A Study of the Interchangeability of Traffic Signal Systems Communication Hardware

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16. Abstract The problem addressed by this study is centered around "manufacturer dependence" or relying on a single source of supply for communication hardware equipment. This study was undertaken to determine the feasibility of establishing a preliminary standard for communication interfaces used in interconnected traffic control systems.

The study concluded that a communication interface hardware standard would be a definite benefit to the users, while the manufacturers would not experience a significant benefit or disbenefit. It was also concluded that currently built communication equipment and techniques used for traffic control did not vary significantly in hardware design or modem characteristics and, therefore, it was feasible to develop a preliminary standard. The two major categories of controllers, Type 170 and NEMA, were considered as part of this study. Since the Type 170 controller already has a standard, the proposed standard applies only to NEMA communication interface hardware.

The proposed standards are modeled after the NEMA Standards Publication TS-1 1983 with regard to environmental and operating characteristics, as well as electrical limits of input-output terminations. The essence of the proposed communication hardware standard is interchangeability. In order to accomplish this end, the proposed standard recommends using a set of connectors with specified pin-outs and functions. Functions are specified for basic dual ring control, detector processing, and standard cabinet functions such as flash. A list of expanded functions was identified in order to accommodate larger and more complex systems. The proposed standard was developed using a "modular by function" concept. A different type connector has been recommended for twisted pair, coaxial and fiber optic cable. Data formats, message content, and line protocol are not covered by this standard.

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1. INTRODUCTION

1.0 PROJECT BACKGROUND

This project was undertaken to determine the feasibility of establishing a preliminary standard for communication interfaces used in interconnected traffic control systems.

The problem addressed by this project is not a new one. It has long been a concern of the traffic engineering community. Early examples of communications equipment that are manufacturer dependent can be found in the volume density type systems and radio communications systems installed in the 1950's and 1960's. Much of this equipment is still in operation throughout the United States. Since this type of equipment is not currently manufactured, maintenance personnel responsible for its operation are forced to search for other systems with similar characteristics that can be purchased from agencies where this equipment is being replaced. This equipment is then cannibalized to provide spare parts. While it is obviously unrealistic to expect manufacturers to support product lines that are 20 to 30 years old, it must be recognized that these communications units have been installed at hundreds and, in some cases, thousands of intersections, and the capital cost of replacement exceeds the budgets of many cities.

In addition, similar examples exist in which relatively new installations have experienced maintenance problems because of unique communications system designs. These problems include:

- Inability to change manufacturers because of unique designs, although such changes are desirable because of unacceptable equipment performance or exorbitant maintenance costs.
- Inadequate equipment designs resulting from non-standard adaptations of existing equipment. Inadequacies include improper performance under existing environmental conditions or unreliable equipment resulting from a low-bid system implementation.

- Inability to provide technical or hardware support between cities. If one city is experiencing an unusual communication problem, assistance in the form of skilled personnel, spares, or test equipment cannot be provided because of the differences in system design.

- Increased manufacturing costs resulting from unique designs prevent the use of standard equipment already available in the commercial marketplace and require a special line of communications products uniquely designed for the traffic control industry.

Further support for the critical nature of this problem can be found in the proceedings of the Engineering Foundation Conference on "Issues in Control of Urban Systems," held in Henniker, New Hampshire in April 1981. During this conference, a discussion group identified the absence of usable communications standards as the most serious problem currently existing in the traffic signal industry.

To be successful, communications standards must be accepted by the industry for which they have been prepared. To promote this acceptance, the project has emphasized:

- Minimizing manufacturers' cost of equipment revisions to meet the standards without preparing a standard that meets the "lowest common denominator" of existing equipment.

- Including industry and user community representatives in the standard development process.

- Promoting the benefits of the standards of both the user community and to industry.

- Where possible, allowing adequate flexibility within the standards to permit innovation and differentiation between various manufacturers' product lines. This is a particularly difficult objective to achieve because incorporation of excessive flexibility could negate the potential benefits that the standards are intended to achieve.

1.1 PROJECT SUMMARY

This section presents the findings of the project in summary form. Each major item is explained in more detail in later sections of this report.

Survey Results

The equipment survey, conducted as part of Task A, concluded that the following characteristics are most frequently employed in traffic control systems:

- Time Division Multiplexed
- Frequency Shift Keying
- Asynchronous
- Full or Half Duplex
- RS 232-C Interface
- Voice Grade, Unconditioned Lines (private or leased, up to 1800 bps capability)
- Bell 200 Series Compatible (300 or 1200 bps)
- 8 data bits
- 1 stop bit
- 1 start bit
- Even or odd parity

It was also concluded, as part of the equipment survey, that the Type 170 controller already had an established and accepted communication standard included in its hardware specification. Further, the chances of achieving interchangeability between integral, NEMA controller communication modules was not possible due to differences in physical size and the internal bus structure of the controllers. Therefore, the last category of communication interface, namely, the external interface, was the only category that could realistically be standardized to achieve hardware interchangeability. It is this category which is addressed in the remainder of this report.

Trade-Off Analysis

The trade-off analysis was conducted for both manufacturers and users that used a different set of benefits and costs for each group.

The manufacturers trade-off analysis produced a range of benefit/cost ratios from 0.81 to 1.44 which straddles the break-even point of 1.00. This led to the conclusion that there is little or no benefit to the manufacturers and, hence, not much of an incentive to develop a communication unit which meets the proposed standards.

The user's benefit/cost analysis on the other hand produced a positive ratio in the range of 1.15 to 2.04. This reflects the benefits to a user of having a communication interface which is available from several sources of manufacture. It also reflects the fact that the acceptance of the standard would increase competition and most likely result in a price reduction due to the competitive bidding nature of the traffic control industry.

Proposed Standards

The proposed standards were developed on a functional level with the exception of the mechanical, electrical, and environmental characteristics which needed to be defined.

The electrical and environmental characteristics are compatible with those found in NEMA Publication TS-1 1983. The mechanical characteristics, primarily the connector and pin-out, are specified to achieve interchangeability. The inputs and outputs, and their functions, are consistent with the definitions and operation of a NEMA controller as defined in Section 14 of NEMA Publication TS-1 1983.

Validation of Proposed Standards

After development of the proposed standards, it was necessary to validate the standards by conducting both laboratory and field tests. While it is difficult to "validate" a particular connector or pin function, the tests were designed as an exercise to determine if there were any omissions or erroneous assumptions in the proposed standards by applying the standard under field conditions.

The results of both the laboratory and field tests concluded that the use of the proposed standards could successfully be applied to control and monitor a NEMA controller without any apparent functional loss compared with the majority of present systems.

1.2 REPORT OUTLINE

This report is divided into six sections. Section 1, Introduction, presents the background as to why this project was undertaken.

Section 2, Proposed Communication Hardware Standards, presents the proposed standard. This standard is for a stand-alone communication interface unit for use with NEMA controllers. The standard addresses the issue of interchangeability.

Section 3, Use of These Standards, outlines a method for educating those who develop, use, and interpret specifications.

Section 4, Project Description, outlines the study approach used on the project and identifies a set of recommendations for future research.

Section 5, Survey Results, presents the results of the equipment survey conducted as part of Task A. It defines the general categories of communication interfaces which were studied and lists the data which was collected from the survey.

Finally, Section 6, Trade-Off Analysis, details the methodology of the benefit/cost analysis which was conducted as part of Task B. In addition to the methodology, this section discusses the trade-off analysis used for the communication hardware.

Both a Glossary and Appendix are included at the back of this report for further reference.

2. PROPOSED COMMUNICATION HARDWARE STANDARDS

2.0 INTRODUCTION

The benefit cost analysis, presented in Section 6 of this report, provided the justification for the development of the traffic signal system communications standards. The system survey of existing communication interface equipment, which can be found in Section 5, provided further justification for such standards because of its conclusion that only minor modifications are required to standardize existing communications equipment.

The standards developed for this project were structured using the NEMA Standard Publication TS-1 1983 format.

2.1 DESCRIPTION OF PROPOSED STANDARDS

These standards respond to the need for a modem and logic interface capable of interchangeability between units of different sources of manufacture.

Consideration was given to the two major categories of controller hardware; namely, Type 170 controllers and NEMA controllers. Of these two categories, the Type 170 controller hardware specification already includes a well-defined standard for a communication interface. The C2 connector and connector pin-out is specified, along with a description of pin functions. An internal modem is also specified for communication over twisted pair cable. The C2 connector may also be used as an RS 232 interface if the internal modem is not used, thereby allowing the Type 170 controller to be interfaced to external modems. Therefore, the proposed standard for the communication interface will address NEMA controllers exclusively.

The interface shall accept serial data from a variety of commercially available modems and perform the necessary serial to parallel conversion and logic operations to control two- through eight-phase NEMA type controllers. This interface shall also be capable of processing NEMA inputs from NEMA controllers and detector data inputs, and performing the necessary logic and parallel to serial conversion for interface to the modem.

It is further anticipated that the communications interface and modem may be packaged separately and need not be furnished by the same supplier. Modems should be transparent to the communication interface as far as amount and type of data transmitted between the central computer and the remote interface unit, and the communication medium such as twisted pair, fiber optic, or coaxial cable.

Figures 1 and 2 are functional block diagrams for the communication interface unit with an external modem and internal modem, respectively.

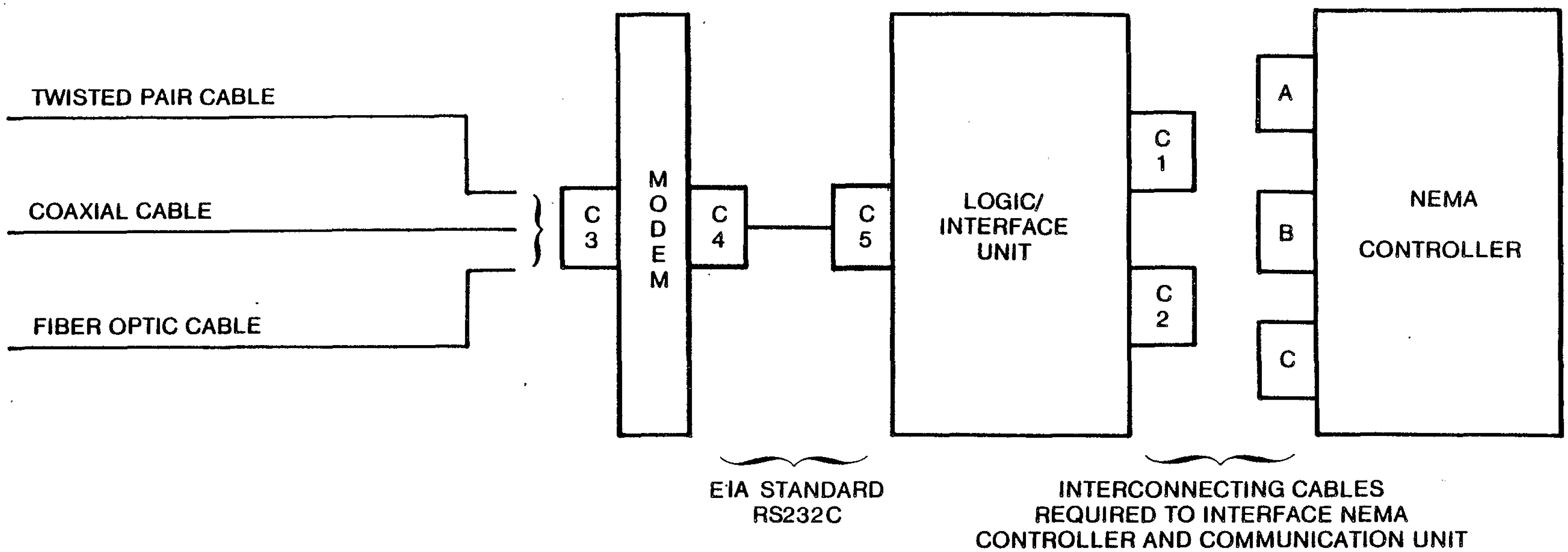
Operational Standards

The communications interface unit shall be capable of accepting serial data from the modem. This shall be accomplished by means of the Electronic Industries Association (EIA) Standard RS 232-C.

The EIA RS 232-C Standard defines the electrical and mechanical characteristics of the interface for interconnecting Data Terminal Equipment (DTE) and Data Communications Equipment (DCE) using serial binary data communications.

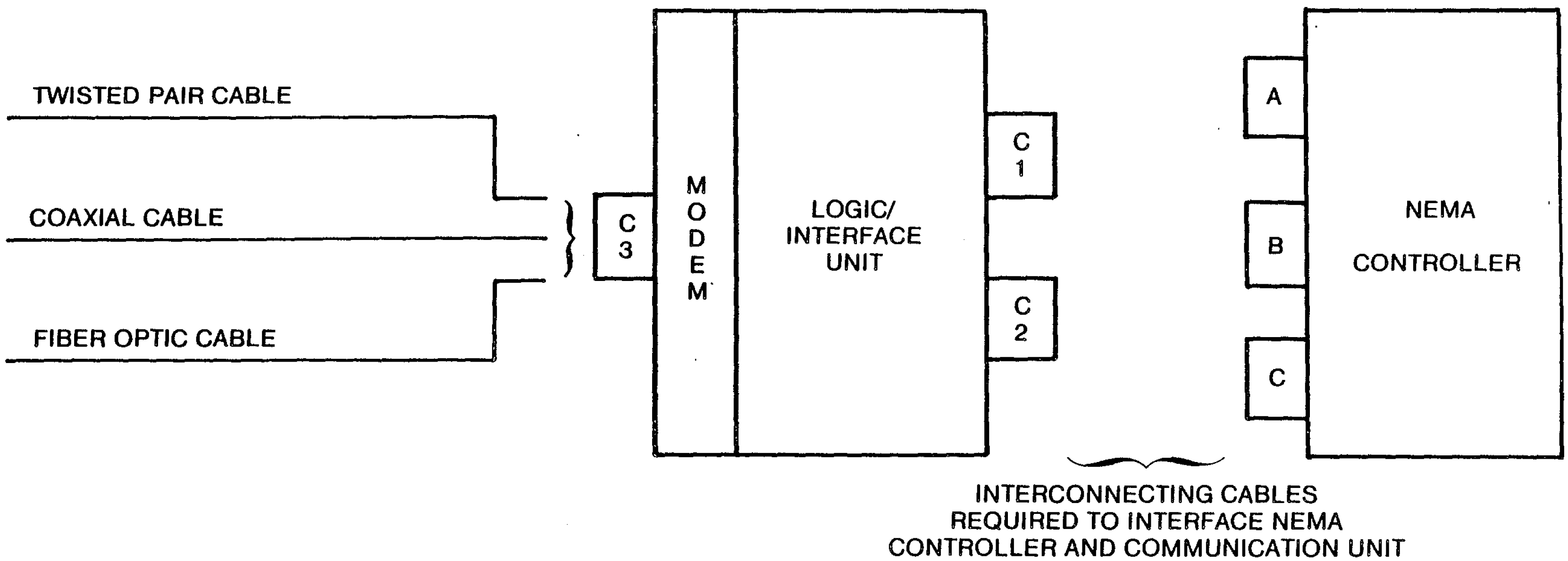
As the terms apply to these standards, Data Terminal Equipment shall be the communications interface unit and the Data Communications Equipment shall be the modem.

The EIA RS 232-C Standard is the most widely used DTE to DCE interface and is well documented in the RS 232-C Standard published by the Electronics Industries Association, Engineering Department, 2001 Eye Street, N.W., Washington, DC 20006.



CONNECTOR	FUNCTION	TYPE
C1	INPUT	SUBMINIATURE D, 37 PIN
C2	OUTPUT	SUBMINIATURE D, 37 SOCKET
C3	COMM LINE	SUBMINIATURE D, 9 PIN (TWISTED PAIR) TYPE F, (COAXIAL CABLE) TYPE SMA, (FIBER OPTIC CABLE)
C4	SERIAL DATA	SUBMINIATURE D, 25 SOCKET (DCE)
C5	SERIAL DATA	SUBMINIATURE D, 25 PIN (DTE)

Figure 1. Communication Interface Unit with External Modem.



CONNECTOR	FUNCTION	TYPE
C1	INPUT	SUBMINIATURE D, 37 PIN
C2	OUTPUT	SUBMINIATURE D, 37 SOCKET
C3	COMM LINE	SUBMINIATURE D, 9 PIN (TWISTED PAIR)
		TYPE F, (COAXIAL CABLE)
		TYPE SMA, (FIBER OPTIC)

Figure 2. Communication Interface Unit with Integral Modem.

The traffic communications interface shall be capable of controlling and monitoring a NEMA two- through eight-phase controller by means of two front panel connectors.

The communication interface unit shall be capable of receiving a polled signal, recognize those signals addressed to it, and immediately responding with status information via the same type of communication system.

The unit shall convert the incoming serial data to parallel form, test for message validity and set certain flags if the data received do not meet proper conditions for framing, parity, and checksum.

Each communication unit will be polled on its channel once per second. Each communication unit on a channel shall have a unique address coded within the command word. Communication units shall transmit only when addressed by the current command word.

Before a message is accepted by the communication unit, it shall first be checked for proper parity and address code. This error checking shall provide an undetected error rate probability of less than one in 10^8 messages. Throughput (probability of accepting a command each second) shall be greater than 99 percent.

Input word format and response word format shall be as required to meet the particular system specifications.

<u>Applicable NEMA Standards</u>

The traffic communications interface unit shall meet or be compatible with all of the requirements of the following sections of NEMA Standards Publication No. TS-1 1983, Traffic Control Systems:

- 2.1 Environmental and Operating Standards
- 13.2 Electrical Limits of Input-Output Terminations

The functional capabilities of the traffic communications interface are based on the physical and functional standards for two- through eight-phase controllers defined in Section 14 of the NEMA Specifications.

Power Inputs

The traffic communications interface unit shall have the following inputs for the application of power:

- AC+ (Line Side) – The fused side of the 120 volt alternating current 60 Hertz power source. This input shall be used to develop all voltages to operate the communication interface.
- AC- (Common) – The unfused and unswitched return side of the 120 volt alternating current 60 hertz power source taken from the neutral output of the AC power source. This shall be the same reference signal for all other AC powered equipment within the controller cabinet.

Chassis Ground

The communication interface unit shall have an input terminal providing an independent connection to the chassis of the unit. This connection shall not be connected to the AC- or the Logic Ground within the unit.

Logic Ground

This ground shall serve as a voltage reference point and current return for the 24 volt DC logic circuits. This termination shall not be connected to the AC- or Chassis Ground within the unit.

Control Outputs

Outputs shall be electrically compatible with Section 13, Subsection 13.2.3, Inputs, of the NEMA Publication TS-1 1983.

