A VERSATILE, LOW COST SYSTEM FOR IMPLEMENTING CATV AUXILIARY SERVICES

Robert V.C. Dickinson

E-Com Corporation
Stirling, New Jersey

ABSTRACT

A versatile, low cost system for implementing CATV auxiliary services is presented which focuses upon a basic unit operating over two-way coaxial networks. A wide variety of services can be implemented with the basic hardware. In addition, this unit can be extended to implement more complex functions in a modular manner requiring the cost increase only at the specific locations where the more complicated task is undertaken. This type of system lends itself to many areas such as security, energy management, traffic control, industrial data gathering and process control, CATV system status monitoring and spectrum analysis, hotel security and room services, low and medium speed data communications, addressable taps, premium CATV control, remote switching of all kinds and a host of others.

INTRODUCTION

The past several years have brought many new non-entertainment services into the field of CATV and RF coaxial communications. The concept of the wired nation is slowly and systematically developing based upon those auxiliary services carried on the cable which in themselves offer economic viability.

There has been a great deal of progress in data communications on coaxial systems. In various cities and certain industrial plants hundreds of point to point data circuits are in operation linking computer to computer, computer to peripherals, etc. These services usually involve continuous high volume transmissions of data and operate at data rates from 100 to over 1 million bits per second. These services are implemented over coaxial links which typically involve CATV transmission components. Modems capable of synchronous or asynchronous operation have been developed. These modems provide fair to good spectral efficiencies and can be characterized by excellent performance and moderate to high unit prices.

As these high volume services have expanded there remains a need for systems and hardware to do the "simple tasks" which do not, in themselves, warrant the assignment of costly hardware. These "simple tasks" are typically: servicing security systems where one need only know the status of a security zone which changes occasionally; the necessity to command a remote function such as opening a door, turning on a light, switching on an air conditioner, etc. These "simple tasks" exist in security, system control, CATV premium services, energy management, hotel management, industrial process control, and a host of others.

We have, in the past few years, seen the development of specialized CATV hardware to implement some of these "simple tasks", i.e., security, traffic light control, and audio intercoms. Little, however, has been done in terms of universal hardware which can be applied in a transparent fashion over a wide spectrum of services.

This paper describes the TRU Coaxial Communications System. This equipment has been designed as a universal, digital, receive and transmit modem, operating within the traditional CATV spectrum. The TRU System can be applied to the full spectrum of "simple tasks" and is readily expandable to more complex functions requiring intelligent terminal behavior.

TRU SYSTEM

The TRU System is designed to operate on a two-way coaxial network. Operation in the receive-only mode in one-way systems is possible at the expense of certain of the system features. The TRU System is organized with a central controller and any number of remote units (TRU-100) up to the addressing capacity of the system (over four thousand). It is a polled system in that the control unit addresses each remote in a predetermined sequence, passing data to the remote and eliciting a response. The remote terminal's response to the poll indicates its presence and can be accompanied by data to the central controller. Figure 1 is a photograph of the TRU-100 remote unit.

Figure 1 - TRU-100 REMOTE UNIT

The TRU System utilizes radio frequency transmission on the coax and therefore every TRU-100 unit contains an RF receiver and transmitter. Both transmitter and receiver sections are crystal controlled and utilize frequency shift modulation. The occupied bandwidth is 250 kHz in each direction (upstream and downstream). Both transmitter and receiver are simple in design but effective in operation and highly reliable. Figure 2 is a block diagram of the TRU-100.

The data portion of the TRU-100 is organized around a low power microprocessor which handles the addressing and data handling and is available for expanded tasks which will be discussed later. The TRU-100 has a number of powering options. Since, in many applications, it is not desirable to have AC line voltages within the unit the TRU-100 is designed to operate on low voltage, external AC or DC (12 volts), or 30 or 60 volts cable power. In addition, a battery back-up option is available, allowing approximately 2 hours of operation on rechargeable Nicad batteries. These batteries are under constant trickle charge when the unit is normally powered.

The TRU System operates on a polled basis under control of the user's computer or a stand-alone, microprocessor-based, TRU controller. The master modem is simply a TRU-100 remote unit with the transmit and receive frequencies interchanged or translated so that the master transmitter will be on the same frequency as the remote receivers and vice versa. This variation is called the TRU-200. In operation all remote units listen continually on the same frequency. Each unit receives all messages and searches for its unique address. Figure 3 depicts a typical TRU System.

