

# TEXAS INSTRUMENTS

## Upgrading The 99/4A Pt. 1 — The TMS9995

by Randy Holcomb

A question on just about everybody's mind is "where do we go from here for more processing power?" Since TI withdrew from the market the 99/8, the only known available upgrade to the home computer family was scrapped forcing 99/4A owners into an awkward position of having to make do with what they have or to sell their 99/4A systems and upgrade to a supported system such as an Apple, IBM or Commodore, usually at a much higher cost than what was originally paid for the 99/4A system.

The stillborn 99/8. Recently one of the prototype 99/8s (the infamous "Armadillo" code-name) was shown at a recent 99/4A user's show in Chicago by Don Bynum, one of the original members of the home computer division of Texas Instruments. Some of its preliminary specs were revealed for the first time: a 10.7 MHz TMS 9995 processor, a full 65kbytes of user memory, a custom version of the TMS 9918A Video display processor and completely redesigned BASIC written entirely in machine code with full bit-map support and special graphics commands, and mapping support for over a megabyte of memory.

Conservative estimates rank this machine's capabilities as being 6 to 8 times faster than the current 99/4A and in many respects would have given Commodore, Apple and IBM a run for their money in terms of performance per dollar. Of course this is all moot because only a handful of these ma-

chines exist and it's further unlikely that TI will license its production. The 99/8 had a switch on it which placed the machine in "4A" mode which dropped it into the GPL monitor and looks like a /4A to maintain compatibility with the /4A software out in the market. However, it becomes apparent after looking at the specs that the 99/4A was just the entry mode for more grand plans.

**First Steps in a New Machine.** The 99/8 took many man-months to design and implement with some very talented people behind the project. To expect something of that magnitude from a handful of people in the /4A community would be expecting a lot; for starters, though, we CAN make a dent into the performance problems with just a little effort and some computer designed expertise. But first, some initial design criteria.

(1) The new machine should be fully compatible with the current /4A environment. This means that the ROM monitor and the GROMs will need to be transplanted into the new machine. GROMs can't be altered because of their inherent design, but the console ROM presents us with a new look at its implementation, and will be dealt with later.

(2) The new machine should be designed with state-of-the-art components with a slant towards providing increased reliability. Although this can increase the price of the unit, these costs are offset by higher reliability due to fewer components being used. Another offshoot of this is that the

amount of heat dissipated will be greatly reduced because of lower power consumption. We all know how hot the /4A consoles can get!

(3) The new machine should provide provisions for additional memory beyond 65K and provide support for a new operating system environment. With the recent price drops in memory chips coupled with 256K DRAMs becoming available it's in everyone's best interest to take advantage of more memory. RAMDISK (simulation of a disk in memory) is also a consideration to be made.

**The TMS9995 Processor.** The heart of the 99/8 was the TMS9995, a third generation microprocessor in the TMS-9900 family. Unlike its grandfather the TMS9900, the 9995 uses an 8-bit data bus versus the 16-bit data bus used by the 9900. (See Figure 1 & 2) "How can the 9995 with its 8-bit bus be faster than the 9900 with a 16-bit bus?" I hear someone ask? The TMS9995 being a third generation processor is in reality a microcoded processor which is designed to walk and talk like a TMS9900 family member. Microcoded processors are processors that understand a special dialect of machine code called microcode. This microcode determines what instructions a processor can execute and describes the sequence in which the execution takes place. In large mainframe computers and in some micros the microcode can be altered to make a computer look like a completely different machine

with a new instruction set. (See Figure 3 and Table 1) Microcode processors are often referred to as a "Micro-Engine."

Besides being microcoded, the TMS9995 takes advantage of a technique called "prefetch" which is found on most third-generation processors. Prefetch involves using the time that the processor is performing an internal operation (such as adding two numbers in the processors ALU) to perform a fetch of the next instruction that is to be executed, and then to decode the prefetched instruction internally while the processor stores the result of the previous operation. In effect this cuts down on the number of clock cycles used by the processor to execute the instruction by maximizing the microengine to do two operations at once. So, throwing all of this technobabble together gives us a processor that runs significantly faster than previously obtainable using standard implementations. In the case of

