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SANDUS
MA164 Digital Data Acquisition System Specifications

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SANDUS

MA164 DIGITAL DATA ACQUISITION SYSTEM

SPECIFICATIONS

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SANDUS

MA164 DIGITAL DATA ACQUISITION

SYSTEM SPECIFICATIONS,

July 9, 1987

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ABSTRACT

The SANDUS will accept data from up to 128 unique analog channels and up to 88 eight bit digital channels. This system is capable of simultaneously conditioning, amplifying, digitizing, and internally storing the data from all channels. The channels record analog signals with amplitudes in the range of 1 mV to 10 V at frequencies from dc to 100 KHz, with accuracy to 99.976%, and/or signals with amplitudes in the range of 8 mV to 4 V at frequencies from dc to 10 MHz, with accuracy to 99.61%. The digitized data is continually output to a remote location for processing. The entire system may be controlled locally, remotely, or automatically in adverse electrical and environmental locations. Appendix 2 has been included to facilitate the withdrawal of any system drawing from the Sandia Film Bank.

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FIGURES

SANDUS GENERAL SPECIFICATIONS

The SANdia Digital Underground System (SANDUS) is a digital data acquisition system capable of collecting data from up to 128 unique analog channels. Each input signal (DC to 10MHz) has its own dedicated signal conditioner, amplifier and data module. The entire system may be set up and controlled via a local or remotely located computer.

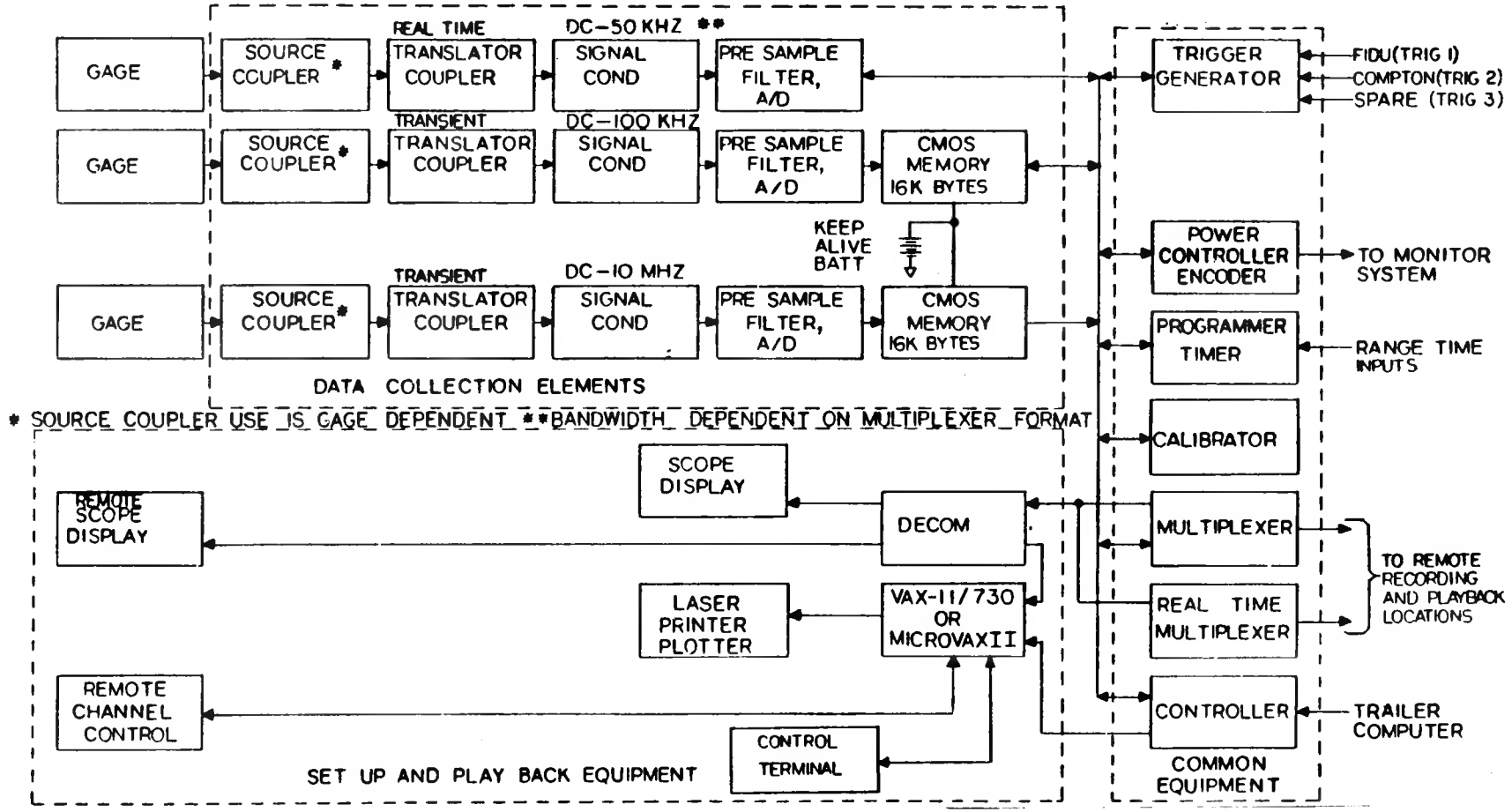
Figure 1 is a simplified diagram of the SANDUS system.

A normal SANDUS contains all the equipment necessary to set up and operate the data collection system. It contains the data collection elements and several elements referred to as common equipment and setup and playback equipment.

> The data collection elements are the source and translator couplers, signal conditioners/amplifiers, data modules and service modules (crates). The signal conditioners/amplifiers provide for bridge completion, calibration and line termination, and for signal gains from less than 1 up to 10,000 (variable). The data modules contain the presample filters, sample rate control (up to 50 million samples per second), trigger controls, analog to digital converters and internal memories. The crates provide power, decode commands and interface the signal conditioner/amplifier and the data modules with the common equipment. Each crate pair controls up to eight signal conditioners and data modules.
>
> The common equipment provides a means to initiate automatic countdowns, provide arms and triggers for the data modules, calibrate the system, control all set up parameters, and provide for output of the digitized data. Each of these functions may be controlled and operated from a remote location.
>
> The test equipment provides communication, calibration equipment and quick look data displays.
>
> The computer provides a means to set up and test the individual channels, and to store and plot the data for analysis.

Gauge signals may be recorded in one of two ways. They may be digitized and output as real time data to a remotely located tape recorder, computer or memory, or they may be taken as transient data and stored in internal 16K memories (battery backed up), for immediate or later readout and processing.

The SANDUS system is designed to take simultaneous samples on all channels that are operated at the same sample rate. This provides a means of directly comparing gauges from similar experiments and accurately time tagging data samples.



MA164 DIGITAL SYSTEM
FIGURE 1

SANDUS DESIGN PHILOSOPHIES

The SANDUS and subsets of the SANDUS (TA698 ACE, TA649 Closure Multiplexer, TA718 High Resolution Sequential Data Logger) have been designed using the following design philosophies.

1. Strive for a complete system, including signal conditioning, amplification, calibration, A/D data conversion, recording, and data playback and analysis.

2. All elements must be interchangeable between SANDUSs. A data module may be plugged into any slot in any crate.

3. Make different kinds of modules look alike to the operator. Setting up a 100KHz module is the same as setting up a 10MHz module.

4. Design the system for as much flexibility as possible. The capability to be remotely controllable and programmable is essential. Build to a modular configuration. Be open to changes and additions for new types of experiments. This is where the Closure Multiplexer, Integrator Multiplexer and binary channels came from. Flexibility adds complexity, it also tends to add non standard elements. These deviations from the normal system design must be kept as manageable as possible.

5. Design for underground test environment: rapid data read out and battery backup on memories and setup parameters. It is essential that the data be resident in nonvolatile memory before the event ground shock arrives at the recording equipment. This time is normally about 120 msec after zero time.

6. Strive for automated diagnostics, setup and verification of setup parameters. There are many diagnostic routines built into the program called DHTEST. Nearly all parameters of the data module are thoroughly checked, plus most of the parameters in the common equipment. For a complete description of test procedures see SANDUS Low Frequency Module Test Routines, SAND86-1396 by James M. Opalka of Division 7121. For a complete description of the use of these test procedures to thoroughly check out a SANDUS system, see SANDUS Checkout Procedure, SAND87-1734 by David K. Werling of Division 7121.

Redundancy has been built into the SANDUS such that any single point failure will not lead to a catastrophic loss of data:

1. The SANDUS is powered from a three phase AC source, and each equipment rack within is powered redundantly. If the prime AC phase fails, the secondary takes over. The SANDUS

will operate correctly with any single phase lost. Approximately two thirds of the system would still be operational if two phases are lost.

2. The TA566A Power Controller/Encoder is designed as a redundant element including the power supplies and AC source. Power control to each piece of essential equipment is backed up within the TA566A.

3. The TA488B Trigger Generator is designed as a redundant element including the power supplies and AC source. The Master Oscillator, Arms and Triggers (for writing data into memory) are all backed up within the TA488B. In addition, a third oscillator is contained within the TA493B Crate Decode 2 Card.

4. The digitized data is continuously being fed into the data stream, both during memory fill and after the memory is full, controlled by the TA484A Digital Multiplexer or TA618 Real Time Multiplexer. This cyclic dump ensures good data even if the data bit stream momentarily loses sync, such as with zero time noise.

5. The digitized data is not only stored down hole in nonvolatile memory, but also in the Remote Recording Facility on magnetic tape or in the mass memory units.

6. The data module memory starts filling when an Arm signal is received by the module. When the selected trigger signal is received, the memory continues to fill to the desired memory size (4K, 8K or 16K bytes), less pretrigger samples (0 or 512 bytes), less eight bytes for sync and status. The sync and status words are written into memory last, then the memory address counters back up by eight addresses such that the sync word is the first word out of memory. This accomplishes a faster readout of the most important data in case the data stream is lost soon after zero time. The first words out of memory are sync and status, then the pretrigger samples, then the the posttrigger samples.

7. The multiplexers may be configured such that the channels are formatted in up to five data streams. This will output the memory data at a 100 MBit per second rate to ensure that all data is out of the recording system before the arrival of ground shock.

8. The ability exists through the Command Link to remotely set up the entire system including power up and power down. The remote monitor stream gives a continuous indication of the health status of the system. If a serious problem is detected, it may be possible to correct it from the Remote Recording Facility before it becomes catastrophic.

DATA COLLECTION ELEMENTS

TA506A SOURCE COUPLER

The source couplers are designed to be located as close to the gauge as practical. They are used for bridge completion and balancing, calibration, providing special control signals to non standard experiments, and interfacing the gauge cabling to the Low Noise Cable (LNC).

This element is only required when it is desired to complete bridges near the active gauge elements, when special calibration control signals are required, and/or when improved signal to noise, and earlier recovery from any zero time noise is essential.

Two types of printed circuit (PC) boards are available for use in the source couplers. One board is completed except for bridge completion resistors and shunt calibration resistors. The other PC board is designed to be built up however the experiment dictates.

Inputs: The TA506A will accept various type gauge cables and configurations. Some of the more common cabling types are single ended or differential coaxial, shielded twisted pair cable, four conductor shielded cable, and shielded thermocouple wire.

Bridge Excitation: Excitation voltage of 1.5 to 15 volts DC at up to 150 milliamperes may be supplied to gauges, bridge completion resistors and shunt calibration resistors from the TA590 Signal Conditioners.

Bridge Completion Circuitry: Resistor locations are provided to complete one, two or three arm bridges. A balancing network is included to remove small gauge imbalances.

Calibration: Various type calibrations may be performed using the source coupler. Some of the more common types are Zero and Shunt Calibration (reference TA489A Calibrator).

External Control: For special experiment calibration, three unique relay closures may be actuated. In addition, various calibration voltages are available for special experiment calibration requirements.

Outputs: The TA506A is designed to operate into the Low Noise Cable, but may be configured to operate into TSP (Twisted Shielded Pair) cable through a MS14-15 connector.

LOW NOISE CABLE AND CONNECTORS

A special Low Noise Cable (LNC) may be used to minimize common mode noise. The cable consists of four RG-58 type coaxial cables with dual braided shields and five control lines (four 20 gauge plus one 18 gauge stranded wires). The shields of the coaxial cables are continuously common to each other and the entire cable bundle is twisted. In addition, an overall cable shield consisting of one braided shield covered by two aluminum mylar shields which in turn is covered by the final braided shield and an outer insulating jacket is included. The LNC is used in conjunction with the TA506A Source Coupler when it is desired to complete bridges near the active gauge elements, when special calibration control signals are required, and/or when improved signal to noise, and earlier recovery from any zero time noise is essential. Figure 2 shows an end view of the cable. The coaxial cables are used for gauge signals, calibration voltages or excitation voltages; the control lines are used for calibration relay control in the TA506A Source Coupler.

A quick disconnect connector is provided to mate the LNC with the TA506A Source Coupler and TA510A through TA514A Translator Couplers.

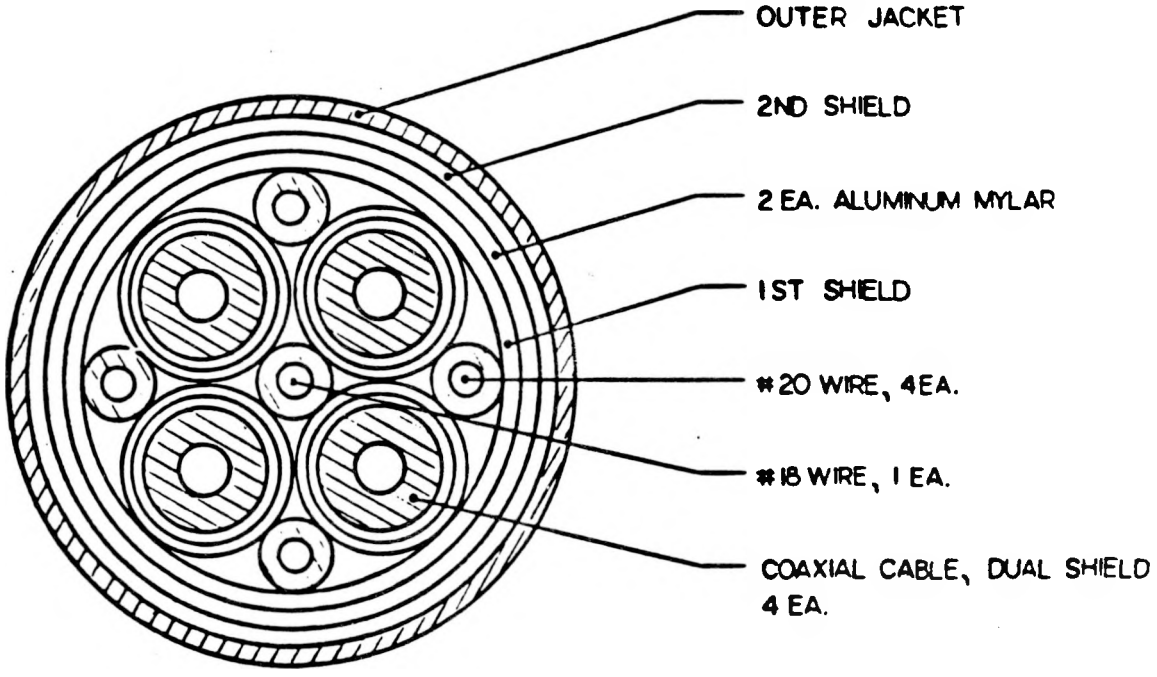


FIGURE 2 LOW NOISE CABLE (LNC)

TRANSLATOR COUPLERS

All translator couplers are located in the SANDUS intrusion panel (window). They are used to transfer data signals from external sources to the SANDUS equipment and calibration signals and excitation voltages from the SANDUS equipment to the external sources (gauges).

TA510A TRANSLATOR COUPLER (LNC)

The TA510A Translator Coupler is designed to keep shield currents from entering the SANDUS.

Inputs: This translator coupler accepts the Low Noise Cable connectors. The outer shields of the LNC are connected to the environmental enclosure at the translator coupler inputs.

Attenuation: Provisions have been made such that BNC type in line attenuators may be installed in the data lines.

Outputs: The outputs are connected to the signal conditioner crates via coaxial cables and control lines. This is the standard SANDUS data cable which contains four RG188 coaxial cables and five 20 AWG wires terminated with an AMP 206708-1 connector on each end.

TA511A TRANSLATOR COUPLER (TSP with MS3120E14-15S Connector)

The TA511A Translator Coupler is designed to interface various twisted shielded pair (TSP) cables to the standard SANDUS data cable. The TSP's shield is connected to the environmental enclosure at the input to the TA511A Translator Coupler.

Inputs: This translator coupler accepts differential signals through a MS3120E14-15S Connector. A variety of two and four wire shielded cables may be used.

Outputs: The outputs are connected to the signal conditioner crates via coaxial cables and control lines. This is the standard SANDUS data cable which contains four RG188 coaxial cables and five 20 AWG wires terminated with an AMP 206708-1 connector on each end.

TA512A TRANSLATOR COUPLER (HN)

The TA512A Translator Coupler is designed to accept single coaxial inputs. The coaxial cable shield is connected to the environmental enclosure at the input to the TA512A Translator Coupler.

Input: Single HN coaxial connector.

Attenuation: Space is available for a BNC type in line attenuator.

Outputs: The outputs are connected to the signal conditioner crates via coaxial cables and control lines. This is the standard SANDUS data cable which contains four RG188 coaxial cables and five 20 AWG wires terminated with an AMP 206708-1 connector on each end.

TA513A TRANSLATOR COUPLER (TWINAXIAL)

The TA513A Translator Coupler is designed to accept twinaxial inputs.

The twinaxial cable shield is connected to the environmental enclosure at the input to the TA513A Translator Coupler.

Input: Single Twinaxial Connector.

Attenuation: Provisions have been made such that BNC type in line attenuators may be installed in the data lines within the TA513A.

Outputs: The outputs are connected to the signal conditioner crates via coaxial cables and control lines. This is the standard SANDUS data cable which contains four RG188 coaxial cables and five 20 AWG wires terminated with an AMP 206708-1 connector on each end.

TA514A TRANSLATOR COUPLER (TSP with MS3120E14-19S Connector)

The TA514A Translator Coupler is designed to interface various twisted shielded pair cables (TSP) to the standard SANDUS data cable. The TSP shield is connected to the environmental enclosure at the input to the TA514A Translator Coupler.

Inputs: This translator coupler accepts differential signals through a MS3120E14-19S Connector. A variety of two and four wire shielded cables may be used.

Outputs: The outputs are connected to the signal conditioner crates via coaxial cables and control lines. This is the standard SANDUS data cable which contains four RG188 coaxial cables and five 20 AWG wires terminated with an AMP 206708-1 connector on each end.

TA590-1 DC TO 100 KHz SIGNAL CONDITIONER

The TA590-1 100 KHz Signal Conditioner, shown in Figure 3 is one of the two types of signal conditioner/amplifiers used in the SANDUS system. Two PC boards and interconnecting hardware make up the TA590-1 module.

Signal Conditioner Features

Line Termination

The signal lines are nominally terminated at the rear of the TA493A Signal Conditioner Crate. Provisions are made to optionally terminate the signal lines directly on the module.

Bridge Completion Circuitry

Through the installation of a 24 pin dual in line package component carrier, (see Figure 16) two resistor locations are provided to complete two or three arm bridges. A balancing network may also be included on the carrier to optionally remove any small gauge imbalances.

