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A DATA COLLECTION SYSTEM
UTILIZING CASSETTE TAPE STORAGE

Battelle

Pacific Northwest Laboratories
Richland, Washington 99352

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PACIFIC NORTHWEST LABORATORY
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A DATA COLLECTION SYSTEM
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Computers and Control Section
Systems Engineering Department

December 1972

BATTELLE
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ABSTRACT

A general purpose data acquisition system has been developed utilizing cassette tape storage. The design requirements for the system included modularity, portability and general purpose features making it usable on a wide variety of data collection applications. The engineering evaluation prototype was developed for the purpose of determining cost effectiveness and technical feasibility for use in a production environment. Initial application involves obtaining weapons fabrication data from production agencies in order to establish a data base to be used for quality assurance and other long term studies.

SUMMARY

A general purpose data acquisition system has been developed utilizing cassette tape storage. The prototype system utilizes a Dicom 344 Cassette Magnetic Tape System and a Battelle developed Data Collection unit. An interface in the Data Collection unit permits on-line output to the cassette storage unit. Header data having variable length and formats may be input from the Data Collection unit via thumbwheel switches or from an off-line Teletype keyboard or paper tape reader. Eight differential input analog channels are multiplexed into one of two card selectable analog-to-digital converters. A dual 80 character buffer provides temporary storage in the Data Collection unit to facilitate outputting a card image record length. Data are output to cassette tape in parallel 8 bit ASCII code.

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INTRODUCTION

Battelle-Northwest was requested by George McFarland of Lawrence Livermore Laboratory to develop a portable digital data acquisition system. Lawrence Livermore Laboratory requires weapons fabrication data from the production agencies in order to establish a data base to be used for quality assurance and other long term studies. Although the initial application of the system is to be for weapons fabrication gaging operations, it is by no means limited to this use. One of the design goals for the prototype instrument is that it be general purpose and modular. Lawrence Livermore Laboratory specified that the output media be digital cassette tape, eight input channels be provided, and the instrument possess high common mode and normal mode noise rejection.

A cursory market survey conducted prior to system design indicated that a data collection system having the required specifications was not available commercially. In particular, high noise rejection, provision for header data entry, and output to digital cassette tape were generally not provided.

A market survey was performed to identify cassette tape units that would meet system requirements. Time did not permit an exhaustive analysis and testing of potential cassette units. The cassette tape survey did indicate that: (1) transports and complete systems are available from many manufacturers with prices ranging from several hundred dollars to \$5,000; (2) there is a wide variance in the quality and lifetime of the units (almost directly related to cost); and (3) there is a complete lack of standardization of recording techniques resulting in no compatibility between different manufacturers' units.

Based upon technical requirements and delivery constraints a Dicom 344 cassette tape system having two transports was purchased. Although

interfaced to this cassette tape system, the data collection system is designed as a separate entity and could, with modest interface redesign, be used with a different manufacturers' cassette tape system.

SYSTEM DESCRIPTION

GENERAL SPECIFICATIONS

The analog inputs to the Data Collection unit consists of 8 differential channels. The signals are applied to one of two analog-to-digital converters (ADC's) through an 8 channel differential multiplexer (MUX). The choice of ADC's is card selectable. Input characteristics for each are listed in Tables 1 and 2.

TABLE 1. Datel Systems Model ADC-12D

Input amplitude	± 1 VFS
Input impedance	100 M ohm
Input overrange	100%
Common mode rejection	80 db
Maximum scan rate	80 Hz

TABLE 2. Analog Devices Model ADC-17I

Input amplitude	± 10 VFS
Input impedance	180 K ohm
Input overrange	none (limited by MUX)
Series mode rejection	70 db
Normal mode rejection	100 db
Maximum scan rate	25 Hz

Although the Analog Device analog-to-digital converter can accept ± 10 VFS inputs through the multiplexer, the Data Display on the front panel is limited to ± 1.999 volts. The units digit will appear only as an overvoltage indication in the recorded data.

All input data are buffered in a dual eighty character buffer in 8 bit ASCII code. Each data record can be preceded by a Header to assist identification of the recorded data. Either manual numeric entry via the front panel or Teletype alphanumeric header entry is possible through the keyboard or paper tape reader.

The data recording unit is a Dicom Cassette Magnetic Tape System Model 344-01-02-03-09 with two tape transports. The recording capability is summarized in Table 3.

TABLE 3. Cassette Tape Recording Characteristics

Record size	80 characters/record plus one control character (carriage return)
File size	1650 records (one tape side)
Tape capacity	133,650 characters per tape side, 267,300 characters per tape
Word size	5 characters per word/16 words per record
Recording time	5.5 minutes per tape side minimum

Mode of operation, header entry control, data display, and several indicators are available from the front panel of the data collection unit. These are summarized in Table 4. Refer to Fig. 1 for their location.

TABLE 4. Front Panel Controls and Indicators

<u>Control/Indicator</u>	<u>Function</u>
Manual Data (6 TW switches)	Permits manual numeric header entry
Dwell (Ø-7) TW switch	Selects displayed channel
Stop (Ø-7) TW switch	Selects last channel in scan (starting from zero)
Scan rate	Selects an internally selected rate or externally controlled rate.
Power ON	AC power control
Enter Manual	Loads 6 digit header into 80 char. buffer
Record	
Manual	Permits front panel header entry
Auto	Permits data recording while scanning
Inhibit	Inhibits data recording while scanning
Start	Permits manual starting and stopping of data recording

Reset	Initializes system and selects Dicom ON LINE mode
Scan Enable	Selects internal or external control
Space	Separates manual data entry words
CR (carriage return)	Fills remainder of buffer with spaces (in manual mode) and terminates with CR
POL	Voltage polarity indicator illuminated for positive voltage using the Datel unit and for negative voltage using the Analog Devices unit
OV	Overvoltage indicator illuminated for voltages one volt or greater.
Data Display (4 decades)	
Manual mode selected	Left-most digit indicates manual entry count
Auto mode selected	Indicates ADC output of selected channel
Scan Mode	Indicates scan mode has been selected and no faults exist when illuminated
Power Lamp	Illuminated with application of AC power.

