

AMSAT Oscar-Echo, SDR-1000, and higher speed FSK

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If all goes well, in May 2004 AMSAT-NA will launch its newest satellite on the Dnepr LV (converted SS-18) from a Russian launch site. The satellite has the ability to support several digital modes. They will be difficult to support using off the shelf conventional transceivers. Recently, a realistic candidate has emerged in the form of an affordable and easily usable software defined radio (SDR). In this paper we will describe the digital capabilities of AMSAT-ECHO, the new satellite, and how the software defined radio can be the ideal terrestrial station for exploiting those modes. We will discuss the changes and upgrades to the SDR, to be provided by the manufacturer, that will be necessary for this added functionality.

AMSAT Oscar Echo

In 1990, AMSAT-NA launched four Microsats: AO-16, DO-17, WO-18, and LU-19. Four subsequent satellites, the IO-26, AO-27, MO-30, and the SO-41, were designed and built based on these original Microsats, using technology licensed from AMSAT-NA. In early 2002 the AMSAT-NA board of directors entered into an agreement with Spacequest, Inc., which had been exploiting the Microsat concepts, to develop a spacecraft with their updated version of the technology. AMSAT-NA would create unique modules for the payload, and would carry out the integration jointly with Spacequest. It appears now that that the result will be launched in May 2004 on a Dnepr (converted Soviet SS-18). The new satellite will have a very digital flavor onboard along with the very popular "FM-sat/Easysat" mode.

The initial and primary operational mode for the new satellite will be Mode J (2 meter uplink, 70 centimeter downlink). It will carry four receivers configured either for FM audio or FSK-modulated data signals. Downlink will be provided by two high-power 70cm transceivers, each capable of 8 watts output. This is definitely no low-power satellite. On a typical pass, the link margin – the level of power in excess of what is required to complete a digital transaction with the satellite -- should be more than adequate to support the use of 0 dBd omni antennas for both uplink and downlink. The link margin for digital signals at 9.6 kbps at elevation angles above 10 degrees will be several dB.

The onboard computer will run the now well-known SCOS (Spacecraft Operating System) from Harold Price, NK6K. This computer has sufficient power to allow us to not talk to the fishes in the middle of the ocean (unless first called) and will greatly increase the power budget available for the high power transmitters over more populous areas.

In addition to the now standard 9600 bps FSK mode, the satellite will carry an L band receiver and an S band transmitter. Together these assets will enable downlink data rates

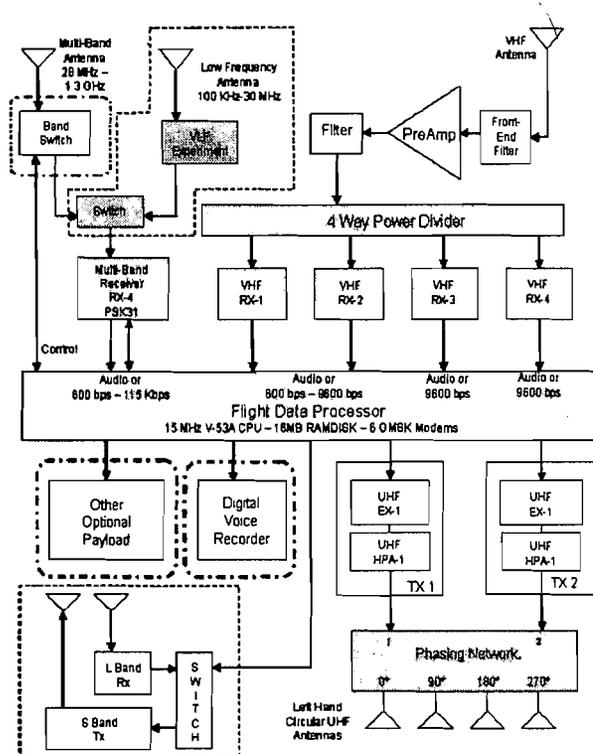
up to 76.8 kbps. The L band receiver will be capable of receiving FSK data at rates up to 56 kbps. It should be clear this will not be enabled by a quick press of the data button on your favorite satellite or terrestrial radio. The interested reader is referred to a recent paper by the AMSAT executive VP and ECHO project manager W2GPS (1).



