GTE Communications Transmission Systems

DEMODULATOR

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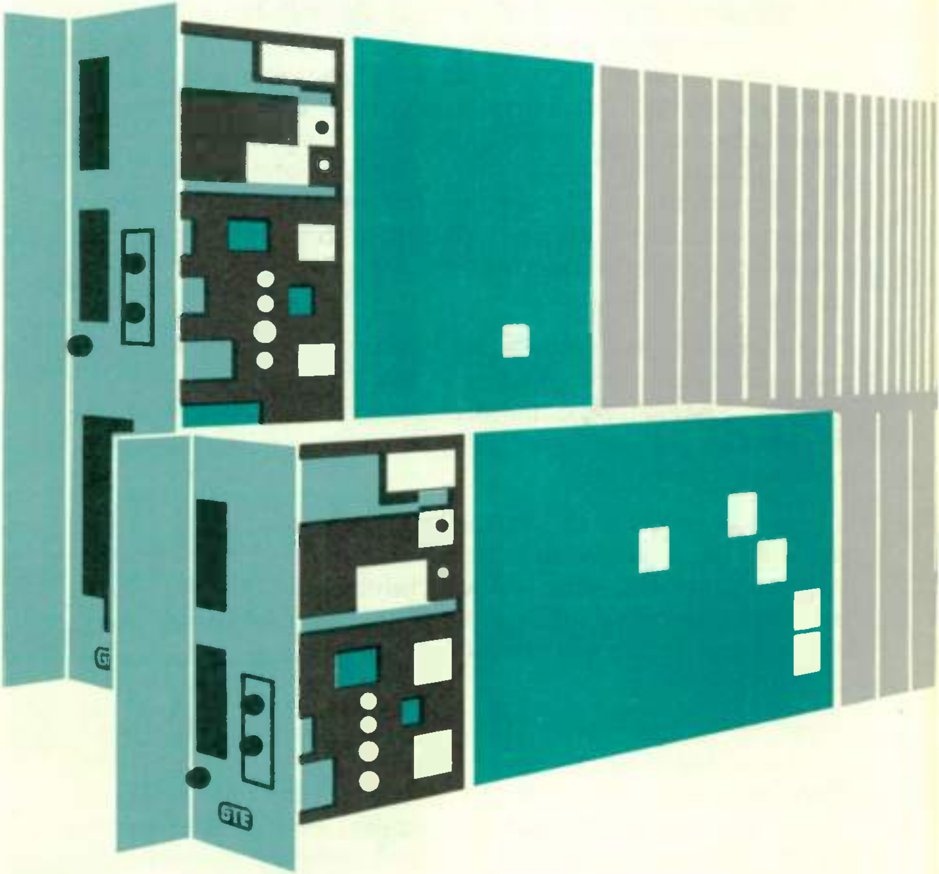

Special Services

Parts One & Two

Special Services, Part One

The December 1974 GTE Lenkurt Demodulator presented an introduction to Special Services. Since that time, there has been a tremendous increase in the demand for these services. During this same time period, business people have become much more knowledgeable in the area of communications. Today, many corporations employ "Communications Managers" whose job is to define the communications needs of the corporation and determine the most cost-effective method for satisfying those needs.

The increases in demand and customer's knowledge have led to increased competition in the Special Services market. Specialized common carriers and interconnect companies are competing with telephone companies for business customers.

These competitive forces have led to a number of technological innovations and improvements in Special Service products. Whole new "families" of these products are being introduced. These technological developments are the subject of this issue of the Demodulator.

The new technological developments in Special Service products are easier to understand if they are divided into two categories. The first category includes new products which are intended to replace older special services equipment. Although they perform essentially the same functions, the new products offer more reliable and economical operation. These products are discussed in Part 1 of this two part article.

The second category of new products includes products which offer special services not previously available except through unique custom-engineering design. One of these products, which provides integrated voice/data service, is discussed in Part 2.

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The latest special services products use an enhanced modular design and take advantage of large scale integration technology to reduce size, weight, power consumption and heat dissipation. This enhancement of the existing modular concept has several other advantages that are attractive to both the manufacturer and end user. These advantages are brought out in the following discussion which uses several devices produced by GTE Lenkurt Special Service Products Division for illustrative purposes.

The enhanced modular design is based on a major assembly/subassembly approach. The major assemblies are single card transmission modules with edge connectors that plug into appropriate shelves or adapters. The transmission boards may be used independently or equipped with plug-on subassemblies to provide various types of signaling, power supplies and special features. In other words, a complete module may consist of a basic transmission board or a transmission board equipped with one or several subassemblies. In any case, the module is assembled, shipped and maintained as a single unit. The exact configuration of transmission board and subassemblies is indicated on the faceplate. Table 1 lists 10 basic types of transmission boards, which by themselves, or equipped with appropriate subassemblies, cover pratically the entire spectrum of special services, VF applications.

It is apparent that the modular design provides maximum flexibility with a minimum number of components. From the manufacturer's viewpoint. this means better inventory control. There are fewer transmission boards or signaling functions to design, build or inventory and the chances for shortages of a specific module or product are greatly reduced. Furthermore, by exercising rigorous design discipline, the variety and values of piece parts required to make the transmission boards and subassemblies can be limited to perhaps 500. The result is simplified purchasing and documentation plus fewer dollars tied up in parts inventory.

From the telephone company or other service suppliers viewpoint, the modular concept reduces spare parts requirements, simplifies maintenance procedures and improves restoral time in the event of service outage.

The spare parts requirements are reduced because a single plug-in unit, equipped with optional subassemblies, contains all the functions which require two or three plug-ins of older designs. For this same reason, the mounting space requirements for the modular units are 1/3 to 1/2 those of older designs. Stated another way; the same Relay Rack that accommodates 33 or 49 conventional design circuits can accommodate 99 circuits using GTE's new, modular-designed plug-ins.

Another strong advantage of this enhanced modular concept is the

Description
Blank
Four Wire Line Amplifier
Two Wire to Four Wire Line Amplifier
Four Wire Repeat Coil (or Dual Two Wire Repeat Coil)
Two Wire Repeat Coil
Four Wire Term Set
Two Wire Voice Frequency Repeater
Central Office Interface
Data Station Termination
Special

Table 1. Transmission Board Plug-In Modules

greatly reduced power requirements. For example, the GTE Special Service Products Division's 4-wire amplifier has a maximum current requirement of 20 milliamperes. The 99 circuits mentioned in the previous paragraph would require a maximum of 1.98 amperes.

A power supply with a 2 ampere capacity could fulfill this requirement. By way of contrast, conventionally designed circuits require 60 to 70 milliamperes per circuit so, 99 circuits would require power sources with 6 to 7 ampere total capacities.

From the foregoing, it is apparent that the modular concept provides power savings in two ways: (1) the initial cost of the power supply and; (2) ongoing power consumption.

Transmission Boards

Returning to our discussion of the transmission boards (TB), each board provides appropriate impedance matching, isolation, protection, level control, equalization and 2-wire to 4-wire conversion as required. Each TB has a facility and an equipment side. These are sometimes referred to as A and B or line and drop sides.

The impedances are switchable for matching purposes. Four-wire outputs are switchable to 150, 600 or 1200 ohms. Two-wire outputs are switchable to 600 or 900 ohms. The input impedances are switchable over the same ranges and the input/output impedances are independent of each other. Simplex and/or A/B leads are provided for use both externally and within the subassemblies.

The transmission boards providing level control have separate amplifiers for each direction of transmission. The amplifier circuits can be switched for gain or loss and provide adjustments from 0 to 24 dB switchable in 0.1 dB steps.

Each amplifier has an associated, active equalizer circuit which can be adjusted or switched out. Equalization is provided for the 3000 Hz signal compared to 1000 Hz. Since the equalizer is active and designed to be independent of the 1000 Hz level, there is no interaction between the level setting and the equalizer setting. The level is set independently and requires no readjustment after equalization.

Equalization is also provided for the 300 Hz signal compared to 1000 Hz. This is required so that loaded cables can be equalized as well. As with the high frequency equalization, there is no interaction between the level settings and the 300 Hz equalizer setting. The level is set independently and requires no readjustment after equalization.

When 2-wire to 4-wire conversion is required, the TB provides the necessary hybrid circuitry. Each hybrid has switchable 600 or 900 ohm 2-wire impedances and switchable 150, 600 or 1200 ohm 4-wire impedances. Since the hybrid uses active circuitry, its internal losses are automatically compensated so the insertion loss is 0 dB. The overall level adjustment is exactly as selected by the switches.

These transmission boards have plug arrangements for precision balance networks or build-out capacitors. A compromise balance network is included as part of the transmission board and is selectable for 600 or 900 ohms in series with 2 microfarads, to match the 2-wire drops.

Subassemblies

The transmission boards have plug arrangements to accept signaling, special feature and power subassemblies. The signaling subassemblies are listed in Table 2. These assemblies are also assigned facility and equipment sides and are equipped with a reversing switch for applications where the sides must be reversed relative to the transmission board. An option switch is also provided on foreign exchange (FX) assemblies to select loop start or ground start operation.

The transmit cut and terminate function can be disabled on the E&M assemblies to allow the unit to be used for Strowger automatic toll ticketing (SATT) applications. Each signaling subassembly incorporates its own 20 Hz ringing generator and ring detection circuitry, as well as its own 2600 Hz SF oscillator. Connections to external ring generators and SF oscillators are not required.

Feature Subassemblies

The optional feature subassemblies are factory installed on the transmission boards. Installation

Description
None
E&M to SF (Single Frequency)
SF to FXS (Foreign Exchange Station)
SF to FXO (Foreign Exchange Office)
SF to FXS/FXO
SF to Ringdown
SF to Loop Dial
SF to DX (Duplex)
E&M to FXS
E&M to FXO
E&M to FXS/FXO
E&M to Ringdown
E&M to Loop Dial
E&M to DX
Dial Long Line (LS/SG) (Loop Start or Ground Start)
Dial Long Line (LS Only)
Loop Extender
2W Automatic Ringdown

Table 2. Signaling Plug-On Units

is simply a matter of plugging on the appropriate subassembly and mounting an identifying faceplate on the board. The entire process is accomplished in a matter of minutes. The optional-feature, plug-on units are listed in Table 3.

The subassemblies include tone loopback, adjustable level loopback, transhybrid loopback and precision build-out networks (PBN). The PBN's are designed for H88 and D66 loading and are also available for non-loaded and universal circuits or as a simple build-out capacitor.

The single-frequency, loopback control unit can be activated by an on-line tone, simplexed DC current or local "LOOP" pushbutton. The standard control tone is 2713 Hz but the subassembly can be factory adjusted to any tone from 1300 to 2713 Hz. The multifrequency model has a switch so that any one of 16 possible frequencies can be selected in the field. Guard circuitry eliminates the need for threshold adjustment while assuring reliable control. A unit left in the loopback mode locally can be released by transmitting a release tone from the central office.

On 4-wire amplifiers, an adjustable level subassembly is provided in addition to the loopback control. The circuit is set so that a tone sent at 0 dBm from the testing point is returned as if a 0 dBm tone were transmitted from the drop side of the loopback point. This eliminates the necessity for referring to circuit records for differences between receive and transmit levels. On the 4-wire amplifier, the loopback point is switchable so the unit can be looped on either the facility or equipment side. In addition, the adjustable level loopback can be switch selected for equal level loopback when required.

On 2-wire/4-wire devices, the transhybrid loopback subassembly loops the receive to the transmit through all active components. The unit is arranged so that the level transmitted to the local 2-wire equipment is the level that is looped back to the transmit input.

Signaling may also be looped on any E&M unit. Looping connects the E lead to the M lead through conversion circuitry. The signaling as well as the transmission circuitry can be tested.

Power Subassemblies

Available power options provide for powering the total assembly from the sealing current and provide bat-

ALLB: Adjustable Level Loopback: DC Loopback for 4 Wire Amplifiers only.
TCLB: Local or Tone Controlled Loopback
THLB: Transhybrid DC Loopback for Hybrid
Selectable Frequency Loopback Control
SGLB: Signaling Loopback: E&M Units Only
PBN: Precision Balance Network Universal
PBN: H88 Loaded
PBN: D66 Loaded
PBN: Non-Loaded
Buildout Capacitors (BOC)
Switched Gain Control: 2 Wire VFR's Only

Table 3. Feature Plug-On Units

tery backup and/or sealing current to the line as additional options. Both battery back-up and line powering functions can be provided by the same subassembly. The battery gives about two hours service during testing or in the event of a power failure. The battery is automatically charged under normal power conditions.

Summary

In summary, the advantages of the modular concept are:

1. Reduced space requirements. A single plug-in board replaces 2 to 4 conventional types.

2. Reduced spare parts requirements. Fewer boards means fewer spares.

3. Reduced power requirements. Units can be powered by sealing current because of low power consumption.

4. Reduced alignment requirements. Prescription adjustments are set with DIP switches. All adjustments are non-interactive adjustments. No potentiometers are used for adjustments on any of the modules.

5. Reduced maintenance and outage time. Troubleshooting is reduced to the isolation and replacement of the single malfunctioning plug-in unit. Prescription settings for the replacement unit are "read" off the unit being replaced.

6. Reduced installation costs and testing due to standardized wiring and on shelf auto test capability.

Special Services, Part Two

There is substantial agreement among telecommunications experts that the 1980's will see a strong demand for business communications systems which offer integrated voice and data services. Many of the communications services included in the "automated office of the future" concept require data switching capabilities. If fact, an integrated digital telecommunications system capable of transmitting voice, data and images is fundamental to this concept.

The growing use of data processing equipment and systems by business and the increasing availability of data networks to interconnect these systems are creating a demand for both switched and point-to-point data services. As the same time, the growth of large scale integrated (LSI) technology has made the cost-effective implementation of these services possible. The nature of both the traffic and the technology make digital transmission the most practical method for this implementation.

Since the greatest demand for integrated voice/data services is in the business sector, it is apparent that there is a requirement for digital voice/data transmission equipment which can operate behind a PABX.

The voice/data equipment described in this article is being developed by GTE Lenkurt; Special Products Division, Aurora, Colorado. The equipment provides point-to-point digital voice/data transmission over standard T-I lines and switched, digital voice/data through digital PABX's such as Automatic Electric's GTD-1000 and GTD-4600.

From the user's viewpoint, switched digital data service appears identical to that provided by using analog modems. Calls are originated by pressing the "voice" key on an associated key telephone set and dialing the called station number or by using an automatic calling unit. Voice communications take place in the usual way.

To transfer from voice to data, each party depresses the "Data" button. After a handshaking routine, data transfer can be accomplished. When the transfer is completed, the call reverts back to the voice mode or is automatically terminated. Automatic answer and long-space disconnect are provided. In addition to the modified key telephone set, the GTE hardware implementation of voice/data transmission requires two other units; a Subscriber Data Unit (SDU)™ and a Data Access Channel Unit (DACU)™

In a switched data application, the SDU provides an interface between the local loop to a PBX and the customer's data-terminating equipment (DTE). The loop carries digital information (voice or data plus supervisory signaling) at a 64 kilobit per second (kb/s) rate. The DACU connects the 64 kb/s line to a PCM channel bank, such as the Lenkurt 9004A which multiplexes the 64 kb/s into a T-1 stream. At this point, the information is indistinguishable from any other service on the T-1 line and can be switched by any PBX with bit integrity and a T-1 interface. Timing is derived from the T-1 stream.

The fact that the voice/data capability can be added to many existing, in-place PABX's is one principal advantage of the GTE approach. The capability can be added without modifying the in-place equipment or making it obsolete.

The switched voice/data system is attractive to businesses with a large number of widely distributed data entry points or a distributed processing system. Businesses which make extensive use of word processing and order entry systems will also find switched data networks useful.

Point-to-point (non-switched) systems are used to provide a consistently high-quality transmission path or to satisfy large traffic requirements. In these applications, the SDU's at each end can be directly connected by wire or, by using a DACU, can be connected by a T-1 line. Timing can be in a master/slave configuration with the clock in one SDU providing timing for the system or timing can be derived from the T-1 stream as in the switched system. The following paragraphs present an electrical description of the SDU and DACU.

Functional Description

The SDU provides microprocessor controlled bipolar conversion, maintenance and handshaking routines, code detection and generation, signaling and framing information, and interfaces to the data equipment and telephone set. The

DACU provides bipolar conversion, maintenance features, code detection, retiming buffers, signaling and framing information and an interface to the 9004A 64 kb/s circuitry.

The SDU and DACU interface over a 4-wire line at a 64 kb/s line rate in a 50% bipolar, return-to-zero (RZ) format. This allows isolation of the electronic circuitry for protection against large, induced longitudinal voltages on the cable pairs.

An automatic line build out network and fixed equalization are provided at both the SDU and DACU receive line interfaces, to compensate for variations in loop length. The maximum allowable line length is based on a expected measured line-loss of 31 dB at the 32 kHz Nyquist frequency. The Nyquist frequency is the highest frequency whose waveform can be reproduced for a given sampling rate. Since a minimum of two samples are required for good reproduction of a waveform, 32 kHz is the Nyquist frequency for a 64 kb/s sampling rate.

The 31 dB line loss equates to 12.8 kilometers (7.7 miles) of 0.9 mm (19 AWG) cable or 3.54 km (2.2 miles) of 0.4 mm (26 AWG) cable. These are the maximum lengths that can be used without a repeater.

The lines must be non-loaded and not have any bridging capacitors. There are also limits on bridged tap length. The maximum length for a single tap is 2,000 feet and the cumulative total of all bridged tap lengths should not exceed 2500 feet per repeatered section.