Infrequently used operator controls and inputs are available on the rear panel as summarized in Table 5. Refer to Fig. 2 for their location.

TABLE 5. Rear Panel Controls and I/O Connectors

<u>Control Input</u>	<u>Function</u>
Analog Input (8 channels)	Data inputs to be recorded
A/D Trigger	External scan rate control input
Scan Enable	External scan mode control input
Elco connector (38 pin)	Interface connector to Dicom tape unit
60 Hz Adjust (6 position)	Permits selecting frequencies near 60 Hz to zero beat with AC line frequency
Lamp Test	Facilities testing LED data display.

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FIGURE 1. Data Collection System

Recorded data words consist of five characters. The first character is always an alpha character. It represents status information: e.g., voltage polarity, overvoltage. The second character indicates the analog channel number being represented. The third through fifth character represents the analog data in millivolts. Appendix C illustrates the data format. Refer to Appendix D for interpretation of the status word.

DATA COLLECTION UNIT

A picture of the Data Collection unit with the top cover removed is shown in Fig. 3. The logic type used in the Data Collection unit is primarily bipolar TTL. The dual eighty bit static shift registers are MOS/LSI. Several RTL inverters are used to facilitate using a card selectable choice of two different analog-to-digital converters. All input and output signals are DTL/TTL compatible. Augat wire wrap panels were used to facilitate design modifications.

Installation

Use care when unpacking the Data Collection unit or when handling the unit for rack mounting or maintenance. Do not support the rear of the unit by holding on to the power supplies mounted in the rear. Both the Data Collection unit and the Dicom 344 storage unit are 19 inch RETMA standard rack mountable.

Analog input signals require connectors which will mate with the bulkhead connectors, Trompeter type BJ-72 installed. Either twinax or triax cable can be accommodated. Possible cable connectors are Trompeter types PL-75, PL-76, PL-77 and PL-78, depending upon the cable used. A PL-75 1/4-inch twinax connector is supplied with the analog low, high, and ground inputs tied together to permit shorting the input to channel 7 when not used.

The multiplexer is normally monitoring channel 7 prior to starting each scan. To prevent this 'floating' input from presenting a large off-set voltage at the input to the analog-to-digital converter, the shorting plug provided should be inserted. Failure to comply with this requirement

FIGURE 2. Data Collection Unit
(Rear View)

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will cause a temporary change in the full scale reading from the analog-to-digital converter.

Analog ground *and* analog low must be connected to each channel used to permit proper A/D conversion. The analog multiplexer must not be allowed to scan over floating (open circuit) inputs. The ADC may not provide an "end of conversion" signal, thus halting further scanning even though the Scan Mode indicator will remain illuminated. To scan four channels, for example, use analog inputs 0-3 and set the STOP thumbwheel switch to "3" and insert the shorting plug into Analog input 7.

Data Input Requirements

CAUTION: Do not exceed ± 15 V on the analog input lines. The analog multiplexer will be damaged as the result.

CAUTION: Do not exceed -0 $+5$ V on the BNC input connectors or integrated circuit damage may result.

Normal full scale data inputs are ± 1 V. Maximum usable data inputs are ± 1.999 V. For voltages $\geq \pm 1$ V $\leq \pm 1.999$ V the OV indicator will be illuminated when Dwelling (displaying) a channel with such an input. An overvoltage indication is included in the status character of the recorded data word.

Control Input Requirements

All input signals are negative true and DTL/TTL compatible. A true or logic "1" should be $0 \leq 0.5$ V, sinking 7 ma. A false or logic "0" should be 2.5 V ≤ 4.5 V. Rise and fall times should not exceed 1 μ sec. Pulse widths should be ≥ 500 nsec.

The cassette tape output signal, Teletype serial compatible, is available through a Winchester connector labeled "TTY" on the rear of the Dicom 344 tape unit. A description of the Teletype I/O driver and receiver is detailed in the Dicom 344 Operating and Interface manual pages 4-16 and 4-17.

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FIGURE 3. Data Collection Unit

Operating Procedure

Prior to turning on power, the appropriate ADC should be installed in the Data Collection unit. The Datel ADC-E12D2 is installed in location F3 when shipped. Refer to Fig. 5 for location. The top cover can be removed by removal of the two brass screws located along the top rear of the cabinet. The ADC is now accessible. To use the Analog Devices ADC-17I, remove card F3 and insert ADC-17I in slot F4. Refer to Appendix A to determine ADC choice.

Power-up. Turn on power to the Data Collection unit first. This prevents the Dicom 344 from receiving inadvertent write commands. Depress the "power on" switch on the Dicom tape unit. Insert magnetic tape cartridges into transports 1 and 2 as desired. (Refer to Dicom 344 Operating and Interface manual if needed.) The Data Collection unit will automatically select Transport 1 first. If cartridges were previously installed, they will automatically rewind when power is applied. This prevents accidental erasure of data. When rewinding is complete the "READY" lamp(s) will be illuminated. Depress "RESET" on the Data Collection unit. This initializes the system and selects ON-LINE mode of operation for the Dicom 344 recording unit.

Record Inhibit. To monitor analog input channels without recording, select the RECORD INH mode. Set STOP switch for last channel in scan and DWELL for channel to be monitored on the front panel of the Data Collection unit. Select desired Scan Rate and Scan Enable mode to be used. To start and stop scan internally, select Scan Enable INT and depress START switch. Depress once again to stop scanning.

Header Entry. To provide a Teletype entry with alpha-numeric capability, select OFFLINE, desired deck, and WRITE command from Dicom 344 tape unit. Input desired header from Teletype keyboard or paper tape reader.

