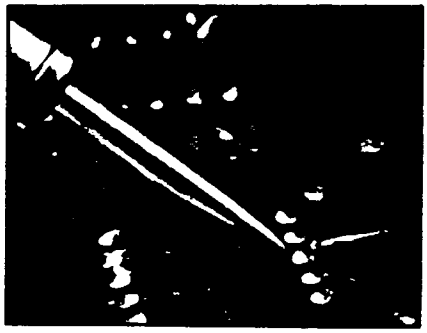
ACTS sets computer time and much more



By Donald Sullivan

On March 9, 1988, the National Institute of Standards and Technology (NIST), formerly the National Bureau of Standards, initiated the Automated Computer Time Service (ACTS). It is a telephone time service designed to provide computers with telephone access to NIST time at accuracies approaching one 1ms (0.001s). Features include automated compensation for telephone-line delay, advanced alert for changes to and from daylight-saving time and advanced notice of insertion of leap seconds. The ASCII-character time code operates with most standard modems and computer systems. Although the system can be used to set computer clocks, simple hardware also can be developed to set non-computer clock systems. The service can be accessed by calling 303-494-4774.

Computer-access procedure

With the correct user software, NIST-ACTS provides three modes for checking and/or setting computer time-of-day clocks. In the simplest form of the 1,200-baud service, the user receives the time code and an on-time marker/character. The marker/character is advanced a fixed period to approximately account for modem and telephone-line delays. Accuracy in this mode should be no worse than 0.1s, unless the connection is routed through a satellite.

If the user's 1,200-baud system echoes all characters back to NIST, the round-trip line delay will be measured and the on-time marker advanced to compensate for that delay. The accuracy in this mode should be better than 10ms. Our experience so far indicates that the asymmetry in conventional 1,200-baud modems limits the accuracy at this level. Repeatability is about 1ms.

Access at 300 baud provides the same service, but there generally is less problem with modem asymmetry. The accuracy is approximately 1ms.

Predicted accuracy is based upon the assumption that the telephone connection is reciprocal, that is, both directions of communication follow the same path with the same delay. Discussions with telephone carriers indicate that this is the general mode of operation and our tests support that position.

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Displayed time

Table 1 shows what your computer screen will display upon accessing the NIST time service. The current time is valid at the *on-time marker* (OTM), with either an (*) or a (#). The on-time marker (*) will be transmitted 45ms early to account for the 8ms required to send one character at 1,200 baud, plus an additional 7ms for delay from NIST to the user, and approximately 30ms *scrambler* delay inherent in 1,200-baud modems.

If the caller echoes all characters, NIST will measure the round-trip delay and advance the on-time marker so that the midpoint of the stop bit arrives at the user on time. The amount of MSADV will reflect the actual required advance in milliseconds and the OTM will be a (#). The NIST system requires four consecutive and consistent delay measurements before switching from (*) to (#).

? = HELP
National Institute of Standards and Technology
Telephone Time Service

(1 second pause here)

								D				L	D
MJD	YR	MO	DA	H	M	S	ST	S	UT1	MSADV	OTM		
47222	88	03	02	21	39	15	83	0	+.3	045.0	UTC(NIST)	*	
47222	88	03	02	21	39	16	83	0	+.3	045.0	UTC(NIST)	*	
47222	88	03	02	21	39	17	83	0	+.3	045.0	UTC(NIST)	*	
47222	88	03	02	21	39	18	83	0	+.3	045.0	UTC(NIST)	*	
47222	88	03	02	21	39	19	83	0	+.3	037.6	UTC(NIST)	#	
47222	88	03	02	21	39	20	83	0	+.3	037.6	UTC(NIST)	#	

etc..etc...etc .....

Table 1. Typical screen display of connection sequence and time when accessing the ACTS system at 1,200 baud.

Highly accurate

If the user has a 1,200-baud modem with the same internal delay as that used by NIST, then the (#) OTM should arrive at the user within ±2ms of the correct time. However, NIST has studied different brands of 1,200-baud modems and found internal delays from 24ms to 40ms and offsets of the (#) OTM of ±10ms.

