Radio Communications

In This Section, You Will Learn About Sending Telemetry Data Using a Radio Transmitter and a Ground Station

You Will Learn How to Write Software to Send Telemetry

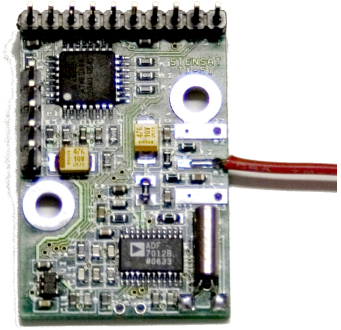
You Will Learn How to Set up a Ground Station and Collect the Telemetry

Telemetry

- At this point, the CanSat structure has been assembled with the data handling unit and sensor payload module, and the transmitter.
- Software should have been written to collect the sensor data and process the data in to understandable units.
- This section will explain how to transmit the processed data to the ground station.

RF Communications

- The Transmitter Module Consists of a Processor and a Transmitter Integrated Circuit (IC)
- The Processor Collects the Data From the Satellite Computer and Generates an AX.25 Protocol Data Stream
  - The Data Stream Is Sent to the Transmitter IC As Two Tones, 1200 Hz and 2400 Hz, Which Represent a Logic ‘1’ and ‘0’
  - The RF Transmitter IC Uses the Tones to Frequency Modulate a 433 MHz Carrier Signal
  - The Modulated Carrier Signal Is Transmitted on a Wire Antenna
- The Data Is Sent at a Rate of 1200 Bits Per Second; This Is Not a Fast Rate
- The Rate Was Chosen Because the Amount of Data to Be Transmitted Is Small and the Transmitter Circuitry Can Be Kept Simple
- Higher Data Rates Require More Complex Circuitry and a More Complicated Ground Station



Communications Protocols

- Most Communications Use Some Type of Protocol
  - A Protocol Is Basically a Method of Formatting Information and a Communication Method
  - A Data Structure Is Used That Contains Information for Addressing a Receiver, Identifying the Transmitter, Identifying the Type of Data, and Error Checking and Correction
- A Protocol Can Also Include a Sequence of Operations
  - For Instance, There Can Be a Protocol for Requesting a Connection, Acknowledging Receipt of Data, Request for Retransmission, etc.
- A Protocol Can Be As Simple As a Description of the Transmission Format
- For Example:

Header	Data	Checksum
1 byte	32 bytes	2 bytes

- The Protocol Above Is Nothing More Than a Format
  - The First Byte Is the Header Which Would Be Used by the Receiver to Detect the Start of a Message
  - The Next Thirty-Two Bytes Are the Data
  - The Last 2 Bytes Are for the Checksum Which Is Used by the Receiver to Determine If All of the Data Was Received Without Error

AX.25 Protocol

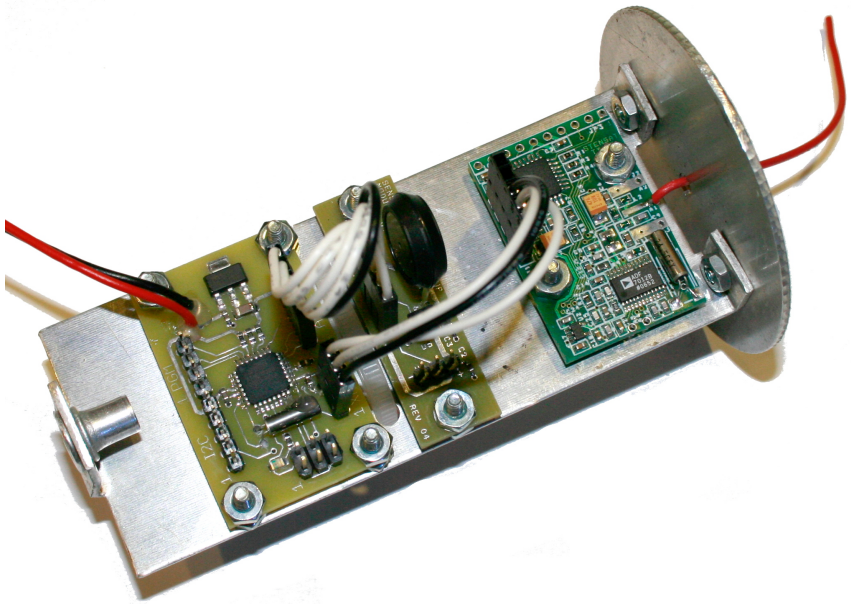
- The AX.25 Protocol Is a Digital Communications Protocol for Amateur Radio
  - It Has Been Modified From the X.25 Protocol to Support Amateur Radio Call Signs
  - The *CanSat* Uses a Subset of the AX.25 Protocol Called the Unconnected Information (UI) Frame
  - AX.25 Protocol Is Used for Another Type of Communications Called APRS (Automatic Position Reporting System)
  - APRS Uses the AX.25 Protocol to Transmit Bursts of Data
  - It Is Widely Used in the Amateur Radio Community for Sending Weather Reports, Position Coordinates and Other Short Sets of Data
  - The *CanSat* Uses the APRS Format