Not more than 80 characters should be input without a carriage return control character. Since a Teletype is limited to 72 characters per line, a carriage return, line feed is automatically in order at the end

of every line. Always terminate with a carriage return control character, however, since this will cause the tape storage unit to "dump" its 100 character buffer onto the selected tape cartridge and generate an end-of-record gap. Now depress ON LINE to reconnect the Data Collection unit to the Dicom 344.

To supply header entry from the front panel of the Data Collection unit, select Record MAN. Dial desired number with the Manual Data switches and depress ENTER MANUAL switch. Header may be any length. Spaces may be inserted after any six numeric character entry by depressing SPACE. Terminate header with a carriage return by depressing CR. Note that the left-most digit of the data display increments each time the ENTER MANUAL or SPACE pushbutton is depressed.

Data Recording - Internal Control. Select Record AUTO, Scan Enable INT, desired Scan Rate, and STOP switch to last channel to be scanned. Depress START to initialize scan. The Scan Mode lamp will be illuminated. Depress START again to terminate scan.

Data Recording - External Control. Select record AUTO, Scan Enable EXT and desired Scan Rate (either internal or external). Present a true level at the rear panel BNC input labeled "Scan Enable" during the desired recording interval. Note that the Scan Mode lamp is illuminated during this interval.

Second Entry. All following Header and Data entries are accomplished as outlined previously. Do not depress RESET on the Data Collection unit except to initialize the system. If RESET is depressed while using tape transport 2, tape transport 1 will be selected when data and/or Header information are output to the recording unit. It is permissible to remove or install a tape cartridge while the other transport is recording.

Note: If it is anticipated that both tape transports will be used during a data acquisition scan, advance the second tape cartridge beyond its leader before starting the scan as follows: Depress OFF LINE, deck transport number of interest, and WRITE. After the READY light of the selected deck is illuminated, depress ON LINE. The scan mode may now be selected.

Data Playback. Reading recorded data is accomplished with the Dicom 344 in the OFF LINE mode, appropriate deck selected, and READ command selected. The output is Teletype serial compatible. Every 81st character is a carriage return control character. To inhibit reading at the end of an 80 character record, a "Break" command from a connected Teletype or Teletype compatible data line may be used. A second "Break" command releases the inhibit to permit continued reading. Depressing HALT terminates the READ mode.

Theory of Operation

A simplified block diagram of the Data Collection System is shown in Fig. 4. Analog information is input through an eight channel differential multiplexer. A choice of two analog-to-digital converters is provided and is card selectable. Manual Header information and ADC output is in BCD form which is converted to ASCII code. Scanning rate is internally selectable or can be controlled externally. When the 60 Hz rate is selected, a six position 60 Hz ADJ switch located in the rear of the unit, permits zerobeating the conversion rate with the line frequency.

The 60 Hz ADJ switch provides rates slightly above and below the 60 Hz line frequency powering the equipment. If line frequency analog data are input while using the Datel analog-to-digital converter, the displayed data will rise and fall (zerobeat) at a rate determined by the following formula:

$$Z = \frac{S - L}{60}$$

where Z = zerobeating frequency

S = scanning rate

L = line frequency

This feature permits the experimenter to observe the 60 Hz noise in the data, if present.

When recording Header information in the manual mode, the binary coded decimal (BCD) to ASCII converter outputs to the dual 80 character static shift register buffer. When the first buffer is filled, it is output to the Dicom 344 recording unit. The second buffer can be filled

FIGURE 4. Data Collection System Simplified Block Diagram

while the first buffer is being emptied, either simultaneously or independently. When the automatic recording mode is selected, status information, channel address, and BCD data are input to the same buffers through the BCD to ASCII converter in the same manner.

To assist the operator in keeping track of the manual Header entry, the left-most digit of the Data Display increments each time the Manual Entry or Space pushbuttons are depressed. The Manual Entry Counter is inhibited when in the Auto Record or Inhibit Record modes to permit monitoring the voltage present on the channel selected by the DWELL TW switch. The Inhibit Record mode, however, prevents loading the 80 character buffers while permitting scanning and channel-to-channel monitoring.

Fig. 5 identifies the power supplies used in the data collection unit. Power supply (1) provides the required -12 V to drive the 80 character MOS static shift registers. Power supply (2) provides the +5 V logic power for card groups D, E, F, and G as well as the drive for all LED displays and indicators. Power supply (3) provides the ± 15 V power required in Group F for the analog multiplier and ADC. The +5 V supplies are overvoltage protected. A 2 ampere slow blow AC line fuse is used for input protection.

The Interface Logic controls the 8 bit ASCII output to the Dicom 344 recording unit. Depressing RESET causes an ON LINE mode to be selected and causes tape transport (1) to be selected when the first Write command is issued. Write commands commence upon receiving the "input buffer full" signal. If an externally applied Scan Rate clock frequency is too high for the recording unit, the input buffer will fill faster than the output buffer is emptied. This results in a FAULT condition which terminates the scan. Data loaded into a buffer must be transferred to the tape unit before reloading can begin. RESET must be depressed to clear the fault since data have been lost. The interface logic also "looks" at the end of every record output to determine if the end of tape side has been reached. If so, the following record will be output to the other tape transport.

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FIGURE 5. Data Collection Unit
(Top View)

The Teletype I/O is self contained in the Dicom 344 cassette magnetic tape system. Header information can be recorded and recorded tapes read back through a Teletype; e.g., ASR-33 or ASR-35 in the OFF LINE mode.

Maintenance

Logic drawings for the Data Collection Unit are included in Appendix E. Refer to page 11 for a more detailed block diagram. No preventive maintenance is required on the Data Collection Unit. Appendix B includes Interface Commands and Appendix F contains the Parts List.

Preventive maintenance such as cleaning and lubrication is required on the recording unit. Refer to the Dicom 344 Cassette Magnetic Tape System Maintenance Manual.

DATA STORAGE UNIT

The cassette magnetic tape system supplied is a Dicom Industries Model 344-01-02-03-09. Options -01, -02, -03 provide a two transport system with a TTY interface included in the universal controller and a 100 character buffer for asynchronous Off-Line communication with the TTY. Option -09 provides the Break feature which permits starting and stopping at the end of a record. (An end-of-record on tape is issued upon receipt of a carriage return control character.) Refer to Dicom 344 Cassette Magnetic Tape System Operating and Interface Manual page 1-11 for physical properties and performance characteristics.

