Doppler Corrections for Satellite Communications

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The Challenge: Developing a system that automatically tunes a radio to the correct frequency, taking into account the Doppler shift of an overhead pass of a communication satellite.

The Solution: Using LabVIEW as a client to communicate with another program using the dynamic data exchange (DDE) to obtain data used to calculate a Doppler frequency. This frequency was then used to tune the radio via the serial port.

Introduction
Transmitting or receiving data from low earth orbit (LEO) satellites requires correcting the frequency in response to the motion of the satellite with respect to the observer (Doppler shift). We can perform this correction manually, but an automated system is preferable. A program, NOVA for WINDOWS (NfW32), tracks LEOs and other satellites that function as DDE servers. LabVIEW can act as a DDE client that obtains data from this tracking program, which can be converted to Doppler frequencies. We can use these frequencies to tune the radio. The program we created in LabVIEW offers a unique method for communicating with LEO satellites.

DDE Information
The NfW32 program can act as a DDE server. It can supply satellite tracking and range-rate data to any standard DDE client application, and we can use this information to implement customized interfaces for antenna tracking or radio tuning. In this application only the range-rate data is used for radio tuning.

We transmit the DDE information to the client in the following format:

SatName AZ: Azimuth EL: Elevation RR: RangeRate. Figure 1 shows this information in the data section. In the first part of the program, LabVIEW uses the DDE data to get the range-rate data and then converts it to a Doppler frequency. The frequency information is input into either 2m FREQ or 440 FREQ, or both. The resulting frequency plus Doppler is shown at the bottom of Figure 1.

Radio Interface
The radio connects through a level converter to a computer equipped with an RS-232 port with which the computer controls the radio functions. Each radio has a specific address that the computer recognizes. Figure 2 shows the basic message format sent by the computer to the radio – FE is the preamble code, ra is the radio address, E0 is the transmit address, cn is the command number, sc is the sub command number, dt is the data area, and FD is the end of message code. Each of these HEX numbers must be changed to their ASCII equivalent before transmission to the serial port.
**Frequency Data Format**

The operating frequency data length is 5 data bytes, each of which is specified in BCD code. We wrote a sub-VI that completed all the above automatically.

Because radio is dual band, a specific sequence of events must occur to tune both bands. First, we select the main band and load the frequency + Doppler. Next, we select the sub-band and load its frequency. All this is done automatically under computer control. Figure 1 shows the rate of frequency update for both bands.

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**Results**

We created a LabVIEW program that successfully calculates the Doppler frequency for control of a radio used for communication with LEO satellites. A recent experiment involving the MIR space station inspired the transmission of pictures via SSTV, where it is imperative that the transmitter and receiver remain on frequency to get good pictures. Use of the technique outlined herein would work well for such applications.

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