

**DESIGN AND TEST OF MULTIPLE NETWORKS
ON A SINGLE BROADBAND CABLE PLANT**

by
Kuo Chen Wang

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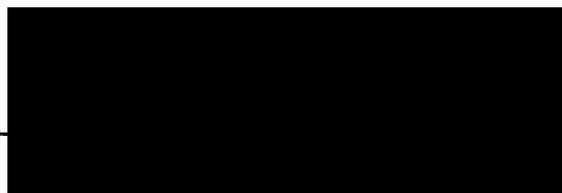
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APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:



Ralph Martinez
Associate Professor of
Electrical and Computer Engineering

25 Nov 86
Date

DEDICATION

This thesis is dedicated to my wife, my mother, my family, and my wife's family. This thesis is especially dedicated to my late father whose love and teaching has been the spiritual motivation of my study.

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ABSTRACT

In this thesis, the description of a multiple local area network testbed system built on a single coaxial cable plant will be presented. The multiple local area networks consist of a Sytek LocalNet 20, a Sytek System 6000 (PC-NET), and a Concord Data Systems Token/Net. Each network has its own features, and is suitable for its special application area.

The main goal of this thesis is to design and test the above mentioned multiple networks on a single coaxial broadband cable plant on a non-interfering basis, so that separate cables do not need to be installed for each network. This thesis involves the design and test of hardware and software. It has been proven that these three networks can coexist on the same cable plant without causing interference. The testbed lays the foundation for providing extensive multiple services including data, voice and video on the campus broadband network. These three networks have been switched to the existing Sytek cable plant and are currently operating successfully in the Computer Engineering Research Laboratory.

CHAPTER 1

INTRODUCTION

Over the past few years, the University of Arizona has successfully connected different kinds of terminals and host computers together among departments on a single coaxial cable by using the Sytek LocalNet 20 data communication system. This broadband cable network uses a Sytek LocalNet 50/50 translator to receive low band radio frequency (RF) signals from transmitting devices connected to the network and upconverts these signals to high RF signals. It then retransmits the RF signals to receiving devices connected to the network (Sytek, 1984a).

Here, a midsplit system has been adopted for frequency allocation which provides reverse frequency from 5 to 116 MHz and forward frequency from 168 to 400 MHz. In this way, different types of terminals and host computers may communicate with one another through different kinds of interface devices such as Packet Communication Units (PCUs) which are implemented by Frequency Division Modulation (FDM) and Carrier Sense Multiple Access with Collision Detection (CSMA/CD) techniques on a single coaxial cable system. Thus, different departments can share resources through this broadband network, and reach a higher level of utilization

of resources by sharing data, files and devices. Also, this broadband cable system provides the potential to make multiple services including data, voice, and video become possible on the same cable plant.

1.1 Statement of the Problem

In this thesis project, a testbed system which allows a Sytek LocalNet 20, a Sytek System 6000, and a Concord Data Systems (CDSs) Token/Net to share a single coaxial cable was designed and built.

The advantages of multiple networks piggy-backing on a single coaxial cable is that separate cables do not need to be constructed for each network. Besides, data, voice and video can coexist on the same cable plant. The criteria for selecting these three networks were based on the characteristics associated with each network:

1. The Sytek LocalNet 20 has medium user data rate between 75 to 19,200 bps (bits per second).
Therefore, it is suitable for data communications between terminals and computers. Furthermore, its medium access method is CSMA/CD, and its service distance from an outlet to the headend can reach up to 5 KM. Each channel in the LocalNet 20 has a data rate of 128 Kbps.
2. The Sytek System 6000 is specially designed for data communications between IBM personal computers (PCs)

(or compatibles). It is suitable for file sharing among PCs. It has a data rate of 2 Mbps, and can serve up to 5 KM of cable distance. The maximum number of PC's per network is 1000. Its medium access method is also CSMA/CD.

3. With a high data rate of 5 Mbps, a CDS Token/Net is excellent for data communications between host computers. It is suitable for file transfers, and can serve up to 32 KM (20 miles) of cable distance. Its medium access method is Token Passing algorithm implemented on a bus.

There are two phases which are of concern in this thesis. During the first phase, an experimental broadband single cable plant for testing and analyzing the feasibility and reliability of multiple networks will be installed. Figure 1.1 shows this type of basic structure for multiple networks. During the second phase, if it is proven that the multiple networks on the same cable plant are reliable and non-interfering, it will be valuable to adopt this structure to expand the current Sytek LocalNet 20 broadband cable system to provide multiple services and to extend the service area.

Multiple Headends

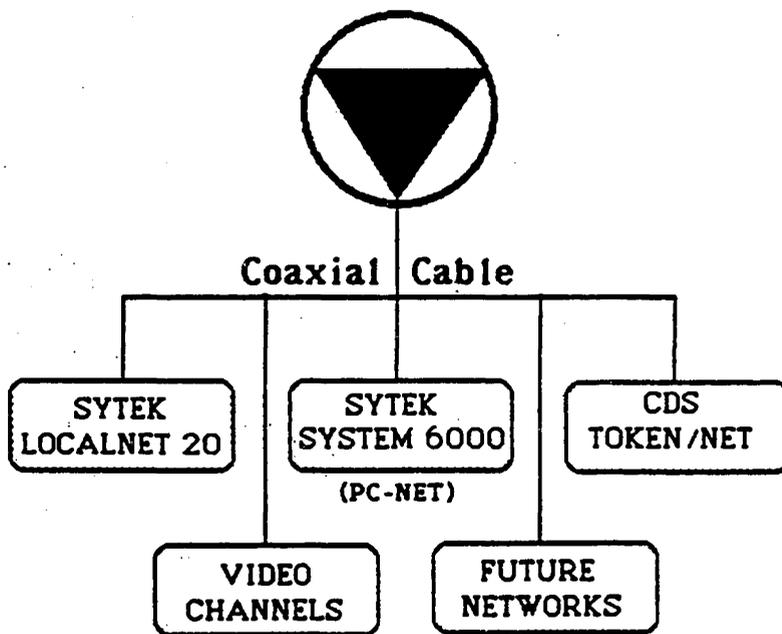


Figure 1.1. Multiple Networks Basic Structure

1.2 Thesis Objectives

The objective of this thesis is to design, build, and test multiple local area networks on an existing single broadband cable plant. The resulting networks are to be assembled into a testbed using computer hosts and CRTs on each network, including the testing of PC-NET software services. The testbed will provide the basis for multiple networks on the College of Engineering broadband cable plant.

1.3 Approach

Since broadband cable system design is an art involving not only broadband network technology but also practical experience, the primary data source was collected from the existing Sytek network to analyze those design factors such as system structure, physical layout, frequency allocation, signal level in each outlet, noise and distortion. The secondary source will include specifications and documentation of the three networks, and network components such as a coaxial cable, Packet Communication Units (PCUs), Token/Net Interface Modules (TIMs), PC Network Adapter Cards, frequency translators, a diplexer, amplifiers, splitters, combiners, terminators and directional couplers.

To design and implement this experimental network, the following areas of inquiry will be pursued (Cooper,

1984):

1. Decide system structure and physical layout.
2. Allocate frequency for multiple networks.
3. Design reasonable signal levels for these three different networks on their respective outlets.
4. Analyze noise level and distortion.
5. Design a headend containing three translators.
6. Adjust each translator gain.
7. Proceed with trunk design.
8. Install software for each network including PC-NET.
9. Analyze performance of each network.
10. Perform overall system adjustment to create an optimal operational environment.

After understanding broadband network techniques and those broadband network component functions, the next step was designing a multiple network system, and then ordering parts for this testbed system. The final steps were installing, testing, adjusting, and analyzing the system together.

1.4 Local Area Networks Background

There are three types of Local Networks: Local Area Networks (LANs), High Speed Local Networks (HSLNs), and Computerized Branch Exchange (CBXs) (Stallings, 1985). Among these Local Networks, LANs are the most popular and

widely used. LANs can support the communications among terminals, personal computers and host computers within a small area. In the following subsections, the characteristics of LANs in terms of topologies, transmission media, protocols, broadband versus baseband, frequency allocation formats, and single cable versus dual cable will be elaborated.

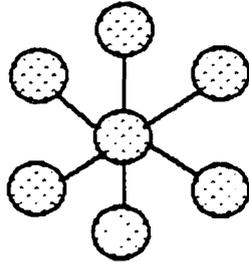
1.4.1 Topologies

Topology means the physical or logical placement of nodes in a computer network. Star, ring, bus and tree are four common topologies which are shown in Figure 1.2. The choice of a suitable topology depends on these application needs: flexibility, complexity, reliability, expandability and performance. In this thesis project, we adopted a tree structure because of its expandability. Actually, a tree structure is a generalization of a bus structure with no loop in its transmission medium.

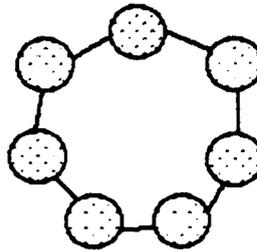
1.4.2 Transmission Media

Transmission media are the physical connection materials among nodes in the computer networks. A twisted pair, a coaxial cable and an optical fiber are common transmission media (Martinez, 1985). A twisted pair can transmit digital signals (10 MHz), and are usually applied in the baseband LANs. Its new applications are for office

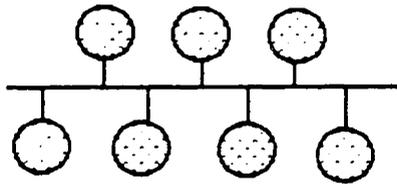
1. Star



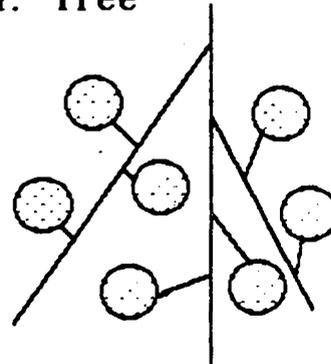
2. Ring



3. Bus



4. Tree



Node



Transmission Media

Figure 1.2. Basic Local Area Networks Topologies

automation and PC networks. A twisted pair is often used because it is inexpensive. However, it is noisier than a coaxial cable when used in the higher frequency 10 - 100 MHZ. A twisted pair cannot support the high data rates which are supported by a coaxial cable or an optical fiber.

The most versatile transmission medium for local area networks is a coaxial cable because it has a higher noise immunity and higher capacity than a twisted pair. A coaxial cable can transmit digital signals (10 MHZ) or RF signals (5 - 400 MHZ), and is usually applied in the baseband and broadband LANs. Using an optical fiber as a transmission medium is a new trend for local area networks. It can transmit light signals (300 GHZ), and is usually applied in the mixed service networks. On the other hand, it is expensive and difficult to make a connection between cables. Therefore, in this thesis project, a coaxial cable was adopted as the transmission medium.

1.4.3 Protocols

A protocol is a set of conventions between communication processes of the formats and contents to be transmitted. It usually defines data formats, error detection and error recovery techniques, timing, hardware, and software configurations. Presently, CSMA/CD, Token-Passing Bus, and Token-Passing Ring are the most popular media access schemes.

A CSMA/CD is a collision technique popularly used in the local area networks. It is an IEEE 802.3 standard specifications for local area networks (IEEE, 1985a). It means that a node preparing to transmit first senses the transmission medium and transmits only when the medium is idle. If it detects a collision, it ceases transmitting and waits a random amount of time, then attempts to regain the medium. The Sytek LocalNet 20 and Sytek System 6000 PC Network System which are used in this thesis project utilize a CSMA/CD scheme.

A Token-Passing Bus is an IEEE 802.4 standard specifications for local area networks (IEEE, 1985b). It means that the nodes on the bus form a logical ring, and a token frame is passed around the logical ring. A node may transmit and receive the token, and then must pass the token to the next node in the ring when time is out or finishes transmitting. The Token-Passing Bus algorithm is outlined below (Martinez, 1985):

1. Token is passed among nodes in a descending node address order.
2. Token sender listens to make sure that the next node has received the token.
3. If there is no response on the next node, this node sends a "Who-Follows" frame.
4. If there is still no response, this node send a

second "Who-Follows" frame.

5. If there is no response to the second "Who-Follows" frame, this node sends a "Solicit-Successor" frame. All nodes respond to re-establish logical ring by using Response Windows.
6. If two "Solicit-Successor" attempts fail, this node gives up.

The CDS Token/Net is one of the networks which is implemented by a Token-Passing Bus scheme.

A Token-Passing Ring is an IEEE 802.5 standard specifications for local area networks. It means that a token circulates around the ring. A node may transmit by grasping the token, inserting a packet into the ring, and then retransmitting the token to the next node. The IBM corporation has adopted the Token-Passing Ring protocol in one of its computer network products, the IBM Token Ring Network.

1.4.4 Broadband verse Baseband

Broadband and baseband are two transmission signalling techniques which are used in the local area networks. Broadband is a term used to mean a wideband type of communication network. It is a transmission technique using analog signaling in radio frequency (RF) where the digital data are modulated onto a RF carrier frequency. The community Antenna Television (CATV) industry has used this

technique to build 75 ohm cable TV systems in municipalities. The local area network industry also has adopted this technique to develop a so-called broadband network. A broadband network can provide multiple services, such as, data, video and voice on a single cable plant.

Baseband refers to the digital signaling transmission in its digital form without being modulated. It uses the entire frequency band by transmitting a single digital signal with encoded data bits. A representative baseband LAN is the Ethernet Local Area Network (XEROX, 1982).

The main characteristic differences between broadband and baseband are shown in Table 1.1 (Stallings, 1984). From Table 1.1, it is concluded that a baseband technique is suitable for application to a smaller area with low communication demands in the local area network. A broadband technique is suitable for multiple services LANs over a wider geographical area.

1.4.5 Frequency Allocation Formats

Currently, there are three different frequency allocation formats being used for broadband systems: subsplit, midsplit, and highsplit (Cooper, 1984). A subsplit Format is used by most of CATV two way cable system. Its reverse band is from 5 to 30 MHZ, and its

Table 1.1. Comparison of Broadband versus Baseband Characteristics

Characteristics	Broadband	Baseband
Media	Coaxial Cable	Twisted-pair Coaxial Cable
Topology	Tree/Bus	Bus
Signal	Analog	Digital
Bandwidth(BW)	Channels by FDM Technique	Required Whole BW
Directionality	Unidirectional	Bidirectional
Services	Multiple- data Voice, Video	Single
Distance Order	10 KM	1 KM
Capacity	High	Low
Cost	Medium	Low

forward band is from 54 to 400 MHz. Due to the high bandwidth of forward band, it is suitable for a system where most of the information originates from the headend. A CATV system is a good example of this.

A midsplit format is used by the three broadband networks in this testbed system. It is usually used by data communication networks. Its reverse band is from 5 to 116 MHz and its forward band is from 168 to 400 MHz. Due to the greater reverse bandwidth, it is suitable for two way interactive data, voice or video networks. The IEEE 802 specifications have adopted this format as the standard for LANs.

A highsplitted format is suitable for a system which needs high reverse bandwidth. Its reverse band is from 5 to 174 MHz and its forward band from 232 to 400 MHz.

1.4.6 Single Cable versus Dual Cable

In the broadband cable system, we might use either a single coaxial cable or a dual coaxial cable as a transmission medium. A single cable system is a two-way communication system which transmits different signals on different channel frequencies in the opposite directions by dividing the available frequency spectrum on the cable into two frequency bands. These two frequency bands are called a forward band and a reverse band. A reverse band is a low band where signals are transmitted toward a frequency

translator called a headend. A forward band is a high band where signals are transmitted away from a headend. A single cable system is usually used by universities, research institutes, or businesses.

A dual cable system uses two cables, one for forward direction transmission, the other for reverse direction transmission. Normally, the reverse band is from 40 to 400 MHZ and the forward band is also from 40 to 400 MHZ. Dual cable systems don't need to have a diplexer (also called diplexer filter) on the front end of a headend or inside an amplifier because there is no interaction or interference between reverse and forward signals. It is usually used by governments or military units because of security and availability considerations.

Except for reasons previously mentioned or special purposes, a single cable system is better than a dual cable system. A dual cable system uses almost twice the equipment that a single cable system requires. Furthermore, a dual cable system is not easy to maintain compared to a single cable system.

CHAPTER 2

MULTIPLE NETWORKS COMPONENT DESCRIPTION

In this chapter, the characteristics and functions of multiple network components will be described. The three networks in this testbed system are a Sytek LocalNet 20, a Sytek System 6000 (PC-NET) and a Concord Data Systems Token/Net.

2.1 Sytek LocalNet 20

A Sytek LocalNet 20 is a broadband Local Area Network. It applies the same techniques and equipment as CATV to build its transmission medium in such a way that it can provide a wide variety of data communication services on a single coaxial cable. A LocalNet 20 can serve up to 200 simultaneous active users on a single channel within a range of 5 KM area. A LocalNet 20 Packet Communication Unit (PCU), either a LocalNet 20/100 or a LocalNet 20/220, and a Central Retransmission Unit (also called a translator or headend) LocalNet 50/50 are two basic units combined to form a LocalNet 20 system on a single cable plant.

A PCU can connect one or more terminals, host computers or other devices to the network with a reverse band transmitting frequency of 70 - 76 MHZ signal through

the cable network to the translator LocalNet 50/50. The translator with an offset frequency of 156.25 MHz then retransmits the signal with a higher forward band frequency of 226.25 - 232.25 MHz to another PCU which is also connected to terminals, host computers, or other devices. By means of a translator, two-way data communications on a single cable becomes possible. PCUs also have frequency agile modems which can be set by a user to one of several frequency channels.

2.1.1 LocalNet 50/50 Central Retransmission Unit

A LocalNet 50/50 Central Retransmission Unit is a frequency translator which is located at the headend of a network. Depending on the specific options, it has different reverse band frequencies (40 - 106 MHz), and forward band frequencies (192 - 262 MHz) (Sytek, 1983a). In this project, a channel group A (70 - 76 MHz) is available. Its basic operation is to receive reverse low band signals (70 to 76 MHz) from source PCUs, translate these signals to forward high band signals (226.25 - 232.25 MHz), and then retransmit these signals to destination PCUs in the forward direction. The specifications of LocalNet 50/50 is shown in APPENDIX A.1.

On the front panel of LocalNet 50/50, there are two attenuation knobs, one for reverse attenuation, the other for forward attenuation. Both of the attenuators have to be

set to the right values in order for the LocalNet 50/50 translator and the cable network to operate properly. The reverse signal first goes to the reverse attenuator. The reverse attenuation knob can be used to adjust the signal level received from the cable network from 0 to 50 dB by turning the outer dial in 10 dB increments and the inner dial in 1 dB increment. The amplifier in the translator then amplifies the signal level with about 50 dB gain. Afterwards, the signal goes to the forward attenuator which does the same thing as the reverse attenuator with attenuation variance from 0 to 50 dB. The reverse monitor on the front panel can also be used to measure the input signal to the translator which is 20 dB below the input signal level. The forward monitor does the same job for the output signal level of the translator. And, the power LED turns red when the AC power is on. The LOCAL OSCILLATOR jack is used to provide internal local oscillator output signal with 20 dB attenuation.

