Phase A

Ground Station RF Transceiver

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16/06/2006
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RECORD OF REVISIONS

ISS/REV	Date	Modifications	Created/modified by
1/0	16/06/2006	Initial Issue	Hui Qiu

FOREWORD

INTRODUCTION

This work Package summarizes the work expected from the EPFL-LEMA during the Phase A of the SwissCube Project. The expected duration of the work is from 20-03-2006 till 30-06-2006.My project is responsible for the development of the Ground Segment (GS) telecom system. This includes the link analysis, architecture design, selection and test of the transceiver, modem and antennas. This also includes an estimation of the cost and schedule for delivery of the components.

1 REFERENCES

Projet “SwissCube”, http://swisscube.epfl.ch/

Kenwood corporation, http://www.kenwood.com/

M^2 Antenna Systems, http://www.m2inc.com/

Radio Amateur Satellite Corporation, http://www.amsat.org/

Laboratorio Mederos, WispDDE, http://www.laboratoriomederos.com/CX6DD/wispdde/

TRX-Mabager home page, http://www.trx-manager.com/

Shop for GS, http://www.wimo.de/

Data of satellite, http://celestrak.com/NORAD/elements/

Forum of ham, http://www.eham.net/

Introduction to Amateur Satellites, http://www.PlanetEmily.com

Icom corporation, http://www.icomamerica.com/receivers/default.asp

Rigpix database, http://www.rigpix.com/index.shtml

ENST Bretagne Réalisation d’une station d’émission-réception de satellite amateur by Adrien Blanchi

2 (SEMESTER) PROJECT OBJECTIVES

-- Designing for the GS telecom subsystem , base on the performances ,specifications; and definition of the interface.

-- Selection of the components, to make market research and the assemblage of the whole system,

-- To also find in the market an adequate control program.

-- To put the GS in function. Tests will be made based on satellites already in orbit.

-- for the end, valid the whole assemblage to function

-- Documentation ,preparation of the end-of-phase review.

3 RESEARCH PRELIMINARY

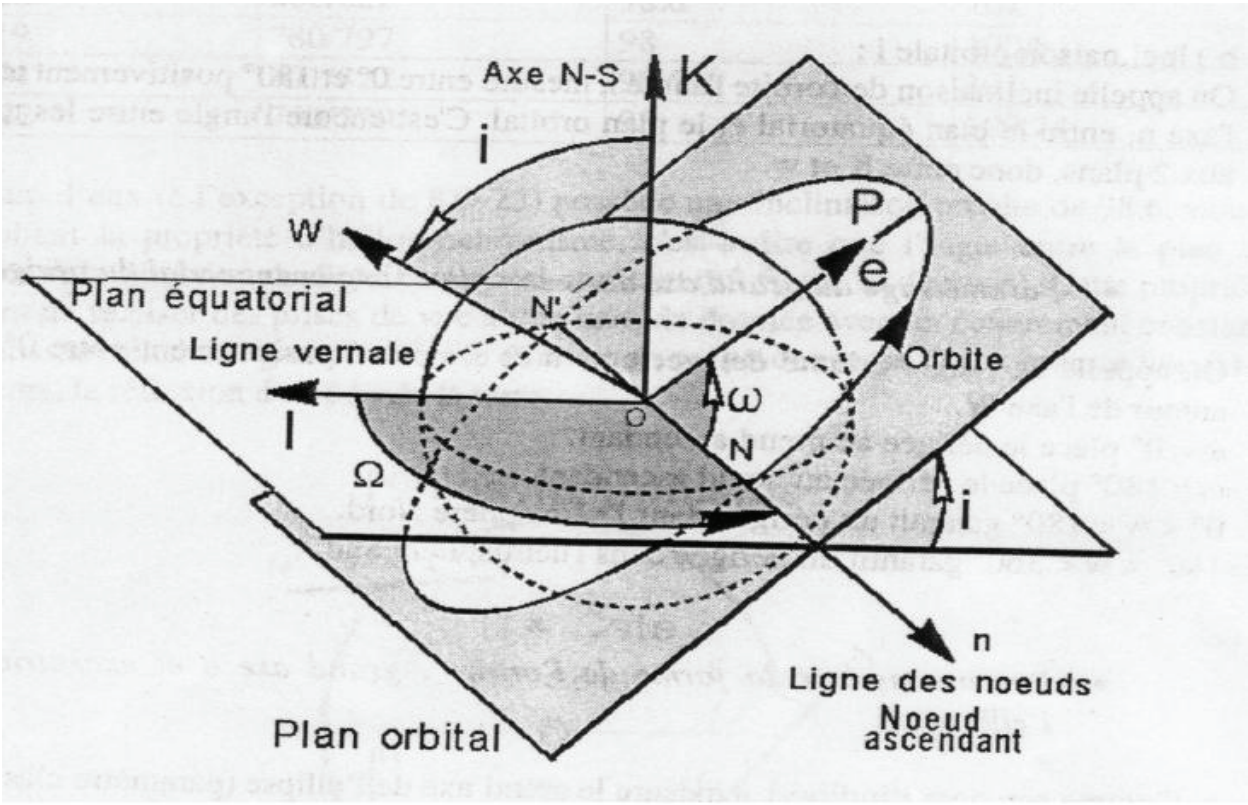
3.1 Some Important Terms

Orbit	The path a satellite around the earth
Doppler	A shift in frequency caused by satellite motion
LEO	A satellite in Low Earth Orbit
HEO	A satellite in High Earth Orbit
Uplink	The frequency used to transmit to a satellite
Downdlink	The frequency used to receive a satellite
Inclination	The angle of the satellite where equator=zero

3.2 The satellites in earth low orbit.

In fact these are the satellites interest us more particularly. After a study of their trajectory (thus the attitude varies between 500 and 1500 km), we will analyze the characteristics of the signals which they emit.

3.2.1 General research of trajectory



To follow constantly the satellite in reference mark IJK, with the recourse of these different parameter settings:the one of orbital plan, large axis of the ellipse, the shape of the ellipse and position on the orbit.

- N, the point where the satellite passes from the southern hemisphere to the northern hemisphere, is called the ascending node of the orbit;
- N', the point where the satellite passes from the northern hemisphere to the southern hemisphere, is called the downward node of the orbit;
- Vernal longitude **Ω**(or sidereal hour of the line of the nodes);
- Orbital slope i ;
- Parameter setting of the large axis in its plan: nodal argument of the perigee **ω** ;

we know that **ω** angle which is directed of vectors N measured positively between 0° and 360° around the axis W.

ω = 0° place the perigee with the ascending node
ω = 180° place the perigee with the downward node

0°< ω < 180° aperigee in the Northern hemisphere is guaranteed.
180° < ω < 360° aperigee in the Southern hemisphere is guaranteed.

