INPUT

FIELD SERVICE PLANNING INFORMATION PROGRAM

FIELD SERVICE BRIEF

INSTRUMENTATION TRENDS

DECEMBER 1979

FIELD SERVICE PLANNING INFORMATION PROGRAM

OBJECTIVE: To provide senior field service managers with basic information and data to support their planning and operational decisions.

DESCRIPTION: Clients of this program receive the following services each year:

- Field Service Briefs - Six reports which analyze important new technical and management issues within the field service areas. Reports focus on specific issues that require timely attention by senior management.
- Major Planning Reports - Three reports that will present an in-depth analysis and recommendations of a major technical or management issue that will assist in the formulation of major policy alternatives in the planning of field services.
- Annual Report - This report will summarize major activities in the field services industry during that year in order to determine major trends and their effect on the establishment of future field service planning. Forecasts will be provided of the likely technical and management changes that may occur in order to meet the future requirements of users of these services.
- Annual Presentation - INPUT staff will make an annual in-house presentation to field service executives to summarize the results of the previous year's research and to formulate jointly the strategic guidelines for the research program for the current year. These presentations will occur in the Spring of each year.
- Consulting Support - Individual consultation with INPUT research staff on an as-needed basis through telephone inquiries and visits.

RESEARCH METHOD: INPUT carries out extensive research in computers, communications and associated fields:

- Research topics are selected by INPUT based on discussions with client representatives.
- Research for this program includes professional interviews with users, vendors, universities, industry associations, and other analysts.
- Conclusions derived from the research are based on the judgement of INPUT's staff.
- Professional staff supporting this program have 20 or more years of experience in data processing and communications, including senior management positions with major vendors and users.

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1 INTRODUCTION

I INTRODUCTION

- In considering the acquisition of new test equipment, field service managers should be aware that proper instrumentation is a key factor in addressing a number of management problems, for example:

  - Spares inventory maintenance.

  - Increasing labor costs.

  - The shortage of skilled technicians.

- Thus, the instrumentation approach should not be perceived as a standalone decision but an integral part of a set of decisions affecting the viability of the long-range field service plan and the key issue of productivity.

- The industry has begun to be responsive to these kinds of requirements. In the past few years, for example, it has developed a new breed of "smart" portable diagnostic instruments capable of efficiently and easily locating causes of equipment malfunctions in the field.

- The increased availability and lower cost of intelligence are impacting the instrumentation industry to a significant degree. As a result, two relatively new primary instrumentation approaches to maintenance will be generally evident in the computer industry within the next five years. They are:

- Systems designed to accommodate diagnostics which are controlled from remote locations.

- Standalone maintenance "computers."

- Across the spectrum of instrumentation, the computer industry is making increasingly higher demands of the instrumentation suppliers. For example:

  - Wider bandwidths.

  - Higher accuracy and sensitivity.

  - Faster speeds.

  - Easy maintenance of the instruments themselves.

  - Higher stability (increasing calibration intervals).

  - Long life.

  - Versatility.

- In this report, INPUT has attempted to highlight some of the factors impacting the future of instrumentation systems and to identify some of the trends that will become evident over the next five years.

- Client comments, questions, and suggestions are invited.

II DRIVING FORCES AND TRENDS

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A. DRIVING FORCES

- There are a number of complex factors, many interrelated, that will impact the future course of instrumentation. Both equipment vendors and instrument suppliers need to fully comprehend the significance of these factors in order to apply them to their own operations.

  - INPUT has found that sensitivity to these issues varies widely in the industry. On the equipment side, there are very few companies that devote enough time to fully understand how these factors will impact the service function in total - let alone the sub-impact on instrumentation.

  - Since most of the instrumentation suppliers respond largely to the perceived needs of their customers rather than forming independent judgements, very few are on solid ground in their own long-term product planning.

- In INPUT's view, the following factors are among the most important ones to impact the future course of instrumentation.

1. PERSONNEL

- As pointed out in INPUT's study, "Maintenance Requirements For The Information Processing Industry, 1978-1983," the computer industry is undergoing an acute shortage of qualified service personnel.

  - As a direct result of this shortage, coupled with the deleterious effects of affirmative action programs, the average skill level of field engineers is decreasing.

  - Instrumentation must obviously match the skills of the people who use them.

- Ultimately, INPUT believes a three-tiered maintenance personnel structure will emerge:

  - Local field service technicians whose function is to handle routine testing and maintenance functions using "cookbook" methods of diagnosis and repair.