The AX.25 Frame **All APRS Transmissions Use AX.25 UI-Frames, With 9 Fields of Data:**

AX.25 UI-Frame Format								
Flag	Destination Address	Source Address	Digipeater Addresses (0-8)	Control Field (UI)	Protocol ID	Information Field	Frame Checksum	Flag
Bytes: 1	7	7	0-56	1	1	1-256	2	1

Installing the Transmitter

- Take the Transmitter Harness and Connect the 3-Wire Connector to the Processor Board With the Black Wire at Pin '1'
- Connect the 5-Pin End to the Transmitter With the 3 Wires Closest to the Screw



Communications System

- To Send Data to the Transmitter Module, the Following Command Is Used:

```
Serial.print("S");
```

- The "S" Tells the Transmitter to Transmit the Data.
- You can use several Serial.print() Functions to send information to the transmitter for transmission.
- The last thing you send to the transmitter, use the Serial.println(); function. This tells the transmitter to transmit.

How to use the Transmitter

- One of the First Things Needed to Be Done With the Transmitter Is Setting the Call Sign
  - All Call Signs Are Used to Identify the Transmitter
  - An Example Is “KN4JHF”
- No More Than Six Characters are Allowed for the Call Sign
- The Following Command Statements Set the Call Sign to “KN4JHF”

```
Serial.print("CKN4JHF");
```

How to Use the Transmitter

- **Here Is an Example on How to Use the Transmitter**

```
Serial.println("SThis is a test");
```

- **The Above Instructions Send a Sentence to the Transmitter**
- **To send a variable, you need to do the following:**

  Serial.print("S");
  Serial.println(variable);
- **To send multiple variables, do the following:**

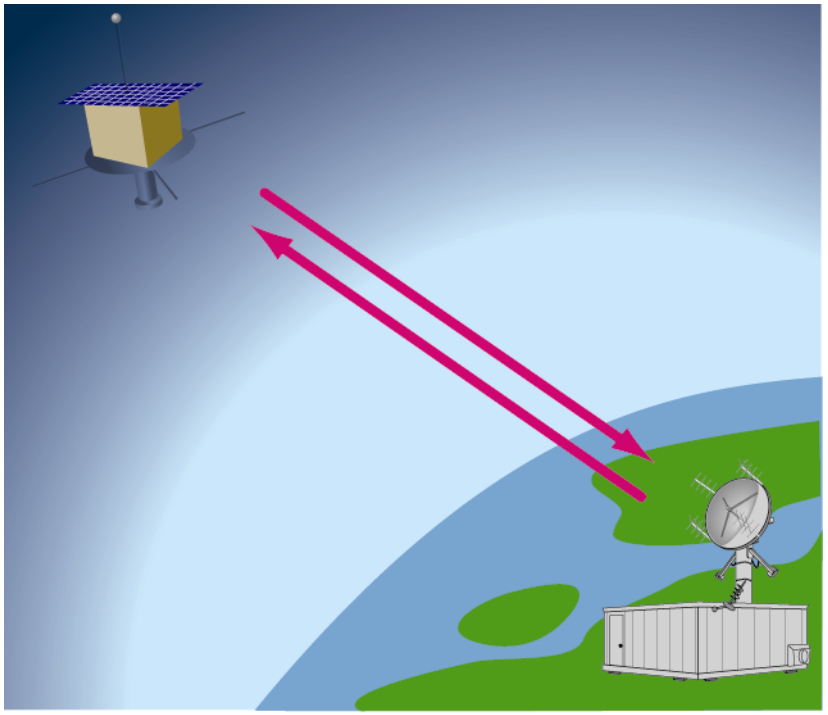
  Serial.print("S");
  Serial.print(variable1);
  Serial.print(" ");
  Serial.println(variable2);

Experimenting With the Transmitter

- Now It Is Time to Experiment With the Transmitter
  - Use the Program to Read the Temperature Sensor and Insert the 'Serout' Command to Send the Temperature Data to the Transmitter
- Set up the Ground Station to Receive and Record the Transmission
  - The Instructions Follow

Ground Station

- The Ground Station Is Where the Data Is Collected From the *CanSat*
  - The Ground Station Consists of an Antenna, a Receiver, a Terminal Node Controller (TNC), and a Computer
- The Antenna Is a Yagi Type Antenna
  - It Is Designed to Focus the Antenna in One Direction
  - This Focusing Adds Signal Gain to the Antenna
  - It's Like an Amplifier
  - The Yagi Antenna Used for the Ground Station Doubles the Signal Level Received
  - When the *CanSat* Is Launched in the Air, You Need to Point the Antenna in the Direction of the *CanSat*, If You Point Away, You May Lose the Signal
- The Receiver Is a Radio That Detects and Amplifies the Signal; It Also Demodulates
  - The Modulation Used Is FM or Frequency Modulation
  - The Radio Demodulates the Signal and Generates an Audio Frequency Signal Which Is Sent to the Computer