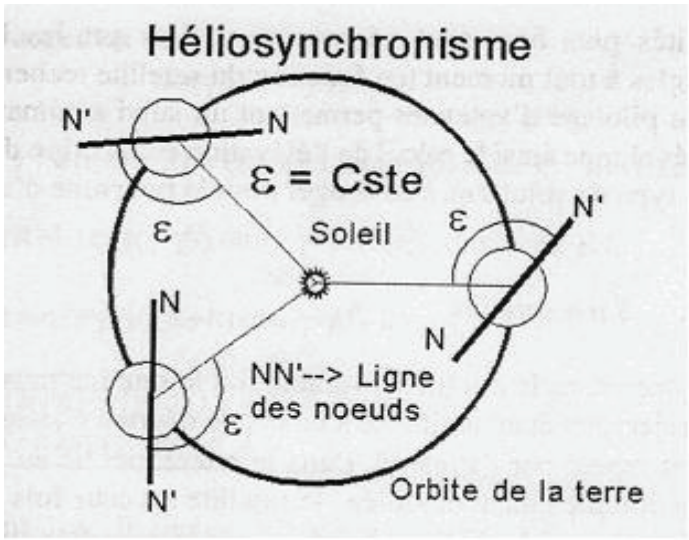
- The following table presents some of the orbital characteristic of the satellites, the satellites indicated in orange work with 9600 bauds in FSK.Sud.

Satellite	Perigee/Apogee (KM)	Inclinaison	Period(min)
AO-16	781/797	98	100.6
IO-26	799/823	98.6	100
KO-23	1304/1328	66	112
KO-25	800/822	98.6	101
LO-19	780/797	98	100.8
UO-22	760/770	98	100.24

Example of one satellite :

AMSAT Echo
Launched June 2004 into Sun Synchronous Orbit.

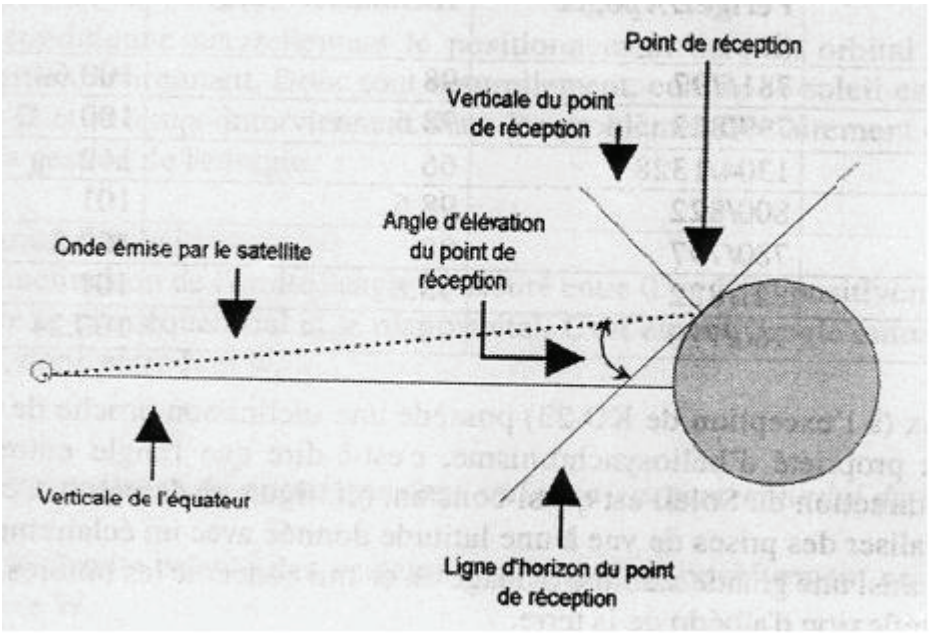
- FM Voice repeater: 435.225 Downlink, 145.920 Uplink(requires PL-67 tone)
- 9600bps AX.25 FSK Digital: 435.150 Downlink with telemetry, 145.860 Uplink
- Additional SSB/CW: 10m-23cm Receive, 13cm Transmitter
- Psk-31 Mode



Each one of them (exception to KO-23) has a slope close to 98.6, value exploiting the property of heliosynchronism, this means the angle between the plan of the orbits and the direction of the Sun is quasi-constant (cf appear below). This property makes it possible to carry out catches of sight to a attitude given with an illumination thus guaranteeing great a stability of image with regard to the shades, the relief, the colors, la reflexion of albedo of the ground

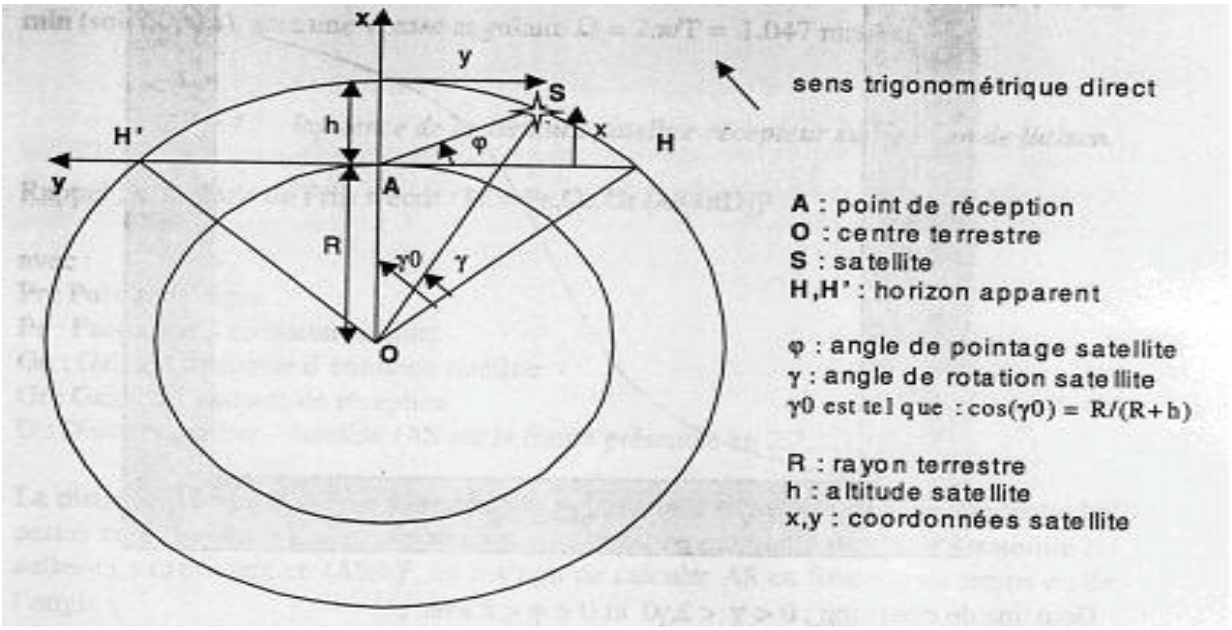
3.2.2 Parameters rerained for tracking satellite.