  - Branch field service support specialists whose function is to diagnose problems beyond the competency of the local technicians.

  - Central or regional support specialists who comprise the penultimate support level.

- At each tier, different instrumentation will be required. Differences will be found in level of sophistication, degree of automation, and functionality.

2. INCREASING RELIABILITY

- There is no question that most recently announced products and those on the drawing boards are inherently more reliable devices than those developed in the past.

- As MTBF increases significantly, the ratio of service people/installed base of equipment maintained will significantly decrease.

- However, those very features that make a system more reliable will, in many cases, make it that much more difficult to repair.

- Thus, many products may experience lower MTBF but higher MTTR than encountered on earlier product lines.

- The result will be increased emphasis on instrumentation systems and instruments which clearly directly affect MTTR.

3. DISTRIBUTED AND DISPERSED DATA PROCESSING

- The advent of distributed data processing and the growing use of small business computers, simple terminals, word processors, etc., means that a significant portion of the installed base of equipment will be dispersed over a wide geographic area.

- Systems suppliers will turn increasingly to remote diagnostics, customer involvement, depot repair, stocking of on-site spares, etc., as ways to reduce the cost of delivering people and parts to remote areas containing a relatively low volume of equipment.

- These forces create a number of demands upon instrumentation. For example, portability is paramount if the field engineer has to be dispatched to the site and travel by plane.

4. DEPOT REPAIR

- Counter to the MTTR effect just mentioned, improved technology will also influence the way in which components are packaged. Smaller boards (or more components packed onto the same board) and more modular construction results.

- Devices that take advantage of this packaging lend themselves to board, module or even unit replacement as a field repair technique.

- Units susceptible to this repair method are repaired at depots. INPUT believes that depot repair at the component and board levels, at least, will become standard in the computer industry within ten years. Certainly, several companies have already committed to these procedures.

- Depot maintenance means that instruments located at the depot can be stationary, eliminating the portability requirement so often emphasized by instrument suppliers.

- In addition, depot maintenance can also mean that at least some repair and diagnostic functions can be set up on an assembly line basis. This will create more demand for highly automated, flexible instruments, many of which will require a high degree of programmability.

5. CUSTOMER INVOLVEMENT

- INPUT's earlier work looked at the feasibility of increased user involvement in the processes of installation, diagnosis and repair.

  - A significant percentage of users were indeed willing to participate in the maintenance function, and this trend will become increasingly evident as suppliers provide better diagnostic tools and back-up support systems.

- Whether built-in or separate, new field instruments will increasingly have to take into account that this new group will be using them.

6. COMPLEX CIRCUITRY

- More circuits are being squeezed into smaller spares. Future chips, for example, may have as many as 100 million gates. The technology will reflect

back into test equipment requirements and repair procedures, placing new demands for cost effective systems from the production line to the field.

- Instruments will be required to offer greater measuring power, more capabilities and features and still be easy to use.

- In particular, these will be a strong demand for in-circuit emulation.

7. MULTI-VENDOR INSTALLATIONS

- Multi-vendor installations are becoming more evident, partly as a result of IBM's inability to produce enough to fill their own market requirements, and because there are so many quality products on the market from so many vendors.

- In addition, the increasing use of communications has brought the carriers (AT&T, et al) into the picture, creating de facto multi-vendor installations.

- As systems which include multiple computers, controllers, tape and disk drives, modems, terminals, etc., proliferate, there is increasing need for instrumentation systems capable of isolating data flow problems between systems elements.

  - Such instruments will be able to trap errors, determine time-interval problems and find invalid "hand-shaking" protocols.

8. SERVICE AS A PRODUCT

- There is increasing recognition in the computer industry that service is, in many cases, a product with greater profit potential than the hardware it is established to support.

- Of fifty companies surveyed by INPUT, half treated service as a profit center and a significant percentage of the rest planned to convert from a cost to a profit center within a year.

- The implications of placing increased emphasis on the profitability of a service operation will have important ramifications for instrumentation buyers and sellers alike.

  - When service is run as a cost center, management pressure is exerted to minimize expenses, of which the cost of instruments is a major component.

  - When service is a profit center, management is likely to look at instrumentation as a key element of his service product offering. In this situation, a company is likely to seek the best instruments it can find with less emphasis on the cost of those instruments because it will recover those costs in the sale of the service product.