As a minimum, the following outputs shall be provided by the communication interface:

- Hold-on-Line – Shall be used to satisfy the once-per-second polling sequence within the communication interface. This output may also be used to trigger an external backup coordination unit.
- Yield Ring 1 – Shall be connected to the controller phase 2 hold circuit.
- Yield Ring 2 – Shall be connected to the controller phase 6 hold circuit (or other coordinated phase if controller is not operating as a quad left dual ring).
- Force Off Ring 1 – Shall be connected to the controller force-off Ring 1 circuit.
- Force Off Ring 2 – Shall be connected to the controller force off Ring 2 circuit.
- Cycle Controller – Shall be connected to the controller external minimum recall circuit.
- Flash – Shall be connected to the cabinet flash circuitry either directly or indirectly.
- Special Function – This is an undefined output which may be used to interface with an external piece of equipment such as a school flasher or an illuminated sign.

Monitor Inputs

Inputs shall have compatible electrical characteristics as defined under Section 13, Subsection 13.2.4, Outputs, of the NEMA Publication TS-1 1983.

As a minimum, the following inputs shall be provided by the communication interface:

- Phase 1 Green
- Phase 2 Green
- Phase 3 Green
- Phase 4 Green
- Phase 5 Green
- Phase 6 Green
- Phase 7 Green
- Phase 8 Green

} Used by central to monitor controller operations

Indicators

As a minimum, the following front panel LED indicators shall be furnished:

- On-Line
- Transmit status
- Receive status
- Advance/yield
- Force Off 1/Force Off 2
- Special Function
- Standby
- Free

Controls

As a minimum, the following front panel controls shall be furnished:

- Address select switch
- Power on/off

Pin Assignments

Input-output pin assignments shall conform to the following tabulations.

Connector C1 inputs shall mate with a sub-miniature "D" type, slide latch, 37 pin connector.

1	AC+
2	Flash
3	Green 1
4	Green 2
5	Green 3
6	Green 4
7	Green 5
8	Green 6
9	Green 7
10	Green 8
11	Logic Ground
12	Sensor 1

13	Sensor 2
14	Sensor 3
15	Sensor 4
16	Sensor 5
17	Sensor 6
18	Sensor 7
19	Sensor 8
20	Manual
21	AC-
22	Status Bit A (1)
23	Status Bit B (1)
24	Status Bit C (1)
25	Status Bit A (2)
26	Status Bit B (2)
27	Status Bit C (2)
28	Preempt
29	Special Function 1
30	Special Function 2
31	Special Function 3
32	Special Function 4
33	Sensor 9
34	Sensor 10
35	Sensor 11
36	Sensor 12
37	Chassis Ground

Connector C2 outputs shall mate with a sub-miniature "D" type, slide latch, 37 socket connector.

1	Hold-on-Line
2	Yield (1)
3	Yield (2)
4	Force Off (1)
5	Force Off (2)
6	Cycle Controller
7	Flash
8	Special Function 1
9	Special Function 2
10	Special Function 3
11	Special Function 4
12	Inhibit Max Term (1)
13	Inhibit Max Term (2)
14	Call to Non Act I
15	Call to Non Act II
16	Max II Select (1)
17	Max II Select (2)
18	Walk Rest Modifier

19	Undefined
20	Undefined
21	Undefined
22	Undefined
23	Undefined
24	Undefined
25	Undefined
26	Undefined
27	Undefined
28	Undefined
29	Undefined
30	Undefined
31	Undefined
32	Undefined
33	Undefined
34	Undefined
35	Undefined
36	Undefined
37	Undefined

Physical Characteristics

These standards cover a communication interface unit which shall meet the following physical configuration.

The unit shall be shelf mounted and powered from 120 volt AC power source. The internal power supply shall be capable of developing all of the necessary voltage and logic levels for internal circuitry and the solid state inputs and outputs.

The unit shall not exceed the following dimensions, excluding mating connectors, switches, and indicators:

- Height — 8 inches
- Width — 10 inches
- Length — 12 inches

Functional Characteristics

The communications interface unit shall be of modular design with either top or rear access to the printed circuit cards. The printed circuit cards shall be modular by function to the fullest extent possible.

The following board types are presented as an example of the "modular by function" concept.

Input Board — This board shall provide the interface between the NEMA controller and the communication unit. The input board shall handle up to 32 inputs.

Sensor Processor Board — This board shall provide the interface between the system detector amplifiers and the communication unit. The sensor processor board shall handle inputs from up to eight sensors.

The sensor processor board accepts inputs from the system detector unit as a vehicle passes over it. Upon detection of a vehicle, an occupancy register shall be caused to count, by an internal clock, at the rate of 30 Hz. Five bits will be reserved for this count. When the vehicle finishes passing over the detector, the count will stop and the volume register will be incremented. Two bits will be reserved for the volume counter. Both registers or counters will be reset to zero when the unit is polled by the central computer.

Output Board — This board shall provide the interface between the NEMA controller and the communication interface unit. Outputs from the communication unit shall be compatible with NEMA inputs. The output board shall handle up to 32 outputs.

3. USE OF THESE STANDARDS

3.0 INTRODUCTION

These standards define the communications interface between the remote communication interface unit and the communication equipment in a centrally controlled traffic signal system. They have been developed to simplify the process of designing, procuring, and maintaining digitally controlled systems by ensuring local traffic engineering agencies of the availability of multiple sources of supply for communications equipment.

It has been shown that communications standards will benefit the manufacturers, consultants, and traffic agencies because they eliminate the need for the costly design, manufacture, and maintenance of unique communications equipment for each new traffic signal system.

3.1 EDUCATION OF CONSULTANTS, USERS, AND MANUFACTURERS

In order for these standards to become accepted and used, the traffic engineering community must become educated as to their existence, application, and benefits. This education process should include consultants, users, and manufacturers.

One technique would be to print and disseminate the standards to all those involved with computerized traffic control systems. This could be accomplished by publishing a notice in the trade journals which makes known the availability of the standards. The standards could then be distributed by request. As an alternative, the standards could be published in the ITE Journal to achieve more rapid and widespread distribution.

Another technique for educating those involved with traffic control systems would be to hold a conference or seminar in which the use of these standards would be presented.

3.2 RELATION OF STANDARDS TO EXISTING STANDARDS AND PRACTICES

The communication hardware interface standards are modeled after the NEMA controller standards. The intent is to provide connector compatibility between interface units and electrical and functional compatibility between the interface unit and NEMA controllers.

4. PROJECT DESCRIPTION

4.0 INTRODUCTION

This project used a structural approach in developing the proposed communication interface standards. First, a survey of existing communication interface equipment was conducted and the results analyzed. Second, a trade-off analysis was performed to determine the benefits of having a standard and the associated cost implications. Third, a proposed standard was developed based on the results of the survey and trade-off analysis. Finally, the standards were validated to help determine if they required any changes or modifications before finalization.

This section presents the detailed study approach which was used and recommendations for future research.

4.1 STUDY APPROACH

The technical approach was structured in the manner defined by the RFP. This structure included four major tasks divided into 10 subtasks as shown in Figure 3.

The following sections describe each of these activities in greater detail.

TASK A: SURVEY OF EXISTING COMMUNICATIONS INTERFACES

The survey of existing communication interfaces was divided into three subtasks which consisted of listing the existing communication interfaces, identifying the characteristics of these interfaces, and finally evaluating each interface.

The results of Task A provided the required input for Task B. The survey was conducted by contacting each major manufacturer or supplier and requesting information about their particular line of equipment. To supplement this effort, PRC also contacted system users to gain information about their communication interface units.

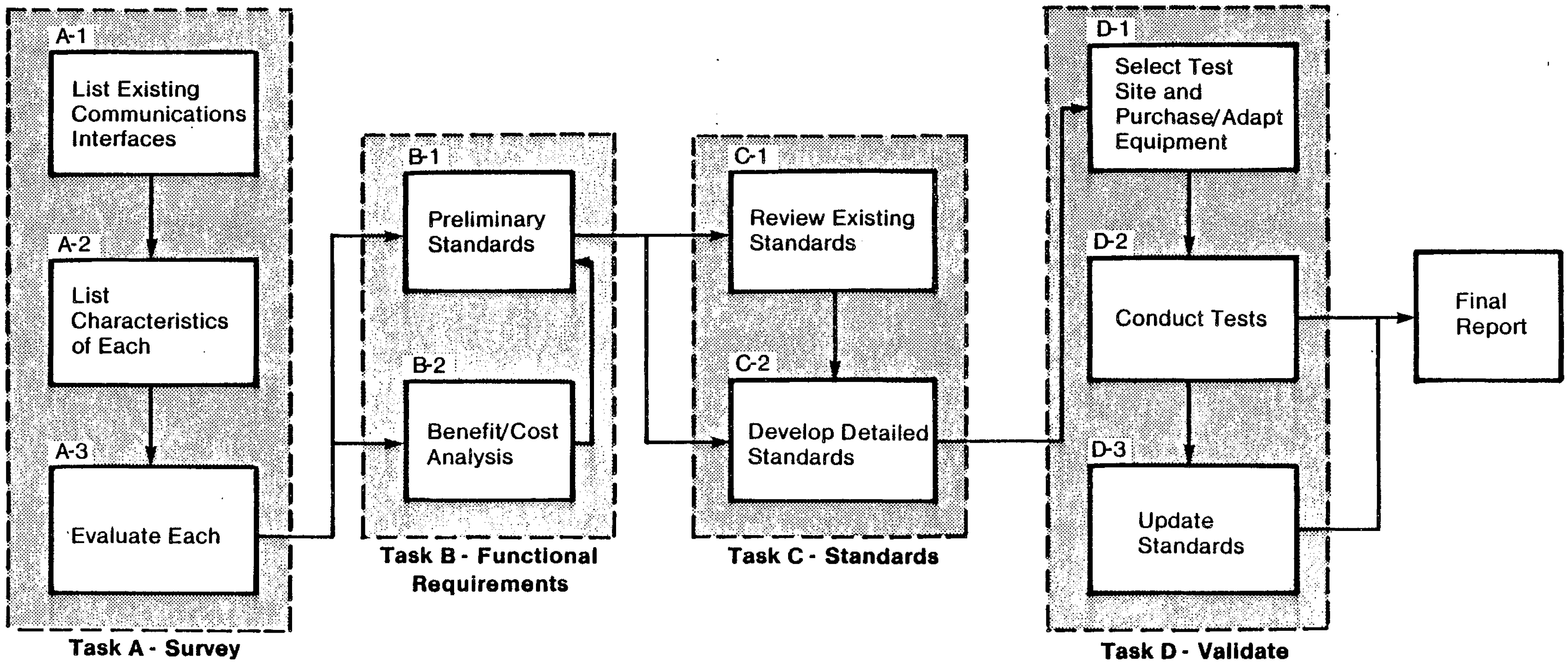


Figure 3. Work Flow.

Each of the subtasks is described below in more detail.

Subtask A.1: List Existing Communications Interfaces

This subtask consisted of completing a list of communications equipment installations. This compilation focused on equipment installed within the past five years to avoid biasing the study results with large numbers of equipment and techniques that did not represent the current state-of-the-art. The objective of this subtask was to identify 90 percent of the equipment that has been installed within this time period.

Table 1 is a list of the manufacturers and suppliers which were contacted as part of this survey.

Subtask A.2: List Characteristics of Each Interface

Based on the results of the initial survey conducted in Subtask A.1, categories of devices were developed that were related to the type of system in which they were installed.

The information which was collected included all detail required to serve as the basis for the activities to be performed in subsequent tasks. This data was organized into categories of:

- Physical Characteristics
- Environmental Characteristics
- Electrical Characteristics
- Maintenance Characteristics
- Functional Characteristics

Subtask A.3: Evaluation of Each Interface

The evaluation of interfaces was performed for each major category listed above. This evaluation included the development of a descriptive profile for each unit.

Table 1. System Suppliers and Predominant Communications Manufacturers.

System Suppliers

JHK and Associates
Multisonics
Sperry Systems Management
Automatic Signal
Computran
Eagle Signal
PRC Engineering

Communications Manufacturers (TDM equipment only)

TOCOM
Winkomatic
Sonex
Multisonics
Traffic Control Devices (TDC)

Controller Manufacturers with Integral Communications Processing

Type 170 Controller Manufacturers
Automatic Signal
Multisonics
Econolite
Traffic Control Technologies

Manufacturers Offering Cable TV and/or Fiber Optic Interfaces

TOCOM
Multisonics
Cabinet Systems
Winko-Matic

Manufacturers Offering Distributed Communications Systems

Transyt
Traconex
Automatic Signal
Traffic Control Technologies
Econolite

The descriptive profile defined typical characteristics for each unit and the likely range of characteristics.

Once typical profiles were developed, it was possible to evaluate the characteristics of each device. This process included both qualitative and quantitative evaluations of each. The qualitative evaluation considered elements such as:

- Ease of Maintenance — The ability of local agency maintenance staff to identify the causes of malfunctions and repair them.

- Useful Life — Does the device represent a newly emerging technology; an outdated technology that is unlikely to be supported in the future; or a stable, proven technology?

- Uniqueness — Is the device unique to a specific manufacturer or, worse yet, a specific system? More desirable, does it represent a popular form of implementation used both in the traffic control field and other fields as well; thus ensuring large quantity production and a long production life.

- Form of Implementation — Is the evaluation of a device likely to be biased by a poor implementation of a useful concept? In several cases, communications interface units have provided poor operational experience as a result of poor quality components or inadequate physical design. Yet the communications interface technique used represented a proven state-of-the-art communications system design.

In addition to these qualitative factors, the quantitative factors listed in Table 2 were also evaluated. These factors served as the basis for the benefit/cost analysis conducted in Task B.

Table 2. List of Quantitative Evaluation Factors.

Connector Types and Pin Assignments
Signal Characteristics
Data Rates
Mean Time Between Failures
Mean Time to Repair
Error Detection
Error Correction
Maximum Number of Units Per Line (function of user)
Purchase Price
Price Escalation
Maintenance Cost
Spares Cost
Test Equipment Cost

TASK B: DEVELOP FUNCTIONAL REQUIREMENTS AND DETERMINE FEASIBILITY

This task consisted of two distinct activities; the development of a preliminary standard that met the functional needs of the communications interface, and the performance of a benefit/cost analysis.

The performance of those two subtasks used an iterative approach. That is, a preliminary set of standards was prepared which was then subjected to an analysis in Subtask B.2. If this analysis indicated an improved benefit/cost ratio was possible through revision of the preliminary standards, the appropriate changes were made and reevaluated.

Subtask B.1: Preliminary Standards

As previously indicated, the preliminary set of standards which was developed emphasized the functional needs of the communications interface, as well as the physical and electrical characteristics which affected the results of the benefit/cost analysis.

The format for these standards is based on the latest version of the NEMA controller standards, TS-1 1983.

Subtask B.2: Benefit/Cost Analysis

The benefits and costs analyzed in this subtask were primarily those that were realized by the local traffic engineering departments responsible for the implementation of computerized traffic control system. Although it was realized that some marginal benefits might accrue to the motoring public, these benefits were difficult to evaluate since they were a result of more rapid intersection repair times which in turn are a function of the improved availability of spares and possible simplified maintenance procedures, both of which are difficult to evaluate.

For this reason, the benefit/cost analysis focused on the benefits and costs of the local traffic engineering agency. Two possible forms of the benefit/cost equation were considered:

$$B/C = \frac{U - K}{I} \quad (1)$$

and

$$B/C = \frac{U}{I + K} \quad (2)$$

where:

U	=	User benefits
I	=	Annualized one-time capital cost
K	=	Annual recurring cost

Equation (2) is most frequently used for highway economic analysis because it segregates the user benefits from the agency costs. Since the beneficiaries are not usually part of the same group as the financiers of the system, it is appropriate to segregate the benefits and costs in this manner. In addition, equation (2) is recommended by AASHTO.

However, in the case of communications equipment, the local agency is both the beneficiary and the financier of the system which eliminates one of the primary reasons for the use of equation (2). In addition, it was decided that equation (1) should be used whenever possible for the following reasons:

- The benefit/cost ratio concept is based on the premise of determining whether a satisfactory rate of return can be realized on an initial investment. In this case, "I" represents the initial investment and the rate of return should be expressed in dollar benefits, less the cost of continuing operation as in equation (1).
- Equation (1) correctly represents the segregration of recurring costs and benefits in the numerator and one-time costs in the denominator.
- Equation (2) should only be used where cost accounting procedures (profit and loss statements) consider depreciation expense as an operating expense. Since this is not usually the case in governmental agencies, equation (2) is inappropriate.

For these reasons, the form of equation (1) was used as the basis for the benefit/cost evaluation of the communications standards.

TASK C: DEVELOP FUNCTIONAL AND ELECTRICAL STANDARDS

The purpose of this task was to produce a comprehensive set of standards for the communication interface that will be of use to users and vendors in defining interfaces for interconnected traffic control systems. The following guidelines were adhered to in producing these standards:

- Maximum use was made of existing and proven equipment functional and electrical capabilities.
- The standards were based on the conclusions of Task B in order to ensure that their cost-effectiveness could be demonstrated.
- All comments received from the Technical Review Group (TRG) were carefully considered because of the experience and influence that this group represents. The roster of the TRG is indicated in Table 3.
- The standards considered existing communications technology and likely future industry directions to assure their long-term usefulness.
- The format and content of existing communications standards, already prepared for the traffic control industry and the electronics industry, were reviewed and used as models for the new standards.

This task consisted of two subtasks which included a review of existing standards and the development of the new standards.

Subtask C.1: Review Existing Standards

The standards listed in the Table 4, along with their intended applications were reviewed for this project. Although Table 4 presents numerous standards, many are simply an improvement on a previous standard. The review of standards was restricted to the most recent version of each.

Table 3. Technical Review Group Roster.

