511173526320532703546645555 79B561705574512 58388E59451C
60A2A4615FC16241456333506444026 51E0C660EA467F00E68000E69000F
UOSAT-2   9804232225114

00302101338902242603506004040005028F06014307039D08034F09027C
10498411307412000313053414170315584D16184A17425518444D194862
20395D2122122226457230001240000625000726085927452628458329454E
3050423102773227513357313400073522 6036279937391F38431D39462A
40738841095942628A430546441537450001460002474430484 61F494292
505321511173526331532756546672255 579B561705574512 58388E59451C
60A2A4615FC16241456333506444026 51E0C661F2C67F00E68000E69000F
UOSAT-2   9804232225119

00322301353402232103505304040005028F06014307040308034F09027C
10498411307412000313053414173015584D16184A17425518445C194862
20358C21220322264572300012400006250007260859274526284 57C29454E
30503531027732275133572034000735227136279937391F38431D39462A
40738841095942628A430531441540450001460002474430484 61F494292
505437511173526346532985546645555 79B561705574512 58388E59451C
60A2A4615FC16241456333506444026 51E0C6607E967F00E68000E69000F
UOSAT-2   9804232225124

00328901372702225703515204040005028F06014307040308034F09027C
10497B11307412000313053414169B15584D16183D17424418446F194862
2032742122122226457230001240000625000726085927453728457C29454E
3050353102773227513357463400073522 9F36281E37391F38431D39462A
40738841095942628A430546441540450001460002474430484 61F494292
5054515111735263645328 2E54660155579B561705574512 58388E59451C
60A286615FC16241456333506444026 51E0C6607E967F00E68000E69000F
UOSAT-2   9804232225129

00351701372702225703518F04041105028F06014307040308034F09027C
10498411307412000313053414165715584D16183D174244184481194851
2032562122032226457230001240000625000726085927453728456D29454E
3050423102773227513357463400073522 8E36280F37391F38431D39462A
40738841095942627543055744154045000146000247443048461F494292
505365511173526357536415546645555 79B561705574512 58388E59451C
60A286615FC16241456333506444026 51E0C661CA767F00E68000E69000F
UOSAT-2   9804232225133

00370401369D02228A03527304041105028F06014307040308034F09027C
10498411307412000313053414159815584D16183D174255184490194851
2031882122032226457230001240000625000726085927453728456D29454E
3050423102773227513357133400073522 8E36280F37391F38431D39462A
40738841095942628A430564441540450001460002474430484 61F494292
505365511173526357536415546645555 79B561705574512 58388E59451C
60A286615FC16241456333506444026 51E0C66088067F00E68000E69000F

UOSAT-2   9804232225138

00389201384E02221303529D04041105028F06014307040308034F09027C
10498411307412000313053414175615584D16183D174255184519194851
20288021220322264572300012400006250007260859274540284555E29454E
305035310277322751335702340007352286361E37391F38431D39462A
40738841095942628A430557441540450001460002474430486461F494292
50541551117352636453641554664555579B56170557451258388E59451C
60A286615FC1624145633350644402651E0C660BA167F00E68000E69000F
UOSAT-2   9804232225143

00405101406302215403534104041105028F06014307040308034F09027C
10498411307412000313054314155415584D16183D17425518452A194851
20264221220322264572300012400006250007260859274540284554F29454E
305024310277322751335746340007352299F36281E37391F38431D39462A
40738841095942628A430557441540450001460002474430486461F494292
50538B511173526364536415546645555579B56170557451258388E59451C
60A286615FC1624145633350644402651E0C661CA767F00E68000E69000F
UOSAT-2   9804232225148

00436101405002214503534104041105028F06014307040308034F09027C
10499511307412000313053414155415584D16183D17425518453B194840
20271621220322264572300012400006250007260859274540284554F29454E
305042310277322751335746340007352271362800F37391F38431D39462A
40737741095942628A430557441540450001460002474430486461F494292
50525751117352634653639A54672255579B56170557452158388E59451C
60A286615FC1624145633350644402651E0C660EA467F00E68000E69000F
UOSAT-2   9804232225153