On the back panel of LocalNet 50/50, the RF INPUT port is used to receive the reverse RF signal from the cable network. The RF OUTPUT port outputs the forward RF signal to the cable network. If there is a LocalNet 50/55 Redundant Headend Switch, the PILOT OUTPUT port can provide a forward pilot signal to the Switch and the PILOT INPUT

port can receive the pilot signal from the Switch. The AC POWER CONNECTOR is used to connect to a power cord.

2.1.2 Packet Communication Unit (PCU)

A PCU is an intelligent network interface device. Its essential functions are packet assembly and disassembly, buffering, session management, protocol and code conversion, baud rate matching, data security, error control, and flow control (Sytek, 1984). Its basic service to user devices is to provide full duplex transporting of data bytes between source and destination devices during a session. The PCU uses a communication access method called Carrier Sense Multiple Access with Collision Detection (CSMA/CD). This method allows a PCU to share the communication channel with other PCUs at the same time.

A CSMA/CD access method has the following characteristics (IEEE, 1985a):

1. A CSMA/CD is a medium access control method used in a multiple access transmission medium.
2. A node ready to transmit data first senses the medium to make sure if the medium has carriers or is idle. If the medium is idle, the node begins to transmit. Otherwise, the node waits a random period of time, then senses the medium again.
3. During transmitting, the node continues to monitor

for collisions. If it detects an occurrence of collision, it ceases transmitting.

There are two kinds of PCUs. One is a LocalNet 20/100 with 2 ports. The other is a LocalNet 20/220 PCU with the port number up to 32. The baud rate may range from 75 to 19.2 Kbps (Kilo bits per second). The hardware interface is EIA RS-232C compatible. The specifications of LocalNet 20/100 PCU is shown in APPENDIX A.2.

A PCU has three interface modes: command, autobaud, and data transfer (Sytek, 1984a). A command mode is indicated by a prompt sign "#". An autobaud process begins when the reset button at the back panel of a PCU has been pressed twice (double reset). The PCU tries at a baud rate of 19.2 Kbps the first time, then decreases the baud rate to the next lower level if the baud rate is not matched between the PCU and the device. The user must press the carriage return (CR) several times in order for the PCU and the device to match their transmission speed. Then, the user may begin to make a connection to a remote computer. After a successful CALL or PCALL command has been issued, the PCU enters data transfer mode. At this time, a session is established. Then, a user can log-in to the remote computer, and start to transmit and receive data.

As for PCU management, there are two types of attributes: one for global PCU management attributes; the

other for specific port data handling attributes. The global attributes include UNIT (unitid), CHANSP (channel spacing), LOCATION (linkaddress, channelNo), PRIVILEGE, and enabled commands, which are used to control the identification of a PCU, its location, and its protection status on the network. These global attributes are the same for all ports on a given PCU. The specific attributes for each port are those commands shown on the STATUS command excluding the global attributes shown above. According to different needs for each port, specific parameters may be specified for each ports. The LocalNet 20 Reference Manual and Installation Guide (Sytek, 1984a) contains a detailed description of each command, or refer to APPENDIX F for additional LocalNet 20 command description.

On the front panel of a PCU, there are two LEDs, one for POWER indication, the other for STATUS indication. On the back panel of a PCU, there are the following elements: a power connector, two DB-25 connectors (two ports, port 0 and port 1, on the LocalNet 20/100), a type F coaxial cable connector, and a RESET push button. A DB-25 connector is used to connect a PCU to a terminal or a computer through a RS-232C cable (Usually, only pin number 1 through 8 and 20 are used for LocalNet 20). The RESET button is used to cause the PCU to do self tests and to reset most of its

attributes to its initial values. The PCU is now ready to proceed to autobaud process.

2.2 Sytek System 6000

A Sytek System 6000 is designed for IBM Personal Computer (PC) to IBM PC (or compatibles) data communications. It facilitates resources sharing, file transfer, and terminal access among PCs. Its medium access method is the CSMA/CD technique. It is the Sytek version of the PC Network. Its frequency translator Sytek 6050 is fully compatible with the IBM PC Adapter Card. The Sytek 6051 Network Translator which is used by the IBM PC Network can support up to 72 PCs for small networks. The Sytek 6050 Network Translator can support up to 1000 PCs for large networks. The basic components of Sytek System 6000 for a single cable plant in this thesis project are a Sytek 6120 Network Adapter Card and a Sytek 6050 Network Translator.

A Sytek 6120 Network Adapter Card is a special network interface card for connecting IBM PC, XT, AT, RT, or IBM PC compatible personal computers to a broadband PC network. In this thesis project, an AT&T 6300 and an Artisoft XT were connected to the PC Network. The Sytek 6120 Network Adapter Card can also be applied to the following IBM PC compatible personal computers: Zenith Z-151, Z-158 and Z-2000, NCR Model 6, Model 8, Model 4i with dual disk or hard disk, NCR Model 4 with dual disk, ITT

Xtra, Compaq Deskpro, Model 286, and Compaq Portable (Sytek, 1986). In order for a PC to be connected to the PC Network, its minimum configuration is:

1. DOS 3.10
2. 128 KB of memory
3. a 320 KB diskette drive
4. a PC Network Adapter Card (Sytek 6120).

The Sytek 6050 Network Translator is used to receive a reverse low band frequency signal, convert it to a high frequency, and retransmit it to a forward high band frequency, thereby providing two-way data communications between PCs on a single coaxial cable plant.

2.2.1 Sytek 6050 Network Translator

The Sytek 6050 Network Translator uses a midsplit format. It receives signals from 47.75 to 53.75 MHZ (channel T14) in the reverse direction and transmits the forward signal from 216 to 222 MHZ (channel J) in the forward direction. The Sytek 6050 allows the expansion of the IBM PC Network capacity from 72 nodes to 1000 nodes without performance sacrifices. Its service area can reach up to 5 KM. The specifications of the Sytek 6050 is shown in APPENDIX A.3. Due to the electrical characteristics of the Sytek 6050, Sytek suggests not using the adjacent

channel T13 (41.75 - 47.75 MHz) to provide the other type of service (Sytek, 1985a).

On the front panel of Sytek 6050, the POWER ON switch is used to control power to the translator. When POWER ON switch is raised, the POWER SUPPLY LED should turn green. There are two -20 dB TEST points, one for the RF input signal coming into the input converter, and the other for the RF output signal coming out the output converter. That is to say, the signal levels of the test points are 20 dB below its corresponding signal level. Also, the OUTPUT LEVEL knob is for gain control.

2.2.2 Sytek 6120 Network Adapter Card

A Sytek 6120 PC Network Adapter Card is an upgrade card of the IBM PC Network Adapter Card. It is a single board communication controller that facilitates IBM Personal Computers (or compatibles) communications through a broadband single coaxial cable network. All required network protocols and signals are controlled by this Network Adapter Card. The data rate specification for the Sytek 6120 is 2 Mbps. The specifications of Sytek 6120 are shown in APPENDIX A.4.

The major components of the card are an Intel 80188 microprocessor, an RF modem, a Basic Input Output System (BIOS) ROM, an Intel 85286 communications controller, a data bus and an I/O bus. The BIOS ROM in the card is used

to support network communication functions and is an extension of PC software. The only point to be connected to the outside is a F-type RF connector which is used to attach the Sytek 6120 to the cable network through a coaxial cable (Sytek, 1986).

2.3 Concord Data Systems Token/Net

A Concord Data Systems (CDSs) Token/Net Local Area Network is designed for data communications among terminals, computers and other devices. It implements the Token-Passing Bus Access Method as specified in the IEEE 802.4 local area network specifications (IEEE, 1985b).

A CDS Token/Net may operate at a data rate of 5 Mbps over a communication distance up to 20 miles. Based on this, a Token-Passing Bus network may operate on a wider area than a CSMA/CD network does. In addition, the hardware implementation of the Token-Passing Bus technique is more complex than a CSMA/CD implementation. Generally, a Token-Passing Bus network may be applied in the Real-Time applications where fixed bounded response time is required. This is due to the deterministic nature of the Token-Passing Bus Access Method. A CSMA/CD network, on the other hand, is unsuitable for Real-Time applications due to the undeterministic nature of contention access with no upper limit to the access time (Martinez, 1985). Therefore, the

access of each node to the medium for the Token-Passing Bus Access Method is fairer than the CSMA/CD's.

The Token-Passing Bus Access Method is a medium access method for a bus structure network. Nodes in the bus form a logical ring in which an explicit token is passed. A node may transmit data for a specified time period only after receiving the token, and then must pass the token to the next node when its time is out or when it is finishing transmitting.

The Token-Passing Bus Protocol involves the following functions (Stallings, 1984):

1. Ring initialization

When one or more nodes sense the period of bus inactivity longer than a time-out, the ring initialization occurs. At this moment, the token is presumed lost. Two possible reasons account for this, either the network has been powered up or the token holding node fails.

2. Addition of a node

The token holding node can invite nodes to enter the ring by sending a Solicit-Successor frame.

3. Deletion of a node

If a node plans to leave the ring, it waits until it holds the token, then sends a Set-Successor frame to inform its predecessor to connect to its successor.

4. Error management

The token holding node is usually in charge of error recovery upon different error conditions.

5. Service classification

There are four classes of service: Synchronous, Asynchronous urgent, Asynchronous normal, and Asynchronous time-available, in descending order of their priorities to access the bus.

The basic components of CDS Token/Net are Token/Net Interface Modules (TIMs) and a translator, or a remodulator. In this thesis project, a translator is used. The main difference between a translator and a remodulator is explained below. A translator just amplifies the reverse frequency signal, converts this reverse signal from low band frequency to high band frequency, and then retransmits it to the forward path. But a remodulator first demodulates the reverse analog signal providing digital assessment, repeating and retiming the resulting baseband data, remodulates the data to the forward frequency, and then retransmits the data to the forward path. The IEEE 802.4 Token-Passing Bus specifications recommend using a remodulator for broadband networks. Usually, a remodulator is superior to a translator in error performance and token passing rates, but it is more complex and expensive than a translator.

2.3.1 Token/Net Translator

A Token/Net translator provides essential two-way data communication functions of converting low band frequency signals (77.75 to 83.75 MHz, for this thesis project) received from reverse direction to high band frequency signals (270 to 276 MHz) and retransmits them to the destination node. The specifications of the translator is shown in APPENDIX A.5. Because it must translate all the low band frequency signals from all the TIMs, it is usually located on the root of the cable system "tree" (CDS, 1983).

On the front panel of the translator, when a ON/OFF switch is lifted, the POWER LED should turn YELLOW. The -20 dB INPUT TEST and -20 dB OUTPUT TEST connectors, like the other translators, are used to test the input signal level and the output signal level with 20 dB down. The GAIN control knob is used to adjust the gain of the amplifier in the translator by using a screw driver.

On the back panel of the translator, the INPUT port is used to connect to the reverse path cable which carries the RF input signal. The OUTPUT port is used to connect to the forward path cable which carries the RF output signal.

2.3.2 Token/Net Interface Module

The most important component of the CDS Token/Net system is a Token/Net Interface Module (TIM). A TIM contains data ports as an interface to a coaxial cable, and

internal logic to receive data from the ports and to distribute messages to the destination node through the cable.

The basic TIM's functions are data port functions and LAN protocol functions. Data are sent by the data port functions of the source TIM, through the remote port functions, and are transmitted to the data port of the destination TIM (CDS, 1983). Also, a TIM is designed to operate on a broadband cable system which is a broadcast medium with high bandwidth. The specifications of the TIM are shown in APPENDIX A.6.

The basic units inside the TIM include an RF modem, an Access Unit, a Control Unit, and a power supply. The first card slot of the TIM is an RF modem. The RF modem provides the interface to the broadband coaxial cable via a F type connector on the back panel of the module, and is used to convert digital data to analog data or vice versa. The modem operates at 5 Mbps on a midsplit cable system. Since it is a frequency agile modem, it can operate on any one of six pairs of transmitting channels and receiving channels. APPENDIX B.1 contains the frequency pair characteristics of the TIM. The default channel pair are (4A, R). Considering the overall frequency allocation for the multiple networks, the (5, S) pair were selected. Moreover, there are 16 settings of the TIM transmitting

output level. These values vary from 50 dBmV to 27.5 dBmV in 1.5 dB steps. APPENDIX B.2 contains the approximate output levels and their hexadecimal memory settings. Depending on the CDS Token/Net signal level requirements, a suitable transmitting signal level can be chosen for a TIM through software control. In this thesis project, the default value (+ 44.0 dBmV) was selected. The second card slot of TIM is an Access Unit. The Access Unit is in charge of implementing Token-Passing Bus Protocol. The third card slot of TIM is a Control Unit. The Control Unit provides some TIM functions like the session and transport layer functions. These functions include session establishment, error control, and flow control. It also provides the interfaces to the four user devices through four 25-pin RS-232C connectors (port 1 to port 4) (CDS, 1984b).

CHAPTER 3

MULTIPLE NETWORKS DESIGN ISSUES

The basic principle of multiple networks on a single cable plant design is not to cause interference between the different networks. In order to follow this guideline, the following main issues should be of concern when designing such a multiple networks system:

1. System topology structure
2. Physical layout
3. Frequency allocation
4. Signal level
5. Noise level
6. Distortion

The whole design of this system can be divided into two parts: one for the headend design and the other for cable plant trunk design. Adhering to the design issues, the headend is designed first, and the trunk is designed next.

3.1 Design Factors

Because the network system built is an experimental system in the Computer Engineering Research Laboratory (CERL), the factors described here might be insufficient to design a commercial network system. Here, only network

design factors which will affect the testbed system are discussed. For example, since the system size is small, no amplifiers are needed in the testbed system. Therefore, amplifier selections or applications will not be considered in the design issues. Later, a discussion will be given on how to extend the testbed system into a campus wide system.

3.1.1 System Topology Structure

System topology structure must be decided first, because other design factors might relate to it. Tree, star, ring, and bus are some basic topology structures. Since the existing Sytek cable system is a tree architecture, tree architecture was selected in this testbed system. The tree architecture is easy for data communications between any two nodes using switching functions. The system block diagram of multiple networks is shown in Figure 3.1.

3.1.2 Physical Layout

After deciding system structure, the next step is to decide the physical headend location, cable route, and each outlet location. Because the testbed system is experimental, it will eventually be switched to the existing Sytek cable plant. Since the existing headend is located in the Room 160 of the Electrical Engineering Building, all the equipment in this testbed system will be located in this

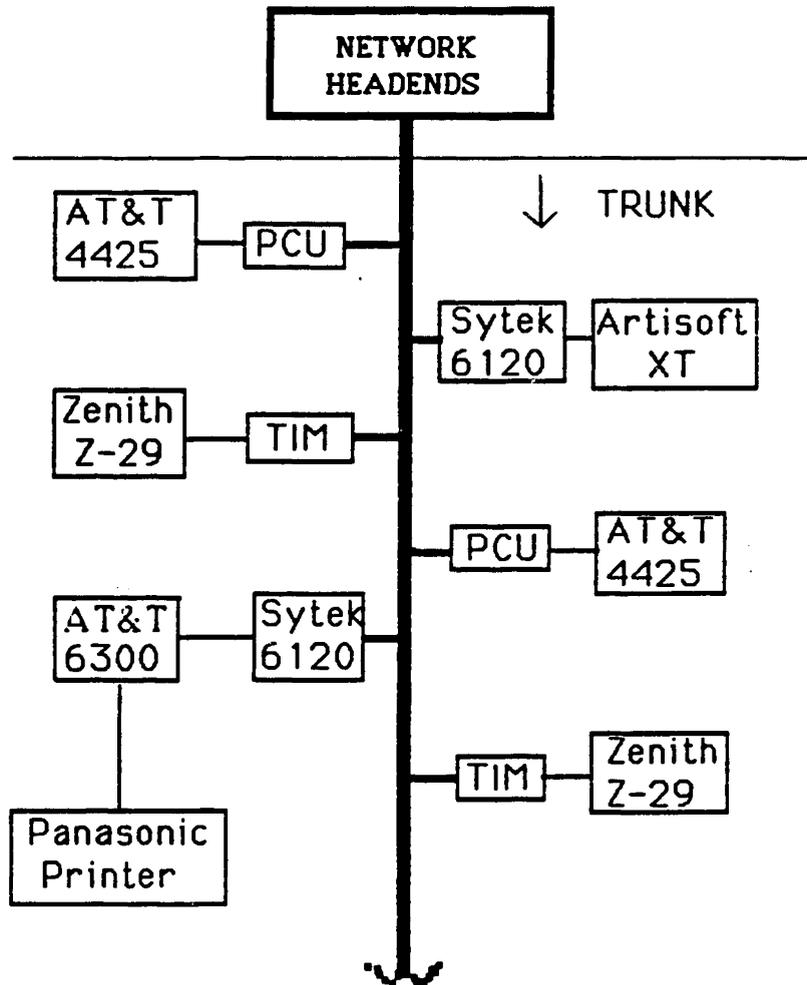


Figure 3.1. System Block Diagram of Multiple Networks

room. The PCs and CRTs used in the testbed system are also located in this room.

3.1.3 Frequency Allocation

When allocating frequency for multiple networks, the first step is drawing up a frequency allocation chart. Such a chart shows how each network occupies a frequency band and that no conflicting frequency assignments occur. The reverse and forward frequency allocation for different LANs are shown in Figure 3.2 and Figure 3.3 respectively. In these two Figures, not only the frequency allocation for the LocalNet 20, Sytek System 6000 and Concord Data Systems Token/Net are included, but also the frequency allocation for the Sytek System 2000 (Sytek, 1985c), and three TV channels. To avoid frequency conflict among different networks, the frequency allocation for existing networks, possible future networks, and the multiple networks in this testbed system are considered. The frequency allocation sequence begins with systems whose interface devices operate on a fixed frequency, and do not have the option to change frequency. The frequencies for the other networks are then allocated.

