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the cover

Meandering magnetic bubbles are an example of a decade-old technology with significant new applications. Find out more about the state of electrotechnology in this and other areas in the articles beginning on p. 24 of this special review issue.

articles

departments

TECH-NOL-OGY '78

Consumers as programmers

TV networks are upstaged by VCRs and video games; turnkey personal computers plunge in price

Video tape for the home has been vindicated! Despite a decade of rumors, promises, and abortive new product introductions, consumers are now offered two well-designed (but incompatible) video cassette systems marketed under a dozen different brand names. And all these video cassette machines are reportedly brisk sellers, commanding retail prices of around $1000 each.

Video-cassette recorders

Although the large-scale introduction of video cassettes made 1977 a special year for consumer electronics, it's not the only story of note these days. Some other recent technical accomplishments almost as impressive include: production of fully assembled personal computing systems for under $600; development of self-contained electronic games and more advanced video games; 40-channel citizens band radios that have started doing some thinking for themselves; programmable calculators outfitted with solid-state software; and TV tuners that beat stability and mistuned master antenna problems with frequency synthesis. Low-end microprocessors, of course, have had a lot to do with these developments. In fact, integrated circuit manufacturers now expect that much of their future growth will be determined by the huge and still expanding needs of the consumer electronics industry.

Everybody is a star

Television programmers—those faceless network executives whose prime mission seems to be scheduling the two best shows of the evening in congruent time slots—may soon find that their manipulations are irrelevant to the eternal quest for "high ratings," now that the widespread introduction of video cassette recorders (VCRs) has given the TV fan some new and powerful options. Viewing time no longer need adhere to broadcasting schedules. And on replay, original program content may be edited, modified, sampled sparsely, or absorbed completely—all at the VCR owner's discretion.

Beta format

VHS format

Though many consumer VCR product "brands" are now available, all those that have made significant commercial impact (to date) are based on just two different helical-scan recording systems, each using half-inch-wide video tape (Fig. 1). Unfortunately, the two approaches (Beta format and VHS format) are not compatible. Both systems are the fruit of Japanese engineering talent and are now being widely exported.

The first of these new VCR systems to be made commercially available in the U.S. was Sony's Betamax SL-7200, which has been on the market for over a year (see "More fun for the consumer," Jan. 1977, p 66). This machine can record up to one hour of video material on a single cassette. Next came Sony's two-speed SL-8200 that has both a one-hour and two-hour recording capability, yet maintains complete interchangeability with earlier Beta-format (single-speed) VCRs. Sony has also demonstrated thinner video tapes that allow up to three hours' recording on an SL-8200, and 1½ hours on an SL-7200. However, availability of the long-play tape is not firm, described only as "next spring [1978] at a yet-to-be-determined price."

Since June 1977, Sony, Toshiba, Zenith, and all other manufacturers/distributors of Beta-format machines in the U.S. have been officially on notice about their first serious competition: the Video Home System (VHS) format implemented in VCRs from GTE Sylvania, Hitachi, JVC Industries, Panasonic, Magnavox, and RCA. Last June was the month when JVC Industries, inventors of the VHS format, announced its two-hour Vidstar VHS system at a list price of $1280. Compact and energy-efficient, Vidstar consumes only 28 watts, and incorporates five technological advances that its developers describe as particularly significant. (They are also indicative of the performance problems all VCR designs have had to overcome before being introduced commercially.)

- *Double limiter frequency modulation.* This modulation is obtained with a patented, Dolby-like circuit that surpresses noise in the black-and-white (luminance) part of the video signal during playback.
- *Burst level up.* Noise in the color (chrominance) video signal is suppressed with special circuits that double the burst level when recording and then cut it 50 percent during playback. (The color burst signal is a 3.58-MHz pulse that puts color information into proper phase before each horizontal line of the picture is scanned.)
- *Phase shift color.* Because guard bands were removed so the maximum tape surface could be available for video recording, crosstalk became a problem at low video frequencies (color information). JVC has employed a phase shifter as part of a signal-canceling scheme that effectively eliminates such crosstalk interference.
- *"M" loading.* This space-saving parallel loading technique for tape was first used in audio cassettes, and now has been adapted to video cassettes.
- *Small video head.* Contributing to Vidstar's compact design is its 62-mm-diameter video head drum. Picture quality is directly related to drum diameter as well as tape speed, so a "systems approach" involving all the noise-reduction and phase-correction techniques mentioned thus far was employed on behalf of the small head.