Calibration/Module Tests

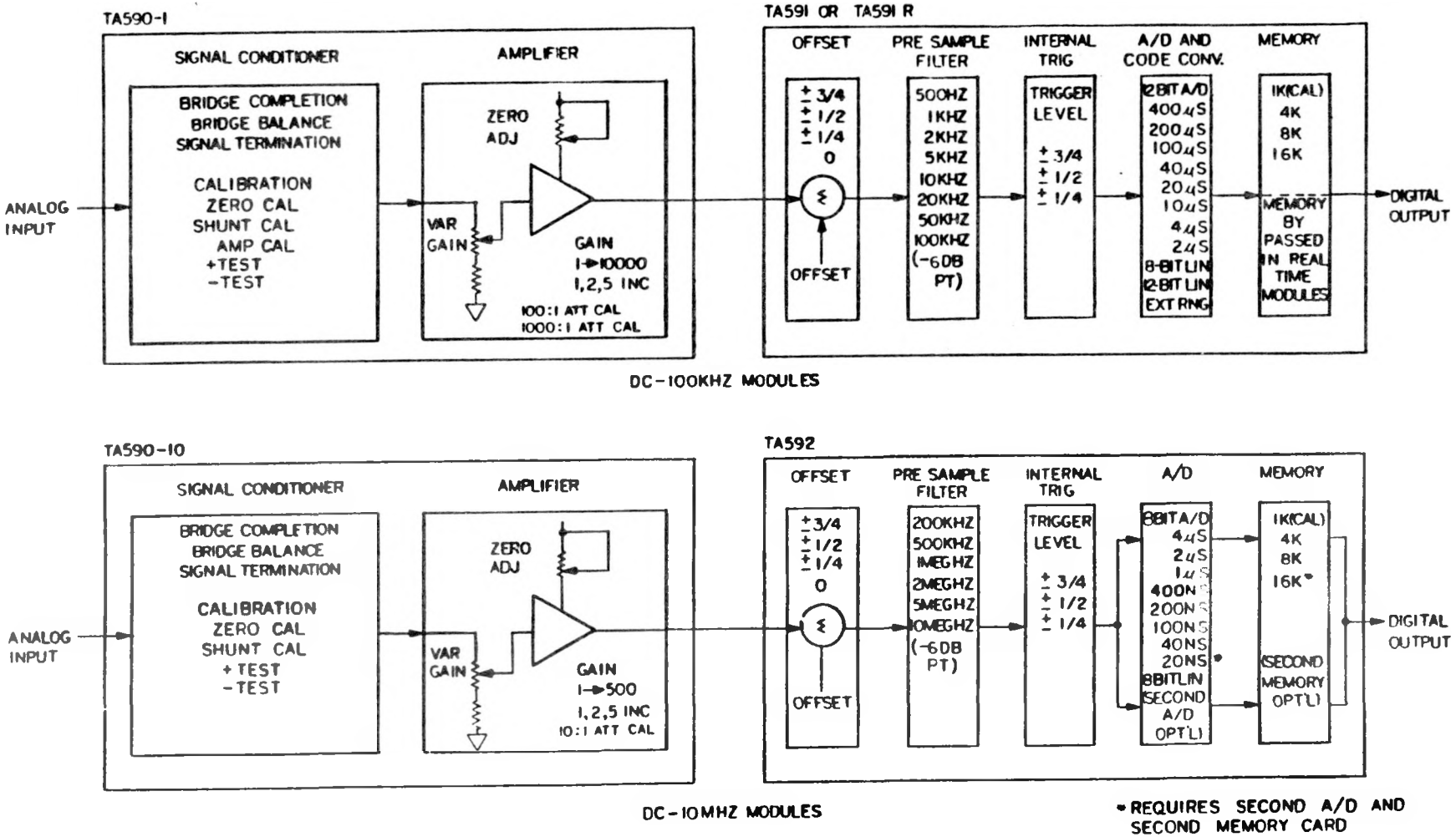
Five types of calibration are allowed using the TA590-1 Signal Conditioner (reference TA489A Calibrator for an explanation of each). These are all remotely controllable via the Command Link (TA485A Controller).

1. Zero Calibration
2. Shunt Calibration
3. Voltage Amplifier Calibration
4. Voltage Attenuator Calibration 100:1
5. Voltage Attenuator Calibration 1000:1

Two amplifier checks may be performed using the twelve bit internal D/A Converter.

1. Plus Internal Test
2. Minus Internal Test

Calibration and internal tests are controlled via the TA485A Controller, TA489A Calibrator and/or the front panel. Front panel controls may be used to actuate zero calibration, shunt calibration, and plus and minus internal test.



SIGNAL CONDITIONERS & DATA MODULES
FIGURE 3

Bridge Excitation

Constant Voltage Supply

The isolated output voltage, front panel switch enabled, is 1.5 to 15 volts continuously adjustable via the front panel, with a rated current capacity of 150 milliamperes.

Amplifier Features

Input (see Figure 4)

Differential

The amplifier may be operated single ended with no degradation in normal mode performance. To operate single ended, the negative input must be connected to signal common (normally at the channel termination at the rear of the TA493A Signal Conditioner Crate).

Differential Input Impedance (see Figure 4)

196K Ohm
1.1 Meg Ohm each leg to signal common

Single Ended Input Impedance

187K Ohm

Common Mode Rejection

81 DB at 100KHz

Common Mode Voltage

Plus and minus 8.2 volts minimum before clipping through VR1 and VR2 (see Figure 4)

Normal Mode Voltage

Plus and minus 10 Volts before amplifier saturation

Frequency Response

DC-100KHz (-3DB at 100KHz)

Voltage Gain

1 to 10,000 in 1, 2, 5 increments. Gain settings may be remotely set up through the Command Link (reference TA485A Controller).

Variable gains are provided at all gain settings by

adjustment of the front panel variable gain control. When the variable gain adjustment is out of the calibrated position a front panel LED is illuminated.

NOTE: The channel must be operated as a bipolar channel when variable gain is used.

Output

Single Ended

Output Impedance

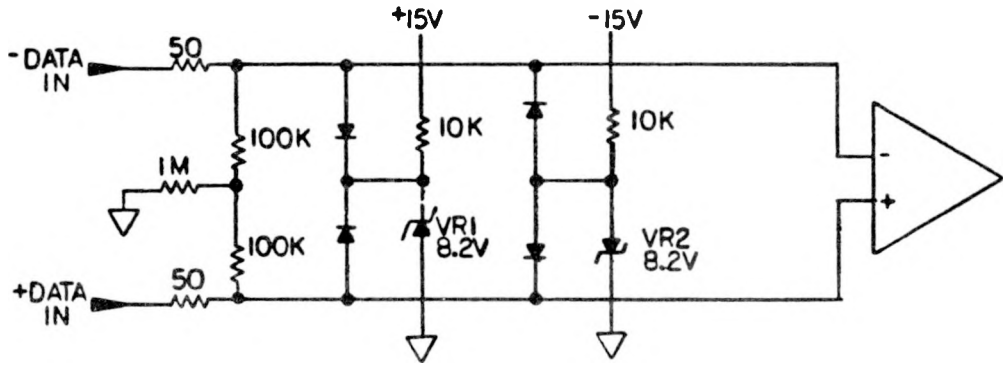
Less than 2 ohms

Output Voltage Swing

Plus and minus 5 volts (calibrated gain position only) into 10K Ohms (TA591 Data Module input impedance)

Output Zero Adjust

A front panel adjustment is provided to allow zeroing of the amplifier's input.



100 KHZ AMPLIFIER INPUT
FIGURE 4

TA590-10 DC TO 10MHz SIGNAL CONDITIONER

The TA590-10 Signal Conditioner shown in Figure 3, is one of the two types of signal conditioner/amplifiers used in the SANDUS. Two PC boards and interconnecting hardware make up the TA590-10 module.

Signal Conditioner Features

Line Termination

The signal lines are nominally terminated at the rear of the TA493A Signal Conditioner Crate. Provisions are made to optionally terminate the signal lines directly on the module.

Bridge Completion Circuitry

Through the installation of a 24 pin dual in line package component carrier, (see Figure 16) two resistor locations are provided to complete two or three arm bridges. A balancing network may also be included on the carrier to optionally remove any small gauge imbalances.

Calibration/Module Tests

Four types of calibration are allowed using the TA590-10 Signal Conditioner (reference TA489A Calibrator for an explanation of each). These are all remotely controllable through the Command Link (TA485A Controller).

1. Zero Calibration
2. Shunt Calibration
3. Voltage Amplifier Calibration
4. Voltage Attenuator Calibration 10:1

Two amplifier checks may be performed using the twelve bit internal D/A Converter.

1. Plus Internal Test
2. Minus Internal Test

Calibration and internal tests are controlled via the TA485A Controller, TA489A Calibrator and/or the front panel. Front panel controls may be used to actuate zero calibration, shunt calibration, and plus and minus internal test.

Bridge Excitation

Constant Voltage Supply

The isolated output voltage, front panel switch enabled, is 1.5 to 15 volts continuously adjustable via the front panel, with a rated current capacity of 150 milliamperes.

Amplifier Features (see Figure 5)

Input

Differential

The amplifier may be operated single ended with no degradation in normal mode performance. To operate single ended, the negative input must be connected to signal common (normally at the channel termination at the rear of the TA493A Signal Conditioner Crate).

Differential Input Impedance (see Figure 5)

2 Meg Ohm
1 Meg Ohm each leg to signal common

Single Ended Input Impedance

1 Meg Ohm

Common Mode Rejection

52 DB at 100KHz
45 DB at 10MHz

Common Mode Voltage

Plus and minus 4.5 volts minimum before clipping through VR1 and VR2 (see Figure 5)

Normal Mode Voltage

Plus or minus 4 Volts minimum before amplifier saturation

Frequency Response

DC-10MHz (-3DB at 10 MHz)

Voltage Gain

1 to 500 in 1, 2, 5 increments. Gains may be remotely set through the Command Link (reference TA485A Controller).

Variable gains are provided at all gain settings by adjustment of the front panel variable gain control. When the variable gain adjustment is out of the calibrated position a front panel LED is illuminated.

NOTE: The channel must be operated as a bipolar channel when variable gain is used.

Output

Single Ended

Output Impedance

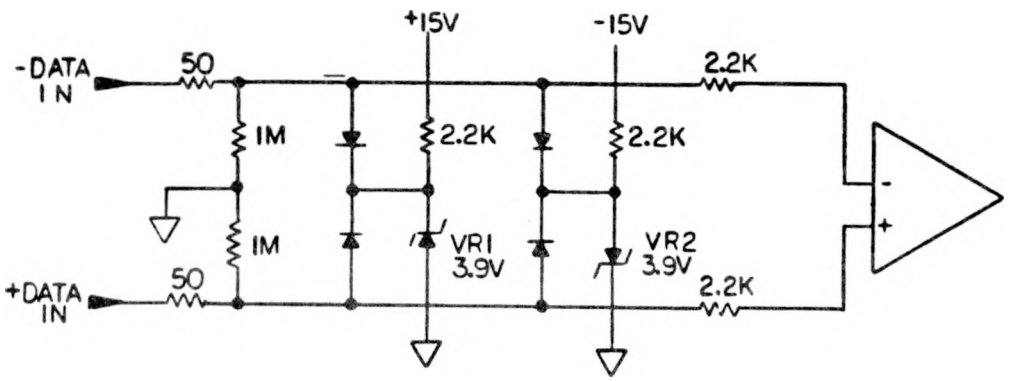
Less than 2 ohms.

Output Voltage Swing

Plus or minus 4 volts (calibrated gain position only) into 50 ohms (TA592 Data Module input impedance).

Output Zero Adjust

A front panel adjustment is provided to allow zeroing of the amplifier's input.



10 MHZ AMPLIFIER INPUT
FIGURE 5

TA591 DC TO 100 KHz DATA MODULE

The TA591 Data Module shown in Figure 3, is the "low frequency" data module. Three PC boards are required to make a single module: an analog to digital (A/D) board, a memory board and a control board.

The module may be operated in one of three modes.

1. As a transient data recorder (TA591M) with individually set up parameters and with 4, 8 or 16 kilo bytes of internal memory. The memory operates in a transparent mode while it is filling, that is, the input data is present on the output lines while the memory is being written.

2. As a real time module (TA591R) with individually set up parameters but at a fixed sample rate (determined by the TA484A Digital Multiplexer or the TA618 Real Time Multiplexer), with the only limit on record time being the recording medium at the remote recording facility.

   To operate as a real time module the memory PC board is replaced by a real time memory board.

3. As a digital module (TA591D) where individual digital bits may be recorded as transient data or as real time data. This module optically isolates and buffers the input signals, and the sample rate selects the speed of recording. No signal conditioner module is used when the data module is used as a digital module.

   To operate as a digital module, the A/D PC board is replaced by a special buffer board (S79685)

Input Analog Signal

10V p-p into 10K ohms

Input Digital Signals (Digital Data Converter)

Any combination of eight TTL levels or switch closures

Input Data Offset Selection

The data input is offset to match the expected signal from individual gauges. These offset settings may be remotely set through the Command Link (reference TA485A Controller). The offset value defines the zero volt level of the data.

```
plus  3/4 Full Scale -  (Data Band = plus 1.25V
plus  1/2 Full Scale     to minus 8.75V)
plus  1/4 Full Scale
       0  Center Band -  (Data Band = plus 5V
minus 1/4 Full Scale     to minus 5V)
minus 1/2 Full Scale
minus 3/4 Full Scale
minus     Full Scale -   (Data Band = 0V to
                          plus 10V)
```

Pre Sample Filter Selection

The presample filter is a low pass filter used to condition the data to prevent aliasing. The following -3dB filter settings may be remotely set through the Command Link (TA485A Controller). The data sample rate is typically selected to be five times the filter cutoff frequency.

```
500 Hz
  1 KHz
  2 KHz
  5 KHz
 10 KHz
 20 KHz
 50 KHz
100 KHz
200 KHz  (Filter Bypassed, the amplifier
                acts as the filter)
```

A/D Conversion

The A/D Converter is a twelve bit successive approximation type of converter. Successive approximation is a conversion method that compares in sequence a series of binary weighted values with the analog input to produce an output digital word in just "n" steps, where "n" is the resolution in bits.

Master Oscillator

The data module accepts a 50MHz oscillator signal from the TA493B Data Module Crate Decode 2 Board. The decode board receives this signal from the TA488B Trigger Generator and regenerates it as the master clock. This clock is divided on the data module's control board to create individual sample intervals for each data module.

Sample Interval (Transient Modules)

The following are the normal sample intervals provided by the data module. They may be remotely set through the Command Link (TA485A Controller):

400 usec/sample	(2.5K samples/sec)
200 usec/sample	(5K samples/sec)
100 usec/sample	(10K samples/sec)
40 usec/sample	(25K samples/sec)
20 usec/sample	(50K samples/sec)
10 usec/sample	(100K samples/sec)
4 usec/sample	(250K samples/sec)
2 usec/sample	(500K samples/sec)

Sample Interval (Real Time Modules)

Sample intervals for the real time modules are controlled by the TA484A Digital Multiplexer or the TA618 Real Time Multiplexer.

The minimum sample interval is 4us (250K samples/sec). There is no maximum sample interval but if a one millisecond sample interval is exceeded the internal presample filters become ineffective to prevent possible aliasing errors. External presample filters should then be provided.

Data Conversion

The following data conversions are provided; each may be set through the Command Link (TA485A Controller):

1. Eight Bit Linear, LSB ~ 39.1mv (10V full scale)

2. Twelve Bit Linear, LSB ~ 2.44mv (10V full scale)

3. Extended Range, a mode where twelve bit data is converted but only eight bit data is output. The dynamic range resolution is approximately six bits throughout the range, regardless of the signal amplitude. The output may be described as approximately twelve bit resolution near center band but decreases to approximately six bits near the band edges. This conversion is used in place of twelve bit to increase the record time on transient modules, since twelve bit automatically decreases the maximum memory size to 8 kilo samples.

Module Arm (Transient Modules)

This signal causes the module to start data conversion and storing of the data in memory.

The module will accept one of three different arm signals:

1. Arm initiated via the TA485A Controller (Command Link).

2. Crate arm from the TA488B Trigger Generator, which is originated by either the TA486A Programmer Timer (range time signals) or the TA489A Calibrator.

3. Manual arm from the TA493B Crate Decode Board.

Trigger Inhibit (Transient Modules)

This signal is generated by the TA488B Trigger Generator and distributed to all Data Modules within the system. Each module may individually be programmed through the Command Link (TA485A Controller) to accept or reject this signal. When inhibit is enabled and the signal is present, no trigger will be accepted, with the exception of External Trigger A, but only when the module is in Calibration Mode. The Trigger Inhibit signal is used to prevent premature triggering due to zero time noise for modules which are to be triggered after zero time (at plus time).

Trigger Mode (Transient Modules)

There are four different trigger modes. The trigger mode function and internal trigger level may be set through the Command Link (TA485A Controller).

1. Manual (Command Link, TA485A Controller)

2. External A (bussed signal from TA488B Trigger Generator on crate basis, or manually created on the TA493B Crate Decode 2 Board, also the Calibration Trigger Signal)

3. External B (bussed signal from TA488B Trigger Generator on crate basis or manually created on the TA493B Crate Decode 2 Board)

4. Internal (trigger on signal)

   The module will trigger when the signal reaches one of the following programmable levels:

   Internal Trigger Levels

   plus 3/4 Full Scale
   plus 1/2 Full Scale
   plus 1/4 Full Scale
   0 (Center Band)
   minus 1/4 Full Scale
   minus 1/2 Full Scale
   minus 3/4 Full Scale

   The internal trigger level is dependent on the offset plus the signal level. The above list is based on an input data offset of zero (center

band). For more details regarding the use of this option, refer to SAND87-1736, TA591 100 KHz Data Module Operation and Maintenance Manual, by David K. Werling, Division 7121.

Pre Trigger Samples (Transient Modules)

Pre trigger samples are data samples saved prior to the receipt of the trigger signal. There are two settings, either of which may be set through the Command Link (TA485A Controller):

	8 Bit Linear & Extended Range	12 Bit Linear
1.	0 Samples	0 Samples
2.	512 Samples	256 Samples

Memory Size

The available memory size is dependent on the mode of data conversion programmed and the actual memory size programmed into the module. Each of these functions may be set through the Command Link (TA485A Controller).

8 Bit Linear & Extended Range	12 Bit Linear
0 (real time)	0 (real time)
1K (Calibrate only)	512 (Calibrate only)
4K samples	2K samples
8K samples	4K samples
16K samples	8K samples

Memory Type

CMOS technology (32 each 4K X 1)

The memories retain data for a minimum of ten days without external power using batteries contained within the TA493B Crates.

Record Time (Transient Modules)

Normal record time is a function of the memory size and sample interval, each of which may be programmed through the Command Link (TA485A Controller). The following list shows the approximate total record time with no pretrigger samples:

Sample Interval	Memory Size 4K	8K	16K
2 usec	8.19 msec	16.4 msec	32.8 msec
4 usec	16.4 msec	32.8 msec	65.5 msec
10 usec	40.7 msec	81.9 msec	164 msec
20 usec	81.9 msec	164 msec	328 msec
40 usec	164 msec	328 msec	655 msec
100 usec	410 msec	819 msec	1.64 sec
200 usec	819 msec	1.64 sec	3.28 sec
400 usec	1.64 sec	3.28 sec	6.55 sec

Record Time (Real Time Modules)

Record time is a function of the recording facility external to the SANDUS and AC power supplied to the SANDUS.

If a computer logging program is used the record time is virtually unlimited as long as the SANDUS remains powered. If the data is recorded on a tape machine it is limited to the record time of the tape machine.

Memory Organization (Transient Modules)

The memory starts filling when an Arm signal is received by the module. When the selected trigger signal is received, the memory continues to fill to the selected memory size (4K, 8K or 16K), less pretrigger samples (0 or 512), less eight bytes for sync and status. The sync and status words are written into memory last, then the memory address counters back up by eight addresses such that the sync word is the first byte out of memory. This accomplishes a faster readout of the most important data in case the data stream is lost soon after zero time. The first bytes out of memory are sync and status, then the pretrigger samples, then the posttrigger samples. The data is continuously being fed into the data stream, both during memory fill and after the memory is full, controlled by the TA484A Digital Multiplexer or TA618 Real Time Multiplexer. This cyclic dump ensures good data even if the data bit stream momentarily loses sync, such as with zero time noise. While the Sync Words and Status Registers are being written to memory, reading and writing of the status registers by the TA485A Controller (Command Link) is disabled.

Internal Calibration (Linearity Check)

Linearity Check (Lin Check) consists of 16 discrete equal increment steps from lower band edge to plus 7/8 full scale. Each step is held for 32 samples. When a memory module is placed in Lin Check, the memory size is automatically reset to the maximum available. Lin Check is controlled through the Command Link (TA485A Controller).

External Calibration (Memory Modules)

When a calibration signal and a module arm signal are received at the data module, the module changes to 1 kilo byte memory size and to a trigger mode of External Trigger A. The module also writes a calibration code into its internal status register.

External Calibration (Real Time Module)

When a calibration signal and a module arm signal are received at the data module, the real time module changes to a memory module with 1 kilo byte of memory. Control of the sample rate is removed from the TA484A Digital Multiplexer or TA618 Real Time Multiplexer, and set to an internal 100 microsecond rate. The module will only accept External Trigger A and it outputs a calibration code in its internal status register.

The module will return to real time from memory mode when an arm is received without a calibration signal being present.

Special Recording Option (Transient Modules)

There is an additional operating mode that allows for special data recording called sample rate switching. This operation automatically switches the master oscillator rate to an entire crate at a predetermined time. The time is selected by a switch which enables a PROM controlled timer on the decode board (Decode 2).

The following table reflects some of the possible sample rates and total record times (assuming no pre-samples, 8 bit data, switching on the first clock after trigger and 16 kilo bytes of memory) using the TA493B Crate Decode 2 Board to provide other than standard clock rates.

CLOCK RATE	SAMPLE RATE	APPROXIMATE RECORD LENGTH
50 MHz	2 us	32.8 ms
50 MHz	4 us	65.5 ms
50 MHz	10 us	164 ms
50 MHz	20 us	328 ms
50 MHz	40 us	655 ms
50 MHz	100 us	1.64 sec
50 MHz	200 us	3.28 sec
50 MHz	400 us	6.55 sec

NOTE: 50MHz is the master clock rate. Other rates are submultiples of this value.