In Figure 3.2, there is a slight frequency overlap between the LocalNet 20 and the Sytek System 2000. The overlapping frequency is from 71.75 MHz to 76 MHz. In addition, these two network systems are compatible and use

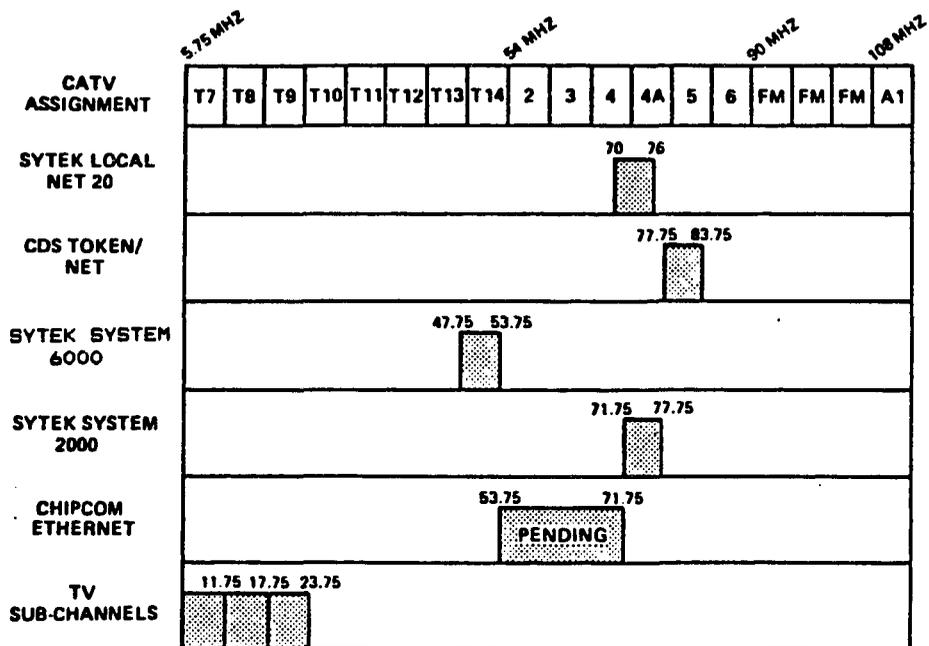


Figure 3.2. Reverse Frequency Allocation in Testbed

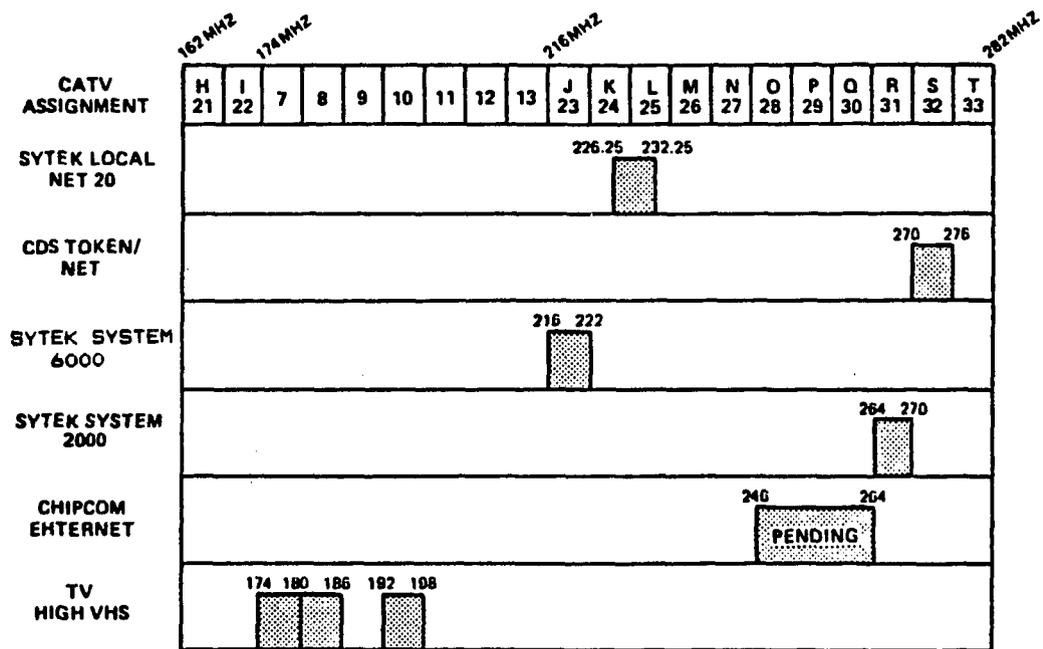


Figure 3.3. Forward Frequency Allocation in Testbed

the same medium access protocol CSMA/CD, but with different offset frequency (LocalNet 20 - 156.25 MHz, Sytek System 2000 - 192.25 MHz) in each translator. Based on this information, and the PCUs in the LocalNet 20 and PCUs in the Sytek System 2000 having the same transmitting frequency (T), but with different receiving frequencies (R1, R2):

1. LocalNet 20, $R1 = T + 156.25$
2. Sytek System 2000, $R2 = T + 192.25$

In such a way, the users in the LocalNet 20 and the users in the Sytek System 2000 may communicate with each other. The only restriction to these two systems is that they must have unique UNIT addresses (UNITid) between the two networks. The use of these two networks on the same broadband cable system makes such interconnection possible.

3.1.4 Signal Level

The distribution network should be designed to supply a suitable signal level to each node. The signal level calculation including transmitting signal level (T) and receiving signal level (R), the translator gain (G), and the path loss including forward loss (FL) and reverse loss (RL) has the following relation:

$$T - R + G = FL + RL$$

where the path loss (FL + RL) = passive loss

(directional coupler insertion loss or tap attenuation,

and splitter insertion loss etc.) + active gain
(amplifier gain) + cable loss.

Although the cable loss is related to the frequency being used (called cable tilt), there is not a big difference among these three networks. Because the size of this experimental system is small, we do not really need to worry about this. The passive loss and the active gain are the same for each network. Therefore, the path loss is nearly same for these three networks. As a result, matching T, R and G among these three networks becomes the main signal level design consideration. Thus, the relationship becomes important when a large geographical area for the cable plant exists.

Because there are three different networks on the single cable plant, proper signal levels must be attained for nodes on the different networks. The signal level specifications for each network translator and interface devices are shown in TABLE 3.1. The associated attenuation for each passive element including cable loss is shown in Table 3.2 (General Instrument, 1985a - 1985c).

In order to design a transparent communication network system, a reference signal level has to be chosen. Usually, a video carrier level is used as a reference signal level to design the whole system for multiple services. The video interface device transmitting signal level is +56

Table 3.1. Signal Levels on Multiple Networks

Network	Network Translator				Interface Device		
	Type	Input Level	Output Level	Gain	Type	Input Level	Output Level
LocalNet	Sytek 50/50	-12 - 10	38 - 60	50 +/- 2	LocalNet 20/100	-2 +/- 6	+46
Sytek 6000	Sytek 6050	+10	+58	33 - 53	Sytek 6120	8.5 +/- 15.5	+56
Token/Net	Translator	-10 - 10	15 - 55	25 - 45	TIM	-10 - 10	+44 (30-50)
Sytek 2000	Sytek 2550	+9(Max)	+56 +59(Max)	26 - 50	Sytek 2502	-2 +/- 6	+46
Cable TV	Processor	+10 +/- 3.5	+56 +/- 2	+46	TV/Modulator	+6 +/- 3.5	+56 +/- 2

Table 3.2. Part Lists of Testbed System

Description	Model Number	Quantity	Attenuation	Bandwidth
Jerrold CATV Combiner/ Splitter	HC-8X	2	16 dB +/- 2 dB	5-550 MHz
Jerrold CATV Headend Return Channel Filters	TF-108D-HE	1	0.6 dB	5-108 MHz and 168-400 MHz
Jerrold UHF/VHF 2 Way Splitter	1596C	3	3.5 dB	5-890 MHz
Directional Coupler	DCT1-12	2	0.8 dB (5-400 MHz)	5-890 MHz
Directional Coupler	DCT1-19	2	0.6 dB (5-400 MHz)	5-890 MHz
Directional Coupler	DCT1-24	4	0.4 dB (5-400 MHz)	5-890 MHz
Directional Coupler	DCT4-24	1	0.7 dB (5-300MHz)	5-890 MHz
General Instrument All channel Terminator	TR-75F	30	30 dB (return loss for VHF)	54-216 MHz and 470-890 MHz
Test Probe Adapter	SPD-30F-Female F to Male G	1	30 dB	DC-450 MHz
Coaxial Cable	CAC-6-1000	200 feet	4dB per 100' at 300 MHz	5-450 MHz

dBmv, and the video interface device receiving signal level is +6 dBmv. The video signal levels are also shown in Table 3.1 for reference. In addition, the normal path loss from the headend to an outlet (forward path) is about 50 dB. The detailed CATV system design specifications is shown in APPENDIX C.

As a general rule, a forward path design is usually undertaken first. The signal level relation between the video signal level (VSL) and the data signal level (DSL) is described by the following formula:

$$DSL = VSL - 10 \log(N)$$

where N is the maximum data channel number that occupies a 6 MHz bandwidth.

We should use this formula to verify each data network signal level; otherwise, the amplifiers in the system might be overdriven, and the output signals might be distorted (Cooper, 1984).

Normally, the lower the bandwidth, the lower the noise level, so a lower signal level may be used for a lower bandwidth system, furthermore, the lower the data signal level, the less intermodulation distortion. This is why the above formula is used. For example, a Sytek LocalNet 20 system has 20 channels in a 6 MHz bandwidth. Therefore, the data signal output level should be $DCL = 56 - 10 \log(20) = 43$ dBmv. And, the data signal input level is $DCL = -6 - 10$

* $\log(20) = -7$ dBmv. These two signal levels meet the Sytek LocalNet 20 specifications.

3.1.5 Noise Level

The noise level discussed here refers to thermal noise. When the working temperature of a device is above absolute zero, thermal noise is produced. A system with a 4 MHZ bandwidth channel, 75 ohm impedance and operating at 68 degree Fahrenheit has a noise floor of -59 dBmv (Cooper, 1984). Here, a noise floor is the minimum possible noise level. The following equation may be used to calculate the noise floor of a system with a bandwidth B (HZ):

$$E_n = -125 + 10 * \log(B) \text{ dBmv}$$

where E_n : noise floor.

For example , a system with 6 MHZ bandwidth has the noise floor of about -57.2 dBmv.

Since the size of the testbed system is small, there is no need to have amplifiers to amplify signals. So, the noise figure of an amplifier, or signal to noise ratio (S/N) is an unnecessary consideration. Since the noise level is an important factor in a commercial network system, or a large network system, we still address this consideration for reference.

In addition, the noise effect is not identical in the bidirection of the network. For example, the noise effect at a splitter/combiner in the reverse path is greater

than that of the forward path. Usually, the overall noise effect in the reverse direction is greater than that of noise effect in the forward direction. As a result, C/N (Carrier /Noise) ratio could be degraded. So, noise effect is the dominating effect in the reverse direction when deciding the system size. As a result, noise effect has to be considered especially when designing the reverse path of the trunk. For the forward path, distortion which will be discussed in the next section, is the limiting factor in determining the system size. If the noise effect is significant, a higher signal level should be used to maintain S/N ratio to keep a certain service quality. Generally speaking, the reverse noise in two-way communications will be the dominant factor in deciding system size.

3.1.6 Distortion

As previously mentioned, distortion is another important factor when determining the system size, especially in the forward path design, since the forward path usually contains several carriers. As a result, the input level of an amplifier has to be decreased, otherwise, distortion might occur.

When the system has more amplifiers, the input levels to the amplifiers should be less, thus avoiding distortion. However, the more the number of amplifiers the

system has, the more serious the noise effect might be. So the input signal to the amplifier should be increased to maintain a reasonable signal to noise ratio. Therefore, the compromise between noise and distortion is the main factor determining system design and system size (Cooper, 1984). Amplifiers, which might cause distortion, are not needed in this testbed system because of its small size. Therefore, this system design need not be concerned with the distortion factor.

3.2 Headend Design

The headend, which is usually designed before the rest of the network, is the most important part of a network. According to the design factors considered in Section 3.1, suitable components are selected for the headend. In Figure 3.4, the upper part is the testbed headend design. The basic components of this headend include three translators, two combiners, and one diplexer. Here, two combiners are used for signal splitting and combining. This makes future expandability easy. A diplexer is used to avoid the interaction between reverse signals and forward signals. A pair of back-to-back directional couplers with a two-way splitter form a reverse and forward path test point. Another two-way splitter is connected to each combiner respectively. The unused ports of the two splitters could be used to connect to another pair of

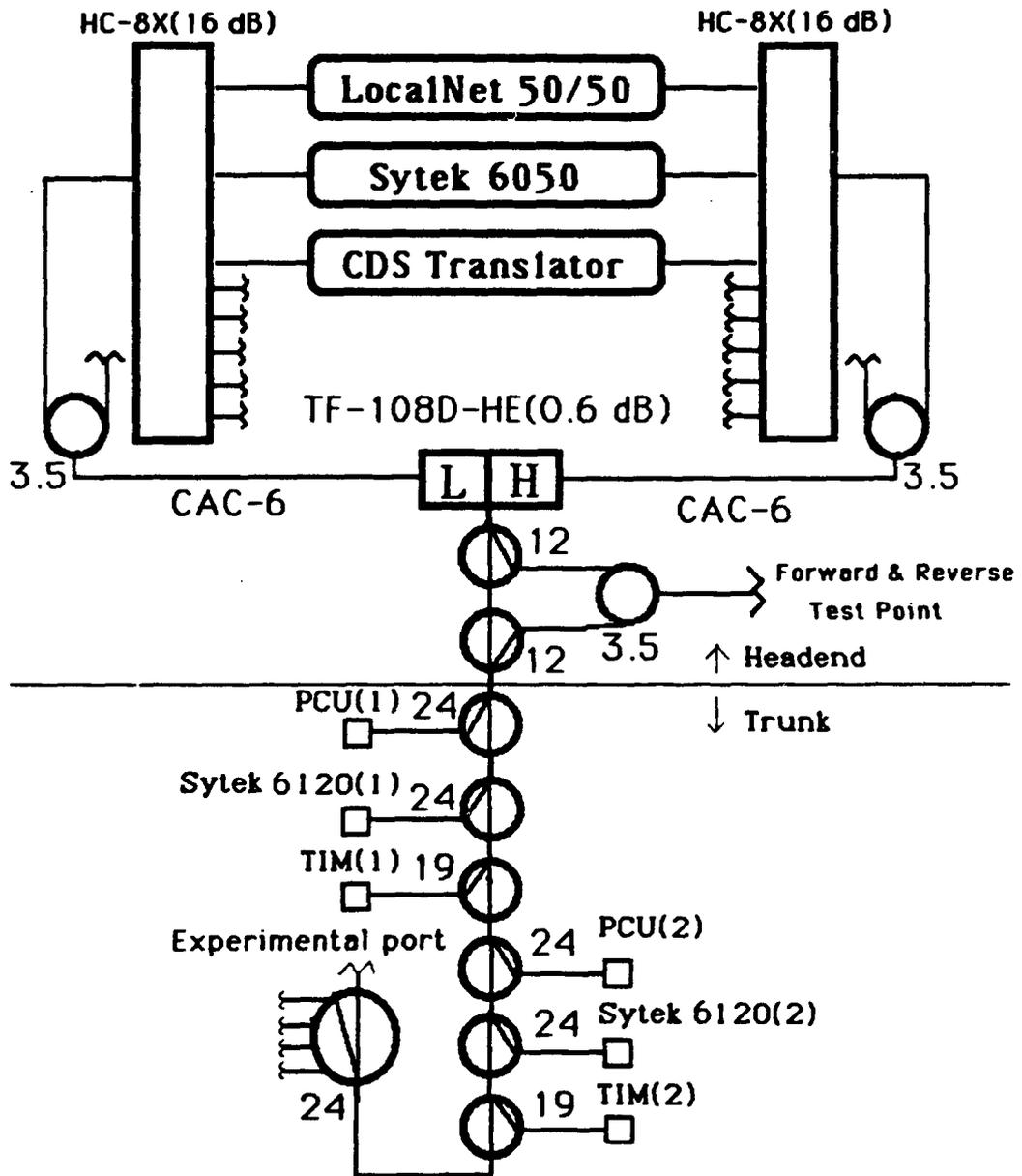


Figure 3.4. Multiple Networks Configuration

combiners for possible future expansion. The unused ports of the combiners and splitters should be terminated.

By doing this, when adding more translators or processors (for TV channels) in the headend, no system readjustment is needed as long as frequency band is available. Thus, new system expansion will not affect the continuous services of the existing system. APPENDIX D contains these broadband component description, and APPENDIX E includes the corresponding broadband graphic symbol representation (NCTA, 1976).

3.3 Cable Plant Trunk Design

In this experimental system, the minimum configuration, requiring six outlets is considered. Because this system is small, a CAC-6 type cable is used as a trunk cable. The CAC-6 cable loss is about 2.4 dB per 100 feet at reverse frequency 116 MHZ and about 4.0 dB per 100 feet at forward frequency 300 MHZ. The cable loss versus frequency for different types of cables is shown in Figure 3.5 (Cooper, 1984). A forward path is usually designed first. If all the networks in the system are compatible to a video cable system, then the whole system can be designed by using video signal level as a reference signal level. We may always use a video signal level as a reference signal level to design the whole system first. Depending on whether or not a network is compatible to a video cable system, we

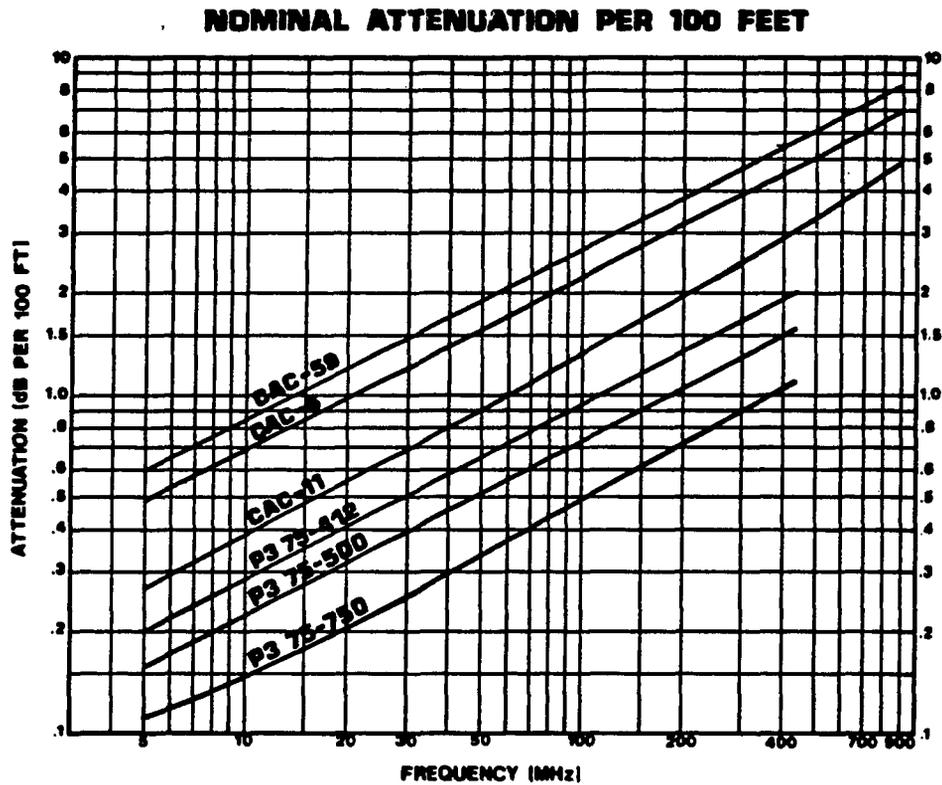


Figure 3.5. Cable Attenuation versus Frequency for Various Sizes of Coaxial Cables

might need to adjust the tap values of directional couplers on the corresponding outlets.