The azimuth locates the direction in which the satellite is located, corresponding to the projection of the vector receiver-satellite on the horizon(to define it, a software of prediction needs the exact position of the receiver). This angle varies between 0° and 360°, 0° corresponding to north and 180° to south.



3.2.3 Tracking satellite.

Facts of the case :



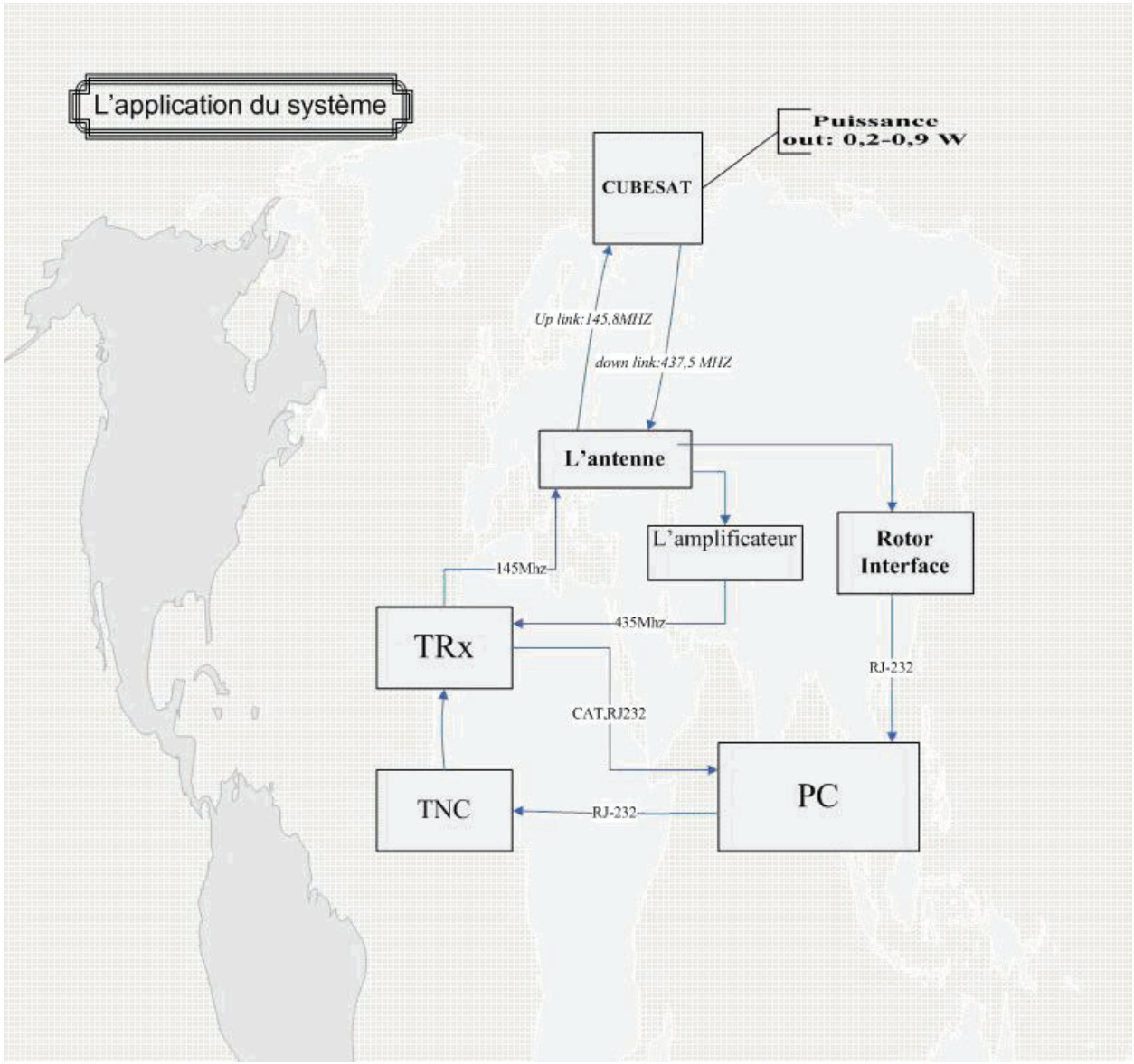
$$\varphi = \frac{\pi}{2} + \operatorname{Arctan}\left(\frac{(R+h)\sin(\gamma-\gamma_0)}{(R+h)\cos(\gamma-\gamma_0)-R}\right)$$

4 SCHEDULE OF CONDITIONS

4.1 General Infomation.

After the preliminary study above, we have the structure of station presented below.

Each of the element of this chain will be described more in detail below.



4.2 Tnc and TRx.

4.2.1 Transceiver(TRx)

The specifications for the purchase of a transceiver must answer the following criterion:

1. Band of frequencies adapted to the frequencies of the CUBESAT radio amateurs (145,8MHz for upload and 437,5 MHz for download).

2. The transceiver must be able to recognize all the modes used stalemate the CUBESAT radio amateur: FM, USB, LSB, CW, AM, AFSK, 9600 bauds packet, 1200 bauds packet.

3. Possibility of controlling the transceiver by PC (interface CAT).

4. Good compensation of the Doppler effect: the step of the synthesizer must be to the maximum of 1 KHZ.

5. We don't ask the transmission is simultaneous to the reception (not Full duplex).

6. broadcast on a band and reception on the other one (VHF > UHF or UHF> VHF).

7. Catch 9600 bauds or possibility to transform it easily

Here is a list of the devices corresponding to this specifications :

Icom :910H

Yaesu :FT-847

Kenwood :TS-2000

4.2.2 Modem(Tnc)

The modem should be:

- capable to decode the Pacsat protocol.
- adapted to the speed of transmission going from 1200 to 38400 Bauds.

The device SYMEK TNC2H-DK9SJ is satisfied with our conditions.

4.2.3 Antennas.

4.2.3.1 Realisation assessment of liaison

Wu could use the formula of Friis:

$Pr=Pe.Ge.Gr.(\lambda/(4\pi D))^2$

With :

Pr: Recived poeer

Pe: Power of broadcast satellite

Ge: Gain of the receipt antenna

λ: Length of wave used;

D : Distance station-satellite

4.2.3.2 Caracteristic of the antenna.

- Radiating to a frequency of about 437.5 MHz (downlink) and 145.8Mhz (uplink).
- Find a balances between the gain of reception and the dimensions of the antennas.also calculate the gain min for receiving the signal .
- Adapted well to the level of the power supply

4.3 Packet station

- Packet station send data to the satellite using a TNC to modulate and demodulate the signals.
- May be 1200bps,but also use 9600bps up to 78400 bps.
- Some just repeat digital packets or may have a store-and-forward bulletin board system.
- Telemetry is also send using packet data.

5 TECHNICAL RESEARCH AND MARKET INVESTIGATION

5.1 Transceiver

5.1.1 Description(transceiver choice)

In the preceding part, we have three cadidats: **yaesu ft-847**, **icom 910-H**, **kenwood ts-2000**. They have very good qualities and conrespond completely for our schedule of conditions.