Name and Address	Representing
Jack Brown Florida Department of Transportation Traffic Engineering Division 605 Suwanee Street Tallahassee, Florida 32301	State of Florida
George L. Butzer, P.E. Systems Engineer City of Columbus Traffic Engineering Division 50 West Gay Street Columbus, Ohio 43215	ITE Committee 7S-6 Communications for Traffic Control Systems and City of Columbus, Ohio
Michael C. Doyle Stone and Doyle 77 North Oak Knoll Avenue Suite 114 Pasadena, California 91101	Acting Representative of NEMA
Raymond S. Pusey, P.E. Chief Traffic Engineer Delaware Department of Transportation Traffic Engineering Division PO Box 778 Dover, Delaware 19901	State of Delaware
George W. Schoene, P.E. Assistant Director City of Washington, D.C. Traffic Engineering Division 613 G Street, N.W. Room 712 Washington, D.C. 20001	City of Washington, D.C.
John C. Tsiknas, P.E. Senior Traffic Engineer City of San Diego Traffic Engineering Division 1222 First Avenue San Diego, California 92101	City of San Diego, California

Table 4. Review of Communications Standards

Standard	Application	Comments
RS 232-C	Uses unbalanced lines, recommended for 50 feet or less of data transfer capability. Often excluded in many applications.	U.S. commercial/industrial. Used in many computer/peripheral applications
RS 422	Uses balanced long lines	Same as RS 232-C
RS 423	Uses unbalanced lines — upgrade of RS 232-C	Same as RS 232-C
RS 449		This is a system standard that covers the use of RS 422 and RS 423
V.24	Similar to RS 232-C	CCITT Vol. III International Standard
V.26	Similar to RS 423	CCITT No. 97 International Standard
V.27	Similar to RS 422	CCITT No. 97 International Standard
MIL-STD-188C	Similar to RS 232 except for wave shape parameters	Department of Defense applications
MIL-STD-188-114	Similar to RS 422 and RS 423	Department of Defense applications
FED-STD-1020	Identical to RS 423	U.S. Government, GSA generated
FED-STD-1030	Identical to RS 422	U.S. Government, GSA generated
IEEE-STD-583-1975	Originally intended for Nuclear Instrumentation	Similar to DTL-TTL logic levels
IEEE-488	Parallel interface for instrumentation	Originally developed by Hewlett Packard
RS 357	Used for facsimile equipment	Uses most of RS 232-C specification

Table 4, Review of Communications Standards. (Continued)

Standard	Application	Comments
RS 366	Used principally for automatic telephone calling equipment	Uses most of RS 232-C specifications
RS 408	Used in numerically controlled equipment	Uses short lines, typically less than 4 feet

This subtask defined the electrical and mechanical standards, and identified which of these parameters industry has chosen to accept.

Another consideration of the standards review was that of the modem standards.

The compatibility of communications modems for traffic signal communication interfacing was a major activity of this subtask. Table 5 is a summary of modem characteristics.

In summary, this subtask reviewed all applicable United States standards. The various electrical and mechanical specifications of these standards were evaluated for their potential application to traffic control communications.

Subtask C.2: Develop Detailed Functional and Electrical Standards

The standards reviewed during Subtask C.1 were used as the basis for the traffic systems communications standards developed under this task.

The specific requirements incorporated in these standards made maximum use of existing standards such as RS 232-C and NEMA. Deviations from the characteristics of existing communications equipment were avoided.

The result of this subtask was a comprehensive set of standards prepared for review by the TRG. These standards served as the basis for the validation tests that were performed under Task D.

TASK D: VALIDATE STANDARDS

The purpose of this task was to perform testing of the standards to validate their usability for traffic control applications.

The tests performed under this task included both laboratory tests and field tests. The objectives of the laboratory tests were:

Table 5. Summary of Modem Standards.

CCITT	Bell	Speed (Bps)	Data Format	Mod	Compatibility
V.21	103/113	Up to 300	Async	FSK	No
V.22	212A	1200/600 up to 300	Async/sync Async	PSK	Yes at 1200 bps No at 300 bps
V.23	202	1200/600/75*	Async/sync	FSK	Usually
V.26	201B	2400/75*	Sync	PSK	Yes, V.26 alt B
V.26 bis	201C	2400/1200/75*	Sync	PSK	Yes, at 2400 bps
V.27	208B	4800/75*	Sync	PSK	No
V.27 bis	208B	4800/2400/75*	Sync	PSK	No
V.27 ter	208A	4800/2400/75*	Sync	PSK	No
V.29	209	9600/7200/4800	Sync	OAM	No

*75-bps backward channel always uses asynchronous data and FSK modulation.

- Preliminary testing of field equipment prior to its installation in a field environment to eliminate the possibility of field maintenance problems.
- Testing of all equipment under a wide range of operational conditions that are not necessarily achievable in a field environment.
- Testing of a variety of equipment configurations that would be impractical to identify and implement in the field.

These tests were then supplemented by field tests in an actual, operational traffic control system to provide the credibility required for the acceptance of the specifications. The field tests were performed with the objective of:

- Identifying potential problems that might not occur in a laboratory environment.
- Evaluating the ability of the equipment to be interconnected with control equipment in operational cabinets.
- Evaluating the acceptability of the equipment to operations and maintenance staffs.

Subtask D.1: Select Test Site and Purchase/Adapt Equipment

The selection of a field test site was performed with the guidance of the Contracting Officer's Technical Representative (COTR). The City of Alexandria, Virginia was selected because it offered the characteristics most commonly found in a modern, centrally controlled computerized traffic signal system; namely, private, twisted pair cable.

Subtask D.2: Conduct Tests

As previously indicated, both field tests and laboratory tests were conducted during this subtask. The field tests were preceded by the laboratory testing of all equipment under controlled conditions, to be able to compare operation under field conditions.

The configuration that was tested is shown in Figure 4. The IBM PC/AT was programmed to transmit actual communications data which was then received, processed and recorded at the controller end of the tests. The test simulated the types of data normally expected by communication interface units. Provisions were made to incorporate errors in the transmitted data to evaluate the field equipment's response to error conditions.

Field tests were performed using private, voice grade, twisted pair cable All test equipment was located at central, while the cable pairs were looped in the field. It was impractical and undesirable to make major modifications to an operational computerized system, and therefore, the technique that was used included one of the communications lines to be tested. The microcomputer transmitted and received data in a format compatible with the new communications system.

Field tests were conducted for a period of 30 days during which the types of errors and error rates were recorded, and system operation was evaluated to determine the effectiveness of the proposed standards.

Subtask D.3: Update Standards

During this subtask, the results of Subtask D.2 were evaluated to identify any modifications that might be required to the standards. The need for such modifications was based on lack of desired communications reliability, or operational problems identified during the tests.

4.2 RECOMMENDATIONS FOR FUTURE RESEARCH

The purpose of this research project was to determine the feasibility of developing a standard for communication hardware which could be interchangeable in the same manner as NEMA controllers.

The results of this project proved that this concept of interchangeability is feasible. There is enough commonality between present systems to develop a

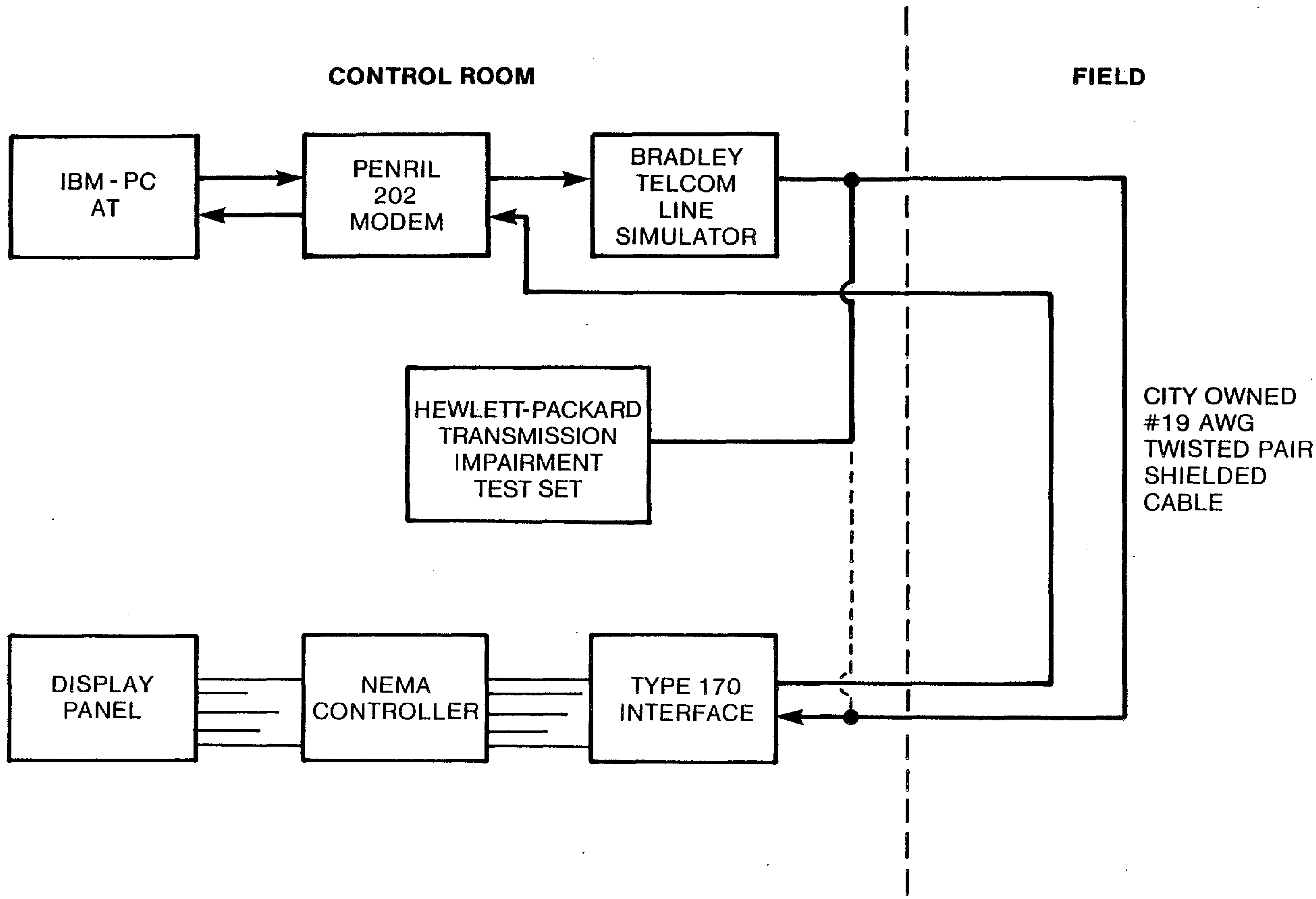


Figure 4. Test Configuration Block Diagram.

functional standard and physical standard, and it was shown that the standard would be a definite benefit to users.

In order for this standard to become accepted and implemented on an industrywide basis, the manufacturers must become involved.

Therefore, it is recommended that this project be viewed as the first step toward gaining acceptance of a communication hardware standard. The FHWA's role from this point forward should be to educate users, manufacturers, and consultants as to the benefits and usefulness of a communication hardware standard.

5. SURVEY RESULTS

5.0 INTRODUCTION

The survey was conducted through the use of questionnaires which were mailed out to both manufacturers and suppliers of communication interface equipment.

In general, there was a total lack of response to the questionnaires. PRC Engineering then questioned users about thier communication equipment and conducted a literature search of PRC files which contain catalog cuts from past projects.

The survey data were compiled primarily from these last two sources of information.

5.1 GENERAL CATEGORIES OF INTERFACES

The three general categories of equipment interfaces considered were:

- Type 170
- Integrated NEMA
- Stand alone NEMA

The Type 170 interface has been well defined in the Type 170 Traffic Signal Control System Hardware Specification FHWA-IP-78-16. This document specifies both the modem characteristics and connector type.

The second type of interface, which is the integral communications module for NEMA controllers, is designed by the particular NEMA controller manufacturers for operation in a specific model controller. Therefore, these modules vary in size, function, and design, and are not interchangeable between NEMA manufacturers.

Stand alone interfaces have been used for NEMA, non-NEMA, and electromechanical controllers. In general, these interfaces have been designed and manufactured to meet the particular specifications of a project. While this type of interface varies from system to system, there is some commonality between units. Since this category of interface equipment is external to the NEMA controller, it was possible to develop a set of standards which can guarantee interchangeability.

5.2 SUMMARY OF CURRENT INTERFACE EQUIPMENT

The results of the survey performed to meet the objectives of Task A are presented in this section. The survey was performed through the review of existing system characteristics and available manufacturer's product information.

These results are presented in two sections. The first describes the survey's conclusions related to the transmission media currently in use, and the second describes existing controller interfaces for Type 170 and NEMA interfaces. The NEMA interfaces have been divided into the categories of stand alone interfaces and integral interfaces.

Transmission Media

The predominant communication medium used for traffic control is wire pair transmission. With few exceptions, all of the communications hardware meets Bell 202 standards for transmission over 3002 voice grade unconditioned lines.

The second most common form of transmission medium for traffic control is over coaxial cable. In some cases, cable televsion (CATV) systems share this medium. There is currently no standardization applied to the use of coaxial cable. Data rates vary from 9600 bps to 56K bps and the frequencies used for transmission and reception vary according to available channel space (range from 5 to 300 MHz).

Fiber optic cable was the third form of medium that was identified. Only one system has been installed to date which uses fiber optic technology. In this case, the fiber optic cable is being used as a trunk cable and is transparent to the end equipment; that is, the central computer communicates using 1200 baud, RS 232 standards. The data are fed into a multiplexing device which aggregates slower 1200 buad channels into a single high-speed channel at 64K bps. This high-speed channel is then fed through a fiber optic modem. At the remote end, the process is reversed. The high-speed channel is fed through a fiber optic modem into a demultiplexer, which reconstructs the individual 1200 baud channels. These 1200 baud channels (RS 232) are then fed into Bell 202 modems for transmission over wire pair cable.

On the basis of this survey, it was concluded that an adequate degree of standardization exists within the use of twisted pair conductors to consider the development of communications standards. Coaxial cable systems, currently in use, are too varied and few in number for a practical (cost-effective) standard to be developed. At the present time, there are no fiber optic systems used in traffic control systems, except for trunking applications. Furthermore, fiber optic technology is rapidly changing. As a result, it was not considered cost-effective to consider developing a standard for this area.

Controller Interfaces

This section summarizes the conclusions developed from the survey of controller characteristics. Detailed results are presented in Appendices B through F.

The survey of controller interface characteristics revealed a degree of commonality among existing equipment. The following parameters were found to be uniformly applied to the majority of interface equipment:

- Data Rate: 1200 bps
- Communications Type: TDM - FSK
- Communications Mode: Full or Half Duplex, Asynchronous
- Modem Spec: Bell 202 Compatible (F_{mark} = 1200 Hz, F_{space} = 2200 Hz)

- Input Impedance: 600 Ohms
- Environmental: NEMA Environmental Ranges
- Error Detection: Parity and Checksum
- Maximum Units per Line: 8 Units per Line

Type 170 Controller – The conclusion reached during the analysis of the Type 170 Controller is that, regardless of the type of system or type of control, the interface standards are well-defined. This is due to the fact that the 170 hardware specification already includes an integral modem (Model 400) and the C2 connector which are defined in detail.

The differences between systems that occur in data formatting and error correction are implemented in the controller firmware. These differences are accommodated without hardware change by making modifications to the firmware.

NEMA Controller with Stand Alone Interfaces – The analysis of the separate communications interface unit for NEMA controllers concluded that modem, environmental, and electrical characteristics were relatively standard for all equipment.

The modem specification is, again, Bell 202 compatible with environmental specifications that meet NEMA standards. The electrical characteristics are also determined, to a large degree, by NEMA standards for controller input and output.

Some variations existed in the physical and functional characteristics. The key physical characteristics are dimensions, physical design, connector type, controls, and indicators. The following conclusions were reached related to these issues:

- The dimension will be specified as "not to exceed" for the height, width, and depth.
- This interface type is a self-contained unit and, therefore, must have an integral power supply and modem, as well as be shelf-mounted.
- Connections should be a D-type subminiature connector corresponding with the latest trend in this area.

- The indicators and controls will be stated as a minimum specification. Controls will include address selection, on/off switch, and a test/normal switch for diagnostics. The minimum indicators provided will include carrier detect, received data, and transmitted data in the form of LED's.

Functional characteristics are primarily determined by system type and system specifications. It was determined that there are only slight variations for most of the stated functional characteristics. For example, almost all units surveyed use parity and checksum for error detection and can operate in either full or half duplex mode. Each interface unit is designed for connection with a single controller and a variable number of detectors in the range of 2 to 8.

NEMA Controllers with Integral Interfaces — The interface survey demonstrated that in the case of an integral communications module, the physical characteristics of the interface cannot be specified since each NEMA manufacturer produces a different size machine which uses a unique bus structure.

Even though it is possible to specify modem characteristics, environmental capabilities, and connector types, it is not possible to guarantee interchangeability of integral communication modules for this type of interface.

6. TRADE-OFF ANALYSIS

6.0 INTRODUCTION

A benefit/cost analysis was performed to help evaluate the proposed communications hardware standard. Based on comments received at a Technical Review Group (TRG) meeting, it was decided that separate analyses should be conducted for both the suppliers and users of the hardware since the costs and benefits for each group are quite different. The supplier's benefit/cost was calculated only for the manufacturers of communications interface devices. The user's benefit/cost was restricted to the local traffic engineering departments responsible for the implementation of computerized traffic control systems.

Because of the uncertainty involved in estimating the benefits and costs for each group, a range was calculated for each benefit/cost analysis rather than calculating a specific benefit/cost figure. The ranges were calculated using the assumption that the benefit and cost estimates were accurate within plus or minus 25 percent. Details of the specific analysis are presented in the following sections.

6.1 METHODOLOGY

The actual form of the equation used in the benefit/cost analysis was:

$$B/C = \frac{(U_P - U_B) - (K_p - K_B)}{(I_p - I_B) \quad CR} \qquad (3)$$

Where the subscripts P and B refer to the proposed standard system and the baseline system respectively. CR is the Capitol Recovery Factor. It was used to translate the one-time investment cost to an equivalent annual cost according to the equation:

$$CR = \frac{i\,(1 + i)^n}{(1 + i)^n - 1}$$

where:

i	=	interest rate (cost of money)
n	=	system life in years

The variables of equation (3) were calculated in the following manner.

- $U_P - U_B$, the net user benefits for the proposed standard over those for the existing nonstandard (baseline), were calculated as a composite term. The types of benefits that were estimated for this term included:
  - Reduced maintenance training.
  - Effect of increased system life due to availability of replacement components.
  - Reduced system design costs.
  - Reduced system redesign costs.
- K_P and K_B, reflect the annual maintenance costs for the existing and standard systems. K_B was calculated based on data acquired during the survey of Task A. K_P was based on estimates from the information developed during the preparation of the preliminary standards. The factors used to estimate K_P and K_B included:
  - Maintenance labor costs calculated from existing and projected MTBF and MTTR data.
  - Spares costs.
  - Estimated benefits of competitive procurement of spares.
  - Test equipment costs.
  - Cost of spares storage.
- I_P and I_B, the one-time costs of the equipment, included both purchase price and installation costs. The baseline values were derived from the reported costs of Task A. The projected costs were obtained using cost data available from similar equipment.