6.25 MHz	16 us	262 ms
6.25 MHz	32 us	524 ms
6.25 MHz	80 us	1.31 sec
6.25 MHz	160 us	2.62 sec
6.25 MHz	320 us	5.24 sec
6.25 MHz	800 us	13.12 sec
6.25 MHz	1.6 ms	26.24 sec
6.25 MHz	3.2 ms	52.48 sec
781.25 KHz	128 us	2.09 sec
781.25 KHz	256 us	4.19 sec
781.25 KHz	640 us	10.48 sec
781.25 KHz	1.28 ms	20.96 sec
781.25 KHz	2.56 ms	41.92 sec
781.25 KHz	6.4 ms	1.75 min
781.25 KHz	12.8 ms	3.50 min
781.25 KHz	25.56 ms	7.00 min
97.65625 KHz	1.024 ms	16.72 sec
97.65625 KHz	2.048 ms	33.44 sec
97.65625 KHz	5.120 ms	1.40 min
97.65625 KHz	10.24 ms	2.80 min
97.65625 KHz	20.48 ms	5.60 min
97.65625 KHz	51.20 ms	14.0 min
97.65625 KHz	102.4 ms	28.0 min
97.65625 KHz	204.8 ms	56.0 min
12.20703 KHz	8.19 ms	2.23 min
12.20703 KHz	16.38 ms	4.46 min
12.20703 KHz	40.96 ms	11.20 min
12.20703 KHz	81.92 ms	22.40 min
12.20703 KHz	163.8 ms	44.80 min
12.20703 KHz	409.6 ms	1.86 hr
12.20703 KHz	819.2 ms	3.73 hr
12.20703 KHz	1.64 sec	7.47 hr

1.525879 KHz	65.52 ms	17.84 min
1.525879 KHz	131.0 ms	35.68 min
1.525879 KHz	327.7 ms	1.49 hr
1.525879 KHz	655.2 ms	2.98 hr
1.525879 KHz	1.31 sec	5.96 hr
1.525879 KHz	3.28 sec	14.93 hr
1.525879 KHz	6.55 sec	29.81 hr
1.525879 KHz	13.1 sec	59.61 hr
190.735 Hz	524.2 ms	2.39 hr
190.735 Hz	1.048 sec	4.77 hr
190.735 Hz	2.622 sec	11.93 hr
190.735 Hz	5.243 sec	23.86 hr
190.735 Hz	10.48 sec	47.70 hr
190.735 Hz	26.24 sec	4.98 day
190.735 Hz	52.48 sec	9.95 day
190.735 Hz	1.75 min	19.91 day
23.8419 Hz	4.194 sec	19.08 hr
23.8419 Hz	8.387 sec	38.17 hr
23.8419 Hz	16.77 sec	76.32 hr
23.8419 Hz	41.94 sec	7.95 day
23.8419 Hz	1.40 min	15.93 day
23.8419 Hz	3.50 min	39.82 day
23.8419 Hz	7.00 min	79.64 day
23.8419 Hz	14.00 min	159.27 day
2.9802 Hz	33.55 sec	6.36 day
2.9802 Hz	1.12 min	12.74 day
2.9802 Hz	2.24 min	25.49 day
2.9802 Hz	5.59 min	63.60 day
2.9802 Hz	11.20 min	127.43 day
2.9802 Hz	28.00 min	45.51 wk
2.9802 Hz	56.00 min	91.02 wk
2.9802 Hz	112.0 min	182.04 wk

The above list is helpful in the understanding of Sample Rate Switching, but since the exact described conditions cannot be met (the capability does not exist to sample rate switch on the first clock after trigger), the following list has been included in this document. This list is useful when calculating the switch times and in the determination of the switching capabilities of each channel. The partial samples (e.g., 163.84, 491.52, etc.) are shown to illustrate that the actual rate switch occurs at some point between samples. To determine the total data record time of a sample rate switched channel, multiply the initial sample interval by the presamples plus samples to be taken until switch, then add to this the remaining number of memory locations (minus 8 for sync and status) times the switched sample interval.

INITIAL SAMPLE INTERVAL	TIME TO SWITCH AFTER TRIGGER	NUMBER OF SAMPLES TAKEN AT SWITCH	POSSIBLE NEW SAMPLE INTERVAL
2 USEC	327.68 USEC	163.84	16 USEC
	983.04 USEC	491.52	128 USEC
	1310.72 USEC	655.36	1.024 MSEC
	3932.16 USEC	1966.08	8.19 MSEC
	5242.88 USEC	2621.44	65.52 MSEC
	15728.64 USEC	7864.32	524.2 MSEC
	20971.52 USEC	10485.76	4.194 SEC
	62914.56 USEC	16384.00	33.55 SEC
	83886.08 USEC	16384.00	
	251658.24 USEC	16384.00	
	335544.40 USEC	16384.00	
	671088.80 USEC	16384.00	
4 USEC	327.68 USEC	81.92	32 USEC
	983.04 USEC	245.76	256 USEC
	1310.72 USEC	327.68	2.048 MSEC
	3932.16 USEC	983.04	16.38 MSEC
	5242.88 USEC	1310.72	131.0 MSEC
	15728.64 USEC	3932.16	1.048 SEC
	20971.52 USEC	5242.88	8.387 SEC
	62914.56 USEC	15728.64	1.12 MIN
	83886.08 USEC	16384.00	
	251658.24 USEC	16384.00	
	335544.40 USEC	16384.00	
	671088.80 USEC	16384.00	
10 USEC	327.68 USEC	32.76	80 USEC
	983.04 USEC	98.30	640 USEC
	1310.72 USEC	131.07	5.12 MSEC
	3932.16 USEC	393.21	40.96 MSEC
	5242.88 USEC	524.29	327.7 MSEC
	15728.64 USEC	1572.86	2.622 SEC
	20971.52 USEC	2097.15	16.77 SEC
	62914.56 USEC	6291.46	2.24 MIN
	83886.08 USEC	8388.61	
	251658.24 USEC	16384.00	
	335544.40 USEC	16384.00	
	671088.80 USEC	16384.00	

20 USEC	327.68 USEC	16.38	160 USEC
	983.04 USEC	49.15	1.28 MSEC
	1310.72 USEC	65.54	10.24 MSEC
	3932.16 USEC	196.61	81.92 MSEC
	5242.88 USEC	262.14	655.2 MSEC
	15728.64 USEC	786.43	5.243 MSEC
	20971.52 USEC	1048.58	41.94 SEC
	62914.56 USEC	3145.73	5.59 MIN
	83886.08 USEC	4194.30	
	251658.24 USEC	12582.91	
	335544.40 USEC	16384.00	
	671088.80 USEC	16384.00	
40 USEC	327.68 USEC	8.19	320 USEC
	983.04 USEC	24.58	2.56 MSEC
	1310.72 USEC	32.77	20.48 MSEC
	3932.16 USEC	98.30	163.8 MSEC
	5242.88 USEC	131.07	1.31 SEC
	15728.64 USEC	393.22	10.48 SEC
	20971.52 USEC	524.29	1.40 MIN
	62914.56 USEC	1572.86	11.20 MIN
	83886.08 USEC	2097.15	
	251658.24 USEC	6291.46	
	335544.40 USEC	8388.61	
	671088.80 USEC	16384.00	
100 USEC	327.68 USEC	3.27	800 USEC
	983.04 USEC	9.83	6.4 MSEC
	1310.72 USEC	13.11	51.20 MSEC
	3932.16 USEC	39.32	409.6 MSEC
	5242.88 USEC	52.43	3.28 SEC
	15728.64 USEC	157.29	26.24 SEC
	20971.52 USEC	209.72	3.50 MIN
	62914.56 USEC	629.15	28.00 MIN
	83886.08 USEC	838.86	
	251658.24 USEC	2516.58	
	335544.40 USEC	3355.44	
	671088.80 USEC	6710.88	
200 USEC	327.68 USEC	1.63	1.6 MSEC
	983.04 USEC	4.92	12.8 MSEC
	1310.72 USEC	6.55	102.4 MSEC
	3932.16 USEC	19.66	819.2 MSEC
	5242.88 USEC	26.21	6.55 SEC
	15728.64 USEC	78.64	52.48 SEC
	20971.52 USEC	104.86	7.00 MIN
	62914.56 USEC	314.57	56.00 MIN
	83886.08 USEC	419.43	
	251658.24 USEC	1258.29	
	335544.40 USEC	1677.72	
	671088.80 USEC	3355.44	

400 USEC	327.68 USEC	0.82	3.2 MSEC
	983.04 USEC	2.46	25.56 MSEC
	1310.72 USEC	3.28	204.8 MSEC
	3932.16 USEC	9.83	1.64 SEC
	5242.88 USEC	13.11	13.1 SEC
	15728.64 USEC	39.32	1.75 MIN
	20971.52 USEC	52.43	14.00 MIN
	62914.56 USEC	157.29	112.0 MIN
	83886.08 USEC	209.72	
	251658.24 USEC	629.15	
	335544.40 USEC	838.86	
	671088.80 USEC	1677.72	

**** WARNING ****

When this method is used all channels in the selected crate are affected.

When the master oscillator rate is changed, aliasing errors are possible since the Pre Sample Filter cutoff frequency does not automatically change.

The time of the next sample after switch is uncertain by one sample period.

TA592 DC TO 10 MHz DATA MODULE

The TA592 Data Module shown in Figure 3, is the "high frequency" data module. Three or four PC boards make up the TA592 module, an analog to digital converter (A/D) board, either one or two memory boards, and a control board.

The TA592 was designed using 25 megasample per second flash A/D converters. A flash converter (also called a parallel converter) is an ultrafast method of A/D conversion which uses an array of 2**(n-1) comparators to directly implement a quantizer, where "n" is the resolution in bits. The quantizer is followed by a decoder circuit which converts the comparator outputs into binary code. Two of these converters alternate in taking samples (ping-pong) to allow data conversions at a 50 Megasample per second rate.

The TA592 may be operated using a single A/D if the data records need not be more than 8 kilo samples long and a 50 megasample rate is not required.

	Single A/D & Memory	Dual A/D & Memory
Sample Interval	40ns to 4us (25M-250K samples/sec)	20ns to 4us (50M-250K samples/sec)
Memory Size	8K maximum	16K maximum
Resolution	8 Bit	8 bit (approximately 8 Bit at 20 nsec Sample Interval)

The only TA592 modification required to operate using a single A/D is to remove one of the two memory PC boards. This automatically deactivates one of the two A/D converters on the A/D board, but it does not have to be physically removed for the module to continue to operate.

The module may be operated as a digital module (TA592D). To operate in this mode, the A/D PC board is replaced by a special buffer board (S90637). Individual digital bits may then be recorded in memory. This module buffers the input signals, and the sample rate selects the speed of recording. No signal conditioner module is used when the data module is used as a digital module.

Input Analog Signal

4V p-p into 50 ohms

Input Digital Signals (Digital Data Converter)

Any combination of eight TTL levels or switch closures, terminated into 51 ohms

Input Data Offset Selection

The data input is offset to match the expected signal from individual gauges. The input offset may be programmed through the Command Link (TA485A Controller). The offset value defines the zero volt level of the data.

plus	3/4 Full Scale	- (Data Band = plus 0.5V
plus	1/2 Full Scale	to minus 3.5V)
plus	1/4 Full Scale	
	0 Center Band	- (Data Band = plus 2V
minus	1/4 Full Scale	to minus 2V)
minus	1/2 Full Scale	
minus	3/4 Full Scale	
minus	Full Scale	- (Data Band = 0V to plus 4V)

Pre Sample Filter Selection

The presample filter is a low pass filter used to condition the data to prevent aliasing. The following -3dB filter settings may be programmed through the Command Link (TA485A Controller). The data sample rate is typically selected to be five times the filter cutoff frequency.

200 KHz
500 KHz
1 MHz
2 MHz
5 MHz
10 MHz

Master Oscillator

The data module accepts a 50MHz oscillator signal from the TA493B Data Module Crate Decode 2 Board. The decode board receives this signal from the TA488B Trigger Generator and regenerates it as the master clock. This clock is divided on the data module's control board to create individual sample intervals for each data module.

Sample Interval

The following are the normal sample intervals provided by the data module. They may be remotely set through the Command Link (TA485A Controller):

4us/sample	(250K samples/sec)
2us/sample	(500K samples/sec)
1us/sample	(1000K samples/sec)
400ns/sample	(2500K samples/sec)
200ns/sample	(5000K samples/sec)
100ns/sample	(10000K samples/sec)
40ns/sample	(25000K samples/sec)
20ns/sample	(50000K samples/sec requires 2 A/Ds and 2 memory boards)

Data Conversion

Eight Bit Linear

Module Arm

This signal causes the module to start data conversion and the storing of data in memory.

The module will accept one of three different arm signals:

1. Arm initiated via the TA485A Controller (Command Link).

2. Crate arm from the TA488B Trigger Generator, which is originated by either the TA486A Programmer Timer or the TA489A Calibrator.

3. Manual arm from the TA493B Crate Decode 2 Board.

Trigger Inhibit

This signal is generated by the TA488B Trigger Generator and distributed to all Data Modules within the system. Each module may individually be programmed through the Command Link (TA485A Controller) to accept or reject this signal. When inhibit is enabled and the signal is present, no trigger will be accepted, except for External Trigger A, but only when the module is in Calibration Mode. The Trigger Inhibit signal is used to prevent premature triggering due to zero time noise for modules which are to be triggered after zero time (at plus time).

Trigger Mode

There are four different trigger modes. The trigger mode and internal trigger level may be programmed through the Command Link (TA485A Controller).

1. Manual (Command Link, TA485A Controller)

2. External A (bussed signal from TA488B Trigger Generator on a crate basis or manually created on

the TA493B Crate Decode 2 Board, also the Calibration Trigger Signal)

3. External B (bussed signal from TA488B Trigger Generator on a crate basis, or manually created on the TA493B Crate Decode 2 Board)

4. Internal (trigger on signal)

   The module will trigger when the signal reaches one of the following programmable levels:

   Internal Trigger Levels

   plus 3/4 Full Scale
   plus 1/2 Full Scale
   plus 1/4 Full Scale
   0 (Center Band)
   minus 1/4 Full Scale
   minus 1/2 Full Scale
   minus 3/4 Full Scale

The internal trigger level is dependent on the offset plus the signal level. The above list is based on an input data offset of zero (center band). For more details regarding the use of this option, refer to SAND87-1736, TA591 100 KHz Data Module Operation and Maintenance Manual, by David K. Werling, Division 7121.

Pre Trigger Samples

Pre trigger samples are data samples saved prior to the receipt of the trigger signal. There are two settings, either of which may be set through the Command Link (TA485A Controller):

	Pre Trigger Samples
1.	0
2.	512

Memory Size

The available memory size is dependent on the available memory in the module (8 kilo byte or 16 kilo byte) and the actual memory size programmed into the module. This function is controllable through the Command Link (TA485A Controller).

1K byte (calibrate only)
4K byte
8K byte
16K byte (requires 2 A/Ds and 2 memory boards)

Memory Type

CMOS technology (16 each 1K X 4 on each board)

The memory retains data for a minimum of ten days without external power using batteries contained within the TA493B Crates.

Record Time

Normal record time is a function of memory size and sample interval. The memory size and sample interval may be remotely set through the Command Link (TA485A Controller). The following list shows the approximate total record time with no pretrigger samples:

Sample Interval	Memory Size 4K	8K	16K
20 nsec	81.9 usec	164 usec	328 usec
40 nsec	164 usec	328 usec	655 usec
100 nsec	410 usec	819 usec	1.64 msec
200 nsec	819 usec	1.64 msec	3.28 msec
400 nsec	1.64 msec	3.28 msec	6.55 msec
1 usec	4.10 msec	8.19 msec	16.4 msec
2 usec	8.19 msec	16.4 msec	32.8 msec
4 usec	16.4 msec	32.8 msec	65.5 msec

Memory Organization

The memory starts filling when an Arm signal is received by the module. When the selected trigger signal is received, the memory continues to fill to the selected memory size (4K, 8K or 16K), less pretrigger samples (0 or 512), less eight bytes for sync and status. The sync and status words are written into memory last, then the memory address counters back up by eight addresses such that the sync word is the first byte out of memory. This accomplishes a faster readout of the most important data in case the data stream is lost soon after zero time. The first bytes out of memory are sync and status, then the pretrigger samples, then the posttrigger samples. The data is continuously being fed into the data stream, both during memory fill and after the memory is full, controlled by the TA484A Digital Multiplexer or TA618 Real Time Multiplexer. This cyclic dump ensures good data even if the data bit stream momentarily loses sync, such as with zero time noise. While the Sync Words and Status Registers are being written to memory, reading and writing of the status registers by the TA485A Controller (Command Link) is disabled.

Internal Calibration

Linearity Check (Lin Check) consists of 16 discrete equal increment steps from lower band edge to plus 7/8 full scale. Each step is held for 32 samples. When a module is placed in Lin Check, the memory size is automatically reset to the maximum available. Lin Check is controlled through the Command Link (TA485A Controller).

NOTE: All TA592 modules do not operate well in Lin Check at a 20 nsec sample interval.

External Calibration

When a calibration signal and a module arm signal are received at the data module, the module changes to 1 kilo byte memory size and to a trigger mode of External Trigger A. The module also writes a calibration code into its internal status register.

Special Recording Option

There is an additional operating mode that allows for special data recording called sample rate switching. This operation automatically switches the master oscillator rate to an entire crate at a predetermined time. The time is selected by a switch which enables a PROM controlled timer on the decode board (Decode 2).

The following table reflects some of the possible sample rates and total record times (assuming no pre-samples, 8 bit data, switching on the first clock after trigger and 16 kilo bytes of memory) using the TA493B Crate Decode 2 Board to provide other than standard clock rates.

CLOCK RATE	SAMPLE RATE	APPROXIMATE RECORD LENGTH
50 MHz	20 ns	328 usec
50 MHz	40 ns	655 usec
50 MHz	100 ns	1.64 msec
50 MHz	200 ns	3.28 msec
50 MHz	400 ns	6.55 msec
50 MHz	1 us	16.4 msec
50 MHz	2 us	32.8 msec
50 MHz	4 us	65.5 msec

NOTE: 50MHz is the master clock rate. Other rates are submultiples of this value.

6.25 MHz	160 ns	2.62 msec
6.25 MHz	320 ns	5.24 msec
6.25 MHz	800 ns	13.12 msec
6.25 MHz	1.6 us	26.24 msec
6.25 MHz	3.2 us	52.40 msec
6.25 MHz	8 us	131.2 msec
6.25 MHz	16 us	262.4 msec
6.25 MHz	32 us	524.0 msec
781.25 KHz	1.28 us	20.97 msec
781.25 KHz	2.56 us	41.92 msec
781.25 KHz	6.40 us	104.9 msec
781.25 KHz	12.8 us	209.9 msec
781.25 KHz	25.6 us	419.2 msec
781.25 KHz	64.0 us	1.050 sec
781.25 KHz	128 us	2.099 sec
781.25 KHz	256 us	4.192 sec
97.65625 KHz	10.24 us	167.8 msec
97.65625 KHz	20.48 us	335.4 msec
97.65625 KHz	51.20 us	839.7 msec
97.65625 KHz	102.4 us	1.679 sec
97.65625 KHz	204.8 us	3.354 sec
97.65625 KHz	512.0 us	8.397 sec
97.65625 KHz	1.024 ms	16.79 sec
97.65625 KHz	2.048 ms	33.54 sec
12.20703 KHz	81.92 us	1.342 sec
12.20703 KHz	163.8 us	2.683 sec
12.20703 KHz	409.6 us	6.717 sec
12.20703 KHz	819.2 us	13.43 sec
12.20703 KHz	1.638 ms	26.83 sec
12.20703 KHz	4.096 ms	67.17 min
12.20703 KHz	8.192 ms	2.24 min
12.20703 KHz	16.38 ms	4.47 min
1.525879 KHz	655.4 us	10.73 sec
1.525879 KHz	1.311 ms	21.46 sec
1.525879 KHz	3.277 ms	53.74 sec
1.525879 KHz	6.554 ms	1.79 min
1.525879 KHz	13.11 ms	3.58 min
1.525879 KHz	32.77 ms	8.96 min
1.525879 KHz	65.54 ms	17.91 min
1.525879 KHz	131.1 ms	35.77 min
190.735 Hz	5.243 ms	85.90 sec
190.735 Hz	10.49 ms	2.86 min
190.735 Hz	26.21 ms	7.17 min
190.735 Hz	52.43 ms	14.33 min
190.735 Hz	104.9 ms	28.62 min
190.735 Hz	262.1 ms	71.65 min
190.735 Hz	524.3 ms	2.39 hr
190.735 Hz	1.048 sec	4.77 hr

23.8419 Hz	41.94 ms	11.45 min
23.8419 Hz	83.89 ms	22.89 min
23.8419 Hz	209.7 ms	57.32 min
23.8419 Hz	419.4 ms	1.91 hr
23.8419 Hz	838.9 ms	3.82 hr
23.8419 Hz	2.097 sec	9.55 hr
23.8419 Hz	4.194 sec	19.11 hr
23.8419 Hz	8.389 sec	1.59 day
2.9802 Hz	335.5 ms	91.63 min
2.9802 Hz	671.1 ms	3.05 hr
2.9802 Hz	1.678 sec	7.64 hr
2.9802 Hz	3.355 sec	15.29 hr
2.9802 Hz	6.711 sec	30.52 hr
2.9802 Hz	16.78 sec	3.18 day
2.9802 Hz	33.55 sec	6.37 day
2.9802 Hz	67.11 sec	12.72 day

The above list is helpful in the understanding of Sample Rate Switching, but since the exact described conditions cannot be met (the capability does not exist to sample rate switch on the first clock after trigger), the following list has been included in this document. This list is useful when calculating the switch times and in the determination of the switching capabilities of each channel. The partial samples (e.g., 3276.80, 9380.40, etc.) are shown to illustrate that the actual rate switch occurs at some point between samples. To determine the total data record time of a sample rate switched channel, multiply the initial sample interval by the presamples plus samples to be taken until switch, then add to this the remaining number of memory locations (minus 8 for sync and status) times the switched sample interval.

