ILIR TASK OF DIGITAL RECOIL TRAVEL MEASUREMENT SYSTEM

(A) ARMY COMBAT SYSTEMS TEST ACTIVITY (PROV) ABERDEEN
PROVING GROUND MD  V A BETZOLD ET AL. JUL 84

UNCLASSIFIED  USACSTA-6045
FINAL REPORT

ILIR TASK

OF

DIGITAL RECOIL TRAVEL

MEASUREMENT SYSTEM

V. A. BEIZOLD
C. L. FRANCIS

MEASUREMENTS AND ANALYSIS DIRECTORATE

US ARMY COMBAT SYSTEMS TEST ACTIVITY (PROVISIONAL)
ABERDEEN PROVING GROUND, MD 21005-5059

JULY 1984

Period Covered:
October 1982 to July 1984

US ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MD 21005-5055

DISTRIBUTION UNLIMITED
REPRODUCTION LIMITATIONS

NONE

DTIC is authorized to reproduce this document for United States Government purposes.

DISPOSITION INSTRUCTIONS

Destroy this report in accordance with appropriate regulations when no longer needed. Do not return it to the originator.

DISCLAIMER

Information and data contained in this document are based on input available at the time of preparation. Because the results may be subject to change, this document should not be construed to represent the official position of the US Army Materiel Development Readiness Command unless so stated.

The use of trade names in this report does not constitute an official indorsement or approval of the use of such commercial hardware or software. This report may not be cited for purposes of advertisement.
A study was conducted to improve measurement of large caliber weapon recoil travel. Since the 1950s, a continuous rotation, single turn potentiometer driven by a rack and pinion gear has been used on a variety of weapons. Satisfactory data has been produced by this system, but the data records suffer from a number of problems caused by the potentiometer. Therefore, the potentiometer was replaced by a digital incremental optical shaft encoder.
20. Circuitry was developed to interface the encoder output to a digital data acquisition system. Software was then written to process the data at the firing site, and provide a near real-time plot of recoil travel and velocity versus time. Original supplied keywords include: Ballistic Test Site Terminal, and Incremental Optical Encoder.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOREWORD</td>
<td>1</td>
</tr>
<tr>
<td><strong>SECTION 1. SUMMARY</strong></td>
<td></td>
</tr>
<tr>
<td>1.1 BACKGROUND</td>
<td>3</td>
</tr>
<tr>
<td>1.2 OBJECTIVES</td>
<td>5</td>
</tr>
<tr>
<td>1.3 SUMMARY OF PROCEDURES</td>
<td>5</td>
</tr>
<tr>
<td>1.4 SUMMARY OF RESULTS</td>
<td>12</td>
</tr>
<tr>
<td>1.5 ANALYSIS</td>
<td>16</td>
</tr>
<tr>
<td>1.6 CONCLUSIONS</td>
<td>18</td>
</tr>
<tr>
<td>1.7 RECOMMENDATIONS</td>
<td>18</td>
</tr>
<tr>
<td><strong>SECTION 2. GENERAL DISCUSSION OF SYSTEM DEVELOPMENT</strong></td>
<td></td>
</tr>
<tr>
<td>2.1 TRANSDUCER SELECTION</td>
<td>19</td>
</tr>
<tr>
<td>2.2 ELECTRONIC INTERFACE CIRCUITRY DESIGN</td>
<td>21</td>
</tr>
<tr>
<td>2.3 SOFTWARE DEVELOPMENT</td>
<td>27</td>
</tr>
<tr>
<td>2.4 FUTURE DEVELOPMENTS</td>
<td>28</td>
</tr>
<tr>
<td><strong>SECTION 3. APPENDICES</strong></td>
<td></td>
</tr>
<tr>
<td>A ILIR INVESTIGATION PROPOSAL AND AUTHORIZATION</td>
<td>A-1</td>
</tr>
<tr>
<td>B ENCODER SPECIFICATIONS, CONNECTOR PIN ASSIGNMENTS</td>
<td>B-1</td>
</tr>
<tr>
<td>C SOFTWARE LISTINGS</td>
<td>C-1</td>
</tr>
<tr>
<td>D REFERENCES</td>
<td>D-1</td>
</tr>
<tr>
<td>E DISTRIBUTION LIST</td>
<td>E-1</td>
</tr>
</tbody>
</table>