The development of these costs required that the quantities and number of agencies involved also be estimated. This estimate was performed over the anticipated useful life of the standard (10 years, based on the pace of new communications developments) and the rate at which traffic signal systems are being installed. The traffic signal industry has seen a relatively stable rate of installation of approximately 500 computer controlled intersections per year in the United States. This figure was refined based on the data available from the Computer Control System Applications Group, FHWA files of bid specifications, and PRC files. The resulting quantities were used as the basis for the development of the benefit/cost evaluation.

6.2 EXAMPLE OF TRADE-OFF FOR COMMUNICATION HARDWARE

Manufacturer's Benefit/Cost Ratios

The first step in developing a benefit/costs analysis for the communications hardware manufacturers was to identify the components of the benefits and cost. To accomplish this task, it was necessary to make certain assumptions for performing the analysis. The first assumption was that the benefit/cost is for the entire traffic communications hardware industry. The second assumption was that, since the communications device comprises a small percentage of the total costs of a computerized traffic control system, the demand or number of units sold per year would not be affected by the development of a communications standard. Whether the price of the communications device increases or decreases, the number of intersections placed under computer control will not be affected. A third assumption concerning the selling price of the units was also necessary. This assumption concluded that the selling price would increase by $100 to permit the manufacturers to recover the capital cost of product modification, while leaving existing profit margins fixed.

The manufacturer's cost used for the benefit/cost analysis was defined as being the one-time capital cost associated with the redesign of the communications interface device. The benefit is the annual cost savings or increases that may occur as a result of a new communications standard. The items that were considered as one-time cost items were:

- Cost of redesign.

- Cost of retooling or assembling a new production process.
- Cost of testing and quality control for the new product.
- Cost of writing off any obsolete inventory.
- Unrecovered development costs for old types of units.

The manufacturer's benefits, or annual cost differences, that were considered applicable to the suppliers, were:

- Reduced documentation costs.
- Reduction or increase in operating profit, depending on the effects of competition.
- Reduced inventory cost.
- Reduced maintenance and warranty cost.

There are currently five different suppliers for NEMA type interfaces:

- TOCOM
- Winko-Matic
- Sonex
- Multisonics
- Automatic Signal

Because of the rapid advancements in technology in the electronics industry, five years was selected as the analysis period for conducting the manufacturer's benefit/cost. Other assumptions required to perform the analysis for both the manufacturer and user involved the quantities to be used in the analysis. The first assumption was that the growth in computer controlled intersections would remain constant at the rate of approximately 500 intersections per year. It was further assumed that 60 percent of these intersections would be using NEMA-type controllers, while 40 percent would use Type 170's. Based on a review of the existing systems, the average size of a computerized system was assumed to be 100 intersections for the purpose of this analysis. Therefore, five new systems will be installed per year, of which three will use NEMA type controllers. Using the three systems per year and a five-year analysis period, the average number of new systems in place for each of the five years will be nine.

The form of the equation to calculate the average value of the number of systems installed over the five year period for each year is as follows:

$$AVG = (\frac{N}{2}(2A + (N - 1) D))/N$$

Where:

N	=	Number of years
A	=	Number of systems the first year
D	=	Number of systems installed each year

The price increase associated with the new standard was estimated to be $100 per unit, of which $50 was assumed to be for recovery of capital investment required to manufacture the new device.

The one-time capital cost for the manufacturers due to a new communications standard were estimated as follows:

Average Labor Cost:

$30,000/yr. x 1.35 fringes x 100% overhead = $6,250 man-month

1.	Average redesign cost per supplier 2 man-months @ $6,250/month x 5 suppliers	=	$62,500
2.	Average cost of retooling $10,000 x 5 suppliers	=	50,000
3.	Average cost for testing and quality control 4 man-months @ $6,250/month x 5 suppliers	=	125,000
4.	Average cost of inventory write-off $10,000 x 5 suppliers (Partial write-off for equipment that would have gone into a new system)	=	50,000

Total one-time capital cost = $287,500

Capital recovery factor (i = 12%, n = 5 yrs)	=	0.27741
Equivalent annual cost $287,500 x 0.27741	=	79,755
Capital recovery from price increase $50 x 300 units/year	=	15,000
Net annual cost	=	$64,755

The annual benefits estimated for the manufacturers were as follows:

1.	Reduced docuentation cost 1 man-month @ $6,250 x 3 systems/year (Average number of systems installed each year)	=	$18,750
2.	Operating profit was assumed to remain constant	=	0
3.	Average annual inventory cost reduction $3,000 x 5 suppliers	=	15,000
4.	Reduced quality control and maintenance $4,000 x 9 systems (Average number of systems installed and in place each year over 5	=	36,000
Total Annual Benefits		=	$69,750

Assuming that the benefit and cost estimates are accurate within plus or minus 25 percent, a range of benefit/cost ratios was calculated using two assumptions. In the first case, the average benefits that were estimated were held constant and the costs were varied from 75 to 125 percent of the estimated value. In the second case, the estimated average costs were held constant and the benefits were varied by 25 percent. Using this technique, the range of benefit/cost ratios that were calculated were 0.81 to 1.44, which straddles the break-even point of 1.00.

User's Benefit/Cost Ratios

The benefit/cost analysis for the user was assumed to apply only to those users that would be installing a new system or redesigning an older system and could take advantage of the new standard. Those users maintaining an existing system would not be able to benefit from the development of a communications standard since it would be impractical to replace all communications units with the new devices. As a result, there will be a period after the new standard is accepted, during which suppliers will have to continue to manufacture their nonstandard units in order to support existing systems.

To perform the benefit/cost analysis for the users, certain assumptions, including the same used in the manufacturer's analysis, were necessary. The number of controllers and systems used in the manufacturer's analysis was also used for the user's benefit/cost analysis.

It was further assumed that 60 percent of these intersections would be using NEMA type controllers, while 40 percent would use Type 170's. Based on a review of the existing systems, the average size of a computerized system was assumed to be 100 intersections. Therefore, five new systems will be installed per year, of which three will use NEMA type controllers. In addition, it was assumed that one existing system per year would be redesigned using NEMA controllers. The time period for the analysis was assumed to be ten years calculated on the useful life of a system. Based on 300 new computerized intersections being installed per year for ten years, the average number of new intersections under computer control for each of the ten years will be 1,650. (The same formula used to calculate the average number of systems found on Page 45, was used to calculate the average number of new intersections under computer control.)

The benefits that the users could expect to receive from the development of a communications standard were:

- Reduced system design cost.
- Reduced system redesign cost.
- Increased system life due to availability of spare parts.
- Reduced costs for procurement of spares due to competition.

The costs that the user would have to pay would be the cost difference between the existing communications units and the new proposed units.

A very conservative approach was used for estimating the benefits from increased system life due to availability of spares. For purposes of this analysis, it was assumed that the new standard would extend the system life by two years. Using the 300 intersections per year figure, and the assumption of a two-year extended life, the average number of intersections affected per year would be 600. The benefit of the increased system life would be the difference in the equivalent annual cost of replacing 600 communications units every 12 years instead of every 10 years. This is very conservative, since only the cost of the communications units are considered. An average cost of $1,000 per unit was used for the analysis.

The annual benefits estimated for the users were as follows:

1.	Reduced system design costs $5,000 per system x 3 systems per year	=	$15,000
2.	Reduced system redesign costs $5,000 per system x 1 system per year	=	5,000
3.	Increased system life due to availability of spares CRF (i = 12%, n = 10 years) CRF (i = 12%, n = 12 years)	= =	0.17698 0.16144
	Equivalent annual cost, 10 year life 600 units x $1,000/units x 0.17698	=	$106,188
	Equivalent annual cost, 12 year life 600 units x $1,000/unit x 0.16144	=	$96,864
	Annual Benefit $106,188 - $96,864	=	$9,324
4.	Reduced cost of spares due to competition $200 per spare x 1,650 units x 5% spares	=	$16,500
	Total annual benefits	=	$45,824

The annual costs for the users due to a new communications standard were estimated as follows:

1.	Increased price of the new units compared to the existing $100 per unit x 300 units/year	=	$30,000

Since a constant number of new intersections to be installed per year was assumed, the estimated benefits and costs are annualized. Thus, there is no need to apply a capital recovery factor. Assuming that the benefit and cost estimates are accurate within a plus or minus 25 percent, a range of benefit/cost ratios were calculated as was done for the suppliers benefit/cost analysis. Using this technique, the range of benefit/cost ratios for the users was calculated to be 1.15 to 2.04.

GLOSSARY

Address – The process of selecting a specific receiving unit on a multidrop line so that the message can be sent to that unit alone.

Applications Layer – Computer programs which perform control strategy functions and such tasks as basic detector data processing, computing signal transitions, analyzing equipment operation for malfunctions, etc.

Asynchronous – A mode of operation in which the time between sequential events is unpredictable.

Bits per Second – The number of bits passing a designated point in a system each second.

Byte – The term used to indicate a number of consecutive binary digits that are usually operated on as a unit. Eight bits usually constitute one byte.

Channel – A path of communication

Communication Error – Any case wherein the data received from a channel does not agree with the data transmitted. (Also known as a data error.)

Complement – The process of reversing the ones and zeros in a data byte.

Conditioned Line – A communications line especially compensated to provide improved transmission characteristics.

Conditioning – A common-carrier service whereby the electrical characteristics of a channel are tuned so as to give improved data transmission.

Controller – A device which controls the sequence and duration of indications displayed by traffic signals.

Cycle Length – The time required for one complete sequence of signal indications.

Data Communications Equipment – The interfacing equipment required to couple the data terminal equipment (DTE) into a transmission circuit or channel, and from a transmission circuit or channel into the DTE. In a traffic control system, the modem is usually the data communications equipment.

Data Terminal Equipment – Equipment consisting of digital end instruments that convert user information into data signals for transmission, or reconvert the received data signals into user information. In a traffic control system, the data terminal equipment is usually the master or the controller.

DCE – See data communications equipment.

GLOSSARY (continued)

Dedicated Lines — Communication lines used solely to interconnect two or more locations.

Demodulation — The process of retrieving information from some previously modulated soruce. The reverse of modulation.

Detector — A device to detect the presence or passage of a vehicle in the roadway; e.g., a loop detector uses a coil of wire embedded in the roadway to identify the presence of a vhicle.

Downloading — A process in a traffic control system whereby the master transmits data to the controller that is used to modify the data stored in the controller's data base.

DTE — See data terminal equipment

Duplex — Two-way communication on a single communication channel. (See half duplex, full duplex.)

Echo — A method of checking the accuracy of transmission of data, by which the received data are returned to the sending end for comparison with the original data.

EIA-RS 232-C — Standard interface between data terminal equipment and data communication equipment employing serial binary data interchange.

Error Detection — The process by which information is checked to identify erroneously received data.

Frequency Shift Keying — A form of data transmission whereby the frequency of a sinusoidal waveform (carrier) is changed with the information that is to be transmitted. Typically, one frequency is assigned to the transmission of a mark (binary one), and a second frequency is assigned to the transmission of a space (binary zero). Additional frequencies may be used to indicate that no data is being transmitted, or to provide control information.

FSK — See frequency shift keying.

Full Duplex — A communication facility providing simultaneous transmission and reception in both directions.

FDX — See full duplex.

Half Duplex — A communication facility providing both transmission and reception in both directions, but not simultaneously.

HDX — See half duplex.

Interface – A common boundary at which two separate systems or portions of each join or interact. An interface can be mechanical, as in adjoining hardware surfaces, or it can be electrical, as in signal level transformation points.

Local Control – A controller supervising the operation of traffic signals at a single intersection without receiving commands from an external source.

Master – A device which imposes control or supervision on signalized intersections. A master may be a digital computer.

Medium – the path along which a communications signal is propagated, such as wire pair, coaxial cable, waveguide, optical fiber or radio path.

Modem – A device used at both ends of a communication channel to transmit and receive data. Contraction of Modulator Demodulator.

Modulation – the process whereby information is superimposed on another signal, usually a sinusoidal waveform for the purpose of transmitting the information over a communication link. The desired information is retrieved by a demodulation process.

Multidrop Connection – The connection of two or more data receiver/transmitter stations to a single communications channel. Special control signals must then be used to allow communication between the proper units. Multidrop connection is similar to a telephone party line.

Multiplexing – A communications technique which allows more than one item of information to be transmitted or received over the same medium.

Offset – The time between the start of the green at one intersection and the start of green at another intersection, or from a common system time base.

Packet – A group of data and control characters in a specified format, transferred as a whole.

Parallel Data – The simultaneous transmission of a group of bits, usually one byte long.

Parity – The addition of non-information bits to a character being transmitted in order to make the number of one bits in each character always be odd or even. At the receiver, the bits in each received character are checked to see that an odd number of one bits per character has been received in order to detect the presence of errors in the received data.

Polling – A communications technique in which the master sequentially transmits data to the controllers and requests their transmission of data back to the master.

Serial Transmission – A method of digital data transmission whereby the bits that represent an item of information are transmitted sequentially over a single channel.

Signal Timing – the amount of time allocated for the display of the sequence of signal indications that make up a signal cycle.

Sinusoidal – A waveform having the shape of the mathematicaly defined sine function. This wave shape is commonly used to define frequency related parameters in communications systems.

Software – Various programs to facilitate the efficient operation of the system. Such software items include various assemblers, compilers, subroutines, applications programs, operating systems, and libraries.

Split – A percentage of the cycle length allocated to each of the various pahses in a cycle.

Start Bit – See start-stop transmission

Start-Stop Transmission – Signaling in which each byte is preceded by a single bit which serves to prepare the receiving mechanism for the reception and storage of the byte. The byte is followed by a single bit which serves to bring the receiving mechanism to rest in preparation for the reception of the next byte.

Stop Bit – See start-stop transmission

Threshold – A preset level or value of a parameter which indicates that a change of activity will occur if the current value is above or below this level.

Time Base Coordination – Traffic signal coordination based on an internal electronic clock rather than information transmitted from a master.

Time Division Multiplexing – A technique for transmitting several different messages over one pair of wires by dividing a fixed interval of time into several time slots in which a discrete message is sent in each time slot.

Timing Plan – A set of cycle length, splits, and offsets within a group of signals.

Transmission – The electrical transfer of signal, message, or data from one point to another.

Unconditioned Line – A voice grade private line data channel that does not include special circuitry to control its electrical properties.

UTCS – Urban Traffic Control System

Volume – The number of vehicles passing a given point per unit of time.

REFERENCES

1. A Study of the Interchangeability of Traffic Signal Systems Communications Hardware Task A and B Interim Report, U.S. Department of Transportation, Federal Highway Administration, Contract No. DTFH61-84-C-0037, January 1985.

2. National Electrical Manufacturers Association (NEMA) Standards Publication No. TS-1 1983, Traffic Control Systems, 1083.

3. Bell System Specifications

Type 201	AT&T Technical References	41210
	Bell System Practices	592-029-120
Type 202	AT&T Technical References	41212
	Bell System Practices	592-021-180
		592-031-100
		592-861-100
Type 212	AT&T Technical References	41215
	Bell System Practices	592-039-100

4. Electronic Industries Association (EIA) Standards RS 232-C

APPENDIX A. SURVEY RESULTS

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

Model: 920 MODEM

Manufacturer/ System Supplier: INTERACTIVE SYSTEMS/3M
3920 VARSITY DRIVE
ANN ARBOR, MI
(313)973-1500

Contact:

System Supplier:
Controller Manufacturer:
Communication Equipment: X
Manufacturer

PHYSICAL CHARACTERISTICS:

Dimensions: 2.00 H 8.00 W 12.00 D
Connector: DB-25 "F"CONNECTOR
Heat Dis: 7 WATTS

Integral Power Supply: Y
Integral Modem: Y
Access:

Number of PC Cards: 1
Expansion Options: -
Mounting: SHELF

Controls:
1. DATA RATE
2. SYNC/ASYNC
3. RTS ON-OFF
4. DTR ON-OFF
5. NORM-LOOP
6. RTS/CTS DELAY

Indicators:
1. TxD
2. RxD
3. CTS
4. RTS
5. CDI
6. DSR
7.

MODEM CHARACTERISTICS:

Data Rate: 50-10000 BAUD
Modulation: FSK
Transmission Type: SYNCH:ASYNCH
Transmission Mode:
SIMPLEX:HALF DUPLEX:FULL DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: .35,8,55 Msec

Center Frq: 0 Hz
Mark Frq: 0 Hz
Space Frq: 0 Hz
Soft Carrier: 0 Hz

Transmitter Output Level: LO 30 DBM HI 45 DBM
Receiver Input Level: LO -15 DBM HI 10 DBM
Input Impedance: 75 ohms

Comments: ANY OF 75 DATA CHANNELS ON T9-T14 RECEIVE ON 7,J,K,L,M,N

ENVIRONMENTAL CHARACTERISTICS:

Temp Range: 0C to 50C
Fluctuation Tol: +-15%
Humidity:
Electrical Interf Spec:

ELECTRICAL CHARACTERISTICS:

115 VOLTS 0.000 AMPS 7.0 WATTS
Over Voltage Protection: Y
Type: UNKNOWN
Connector Type: DB-25
Data Trans Rate: 50-10Kbps
Lighting Protection: UNKNOWN
Isolation:

MAINTENANCE CHARACTERISTICS:

Test Equipment Required:
1. SPECTRUM ANALYZER
2. RF SIGNAL STRENGTH METER

Comments:

FUNCTIONAL CHARACTERISTICS:

Operation Modes: NORM/LOOP BACK
Error Detection:
Error Correction:
Communication Modes: SIMPLEX - X
HALF DUPLEX - X
FULL DUPLEX - X

Bit Error Rate: <1 x 10-9
Trans Fault Det:
Comm Standards: RS-232 C
Turn-around Time: .35 - 55MS
Type Data Xmited: SYNCH/ASYNCH

Number of Detectors Processed:
Number of Controllers:
Max # Units Sharing Line:
Failsafe Features:

Comments: MODEM ONLY, OTHER VALUES DEPEND ON SYSTEM CONFIGURATION

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

Model: TR 12

Manufacturer/ System Supplier: SAFETRAN
1485 GARDEN OF THE GODS ROAD
COLORADO SPRINGS, CO 80933
(303)599-5600
Contact:

System Supplier:
Controller Manufacturer: X
Communication Equipment Manufacturer: X

PHYSICAL CHARACTERISTICS:

Dimensions: 7.00 H 8.00 W 10.00 D
Connector: 37 PIN/24 PIN MS
Heat Dis: 5 WATTS

Integral Power Supply: Y
Integral Modem: Y
Access: FRONT

Number of PC Cards: 4
Expansion Options: NONE
Mounting: SHELF

Controls:

1.
2.
3.
4.
5.
6.