00457601404102217603542004041105028F06014307040308034F09027C
10499511307412000313053414167515584D16183D17426618454C194840
20271621221222264572300012400006250007260859274551284538294546
305042310277322751335757340007352260362799373 91F38431D39462A
40737741095942628A43055744154045000146000247443 04B1B
 WOD commenced 19 /3 /98 at 16 :0 :5
 with channels 1 ,2 ,3 ,61 ,
 Last Command: 109 to 0 , 0
 Attitude control initiated, mode 3

 ** UoSAT-OSCAR-11 OBC **
 Diary Operating System V3.7

 Date: 21 /4 /98   (Tuesday)
 Time: 22 :43 :36 UTC
 Auto Mode is selected
 Spin Period: - 358
 Z Mag firings: 362
 + SPIN firings: 3
 - SPIN firings: 128
 SEU count   -9077
 RAM WASH pointer at 113F
 WOD commenced 19 /3 /98 at 16 :0 :5
 with channels 1 ,2 ,3 ,61 ,
 Last Command: 109 to 0 , 0
 Attitude control initiated, mode 3

04FA3612145315FC0C
05024732085505FCDD
050A5632194685FCBC
05125122293545FC0A
051A4002633175FC18
04D24881705295FCB9
04DA5461754355FCE2
04E24831933405FC76
04EA3752143385FC03
04F23042284215FC6E
05223322584015FCFF
052A3292735185FCCD
05324262695735FC76
053A5362665285FCAB
05425722854055FC6C
054A4873093145FCBD
05523613363265FC9D
055A2893474405FC42
05623473365535FC78
056A4673315885FC1F
05725803395135FC6A
057A5853553805FCD6
05824843852905FC91
058A3464063235FCB2
05922764114495FC49
059A3414055785FC51
05A24834006165FC6C
05AA6084075315FCBC
05B26194303795FC34
05BA5014642665FC25
05C23374893055FC24
05CA2504994565FCA2
05D23314936095FC09
05DA5024906505FCEA
05E26435015425FC3D
05EA6575323655FCCF
05F24925722545FC60
05FA3196003275FC6F
06022606074995FCA6
060A3776036365FCEB
06125516046325FC0A
061A6476234975FC89
06225916563495FC54
062A4406883175FC9E
06323337024225FC1D
063A3637015555FCB2
06424846985995FCAE
064A5777065285FCB4
06525647244235FCA7
065A4687433905FC11
06624027494535FCA5
066A4297445345FC99
06725027405415FCAE
067A5417444725FC33
06825017504125FCBF
068A4327544265FC6F
06924157494995FC1C

```
069A4677365515FC1C
06A25657175325FC53
06AA5917124335FC24
06B24917233585FCE8
06BA3917253995FC9E
06C23697155025FC63
06CA4326885915FC90
06D25656665685FC9F
06DA6106604405FC1A
06E25266713505FCDD
06EA4056753635FCE0
06F23506684735FC8A
06FA3936395775FC69
07025206275765FCE4
070A6026044955FCFE
07125596103665FCC4
071A4386203445FCF0
07223466134275FC04
072A3806015405FCBA
07324835825745FCFA
073A5695615245FC7C
07425655714175FC76
074A4785723495FC2A
07523875793975FCBF
075A3595644905FC00
07624395535565FC61
076A5235385405FC9F
07725655334525FC49
077A5145443795FC5B
07824205483735FC4A
078A3665454455FC2D
07923975335315FC19
079A4765225515FC22
07A25535114925FC0D
07AA5445144035FCA0
07B24655223585FC16
07BA3785243995FCB9
07C23595164865FCF0
07CA4255035545FC5F
07D25134945445FCE8
07DA5654904635FC74
07E25294973765FC8F
07EA4325013485FC42
07F23525034135FC4D
07FA3504845125FCC7
08024364695735FC91
080A5414515445FCC4
08125834474415FC88
081A5264613425FCC3
08224044643265FCF7
082A3144614175FCF1
08323334395385FCD0
083A4484155995FC75
08425693935435FC24
084A5993884075FC34
08525074012965FCB7
085A3564043125FCE2
```