the 9995 versus the 9900 a MOV B, R1 instruction would take 14 clock cycles on

Continued on page 134

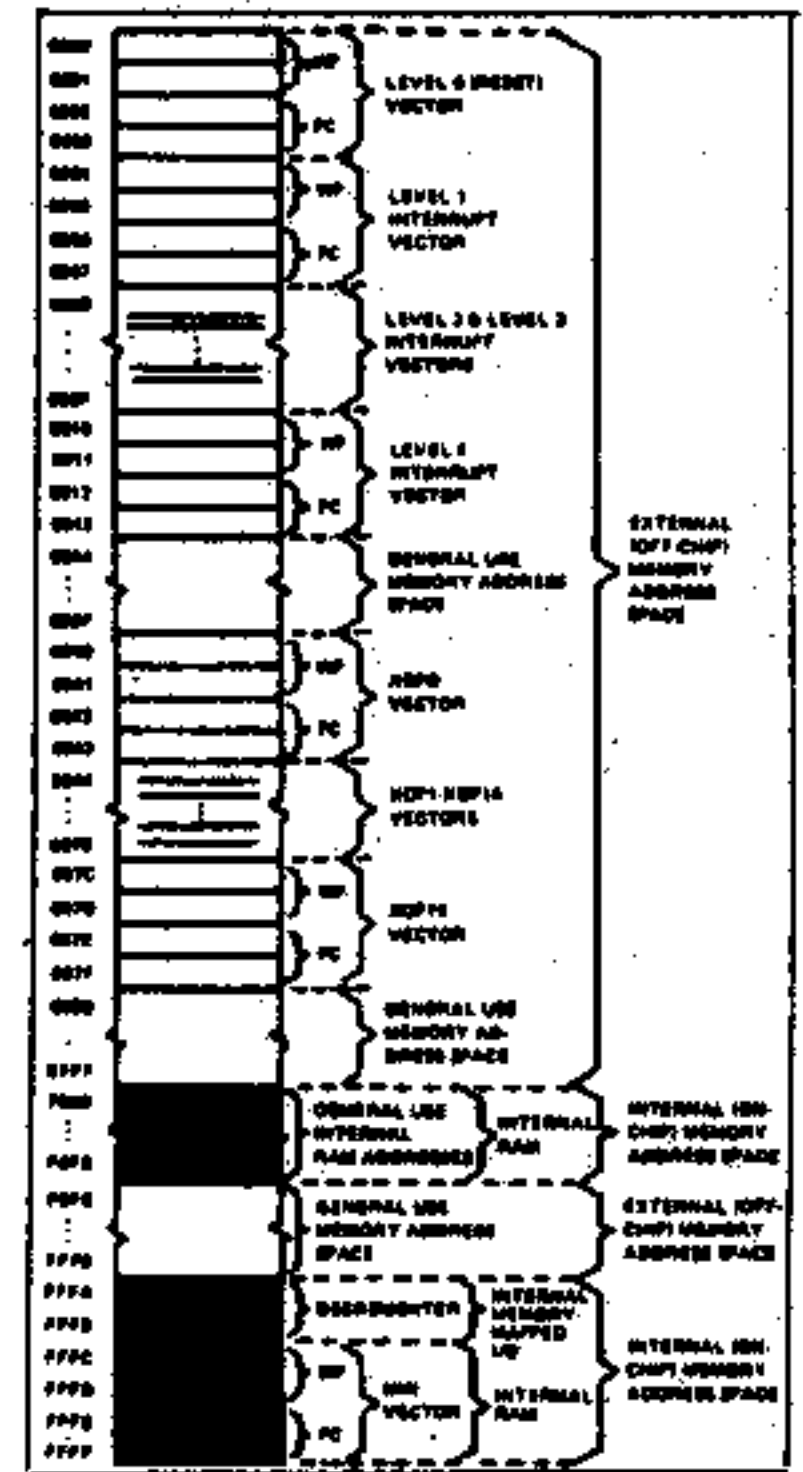


Figure 2—TMS9995 Memory Map

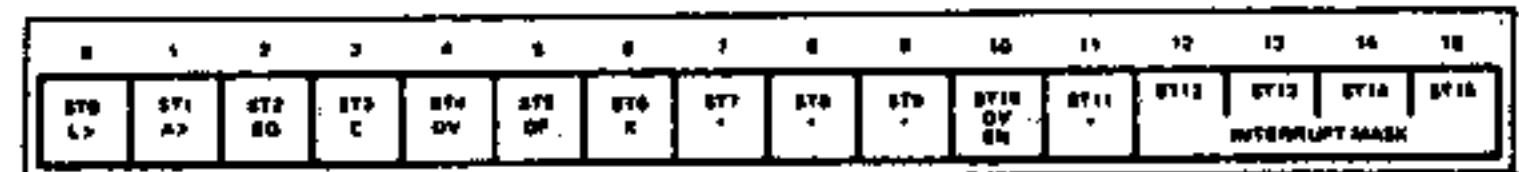


Figure 3—Status Register Bit Assignments

BIT	CRU BIT ADDRESS <sup>1</sup>	DESCRIPTION
FLAG0	1E00	Set to 0: Decrementer configured as Interval Timer. Set to 1: Decrementer configured as Event Counter.
FLAG1	1E02	Set to 0: Decrementer not enabled. Set to 1: Decrementer enabled (with decrement and can set interval latch that requires a level 3 interrupt).