The data transmission both to and from the remote units utilize the same speed and general format. The data rate is 38,400 bits per second (38.4 kBs) in a standard 11 bit asynchronous character format. The 11 bits include a START bit, 8 data bits, a parity bit, and a STOP bit. Each transmission includes a initialization byte (a byte is one 11 bit asynchronous character), a control byte, one or two address bytes, and optional message bytes. The system is capable of addressing over 4,000 units using 12 binary bits which require 2 address bytes. A system of 250 units or less needs only 8 bits for addressing and therefore utilizes only one address byte.

The control byte has numerous housekeeping functions including specifying the number of data bytes in a given transmission. In some cases it is only desirable to know that a remote unit is there and functioning. In this case data messages, downstream or upstream, are not necessary and no data bytes are transmitted in either direction. In the more common application, a number of message bits are transmitted downstream along with each poll and a specific number of status bits are returned with each remote unit response.

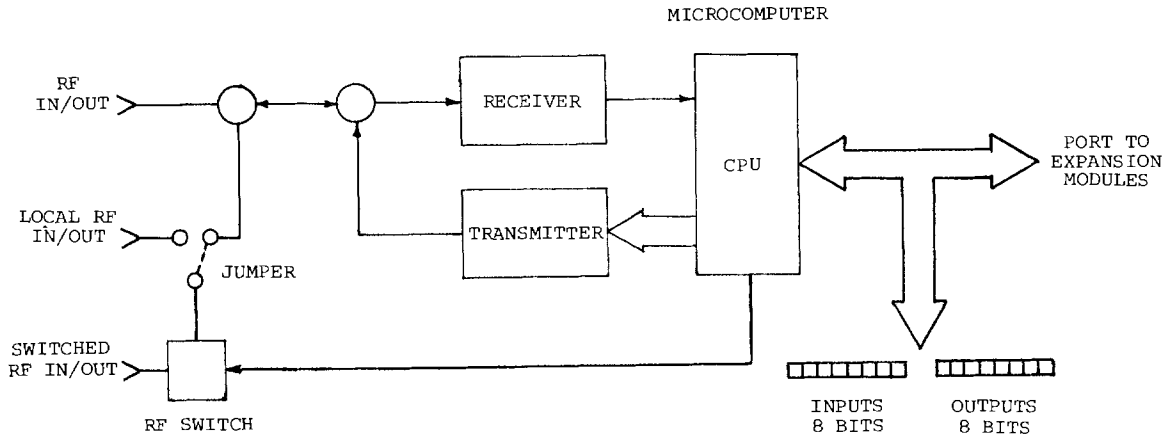

Figure 2 - TRU-100 BLOCK DIAGRAM

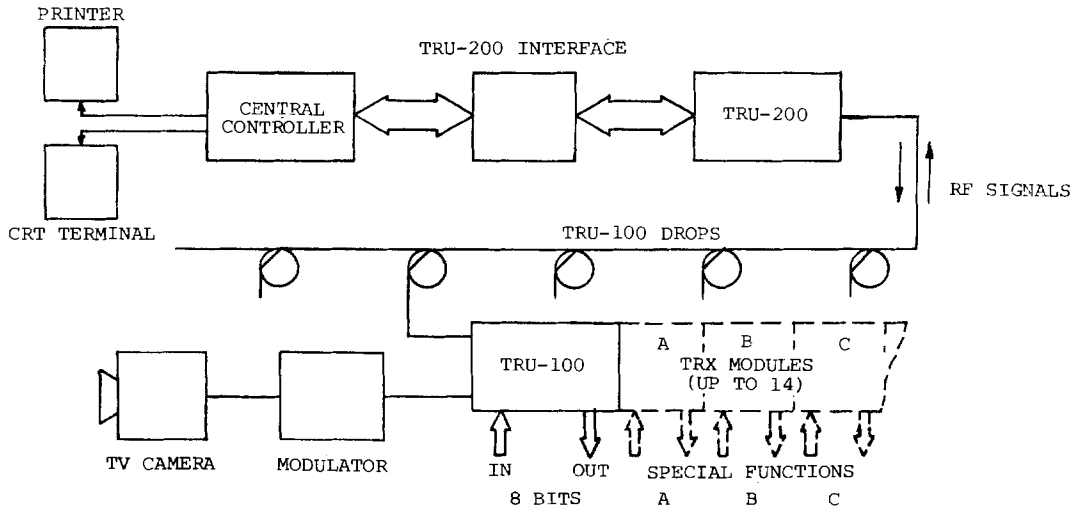

Figure 3 - TYPICAL TRU SYSTEM

The TRU-100 remote unit is organized to receive 8 bits of data on each downstream poll. These are presented as 8 saturated transistor outputs, with high voltage protection, on a terminal strip within each unit. The TRU-100 receives one additional bit of information on each poll which is utilized to open or close an RF switch that is contained within the unit. This RF switch can be arranged to switch the entire cable system downstream spectrum, as would be required to turn a CATV drop on or off. It may also be configured to switch a local RF source, such as a modulator for a camera, thereby allowing central command of local RF functions.