INITIAL SAMPLE INTERVAL	TIME TO SWITCH AFTER TRIGGER	NUMBER OF SAMPLES TAKEN AT SWITCH	POSSIBLE NEW SAMPLE INTERVAL
20 NSEC	327.68 USEC	16384.00	160 NSEC
	983.04 USEC	16384.00	1.28 USEC
	1310.72 USEC	16384.00	10.24 USEC
	3932.16 USEC	16384.00	81.9 USEC
	5242.88 USEC	16384.00	655.2 USEC
	15728.64 USEC	16384.00	5.242 MSEC
	20971.52 USEC	16384.00	41.94 MSEC
	62914.56 USEC	16384.00	335.5 MSEC
	83886.08 USEC	16384.00	
	251658.24 USEC	16384.00	
	335544.40 USEC	16384.00	
	671088.80 USEC	16384.00	

40 NSEC	327.68 USEC	8192.00	320 NSEC
	983.04 USEC	16384.00	2.56 USEC
	1310.72 USEC	16384.00	20.48 USEC
	3932.16 USEC	16384.00	163.8 USEC
	5242.88 USEC	16384.00	1.31 MSEC
	15728.64 USEC	16384.00	10.48 MSEC
	20971.52 USEC	16384.00	83.87 MSEC
	62914.56 USEC	16384.00	672 MSEC
	83886.08 USEC	16384.00	
	251658.24 USEC	16384.00	
	335544.40 USEC	16384.00	
	671088.80 USEC	16384.00	
100 NSEC	327.68 USEC	3276.80	800 NSEC
	983.04 USEC	9830.40	6.4 USEC
	1310.72 USEC	13107.20	51.2 USEC
	3932.16 USEC	16384.00	409.5 USEC
	5242.88 USEC	16384.00	3.276 MSEC
	15728.64 USEC	16384.00	26.21 MSEC
	20971.52 USEC	16384.00	209.7 MSEC
	62914.56 USEC	16384.00	1.6775 SEC
	83886.08 USEC	16384.00	
	251658.24 USEC	16384.00	
	335544.40 USEC	16384.00	
	671088.80 USEC	16384.00	
200 NSEC	327.68 USEC	1638.40	1.6 USEC
	983.04 USEC	4915.20	12.8 USEC
	1310.72 USEC	6553.60	102.4 USEC
	3932.16 USEC	16384.00	819 USEC
	5242.88 USEC	16384.00	6.552 MSEC
	15728.64 USEC	16384.00	52.42 MSEC
	20971.52 USEC	16384.00	419.4 MSEC
	62914.56 USEC	16384.00	3.355 SEC
	83886.08 USEC	16384.00	
	251658.24 USEC	16384.00	
	335544.40 USEC	16384.00	
	671088.80 USEC	16384.00	
400 NSEC	327.68 USEC	819.20	3.2 USEC
	983.04 USEC	2457.60	25.6 USEC
	1310.72 USEC	3276.80	204.8 USEC
	3932.16 USEC	9830.40	1.638 MSEC
	5242.88 USEC	13107.20	13.1 MSEC
	15728.64 USEC	16384.00	104.84 MSEC
	20971.52 USEC	16384.00	838.8 MSEC
	62914.56 USEC	16384.00	6.71 SEC
	83886.08 USEC	16384.00	
	251658.24 USEC	16384.00	
	335544.40 USEC	16384.00	
	671088.80 USEC	16384.00	

1 USEC	327.68 USEC	327.68	8.0 USEC
	983.04 USEC	983.04	64 USEC
	1310.72 USEC	1310.72	512 USEC
	3932.16 USEC	3932.16	4.095 MSEC
	5242.88 USEC	5242.88	32.76 MSEC
	15728.64 USEC	15728.64	262.1 MSEC
	20971.52 USEC	16384.00	2.097 SEC
	62914.56 USEC	16384.00	16.775 SEC
	83886.08 USEC	16384.00	
	251658.24 USEC	16384.00	
	335544.40 USEC	16384.00	
	671088.80 USEC	16384.00	
2 USEC	327.68 USEC	163.84	16 USEC
	983.04 USEC	491.52	128 USEC
	1310.72 USEC	655.36	1.024 MSEC
	3932.16 USEC	1966.08	8.19 MSEC
	5242.88 USEC	2621.44	65.52 MSEC
	15728.64 USEC	7864.32	524.2 MSEC
	20971.52 USEC	10485.76	4.194 SEC
	62914.56 USEC	16384.00	33.55 SEC
	83886.08 USEC	16384.00	
	251658.24 USEC	16384.00	
	335544.40 USEC	16384.00	
	671088.80 USEC	16384.00	
4 USEC	327.68 USEC	81.92	32 USEC
	983.04 USEC	245.76	256 USEC
	1310.72 USEC	327.68	2.048 MSEC
	3932.16 USEC	983.04	16.38 MSEC
	5242.88 USEC	1310.72	131.0 MSEC
	15728.64 USEC	3932.16	1.048 SEC
	20971.52 USEC	5242.88	8.387 SEC
	62914.56 USEC	15728.64	1.12 MIN
	83886.08 USEC	16384.00	
	251658.24 USEC	16384.00	
	335544.40 USEC	16384.00	
	671088.80 USEC	16384.00	

**** WARNING ****

When this method is used all channels in the selected crate are affected.

When the master oscillator rate is changed, aliasing errors are possible since the Pre Sample Filter cutoff frequency does not automatically change.

The time of the next sample after switch is uncertain by one sample period.

TA493A SIGNAL CONDITIONING CRATE

The signal conditioning crates (commonly referred to as "A Crates") are designed to house the TA590-1 and TA590-10 Signal Conditioner/Amplifiers. Each crate will hold up to eight TA590 Signal Conditioners, provide power for the modules, contain isolated excitation power supplies and interconnect the Signal Conditioners to all other system elements.

The crate also contains an analog switching matrix for use in routing voltage calibration signals to individual channels. This circuitry is contained on the Decode A Board which also routes the calibration control signals to the signal conditioners.

TA493B DATA MODULE CRATE

The data module crates (commonly referred to as "B Crates") are designed to house, provide power for and interconnect the data module to all other system elements. Each crate will accept up to eight TA591 and/or TA592 Data Modules.

The crate contains circuitry to generate arms and triggers for the modules, decode commands and regenerate control strobes. Each crate contains a backup oscillator and auto switching circuitry for use if the TA488B Trigger Generator's master oscillator is lost. Also a switch selectable option is included to reduce the master oscillator frequency available to the modules. The above described circuitry is contained on the two Decode Boards. The crate contains a 20 ampere-hour 4 volt lead acid battery to allow the data module status registers and memories to retain their data for a minimum of ten days.

COMMON EQUIPMENT

TA484A DIGITAL MULTIPLEXER

The TA484A is part of the data playback system shown in Figure 6. It is a stored program multiplexer that accesses data from the data modules (either transient or real time) and status from other common equipment. An internal programmable memory controls the formatting and an internal clock determines the output bit rate. The multiplexer outputs a parallel data stream for use in the local playback system and also generates two identical serial 20 megabit per second data streams for recording and processing in the remote recording facility.

Inputs: The TA484A accepts eight bit parallel data from up to 128 data modules via system parallel busses. Data from modules are input on a crate basis. Another 88 data channels may be input via system parallel busses from the TA649 Closure Multiplexer or the TA698 ACE. Twelve status bits from the TA489A Calibrator are input during calibration for use by the playback system.

Bit Rate: The output bit rate is remotely selectable in binary increments from 9.76 kilo bits to 20 mega bits per second. Bit rates are selected via the TA485A Controller (Command Link).

Time Reference Counters: Arms, triggers and the master oscillator are received from the TA488B Trigger Generator. These signals are used to start and stop six 32-bit internal counters which are used to time tag each data module to within 20 nsec of zero time, regardless of the sample interval. This time count is formatted into the output data stream.

Formats: Up to four unique formats may be stored in the multiplexer at one time. Each format is 8 bits per word, frame lengths may be from 16 to 128 words and subcom depth is from 1 to 128 frames deep. These stored formats may be remotely selected via the TA485A Controller (Command Link) or the front panel.

Outputs: Eight bit parallel data and ID tags (such as Format ID (FMID) and Subcom ID (SCID)) are output to the local playback system for processing. Two identically formatted serial Bi-Phase L (BIO-L) coded data streams are output to a remote recording location. One of these outputs may be time delayed from the other to improve the data reliability (e.g., to prevent loss of information due to data dropout during zero time noise or ground shock).

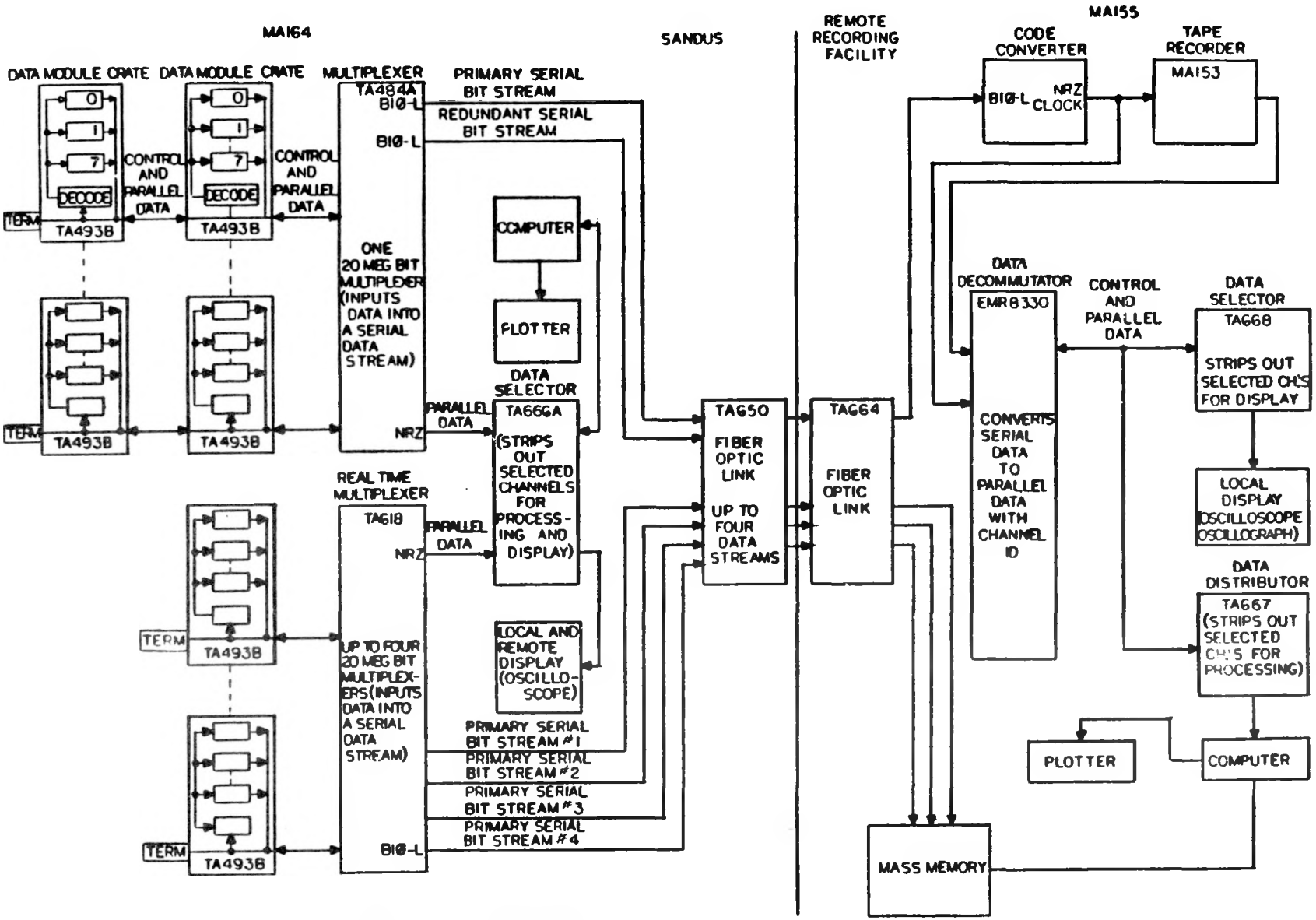


FIGURE 6 DATA PLAYBACK BLOCK DIAGRAM

TA485A CONTROLLER

The TA485A Controller is part of the command system (Command Link), shown in Figure 7. It is the element in the SANDUS system that receives commands via the local computer or from remote locations such as the digital recording trailer (remote recording facility). Its main function is to load and interrogate other system elements. The unit contains a microprocessor and firmware that implements this feature.

Inputs: The controller may accept asynchronous parallel data from the remote recording facility through the TA657 DCS II, serial BIO-L data from the remote recording facility or other sources, serial RS422 data from the remote recording facility through a DEC Server Terminal Line, and parallel data from the system computer.

Data Processing: From the input message, the master TA485A determines which controller is being addressed and transfers the message to that TA485A via an isolated serial port if the message is not intended for the master controller. The data is then transferred to/from the addressed system element.

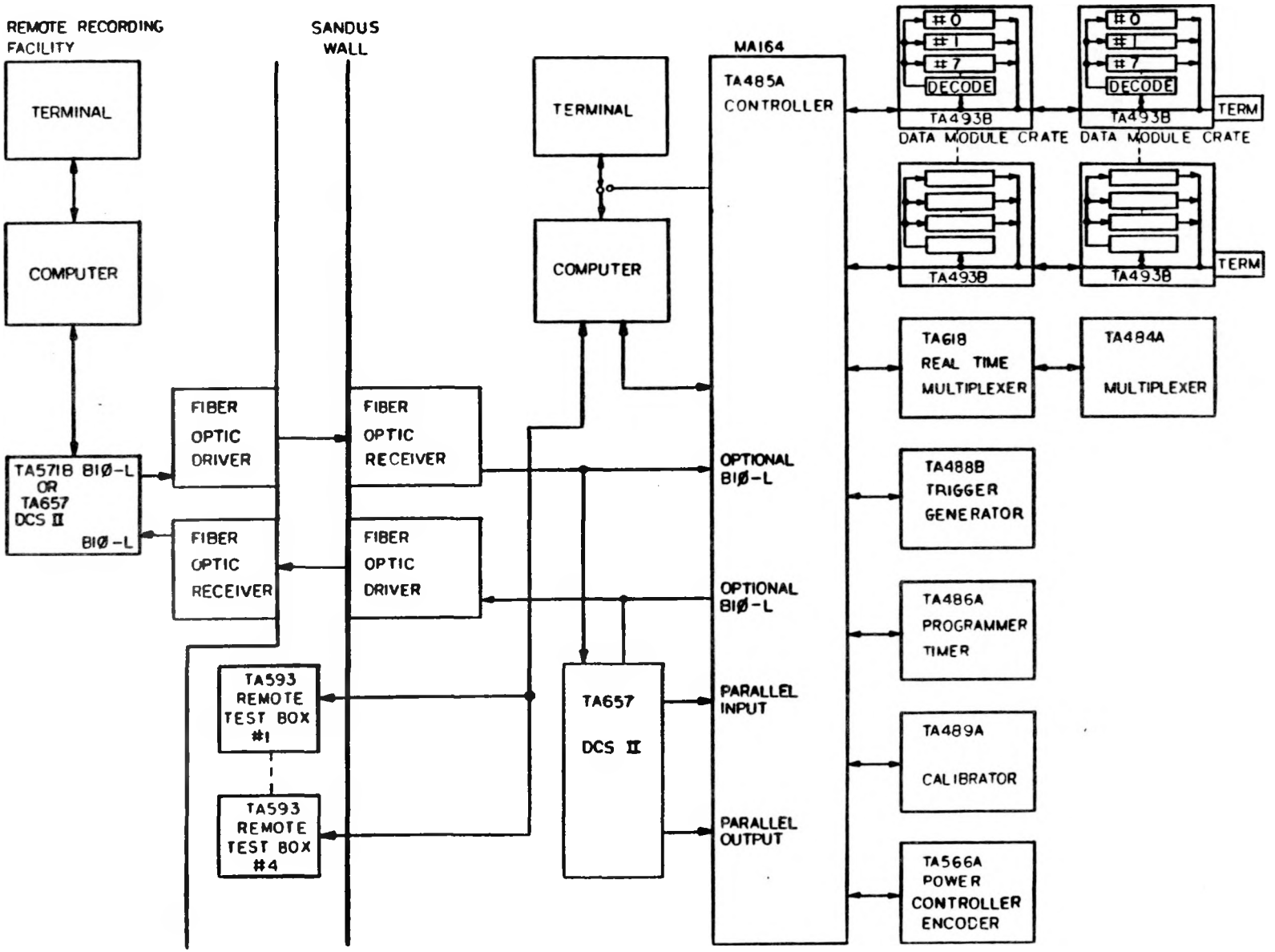
Internal Program: The internal processor is one of the Digital Equipment Corporation LSI-11 family microprocessors. The firmware decodes the input message to determine its validity. The element to which the message is addressed is determined along with the type of message and the number of bytes contained in the message. The program also determines if the message can be processed at the present time. Only reads are allowed in initial lockout (set through the Command Link) and no messages are allowed during final lockout (set by the TA486A Programmer Timer during countdown). The processor then writes or reads the element and formats a return message.

System Busses: Parallel bidirectional busses are supplied to the following SANDUS elements to allow reading and writing of the internal setup registers. Some of the elements are daisy chained to reduce the quantity of connectors on chassis rear panels (thus chassis size) and to reduce the system cabling.

TA484A Digital Multiplexer
TA486A Programmer Timer
TA488B Trigger Generator
TA489A Calibrator
TA566A Power Controller/Encoder
TA591 Data Module
TA592 Data Module
TA618 Real Time Multiplexer

Outputs: After messages are processed, the return data is formatted into a return message and transmitted to the sender. The output to the remote recording facility may be through the TA657 DCS II communication multiplexer or a DEC Server Terminal Server, and parallel data is output directly to the local system computer. This return message is also available as a BIO-L serial stream if the incoming message was via the BIO-L serial port.

For more information on the Command Link structure and use, refer to SANDUS (MA164) Command System Message and Data Format, SAND86-1398, by L. W. Ebinger, J. M. Opalka, & D. K. Werling, Division 9321.



CAMP 12/ CP14

COMMAND LINK BLOCK DIAGRAM

FIGURE 7

TA486A PROGRAMMER TIMER

The Programmer Timer shown in Figure 8, is used for the generation of timing signals required to operate the system during an automatic or manual countdown.

Normally the TA486A generates auto calibration commands, initiates module arms and generates trigger inhibit signals and final lockout for the SANDUS system.

Inputs: The programmer accepts twenty eight closures or TTL level negative true input signals. It also accepts four positive true pulse inputs, typically from the TA488B Trigger Generator. Each signal may be simulated via the front panel and externally simulated through the TA485A Controller. All input signals may be manually disabled through the TA486A front panel. This disable function is remotely resettable through the Command Link (TA485A Controller) and locally through the front panel Reset button.

Internal Timer: The timer is controlled by one of the Digital Equipment Corporation LSI-11 family microprocessors running firmware. The processor may control any output function (signal) depending on time, and/or the state of any number of input signals and/or any number of output functions. This timer may be programmed to start timing as early as -99:59.99 minutes and will continuously time events through +99:59.99 minutes. The programmable resolution is 10 milliseconds.

Standard Outputs: There are 32 unique output signals (output functions). Each output may be activated and deactivated manually (front panel), directly by any input (the first 30 outputs only, when high reliability is required), by the internal timer, or externally activated through the TA485A Controller (Command Link).

Special Features: Input signals may be diode patched directly to outputs for use regardless of the power on or off state of the TA486A.

Pulse Outputs: There are four special high speed timers internal to the TA486A which will create delayed output pulses. Each timer is started via one of the pulse inputs. The delay may be individually programmed to count from 100 nanoseconds to 68 minutes. The resolution is dependent upon which range has been selected:

Range	Maximum Delay Time	Resolution
1	409.5 usec	0.0001 msec
2	4.095 msec	0.001 msec
3	40.95 msec	0.01 msec
4	409.5 msec	0.1 msec
5	4.095 sec	1.0 msec
6	40.95 sec	10.0 msec
7	409.5 sec	100.0 msec
8	4095 sec	1000.0 msec

Programmability: The TA486A may be programmed through its front panel mounted terminal, a remote terminal, or through the TA485A Controller (Command Link). The program is stored on a CMOS memory card within the LSI-11 card cage. A listing of the resident program may be obtained at any time by using a printer contained within the TA486A.

For programming instructions, refer to the Programming Instruction Manual for the TA486A Programmer Timer, dated May 22, 1984, by L. W. Ebinger, 7121.

Extension Panel: A cable fan out panel was designed for simplification of system cabling within the SANDUS. The TA486A, although built for universal applications, with this panel attached, becomes dedicated to the SANDUS. Special functions, such as an internally generated trigger may be cabled directly from the TA486A Extension Panel, JOUT to the TA488B Trigger Generator, JAUX.