FLAG2	1E04	Level 1 Internal Interrupt Request Latch CRU Input (input-only). 0: Level 1 request not present 1: Level 1 request present
FLAG3	1E06	Level 2 Internal Interrupt Request Latch CRU Input (input-only). 0: Level 2 request not present 1: Level 2 request present
FLAG4	1E08	Level 3 Internal Interrupt Request Latch CRU Input (input-only). 0: Level 3 request not present 1: Level 3 request present
FLAG5	1E0A	User Defined
FLAG6	1E0C	
FLAG7	1E0E	
FLAG8	1E10	
FLAG9	1E12	
FLAGA	1E14	
FLAGB	1E16	
FLAGC	1E18	
FLAGD	1E1A	
FLAGE	1E1C	
FLAGF	1E1E	

Table 1—Interrupt Level Data

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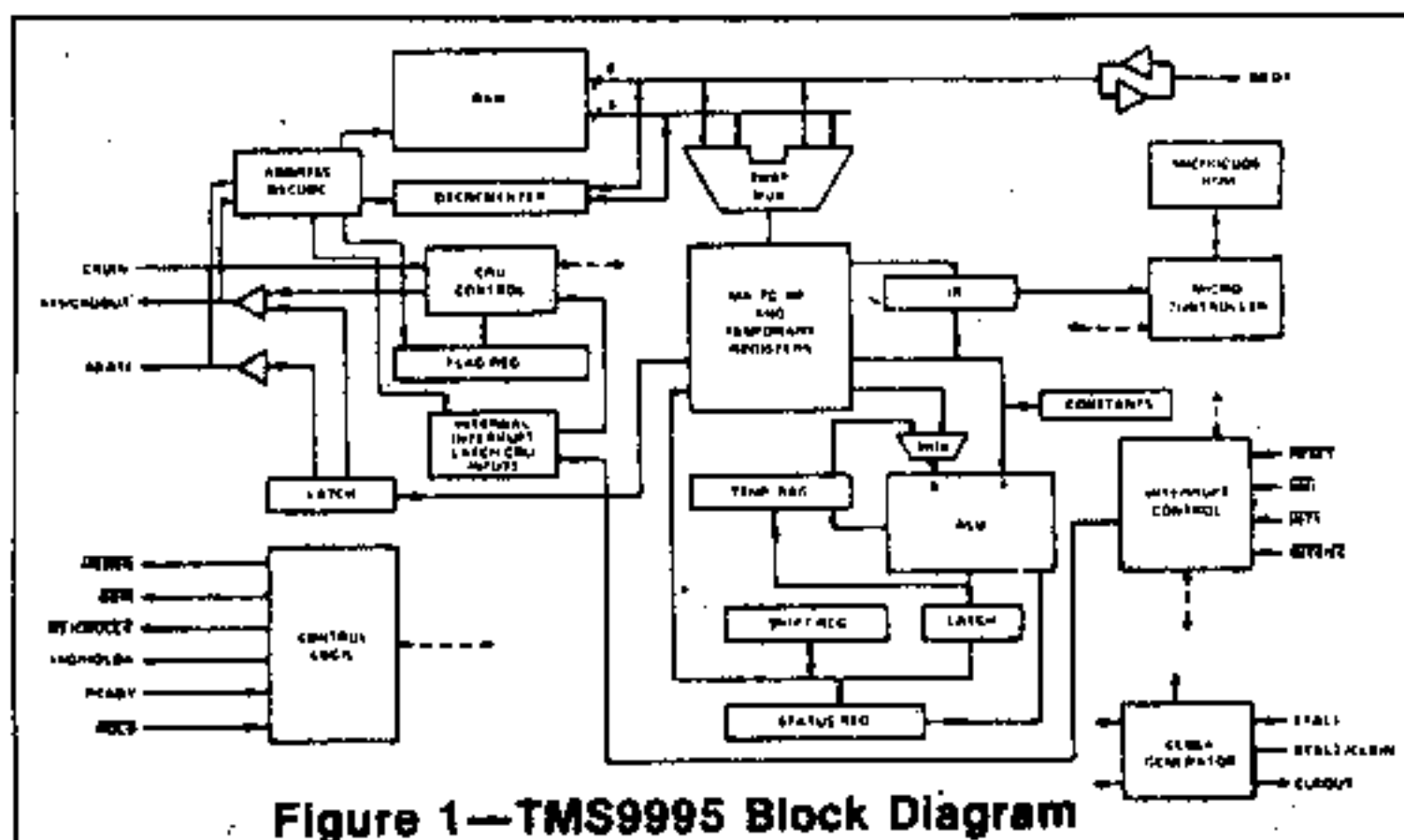