RECOMMENDATIONS FOR MULTIPLE UNIT FABRICATION

The cost to fabricate duplicate units is a function of the number of units to be built. The cost to fabricate one additional identical unit is estimated to be as follows:

Parts:	\$2,990.00
Dicom 344-01-02-03-09 Cassette Tape	2,100.00
Labor: 3 1/2 man weeks @ \$600/wk	<u>4,300.00</u>
	\$9,390.00

A Dicom tape unit, which is the large cost item, includes two transports. A single transport unit with the same options sells for \$3,400. Due to the rapid increase in technology and continued price reductions, cassette

tape units having a much lower cost could be used. It is estimated that if ten systems were fabricated a system cost of \$6,000 each could be attained. This estimate assumes that a single transport tape unit would be used.

It is recommended that if additional units are fabricated several changes be considered. It would be desirable to use a tape system having an American National Standards Institute (ANSI) standard for recording. At the present time phase encoding is the proposed standard. However, pulse-width encoding has recently gained popularity and is being pushed by several manufacturers. Another tape consideration is maximum recording rate. The DICOM records at a rate of 500 characters per second which is typical of commercial units. An analog sampling rate of 100 points per second is in keeping with this recording rate, i.e., the recorder is not capable of keeping up with a faster analog-to-digital conversion rate. Recent advancements in cassette transports (e.g., CIPHER) provide 2000 maximum writing rates of 1200 characters per second which is approximately 2.5 times as fast. Thus, an input scanning rate of 200 points per second could be easily attained using a faster ADC. The Datel ADC presently used as one of two options can accept this rate with its maximum conversion rate of 200 Hz. If input scanning rates greater than 200 points per second are desired, a recording media much faster than cassette tape will be required.

After field testing of the prototype instrument has been accomplished, design modifications may be desired. This may result in an elimination of certain operational features such as two analog-to-digital converters, 60 Hz frequency provision for zero beating with the line frequency and the use of dual slope ADC's for high noise rejection. If the manual data entry thumbwheel switches are found to be undesirable because of operator difficulty, lever action switches could offer an improvement.

ACKNOWLEDGMENT

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CASSETTE TAPE SYSTEM REFERENCE DOCUMENTS

1. 344 Cassette Magnetic Tape System Operation and Interface (Preliminary), Dicom Industries, Sunnyvale, California.
2. 344 Cassette Magnetic Tape System Maintenance Manual, Dicom Industries, Sunnyvale, California, 1970.

APPENDIX A
DETAILED SPECIFICATIONS

APPENDIX A

DETAILED SPECIFICATIONS

1. Analog Devices ADC-17I
2. Datel Systems, Inc. ADC-E12D2
3. Analog Devices MPX-8A Multiplexer
4. Power Supplies

1. Analog Devices ADC-17I
 Dual Slope Integrating ADC
 Specifications (a)

Resolution	4 1/2 BCD digits plus sign
Accuracy	
Realtive Calibration	Adj. to 0.01% $\pm$ 1 bit Every six months
Input Characteristics	
Analog	$\pm$ 10 VFS (20% overrange)
Overload	$\pm$ 100 V maximum
Peak series mode	$\pm$ 75 V maximum
Series mode rejection	- 70 db
Normal mode rejection	- 110 db
Impedance	180K ohm
Temperature Coefficient	
Zero	$\pm$ 30 μ V/ $^{\circ}$ C (0 $^{\circ}$ to 70 $^{\circ}$ C)
Gain	$\pm$ 5 ppm exclusive of ref.
Reference	$\pm$ 30 μ V/ $^{\circ}$ C
Convert Command	Positive pulse $\geq$ 100 ns $\leq$ 100 μ s.
Sign Polarity	Logic '1' during negative input
Status	Logic '0' during conversion
Power Supplies Required	$\pm$ 15 @ 30 mA + 5V @ 200 mA
Calibration	Apply -8.750V and adjust + REF. Reverse polarity and adjust -REF. Future adjustments done by adjusting GAIN potentiometer.
Speed	25 Conversions per second maximum

(a) At 25 $^{\circ}$ C and rated supply voltage.

2. Datel Systems ADC E12D2

Modified Dual Slope ADC

Specifications

Resolution	3 BCD digits plus sign
Accuracy	
25°C	$\pm 0.05\%$ of FS
Temperature Coefficient	± 50 ppm/°C (0° to 71°C)
Input Characteristics	
Analog Voltage	$\pm$ Full Scale, differential 100% overrange
Overload	± 15 V maximum
Common Mode Rejection	80 db @ 60 HZ
Impedance	> 100 Meg Ohms
Convert Command	Positive Pulse ≥ 100 nsec ≤ 1 μ sec
Sign Polarity	Logic '1' during positive input
Status	Logic '1' during conversion
Power Supplies Required	± 15 V @ 50 ma $+ 5$ V @ 150 ma
Calibration	Apply ± 1.900 V and adjust gain potentiometer for correct reading.
Speed	200 conversions per second maximum

3. Analog Devices

MPX-8A Multiplexer

Specifications

Channels	8 single-ended or 4 differential
Voltage Range	
Operating	-10 V to + 10 V
Overvoltage Protection	-15 V to + 15 V
Crosstalk	< -80 db
Transfer Accuracy ^(a)	Up to 0.01%
Input Impedance ^(a)	Up to 10^{10} ohms
Common Mode Rejection ^(a)	Up to 120 db
Channel Resistance	
ON	1000 ohms
OFF	$\geq$ 1000 megohms
On Leakage Current	100 nA, max. @ 70°C
Throughput Rate	500 KHz maximum
Fault Protection	Binary address selection allows only one address selected at a time
Power Requirements	+ 15 V $\pm$ 1 V @ 6.2 mA - 15 V - 1 V + 0 @ 4 mA + 5 V $\pm$ 10% @ 102 mA
Temperature	
Operating	0°C to 70°C
Storage	- 65°C to 150°C

