Gateway to Amateur Satellites for Internet Users

By Bo, Junsang, Suresh, Vinh

http://www.livemotion.us
Gateway to Amateur Satellites for Internet Users

HISTORY: Beginning

First milestone
- The first satellite was Sputnik I by Soviets. The first successful United States launch took place four months after launching Sputnik I.

Second milestone
- SCORE: often referred to as first comsat. However, it carried only a taped message for playback. It could not be used for relaying signals.

Now over 2500 satellites on the sky…
**HISTORY: Beginning Amateur Satellites**

### OSCAR 5

- It is called AO-5 (Australia's - OSCAR 5).
  - Built by several students at the University of Melbourne, most undergraduate engineering major for 3 years. However, it was not launched.

### AMSAT (the Radio Amateur Satellite Corporation)

- AMSAT was formed in order to support AO-5.
  - Finally, AO-5 was launched on March 3rd, 1969.
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SAT SPEC: Operation modes

**Analog Communication Mode (CW & SSB)**
- Linear mode – receives a slice of one amateur band and shifts the entire slice to a different band.
- Real time communication (use voice)

**Digital Communication Mode (FSK & PSK)**
- Non linear mode – these vary in speed and in the modulation techniques employed.
- Not real time – store & forward communication (use software)

**Special Modes** (Repeater, Broadcast, ROBOT etc...)
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SAT SPEC: Orbits

HISTORY

SATELLITE SPECS

Low Earth Orbit (LEO)
- Could be accessed with low power and simple antennas.
- They generally used lower frequencies for which transmitting and receiving equipment is widely available.
- Limited communication time (usually less than 20 minutes per day)

High Earth Orbit (HEO)
- Need high power, beam antennas and very sensitive receivers.
- Biggest obstacle communicating with these satellites is the high frequency being used (antenna precision)
- Longer communication time

ANTENNA SYSTEM
PRE AMPLIFICATION
ROTATOR CONTROLLER
MODEM/TNC
SOFTWARE
POWER SYSTEM
BACKUP PLAN
TIMELINE
OBSTICLES
QUESTION
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SAT SPECS: Target Satellites

HISTORY

SATELLITE SPECS

ANTENNA SYSTEM

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Digital Communication Mode (FSK & PSK)

- 1200 bps & 9600 bps
- software base

Low Earth Orbit (LEO)

- UO-22
- KO-23
- KO-25

REASONS:

- Make the system easier to implement
- Limited funding
- Can avoid undesired signal distortions due to Doppler Effect, Faraday Rotation Effect and Spin Modulation effect.
ANTENNA SYSTEM: Characteristics

1. Directional Properties (gain and pattern)
2. Transmission vs Reception properties
3. Efficiency
4. Polarization
5. Link effect (spin modulation, Faraday rotation)
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**ANTENNA SYSTEM: Direction properties**

**Idle antenna**
- An array that radiates power equally in all directions

**Expected antenna: Yagi**
- A beam acts by concentrating its radiated energy in a specific direction.

Yagi has better gain than dipole.

Yagi = 2 * dipole
**ANTENNA SYSTEM: RX & TX properties**

*Basic Law: reciprocity principle*
- The gain pattern of an antenna is same for reception as for transmission.

*Real World: signal & noise (S/N ) ratio*
- Though high efficiency and gain contribute to our goal, the shape of the gain pattern and the location of null may have a significant impact on S/N ratio by reducing noise and interfering signals.

*Thumb of Rule*
- A good antenna for transmitting to satellite is not necessary a desirable antenna for receiving signals from a satellite.
ANTENNA SYSTEM: Efficiency

- A transmitting antenna that is 100% efficient radiates all the power reaching its input terminals.

- A transmitting antenna that is 50% efficient only radiates half the power appearing at its input terminals.

- **Note**: If efficiency is lower than 80%, antenna needs to be disconnected to avoid damage to Radio.
Radio waves consist of electric and magnetic fields, both of which are always present and inseparable. When a radio wave passes a point in space, the electric field at that point varies cyclically at the frequency of the wave. When we discuss the ‘polarization of a radio wave’ we’re focusing on how the electric field varies.