Here is a small liste :

	Power of 2m	Power of 70cm	Optional
Icom 910H	100W	75W	**23cm**
Yaesu FT-847	50W	50W	**HF**
Kenwood TS2000	100W	50W	HF and 23cm

traditional leo modes:

Mode A= 10m/2m

mode B= 2m/70 cm

mode J=70cm/2m

malheursement after the research of the market investigation, we have found that the **yaesu ft-847** does not manufacture any more. Perhaps there is still stock in the second hands market, but our cubesat will be envoyed at the 2008, therefore we can't choose a product may be any more exsite after 2 years.

To choose a transceiver for our project, we must concentrate our attention on the satellite operation, these three products can all function perfectly. Their specifications are very simulate. but there are some remarkable points:

1. Full Duplex :

Amateur satellite receive on one band and transmit on another,uplink in regular operation, satellite mode can handle uplink/downlink frequency combinations simultaneously in all operating modes.

In phase A, we did not ask Full Duplex, but it is a function very useful, there is the possibility to make the developement in future project. So I also put it in the report as a condition.

Kenwood ts-2000

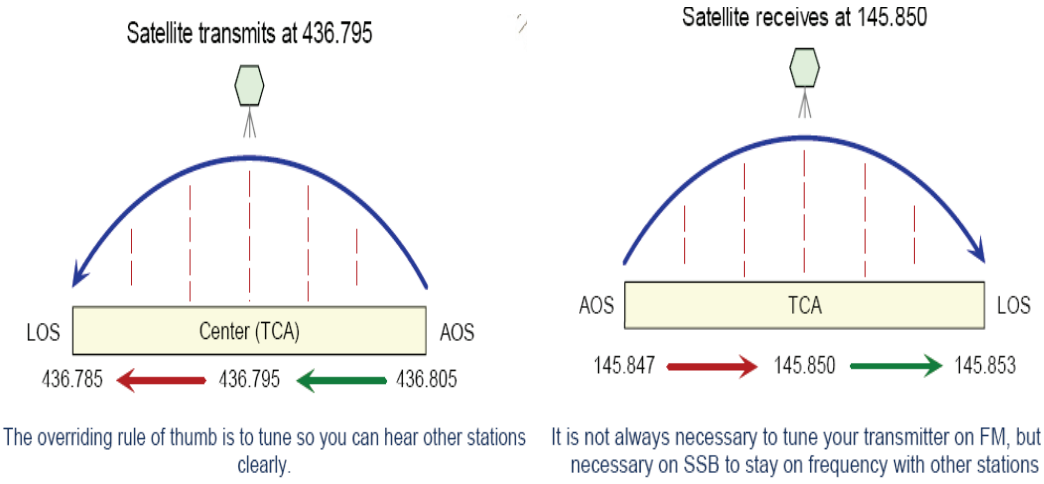
		UPLINK			
	Band	HF ~ 50 MHz	144 MHz	430/ 440 MHz	1.2 GHz
DOWN LINK	HF ~ 50 MHz		√	√	√
	144 MHz	√		√	√
	430/ 440 MHz	√	√		√
	1.2 GHz	√	√	√	

Icom 910H could work for Full duplex. But some of the users said : as soon as they go to the SATELLITE mode for full duplex, the data stream from the radio to the TNC stops. Switch out of SAT mode and it comes right back.

2. Doppler shift :

it is another aspect that we must take into account when working the satellite.As a target satellite travels away,frequencies on which you will receive change..

Doppler for Beginners-tranmits and receiving



The overriding rule of thumb is to tune so you can hear other stations clearly.

It is not always necessary to tune your transmitter on FM, but is necessary on SSB to stay on frequency with other stations

These two transceivers have a function that automatically keeps the sum of diference between the two frenquenies odentical when you change the receive frequence.

We will do the doppler correction by the pc's program.

3. To support by software.

We like to find a software which can control the interface of rotor and the radio in same time. But it doesn't existe…. Just like NOVA it must pass one samll program(WISPDDE) to control the radio.
After research,we have decided two combinaisons(present in details in the following point).

The **kenwood ts-2000** can be supported by both of two softwares, but the **icom 910H** can be controlled only one software.

Lastly, the transceiver of our station is **Kenwood ts-2000**, the caracteristic principal is in appendix.

5.1.2 Connection

The COM connector allows us to directly connect a PC by using an RS-232c cable terminated with a female connector.(manual P93)

5.1.3 Power supply

According to the manual of the user, the alimentation required is as follows

- Power requirement : DC 13.8 V +/-15%
- Courant : transmit :20.5A (HF, 6m, 2m); 18A (70cm); 9A (23cm), Standby: 2.6A

So we have bought a power supply DC of **GSV-3000**

Input voltage :110/220

Output voltage :1-15 V

Output current: 34Amax. ;30 A continously

5.2 Modem

5.2.1 Technial caracteristic

To refer at the corresponding annex. This modem, the TNC-2H perfectly answers (TNC for Terminal Node Contrôler) the specifications that one imposed itself.

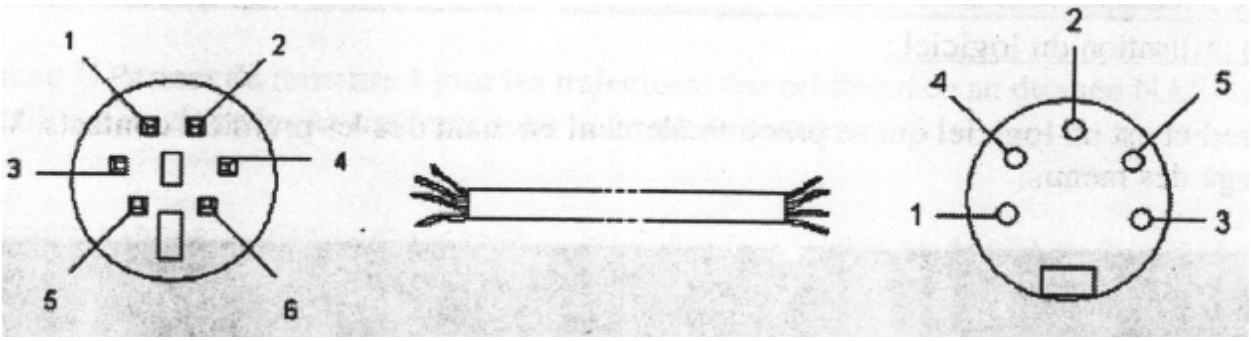
5.2.2 Connection between modem and PC

Between the modem and pc , we have brought one cable for the connection.

