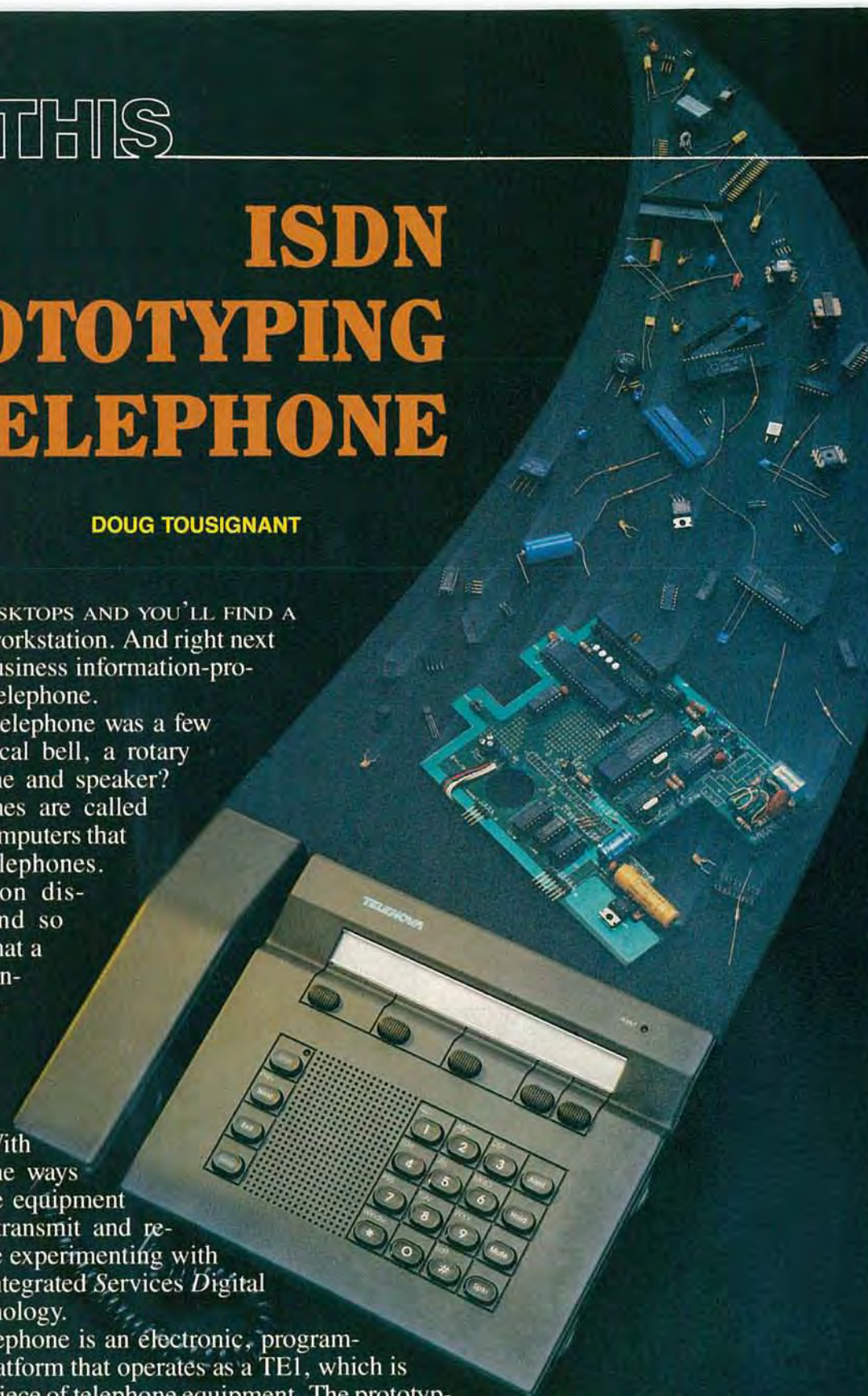# ISDN PROTOTYPING TELEPHONE

DOUG TOUSIGNANT

LOOK ON BUSINESS DESKTOPS AND YOU'LL FIND A personal computer or workstation. And right next to it, there's another business information-processing computer—a telephone.

Remember when a telephone was a few relays, a big mechanical bell, a rotary dial, and a microphone and speaker? Today, office telephones are called station sets; they are computers that also happen to be telephones. They have information displays, keyboards, and so many other features, that a telephone call is no longer just talking—it's digital signal processing.

Introducing the Millcom Prototyping Telephone. With it, you can explore the ways that modern telephone equipment does more than just transmit and receive voices. You'll be experimenting with the fundamentals of *I*ntegrated *S*ervices *D*igital *N*etwork (ISDN) technology.

