P QUARK

(PROGRAMMABLE QUANTIZER, ANALYZER, AND RECORD KEEPER)

DESCRIPTION

COMMON MICROWAVE RADIO TRANSMISSION SYSTEMS

CONTENTS PAGE

1. INTRODUCTION

A. General

1.01 P QUARK, which is the acronym for Programmable Quantizer, Analyzer, and Record Keeper, is a versatile, remotely accessed and operated data acquisition system which accepts and records a wide variety of analog, digital, alarm, and status inputs. Typical applications would include in-service performance monitoring of new systems and troubleshooting. The ability of P QUARK to record events and compile long-term operational statistics together with time of day and associated system parameters provides an ideal tool for isolating transient and intermittent problems which are notoriously difficult to track down and resolve. The programming capability of P QUARK provides a level of flexibility to the extent that its range of application is essentially limited only by the imagination of the user. Heretofore, experiments undertaken with QUARK (the predecessor of P QUARK), as applied to such diverse systems as digital radio (from a variety of manufactures) satellite propagation, T1 and T1D carrier and FT2 fiber optic performance, have clearly demonstrated the benefits derived from the concept. Here also, programming flexibility allows configuration options ranging from simple statistical event recording to the gathering of data which is deeply conditioned; i.e., contingent on the presence of other factors and therefore highly selective and specific to the particular area of concern. While the strength of P QUARK resides primarily in the gathering of long-term (periods greater than one hour) statistical information about a system or phenomenon, a limited logging capability has also been installed allowing collection of time series data of relatively high granularity.

1.02 Whenever this section is reissued, the reason for reissue will be stated in this paragraph.

B. Scope

1.03 This descriptive section provides the reader with a fundamental knowledge of P QUARK, in terms of what it is, what it does, and how it performs. While the emphasis of this section is directed to P QUARK applications in conjunction with radio transmission systems, this should not be taken to exclude its application to other media such as the aforementioned carrier and lightguide systems. As will become apparent to readers of this document, P QUARK is characterized by a high level of flexibility in regard to application and in the selection of specific and meaningful data to be gathered and analyzed in a situational context. Thus, although somewhat understated within the scope of this document, it should be recognized that the user, in addition to being called upon to analyze data, is also heavily involved in application planning and experiment design, as without such user attention the effectiveness of P QUARK can be greatly reduced. This topic is more properly expounded in the P QUARK User Manual.

1.04 Implicit in such user involvement as noted above is the need for an in-depth understanding of both the systems and problems which lend themselves to P QUARK examination, as well as a knowledge of the design intent, purpose, and capabilities of P QUARK as the data-gathering medium. Hence, the descriptive facts as presented herein are linked to the provision of P QUARK philosophy as essential to its effective use.

2. DESCRIPTION

A. Basics

2.01 A fully equipped P QUARK in conjunction with a data set (which affords a comparative size approximation) is shown in Fig. 1. As is apparent from the illustration, a modular structure is employed together with a master-slave architecture, providing a configuration which conforms to a design intent of good measurement speed (all activity is completed in approximately 5 milliseconds of an available 10 milliseconds) together with high reliability and structural flexibility. The design is based on standard industrial components and reflects a central concept of unattended operation for long periods of time. For this reason, convection cooling is used rather than a fan. A basic P QUARK consists of a master module; a 128-kbyte magnetic bubble memory module; a universal level detector, binary interface, event counter (UBE) slave module; and a power supply module. Most users would probably find it advantageous to employ two slave modules, although P QUARK can accommodate up to five slaves as shown in Fig. 1. A standard P QUARK equipped with only two slaves would be capable of simultaneously monitoring and recording all of the following:

(a) Fading on four radio channels

(b) Error performance from ten sources

(c) Twelve status and/or alarm inputs.

The data from this monitoring operation would be stored in magnetic bubbles for subsequent retrieval. If data summaries were desired, say, on a time frame of every 12 hours, then the memory could accommodate approximately 1 month's worth of data before the oldest entries would be overwritten. Accessing the memory does not destroy the contents. As a result, multipoint access is possible at different times to suit the need. Figure 2 provides a detailed view of panel nomenclature, controls, and indicators, while Fig. 3, 4, and 5 provide internal views of the master, slave, and memory modules.

2.02 The P QUARK weighs approximately 25 pounds, and measures 19 by 8-1/2 by 15 inches. The unit mounts in a standard 19-inch wide equipment bay. The height requirement is 14 inches, which includes 2 inches of space above and below for ventilation. In general, it is best to mount the unit in the

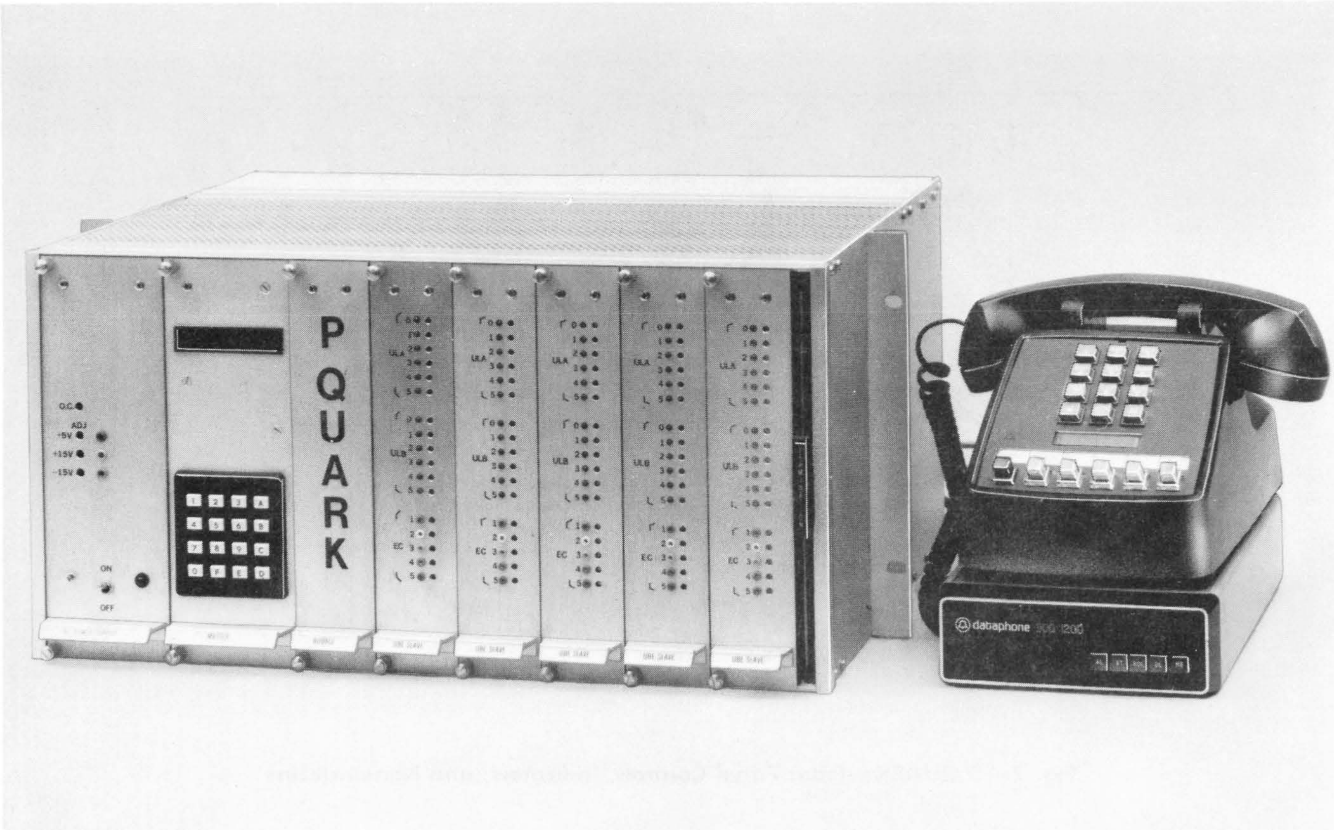

Fig. 1—P QUARK and Data Set

vicinity of the radio bays (when so used) for easy access to AGC voltages. Once mounted, P QUARK is powered by plugging the line cord into a 60-Hz 110V outlet. Firm ac power is recommended to avoid outages. The time-of-day clock, which has battery backup, and the bubble memory content are, however, not lost upon power failure. Power consumption is approximately 70 watts, and filtering is used to reduce susceptibility to radio frequency interference. P QUARK is also available for operation on 24V direct current, and can be so ordered, if specified.

B. Communications Interface

2.03 All data recorded by P QUARK is remotely accessible over the direct distant dialing (DDD) network at speeds of 300 or 1200 baud, using a 212A data set and any standard computer terminal. A convenient P QUARK option permits conversion of the two serial ports (S1 and S2) from data communications equipment (DCE) to data terminal equipment (DTE) interface. In the absence of a data set, the data may be obtained locally by attaching a computer terminal directly to P QUARK, or by reading the light-emitting diode (LED) display (located above the keyboard of the P QUARK master and appearing as the dark rectangle in Fig. 1 and 2). At locations where a service channel rather than a telephone line is used to connect a data set to P QUARK, a "three wire" but fixed rate; i.e., 300 or 1200 baud connection, is possible— provided certain pins on P QUARK and the data set are strapped together to simulate the presence of signals such as clear to send (CTS) and data terminal ready (DTR). Data is accessed by first dialing the number of the remote data set, and after acknowledgement, typing the password which can be customized to grant only personal access. An accepted password is indicated by an asterisk (*), after which the user may ask for data, the basic forms of which, as noted in the introduction, are log and statistics, each having its own set of commands.

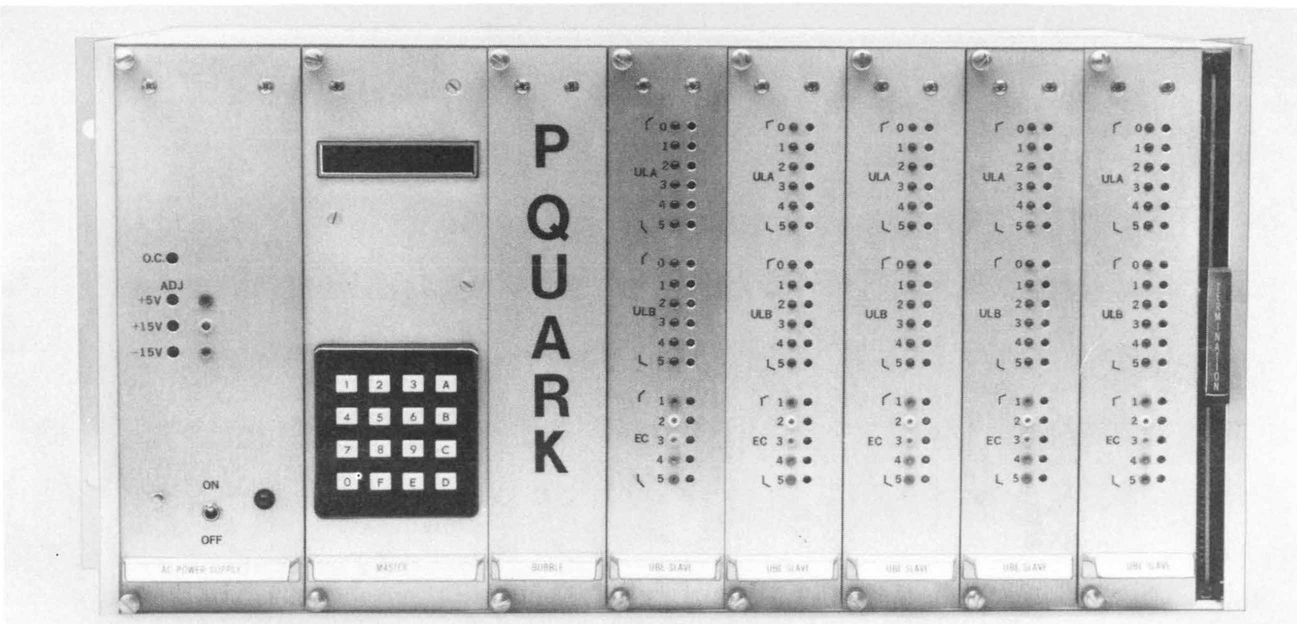

Fig. 2—P QUARK—Front Panel Controls, Indicators, and Nomenclature

C. Philosophy

Overview

2.04 P QUARK performs several important measurements and data acquisition functions. First, it collects measurement data, which includes counting errors, measuring fade depth, and determining system status such as the occurrence of a protection switch and the existence of alarm conditions. Second, this data is processed to permit storage of compressed information comprised of performance statistics, and to generate a real-time log of special events consisting of significant channel variations or changes in performance levels. In addition to providing stored data, P QUARK can allow remote real-time access to current measurements on a second-by-second basis. Note that the phrase "compressed information" appearing above implies that P QUARK is conservatively configured to generate the least amount of data capable of providing the greatest amount of information. This parsimony does not imply that data is impoverished, but does call upon user analysis in the extraction of information. It should also be recognized that P QUARK is not intended as a research tool but directed to performance monitoring and troubleshooting. Since both data and human analysis are, however, necessary to research as well as to P QUARK applications, the possible use of P QUARK data as an adjunct to certain areas of research cannot be categorically excluded.