Lingering VCR performance problems had most definitely been recognized and solved by early 1977, but the questions of price and availability were still to be tackled head-on. An important move on these fronts was made last August by the RCA Corporation when it launched a major campaign to make consumers abundantly aware of

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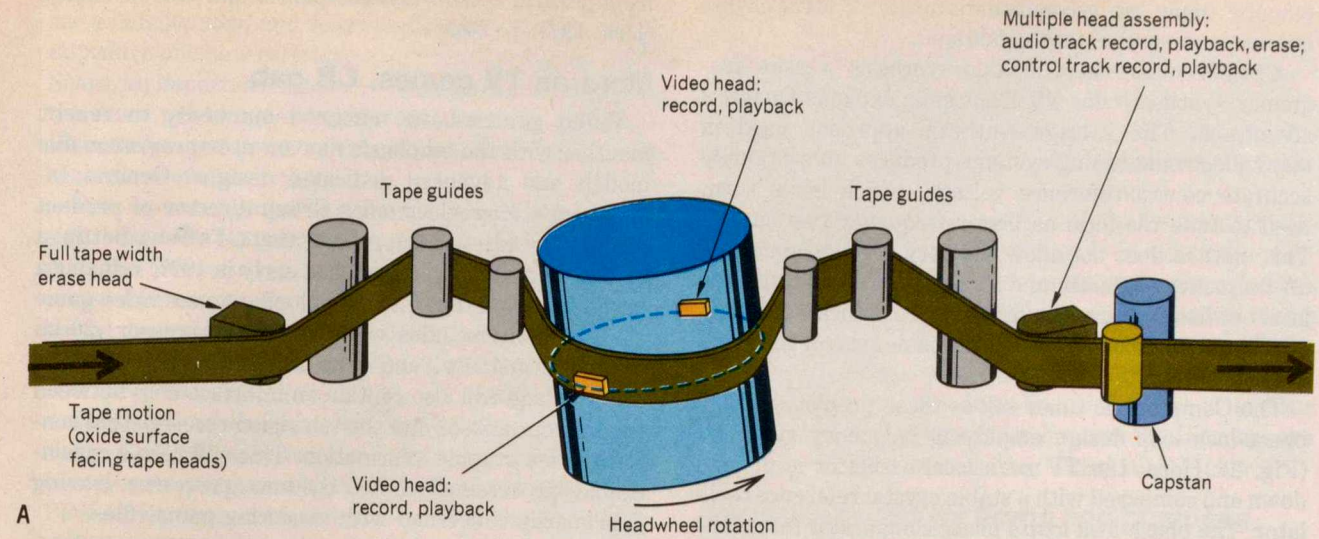
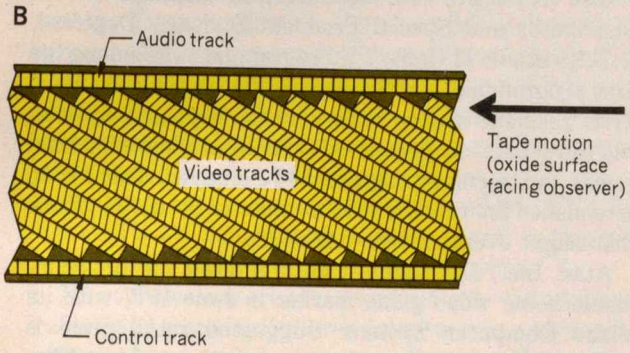




[1] Helical-scan VHS-format VCR recording uses two video heads rotating at 30 r/s on a skewed headwheel (A). Each resulting diagonal track of video information (B) comprises one TV picture (60 pictures/second required). Headwheel rotation increases the relative speed between the video heads and the tape so high video frequencies can be recorded with moderate horizontal tape motion. A separate audio erase head in the multiple-head assembly allows addition of new or supplementary sound information.

the VCR. Entering the market with SelectaVision, a four-hour version of the VHS format priced at $1000, RCA executives predicted VCRs would blossom into a billion-dollar industry within three years. SelectaVision is produced in Japan for RCA by Matsushita. (A similar unit bearing Matsushita's Panasonic brand is also available in the U.S.) Two optional black-and-white television cameras, again of Japanese manufacture, allow SelectaVision owners to make original TV programs at home. SelectaVision's biggest surprise was its price tag—initially about $300 less than other comparable products. But so far the effect has been muted by a seller's market for all consumer VCR equipment. Dealers with whom *Spectrum* talked reported selling every VCR they could get delivery on, with price less a factor than availability.