Indicators:

1. 12 LED STAT
2.
3.
4.
5.
6.
7.

MODEM CHARACTERISTICS:

Data Rate: 100 BAUD
Modulation: FSK
Transmission Type: ASYNCH
Transmission Mode:

Center Frq: 1400 Hz
Mark Frq: 1300 Hz
Space Frq: 1500 Hz
Soft Carrier: 0 Hz

Transmitter Output Level: LO -10 DBM HI 7 DBM
Receiver Input Level: LO -40 DBM HI 0 DBM
Input Impedance: 600 ohms

Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: Msec

Comments:

ENVIRONMENTAL CHARACTERISTICS:

Temp Range: -35C to 75C
Fluctuation Tol: 90VAC - 135VAC
Humidity: 5% - 95%
Electrical Interf Spec:
600 VOLTS PEAK

ELECTRICAL CHARACTERISTICS:

117 VOLTS 0.000 AMPS 5.0 WATTS
Over Voltage Protection: Y
Type: 600 VOLTS RC II
Connector Type:
Data Trans Rate: 100 bps
Lighting Protection: SPARK GAP
Isolation: TRANSFORMER

MAINTENANCE CHARACTERISTICS:

Test Equipment Required:
1.
2.

Comments:

FUNCTIONAL CHARACTERISTICS:

Operation Modes:
Error Detection: PARITY
Error Correction: REJECTION
Communication Modes: SIMPLEX -
HALF DUPLEX -
FULL DUPLEX - X

Bit Error Rate:
Trans Fault Det: MULTI BIT PARITY
Comm Standards:
Turn-around Time:
Type Data Xmited:

Number of Detectors Processed:
Number of Controllers: 1
Max # Units Sharing Line:
Failsafe Features:
1.5 SEC DLY AFTR PWR ON
Comments: MONITORS 12 INPUTS AND LATCHES 12 OUTPUTS

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

Model: PTC 100

Manufacturer/ System Supplier: SONEX
931-939 E. LYCOMING AVENUE
PHILADELPHIA, PA 19124
(215)533-4900

Contact:

System Supplier:
Controller Manufacturer:
Communication Equipment Manufacturer: X

PHYSICAL CHARACTERISTICS:

Dimensions: 5.50 H 5.50 W 10.00 D
Connector: 3-MS
Heat Dis: 18 WATTS

Integral Power Supply: Y
Integral Modem: Y
Access: TOP

Number of PC Cards: 8
Expansion Options: 4 SLOTS
Mounting: SHELF

Controls:
1. ON-OFF
2.
3.
4.
5.
6.

Indicators:
1.
2.
3.
4.
5.
6.
7.

MODEM CHARACTERISTICS:

Data Rate: 0-1800 BAUD
Modulation: FSK
Transmission Type: ASYNCH
Transmission Mode:
HALF DUPLEX:FULL DUPLEX
Carrier Detect Turn ON: 4.0 Msec
Carrier Detect Turn OFF: 3.0 Msec
Delay from Request to Send - Clear to Send: 4.5 Msec

Center Frq: 0 Hz
Mark Frq: 1200 Hz
Space Frq: 2200 Hz
Soft Carrier: 900 Hz

Transmitter Output Level: LO -10 DBM HI 0 DBM
Receiver Input Level: LO -45 DBM HI 0 DBM
Input Impedance: 600 ohms

Comments:

ENVIRONMENTAL CHARACTERISTICS:

Temp Range: -40C to 80C
Fluctuation Tol: 95VAC - 135VAC
Humidity: 9% - 95%
Electrical Interf Spec:

ELECTRICAL CHARACTERISTICS:

117 VOLTS 0.000 AMPS 18.0 WATTS
Over Voltage Protection: Y
Type: FUSE
Connector Type: 3-MS
Data Trans Rate: 0-1800
Lighting Protection:
Isolation: TRANSFORMER

MAINTENANCE CHARACTERISTICS:

Test Equipment Required:
1.
2.

Comments:

FUNCTIONAL CHARACTERISTICS:

Operation Modes:
Error Detection: PARITY
Error Correction:
Communication Modes: SIMPLEX -
HALF DUPLEX - X
FULL DUPLEX - X

Bit Error Rate: 1 x 10-10
Trans Fault Det: 3 SECOND TIME OUT
Comm Standards:
Turn-around Time:
Type Data Xmited: ASYNCH

Number of Detectors Processed: 16
Number of Controllers: 1
Max # Units Sharing Line:
Failsafe Features:

Comments:

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

Model: PTC 110A

Manufacturer/ System Supplier: SONEX
931-939 E. LYCOMING AVENUE
PHILADELPHIA, PA 19124
(215)533-4900

Contact:

System Supplier:
Controller Manufacturer:
Communication Equipment: X
Manufacturer

PHYSICAL CHARACTERISTICS:

Dimensions: 5.50 H 5.50 W 10.00 D
Connector: AMP CPC
Heat Dis: 18 WATT

Integral Power Supply: Y
Integral Modem: Y
Access: TOP

Number of PC Cards: 10
Expansion Options:
Mounting: STAND ALONE

Controls:
1. ON/OFF
2. INHIBIT
3.
4.
5.
6.

Indicators:
1. RTS/CRS
2. FLASH
3. SSF
4. F01,F02
5. ADV
6. YIELD
7. HOL

MODEM CHARACTERISTICS:

Data Rate: 1550 BAUD BAUD
Modulation: FSK
Transmission Type: ASYNCH
Transmission Mode:
FULL DUPLEX
Carrier Detect Turn ON: 4 Msec
Carrier Detect Turn OFF: 3 Msec
Delay from Request to Send - Clear to Send: 4.5 Msec

Center Frq: 1700 Hz
Mark Frq: 1200 Hz
Space Frq: 2200 Hz
Soft Carrier: 900 Hz

Transmitter Output Level: LO -10 DBM HI 0 DBM
Receiver Input Level: LO -45 DBM HI 0 DBM
Input Impedance: 600 ohms

Comments:

ENVIRONMENTAL CHARACTERISTICS:

Temp Range: -35F to 165F
Fluctuation Tol:
Humidity: 0% - 95%
Electrical Interf Spec:
95VAC - 135VAC

ELECTRICAL CHARACTERISTICS:

115 VOLTS 0.000 AMPS 18.0 WATTS
Over Voltage Protection: Y
Type:
Connector Type:
Data Trans Rate: 1550 BAUD
Lighting Protection: GAS TUBE & ZENER
Isolation: TRANSFORMER

MAINTENANCE CHARACTERISTICS:

Test Equipment Required:
1. SCOPE
2.

Comments:

FUNCTIONAL CHARACTERISTICS:

Operation Modes:
Error Detection: PARITY:CHECKSUM
Error Correction:
Communication Modes: SIMPLEX -
HALF DUPLEX -
FULL DUPLEX - X

Bit Error Rate: 1 x 10-9
Trans Fault Det:
Comm Standards:
Turn-around Time:
Type Data Xmited: ASYNCH

Number of Detectors Processed:
Number of Controllers:
Max # Units Sharing Line:
Failsafe Features:

Comments:

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

Model: REMOTE INTERFACE UNIT III

Manufacturer/ System Supplier: MULTISONICS
6444 SIERRA COURT
DUBLIN, CA 94566
(415)829-3300
Contact:

System Supplier: X
Controller Manufacturer: X
Communication Equipment: X
Manufacturer

PHYSICAL CHARACTERISTICS:

Dimensions: 9.75 H 5.63 W 8.63 D
Connector: 50 PIN RIBBON,36 PIN RIBBON
Heat Dis: UNKNOWN

Integral Power Supply: Y
Integral Modem: Y
Access: FRONT

Number of PC Cards: 4
Expansion Options: INCLUDED
Mounting: SHELF

Controls:

1. ADDRESS	4.
2.	5.
3.	6.

Indicators:

1. LOS	4. PRE-EMPT	7.
2. STANDBY	5. COORD	
3. HOL	6.	

MODEM CHARACTERISTICS:

Data Rate: 1200 BAUD
Modulation: FSK
Transmission Type: ASYNCH
Transmission Mode:
HALF DUPLEX/FULL DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: 1.5 Msec
Delay from Request to Send - Clear to Send: 8 Msec

Center Frq: 0 Hz
Mark Frq: 1215 Hz
Space Frq: 2157 Hz
Soft Carrier: 0 Hz

Transmitter Output Level: LO 0 DBM HI 0 DBM
Receiver Input Level: LO -36 DBM HI 0 DBM
Input Impedance: 600 ohms

Comments:

ENVIRONMENTAL CHARACTERISTICS:

Temp Range: -37C to 74C
Fluctuation Tol: 95VAC - 135VAC
Humidity: 5% - 95%
Electrical Interf Spec:
MOV

ELECTRICAL CHARACTERISTICS:

-9 VOLTS 0.000 AMPS 0.0 WATTS
Over Voltage Protection: Y
Type: FUSE
Connector Type:
Data Trans Rate: 1200
Lighting Protection: NONE
Isolation: TRANSFORMER

MAINTENANCE CHARACTERISTICS:

Test Equipment Required:
1. SCOPE
2. TEST CABLE

Comments: *-9 24 or 117 VOLTS

FUNCTIONAL CHARACTERISTICS:

Operation Modes: ONLINE,STNDBY,PRE-EM
Error Detection:
Error Correction:
Communication Modes: SIMPLEX -
HALF DUPLEX -
FULL DUPLEX -

Bit Error Rate:
Trans Fault Det:
Comm Standards:
Turn-around Time:
Type Data Xmited:

Number of Detectors Processed: 0
Number of Controllers: 0
Max # Units Sharing Line:
Failsafe Features:

Comments: FUNCTIONAL CHARACTERISTICS UNKNOWN

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

Model: CM-250

Manufacturer/ System Supplier: MULTISONICS
6444 SIERRA COURT
DUBLIN, CA 94566
(415)829-3300
Contact:

System Supplier: X
Controller Manufacturer: X
Communication Equipment Manufacturer: X

PHYSICAL CHARACTERISTICS:

Dimensions: 6.00 H 2.50 W 12.00 D
Connector: MS, "F" CONNECTOR
Heat Dis: 10 WATT

Integral Power Supply: N
Integral Modem: Y
Access:

Number of PC Cards: 0
Expansion Options: UNKNOWN
Mounting: SHELF

Controls:
1. TEST-NORM SWITCH
2. RCV SENSITIVITY
3. XMIT LEVEL
4.
5.
6.

Indicators:
1. RTS
2. TxD
3. CD
4. RxD
5.
6.
7.

MODEM CHARACTERISTICS:

Data Rate: 0-10,000 BAUD
Modulation: FSK
Transmission Type: SYNCH:ASYNCH
Transmission Mode:
FULL DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: 10 Msec

Center Frq: -9 Hz
Mark Frq: -9 Hz
Space Frq: -9 Hz
Soft Carrier: -9 Hz

Transmitter Output Level: LO 30 DBM HI 45 DBM
Receiver Input Level: LO -15 DBM HI 10 DBM
Input Impedance: 75 ohms

Comments: *-9 ANY OF 75 DATA CHANNELS ON
T9-T11 RECEIVE ON 7,J OR K

ENVIRONMENTAL CHARACTERISTICS:

Temp Range: -34C to 74C
Fluctuation Tol: UNKNOWN
Humidity:
Electrical Interf Spec:
RS-232 C

ELECTRICAL CHARACTERISTICS:

-9 VOLTS 0.150 AMPS 0.0 WATTS
Over Voltage Protection: ?
Type:
Connector Type: MS
Data Trans Rate: 0-10,000
Lighting Protection: UNKNOWN
Isolation:

MAINTENANCE CHARACTERISTICS:

Test Equipment Required:
1. SPECTRUM ANALYZER
2. RF SIGNAL STRENGTH METER

Comments: *-9 +- 12 VOLTS

FUNCTIONAL CHARACTERISTICS:

Operation Modes:
Error Detection:
Error Correction:
Communication Modes: SIMPLEX -
HALF DUPLEX - X
FULL DUPLEX - X

Bit Error Rate: 1 x 10-8
Trans Fault Det:
Comm Standards: RS-232-C
Turn-around Time:
Type Data Xmited: ASYNCH

Number of Detectors Processed: 0
Number of Controllers: 1
Max # Units Sharing Line: *
Failsafe Features:
CONT WATCHDOG DISABL XMT
Comments: * VARIABLE

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

Model: CM-251

Manufacturer/ System Supplier: MULTISONICS, 6444 SIERRA COURT, DUBLIN, CA 94566, (415)829-3300

Contact:

System Supplier: X
Controller Manufacturer: X
Communication Equipment Manufacturer: X

PHYSICAL CHARACTERISTICS:

Dimensions: 5.00 H 2.50 W 9.50 D
Connector: MS, "F" CONNECTOR
Heat Dis: 10 WATT

Integral Power Supply: N
Integral Modem: Y
Access:

Number of PC Cards: 0
Expansion Options: UNKNOWN
Mounting: SHELF

Controls:

1. TEST-NORM SWITCH
2. RCV SENSITIVITY
3. XMIT LEVEL
4. 5 OR 12 INTRF LVL
5.
6.

Indicators:

1. RTS
2. TxD
3. CD
4. RxD
5.
6.
7.

MODEM CHARACTERISTICS:

Data Rate: 0-10,000 BAUD
Modulation: FSK
Transmission Type: SYNCH:ASYNCH
Transmission Mode: HALF DUPLEX:FULL DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: 10 Msec

Center Frq: -9 Hz
Mark Frq: -9 Hz
Space Frq: -9 Hz
Soft Carrier: -9 Hz

Transmitter Output Level: LO 30 DBM HI 45 DBM
Receiver Input Level: LO -15 DBM HI 10 DBM
Input Impedance: 75 ohms

Comments: *-9 ANY OF 75 DATA CHANNELS ON T9-T11 RECEIVE ON 7,J OR K

ENVIRONMENTAL CHARACTERISTICS:

Temp Range: -34C to 74C
Fluctuation Tol: UNKNOWN
Humidity:
Electrical Interf Spec:

ELECTRICAL CHARACTERISTICS:

9 VOLTS 0.150 AMPS 0.0 WATTS
Over Voltage Protection:
Type: UNKNOWN
Connector Type:
Data Trans Rate: 0-10,000
Lighting Protection: UNKNOWN
Isolation:

MAINTENANCE CHARACTERISTICS:

Test Equipment Required:
1. SPECTRUM ANALYZER
2. RF FIELD STRENGTH METER

Comments: *9 SUPPLY VOLTAGE 15V to 24V

FUNCTIONAL CHARACTERISTICS:

Operation Modes:
Error Detection:
Error Correction:
Communication Modes: SIMPLEX -
HALF DUPLEX - X
FULL DUPLEX - X

Bit Error Rate: 1 x 10-8
Trans Fault Det:
Comm Standards:
Turn-around Time:
Type Data Xmited: ASYNCH

Number of Detectors Processed: 0
Number of Controllers: 1
Max # Units Sharing Line: *
Failsafe Features:

Comments: * VARIABLE

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

Model: CM-252

Manufacturer/ System Supplier: MULTISONICS
6444 SIERRA COURT
DUBLIN, CA 94566
(415)829-3300
Contact:

System Supplier: X
Controller Manufacturer: X
Communication Equipment Manufacturer: X

PHYSICAL CHARACTERISTICS:

Dimensions: 6.00 H 2.50 W 12.00 D
Connector: MS, "F" CONN
Heat Dis: 10 WATT

Integral Power Supply: Y
Integral Modem: Y
Access:

Number of PC Cards: 0
Expansion Options: UNKNOWN
Mounting: SHELF

Controls:
1. TEST NORM SWITCH
2. RCV SENSITIVITY
3. XMIT LEVEL
4.
5.
6.

Indicators:
1. RTS
2. TxD
3. CD
4. RxD
5.
6.
7.

MODEM CHARACTERISTICS:

Data Rate: 0-10,000 BAUD
Modulation: FSK
Transmission Type: SYNCH:ASYNCH
Transmission Mode:
HALF DUPLEX:FULL DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: 10 Msec

Center Frq: -9 Hz
Mark Frq: -9 Hz
Space Frq: -9 Hz
Soft Carrier: -9 Hz

Transmitter Output Level: LO 30 DBM HI 45 DBM
Receiver Input Level: LO -15 DBM HI 10 DBM
Input Impedance: 75 ohms

Comments: *-9 ANY OF 75 DATA CHANNELS ON T9-T11 RECEIVE ON 7,J OR K

ENVIRONMENTAL CHARACTERISTICS:

Temp Range: -34C to 74C
Fluctuation Tol: UNKNOWN
Humidity:
Electrical Interf Spec:
RS-232

ELECTRICAL CHARACTERISTICS:

117 VOLTS 0.000 AMPS 10.0 WATTS
Over Voltage Protection:
Type: 1/4 AMP FUSE
Connector Type:
Data Trans Rate: 0-10,000
Lighting Protection:
Isolation:

MAINTENANCE CHARACTERISTICS:

Test Equipment Required:
1. SPECTRUM ANALYZER
2. RF SIGNAL STRENGTH METER

Comments:

FUNCTIONAL CHARACTERISTICS:

Operation Modes:
Error Detection:
Error Correction:
Communication Modes: SIMPLEX -
HALF DUPLEX - X
FULL DUPLEX - X

Bit Error Rate: 1 x 10-8
Trans Fault Det:
Comm Standards: RS-232 C
Turn-around Time:
Type Data Xmited: SYNCH:ASYNCH

Number of Detectors Processed: 0
Number of Controllers: 1
Max # Units Sharing Line: *
Failsafe Features:

Comments: *VARIABLE

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

Model: CM-253

Manufacturer/ System Supplier: MULTISONICS
6444 SIERRA COURT
DUBLIN, CA 94566
(415)829-3300
Contact:

System Supplier: X
Controller Manufacturer: X
Communication Equipment Manufacturer: X

PHYSICAL CHARACTERISTICS:

Dimensions: 6.00 H 2.50 W 12.00 D
Connector: DB25, "F" CONN
Heat Dis: 10 WATT

Integral Power Supply: Y
Integral Modem: Y
Access:

Number of PC Cards: 0
Expansion Options: UNKNOWN
Mounting: SHELF

Controls:
1. TEST NORM SWITCH
2. RCV SENSITIVITY
3. XMIT LEVEL
4.
5.
6.

Indicators:
1. RTS
2. TxD
3. CD
4. RxD
5.
6.
7.