^(a) Determined by following amplifier

4. Power Supplies

Specifications

Analog Devices 0)02 (Dual), Options D, I

Output Voltage	± 15 V
Output Current	± 100 mA
Warm-up Drift	45 mv
Regulation	
Load	0.1%
Line	0.05%
Operating Temperature	0° to 55°C (0° to 70°C derated)
Output Error	+ 300 mV - $\emptyset$ mV
Options	
I	Transformer inwinding shield
D	Overvoltage protection

Powertec Airtronics 2B15 - 1.3

Output Voltage	12 V or 15 V
Output Current	1.5A or 1.3A
Regulation	+0.25% (line & Load)
Operating Temperature	0° to 40°C (0 to 70°C derated to 30%)

Powertec Airtronics 2B5 - 3

Output Voltage	5 V or 6 V
Output Current	3 A or 2.5 A
Regulation	$\pm 0.25\%$ (Line & Load)
Operating Temperature	0° to 40°C (0° to 70°C derated to 30%)
Protection	Overvoltage option current limiting

APPENDIX B
INTERFACE COMMANDS

APPENDIX B

INTERFACE COMMANDS

The communication commands between the Data Collection Unit and the Dicom 344 Tape Storage unit are itemized below. For timing information, refer to the Dicom 344 Cassette Magnetic Tape System Operation and Maintenance Manual

<u>SIGNAL</u>	<u>DESCRIPTION</u>	<u>OPERATION</u>
INTLZ-1	Initialize	Initialize Tape Deck and Select On-Line Mode
DKS0C-1	Deck Select	LSB
DKS1C-1		MSB
DRDYS-1	Device Ready	Tape Unit Ready for a WRITE Command
WRITC-1	Write Command	Tape Deck Driven up to Speed
FLAGS-1	Flag Status	Tape Unit Ready to Receive Data
L/OXS-1	Leader/Oxide	EOT/BOT Status Indicator
CMDT-1	Command Strobe	ANDED with DECK SELECT and WRITE COMMAND
NDAT0-1	8 Bit ASCII	LSB
NDAT7-1		MSB
NDATT-1	Input Data Strobe	ANDED with DATA
STATT-1	Status Strobe	(Tied to ground) Permits Constantly Monitoring Tape Unit Status

APPENDIX C
RECORD DATA FORMAT

APPENDIX C

RECORD DATA FORMAT

The following is a sample data record using the Datel ADC-E12D2 analog-to-digital converter in the Data Collection unit.

To be read as +1.100 volts
on channel 0

To be read as +320 mV
on channel 7

SAMPLE OUTPUTS

TO DEMONSTRATE THE ABILITY OF THE HEADER TO BE ANY LENGTH AND TO BE INPUT FROM A TELETYPE, RATHER THAN THE FRONT PANEL VIA MANUAL ENTRY, THIS SPECIAL HEADER IS BEING WRITTEN FOR YOU... 0123456789. AS YOU CAN SEE WITH YOUR OWN EYES, TTY ENTRY PERMITS AN ALPHA-NUMERIC HEADER ENTRY. NOW FOR A SHORT NU... OOPS! NOW FOR A SHORT RUN.

```
+0100*1900*2700*3500*4400*5300*6200*7100+0100*1900*2700*3500*4400*5300*6200*7100
+0100*1900*2700*3500*4400*5300*6200*7100+0100*1900*2700*3500*4400*5300*6200*7100
+0100*1900*2700*3500*4400*5300*6200*7100+0100*1900*2700*3500*4400*5300*6200*7100
+0100*1900*2700*3500*4400*5300*6200*7100+0100*1900*2700*3500*4400*5300*6200*7100
+0100*1900*2700*3500*4400*5300*6200*7100+0100*1900*2700*3500*4400*5300*6200*7100
+0100*1900*2700*3500*4400*5300*6200*7100+0100*1900
```

NOW I'M GIVING YOU A 2ND HEADER ENTRY VIA TTY AND ANOTHER SHORT DATA RUN.

```
+0100*1900*2700*3500*4400*5300*6200*7100+0100*1900*2700*3500*4400*5300*6200*7100
+0100*1900*2700*3500*4400*5300*6200*7100+0100*1900*2700*3500*4400*5300*6200*7100
+0100*1900*2700*3500*4400*5300*6200*7100+0100*1900*2700*3500*4400*5300*6200*7100
+0100*1900*2700*3500*4400*5300*6200*7100+0100*1900*2700*3500*4400*5300*6200*7100
+0100*1900*2700*3500*4400*5300*6200*7100+0100*1900*2700*3500*4400*5300*6200*7100
+0100*1900*2700*3500*4400*5300*6200*7100+0100*1900*2700*3500*4400*5300*6200*7100
+0100*1900*2700*3500*4400*5300*6200*7100+0100
```


APPENDIX D
STATUS WORD

APPENDIX D

STATUS WORD

The status word is represented by the first character of each group of five characters representing the recorded data words. Although the groups are not separated by spaces, the status information is easily recognized since it is the only alpha character in the data stream. The status character code for the two separate ADC's presently employed in the Data Collection unit are different and are itemized below:

<u>ADC Model</u>	<u>Parameter</u> ^(a)	<u>Status Character</u>
Analog Devices ADC-17I	OV, +V	)
	+V	(
	OV, -V	+
	-V	*
Datel Systems ADC E12D2	OV, +V	+
	+V	*
	OV, -V	)
	-V	(

(a) OV (over voltage or over range) represents voltages
 $\geq \pm 1 \text{ V} \leq 1.999 \text{ V}$

APPENDIX E
LOGIC DRAWINGS

APPENDIX E

LOGIC DRAWINGS

1. Timing and Data Display
2. State Logic
3. Buffer I/O Control
4. Analog MUX and Control
5. ADC's and Display Control
6. Clocks
7. Manual Control
8. Address Control
9. Dicom Interface
10. I/O Buffering and Manual Input Control
11. Block Diagram
12. IC Locator Group A
13. IC Locator Group B
14. IC Locator Group C
15. IC Locator Group D
16. IC Locator Group E
17. Discrete Locator Sheet 1
18. Discrete Locator Sheet 2
19. I.C. Group Locator Sheet 1
20. I.C. Group Locator Sheet 2

STATE LOGIC

ANALOG
INPUT

* ANALOG GROUND MUST BE CONNECTED FOR SINGLE-ENDED INPUT. ANALOG LOW AND ANALOG GROUND MUST BE TIED TOGETHER AT REAR PANEL CONNECTOR END OF CABLE.