5.2.3 Connection between modem and transceiver

For this connection, we also buy one cable, but may be we will need to fabricate one cable like :

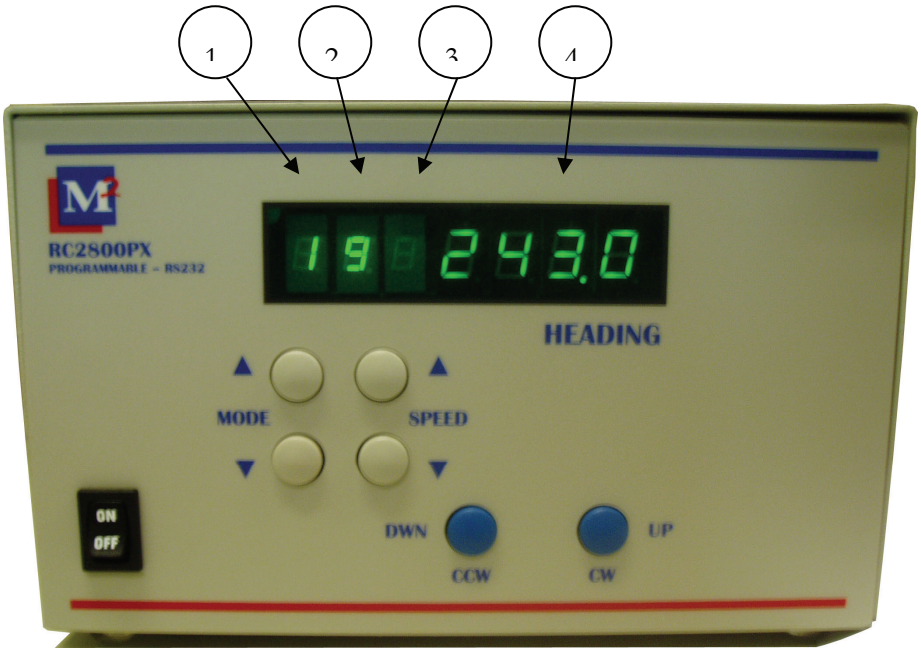
Part of transceiver part of modem



1 DATA IN(.green wire)
2.GND (white wire)
3.PTT(brown wire)
4.DATA OUT(9600 bps-yellow wirw)
5.DATA OUT(1200 bps-not connect)
6.SQL(not connect)

1. exit BF of TNC(green wire)
2. GND(white wire)
3. PTT(brown wire)
4. entrance BF of TNC(yellow wire)
5. not connect

5.3 RC2800PX-EL Controller (interface of rotor)



Contrôleur RC2800PX

The screen of posting is composed four distinct parts:

1. operational Mode, iit exist three, introduction is below.
2. rotation speed of 1 to 9.
3. Indicate a "L" when a limit zone is reached (for example between 346.0° and 0.0°) or a sequence of pulsate at the time of the execution of a calibration.
4. Position of rise or azimuth of the rotor in degree.

The buttons of control could be selected:

:

1. the operational mode: « MODE ».
2. the rotation speeed: « SPEED ».
3. A position to be reached according to the operational mode : « CW » (UP) and « CCW » (DWN).

5.4 PC's programs

5.4.1 Program of tracking satellite

- Nova For Windows
- SatPC32 For Windows
- SCRAP

Specifications for the program:

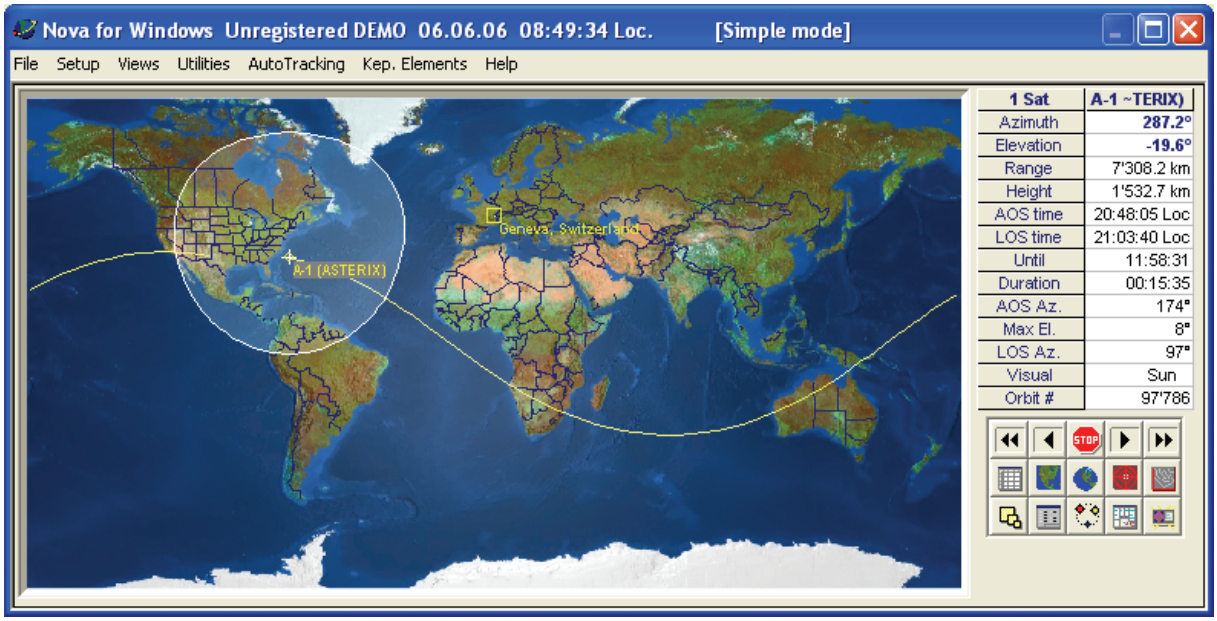
1. Interface of contrlling antennas M2 RC2800
2. Radio Interface
3. Update the parameter orbit (format TLE)
4. Radar mode
5. Licence
6. Supplemental Source code
7. Algorithm of tracking
8. Possibility of change the object of tracking the satellite.

Finally, we choose the program NOVA:

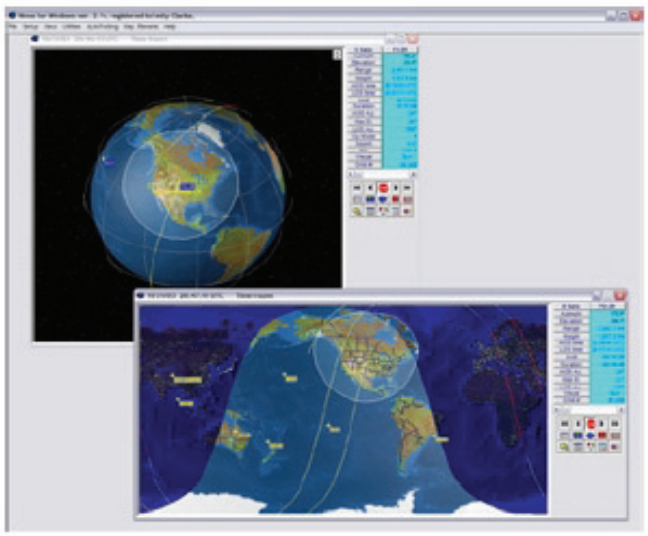
Reasons:

1. it can be complemented by one small program WISPDDE to control the transceiver.(we will introduce and test WISPDDE in 5.4.2)

2. This software allows in particular the use of a joystick to control the antenna. This can prove strongly useful at the time of a phase of test.