Figure 1—TMS9995 Block Diagram

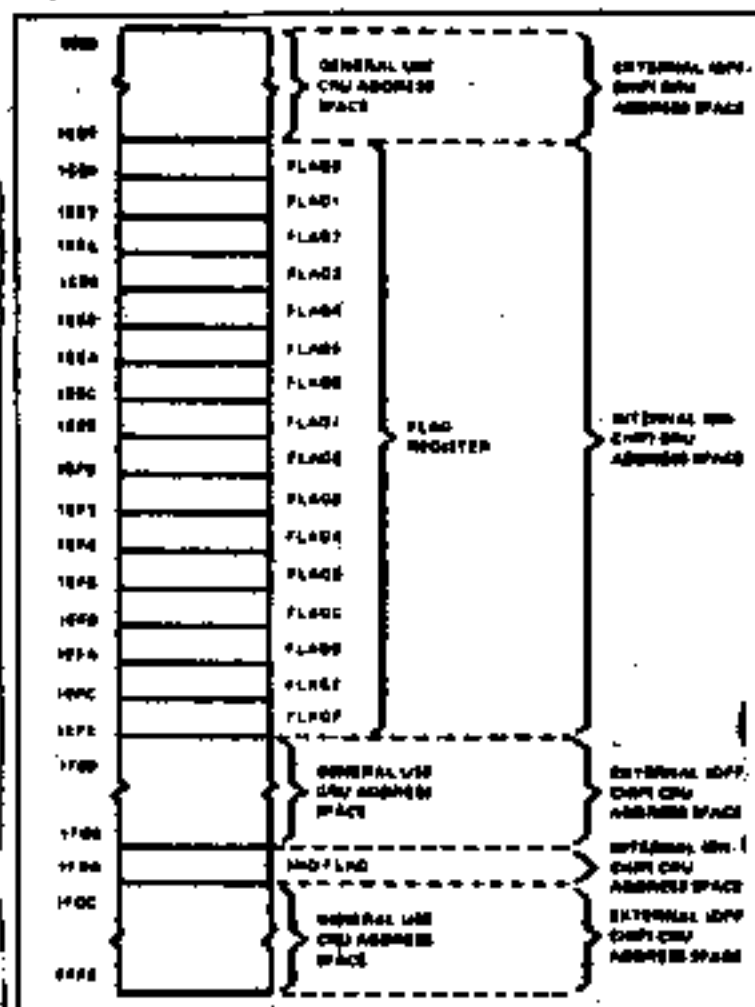
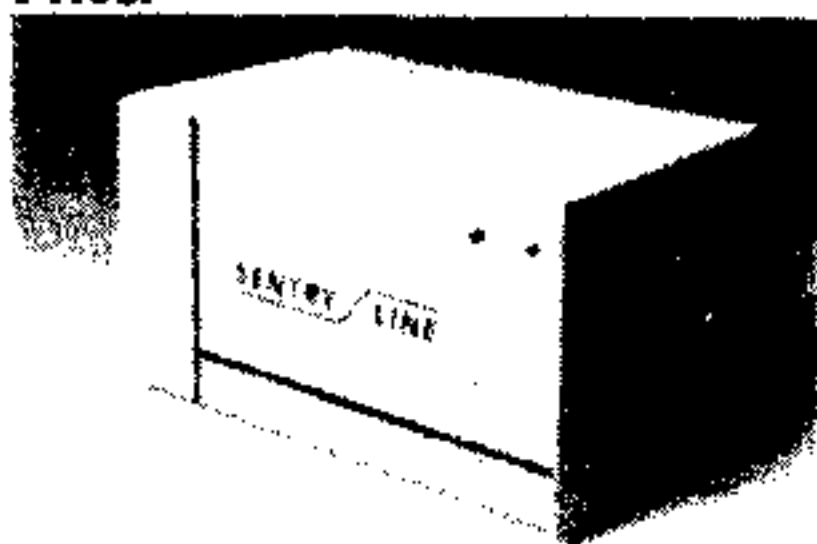