It should be noted that the four-hour record/playback capability of RCA and Panasonic VCRs is obtained with some small sacrifice of picture quality, which is perceived as slightly more "snow" in the video image, though the overall appearance remains acceptable. However, RCA spokesmen explain that when using the low-speed (four-hour) mode, tapes should be made and played back on the *same* machine for optimum video quality. Exchanging video tapes with friends who also own VHS-format machines is best suited to high-speed (two-hour-mode)recordings.

Apparently, moisture condensing out of the air on critical VCR components such as the video head can also cause problems. Most VCRs come with a small "dew light" that, when activated, indicates excessive moisture is present. Interlocks prevent VCR operation under these conditions. Just what the operator is supposed to do next isn't clearly indicated. But JVC has solved the problem with a built-in thermal heating system for its Vidstar VHS that automatically keeps critical heads and tape surfaces free of excess moisture.

And what of video disks? Their chances for commercial success dim with every VCR that's sold. RCA spokesmen, questioned about the status of their own capacitive-pickup video disk project, say only that the disk remains a "complementary [to tape] technology not yet ready for commercialization."

Four-hour recording

Offset no upset to new tuner

With or without a VCR, TV viewers require a dependable, drift-free tuner to pull in the programs they want. Electronically controlled varactors that change channels without mechanical switching have helped tremendously in this respect. Now, the residual problems of aging, thermal drift, and obtaining clear reception from mistuned master antenna systems are being met with a "frequency synthesis" tuner design that employs microcircuits and a crystal-controlled reference oscillator. Quasar, with its Compumatic tuner in its top-of-the line color sets, has been a leader in this area.

Frequency-synthesis tuner

The key elements of the Compumatic tuner are a crystal reference oscillator, a phase-lock loop IC containing programmable dividers and a comparator, and a microprocessor control circuit. The microprocessor accepts, then implements, keyed-in channel-selection commands and manual fine-tuning adjustments. The chip also continuously monitors picture carrier detector output, sound carrier detector output, vertical sync, a "threshold" signal provided by the TV set's automatic gain control, and a tuning accuracy "window" derived from the set's discriminator circuit. Tuning corrections based on these five inputs are fully automatic.

Mistuned master antenna

This ability to track wayward RF signals is particularly important when TV sets must operate off casually maintained cable or master antenna systems. The RF supplied from such "services" is not always held to the close frequency tolerances associated with commercial broadcasting (Government regulations). Quasar's Com-

pumatic tuner can accommodate up to ±2 MHz of frequency error under such conditions.

A brief comparison of "voltage synthesis" versus "frequency synthesis" for TV front ends explains Quasar's advantage. The voltage-synthesis approach used in many electronic tuning systems produces an extremely accurate control/reference voltage, which is, in turn, used to tune the local oscillator frequency (varactors). This method does not allow the easy accommodation of off-frequency channels, and thermal drifts can cause the local oscillator to produce different frequencies at different times even though exactly the same control voltage is applied.

Video-game chip set

The Compumatic tuner solves these problems with a phase-lock loop design employing frequency synthesis (Fig. 2). Here, the TV set's local oscillator is divided down and compared with a stable crystal reference oscillator. The phase-lock loop's phase comparator forces the counted-down signal to be exactly the same frequency as the reference signal. Channels are selected by changing the countdown ratio in the frequency divider between the local oscillator and the phase comparator. Since the phase-lock loop forces both phase comparator inputs to be the same frequency, each change in the countdown ratio produces a different local oscillator frequency.