Principal Windows of NOVA



Nova for Windows

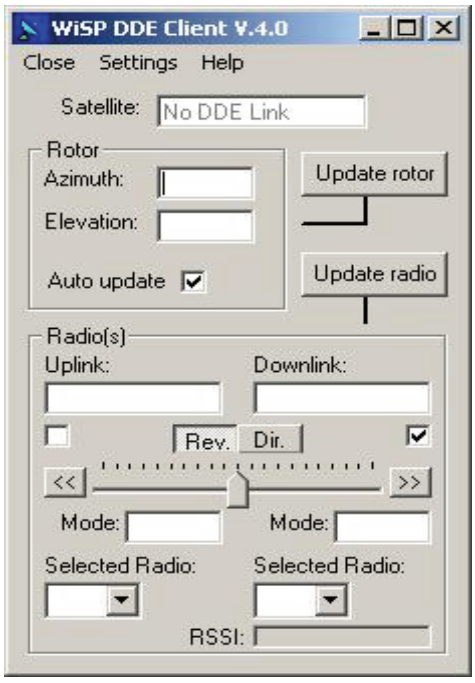
you can find plus detail in the report "**Software Development of a Satellite Ground Station Antenna Pointing Algorithm"** of Mabillard Jean.

5.4.2 Program of control the transceiver

This program resolute one only problem is the Doppler correction

For the same reason of having not the transceiver, so I can't di the test.

5.4.2.1 WISPDDE



- This program is small and free ware.
- Not powerful in the part of controlling rotors and radios.
- Support little model of the radio and rator.

WiSPDDE accepts DDE information from WiSP, AmSAT-BDA's Station Program, EA4TX's ARS, WinOrbit, Nova for Windows, SatPC32, Satscape and WXtrack. Station sends only rotor positions data thru DDE so no rig control is possible in this case.

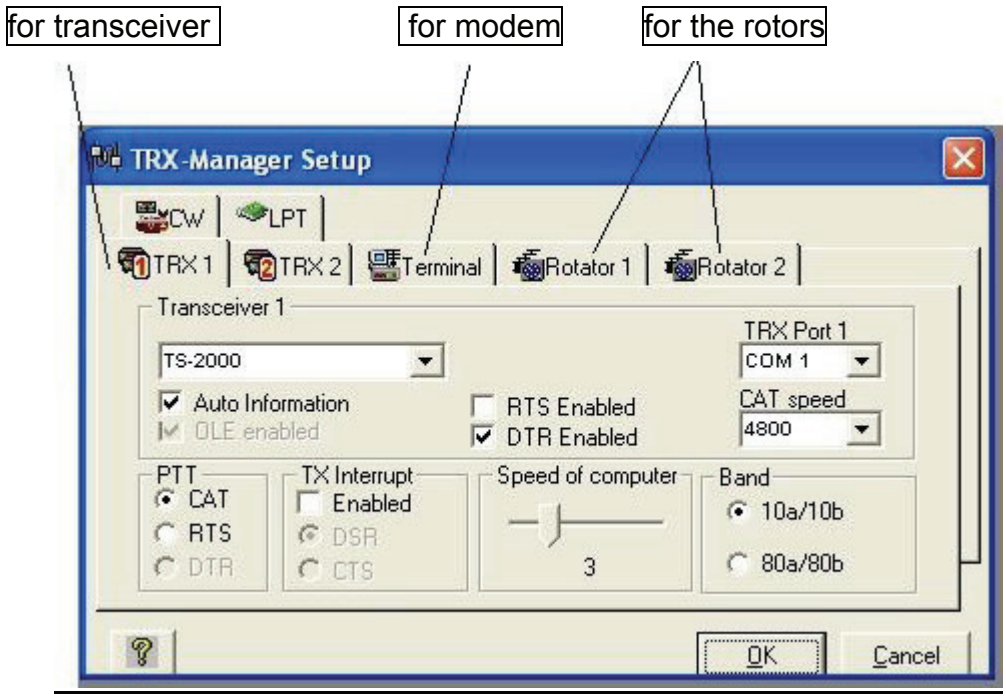
Radios supported are: IC-821, IC-970, IC-275, IC-475, IC-746, IC-R7000, IC-R8500, PCR-1000, FT-847, FT-817, FT-100, FT-736, VR-5000, AR-5000, AR-8000, TH-D7, TM-D700, TS-790 and **TS-2000**.

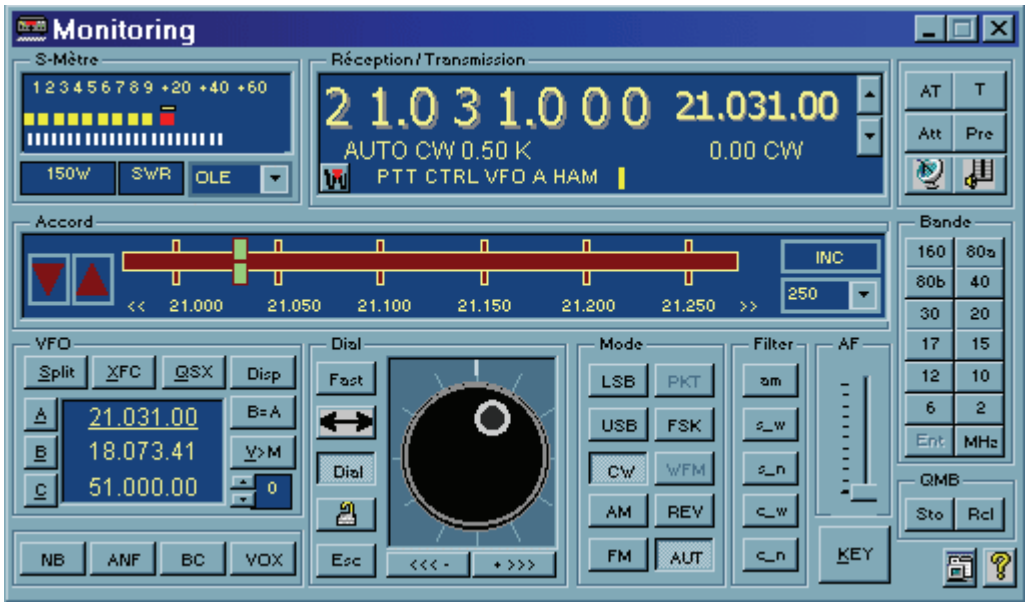
5.4.2.2 TRX□Manager

- Large compared to WiSPDDE (about 20M)
- Very powerful ,it control almost everything of system(radio, modem)
- Interface is easy to understand.
- Sofeware is not free.
- Very good liaison to program NOVA

TRX-manager supports almost all the functions of up to 80 transceivers fully integrated in a comprehensive package for Radio Amateurs. TRX-Manager implements all these functions in conjunction with very fast monitoring and easier, more effective SW Listening, DX Spotting, Logging, Award tracking, Satellite, Rotator control and much more... In addition it can even operate simultaneously with several other programs including PDA's LOGic logging program. A control of a remote HF station by packet, Internet or a LAN is also provided along with many other original features....