Figure 4—CRU Address Map

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the 9900 but only 4 clock cycles in a 9995. Since each clock cycle is 333 ns the 9900 takes 4.6 usec to do the MOVb, the 9995 takes only 1.2 usec.

Other 9995 Features. Increased isn't the only thing the 9995 gives us. The CRU address (See Figure 4) space has been increased from 4096 bits to 32,768 bits, allowing us to increase our available I/O space beyond >1FFF to >7FFF, but several patches will need to be applied to both ROM code and to some utility code to allow us to get at all of this new space. Two new instructions, signed multiply and signed divide, have been added

XTAL1	1	46	AT5CRUOUT
XTAL2/CLKIN	2	38	A14
CLKOUT	3	39	A12
D7	4	37	A12
D6	5	38	A11
D5	6	38	A10
D4	7	34	A8
D3	8	33	A8
D2	9	32	A7
VCC	10	31	V88
D1	11	30	A6
D0	12	29	A6
CRUIN	13	28	A4
INT/ACC	14	27	A3
RST	15	26	A2
IAQ/HOLDA	16	25	A1
DBIN	17	24	AB
MODE	18	23	READY
WE/CRUCLK	19	22	RESET
RESER	20	21	NR

Figure 5—TMS9995 Pin Assignments

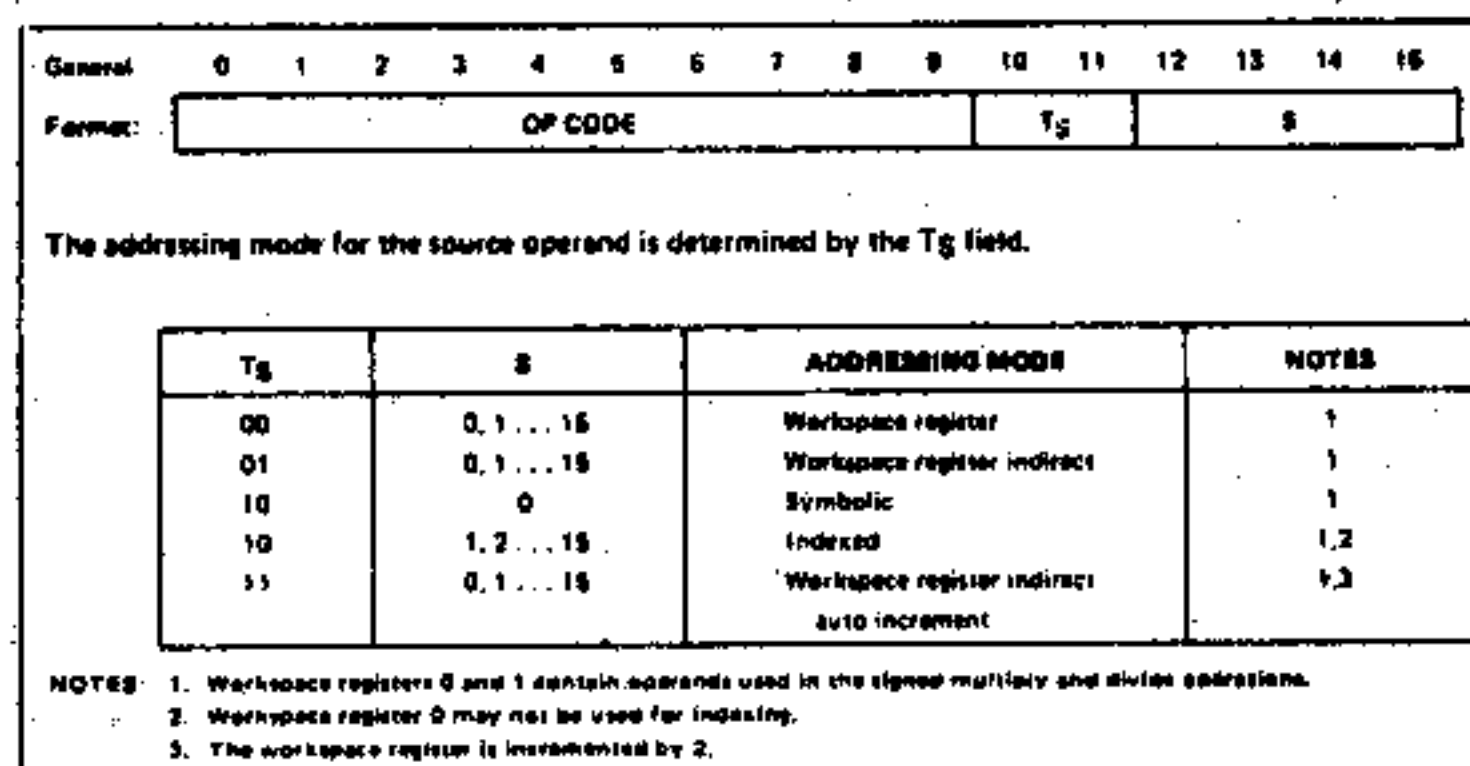
to the 9900 instruction repertoire. Other hardware additions include a built-in interval timer/event counter resid-

ing at memory location >FFFA->FFFB, trapping of illegal instructions through a

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OPERAND	OP CODE								MEANING	RESULT COMPARED TO S	STATUS BITS AFFECTED	DESCRIPTION
	0	1	2	3	4	5	6	7				
MPLY	0	0	0	0	0	0	1	1	Signed Multiply	Yes	0,2	Multiply signed two's complement integer in WRO by signed two's complement integer (SA) and place signed 32-bit product in WRO (most significant) and WRI (least significant).
DIVS	0	0	0	0	0	0	1	0	Signed Divide	Yes	0,2,4	If the quotient cannot be expressed as a signed 16-bit quantity (8000 hex) is a valid negative number, set ST4. Otherwise, divide signed two's complement integer in WRO and WRI by the signed two's complement integer (SA) and place the signed quotient in WRO and the signed remainder in WRI. The sign of the quotient is determined by algebraic rules. The sign of the remainder is the same as the sign of the dividend and REMAINDER < (DIVISOR)