Every time a TRU-100 remote receives a poll it immediately responds. The normal response can include the entire address or a portion of the same at the system operator's discretion. This response verifies that the unit in question is active and has received a valid address and has responded to it. The TRU-100 at this time can return 8 bits of status information. These 8 bits are presented to the TRU-100 as either switch closures or logic level signals at 8 additional points on the terminal strip.

It can be seen that both the downstream and upstream information can readily be applied to all sorts of services. Security zones can be sensed as well as thermostat closures, panic button actuations, and status indications of all kinds. The downstream information can also be used in many ways. Blowers, compressors, air conditioners, etc. can be controlled for energy management; door strikes can be actuated for security; camera controls can be implemented; and various functions can be activated in process control systems; to mention but a few.

In summary, the basic TRU-100 can be employed in systems as large as several thousand units. The entire system occupies only one 250 kHz channel in the upstream direction and one in the downstream direction. Eight bits of data can be supplied on every poll plus control of a local RF switch, and 8 bits can be returned on every response. Polling of all units in a system of 250 can be achieved several times every second. All units in a system of 4,000 units can be accessed once in approximately 6 seconds. It can be seen that the basic TRU System can be widely applied and provide a low cost means of implementing many, many status and control functions where communications on a coaxial system are available.

EXPANSION

There is a large additional area which has been addressed in the TRU. In many systems, requirements arise which will not fit conveniently within the basic "8 bits down, 8 bits back" format. As an example consider complete control of a surveillance camera. In this case pan, tilt, zoom, and iris control need to be implemented with two functions each (up/down, left/right, etc.) plus high and low speed. There are often other camera controls such as power, windshield washer and wiper, heater, cooler, etc. It is also desirable, in certain applications, to have preset options available and to provide common sync for the cameras. It is obvious that there are many more functions here than can be handled with the 8 control bits available on the basic TRU-100.

The design of the TRU-100 is such that the microprocessor system buss and control lines are available for this eventuality, on a printed circuit connector conveniently located at one end of the unit. When a particularly complex task is required, a TRU extender (TRX) is constructed which includes the hardware necessary to do the task. In the case of elaborate camera controls, this hardware includes some electronic circuitry and a number of relays to switch the relatively high voltages and currents needed by the various camera and mount functions. This module interfaces with the TRU-100 processor buss and also contains the program to direct the special functions provided by the module. In this case, the downstream data required to control the camera might well employ three or four 8 bit data words on each downstream poll. As mentioned before, the basic system protocol is capable of expansion to the required number of data bytes necessary for each individual remote unit (the 8 bits down and back are still available for other uses such as security zones, door strikes, energy management, etc.). The TRU-100 remote unit is capable of accepting up to 14 modules which may be individually or collectively addressed.

The advantages of the TRU System organization described above are numerous.

1) The basic system is low cost, which allows deployment for simple tasks while retaining economic viability. When more complex tasks are implemented with plug-in modules, these modules need only be installed at those locations where the particular functions are required. In

this way the economics of function expansion are excellent as there is no need for the whole system to be upgraded.

2) All TRU-100 remote units (excluding plug-ins) in a system are identical with the exception of the specific addresses which are set in at the time of installation. This means that logistically there is no difference between remote units. One spare TRU-100 carried by a service man can be used to replace any unit in the field.

3) The loading of the data stream by the more complex tasks with greater transmission requirements again is not system wide, but only to the extent necessary to service the specific extra capability modules, and only at those specific times when extra data is necessary.

4) Additional units can be added to the system at will. It is simply a matter of installing a proper cable drop and adding the additional address to the polling index and setting it into the TRU-100 remote.

5) The system is self-testing since the system controller is immediately alerted to the fact that there is trouble when either no answer or an improper answer is received to a poll. In this manner diagnostics of system problems such as broken cables, amplifier outages, and the like can be done from the central control point and lead to rapid identification, location, and correction.

