

DSP-93 Update: The TAPR/AMSAT Joint DSP Project

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Abstract

This paper discusses the geniuses of the TAPR/AMSAT Joint DSP project. The end result was the TAPR/AMSAT DSP-93. As of July 1995, 300 units have been made available to amateurs for construction. Items to be covered include: a history of the project, history of the DSP-93, DSP-93 design, current software suite, code development, and comments on the successful use of Internet for project support.

Introduction

In 1987, DSP-based modems were seen as the coming amateur trend [1,2]. Digital signal processing techniques have been a promise of improved reliability and lower cost since 1986. In July 1988, TAPR and AMSAT entered into the Joint DSP Program, in order to fund the development of an eventual DSP unit for amateur usage. The hope was to fulfill the dream of having a low-cost, flexible amateur kit. The DSP-1 was based on a TI TMS320C15 at 25Mhz, with 4K of program memory. In addition, a GPP board (NEC V40 with 72001 serial I/O chip) was developed to interface the DSP-1 to a PC for programming. Progress was made during the early stages of the project [3,4], but later trailed off as other projects appeared. The articles in the reference provide a good snapshot for those early days. The DSP-1 platform, along with experience gained from the earlier Delanco

Spry boards, while never reaching a final kit, proved invaluable in the learning process. These early developments are reflected to some degree in the final DSP-93 project.

In 1993, the TAPR/AMSAT co-management team made the deliberate decision to stop work on the DSP-1 project and to proceed with a proposal by Bob Stricklin, N5BRG, in Dallas, Texas that focused on a modular, stand alone DSP system. The Stricklin KISS design [5], later renamed DSP-93, offered many of the elements that the initial design goals of the project had specified. Seven years into the joint project and fifteen months after the decision was made to proceed with the DSP-93 development, TAPR and AMSAT shipped the first 110 units of the project. In July of 1995, a second batch of 180 units was produced and shipping began - an end to a long journey.

The history of DSP-93 can be traced back to 1991 when development began on the KISS DSP. The KISS DSP was a single board DSP engine designed around the Texas Instruments TMS320C25. The KISS DSP board, as described in an earlier AMSAT publication [5], included the DSP, memory, serial I/O, and a limited audio interface. The KISS DSP was designed as a stand alone box to interface between the computer and radio. In some cases, a TNC was needed to process the HDLC digital data. To simplify the computer interface, a monitor routine (DSP BIOS) was developed which included functions to download DSP programs from a computer, view and change program memory, data memory, and DSP registers. To make software development possible, work was undertaken with Thomas Anderson of Speech Technology in Issaquah, Washington to produce a TMS320C25 assembly table for his assembler. The result was an inexpensive assembler for the a TMS320C25-based DSP.

Several amateurs obtained and built the KISS DSP boards and placed them in operation. The KISS DSP experiments served as an excellent initial platform to develop and understand the realities of developing DSP software and hardware for amateur applications. Areas which needed work were the radio interface circuitry and understanding how to match the hardware with the particular application. A single 'do all' DSP box is not a practical solution to all amateur DSP applications. It is not "Only Software." It is a combination of selecting the best hardware for the particular application and developing the software around the selected hardware. Since most amateurs are looking for a cost effective solution, you can sacrifice some of the capability and provide them as future additions.

Based on the KISS DSP lessons, DSP-93 was designed in a modular fashion with multiple four-layer boards which include the interconnecting bus structure. The boards include a DSP engine board and a radio and computer interface board. Any of these boards can be replaced with a future board designed for any number of unique applications. It's sort of like adding a new application card to a PC without redesigning the complete PC. Figure 1 shows the basic hardware block diagram. Figure 2 shows overall structure of the assembled unit with enclosure.

The bottom board (DSP Engine) contains the TMS320C25 DSP, 64K by 16 bits of program and data memory, the clock circuitry and programmable array logic (PALs) for system I/O. All the DSP lines are connected to the backplane bus. This was intended to make it easier to add additional features on additional DSP-93 boards. The floating input lines all have 100K pull up resistors. The clock circuit for driving the DSP is also included on the DSP Engine board. Since slower EPROMs are used to boot the system, the clock is designed to shift between half the maximum rate and full speed. Clock shifts are software controlled and will be transparent to the application. The target clock speed is 40 MHz; however, we have demonstrated that 26 MHz is adequate for most amateur applications. Additional testing of the Beta boards will be required to establish the final clock rate.