  - Another way to state this is that if better instruments provide better service, a higher price can be justified for the service product.

B. IMPACT OF THE MICROPROCESSOR

- Since the advent of the microprocessor, which became commercially available six years ago, both the techniques and the tools used for effective testing of new generation products have changed significantly.

  - Conventional test and repair methods relied primarily on software diagnostics and the use of time domain instruments such as scopes, meters, logic pens, etc.

- The first logic analyzer appeared about five years ago. By the end of 1976, complete microprocessor-based development systems had been announced.

- Now microprocessors can be found in almost any type of instrument.

- The microprocessors will permit many instruments to have controller and decision capabilities built into their interfaces, enabling direct attachment to bus or channel.

- As a result, field engineers can expect to be significantly more productive as the new instrumentation will permit.

  - Self-testing.

  - Unattended and constant monitoring.

  - Sophisticated displays.

  - Fast and accurate methods of fault detection.

- Microprocessor based products can have trouble-shooting aids designed into the product at the outset.

  - With a microprocessor as part of the design of equipment, one can add special test routines and functions to verify performance, simplify adjustments and trouble-shooting, and detection of internal failures.

- The new instruments will go beyond just providing hardware debugging capabilities. They will also include facilities for debugging software programs. Ultimately, they will allow the field engineer to analyze signal timings and look for glitches, as well as tracing program execution with the ability to relate that to the device control signals.

- One note of caution, however: when a microprocessor controls a field test instrument entirely, one must determine whether the processor is functioning before attempting to isolate faults in the rest of the instrument.

  - This means that instrument suppliers will have to build in redundancy, self-test mechanisms, or find some means of assuring instrument reliability before the systems will be useful.

III MULTI-VENDOR ENVIRONMENTS

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- In a multi-vendor environment at a customer site, many vendors take the attitude that they are "finger touching" not "finger interlocking." Cooperation is usually restricted to self-test or diagnostics run on their particular device. This "show me" attitude has caused customers to be placed in the middle of a competitive situation and long repair times often result.

  - The problems are compounded because system diagnostics are frequently ineffective or even not available to individual vendors.

- The burden of proof usually lies with the I/O device vendor to isolate a problem.

  - Thus, device manufacturers must often provide diagnostics, self-tests, and diagnostic displays to aid in isolating the system problem as well as to repair the device once it has been isolated as the failing unit on the system.

  - However, most test equipment used by I/O equipment manufacturers is designed for their specific devices. Rarely do they address the interface problem.

- Unravelling the network transactions is the first priority for trouble-shooting. In other words, servicing a multi-vendor system is not a trivial task that a simple tester can perform. However, some general purpose testers have proved usable in a variety of these applications areas.

- Remote diagnostics are a feasible (indeed possibly desirable) approach to maintenance for single vendor computer environments, but are often not suited to a multi-vendor environment.

  - Remotely obtained information is usually restricted to I/O sense and status information and is not detailed enough to make a logical failure determination.

  - Many failures involve interrogation of a sequence of events leading up to, during, and after the failure occurred.

- Field service obviously needs a capability to test an I/O device independently from the rest of a system.

  - Because device self-testing is performed "off-line," interface functions and some interface related options may not be tested.

- There are two approaches to self-testing which, either alone or together, constitute an industry trend. These are:

  - "Built-in" testers (instruments).

  - Use of microdiagnostics.

- To obtain satisfactory performance from built-in testers requires close cooperation between field service, R&D, engineering, and subassembly suppliers, since the devices must be engineered into the equipment.

- The use of microdiagnostics for I/O equipment is a relatively new phenomenon which ultimately holds great promise.

  - Microdiagnostics are becoming economically feasible as the costs of microprocessors and memory decrease.

  - They can be fully built-in (hardwired), or can be loadable, using, for example, a cassette or floppy disk.

- Microdiagnostics can be tailored to fit different requirements. For example, a simple test may be provided that is designed to be run by a customer, while more complex tests designed for use by trained service personnel can be run when the occassion calls for it.

  - With the trend toward higher user participation in maintenance, the use of microdiagnostics is likely to accelerate at a dramatic rate over the next few years.

- In summary, microdiagnostics will be used extensively on-site in multi-vendor installations, but because of the nature of the system, will not function well on a remote basis.

- There is a trend toward incorporation of controllers and other decision making devices into interfaces, permitting direct device attachment to buses or channels.