2.05 The ability to get performance statistics, a time referenced log of significant events, and access to current measurements, is a valuable asset for trouble isolation. Not only does it permit the user to identify that the system monitored has malfunctioned, but will often enable the user to identify the specific cause of the problem. This greatly reduces the likelihood of sending maintenance personnel to the wrong location. It also ensures that they come equipped to repair or replace the appropriate equipment, thus greatly reducing downtime and thereby improving rating indices.

Statistics

2.06 The performance statistics typically contain data indicating, for example, the amount of time a radio channel is faded below each of six selectable fade thresholds, and the number of times each threshold was crossed. The setting of thresholds (see

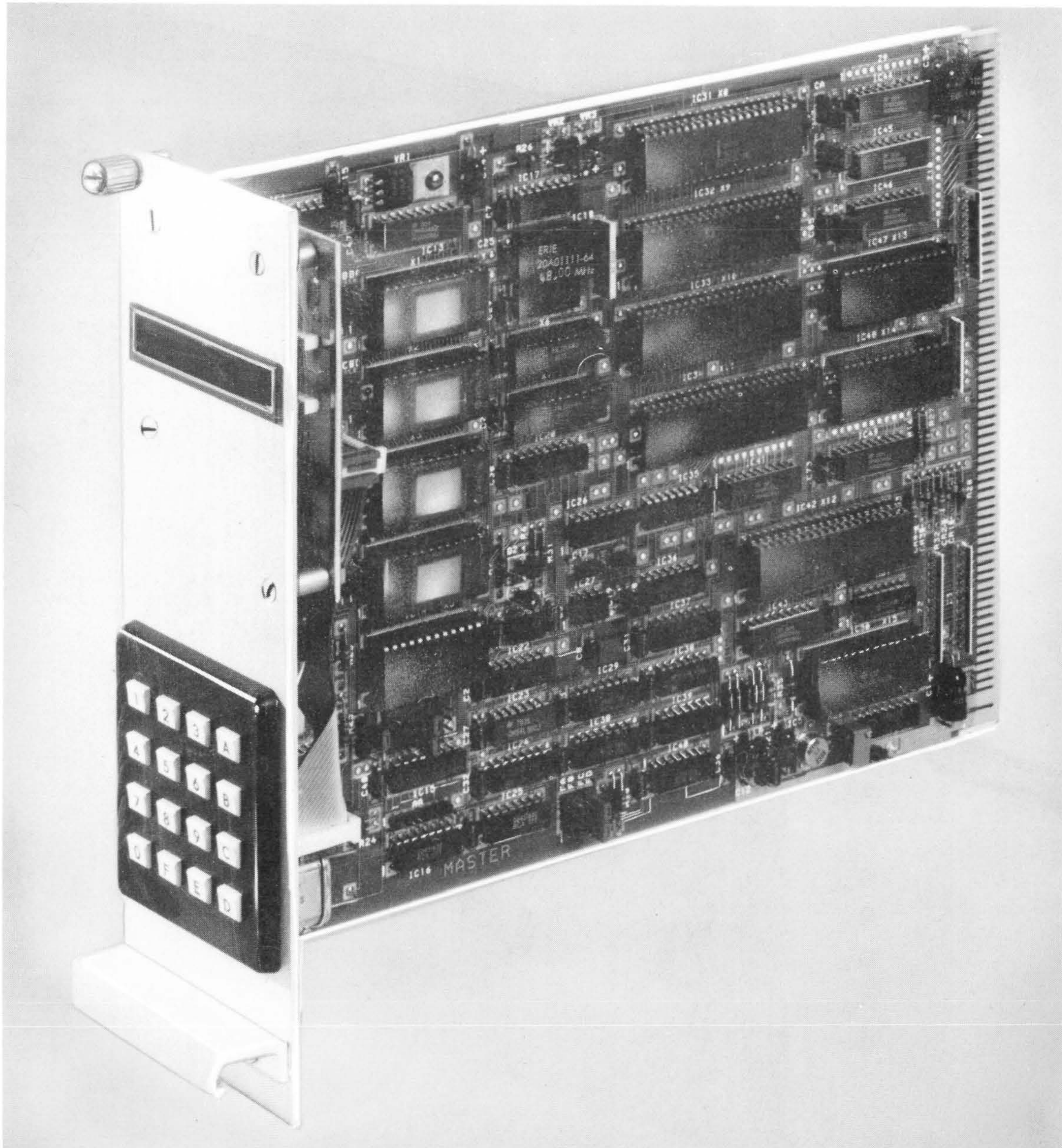

Fig. 3—P QUARK Master—Internal View

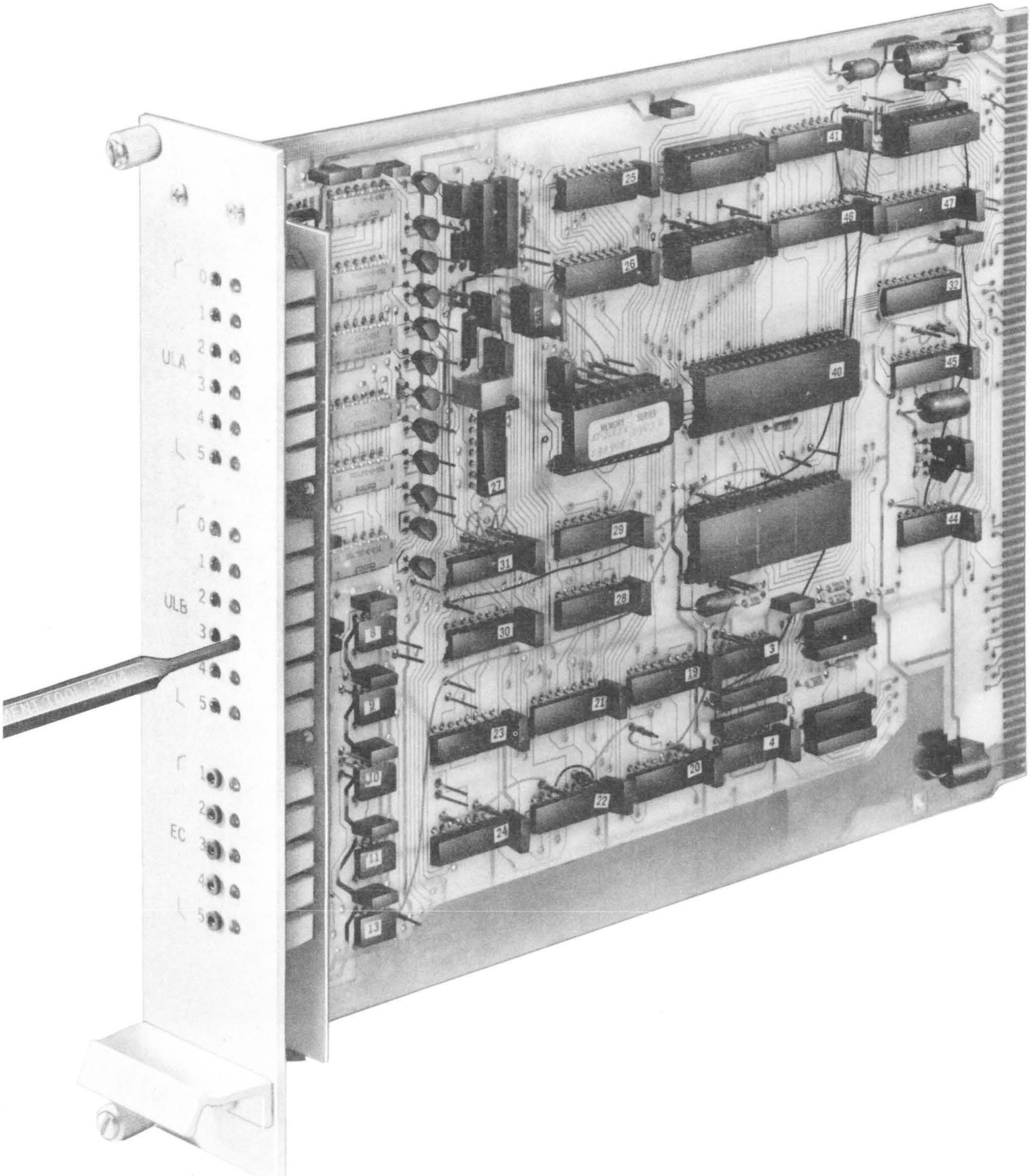

Fig. 4—Slave Module—Internal View With Calibration Tool

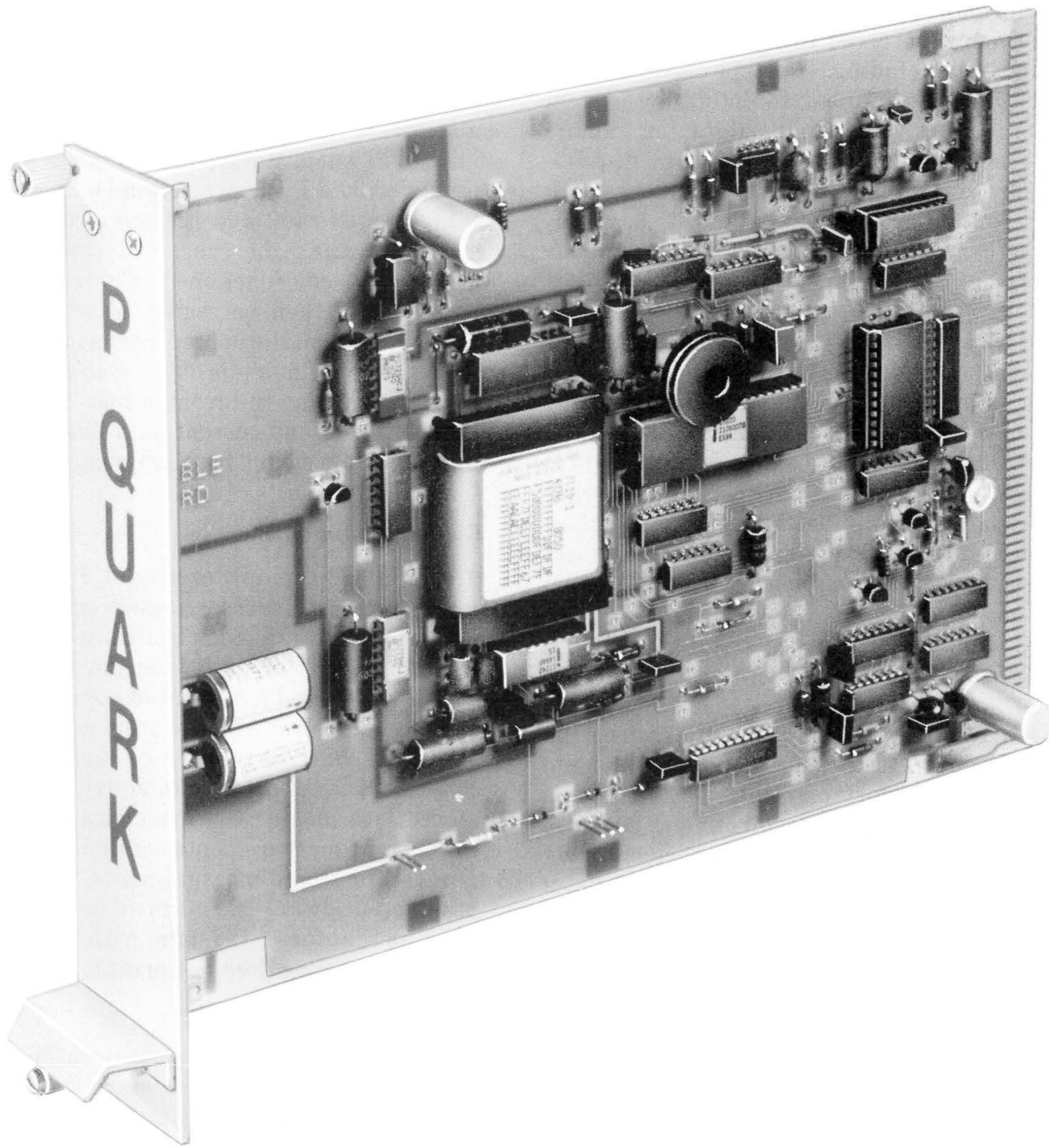

Fig. 5—Bubble Memory Module—Internal View

tool insertion in Fig. 4) is part of a calibration procedure in which the user inserts the desired threshold voltage level and adjusts the control until the associated LED (on the left of the Fig. 4 universal levels A and B [ULA, ULB] adjustment ports) goes on, indicating that beyond that point the desired threshold level would be exceeded and recorded. In monitoring error performance, P QUARK records the amount of time the error rate resides in each of the six selectable performance ranges. For example, how many errored seconds had: 1 to 3 errors, 4 to 49 errors, 50 to 499 errors, 500 to 1500 errors, 1500 to 5000 errors, and greater than 5000 errors. In addition to recording the fade and performance results separately, P QUARK can also record statistics that occur only when additional criteria are satisfied. For example, it is useful to know whether the observed errors are due to fading or to equipment problems. Thus, instead of simply recording the distribution of errored second performance, P QUARK also records the error performance observed to occur only when the system is undergoing fading. This type of conditioned or "nested" data can be used to determine system fade margin, system susceptibility to fading impairments, and to isolate errors due to equipment problems. Thus, by examining the statistics, the user can quickly determine how well the system is performing, and whether the observed errors and/or alarms are due to fading, equipment problems, etc.