The top board (Radio Interface Board) contains two eight pin mini-DIN connectors for the radio interface. Incoming radio signals pass through a voltage divider to establish the initial levels, then through an eight channel multiplex chip. The multiplex

Figure 1: Basic hardware black diagram.

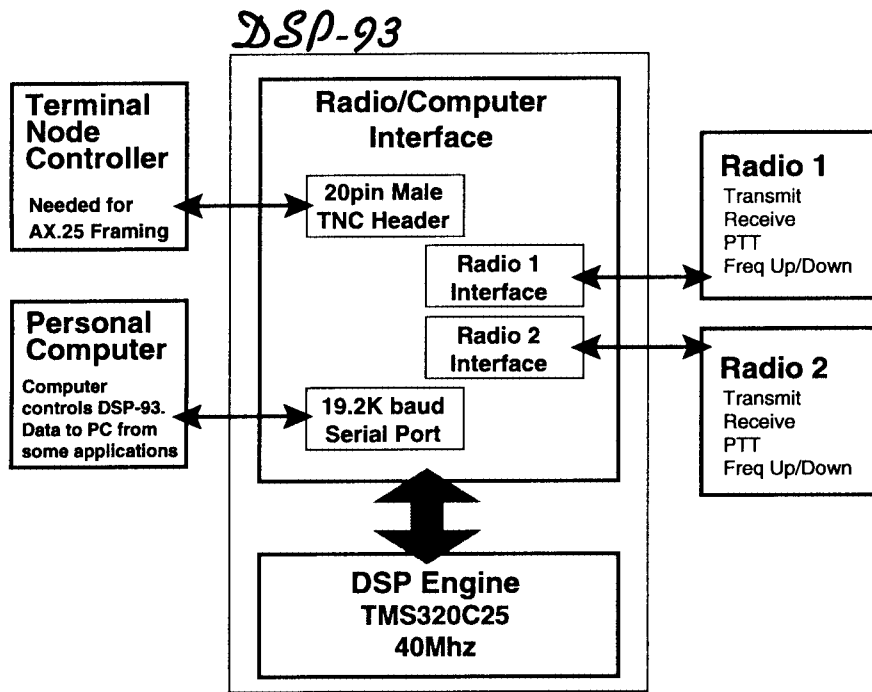
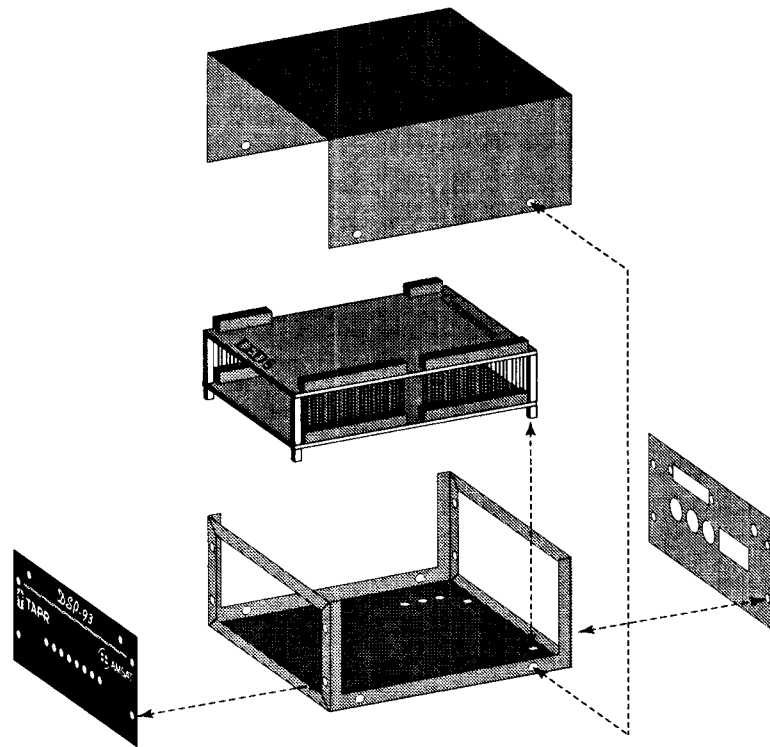


Figure 2: Overall structure of the assembled unit with enclosure.



chip will feed the single A/D input with either of the radio inputs or one of the six auxiliary inputs. Before reaching the A/D, the signal is conditioned by an OP-AMP whose gain is software selectable. Gain options include; 1X, 2X, 5X, 10X, 20X, 100X, 1000X and a comparator mode with ground being the reference voltage. Once again this is all software controlled and it should make for some nice adaptive signal conditioning algorithms. The Texas Instruments TLC32047 Analog I/O chip is used on board two. This chip samples and updates at a rate of 45K operations per second and it includes aliasing filters. The chip communicates with the DSP using a 5 MHz serial interface. The 5 MHz interface is routed through a selection PAL to allow the user to disable this serial device in favor of another.