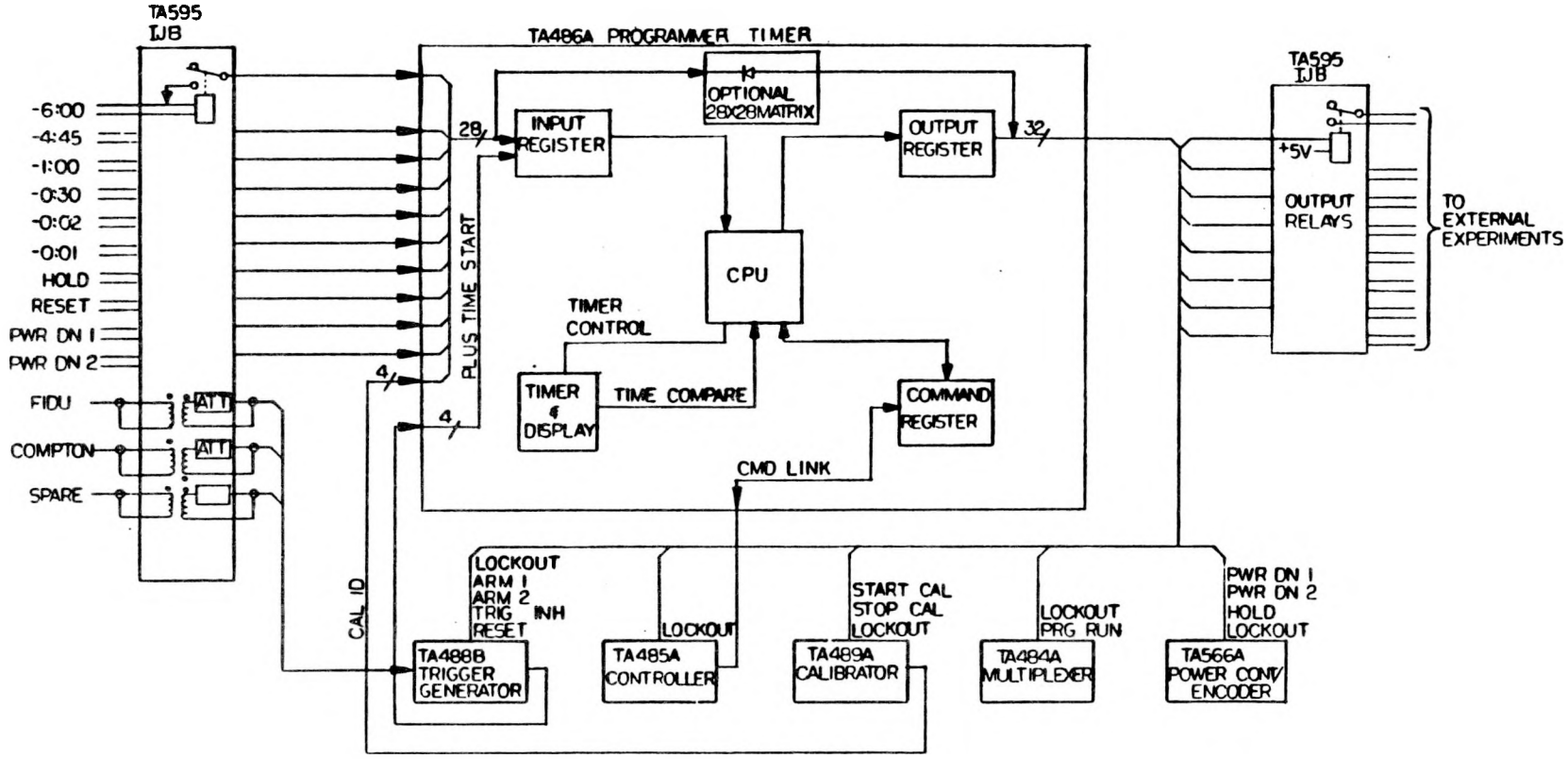


FIGURE 8 TYPICAL RANGE TIME SIGNAL FLOW DIAGRAM

TA488B TRIGGER GENERATOR

The TA488B Trigger Generator shown in Figure 9, is essentially a redundant element that initiates arms, triggers, and trigger inhibit signals, and provides the master oscillator for the data modules. It also provides arms and triggers for the simulators.

Arm Signals

Arm Inputs: Two unique arm signals are accepted from the TA486A Programmer Timer and a common arm is generated by the TA489A Calibrator. These signals may also be remotely generated via the TA485A Controller.

Arm Outputs: There are two arm signals available for output to the crates and simulators, Arm 1 and Arm 2. Each crate may accept either one of these arm signals as programmed into the TA488B Trigger Generator.

Special Features: During a typical countdown sequence, the Final Lockout Signal is activated by the TA486A Programmer Timer at a time of -00:01.80 (after the Arm Signal). After receipt of the Final Lockout Signal, no arm signals are allowed to be initiated until the TA488B Trigger Generator is reset. This reset may be remotely generated through the Command Link (TA485A Controller), or manually from the TA488B front panel.

Trigger Inhibit

The inhibit signal is generated by the TA486A Programmer Timer and is distributed to each TA493B Crate via the TA488B Trigger Generator. This signal, when enabled by a data module, will prevent that module from triggering on any signal until the inhibit is removed (reference TA591 & TA592 Data Modules). This signal is normally activated at some minus time and deactivated at some plus time for channels requiring a plus time trigger.

Trigger Signals

Trigger Inputs: There are three unique trigger inputs and each is redundant. They are typically defined as Fidu (Trigger 1), Compton (Trigger 2) and Spare (Trigger 3). By means of an internal jumper arrangement, the number of unique inputs may be increased to six. This eliminates the input redundancy and the respective delayed trigger output. There are 16 additional (auxiliary)

trigger inputs dedicated to sets of crates. All triggers may be remotely simulated via the TA485A Controller (Command Link). The TA488B may be programmed to provide the auxiliary triggers as Trigger A or Trigger B to the crates as shown in the following list. Triggers 4 and 5 are divided into 4A, 4B, 5A, and 5B and displayed on four front panel LEDs.

Auxiliary Trigger		Dedicated to Crate:
0	(4A0)	0 & 1
1	(5A1)	0 & 1
2	(4A2)	2 & 3
3	(5A3)	2 & 3
4	(4A4)	4 & 5
5	(5A5)	4 & 5
6	(4A6)	6 & 7
7	(5A7)	6 & 7
10	(4B10)	10 & 11
11	(5B11)	10 & 11
12	(4B12)	12 & 13
13	(5B13)	12 & 13
14	(4B14)	14 & 15
15	(5B15)	14 & 15
16	(4B16)	16 & 17
17	(5B17)	16 & 17

Trigger Delays:

Trigger 1 (Fidu) may be delayed from 0 to 9.999 ms in 1 us increments.
Trigger 2 (Compton) may be delayed from 0 to 999.9 us in 100 ns increments.
Trigger 3 (Spare) may be delayed from 0 to 99.99 ms in 10 us increments.
There are no programmable delays associated with the auxiliary triggers (4 & 5).

Trigger Outputs: There are eight trigger output signals selectable for routing to the TA493B Crates and various simulators. These output signals are the six trigger inputs and the two unique auxiliary triggers for each set of crates. See the list at the end of this section for a definition of which trigger may be programmed to each crate. The Delayed Triggers may be selectively replaced by another external trigger signal. Each crate may accept any two of these trigger signals selectable as Trigger A and Trigger B. There are six trigger signals available for output to the TA484A Digital Multiplexer to allow it to accurately time tag each. These may be jumper selected to be the three input triggers plus their delayed outputs,

or any of the auxiliary triggers as shown in the following list. There are also two trigger signals available for output to a remote recording location.

TA488B Inputs	TA484A Triggers					
	Trg1	Trg2	Trg3	Trg4	Trg5	Trg6
Trig 1 (Fidu)	X					
Trig 1 Delay		X				
Trig 2 (Compton)			X			
Trig 2 Delay				X	X	X
Trig 3				X	X	X
Trig 3 Delay				X	X	X
Trig 4A0					X	
Trig 4A2					X	
Trig 4A4				X	X	
Trig 4A6				X	X	
Trig 4B10				X		X
Trig 4B12				X		X
Trig 4B14						X
Trig 4B16						X

Master Oscillator

The master oscillator is a redundant 50MHz clock generated and distributed to each TA493B Crate in order to generate and time simultaneous samples in the data modules. It is also routed to the TA484A Digital Multiplexer as the clock for the trigger time counters.

	CR0	CR1	CR2	CR3	CR4	CR5	CR6	CR7	CR10	CR11	CR12	CR13	CR14	CR15	CR16	CR17	SIM 1-4
TRIG 1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TRIG 1 DEL	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
TRIG 2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TRIG 2 DEL	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
TRIG 3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TRIG 3 DEL	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
AUX TRIG 0 (4A0)	X	X															X
AUX TRIG 1 (5A1)	X	X															
AUX TRIG 2 (4A2)			X	X													X
AUX TRIG 3 (5A3)			X	X													
AUX TRIG 4 (4A4)					X	X											X
AUX TRIG 5 (5A5)					X	X											
AUX TRIG 6 (4A6)							X	X									X
AUX TRIG 7 (5A7)							X	X									
AUX TRIG 10 (4B10)									X	X							X
AUX TRIG 11 (5B11)									X	X							
AUX TRIG 12 (4B12)											X	X					
AUX TRIG 13 (5B13)											X	X					
AUX TRIG 14 (4B14)													X	X			
AUX TRIG 15 (5B15)													X	X			
AUX TRIG 16 (4B16)															X	X	
AUX TRIG 17 (5B17)															X	X	
ARM 1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ARM 2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

ARM & TRIGGER PROGRAMMING OPTIONS FOR EACH CRATE

NOTE: TRIGGER INHIBIT IS A SIGNAL ACTIVATED BY THE PROGRAMMER TIMER. THIS SIGNAL IS NORMALLY USED TO INHIBIT ZERO TIME TRIGGERS ON A CHANNEL THAT IS TO TRIGGER AT PLUS TIME. TYPICALLY, TRIGGER INHIBIT IS TURNED ON AT -0.5 SEC AND OFF AT +50 MSEC.

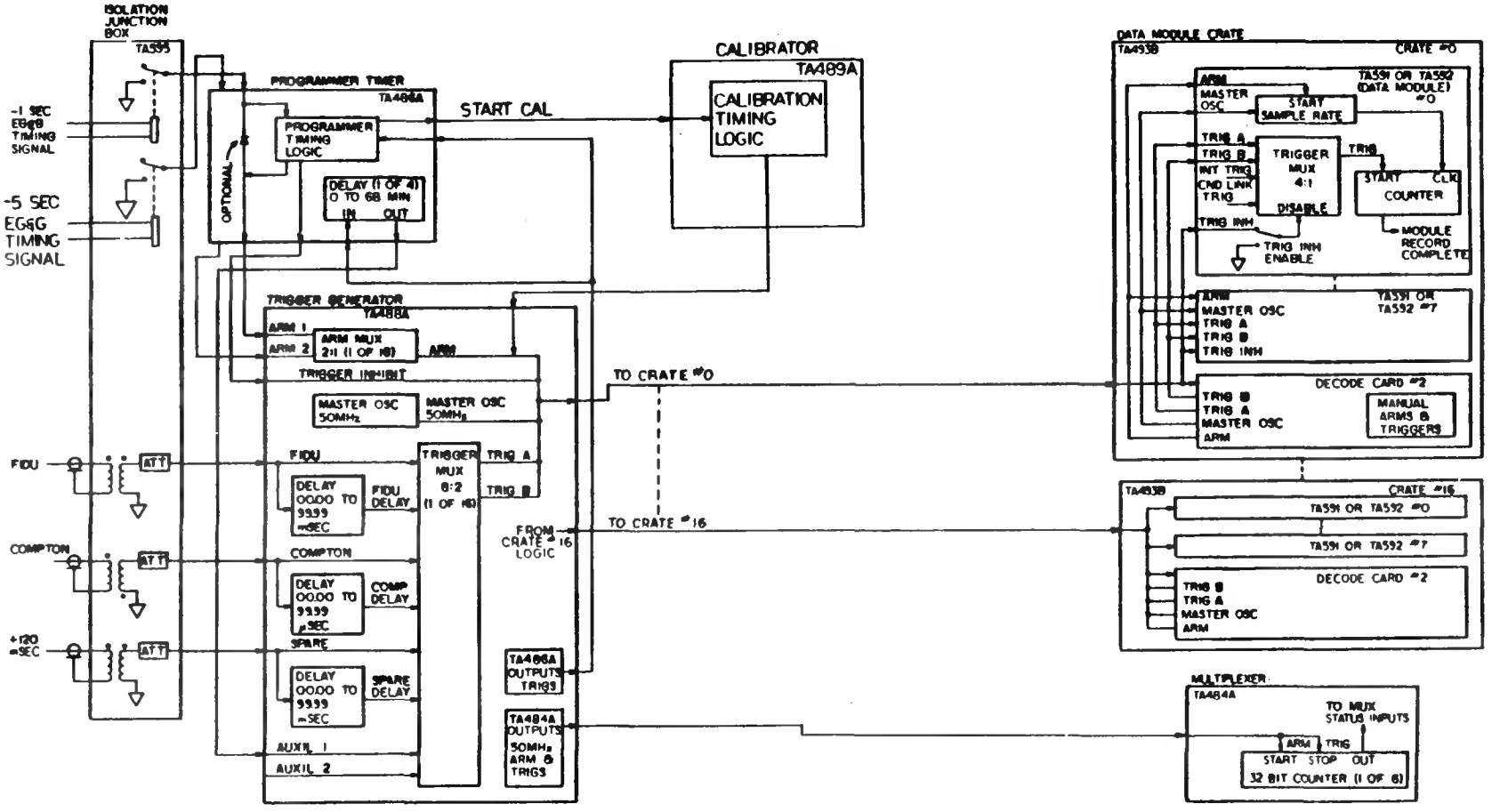


FIGURE 9 TYPICAL ARM AND TRIGGER BLOCK DIAGRAM

TA489A CALIBRATOR

The TA489A Calibrator controls the calibration system as shown in Figure 10. It may be operated manually (front panel), remotely (TA485A Controller), or run automatically (TA486A Programmer Timer). The element uses a Digital Equipment Corporation LSI-11 family microprocessor running firmware (in EPROM) to control calibration.

Analog channels are calibrated sequentially, and each channel may be calibrated by using up to four unique types of calibration. Some of the presently defined calibration configurations are:

1. Zero Calibration: Consists of automatically removing the gauge and tying each input signal line to signal common through a resistor (nominally 50 ohms). This may be accomplished at the TA506A Source Coupler or the TA590-1/TA590-10 Signal Conditioner by using the proper calibration header as shown in Figure 18. This mode may be initiated by the TA489A Calibrator, the TA485A Controller (through the channel's status registers) or by the use of a front panel switch on the Signal Conditioner. Zero Calibration shows the zero level of the channel with no input signal. The amplifier may be zeroed while holding the channel in this calibration state.

2. Shunt Calibration: Consists of paralleling one leg of a bridge circuit with a known impedance. This may be accomplished at the TA506A Source Coupler or the TA590-1/TA590-10 Signal Conditioner by using the proper calibration header (Figure 18). This mode may be initiated by the TA489A Calibrator, the TA485A Controller (through the channel's status registers) or by the use of a front panel switch on the Signal Conditioner. Shunt Calibration presents a voltage to the Signal Conditioner from the gage, so a gage calibration may be calculated. Shunt Calibration is extremely useful to show that the gage is connected properly and operational.

3. Amplifier Calibration and Attenuator Calibration: Calibration consists of automatically removing the gauge signal and presenting a very accurate voltage into the input circuitry. This may be accomplished at the TA590-1/TA590-10 Signal Conditioner using amplifier and attenuator calibration. The voltage is supplied by a 20 bit programmable differential output voltage source programmed from data in the calibrator's internal memory. Any voltage from plus or minus ~9.8 microvolts to plus or minus ~10.24 volts may be selected for any channel. Amp Calibration presents a calibrated voltage to the Signal Conditioner so the

channel calibration may be calculated. Attenuator Calibration presents the calibrated voltage through an attenuator present on the Calibration and Bridge Board of the Signal Conditioner. The TA590-1 is capable of 1:1, 100:1 and 1000:1 attenuation steps, the TA590-10 is capable of 1:1 and 10:1 attenuation steps. The attenuation allows higher gain settings to be accurately calibrated as the signal to noise ratio of a very small voltage out of the voltage source is higher than that of a larger, attenuated voltage (the noise is also attenuated).

4. Internal Test: This test consists of removing the gauge at the TA590-1/TA590-10 Signal Conditioner and inputting an internally generated voltage which is selected via the amplifier's gain code. Internal test may be initiated via the TA485A Controller either through the TA489A Calibrator or through the Signal Conditioner's status registers, or through a front panel switch on the Signal Conditioner, but because of its limited accuracy it is not considered an adequate calibration. Internal Test is more useful as a diagnostic tool rather than as a Calibration. Since +/- Test may be initiated by the Command Link, it is used quite frequently in the automated testing routines to show the operational status of the amplifier.

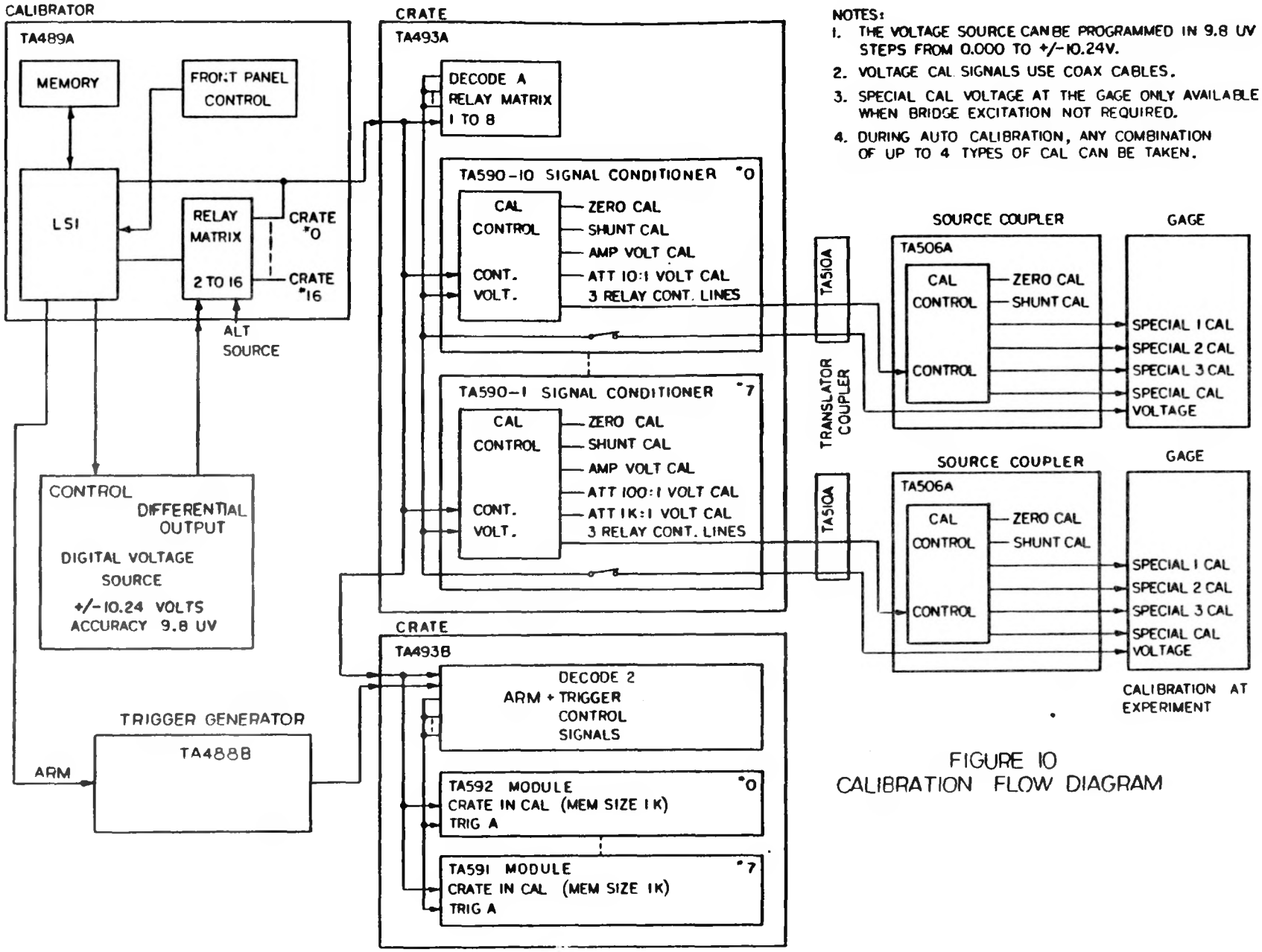
5. Step Response: This function is available for manual and automatic module testing. A known differential signal (amplitude and width) is fed to the module to allow the automated test routines to check the sample rate and presample filter. This may be accomplished through the Command Link (TA485A Controller) or, less accurately through front panel control.

Inputs: The calibrator accepts remote commands from the TA485A Controller (Command Link), TA486A Programmer Timer, or its front panel. It also accepts the differential output from the voltage source and maintains its differential status throughout the chassis.

Internal Program: The internal microprocessor has complete control of all calibration functions. It controls auto calibration, single channel calibration, internal memory reads and writes, etc. The microprocessor also controls the arming and triggering of data modules during calibration.

