Gateway to Amateur Satellites for Internet Users

By Bo, Junsang, Suresh, Vinh

HISTORY: Beginning

HISTORY
SATELLITE SPECS
ANTENNA SYSTEM
PRE AMPLIFICATION
ROTATOR CONTROLLER
MODEM/TNC
SOFTWARE
POWER SYSTEM
BACKUP PLAN
TIMELINE
OBSTICLES
QUESTION

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.

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…)

SAT SPEC: Orbits

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

SAT SPECS: Target Satellites

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)

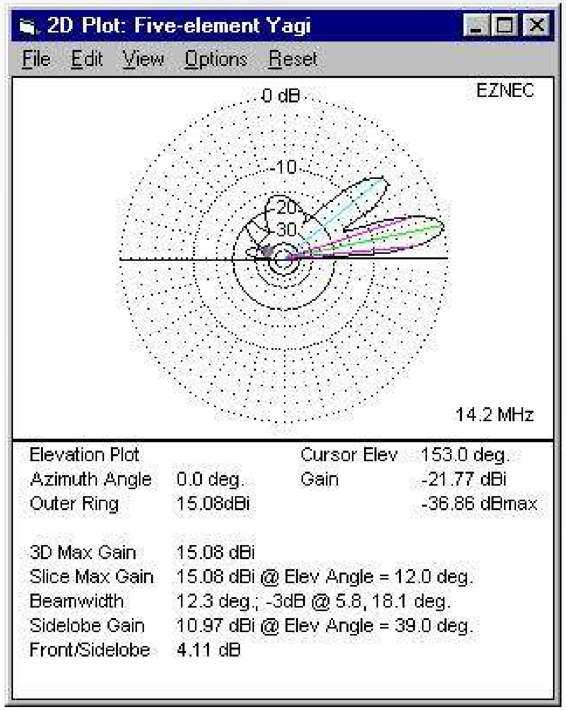
ANTENNA SYSTEM: Direction properties

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.

ANTENNA SYSTEM: Polarization

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.

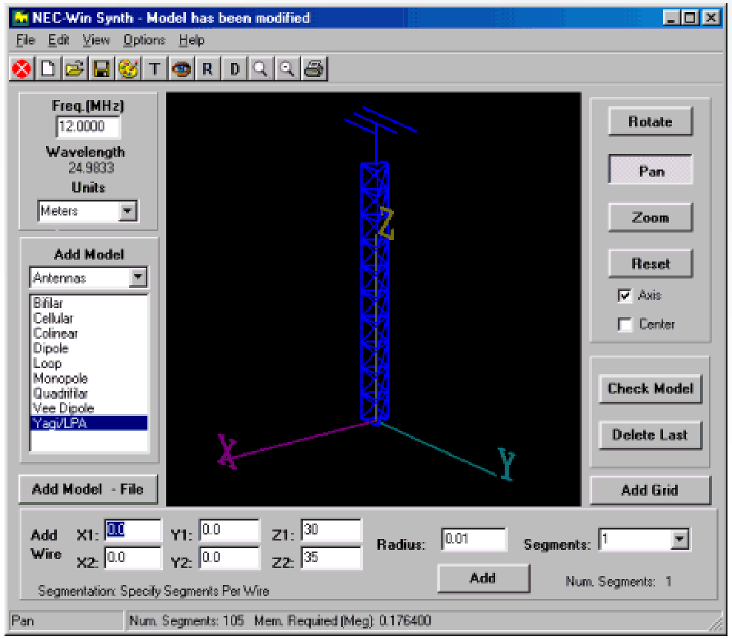
Most amateur antennas are designed to respond primarily to the electric field.

ANTENNA SYSTEM: How to build

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

ANTENNA SYSTEM: Specification for ours

The length of two Antennas

- 70 cm & 2 meters

Height

- 2 meters

Power

- 12 V & Max 10A

Cost (without rotator)