MODEM CHARACTERISTICS:

Data Rate: 0-10,000 BAUD
Modulation: FSK
Transmission Type: AYNCH:ASYNCH
Transmission Mode: HALF DUPLEX:FULL DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: 10 Msec

Center Frq: -9 Hz
Mark Frq: -9 Hz
Space Frq: -9 Hz
Soft Carrier: -9 Hz

Transmitter Output Level: LO 30 DBM HI 45 DBM
Receiver Input Level: LO -15 DBM HI 10 DBM
Input Impedance: 75 ohms

Comments: *-9 ANY OF 75 DATA CHANNELS ON T9-T11 RECEIVE ON 7,J OR K

ENVIRONMENTAL CHARACTERISTICS:

Temp Range: -34C to 74C
Fluctuation Tol: UNKNOWN
Humidity:
Electrical Interf Spec: RS-232 C

ELECTRICAL CHARACTERISTICS:

117 VOLTS 0.000 AMPS 10.0 WATTS
Over Voltage Protection:
Type: 1/4 AMP FUSE
Connector Type:
Data Trans Rate:
Lighting Protection:
Isolation:

MAINTENANCE CHARACTERISTICS:

Test Equipment Required:
1. SPECTRUM ANALYZER
2. RF SIGNAL STRENGTH METER

Comments:

FUNCTIONAL CHARACTERISTICS:

Operation Modes:
Error Detection:
Error Correction:
Communication Modes: SIMPLEX -
HALF DUPLEX - X
FULL DUPLEX - X

Bit Error Rate: 1 x 10-8
Trans Fault Det:
Comm Standards: RS-232 C
Turn-around Time:
Type Data Xmited: SYNCH:ASYNCH

Number of Detectors Processed: 0
Number of Controllers: 1
Max # Units Sharing Line: *
Failsafe Features:

Comments: *VARIABLE

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

Model: 400 MODEM FOR 170 CONTROLLER

Manufacturer/ System Supplier: MULTISONICS, 6444 SIERRA COURT, DUBLIN, CA 94566, (415)829-3300

Contact:

System Supplier: X
Controller Manufacturer: X
Communication Equipment Manufacturer: X

PHYSICAL CHARACTERISTICS:

Dimensions: 9.38 H 6.25 W 0.00 D
Connector: 44 PIN .125 EDGE CONNECTOR
Heat Dis: 2.4 WATT

Integral Power Supply: N
Integral Modem: Y
Access: FRONT

Number of PC Cards: 1
Expansion Options: -
Mounting: THUMB EJECTORS

Controls:

1. 2W/4W
2. FULL/HALF
3. SLICER
4. SOFT CARR TIME DLY
5. XMIT AMPLITUDE
6.

Indicators:

1. CD
2. TxD
3. RTS
4. RxD
5.
6.
7.

MODEM CHARACTERISTICS:

Data Rate: 300-1200 BAUD
Modulation: FSK
Transmission Type: ASYNCH
Transmission Mode: HALF DUPLEX:FULL DUPLEX
Carrier Detect Turn ON: 8 Msec
Carrier Detect Turn OFF: 10 Msec
Delay from Request to Send - Clear to Send: 10 Msec

Center Frq: 0 Hz
Mark Frq: 1300 Hz
Space Frq: 2100 Hz
Soft Carrier: 900 Hz

Transmitter Output Level: LO 0 DBM HI 0 DBM
Receiver Input Level: LO -40 DBM HI 0 DBM
Input Impedance: 600 ohms

Comments:

ENVIRONMENTAL CHARACTERISTICS:

Temp Range: -37C to 74C
Fluctuation Tol: +-17%
Humidity: 5% - 95%
Electrical Interf Spec: PROVIDED EXTERNALLY

ELECTRICAL CHARACTERISTICS:

-9 VOLTS 0.100 AMPS 1.2 WATTS
Over Voltage Protection: Y
Type: PROVIDED EXTERN
Connector Type: 44 PIN EDGE
Data Trans Rate: 300-1200
Lighting Protection: NONE
Isolation: TRANSFORMER

MAINTENANCE CHARACTERISTICS:

Test Equipment Required:
1. DIAGNOSTIC PROGRAM
2.

Comments: *-9 +-12 VOLTS

FUNCTIONAL CHARACTERISTICS:

Operation Modes: *
Error Detection: PARITY*:CHECKSUM*
Error Correction: *
Communication Modes: SIMPLEX -
HALF DUPLEX - X
FULL DUPLEX - X

Bit Error Rate: 1 x 10-5
Trans Fault Det: *
Comm Standards: RS-232-C
Turn-around Time: *
Type Data Xmited: ASYNCH

Number of Detectors Processed: 0
Number of Controllers: 1
Max # Units Sharing Line: *
Failsafe Features: *

Comments: *VARIABLE,DEPENDING UPON CHAR SPECIFIED IN HOST 170 PROGRAM

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

Model: RIU-810

Manufacturer/ System Supplier: MULTISONICS
6444 SIERRA COURT
DUBLIN, CA 94566
(415)829-3300
Contact:

System Supplier: X
Controller Manufacturer: X
Communication Equipment Manufacturer: X

PHYSICAL CHARACTERISTICS:

Dimensions: 5.50 H 10.00 W 9.00 D
Connector: 44 PIN EDGE CONNECTION
Heat Dis: ?

Integral Power Supply: Y
Integral Modem: Y
Access: FRONT

Number of PC Cards: 3
Expansion Options: ROOM FOR 3 MORE CRDS
Mounting: SHELF

Controls:
1. FORCE STANDBY-ON
2.
3.
4.
5.
6.

Indicators:
1. POWER
2. LOS
3. STAND BY
4. PRE-EMPT
5. COORD
6. CD
7. RTS

MODEM CHARACTERISTICS:

Data Rate: 1200 BAUD
Modulation: FSK
Transmission Type: ASYNCH
Transmission Mode: HALF DUPLEX/FULL DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: Msec

Center Frq: -9 Hz
Mark Frq: 1200 Hz
Space Frq: 2000 Hz
Soft Carrier: 0 Hz

Transmitter Output Level: LO 0 DBM HI 0 DBM
Receiver Input Level: LO 0 DBM HI 0 DBM
Input Impedance: 600 ohms

Comments: *-9 BELL 202 COMPATIBLE

ENVIRONMENTAL CHARACTERISTICS:

Temp Range: -37C to 74C
Fluctuation Tol: 95VAC - 135VAC
Humidity: 5% - 95%
Electrical Interf Spec: MOV

ELECTRICAL CHARACTERISTICS:

117 VOLTS 0.000 AMPS 0.0 WATTS
Over Voltage Protection: Y
Type: MOV
Connector Type: 44 PIN EDGE
Data Trans Rate: 1200 bps
Lighting Protection: EXTERNAL GAS-TUBE
Isolation: TRANSFORMER

MAINTENANCE CHARACTERISTICS:

Test Equipment Required:
1. RIU-810 TEST SET
2.

Comments:

FUNCTIONAL CHARACTERISTICS:

Operation Modes: ONLINE,STNDBY,PRE-EM
Error Detection:
Error Correction:
Communication Modes: SIMPLEX -
HALF DUPLEX - X
FULL DUPLEX - X

Bit Error Rate: UNKNOWN
Trans Fault Det:
Comm Standards:
Turn-around Time:
Type Data Xmited:

Number of Detectors Processed: 0
Number of Controllers: 1
Max # Units Sharing Line: 16
Failsafe Features:

Comments:

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

Model: NO NAME

Manufacturer/ System Supplier: TOCOM
P O BOX 47066
DALLAS, TEXAS 75247
(214)438-7691
Contact:

System Supplier:
Controller Manufacturer:
Communication Equipment: X
Manufacturer

PHYSICAL CHARACTERISTICS:

Dimensions: 8.00 H 8.00 W 8.00 D
Connector: MS,F
Heat Dis:

Integral Power Supply: Y
Integral Modem: Y
Access: TOP

Number of PC Cards: 0
Expansion Options:
Mounting: SHELF

Controls:
1. 4.
2. 5.
3. 6.

Indicators:
1. 4. 7.
2. 5.
3. 6.

MODEM CHARACTERISTICS:

Data Rate: 56K, 28K BAUD
Modulation: FSK
Transmission Type: ASYNCH
Transmission Mode:
FULL DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: Msec

Center Frq: 0 Hz
Mark Frq: 0 Hz
Space Frq: 0 Hz
Soft Carrier: 0 Hz

Transmitter Output Level: LO 0 DBM HI 0 DBM
Receiver Input Level: LO 0 DBM HI 0 DBM
Input Impedance: 0 ohms

Comments:

ENVIRONMENTAL CHARACTERISTICS:

Temp Range: to
Fluctuation Tol:
Humidity:
Electrical Interf Spec:

ELECTRICAL CHARACTERISTICS:

115 VOLTS 0.000 AMPS 0.0 WATTS
Over Voltage Protection:
Type:
Connector Type:
Data Trans Rate:
Lighting Protection:
Isolation:

MAINTENANCE CHARACTERISTICS:

Test Equipment Required:
1.
2.

Comments:

FUNCTIONAL CHARACTERISTICS:

Operation Modes:
Error Detection: PARITY:CHECKSUM
Error Correction:
Communication Modes: SIMPLEX -
HALF DUPLEX -
FULL DUPLEX -

Bit Error Rate:
Trans Fault Det:
Comm Standards:
Turn-around Time:
Type Data Xmited: ASYNCH

Number of Detectors Processed:
Number of Controllers:
Max # Units Sharing Line:
Failsafe Features:

Comments:

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

Model: KTM-1

Manufacturer/ System Supplier: ECONOLITE
3360 E LA PALMA, PO BOX 6150
ANAHEIM, CA 92806
(714)630-3700

Contact:

System Supplier:
Controller Manufacturer: X
Communication Equipment:
Manufacturer

PHYSICAL CHARACTERISTICS:

Dimensions: 10.45 H 3.10 W 10.62 D
Connector: 25 P D-SUBMIN/25&50 PIN D-SUBM
Heat Dis:

Integral Power Supply: N
Integral Modem: Y
Access: FRONT

Number of PC Cards: 2
Expansion Options:
Mounting: INTGRL/STND ALN

Controls:

1. ADDRESS
2.
3.
4.
5.
6.

Indicators:

1. RECV CARRIER
2. VALID DATA
3. TRANSMIT
4.
5.
6.
7.

MODEM CHARACTERISTICS:

Data Rate: 1200 BAUD BAUD
Modulation: FSK
Transmission Type: ASYNCH
Transmission Mode:
FULL DUPLEX

Center Frq: 0 Hz
Mark Frq: 1200 Hz
Space Frq: 2200 Hz
Soft Carrier: 0 Hz

Transmitter Output Level: LO 0 DBM HI 0 DBM
Receiver Input Level: LO -34 DBM HI 0 DBM
Input Impedance: 600 ohms

Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: Msec

Comments:

ENVIRONMENTAL CHARACTERISTICS:

Temp Range: -35C to 75C
Fluctuation Tol: 95VAC - 135VAC
Humidity: 18% -95%
Electrical Interf Spec:

ELECTRICAL CHARACTERISTICS:

115 VOLTS 0.000 AMPS 0.0 WATTS
Over Voltage Protection: Y
Type: REGULATOR&ZENER
Connector Type: 50 PIN D-SUB
Data Trans Rate: 1200 BAUD
Lighting Protection: GAS TUBE&VARISTOR
Isolation: TRANSFORMER

MAINTENANCE CHARACTERISTICS:

Test Equipment Required:
1. DMM, SCOPE
2. FREQ CTN

Comments:

FUNCTIONAL CHARACTERISTICS:

Operation Modes:
Error Detection: PARITY:CHECKSUM
Error Correction:
Communication Modes: SIMPLEX -
HALF DUPLEX -
FULL DUPLEX - X

Bit Error Rate:
Trans Fault Det:
Comm Standards:
Turn-around Time:
Type Data Xmited: ASYNCH

Number of Detectors Processed:
Number of Controllers: 1
Max # Units Sharing Line: 24
Failsafe Features:

Comments:

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

Model: 118 COMM MODULE

Manufacturer/ System Supplier: LFE TRAFFIC CONTROL

Contact:

System Supplier:
Controller Manufacturer: X
Communication Equipment: Manufacturer

PHYSICAL CHARACTERISTICS:

Dimensions: 0.00 H 0.00 W 0.00 D
Connector: 37 PIN D SUBMINIATURE
Heat Dis:

Integral Power Supply: N
Integral Modem: Y
Access: FRONY

Number of PC Cards: 1
Expansion Options:
Mounting: INTEGRAL MODULE

Controls:

1. ADDRESS
2. CYCLE LENGTH
3. AUTO/STBY/FREE
4.
5.
6.

Indicators:

1. SYSC
2. AUTO/STBY/FR
3. COMM FAIL
4. CARRIER DET
5. TRANSMITING
6.
7.

MODEM CHARACTERISTICS:

Data Rate: 1200 BAUD BAUD
Modulation: FSK
Transmission Type: ASYNCH
Transmission Mode: FULL DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send -- Clear to Send: Msec

Center Frq: 1700 Hz
Mark Frq: 1200 Hz
Space Frq: 2200 Hz
Soft Carrier: 900 Hz

Transmitter Output Level: LO -12 DBM HI 0 DBM
Receiver Input Level: LO -30 DBM HI 0 DBM
Input Impedance: 600 ohms

Comments:

ENVIRONMENTAL CHARACTERISTICS:

Temp Range: to
Fluctuation Tol:
Humidity:
Electrical Interf Spec:

ELECTRICAL CHARACTERISTICS:

0 VOLTS 0.000 AMPS 0.0 WATTS
Over Voltage Protection:
Type:
Connector Type:
Data Trans Rate: 1200 BAUD
Lighting Protection: ZENER
Isolation: TRANSFORMER

MAINTENANCE CHARACTERISTICS:

Test Equipment Required:
1. SCOPE
2.

Comments:

FUNCTIONAL CHARACTERISTICS:

Operation Modes:
Error Detection: PARITY:CHECKSUM
Error Correction:
Communication Modes: SIMPLEX -
HALF DUPLEX -
FULL DUPLEX - X

Bit Error Rate:
Trans Fault Det:
Comm Standards:
Turn-around Time:
Type Data Xmited: ASYNCH

Number of Detectors Processed: 8
Number of Controllers: 1
Max # Units Sharing Line: 8
Failsafe Features:

Comments:

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

Model: MK II MP-100

Manufacturer/ System Supplier: WINKO-MATIC
659 MILLER ROAD
AVON LAKE, OH 44012
(216)933-2122
Contact:

System Supplier:
Controller Manufacturer:
Communication Equipment: X
Manufacturer

PHYSICAL CHARACTERISTICS:

Dimensions: 9.00 H 6.00 W 10.50 D
Connector: AMP CPC
Heat Dis: 25 WATT

Integral Power Supply: Y
Integral Modem: Y
Access: REAR

Number of PC Cards: 0
Expansion Options:
Mounting: SHELF

Controls:

1. INDICATORS ON/OFF
2. PICK-UP/DROP
3. ADDRESS
4.
5.
6.

Indicators:

1. HOL
2. FO1,FO2
3. ADV
4. SF1,SF2
5. CD
6. TMT
7.

MODEM CHARACTERISTICS:

Data Rate: 1200 BAUD BAUD
Modulation: FSK
Transmission Type: ASYNCH
Transmission Mode:
FULL DUPLEX:HALF DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: Msec

Center Frq: 0 Hz
Mark Frq: 1200 Hz
Space Frq: 2200 Hz
Soft Carrier: 0 Hz

Transmitter Output Level: LO -7 DBM HI 4 DBM
Receiver Input Level: LO -34 DBM HI 0 DBM
Input Impedance: 0 ohms

Comments:

ENVIRONMENTAL CHARACTERISTICS:

Temp Range: -30F to 165F
Fluctuation Tol:
Humidity: 0% - 95%
Electrical Interf Spec:

ELECTRICAL CHARACTERISTICS:

115 VOLTS 0.000 AMPS 0.0 WATTS
Over Voltage Protection:
Type:
Connector Type: AMP CPC
Data Trans Rate: 1200 BAUD
Lighting Protection:
Isolation:

MAINTENANCE CHARACTERISTICS:

Test Equipment Required:
1.
2.

Comments:

FUNCTIONAL CHARACTERISTICS:

Operation Modes:
Error Detection:
Error Correction:
Communication Modes: SIMPLEX -
HALF DUPLEX - X
FULL DUPLEX - X

Bit Error Rate:
Trans Fault Det:
Comm Standards:
Turn-around Time:
Type Data Xmited: ASYNCH

Number of Detectors Processed:
Number of Controllers: 1
Max # Units Sharing Line: 8
Failsafe Features:

Comments:

APPENDIX B. SUMMARY OF PHYSICAL CHARACTERISTICS

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

PHYSICAL CHARACTERISTICS: 920 MODEM — MANUFACTURER: INTERACTIVE SYSTEMS/3M

Dimensions: 2.00 H 8.00 W 12.00 D	Integral Power Supply: Y	Number of PC Cards:	1
Connector: DB-25 "F"CONNECTOR	Integral Modem: Y	Expansion Options:	-
Heat Dis: 7 WATTS	Access:	Mounting:	SHELF

Controls:		Indicators:		
1. DATA RATE	4. DTR ON-OFF	1. TxD	4. RTS	7.
2. SYNC/ASYNC	5. NORM-LOOP	2. RxD	5. CDI	
3. RTS ON-OFF	6. RTS/CTS DELAY	3. CTS	6. DSR	

PHYSICAL CHARACTERISTICS: TR 12 — MANUFACTURER: SAFETRAN

Dimensions: 7.00 H 8.00 W 10.00 D	Integral Power Supply: Y	Number of PC Cards:	4
Connector: 37 PIN/24 PIN MS	Integral Modem: Y	Expansion Options:	NONE
Heat Dis: 5 WATTS	Access: FRONT	Mounting:	SHELF

Controls:		Indicators:		
1.	4.	1. 12 LED STAT	4.	7.
2.	5.	2.	5.	
3.	6.	3.	6.	

PHYSICAL CHARACTERISTICS: PTC 100 — MANUFACTURER: SONEX

Dimensions: 5.50 H 5.50 W 10.00 D	Integral Power Supply: Y	Number of PC Cards:	8
Connector: 3-MS	Integral Modem: Y	Expansion Options:	4 SLOTS
Heat Dis: 18 WATTS	Access: TOP	Mounting:	SHELF

Controls:		Indicators:		
1. ON-OFF	4.	1.	4.	7.
2.	5.	2.	5.	
3.	6.	3.	6.	