Because many computer internal clocks can be set only with granularity of 20ms to 50ms, the ±10ms accuracy should be more than adequate. In any case, the repeatability of the offset for the (#) OTM should be within ±2ms, if the dial-up path is reciprocal and the user doesn't change the brand or model of modem used.

This should be true even if the dial-up path on one day is a land line of less than 40ms (one way) and on the next day is a satellite link of 260ms to 300ms. In the rare event that the path is one way by satellite and the other way by land line with a round-trip measurement in the range of 90ms to 260ms, the OTM will remain an (*), indicating 45ms advance. In other words, the NIST system is designed to reject a delay that probably arises from a connection involving satellite transmission in one direction and land line in the other.

If you want the best possible accuracy

at the OTM, NIST offers an alternate 300-baud service with only HH:MM:SS MSADV and OTM. To use the alternate service, simply call at 300 baud. Because of the simple FSK modulation scheme used at 300 baud, all modems tested had the same delay within about 1ms.

Other applications

Although primarily intended for setting time in computers, NIST-ACTS can be used with other circuits for a variety of purposes. For example, it is capable of providing frequency comparisons at parts in 10^9 for one day. Frequency comparisons make use of the interactive echo mode in which NIST adjusts OTM to a repeatability of about 1ms. If you have a high-quality oscillator signal divided to 1pps, then this signal can be compared with the OTM with a digital counter on a daily basis. Because there are 86,400s in a day (approximate-

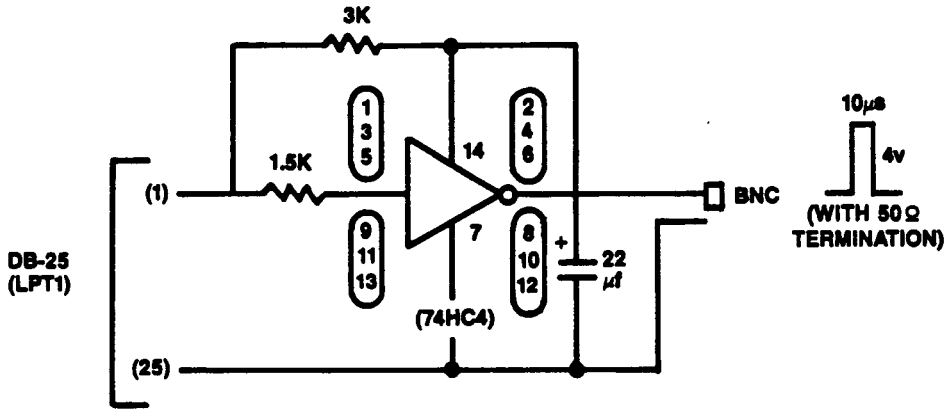

Figure 1. A small inverter can be mounted in a DP-25 plug. By using the correct software, you easily can obtain a 10s pulse at one pulse per second (pps).