According to the cable loss, the tap values of directional couplers, and the insertion losses of directional couplers, a diplexer, or combiners, the signal levels on different outlets can be calculated. Here, we assume the output signal levels of translators are +56 dBmV. And, the cable loss computations are based on 4 dB attenuation per 100 feet at 300 MHz frequency. The resulting video input signal levels of outlets are shown in APPENDIX F.7.

According to the specifications of multiple networks shown from APPENDIX A.1 to APPENDIX A.6, we can compare the gain of each network translator and the output level of each interface device with video reference signal levels. Basically, a PCU and a PC with a Sytek 6120 Network Adapter Card in the adjacent location may use the same tap value ports. That means that the same port designed for a LocalNet 20 can be used for a Sytek System 6000, since they are compatible. A 24 dB-tap directional coupler is designed for each PCU or Sytek 6120. However, for these two TIMs, the lower tap values of directional couplers (19 dB) are used because the Token/Net translator has less gain (25 to 45 dB) than the other two translators' (LocalNet 20: 50 +/- 2 dB, Sytek 6050: 33 to 53 dB). And, a TIM has less nominal

transmitting signal level (44 dBm) than the other two network interface devices (PCU: 46 dBm, Sytek 6120: 56 dBm). According to the discussion of Section 3.1.4 and TABLE 3.1, we can do the path loss calculation by using the nominal value for each parameter in the formula:

1. Video cable system

$$\text{Path Loss} = T - R - G = 56 - 6 + 46 = 96 \text{ (dB)}$$

2. LocalNet 20

$$\text{Path Loss} = T - R - G = 46 - (-2) + 50 = 98 \text{ (dB)}$$

3. Sytek System 6000

$$\text{Path Loss} = T - R + G = 56 - 8.5 + 48 = 95.5 \text{ (dB)}$$

4. CDS Token/Net

$$\text{Path Loss} = T - R + G = 44 - 0 + 44 = 88 \text{ (dB)}$$

Based on the above calculation results, we may understand why a CDS Token/Net is not exactly compatible to a video cable system and why a lower tap value of the directional coupler was used for each TIM.

Considering that these three networks will be connected to the existing Sytek cable system eventually, we wish that they can share the same tap port without requiring a change in the tap value for specific interface devices (PCU, Sytek 6120, or TIM). Then the cable system would be totally transparent to these three different networks. Therefore, based on this goal, a 4-port 24-tap direction coupler is added to the testbed system. If it can be proven

that these interface devices can share the same port, it will be quite beneficial to the future expansion. In other words, when switching the testbed system to the existing campus Sytek cable plant, we can connect a PCU, a Sytek 6120, or a TIM to any existing outlet without readjusting the tap value of outlets or redesigning the whole cable system. Therefore, a video signal level has been suggested as a reference signal level to design a broadband cable network in order to have a transparent cable system for different kinds of networks.

After finishing the forward path design, the next step is checking the reverse path signal levels to make sure that each PCU, Sytek 6120 or TIM can supply sufficient signal levels to each translator's RF INPUT port respectively. They must meet the input signal level specifications for each translator. If they do not, a redesign procedure of the forward path must be done. The procedure is to redesign the forward path first, then to check reverse path until a satisfactory result has been attained. The trunk portion of this testbed system has been shown in Figure 3.4. Also, the parts list including the associated attenuation and bandwidth of each component for this testbed system has been shown in TABLE 3.2.

Another important concept in the trunk design is so called Unity Gain Criterion. This criterion is related to

amplifiers. Although no amplifiers were used in this testbed system, it still deserves to be mentioned here for reference. This criterion is outlined below (Cooper, 1984):

1. With respect to gain, equalization, and noise figure, all selected trunk amplifiers are identical.
2. All trunk amplifiers are separated by the same cable distance.
3. Amplifier Gain = Flat Loss + Cable Loss

The Flat Loss is the loss associated with passive elements described in APPENDIX D.3. The Flat Loss and Cable Loss are the path loss between the previous amplifier and the current amplifier.

The goal of this criterion is to have the same output levels for all the trunk amplifiers. As a result, by consistently following this criterion, the system will be easy to design, adjust, and maintain.

CHAPTER 4

HARDWARE INSTALLATION, TEST AND ADJUSTMENT PROCEDURE

In this chapter, the detailed hardware configuration, installation, test and adjustment procedures for the multiple networks are described. Also, the required test equipment is described here.

4.1 Testbed Hardware Configuration

In this testbed system, three translators, two combiners and one diplexer are all mounted to the same cabinet, which constitute the main portion of the headend. Figure 4.1 shows the physical layout of the headends in a 19-inch rack. Between each translator, combiner, or diplexer, a standard panel space of 1 and 3/4 inches was inserted for ventilation. The testbed hardware configuration has already been shown in Figure 3.4.

4.2 Required Test Equipment Description

In order to perform measurement to the testbed system, three pieces of test equipment were used in this thesis project. They are a Tektronix Type 191 Constant Amplitude Signal Generator, a Wavetek SAM III Signal Analysis Meter and a Sytek LocalNet 50/70 Cable Test Unit. The first two pieces of equipment are the minimum required

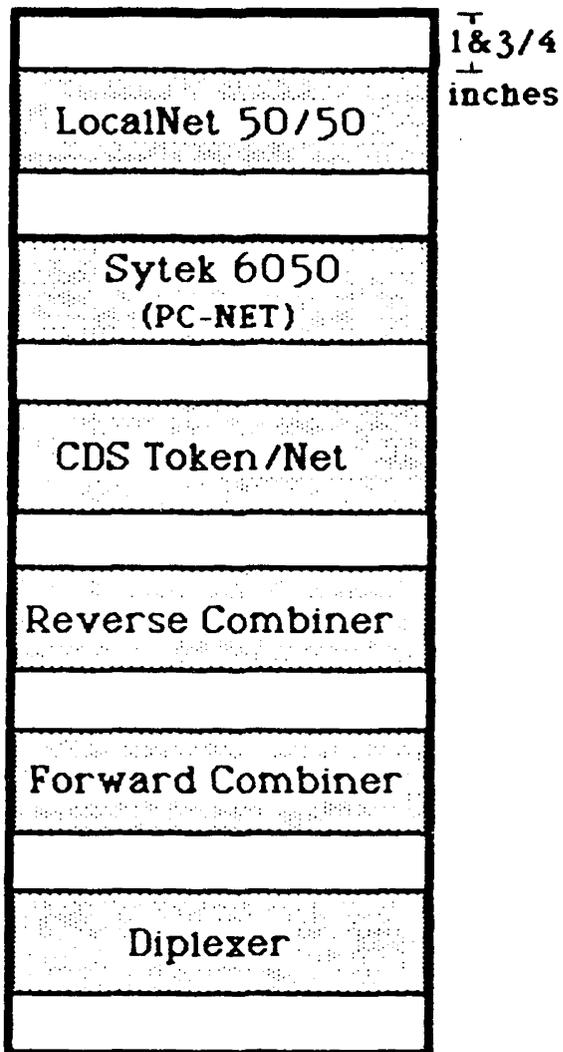


Figure 4.1. Headend Physical Layout in Testbed

instruments (a signal generator and a signal analysis meter) for testing a cable network system. The third one, combining generator and signal analysis meter functions together, is specially designed for measuring signal levels on the Sytek LocalNet 20 system. Also, it may be used to measure the video signal level. It is convenient to use such a portable cable test unit.

4.2.1 Type 191 Constant Amplitude Signal Generator

This Constant Amplitude Signal Generator (Signal Generator) is made by Tektronix. It generates sine waves whose amplitude keeps constant as the frequency is changed. It is suitable for measuring the frequency response of broadband networks which are operating in the frequency range from 350 KHZ to 100 MHZ.

The output impedance of this equipment is 50 ohm. But the broadband multiple networks, which are going to be tested, are designed to have 75 ohm impedance. In order to match the impedance between them, a HEWLETT-PACKARD (HP) 11694A 50 ohm to 75 ohm transformer, operating frequency 3 - 500 MHZ, must be used to match the impedance difference between the Signal Generator and multiple networks. Because calibrating the Signal Generator requires special test equipment, we use a Signal Analysis Meter instead to measure its exact frequency and signal level before applying the signal to the network system. So, the calibration

procedure for the Signal Generator will not be described here. We can refer to its instruction manual for more information (Tektronix, 1966).

The basic operation of this Signal Generator is outlined below (Tektronix, 1966):

1. First, select a suitable frequency range by turning the FREQUENCY RANGE knob to the corresponding position. According to this frequency range, turn the frequency dial on the left hand side of the front panel of the Signal Generator to the selected frequency position.
2. In the same way, choose a desired signal amplitude by turning the AMPLITUDE RANGE knob, AMPLITUDE knob, and VARIABLE amplitude knob on the right hand side of the front panel. The VARIABLE amplitude knob is used to provide a smooth variation of the output signal amplitude between the fixed amplitudes which is decided by the AMPLITUDE knob.
3. Connect the power cord to a suitable power outlet and turn on the POWER switch. The power LED should be on.
4. Connect the OUTPUT port to the Wavetek Signal Analysis Meter through a HP 50 to 75 ohm transformer and a coaxial cable. Refer to Section 4.2.2 for the operation procedure of SAM III Signal Analysis Meter

(SAM III).

This step is used to get actual frequency and amplitude values of the Signal Generator from the SAM III.

5. Readjust the frequency and amplitude of the Signal Generator until desired frequency and amplitude are displayed on the SAM III.
6. Apply this signal to the selected outlet on the cable system.

4.2.2 SAM III Signal Analysis Meter

This versatile signal analysis meter is made by Wavetek Indiana. It is designed for testing and maintaining 75 ohm CATV cable systems. Its measurable frequency range is from 4 to 450 MHz. This signal analysis meter can be used to measure signal level, signal to noise ratio (S/N) and hum modulation etc... .

In the following, the basic calibration procedure of SAM III is described (Wavetek, 1983):

1. When using the SAM III the first time, we must perform calibration adjustments. Since the SAM III provides a high accuracy signal with amplitude +20 dBmV at 150 MHz at the CALIBRATION OUT port, it can be used for calibrating.
2. Turn the FUNCTION knob to the SLM position. Connect the CALIBRATE OUT port to the RF IN port through a

coaxial cable which will be the same cable for measuring signal level.

3. Set the METER window to have a signal level range between +15 and +25 dBmV by turning the ATTENUATOR control knob. Also, turn the GAIN control knob to the CAL position.
4. Set PGM/MAN switch to MAN position. Use the TUNNING control knob to select a frequency manually such that 150.0 MHz is displayed on the FREQUENCY DISPLAY window.
5. Turn the CALIBRATE SET control knob such that the METER window has exact +20 dBmV reading.

The signal level test procedure of SAM III is described below (Wavetek, 1983):

1. Before we use SAM III to measure signal levels, we must do a battery check. First, turn on the POWER switch, and set the FUNCTION switch to the BATT CHK position. If the METER indicator is located in the range of BATT GOOD, it means the battery is good enough to assure the proper operation of the SAM III. Otherwise (in the range of RECHARGE), the battery should be recharged before tests are performed.
2. In addition to doing a battery check, perform the calibration before the first measurement. The

calibration procedure is outlined above.

3. If the battery is good, turn the FUNCTION control knob to the SLM position and the GAIN knob to the CAL position. Also, set AFC switch up and S/N switch down. Besides, set AUDIO and LIGHT as desired. Do not be concerned about the other knobs or switches.
4. Connect the RF IN port of the SAM III to a desired test port. Tune the frequency of interest and turn the ATTENUATOR control knob such that the METER indicator is located within the selected signal level range. Record the signal level in dBmV shown on the METER window.

4.2.3 LocalNet 50/70 Cable Test Unit

LocalNet 50/70 Cable Test Unit is designed for the LocalNet 20 cable system. It also can be used to measure video signal levels. Instead of requiring at least two pieces of test equipment, a signal generator and a signal analysis meter, for testing the cable system, LocalNet 50/70 is a portable, single cable test set for measuring a LocalNet 20 cable system.

LocalNet 50/70 transmitter transmits 70.1 MHz to the LocalNet 50/50 translator which has the offset frequency 156.25 MHz. The translator then converts the frequency from 70.1 MHz to 226.35 MHz, and retransmits the signal to the

LocalNet 50/70 receiver. The receiver then drives the meter through the detector to indicate the signal level.

The basic operation of LocalNet 50/70 is listed below (Sytek, 1984b):

1. Turn on the power switch. The power indicator will turn red.
2. Turn the BATTERY TEST switch in the upward direction to perform battery test and make sure that the battery is good. If the meter indicator is located in the blue region, the battery is good. Otherwise, recharge the battery.
3. If the battery is good, release the BATTERY TEST switch. Then, turn the RECEIVE LEVEL switch to +6 position and the TRANSMIT LEVEL switch to the +46 position. Then, push the CALIBRATE-MEASURE switch to the upward direction (CALIBRATE). The CALIBRATE LED will turn red.
4. Keep the CALIBRATE switch up, and adjust the knob for a zero reading.
5. So far, we have already made sure that the battery is good and have calibrated the cable test set. Next, turn the RECEIVE LEVEL switch to the -4 position (for LocalNet 20) and TRANSMIT LEVEL switch to the +46 position (for LocalNet 20). Push the CALIBRATE-MEASURE switch to the downward direction.

If the meter indicator is located in the green region, it means that the signal level is good for LocalNet 20. In the green region for LocalNet 20, the signal level is between 0 to -8 dBmV which meets the LocalNet 20 specifications.

6. In the same way, the LocalNet 50/70 may be used to measure a video reference signal level. Turn the RECEIVE LEVEL switch to the +6 position and the TRANSMIT LEVEL switch to +56 position. Then, follow the same procedure described above. Therefore, the LocalNet 50/70 Cable Test Set may be used to measure the video reference signal level too.

4.3 Trunk Installation

According to the trunk portion of the testbed hardware configuration shown in Figure 3.4, install two 24-tap directional couplers for two PCUs, two 24-tap directional couplers for two Sytek 6120s, and two 19-tap directional couplers for two TIMs. In addition, based on the idea mentioned earlier for the multiple networks for sharing the same outlet location without requiring a change in the tap value for specific interface devices, install another 4-port 24-tap directional coupler to the end point of the trunk cable.

Between the output port of any directional coupler and the input port of adjacent directional coupler, use a 10

foot CAC-6 cable to connect them together. Use a 5-foot CAC-6 cable to attach each interface device (PCUs, Sytek 6120s or TIMs) to the corresponding tap port of the directional coupler. Terminate the output port of the 4-port 24-tap directional coupler. Make sure terminate any tap port if there is no interface device connected to it.

4.4 Sytek LocalNet 20

The basic components of LocalNet 20 network system are a LocalNet 50/50 translator and an interface device called a Packet Communication Unit (PCU). In the following, the installation procedures for the translator and the PCU will be described. In order to test each network independently at the first time, the other two networks should be disconnected from the system.

4.4.1 LocalNet 50/50 Translator Installation Procedure

The LocalNet 50/50 installation procedure is outlined below (Sytek, 1983):

1. Mount the LocalNet 50/50 to the cabinet.
2. Connect a power cord to the LocalNet 50/50.
3. Connect a 4-foot CAC-6 cable from the LocalNet 50/50 RF INPUT port to the reverse Headend Combiner Model HC-8X (reverse combiner) IN/OUT port J1.
4. Connect another 4-foot CAC-6 cable from the LocalNet 50/50 RF OUTPUT to the forward Headend Combiner

- (forward combiner) HC-8X IN/OUT port J1.
5. Connect the power cord to a grounded AC outlet. The POWER indicator on the front panel of the LocalNet 50/50 will turn to red eventually. Otherwise, the translator is bad.
 6. Attach two 75 ohm terminators to the PILOT INPUT and PILOT OUTPUT connectors on the LocalNet 50/50 rear panel. When a LocalNet 50/55 Redundant Headend Switch is not used, these two connectors should be terminated.
 7. Connect a 1-foot CAC-6 cable from the COMMON port J9 of the reverse combiner HC-8X to one of the OUT ports of the two-way splitter on the reverse path. In the same way, connect another 1-foot CAC-6 cable from the COMMON port J9 of the forward combiner HC-8X to one of the OUT ports of another two-way splitter on the forward path.
 8. Connect a 1-foot CAC-6 cable from the IN port of the two-way splitter on the reverse path to the LOW port of the Head-End Return Channel Filters (also called Diplexer) TF-108D-HE. Similarly, connect another 1-foot CAC-6 cable from the IN port of two-way splitter on the forward path to the HIGH port of the same Head-End Return Channel Filters TF-108D-HE.
 9. Install two 12-tap directional couplers back-to-back

(their output ports connected together), and connect their tap ports to the two IN ports of a two-way splitter. Thus, the IN port of this two-way splitter may be used as a forward and reverse test point.

10. Connect a 10-foot CAC-6 cable from the COMMON port of the Head-End Return Channel Filter TF-108D-HE to the INPUT port of the nearer 12-tap directional coupler (non-reverse one).
11. Always be sure to terminate those unused ports including the ports on the translator, combiners, splitters and directional couplers

4.4.2 LocalNet 20/100 PCU Installation Procedure

The LocalNet 20/100 PCU installation procedure is outlined below (Sytek, 1984a):

1. Attach a power cord from a PCU to an AC power (110 V) outlet. The POWER indicator on the front panel of the PCU should turn red during the first few seconds. Next, the STATUS indicator should also turn red. At this time, both indicators are red. After several seconds, the POWER indicator turns green and the STATUS indicator should turn off.
2. Connect a RS-232C cable from a terminal to the port 0 DB-25 connector on the back panel of the PCU. Here, two AT&T 4425 terminals are used to connect to

the two PCUs on the LocalNet 20 respectively.

3. Press the reset button (white one) on the back panel of the PCU once. While the POWER and STATUS indicators are both red, press the reset button again. At this moment, the PCU begins to run several test by itself.
4. While the PCU's POWER indicator becomes green and the STATUS indicator turns off, the PCU is ready for Autobaud process. Press the Carriage Return (CR) several times to get the following message on the terminal:

```
LOCALNET-<hardware version>-<software version>
```

```
(C) Sytek 1982
```

A prompt "#" will appear on the CRT. The display of prompt "#" means that the PCU is ready to accept input commands. If the QUIET command is set to ON, then this message will not be shown. We can type STATUS command to make sure of this. If so, and there is a QUIET command available in the HELP file, type "QUIET OFF" to turn the QUIET command OFF.

5. After getting the banner message, the PCU is ready to be connected to the cable system. Otherwise, we have to check the PCU status, and also check the terminal to see if it expects to receive characters with one stop bit and no parity. Then, repeat the

same procedure to make sure whether the PCU is good or bad.