  - These "smart" front ends provide an opportunity to build in diagnostic systems capable of monitoring and self-testing interfaces.

  - The availability of such systems will greatly enhance the ability of field service people to isolate faults in a multi-element system.

IV PRESENT DEVICE TEST EQUIPMENT

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A. FREQUENCY AND TIME DOMAIN DEVICES

- The test equipment most commonly used to facilitate analysis using frequency and time domain techniques includes voltmeters, oscilloscopes, counters, and spectrum analyzers.

  - Oscilloscopes and digital multimeters were among the first instruments to use computing circuits. Now, these capabilities are rapidly becoming commonplace throughout the entire spectrum of test and measurement instruments.

- Specific measurement needs should be the primary guide in selecting portable instruments in this category.

1. OSCILLOSCOPES

- Processing power, which appeared in scopes a few years ago displaying numerical or alphanumerical information, will continue to grow, both in laboratory and portable field scopes. Today a scope can be a logic analyzer, a spectrum analyzer, a DMM, a counter or a thermometer. Although bandwidth, sensitivity, accuracy and sweep specs have not changed rapidly for some time, this is likely to change in the near future.

- Tektronix has a DM44 Differential-Time/DMM option for their 400 series oscilloscopes, making 1% timing measurement, voltage, resistance, and temperature measurements much easier. Readings are displayed from a 3-1/2 digit LED panel. All this is in one portable unit attached to the scope.

- The virtues of digital techniques in scopes must be realized. The advantages of memories, microprocessors and fast A/D converters to capture and manipulate signals for desired results are obvious.

  - The Explorer III from Nicolat adds even integral disk memory.

- One prominent movement in scopes centers on the measurement of time intervals to eliminate the time consuming counting of divisions on the screen, and interpolations or calculations. Microprocessor control provides direct digital readout of delta time, frequency, dc volts, instantaneous volts and percentage amplitude.

- Along with size, storage appears to be a growing concern. Some vendors are including RAMs, with the advantages of permanent storage, comparison of two traces, roll modes, and more.

- A key to producing high-performance, yet affordable, scopes lies in the design and construction of CRTs. Improvements in the CRT will bring sharper displays and higher writing speeds. The Tektronix 485, at 350 MHz, still holds the lead for the widest bandwidth in a portable.

- Pressure is relentless for still smaller, lighter units. The conflict lies between the need for light weight and larger screens. Metal alloy cases, integrated circuits, new CRTs, and smaller, lighter power are being developed.

- At this time field scopes will handle DC to approximately 350 MHz as compared with logic analyzers with clocking around 200 MHz. With data processing speeds increasing, the demand for faster test equipment will also be increasing.

- Although the scope market has been dominated by Tektronix and Hewlett-Packard, Gould, Nicolet and Philips are offering new products with many advanced features.

2. DIGITAL MULTIMETERS

- Digital multimeters (DMMs) were the first instruments to incorporate digital LSI circuits providing high accuracy while becoming smaller and less costly.

  - DMMs provide measurements faster and more accurately than ever before, with built-in features such as self-calibration, self testing and keyboard programmability. In addition, digital multimeters with microprocessor control provide measurement functions previously requiring expensive data acquisition systems.

  - The shrinking size, cost, and power consumption of integrated circuits allow functions, measurement accuracy, number of ranges, etc., in hand held DMMs to rival those previously restricted to much larger units.

- Digital multimeters with microprocessor control will provide measurements previously requiring more expensive systems. Built-in memory will store measurements while unattended, and, upon recall, show the minimum, maximum, or average number of readings taken.

- Because the functions (and small size) of DMMs can be built so inexpensively, there is a trend toward combining DMMs with other pieces of test equipment, as noted in the earlier example of the Tektronix 475A.

B. LOGIC ANALYZERS

- Logic or bus analyzers are used in two basic applications:

  - Examining the timing relationship of the input signals to and output signals from a device.

  - Analyzing information transferred on the address or data lines of a computer system.

- A logic analyzer is a passive device. It can view and record data but cannot "get inside" a device under test and manipulate its programs, examine memory or change device functions.

  - For a logic analyzer to be useful at all, at least part of the device under test must be functional - otherwise there is nothing to record.

- Logic analyzers are expensive and are generally considered as a branch office tool.

- The principal advantage of a logic analyzer is its generality. It can handle any digital circuit, including those found in microprocessor based systems.

  - A principal disadvantage is that its use requires a relatively skilled operator.