Figure 6—Signed Multiply and Divide Instructions



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# Randy's Ravings

by Randy Holcomb  
Well, it's a New Year, and that means resolutions. My resolution is to try and dig up even more information to make using your 99/4A a more pleasurable experience. Now on to this month's column and its contents: More TSG Software reviews and a look at sector-copying software, plus the latest TI News.

**Other TSG Software:** In a previous column I reviewed some software from Technologies Support Group of Spencer, MA., most notably the Pro-Mod and Multi-Sort packages. Both of these packages I found useful in their own peculiar way. Sektch-it, TSG's cellular-based graphics program, isn't easy to use, compared to the bit-mapping "Draw-a-Bit" from Data Force. Let's face it - it's easy to do GOOD graphics in Basic but if you can master graphics techniques in assembler, you're far better off, especially bit-map mode. I could not honestly get excited with Sketch-It. Along similar lines, the same goes to Auto-Type, even though its direct-output mode I find quite useful. The same effect can be achieved with a quick-and-dirty Basic program, combined with the fact that TI-Writer does such a nice job and is perhaps the most popular piece of software that TI ever introduced. Even today, TI-

Writer is still readily available at a nominal price. As for all other software houses, the formula for those who want to succeed is to write something that is unique and that people want. Price it reasonably, and give good support. It's rare to find any one company that gives you all of the above.