4.4.3 Test and Adjustment Procedure

For the LocalNet 20 System, the test and adjustment procedure could be divided as two parts: one for the LocalNet 50/50 translator, the other for the trunk test.

4.4.3.1 LocalNet 50/50 Translator Test. The main concerns of the LocalNet 50/50 translator test are testing and adjusting the translator gain in order to obtain the design value, and measuring the accuracy of frequency conversion and its bandwidth.

The following procedure is for the LocalNet 50/50 translator test and adjustment:

1. Attach an HP 11694A 50 ohm to 75 ohm transformer to the OUTPUT port of the Signal Generator to match the 75 ohm impedance of CATV equipment.
2. Connect the output connector of the transformer to the RF IN port of the SAM III through a 4-foot CAC-6 cable.
3. Adjust the Signal Generator's frequency to 73 MHZ and the signal level to zero dBm.
4. On the SAM III, adjust the frequency on the meter to 73 MHZ. The METER should read zero dBm. If not, adjust the signal frequency and signal level amplitude in the Signal Generator until the METER on

the SAM III has zero dBmV reading at the frequency 73 MHz.

5. Connect the Signal Generator through the same 4-foot CAC-6 cable used above to the RF INPUT port of LocalNet 50/50.
6. Connect the SAM III through a 4-foot CAC-6 cable to the RF OUTPUT port of the LocalNet 50/50.
7. Adjust the forward and reverse attenuation knob on the front panel of the LocalNet 50/50 to have approximately a 45 dB gain reading at the frequency 229.3 MHz on the SAM III.

In the same way, we can apply different frequencies and different signal levels from the Signal Generator to the RF INPUT of the LocalNet 50/50, and adjust the reverse and forward attenuation knob until we get a satisfactory result on the RF OUTPUT of the LocalNet 50/50. Before we apply different frequencies and different signal levels from the Signal Generator to the translator, we have to apply the same procedure outlined in Section 4.4.3.1, Step 1 to 4, to make sure of the accuracy of the frequency and signal level of the Signal Generator. We also may use the SAM III to measure the signal levels on the PILOT INPUT port and PILOT OUTPUT port. The detailed test data sheet is shown in APPENDIX F.1.

4.4.3.2 LocalNet 20 Trunk Test. The procedure of the LocalNet 20 trunk test is outlined below:

1. Follow the same procedure outlined in the Section 4.4.3.1, Step 1 to 4, to set the Signal Generator with the frequency 73 MHz and the signal level +46 dBm.
2. Connect the Signal Generator through a 5-foot CAC-6 cable to the tap port of the 24-tap directional coupler which is for PCU 1.
3. Connect the SAM III through a 5-foot CAC-6 cable to the tap port of the 24-tap directional coupler which is for PCU 2.
4. Adjust the TUNNING control knob on the SAM III to manually select the frequency until the FREQUENCY DISPLAY has the reading 229.3 MHz. Actually, the accurate frequency should be 229.25 MHz, but the SAM III can only read four digits.
5. Adjust the ATTENUATOR control knob to select a suitable RF input level range and METER scale ,and then read the METER on the SAM III.

In the same way, we can apply different frequencies and different signal levels to a selected port location including the 4-port 24-tap directional coupler, and then read the signal frequencies and signal levels on another

selected port location. The detailed test data are shown in APPENDIX F.2.

4.4.4 Results

According to the test data sheet in APPENDIX F.1, we can confirm that the overall gain on the LocalNet 50/50 is approximately 45.4 dB. Actually, the amplifier gain on the LocalNet 50/50 is 55.4 dB (reverse attenuation +5 dB and forward attenuation +5 dB). Furthermore, the translator has bandwidth of approximately 18 MHz. That is, the translator accepts reverse frequency range from 58 MHz to 76 MHz, and converts it to the corresponding forward frequency range from 214.25 MHz to 232.25 MHz. Thus, the translator accepts the reverse frequency not just from 70 MHz to 76 MHz as mentioned earlier. This is one of the reasons to build this multiple network testbed system. From the test data sheet in APPENDIX F.2, we confirm that the input signal level on each PCU port meets the specifications of PCU input level.

4.5 Sytek System 6000

The basic components of Sytek 6000 Network System are a Sytek 6050 translator and a Sytek 6120 Network Adapter Card. In the following, the installation procedure for these two devices will be described. In order to test each network independently the first time, the other two network translators and interface devices (PCUs, TIMs) should be

disconnected from the system. Except for these changes, the system configuration (Headend and Trunk) remains the same.

4.5.1 Sytek 6050 Installation Procedure

The Sytek 6050 installation procedure is outlined below (Sytek, 1985a):

1. Mount the Sytek 6050 on the cabinet. On the top and bottom of the Sytek 6050, we should leave some space for ventilation.
2. Plug the power cord into the electrical outlet on the cabinet.
3. Turn on the power switch on the front panel. The power indicator should be green.
4. Attach a 4-foot CAC-6 coaxial cable from the return combiner HC-8X IN/OUT port J2 to the RF IN connector on the rear panel of the Sytek 6050.
5. Attach another 4-foot CAC-6 coaxial cable from the forward combiner HC-8X IN/OUT port J2 to the RF OUT connector on the rear panel of the Sytek 6050.
6. Terminate all the unused ports on the translator, combiners, splitters, and directional couplers.

4.5.2 Sytek 6120 Network Adapter Card Installation Procedure

The installation procedure of Sytek 6120 Network Adapter Card is outlined below (Sytek, 1986):

1. Before installing a Sytek 6120 Card to an IBM Personal Computer or IBM PC Compatible Personal Computer, always turn off the PC's power before proceeding. In this thesis, an AT&T 6300 and an ARTISOFT XT are used for the PC Network.
2. Remove all wire connections and screws from the rear panel of the personal computer.
3. Remove the cover (top panel) from the personal computer.
4. Release the screw from a blank card filler, and remove the card filler.
5. Insert the Sytek 6120 Card into the expansion slot of the PC board. Do not touch the elements (ICs) of the Sytek 6120 Card.
6. Put the cover back on the personal computer.
7. Remount all the screws on the rear panel.
8. Connect an RF modem cable from the connector on the rear panel of the Sytek 6120 Card to an outlet which is for a Sytek 6120 Card.
9. Restore all the cable connections on the rear panel of the personal computer.
10. Turn on the power switch of the personal computer.

4.5.3 Test and Adjustment Procedure

For the Sytek System 6000, the test and adjustment procedure could be divided into two parts: one for the Sytek 6050 translator, the other for the trunk test.

4.5.3.1 Sytek 6050 Translator Test. The main concerns of the Sytek 6050 translator test are testing and adjusting the translator gain to obtain the design value, and measuring the accuracy of the frequency conversion and its bandwidth.

The following procedure is for the Sytek 6050 translator test and adjustment:

1. Attach an HP 11694A 50 ohm to 75 ohm transformer to the OUTPUT port of the Signal Generator to match the 75 ohm impedance of CATV equipment.
2. Connect the output connector of the transformer to the RF IN port of the SAM III through a 4-foot CAC-6 cable.
3. Adjust the Signal Generator's frequency to 50.8 MHz (actual value should be 50.75 MHz) and the signal level to 10 dBmV.
4. On the SAM III, manually adjust the frequency to 50.8 MHz by turning the TUNNING control knob. The METER should read 10 dBmV. If not, adjust the signal frequency and signal level amplitude in the Signal Generator until the METER has 10 dBmV reading at

frequency 50.8 MHz on the SAM III.

5. Connect the Signal Generator through the same 4-foot CAC-6 cable used above to the RF IN port of the Sytek 6050 translator.
6. Connect the SAM III through a 4-foot CAC-6 cable to the RF OUT port of the Sytek 6050 translator.
7. It should have approximately 48 dB gain reading at the frequency 219 MHz on the SAM III. The Sytek 6050 gain is already preset at 48 dB. So, we do not really need to adjust the translator gain through the OUTPUT LEVEL on the front panel of the Sytek 6050 by using a screw driver.

In the same way, we may apply different frequencies and different signal levels (less or equal 10 dBmV) from the Signal Generator on the RF IN port of the Sytek 6050, and measure the frequency and signal level of the RF OUT port of the Sytek 6050 on the SAM III. Before we apply different frequency and different signal levels from the Signal Generator to the translator, we have to apply the same procedure outlined in Section 4.5.3.1, Step 1 to 4, to insure the accuracy of the input signal frequency and the signal level. The detailed test data is shown in APPENDIX F.3.

4.5.3.2 Sytek System 6000 Trunk Test. The procedure of the Sytek System 6000 trunk test is outlined below:

1. Follow the same procedure outlined in the Section 4.5.3.1, Step 1 to 4, to set the Signal Generator with the frequency 50.8 MHZ and signal level +56 dBmv.
2. Connect the Signal Generator through a 5-foot CAC-6 cable to the tap port of 24-tap directional coupler which is for the first Sytek 6120 Card.
3. Connect the SAM III through a 5-foot CAC-6 cable to the tap port of another 24-tap directional coupler which is for the second Sytek 6120 Card.
4. Adjust the TUNNING control knob on the SAM III to manually select the frequency until the FREQUENCY DISPLAY has the reading 219 MHZ. Actually, the corresponding forward frequency should be 219.05 MHZ which is achieved by adding the offset frequency 168.25 MHZ to the reverse frequency 50.8 MHZ, but the SAM III can only read four digits.
5. Adjust the ATTENUATOR control knob to select a suitable RF input level range and METER scale, and then read the METER on the SAM III.

In the same way, we can apply different frequencies and different signal levels to a selected port location

including the 4-port 24-tap directional coupler, and then read the signal frequencies and signals level on another selected port location. The detailed test data are shown in APPENDIX F.4.

4.5.4 Results

According to the test data sheet in APPENDIX F.3, we can confirm that the actual gain of the Sytek 6050 is approximately 48.1 dB. Moreover, the Sytek 6050 translator has bandwidth around 6 MHz. That is, the translator accepts reverse frequency range from 47.75 MHz to 53.75 MHz and converts it to the corresponding forward frequency range from 216 MHz to 222 MHz. From the test data sheet in APPENDIX F.4, we confirm that the input signal level on each Sytek 6120 port meets the specifications of Sytek 6120 input signal level.

4.6 Concord Data Systems Token/Net

The basic components of Concord Data Systems are a Token/Net translator and a Token/Net Interface Module (TIM). In the following, we will describe their installation procedures respectively. In order to test each network independently the first time, the Sytek LocalNet 20's translator and PCUs, and the Sytek System 6000's translator and PCs (with a Sytek 6120 Card) should be disconnected from

the system. Except for these changes, the system configuration remains the same.

4.6.1 Token/Net Translator Installation Procedure

The Token/Net translator installation procedure is outlined below:

1. Use four screws to mount the Token/Net translator to the cabinet. Be sure that ventilation holes are not covered.
2. Connect the power cord from the Token/Net translator and to an electrical power outlet.
3. Turn on the power switch on the front panel of the Token/Net translator. The front panel power indicator will turn orange.
4. Attach a 4-foot CAC-6 coaxial cable from the return combiner HC-8X IN/OUT port J3 to the INPUT connector on the rear panel of the Token/Net translator.
5. Attach another 4-foot CAC-6 coaxial cable from the forward combiner IN/OUT port J3 to the OUTPUT connector on the rear panel of Token/Net translator.
6. Terminate all the unused ports on the translator, combiners, splitters, and directional couplers.

4.6.2 TIM Installation Procedure

The TIM installation procedure is outlined below (CDS, 1984b):

1. Connect a RS-232C cable from an asynchronous ASCII terminal to the PORT 1 RS-232C Connector of the Control Unit card on the rear panel of TIM. In this thesis, two Zenith Z-29 terminals are connected to two TIMs respectively.
2. Set terminals to 9600 bps, 8 bits/per character, a stop bit, no parity, and no echo.
3. Slide the PORT/CNSL on the rear panel of the Control Unit card to the CNSL location. The PORT 1 will operate in the CONSOLE mode.
4. Plug the power cord into the socket on the rear panel of the TIM, and plug the other side to an electrical outlet.
5. After a few seconds, the power indicator on the front panel of the TIM will turn green. Otherwise, a failure has occurred in the initialization process.
6. If the POWER indicator turns green, the following message will show on the terminal screen:
"Password:"
7. Now the TIM is ready to be configured by using the console. Use the TCM CONfigure command to adjust the parameters including the node address and the broadband channel pair on which the TIM will operate.

8. When the TIM displays "Password:" again, it means that the new configuration change is now in effect.
9. Connect the terminal to PORT 1 and slide the CNSL/PORT switch to the PORT position.
10. Connect a 5-foot CAC-6 coaxial cable from the connector on the rear panel of the Modem Card of the TIM to an outlet which is for the TIM.
11. Perform a console BOOT.
12. At this time, the POLL indicator of the TIM will turn yellow and the terminal on the PORT 1 should display the following message:

spa:

4.6.3 Test and Adjust Procedure

For the Token/Net System, the test and adjustment procedure could be divided into two parts: one for the Token/Net translator, the other for the Token/Net trunk test.

4.6.3.1 Token/Net Translator Test. The main concerns of the Token/Net translator test are testing and adjusting the gain to obtain the design value, and measuring the accuracy of the frequency conversion and its bandwidth.

The following procedure is for the Token/Net translator test and adjustment:

1. Attach an HP 11694A 50 ohm to 75 ohm transformer to the OUTPUT connector of the Signal Generator to

match 75 ohm impedance with the CATV equipment.

2. Connect the output connector of the transformer to the RF IN connector of the SAM III through a 4-foot CAC-6 cable.
3. Adjust the Signal Generator's frequency to 80.8 MHZ. Actually, the value should be 80.75 MHZ, but the SAM III can only read four digits. Next, set the signal level to 10 dBmv.
4. On the SAM III, manually adjust the frequency to 80.8 MHZ. The meter should read 10 dBmv. If not, adjust the signal frequency and signal level amplitude on the Signal Generator until the METER has a 10 dBmv reading at the frequency 80.8 MHZ on the SAM III.
5. Connect the Signal Generator through the same 4-foot CAC-6 cable used above to the INPUT connector on the rear panel of the Token/Net translator.
6. Connect the SAM III through a 4-foot CAC-6 cable to the OUTPUT connector on the rear panel of the Token/Net translator.
7. Use a screw driver to adjust the GAIN knob on the front panel of the Token/Net translator such that the output level is about 52 dBmv at the frequency 273 MHZ on the SAM III.

In the same way, we may apply different frequencies and different signal levels (less or equal 10 dBmV) from the Signal Generator to the INPUT connector of the Token/Net translator, and measure the OUTPUT connector of the translator by using the SAM III. Before we apply different frequencies and signal levels from the Signal Generator to the translator, we must apply the same procedure outlined in Section 4.6.3.1, Step 1 to 4, to insure the accuracy of the input signal frequency and the signal level. The detailed test data is shown in APPENDIX F.5.

4.6.3.2 Token/Net Trunk Test. The procedure of the Token/Net trunk test is outlined below:

1. Follow the same procedure outlined in Section 4.6.3.1, Step 1 to 4, to set the Signal Generator with the frequency 80.8 MHz, signal level +44 dBmV.
2. Connect the Signal Generator through a 5-foot CAC-6 cable to the tap port of the 19-tap directional coupler which is for TIM 1.
3. Connect the SAM III through a 5-foot CAC-6 cable to the tap port of the 19-tap directional coupler which is for TIM 2.
4. Adjust the TUNNING control knob on the SAM III to manually select the frequency until the FREQUENCY DISPLAY has the reading 273 MHz. Actually, by adding the offset frequency 192.25 MHz to the

reverse frequency 80.8 MHz, the corresponding forward frequency should be 273.05 MHz, but the SAM III can only read four digits.

5. Adjust the ATTENUATOR control knob to select a suitable RF input level range and METER scale, and then read the METER on the SAM III.

In the same way, we can apply different frequencies and signal levels to a selected port location including the 4-port 24-tap directional coupler, and read the signal frequencies and signal levels on another selected port location. The detailed test data are shown in APPENDIX F.6.

4.6.4 Results

According to the test data sheet in APPENDIX F.5, we can confirm that the actual gain of the Token/Net translator is approximately 41.5 dB. In addition, this translator has a bandwidth of approximately 6 MHz. That is, the translator accepts reverse frequency range from 77.75 MHz to 83.75 MHz and converts it to the corresponding forward frequency range from 270 MHz to 276 MHz. From the test data sheet in APPENDIX F.6, we confirm that the input signal level on each TIM port meets the specifications of TIM input signal level.

4.7 Overall System Test and Adjustment Procedure

After testing and adjusting each network respectively, connect these three networks to the cable

system simultaneously. A similar procedure is performed on each network to see if the frequencies and signal levels are the same as before.

4.7.1 Method

Since measurement errors on the test equipment sometimes affect test results, we cannot really be sure whether the test data variance is caused by measurement errors or is affected by other networks. Therefore, a different measurement method has to be adopted. Instead of comparing two test data resulting from individual network test and integrating networks test, a single measurement is performed:

1. Turn on the power of the LocalNet 20 system including the LocalNet 50/50 and PCUs. Perform the test on a specific point by using the SAM III. Inspect the METER reading of the SAM III.
2. Turn on the power of either the PC-NET or Token/Net system including their translators and interface devices. Inspect the METER reading of the SAM III again.
3. By comparing the SAM III METER reading in Step 1 and Step 2, we can tell if one network operation is affected by the other two network operations.
4. Do the same procedure for the PC-NET and Token/Net.

4.7.2 Procedure

By following the measurement method outlined above as well as the same test and adjustment procedures performed for each network in the previous sections, the overall test results can be attained. Furthermore, a +56 dBmV video signal level at the frequency 70.1 MHz is injected to the network by using the LocalNet 50/70 Cable Test Set. At the same time, measure the signal level at frequency 226.35 MHz with the same LocalNet 50/70 at the same port location. In this way, whether or not this cable system is compatible to a video cable system can be verified. The detailed test data are shown in APPENDIX F.7.

4.7.3 Results

The integrating test result for each network is the same as its individual test results shown in APPENDIX F.1 to APPENDIX F.7 respectively. Therefore, we have proven that these three networks can coexist at the same single cable plant from the hardware point of view. Also, based on test data in APPENDIX F.7, we confirm that the trunk design meets with the broadband network design guideline by using the video signal level as a reference signal level.

CHAPTER 5

SOFTWARE INSTALLATION AND APPLICATION PROCEDURE

For a Sytek LocalNet 20 system, the software installation involves to set parameters for each PCU in order for terminals or computers to communicate with one another. For a Sytek System 6000, the PC Network Program needs to be installed on each PC with a Sytek 6120 Network Adapter Card. For a CDS Token/Net, the system configuration parameters need to be set up for each TIM in order for its associate terminals or computers to communicate with one another. In the following sections, detailed software installation and application procedure for each network will be described.

5.1 Sytek LocalNet 20

After installing two PCUs to the tap ports of the LocalNet 20, and an AT&T 4425 terminal to each PCU PORT 0, press the carriage return key (CR) several times to see if we can get a prompt sign "#" on the terminal. If we can get a prompt sign "#" that means the terminal has been properly connected to the PCU. Otherwise, push the reset button on the PCU twice to match the baud rate between the PCU and the terminal.