REV. NO.		REV. BY		DRAWING STATUS		DATE		APPRO		DATE		APPRO		DATE		APPRO		DATE	
NO.		DATE		DATE		DATE		DATE		DATE		DATE		DATE		DATE		DATE	
CHECKED		DRAWN		SCALE		CLASSIFIED BY		CLASSIFICATION		DATE		DATE		DATE		DATE		DATE	
1/17/73		1/17/73		1/17/73		1/17/73		1/17/73		1/17/73		1/17/73		1/17/73		1/17/73		1/17/73	
U.S. ATOMIC ENERGY COMMISSION		PACIFIC NORTHWEST LABORATORY		OPERATED BY BATTELLE MEMORIAL INSTITUTE		ANALOG MUX & CONTROL		E-5		4		SHEET NO.		SHEET NO.		SHEET NO.		SHEET NO.

REV. NO.	REV. BY	DATE	DRAWING STATUS	APPD. BY	DATE	FOR	MICRO P.M'D
DFTG APPD			DATE	APPD			DATE
CHECKED				APPD			DATE
DRAWN				ENGR			DATE
BLDG NO.				INDEX NO.			
SCALE				CLASSIFIED BY			
				DATE			
DWG NO.							
REV NO.							
DRAWING TITLE OR INDEX NO.							
REFERENCE DRAWINGS							
RICHLAND OPERATIONS OFFICE							
U. S. ATOMIC ENERGY COMMISSION							
 Pacific Northwest Laboratories							
- ADCs & DISPLAY CONTROL -							
DWG NO.							
E-6							
SHEET NO.							
5

CLASSIFIED BY
JC Fox
DATE 1/17/73

CHAS. BREUNING CO., 177 #24-1900-643EA, 200 (12-70)

DWG NO.	REV NO.	DRAWING TITLE OR INDEX NO.
REFERENCE DRAWINGS		
RICHLAND OPERATIONS OFFICE U. S. ATOMIC ENERGY COMMISSION
Bancor Pacific Northwest Laboratories		

DICOM INTERFACE

A	B	C	TW
0	0	0	A
0	0	1	B
0	1	0	C
0	1	1	D
1	0	0	E
1	0	1	F

Serial Scan Control for
Thumbwheel Switches

Manual or Auto
Data

BCD to ASCII

30. 3V Supply
Switching

Relay II or II
Data or CR

U.S. ATOMIC ENERGY COMMISSION RICHMOND OPERATIONS OFFICE PACIFIC NORTHWEST LABORATORY OPERATED BY BATTelle MEMORIAL INSTITUTE	
DATE	11/13/53
BY	W. J. B. / J. H. B.
REVISION	11/13/53
CHANGES	
REMARKS	INPUT/OUTPUT BUFFERING AND Manual Input Control
DESIGNED BY	W. J. B.
CHECKED BY	J. H. B.
APPROVED BY	
DATE	11/13/53
BY	W. J. B.
REVISION	
CHANGES	
REMARKS

REV. NO.				REV. NO.				DRAWING TITLE OR INDEX NO.			
REV. BY				DRAWING STATUS				REFERENCE DRAWINGS			
NO. DATE				APPD. BY				RICHLAND OPERATIONS OFFICE			
DATE				DATE				U.S. ATOMIC ENERGY COMMISSION			
DFTG APPD				APPD				Pacific Northwest Laboratories			
CHECKED				ENGR				1/17/73			
DRAWN				P. HOF				11/6/72			
BLDG NO.				INDEX NO.							
SCALE				CLASSIFIED BY				BLOCK DIAGRAM			
DATE 11/11/73											

LOCATION	I.D. NUMBER	POWER CONN.		CIRCUITS PER I.C.				PANEL	GROUP	
								1	A	
		+5 V	GND		CIRCUIT PAGE LOCATION					
					1	2	3	4	5	6
1	7474	16	7	2	3	8	X			
2	7404	16	7	6	7	3	3	10	10	5
3	7402	16	7	4	3	3	10	5	X	
4	7451	16	7	2	10	10	X			
5	7427	16	7	3	10	8		X		
6	7440	16	7	2	2	2	X			
7	7402	16	7	4	7	7	7	3	X	
8	7425	16	7	2	2	2	X			
9	Discretes									
10	74123	16	8	2	10	10	X			
11	7408	16	7	4	3		3	3	X	
12	7432	16	7	4	2	7	8	8	X	
13	7425	16	7	2	2	2	X			
14	7474	16	7	2	2	2	X			
15	74123	16	8	2	10		X			
16	74123	16	8	2	2	3	X			
17	7408	16	7	4	2	3	3	3	X	
18	7425	16	7	2	2	2	X			
19	7476	5	13	2	2	2	X			
20	7408	16	7	4	8	8	8	8	X	
21	7427	16	7	3	2	2	2	X		
22	7442	16	8	1	2	X				
23	7476	5	13	2	2	2	X			
24	7432	16	7	4	8	8	8		X	
25	7474	16	7	2	8	8	X			
26	7427	16	7	3	2	2	2	X		
27	7404	16	7	6	2	10	8	8		
28	7400	16	7	4	8			8	X	
29	7475	5	12	4	2	2	2	2	X	
30										