Accession For

<table>
<thead>
<tr>
<th>NTIS GRA &amp;I</th>
<th>DTIC TAB</th>
<th>Unannounced</th>
</tr>
</thead>
</table>

Justification

By

Distribution/

Availability Codes

Avail and/or

Special

Dist

A

(Page ii Blank)
FOREWORD

The US Army Combat Systems Test Activity (USACSTA (Prov)) (formerly Materiel Testing Directorate (MTD)), Aberdeen Proving Ground (APG), MD, conducted this investigation and prepared this report as part of an effort to improve the quality of ballistic measurements. Acknowledgement is given to Mr. Bryan Mitchell for fabrication and field testing of the Digital Recoil Travel Measurement System.
SECTION 1. SUMMARY

1.1 BACKGROUND

Measurement of weapon recoil travel versus time has been a standard ballistic measurement requirement for many years. Since the 1950s, a continuous rotation, single turn potentiometer driven by a rack and pinion gear has been used on a variety of large caliber weapons. A sample record obtained with this transducer is in Figure 1.1-1. Satisfactory data have been produced by this system, but the data records suffer from a number of problems:

a. When the potentiometer rotor crosses the gap between the ends of the stator element, an open circuit noise spike is generated.

b. The potentiometer noise output increases with wear.

c. The recording bandwidth must be high enough to capture the level change generated by crossing the gap in the stator. This is normally an order of magnitude higher than the actual motion bandwidth.

d. The record generated by the potentiometer cannot be read directly, but rather must be processed by a computer program which generates a displacement versus time record.

Problems a and b apply equally to analog or digital data acquisition systems. Problem c applies primarily to a digital system where limited memory is used rapidly by the higher sample rate needed to accurately reproduce the gap transition. Problem d applies primarily to an analog system as there is no way to perform the analysis at the test site whereas in a digital system the problem means additional processing time.

Providing the test director with an immediate indication of test results was generally not possible until recently, when the transition from analog to digital data acquisition facilities occurred. The new Ballistic Test Site Terminals (BTST) are digital data acquisition systems which provide the technician with a means to reduce data to engineering units in the field, with the prerequisite that he have a transducer which produces a usable signal and the software to interpret that signal.

The problems with the potentiometer output have been recognized for several years. A digital means of measuring recoil was attempted by J. G. Yeager as detailed in TECOM Report No. DFS-2363, 1967. Mr. Yeager discussed the results of development of an optical measurement system, in which a photoelectric transducer head and coded tape were used to produce a pulse output.

Considering the results achieved by this method and the advances in technology, additional investigation was considered necessary. Elimination of the rack and pinion concept is not of great benefit; after the initial investment in design and fabrication, they last indefinitely and require adjustment infrequently. Replacement of the potentiometer was considered to be the key to improving the measurement.
1.1 (Cont’d)

Figure 1.1-1. Recoil travel potentiometer output signal.
1.2 OBJECTIVES

The objectives of this project are to identify an improved recoil travel transducer, and to provide the test director with recoil travel versus time plots in near real time, at the test site.

1.3 SUMMARY OF PROCEDURES

An incremental shaft encoder (fig. 1.3-1, 1.3-2, and 1.3-3) was selected as a replacement for the continuous potentiometer. Circuitry was then developed (fig. 1.3-4, 1.3-5 and, 1.3-6) to interface pulses from the shaft encoder to a Hewlett Packard 1000 computer in the BTST. Finally, software was written to provide recoil distance traveled, a plot of recoil travel versus time, and a plot of recoil velocity versus time.
Figure 1.3-1. Incremental shaft encoder and pinion gear mount. (Note flexible shaft couplings.)
1.3 (Cont'd)

Figure 1.3-2. Incremental shaft encoder on 105-mm M68 recoil travel rack.
Figure 1.3-3. Incremental shaft encoder on 105-mm M68 recoil travel rack.
1.3 (Cont'd)

Figure 1.3-5. Recoil travel interface circuit card, component side.
1.3 (Cont'd)