Phase-lock-loop design

The Compumatic tuner is but one example of a trend much more significant than improved TV reception: the proliferation of consumer electronics designed with or around microcircuits. *Spectrum* has already reported extensively on several developments in theis area: General Electric's AM/FM radio chip (Mar. 77, p. 54), automotive electronics for ignition and pollution control (Nov. 1977, pp. 34, 37), and electronic game products from several established companies and entrepreneurs (Dec. 1977, p. 20).

Cartridge games

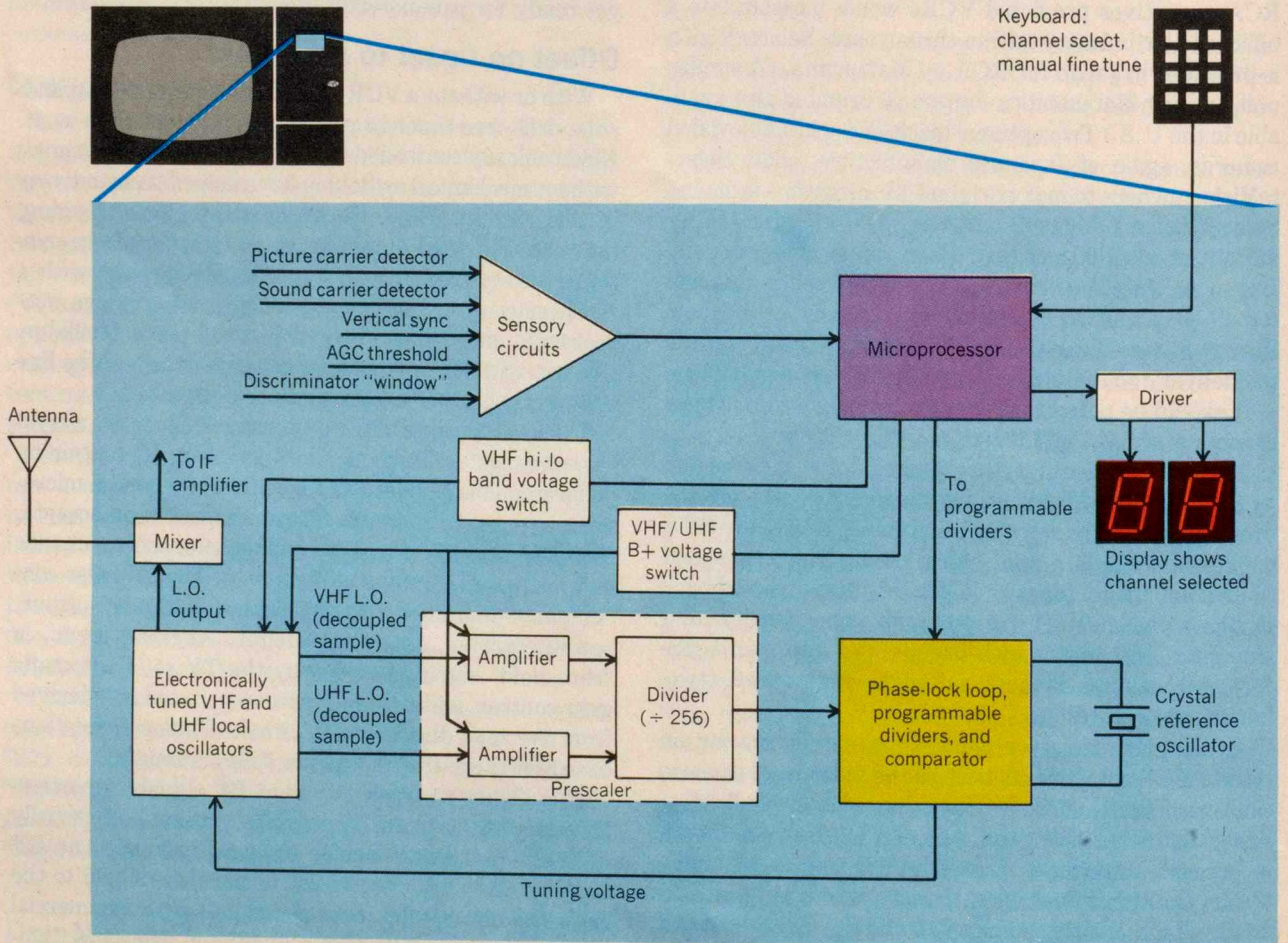
More on TV games, CB gab

Video games have matured markedly in recent months, with the emphasis now on user-programmable models and advanced dedicated designs. General Instrument's Microelectronics Group director of product planning, Andrew Sass, reports that GI's Tank Battle, a dedicated game chip introduced early in 1977, remains a best seller, and that GI is developing a new video game chip set that includes a 16-bit microprocessor, 20-kb read-only memory, and 8-kb random-access memory. The package will also contain an interface chip between the microprocessor and the television receiver that contains video graphic information. This will take a considerable "processing" load off the microprocessor, leaving it primarily concerned with executing game rules.

Also very active with video game development is RCA Distributor and Special Products Division, Deptford, N.J. Its Studio II Home TV Programmer was among the first programmable video games offered the consumer. Five "resident" games come with the keyboard console, and ten separately purchased cartridges allow additional games and learning programs to be enjoyed. There is no established limit on the total number of Studio II games that might eventually be developed.

Atari Inc., Los Gatos, Calif., entered the programmable home video game market in June 1977 with its Video Computer System. Suggested retail price is $199.95 for the console and one "combat" cartridge. Nine

[2] Solid-state "frequency synthesis" design automatically corrects for most carrier-frequency errors.



different cartridges containing from 14 to 50 games each are available now, and Atari is planning to develop and introduce one new cartridge every month through 1978. Sears, an important retailer of video games, also handles the Atari product (relabeled Video Arcade). However, all consoles and game cartridges are fully compatible, regardless of distributor.

Coin-operated pinball is also undergoing a major redesign based on the microprocessor. Gottlieb, a leading manufacturer of electromechanical pinball games, has joined forces with Rockwell International in a concentrated design/development effort to update pinball with microcircuits. The fruit of this effort is the PPS-4/2 microprocessor system.

Consisting of six chips (central processing unit and clock, 4-kb read-only memory, random-access memory, two general-purpose I/Os, and keyboard display), the PPS-4/2 system replaces the latches, coils, relays, point-to-point wiring, etc., of electromechanical pinball, yet the flippers, flashing lights, noises, and speeding silver ball of yesteryear are retained in all their glory. Contact point burnout has been virtually eliminated because only a few milliamperes are transmitted through mechanical contacts as input to power transistors that drive the solenoids. And for a family of pinball games, each game having a different playing field, the same basic PPS-4/2 control module can be used everywhere with specific game features held in PROMs.

Microprocessors are also responsible for the advanced calling and scanning features found on some 40-channel citizens band radio equipment introduced recently. David Morris, an engineer with SBE, Watsonville, Calif., explains that his company's KEY/COM 1000 radio uses microcircuits to produce three useful options:

- *Normal scanning.* The radio automatically hops from channel to channel looking for a signal strong enough to open the squelch circuit. Scanning continues only after transmissions cease on a "found" busy channel. A reciprocal of this feature, called "scan for open channel," is being developed for future SBE radios. Here, the scanning feature ignores all occupied bands and finds the CB operator a clear channel for broadcasting.
- *Memory scan.* Up to ten preselected channels can be repetitively scanned (all other channels ignored).
- *Priority channel.* The microprocessor continuously monitors the status on one preselected "priority" channel while the CB operator listens or converses on some other channel. However, should a signal appear on the priority channel, this activity is brought to the operator's attention automatically. Any other monitoring or transmitting activities are interrupted.

Mr. Morris also mentioned that microprocessors can help control certain analog functions for an all-around improvement in CB radio performance. As an example, consider the performance of automatic-gain-control circuits (AGC). Both AM and single-sideband (SSB) operation require fast attack, but SSB needs slower decay to account for the brief intervals between spoken words when no RF "signal" is present (with AM, the carrier keeps the squelch open and the IF gain fixed regardless of modulation pauses). Microprocessors can be programmed to handle these subtleties nicely.

A new base station CB radio with a custom chip for displaying time or transmitted and received frequency digitally is expected from Dynascan, Chicago, Ill., sometime this month. Dynascan's vice president of engineering, Richard Goldstein, believes that microprocessors are not always the most cost-effective route to better CB equipment. He says that nearly the same performance can sometimes be obtained from lower-cost analog techniques; however, the microprocessor's unquestioned capability has served as a stimulus for developing these alternative approaches.