AO-E Block Diagram



- Four VHF receivers
- One Multi-Band Multi-Mode Receiver
- Two UHF transmitters
- Six modems
- Flight computer
- RAM disk
- Batteries
- Battery charger and voltage regulators
- Wiring harness
- RF cabling
- RF switching and phasing networks
- 56 channels of telemetry
- Magnetic attitude control



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Software Defined Radio

In the July/August 2002 issue of QEX, Gerald Youngblood, AC5OG, gave us the first of four articles which introduced the outcome of a four year struggle to bring a real software defined radio transceiver with high performance to amateur radio. The performance of the nearly direct conversion receiver is due to a unique “mixer” at the front end. Youngblood calls it the Quadrature Sampling Detector (QSD for short). It is essentially a four-phase sample-and-hold, which, with outputs combined properly, produces a complex version of the received signal and mixes it down to the last IF at 11025 Hz. This last IF

is passed to a general-purpose personal computer via the stereo line-in to its soundcard. This front-end hardware, together with the software designed to control the hardware and interface with the user, forms a complete system called the SDR-1000. It realizes a ham band transmitter and a general coverage receiver operating 11.025 KHz to 60 MHz. It currently uses a 44100 Hz sample clock. As is characteristic of SDRs, most significant changes in the capabilities of the system involve software and not hardware. We will return to this theme in a moment. A number of early users have been contributing to the improvement and enhancement of the SDR-1000 signal-processing software. Among the areas addressed are the complex or phasing detector for sideband, implementing AM, and CW modes on both transmit and receive, automatic noise cancellation and tone removal, etc.

The present authors, among others, are very interested in adding digital mode capabilities. This work is a high priority following the completion of noise-blanking algorithm and implementation.

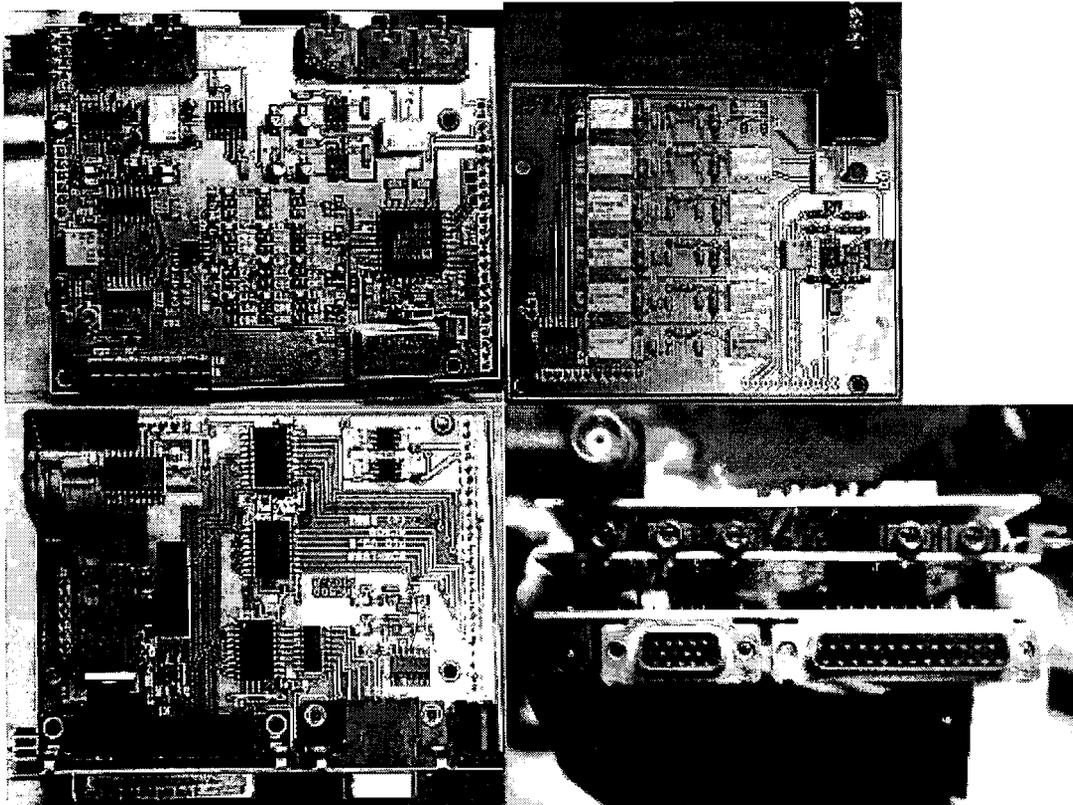


Fig.2 (clockwise from top left) Transceiver board, Filter/Amplifier board, Parallel I/O board, and the full stack.