Figure 1.3-6. Recoil travel interface circuit card, wire wrap.
1.4 SUMMARY OF RESULTS

A typical record of recoil travel versus time is shown in Figure 1.4-1. Occasionally, data with obvious discontinuities is acquired, as in Figure 1.4-2. These discontinuities have been found to be the result of a misalignment of the rack and pinion gear. Figure 1.4-3 illustrates a failure to return to zero, which may be a misaligned rack or a failure of the weapon to return to battery. When the technician encounters this situation, firing should be stopped and the problem discussed with the test director.
Figure 1.4-2. Recoil travel versus time plot demonstrating effect of misaligned rack on weapon.
Figure 1.4-3. Recoil travel versus time plot, failure to return to battery.
1.5 ANALYSIS

The digital recoil travel system permits a more detailed analysis of recoil and counterrecoil than the potentiometer method. As a result, some anomalies in recoil travel records not previously observed are currently being investigated. These irregularities appear on displacement versus time records showing the curve passing through zero, indicating counterrecoil motion beyond the recoil start position as shown in Figure 1.5-1. This phenomenon may be the result of an incomplete return to battery on a previous shot(s), resulting in an apparent excessive counterrecoil distance on a successive shot(s) if the gun returns more fully toward battery. The cumulative effect of different recoil starting points must be considered during a test because there is no point of reference between a position on the gun and a numerical output from the incremental shaft encoder circuitry.
1.6 CONCLUSION

Digital recoil measurement is superior to analog recoil measurement in terms of transducer signal quality and speed of data reduction.

1.7 RECOMMENDATIONS

a. Whenever computer controlled test facilities are available, digital recoil measurements should be the preferred test method.

b. Additional digital recoil circuitry should be fabricated for BTSTs. It may be possible to incorporate the circuitry directly into the Adaptive Sampling Rate Digitizers in the BTSTs.
SECTION 2. GENERAL DISCUSSION OF SYSTEM DEVELOPMENT

2.1 TRANSDUCER SELECTION

An incremental, optical shaft encoder was selected as a digital alternative to a continuous potentiometer. A market search of available encoders produced a wide variety of available models. The design features of interest for this project were:

a. Rugged construction. The shock of weapon firing was expected to be a critical factor.

b. Physical size. A direct replacement of the potentiometer was desired. If an encoder of the proper size could be located, modifications to existing rack and pinion gears would be minimized.

c. Slew speed. During recoil, maximum speed of the pinion gear could cause encoder failure.

d. Pulses per revolution. Consideration of pinion gear diameter versus pulses per revolution was necessary to assure adequate resolution.

e. Electrical signal output. Several hundred feet of cable are typically used during a firing test. A line driver output was considered necessary.

f. Environmental specifications. A -51.1°C (-60°F) to 51.7°C (125°F) temperature range is demanded by some environmental temperature tests.

A BEI Electronics, Inc. heavy duty encoder, shown in Figures 1.3-1, -2, and -3, was selected to satisfy the system requirements. The specific part number ordered was H25D-8B-250-ABC-7830-SM18-5, which is interpretable when compared with the encoder specifications in Appendix B. Briefly, the encoder has the following characteristics.

a. 250 pulses per revolution.

b. Dual quadrature, complementary output channels.

c. 0.25 inch shaft diameter.

d. -40°C to 80°C temperature range.

e. Flat on encoder shaft 0.50 inch by 0.03 inch.

f. Incandescent encoder illumination.

This encoder has performed reliably through extensive 155-mm, 120-mm and 105-mm firing. Initially, an LED was preferred to the incandescent illumination, since durability was thought to be superior with an LED. However, the manufacturer recommended an incandescent lamp, and no failures have been experienced to this date.
2.1 (Cont'd)

Two pinion gear diameters are available for recoil tests, selected according to test specifications. The 7.446 inch and 5.108 inch diameters correspond to 0.0296 inch and 0.0204 inch per pulse, which is considered adequate resolution. Certain weapons will exceed the encoder slew speed specification when the smaller gear is used; however, the amount is not excessive and it is a transient condition.

A flexible shaft coupling (fig. 1.3-1) was added to the encoder to minimize axial and radial loading. The coupling selected is produced by Metal Bellows Corporation, model E3-856, PN 26046.