2.07 Statistical output data is supplied to the user on printouts, the form of which represents the form of the data as contained in the registers of the P QUARK operating memory. Figure 12 defines the type and categories of the data appearing on a typical memory page. Many of the P QUARK capabilities are best understood by examining the form in which the data is collected and retrieved. This will be subsequently discussed in conjunction with programmed configurations (paragraph 2.11).

Log

2.08 P QUARK is primarily a statistics gathering machine used to measure long-term system performance. The memory map introduced above is the result of long-term measurements and provides a macroscopic view of events useful in monitoring performance. The log, on the other hand, provides a microscopic view, revealing events of special interest and capable of pinning them to time — to the nearest second if so instructed by user commands. While logging is a time and memory consuming operation and provides limited information, the data is easy to understand and interpret. The ability to correlate events with time makes the log a valuable troubleshooting tool. P QUARK maintains an approximate 300 entry log for each slave. Log data from the slaves is stored in the bubble memory and is updated circularly; that is, the oldest entry is overwritten by the newest entry.

2.09 Assuming, for the sake of illustration, that a statistical printout revealed unusual data or indicated substandard performance, the user can then consult the data log to determine exactly when the trouble occurred and what the system status and activity were during the previous second. The log, the format of which is shown in Fig. 6 together with a representative printout in Fig. 7, contains a listing of key or critical events at the time and order of occurrence together with a status indication showing the peak values of each monitored parameter during the previous second. Any changes in alarm or status signals are also indicated. The log is triggered whenever system parameters or activity (errors, fade depth, alarms, etc.) exceed a predetermined level. By examining the system status, for example, a primary channel faded 30 dB, the protection channel faded 10 dB, a high error rate, and the absence of a protection switch, it might be concluded that the protection switch had malfunctioned. Current measurement access could then be requested which would show present system status and performance. If, by this means, no continuing problem was revealed, it would be assumed that the trouble had been rectified. If, however, past and current data indicated a continuing protection switch problem, remedial action would have to be taken.

Current Measurements

2.10 In addition to stored data, P QUARK permits access to current measurements of both log and statistics data. Such real-time information permits the user to observe what the system is actually doing "now", and a rich set of commands allows access to this form of measurement in a variety of ways. It must, however, be kept in mind that P QUARK gives priority to activity associated with stored data, and in cases in which an external request for current measurements conflicts with an internal request for stored measurements, the latter activity assumes priority. The form of presentation is the same as that for stored data, with the exception that the real-time log does not print a header.

Programmed Configurations

2.11 In contrast to the long-term mass storage of the bubble memory, each slave has its own operating memory or accumulating registers. These accumulating registers can be visualized in terms of the "page" structure of Fig. 12, each with 16 rows (or 8-row pairs) with 6 registers in each row, and 96 addressable registers per page. P QUARK scans each input every 10 milliseconds and increments the counts in the appropriate registers. There are four preprogrammed or "canned" data arrangements which are selectable via a configuration command and are defined as configurations 0, 1, 2, and 3. Additional configurations are possible by using a load configuration command, and software support available on the UNIX* system (the UNIX system is avail-

* Trademark of Bell Laboratories

MM/DD	HH:MM:SS	SLAVE	ULA	ULB	ULS	EC1	EC2	EC3	EC4	EC5	ABCDEF
10/21	08:45:15	.2....	LV2	LV1	LV1	10	0	0	0	0	100101
10/21	08:42:31	1.....	LV1	LV3	LV1	27	841	12923	68	0	010010
		•									
		•									
		•									

LEGEND:

LV0 – LV5 ARE LEVELS CORRESPONDING TO THRESHOLD SET BY UNIVERSAL LEVEL DETECTOR (ULD) POTENTIOMETER ON THE FACEPLATE OF THE UBE SLAVE

SLAVE GIVES THE SLAVE NUMBER – SLAVE 1 AND 2 IN THIS CASE

ABCDEF ARE STA0 – STA5, THE STATUS INPUTS, 1=ACTIVE, 0=INACTIVE

EC1 – EC5 ARE THE EVENT COUNTER INPUTS (ACTUAL COUNTS GIVEN)

ULA, ULB: UNIVERSAL LEVELS A AND B

ULS: SWITCHED FADE LEVEL

Fig. 6—P QUARK Log Format

MM/DD	HH:MM:SS	SLAVE	ULA	ULS	ULB	EC1	EC2	EC3	EC4	EC5	ABCDEF
01/01	07:45:13	1.....	LV0	LV0	LV0	5198	0	0	0	0	000000
01/01	07:45:12	1.....	LV0	LV0	LV0	9821	0	0	0	0	000000
01/01	07:45:11	1.....	LV0	LV0	LV0	7271	0	0	0	0	000000
	•		•	•							
	•		•	•							
	•		•	•							
01/01	04:35:43	1.....	LV3	LV1	LV1	1	0	0	0	0	000000
01/01	04:35:42	1.....	LV2	LV1	LV1	3	0	0	0	0	000000
01/01	04:35:41	1.....	LV3	LV0	LV0	7	0	0	0	0	000000
01/01	04:35:34	1.....	LV3	LV1	LV1	5	0	0	0	0	000000
01/01	04:35:32	1.....	LV3	LV1	LV1	23	0	0	0	0	000000
01/01	04:35:27	1.....	LV3	LV0	LV0	17	0	0	0	0	000000

LEGEND:
LV0 - LV5 ARE LEVELS CORRESPONDING TO THRESHOLD SET BY UNIVERSAL LEVEL DETECTOR (ULD) POTENTIOMETER ON THE FACEPLATE OF THE UBE SLAVE
SLAVE GIVES THE SLAVE NUMBER - SLAVE 1 AND 2 IN THIS CASE
ABCDEF ARE STA0 -STA5, THE STATUS INPUTS; 1 = ACTIVE, 0 = INACTIVE
EC1 - EC5 ARE THE EVENT COUNTER INPUTS (ACTUAL COUNTS GIVEN),
ULA, ULB: UNIVERSAL LEVELS A AND B
ULS: SWITCHED FADE LEVEL

Fig. 7—P QUARK Sample Log Output

able for purchase from Western Electric) permits the user to generate customized configurations for specialized applications.

2.12 The four data configurations are shown in Fig. 13 through 16 and summarize data arrangements, statistics, conditioning, and event counters available in each. Configuration 1 (Fig. 14) is the default configuration. Unless otherwise instructed, this mode is selected automatically for each slave, and the data conditioning will be as indicated. Note that the protection switch indication must be wired to the STA0 status input corresponding to the slave of interest operating in configuration 1. Configurations 1, 2, and 3 allow the selection of different error counters and different conditioning. For all canned configurations, the first ten rows will be dedicated to analog data [typically automatic gain control (AGC) voltages indicating fade activity] and status or alarm data. Configurations can be selected independently for each slave; thus it is possible to have all slaves operating in the same configuration or separate configurations. Since there are five slaves and only four preprogrammed configurations, two slaves will have the same configuration unless the user generates a new configuration.

2.13 P QUARK, as previously noted, is primarily aimed at collecting performance statistics; i.e., how many seconds had error counts between 1 and 10; how many seconds had error rates worse than 10^{-3}; etc. Thus, when a slave scans the data, it first categorizes it by determining what level of performance it represents. This, in turn, determines where the data should be stored within, say, the error second distribution row in memory. In addition to categorizing the individual statistics, P QUARK must also look for time correlation among the various inputs. For example, with collecting the errored second distribution for all errors, there might also be a memory row allocated to errored second distribution when the fade depth exceeds 15 dB. In that case, only errored seconds which also included fading to 15 dB would be counted in that row.

2.14 The operating memory accumulates counts. For example, referring to the memory map in Fig. 12, observe that rows 1 through 8 collect fading information. Here we can pair rows, and a row pair consists of six time registers and six event registers. Each time/event register pair is associated with a particular fade threshold. For example, if the primary channel was unfaded, then none of the thresholds would have been exceeded, and thus, no counts would be entered in any register. If the channel now faded, say 6 dB, then the first register pair (shown as registers 1 and 7) would be triggered. At the end of the first 0.01 second, a count would be entered in register 1, the time register, to show that the threshold had been exceeded for 0.01 second. Similarly, a count would be entered in register 7 to indicate that the 5-dB threshold had been crossed going in a negative direction. At the end of the next 0.01-second interval, if the signal was still below 5 dB, a second count would be entered in register 1 to show the accumulated time below 5 dB. Note, however, that no additional count will be entered in register 7 since the threshold had not been crossed again. At the end of a fading epoch, the time registers indicate the total amount of time accumulated below their respective thresholds. The event registers, on the other hand, will indicate the number of times each threshold has been exceeded; i.e., the number of events.The status and alarm inputs have the same time and event structure. For example, in rows 9 and 10 of Fig. 12, the register pair 50 and 56 would respectively indicate the total time for which a carrier group alarm (CGA) condition existed, and the number of alarms that occurred.

2.15 The accumulation of error distributions does not relate to time and events. Rather, error performance is accumulated as shown in rows 11 and 12. In this case, the row normally interpreted as the time row accumulates the total number of seconds which had error counts in a particular range. For example, during a 1-day monitoring period, assume there were 3 seconds with 6 errors, 2 seconds with 500 errors, and 1 second with 5000 errors. This would result in counts of 3 in register 61, 2 in register 63, and 1 in register 64. If we further assume that the errored seconds with 500 and 5000 errors occurred during fading (in excess of 15 dB), then registers 69 and 70 in the next row would also show counts of 2 and 1, respectively. This happens because this row records only those errored seconds which occur during fades. Thus, the memory structure shown here allows the accumulation of basic statistics of fading, error performance, alarms, etc., and also facilitates the correlation of one set of measurements with another as was done with the error distribution during fading. Many other options regarding correlation of statistics are possible, particularly if P QUARK is equipped with multiple slaves.

3. ARCHITECTURE

A. General

3.01 This part comprises an extended discussion of P QUARK theory and methodology. Since a knowledge of user inputs is central to P QUARK, and is of presumed major interest to readers of this descriptive document, emphasis is directed to the UBE slaves as the primary interface linking P QUARK to the monitored system. Following an introductory block diagram discussion covering P QUARK master and memory architecture, separate emphasis is given to descriptions of the slave universal level detector, binary interface, and event counter as representing the slave-environment interface. Since slave related "program plugs" comprise a necessary interface element, this topic is also incorporated.

B. Conceptual Block Diagram Description

P QUARK Master Module

3.02 The master module, as shown in the P QUARK conceptual block diagram of Fig. 17, coordinates the operations performed by P QUARK. These operations include synchronization of slave units, servicing user requests, managing bubble storage, timekeeping, and the shuffling of data to and fro within the system. The major elements comprising the master are described below.

Central Processing Unit (CPU)

3.03 The central processing unit, a Z80A microprocessor, is in control of this module. It can execute programs either in programmable read only memory (PROM) or in random access memory (RAM). The program in PROM gives the basic features, while programs implementing additional features are executed in RAM, by first copying them from the mass storage bubble module into RAM then transferring execution to the newly loaded program.

Direct Memory Access (DMA)

3.04 The direct memory access circuit transfers data at high speed in and out of memory with minimal CPU interaction. With the exception of transfers between the bubble module and RAM, all other DMA transfers are CPU initiated. The DMA transfer begins with the DMA circuit requesting the local bus, then after the CPU relinquishes control, the DMA transfers data either between RAM and the bubble memory or between RAM locations. At the end of the data transfer, the DMA chip returns the bus, allowing the CPU to regain control of the module.

Keyboard and Display

3.05 Occasionally, especially during installation, it is necessary to have access to data which is intimately related to the operation of P QUARK. This is done with the keyboard and display circuit, located on the front panel of the master module for easy access. In addition to the raw input data and other information, the clock time is also accessible this way.