5.1.1 PCU Set Up

Make sure both PCUs have the same channel, channel spacing, and group settings. And, check the PCU to see if its COMMAND is set to "Esc" and "Del" two keys (default value). Of course, we may use the other COMMAND keys. For example, the RS-232C BREAK key, or any two ASCII characters (Sytek, 1984a) can be chosen.

For the first PCU, type:

#UNIT 0001 <CR>

#LOCATION 12,1 <CR>

#GROUP A <CR>

#BAUD 9600 <CR>

where <CR> means to press the carriage return key, and the underlined characters are typed by the user.

For the second PCU, type:

#UNIT 0002 <CR>

#LOCATION 12,2 <CR>

#GROUP A <CR>

#BAUD 9600 <CR>

The other parameters can be the same settings as the default PCU settings shown in Figure 5.1. Also, regarding to the command names, we actually only need to type the necessary substring of a command name in order to distinguish it from the other command names.

#status

LOCALNET 20/100 8401 0000 19 V2.2.1

UNIT	0001,1	BAUD	9600	IDLE	5
GROUP	A	PARITY	NONE	EOM COUNT	0
CHANSF	300	STOPS	1	EOM CHARACTER	NONE
LOCATION	12,1	AUTOBAUD	OFF	NEWLINE	0D
COMMAND	1B,7F	DCD CONTROL	OFF	EXPAND	NONE
LISTEN	ON	DSR CONTROL	OFF	XON	11
PRIVILEGE	ON	DTR CONTROL	OFF	XOFF	13
MAXSESSION	1	ECHO	OFF	FLOW	NONE
PCALL	OFF	QUIET	OFF	TIMEOUT	0
PUNIT	0000,0				

SESSION - 1

1) 0002,0* ACTIVE

Figure 5.1 PCU Status Display

5.1.2 PCU Status and Help

After a prompt sign "#" is shown on the terminal, type "STATUS" to check the parameter settings on the PCU. The sample form of the STATUS display on the terminal has been shown in Figure 5.1. Then, type "HELP" to see what commands are available. The sample form of HELP display on the terminal is shown in Figure 5.2.

5.1.3 Make a Connection

On the AT&T 4425 (terminal 1), type:

CALL 0002,0 <CR>

We will see the following message displayed on terminal 1 which is connected to the calling PCU 1.

CALL COMPLETED TO 0002,0

The called PCU should display the following message on another AT&T 4425 (terminal 2).

CALL RECEIVED FROM 0001,0

Then, two terminals can be entered any data to communicate with each other. After completing communication, we (usually the calling user) may press "Esc" and "Del" two keys to close the session. Additional LocalNet 20 commands related to this section are described in APPENDIX G.

5.2 Sytek System 6000

The PC Network Program can be installed to any IBM Personal Computer (or compatibles) with a Sytek 6120 Network

#help

AUTOBAUD	BAUD	CALL	CHANSP	COMMAND	DCD
DISABLE	DONE	DSR	DTR	ECHO	ENABLE
EOM	EXPAND	FLOW	GROUP	HELP	IDLE
INTERRUPT	LISTEN	LOCATION	MAXSESSION	NEWLINE	PARITY
PCALL	PRIVILEGE	PUNIT	QUIET	REMOTE	SSTAT
STATUS	STOPS	SUSPEND	SWITCH	TIMEOUT	UNIT
XOFF	XON				

Figure 5.2 PCU Help Display

Adapter Card. The user functions offered by the PC Network Program are listed here (IBM, 1985b):

1. Exchange messages between PCs.
2. Share user devices including disk drives, directories, files and printers to the PC Network.
3. Use network devices (same as 2).
4. Check the network status including printer queues, devices that the user is sharing, devices that the user is using, names that can receive message at the user PC.
5. Pause or continue tasks. For example, pause or continue using network devices or sharing user devices.
6. Save or cancel the network set up. This function allows the user to save or cancel the way he is using the PC Network.

The set up procedures during installation will vary depending on installing the PC Network Program on a floppy disk or a hard disk of a PC.

5.2.1 PC Network Program Installation:

After installing a Sytek 6120 Network Adapter Card to either the ARTISOFT XT or the AT&T 6300 Personal Computer, if we do not connect the Network Adapter Card through a coaxial cable to the Sytek 6050 translator, the following error message will appear:

3015 12 8F Network Card 0: Analog Look Back Test Failed

Press F1 to resume

After the Network Adapter Card has been connected to the translator through a coaxial cable, turn on the PC power switch. The PC will do the diagnostic check for its environment including the Network Adapter Card. If the PC passes the diagnostic test, it means that the Network Adapter Card works normal up to now. Otherwise, the following message might appear:

3013 04 40 Network Card 0: Interrupt test failed

(check IRQ jumper)

If so, change the jumper locations between w3 and w4 on the Network Adapter Card. Depending on the different IBM PC compatible personal computers we use, the jumper might need to be set at either w3 or w4.

Depending on a PC configuration, memory capacity, a PC can be configured as a redirector, receiver, messenger, or server. The IBM PC Network Program User's Guide (IBM, 1985b) includes each configuration requirements and tasks we can do for each configuration. Since both AT&T 6300 and ARTISOFT XT have a hard disk, they were configured as servers. We need to follow the instructions in the Section 5.2.1.1 to install the IBM PC Network program on the hard disk for each PC. Section 5.2.1.2, for PCs with at least one 320 KB floppy disk drive, is for reference only.

5.2.1.1 PC Network Program Installation for a PC with a Hard Disk. Use the PC Network Program Installation Aid diskette to assist installing the PC Network Program on a hard disk. Follow the menu of PC Network Program Installation Aid to set up software structure and applications. The following steps are for installing the PC Network Program on a hard disk (IBM, 1985b):

1. Insert the DOS 3.10 (IBM, 1985a) diskette in drive A and restart the system by turning on the computer or press "Ctrl, Alt, Del," three keys.
2. Enter date and time, and then remove the DOS 3.10 diskette from drive A.
3. Insert the PC Network Program Installation Aid diskette to drive A.
4. Type G and then press the Carriage Return (CR).
5. Follow the menu instruction to install the DOS 3.10, PC Network Program, applications and network users.
6. Then, restart the DOS 3.10 by pressing "Ctrl, Alt, Del," three keys.
7. Type "NET" to start the PC Network and follow the menu, or start the PC Network with NET START command with suitable parameters.

If we can see the PC Network tasks menu, or start PC Network program by using NET START command without being issued an error, that indicates the Sytek 6120 Network

Adapter Card works well so far. Otherwise, we might receive the following error message:

**NET 041: Network Adapter Card not installed or not
functioning**

For example, if we install a Network Adapter card to an NCR Personal Computer Model 4, we will receive the above error message, because this type of PC is not exactly compatible to IBM Personal Computers. Therefore, when installing a Sytek 6120 Network Adapter Card to a PC, make sure that the PC is exactly IBM PC compatible.

In addition, the original CONFIG.SYS file name (if we have one) might have been changed to CONFIG.NIA and a new CONFIG.SYS file is created. The new CONFIG.SYS is shown in Figure 5.3 which reflects the necessary configuration for the PC to run the PC Network program. The DOS3.10 (IBM, 1985a) or IBM PC Network User's Guide (IBM, 1985b) contains the detailed description of each command. Moreover, the PC Network Program Installation Aid diskette can help set up the software system and applications. It arranges the PC Network Program files on the suitable directories. The directory structure created by the PC Network Program Installation Aid diskette is shown in Figure 5.4 (IBM, 1985b).

```
LASTDRIVE=N  
DEVICE=VDISK.SYS 160 512 64  
BUFFER=10  
FILE=100  
FCBS=16,8
```

Figure 5.3 PC CONFIG.SYS File Listing

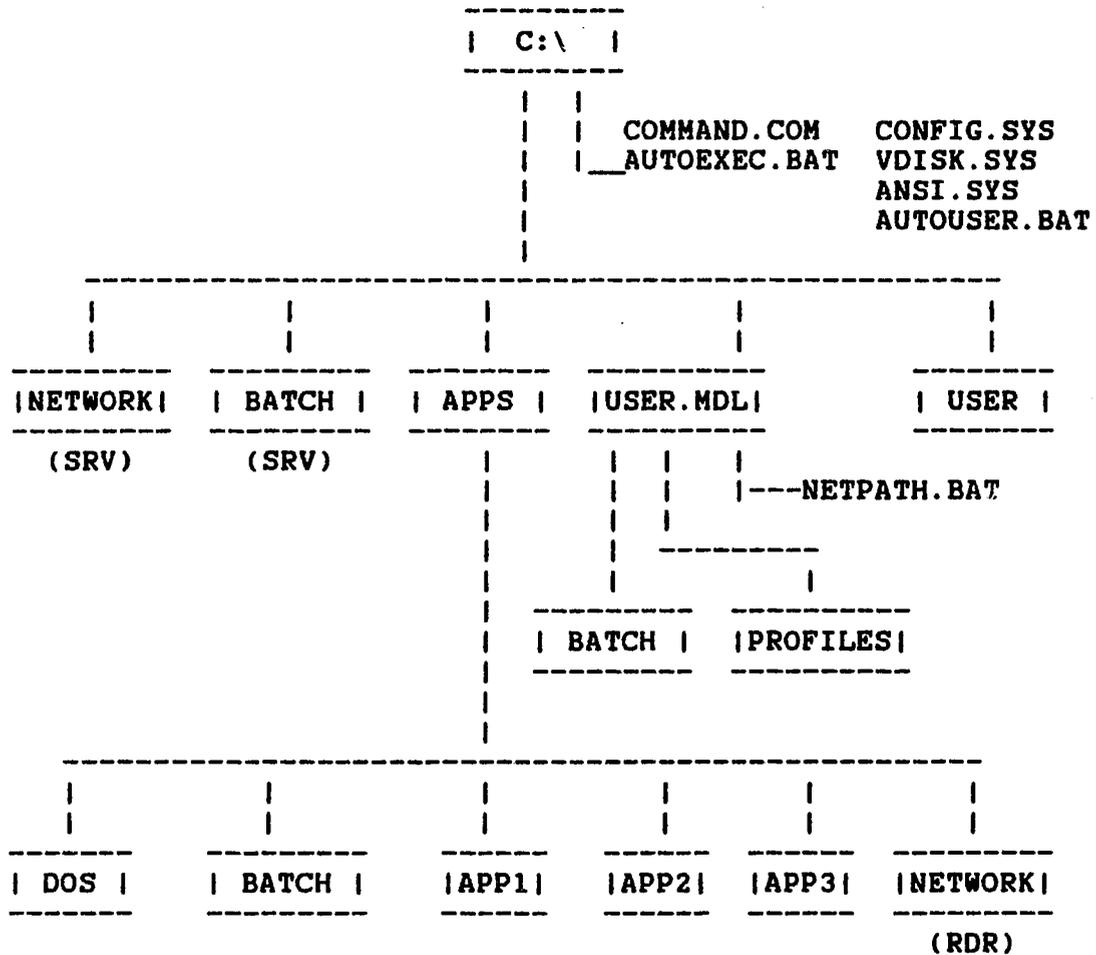


Figure 5.4 Suggested Fixed Disk C Directory Structure for PC Network

5.2.1.2 PC Network Program Installation for PC with at Least One 320 KB (double sided) Floppy Disk Drive Follow the following procedure to install the PC Network Program on a 320 KB disk drive (IBM, 1985b):

1. Boot DOS 3.10 from drive A.
2. Type "FORMAT b:/s."
3. Depending on the number of disk drives, do one of the following:
 - (i) If the computer has one disk drive A:
Remove the DOS 3.10 diskette and insert the blank diskette in drive A.
 - (ii) If the computer has two disk drives:
Insert a blank diskette in drive B.
4. After the completing formatting, remove the formatted diskette.
5. Insert the PC Network Program diskette in drive A.
6. Depending on the number of disk drives:
 - (i) If the computer has two drives:
Insert the previously formatted diskette in drive B and type:
INSTALL B: ds <CR>
where ds means doublesided
 - (ii) If the computer has only one drive:
type:
INSTALL B: ds <CR>

After a request to insert a diskette to drive B, remove PC Network Program from drive A, and insert the formatted diskette in drive A.

7. Remove the diskettes from the drives.
8. Insert the new copy of PC Network Program with DOS 3.10 diskette in drive A.
9. Press "Ctrl, Alt, Del," three keys, to restart the DOS system.
10. Type "NET" to start the PC Network Program, or use command "NET START" with suitable parameters to start the PC data communication tasks.

5.2.2 PC Network Program Tasks

There are seven different tasks that may be performed on the PC Network Program (IBM, 1985b). Once we start the PC Network Program by typing "NET", the task selection of the main menu (Figure 5.5) will appear on the screen. On each task, in addition to using the menu to proceed the PC Network data communications, we may also use PC Network commands to proceed PC Network Program tasks if we are already familiar with the PC Network Program commands.

In the following, the message task is used as an example to see how the menu work. On the AT&T 6300, type "1" and <CR> to select the Message tasks. Type "1" and <CR> to select the Send message task. Type a computer name

Main Menu - Task Selection

1. Message tasks
2. Printer tasks
3. Disk or directory tasks
4. Print queue tasks
5. Network status tasks
6. Pause and continue tasks
7. Save or cancel the network set up

1 Choice

Enter - Continue

F1 - Help

Esc - Exit

Figure 5.5 PC Network Program Tasks

RALPHM (ARTISOFT XT computer name) and enter "Tab" key to move cursor to another field. Type "Hello!" and press "Ctrl" and <CR> two keys at the same time to send out the message to the ARTISOFT XT. The corresponding network command under the DOS prompt is:

NET SEND RALPHM HELLO! <CR>

After the message has been sent out, the ARTISOFT XT will receive a message showing that a message is coming. If the ARTISOFT XT is in the network menu mode, we only need to type "F3" key to view the incoming message. On the other hand, if the PC is in the DOS commands mode, we either press "Ctrl, Alt, Break," three keys, to view the receiving message, or press "Ctrl, Break," two keys, to continue the normal work. We can resume the normal work in either case.

Here, only the sending message task is presented. The IBM PC Network Program User's Guide (IBM, 1985b) includes the other tasks' information. In this thesis project, different tasks were performed on each PC to make sure two Sytek 6120 Network Adapter Cards and the IBM PC Network Program function normally. It has been proven that they are working well.

Having performed different tasks by using the PC Network menu, we might decide to save these network settings such that we do not need to set up the PC for PC Network again when we restart the PC. Of course, we can update the

PC Network set up by the similar procedure. If we choose to save the network settings, the original AUTOEXEC.BAT file name on the PC will be changed as the AUTOUSER.BAT. The new generated AUTOEXEC.BAT file will include all the network set up commands. The sample AUTOEXEC.BAT file listing for the Artisoft XT is shown in Figure 5.6. In Figure 5.6, we see a "*" shown on the NET SHARE commands which means the PC will ask the user to type the password when these commands are executed. The password feature is another protection function to prevent the network device from being abused by unauthorized users. So, only inform authorized users of the password of the network device. However, one disadvantage of this password function is that the PC Network Program echoes the password which should not be displayed on the screen.

Once we start the PC Network Program, essentially, we can use all the DOS commands except the "Ctrl, PrtSc" and "Shift, PrtSc," two screen hardcopy commands, and the PRINT command, which are no longer valid. We have to use the NET PRINT instead of the PRINT command. Except these commands, we may use a network drive as a local drive. For example, we may specify a network disk drive on another PC as the local disk drive M. Then, the following computer session on the PC actually proceeds the file transfer between two PCs:

```
C: COPY M:AUTOEXEC.BAT C:AUTOEXEC.BAK <CR>
```

or

```
:*** Network Batch File ***  
:  
:  
ECHO OFF  
PATH C:\NETWORK  
YNPROMPT Y N 39 Do you want to start the network (Y/N)?  
IF ERRORLEVEL 1 GOTO A  
ECHO ON  
MODE BW80  
NET START SRV RALPHM /SRV:5 /MBI:1600 /SHR:10 /SES:18  
NET SHARE APPS=C:\APPS /R  
NET SHARE CERL=C:\CERL *  
NET SHARE CHARLESG=C:\CHARLESG *  
NET NAME MARTINEZ  
ECHO OFF  
GO TO B  
A:  
PATH \  
:B  
ECHO ON  
AUTOUSER.BAT
```

Figure 5.6 PC AUTOEXEC.BAT File Listing

C: M: <CR>

M: COPY C:CONFIG.SYS M:CONFIG.BAK <CR>

5.2.3 PC Network Program Commands

As previously mentioned, in addition to starting the PC Network Program by using the network menu, we may also start the PC Network Program by using the NET START command with suitable parameters which depend on the PC applications. We can also share devices with the PC Network if the PC is a server. The basic procedure for sharing a device to the PC Network is first to inform the PC Network that we want to share the device by using the NET SHARE command. Without this step, other PCs cannot use the device. So, it is better to put NET START and NET SHARE commands on the AUTOEXEC.BAT file if the PC is a server.

If we wish to use some network device, we must issue a NET USE command to specify the device that we are going to use. All of the PC Network Program commands are external commands. APPENDIX H contains additional PC Network command description.

5.2.4 PC Network Management

For a server PC, we must seek a good way to manage it. Otherwise, someone might steal or destroy files on the server PC. Or, the server PC might run inefficiently. Some guidelines for managing a server PC are outlined in the

following:

1. Use the PC Network Program Installation Aid to organize the directory structure of a server's fixed disk. The PC Network recommended directory structure was shown in Figure 5.4.
2. Analyze the server PC applications and other PC requests for the server PC. Next, choose suitable parameters for the NET START command. For example, depending on the ratio of foreground server tasks (a local user) and background tasks (remote users), we might adjust a suitable time value for TSI (time slice intervals) parameter. A better way to increase a server PC efficiency is selecting suitable parameters for its NET START command.
3. Assign proper access rights (Read/Write/Create/Delete) to the files on the shared disks and directories. For example, share the applications with "Read Only" access right. Also, assign a password to each network device (disk, directory, or printer), and only inform authorized users of the password.

5.3 Concord Data Systems Token/Net

After connecting each TIM through a coaxial cable to the respective tap port on the network and attaching a Zenith Z-29 terminal through a RS-232C cable to each TIM's

port 1, the next step is to set up the configuration parameters.

5.3.1 TIM Set Up

The configuration settings for two TIMs are described in this section. It facilitates terminals to communicate with each other through TIMs and the cable network. In the following sample session for TIM 1, the underlined characters are the input data that a user must respond to the system, and a <CR> means to enter the Carriage Return after each command. First, turn on the POWER switch for each TIM. Next, respond to the prompt message.