PHYSICAL CHARACTERISTICS: PTC 110A — MANUFACTURER: SONEX

Dimensions: 5.50 H 5.50 W 10.00 D	Integral Power Supply: Y	Number of PC Cards:	10
Connector: AMP CPC	Integral Modem: Y	Expansion Options:	
Heat Dis: 18 WATT	Access: TOP	Mounting:	STAND ALONE

Controls:		Indicators:		
1. ON/OFF	4.	1. RTS/CRS	4. F01,F02	7. HOL
2. INHIBIT	5.	2. FLASH	5. ADV	
3.	6.	3. SSF	6. YIELD	

PHYSICAL CHARACTERISTICS: REMOTE INTERFACE UNIT 111 — MANUFACTURER: MULTISONICS

Dimensions: 9.75 H 5.63 W 8.63 D	Integral Power Supply: Y	Number of PC Cards:	4
Connector: 50 PIN RIBBON,36 PIN RIBBON	Integral Modem: Y	Expansion Options:	INCLUDED
Heat Dis: UNKNOWN	Access: FRONT	Mounting:	SHELF

Controls:		Indicators:		
1. ADDRESS	4.	1. LOS	4. PRE-EMPT	7.
2.	5.	2. STANDBY	5. COORD	
3.	6.	3. HOL	6.	

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

PHYSICAL CHARACTERISTICS: CM-250 MANUFACTURER: MULTISONICS

Dimensions: 6.00 H 2.50 W 12.00 D	Integral Power Supply: N	Number of PC Cards:	0
Connector: MS, "F" CONNECTOR	Integral Modem: Y	Expansion Options:	UNKNOWN
Heat Dis: 10 WATT	Access:	Mounting:	SHELF

Controls:		Indicators:		
1. TEST-NORM SWITCH	4.	1. RTS	4. RxD	7.
2. RCV SENSITIVITY	5.	2. TxD	5.	
3. XMIT LEVEL	6.	3. CD	6.	

PHYSICAL CHARACTERISTICS: CM-251 MANUFACTURER: MULTISONICS

Dimensions: 5.00 H 2.50 W 9.50 D	Integral Power Supply: N	Number of PC Cards:	0
Connector: MS, "F" CONNECTOR	Integral Modem: Y	Expansion Options:	UNKNOWN
Heat Dis: 10 WATT	Access:	Mounting:	SHELF

Controls:		Indicators:		
1. TEST-NORM SWITCH	4. 5 OR 12 INTRF LVL	1. RTS	4. RxD	7.
2. RCV SENSITIVITY	5.	2. TxD	5.	
3. XMIT LEVEL	6.	3. CD	6.	

PHYSICAL CHARACTERISTICS: CM-252 MANUFACTURER: MULTISONICS

Dimensions: 6.00 H 2.50 W 12.00 D	Integral Power Supply: Y	Number of PC Cards:	0
Connector: MS, "F" CONN	Integral Modem: Y	Expansion Options:	UNKNOWN
Heat Dis: 10 WATT	Access:	Mounting:	SHELF

Controls:		Indicators:		
1. TEST NORM SWITCH	4.	1. RTS	4. RxD	7.
2. RCV SENSITIVITY	5.	2. TxD	5.	
3. XMIT LEVEL	6.	3. CD	6.	

PHYSICAL CHARACTERISTICS: CM 253 MANUFACTURER: MULTISONICS

Dimensions: 6.00 H 2.50 W 12.00 D	Integral Power Supply: Y	Number of PC Cards:	0
Connector: DB25, "F" CONN	Integral Modem: Y	Expansion Options:	UNKNOWN
Heat Dis: 10 WATT	Access:	Mounting:	SHELF

Controls:		Indicators:		
1. TEST NORM SWITCH	4.	1. RTS	4. RxD	7.
2. RCV SENSITIVITY	5.	2. TxD	5.	
3. XMIT LEVEL	6.	3. CD	6.	

PHYSICAL CHARACTERISTICS: 400 MODEM FOR 170 CONTROLLER MANUFACTURER: MULTISONICS

Dimensions: 9.38 H 6.25 W 0.00 D	Integral Power Supply: N	Number of PC Cards:	1.
Connector: 44 PIN .125 EDGE CONNECTOR	Integral Modem: Y	Expansion Options:	-
Heat Dis: 2.4 WATT	Access: FRONT	Mounting:	THUMB EJECTORS

Controls:		Indicators:		
1. 2W/4W	4. SOFT CARR TIME DLY	1. CD	4. RxD	7.
2. FULL/HALF	5. XMIT AMPLITUDE	2. TxD	5.	
3. SLICER	6.	3. RTS	6.	

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

PHYSICAL CHARACTERISTICS: RIU-810 MANUFACTURER: MULTISONICS

Dimensions: 5.50 H 10.00 W 9.00 D
Connector: 44 PIN EDGE CONNECTION
Heat Dis: ?

Integral Power Supply: Y
Integral Modem: Y
Access: FRONT

Number of PC Cards: 3
Expansion Options: ROOM FOR 3 MORE CRDS
Mounting: SHELF

Controls:
1. FORCE STANDBY-ON
2.
3.
4.
5.
6.

Indicators:
1. POWER
2. LOS
3. STAND BY
4. PRE-EMPT
5. COORD
6. CD
7. RTS

PHYSICAL CHARACTERISTICS: NO NAME MANUFACTURER: TOCOM

Dimensions: 8.00 H 8.00 W 8.00 D
Connector: MS,F
Heat Dis:

Integral Power Supply: Y
Integral Modem: Y
Access: TOP

Number of PC Cards: 0
Expansion Options:
Mounting: SHELF

Controls:
1.
2.
3.
4.
5.
6.

Indicators:
1.
2.
3.
4.
5.
6.
7.

PHYSICAL CHARACTERISTICS: KTM-1 MANUFACTURER: ECONOLITE

Dimensions: 10.45 H 3.10 W 10.62 D
Connector: 25 P D-SUBMIN/25&50 PIN D-SUBM
Heat Dis:

Integral Power Supply: N
Integral Modem: Y
Access: FRONT

Number of PC Cards: 2
Expansion Options:
Mounting: INTGRL/STND ALN

Controls:
1. ADDRESS
2.
3.
4.
5.
6.

Indicators:
1. RECV CARRIER
2. VALID DATA
3. TRANSMIT
4.
5.
6.
7.

PHYSICAL CHARACTERISTICS: 118 COMM MODULE MANUFACTURER: LFE TRAFFIC CONTROL

Dimensions: 0.00 H 0.00 W 0.00 D
Connector: 37 PIN D SUBMINIATURE
Heat Dis:

Integral Power Supply: N
Integral Modem: Y
Access: FRONY

Number of PC Cards: 1
Expansion Options:
Mounting: INTEGRAL MODULE

Controls:
1. ADDRESS
2. CYCLE LENGTH
3. AUTO/STBY/FREE
4.
5.
6.

Indicators:
1. SYSC
2. AUTO/STBY/FR
3. COMM FAIL
4. CARRIER DET
5. TRANSMITING
6.
7.

PHYSICAL CHARACTERISTICS: MK II MP-100 MANUFACTURER: WINKO-MATIC

Dimensions: 9.00 H 6.00 W 10.50 D
Connector: AMP CPC
Heat Dis: 25 WATT

Integral Power Supply: Y
Integral Modem: Y
Access: REAR

Number of PC Cards: 0
Expansion Options:
Mounting: SHELF

Controls:
1. INDICATORS ON/OFF
2. PICK-UP/DROP
3. ADDRESS
4.
5.
6.

Indicators:
1. HOL
2. FO1,FO2
3. ADV
4. SF1,SF2
5. CD
6. TMT
7.

APPENDIX C. SUMMARY OF MODEM CHARACTERISTICS

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

MODEM CHARACTERISTICS: 920 MODEM — MANUFACTURER: INTERACTIVE SYSTEMS/3M

Data Rate: 50-10000 BAUD
Modulation: FSK
Transmission Type: SYNCH:ASYNCH
Transmission Mode: SIMPLEX:HALF DUPLEX:FULL DUPLEX
Center Frq: 0 Hz
Mark Frq: 0 Hz
Space Frq: 0 Hz
Soft Carrier: 0 Hz
Transmitter Output Level: LO 30 DBM HI 45 DBM
Receiver Input Level: LO -15 DBM HI 10 DBM
Input Impedance: 75 ohms
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: .35,8,55 Msec
Comments: ANY OF 75 DATA CHANNELS ON T9-T14 RECEIVE ON 7,J,K,L,M,N

MODEM CHARACTERISTICS: TR 12 — MANUFACTURER: SAFETRAN

Data Rate: 100 BAUD
Modulation: FSK
Transmission Type: ASYNCH
Transmission Mode:
Center Frq: 1400 Hz
Mark Frq: 1300 Hz
Space Frq: 1500 Hz
Soft Carrier: 0 Hz
Transmitter Output Level: LO -10 DBM HI 7 DBM
Receiver Input Level: LO -40 DBM HI 0 DBM
Input Impedance: 600 ohms
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: Msec
Comments:

MODEM CHARACTERISTICS: PTC 100 — MANUFACTURER: SONEX

Data Rate: 0-1800 BAUD
Modulation: FSK
Transmission Type: ASYNCH
Transmission Mode: HALF DUPLEX:FULL DUPLEX
Center Frq: 0 Hz
Mark Frq: 1200 Hz
Space Frq: 2200 Hz
Soft Carrier: 900 Hz
Transmitter Output Level: LO -10 DBM HI 0 DBM
Receiver Input Level: LO -45 DBM HI 0 DBM
Input Impedance: 600 ohms
Carrier Detect Turn ON: 4.0 Msec
Carrier Detect Turn OFF: 3.0 Msec
Delay from Request to Send - Clear to Send: 4.5 Msec
Comments:

MODEM CHARACTERISTICS: PTC 110A — MANUFACTURER: SONEX

Data Rate: 1550 BAUD BAUD
Modulation: FSK
Transmission Type: ASYNCH
Transmission Mode: FULL DUPLEX
Center Frq: 1700 Hz
Mark Frq: 1200 Hz
Space Frq: 2200 Hz
Soft Carrier: 900 Hz
Transmitter Output Level: LO -10 DBM HI 0 DBM
Receiver Input Level: LO -45 DBM HI 0 DBM
Input Impedance: 600 ohms
Carrier Detect Turn ON: 4 Msec
Carrier Detect Turn OFF: 3 Msec
Delay from Request to Send - Clear to Send: 4.5 Msec
Comments:

MODEM CHARACTERISTICS: REMOTE INTERFACE UNIT 111 — MANUFACTURER: MULTISONICS

Data Rate: 1200 BAUD
Modulation: FSK
Transmission Type: ASYNCH
Transmission Mode: HALF DUPLEX/FULL DUPLEX
Center Frq: 0 Hz
Mark Frq: 1215 Hz
Space Frq: 2157 Hz
Soft Carrier: 0 Hz
Transmitter Output Level: LO 0 DBM HI 0 DBM
Receiver Input Level: LO -36 DBM HI 0 DBM
Input Impedance: 600 ohms
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: 1.5 Msec
Delay from Request to Send - Clear to Send: 8 Msec
Comments:

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

MODEM CHARACTERISTICS: CM-250 MANUFACTURER: MULTISONICS

Data Rate: 0-10,000 BAUD
Modulation: FSK
Transmission Type: SYNCH:ASYNCH
Transmission Mode:
FULL DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: 10 Msec

Center Frq: -9 Hz
Mark Frq: -9 Hz
Space Frq: -9 Hz
Soft Carrier: -9 Hz

Transmitter Output Level: LO 30 DBM HI 45 DBM
Receiver Input Level: LO -15 DBM HI 10 DBM
Input Impedance: 75 ohms

Comments: *-9 ANY OF 75 DATA CHANNELS ON T9-T11 RECEIVE ON 7,J OR K

MODEM CHARACTERISTICS: CM-251 MANUFACTURER: MULTISONICS

Data Rate: 0-10,000 BAUD
Modulation: FSK
Transmission Type: SYNCH:ASYNCH
Transmission Mode:
HALF DUPLEX:FULL DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: 10 Msec

Center Frq: -9 Hz
Mark Frq: -9 Hz
Space Frq: -9 Hz
Soft Carrier: -9 Hz

Transmitter Output Level: LO 30 DBM HI 45 DBM
Receiver Input Level: LO -15 DBM HI 10 DBM
Input Impedance: 75 ohms

Comments: *-9 ANY OF 75 DATA CHANNELS ON T9-T11 RECEIVE ON 7,J OR K

MODEM CHARACTERISTICS: CM-252 MANUFACTURER: MULTISONICS

Data Rate: 0-10,000 BAUD
Modulation: FSK
Transmission Type: SYNCH:ASYNCH
Transmission Mode:
HALF DUPLEX:FULL DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: 10 Msec

Center Frq: -9 Hz
Mark Frq: -9 Hz
Space Frq: -9 Hz
Soft Carrier: -9 Hz

Transmitter Output Level: LO 30 DBM HI 45 DBM
Receiver Input Level: LO -15 DBM HI 10 DBM
Input Impedance: 75 ohms

Comments: *-9 ANY OF 75 DATA CHANNELS ON T9-T11 RECEIVE ON 7,J OR K

MODEM CHARACTERISTICS: CM-253 MANUFACTURER: MULTISONICS

Data Rate: 0-10,000 BAUD
Modulation: FSK
Transmission Type: AYNCH:ASYNCH
Transmission Mode:
HALF DUPLEX:FULL DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: 10 Msec

Center Frq: -9 Hz
Mark Frq: -9 Hz
Space Frq: -9 Hz
Soft Carrier: -9 Hz

Transmitter Output Level: LO 30 DBM HI 45 DBM
Receiver Input Level: LO -15 DBM HI 10 DBM
Input Impedance: 75 ohms

Comments: *-9 ANY OF 75 DATA CHANNELS ON T9-T11 RECEIVE ON 7,J OR K

MODEM CHARACTERISTICS: 400 MODEM FOR 170 CONTROLLER MANUFACTURER: MULTISONICS

Data Rate: 300-1200 BAUD
Modulation: FSK
Transmission Type: ASYNCH
Transmission Mode:
HALF DUPLEX:FULL DUPLEX
Carrier Detect Turn ON: 8 Msec
Carrier Detect Turn OFF: 10 Msec
Delay from Request to Send - Clear to Send: 10 Msec

Center Frq: 0 Hz
Mark Frq: 1300 Hz
Space Frq: 2100 Hz
Soft Carrier: 900 Hz

Transmitter Output Level: LO 0 DBM HI 0 DBM
Receiver Input Level: LO -40 DBM HI 0 DBM
Input Impedance: 600 ohms

Comments:

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

MODEM CHARACTERISTICS: RIU-810 MANUFACTURER: MULTISONICS

Data Rate:	1200 BAUD	Center Frq:	-9 Hz	Transmitter Output Level:	LO 0 DBM HI 0 DBM
Modulation:	FSK	Mark Frq:	1200 Hz	Receiver Input Level:	LO 0 DBM HI 0 DBM
Transmission Type:	ASYNCH	Space Frq:	2000 Hz	Input Impedance:	600 ohms
Transmission Mode:		Soft Carrier:	0 Hz		

HALF DUPLEX/FULL DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: Msec

Comments: *-9 BELL 202 COMPATIBLE

MODEM CHARACTERISTICS: NO NAME MANUFACTURER: TOCOM

Data Rate:	56K, 28K BAUD	Center Frq:	0 Hz	Transmitter Output Level:	LO 0 DBM HI 0 DBM
Modulation:	FSK	Mark Frq:	0 Hz	Receiver Input Level:	LO 0 DBM HI 0 DBM
Transmission Type:	ASYNCH	Space Frq:	0 Hz	Input Impedance:	0 ohms
Transmission Mode:		Soft Carrier:	0 Hz		

FULL DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: Msec

Comments:

MODEM CHARACTERISTICS: KTM-1 MANUFACTURER: ECONOLITE

Data Rate:	1200 BAUD BAUD	Center Frq:	0 Hz	Transmitter Output Level:	LO 0 DBM HI 0 DBM
Modulation:	FSK	Mark Frq:	1200 Hz	Receiver Input Level:	LO -34 DBM HI 0 DBM
Transmission Type:	ASYNCH	Space Frq:	2200 Hz	Input Impedance:	600 ohms
Transmission Mode:		Soft Carrier:	0 Hz		

FULL DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: Msec

Comments:

MODEM CHARACTERISTICS: 118 COMM MODULE MANUFACTURER: LFE TRAFFIC CONTROL

Data Rate:	1200 BAUD BAUD	Center Frq:	1700 Hz	Transmitter Output Level:	LO -12 DBM HI 0 DBM
Modulation:	FSK	Mark Frq:	1200 Hz	Receiver Input Level:	LO -30 DBM HI 0 DBM
Transmission Type:	ASYNCH	Space Frq:	2200 Hz	Input Impedance:	600 ohms
Transmission Mode:		Soft Carrier:	900 Hz		

FULL DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: Msec

Comments:

MODEM CHARACTERISTICS: MK II MP-100 MANUFACTURER: WINKO-MATIC

Data Rate:	1200 BAUD BAUD	Center Frq:	0 Hz	Transmitter Output Level:	LO -7 DBM HI 4 DBM
Modulation:	FSK	Mark Frq:	1200 Hz	Receiver Input Level:	LO -34 DBM HI 0 DBM
Transmission Type:	ASYNCH	Space Frq:	2200 Hz	Input Impedance:	0 ohms
Transmission Mode:		Soft Carrier:	0 Hz		

FULL DUPLEX:HALF DUPLEX
Carrier Detect Turn ON: Msec
Carrier Detect Turn OFF: Msec
Delay from Request to Send - Clear to Send: Msec

Comments:

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

920 MODEM — MANUFACTURER: INTERACTIVE SYSTEMS/3M

ENVIRONMENTAL CHARACTERISTICS:	ELECTRICAL CHARACTERISTICS:	MAINTENANCE CHARACTERISTICS:
Temp Range: 0C to 50C	115 VOLTS 0.000 AMPS 7.0 WATTS	Test Equipment Required:
Fluctuation Tol: +-15%	Over Voltage Protection: Y	1. SPECTRUM ANALYZER
Humidity:	Type: UNKNOWN	2. RF SIGNAL STRENGTH METER
Electrical Interf Spec:	Connector Type: DB-25	
	Data Trans Rate: 50-10Kbps	Comments:
	Lighting Protection: UNKNOWN	
	Isolation:	

TR 12 — MANUFACTURER: SAFETRAN

ENVIRONMENTAL CHARACTERISTICS:	ELECTRICAL CHARACTERISTICS:	MAINTENANCE CHARACTERISTICS:
Temp Range: -35C to 75C	117 VOLTS 0.000 AMPS 5.0 WATTS	Test Equipment Required:
Fluctuation Tol: 90VAC - 135VAC	Over Voltage Protection: Y	1.
Humidity: 5% - 95%	Type: 600 VOLTS RC II	2.
Electrical Interf Spec:	Connector Type:	
600 VOLTS PEAK	Data Trans Rate: 100 bps	Comments:
	Lighting Protection: SPARK GAP	
	Isolation: TRANSFORMER	