Tariffs and quotas

Mr. Goldstein is also outspoken on the controversy over imports now stirring among U.S. CB radio manufacturers who want tariff or quota protection. He feels that such demands are not valid because imported radios started the U.S. CB boom, and have always held the lion's share of the market. However, Mr. Goldstein does acknowledge the fact that the U.S. faces a serious economic challenge from Japan because the Japanese are extremely skilled in exploiting Third World labor.

Six-chip pinball

Turnkey micros for home and business

But there is a most important new consumer electronics device that (so far) is primarily a U.S. phenomenon, both in application and manufacture. It's the personal and/or "hobby" microcomputer. This product concept started life as a kit maker's brainchild just a few years ago, and now promises to become as much a part of everyday life as the telephone. (See "Everybody's doing it, 'computing' at home," May 1977, p. 29.)

Personal computers

An important step toward making personal computing accessible to everyone has been taken by three manufacturers: Commodore Business Machines, the Heath Company, and Radio Shack. All now market relatively low-cost microcomputers (some kits, some assembled) that converse in Basic, a high-level computer language most novice programmers can learn easily.

CB scanning

Radio Shack announced its completely wired and tested TRS-80 microcomputer system in August 1977. Priced at $599.95, the TRS-80 system includes a 53-key keyboard and Z-80 microprocessor plus regulated power supply, a cassette recorder for program storage, and a video display monitor. A free blackjack/backgammon cassette comes with the system package so its video game capabilities can be demonstrated immediately.

In addition, the TRS-80 is being heavily promoted for small business applications (payroll, accounts receivable, inventory control), but anyone interested in performing these tasks with the TRS-80 should be aware that $599.95 buys just 4 kb of read-only memory (ROM) and 4 kb of dynamic read/write memory (RAM). More memory is available at additional cost, and Radio Shack's microcomputer is internally expandable to 12-kb ROM and 16-kb RAM. However, the system's total memory capability of 62 kb requires external connections.

Software for the TRS-80 consists of an owner's manual and Radio Shack Level I Basic in ROM. Level I Basic includes: standard Basic statements; floating-point arithmetic; numeric, array, and string variables; video graphics commands; and cassette save/load commands. Peripherals are also being developed for the TRS-80. Radio Shack expects to begin marketing a disk drive and a printer early this year.

New computer kits

In June 1977, the Heath Company unveiled two personal computer kits—the H8 and H11. Built around the 8-bit 8080A microprocessor, the H8 features an intelligent front panel with a nine-digit, seven-segment octal display and keyboard. A 1-kb bootstrap monitor controls all front-panel load-dump operations. Up to 32 kb of memory can be plugged into an exclusive Heath-

designed 50-pin bus (*not* compatible with the S-100 bus introduced by MITS). Heath claims its bus is fully buffered to eliminate noise and crosstalk, and is essentially "glitch" free. The H8 mainframe, including all system software (Benton Harbor Basic) on an audio cassette, costs $375. However, an optional memory, cassette interface, cassette recorder/player, and video display/keyboard can bring the total system price to $1240.

FCC decision due

Heath's H11 represents a joint development effort between Heath and the Digital Equipment Corporation (DEC). It utilizes DEC's LSI-11 microcomputer module that features the well-known PDP-11 instruction set. In fact, H11 purchasers are required to sign a special "HEATH/DEC software license agreement," a nontransferable and nonexclusive sublicense to use DEC's software.

Fully wired CPU

Other main features of the H11 include a fully wired and tested 16-bit central processing unit with 4-kb dynamic RAM (expandable to 20 kb), built-in backplane, power supply, and flexible I/O interface accessories. However, a minimum of 8 kb of memory is required to run the software so H11 buyers will have to spend more than the $1295 "bare bones" kit price to get their computer on line. System packages that include extra memory, parallel and serial interfacing, keyboard with video terminal, and a paper-tape reader/punch start at $2508.