TYPICAL APPLICATIONS

The following are brief descriptions of typical applications and installations of the TRU System. These are not complete in every detail but do serve to illustrate the various applications and implementations using the TRU equipment.

Residential Security Carried on Entertainment CATV Network

This is a typical situation in which a CATV operator wishes to develop a source of additional revenue. Generally a security service is contracted to respond to alarms, while the CATV operator is responsible for the transmission equipment and system maintenance.

Let us assume that it is desired to provide intrusion security, smoke detection, medical alarm, panic alarm, and power outage sensing. Let us also assume a requirement to control residential outside lights and siren or bell alarms from the central station. All of these services are to be offered to the customers on the system, but can be individually accepted or rejected. Regardless of the number of services selected, each customer is supplied with a TRU-100 remote terminal. This is mounted in an inconspicuous space within the residence. Each TRU-100 can handle up to 8 separate commands downstream and return 8 separate bits of status information upstream. In the case of intrusion protection, the residence is wired with normal sensors, such as window and door switches, tapes, sonic, infrared, or microwave motion detectors, and the like. If simple loops are employed, no security junction box is needed, reducing the cost of the sensor installation. All circuits terminate at the TRU-100. It may be desirable (or more convenient) to assign separate bit inputs on the TRU-100 to separate zones of the residence, or separate sensors, such as motion detectors. Any arbitrary assignment is acceptable as long as correlating information is given to the controlling computer at the central station. Medical and panic alarms are handled in the same manner by utilizing separate bit inputs on the TRU-100. Power outage sensing is automatically provided through control information in the TRU data stream (in addition to the 8 bits under discussion). If local power goes off, the TRU-100 will continue to function for approximately 2 hours on its internal batteries, however, an alarm will immediately be given and service personnel can be dispatched.

Since downstream control is possible there are many deterrent measures which can be instituted by the central station operator. It may be desirable to delay lights and alarms after violation of a security zone and put them under the control of the central station operator. Interfacing to these services from the TRU-100 can be handled directly if low voltage DC control circuits are available. In the case where higher power must be controlled, an external relay is required whose control winding is connected to a power supply and to the TRU-100 (power relays are available in modules such as the TRX-403). Figure 4 gives a schematic representation of a typical residential installation.

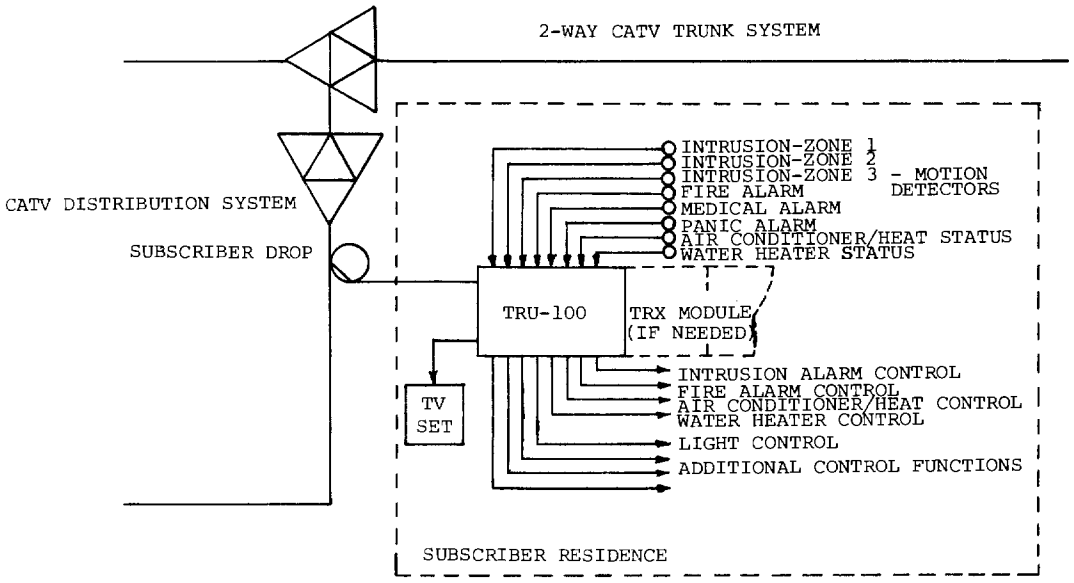

Figure 4 - TYPICAL TRU/CATV RESIDENTIAL APPLICATION

The TRU system employs a master modem (TRU-200) which is connected to an intelligent controller, programmed for the functions required. The control system is often available at the local security central station so that only a TRU interface module is required to connect the TRU-200 to the security controller. In stand-alone systems a series of special TRU controllers are available.