The -40° C temperature specification for the encoder is not adequate for all environmental chamber tests. The feasibility of applying a thermal element to the inside surface of the encoder is currently being investigated.
Pulses from the shaft encoder are not directly compatible with a computer. Interface hardware is required to detect direction of shaft rotation, increment or decrement a counter, and provide a latched signal to the computer interface circuit. A block diagram is shown in Figure 2.2-1.

A schematic drawing of the electronic interface circuitry is shown in Figure 2.2-2. Dual differential receiver U12 receives two output signals in quadrature from the encoder and provides TTL signals to D flip-flop U8. If U8-3 (clock) goes high while U8-2 (D input) is high, then U8-5 (IQ output) is high. These conditions exist while the weapon is recoiling. Since U7-2 is high, pulses from the encoder are applied to the B1 input of one-shot U5. One-shot U5 then generates a 0.6 microsecond pulse at U5-4 (IQ output) for each pulse from the encoder. These pulses increment BCD counters U21, U22, U23, and U24.

During counterrecoil, U8-5 is low and U8-6 is high. This results in pulses being applied to the B2 input of one-shot U5. One-shot U5 generates a 0.6 microsecond pulse at U5-12 (IQ output) for each pulse from the encoder. These pulses then decrement BCD counters U21, U22, U23, and U24.

Following the counter circuitry, 74LS174 latches U18, U19, and U20 ensure that the output data cannot change at the time of computer sampling. There are two examples of latch circuit operation shown in Figure 2.2-3. On the rising edge of the pulse generated by the shaft encoder, U7-3 (increment, recoil) or U7-6 (decrement, counterrecoil) triggers a 0.6 microsecond low pulse from U5-4 (increment) or U5-12 (decrement). The rising edge of an up or down pulse from the shaft encoder also produces a 1.2 microsecond low pulse from U3-4. The computer samples the counting circuit at an interval defined by a software cycle. Sampling is completed when DFLGA goes low, which produces a high pulse of 1.4 microsecond duration at U3-5. There are two requirements to assure proper sampling. First, approximately 20 nanoseconds must be allowed for the counter output to settle after changing count input. Second, approximately 20 nanoseconds must be allowed for the latch output to settle after changing the latch input. When reviewing the timing diagram, it is also important to note that the minimum time period expected between pulses from the encoder for the highest velocity recoil is approximately 100 microseconds. The computer sampling period is approximately 1 millisecond. There is no dependency between the varying rate of pulse output from the encoder and the fixed computer rate of sampling.

In the first timing example in Figure 2.2-3, the computer is signaled that the data input operation is complete on the negative edge of DFLGA. U3-5 then goes high for 1.4 microseconds. The latches are clocked once by U7-8 when U3-4 goes low, latching at the circuit output the most recent counter output. When the counter change does occur, U3-4 stays low for a short period so that the latch is not allowed to update until the counters have settled. U3-5 then goes low, and the latches are again updated, but with the new count.

In this example, since the computer is signaled that the data input operation is complete immediately before a counter change, two latch updates occur.
2.2 (Cont'd)
In the second example in Figure 2.2-3, only one latch update occurs, because the negative going DTLGA transition occurs after the counter change. Regardless of the manner in which the latch update occurs, the computer reads the latch output which was updated at the completion of the previous computer input operation. Latch updates only occur after the computer completes an input operation.
Figure 2.2-1. Recoil travel interface unit, block diagram.
2.2 (Cont'd)

Encoder
U7-3 or U7-6

'L23Q
U5-4 or U5-12

'L23Q U3-4

Example 1:

DFLGA

'L23Q U3-5

U7-8 to latches
(U3-4 NAND U3-5)

Example 2:

DFLGA

'L23Q U3-5

U7-8 to latches
(U3-4 NAND U3-5)

Figure 2.2-3. Interface unit timing diagram.
2.3 SOFTWARE DEVELOPMENT

The philosophy used in the software development was to take the data from the hardware circuitry and format it into a data file which is identical to that produced by a BTST. This format is described in detail in Appendix L of NDI Task Final Report of Research and Development of Software, Ballistic Test Site Terminal, C. L. Franqis, Report AFGL-TR-5952, January 1984. The advantage of this technique is that all of the BTST software is available to plot and process the recoil travel data. The only disadvantage of this technique is that the hardware supports a range of 0 to 9999 counts but the BTST file format supports a range of -2048 to +2047. With the available rack and pinion gears and the anticipated weapon recoil ranges, this is not a problem as long as the reduced range is taken into account.