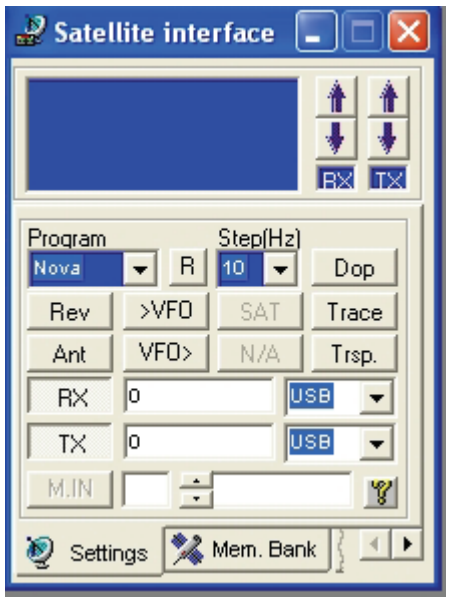
<u>setup for the TRX-Manager:</u>





Control Panel

Full Monitoring and Dxing



satellite interface

So we have choosed this pretty program **TRX-Manager**.

6 TEST AND SIMULATION

6.1 Groundstation considerrations:

- invest heavily in our receive setup and preamps as needed
- use filters in Mode J(V/U) to eliminate desense(not necessary)
- keep coax runs as short as possible
- use circular polarization whenever possible
- keep everything grounded including computer equipment

6.2 General Operating Procedures :

Because of the absence of the transceiver and modem(not the stock in shop, as we decided the hard wares) and we have waited week after week before the deadline of handing in this report…..so in this part ,we will just describe what we should do for testing the GS. I wish it will be helpful for the students who continue this project□□

- Your first QSO(vhf/uhf band)
- Listen for the satellite beacon or other operators before transmitting
- Turn and configuration into the satellite mode.(P54 of manual)
- Storing satellite memory channels and those names. (10 satellites).
- As the satellite moves, fine tune to the changing downlink frequency of the satellite using the Tuning control (adjusting the Doppler effect).
- We can choose two different type satellite to test, One analogical satellite(ex. UO-14),and the other numeric satellite(ex.UO-22O-14).
- Pre-amplifier and the filters for noise reduction (P55-56 in the manual).
- Especially be patient.

7 CONCLUSION AND FUTUR WORK

7.1 Summary

In relation to the choice of the matetrials of our ground station:

In the beginning of this project, we have thought that we had a lot of choices for the transceiver and for the software .But in fact, it is very difficult to find a good solution in relation to the compatibility of prorams and materials, the price is also a reason. Finally, we had only 2 transceivers to choice…

In relation to the specifications:

We succeeded has achieved of tracking the satellite(data integrate in the program NOVA),seen the turn of the rotor.

We didn't have time to be interested in the practice of the test the whole system.

We have achieved the theoretical research of the part satellite and a little part of the antenna.

After many tests to the level of software, we have found a excellent combination : Nova (tracking satellite program) and TRx-manager (transceiver control program).

7.2 Futur work :

Part of transceiver :

- finalize and test the ground station
- complete control of the transceiver (frequency, mode, Doppler correction, ...)
- track the satellite by using the orbit data

Part of antenna:

- To continue the research of the antenna .
- Choose, construct and to test the antennas. .
- Measure of the gain and diagram of radiance of the receipt antenna. .

8 ANNEXES

8.1 Transceive Kenwood TS-2000

Specifications

	TS-2000/TS-2000X/TS-B2000
GENERAL	
Transmitter Frequency Range	Main: 160, 80, 40, 30, 20, 17, 15, 12, 10, 6, 2 meter bands, 70, 23 (TS-2000X only) cm bands Sub: 2 meter band, 70cm band
Receiver Frequency Range	Main: (0.03) 0.5 ~ 30 MHz, (30) 50 ~ 54 (60) MHz, (142) 144 ~ 148 (152) , (420) 430 ~ 450 MHz, 1240 ~ 1300 MHz (TS-2000X only), Sub: (118) 144 ~ 148(174) MHz, (220) 438 ~ 450 (512) MHz * Figures in parenthesis ( ) indicate VFO coverage range
Mode	A1A (CW), J3E (SSB), A3E (AM), F3E (FM), F1D (FSK), F2D
Power Requirement	13.8 V DC ±15%
Current Drain (Less than)	Transmit: 20.5 A (HF, 6m, 2m), 18 A (70cm), 9 A (23cm) Standby: 2.6 A
Operating Temperature	14° F ~ +122° F (-10° C ~ +50° C)
Frequency Stability	Main: Other mode within ±0.5 x 10^{-6} (±0.5 ppm) FM TX mode within ±0.5 x 10^{-6} ± 2 kHz Sub: Within ±0.5 x 10^{-6} ± 600 Hz
Antenna Impedance	50Ω
Microphone Impedance	600 Ω
Dimensions, projections not included (W x H x D)	TS-2000/X: 10-5/8 x 3-3/4 x 12-1/2 inch (270 x 96 x 317 mm) TS-B2000: 10-5/8 x 3-3/4 x 12-1/2 inch (270 x 96 x 317 mm)
Weight (approx.)	TS-2000: 17.19 lbs. (7.8 kg) TS-2000X: 18.07 lbs. (8.2 kg) TS-B2000: 16.53 lbs. (7.5 kg)
TRANSMITTER	
RF Output Power	SSB/CW/FM/FSK=100W, AM=25W (HF, 6m, 2m), SSB/CW/FM/FSK=50W, AM=12.5W (70cm) SSB/CW/FM/FSK=10W, AM=2.5W (23cm)
Modulation SSB FM AM	 Balanced modulation Reactance modulation Low-level modulation
Maximum Frequency Deviation (FM)	Less than ±5 kHz (wide) Less than ±2.5 kHz (narrow)
Spurious Radiation	1.8 ~ 28MHz: Less than –50dB 50 ~ 430MHz: Less than –60dB 1200MHz: Less than –50dB
Carrier Suppression	More than 50 dB
Unwanted Sideband Suppression	More than 50 dB
Transmit Frequency Response (SSB)	400 ~ 2600 Hz (within -6 dB)
XIT Variable Range	±20.00 kHz
Antenna Tunable Range	16.7Ω ~ 150Ω (160 ~ 6m Band)
RECEIVER	
Circuitry Main: SSB/CW/AM/FSK FM Sub: AM/FM	 Quadruple superheterodyne Triple conversion superheterodyne Double conversion superheterodyne
Intermediate Frequency Main: 1st IF 2nd IF 3rd IF 4th IF Sub: 1st IF 2nd IF	 69.085 MHz or 75.925 MHz (HF ~ 50 MHz) 41.895 MHz (144/440MHz), 135.495 MHz (1200MHz) 10.695 MHz 455 kHz 12.0 kHz 58.525 MHz 455 kHz