Serial Interface (SIO)

3.06 The Z80A-SIO/0 chip implements the 2-channel serial interface and provides RS232 interface compatibility. Both serial channels are interrupt-driven with channel 0 the higher priority of the two. Pins 19 and 22 of the SIO chip are used for generating interrupt from the local keyboard and from the analog to digital (A/D) converter. Both of these signals are active high.

Parallel Interface (PIO)

3.07 The parallel interface chip, IC42, serves two purposes. It provides the lines to control the slaves; furthermore, it also gives an 8-bit bidirectional parallel port with four control lines. This port is interrupt-driven.

Memories (ROM and RAM)

3.08 The PROM is implemented with 2732-type EPROM devices and the RAM is built of 28B-type dynamic memories controlled by an 8202 RAM controller. The controller takes care of address multiplexing, timing, and automatic refresh control. The CPU time lost to refresh cycles is negligible if execution is in PROM; otherwise it is about 8 percent.

Interrupt Circuits (INT)

3.09 Every important function in P QUARK is interrupt-driven. This increases throughout and reduces software overhead. The interrupt structure fully exploits the Z80 mode 2 interrupt features (vectoring, auto clear, and priority). The interrupt lines in order of decreasing priority are:

MSINT	1-sec interrupt for sync functions
BINT	8-bit port interrupt
SINT0	Slave 0 interrupt
SINT1	Slave 1 interrupt
SINT2	Slave 2 interrupt
SINT3	Slave 3 interrupt
SINT4	Slave 4 interrupt
BERR	Bubble error interrupt
DMA	DMA interrupt
SIO0	Serial channel 0 interrupt (internal)
SIO1	Serial channel 1 interrupt (internal).

A/D Converter

3.10 The 8-channel 8-bit A/D converter is used to monitor various dc or slowly varying voltages of the slave modules. It is useful, for example, to obtain better resolution when monitoring AGC voltages or determining free-space values before threshold adjustments at the slaves by averaging a large number of samples of AGC voltages. The A/D performs ratiometric measurements, that is, every measurement is compared to full scale (5.11V or 20 mV/step—note that this is exactly the upper limit at the output of the UBE slave module's universal level detector interface). A measurement cycle is started by issuing a "start A/D" command (an I/O write to address 0X0Y, where Y is the number of the input channel). When the conversion is complete, the ADINT line is asserted and the service routine reads the latched data. The 5.11V reference voltage is supplied by a Precision Monolithics REF-02. All analog inputs are clamped to prevent the overload and possible destruction of the A/D chip.

Clock Circuits

3.11 P QUARK requires some rather elaborate clock signals. The master clock runs at 48.000 MHz. The 3-MHz CPU clock derived from this is distributed on the main bus to all slave CPUs. The 48-MHz master clock is further divided to get the 500-kHz clock for the A/D converter; then, after some further division, 1-ms, 10-ms, 100-ms, and 1-second timing pulses are generated for the sampling clock (SAMP/). The clock for the 8202 dynamic RAM controller is also generated from the 48-MHz master clock by halving this frequency to get 24 MHz. The clocks for the serial channels are derived from a separate time base with the aid of IC14 and a 1.835-MHz crystal. This chip generates various baud rates (data rates) for the serial channels. The actual rates are determined by the strapping option.

Sanity Timer and Power Fail Circuits

3.12 The reliable operation of any computer depends on error-free program flow. However, for all practical purposes, it is unreasonable to expect error-free operation for extended periods (the probability of error is always finite no matter how small). When an error occurs, the result of any further operations is unpredictable. The sanity timer's function is to reduce the chances of severe malfunction which would cripple the operation of P QUARK. It was designed to dislodge the CPU from infinite loops and "hangups" by issuing, during troubled times, a reset signal to the whole system. During normal operations, the CPU prevents these system resets by periodically resetting the timer from the program. The CPU must issue these reset signals no later than every 25 seconds which is the time it takes the sanity timer to time out. A sanity timer timeout activates the reset signal to the whole system restarting the CPUs. A nonmaskable interrupt can be caused by an impending power failure. This should (given enough time) cause the CPU to quickly clean up any mass storage-related activity and shut the system down in an orderly manner. After power-up, a system reset is automatically executed by the hardware and subsequently by the software.

Bus Interface Logic and Wait-State Generation (LGC)

3.13 Generally, this is the most complicated aspect of computer design. Here, the complexity is drastically reduced by the use of programmable array logic (PAL) integrated circuits. These devices directly implement logic equations; hence, the design is easier to follow and implement. The PAL in socket X6 generates the bus, memory, and CPU wait control signals; while the PAL in socket X7 generates the internal bus control signals.

Bubble Memory

3.14 The bubble memory module (as shown in Fig. 17) implements the P QUARK mass storage, time-of-day clock, and a safety device called the fake acknowledge generator, each of which will be elaborated upon below.

Bubble Storage

3.15 The 128-kbyte bubble storage is implemented using an INTEL BPK-72 chip set consisting of:

7210	Bubble Chip
7220	Controller
7230	Current Pulse Generator
7242	Formatter and Sense Amplifier
7250	Predriver
7254	Driver (2 pieces).

The master CPU communicates with the bubble system through the 7220 controller. The controller is mapped in the input/output (I/O) space of the master, occupying the address range C0H-C1H. C0H is the command port and C1H is the data port. An I/O write to the command port causes a bubble command to be written in the controller's command register while a read from the same address yields the current controller status. The data port is used for bubble data and controller-register data transfer. The data transfer to and from the bubble subsystem is through the master's DMA facility — for multipage transfers, the data rate can exceed 200 kbytes/second.

3.16 The 7220 controller generates the proper timing signals for the coil drive circuits (7250, 7254), the bubble generate circuits (7230), and the data transfer and read strobe signals for the formatter/sense amplifier (7242). The bubble module receives the 7220 originated signals through these peripheral circuits. The bubble signals are current pulses used either for driving the field coils (to rotate the bubbles) or for generating, replicating, and swapping bubbles at bubble loops.

Time-of-Day Clock

3.17 This clock is very similar to a watch circuit except that the interface is to a microprocessor and not to a display. The clock is backed up by two lithium oxide primary batteries for reliable nonvolatile operation. In addition to the clock function, the MM58167 chip also offers a general purpose 8-byte memory also backed up by the batteries. These memory locations in addition to the clock registers occupy the A0H-BFH I/O address range of the P QUARK master. The clock chip uses a 32,768-Hz tuning fork as time base which must be adjusted in the factory to within 100 ppm of its nominal value. The LS74 D-type latch connected to the clock's ready line implements a wait-state generator to avoid reading erroneous data during counter turnovers within the clock chip.

The Fake Acknowledge Generator

3.18 This circuit is a retriggerable timer intended to terminate long CPU wait cycles caused intentionally during program initialization in searching for slave modules or unintentionally due to bus errors. The timer is triggered whenever the CPU wait signal is active (low). If this signal remains low for longer than 56 to 64 μsec, the timer times out causing a MOACK/(master off-board acknowledge) which terminates the wait cycle. Notice that the CPU will get whatever happens to be on the bus — that is generally FFH which is a "rstp 7" instruction causing the CPU to vector to location 38H where the program is restarted, if the wait cycle was entered during opcode fetch.

Timing and Decoding Circuitry

3.19 Most components on this module require a 4-MHz clock. This signal is derived from the 12-MHz system clock by a novel divide-by-three circuit. This clock is also made available on the backplane through VMOS drivers.

3.20 The address and control signal decoding is done by a PAL12L6 IC (programmable array logic). The logic equations are given on the circuit schematics. The MOACK/ signal can be activated by addressing the clock chip, the bubble memory controller or, as described above, by the fake acknowledge generator.

C. Slave/User Interface

3.21 System inputs to be measured by P QUARK are applied to the UBE slave circuit packs using 44 pin connectors (J4A through J8A), mounted on the rear of the shelf unit. The functional designation UBE applied to the slaves stands for universal level detector, binary interface, event counter, and describes the three basic types of input signals which can be monitored. Much of the installation process consists of connecting these signals to the slave and adjusting input conditions to accommodate these signals. The universal level detector, of which there are two inputs per slave (ULA and ULB), is designed to monitor slowly varying analog signal levels such as AGC voltage, which is envisioned as the most typical application. The binary interface provision accommodates slowly "flipping" binary levels such as status indications, and any other on/off signals of this type. The event counter, on the other hand, can be used to count fast flipping pulse streams having repetition rates up to 6.5 MHz (6.5 MHz guaranteed, with 7 MHz typical), a typical application of which would be monitoring the output streams generated by pseudorandom signal receivers. These three input categories are shown on the slave block diagram of Fig. 17.

3.22 As in any measuring system which interfaces with the external environment and accepts a variety of inputs, it is necessary to program the interface circuit to meet the input conditions imposed by P QUARK requirements. The required interface matching is achieved by the use of DIP (dual in-line pin) component carriers or "program plugs", accommodated by four sockets on each slave circuit board. In the case of the event counter, this programming task is reduced to adjusting potentiometers which vary the input threshold level. The two user test outputs (ULATST and ULBTST) shown associated with the universal level detector are used in calibrating the six discrete levels which can be detected by each ULD — a process otherwise known as "slicing" of the input range.

Program Plugs

3.23 As noted above, certain user inputs, in being characterized by situational variability, must be rendered compatible with P QUARK input requirements via program plugs. The two signals falling within this category are the ULD inputs, which typically accommodate widely varing AGC voltages, and the binary interface or status inputs which tend to be nonstandard. Since it is assumed that in radio applications the two ULD inputs will typically be used for measurement of AGC levels, prefabricated plugs are available for the standard radio systems, and are supplied with the slave units. In the case of the status inputs, however, the variety of inputs is such that prefabrication is not practical, and the user must therefore build his own plugs. For this purpose, blank component carriers (see Fig. 8) are also supplied which, with the addition of several 5 percent resistors in accordance with a supplied table of instructions, will satisfy the various requirements.

3.24 There are three parameters which must be considered in designing program plugs: input range, sense, and polarity. Range refers to the total voltage swing. For example, an AGC input which ranged from −3 volts to +8 volts would have a total range of 11 volts. Sense refers to the direction the signal will go when changing from the inactive to the active condition; i.e., an AGC voltage which became more positive when compensating for a faded signal would have a positive sense. The polarity parameter describes whether or not the input range includes negative values, that is, whether or not it crosses zero. The polarity parameter is adjusted merely by reversing the input leads when necessary — the process being otherwise known as inversion. Using the ULD AGC input as an example, the P QUARK requirements specify a positive-going signal ranging from zero to a maximum of +5.11 volts as measured at the ULD TST outputs. If, as previously stated, the actual AGC signal ranges from −3V to +8V, and thus has a total range of 11 volts, the first task of the program plug is to compress the signal so as to yield a total range of 5.11 volts. When this is done, the range will extend from −1.4 volts to +3.72 volts, providing the required 5.11V swing. The second step (otherwise known as offset control), then raises the entire range in the positive direction such that the previous −1.40 voltage level is now set to zero, effectively adding it to the +3.72V and resulting in a positive signal with a total excursion falling between 0 and +5.11 volts at the test outputs as required. Since the signal is positive-going, no inversion is necessary in this case.