Password: SYSTEM <CR> (default password is SYSTEM)

Console Monitor SPA 1.1j

tcm: con write mac: 06 02 00 00 00 00 f0 <CR>

10E: 06 02 00 00 00 00 f0

tcm: con write phy: 03 03 <CR>

10B: 03 03

tcm: con sav all <CR>

copy complete

tcm: boot <CR>

In the same way, we can set parameters for TIM 2. The only difference is to replace f0 with f2. After restarting each TIM, the system will request to enter the password again. Type "SYSTEM" to each TIM, then uses a

screw driver to turn CTRL/PORT switch on the back of the TIM from CTRL to PORT position. After this, the "spa:" (serial port application) prompt will be displayed on the terminal screen.

5.3.2 TIM Status and Help

We may check a TIM status by typing "STATUS". Actually, we only need to enter the first three characters. The sample STATUS format is shown in Figure 5.7 (CDS, 1984a). In addition, we may type "HELP" to check what commands are available and the explanation for each command. The sample HELP display is shown in Figure 5.8 (CDS, 1984a). After making sure that each TIM's settings are correct, we may make a connection between two terminals. Otherwise, we must use the same procedure outlined above.

5.3.3 Make a Connection

Now, we can try to make a connection. On terminal 1 (connected to TIM 1), enter:

```
call #f2.3.1 <CR>
```

We will see the following message on the screen:

```
To cancel call, return to command mode.
```

```
calling 02 00 00 00 00 f2.03.01.
```

```
Connected to 02 00 00 00 00 f2.03.01
```

```
Entering data state.
```

Then, we may begin to enter data to the terminal. In this way, two terminals may communicate with each other. If we

spa: status

Unit Address : 02 00 00 00 00 F0

Slot Number : 3

Port Number : 1

Call Compartments : 00 00 00 00 00 00 00 01

Local Names : - blank -

: - blank -

: - blank -

: - blank -

Default Remote Station : - blank -

Figure 5.7 TIM Status Display

spa:help

Answer	Accepts incoming call to your terminal.
Call	Establishes a connection to the port you specify.
Configure	Enables you to change basic operational settings.
End	Ends a session and clears the call to your computer or terminal.
Help or ?	Provides information on available commands and formats.
Reject	Refuses an incoming call to your terminal.
Resume	Returns you to a suspended session.
Status	Displays the status of your current sessions or port.

All of the above commands can be shortened to a minimum of three characters.

Typing **HELP** or **?** following by a specific command will provide the command's format, parameters, and switches.

Figure 5.8 TIM Help Display

have completed communication, just press "Break" key twice to terminate the session. Similarly, terminal 2 (connected to TIM 2) may call terminal 1 by entering:

call #f0.3.1 <CR>

We will see a similar message as shown above. APPENDIX I contains additional Token/Net command description.

CHAPTER 6

SUMMARY AND CONCLUSION

This thesis project involved network and cable plant design, test, and analysis steps. It has been proven that the multiple networks testbed system runs pretty well without causing any interference among the different networks. The three networks systems share the same cable plant, and transmit and receive data on their own channels.

6.1 Current System Constraints

The current system is a testbed set up in the CERL. It shows that it is feasible to install different networks on different channels on the same coaxial cable without causing any interference. It can be used as a blue print to design a commercial or a campus broadband cable network. Before switching this system to the existing Campus Sytek cable plant, a detailed survey and design will have to be performed. By computing the ratio between the occupied frequencies and the whole frequency band in either reverse or forward frequency band, about 30% of the campus broadband frequency spectrum is used by the proposed configuration.

The testbed system is so small that many design factors, such as noise and distortion, were not considered

in this thesis project. The main source of noise and distortion is caused by amplifiers. Cable tilt, a power supply, AC terminators, amplifiers, equalizers, and unity gain criterion were not important in this thesis project. This does not mean the testbed system is not practical. It is still valuable to have an experimental proof that such a testbed system constituted by these three different networks can be realized.

Basically, if the existing campus Sytek broadband network cable plant has been designed by using the video signal level as a reference signal level and has followed all the CATV design guidelines, then each TIM or Sytek 6120 may be installed to any existing Sytek cable outlets without requiring a change to the tap port value of the outlets. We have already proven this possibility on the testbed system. This is due to big tolerance of the input signal level on the interface devices. Nevertheless, we might need to monitor the operation and performance of the CDS Token/Net to further confirm this point. If its network components cannot operate on their nominal signal levels, we may increase the translator gain, or increase the transmitting output level of the TIM by changing its setting through software control.

6.2 Future work to be performed

In this thesis project, three different networks coexisting on the same cable are designed and tested successfully. The second phase is to install three networks to the existing campus Sytek cable system. The proposed campus headend structure is shown in Figure 6.1. The LocalNet 50/50 and two TV channel processors currently exist on the Sytek cable plant. These two TV channel pairs (T8 - CH8 and T9 - CH10) are currently used by the Microcampus to broadcast lectures or seminars from the Microcampus to the campus where the campus Sytek broadband cable outlets are available. The third one (T7 - CH7) will be used with a portable camera and a modulator to broadcast a lecture or an activity from any campus building to the whole campus if the campus Sytek broadband outlets are available for these buildings. Thus, the cable TV on campus might be more flexible.

Moreover, a Sytek 2550 Network Translator, a second LocalNet 50/50 translator, a LocalNet 50/55 Redundant Headend Switch and a LocalNet 50/201 InterNet Bridge InterNet Link will be installed to the headends. The Sytek 2550 is the Network Translator of the Sytek System 2000. The Sytek System 2000 contains Sytek 2500 Network Loader, Sytek 2502 (or Sytek 2532) PCUs, and Sytek 2550 Network Translator. It is completely compatible with the LocalNet

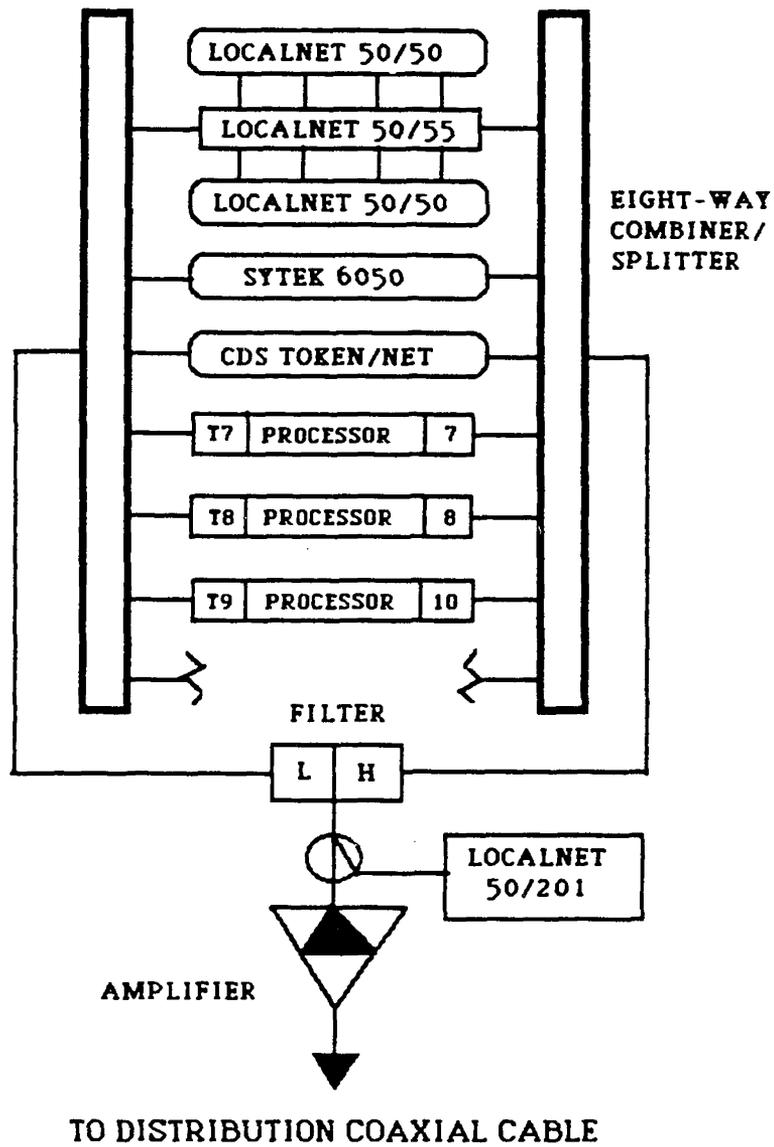


Figure 6.1. Proposed Headend Structure for the Campus Broadband Cable Plant

20, and can communicate with the LocalNet 20. The LocalNet 50/55 will automatically switch the cable network to the backup LocalNet 50/50 if the existing LocalNet 50/50 goes bad. As a result, this broadband network system may provide more reliable services to the ever-growing users. A LocalNet 50/201 Bridge/Link can interconnect PCUs on the different channels. Thus, the PCUs on the different channels may communicate with one another, and share the same address space and resources. Presently, only the channel 12 (central frequency 73.9 MHz) is used on the campus broadband network. Facing the rapid growth of the broadband users, a second (or third) is needed to relieve the busy traffic on the channel 12. Also, by using the LocalNet 50/201 Bridge/Link, the overall utilization of LocalNet may be increased.

When expanding the existing system, the same design issues outlined in the Chapter 3 should be considered again. Before installing a TIM or a PC with Sytek 6120 Card to an outlet, we have to use a Signal Generator to generate a corresponding transmitting signal and a Signal Analysis Meter to measure the receiving signal level on the outlets to make sure that TIMs, Sytek 6120 Cards, or TVs are operating on the proper signal levels. When designing an outlet, we have to survey the present and future needs in order to install suitable multiple-tap directional couplers

for the Cable TV, LocalNet 20, Sytek System 6000 (PC-NET), CDS Token/Net, or Sytek System 2000.

After that, the third phase is to develop or purchase gateways for any two of networks to exchange information and to share resources. The following interconnection of networks using gateways is possible on an expanded campus multiple network system:

1. LocalNet 20 to PC-NET
2. LocalNet 20 to CDS Token/Net
3. Sytek System 2000 to PC-NET
4. CDS Token/Net to PC-NET

The first gateway can be purchased and the other gateways must be developed (Martinez, 1986).

Depending on the university needs, the following work could be developed for the campus broadband network:

1. Video conferencing
2. Voice (telephone) communication through a voice modem
3. Connecting to a baseband network such as the Ethernet LAN
4. Energy management system
5. Security system including area access control, fire alarm, and building surveillance

There are commercial interface devices available for connecting the Ethernet baseband network to the broadband

network. It will require 18 MHZ bandwidth in the broadband frequency spectrum. However, this approach might need to sacrifice some existing Sytek LocalNet 20 channels.

In addition, for each network system, a performance evaluation should be performed. In this way, we might be able to adjust the system parameters, or operation environment to increase system efficiency. For example, on the PC Network, we may analyze the applications for a server PC and determine suitable parameters for its NET START command. Thus, the server PC may improve in performance.

Other work which deserves to be done is building a Cable Plant Expert System. This Expert System should be able to assist to design, maintain, and manage a cable plant that may help relieve the burden of rapid growth of broadband networks. It is estimated that the operating cost of a cable plant is over 50% of the total expenditure for a broadband network system. Therefore, the operating cost of a broadband network system could be reduced by using a Cable Plant Expert System which will apply new artificial intelligence technology, and is expected to help make cable planning more efficient and more manageable.

APPENDIX A

MULTIPLE NETWORKS SPECIFICATIONS

A.1 LocalNet 50/50

Characteristics	Value
Input/Output Impedance	75 ohm
Bandwidth	18 MHz
Offset Frequency	156.25 MHz
Reverse Frequency	64 to 82 MHz
Forward Frequency	220.25 to 238.25 MHz
Translator Input Level	-12 to +10 dBm
Translator Output Level	+38 to +60 dBm
Translator Gain	50 dB +/- 2 dB
Noise Figure	8 dB (Nominal) 10 dB (Max.)
Carrier to Noise Ratio	50 dB (Min.)
Reverse RF Attenuation	0 to 50 dB Rotary Attenuator
Forward RF Attenuation	0 to 50 dB Rotary Attenuator

A.2 LocalNet 20/100 PCU

Characteristics	Value
Input/Output Impedance	75 ohm
Medium Access Method	CSMA/CD
Cable Topology	Branching Tree
Transmit Frequency	70 to 76 MHZ
Receive Frequency	226.25 to 232.25 MHZ
Transmitter Output Level	+46 dBm
Receiver Input Level	-2 dBm +/- 6 dB
Data Rate	75 bps to 19,200 bps
Channel Capacity	200 Simultaneous Active Users
Medium Capacity	120 Channels
System Capacity	24,000 Simultaneous Active Users
Frequency Agility	20 Channels (300 KHZ Channel Spacing)
Error Rate	Less Than 1 in 10**9 Bits

A.3 Sytek 6050 Translator

Characteristics	Value
Input/Output Impedance	75 ohm
Channel Bandwidth	4.7 MHz
Channel Spacing	6 MHz
Offset Frequency	168.25 MHz
Reverse Center Frequency	50.75 MHz
Forward Center Frequency	219 MHz
Translator Input Level	+10 dBm
Translator Output Level	+58 dBm
Translator Gain	33 to 53 dB
Noise Figure	10 dB (Max.)

A.4 Sytek 6120 Network Adapter Card

Characteristics	Value
Input/Output Impedance	75 ohm
Medium Access Method	CSMA/CD
Cable Topology	Branching Tree
Transmit Frequency	50.75 MHZ
Receive Frequency	219 MHZ
Transmitter Output Level	+56 dBm (Nominal)
Receiver Input Level	+8.5 dBm +/- 15.5 dB
Data Rate	2 Mbps
Maximum Distance to Network Translator	16,500 ft. (5 KM)
Maximum PC's Per Network	1000

A.5 Token/Net Translator

Characteristics	Value
Input/Output Impedance	75 ohm
Channel Bandwidth	6 MHz
Offset Frequency	192.25 MHz
Reverse Frequency	77.75 to 83.75 MHz
Forward Frequency	270 to 276 MHz
Translator Input Level	-10 to +10 dBm
Translator Output Level	+15 to +55 dBm
Translator Gain	25 to 45 dB

A.6 Token/Net Interface Module

Characteristics	Value
Input/Output Impedance	75 ohm
Medium Access Method	Token Bus
Cable Topology	Branching Tree
Transmit Frequency	77.75 to 83.75 MHz
Receive Frequency	216 to 222 MHz
Transmitter Output Level	+30 to +50 dBm +44 dBm (Nominal)
Receiver Input Level	-10 to +10 dBm
Data Rate	5 Mbps

APPENDIX B

CDS TOKEN/NET FREQUENCY PAIRS AND OUTPUT SIGNAL LEVELS

B.1 TIM Frequency Pairs

Channel Selector Number	Transmit Channel Name	Transmit Frequency	Receive Channel Name	Receive Frequency
00	3	59.75-65.75	P	252-258
01	4	65.75-71.75	Q	258-264
02	4A	71.75-77.75	R	252-258
03	5	77.75-83.75	S	258-264
04	6	83.75-89.75	T	264-270
05	FM	89.75-95.75	U	270-276

B.2 TIM Output Signal Levels

NO	Setting	TIM Transmitting Output Level
1	0F	50.0 dBmV
2	0E	48.5 dBmV
3	0D	47.0 dBmV
4	0C	45.5 dBmV
5	0B	44.0 dBmV
6	0A	42.5 dBmV
7	09	41.0 dBmV
8	08	39.5 dBmV
9	07	38.0 dBmV
10	06	36.5 dBmV
11	05	35.0 dBmV
12	04	33.5 dBmV
13	03	32.0 dBmV
14	02	30.5 dBmV
15	01	29.0 dBmV
16	00	27.5 dBmV

APPENDIX C

CATV DESIGN SPECIFICATIONS

Characteristics	Value
System Spectrum	5-300 MHz 400-450 MHz (Optional)
Reverse Frequency	5-108 MHz (Midsplit)
Forward Frequency	162-300 MHz (Midsplit) 400-450 MHz (Optional)
Passive Equipment Frequency	5-300 MHz 400-450 MHz (Optional)
Headend Input Level	10 dBmV +/- 3.5 dB
Headend Output Level	56 dBmV +/- 2 dB
Reverse Output Level of Outlet	56 dBmV +/- 2 dB
Forward Input Level of Outlet	6 dBmV +/- 3.5 dB
Outlet Insolation	>= 20 dB

APPENDIX D

BROADBAND COMPONENT DESCRIPTION

All the broadband components used in the Local Area Networks have 75 ohm impedance. All the components except amplifiers and power supplies are passive elements (Cooper, 1984).

D.1 Coaxial Cables

A coaxial cable is an electromagnetic transmission medium which consists of a center conductor, dielectric, outer conductor, flooding compound (optional), and jacket (optional). There are two kinds of cables used in the transmission media. One is a 50 ohm cable used only for digital transmission, called a baseband cable. The other is a 75 ohm cable used for analog signaling with FDM, called a broadband cable. The 75 ohm broadband cable is used by CATV and Local Area Networks.

The attenuation of cables varies with frequency and temperature. Cable attenuation increases with increasing frequency nonlinearly (Figure 3.5). This phenomenon called cable tilt is usually compensated by an equalizer which has reverse characteristics of cable tilt. A qualizer is generally installed inside an amplifier or a diplexer. On

the other hand, the attenuation of a cable also increases with temperature at the rate of 0.11% per Fahrenheit.

There are three kinds of cables: trunk cables, feeder cables and drop cables. Each one has its own application area. Generally, trunk cables have a diameter beyond 0.5"; feeder cables have a diameter around 0.5"; drop cables have a diameter below 0.5". The bigger the diameter of a cable, the less cable loss it will be.

D.2 Amplifiers

An amplifier is used to compensate for signal loss in the transmission medium. It increases signal strength over a specific frequency range. Usually, a reverse equalizer and a forward equalizer could be installed inside the case of an amplifier. Depending on how much cable tilt needs to be compensated, choose equalizers of suitable value. In this way, less amplification is reached at lower frequencies. When the input signal to a amplifier is too high, a pad may be installed inside the amplifier module to reduce the signal level.

There are four different types of amplifiers used in the broadband network: trunk, bridging, line extender and distribution amplifier. Each one has its features and application area.

D.3 Passive Elements

Passive elements are the elements which do not need to be supplied power to operate. All passive elements when inserted to the network will cause insertion loss.

D.3.1 Diplexers

A diplexers is sometimes called a duplex filter. It directs the reverse frequency signals from the trunk to translators or channel processors, and also direct the forward frequency signal from the headend to the trunk. It is designed for a two-way single cable network. The diplexer could be used to restrict the occurrence of intermodulation and cross-modulation in a two-way single cable communication system. In this testbed system, a diplexer is used, which has 0.6 dB insertion loss.

D.3.2 Combiners/Splitters

A combiner usually is used at the headend. In the reverse direction, a combiner acts like a splitter which splits one signal into several signals for distribution along different paths. In the forward direction, it is truly a combiner which combines several signals for transmission to the trunk. The main point for using a combiner is to allow a system to introduce more services without having to readjust the system to adapt to a new service. In the testbed system, two 8-way combiners are

used in the reverse and forward direction respectively to direct the signals to and from the headend.