Most amateur antennas are designed to respond primarily to the electric field.
Obstacles

- Building an antenna that can match all these characteristics is a difficult task.

Fortunately, we are able to make use of already developed software for antenna design.

Software will generate exact measurements for each element of the antenna.
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ANTENNA SYSTEM: Specification for ours

**History**

**Satellite specs**

**Antenna system**

**Pre amplification**

**Rotator controller**

**Modem/TNC**

**Software**

**Power system**

**Backup plan**

**Timeline**

**Obstacles**

**Question**

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**The length of two Antennas**
- 70 cm & 2 meters

**Height**
- 2 meters

**Power**
- 12 V & Max 10A

**Cost (without rotator)**
- $60
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PRE AMPLIFICATION

- Amplifier signal from satellite
- One Pre-Amplifier circuit needed
- Components
  - (8) Capacitors
  - (3) Inductors
  - (1) Diode
  - (2) RCA Jack
  - (1) MES FET
  - (4) Resistors

Estimated cost $20
ROTATOR CONTROLLER

- M68HC11 Motorola Microcontroller
- Max232 chip for serial communication
- Breadboard, wires, capacitors, resistors etc
- D/A converter, connectors

Estimated cost $25
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MODEM/TNC

- 9600 baud rate modem
- Modem/TNC circuit on single board
- Components
  - (5) TL064 IC
  - (2) CD4538
  - (2) CD4013
  - (2) LEDs
  - (2) Zeners
  - Breadboard, resistors and capacitors

Estimated cost $27
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CODES

- Assembly codes for M68HC11
- Assembly codes for TNC/Modem
- User GUI using .NET platform
- Internet services in Java or .NET
- Tracking software in .NET platform
POWER SYSTEM

• Need a lot of power to transmit signal
• Borrow power equipment from EE lab if there is no power source available outside the building.
• Most of the time we will use wall outlets and a step down transformer to power equipment.
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BACKUP PLAN

- Big problem in sending signal
- Communicate with analog satellites
- Test send and receive unit on ground
## Gateway to Amateur Satellites for Internet Users

### TIMELINE: Summer 2004

<table>
<thead>
<tr>
<th>Month</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
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<td>W3</td>
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<tr>
<td>Vinh</td>
<td>Research</td>
<td>Design and Implementation</td>
<td>Testing, Optimization and Integration</td>
<td>Project Integration and Testing in Live Environment</td>
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<tr>
<td>Junsang</td>
<td>Research</td>
<td>Design &amp; Implementation</td>
<td>Testing</td>
<td>Testing with Modem, Pre-Amp and rotator controller</td>
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<tr>
<td>Suresh</td>
<td>Research / Design</td>
<td>Circuit Simulation. Gather parts</td>
<td>Build circuit</td>
<td>Program Microcontroller</td>
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<tr>
<td>Bo</td>
<td>Research and gather parts</td>
<td>Design and Implementation</td>
<td>Testing</td>
<td>Project Integration and Testing in Live Environment</td>
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**TIMELINE:** Summer 2004
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**TIMELINE: Fall 2004**

<table>
<thead>
<tr>
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<th>September</th>
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<tr>
<td>Vinh</td>
<td>GUI Interface Design and development</td>
<td>Testing and Debugging</td>
<td>Final Testing of Overall Project</td>
<td>Documentations and Project Submission</td>
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<tr>
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<td>Research and Development for tracking modules</td>
<td>Integrating with Hardware</td>
<td>Final Testing of Overall Project</td>
<td>Documentations and Project Submission</td>
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<tr>
<td>Junsang</td>
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<tr>
<td>Suresh</td>
<td>Develop 2-D mapping for the tracking and bearing calculations</td>
<td>Integrate with J-track data</td>
<td>Integrate with tracking and Network modules</td>
<td>Final Testing of Overall Project</td>
</tr>
<tr>
<td>Bo</td>
<td>Develop Networking module</td>
<td>Testing and Debugging</td>
<td>Final Testing of Overall Project</td>
<td>Documentations and Project Submission</td>
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OBSTICLLES

• Cost for components (rotator)
• Satellite footprint
• Available operational satellites
• Weather conditions in final testing stage (winter 2004)
• Lack of experience in satellite communication
QUESTIONS

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