Universal Level Detector

3.25 The ULD provides for the simultaneous monitoring of two analog inputs (ULA and ULB).

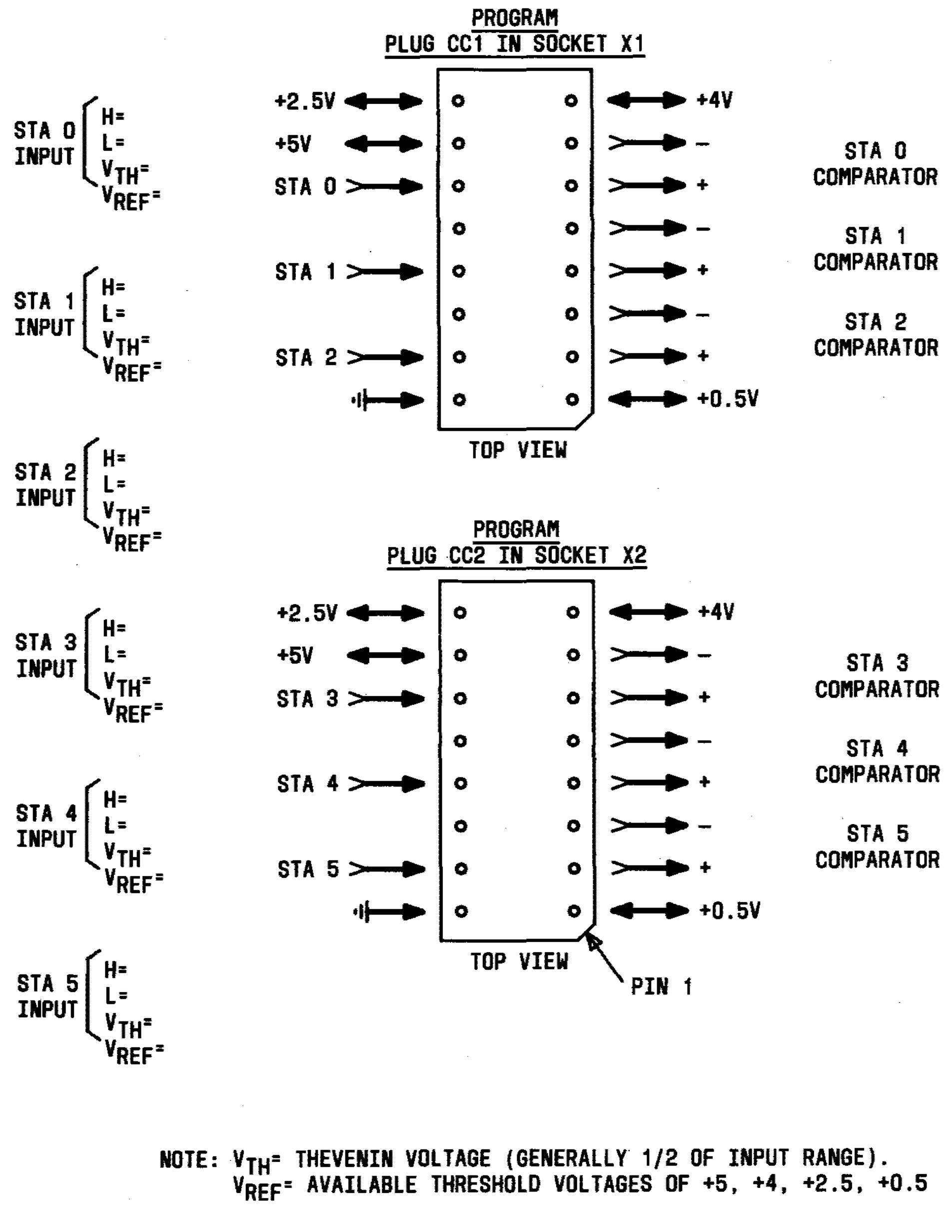

Fig. 8—P QUARK Status Input Blank Program Plugs

The operation of this provision is perhaps best presented in conjunction with its typical application in monitoring fade depth via changing AGC voltages. Since two inputs are available, it becomes possible to simultaneously monitor performance of main and diversity receivers when required.

3.26 In order to measure fading, the AGC voltage for each of the receivers (in the assumed case of main and diversity) must be connected to P QUARK and the ULD thresholds or slicing levels set. First, however, the approximate voltage range and sense must be known in order to select the appropriate program plug. For this example, the most positive value is 0 volts, corresponding to the minimum gain for an upfaded signal, and −8.0 volts for the deepest fade. With range and sense determined, the list of program plugs is consulted to determine the proper plug, or the nearest plug if an exact plug is not available. These plugs are then inserted into the sockets on the slave board.

3.27 Keeping in mind the polarity of the input signals, the AGC voltage inputs, each of which should be carried over a shielded, twisted pair of leads, are connected to the respective ULA and ULB input terminals, after which threshold calibration or slicing of the input voltage into six amplitude levels is undertaken. If the relation of fade level to AGC voltage is known, a somewhat simplified calibration procedure, as will be presented here, can be used. If this relation is not known, the free-space signal level must first be determined and simulated by injecting an IF signal into the main IF amplifier, after which the relative slicing levels are established with respect to the free-space voltage as measured at the ULD test outputs. For this discussion, assume that the fade versus AGC level is known, and that the six fade ranges of interest are as follows:

+2 dB	0V	(LV0)	>−2 dB
−2 dB	−1.1V	(LV1)	>−15 dB
−15 dB	−2.6V	(LV2)	>−25 dB
−25 dB	−3.5V	(LV3)	>−30 dB
−30 dB	−5.6V	(LV4)	>−35 dB
−35 dB	−6.8V	(LV5)	

The threshold potentiometers corresponding to the six levels are then adjusted to follow the fading signal in a monotonically decreasing order. For calibration, the slave board can be put into a slot not yet wired with AGC voltages, and a variable dc power supply connected to the appropriate pins. With the voltage set to zero, the port adjacent to ULA0 is adjusted until the associated LED just lights. The voltage is then changed to −1.1 volts and the ULA1 potentiometer is adjusted until the ULA1 LED goes on, and so on until all six thresholds for both main and diversity receivers (ULA and ULB) have been set, and at which point the slave is ready to record fade activity.

3.28 The first location in the memory map; i.e., row 0, column 0 (0, 0), would record all the time for which the primary signal is below a +2 dB upfade. Under normal circumstances, this would be virtually all the time for which the signal is being monitored. To find the amount of time for which the upfade exceeds +2 dB, the time shown in (0, 0) should be subtracted from the total time of monitoring. Location (0, 1) would contain the time for which the signal is faded below −2 dB. In a similar manner, each column in row 0 will record the amount of time faded below the corresponding threshold.

Binary Interface

3.29 The recording of status and alarm inputs is similar to that of the ULD described above. The outstanding difference resides in the fact that here the signal can assume only two states: active and inactive. Once again, program plugs must consider range, sense, and polarity as the significant parameters in adjusting the variety of signals to P QUARK input requirements. Here, however, the plugs are not prefabricated and must be constructed by the user to meet particular conditions. Since the inputs are 2-state binary, slicing potentiometers are not used. A threshold level (to preclude false recording of noise or cable ringing) is, however, established via the program plugs. Here also, as a result of the 2-state signal characteristic, comparators rather than operational amplifiers are used in the slave input circuit. The comparator outputs are latched, and the latches are periodically interrogated and reset by the slave microprocessor. In radio applications, where the monitoring of protection switching is essential, the first input (STA0) should be used to monitor the protection switch status. This assures that rows 7 and 8 (time and event rows for switched fading) in the memory map, correctly monitor the variations seen by the message carrying signal, whether on the primary or the protection channel.

Event Counter

3.30 The event counter measures fast changing (up to 6.5 MHz) binary pulses, indicative of errors. The nature of the input signal is such that proper termination of the input cable is necessary to avoid ringing and false counts. As with status inputs, the event counter inputs are also interfaced with comparators; however, in this case, program plugs are unnecessary. The output of the comparators is connected to the source inputs of an AMD9513 IC, which has five 16-bit counters each of which is periodically read by the microprocessor. There are five separate event inputs, each of which has a row in the memory map. The counter counts the events in each second and puts the number in the appropriate register. Each of the five inputs has its own threshold adjust potentiometer accessible from the front panel. Here again, the potentiometers do not slice, but establish a threshold continuously adjustable from −2.5 to +2.5 volts, which assures that noise will not be counted.

These potentiometers are typically set at one-half of the pulse height. A block diagram of the event counter appears in Fig. 9.

4. DATA RETRIEVAL AND ANALYSIS

A. General

4.01 As noted throughout this section, a prime advantage of P QUARK resides in the ability to provide remote access to performance data available as statistics in memory map format, log data, and real-time data in log format but consisting of actual measurements as they occur. While the topic of data analysis, in being characterized by situational variables, and user options represents a vast and complex domain, the following illustration affords practical insight regarding the application of gathered information in resolving the cause of observed transmission error. The error in this case consisted of 3 seconds having error rates greater than 10^{-3}. The presumed system for which the experiment is designed is a new digital radio route undergoing performance analysis. Fading is measured on both main and diversity receivers.

4.02 To retrieve P QUARK data, the terminal must first be attached to the phone line through an acoustic coupler, or 212A data set. The phone number is then dialed, and after acknowledgement, the password terminated by a return is typed in. If, as previously noted in paragraph 2.03, the correct password has been used, the response is an asterisk, after which a command specifying the type of data is inserted. This results in the prompt display of log or statistical data as requested. If no additional data is requested, the interaction is terminated by simply hanging up.

B. Configuration and Analysis

4.03 For this example, which calls upon both statistics and log, the statistical format is that of configuration 3 (Fig. 16). Inputs have been connected such that rows 1 and 2 contain primary receiver fade information (times and events); rows 3 and 4 contain time and event diversity receiver information; rows 5 and 6 contain time and event joint fading statistics; i.e., the fading associated with an instantaneous selection of the less faded of the two signals; and rows 7 and 8, in turn, contain the T and E encountered as the message signal is processed by either the primary or diversity receiver according to the protection switch status.

4.04 Having obtained the data, analysis can begin as to what caused the three errored seconds of observed outage. Typically, the first dump would be the statistics dump. This is shown in Fig. 10, and spans the period from 12 midnight until 8:00 a.m. The first item of note is that the incoming radio signal has seen significant fading. From row 1, column 5, it can be seen that the signal on the primary antenna spent 12 seconds faded below 30 dB. With protection, the signal incurred only 2 seconds faded below 30 dB, as can be seen in row 7, column 5. To achieve this improvement, the protection switch was activated three times for a total of 27 seconds, as seen in rows 9 and 10, column 1, time and events. The other item of note is that 3 seconds had error rates greater than 10^{-3} (row 11, column 5). By correlating the errors with fading, as is done in row 12, it can be seen that none of the errored seconds occurring during fading had a 10^{-3} error rate. This infers that the 3 seconds of observed outage were due to problems other than propagation. P QUARK, therefore, is indicating a problem other than fading. Now it is useful to look at the log data.

4.05 A sample listing of log data for this measurement was previously given in Fig. 7. Note that the 6 errored seconds coinciding with fading are about 4:35 a.m. The 3 seconds with error rates greater than 10^{-3} were contiguous and occurred at 7:45:11, 7:45:12, and 7:45:13. With this information, it was determined that shortly after 7:45 that morning, crafts people were working in the vicinity and had introduced errors to ensure that the performance recording was working properly. The point is that by using both the statistics and the log, it is possible to quickly isolate the causes of observed errors.

5. COMMANDS AND OPTIONS

A. Overview

5.01 Following acceptance of the user password, P QUARK is ready for data requests, the two basic forms of which are log and statistics, each having its own set of commands. Statistics are available in pages either by slave number, by date, or by page number. Page 0 is always the current page from any slave. P QUARK stores 210 pages, which are overwritten circularly (newest overwrites oldest) and which are apportioned according to the number of slaves involved; i.e., three slaves would get 70 pages each. The set of commands related to page (or statistics) data allow searching the bubble memory in vari-