The software assigns channel 30 as the recoil travel channel. The labels, comments, and transducer gage factor are entered into this channel's parameter area. Since there is only one 32 channel BTST, this use of channel 30 generates no conflict with the other data acquisition channels. The data samples are stored in computer memory until the required number is obtained. Then the data samples are reformatted and written to disc in BTST data record format. In addition, a sample to sample difference is generated and stored as channel 31 to provide velocity versus time.

The software generated for this task consists of:

a. FORTRAN program RCOIL which:
(1) Obtains number of samples to be taken.
(2) Starts data acquisition on command.
(3) Provides options of saving or forgetting data.

b. HP 1000 assembly language routine READR which:
(1) Provides a synchronization pulse at the start of data acquisition cycle.
(2) Reads data from hardware using a software timing cycle and stores values in computer memory.

c. FORTRAN subroutine RTRAN which:
(1) Stores available documentation information on disc.
(2) Reformats data samples and stores on disc in BTST format as channel 30.
(3) Stores sample to sample differences as channel 31.

d. FORTRAN function JBCD which converts BCD data to 2's-complement binary data.

Listings of the software are contained in Appendix C.
2.4 FUTURE DEVELOPMENTS

2.4.1 LOWER TEMPERATURE RANGE EXPANSION

Weapons are exposed to a variety of environmental conditions during developmental testing. The shaft encoder cited in this report is rated to -40°C (-40°F), and will operate properly for the majority of weapon tests conducted under cold temperature conditions. However, for testing conducted from -40°C to -53.9°C (-40°F to -65°F), addition of a heating element to the shaft encoder is planned. The element is expected to be a thin rubber mat, attached to the inner wall of the encoder. Current to the element will be controlled by a temperature sensor in the encoder, providing a feedback signal to circuitry in the BTST.

2.4.2 INTEGRATION INTO BTST

The standalone circuitry and software generated by this task provided an easy way to test the concept of using a digital shaft encoder to record recoil travel. Each BTST contains an Adaptive Sample Rate Digitizer (ASRD) which is described in detail in Appendix D of RDI Task Final Report of Research and Development of Software, Ballistic Test Site Terminal, C. L. Francis, Report APG-MT-5952, January 1984. If the analog-to-digital (A/D) converter board is removed from the ASRD and an appropriate interface card substituted, then the recoil travel channel can be recorded in the same manner as any other ballistic signal. By integrating the recoil travel into an ASRD channel, this data can now be synchronized with the other channels and all of the triggering and data compression features of an ASRD channel are available. The data word will be changed to 12 bit binary with a range of -2048 to +2047 instead of the current 16 bit BCD with a range of 0 to 9999. It should be possible to automatically reset the interface when an ASRD arm command is issued.
### DISPOSITION FORM

**REFERENCE OR OFFICE SYMBOL** | **SUBJECT**  
--- | ---  
STEAP-MT-M | FY84 ILIR Program

**TO** Chief, M&A Division  
**FROM** Chief, M&T Division  
**DATE** 4 November 1983  
**CMT** 1  
**G. Thomson/vh/2444**

1. Authorization is hereby provided for the following ILIR Project (Encl 1):

   **TITLE/TRMS No.** Digital Recoil Travel Measurement System/7-C0-IL4-AP1-001

2. This project has been assigned funding in the amount of $5000 under XO/WO 30595401-02.

3. The special instructions contained in Enclosure 2 are applicable to this ILIR project. Assistance on matters pertaining to this project can be obtained from George Thomson, ext. 2444/2734.

2 Encl

As

EDWARD V. SOMODY
Attached is an ILIR project proposal.

Incl

as

STEAP-MT-G (18 Feb 83)

Recommend approval of this proposal.