Code Development

A low cost shareware assembler is available for code development. Thomas Anderson of Speech Technology in Issaquah, Washington has worked with the DSP-92 development group to produce a TMS320C25 assembly table for his assembler. All the details needed to write DSP code is supplied with the kits. An in-depth programming guide has been developed and is available for DSP-93 developers.

Project Team

Much of the development and current success of the DSP-93 project can be contributed to the designers, developers, and testers. Designer: Bob Stricklin, N5BRG. Project Managers: Bob Stricklin, N5BRG and Greg Jones, WD5IVD. Joint DSP Project Officers: Robert Diersing, N5AHD (AMSAT) and Greg Jones, WD5IVD (TAPR). The Alpha-Team: Bob Stricklin, N5BRG, Frank Perkins, WB5IPM, Jon Bloom, KE3Z, Lon Cecil, WB5PKJ, Tom McDermott, N5EG, Robert Diersing, N5AHD, UoSAT/Doug Loughmiller, K05I/GOSYX, John Conner, WDOFHG, Greg Jones, WDSIVD, and Bill Reed, WDOETZ. The Beta-Team: Jack Davis, WA4EJR, Paul Beckmann, WAORSE, Scott Zehr, K9GKC, Ron Parsons, W5RKN, Jim Tittsler, 7JIAJH/AI8A, Michael Zingman, N4IRR, Stan Salek, KDGCVL, Mark Hammond, KC4EBR, Marcel Losekoot, Bill Beech, NJ7I?, Gould Smith, WA4SXM, Roy Welch, WOSL, Greg Ratcliff, NZ8R, Brian Straup, NQ9Q, Doug Howard, KG50A, and Robert Greenfield, VE3DSC.

The current DSP-93 development group consists of: Bob Stricklin, N5BRG, Frank Perkins, WB5IPM, Tom McDermott, N5EG, Ron Parsons, W5RKN, Scott Zehr, K9GKC, Stan Salek, KDGCVL, Mark Hammond, KC4EBR, Gould Smith, WA4SXM, Roy Welch, WOSL, Brian Straup, NQ9Q, Michael Zingman, N4IRR, Lon Cecil, WBSPKJ, and Robert Diersing, N5AHD.

Basic Software Suite

As of June 1995, the DSP-93 had the following software available. Some modems have multiple versions to accommodate various radios and are not shown.

9600 bps Modems

FSK93U1/2	Half or full duplex operation, active DCD	WB5IPM/W5RKN/WOSL
FSK93U1/2B	Weak signal optimized FSK93U1/2	WBSIPM/W5RKN/WOSL
FSK93K1/2	IS1 camp. for KO-23/25, active DCD	WB5IPM/W5RKN/WOSL
TPRS931/2	TPRS with NRZI in/out, active DCD	WB5IPM

1200 bps Modems

PKT931/2	Standard AFSK, active DCD	WBSIPM
PSK93R1/2J	Satellite PSK, active DCD, SmartTune	WB5IPM
PSK93R1/2Y	Sat. PSK, active DCD, SmartTune, YAESU	WB5IPM

HF Modems

HOT HF93	RTTY modem, Viterbi soft detection	W3HCF
HF-9;HT1/2	300 bps FSK, active DCD, adpt. threshold	WB5IPM
HF_93U1/2	AMTOR using TOR.EXE, adpt. threshold	WB5IPM

Sat. Pic/Telem

APT 93HX1/2	Carrier-sync. pixels eliminate doppler bow	WBSIPM
P3C93T1/2	AO-13 400 bps telemetry, P3C.EXE camp.	WBSIPM
UO11	UO-11 telemetry decode.	WB5IPM

Noise Processing

W9GR 93	Adpt. carrier null, channel enh., BP filters	N4IIR/KBGKC/W9GR
CW93j1D	CW filter	WBSIPM

Instrumentation

D93WE (PC)	Control Loader, audio oscilloscope, function generator and spectrum analyzer (Figure 3)	N5EG
DSP-93 (Mac)	Control Loader, audio oscilloscope (Figure 4), function generator and spectrum analyzer	w5RKN

Diagnostics

Monitor	Basic DSP-93 Monitor and SW utilities	N5BRG
DSP-93 tests	Check-out of all DSP-93 functions	WB5PKJ/N5EG/W5RKN

Software is being distributed on Internet, the Amateur Satellites, as well as being made available on disk as part of the TAPR software library. The idea of software for the DSP-93 is to make it as easy as possible to get and upgrade software in the future.