LOCATION	I.D. NUMBER	POWER CONN.		CIRCUITS PER I.C.							PANEL	GROUP
		+5 V	GND								1	B
					CIRCUIT PAGE LOCATION							
					1	2	3	4	5	6		
1	7476	5	13	2	3	3	X					
2	7493	5	12	1	3	X						
3	7490	5	12	1	3	X						
4	7493	5	12	1	3	X						
5	7490	5	12	1	3	X						
6	7476	5	13	2	3	3	X					
7	7475	5	12	4	10	10	10	10	X			
8	7400	16	7	4	7	3	3	8	X			
9	74123	16	8	2	3	10	X					
10	74121	16	7	1	3	X						
11	7474	16	7	2	7	7	X					
12	7427	16	7	3	7	7	3	X				
13	7408	16	7	4	7	7	3	10	X			
14	Discretes											
15	Discretes											
16	7474	16	7	2	7	7	X					
17	7413	16	7	2	7		X					
18	7476	5	13	2	7	7	X					
19	7413	16	7	2	7	7	X					
20	Discretes											
21	7440	16	7	2	7	9	X					
22	7413	16	7	2	7	7	X					
23	7413	16	7	2	7	7	X					
24	7413	16	7	2	7	7	X					
25	7413	16	7	2	7	7	X					
26	Connector											
27	Discretes											
28	Discretes											
29	Connector											
30	Discretes											

LOCATION	I.D. NUMBER	POWER CONN.		CIRCUITS PER I.C.				PANEL	GROUP	
								1	C	
		+5 V	GND		CIRCUIT PAGE LOCATION					
					1	2	3	4	5	6
1	7404	16	7	6	9	9	9	9	9	9
2	7493	5	12	1	8	X				
3	7476	5	13	2	3	3	X			
4	7476	5	13	2	3	4	X			
5	Discretes									
6	7476	5	13	2	9		X			
7	7400	16	7	4	4	4	4	10	X	
8	7440	16	7	2	6	6	X			
9	7476	5	13	2	3	3	X			
10	Discretes									
11	7476	5	13	2	10	8	X			
12	7474	16	7	2	6	7	X			
13	7474	16	7	2	7	6	X			
14	7410	16	7	3		10	10	X		
15	7408	16	7	4	7	2	3	3	X	
16	7490	5	12	1	6	X				
17	7497	16	8	1	6	X				
18	7497	16	8	1	6	X				
19	7493	5	12	1	6	X				
20	7493	5	12	1	6	X				
21	7490	5	12	1	6	X				
22	7490	5	12	1	6	X				
23	7490	5	12	1	6	X				
24	7490	5	12	1	6	X				
25	7490	5	12	1	6	X				
26	7490	5	12	1	6	X				
27	7490	5	12	1	6	X				
28	Connector									
29	8MHz XTAL			1	6	X				
30	7404	16	7	6	6	6	6	6	6	6

LOCATION	I.D. NUMBER	POWER CONN.		CIRCUITS PER I.C.							PANEL	GROUP
		+5 V	GND								1	D
					CIRCUIT PAGE LOCATION							
					1	2	3	4	5	6		
1	Discretes											
2	Discretes											
3	Discretes											
4	74157	16	8	1	10	X						
5	74157	16	8	1	10	X						
6	3102	9	13	1	10	X						
7	3102	9	13	1	10	X						
8	3102	9	13	1	10	X						
9	74157	16	8	1	10	X						
10	74157	16	8	1	10	X						
11	3102	9	13	1	10	X						
12	3102	9	13	1	10	X						
13	3102	9	13	1	10	X						
14	3102	9	13	1	10	X						
15	74123	16	8	2	9	9	X					
16	7400	16	7	4	10	10	10	10	X			
17	3102	9	13	1	10	X						
18	8800	4/ 16	3	k	10	X						
19	8800	4/ 16	3	1	10	X						
20	7404	16	7	6	10	10	10	9	9			
21	7400	16	7	4	10	10	10	10	X			
22	Discrete											
23	7413	16	7	2	10	10	X					
24	74123	16	8	2	5	9	X					
25	7493	5	12	1	10	X						
26	CONN											
27	CONN											
28	7402	16	7	4	9	9	9		X			
29	7474	16	7	2	9	9	X					
30	7400	16	7	4	9				X			

LOCATION	I.D. NUMBER	POWER CONN.		CIRCUITS PER I.C.							PANEL	GROUP
		+5 V	GND								1	E
					CIRCUIT PAGE LOCATION							
					1	2	3	4	5	6		
1	789	13	4	6	5	5						
2	789	13	4	6	5	5	5	5	5	5		
3	Discretes											
4	Connector											
5	Connector											
6	7475	5	12	1	5	X						
7	7475	5	12	1	5	X						
8	7475	5	12	1	5	X						
9	7475	5	12	1	5	X						
10	7475	5	12	1	5	X						
11	74151	16	8	1	10	X						
12	7404	16	7	6	9	9	9					
13	74151	16	8	1	10	X						
14	74151	16	8	1	10	X						
15	74151	16	8	1	10	X						
16	7430	16	7	1	5	X						
17	7408	16	7	4	5	5	9	5	X			
18	74157	16	8	1	10	X						
19	7400	16	7	4	10	10	10	10	X			
20	7400	16	7	4	10	10	10	10	X			
21	7490	5	12	1	5	X						
22	74151	16	8	1	10	X						
23	74151	16	8	1	10	X						
24	74151	16	8	1	10	X						
25	74151	16	8	1	10	X						
26	7440	16	7	2	5	5	X					
27	74157	16	8	1	5	X						
28	Discretes											
29	Discretes											
30	Discretes											