PTC 100 — MANUFACTURER: SONEX

ENVIRONMENTAL CHARACTERISTICS:	ELECTRICAL CHARACTERISTICS:	MAINTENANCE CHARACTERISTICS:
Temp Range: -40C to 80C	117 VOLTS 0.000 AMPS 18.0 WATTS	Test Equipment Required:
Fluctuation Tol: 95VAC - 135VAC	Over Voltage Protection: Y	1.
Humidity: 9% - 95%	Type: FUSE	2.
Electrical Interf Spec:	Connector Type: 3-MS	
	Data Trans Rate: 0-1800	Comments:
	Lighting Protection:	
	Isolation: TRANSFORMER	

PTC 110A — MANUFACTURER: SONEX

ENVIRONMENTAL CHARACTERISTICS:	ELECTRICAL CHARACTERISTICS:	MAINTENANCE CHARACTERISTICS:
Temp Range: -35F to 165F	115 VOLTS 0.000 AMPS 18.0 WATTS	Test Equipment Required:
Fluctuation Tol:	Over Voltage Protection: Y	1. SCOPE
Humidity: 0% - 95%	Type:	2.
Electrical Interf Spec:	Connector Type:	
95VAC - 135VAC	Data Trans Rate: 1550 BAUD	Comments:
	Lighting Protection: GAS TUBE & ZENER	
	Isolation: TRANSFORMER	

REMOTE INTERFACE UNIT III — MANUFACTURER: MULTISONICS

ENVIRONMENTAL CHARACTERISTICS:	ELECTRICAL CHARACTERISTICS:	MAINTENANCE CHARACTERISTICS:
Temp Range: -37C to 74C	-9 VOLTS 0.000 AMPS 0.0 WATTS	Test Equipment Required:
Fluctuation Tol: 95VAC - 135VAC	Over Voltage Protection: Y	1. SCOPE
Humidity: 5% - 95%	Type: FUSE	2. TEST CABLE
Electrical Interf Spec:	Connector Type:	
MOV	Data Trans Rate: 1200	Comments: *-9 24 or 117 VOLTS
	Lighting Protection: NONE	
	Isolation: TRANSFORMER	

CM-250

MANUFACTURER: MULTISONICS

ENVIRONMENTAL CHARACTERISTICS:	ELECTRICAL CHARACTERISTICS:	MAINTENANCE CHARACTERISTICS:
Temp Range: -34C to 74C	-9 VOLTS 0.150 AMPS 0.0 WATTS	Test Equipment Required:
Fluctuation Tol: UNKNOWN	Over Voltage Protection: ?	1. SPECTRUM ANALYZER
Humidity:	Type:	2. RF SIGNAL STRENGTH METER
Electrical Interf Spec:	Connector Type: MS	
RS-232 C	Data Trans Rate: 0-10,000	Comments: *-9 +- 12 VOLTS
	Lighting Protection: UNKNOWN	
	Isolation:	

CM-251

MANUFACTURER: MULTISONICS

ENVIRONMENTAL CHARACTERISTICS:	ELECTRICAL CHARACTERISTICS:	MAINTENANCE CHARACTERISTICS:
Temp Range: -34C to 74C	9 VOLTS 0.150 AMPS 0.0 WATTS	Test Equipment Required:
Fluctuation Tol: UNKNOWN	Over Voltage Protection:	1. SPECTRUM ANALYZER
Humidity:	Type: UNKNOWN	2. RF FIELD STRENGTH METER
Electrical Interf Spec:	Connector Type:	
	Data Trans Rate: 0-10,000	Comments: *9 SUPPLY VOLTAGE 15V to 24V
	Lighting Protection: UNKNOWN	
	Isolation:	

CM-252

MANUFACTURER: MULTISONICS

ENVIRONMENTAL CHARACTERISTICS:	ELECTRICAL CHARACTERISTICS:	MAINTENANCE CHARACTERISTICS:
Temp Range: -34C to 74C	117 VOLTS 0.000 AMPS 10.0 WATTS	Test Equipment Required:
Fluctuation Tol: UNKNOWN	Over Voltage Protection:	1. SPECTRUM ANALYZER
Humidity:	Type: 1/4 AMP FUSE	2. RF SIGNAL STRENGTH METER
Electrical Interf Spec:	Connector Type:	
RS-232	Data Trans Rate: 0-10,000	Comments:
	Lighting Protection:	
	Isolation:	

CM-253

MANUFACTURER: MULTISONICS

ENVIRONMENTAL CHARACTERISTICS:	ELECTRICAL CHARACTERISTICS:	MAINTENANCE CHARACTERISTICS:
Temp Range: -34C to 74C	117 VOLTS 0.000 AMPS 10.0 WATTS	Test Equipment Required:
Fluctuation Tol: UNKNOWN	Over Voltage Protection:	1. SPECTRUM ANALYZER
Humidity:	Type: 1/4 AMP FUSE	2. RF SIGNAL STRENGTH METER
Electrical Interf Spec:	Connector Type:	
RS-232 C	Data Trans Rate:	Comments:
	Lighting Protection:	
	Isolation:	

400 MODEM FOR 170 CONTROLLER

MANUFACTURER: MULTISONICS

ENVIRONMENTAL CHARACTERISTICS:	ELECTRICAL CHARACTERISTICS:	MAINTENANCE CHARACTERISTICS:
Temp Range: -37C to 74C	-9 VOLTS 0.100 AMPS 1.2 WATTS	Test Equipment Required:
Fluctuation Tol: +-17%	Over Voltage Protection: Y	1. DIAGNOSTIC PROGRAM
Humidity: 5% - 95%	Type: PROVIDED EXTERN	2.
Electrical Interf Spec:	Connector Type: 44 PIN EDGE	
PROVIDED EXTERNALLY	Data Trans Rate: 300-1200	Comments: *-9 +-12 VOLTS
	Lighting Protection: NONE	
	Isolation: TRANSFORMER	

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

RIU-810

MANUFACTURER: MULTISONICS

ENVIRONMENTAL CHARACTERISTICS:

- Temp Range: -37C to 74C
- Fluctuation Tol: 95VAC - 135VAC
- Humidity: 5% - 95%
- Electrical Interf Spec: MOV

ELECTRICAL CHARACTERISTICS:

- 117 VOLTS 0.000 AMPS 0.0 WATTS
- Over Voltage Protection: Y
- Type: - MOV
- Connector Type: 44 PIN EDGE
- Data Trans Rate: 1200 bps
- Lighting Protection: EXTERNAL GAS-TUBE
- Isolation: TRANSFORMER

MAINTENANCE CHARACTERISTICS:

- Test Equipment Required:
  1. RIU-810 TEST SET
  2.
- Comments:

NO NAME

MANUFACTURER: TOCOM

ENVIRONMENTAL CHARACTERISTICS:

- Temp Range: to
- Fluctuation Tol:
- Humidity:
- Electrical Interf Spec:

ELECTRICAL CHARACTERISTICS:

- 115 VOLTS 0.000 AMPS 0.0 WATTS
- Over Voltage Protection:
- Type:
- Connector Type:
- Data Trans Rate:
- Lighting Protection:
- Isolation:

MAINTENANCE CHARACTERISTICS:

- Test Equipment Required:
  1.
  2.
- Comments:

KTM-1

MANUFACTURER: ECONOLITE

ENVIRONMENTAL CHARACTERISTICS:

- Temp Range: -35C to 75C
- Fluctuation Tol: 95VAC - 135VAC
- Humidity: 18% -95%
- Electrical Interf Spec:

ELECTRICAL CHARACTERISTICS:

- 115 VOLTS 0.000 AMPS 0.0 WATTS
- Over Voltage Protection: Y
- Type: REGULATOR&ZENER
- Connector Type: 50 PIN D-SUB
- Data Trans Rate: 1200 BAUD
- Lighting Protection: GAS TUBE&VARISTOR
- Isolation: TRANSFORMER

MAINTENANCE CHARACTERISTICS:

- Test Equipment Required:
  1. DMM, SCOPE
  2. FREQ CTN
- Comments:

118 COMM MODULE

MANUFACTURER: LFE TRAFFIC CONTROL

ENVIRONMENTAL CHARACTERISTICS:

- Temp Range: to
- Fluctuation Tol:
- Humidity:
- Electrical Interf Spec:

ELECTRICAL CHARACTERISTICS:

- 0 VOLTS 0.000 AMPS 0.0 WATTS
- Over Voltage Protection:
- Type:
- Connector Type:
- Data Trans Rate: 1200 BAUD
- Lighting Protection: ZENER
- Isolation: TRANSFORMER

MAINTENANCE CHARACTERISTICS:

- Test Equipment Required:
  1. SCOPE
  2.
- Comments:

MK II MP-100

MANUFACTURER: WINKO-MATIC

ENVIRONMENTAL CHARACTERISTICS:

- Temp Range: -30F to 165F
- Fluctuation Tol:
- Humidity: 0% - 95%
- Electrical Interf Spec:

ELECTRICAL CHARACTERISTICS:

- 115 VOLTS 0.000 AMPS 0.0 WATTS
- Over Voltage Protection:
- Type:
- Connector Type: AMP CPC
- Data Trans Rate: 1200 BAUD
- Lighting Protection:
- Isolation:

MAINTENANCE CHARACTERISTICS:

- Test Equipment Required:
  1.
  2.
- Comments:

APPENDIX E. SUMMARY OF FUNCTIONAL CHARACTERISTICS

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

FUNCTIONAL CHARACTERISTICS: 920 MODEM — MANUFACTURER: INTERACTIVE SYSTEMS/3M

Operation Modes: NORM/LOOP BACK	Bit Error Rate: <1 x 10-9	Number of Detectors Processed:
Error Detection:	Trans Fault Det:	Number of Controllers:
Error Correction:	Comm Standards: RS-232 C	Max # Units Sharing Line:
Communication Modes: SIMPLEX - X	Turn-around Time: .35 - 55MS	Failsafe Features:
HALF DUPLEX - X	Type Data Xmited: SYNCH/ASYNCH	
FULL DUPLEX - X		Comments: MODEM ONLY, OTHER VALUES DEPEND ON SYSTEM CONFIGURATION

FUNCTIONAL CHARACTERISTICS: TR 12 — MANUFACTURER: SAFETRAN

Operation Modes:	Bit Error Rate:	Number of Detectors Processed:
Error Detection: PARITY	Trans Fault Det: MULTI BIT PARITY	Number of Controllers: 1
Error Correction: REJECTION	Comm Standards:	Max # Units Sharing Line:
Communication Modes: SIMPLEX -	Turn-around Time:	Failsafe Features:
HALF DUPLEX -	Type Data Xmited:	1.5 SEC DLY AFTR PWR ON
FULL DUPLEX - X		Comments: MONITORS 12 INPUTS AND LATCHES 12 OUTPUTS

FUNCTIONAL CHARACTERISTICS: PTC 100 — MANUFACTURER: SONEX

Operation Modes:	Bit Error Rate: 1 x 10-10	Number of Detectors Processed: 16
Error Detection: PARITY	Trans Fault Det: 3 SECOND TIME OUT	Number of Controllers: 1
Error Correction:	Comm Standards:	Max # Units Sharing Line:
Communication Modes: SIMPLEX -	Turn-around Time:	Failsafe Features:
HALF DUPLEX - X	Type Data Xmited: ASYNCH	
FULL DUPLEX - X		Comments:

FUNCTIONAL CHARACTERISTICS: PTC 110A — MANUFACTURER: SONEX

Operation Modes:	Bit Error Rate: 1 x 10-9	Number of Detectors Processed:
Error Detection: PARITY:CHECKSUM	Trans Fault Det:	Number of Controllers:
Error Correction:	Comm Standards:	Max # Units Sharing Line:
Communication Modes: SIMPLEX -	Turn-around Time:	Failsafe Features:
HALF DUPLEX -	Type Data Xmited: ASYNCH	
FULL DUPLEX - X		Comments:

FUNCTIONAL CHARACTERISTICS: REMOTE INTERFACE UNIT 111 — MANUFACTURER: MULTISONICS

Operation Modes: ONLINE,STNDBY,PRE-EM	Bit Error Rate:	Number of Detectors Processed: 0
Error Detection:	Trans Fault Det:	Number of Controllers: 0
Error Correction:	Comm Standards:	Max # Units Sharing Line:
Communication Modes: SIMPLEX -	Turn-around Time:	Failsafe Features:
HALF DUPLEX -	Type Data Xmited:	
FULL DUPLEX -		Comments: FUNCTIONAL CHARACTERISTICS UNKNOWN

FUNCTIONAL CHARACTERISTICS: CM-250 MANUFACTURER: MULTISONICS

Operation Modes:	Bit Error Rate: 1 x 10-8	Number of Detectors Processed: 0
Error Detection:	Trans Fault Det:	Number of Controllers: 1
Error Correction:	Comm Standards: RS-232-C	Max # Units Sharing Line: *
Communication Modes: SIMPLEX -	Turn-around Time:	Failsafe Features:
HALF DUPLEX - X	Type Data Xmited: ASYNCH	CONT WATCHDOG DISABL XMT
FULL DUPLEX - X		Comments: * VARIABLE

FUNCTIONAL CHARACTERISTICS: CM-251 MANUFACTURER: MULTISONICS

Operation Modes:	Bit Error Rate: 1 x 10-8	Number of Detectors Processed: 0
Error Detection:	Trans Fault Det:	Number of Controllers: 1
Error Correction:	Comm Standards:	Max # Units Sharing Line: *
Communication Modes: SIMPLEX -	Turn-around Time:	Failsafe Features:
HALF DUPLEX - X	Type Data Xmited: ASYNCH	
FULL DUPLEX - X		Comments: * VARIABLE

FUNCTIONAL CHARACTERISTICS: CM-252 MANUFACTURER: MULTISONICS

Operation Modes:	Bit Error Rate: 1 x 10-8	Number of Detectors Processed: 0
Error Detection:	Trans Fault Det:	Number of Controllers: 1
Error Correction:	Comm Standards: RS-232 C	Max # Units Sharing Line: *
Communication Modes: SIMPLEX -	Turn-around Time:	Failsafe Features:
HALF DUPLEX - X	Type Data Xmited: SYNCH:ASYNCH	
FULL DUPLEX - X		Comments: *VARIABLE

FUNCTIONAL CHARACTERISTICS: CM-253 MANUFACTURER: MULTISONICS

Operation Modes:	Bit Error Rate: 1 x 10-8	Number of Detectors Processed: 0
Error Detection:	Trans Fault Det:	Number of Controllers: 1
Error Correction:	Comm Standards: RS-232 C	Max # Units Sharing Line: *
Communication Modes: SIMPLEX -	Turn-around Time:	Failsafe Features:
HALF DUPLEX - X	Type Data Xmited: SYNCH:ASYNCH	
FULL DUPLEX - X		Comments: *VARIABLE

FUNCTIONAL CHARACTERISTICS: 400 MODEM FOR 170 CONTROLLER MANUFACTURER: MULTISONICS

Operation Modes: *	Bit Error Rate: 1 x 10-5	Number of Detectors Processed: 0
Error Detection: PARITY*:CHECKSUM*	Trans Fault Det: *	Number of Controllers: 1
Error Correction: *	Comm Standards: RS-232-C	Max # Units Sharing Line: *
Communication Modes: SIMPLEX -	Turn-around Time: *	Failsafe Features:
HALF DUPLEX - X	Type Data Xmited: ASYNCH	*
FULL DUPLEX - X		Comments: *VARIABLE,DEPENDING UPON CHAR SPECIFIED IN HOST 170 PROGRAM

COMMUNICATION EQUIPMENT/SYSTEMS DESCRIPTION

FUNCTIONAL CHARACTERISTICS: RIU-810 — MANUFACTURER: MULTISONICS

Operation Modes: ONLINE,STNDBY,PRE-EM	Bit Error Rate: UNKNOWN	Number of Detectors Processed: 0
Error Detection:	Trans Fault Det:	Number of Controllers: 1
Error Correction:	Comm Standards:	Max # Units Sharing Line: 16
Communication Modes: SIMPLEX -	Turn-around Time:	Failsafe Features:
HALF DUPLEX - X	Type Data Xmited:	
FULL DUPLEX - X		Comments:

FUNCTIONAL CHARACTERISTICS: NO NAME — MANUFACTURER: TOCOM

Operation Modes:	Bit Error Rate:	Number of Detectors Processed:
Error Detection: PARITY:CHECKSUM	Trans Fault Det:	Number of Controllers:
Error Correction:	Comm Standards:	Max # Units Sharing Line:
Communication Modes: SIMPLEX -	Turn-around Time:	Failsafe Features:
HALF DUPLEX -	Type Data Xmited: ASYNCH	
FULL DUPLEX -		Comments:

FUNCTIONAL CHARACTERISTICS: KTM-1 — MANUFACTURER: ECONOLITE

Operation Modes:	Bit Error Rate:	Number of Detectors Processed:
Error Detection: PARITY:CHECKSUM	Trans Fault Det:	Number of Controllers: 1
Error Correction:	Comm Standards:	Max # Units Sharing Line: 24
Communication Modes: SIMPLEX -	Turn-around Time:	Failsafe Features:
HALF DUPLEX -	Type Data Xmited: ASYNCH	
FULL DUPLEX - X		Comments:

FUNCTIONAL CHARACTERISTICS: 118 COMM MODULE — MANUFACTURER: LFE TRAFFIC CONTROL

Operation Modes:	Bit Error Rate:	Number of Detectors Processed: 8
Error Detection: PARITY:CHECKSUM	Trans Fault Det:	Number of Controllers: 1
Error Correction:	Comm Standards:	Max # Units Sharing Line: 8
Communication Modes: SIMPLEX -	Turn-around Time:	Failsafe Features:
HALF DUPLEX -	Type Data Xmited: ASYNCH	
FULL DUPLEX - X		Comments:

FUNCTIONAL CHARACTERISTICS: MK II MP-100 — MANUFACTURER: WINKO-MATIC

Operation Modes:	Bit Error Rate:	Number of Detectors Processed:
Error Detection:	Trans Fault Det:	Number of Controllers: 1
Error Correction:	Comm Standards:	Max # Units Sharing Line: 8
Communication Modes: SIMPLEX -	Turn-around Time:	Failsafe Features:
HALF DUPLEX - X	Type Data Xmited: ASYNCH	
FULL DUPLEX - X		Comments: