Learning DSP by Porting Programs to the TAPR/AMSAT DSP-93 Modem

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Abstract.

This paper is about porting some assembler programs in the text authored by Rulph Chassaing and Darrell W. Horning, titled, "Digital Signal Processing With the TMS320C25", published by John Wiley & Sons New York, ISBN O-471-51 066-1, 1990, phone I-800-CALL-WILE, (hereafter the text) to the TAPR/AMSAT DSP-93 ham radio modem kitted by the Tucson Amateur Packet Radio, Corp. (TAPR), Tucson:, Az, phone I-81 7-383-0000. Porting these senior/l st year graduate electrical/computer engineering student level programs taught the author many things about digital signal processing (DSP) in general and TAPR/AMSAT DSP-93 modem in particular. AMSAT is an acronym for Radio Amateur Satellite Corporation.

Key Words

Assembler, DSP, Programming, Modem, TMS320C25

Introduction.

There are several different dialects of the programming language of Assembler. It is fortunate from a learning prospective that the Speech Technology Inc.'s shareware Table Driven Assembler (TASM) program[7] supplied with the TAPR/AMSAT DSP-93 modem will not process the Texas Instruments, Inc. (TI) dialects used in the text. These dialects are TI-Tag, COFF (common object file format), and TI-Tag macro.

Porting Programs to the TAPR/AMSAT DSP-93 Modem.

While porting some of the numerous TI-Tag programs the author made some notes that might make the learning path easier for other hams.

		TI-Tag		TASM		
Change	AORG	t o	.ORG		
	END	to	.END		
	DATA	to	.WORD		
	>	to	h	hex example:	>2E to 02Eh
	*	to	;	for comments	
	EQU	to	.EQU		
	BIOZ	to	WAIT4		

1. Use .MSFIRST before the first .WORD or the bytes will store reversed.

2. Move tables to the bottom of the program.

3. Move interrupt routines to the bottom of the program.

4. On the modem BO is in program memory, initially.

5. Prefix a comment in an instruction line with a semi-colon.

6. .WORD converts a minus base IO number to a 2's compliment number in base 16.

   example: -7782 will appear on the assembly listing as E19A
                   IO   16

7. The use of .ORG in the table definition is not required and using it my result in code overlaying other code in memory.

8. Any address in a statement in the inclusive range of 60-6F on page 0 must be changed to another address as the modem's monitor uses these addresses.

9. All 4 digit hexidecimal numbers must be prefix with a zero if the left digit is not zero.

   Example: 7E52 is coded 07E52

10. Do not use the SXF and BIOZ instructions because they cause halts.

11. Insert the following at the top of the program.

```
AR0     .EQU     00h
AR1     .EQU     01h
AR2     .EQU     02h
AR3     .EQU     03h
AR4     .EQU     04h
AR5     .EQU     05h
AR6     .EQU     06h
AR7     .EQU     07h
```

12. Do not use MODE and RATE instructions because they are Analog Interface Board (AIB) instructions. The parameters in them can be used in the Analog Interface Chip (AIC) initialization routine.

13. TAPR/AMSAT DSP-93's AIC is TLC32044 (sin x/x feature).
    Text's AIC is TLC32041 (no sine x/x feature).

14. 10 - 22,000 hz is the range of music.

The text has Texas Instrument (TI) assembler programs for both the Analog Interface Board (AIB) and the Analog Interface Chip (AIC), similar to the one that's in the modem. Porting the AIC programs just requires some syntax changes, address changes, and re-ordering the data blocks and routines. The AIB programs also requires the AIB initialization code (mode, rate) to be replaced by AIC registers initialization code and interrupt routines.

The monitor[2] (operating system) supplied with the modem uses certain registers and memory locations, so any portion of the text program using these memories must be moved by changing register names and memory addresses, and/or memory page numbers. To manage memory it might be helpful to draw and color code registers, memory blocks, and memory pages on paper. Save it for future reference.

The software development kit supplied with the modem has several routines whose calls can be temporary placed in the ported program code to display registers & memory data (CALL DEBUG)[2,] and addresses on a computer screen to assist debugging. Most of these programs loop continuously until the reset button is pushed. If the same address displays every so often, it is looping. Placing LED lighting code[8] after certain instructions can also be helpful in determining what routines are executing, etc.. If a program is not looping, then moving a "display my address" call (TRACE) [2] around in the code can pin point the instruction causing the halt. If the "display my address" call executes before an instruction and not after it, then that's the instruction causing the halt. After the debugging process is complete remove (or comment) all these temporary display calls because they slow the program down.

The following were at-my-elbow (must haves) books/papers during porting.

1. Above text.

2. Ron Parsons, W5RKN, Don Haselwood K4JPJ, & Bob Stricklin, N5BRG, DSP-93 Programming Guide, **published by** Tucson Amateur Packet Radio Corporation, Tucson, Arizona. June 1995, paper, phone 817-383-0000.

3. Frank H. Perkins, Jr., WB5IPM, "DSP-93 Programming Hints", Proceedings of the 14th ARRL DIGITAL COMMUNICATIONS CONFERENCE, published by The American Radio Relay League: Inc. (ARRL), Newington, Conn, ISBN: O-87259-526-9, ARRL Order Number: 5269, 1995, phone I-860-594-0200.