In any of these systems the controller (or special interface unit) initiates the polling of the remotes. The controller stores the normal status of each control bit and alarms changes and reads out pertinent information of the location, owner's name, response instructions, and the like.

It can be seen that even with a rather elaborate security installation the TRU-100 (8 bits down, 8 bits back) provides enough information for complete monitoring and control with some capability left over. In addition, the RF switch in the TRU-100 allows the cable operator to control the TV service either in a connect/disconnect fashion or, by switching of traps or descramblers, for pay TV or similar services. Any unused data is available for other services. In many areas the local power companies are doing residential load shedding in high demand periods by shutting off air conditioners, water heaters, etc. for short periods of time, as required for load reduction. Transmission of the monitoring and control functions for such services can be provided by the CATV operator through the TRU-100 and interfaced with the electrical devices through power company supplied relays or control devices.

Commercial Building - Security and Energy Management

Numerous systems exist for security and energy management in commercial buildings. They are generally based upon installation of twisted pair cables from the central location in the building to each area where control is desired. A prime advantage of using the TRU System is greatly reduced wiring cost since the entire building can be served on a single coaxial cable using CATV drop techniques. The cost of installation is considerably less than the equivalent twisted pair installation. In small and medium size buildings repeater amplifiers are unnecessary. In larger buildings, indoor distribution amplifiers with two-way options may be required. Wherever control is necessary, a standard directional tap is installed to provide the drop with proper signal levels.

One TRU-100 remote unit can service a total of 8 signals coming from security or energy management sensors. With this capacity several rooms may be served with one TRU-100. The security zones and energy management sensors (thermal switches, etc.) are connected to their appropriate bit inputs on the TRU-100. Energy management controls (usually relays) controlling fans, air conditioners, heaters, etc. are connected to the downstream terminal strip on the TRU-100. The control bits in most cases are programmed as latching functions but momentary operation with selectable duration is also available. Latched functions allow a device to be turned "on" and not serviced again until it is required to be turned "off". Since polling is quite rapid in comparison to the length of the device control cycle, the main controller can be programmed to repeat the command at intervals, as a confirmation of the command. This is easily accomplished in the normal polling routine of the controller.

A system in a commercial building is similar to the residential system although it might be considered to be a private CATV network. There is no need to connect to "the outside world" since all of the functions and control decisions are made within the building or building complex. The same TRU System can be extended to entrance and roof door security, smoke and fire sensors, and a multitude of other tasks.

When this system is installed it is obvious that the wide bandwidth of the coax is available to handle other services. Many security cameras can be distributed throughout the building and returned on separate RF channels to the monitoring location. In a case where the amount of spectrum available for surveillance cameras is limited, it might be desirable to assign several cameras to one RF channel. In this case the TRU-100 RF switch feature can be used to gate only one camera at a time. This reduces the number of video channels required on the cable system and eliminates the need for a sequential switcher at the monitor point. TV can also be distributed and sold to occupants of office suites. Audio channels can be carried and, as a matter of fact, the TRU System can be used as an intercom controller. Figure 5 illustrates a commercial building TRU System.