- $60

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

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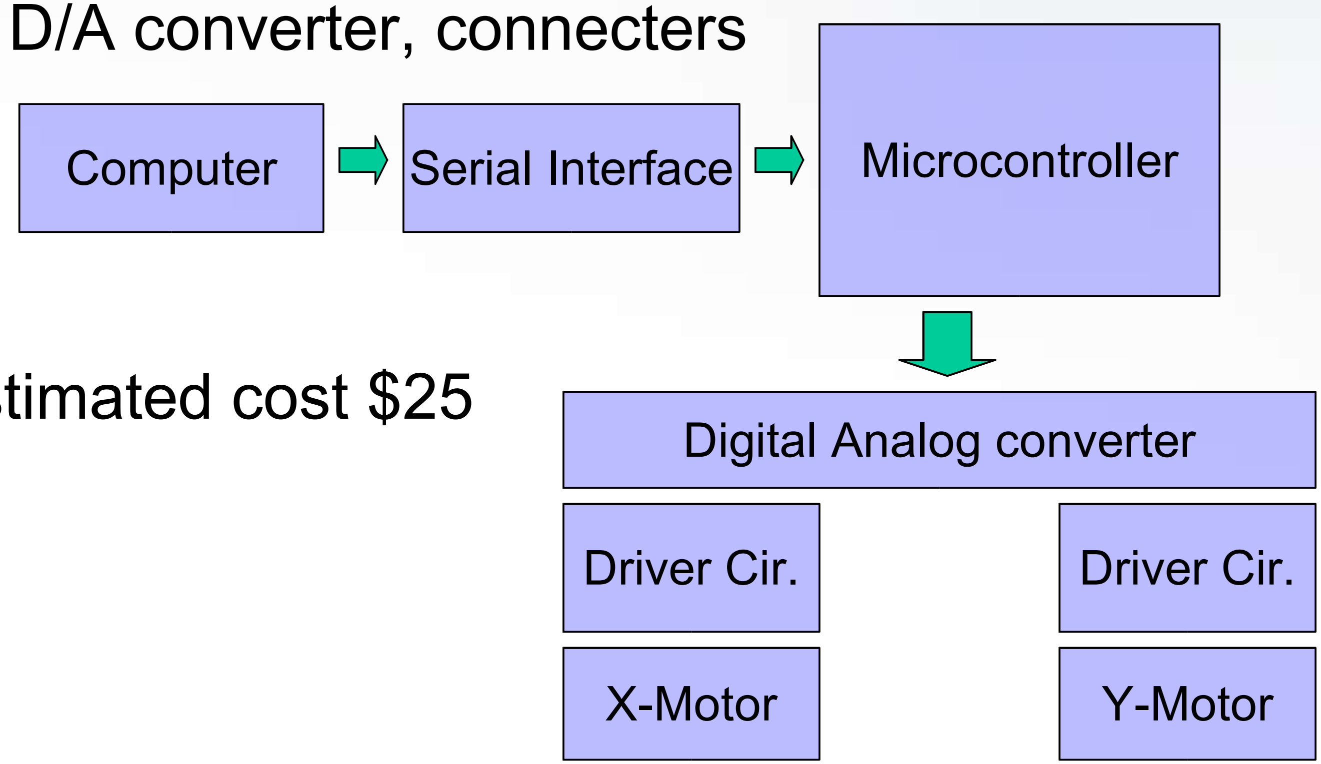
- M68HC11 Motorola Microcontroller
- Max232 chip for serial communication
- Breadboard, wires, capacitors, resistors etc
- D/A converter, connecters



Estimated cost $25

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

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.

BACKUP PLAN

- Big problem in sending signal
- Communicate with analog satellites
- Test send and receive unit on ground

TIMELINE: Summer 2004

<table>
<tr><th>Month</th><th colspan="4">May</th><th colspan="4">June</th><th colspan="4">July</th><th colspan="4">August</th></tr>
<tr><th></th><th>W1</th><th>W2</th><th>W3</th><th>W4</th><th>W1</th><th>W2</th><th>W3</th><th>W4</th><th>W1</th><th>W2</th><th>W3</th><th>W4</th><th>W1</th><th>W2</th><th>W3</th><th>W4</th></tr>
<tr><td>Vinh</td><td></td><td></td><td colspan="2">Research</td><td colspan="4">Design and Implementation</td><td colspan="4">Testing, Optimization and Integration</td><td colspan="4">Project Integration and Testing in Live Environment</td></tr>
<tr><td>Junsang</td><td></td><td></td><td colspan="2">Research</td><td colspan="2">Design & Implementation</td><td colspan="2">Testing</td><td colspan="4">Testing with Modem, Pre-Amp and rotator controller</td><td colspan="4">Project Integration and Testing in Live Environment</td></tr>
<tr><td>Suresh</td><td></td><td colspan="2">Research / Design</td><td colspan="2">Circuit Simulation.
Gather parts</td><td>Build circuit</td><td colspan="2">Program Microcontroller</td><td colspan="2">Testing with motors</td><td colspan="2">Integrate and test with Antenna. Calibration</td><td colspan="4">Project Integration and Testing in Live Environment</td></tr>
<tr><td>Bo</td><td></td><td></td><td colspan="3">Research and gather parts</td><td colspan="3">Design and Implementation</td><td colspan="4">Testing</td><td colspan="4">Project Integration and Testing in Live Environment</td></tr>
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TIMELINE: Fall 2004

<table>
<tr><th>Month</th><th colspan="4">September</th><th colspan="4">October</th><th colspan="4">November</th><th colspan="4">December</th></tr>
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<tr><td>Vinh</td><td colspan="4">GUI Interface Design and development</td><td colspan="4">Testing and Debugging</td><td colspan="4">Final Testing of Overall Project</td><td colspan="4">Documentations and Project Submission</td></tr>
<tr><td>Junsang</td><td></td><td></td><td colspan="3">Research and Development for tracking modules</td><td colspan="3">Integrating with Hardware</td><td colspan="4">Final Testing of Overall Project</td><td colspan="4">Documentations and Project Submission</td></tr>
<tr><td>Suresh</td><td></td><td colspan="3">Develop 2-D mapping for the tracking and bearing calculations</td><td colspan="2">Integrate with J-track data</td><td colspan="2">Integrate with tracking and Network modules</td><td colspan="4">Final Testing of Overall Project</td><td colspan="4">Documentations and Project Submission</td></tr>
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OBSTICLES

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

QUESTIONS

Questions…