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- The Computer Uses a Program to Extract the Telemetry From the Audio Signal
  - The Telemetry Data Can Be Stored for Processing Later

Ground Station Configuration

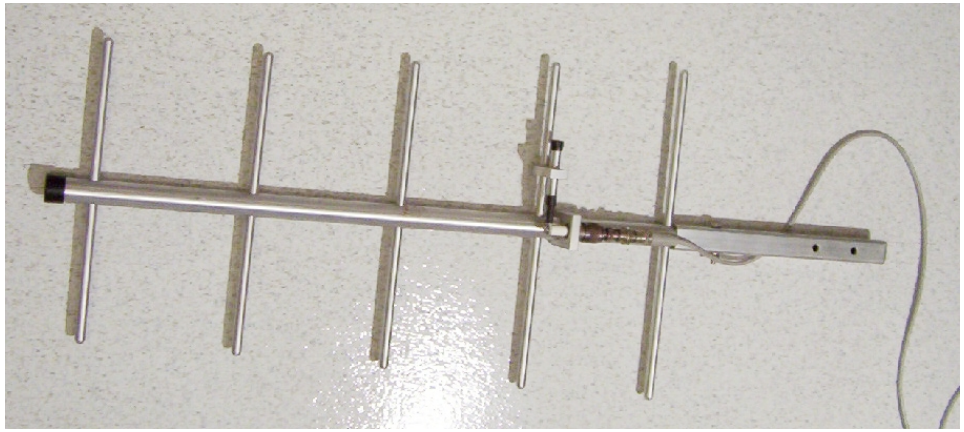
- The Ground Station Described Here Uses a Simple Radio Receiver Module and Computer Software
  - The Receiver Is a Single Frequency Receiver Designed Specifically for the *CanSat* Kit
  - The Output of the Receiver Plugs Into the Microphone Input of a PC Which Can Be a Desktop or Laptop
  - The Software Used Is From the Public Domain
- Other Receivers With Audio Output Can Be Used in Place of the One Described; The Requirements Are:
  - Can Be Tuned to 433.92 MHz
  - Is an FM Receiver
  - Has an Audio Output
- Computer Requirements Are:
  - Pentium Processor or Higher Running at 400 MHz or Higher
  - Windows 98, Windows 2000 Operating System
  - Sound Card With a Microphone Input
- The Software Is Included on the CD That Came With the Kit

Receiver Software Installation

- To Install the Software, Do the Following:
  - Install the CD Into the Computer
  - Locate the AGW Directory on the CD
  - Copy the AGW Directory to the Computer's C Drive
  - Double Click on "AGW Packet Engine" File
  - Click on the Window That Pops Up; It Will Go Away
  - Look at the Bottom Right of the Screen and Right Click on the Icon That Looks Like a Radio Tower
  - Select Properties
  - Click on the "New Port" Button
  - Click OK on the Next Window Prompt
  - A Large Window Should Appear; Look for the Box That Says TNC Type
  - Open the Selection and Locate "Sound Card"
  - Another Window Appears; Click on "OK" and Click on "OK" for the Previous Window
  - Restart the Computer

Configuring the Ground Station

- Take the Audio Cable and Plug One End Into the Radio Receiver Audio Port
- Plug the Other End of the Audio Cable Into the Computer Microphone Jack
- Connect the Antenna to the Radio Receiver Antenna Connector



Antenna

Running the Ground Station

- To Run the Software, Start the Packet Engine by Double Clicking on "AGW Packet Engine" in the `c:\agw` Directory
- When Started, Double Click on the "AGWMonitor2" Program
  - Adjust the Window to Meet Your Requirements
- Everything Is Now Running; Turn on the Radio Receiver and the Computer Is Ready to Receive Telemetry
- If Nothing Is Being Received, Check the Volume Control on the PC for the Microphone

Communications Exercise

- **Write a Program to Read the Sensors, Calculate the Pressure and Temperature, and Transmit the Results**
  - **Insert a Delay So That Transmission Is Not Continuous**
- **Since There Is One Receiver, Only One Group Can Test Their Software at a Time, Turns Will Be Taken**

Output Format

- **Format the Output As Follows:**

```
Pressure Temperature
```

- **Pressure – Put the Pressure Value Here**
- **Temperature – Put the Temperature Value Here**

Example:

```
102.123 24.123
```

Final Programming

- Up to now you have been clicking on the “Debug” button to upload your program and test it out. In order to operate in flight, you need to click on “Program” instead of “Debug”. This allows the program to start automatically when the battery is plugged in.

Summary

- At the End of This Section, You Should Know What Telemetry Data Is and How to Send Telemetry
- You Should Know How to Operate a Ground Station