No funding has been received for this project. Completion of this project would vastly improve data acquisition for the LAT of the M198. The amount of $5,000 is requested for fabrication of hardware and field testing.

Encl
ILIR TASK PROPOSAL

TASK TITLE: Digital Recoil Travel Measurement System

PRINCIPAL INVESTIGATOR: V. A. Betzold

FUNDS REQUIRED: $10,000

SCHEDULE:

<table>
<thead>
<tr>
<th>TASK</th>
<th>COMPLETION (Time from start - months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware/Software Development</td>
<td>4</td>
</tr>
<tr>
<td>Field Testing</td>
<td>9</td>
</tr>
<tr>
<td>Complete Report</td>
<td>12</td>
</tr>
</tbody>
</table>

DESCRIPTION:

Recoil travel measurement of direct fire and artillery weapons is presently accomplished with analog potentiometers and analog recording facilities. The analog data is then processed at a later date by Analytical Branch. This data acquisition process contradicts the ADAPT concept: process the data on site to provide quality control and immediate feedback to the test director.

The Digital Recoil Travel Measurement System provides a direct interface to the ADAPT system. An incremental shaft encoder is used on the weapon in place of the potentiometers, and increments an up/down counter circuit. This circuit is interfaced to a desktop calculator or Ballistic Test Site Terminal computer, and plots of displacement vs time and velocity vs time can be generated at the test site. A sample plot of displacement vs time is attached. Commercial systems do not exist to meet this requirement.
Specification

924 - 02002 - 001

General Specifications
Type H25
Incremental Optical Encoder

Notice: The design and specifications of the instruments and accessories illustrated and described in this publication are subject to improvement without notice.

<table>
<thead>
<tr>
<th>B</th>
<th>General Update</th>
<th>6/24/80</th>
<th>CHK</th>
<th>Dale Laplante</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Paragraph 3.5, Change 36° to 27°</td>
<td>1/23/80</td>
<td>APP</td>
<td>Jerry L. Jandt</td>
</tr>
</tbody>
</table>

© 1979 BEI Electronics, Inc.
1.0 Scope: This specification describes the BEI Industrial Encoder Division Heavy Duty Type H25 Incremental Optical Encoder.

2.0 Mechanical Specifications

2.1 Dimensions See Figures 2, 3 and 4


2.3 Optional Flat on Shaft .50 long X .03 deep

2.4 Shaft Loading Up to 40 lbs Axial and 35 lbs Radial

2.5 Shaft Runout .0005 T.I.R.

2.6 Starting Torque at 25°C (Standard without shaft seal) 1.0 Oz. In. Max.

2.7 Starting Torque at 25°C (With optional sealed bearings) 1.5 Oz. In. Max.

2.8 Starting Torque at 25°C (With optional shaft seal) 5.0 Oz In. Max.

2.9 Bearings Class ABEC 7

2.10 Shaft 416 Stainless Steel

2.11 Housing and Cover Die Cast Aluminum

2.12 Bearing Life (mfg's specifications) $2 \times 10^8$ Revs at rated shaft loading, $5 \times 10^{10}$ Revs at 10% of rated shaft loading.