- To date, logic analyzers have moved the display of "1s" and "0s" to display of actual instruction, program language statements, but all that these amount to are ways to capture parallel data for display purposes. The next step will be to perform more meaningful measurements on data using statistical techniques.

- Hewlett-Packard, Gould-Biomation, and Tektronix probably have the major share of the logic analyzer market but new innovations are appearing from such manufacturers as E.H. International, Moxon, Paratronics and others.

  - E.H. International has developed a variation of logic analyzer which is called the Micro Buss Analyzer (MBA). The instrument probe clips over a microprocessor package capturing and storing 128 steps around a chosen point. The unit captures 32 steps before and 95 steps after the trigger point and the trigger point may be delayed up to 225 occurrences.

  - Moxom's Model 754 logic analyzer contains three separate memories capable of handling 16 parallel channels of 1,024 bits or 16,384 bits serially. The depth of memory and a 20 MHz clock rate make it useful in propagation delay problems.

- One special type of logic analyzer, particularly suited to communications applications is the "signature analyzer." These instruments have the ability to capture large blocks of memory and compress the data block into an alphanumeric signature which is displayed.

- Signature analysis is basically a field service technique, but cannot be divorced from the lab. Unless engineers build signature-analysis capabilities into microprocessor based systems, a field service engineer cannot use the technique to service these systems.

- With a signature analyzer, a relatively inexperienced technician can readily trouble-shoot equipment by checking for proper signatures of data sequence modes. Once the failing mode is found, a step by step procedure is followed to isolate the defective component or subsystem.

- Signature analyzers are made by Hewlett-Packard, Kurz-Kasch and Paratronics, among others. Prices range from about $750 to $2,000.

- The Paratronics Model 532 Signature Analyzer features remote operational/control capability in anticipation of a demand for use in remote diagnostic applications.

C. DIAGNOSTIC DISPLAYS

- Fault isolation circuits coupled to on-device displays have become relatively common and represent a continuing trend.

  - LEDs are the usual display device although liquid crystal displays are becoming more popular especially where power consumption (e.g., battery operated systems) is a problem.

- With the cost of drive circuits and displays decreasing, much more use of them will be made in the future.

  - Built-in fault displays are particulary important for systems that are to be partially maintained (or at least diagnosed) by the user.

D. MICRODIAGNOSTICS

- Complete problem isolation diagnostic support systems are available from many suppliers to support installation and maintenance procedures.

  - Both on-line and standalone diagnostics are provided.

  - The design criteria for detection, isolation and correction should be established to maximize system availability.

- Microdiagnostic systems can run concurrently with the customer's use of the system. This frequently means that the field engineer can trouble shoot at least some problems with little or not interruption of the customer's operation.

- An extension of the microdiagnostic approach, now under experiment by several vendors, is the "Maintenance Computer."

  - The maintenance computer is a relatively complete diagnostic system designed to be carried to the user's site by the field engineer. It is capable of automatically running an entire sequence of tests.

- Depending on the variability of the type of equipment to be serviced, the maintenance computer may be equipped with a loadable microprogram facility, permitting the field engineer to tailor the computer's test parameters to a specific customer's equipment configuration.

  - Microprograms can be stored on cassettes or small disks and kept at the customer's location.

  - A potential problem is keeping track of changes in the customer's system complement.

E. REMOTE ANALYSIS CENTERS

- Led by IBM's concept of the "System Support Center," remote analysis and diagnostic support facilities either have been or are in the process of being established by many companies.

  - The basic idea is to determine or even resolve a problem before physically dispatching a field engineer to the customer's site.

- There is extremely wide variability in the application of the remote analysis center concept.

  - One vendor has set up a center at which relatively unskilled women are trained to "walk" customers through a diagnostic procedure over the telephone.

  - Another vendor is equipped to provide a combination of voice walk-throughs and remote diagnostics.

  - Another vendor locates all of his best talent in the centers with access to extensive back-up information (for example, fault histories and fault-fix data bases), remote diagnostic capability, and documentation more extensive than that made available to the field.

- With the shortage of skilled people intensifying, the remote analysis center concept will attract increasing attention over the next few years.

F. EXERCISERS

- Exercisers, which are basically off-line device testers, are becoming much more versatile instruments with the addition of such things as micro-processors, EROMS, RAM, and even floppy disks.