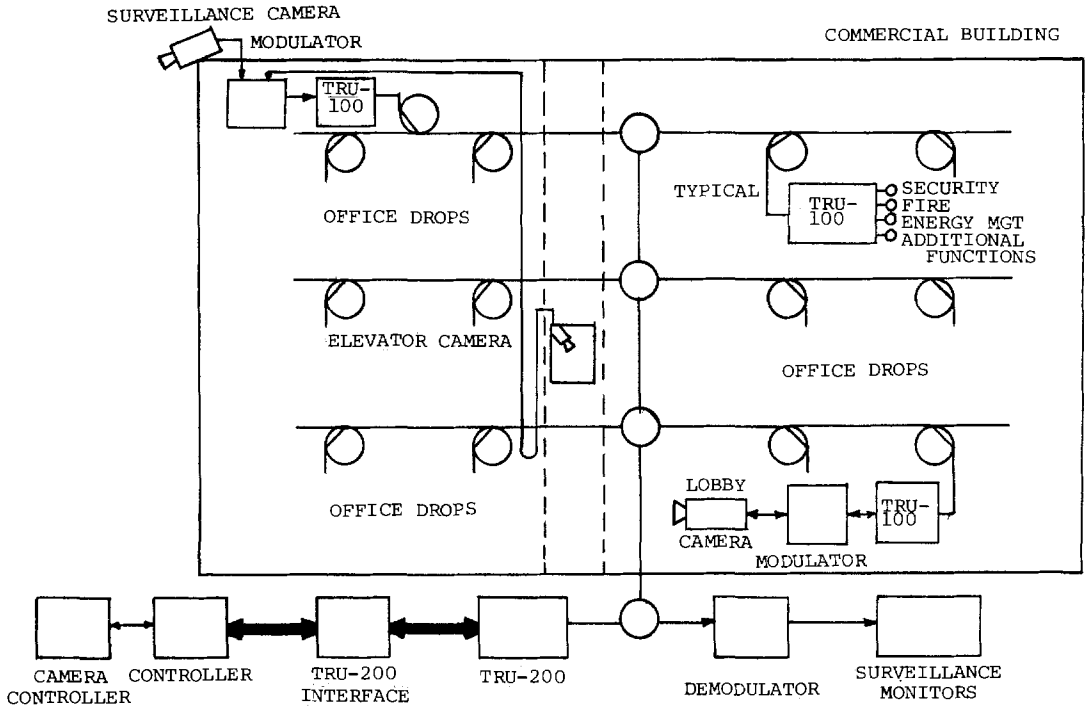

Figure 5 - TYPICAL TRU COMMERCIAL APPLICATION

Industrial Monitoring and Control System

More and more industrial users are employing coaxial communications networks. These have been dubbed "broadband systems" and are now the subject of possible standardization by the EIA. The advantages of broadband are: lower cost of wiring, immunity to noise, resistance to severe environments, and extremely large information capacities, all of which are most attractive to industrial users.

Many industrial processes utilize computer control. In present systems there are a number of limitations imposed by utilization of twisted pairs to interconnect sensors and processing equipment. In many cases minicomputers must be placed in undesirable plant environments to reduce the twisted pair cabling connecting to the sensors. Employment of the TRU System allows location of the TRU-100 remote units in the sensor areas but removal of the processing computers to office environments.

There are other advantages of employing the TRU System. In many cases ON/OFF monitoring is all that is required along with ON/OFF commands. In these instances the basic TRU-100 can supply 8 separate downstream commands and receive 8 separate upstream status signals, all of which can be serviced on each poll. In many applications, however, there are more complex requirements. There is often a need to transmit analog information. This is accomplished in the TRU System by addition of TRX modules with A/D and/or D/A converters which allows digital carriage and processing of the analog signals. Several versions of these modules give a choice to the system designer. A/D conversion is available in 8, 12, or 16 bit resolutions. Commutation switches with 4, 8 or 16 ports are also available to allow the collection or dissemination of data from more than one sensor or transducer at a given TRU remote location. Note that only those locations in a system requiring the special functions need to be outfitted. This means that the cost of the system is only increased at those locations where increased capability is required.

There are still other extensions of the TRU-100 for industrial applications. Since the data processing in the TRU-100 is accomplished by a microprocessor, this computing power is available to any auxiliary function. In a special application it might be required that data be taken locally at a relatively high rate, reduced or processed to obtain peak values, averages, minimums, etc. and the result of these computations, transmitted to the central point when the unit is polled. In a case like this the firmware necessary to implement the data processing is supplied in the special TRX module. In these cases the TRU-100 has become a very intelligent data gathering and processing terminal. The TRX-501 module allows interfacing of low and medium speed asynchronous terminals to the system. By use of the TRX-501, any terminal in the system can communicate with another on an apparent point-to-point basis. The scope of applications for these techniques is limited only by the system designer's imagination.

Other Applications

It can be seen by the three specific applications above that the TRU-100 system can be applied throughout a large area of command and/or monitoring applications. Hospital systems can employ the TRU for nurse call, intercom, data transmission, control and monitoring of medical electronic devices, security, energy management and many other things. Traffic and traffic light control is another obvious application of the TRU System.

Status monitoring and control in CATV systems is also quite attractive. Simple cable amplifier operating functions such as power and AGC monitoring can be done with the standard TRU, leaving additional inputs and outputs for feeder and tap switching, etc. More complicated functions such as remote summation sweeping or spectrum analysis can be accomplished with plug-in TRX units. Microwave system monitoring and control can also be implemented. The list goes on and on.

In summary, the TRU System is an extremely versatile command and monitoring system capable of expansion to more complicated functions, making use of the ubiquitous coaxial communications network.