4. Ron Parsons, W5RKN, "Analog Block" and "Digital Block", published by Tucson Amateur Packet Radio Corporation, Tucson, Arizona, ftp.tapr.org /tapr/dsp93/schems/ or http://www.tapr.org/tapr

5. "Chapter 3, Architecture" and "Chapter 4, Assembly Language Instructions" , TMS320C2x User's Guide, published by Texas Instruments, Inc., Dallas, Texas, 1604907-9721 revision C, SPRU014C, January 1993, free, phone 214-644-5580.

6. "Section 4 - Analog Interface Circuits and Codec, TLC32044C......., Voice-Band Analog Interface Circuits", Data Acquisition Circuits - Data Coversion and DSP Analog Interface - Data Book, published by Texas Instruments, Inc., Houston, Texas, 1995, SLAD001, pages 4-35 thru 4-72, free, phone 214-644-5580.

7. TASM USER'S MANUAL, published by Speech Technology Incorporated, Issaquah, Washington, Version 3, October 1993.

8. TESTLEDS.ASM source code, ftp.tapr.org /tapr/dsp93/software/ or http://www.tapr.org/tapr

The author has not as yet done a live on-the-air test of any of the programs he has ported, nor used an audio signal generator, oscilloscope[3], or spectrum analyzer to test them. He was satisified at the time **with** the modem sending (TRACE)* the same addresses repeatedly to the PC screen during looping, flashing its LED's, and sending expected sounds to the stereo broadcast amplifier-receiver.   He learned about DSP and the TAPR/AMSAT DSP-93 by porting, but has more to learn before he writes his first useful filter, modem, etc., program, if ever. Some of the math he chose to ignore because he did not understand it.

The porting of the few TI-Tag macro and COFF programs briefly discussed in appendix A and C respectively of the text is outside the scope of this paper.

Porting the Hexadecimal Coefficient Table Generators, etc..

The text's GWBASIC programs ported to Microsoft Corp. MS-DOS QBasic, Version 1.1, by changing vector name AS ( ) and variable name TYPE to some other names. And by changing the British pound symbol to the American pound symbol # for double precision.

DSP Articles/Source Code.

The following articles/source code helped the author understand DSP in general, and may be of value to the reader depending on her/his place on the learning curve. Copies of articles are probably available from your nearest college/university library thru inter-library services, or the publisher for a small fee. Most college/university libraries serve the public in addition to the student body and faculty.

A. Jon Bloom, KE3Z, ARRL Staff, "Digital Signal Processing", Chapter 8 - Digital Basics, The ARRL Handbook for Radio Amateurs, published by The American Radio Relay League, Inc.(ARRL), Nlewington, Conn, ISBN: 0-87259-j 71-9, 71st Edition, 1994, pp. 8-36 thru 8-38, phone 860-594-0200

B. Mac A. Cody, "The Fast Wavelet Transform", Dr. Dobb's Journal, M&T Publishing, Inc., San Mateo, Ca, #187, Vol. 17, Issue 4, pp. 16-28, April 1992, phone 415-358-9500.

C. Bill deCarle, VE2IQ, "Fourier Transforms: Math or Magic?", Chapter 29 - Digital Equipment, The ARRL Handbook for Radio Amateurs, published by The American Radio Relay League, Inc., Newington. Conn, ISBN: O-87259-1 71-9, 71 st Edition, 1994, p. 29-I 3, phone 860-594-0200

D. Johan Forrer, KC7WW, "A Low Cost DSP Modem for HF Digital Experimentation", Proceedings of the 13th ARRL DIGITAL COMMUNICATIONS CONFERENCE, published by The American Radio Relay League, Inc. (ARRL), Newington, Conn, ISBN: 0-87259-483-1, ARRL Order Number: 4831, 1994, phone 1-860-594-0200. Source code and schematics were available from Johan Forrer, KC7WW, forrerj@ ucs.orst.edu

E. Dave Hershberger, W9GR, "DSP - An Intuitive Approach", QST, published by The American Radio Relay League, Inc., Newington, Conn, ISSN: 0033-4812, Vol. 80, No. 2, pp. 39-42, Feb 1996, phone 860-594-0200

F. Thomas E. Janzen, "Recovering Corrupted Waveforms", The C Users Journal, published by R&D Publications, Inc., Lawrence, Ks, Vol. 11, No. 6, pp. 39-48, Jun 1993, phone 913-841-1631.

G. Roy E. Kimbrell, "Finding Significance in Noisy Data", Dr. Dobb's Journal, M&T Publishing, Inc., San Mateo, Ca, #189, Vol. 17, Issue 6, pp. 30-42, June 1992, phone 415-358-9500.

H. David L. Mills, W3HCF, FSK modem/TNC for HF RTTY, source code, object code, and documentation, 1995, ft p.tapr.org /tapr/dsp93/software/modem or http://www.tapr.org/tapr

No Warranty.

"The Learning is in the Porting"