Figure 3 - Spectrum Analyzer Display from DSP93WE Windows [lo]

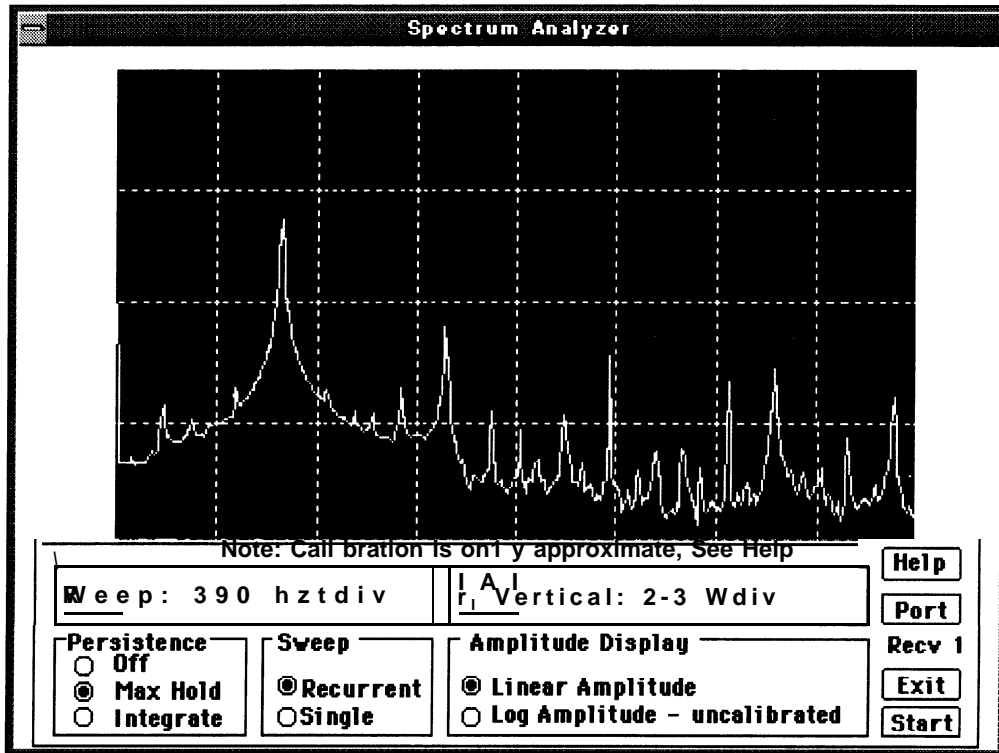
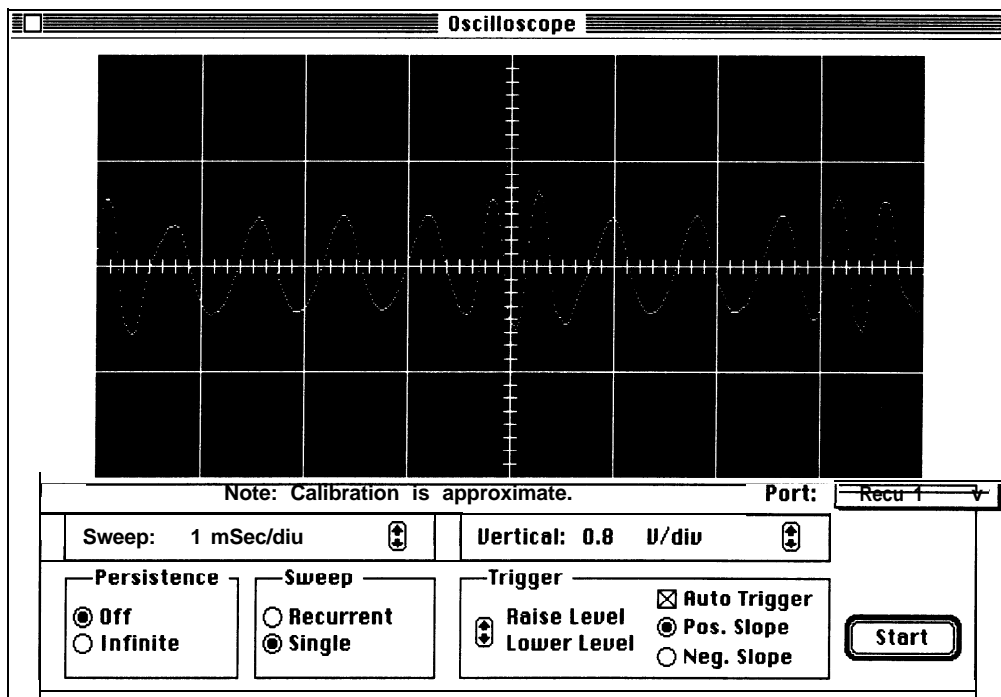