The SDR-1000 as delivered comes with software written in Visual Basic 6, using Intel optimized signal processing libraries and DSP code the SDR project has written. The software is released GPL though it is based on commercial proprietary software which we hope to replace with libraries that do not have such restrictions. Figure 3 shows the

current front panel. It is clear from looking at it why Gerald chose Visual Basic 6 since it made this level of detail easy to construct.

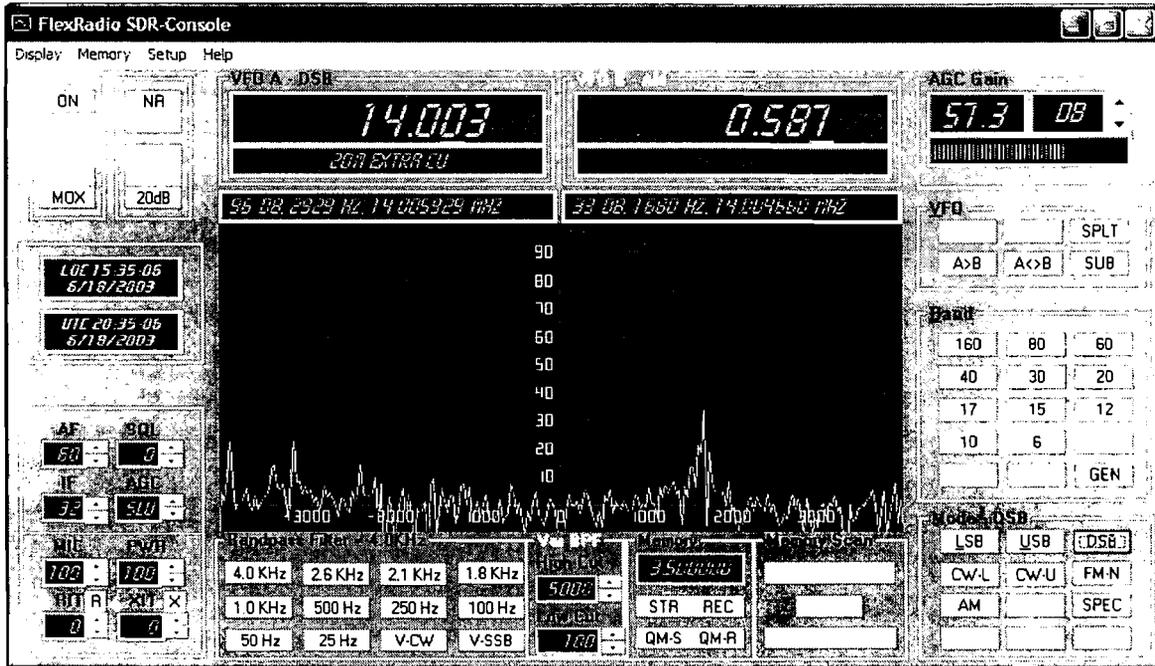


Figure 3 SDR-1000 “front panel” screen capture

Marrying SDR-1000 and AMSAT-ECHO FSK

As currently delivered, the SDR-1000 can handle 9600 bps but not 56 kbps. This limitation is being addressed on two fronts. The SDR-1000’s “mixer” or sample-and-hold circuit works by charging a capacitor through the load presented by the antenna and bandpass filter combination. This “RC” network in the delivered model sets the front end Q to deliver a bandwidth of 40 Khz. A passband of at least 192 Khz will be required to accommodate occupied bandwidth of the FSK, Doppler, and other tuning inaccuracies. The SDR-1000 can be modified to handle this by a change of four chip capacitors! The other hardware change is likely to be the computer soundcard: to capture the necessary additional bandwidth, the sampling rate needs to be increased. There several audio cards out now that will allow sampling at a 192 Khz sample rate. A good candidate is the Lynx L22 (see <http://www.lynxstudio.com/lynx122.html>) in a 24 bit A/D card. For 16 bits, the Turtle Beach Santa Cruz will serve well, although, while it uses an 18 bit A/D, it only delivers 16 bits. The Santa Cruz will not sample at 192 Khz, but should be more than adequate for the 9600 bps that will be used immediately following launch of the new satellite.

Youngblood has set up an official software exchange for the existing Visual Basic SDR-1000 code at Sourceforge. The present authors are working in parallel on Linux versions

of the transceiver software, including that necessary to operate AMSAT-ECHO. If all goes well, a demo will accompany this talk.

Bibliography

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