2.13 Moment of Inertia $4.1 \times 10^{-4}$ Oz. In. Sec.²

2.14 Slew Speed 5000 RPM Max.

2.15 Weight 13 Oz. Typ.
### 3.0 Electrical Specifications

#### 3.1 Code
Incremental

#### 3.2 Cycles Per Shaft Turn
1 to 2540 on code disk

#### 3.3 Supply Voltage
See Table I

#### 3.4 Current Requirements
TTL 200 Ma Max, 150 Ma Typ
CMOS 150 Ma Max, 125 Ma Typ

#### 3.5 Output Format
2 Channels (A and B) in quadrature ± 27° electrical at 10 KHZ. See Figure I.

#### 3.6 Output Format Options
Index & Complementary outputs are available

#### 3.7 Output Options
See Table I

---

**TABLE I**

<table>
<thead>
<tr>
<th>I.C. Number</th>
<th>Type</th>
<th>Feature</th>
<th>Optional Pull-up Resistor</th>
<th>Output</th>
<th>Supply Voltage ±5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>SN7404</td>
<td>T²L</td>
<td>Totem Pole</td>
<td></td>
<td>16 MA/5V</td>
<td>+5VDC</td>
</tr>
<tr>
<td>SN7406</td>
<td>T²L</td>
<td>Open Collector Hi Voltage</td>
<td></td>
<td>470 Ohms</td>
<td>+5VDC</td>
</tr>
<tr>
<td>SN7404</td>
<td>CMOS</td>
<td></td>
<td></td>
<td>40 MA/30V</td>
<td>+5VDC</td>
</tr>
<tr>
<td>MC680</td>
<td>HTL</td>
<td>Totem Pole</td>
<td></td>
<td>15K Ohms</td>
<td>15VDC</td>
</tr>
<tr>
<td>MC681</td>
<td>HTL</td>
<td>Open Collector</td>
<td></td>
<td>15K Ohms</td>
<td>15VDC</td>
</tr>
<tr>
<td>MC689</td>
<td>HTL</td>
<td>Open Collector Hi-Voltage</td>
<td></td>
<td>15K Ohms</td>
<td>20V</td>
</tr>
<tr>
<td>DM8830</td>
<td>T²L</td>
<td>Line Driver</td>
<td></td>
<td>20V</td>
<td>15VDC</td>
</tr>
<tr>
<td>MM88C30</td>
<td>CMOS</td>
<td>Line Driver</td>
<td></td>
<td>5VDC</td>
<td>5 to 15VDC*</td>
</tr>
</tbody>
</table>

*Specify actual voltage*
<table>
<thead>
<tr>
<th>TITLE</th>
<th>General Specifications Type H25 Incremental Optical Encoder</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.8</td>
<td>Illumination</td>
</tr>
<tr>
<td>3.9</td>
<td>Frequency Response</td>
</tr>
<tr>
<td>3.10</td>
<td>Frequency Response (Index)</td>
</tr>
<tr>
<td>4.0</td>
<td>Environmental Specifications</td>
</tr>
<tr>
<td>4.1</td>
<td>Temperature</td>
</tr>
<tr>
<td>Operating</td>
<td>0 to 70°C, Standard</td>
</tr>
<tr>
<td>Storage</td>
<td>-25 to 90°C</td>
</tr>
<tr>
<td>4.2</td>
<td>Shock</td>
</tr>
<tr>
<td>4.3</td>
<td>Vibration</td>
</tr>
<tr>
<td>4.4</td>
<td>Humidity</td>
</tr>
<tr>
<td>5.0</td>
<td>Options (For the following option capability, consult factory for complete specifications)</td>
</tr>
<tr>
<td>5.1</td>
<td>Direction Sensing</td>
</tr>
<tr>
<td>5.2</td>
<td>Interpolation</td>
</tr>
<tr>
<td>5.3</td>
<td>Dual Resolution</td>
</tr>
<tr>
<td>5.4</td>
<td>Sinewave</td>
</tr>
</tbody>
</table>
General Specifications
Type H25
Incremental Optical Encoder

Channel
A
B
Optional
Z
Z

1 cycle
90°

Hi
Lo

FIGURE I
OUTPUT WAVE FORMS

CCW ROTATION
VIEWING SHAFT
Alternate Connector Position

2.52 Dia. Cover
2.50 Max

.3747 Dia.
.3745

1.2500 Dia.
1.2495

2.31 Dia.

1.25

1.65

2.510 Dia.
2.490

See figure 5 for Facemount options

FIGURE 3 - ENCODER DIMENSIONS
TYPE H25E
General Specifications
Type H25
Incremental Optical Encoder