08622703914435FC03
086A3383625765FC2D
08724863326065FC75
087A5983115025FC80
08825733093465FC63
088A4383232705FC54
08922913243545FC0F
089A2723035075FC92
08A24072575945FC13
08AA5442365565FC2C
08B25752194165FC51
08BA4792293075FC46
08C23442403295FC3B
08CA2992204575FCD0
08D23662005515FC1F
08DA4831755435FC93
08E25421684315FCEB
08EA4761723525FC86
08F23471993495FC90
C8FA2942024575FCC3
09023941675355FC76
090A4931545165FCA0
09125301554275FCE9
091A4661763285FC8B
09223631883415FC5C
092A3051904475FCA3
09323811715405FC44
093A5031645435FCC2
09425471594365FC8F
094A4991793285FC25
09523482073215FCE7
095A2981961965FC8F
09623411915505FC24
096A4841715645FCE4
09725731714635FCEE
097A5301883285FC4E
09823842063015FC9C
098A2962093875FCFA
C9922982175415FC26
099A4501875865FCB0
09A25801885005FCFC
09AA5481943515FCD1
C9B24182152945FC36
09BA2932393645FCC0
09C22732535275FCF9
09CA4222246015FC94
09D25642205435FC0C
09DA5972423775FC7D
09E24932652775FC58
09EA3142943225FCF5
09F22463124735FCEB
09FA3533136125FC33
0A025302986055FCD4
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0A125633442935FC5A
0A1A3973842515FC22
0A222504103855FCA0

60

0A2A27640555545FCAC
0A324344026415FCF9
0A3A5944065785FC56
0A426414264165FCE3
0A4A5424652805FC34
0A523774962835FCC5
0A5A2705114165FCB4
0A623105085655FCC4
0A6A4495026345FCB8
0A725885055795FC29
0A7A6355244415FC8D
0A825605523175FC58
0A8A4165802975FCEE
0A923065943985FCE1
0A9A3115945395FC2B
0AA24225856275FC31
0AAA5635836035FC0D
0AB26385954825FCA0
0ABA5906213485FCEF
0AC24536483005FC46
0ACA3306643835FCC3
0AD23136635235FC37
0ADA4176546215FC3A
0AE25556516055FC12
0AEA6286624915FC9B
0AF25826843685FC42
0AFA4557083345FC17
0B023577194135FC1C
0B0A3637165305FCED
0B124537085905FCA2
0B1A5527075555FCD6
0B225797164645FC8A
0B2A5227303995FC8B
0B324507383975FC50
0B3A4167414575FCB8
0B424497365145FCCA
0B4A4927285265FC75
0B525197284855FC87
0B5A5087294525FCC2
0B624787294485FC55
0B6A4657264745FC37
0B724797194905FC0C
0B7A5067114925FC7C
0B825057094515FCBE
0B8A4817074345FC5A
0B924427044565FC72
0B9A4486974825FCA6
0BA24766855145FCEF
0BAA5316754715FCDB
0BB25036784425FC31
0BBA4806734165FCDE
0BC24366714555FCE3
0BCA4506624975FC8E
0BD24766505125FCF6
0BDA5246404845FCDE
0BE25196364315FC3E
0BEA4666384195FC00

61

0BF24236344465FC12
0BFA4236224975FCCB
0C024756115155FC02
0C0A5265974925FC47
0C125235954275FCAF
0C1A4675953975FCF5
0C224055904255FCC5
0C2A3995814925FCCC
0C324535685325FC81
0C3A5165555155FCE5
0C425495444445FC8D
0C4A4945523835FCEF
0C524165513855FC64
0C5A3665404565FC4C
0C623965245345FC51
0C6A4895095525FC52
0C625544984975FCAC

```
** UoSAT-OSCAR-11 OBC **
Diary Operating System V3.7

 Date: 21 /4 /98  (Tuesday)
 Time: 22 :45 :45 UTC
 Auto
Mode is selected
 Spin Period: - 358
 Z Mag firings:  362
 + SPIN firings: 3
 - SPIN firings: 128
 SEU count       -9076
 RAM WASH pointer at 865E
 WOD commenced 19 /3 /98 at 16 :0 :5
 with channels 1 ,2 ,3 ,61 ,
 Last Command: 109 to 0 , 0
 Attitude control initiated, mode 3
```