Outputs: Status bits are output to the TA484A and the TA618 Multiplexers and to the TA486A Programmer Timer. Calibration command bits and calibration voltages are supplied to the TA493A/B Crates for use during calibration.

Programmability: The TA489A is programmed through the TA485A Controller (Command Link). The program is stored in a CMOS memory card within the LSI-11 card cage. A listing of the resident program may be obtained by using the program DHTEST. For programming information, refer to SANDUS (MA164) Command System Message and Data Format, SAND86-1398, by L. W. Ebinger, J. M. Opalka, & D. K. Werling, Division 9321.



NOTES:

1. THE VOLTAGE SOURCE CAN BE PROGRAMMED IN 9.8 UV STEPS FROM 0.000 TO +/-10.24V.
2. VOLTAGE CAL SIGNALS USE COAX CABLES.
3. SPECIAL CAL VOLTAGE AT THE GAGE ONLY AVAILABLE WHEN BRIDGE EXCITATION NOT REQUIRED.
4. DURING AUTO CALIBRATION, ANY COMBINATION OF UP TO 4 TYPES OF CAL CAN BE TAKEN.

FIGURE 10
CALIBRATION FLOW DIAGRAM

TA566A POWER CONTROLLER/ENCODER

The TA566A is essentially a redundant chassis that controls power for most of the SANDUS elements. It also outputs system status for remote monitoring.

Inputs: The TA566A accepts power on/off commands from its front panel and the TA486A Programmer Timer and remote commands through the TA485A Controller (Command Link). It accepts power on indications and internal health status from most other elements. It will also accept 56 binary bits for input to the Sandia Automated Monitoring System.

Monitor Streams: The TA566A creates two monitor bit streams, compatible with the Sandia Automated Monitoring System. The first is dedicated to internal SANDUS status. The second stream is available for the monitoring of special functions. The monitor stream bit rate may be jumper programmed within the TA566A to any of the following rates: 1.2 KHz, 2.4 KHz, 4.8 KHz, 9.6 KHz, 19.2 KHz, 38.4 KHz, or 76.8 KHz.

Auto Power Control: The TA566A contains a system auto power off feature, which is switch enabled. It will power down most of the SANDUS elements if any one of the following occurs:

1. Change of AC input voltage to above 135 volts or below 105 volts or a change in its frequency to below 54 hertz or above 66 hertz.

2. Temperature reading within the equipment racks that exceeds 100 degrees F.

3. Loss of power to any crate.

4. Loss of power to any common equipment chassis.

Outputs: The TA566A outputs system power on/off commands to most elements in the SANDUS system. It outputs a serial Bi-Phase L (BIO-L) coded stream to the digital monitor system.

Displays: The TA566A front panel contains displays of the AC line voltage and frequency, the monitored temperature and a bar graph display of the 64 bits contained in the monitor stream. These monitors include:

Crate 0 through Crate 17 Power OK (16 bits)
TA484A Multiplexer Power OK
TA485A Controller Power OK
TA486A Programmer Timer Power OK
TA488B Arms Enable

TA488B Trigger Generator Power OK
TA489A Power OK
TA566A Power OK
TA486A Programmer Running
TA486A Status OK
TA488B Status OK
System in Calibration
Phase B AC Voltage OK
Phase C AC Voltage OK
Phase A Frequency OK
Fidu
Compton
Spare
Arm 1
Arm 2
Hold
Lockout
Phase A Voltage
MA164 Temperature

TA595 ISOLATION JUNCTION BOX

The TA595 Isolation Junction Box (IJB) provides an interface for all signals entering and leaving the SANDUS except gauge signals and input AC power. It amplifies or converts to fiber optic the Bi-Phase L (BIO-L) coded signal generated by the system multiplexers, attenuates and clips trigger signals, and converts to fiber optic the signals to and from the Terminal Server (Command Link, DECnet, etc.).

All signals that enter and leave the SANDUS via the TA595 IJB are isolated from their respective cable shield, except the signals that are disconnected before an actual test.

Range Time Inputs: The TA595 accepts twelve remote range time signals which may be either 28 volt signals, 60 volt signals, or switch closures. These signals actuate relays within the IJB. The ouputs are routed to the TA486A Programmer Timer.

Range Time Outputs: The IJB accepts eight signals from the TA486A Programmer Timer. These signals control relays in the TA595 IJB so the relay contacts (rated at 2 amps maximum) are available for use external to the SANDUS.

Trigger Inputs: The TA595 IJB accepts six trigger inputs. Each trigger signal is routed through an attenuator, clipper and transformer (where it may be inverted) and output to the TA488B Trigger Generator.

Data Output: The IJB may contain up to four amplifiers and isolation transformers to boost TTL level 20 Mega Bit per second Bi-Phase L coded signals to 50V P-P for transmission to the remote recording facility. Fiber optic line drivers are also included when the system is operated using a fiber optic cable (reference TA650 Fiber Optic Transmitter/Receiver).

Command Link and DECnet from Remote Recording Facility: These signals are transmitted through the DEC Server on terminal lines or may be included within the TA657 DCS II using fiber optic line drivers and receivers for operation with the TA485A Controller and the system computer's DECnet port.

Monitors: The IJB accepts two signals (50 ohm source) from the TA566A Power Controller/Encoder. These two monitor bit streams are output through clippers and transformers with band passes at 1.2 kilo bit per second for operation with the Sandia Automated Monitoring System.

Simulation Triggers: Eight feedthrough type BNC outputs are provided for arming and triggering various simulators and other simulation chassis both internal and external to the SANDUS.

Remote Test Box: Four sets of coaxial and multipair feedthrough connectors are used for the control and monitoring of the TA593A Remote Test Boxes external to the SANDUS. One of these multipair feedthrough connectors is typically used for an external terminal tied to the SANDUS computer.

Communications: Feedthrough connectors are provided for telephone, two way radio communications (Net 8), and remote intercoms.

TA616A MEMORY BACKUP POWER

The TA616A is used as a backup power (battery) source for the data module memories. When it is desired to retain memory data for longer than ten days, this element is used to parallel the TA493B Crate batteries. There are eight 4 volt, 20 ampere-hour, sealed lead acid batteries per chassis. Each battery output includes a diode for isolation from the crate battery. Therefore, two TA616A chassis are needed for memory backup for a 128 channel SANDUS configuration. The TA616A is normally connected from Mandatory Full Participation (MFP) through shot day.

Output: A 4 Volt, 20 ampere-hour, sealed lead acid battery may be connected to each crate.

TA618 REAL TIME MULTIPLEXER

The TA618 Real Time Multiplexer is part of the data playback system shown in Figure 6. It is a stored program multiplexer that accesses data from the TA591 and TA592 Data Modules and status from other common equipment. An internal programmable memory controls the format of the multiplexed data stream and an internal clock determines the output bit rate.

The TA618 Real Time Multiplexer contains four individual 20 mega bit per second multiplexers, which gives the SANDUS the capability of outputting data at a 100 MBit per second rate if the TA484A Multiplexer is also in use. The decommutation equipment (TA666A) within the SANDUS is limited to four inputs, therefore the SANDUS is limited from a practical standpoint to an output data rate of 80 MBit per second. Each multiplexer outputs a parallel data stream to the TA556A Data Distributor or TA666A Data Selector and a serial stream of up to 20 mega bits per second for recording and processing in the remote recording facility.

The TA618 Real Time Multiplexer is required when the real time or memory module bandwidth exceeds the available bandwidth in the TA484A Digital Multiplexer, or when faster memory readout is required. It may be used in addition to the TA484A, and either (but only one) may be connected to any crate in the system.

Inputs: The TA618 Real Time Multiplexer accepts eight bit parallel data from up to 128 data modules via system parallel busses. Twelve status bits from the TA489A Calibrator are input for use during calibration.

Bit Rate: The output bit rate is selectable in binary increments from 159 kilo bit to 20 mega bit per second. Bit rates are remotely selected via the TA485A Controller (Command Link) or the front panel of the TA618.

Formats: Up to four unique formats may be stored in the multiplexer at one time. In each format the data is eight bits wide (word), frame lengths may be from 8 to 128 words with no subcom capability. These formats may be selected via the TA485A Controller or the front panel of the TA618.

Limitations: There are several restrictions when attempting to use the TA618.

1. All four TA618 bit streams must operate at the same bit rate.

2. All TA618 bit streams must have the same frame length.

3. All modules in a single crate must be input into the same bit stream.

Outputs: Four eight bit parallel channels containing data and ID tags (such as Format ID (FMID) and Subcom ID (SCID)) are output to the TA556A Data Distributor or TA666A Data Selector for processing. Four formatted serial Bi-Phase L coded data streams are output to go to a remote recording location.

TA649 CLOSURE MULTIPLEXER

The TA649 Closure Multiplexer operates through the TA484A Digital Multiplexer or TA698 ACE to record various digital channels in the remote recording facility. It is capable of receiving and multiplexing up to 256 bits of gauge information.

Inputs: The TA649 accepts inputs from various gauges that output digital information. TTL levels or relay closures are acceptable inputs. An analog comparator circuit is included to monitor CVR (current viewing resistor) channels. The TA649 will also accept data from specially formatted HP 5345A Digital Counters. The inputs may be optically isolated from the source to minimize the possibility of ground loops.

Outputs: The TA649 outputs an eight bit parallel (RS422) data bus to the TA484A Digital Multiplexer or TA698 ACE. The TA649 may be located in the SANDUS or up to 500 feet away. The Closure Multiplexer accepts channel addressing and data strobe (pulse that strobes the data on to the data bus) information from the TA484A or TA698 ACE Multiplexer.

TA650 FIBER OPTIC TRANSMITTER RECEIVER

The TA650 Fiber Optic Transmitter/Receiver is located in the SANDUS intrusion panel. This chassis may be configured with up to two Fiber Optic Receivers and seven Laser Transmitters.

Inputs/Outputs: The typical inputs to the chassis include the TA484A/TA618 Multiplexer data streams, DECnet information between the local computer and the remote recording facility, Command Link data between the TA485A Controller Interface and the remote recording facility, and a trigger pulse from the TA488B Trigger Generator to the remote recording facility. The SANDUS internal signals are connected via BNC coaxial cables which interface through the Transmitters and Receivers to Fiber Optic Cable.

SANDUS SYSTEM BLOCK DIAGRAM

The complete SANDUS System Block Diagram shown in Figure 11 is included to combine Figures 1, 3, 6, 7, 8, and 9. This diagram should help condense and explain many sections of this manual.

The data flow is shown from the gage or source coupler through the translator coupler, into the signal conditioner and data module and onto the data bus to the TA484A or TA618 Multiplexer.

The Command Link is shown originating in the TA485A Controller, and connecting to the TA484A Digital Multiplexer, TA486A Programmer Timer, TA488B Trigger Generator, TA489A Calibrator, TA493A and TA493B Crates, the TA566A Power Controller/Encoder, and the TA618 Real Time Multiplexer for the set up and control of this equipment.

The TA486A Programmer Timer provides:

Lockout Signal to the TA484A Digital Multiplexer to be output in the data stream for status.

The Arm Signals, Lockout and Trigger Inhibit to the TA488B Trigger Generator.

Start Calibration, Stop Calibration and the Lockout Signal to the TA489A Calibrator.

Hold, Power Down Number 1, Power Down Number 2 and Lockout Signals to the TA566A Power Controller/Encoder for monitoring.

The TA486A Programmer Timer receives status information from the TA489A Calibrator so it knows when the system is in calibration. It also receives the range time signals and outputs control signals through the IJB.

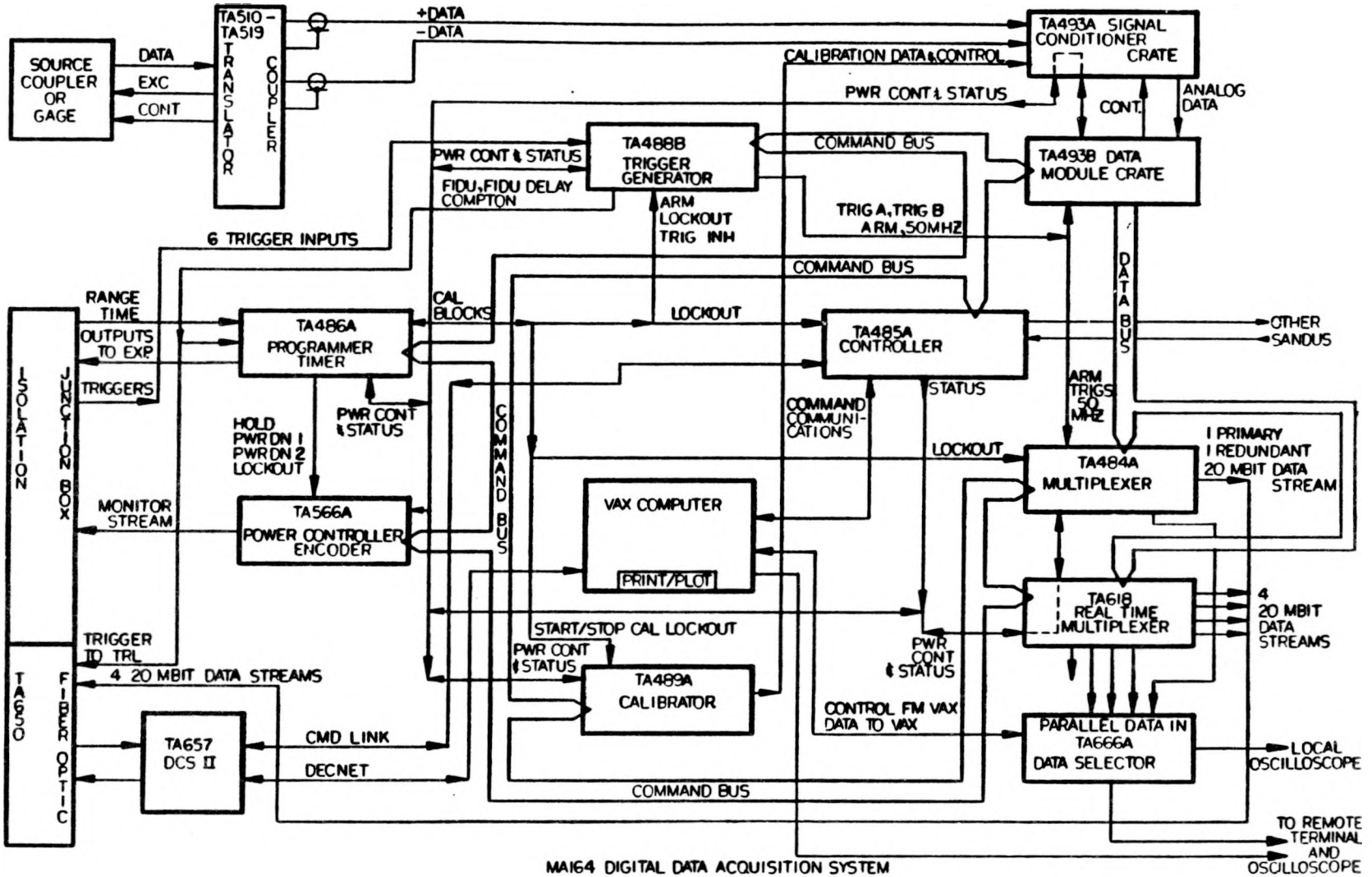
The TA488B Trigger Generator outputs Trigger A, Trigger B, Arm signals and the 50 MHz Master Oscillator to the Data Module Crates. It receives up to 6 trigger inputs through the IJB and up to 16 Auxiliary Triggers from elsewhere. It also outputs up to 6 trigger signals, the Arm signal and the 50 MHz Master Oscillator to the TA484A Digital Multiplexer for Trigger Time Tagging.

The TA489A Calibrator outputs calibration data and control signals to the Signal Conditioner Crates, and receives its control signals from the TA486A Programmer Timer.

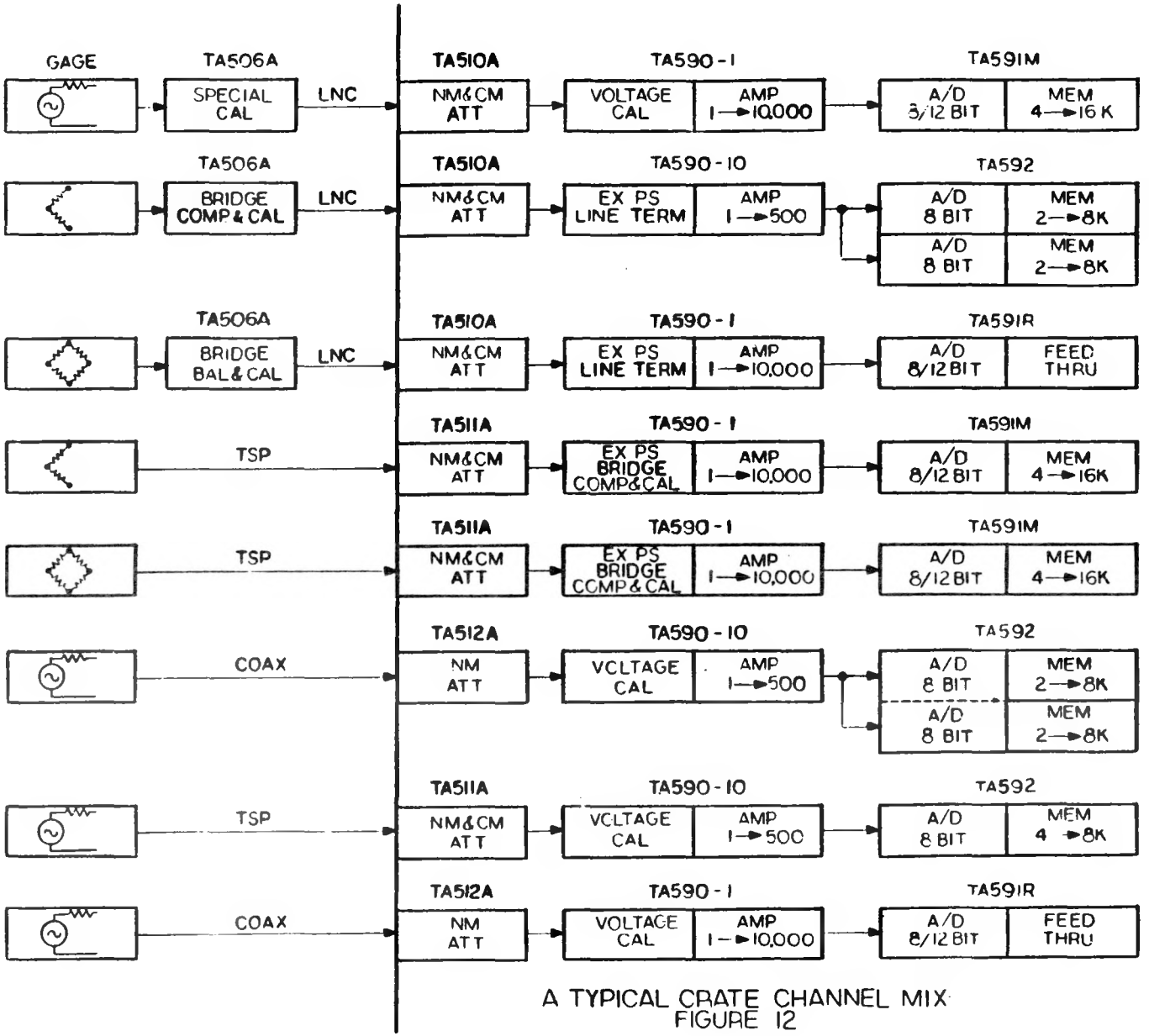
The TA566A Power Controller/Encoder controls the power to all elements (except the TA485A Controller) and receives status from all elements. It outputs this status in a monitor stream through the TA595 IJB.

The TA484A Digital Multiplexer and/or TA618 Real Time Multiplexer may be used to output up to five 20 MBit per second data streams through the TA650 Fiber Optic Transmitter/Receiver.

A Typical Crate Channel Mix, shown in Figure 12, is included in this manual to show some of the flexibility of the MA164 recording system.



MA164 DIGITAL DATA ACQUISITION SYSTEM
SANDUS
FIGURE 11



A TYPICAL CRATE CHANNEL MIX
FIGURE 12

LIMITATIONS:
1) TA591M - 12 BIT LINEAR DATA-MAX MEM SIZE 8K
2) TA591M - MAX SAMPLE RATE 500K SAMPLES/SEC
3) TA591R - MAX SAMPLE RATE 250K SAMPLES/SEC
4) TA592 - DUAL A/D MAX SAMPLE RATE 50 MEG SAMPLES/SEC
5) TA592 - SINGLE A/D MAX SAMPLE RATE 25 MEG SAMPLES/SEC, MAX MEM SIZE 8K

NOTE
LNC = LOW NOISE CABLE
TSP = TWISTED SHIELDED PAIR CABLE
COAX = COAXIAL CABLE
CAL = CALIBRATION
BAL = BALANCE
NM = NORMAL MODE
CM = COMMON MODE
MEM = MEMORY
EX PS = EXCITATION POWER SUPPLY
ATT = ATTENUATION

TA718A HIGH RESOLUTION SEQUENTIAL DATA LOGGER

The TA718 High Resolution Sequential Data Logger is an analog multiplexer and digitizer designed to operate external to the SANDUS. It was specifically designed to be used with the Charge Integrator channels. These channels required decoupling from the SANDUS to eliminate potential ground loop problems.