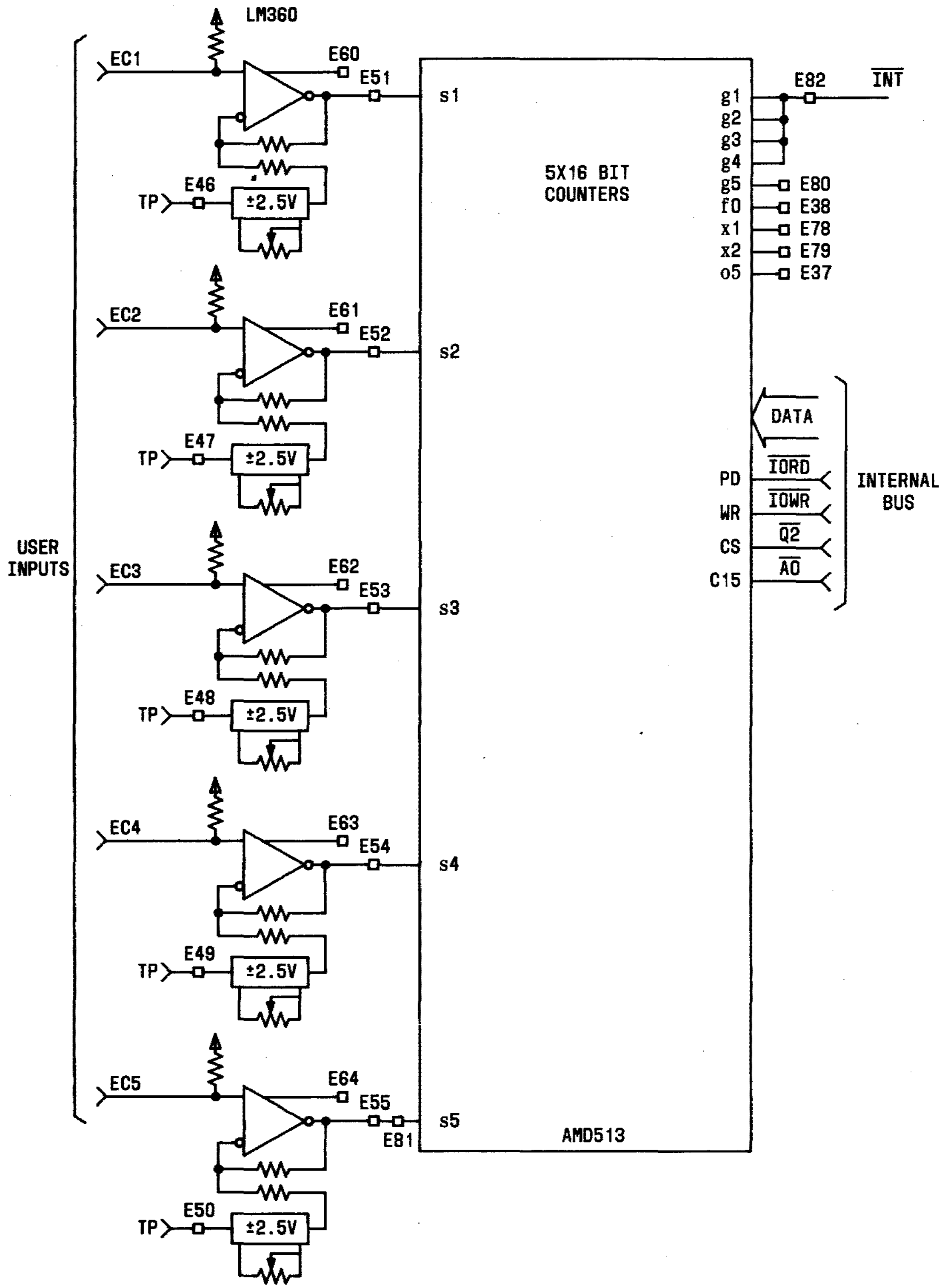

Fig. 9—P QUARK UBE Slave Event Counter—Block Diagram

s1	+5dB 01/01/81 COL 1	-15dB 08:00:00 COL 2	-20dB p15 COL 3	-25dB COL 4	-30dB COL 5	-40dB* COL 6	
R1	7051	2084	1562	1472	1234	0	PRIMARY FADE*
R2	24	19	17	13	11	0	
R3	9617	8513	2134	1270	715	0	DIVERSITY FADE
R4	31	16	19	13	7	0	
R5	5022	1517	982	751	150	0	IDEAL FADE
R6	8	7	3	4	2	0	
R7	3814	2017	1320	817	210	0	SWITCHED FADE
R8	9	6	7	3	3	0	
R9	2745	3724	0	0	0	0	STATUS
R10	3	1	0	0	0	0	
R11	5	1	2	0	3	0	ERRORS ALL CAUSES
R12	0	0	0	0	0	0	ERRORS/15dB
R13	4	1	1	0	0	0	ERRORS MUX REFR
R14	0	0	0	0	0	0	ERRORS/DIV. SW.
R15	0	0	0	0	0	0	NOT USED
R16	0	0	0	0	0	2,880,000	

* THESE HEADINGS ARE NOT PART OF THE PRINTOUT; THEY ARE SHOWN HERE FOR CLARITY ONLY.

Fig. 10—P QUARK Sample Statistics Page Output

ous order according to time and page number. From the local keypad, it is possible to access each register on the current page, one at a time. This, however, is only recommended for maintenance purposes.

5.02 The log again has its set of commands allowing search through the time series data in different order according to slave number and time. P QUARK can store 1500 lines of log entries divided among the slaves, as above. The log has its version of current measurements in the real-time log which provides a second-by-second account of input activity without a header. This can be used to get a paper log of interesting events as selected by the "burp" commands.

5.03 The above outputs are available on either or both terminals, S1 or S2. A data rate of 1200 baud is recommended, as the extent of the data is such that excessive time is consumed at the slower rate of 300 baud.

B. Commands

5.04 Retrieval of log and statistics data is implemented by a set of display or d-commands. In addition to display commands, there are "burps" or b-commands which allow for the occasional display of selected data on a local terminal or printer; load commands which allow slave programming for configurations other than the standard 0 to 3 discussed in paragraphs 2.11 and 2.12. (These programs are otherwise known as Q-map or Q-program of which the four standard versions are implemented via the configuration commands); and, finally, a variety of miscellaneous commands. All commands are typed in lower case and terminated by hitting the "return" key. (Most modern terminals have both upper and lower case, or can be ordered with a lower case option.) The commands are upward compatible in terms of incorporation in new versions of software. Following the introduction of "time" conventions (to be used whenever a command time factor is called for), a listing of representative commands is presented.

Time Conventions

5.05 When time commands are called for, they are typed in this form: YYMMDDHHMM. As should be apparent, the letters stand for year, month, day, hours, and minutes. In other commands such as display d l or d t (the t in this case standing for "tabular" or statistics), an asterisk, representing any legal value, can be substituted for specific values. Some examples of the usage of "time" in commands are as follows (the year, YY, should not be typed here, but seconds, SS, are added):

******0000	—	matches every 10 minutes
*****00000	—	matches every 10 hours and midnights
0522****00	—	matches once a minute on May 22.

Display Commands

5.06 Display commands always begin with a d followed by t for tabulated (statistics); an l for log; or, when slave programming information is requested, an m for Q-map display. The command delimiter is "space". Following the d l, d t, or d m are the various options as described below:

Statistics Commands

d t 0 —	Yields the current statistics for all slaves present.
d t i —	Yields statistics pages i (i ranges from 1 to 210) for all slaves present.
d t "time" —	Yields pages starting with the one corresponding to the designated time in chronological order.
d t i j —	Yields statistics from page i to j (a block of pages somewhere between 1 and 210 printed in ascending order.
d t "time 1" "time 2" —	As above but according to time.

If, in the above commands, si is inserted before the page designators (where i is from 1 to 5), selection is restricted to a particular slave:

d t s2 515 —	Yields pages 5 to 15 from the bubble memory belonging to slave 2.
d t s4 0704123700 0704233700 —	Yields pages stored between indicated times, starting with oldest page.

Log Commands

d l 0 —	Provides real-time log from all slaves second by second, until cancelled.
d l "time" —	Yields log associated with time for all slaves from bubble memory (5 lines maximum).
d l "time 1" "time 2" —	As above, but between time 1 and time 2 for all slaves. Maximum printout is 1500 lines.

Here again it is possible to insert a slave descriptor, si, to select a particular slave:

d l s5 0 —	Real-time log from slave 5.
d l s1 1101231500 —	Gets line corresponding to time given from slave 1.

Display Q-Map Command

Additional commands to display the programming information in slave i are:

d m — For all slaves; gets 5 times everything below.

d m si — Yields 107 bytes in hex notation. This is the Q-machine program for slave i. This program controls the slaves operation: conditioning, sampling rate, and row mapping. The "m" in the commands stands for "map", and the terms Q-map and Q-program are synonymous.

Load Commands

5.07 There are two load commands: one for loading the Q-map (or Q-program) for a new configuration (other than the four available), and another to load the boot loop for the bubble memory chip. These commands should be used only by sophisticated users. The commands are:

l c n — Load configuration n followed by a "return"; then 214 hex characters starting with the number of bytes (214 in this case), and ending with the control X character. Carriage returns are ignored. Here n(4-9) is the configuration number.

l b — Followed by a "return" and the boot loop in hex with the checksum at the end. The boot loop is always 82 characters long. Carriage returns are ignored.

Burp Commands

5.08 These commands cause P QUARK to occasionally "burp" either tabulated (statistics) or log data to a local terminal or printer connected to serial port S2. The generic command is b l or b t for log and statistics, followed by either a slave designator (si), and page or log descriptor as in the display commands:

b l "time" — Causes P QUARK to output a line of log data from all slaves present whenever "time" matches the clock time.

b t "time" — This acts just as above, except the statistics page is printed.

It is possible to insert a slave designator as the third character to direct the commands to a particular slave:

b l s4 'time" -

b t sl "time" -

No more than five burp points are allowed. These, however, can be distributed as desired; i.e., one for each slave or five for one, etc. These can be seen by typing the display burp points command:

d b — Points the listing of the burp points as they have been typed in.

A burp point can be cleared by typing the command exactly as seen on the list.

Configuration Command

5.09 As described in Part 2, P QUARK has four built-in configurations: 0, 1, 2, and 3, which can be selected via this command. Additional user defined configurations (having numbers of 4 or greater) are possible using the previously described load command.

config si n — Sets the configuration of slave i to n. The next "power-up" or master reset command will cause the master to load the designated slave with the Q-map defined by configuration n. ***Examples:*** config sl 4, config s2 5; etc.

config — Lists the current configuration for all slaves present. For example:

01109 means: slave 1 in config 0
slaves 2 and 3 in config 1
slave 4 in config 0
slave 5 in config 9 (if any)

The default is 11111.

Other Commands

5.10 The following commands are categorically covered via an annotated listing. For additional detail, or specific commands within the categories, user documentation should be consulted.

(1) Time Command — Sets time or gives the current time: (month, day, year, hour, minute, seconds).

(2) Mode Command — Sets the logging conditions; i.e., when an event is to be stored (recorded). Ranges from always to once for every 999 events. Can also display the current mode as selected.

(3) Rate Command — Sets the storage rate of statistics pages to n. N will be the elapsed time in hours between statistics pages stored.

(4) Password Command — Inserts new password.

(5) Number of Slaves Command — Gives number and positions of slaves in system.

(6) Test Mode Command — Places P QUARK in test mode. Master suspends data collecting and operates test activity. Slaves operate normally. The terminal is used as a "logic analyzer".

(7) P QUARK Command — Displays current version of P QUARK software.

(8) Wipe Command — Clears all or selected portions of bubble storage.

(9) Moving Average Command — ULD TST outputs (2 each) of four slaves are connected to a linear 8-bit A/D converter on the master module. Command computes a moving average on the eight channels. Command is useful in determination of free-space level in radio systems.

(10) Delay On/Off Command — Causes a 600-ms delay after every carriage return/line feed character. Used with low-speed mechanical printers. (Since serial ports S1 and S2 are delayed, terminal will not keep up with real-time logging.)

(11) Master Reset Command — Activates reset by sanity timer. Similar to a "power up" with true hardware reset.

(12) Special Character Commands — These are generated by striking the control key and other designated keys simultaneously. Uses include canceling current command being executed; suspending printout; and restoring printout.

Hex Commands

5.11 The hex keypad, as noted in paragraph 3.05, is a maintenance aid allowing access to data related to P QUARK operation. Using the keypad, it is possible to examine the statistics registers, to query time, to set the baud rate and observe A/D converter current averages. Information, which appears on the master LED display, is obtained by depressing the F key which permits serial scrolling of a menu consisting of:

TIME?

STATISTICS?

A/D CONV?

BAUD?

When one of these appears, say, for example, TIME?, depression of the D key will give the current time HH:MM:SS. Depression of the B key provides YY/MM/DD, while the A key gives YYMMDDHHMMXX. (Note that seconds cannot be set, and it is necessary to wait for an even minute to set the clock.) The time is set by using the number keys as requested by the previous display, and then depressing D. "A" allows for any error correction, and D reenters the time entry mode.

5.12 A second pressing of the F key yields STATISTICS?, after which depression of D displays the following:

SRRC "bunch of numbers"

S = slave number

RR = the row number

C = column number.

"bunch of numbers" = content of the register in the location addressed by SRRC.

Here, a new coordinate can be selected by pressing:
A and slave number, then D gets new slave
B and RR, then D gets new row

C and C, then D gets new column.
The next F will scroll on to the A/D CONV message.
Pressing D gets the display:

SUi "volts"

S = slave number

U = means ULDXTST output

i = either A or B for ULDA or ULDB

"volts" = the reading at the designated output (averaged as described in conjunction with the moving average command).

By successively pressing the A key, it is possible to scroll through all eight ULDXTST channels. The F key closes this menu entry and gets the BAUD display. Here D gives the display: S1=H (or L) S2=H (or L)

H means high speed generally 1200 baud

L means low speed or 1/4 of the high speed.

The A key can change S1 from H to L and back, and the B key does the same for S2.

5.13 Additional messages displayed on master module display are:

POWER-UP — displayed after a power-up

RESET — midnight reset occurred.

C. Options

5.14 P QUARK has numerous options which, although not essential for normal operation, allow an experienced user to enhance P QUARK measurement capabilities, and which are covered in user documentation. Use of these options requires a detailed knowledge of P QUARK circuits and operation. The following drawings contain detailed information which is helpful in dealing with options:

ED-2C619	Master Drawings and Circuit Description
SD-99646-01	Application Drawing Package
ED-2C620	Bubble Memory Drawings
ED-2C621	UBE Slave Drawings.

6. OBJECTIVE PLANNING

A. Rationale

6.01 The effectiveness of P QUARK as a data gathering and analytical tool is directly related to the thoughtfulness having been applied to its application. As should be apparent at this point, P QUARK operations are characterized by extensive variables in regard to the variety of systems being examined; the selection of data to be collected; the particular conditioning of recorded events so as to reveal otherwise obscure correlations leading to trouble isolation; and, of course, the P QUARK programming flexibility afforded the user. All of these factors necessitate human ingenuity, and the purpose of this discussion is to emphasize that the acquisition of meaningful data is dependent upon careful planning, without which P QUARK can be rendered useless. Such planning, in turn, demands a clear and thorough knowledge of the purpose or the problem for which the particular experiment is to be designed.

6.02 In light of the above, the most important step in using P QUARK effectively is to define an experiment that will provide the information desired. This is a process that requires not only an understanding of the P QUARK, but also the system being measured. In particular, one should understand the purpose of the experiment, what parameters are available, and whether, in fact, one has access to sufficient information to satisfy the aim of the monitoring program.

B. Configuration and Objectives

6.03 It will be recalled that in the example of Part 4, Data Retrieval and Analysis, a new digital route was undergoing performance analysis, and that the gathered data was structured such that the cause of transmission errors was shown to result from their deliberate introduction by craft personnel, rather than from equipment failure or fading. The actual configuration for that experiment is shown in Fig. 11, and incorporates two hops and three stations designated HERE, BETWEEN, and THERE. Since this was a new route, it was decided that performance should be measured to answer the following important questions.

1. Does it meet outage objectives?

2. Does it meet DDS objectives?

3. Is fading a significant problem?

4. Does space diversity improve performance?

5. How does route performance relate to single hop performance?

6. What is the PFV (performance factor for voice)?

6.04 With this set of objectives, it is necessary to measure fading on both the primary and diversity channels, as well as record the fading encountered by the signal as it is switched between primary and diversity channels. In addition, it is necessary to isolate the hop performance from overall route performance. One way to accomplish the latter goal is to have two DS-1 channels available. If it is assumed that the P QUARK is installed at HERE, then one DS-1 signal could be inserted at HERE and looped at THERE. In that way, all four 1-way hops would be monitored in tandem. The second DS-1 signal could be inserted at BETWEEN and thus traverse only one hop. This way, the impact of fading on error performance on that hop can be measured. At this point, the minimum set of measurements which would satisfy these goals are:

1. Received signal level on primary antenna (AGC-1)

2. Received signal level on diversity antenna (AGC-2)

3. Protection switch status

4. Error performance on single hop DS-1 signal

5. Error performance on looped (entire route) DS-1 signal.

It might also be desirable to monitor CGA activity on some DS-1 signals traversing the route, particularly if there is one that has D bank terminations in both HERE and THERE. Multiplex reframe indications and other alarms would likely also prove interesting.

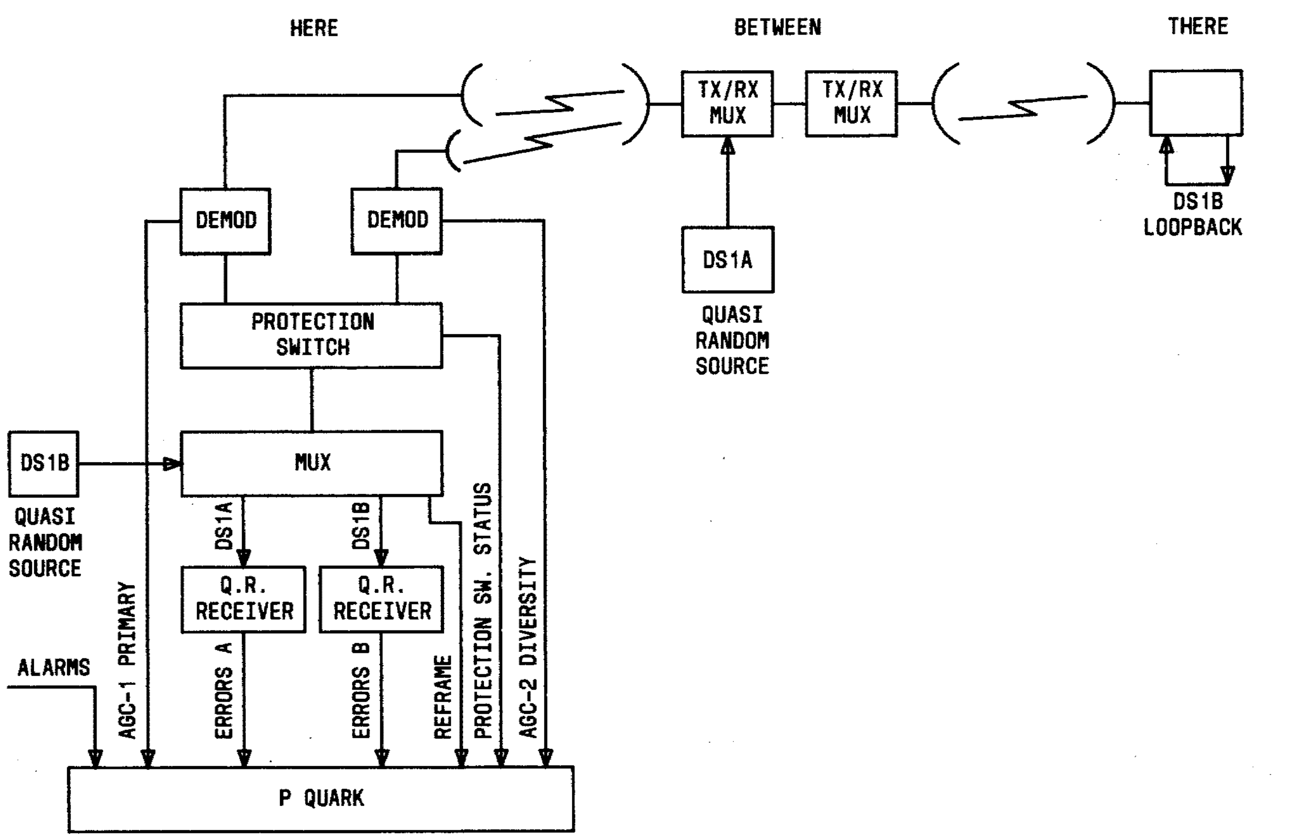

Fig. 11—Digital Radio Measurement Configuration for Performance Analysis

However, the emphasis will remain with the above signals. Note, that as shown on Fig. 11, two DS-1 quasi-random sources, and two receivers are required in addition to P QUARK in this setup. One of these receivers can also function as a source for transmitting the looped DS-1 signal. It should also be recognized that the objective of this experiment is performance analysis rather than troubleshooting, in which case different criteria might be used.

6.05 The log and statistics data collected from this experiment, together with its analysis, has been previously presented in Part 4, paragraphs 4.03 through 4.05. Having now emphasized the importance of planning in the acquisition of this data, reference can be made to the aforementioned paragraphs should a continuing discussion be desired.

C. Planning Checklist

6.06 The following list presents certain questions and facts to be considered in planning.

1. Reasons for P QUARK installation

   (a) Complaints of poor performance:

   (1) Troubleshoot?

   (2) Monitor?

   (b) New installation:

   (1) Troubleshoot?

   (2) Monitor?

   (3) Both?

   (c) Upgrading of older equipment:

   (1) Monitor only new portions?

   (2) Monitor all equipment?

   (d) Just to check things out:

   (1) Errors?

   (2) Status?

   (3) Fading?

   (4) Temperature?

   (5) All?

2. Location of installation

   (a) Central office:

   (1) Electrical noise environment?

   (2) People traffic?

   (3) Craft activity?

   (b) Remote location:

   (1) Telephone line available?

   (2) Temperature variations greater than 32°F to 100°F?

   (3) Power availability?

   (4) Accessibility?

   (5) Ventilation?

3. Required inputs and related considerations

   (a) Analog:

   (1) AGC or others?

   (2) Correct program plugs?

   (3) Shielded twisted pair for inputs?

   (4) Low impedance source?

   (b) Status:

   (1) Type of inputs—CGA, MUX REFRAME, protection switch?

   (2) Input levels—TTL, ECL, relay closure to ground, relay closure to a voltage, other relay closures?

   (3) Program plugs available?

   (4) Input connections—Are twisted, shielded pairs required? Is termination necessary?

   (c) Event counters:

   (1) Input levels—TTL, ECL, others? Must be between −5V and +5V with minimum

pulse width of 75 nanoseconds. (Threshold levels are −2.5 and +2.5 volts.)

(2) Input connection—Coax or twisted pair. Must terminate inputs: Usually 100 to 130 ohms for twisted pairs, and 50 to 75 ohms for coax.

4. Equipment for installation

(1) Oscilloscope with response to 100 MHz

(2) Digital voltmeter

(3) Attenuator to calibrate AGC

(4) Bowmar test sets as needed

(5) Alignment tool for slave ULD.

7. P QUARK SPECIFICATIONS

7.01 The following list itemizes specific P QUARK requirements and characteristics.

1. User interface inputs/outputs

(a) Universal level detector:

(1) Two inputs and outputs per slave: ULDA, ULDB, ULDATST, ULDBTST. Inputs (ULDA, ULDB) are balanced.

(2) Input frequency—<100 Hz

(3) Input voltage—±15V

(4) Input voltage range—0.1 to 30V

(5) Input resistance—1 megohm

(6) Input capacitance—<0.003 μF

(7) Input common mode rejection—40 dB at 60 Hz

(8) Maximum gain—20

(9) Output voltage range—+5.11 inactive, 0V active

(10) Output resistance—1 kohm

(11) Slicing levels—Adjustable to 1/100 of full scale at ULDTST

(12) Connection—45 mil square wire wrap terminals

(13) Level crossings—Latched.

(b) Status inputs:

(1) Six inputs per slave (STA0-STA5)

(2) Inputs are unbalanced comparators

(3) Input frequency—<100 Hz

(4) Input voltage—Determined by program plugs

(5) Input resistance—10 kohm

(6) Input time constant—100 μs

(7) Minimum pulse width—200 μs

(8) Minimum input swing—100 millivolts

(9) Input threshold—1/2 of input range

(10) Connection—45 mil square wire wrap

(11) Inputs are latched, read, and reset every 10 milliseconds.

(c) Event counter inputs:

(1) Five counters per slave, EC1 through EC5

(2) Input type—Balanced comparators

(3) Input frequency—6.5 MHz (7 MHz typical)

(4) Input pulse width—<75 nanoseconds

(5) Input resistance—4.7 kohm

(6) Input capacitance—20pf

(7) Input range—±5V

(8) Input threshold—±2.5V(adjustable)

(9) Minimum input swing—100 millivolts

(10) Input connection—45 mil square wire wrap.

2. Serial and parallel inputs and outputs

(a) Serial communications inputs and outputs (S1, S2):

(1) S1—DTE type RS232

(2) S2—DCE type RS232

(3) S1, S2 maximum transmit/receive rate—19 kbaud

(4) Data format—Even parity, 7 data bits, 1 stop bit

(5) Connection: 25 pin CINCH type (female).

(b) Parallel communications input/output (J2A): Bidirectional 8-bit port with 4 handshake lines, TTL type (220/330 ohm terminations needed at far end):

(1) Maximum transfer rate—100 kbytes/sec

(2) Connection: 25 pin CINCH type (male).

3. Power requirements: 110V ±10% ac at 0.7A.

8. ANCILLARY DOCUMENTATION

8.01 The following list comprises useful Bell System documentation. The application schematic is SD-99646-01.

EQUIPMENT CODE	TITLE	EQUIPMENT DRAWING	CIRCUIT DRAWING	CKT PER UNIT
ED-2C626-[ ]	AC Power Supply	ED-2C626	EPS-2C626-[ ]	1
ED-2C619-[ ]	Master	ED-2C619	EPS-2C619-[ ]	1
ED-2C620-[ ]	Bubble	ED-2C620	EPS-2C620-[ ]	1
ED-2C621-[ ]	UBE Slave	ED-2C621	ESP-2C621-[ ]	1 to 5
ED-2C622-[ ]	Termination	ED-2C622	EPS-2C622-[ ]	1
ED-2C623-[ ]	Programmable Devices	ED-2C623	MC-90000-01, 02 MC-90001-01, 02, 03, 04, 05, 06 microcode	
ED-2C624-[ ]	Component Carriers	ED-2C624		
ED-2C625-[ ]	Backplane	ED-2C625	EPS-2C625	1
ED-2C627-[ ]	Cable Assy.	ED-2C625		
J98739A	P QUARK Assy.		SD-99646-01-[ ]	1

OTHER DOCUMENTATION

8.02 The following list may be used for additional information.

SECTION	DESCRIPTION
592-034-100	212A Data Set Description
592-034-200	212A Data Set Installation

NUMBER	DESCRIPTION
PA-351155	P QUARK User's Manual

FUNCTION (NOTE 1)	SAMPLING RATE	COL / ROW	1	2	3	4	5	6	TIME / EVENT
PRIMARY RX (TIME FADED BELOW)	10 ms	1	5dB 1	15dB 2	20dB 3	25dB 4	30dB 5	40dB 6	T
(NO. OF OCCURRENCES)	10 ms	2	7	8	9	10	11	12	E
DIVERSITY RX (TIME FADED BELOW)	10 ms	3	5dB 13	15dB 14	20dB 15	25dB 16	30dB 17	40dB 18	T
(NO. OF OCCURRENCES)	10 ms	4	19	20	21	22	23	24	E
IDEAL (BETTER OF TWO ABOVE)	10 ms	5	5dB 25	15dB 26	20dB 27	25dB 28	30dB 29	40dB 30	T
	10 ms	6	31	32	33	34	35	36	E
ACTUAL (SWITCHED)	10 ms	7	5dB 37	15dB 38	20dB 39	25dB 40	30dB 41	40dB 42	T
	10 ms	8	43	44	45	46	47	48	E
STATUS INPUTS (DURATION)	10 ms	9	DIV SW 49	CGA 50	MUX REFRAME 51	ALARM 52	ALARM 53	MUX SW 54	T
(NO. OF OCCURRENCES)	10 ms	10	DIV SW 55	CGA 56	MUX REFRAME 57	ALARM 58	ALARM 59	MUX SW 60	E
ERROR (ALL CAUSES)	1s	11	1-7 61	8-63 62	64-511 63	512-4K 64	4K-32K 65	>32K 66	E
ERRORS GIVEN A >15dB FADE	1s	12	1-7 67	8-63 68	64-511 69	512-4K 70	4K-32K 71	>32K 72	E
		13	73	74	75	76	77	78	
		14	79	80	81	82	83	84	
		15	85	86	87	88	89	90	
		16	91	92	93	84	95	NOTE 2 96	

LOCATION: ____________________

DATE: ____________________

PHONE: ____________________

PASSWORD: ____________________

ENGINEER: ____________________

NOTES:
1. SEE GLOSSARY FOR ABBREVIATIONS.
2. REGISTER 96 ALWAYS SHOWS THE TOTAL TIME (IN COUNT OF 10 ms) ELAPSED SINCE THE LAST PAGE RESET (ex: 8640000= 86400s = 1 day)

Fig. 12—Typical P QUARK Memory Page

FUNCTION (NOTE 1)	SAMPLING RATE	ROW \ COL	1	2	3	4	5	6	TIME / EVENT
ULDA	10 ms	1	LV0	LV1	LV2	LV3	LV4	LV5	T
	10 ms	2							E
ULDB	10 ms	3	LV0	LV1	LV2	LV3	LV4	LV5	T
	10 ms	4							E
IDEAL (BETTER OF ULDA &	10 ms	5	LV0	LV1	LV2	LV3	LV4	LV5	T
ULDB)	10 ms	6							E
ACTUAL	10 ms	7	LV0	LV1	LV2	LV3	LV4	LV5	T
	10 ms	8							E
STATUS (BINARY) INPUTS	10 ms	9	STA0 (NOTE 2)	STA1	STA2	STA3	STA4	STA5	T
	10 ms	10							E
EC1	1s	11	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC1/[X,7,3] (NOTE 1)	1s	12	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC2	1s	13	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC2/NO EC1	1s	14	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC2/EC1 "AND" [X,7,3]	1s	15	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC1	10 ms	16	1-7	8-63	64-511	512-4K	4K-32K	NOTE 3	E

LOCATION: ____________

DATE: ____________

PHONE: ____________

PASSWORD: ____________

ENGINEER: ____________

NOTES:
1. STA0 TO 5 ARE STATUS INPUTS; EC IS ERROR COUNTER; LV0 TO 5 ARE LEVELS; [X,Y,Z] NOTATION FOR SLAVE X, ROW Y, COLUMN Z
2. IF USING PROTECTION SWITCH STATUS INDICATOR, IT MUST BE CONNECTED TO STA0
3. TOTAL TIME (IN COUNT OF 10 ms) ELAPSED SINCE THE LAST PAGE RESET

Fig. 13—P QUARK Configuration 0

FUNCTION (NOTE 1)	SAMPLING RATE	ROW \ COL	1	2	3	4	5	6	TIME / EVENT
ULDA	10 ms	1	LV0	LV1	LV2	LV3	LV4	LV5	T
	10 ms	2							E
ULDB	10 ms	3	LV0	LV1	LV2	LV3	LV4	LV5	T
	10 ms	4							E
IDEAL (BETTER OF ULDA &	10 ms	5	LV0	LV1	LV2	LV3	LV4	LV5	T
ULDB)	10 ms	6							E
ACTUAL (SWITCHED)	10 ms	7	LV0	LV1	LV2	LV3	LV4	LV5	T
	10 ms	8							E
STATUS (BINARY) INPUTS	10 ms	9	STA0 (NOTE 2)	STA1	STA2	STA3	STA4	STA5	T
	10 ms	10							E
EC1	1s	11	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC2	1s	12	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC3	1s	13	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC4	1s	14	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC5	1s	15	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC1	10 ms	16	1-7	8-63	64-511	512-4K	4K-32K	NOTE 3	E

LOCATION: ____________

DATE: ____________

PHONE: ____________

PASSWORD: ____________

ENGINEER: ____________

NOTES:
1. EC IS ERROR COUNTER; STA0 TO 5 ARE STATUS INPUTS; LV0 TO 5 ARE LEVELS.
2. IF USING PROTECTION SWITCH STATUS INDICATOR IT MUST BE CONNECTED TO STA0
3. TOTAL TIME (IN COUNT OF 10 ms) ELAPSED SINCE THE LAST PAGE RESET

Fig. 14—P QUARK Configuration 1

FUNCTION (NOTE 1)	SAMPLING RATE	ROW \ COL	1	2	3	4	5	6	TIME / EVENT
ULDA	10ms	1	LV0	LV1	LV2	LV3	LV4	LV5	T
	10ms	2							E
ULDB	10ms	3	LV0	LV1	LV2	LV3	LV4	LV5	T
	10ms	4							E
IDEAL	10ms	5	LV0	LV1	LV2	LV3	LV4	LV5	T
	10ms	6							E
ACTUAL	10ms	7	LV0	LV1	LV2	LV3	LV4	LV5	T
	10ms	8							E
STATUS	10ms	9	STA0 (NOTE 2)	STA1	STA2	STA3	STA4	STA5	T
	10ms	10							E
EC1	1s	11	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC1/[X,7,3] (NOTE 1)	1s	12	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC1/[X,7,4] (NOTE 1)	1s	13	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC1/[X,7,5] (NOTE 1)	1s	14	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC1/[X,9,1] (NOTE 1)	1s	15	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC2	1s	16	1-7	8-63	64-511	512-4K	4K-32K	NOTE 3	E

LOCATION: ____________

DATE: ____________

PHONE: ____________

PASSWORD: ____________

ENGINEER: ____________

NOTES:

1. EC IS ERROR COUNTER; STA0 TO 5 ARE STATUS INPUTS; LV0 TO 5 ARE LEVELS; [X,Y,Z] NOTATION FOR SLAVE X, ROW Y, COLUMN Z
2. IF USING PROTECTION SWITCH STATUS INDICATOR IT MUST BE CONNECTED TO STA0
3. TOTAL TIME (IN COUNT OF 10 ms) ELAPSED SINCE THE LAST PAGE RESET

Fig. 15—P QUARK Configuration 2

FUNCTION (NOTE 1)	SAMPLING RATE	ROW \ COL	1	2	3	4	5	6	TIME / EVENT
ULDA	10 ms	1	LV0	LV1	LV2	LV3	LV4	LV5	T
	10 ms	2							E
ULDB	10 ms	3	LV0	LV1	LV2	LV3	LV4	LV5	T
	10 ms	4							E
IDEAL	10 ms	5	LV0	LV1	LV2	LV3	LV4	LV5	T
	10 ms	6							E
ACTUAL	10 ms	7	LV0	LV1	LV2	LV3	LV4	LV5	T
	10 ms	8							E
STATUS	10 ms	9	STA0 (NOTE 2)	STA1	STA2	STA3	STA4	STA5	T
	10 ms	10							E
EC1	1s	11	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC1/[X,7,3] (NOTE 1)	1s	12	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC1/[X,9,1] (NOTE 1)	1s	13	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC1/[X,9,3] (NOTE 1)	1s	14	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC2	1s	15	1-7	8-63	64-511	512-4K	4K-32K	> 32K	E
EC2/NO EC1	1s	16	1-7	8-63	64-511	512-4K	4K-32K	NOTE 3	E

LOCATION: ____________________

DATE: ____________________

PHONE: ____________________

PASSWORD: ____________________

ENGINEER: ____________________

NOTES:

1. EC IS ERROR COUNTER; STA0 TO 5 ARE STATUS INPUTS; LV0 TO 5 ARE LEVELS; [X,Y,Z] NOTATION FOR SLAVE X, ROW Y, COLUMN Z
2. IF USING PROTECTION SWITCH STATUS INDICATOR, IT MUST BE CONNECTED TO STA0
3. TOTAL TIME (IN COUNT OF 10 ms) ELAPSED SINCE THE LAST PAGE RESET

Fig. 16—P QUARK Configuration 3

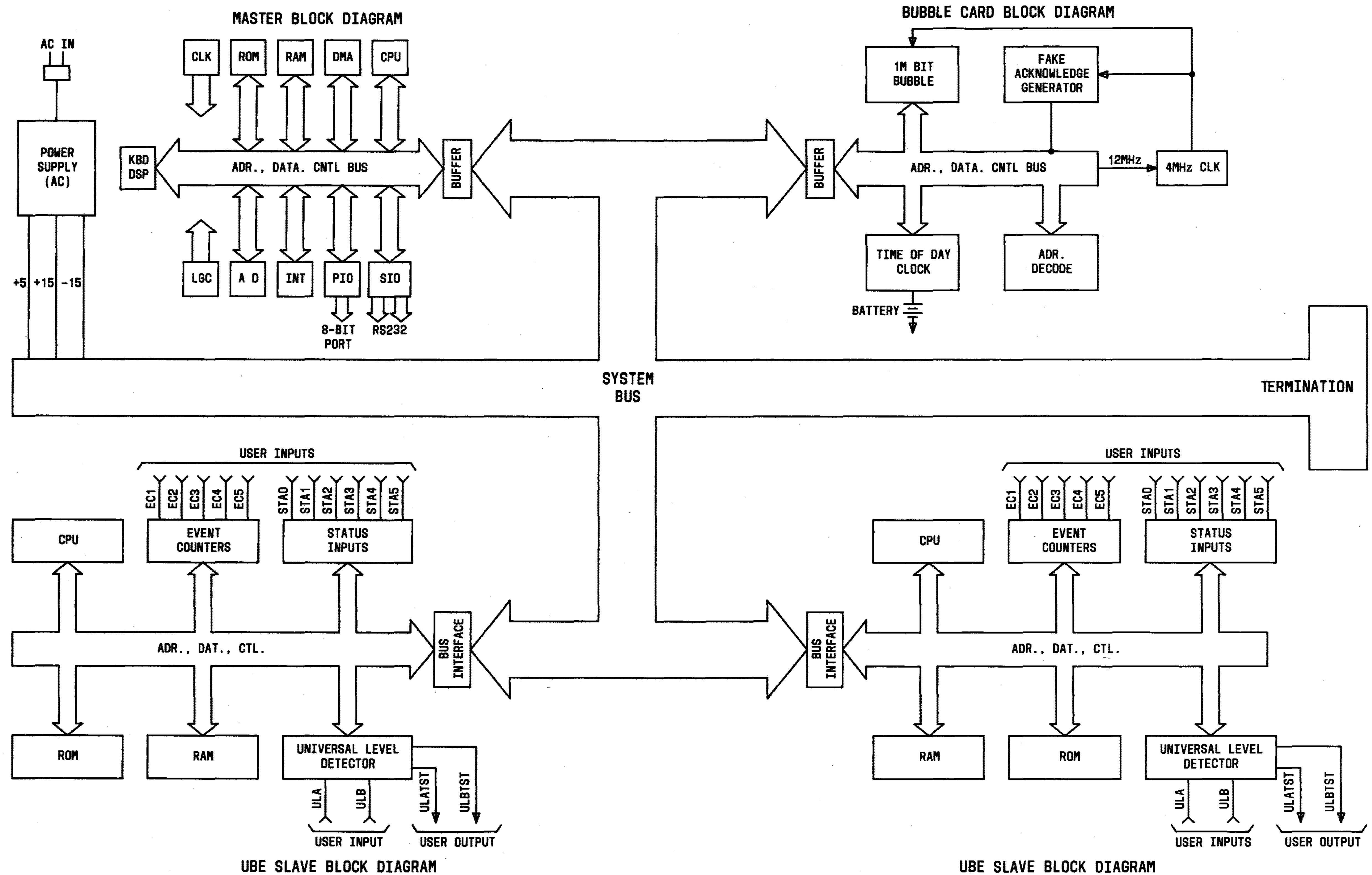

Fig. 17—P QUARK Architecture With Two Slaves