UoSat-Oscar-11 Information Bulletin from Amsat-UK and UOSAT
==

Satellite		Uplink	Downlink	Beacons	Notes
AO-10		435.025-175	145.83-98	145.81/987	
UO-11				145.825/435.025	also 2.401 GHz
OSCAR 16		145.90-96	437.026	437.026/051	Also 2401.143
OSCAR 17				145.825	Also 2401.221
OSCAR 18				437.102	
OSCAR 19		145.84-90	437.154	437.126/154	cw on 437.127
OSCAR 20		145.9-146	435.8-.9	435.797/91	.797=cw, .910=packet
RS 10	mode A)	145.86-90	29.36-40	29.357/403	Robot up 145.820
	(mode K)	21.16-20	29.36-40	29.357/403	Robot up 21.120
	(mode T)	21.16-20	145.86-90	145.857/903	modes KA & KT also
RS 11	(mode A)	145.91-95	29.41-45	29.407/453	Robot up 145.830
	(mode K)	21.21-25	29.41-45	29.407/453	Robot up 21.130
	(mode T)	21.21-25	145.91-95	145.907/953	modes KA & KT also

```
RS 12   (mode A)  145.91-95      29.41-45      29.408/454  Robot up 145.831
        (mode K)   21.21-25      29.41-45      29.408/454  Robot up 21.129
        (mode T)   21.21-25     145.91-95     145.912/959  modes KA & KT
also
RS 13   (mode A)  145.96-146     29.46-50      29.458/504  Robot up 145.840
        (mode K)   21.26-30      29.46-50      29.458/504  Robot up 21.138
        (mode T)   21.26-30    101.96-106     145.862/908  modes CA & KT
also
OSCAR 22"      145.:00/975     435.120          435.120
OSCAR 23       145.850/900     435.175          435.175
OSCAR 25         145.980       436.100 !        436.500
OSCAR 27         145.850      .436.795          436.795  FM. Timed
operations
OSCAR 29         145.9-146     435.8-.9     435.797/91   .797=cw,
.910=packet
```

Satellite transponders are usually rpecified by a mode type i.e. mode-A etc
and a list of the differences, mostly of frequency, follows:

```
Mode A   Uplink 2m, downlink 10m
Mode B   Uplink 70cm, downlink 2m
Mode J   Uplink 2m, downlink 70cm
Mode JL  Uplinks 23cm & 2m coMbined to downlink 70cm
Mode K   Uplank 15m, downlink 10m
Mode L   Uplink 23cm, downlink 70cm
Mode S   Uplink 5pcm, downlink 12cm
Mode T   Uplink 15m, downlink 2m
```

* Feedback Requested *
We are always interested in YOUR comments on the service but few people ell
us. What would you like to see included ?
N3 each bulletin is limited to 3000 bytes.

Please reply to:
UoSAT Command& Control Centre
Centre for Satellite Engineering Research
University"of Surrey
Guildford, Surrey GU2 5XH
United Kingdom
email: C.Jackson@ee.surrey.ac.qk

or send a message to G#RWL via Internet at g3rwl@amsat.org or via terrestrial
packet radio (@ GB7HSN.#32.GBR.EU) or on Oscars 16/19/22/23/25

If you place this bulletin on a terrestrial packet network,Qplease use the
bullepin identifier $BID UO11.114

7fGO6hiichard G3RWL for Alsat-UK and EOSAT

** UoSAT-OSCAR-11 OBC **

```
Diary Operaxing System V7.7

@ Date: 21 /4 98  (@uesday)
 Tima:  2r :46 "41 UTC
 Auto Mode is selected
 Spin Period: - 358
 Z Mag firings:  362
 + PPIN firings: 3
 - SPIN firings: 129
 SEU count      -9076
 RAM WASH qointer at 9624
 WOD commenced 19 /3 /98 at 16 :0 :5
 with channels 1 ,2 ,3 ,@61 ,
 Last Command: 109 to 0 , 0
 Attitude control initiated, mode 3
     UoSat-Oscar-11 Information Bulletin from Amsat-UK and UOSAT
     ====================================================<=========
```