If a device acts like a combiner in the reverse direction, then it will act like a splitter in the forward direction. A splitter is used to divide a signal into several signals for transmitting signals to different routes.

D.3.3 Directional Couplers

Directional couplers are used to tap signals from the trunk to branches that go to buildings. There are three parts in the directional coupler: trunk input, trunk output, and tap(s). The trunk input is placed toward the headend and the trunk output is placed away from the headend. Depending on outlet location, we might need a single tap or multiple taps.

D.3.4 Terminators

In the distribution network, always be sure to terminate unused ports to avoid reflection and the ingress of unwanted signals. There are two kinds of terminators. One is a 75 ohm resistive terminators for ports where there is no AC power. The other is an AC blocking terminator for a port where AC power is on.

D.3.5 Connectors

Although connectors are tiny elements on a distribution network, they are weak points in the broadband network equipment. It is estimated that 75% of system failure was caused by poor connector connections. So, when making a connection, be sure that the connector and the connection are both good.

D.3.6 Outlets

An outlet is usually a tap port of a direction coupler. All unused outlets should be terminated by 75 ohm terminators, otherwise use self-terminating outlets.

D.4 Power Supplies

Power supplies supply AC power to amplifiers, except for internal amplifiers which contain their own power supplies. Power inserters are used to inject power to a coaxial cable, but not interfere with RF signals. For safety reasons, there are circuits inside amplifiers to pass or block AC power to a coaxial cable.

APPENDIX E

BROADBAND GRAPHICS SYMBOLS IN THIS THESIS

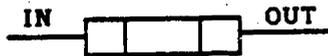
1. Headend



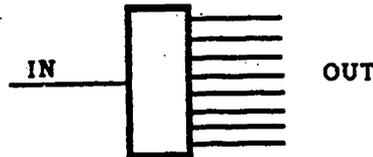
2. Translator



3. Processor



4. Eight-Way Splitter /Combiner



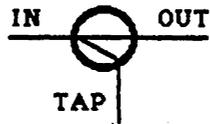
5. Diplexer



6. Amplifier



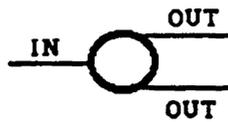
7. Directional Coupler (one-port tap)



8. Directional Coupler (four-port tap)



9. Two-Way Splitter



10. Terminator



11. Interface Device



12. Cable



APPENDIX F

MULTIPLE NETWORKS TEST DATA SHEETS

F.1 LocalNet 50/50 Translator

NO	TRANSMIT			RECEIVE				
	LOC.	FREQ.	SIGNAL LEVEL	LOC.	FREQUENCY		SIGNAL LEVEL	
					EXPECTED	ACTUAL	EXPECTED	ACTUAL
1	RF INPUT	73.0	+0.0	RF OUTPUT	229.25	229.3	+50.0	+45.7
2	RF INPUT	73.0	+0.0	REV. MON.	73.0	73.0	-20.0	-19.8
3	RF INPUT	73.0	+0.0	FWD. MON.	229.25	229.3	+30.0	+26.3
4	RF INPUT	67.0	+0.0	RF OUTPUT	223.25	223.3	+50.0	+45.4
5	RF INPUT	61.0	+0.0	RF OUTPUT	217.25	217.3	+50.0	+45.4
6	RF INPUT	55.0	+0.0	RF OUTPUT	211.25	211.3	-	+23.1
7	RF INPUT	49.0	+0.0	RF OUTPUT	205.25	205.3	-	< -30
8	RF INPUT	79.0	+0.0	RF OUTPUT	235.25	235.3	-	+11.1
9	RF INPUT	85.0	+0.0	RF OUTPUT	241.25	241.3	-	< -30
REFERENCE	TRANSLATOR SETTING:				REVERSE ATTENUATION 5 dB			
					FORWARD ATTENUATION 5 dB			

F.2 LocalNet 20 Trunk

NO	TRANSMIT			RECEIVE				
	LOC.	FREQ.	SIGNAL LEVEL	LOC.	FREQUENCY		SIGNAL LEVEL	
					EXPECTED	ACTUAL	EXPECTED	ACTUAL
1	PCU 1	73.0	+46.0	REVERSE HC-8X OUT	73.0	73.0	+0.0	-0.5
2	PCU 2	73.0	+46.0	REVERSE HC-8X OUT	73.0	73.0	+0.0	-1.8
3	PCU 1	67.0	+46.0	PCU 2	223.25	223.3	-4+/-3.5	-3.9
4	PCU 1	79.0	+46.0	PCU 2	235.25	235.3	-	< -30
5	PCU 1	73.0	+46.0	PCU 2	229.25	229.3	-4+/-3.5	-3.9
6	PCU 2	73.0	+46.0	PCU 1	229.25	229.3	-4+/-3.5	-3.2
7	TEST PT.	73.0	+46.0	PCU 1	229.25	229.3	-	+8.1
8	TEST PT.	73.0	+46.0	PCU 2	229.25	229.3	-	+6.4
9	PCU 1	61.0	+46.0	PCU 2	217.25	217.3	-4+/-3.5	-3.0
10	PCU 1	85.0	+46.0	PCU 2	241.25	241.3	-	< -30
11	PCU 1	55.0	+46.0	PCU 2	211.25	211.3	-	< -30
12	PCU 1	49.0	+46.0	PCU 2	205.25	205.3	-	< -30
13	PCU 1	73.0	+46.0	4-24B	229.25	229.3	-4+/-3.5	-4.8
14	PCU 2	73.0	+46.0	4-24B	229.25	229.3	-4+/-3.5	-5.7
15	4-24B	73.0	+46.0	PCU 1	229.25	229.3	-4+/-3.5	-3.4
16	4-24B	73.0	+46.0	PCU 2	229.25	229.3	-4+/-3.5	-5.0
REFERENCE	TRANSLATOR SETTING:				REVERSE ATTENUATION 5 dB			
					FORWARD ATTENUATION 5 dB			

F.3 Sytek 6050 Translator

NO	TRANSMIT			RECEIVE				
	LOC.	FREQ.	SIGNAL LEVEL	LOC.	FREQUENCY		SIGNAL LEVEL	
					EXPECTED	ACTUAL	EXPECTED	ACTUAL
1	RF IN	50.75	+10.0	RF OUT	219.0	219.0	+58.0	+58.1
2	RF IN	50.75	+10.0	-20dB IN	50.75	50.8	-10.0	-8.9
3	RF IN	50.75	+10.0	-20dB OUT	219.0	219.0	+38.0	+36.6
4	RF IN	44.75	+10.0	RF OUT	213.0	213.0	-	-7.2
5	RF IN	56.75	+10.0	RF OUT	225.0	225.0	-	-17.9

F.4 Sytek System 6000 Trunk

NO	TRANSMIT			RECEIVE				
	LOC.	FREQ.	SIGNAL	LOC.	FREQUENCY		SIGNAL LEVEL	
			LEVEL		EXPECTED	ACTUAL	EXPECTED	ACTUAL
1	6120TAP1	50.75	+56.0	REVERSE HC-8X OUT	50.75	50.8	+10	+8.9
2	6120TAP2	50.75	+56.0	REVERSE HC-8X OUT	50.75	50.8	+10	+7.8
3	6120TAP1	50.75	+56.0	6120TAP2	219.0	219.0	+8 +/- 10	+7.3
4	6120TAP2	50.75	+56.0	6120TAP1	219.0	219.0	+8 +/- 10	+8.0
5	TEST PT.	50.75	+52.0	6120TAP1	219.0	219.0	-	+18.9
6	TEST PT.	50.75	+52.0	6120TAP2	219.0	219.0	-	+17.1
7	6120TAP1	50.75	+56.0	4-24C	219.0	219.0	+8 +/- 10	+6.8
8	6120TAP2	50.75	+56.0	4-24C	219.0	219.0	+8 +/- 10	+5.8
9	4-24C	50.75	+56.0	6120TAP1	219.0	219.0	+8 +/- 10	+8.3
10	4-24C	50.75	+56.0	6120TAP1	219.0	219.0	+8 +/- 10	+6.5

F.5 Token/Net Translator

NO	TRANSMIT			RECEIVE				
	LOC.	FREQ.	SIGNAL LEVEL	LOC.	FREQUENCY		SIGNAL LEVEL	
					EXPECTED	ACTUAL	EXPECTED	ACTUAL
1	RF INPUT	80.75	+10.0	RF OUTPUT	273.0	273.0	+55.0	+51.5
2	RF INPUT	80.75	+10.0	-20dB IN	80.75	80.8	-10.0	-11.1
3	RF INPUT	80.75	+10.0	-20dB OUT	273.0	273.0	+35.0	+33.2
4	RF INPUT	74.75	+10.0	RF OUTPUT	267.0	267.0	-	-19.0
5	RF INPUT	86.75	+10.0	RF OUTPUT	279.0	279.0	-	-11.2

F.6 Token/Net Trunk

NO	TRANSMIT			RECEIVE				
	LOC.	FREQ.	SIGNAL LEVEL	LOC.	FREQUENCY		SIGNAL LEVEL	
					EXPECTED	ACTUAL	EXPECTED	ACTUAL
1	TIM 1	80.75	+44.0	REVERSE HC-8X OUT	80.75	80.8	-10 to 10	+1.2
2	TIM 2	80.75	+44.0	REVERSE HC-8X OUT	80.75	80.8	-10 to 10	-1.9
3	TIM 1	80.75	+44.0	TIM 2	273.0	273.0	-10 to 10	-4.1
4	TIM 2	80.75	+44.0	TIM 1	273.0	273.0	-10 to 10	-3.9
5	TEST PT.	80.75	+44.0	TIM 1	273.0	273.0	-	+4.8
6	TEST PT.	80.75	+44.0	TIM 2	273.0	273.0	-	+1.9
7	TIM 1	80.75	+44.0	4-24D	273.0	273.0	-10 to 10	-7.1
8	TIM 2	80.75	+44.0	4-24D	273.0	273.0	-10 to 10	-10.0
9	4-24D	80.75	+44.0	TIM 1	273.0	273.0	-10 to 10	-5.9
10	4-24D	80.75	+44.0	TIM 2	273.0	273.0	-10 to 10	-9.5

F.7 Design and Test Data for Outlets

NO	TRANSMIT			RECEIVE				
	LOC.	FREQ.	SIGNAL	LOC.	FREQ.	SIGNAL LEVEL		
	TRANSLATOR		LEVEL			DESIGN	STANDARD	TEST*
1	RF OUTPUT	300.0	+56.0	PCU 1	300.0	+8.7	6 +/- 3.5	+8.9
2	RF OUTPUT	300.0	+56.0	PCU 2	300.0	+6.1	6 +/- 3.5	+5.9
3	RF OUTPUT	300.0	+56.0	6120 TAP1	300.0	+7.9	6 +/- 3.5	+8.0
4	RF OUTPUT	300.0	+56.0	6120 TAP2	300.0	+5.3	6 +/- 3.5	+5.1
5	RF OUTPUT	300.0	+56.0	TIM 1	300.0	+12.1	6 +/- 3.5	+16.0
6	RF OUTPUT	300.0	+56.0	TIM 2	300.0	+9.5	6 +/- 3.5	+10.1
7	RF OUTPUT	300.0	+56.0	4-24 TAP	300.0	+3.5	6 +/- 3.5	+5.2
REFERENCE		1. TEST* - This value was the reading of LocalNet 50/70 which was used to measure the signal level for each outlet. 2. Both DESIGN and TEST data are based on the video signal reference level.						

APPENDIX G

ADDITIONAL LOCALNET 20 COMMAND DESCRIPTION

In the following, only those commands used in this thesis project are described. The LocalNet 20 reference manual (Sytek, 1984a) contains other command description. Type only the necessary characters (shown as small letters) which are enough to tell the command from the other commands.

1. `uNIT <nnnn>`

where

`nnnn` is a unitid expressed as a hexadecimal number between 0000 and FFFF.

Each PCU is assigned a unitid which should be unique on the LocalNet 20. For example, type:

`#uNIT 0001 <CR>`

2. `loCATION <channelno>[.linkaddress]`

where

`channelno` specifies the channel on which the PCU will operate. Depending on the GROUP specification, the `channelno` may range from 0 to 119.

`linkaddress` specifies the link address of a PCU in

the LocalNet 20. The linkaddress ranges from 0 to 254.

The linkaddress should be unique for each PCU in the LocalNet 20. For example, type:

#loCATION 12,1 <CR>

3. gROUP <channelgroup>

where

channelgroup specifies a group of channels which ranges from A to F for a midsplit system.

For example, type:

#gROUP A <CR>

4. bAUD <baudrate>

where

baudrate specifies a baud rate on which a PCU will operate. The baud rate ranges from 75 bps to 19200 bps. It should be one of the following list:

19200	9600	4800	2400	1200	600
450	300	150	134	110	75.

For example, type:

#bAUD 9600 <CR>

5. caLL <unitid>[,portid]

where

unitid is a rotary address which ranges from 0000 to

FFFF.

portid specifies a port number.

For example, type:

#caLL 0002,0 <CR>

APPENDIX H

ADDITIONAL PC NETWORK PROGRAM COMMAND DESCRIPTION

In the following, only those commands used in this thesis project are described. The IBM PC Network Program User's Guide (IBM, 1985b) contains other command description.

1. NET START

When issuing a NET START command, we must provide suitable parameters for it, which will tell the PC Network Program how to configure the PC according to the parameters. The default NET START parameter setting for a server PC is:

```
NET START SRV RALPHM /SRV:5 /MBI:1600 /SHR:10 /SES:18  
<CR>
```

Where

SRV - a server PC

RALPHM - the computer name of PC

SRV:5 - the maximum number of different computers
that may be used at one time

MBI:1600 - message buffer size (in bytes) for
receiving message

SHR:10 - maximum number of devices can be shared

SES:18 - maximum NETBIOS session number allowed

2. NET SHARE

A server PC can share its directory, disk drive, or printer to the network. The sample printer sharing command is:

```
NET SHARE CERLP=LPT1 <CR>
```

Where

CERLP - the short name for the printer

LPT1 - the printer DOS name

It means to share the printer with the network with the short name CERLP.

The applications that we want to share with the network, are usually put in the same directory. Therefore, we can share this directory, which contains all the applications, with the network. For example,

```
NET SHARE APPS=C:\APPS /R <CR>
```

Where

APPS - directory network name

C:\APPS - the directory path on the DOS

R: - read only (we usually issue "read only" attribute to the directory containing applications)

Let's see another example.

```
NET SHARE RALPHM=C:\RALPHM PASS <CR>
```

where

RALPHM - directory network name

C:\RALPHM - directory path on the DOS

PASS - the password is PASS

In this example, no access attributes are assigned to the directory. It means that the user can read (R), write (W), create (C), delete files in that directory. That is, R/W/C is the default attribute. In addition, we may issue NET SHARE without any parameters to see what kinds of network devices we are sharing.

3. NET USE

When we want to use some network devices, we should know the network device name, password (if it has one) for that network device, and issue a NET USE command.

The sample command is:

NET USE M: \\RALPHM\RALPHM PASS <CR>

where

M: - the network directory that is treated just like a local disk drive M. We can use any DOS commands on drive M except the PRINT command.

\\RALPHM - the computer name to which the directory belongs

RALPHM - the network name for that directory

PASS - specify the password if the directory has a password assigned to it

We can also use NET USE without any parameters to see what kinds of network devices we are using.

4. NET NAME

We may issue NET NAME to assign another network name to the PC. It is similar to a person having a nickname.

For example,

```
NET NAME MARTINEZ <CR>
```

where

MARTINEZ - In addition to have RALPHM computer name for the PC, an additional name MARTINEZ is assigned to it

So, the other PC on the network can send messages to either names. We may also issue NET NAME without any parameters to check what kinds of computer names are available.

5. NET SEND

We may perform the sending message task by issuing NET SEND. For example,

```
NET SEND MARTINEZ HOW ARE YOU? <CR>
```

where

MARTINEZ - the computer name where the message is sent

HOW ARE YOU? - the sending message

6. NET SEPARATE

We may issue NET SEPARATE for the network printer. In this way, each printing file will have a heading page with a sequence number, which can tell who is printing the file. The sample command is:

```
NET SEPARATE LPT1 <CR>
```

where LPT1 - the printer's DOS name.

In this way, the IBM PC Network Program default separate page file PQ.SEP will be attached to the printer buffer as a heading page. Of course, we can create our own separate page file. In addition, we can issue NET SEPARATE without any parameters to see the separate page status.

7. NET PRINT

When we have started the PC Network, we must use NET PRINT instead of PRINT to send a file to the network printer. For example,

```
NET PRINT \RALPHM\TEST.TXT LPT1 <CR>
```

where

RALPHM - a directory name

TEST.TXT - a file name

LPT1 - the printer DOS name

We may also issue NET PRINT without any parameters to check the status of the printer queue or a network printer queue.

APPENDIX I

ADDITIONAL TOKEN/NET COMMAND DESCRIPTION

In the following, only those commands used in this thesis project are described. The Token/Net reference manual (CDS, 1984b) contains other command description. Type only the necessary characters (shown as small characters) which are enough to tell this command from the other commands.

1. CONFIGURE

This configuration utility is used to modify TIM parameters. After we issue this command to a TIM, it will be operating on the CON mode instead of TCM (TIM Console Monitor Mode) mode. We will see the following prompt:

con:

To go back to TCM mode, type the EXIT command.

Example 1:

con: WRITE (address) data

where

address - specifies a starting address (in hexadecimal form) for placing data.

data - data to be stored in the memory starting at the specified address.

Example 2:

```
tcm: con write phy: 03 03
```

where

write - write data to the memory

phy: 03 - physical layer starting address 03

03 - select channel 5, S

This example is same as:

```
tcm: con
```

```
con: write phy: 03 03
```

```
con: exit
```

Example 3:

```
con: savE (parameter)
```

where

parameter - choose from one of the following list:

PHY,MAC,LLC,NDE,HDL,CNS,ALL

This save command is used to copy current parameter values from the configuration RAM to the nonvolatile memory. For example,

```
tcm: con sav all
```

This command saves all the update data to the nonvolatile memory.

2. tcm: boot

This BOOT command is to initialize the TIM. After executing this command, the local console return to password

state:

 Password:

Enter the password again.

3. call [parameter/switch/ ... /switch] (CDS, 1984a)

 where

 parameter - 1. none - call the default destination

 2. MAC address . slot . port

 slot - slot number

 port - destination port number

 3. Remote destination name - if a
 remote port accepts the entered
 name

 /switch - 1. none - the call uses default session
 conditions

 2. one or more user modifiable call
 switches priority which will affect
 the network priority level for the
 session.

Example:

 call #f2.3.1

This command issues a call to a TIM with the MAC (Medium Access Control) address 02 00 00 00 00 f2 (02 00 00 00 00 is the default value), slot 3 (Control Unit), and port 1.

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