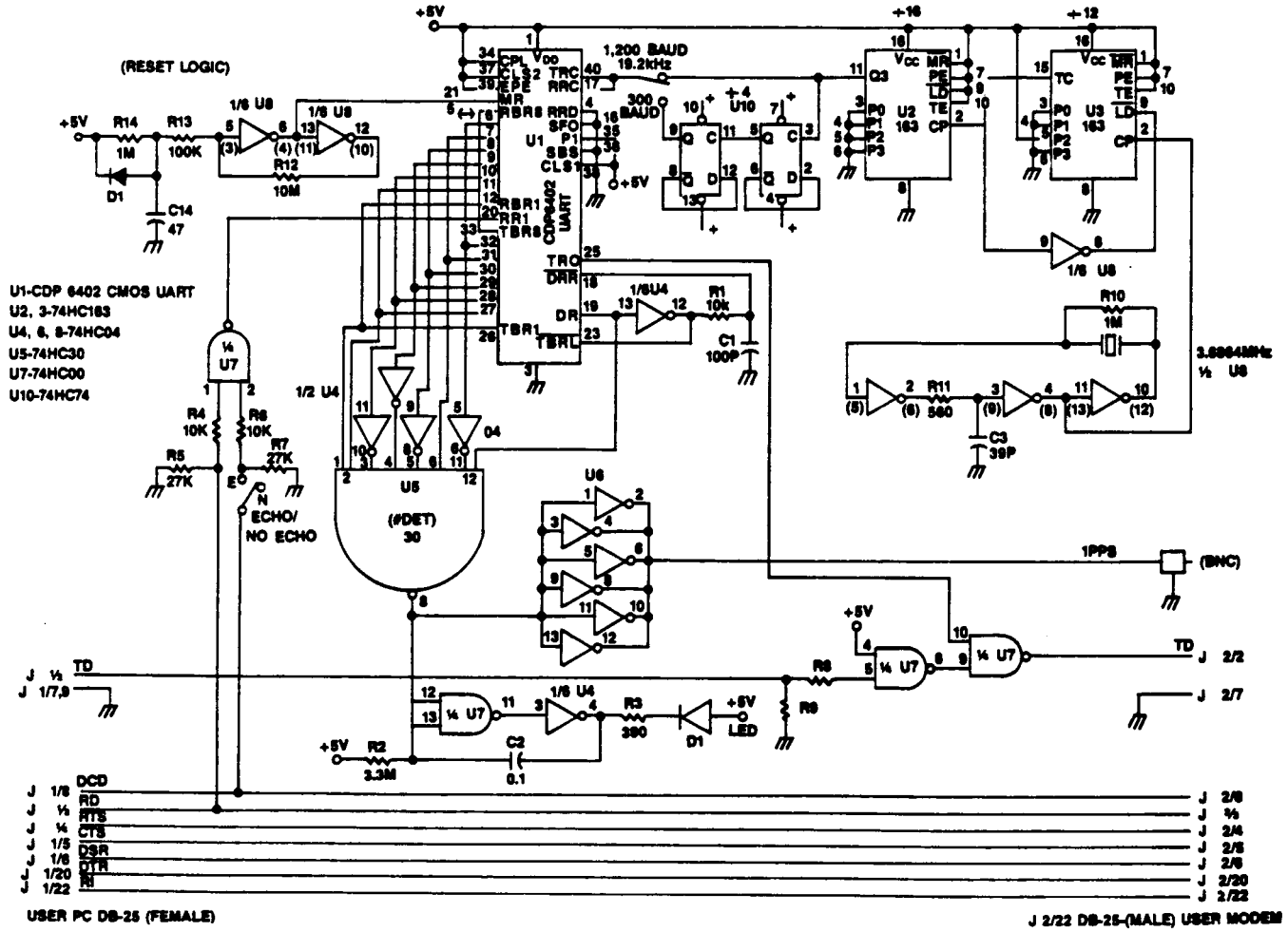

Figure 2. This circuit bridges across the PC-to-modem cable. An output pulse is produced when the (*) OTM is received.

ly 10^{5}s) and the comparison is typically good to 1ms (10^{-3}s), this will provide a frequency calibration with uncertainty of about one part in 10^{8} for one day.

Figure 1 shows a circuit that provides a positive pulse coincident with reception of the corrected OTM. The circuit is designed to be used in conjunction with the program NISTTIME.EXE. The device uses an HCMOS inverter that can be built into a DB-25 male connector. The connector is then plugged into LPT1 on a PC-compatible machine. A BNC connector provides access to the 10s output pulse.

The circuit shown in Figure 2 is designed to interface with an RS-232 serial port and general-purpose communications software. The circuit connects between the serial port and an external modem. After communications are established, the UART will echo all characters sent by NIST, and an output pulse will be generated when the (*) OTM is received.

Many other circuits and configurations are possible. The same functions could even be realized using a single-chip microcontroller. In principle, you could combine modem chips and a single-chip microcontroller, forming a small, self-contained system with 1ms accuracy. The reference signal developed could be used to reference a crystal oscillator or set the time in another system.

Documentation available

Further documentation and example software for the PC and several other popular computers are available from NIST. This software is provided on a 5¼-inch, 360kbyte DOS diskette with instructions. The cost is $35. Contact the NIST Office of Standard Reference Materials, B311 Chemistry Bldg., NIST Room 8101, Gaithersburg, MD 20899; 301-975-6776.

Specify that you want the Automated Computer Time Service documentation. Technical questions and comments should be directed to NIST-ACTS, NIST Time and Frequency Division, 325 Broadway, Boulder, CO 80303.

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