The prototyping telephone is an electronic, programmable development platform that operates as a TE1, which is an ISDN-compatible piece of telephone equipment. The prototyping telephone makes it easy to experiment with DTMF (*D*ual-*T*one *M*ulti *F*requency) encoding and decoding, call-progress information, audio processing for the microphone and speaker, and also shows how TE1's operate in the ISDN environment. Even if you don't have ISDN service available, you'll be able to develop ISDN-like features, and be ready as soon as ISDN hits your area.

The prototyping telephone that we'll describe is a single board

Our prototyping telephone will let you get acquainted with ISDN from the bottom up.

that is designed as an add-on for a *Telenova* station set. The Telenova station set—which you may have seen on *Miami Vice, Moonlighting,* or the movie *Scrooged*—is a telephone that is designed exclusively for use on Telenova and Wang PBX's or PABX's. It features a 2-line by 40-character display, keys for telephone functions, and five "soft keys" whose functions are determined by software running in the phone.

The Telenova station set is controlled by an Intel 8085 microprocessor with 64K of memory. The processor controls the display, the keyboard, and other functions. Installing the prototyping-telephone circuit board and new software in the station set adds several features to it: a serial/parallel interface for connection to a personal computer and a printer, a complete analog telephone on a chip, DTMF encoding and de-

coding, call-progress monitoring, and, of course, the components that make it a TE1.

It is possible to connect the prototyping telephone circuit board directly to a computer and control it through a parallel printer port. In fact, we'll show how that is done next month. Now, however, we'll assume that the kit board will be assembled inside a Telenova station set. The prototyping board connects to the motherboard inside the Telenova station set via a 50-pin connector, and its components are addressable by the station set's 8085. The kit comes with complete assembly instructions, user manual with experiments, and trouble-shooting guide.

There are only three jumpers that have to be installed between the motherboard and the kit board. The kit board mounts perfectly inside the Telenova station set; it can also be

externally mounted and connected to the processor via a ribbon cable.

Why process phone calls?

Whether the prototyping telephone is then connected to tip-and-ring, the Telenova digital switch, or an ISDN interface, the incoming and outgoing telephone functions are all available for processing by the user.

Outbound calls should be processed for a number of reasons. Why should you have to listen to ten rings or perhaps a busy signal, when you can let the computer do that? You can have your PC ring a number every few minutes and report on the number's disposition. You don't even have to pick up the phone if all you want to do is send a FAX or some electronic mail. You can easily find out how much time you spend talking, and how much time you spend listening.
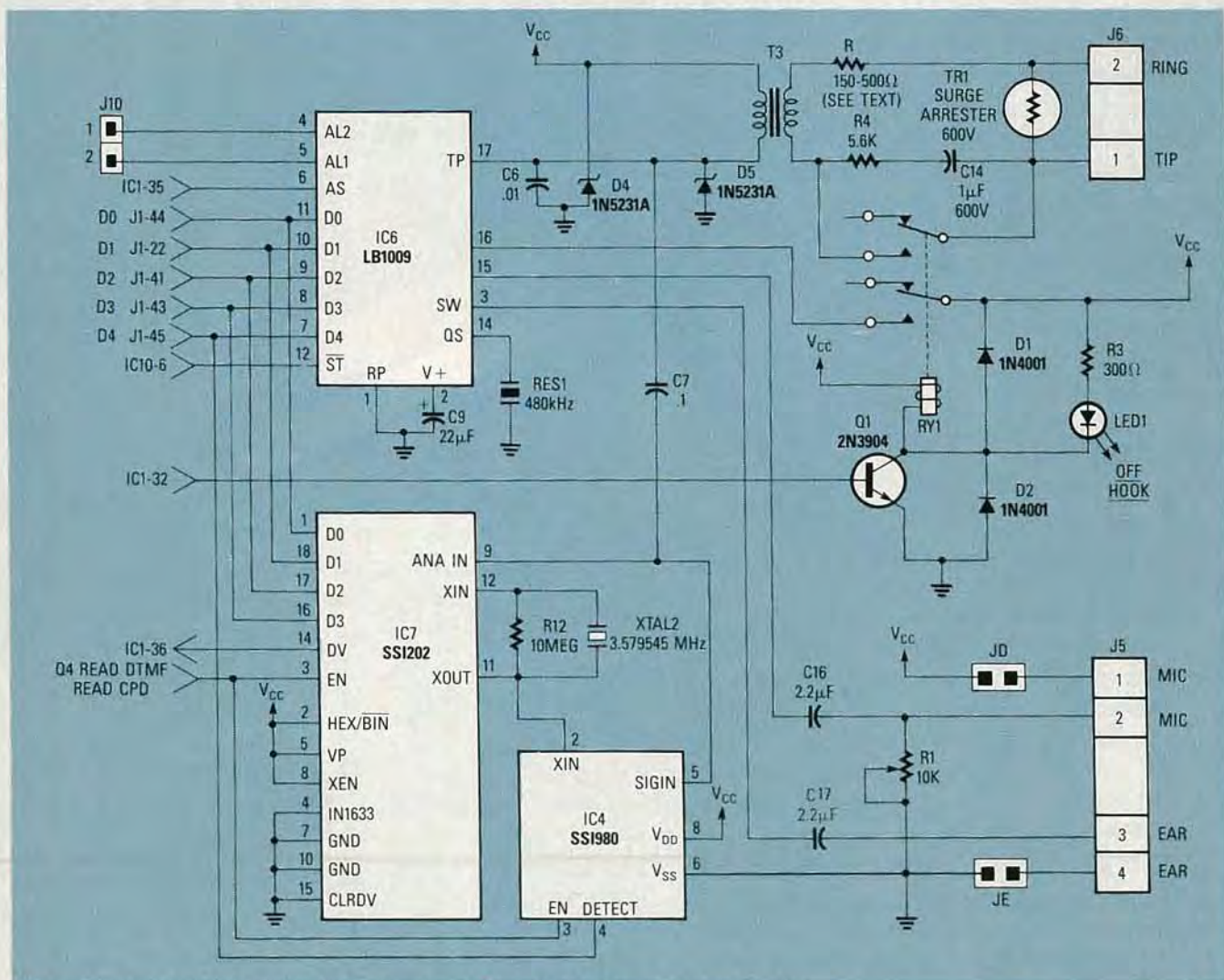
There are many reasons why in-

FIG. 1—THE TIP-AND-RING SECTION is the physical interface between the prototyping telephone and an actual phone line. The LB1009AE provides a complete analog telephone on a chip.
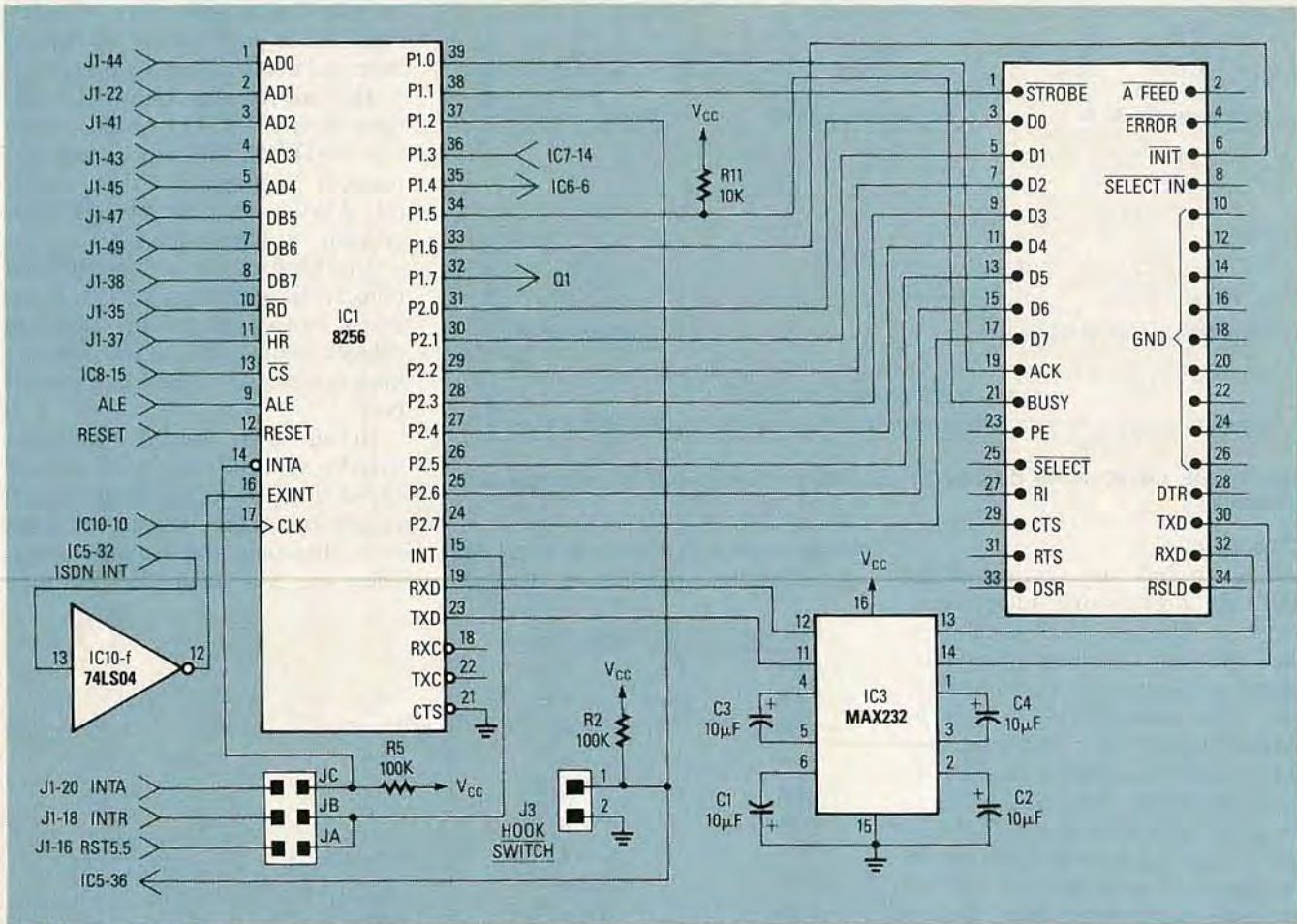
FIG. 2—THE MAX232 IS USED to transmit and receive RS-232-C signals. An 8256 MUART provides serial/parallel communications with the outside world.

bound calls should be processed, too. Before being interrupted by a ringing telephone, why not have the computer first tell you who's calling? Many PBX systems have a "do not disturb" mode. With the prototyping telephone and a computer, you can create your own "do not disturb" mode. You'll be able to tell the machine what incoming numbers to put through, and like many voice-mail systems, a caller can communicate with your phone by pressing numbers instead of talking. You can leave the office, come back two hours later, and look at a list of inbound calls you missed instead of looking through a batch of while-you-were-out slips. Then you can tag the calls you want to return, sort them, and have the computer make the calls for you. Of course all of these features require software. We'll give examples of features for which the Millcom kit can be programmed, and we'll also post a few on the RE-BBS (516 293-2283) to get you started. But the real fun comes when you develop new applications that were previously impossible.
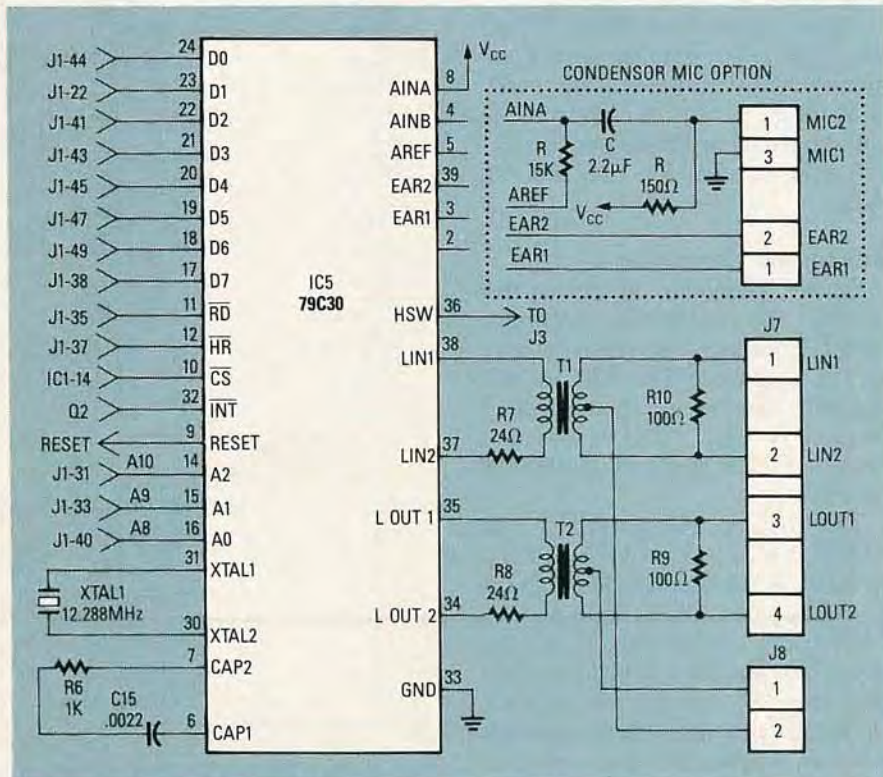

FIG. 3—THE AM79C30A PROVIDES THE TELENOVA telephone with TE1 abilities. It is basically the "ISDN microprocessor," keeping track of all ISDN functions.
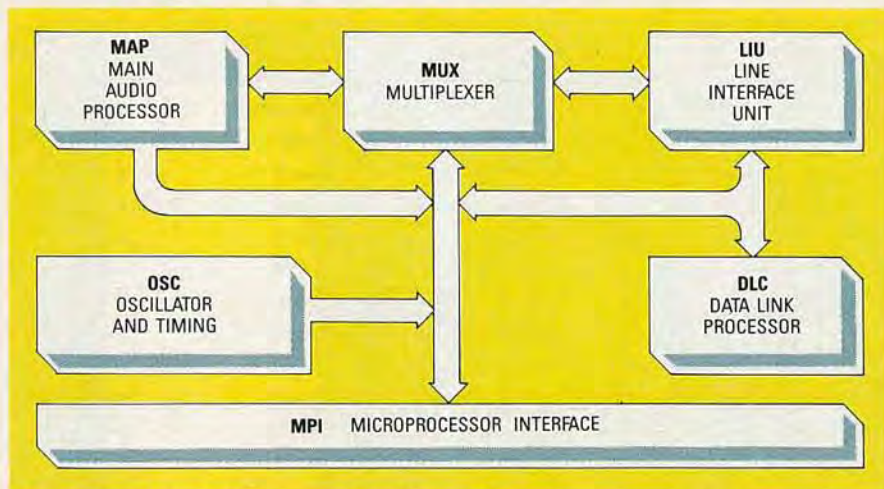
FIG. 4—THE AM79C30A IS DRIVEN BY the 8085 microprocessor in the prototyping telephone.

Circuitry

The tip-and-ring section of the Millcom prototyping telephones, shown in Fig. 1, is the physical interface between the prototyping telephone itself and an actual telephone line. Also contained in Fig. 1 is the AT&T LB1009AE, a 20-pin package that provides a complete analog telephone on a chip. The SSI 202P is an 18-pin IC used to receive DTMF signals (*Touch Tones*) so that they can be processed as numbers. An SSI 980 processes call-progress data, such as busy signals and the ring back (the ring that you hear in the earpiece of your telephone when making a call).

Figure 2 contains an 8256 MUART which provides serial/parallel communications with the outside world. A MAX232 is used to convert the 5-volt serial data inside the phone to 12-volt levels used by RS-232, and vice versa.

Subscriber controller.

Figure 3 contains the device that provides the prototyping telephone with TE1 abilities—that is, it makes it an ISDN device. The AM79C30A digital subscriber controller is basically the "ISDN microprocessor," keeping track of all ISDN functions.

The block diagram of the AM79C30A is shown in Fig. 4. Driven by the 8085 microprocessor in the prototyping telephone, the AM79C30A digital subscriber controller provides 2B + D channel interface, the "S" reference transceiver, D-channel processing with multiple terminal access, and an audio processor. (If you are unsure of the terminology being used here, don't

worry—we will discuss it in greater detail later on.) It communicates with

the companion processor via interrupts and is programmed by reading from and writing to internal registers.

The *Line Interface Unit* (LIU) connects the AM79C30A to the outside world ISDN "S" reference point. Remember, "S" reference data is digital. Also, some framing and error checking is done in the LIU.

The Multiplexer section (MUX) transfers the data from the LIU to the main audio-processing section (MAP), the interface to the companion microprocessor (MPI), or a serial port.

In the *Main Audio Processor* (MAP) section, digital-to-analog conversion is done, and tones are generated for DTMF, the alerter, ringback, dial tone, and the busy signal. There are two attenuation/distortion
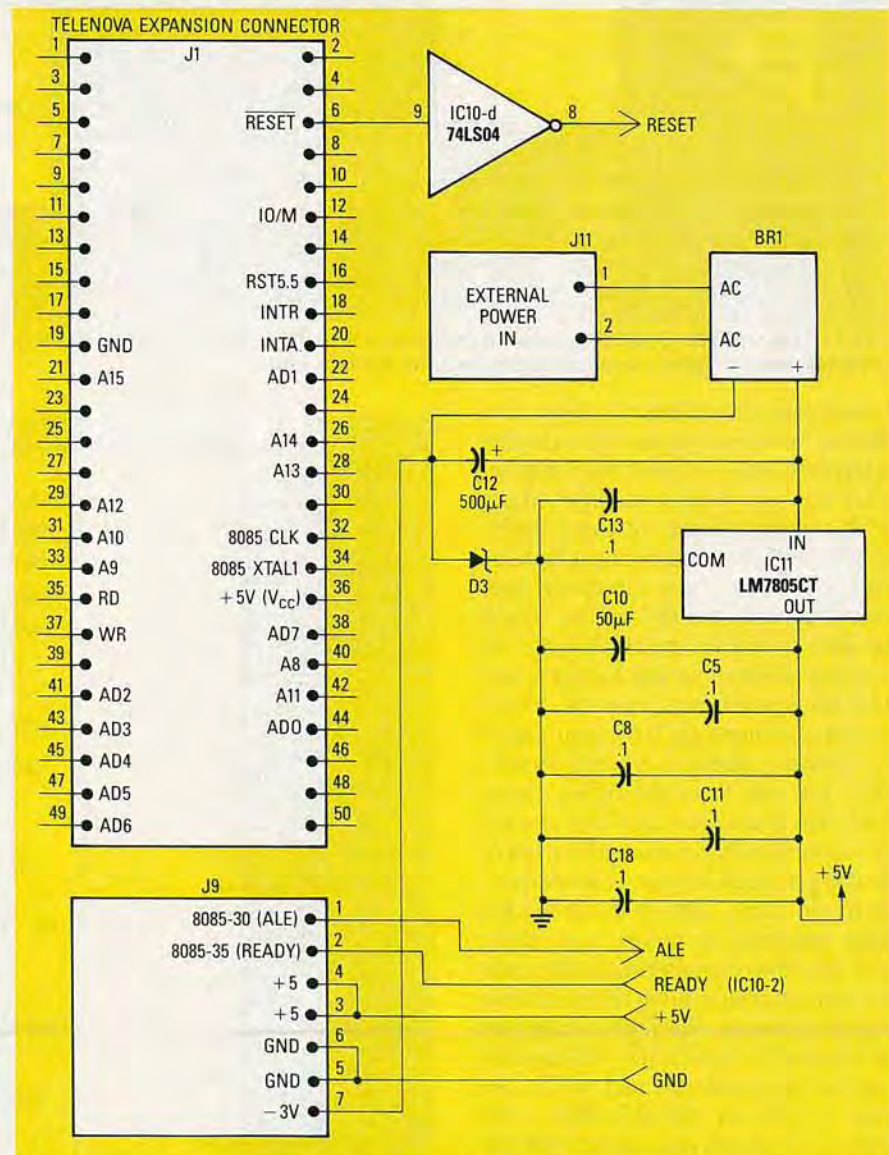

FIG. 5—THE MAJOR DIGITAL SIGNALS from the mother board of the Telenova are brought to the components on the Millcom kit board by J1, and the remaining signals are supplied by J9.

filters, one gain filter in the transmit path, and two gain filters in the receive path, as well as the audio-input ports and the loudspeaker and earpiece drivers.

The *Data Link Controller* (DLC) handles the layer-1 and partial layer-2 LAPD (*Link Access Protocol* for the *D*-channel) processing. Control packets are assembled and received, and some address recognition takes place in the DLC.

The processes inside the AM79C30A are complex, and *Advanced Micro Devices'* publication 09893 describes them in great detail. However, in a simple fashion, lets follow a bunch of bits to and from the 4-wire ISDN "S" reference point through the AM79C30A for a point-to-point TE1.

Incoming and outgoing bits are grouped into frames of 48 bits. The

LIU checks those frames for errors and establishes a synchronization. The LIU determines if the bits from the "S" reference are B-channel data or D-channel data and directs them accordingly. If those bits are D-channel data, the LIU multiplexes the data, which then goes to the DLC. B-channel data would go to the MUX.

In the DLC, more error checking takes place, and rudimentary address recognition is done. D-channel packets are buffered and made available to the companion processor, which further processes the addresses and the packets, decides what to do, then fills

the D-channel transmit buffer and the DLC sends the data back to the LIU and out to the "S" reference.

If the LIU found B-channel data, it would give the data to the MUX. The MUX would forward the data for audio processing in the MAP, information processing in the MPI, or to a serial RAM port. In the MAP, telephone signals such as dial tone and DTMF can be prepared and transmitted, or the alerter can be set off. If the B-channel data is voice, then the MAP filters can be modified to provide different loudness and tone for transmit, receive, and sidetone.

While the B-channel is transmitting and receiving the voice data, the D-channel is still busy checking, signaling, framing, multiplexing, addressing, and assembling packets.

While most of the work is done by the Digital Subscriber Controller, a companion processor like the 8085 in the prototyping-telephone kit has to eventually manage the information to make something happen.

I/O and power

As seen in Fig. 5, the major digital signals from the mother board of the Telenova station set are brought to the components on the Millcom kit board by J1, and the remaining signals are supplied by J9. A +5-volt supply is brought out on J9 for external use. A 117-volt AC power adapter is included with the kit, which must be connected to J11. J11 supplies the main power to BR1, which is used for rectification and prevention of polarity reversal. DC power may be supplied directly so that 9 volts appears across the plus and minus terminals of BR1. The signals "ALE" and "READY" must be tapped off the Telenova's 8505 microprocessor, and brought to J9. The −3 volts is also brought out on J9, which must be wired to the display.

For programming, the I/O addresses for the devices on the prototyping telephone are shown in Table 1. Additional access time is required during the access of the AM79C30A's internal registers. Therefore, IC2, shown in Fig. 6, is required to insert one wait state during those accesses.

Construction

A Parts-Placement diagram is shown in Fig. 7, (which, unfortunately, will appear in *next* month's issue) and the foil patterns for the

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.
R1—10,000 ohms, single-turn potentiometer
R2, R5—100,000 ohms
R3—300 ohms
R4—5600 ohms
R6—1000 ohms
R7, R8—24 ohms
R9, R10—100 ohms
R11—10,000 ohms
R12—10 megohms
Capacitors
C1–C4, C9—22 µF, 16 volts, tantalum electrolytic
C5, C8, C11, C13, C18—0.1 µF, ceramic
C6—0.01 µF, ceramic
C7—1 µF, 25 volts, tantalum
C10—300 µF, 6.3 volts, electrolytic
C12—500 µF, electrolytic
C14—0.1 µF, 400 volts, ceramic
C15—0.0022 µF, ceramic
C16, C17—2.2 µF, 25 volts, tantalum
Semiconductors
IC1—Intel 8256 MUART
IC2—SN74LS74N D flip plop
IC3—Maxim MAX232 or ICL 232CPE, RS-232-C TX/RX
IC4—Silicon Systems SSI75T980-CP, call-progress tone detector
IC5—Advanced Micro Devices AM79C30APC, digital subscriber controller
IC6—AT&T LB1009AE, analog-telephone IC
IC7—Silicon Systems SSI75T202-IP, low-power DTMF receiver
IC8—SN74LS138N, decoder/demultiplexer
IC9—SN74LS02N, quad 2-input NOR gate

IC10—SN74LS04N, hex inverter
IC11—LM7805CT, 5-volt regulator
D1, D2—1N4004 rectifier diode
D3—1N5228A, 3.9-volt Zener diode
D4, D5—1N5231A, 5.4-volt Zener diode
TR1—600-volt surge arrester
BR1—MDA101A 3N247 bridge rectifier
LED1—red light-emitting diode
Q1—2N3904 NPN transistor
Other components
J1—50-pin 0.1-inch center dual row connector
J2—34-pin 0.1-inch center right-angle dual-row connector
J3–J10—Miscellaneous 0.1-inch center right-angle/vertical connector strips.
RES1—400-kHz ceramic resonator
RY1—R2-5-C ITT relay
T1, T2—Precision Components "S/T" custom transformers
T3—1:1 audio-isolation transformer
Miscellaneous: 1-103327-6, VIKSR40FT2R, 103328-3 Amp, 531220-1, MX4-2695, DB95 IDC connector, DB25P IDC connector, 34-pin dual-row 0.1-inch center IDC connector, 34-conductor ribbon cable (6-inch max.), low-profile IC sockets: 8-pin, 14-pin, 16-pin, 18-pin, 20-pin, 40-pin.
Note: The following are available from Millcom, 3014 Pershall, Saint Louis, MO 63136 (314-524-0804): Prototyping Telephone Kit board and all parts, $239. Refurbished Telenova station set with Millcom PROM BIOS monitor, $260. PC board, $39. Flat-rate repair $100.
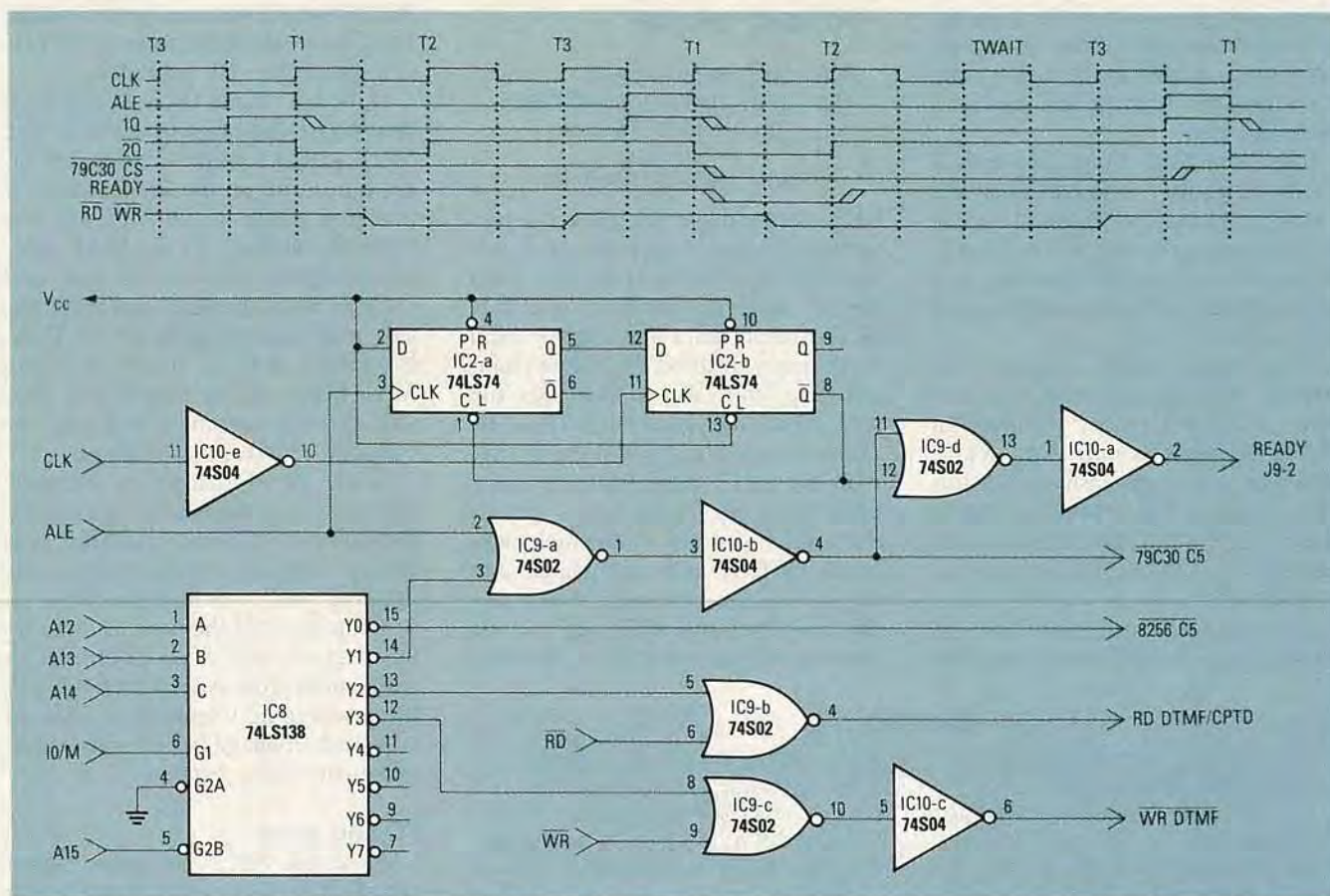
FIG. 6—IC2 PROVIDES THE ADDITIONAL ACCESS TIME required during the access of the AM79C30A's internal registers by inserting one wait state during those accesses.

double-sided PC board are provided in PC Service for those who wish to make their own board. Note that the following instructions apply only if you are installing the Millcom board inside the Telenova station set. Also note that you will need a regular *Touch Tone* telephone and an active phone line for testing, and that we will refer to the *Touch Tone* telephone as a plain old "phone."

To start with, the tip-and-ring interface section must be installed and tested. (Test fit all parts before soldering, and observe component polarity wherever necessary.) Solder R4, C14, RY1, T3, and TR1 to the PC board. Then carefully clip the red and green wires that come from the Telenova's RJ11C connector (tip and ring) close to the PC board, and solder them to their new locations on the Millcom PC board (the tip and ring pads are marked on the upper-right hand side of the Parts-Placement diagram.

Connect a "T" adapter to your existing telephone line so that the prototyping telephone can be connected in parallel. Pick up the handset of the phone, and while listening to the dial tone, plug the prototyping telephone into the T-adapter. You should hear no distinct change in the dial tone's volume because the 600-ohm bridge has not yet been installed across the line. Troubleshooting is required if the dial tone is lost completely.

Solder Q1, D1, D2, LED1, and R3 to the PC board. Using an ohmmeter, check the resistance between the +5-volt trace and ground. Reverse the leads and repeat. If either reading is less than 1 megohm, troubleshooting is required.

Solder in IC11, D1, C10–C13, BR1, and J11. Check for at least 10 kilohms between the +5-volt trace and ground. Apply +9-volts DC to J11 and check for a regulated +5-volts DC and −3-volts DC. (A 9-volt battery can be used for this test.) Wire a temporary hookswitch; a switch in series with a 1K resistor. Apply +5 volts to the base of Q1; the relay should energize and the offhook LED should light. Repeat the test with the prototyping telephone connected in parallel (plugged into the "T" adapter). Listen for a dial tone on the regular phone, and then force the prototyping telephone offhook again. The volume of the dial tone should

decrease slightly as the relay is energized, and the LED should be on. No unusual sounds should be present on the phone. Break the dial tone by dialing any digit, and, again, listen for any unusual noise. Cycle the relay several times while listening for any noise on the phone. Troubleshooting is required if any noise is heard.

If everything's alright so far, dial your local time-and-temperature number on the phone and note the quality of the reception. Your configuration may require a 150- to 500-ohm series resistor, R, shown in Fig. 1. (If you can't break dial tone, troubleshooting is required.) If you have another *Touch Tone* phone around, repeat the test using that phone. Leave the prototyping telephone connected to the "T" adapter, off hook.

If the audio is acceptable, hang up the phone, wait 5 seconds, and then pick it up again and listen. If the time-and-temperature recording is still audible, the 600-ohm transformer (T3) is properly bridging tip and ring. Disconnect the prototyping telephone from the "T" adapter.

Next month, we'll present the parts-placement diagram, finish construction, and get on to exploring applications for ISDN.   **R-E**