**Sector Copiers.** In the last year, we have seen a plethora of software that makes backing up your diskettes a breeze rather than a hassle. The majority of this new-found wealth can be found in programs that backup disks by sector-copying rather than copying a disk file by file. Sector copying involves reading the diskette in its native storage mode (the sector) and writing the data back out in the exact same position on the backup. The advantages of sector copying is that the backup looks exactly like the source diskette (some of the more euphemistic terms are called cloning the disk or making a mirror-image of the disk). The other advantage is that the selection, Super-Duper takes over and prompts you for the parameters needed to perform the requisite function. Oddly enough, it will allow a value of drive zero, which will cause a program error during execution (anybody care to take a crack at WHY they allowed a drive zero as a valid

drive number? I haven't the foggiest).

Super-Duper will format the destination disk automatically if an unformatted disk is used as the copy. Super-Duper's operation is just plain and simple - nothing fancy, it just does the job. Suggested price is around \$30-35.

**Floppy-Copy.** This utility goes all out as far as utility goes: a built-in help file, a cataloger, a disk initializer, and of course backing up your diskettes. It also has a nasty protection scheme that revolves around some form of funny sectoring which caused the first release of Floppy-Copy to fail when using it with the Cor-Comp DSDD Controller (this has been fixed and it does work properly with the CorComp Card). Floppy-Copy runs thru sector copying is fast - typically a sector backup runs 3 to over 10 times faster than a file-level backup. The disadvantage with a sector backup is that if the disk has a large number of small open gaps in

its free disk area, a sector copy will not attempt to compress the disk and move all the free sectors together (a file level copy from a source disk to an empty disk will achieve the above effect).

Since the discovery of the sector I/O routines in the disk DSR, many diskette-backup programs have sprung up: "Super-Duper" from Navarone Industries; "Floppy-Copy" from the Soft-Spot, and "MassCopy," a FREEWARE-type program written by Stephen Lawless. It should be noted that all of these utility programs require an expanded

system with disk (obviously) and 32K of memory. And now, a look at each of the programs. Super-Duper. To use the software, you plug in the Super-Duper cartridge (an 8K Romox cartridge) into the GROM port of your console. You will be presented with 3 selections: TI Basic, Duplicating disks and Verifying disks. After making

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the Editor/Assembler, Mini-Memory or TI Extended Basic. After the initial load, it invokes its copy-protection check; once it's past that it proceeds to bring up a welcome screen (a pixel image of a floppy-copy building?) and then drops you into a help-screen to ask for help. If you ask for help, a sub-menu appears and asks for the sub-menu item to select from. The actual main menu consists of cataloging, initializing and backing up the diskette. It can support multiple backups (making 2 backups at the same time if you have 3 drives).

**MassCopy.** Stephen Lawless of 2514 Maple Ave., Wilmington, DE 19808 took a bold step when he released MassCopy into the FREeware world. FREeware involves the release of software by the original author (who normally holds the copyright on the work) on a concept whereby if a recipient finds the software of

value, a "donation" is made to the original author; whereby, the author places his/her name on a mailing list and sends them the latest version of the program (including documentation and updates to the documentation). In Stephen's case, his return hasn't been all that successful. In a letter I received with his latest version, he has had only .5% response since he released the original many months ago. The latest version of MassCopy acts much like Floppy-Copy except that it has no cataloging feature but can (and will) take advantage of the Foundation 128K card if installed on the system for assisting in the copying. The display that MassCopy uses is informative to say the least - it not only shows you what is going on, but takes advantage of color as well to inform you of its operating mode (reading, writing, etc.). At present, Stephen is asking a \$10 donation for anyone who finds his program useful enough that they would use it.