Satellite		Uplink	Downlink	Beacons	Notas
AO-10		435.025-175	145.8fK98	145.81/987	
UO-11				145>825/435.025	also 2.401 GHz
OSCAR 16		145.90-96	437026	437.026/051	Also 2401.143
OSCAP 17				145.825	Also 2401.22q
OSCAR 18				P437.102	
OSCAR 19		145.84-90	437.154	437.126/154	cw on 437.127
OSCAR 20		145.9-146	435.8-.9	435.797/91	.797=cw,
.910=packet					
RS 10	(mode A)	145.86,90	29.36-40	29.357/403	Robot up 145.820
	(mode K)	21.16-20	29.36-40	29.357/403	Robot up 21.120
	(mode T)	21.16-20	145.86-90	145.857/903	modes KA & KT
also					
RS 11	(mode A)	145.91-95	29.41-45	29.407/453	Robot up 145.830
	(mode K)	21.21-21	29.41-45	29.407/453	Robot up 21.130
	(modeT)	21.21-25	145.91-95	145.907/953	modes KA & KT
also					
RS 12	(moDe A)	145.91-95	29.41-45	29.408/454	Bobot up 145.831
	(mode K)	21.21-25	29.41-45	29.408/454	Robot up 21.129
	(mode"T)	21.21-25	145.91-95	145.912/959	modes KA & KT
also					
RS 13	(mode A)	145.96-146	29.46-50	29.458/504	Robot up 145.840
	P(mode K)	21.26-30	29.46-50	$ 29.458/504	Robot up 21.138
	(mode T)	21.26-30	145.96-146	145.862/908	modes KA & KT
also					
OSCAR 22		145.900/975	435.120	435.120	
OSCAR 23		145.850/900	435.175	435.175	
OSCAR 25		145.980	436.500	436.500	
OSCAR 27		145.850	436.795	436.795	FM. Timed
operations					
OSCAR 28		145.9-146	435.8-.9	435.797/91	.797=cw,
.900=packet					

```
Satellite transponders are usually specified by a mode type i.e. mode-A
etc
and a list of the differences, mostly of frequency, follows:

Mode A  Uplin{ 2m, downlink 10m
Mode B  Uplink 70cm, downlink 2m
```

```
Mode J⁻ Uplink 2m, downlink 70cm
Mode JL Uplinks 23cm & 2m combined to downlink 70cm
Mode K  Uplink 15m, downlink 10m
Mode L  Uplink 23cm, downlink 70cm
Mode S  Uplink 50cm, downlink 12cm
Mode T  Uplink 15m, downlink 2m


* Faedback Requested +
We !re always interested in YOU comments on the service but few people
ell
us. What would you like to see included ?
LB each bulletin is lilited to 3000 bytes.

Please reply to:
UoSAT Command & Control Centre
Centre for Satellite Engineering Research
University of Surrey
Guildford, Surrey GU2 5XH
United Kingdol
email: C.JXckson@ee.wurbdy.ac.uk


or send a message to G3RWL via Internet at g3rwl@amsat.org os via
terrestrial
packet radio (@ GB7HSN.#32.GBR.EU) or on Oscars 16/19/22/23/25

If you place this bulletin on a terrestrial packet netwopk, please use
t`e
bulletin identifier $BID UO11.114


73 de Richard G3RWL for Amsat-UK and UOSAT
@PAEF"!m=\fj
u`|o}wS'PAEF"!m=\<Gfj
u`|oa}7wHS
EPAXF"!m`=\#jfj
u`|oA}7wHS`PAYF"!m=\$:fj
u`|oAy7wHSff`PAG"!m=\%Mfj
u`|oq}7wHS
PAG"!m=\%0fj
u`|oq}7wHSPAGF0``m=\&Sfj
u`|oq}7wHS
)PAG"!m=\&1fj
u`|oq}7wHSPAG"!m=`\'Ofj
u`|oq}7wHS
(PAG"!m=\' fj
u`|oA}7wHS
JPAG"!m=\(fj
u`|oA}7wHS
3PAG"!m=\(Yfj
u`|oA}7wHS
PAG"!m=\(Cfj
u`|oa}7wHSPAG"!m=\}fj
u`|oa}7wHS
iPAG"!m=\){fj
u`|oa}7wHS
QPAG"!m=\)Jfj
u`|oa}7wHS!PAG"!m=\*Kfj
```