The chassis contains two multiplexer/digitizers. One is capable of receiving up to 27 channels, the other up to 13 channels, for a total of up to 40 analog channels. The timing control comes from a SANDUS TA591D channel configured to send a "Start Convert" command. When the analog to digital conversion is completed the TA718 returns an "End Of Convert" signal to the TA591D along with the digitized data which is then strobed into memory. The first 27 channels are input through a single TA591D channel, the next 13 through a second TA591D channel.

Channel Specifications

Input Impedance:	10K Ohms Single Ended
Input Sensitivity:	10 volts full scale (0 to +5, 0 to -5)
Offset Characteristics:	0V = 50% (not adjustable)
Data Conversion:	8 bit or 12 bit (selectable)
Sample Interval:	Selectable in a 1-2-4 sequence from 2 usec to 400 usec
Real Time Capability:	Yes
Calibration:	2 point voltage substitution

Output Signal: The output signals to the SANDUS are eight bit data lines with differential drivers (RS422). Twelve bit data (8/12 bit control from the front panel and the data module status register) consists of the 8 MSBs being sent first and, then (approximately 500 nsec later) the 4 LSBs as MSBs of the next word (the 4 LSBs of this word are always zeroes).

Sync Word: At the beginning of each multiplex cycle, an octal sync word is inserted. This sync word is an alternating 072/305.

Calibration is controlled by two closures from the SANDUS TA486A Programmer Timer. The TA486A receives signals from the TA489A Calibrator which flags which calibration block it is currently operating in. Block 0 provides a "zero cal", which inputs a short to signal common at one of the analog multiplexer inputs for each of the two multiplexer channels. Block 1 provides a voltage reference of +2.50 volts at one of the analog multiplexer inputs. Block 2 provides a voltage reference of -2.50 volts at one of the analog multiplexer inputs.

Manual Control allows for the manual front panel selection of each channel for diagnostic purposes. Control is returned to Auto by front panel control, by either one of the calibration closures being activated, or by a power on reset signal generated when this chassis powered up.

TEST EQUIPMENT

TA556A DATA DISTRIBUTOR

The TA556A Data Distributor is part of the data playback system shown in Figure 6. This chassis was designed to interface to the PDP-11/44 Computer and is resident within SANDUS 501 and 502. It provides for real time observation of the data along with an interface to the system computer for data storage and/or plotting.

The TA556A contains internal circuitry which allows high speed data playback into Digital to Analog Converters (DAC) of memory channels and real time display of TA591R Real Time Data Modules. These outputs are used in conjunction with the TA593A Remote Test Boxes and local data displays.

Input: The TA556A accepts one eight bit parallel data stream input from the TA484A Digital Multiplexer plus up to four eight bit parallel streams input from the TA618 Real Time Multiplexer. It also accepts commands from the system computer for remote control and data output.

Analog Output: The TA556A contains three internal memories that are loaded with data from the transient modules at the multiplexed rate and then dumped into the DACs at a higher rate. This allows for a flicker free display of the data on an oscilloscope. The data is output as eight bit linear, twelve bit linear or eight bit extended range (see TA591 100KHz Data Module). Two of these channels are selected for use with the remote test boxes, while the third is used for local data display. When real time data modules are being processed the memories may be bypassed.

Computer Output: The Data Distributor outputs aligned memory or real time data into the system computer under DMA (Direct Memory Access) control.

TA666A DATA SELECTOR

The TA666A Data Selector is part of the data playback system shown in Figure 6. This is a multi-processor chassis used for local and remote observation of data. The TA666A provides an interface to the system computer for data storage and plotting. The TA666A was designed to interface to one of the Digital Equipment Corporation VAX Family Computers via a DMA (Direct Memory Access) Interface. The VAX computers are resident within SANDUS 503, 504 and 505.

The TA666A contains internal circuitry which allows high speed data playback into Digital to Analog Converters (DAC) of data from memory channels and real time display of other data collected.

Input: The TA666A is designed to accept up to four parallel data streams, each of which may be up to sixteen bits wide. These streams are typically provided as one eight bit parallel data stream from the TA484A Digital Multiplexer and up to three eight bit parallel data streams input from the TA618 Real Time Multiplexer.

Internal Processing: The TA666A contains four microprocessors. One is assigned the task of local data playback, two are used in conjunction with the TA593A Remote Box, the remaining one is used to collect and align data for transfer to the local VAX computer. Each processor operates independently, thus allowing multiple operations to be performed simultaneously.

Local Output: The local data playback processor is normally used for a quick look at data internal to the SANDUS. Channel selection and playback are controlled via the front panel, the VAX DMA interface or by control lines from the TA489A Calibrator. Raw (unprocessed) data may be obtained from any of the four input data streams or the TA666A is able to display previously processed data by down loading the "CHZ" data files through the VAX DMA port.

The processor outputs the module setup parameters obtained from each channel's status words contained in the data stream and special playback options to an eight line by forty character front panel display. The data, after interpolation is routed to a digital to analog converter (DAC) for observation on a local oscilloscope.

The TA666A is able to automatically collect, decode and display nearly all SANDUS memory module data. Special playback selection options are required for the display of a SANDUS digital channel (see TA591 and TA592 sections within this manual). Real time data is

automatically displayed as eight bit data unless twelve bit data contexting is located. Special options allow the user to select extended range real time data or to observe any bit of a digital channel.

Remote Output: The two remote box data playback processors operate the same as the local processor except they have no front panel display and no local controls. All channel selections and special playback options are via the VAX DMA interface through a program called DISPLAY. The data after interpolation is routed to a DAC for observation on a remote oscilloscope.

Computer Output: The computer port processor is used to automatically collect single or multiple channel data from any one of the input data streams, to align that data and route it to the VAX for final processing.

TA593A REMOTE TEST BOXES

Each of the TA593A Remote Test Boxes shown in Figure 13, allows for an "end to end" system observation and control from the signal input location. The Remote Test Box consists of a small hand held special function terminal (reference TA662 Water Monitor/Remote Box Interface). The commands allow the operator to completely exercise all the module functions from a source location.

The Remote Test Box and a small portable oscilloscope are located next to the experiment and/or next to the TA506A Source Coupler. It commands the SANDUS via the local computer. The digital data stored in the data module memories or real time data is converted back to analog data in the TA556A Data Distributor or TA666A Data Selector and output for display at the source location.

The TA593A is designed to facilitate troubleshooting of a gauge or Source Coupler, balancing a bridge, setting up external signal simulators, or measuring calibration voltages without the need for a second person located inside the SANDUS.

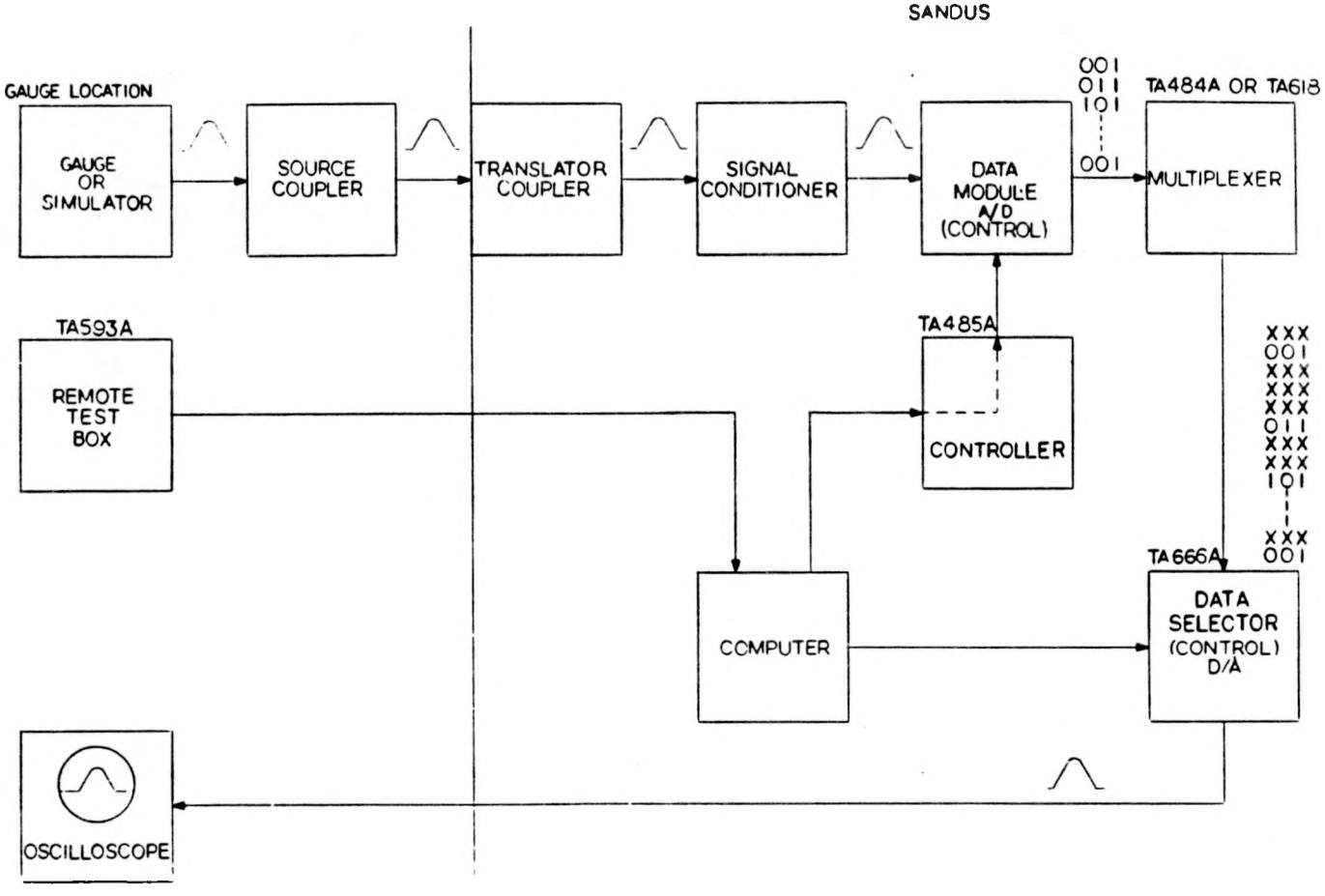


FIGURE 13 REMOTE TEST BOX

LOCAL COMPUTER

The system computer is used for set up, control, testing and local data playback of the SANDUS. The computer system resident within SANDUS 501 and 502 contains the following items:

1. PDP-11/44 with
   A. Floating point processor
   B. 256K bytes of memory
   C. DECnet
2. Versatec printer/plotter
3. TAB 132/15-G graphics terminal
4. Three RL02 5.2 Megaword discs

The computer system resident within SANDUS 503, 504 and 505 is a DEC MicroVAX II containing the following items:

1. MicroVAX II with
   A. Floating point processor
   B. 8 MegaByte main memory
   C. DECnet/Ethernet
2. Talaris T800 laser printer plotter
3. TAB 132/15-G graphics terminal
4. Two RD53 71 MegaByte Discs
5. TK50 95 MegaByte Tape

Interfaces:

The computer interfaces with the TA485A Controller for local control of the SANDUS. It also interfaces with the TA556A Data Distributor (PDP-11/44) or TA666A Data Selector (VAX) for data ingestion to allow data storage and plotting.

Programs: There are four basic programs used by the local computer during normal field operations.

A program called DHTEST is used while setting up the SANDUS system. It allows for the editing of all the parameters required to set up the SANDUS. It also has a multitude of special test programs for verification of signal conditioners and data modules. These test programs are described in SANDUS Low Frequency Module Test Routines, SAND86-1396 by James M. Opalka, 7121.

A program called RMTBX is used to handle all the functions of the TA593A Remote Test Boxes.

The third main program for use with the PDP-11/44 Computer and TA556 Data Distributor is called PROFET. The third main program for use with the VAX series

computer and the TA666A Data Selector is a combination of FETCH and PROCESS. These are data ingestion and playback programs, used to control and ingest calibration data, to store calibration and zero time data on computer discs and to plot the data on a local printer/plotter.

A program called DISPLAY allows the downloading of a plotable data file into the TA666A Data Selector for local or remote oscilloscope display. This enables an experimenter to view his channels at a location other than in the SANDUS.

Hardware and software combined make up a communications package called DECnet. This package allows for transfer of setup files, data files and any other type of file from the local computer to remote computers and vice versa. It also allows remote users to "log in" to the local computer of the SANDUS.

TA617 PORTABLE DATA RETRIEVER

The TA617 Portable Data Retriever is used to read transient data module memories when SANDUS AC power is unavailable. This chassis is contained within a small suitcase which consists of one of the Digital Equipment Corporation LSI-11 family microprocessors and a digital cassette tape recorder. The TA617 Data Retriever sequentially reads data from each data module, one crate at a time. The cassette tapes may be read by a general purpose computer (VAX series or PDP-11) in the remote playback facility in either Camp 12 or at CP14.

Input: The TA617 uses AC power from any external source. It is connected to the TA493B Crate via the J84 Multiplexer connector.

Firmware: The TA617 Portable Data Retriever uses a canned program to read 16K bytes of data from each data module. It then formats and writes the data to cassette tape.

Output: The TA617 Portable Data Retriever outputs proper control signals to the crate to read the data contained in the data module. It also distributes AC power to the TA493B Crate.

TA662 WATER MONITOR/REMOTE BOX INTERFACE

The TA662 Water Monitor/Remote Box Interface provides a monitor and display of the SANDUS chilled water supply status. The TA593A Remote Test Box is interfaced to the computer through the TA662.

Inputs: Three transducers to monitor water flow, input water temperature, and output water temperature are monitored through connector JWater.

I/O: Up to four TA593A Remote Test Boxes and four remote terminals may be connected to the computer through the TA662 connector JCompTerm.

Outputs: The water monitor outputs are provided through a visual display on the front panel. The TA593A Remote Test Boxes require an external electrically floating power supply. This supply is contained within the TA662, and the voltage is output through connector JCompTerm.

ENVIRONMENTAL ENCLOSURE

SHELL

The shell shown in Figures 14 and 15, is the sealed environmental enclosure for the SANDUSs.

There is an intrusion panel that houses the TA510A through TA514A Translator Couplers and the TA595 Isolation Junction Boxes. Isolation and filtering of 30 kilo watts of 3 phase AC input power is provided and each phase is monitored for status display. Each equipment rack within the system is provided two phases of AC power, a primary and a backup. If the primary voltage drops below 105 volts or goes above 130 volts, the secondary phase is switched in. This allows for continuity in AC power. The shell also provides cooling for the electronic equipment via chilled water heat exchangers.

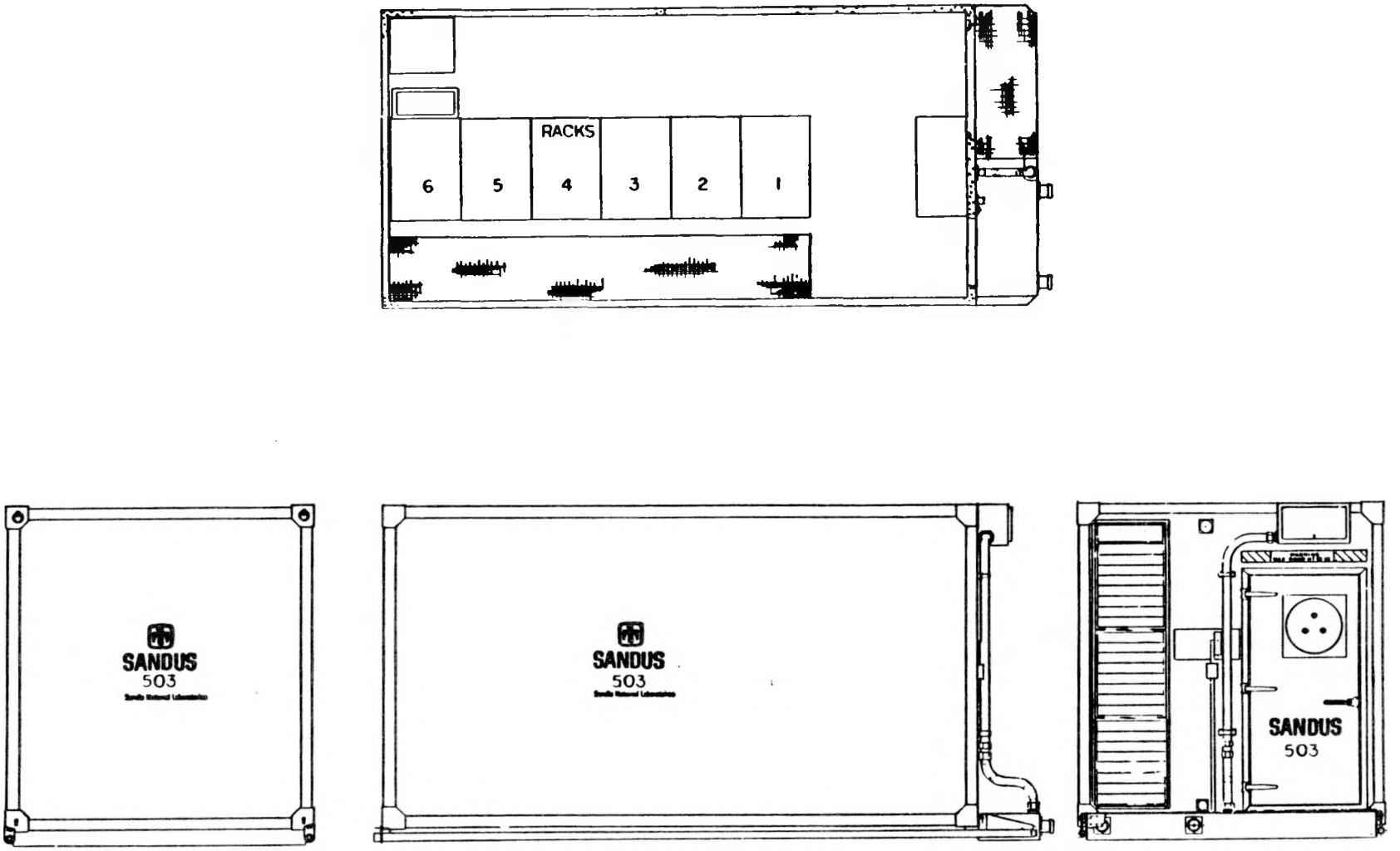


FIGURE 14 **SANDUS** SHELL

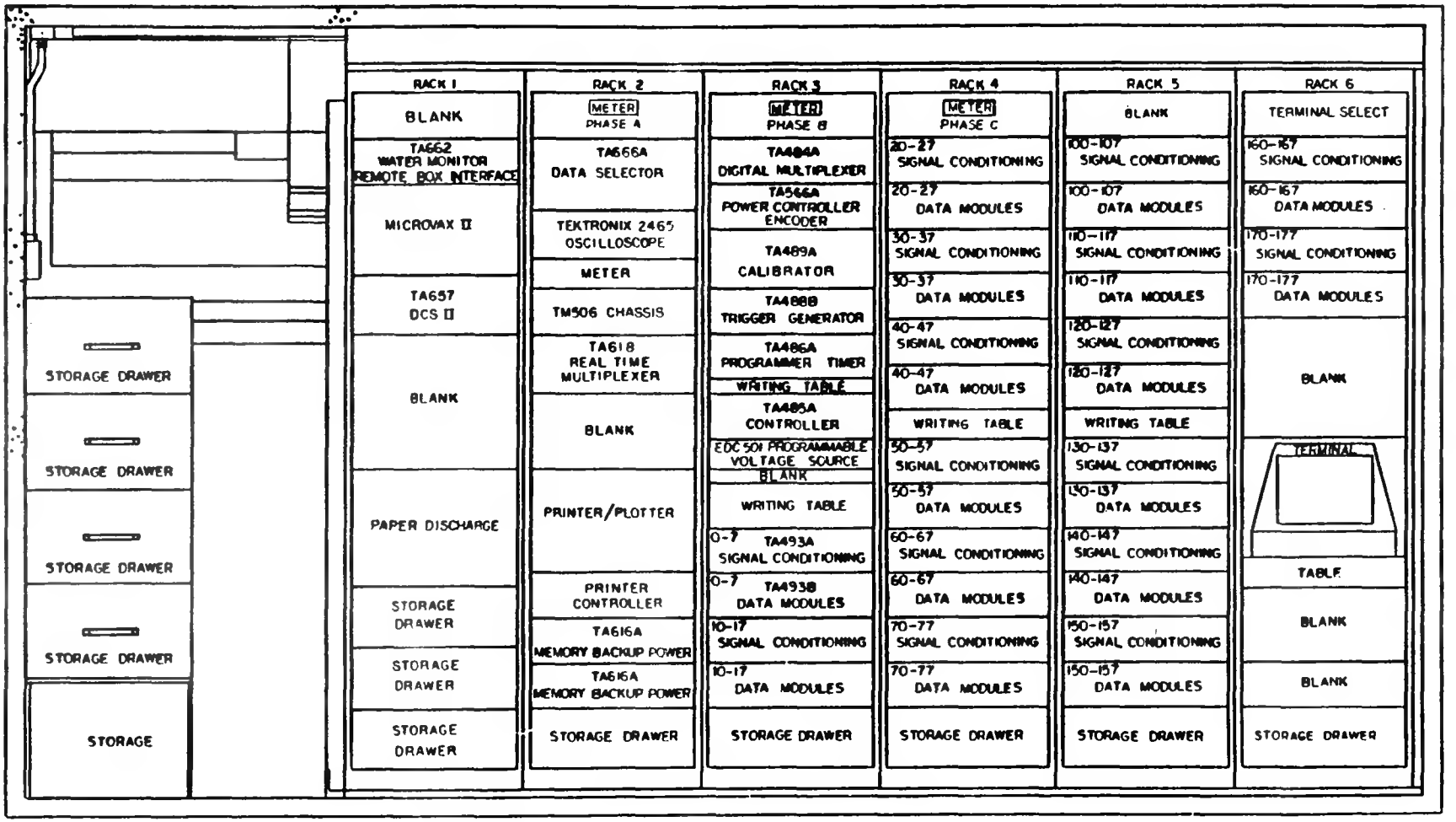


FIGURE 15 TYPICAL SANDUS RACK LAYOUT

SIMULATION

TA665 ZERO TIME SIMULATOR

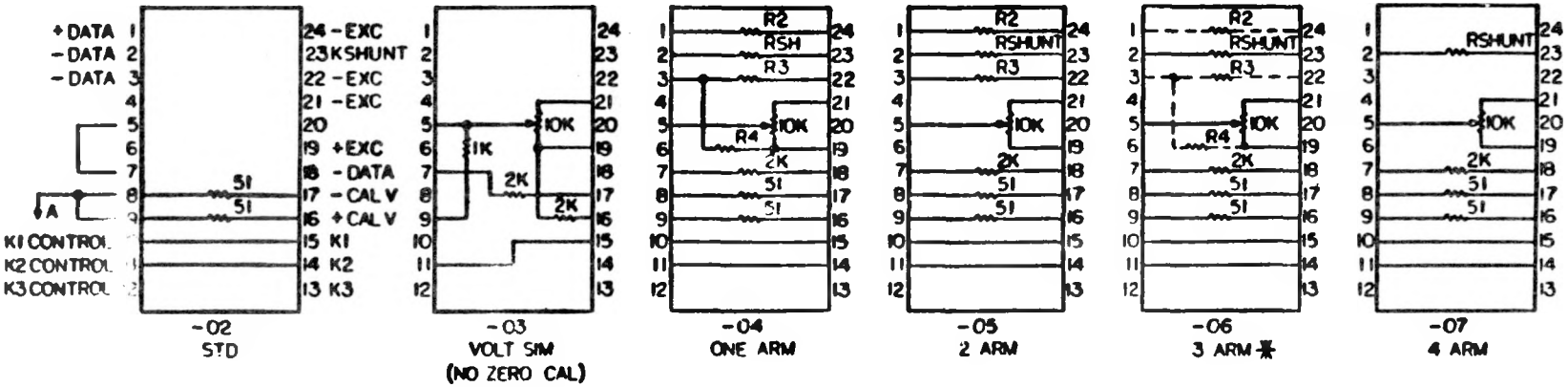
The TA665 Zero Time Simulator is located within each SANDUS and provides up to 128 outputs to activate various signal simulation schemes on any channel.