**Going head-to-head.** In terms of price, MassCopy wins this battle - it's free (that is, if you don't make a donation to the author) with Super-Duper being the most expensive at over \$30 (but it is in a cartridge, so it's impervious to a good magnetic pulse!). Only Super-Duper offers a verify command which reads both the source and object disks and compares the two; Floppy-Copy and MassCopy just have the standard read-after-write verify provided by the disk controller. Both MassCopy and Floppy-Copy provide help files on the disk, Super-Duper is very Spartan in this regard. Super-Duper and Floppy-Copy will not backup copy protected disks; MassCopy gives you a warning message but allows them to be backed up anyway. If you have the CorComp card, having a sector-copier utility is somewhat questionable, especially with the Turbo Option enabled. Really, you don't need one if you have the Cor-

Comp card, but if you have the TI (or Myarc, see the News below!) controller, you may want to look at any of the above utilities to make your floppy worries a little easier.

**TI News.** The Digital Systems Group scored a major coup with their new Explorer machine. Not your typical PC, this beast sports Lisp, megs of memory, and a \$50,000 price tag. It's designed for work in Artificial Intelligence. Nary a week went by when MIT (a big Artificial Intelligence research facility) placed a 200-unit order for the systems. Later on, it was learned that a number of the 200 machines were donations made by TI to MIT. Regardless, this places TI in a new area that they are going to aggressively pursue.

**Myarc,** who makes the Winchester disk system for the 99/4A, is now shipping their DSDD disk controller. Unlike the initial problems that plagued the CorComp controller, the Myarc controller works with the DM II cartridge and comes in a genuine TI clam-shell case. And speaking of CorComp, it has been learned (though unconfirmed) that they have filed for protection under Chapter 11. CorComp has stated that they are still around and will honor all orders. For those of you who have CorComp products and need repair, I'd strongly suggest that (given the current company position) you call CorComp direct and get an RA number from them when shipping a defective unit instead of going through your dealer (unless your dealer will trade even up with you on your products).

**T99 Update.** Due to a slip-up (unintentional) on my part, the character set and a few other items are missing in the listing that the Computer

Shopper is providing. To rectify this, arrangements are being made to also distribute the source code on disk; watch this space for further details. For people who subscribe to CompuServe, I have uploaded the complete source code up the CompuServe where it can be downloaded into your computer. The file is called T99.ASM and can be found in the XA2 Reference Library of the TI Forum (G PCS27 at the menu prompt). In addition, due to the many requests for information on modifying the program, a forthcoming article will go into detail on how to upgrade T99 to capture to disk/printer as well as other topics.

The following addresses refer to software companies mentioned in the above article. For those addresses not given, contact your local TI dealer for more information.

Myarc, Inc.  
241 Madisonville Road  
Basking Ridge, NJ 07920

SofSpot  
P.O. Box 8786  
Silver Spring, MD 20907-0001  
301-439-8084  
Floppy-Copy price: \$25

Navarone Industries, Inc.  
510 Lawrence Expressway  
#800  
Sunnyvale, CA 94086  
408-985-2932  
Price of Super-Duper: \$34.95

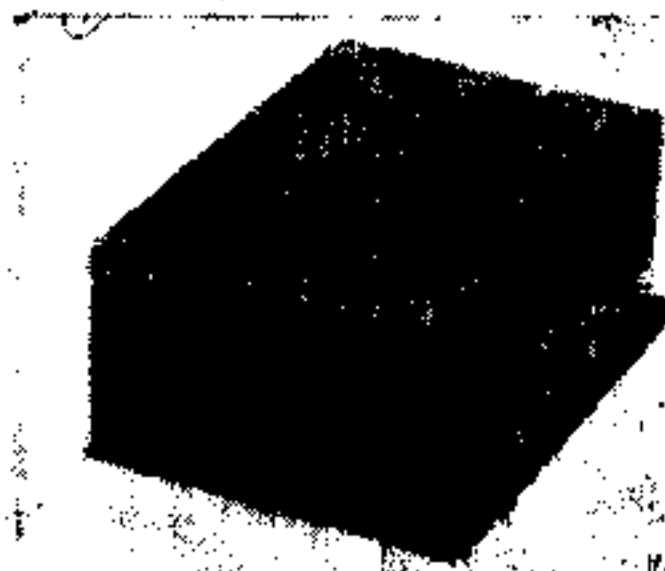
Technologies Support Group  
1225 N. Tustin Ave.  
Anaheim, CA 92807  
Price of Math II: \$34.95

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