PET coming soon

Another important contender in the low-priced personal computer market is the Personal Electronic Transactor (PET) computer from Commodore Business Machines. Wide availability of this fully assembled microcomputer product has been expected for several months, but as of December 1977 only a few hundred units had been delivered. However, PET has made appearances at many recent computing shows, and has been the subject of several feature articles in the home computing trade press. Repeated calls to Commodore revealed that PET is heavily back-ordered, and the company is purposely maintaining a low profile (no advertising, promotional literature, press kits, etc.) until production can catch up with the demand already generated.

PCM for consumer hi-fi

There are actually two PET systems, the PET 8k ($795) and the PET 4k ($595). As the names imply, random-access-memory capacity is the main difference between the two computers. The PET 8k price includes a 6502 microprocessor, 73-key keyboard, video display (CRT), 16-kb read-only memory, 8-kb random-access memory, tape cassette, memory-expansion bus, a connector for a second cassette, IEEE 488 peripheral interface, and 8 kb of Basic software.

Solid-state software

Other important developments in the low-priced personal-computing arena involve calculators. Most hand-held scientific programmables can be addressed only by keystroke or magnetic card, but now a new option is available from Texas Instruments—solid-state software. The TI Programmable 58 and TI Programmable 59 calculators use plug-in modules containing up to 5000 program steps each. The equivalent of a 25-card library can be contained in one such module. TI has modules for surveying, aviation, statistics, real estate/investment, navigation, and a master library "tool kit."

Setting format standards

Calculators are priced from $125 to $300, with solid-state software modules retailing at $35 each.

Hewlett-Packard's first pocket-sized programmable calculator with a built-in thermal printer for hard-copy readout was introduced recently at $345. The new HP-19C calculator has three operating modes: MANUAL provides printout only when the 'Print X' key or list function is operated; NORMAL records all entered data and functions; TRACE prints each step of an executing function and the results of any manual calculation. Another H-P calculator, the HP-10, also features thermal printing, but it is not programmable.

AM stereo, PCM recording

Two important developments that could affect the entertainment electronics market very soon are AM stereo for commercial broadcasting and pulse-code-modulation (PCM) recording for audiophile sound systems.

The question of AM stereo has been tossed around between broadcast industry advocates and the Federal Communications Commission (FCC) for decades, but now a favorable decision seems likely—mainly because AM broadcasters have lost much of their audience to stereo FM during recent years, particularly among automobile listeners. Since FM has line-of-sight reception limitations and multipath problems for this mobile audience, AM broadcasters feel stereo would give them an important advantage. And many existing AM transmitters could be modified for stereo with just the substitution of a stereo exciter for the present monaural exciter. To help the FCC make a selection, the National AM Stereophonic Radio Committee has prepared a nonpartisan report describing three candidate AM stereo systems and summarizing field test data on each. The Commission was given the final draft of this report in December 1977. Data on two other AM stereo systems are also before the FCC under separate covers.

Audio buffs who hunger for the ultimate weapon against distortion, background noise (hiss), and limited dynamic range should welcome the arrival of PCM in consumer hi-fi equipment. PCM is already employed in Great Britain for making digital master recordings, and several Japanese companies have demonstrated samples of home PCM disk and tape systems, according to Dempa Publications' *Journal of the Electronics Industry*. Video cassettes have been adapted to PCM audio recording by Sony and Mitsubishi Electric. And experimental PCM audio disk players have been developed by Sony, Mitsubishi, Teac, Tokyo Denka, Hitachi, and Nippon Columbia.

These PCM audio disk players are reminiscent of the optical video disk players publicly demonstrated by MCA/Philips and Zenith about three years ago. Sound is digitally recorded at 1800 r/min and recovered by reflecting a low-power laser beam off the disk's shiny, microscopically, pitted surface. Focus, tracking, and radial feed servos keep the laser beam positioned correctly. A special PCM amplifier regenerates analog audio from the recovered digital bit stream.

Claims for PCM audio disk performance are impressive. Sony is said to have achieved 85-dB dynamic range, and 0.03-percent harmonic distortion. However, no rush is anticipated in getting PCM audio players into production because standardization between competing systems is still a serious problem. Almon Clegg, manager of audio engineering for Panasonic in Secaucus, N.J., reports that the U.S. Audio Engineering Society and several manufacturers in Japan are presently working on sampling rate and coding format standards for PCM studio recording equipment. Decisions made here will essentially dictate that consumer PCM units adopt a similar, compatible operating mode. ◆