Figure 4 - Sampling Oscilloscope from DSP93 Mac [ll]



Oscilloscope: The display shows a 1200 bps packet audio signal. Note the two different periods of the waveform corresponding to different binary digits.

SUccess of Internet Support

The project, from the beginning, has been supported using only the Internet. Internet and satellite communications have been a major key to the success of the project. Internet e-mail allowed one of the few TAPR projects to include small groups of individuals outside of the main development group located in the Dallas area. We felt that the development group still had to be in a local geographical area or the development process would have been retarded. Much of the initial development required personal visits during the prototyping and initial alpha testing.

TAPR maintains an ftp site at ftp.tapr.org. Updates and archive material relevant to the DSP-93 can be obtained via anonymous ftp from the directory /tapr/dsp93. Copies of all past messages distributed on the dsp-93@tapr.org list by sending mail to 'listserv@tapr.org', subject of 'list', message of 'index dsp-93'. Recently a web page has been created with links to manuals, software, and quicktime movies of various modes. <http://www.tapr.org/tapr>

References:

1. McGwier, Robert, N4HY. DSP Modems: It's Only Software. (1987). Proceedings of the 6th ARRL Commuter Networking Conference. Redondo Beach, California. August, 1987. ARRL: Newington, CT. p. 123.
2. Clark, Tom, W3IW1, and Robert McGwier, N4HY. (1987). Digital Signal Processing and Amateur Radio. Proceedings of the 6th ARRL Computer Networking Conference. Redondo Beach, California. August, 1987. ARRL: Newington, CT. p. 44.
3. Clark, Tom, W3IW1, and Robert McGwier, N4HY. (1988). The DSP Project Update. Proceedings of the 7th ARRL Commuter Networking Conference. Columbia, Maryland. October, 1988. ARRL: Newington, CT. p. 48.
4. Johnson, Lyle, WA7GXD. (1988). The AMSAT/TAPR DSP 1 Project: Hardware Design. Proceedings of the 7th ARRL Commuter Networking Conference. Columbia, Maryland. October, 1988. ARRL: Newington, CT. p. 101.
5. Stricklin, Bob, N5BRG. (1990). KISS DSP for Amateur Applications. Proceedings of the 8th AMSAT-NA Space Symposium. Houston, Texas. October 1990. AMSAT: Silver Spring, MD. p. 22.
6. Stricklin, Bob and Greg Jones. (1993). TAPR/AMSAT DSP-93 Project. Proceedings of the 1993 AMSAT-NA. AMSAT.
7. Stricklin, Bob. (1993). DSP-93: The Joint DSP Program (TAPR/AMSAT). Issue #52, Fall 1993, Packet Status Register. pp. 4-5. Tucson Amateur Packet Radio Corp.
8. Stricklin, Bob. (1994). TAPR/AMSAT Joint DSP Project: DSP-93. Proceedings of the TAPR 1994 Annual Meeting. Tucson Amateur Packet Radio Corp.
9. DSP-93: The TAPR/AMSAT Joint DSP Program. (1994). Issue #55, Summer 1994, Packet Status Register. pp. 1-4. Tucson Amateur Packet Radio Corp.
10. McDermott, Tom, N5EG. (1995). D93WE Windows Development Environment for the TAPR/AMSAT DSP-93. Proceedings of the 1995 TAPR Annual Meeting. St Louis, MO. March, 1995. TAPR: Tucson, AZ. p. 31.
11. Parsons, Ron, W5RKN. (1995). DSP-93 Control Macintosh Development Environment for the TAPR/AMSAT DSP-93. Proceedings of the 1995 TAPR Annual Meeting. St Louis, MO. March, 1995. TAPR: Tucson, AZ. p. 38.
12. Parsons, Ron, W5RKN. (1995). Programming Guide for the DSP-93. June, 1995. TAPR: Tucson, AZ.