- New technology is permitting more functionality with small packaging. The trend is toward these devices becoming portable computers. Ultimately, they will evolve to the "maintenance computer" discussed earlier.

- Although many exercisers are furnished by device manufacturers specifically designed for their own equipment, some firms such as Eilson Laboratories manufacture a wide range of testers for disk drives, tape drives, communications devices, and storage modules.

- Off-line testers usually employ an exerciser coupled with extensive diagnostic capability and displays which are usually specialized for the equipment to be tested.

V TEST EQUIPMENT SELECTION CRITERIA

V TEST EQUIPMENT SELECTION CRITERIA

- Selecting the "right" test equipment from the incredible variety of instruments on the market today is an extremely complex decision-making process for most field service executives.

- It is impossible, in a report of this type, to make definitive recommendations about what kind of test equipment to buy, because they can be specific only in the context of a set of individual requirements and financial contraints. However, in this chapter, INPUT has attempted to establish some general guidelines.

A. GENERAL CONSIDERATIONS

- In many firms, there is a tendency to neglect the fact that field service test instrumentation is a major capital investment item. Thus, longevity is an important factor. To assess the longevity factor properly usually means there must be extremely close cooperation between field service, engineering (new product improvements) and R&D (future product lines).

- Knowing in as much detail as possible what products will have to be maintained downstream has a new meaning today. Where once 7-10 year product life cycles were commonplace, many companies will be seeing 3-6 year life cycles in the future as new technology impacts the competitive environment.

- Thus, versatility may be an extremely important factor in evaluating the useful life of a piece of test equipment.

- Portability is almost always a consideration. In the future, however, the concept of portable instruments will take on new meaning as the average skills level of people in the field diminishes. One may pay a premium to obtain a sophisticated instrument in a small package only to find that the people in the field are not equipped to use it.

- Some field service instruments require that the equipment they are designed to support incorporate basic design modifications. In such cases, it is imperative to know up front that the equipment design can continue to accommodate the instrumentation requirements from the beginning to the end of the product life cycle. Again, close cooperation with engineering and R&D is essential. Thus, adaptability may be another important consideration.

- Although price is often a big issue at capital budget meetings, INPUT believes it should be a secondary consideration - to be studied primarily in the context of some of the items discussed above. The price/performance ratio of commercially available test equipment has, in most areas, kept pace with the experience of the computer industry.

  - Electronic Instrumentation costs can, in general, be expected to stay the same relative to product costs.

- Electromechanical instruments and tools won't change much in price (in fact, may increase) but their use should decline as the use of electronics in products increases relative to their electromechanical content.

- Instrumentation costs can be expected to increase relative to people costs because the instruments themselves coupled with maintenance "systems" will assume a larger share of the maintenance function.

B. EQUIPMENT CONSIDERATIONS

1. LOGIC ANALYZERS

- It is quite possible to buy an advanced state analyzer plus a modest timing analyzer for a lower price than some combined units. Moreover, the state analyzer will probably offer better data-domain performance.

  - If high quality signal information is needed rather than data analysis, a timing analyzer capable of displaying data may be the best choice.

- Buffered triggering should usually be considered as an essential feature of a general purpose logic analyzer.

  - A buffered trigger permits insertion of a predetermined delay in the analyzer's trigger circuit.

  - It comes in both analog and digital forms.

- Some logic analyzers contains the ability to perform self-tests using an internal microprocessor and firmware programmed into ROM. Test routines can be automatically cycled with results presented on front panel displays.

- If the logic analyzer is to be used for "glitch" detection, it should have an operation speed of at least 50MHz.

- Logic analyzers, signature analyzers and in-circuit emulators typically range in price from $800 to $10,000.

  - Some of the primary suppliers are Gould-Biomation, Hewlett-Packard, Intel, Millennium Systems, Paratronics, and Tektronix.

- Logic analyzers have progressed significantly over the last five years. New models offer microprocessor control, placing them in the ranks of "intelligent" instruments capable of automatic and self testing; permitting user defined functions, including emulation, and operating remotely over phone lines.

2. FREQUENCY AND TIME DOMAIN INSTRUMENTS

- Oscilloscopes are still a primary piece of test equipment and will continue to be widely used for the forseeable future.

  - In selecting a scope, a combination of several factors must be considered. Size and weight are obvious for field service applications; but the degree to which packaging is emphasized should depend upon the application and the operators skills.

- Signal bandwidth and rise time are the two specifications most frequently considered. Although rise time is usually the more important parameter when working with fast waveforms, signal bandwidth is the controlling parameter at lower speeds.