DISCRETES

20B

27B

28B

30B

5C

10C

1D

2D

3D

22D

3E

28E

DISCRETES

28E

29E

30E

9A

14B - 15B

19D

18D

A

B

C

5	4	3	2	1	5	4	3	2	1	5	4	3	2	1
7427	7451	7402	7404	7474	7490	7493	7490	7493	7476	*	7476	7476	7493	7404
10	9	8	7	6	10	9	8	7	6	10	9	8	7	6
74123	*	7425	7402	7440	74121	74123	7400	7475	7476	*	7476	7440	7400	7476
15	14	13	12	11	15	14	13	12	11	15	14	13	12	11
74123	7474	7425	7432	7408	*	*	7408	7427	7474	7408	7410	7474	7474	7476
20	19	18	17	16	20	19	18	17	16	20	19	18	17	16
7408	7476	7425	7408	74123	*	7413	7476	7413	7474	7493	7493	7497	7497	7490
25	24	23	22	21	25	24	23	22	21	25	24	23	22	21
7474	7432	7476	7442	7427	7413	7413	7413	7413	7440	7490	7490	7490	7490	7490
30	29	28	27	26	30	29	28	27	26	30	29	28	27	26
	7475	7400	7404	7427	*	CONN.	*	*	CONN.	7404	8MHz	CONN.	7490	7490

*Discretes

E

D

5	74157	74157	*	*	1	5	4	3	*	2	1	5	4	3	2	1
10	74157	74157	3102	3102	7	6	9	8	7475	7	6	10	9	8	7	6
15	74123	3102	3102	13	12	11	14	13	74151	12	11	15	14	13	12	11
20	7404	8800	3102	17	16	3102	7400	7400	74151	7408	7430	20	19	18	17	16
25	7490	74123	7413	22	21	7400	74151	74151	74151	74151	7490	25	24	23	22	21
30	7400	7474	7402	27	26	CONN.	*	*	74157	7440	7440	30	29	28	27	26

*Discretes

APPENDIX F

PARTS LIST

APPENDIX

PARTS LIST

<u>DESCRIPTION</u>	<u>QUANTITY</u>
<u>Capacitors</u>	
100 pf, 1000 V, disc	2
0.001 μ f, 100 V, disc	6
0.01 μ f, 100 V, disc	10
0.1 μ f, 12 V, disc	2
1 μ f, 35 V, solid tantalum	2
2.2 μ f, 20 V, solid tantalum	4
10 μ f, 10 V, solid tantalum	6
<u>Cards and Connectors</u>	
Analog Devices Mounting Board MPD 902	1
Analog Devices Mounting Board AC 1500	1
Analog Devices Mounting Board for MPX-8A	2
Augat Adapter Plug 616 AG 1&2	16
Battelle Display Board	1
BNC Connector	2
CINCH 251 22 30160 (22 pin)	3
Datel P.C. Board PCB 1&2	1
Elco Plug 00-8016-038-000-703	2
Elco Plug, P.C. Board, 3 pin	1
Elco, Receptacle 00-8016-038-000-707	1
Trompeter Jacks, BJ-72	8
Trompeter Plug, PL-75	1
<u>Diodes</u>	
IN 914	14
<u>Displays and Indicators</u>	
Dialight LED Indicator: 5 V, 20 ma	3
Apcoa 7 Segment LED SLA-1	4
Neon Indicator	1
<u>Integrated Circuits</u>	
DM 8800	2
MC 789P	2
SN 7400 N	8
SN 7402 N	3
SN 7404 N	6
SN 7408 N	6
SN 7410 N	1
SN 7413 N	7
SN 7425 N	3
SN 7427 N	4
SN 7430 N	1

Integrated Circuits (cont.)

<u>DESCRIPTION</u>	<u>QUANTITY</u>
SN 7432 N	2
SN 7440 N	4
SN 7442 N	1
SN 7446 N	4
SN 7451 N	1
SN 7474 N	8
SN 7475 N	7
SN 7476 N	10
SN 7490 N	11
SN 7493 N	6
SN 7497 N	2
SN 74121 N	1
SN 74123 N	6
SN 74151 N	8
SN 74157 N	6
TMS 3102 NC	8

Miscellaneous

Fuse Holder 3AG	1
Fuse 2A slo-blo	1
Power Cord, 6 ft. with plug	1
Spectra Strip, 10 twisted pair	12 ft
Cable, 7 line shielded	15 ft
Optima Cabinet K-051715R	1
Augat Interfacing Plug 1P14-3T24-2	4
Augat Wire Wrap Plug 6P26-1T24-1	2
Augat Wire Wrap Plug 6P8-1T24-1	2
Augat Turret Lug 14004-3G7	10
Augat Panel 8136-PG21-60	1
Augat Panel 8136-PG21-90	1
Misc. Wire: #16, #22, #24, #30	undetermined
Misc. Hardware: Mounting bars and bracket	undetermined
Vectron Oscillator, 8MHz, CO-2388	1

Modules

Analog Devices 902 D, I ($\pm$ k5 V, 100 ma)	1
Analog Devices 17I ADC	1
Analog Devices MPX 8A MUX	2
Datel ADC-E12 D2	1
Powertec 2B15-1.3 (12 V, 1.5 A)	1
Powertec 2B5-3 (5 V, 3 A)	2
Powertec OV Protection (5 V)	2

Resistors (1/4 W, $\pm$ 5%)

100 Ω	1
180 Ω	29
270 Ω	2
680 Ω	2

Resistors (1/4 W, $\pm$ 5%) (cont.)

<u>DESCRIPTION</u>	<u>QUANTITY</u>
1K Ω	9
3.3K Ω	2
3.9K Ω	1
4.7K Ω	55
5.6K Ω	16
9.1K Ω	5
10K Ω	1
15K Ω	2
220K Ω	1

Switches

Pushbutton, SPDT, Micro 1PB11	6
Toggle, Miniature, SPDT ALCO MST-115D	1
Rotary, (2-10 position) ALCO MRA-1-10	4
Thumbwheel, Binary Code	2
EECO 206-M-07	
Escutcheon for above	1
EECO 275M-02	
Thumbwheel, Binary code	6
EECO 228-M	
Escutcheon for above	1

Cassette Tape Unit

Dicom 344-01-02-03-09	1
-----------------------	---

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