Input: The TA665 receives a trigger signal from the TA488B Trigger Generator on J88. A floating calibration power supply return reference is provided from the TA489A Calibrator on J89.

Outputs: The TA665 selectively provides a triggered 28 volt pulse to each channel. This signal is used within the TA590 Signal Conditioner to pull in various calibration or simulation signals, e.g., a shunt calibration resistor (either in the TA506A Source Coupler or in the TA590 Signal Conditioner), a voltage simulation, etc. The TA590 Signal Conditioner is set up via a Calibration Header (a 24 pin dual in line package header), see Figure 16.

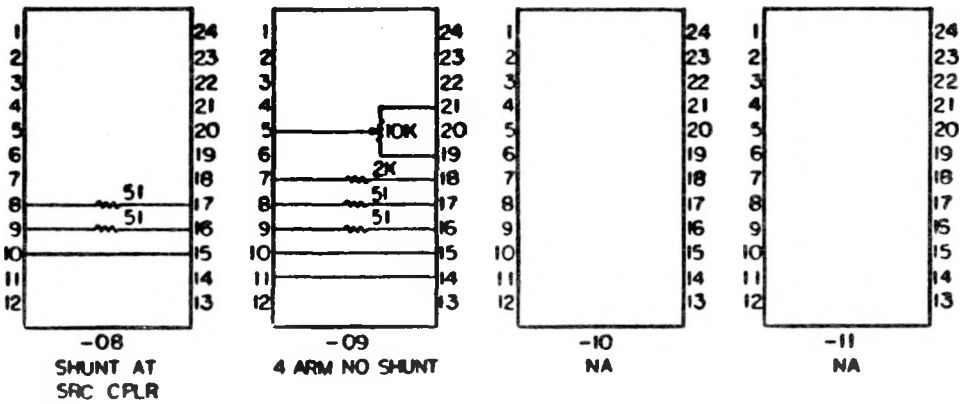
OTHER SIMULATION

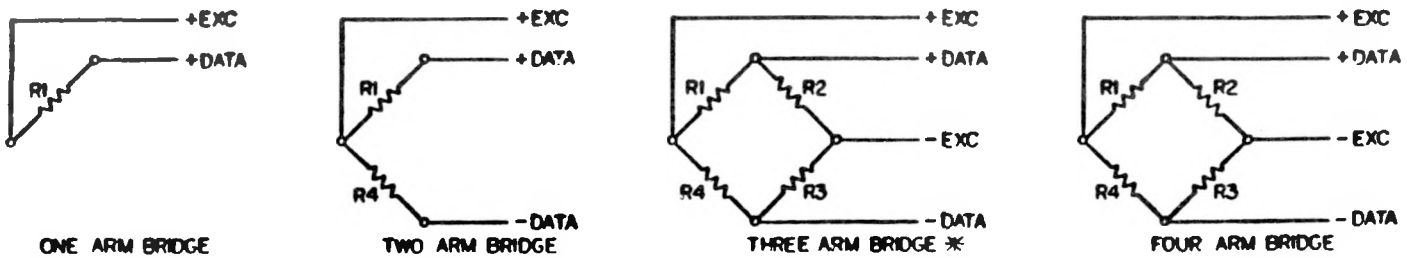
Other simulators may be timed from the SANDUS. The TA488B Trigger Generator is available to output Arms and Triggers through the IJB, and the TA486A Programmer Timer's outputs are buffered through the IJB.



DESIGNATORS:

- -01 NO HEADER INSTALLED
- -02 STANDARD, 50 OHM ZERO CAL
- -03 VOLTAGE SIMULATION FROM TA685
- -04 SHUNT CAL IN SIGNAL CONDITIONER (ONE ARM BRIDGE)
- -05 SHUNT CAL IN SIGNAL CONDITIONER (TWO ARM BRIDGE)
- -06 SHUNT CAL IN SIGNAL CONDITIONER (THREE ARM BRIDGE)
- -07 SHUNT CAL IN SIGNAL CONDITIONER (FOUR ARM BRIDGE)
- -08 SHUNT CAL IN SOURCE COUPLER (FOR SIMULATION)
- -09 FOUR ARM BRIDGE, BALANCE IN SIGNAL CONDITIONER. NO SHUNT CAL
- -10 UNASSIGNED
- -11 UNASSIGNED
- -12 UNASSIGNED
- -13 UNASSIGNED
- -14 UNASSIGNED
- -15 UNASSIGNED





* ANY ONE ARM MISSING EXCEPT R1, INSTALL MISSING ARM AT SIGNAL CONDITIONER

SIGNAL CONDITIONER CALIBRATION/SIMULATION HEADERS
FIGURE 16

APPENDIX 1

"TA/MA NUMBER" (TECHNICAL/MAJOR ASSEMBLY) LIST

TA/MA NUMBER	DESCRIPTION	SCHEMATIC	ASSY	CHASSIS MODS	PARTS LIST
TA484A	MULTIPLEXER	CK-T56552	T56552	T69392	AL-T56552
TA485A	CONTROLLER	CK-T56553	T56553	T69393	AL-T56553
TA486A	PROGRAMMMER TIMER	CK-T56554	T56554	T81274	AL-T56554
	TESTER	CK-T92459	T92459	T92460	
	EXTENSION PANEL	CK-S56612	S56612	S56612	
	RELAY BOARD	CK-T80634	T80634		AL-T80634
TA488A	TRIGGER GENERATOR	CK-T56555	T56555	T81274	AL-T56555
TA488B	TRIGGER GENERATOR	CK-T94748	T94748	S56630	AL-T94748
TA489A	CALIBRATOR	CK-T56556	T56556	T69395	AL-T56556
	RELAY BOARD	CK-T67334	T67334		
TA493A	SIGNAL CONDITIONER CRATE	CK-T56562	T56562		WD-T56562
	DECODE A BOARD	CK-T67271	T67271		AL-T67271
TA493B	DATA MODULE CRATE	CK-T56563	T56563		WD-T56563
	DECODE 1 BOARD	CK-T67202	T67202		AL-T67202
	DECODE 2 BOARD	CK-S49057	S49057		AL-S49057
TA461	ADAPTIVE BIT SYNCHRONIZER		T18503		
TA490B	MONITOR ENCODER		T56541		
TA498	PCM SIMULATOR		T18564		
TA504	CALIBRATION & FIDU DISTRIBUTION				
TA506A	SOURCE COUPLER	CK-T78658	T56557	T56557	
TA510A	TRANSLATOR COUPLER/MICRODOT CONN	CK-T78800	T56558	T67896	
TA511A	TRANSLATOR COUPLER/MS-15 CONNECTOR	CK-T80633	T80633	T67896	
TA512A	TRANSLATOR COUPLER/HN CONNECTOR		T80449		
TA513A	TRANSLATOR COUPLER/TWINAX CONNECTOR				
TA514A	TRANSLATOR COUPLER/MS-19 CONNECTOR		T80633		
TA526	20 MBIT FRAME SYNCHRONIZER		T30954		
TA531	COMPUTER/COMMAND BUS INTERFACE		T30960		
TA532	COMMAND BUS DISPLAY		T30961		
TA533	FUNCTION MATRIX & STATUS INTERFACE		T30962		
TA534	BIT SYNCHRONIZER INTERFACE		T30963		
TA535	DATA EQUALIZER/FILTER		T30964		
TA538A	LINE DRIVER	CK-T68620	T56559		
TA556A	DATA DISTRIBUTOR	CK-T56544	T56544	T69396	
TA559	AMPLIFIER, COMMUNITRONICS				
TA561	RECORD/REPRODUCE ELECTRONICS		T37039		
TA562	REMOTE CONTROL AND STATUS INTERFACE		T37040		
TA566A	POWER CONTROLLER/ENCODER	CK-T56560	T56560	T69397	AL-T56560
	DISPLAY BOARD	CK-T68249	T68249		AL-T68249
TA571A	COMMAND INTERFACE	CK-T56567	T56567	T69398	AL-T56567
TA571B	COMMAND TEST LINK	CK-T68335	T56561	T70706	
TA571C	COMMAND LINK SERIAL INTERFACE	CK-S62720	S62720	S76001	AL-S62720

APPENDIX 1

TA/MA NUMBER	DESCRIPTION	SCHEMATIC	ASSY	CHASSIS MODS	PARTS LIST
TA572	BCD WORLDTIME INTERFACE		T37090		
TA573	TRIGGER DISCRIMINATOR/GENERATOR		T37099		
TA586	TRANSPORT CONT. ISOLATION		T56535		
TA588	PLAYBACK UNIT		T56539		
TA588A	PLAYBACK UNIT DISPLAY		T56539		
TA588A	PLAYBACK UNIT REMOTE		T56540		
TA590-1	SIGNAL CONDITIONER (100KHZ)	CK-T77767	T77767		AL-T77767
	CALIBRATION/BRIDGE BOARD	CK-T77708	T77708		AL-T77708
TA590-10	SIGNAL CONDITIONER (10 MHZ)	CK-T78883	T78883		AL-T78883
TA591	DATA MODULE (100 KHZ)				
	A/D BOARD	CK-T69196	T69196		AL-T69196
	CONTROL BOARD	CK-T66479	T66479		AL-T66479
	MEMORY BOARD	CK-T67773	T67773		AL-T67773
	MEMORY CHECKER BOARD	CK-T93015			
TA591D	DIGITAL DATA CONVERTER BOARD	CK-S79685	S79685		AL-S79685
TA591MN	DATA MODULE (MICRONETWORKS) (100 KHZ)				
	A/D BOARD	CK-T80113	T80113		AL-T80113
	CONTROL BOARD	CK-T66479	T66479		AL-T66479
	MEMORY BOARD	CK-T67773	T67773		AL-T67773
TA591R	REAL TIME DATA MODULE (100 KHZ)				
	A/D BOARD	CK-T69196	T69196		AL-T69196
	CONTROL BOARD	CK-T66479	T66479		AL-T66479
	MEMORY BOARD	CK-T83376	T83376		AL-T83376
TA592	DATA MODULE (10 MHZ)				
	A/D BOARD	CK-T66568	T66568		AL-T66568
	CONTROL BOARD	CK-T69912	T69912		AL-T69912
	MEMORY BOARD	CK-T68454	T68454		AL-T68454
TA592D	DIGITAL DATA CONVERTER BOARD	CK-S90637	S90637		AL-S90637
	TERMINATOR BOARD		T68455	T68455	
TA592-1	DATA MODULE (10 MHZ) (SINGLE A/D)				
	A/D BOARD	CK-T88331	T88331		AL-T88331
	CONTROL BOARD	CK-T69912	T69912		AL-T69912
	MEMORY BOARD	CK-T68454	T68454		AL-T68454
TA593A	REMOTE TEST BOX		T56551		
TA594	TIME/FUNCTION INTERFACE		T56564		
TA595	ISOLATION JUNCTION BOX		T56565		
	TRIGGERS	CK-T68610			
	RANGE TIMES	CK-T68608			
	IJB	CK-T68611			
	COMMUNICATIONS	CK-T70429			
	DECNET	CK-T69431			
	MONITOR	CK-T68614			

APPENDIX 1

TA/MA NUMBER	DESCRIPTION	SCHEMATIC	ASSY	CHASSIS MODS	PARTS LIST
TA599	EXTERNAL STATUS INTERFACE		T56573		
TA616A	MEMORY BACKUP POWER	CK-T78214	T78214	T80858	AL-T78214
TA617	PORTABLE DATA RETRIEVER		S60839	T78215	
TA618	REAL TIME MULTIPLEXER	CK-T78216	T78216	T80740	AL-T78216
TA622	PROGRAMMABLE DATA SELECTOR	CK-T78220	T78220		
TA623	CHANNEL SELECTOR	CK-778221	T78221		
TA649	CLOSURE MULTIPLEXER	CK-T91773 CK-T94709	T94709		
	OPTO ISOLATOR BOARD	CK-S57401	S57401		
	CVR COMPARATOR BOARD	CK-S70271	S70271		
	HP COUNTER BOARD	CK-S77842	S77842		
	POWER SUPPLY BOARD	CK-S76120	S76120		
TA650	FIBER OPTIC TRANSMITTER/RECEIVER	CK-T94711	T94711		
TA650A	FIBER OPTIC TRANSCEIVER	CK-T94711	S96273		
TA652	HDDR STATUS DATA MULTIPLEXER		T94717		
TA653	HDDR CONTROLLER & STATUS DATA DEMUX		T94718		
TA654	HDDR RECORDER/PLAYBACK STATUS REMOTE		T94719		
TA656	DCS MULITPLEXER/DEMULTIPLEXER I	CK-T94721	T94721		
TA657	DCS MULTIPLEXER/DEMULTIPLEXER II	CK-T94722	T94722		
TA658	DCS CMD/STATUS I/O UNIT	CK-T94723	T94723		
TA659	DCS COMMAND/STATUS CONSOLE		T94724		
TA660	DCS COMMAND/STATUS INTERFACE		T94725		
TA661	DCS INTERCOM		T94726		
TA662	WATER MONITOR/REMOTE BOX INTERFACE	CK-T94728	T94728		
TA664	FIBER OPTICS TRANSCEIVER	CK-T94742	T94742	S52601	
TA665	ZERO TIME SIMULATOR	CK-T94743	T94743		AL-T94743
TA666A	DATA SELECTOR	CK-T94795	T94795	S55054	
TA667	PROGRAMMABLE DATA DISTRIBUTOR	CK-T94745	T94745	T68702	
TA668	LOCAL DATA SELECTOR	CK-T94746	T94746	T67802	
TA698	ACE (ALTERNATE COMMON EQUIPMENT)	CK-T94796	T94796	S64850	AL-T94796
	TRIGGER GENERATOR BOARD	CK-S81297	S81297		AL-S81297
	CALIBRATOR BOARD	CK-S81298	S81298		AL-S81298
	COMMAND 1 BOARD	CK-S81299	S81299		AL-S81299
	COMMAND 1 PC BOARD	CK-R08648	R08648		AL-R08648
	COMMAND 2 BOARD	CK-S81300	S81300		AL-S81300
	COMMAND 2 PC BOARD	CK-R08647	R08647		AL-R08647
	MULTIPLEXER BOARD	CK-S81295	S81295		AL-S81295
	DISPLAY BOARD	CK-S90639	S90639		AL-S90639
	PROGRAMMER TIMER BOARD	CK-S81341	S81341		AL-S81341
	DATA BUFFER BOARD	CK-S89897	S89897		AL-S89897
	EIA INTERFACE BOARD	CK-S83582	S83582		AL-S83582
	DUAL DIFFERENTIAL DAC BOARD	CK-S74613	S74613		AL-S74613
	ACE RELAY BOARD	CK-S56684	S56684		AL-S56684

APPENDIX 1

TA/MA NUMBER	DESCRIPTION	SCHEMATIC	ASSY	CHASSIS MODS	PARTS LIST
TA698	ACE (CONTINUED)				
	CAL RELAY BOARD	CK-T67334	T67334		AL-T67334
	PRECISION CALIBRATION SOURCE	CK-S56683	S56683		AL-S56683
	MICRO RESET/ABORT BOARD	CK-S79094	S79094		AL-S79094
	COMMAND SERIAL INTERFACE BOARD	CK-S80509	S80509		AL-S80509
	BATTERY/CHARGER BOARD	CK-S72758	S72758		AL-S72758
	BACKPLANE WIRING	CK-S81336			
TA699	WAFOS TRANSMITTER				
TA702			S62707		
TA703	RANGE TIMING UNIT	CK-S62711	S62711	S69328	
TA704	BIO-L DECODER		S62712		
TA705	DRC (DATA RETENTION CHASSIS)	CK-S62715	S62715	S76191	AL-S62715
TA706	AUTO SIGNAL SIMULATOR	CK-S67805	S62716	S75147	
TA707	ISOLATION RS-485 TRANSCEIVER	CK-S62724	S62724		
TA708	RS-485 TRANSCEIVER	CK-S62725	S62725		
TA709	CAMAC CONTROLLER	CK-S62726	S62726		
TA710	DATA MODULE TESTER CRATE	CK-S62729	S62729		
TA711	FIBER OPTIC TRANSMITTER		S62732		
TA714	WAFOS TRANSMITTER		S62742		
TA715	WAFOS RECEIVER		S62745		
TA718	HIGH RESOLUTION SEQUENTIAL DATA LOGGER				
		CK-S62755	S62755		
TA730	MONITOR ENCODER	CK-S62744	S62744		
TA730A	DUAL MONITOR ENCODER	CK-R14100	R14100	R14483	
TA734	WAFOS ANALOG FIBER OPTIC SYSTEM (XMTR)				
TA735	WAFOS ANALOG FIBER OPTIC SYSTEM (RCVR)				
TC953	HIGH DENSITY DIGITAL RECORDER		T94716		
TC954	DIGITAL COMMUNICATIONS SYSTEM	CK-T94720	T94720		
MA155	DIGITAL RECORDING TRAILER		T18585		
MA164	SANDUS (SANDIA DIGITAL UNDERGROUND SYSTEM)				
		AY-T56543	T78554		
	PHASE SWITCHING CHASSIS		T71707	T72099	T72099
	AUXILIARY POWER BOX	CK-T81669	T81669	T81669	
	GAS ACTUATOR		T97943	T97943	T97942
	TIME/TEMPERATURE PANEL	CK-T84202	S53861	T75839	
	SANDUS CHILLER	CK-T75883	T75883		
	SANDUS POWER		T71707		
	SANDUS CABLES		T93098		
	80 PIN EXTENDER			T70041	
	100 PIN EXTENDER			T71742	
	TERMINATOR BOARD			T68455	

APPENDIX 1

TA/TC/MA NUMBER	DESCRIPTION	SCHEMATIC	ASSY	CHASSIS MODS	PARTS LIST
	5 1/4" X 26" CHASSIS		T65615		
	5 1/4" X 20" CHASSIS		T80647		
	7" X 26" CHASSIS		T68244		
	7" X 20" CHASSIS		T80820		
	8 3/4" X 26" CHASSIS		S69252		
	5 1/4" FRONT PANEL		T67626		
	5 1/4" REAR PANEL		T67625		
	7" FRONT PANEL		T68284		
	7" REAR PANEL		T68283		
MA167	HIGH DENSITY DIGITAL RECORDING SYSTEM		T95715		

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