  - Most scope designs have a gradual roll-off at the high frequency end which frequently permit them to be useful beyond the bandwidth specified for the instrument. Thus, it may be possible to use a less expensive model then reliance on published specifications would justify.

- In a similar vein, it is not usually imperative to obtain very accurate rise time measurements. For example, if the application calls for comparing the rise times of two signals, a scope with a rise time spec equal to the rise times of the applied signal will probably be adequate.

- The two scope features most often wanted by field engineers are multiple input, which permits viewing of more than one signal without changing connections, and delayed sweep, which helps the resolution and accuracy of time interval measurements.

- The other major instrument in this category is the DMM (digital multimeter). For field use, size and feasibility are usually the major factors although accuracy may also be important.

  - More expensive units offer self-calibration and/or self-testing, usually using a built-in microprocessor.

  - Leading suppliers of DMMs include Racal-Dana, Data Precision, Data Tech, Fluke, Philips, Non-linear Systems and Weston.

  - Prices for field types of DMMs are typically in the $100-500 range.

3. OFF-LINE TESTERS/EXERCISERS

- The primary criterion for selection of an off-line tester should be its ability to test the complete system, as it would normally function as a complete unit.

- A secondary but sometimes important consideration would be the ability of a single tester to test multiple devices within a particular family of products.

  - The objective is to reduce costs and the amount of test equipment on hand.

- It is also frequently important to have a superior alphanumeric display capability contained within the tester.

- Most off-line testers are built by equipment vendors, tailored for their own products. However, commercial units are available from companies such as Wilson Laboratories who supplies a line of exercisers for all types of magnetic storage devices.

  - Prices for commercial units typically range from $1,000-5,000.

SUBSCRIPTION PROGRAMS: Designed for clients with a continuing need for information about a range of subjects in a given area. All subscription programs are fixed fee and run on a calendar year basis:

- Planning Service for Computer & Communications Users - Provides managers of large computer/communications facilities with timely and accurate information on developments which affect today's decisions and plans for the future.

- Small Establishments Service - Analyzes and forecasts small establishments' (<500 employees) use of office, communication, and computer services and products. Applications requirements and economics are emphasized.

- Computer Services Market Analysis Service - Provides market forecasts and business information to software and processing services companies to support planning and product decisions.

- Computer Services Company Analysis and Monitoring Program - Provides immediate access to detailed information on over 2,000 companies offering software and processing services in the U.S. and Europe.

- Field Service Planning Information Program - Provides senior field service managers with basic information and data to support their planning and operational decisions.

MULTICLIENT STUDIES: Research shared by a group of sponsors on topics for which there is a need for in-depth "one-time" information. A multiclient study typically has a budget of over $100,000, yet the cost to an individual client is usually less than $10,000. Recent studies specified by clients include:

- Maintenance Requirements For The Information Processing Industry

- Value Added Network Services

- IBM Series/1 Analysis

CUSTOM STUDIES: Custom studies are proprietary to a client. Fees typically range from $10,000 to over $50,000 and are a function of the extent of the research work. Examples of recent assignments include:

- Survey Fortune 500/50 companies to determine plans for distributed data processing.

- Compare the internal charges for EDP services in a large company to those of commercially available services.

- Determine the market potential for an associative Relational Data Base Management System Processor.

- Conduct the 1979 ADAPSO Survey of the Computer Services Industry.

- Analyze the opportunities and problems associated with packaging terminals and/or minicomputers with remote computing services.

ABOUT INPUT

THE COMPANY

INPUT provides planning information, analysis, and recommendations to managers and executives in the information processing industries. Through market research, technology forecasting, and competitive analysis, INPUT supports client management in making informed decisions. Continuing services are provided to users and vendors of computers, communications, and office products and services.

The company carries out continuous and in-depth research. Working closely with clients on important issues, INPUT's staff members analyze and interpret the research data, then develop recommendations and innovative ideas to meet clients' needs. Clients receive reports, presentations, access to data on which analyses are based, and continuous consulting.

Many of INPUT's professional staff members have nearly 20 years experience in their areas of specialization. Most have held senior management positions in operations, marketing, or planning. This expertise enables INPUT to supply practical solutions to complex business problems.

Formed in 1974, INPUT has become a leading international consulting firm. Clients include over 100 of the world's largest and most technically advanced companies.

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