Both the SDU and DACU transmit sections contain line driver amplifiers to couple the bipolar signals to the cable pairs. The drivers contain amplifiers, low-pass filters, and lightning protection circuitry.

Synchronization

The SDU and connected DTE must be slaved to the digital network timing when they are used in conjunction with the DACU and the 9004A D4 Channel Bank. The DACU and SDU are locked to the timing in the received T-1 signal and, in the synchronous mode, the SDU sends the DTE a derived receive clock along with the data.

The SDU also presents a similarly derived transmit clock to the DTE. The data sent by the DTE to the SDU should be timed by this clock. However, synchronous DTE which will not accept the derived clock, but supplies its own transmit clock to the SDU will be accommodated.

In point-to-point applications, where two SDU's are interconnected by a dedicated line, either one but only one of the two SDU's may provide the master clock. In other words, one SDU's clock is selected as the master and the clocks in the other units are synchronized to it in a master/slave arrangement. As in the network arrangement, a DTE may act as if it is the master transmit clock supply but in fact only a SDU can be the master.

Signaling and Control

In the voice mode, eight-bit PCM words are transmitted with the least significant bit of every sixth byte deleted and used for signaling. When one T1 channel is connected to another T1 channel through a PABX digital switch, the second channel will not necessarily choose the same sixth and twelfth words, for A and B signaling, as the first T1 span. This means that each successive stage of tandem switching may corrupt an additional PCM word. In the worst case, it is possible that the eighth bit of every byte could be corrupted, if the channel passes through a channel unit and four or more switches in tandem. For this reason, the eighth bit is not used to carry information in the data mode of operation. This accounts for the seeming disparity between the 64 kb/s line rate and the 56 kb/s data rate.

In the synchronous mode, data is packed into the available seven bits per byte as required by the data rate. At 56 kb/s all seven bits of each byte are used. A control bit is added to form an eight bit byte. This eighth bit of every sixth byte is used for signaling or framing.

In the asynchronous mode, transmit data are sampled at a 56 kb/s rate and transmitted in the seven bits of each byte. The maximum asynchronous data-rate is limited by the phase-jitter performance of the SDU.

User Data Interface

The SDU provides customer data interfaces compatible with EIA standard RS-232-C, type D and CCITT recommendation V.24. The synchronous system's distortion is within the tolerances specified in RS-334. Asynchronous performance is defined in terms specified by RS-404.

Asynchronous performance at 9.6 kb/s is satisfactory for use with a DTE which satisfies the specification's transmitter performance category I or II and receiver performance category A, B, C, PA, or PN. At 19.2 kb/s asynchronous, the DTE's must exceed transmitter performance category I and receiver performance category A.

This concludes our discussion of digital voice/data equipment. As stated in the introduction, the devices used as an example are being developed by GTE Lenkurt's Special Products Division. The final production versions may differ in functional details from those we have described. However, the basic principles will be the same. Present plans call for the first production units to be available in the third quarter of 1982.

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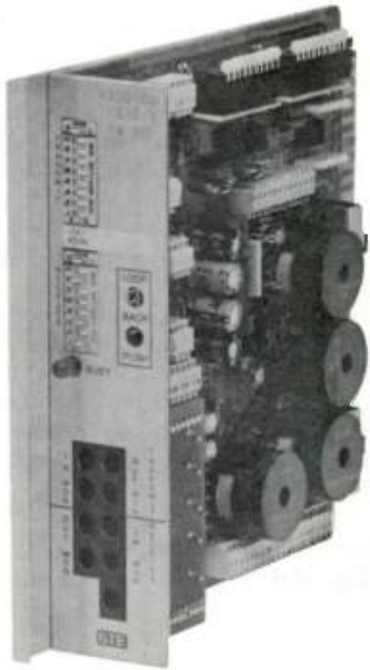
GTE Lenkurt's new 4-Wire Prescription Line Amplifier, the 4100, provides interfacing functions at intermediate or terminal points in 4-Wire voice frequency/data transmission facilities. The amplifier plug-in unit occupies only one mounting position in a series 4000 or equivalent shelf and draws a maximum current of 20 milliamperes.

The 4100 features GAIN/LOSS level control, 300 Hz and 3 kHz equalizers and impedance matching networks for both the line and drop sides of the equipment. Active equalizer circuitry prevents interaction between the level and equalizer adjustments. Levels are "prescription set" by front-panel dipswitches. Impedances of 150, 600 or 1200 ohms are switch-selectable.

Factory installed, plug-on customer options include signaling converters, tone loopback control, adjustable level loopback and line-power battery backup.



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