KENWOOD

	TS-2000/TS-2000X/TS-B2000
RECEIVER (Continued)	
Sensitivity Main: SSB/CW/FSK (S/N 10 dB)	 Less than 4 µV (500 kHz ~ 1.705 MHz), Less than 0.2 µV (1.705 ~ 24.5 MHz), Less than 0.13 µV (24.5 ~ 30 MHz), Less than 0.13 µV (50 ~ 54 MHz), Less than 0.16 µV (144 ~ 148 MHz), Less than 0.11 µV (430 ~ 450 MHz), Less than 0.11 µV (1240 ~ 1300MHz),
AM (S/N 10 dB)	Less than 31.6 µV (500 kHz ~ 1.705 MHz), Less than 2 µV (1.705 ~ 24.5 MHz), Less than 1.3 µV (24.5 ~ 30 MHz), Less than 1.3 µV (50 ~ 54 MHz), Less than 1.4 µV (144 ~ 148 MHz), Less than 1.0 µV (430 ~ 450 MHz), Less than 1.0 µV (1240 ~ 1300MHz)
FM (12 dB SINAD)	Less than 0.22 µV (28 ~ 30 MHz), Less than 0.22 µV (50 ~ 54 MHz), Less than 0.25 µV (144 ~ 148 MHz), Less than 0.18 µV (430 ~ 450 MHz), Less than 0.18 µV (1240 ~ 1300MHz)
Sub: AM (S/N 10 dB)	Less than 2.25 µV (144 ~ 148 MHz), Less than 1.55 µV (438 ~ 450 MHz)
FM (12 dB SINAD)	Less than 0.40 µV (144 ~ 148 MHz), Less than 0.28 µV (438 ~ 450 MHz)
Squelch Sensitivity Main: SSB/CW/AM/FSK	 Less than 18 µV (500 kHz ~ 1.705 MHz), Less than 1.8 µV (1.8 ~ 28.7 MHz), Less than 1.1 µV (50 ~ 54 MHz), Less than 1.1 µV (144 ~ 148 MHz), Less than 1.1 µV (440 ~ 450 MHz), Less than 1.1 µV (1240 ~ 1300MHz)
FM	Less than 0.2 µV (28 ~ 30 MHz), Less than 0.2 µV (50 ~ 54 MHz), Less than 0.16 µV (144 ~ 148 MHz), Less than 0.1 µV (430 ~ 450 MHz), Less than 0.1 µV (1240 ~ 1300MHz)
Sub: AM	Less than 1.1 µV (144 ~ 148 MHz), Less than 1.1 µV (438 ~ 450 MHz)
FM	Less than 0.23 µV (144 ~ 148 MHz), Less than 0.18 µV (438 ~ 450 MHz)
Image Rejection Ratio Main / Sub	 More than 70 dB / More than 60 dB
IF Rejection Ratio Main / Sub	 More than 70 dB / More than 60 dB
Selectivity Main: SSB (Low: 300 Hz, Hi: 2600 Hz)	 More than 2.2 kHz (-6 dB), Less than 4.4 kHz (-60 dB)
AM (Low:100 Hz, Hi:3000 Hz)	More than 6.0 kHz (-6 dB), Less than 12.0 kHz (-50 dB)
FM	More than 12.0 kHz (-6 dB), Less than 25.0 kHz (-60 dB)
FM (Narrow)	More than 8.0 kHz (-6 dB), Less than 20.0 kHz (-50 dB)
Sub: AM	More than 12.0 kHz (-6 dB), Less than 25.0 kHz (-50 dB)
FM	More than 12.0 kHz (-6 dB), Less than 25.0 kHz (-50 dB)
RIT Variable Range	±20.00 kHz
Notch Filter Reduction	More than 30 dB (1 kHz)
Beat Elimination	More than 40 dB (1 kHz)
Low Frequency Output	More than 1.5 W 8 Ω at 10% distortion

8.2 Modem TNC2H

The modem that we choose is the TNC2H produced by SYMEK of which here is the technical characteristics:

- Alimentation :

12 Vcc(min. 9v,max 16v),typ. 160 mA ,alimentation internal :5 Vcc. Standard regulator 7805.

- Dimensions :

105*170*42 mm,450g

- Computer Interface

RS232 (+/- 10 Volt), 25-pin Sub-D receptacle with UNC-nut bolts.
Baudrate : 150; 300; 1200; 2400; 4800; 9600; 19200; 38400 Baud
Parity: none , word length 8 Bit (may be configured by software)
outputs: data out (Pin 3), CTS (Pin 5) optional: DCD (Pin 9) and DSR (Pin 6)
inputs: data in (Pin 2), RTS (Pin 4) optional DTR (Pin 20)

- Interface modem

CMOS -level 5 volt. TXData, TXClock, RXData, RXClock, RTS CTS, DCD, + 5 Volt, Reset, ground. The TNC2H may supply up to 200mA for a external modem, connected to the 20 pin modem-connector. Connection of additional modems to the TNC2H digital controller via 20 pin ribbon cable and connector. Assignment of the 20 pin modem connector according to the recommendation of DF9IC for high-speed-modem-disconnect connections.

- Program storage(Eprom) :

2 x 32 kbyte containing 2 soft wares, selectable by DIP-switch

- Data Stockage(cmos-RAM) :

32Ko, about 24Ko available for data.

- Battery

3 Volt lithium battery with automatic switch over by MAX691. Calculated lifetime: 8 years

8.3 The interface of Rotor

We use the product M2 ,model RC-2800 PX for the interface of rotor . RC-2800 system can be controlled via RS232 port pass one logical external.

Specifications		Specifications	
Wind Area Capacity	35 sq. Ft.	Rotation Range	0-360 degrees -+ 14 degrees
Starting Torque	3500 in. lbs.	Readout Resolution	0.1 degrees
Rotating Torque	2800 in. lbs.	Travel Accuracy	+ - .5 degrees
Braking Torque	17,000	Input Voltage	110 / 220 VAC
Vertical Load Capacity	1800 lbs	Motor Voltage	28-42 VDC
Total height positioner and clamps	15.75	Cable req. - min	2-#18, 2-#22
Mast Size (OD)	1.75-3"	Weight (rotator unit)	42 lbs.
Rotation Speeds / 360 degrees	40 TO 70 sec.	Shipping Weight	53 lbs. UPS