65

```
u`|oa}7wHS
$PAG"!m=\*2fj
u`|oa}7wHS
```

** UoSAT-OSCAR-11 OBC **
Diary Operating System V3.7

 Date: 21 /4 /98 (Tuesday)
 Time: 22 :47 :18 UTC
 Auto Mode is selected
 Spin Period: - 358
 Z Mag firings: 362
 + SPIN firings: 3
 - SPIN firings: 128
 SEU count   -9076
 RAM WASH pointer at AE6B
 WOD commenced 19 /3 /98 at 16 :0 :5
 with channels 1 ,2 ,3 ,61 ,
 Last Command: 109 to 0 , 0
 Attitude control initiated, mode 3

** UoSAT-OSCAR-11 OBC **
Diary Operating System V3.7

 Date: 21 /4 /98 (Tuesday)
 Time: 22 :47 :28 UTC
 Auto Mode is selected
 Spin Period: - 358
 Z Mag firings: 362
 + SPIN firings: 3
 - SPIN firings: 128
 SEU count   -9076
 RAM WASH pointer at B271
 WOD commenced 19 /3 /98 at 16 :0 :5
 with channels 1 ,2 ,3 ,61 ,
 Last Command: 109 to 0 , 0
 Attitude control initiated, mode 3

** UoSAT-OSCAR-11 OBC **
Diary Operating System V3.7

 Date: 21 /4 /98 (Tuesday)
 Time: 22 :47 :38 UTC
 AutO Mode is selected
 Spin Pariod: - 358
 Z Mag firings: 362
 + SPIN firings: 3
 - SPIN firings: 128
 SEU count   -9076
 RAM WASH pointer at B684
 WOD commenced 18 /3 /98 at 16 :0 :5
 with channels 1 ,2 ,3 ,61 ,
```

Last Command: 109 to 0, 0
Attitude control initiated, mode @3


** UoSAT-OSCAR-11 OBC **
Diary Operating System V3.7

 Date: 21 /4 /98  (Tuesday)
 Time: 22 :47 :4' UTC
 Auto Mode is selected
 Spin Period: - 358
 Z Mag firings:  362
 + SPIN firingc: 3
 , SPIN firings: 128
 SEU count        -9076
 RAM WASH pointer at BA8A
 WOD commenced 19 /3 /98 at 16 :0 :5
 with channels 1 ,2 ,3 ,61 ,
 Last Command: 109 to 0 , 0
 Attitude co8trol initiated, mode 3


** UoSAT-OSCAR-11 OBC **
Diary"Operatig System 5f7

 Date: 21 /4 /98  (Ttesday)
 Time: 22 :47 :56 UTC
 Auto Mode is selected
 Spin Period: - 358
 Z Mag firings:  362
 + SPIN firings: 3
 - SPIN firings: 128
 SEU count        -9076
 RAM WASH pointer at C032
 WOD commenced 19 /3 /98 at 16 :0 :5
 with channels 1 ,2 ,3 ,61 ,
 Last Command: 109 to 0 , 0
 Attitude control initiated, mode 3


** UoSAT-OS@AR-11 OBC **
Diary Operating System V3.7

 Date: 21 /4 /98  (Tuesday)
 Time: 22 :48 :11 UTC
 Auto Mode is selected
 Spin Period: - 358
 Z Mag firings:  362
 + SPIN firings:3
 - SPIN firings: 128
 SEU count        -9076
 RAM WASJ pointer at C4AA
 WOD commenced 19 /3 /98 at 16 :0!:5
 with channels 1 ,2 ,3,v1 ,

Last Command: 109 to 0 , 0
Attitude condB1 ini4iated, mOd 3

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THANK YOU