MS3102E Connector
see Table II for size

Figure 4
Encoder Dimensions
Type H25G

NOTE: Shaft Seal is not available in this housing configuration
**FIGURE 5**

Face Mount Options

**F1**
- 10-32 UNF-2B
- .188 Min. Deep
- 3 places equally spaced on a 1.875 Dia. bolt circle.

**F2**
- 4-40UNC-2B
- .250 Min. Deep
- 4 places equally spaced on a 1.272 Dia. bolt circle (.900 square, Ref)

Not available on H25D or H25E

**F3**
- 4-40UNC-2B
- .250 Min. deep
- 4 places equally spaced on a 2.000 Dia. bolt circle

**F4**
- 6.32UNC-2B
- .250 Min. deep
- 3 holes equally spaced on a 2.000 Dia. bolt circle
<table>
<thead>
<tr>
<th>CONNECTOR</th>
<th>MS3102E-16S-1P</th>
<th></th>
<th>MS3102E-18-1P</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTPUT OPTION</td>
<td>CHANNELES A, B AND Z</td>
<td>CH. A &amp; B WITH COMPLEMENTS</td>
<td>CH. A &amp; Z WITH COMPLEMENTS</td>
<td>PIN</td>
</tr>
<tr>
<td>PIN:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>CH. A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>B</td>
<td>CH. B</td>
<td>B</td>
<td>A̅</td>
<td>B</td>
</tr>
<tr>
<td>C</td>
<td>CH. Z</td>
<td>A̅</td>
<td>Z</td>
<td>C</td>
</tr>
<tr>
<td>D</td>
<td>+V</td>
<td>+V</td>
<td>+V</td>
<td>D</td>
</tr>
<tr>
<td>E</td>
<td>NO CONN.</td>
<td>A̅</td>
<td>Z</td>
<td>E</td>
</tr>
<tr>
<td>F</td>
<td>GROUND</td>
<td>GROUND</td>
<td>GROUND</td>
<td>F</td>
</tr>
<tr>
<td>G</td>
<td>CASE GROUND</td>
<td>CASE GROUND</td>
<td>CASE GROUND</td>
<td>G</td>
</tr>
<tr>
<td>H</td>
<td></td>
<td></td>
<td>A̅</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td></td>
<td></td>
<td>B̅</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td></td>
<td></td>
<td>Z̅</td>
<td></td>
</tr>
</tbody>
</table>
### General Specifications

**Type H25 Incremental Optical Encoder**

**6.0 Ordering Information:** Encoder may be specified using the following model numbering system:

<table>
<thead>
<tr>
<th>TYPE</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASIC SIZE</td>
<td>25 = 2.500</td>
</tr>
<tr>
<td>HOUSING CONFIGURATION LETTER:</td>
<td></td>
</tr>
<tr>
<td>D = Square Flange (Fig. 2)</td>
<td></td>
</tr>
<tr>
<td>E = 2.50 Dia Servo Mount (Fig. 3)</td>
<td></td>
</tr>
<tr>
<td>G = 2.62 Dia Servo Mount (Fig. 4)</td>
<td></td>
</tr>
<tr>
<td>FACE MOUNT OPTIONS (Fig. 5)</td>
<td></td>
</tr>
<tr>
<td>F1, F2, F3, or F4</td>
<td></td>
</tr>
<tr>
<td>Blank = None</td>
<td></td>
</tr>
<tr>
<td>SHAFT SEAL CONFIGURATION:</td>
<td></td>
</tr>
<tr>
<td>SS = Shaft Seal (Not available on H25G)</td>
<td></td>
</tr>
<tr>
<td>SB = Seal, Integral with Bearing</td>
<td></td>
</tr>
<tr>
<td>Blank = Shielded Bearing</td>
<td></td>
</tr>
<tr>
<td>CYCLES PER TURN:</td>
<td></td>
</tr>
<tr>
<td>Enter Cycles:</td>
<td></td>
</tr>
<tr>
<td>500 = 500 cycles</td>
<td></td>
</tr>
<tr>
<td>2500 = 2500 cycles</td>
<td></td>
</tr>
<tr>
<td>Etc.</td>
<td></td>
</tr>
<tr>
<td>NO. OF CHANNELS:</td>
<td></td>
</tr>
<tr>
<td>A = Single Channel</td>
<td></td>
</tr>
<tr>
<td>AB = Dual Quadrature Channels</td>
<td></td>
</tr>
<tr>
<td>ABZ = Dual with Index</td>
<td></td>
</tr>
<tr>
<td>AZ = Single with Index</td>
<td></td>
</tr>
<tr>
<td>COMPLEMENTS:</td>
<td></td>
</tr>
<tr>
<td>C = Complementary Outputs</td>
<td></td>
</tr>
<tr>
<td>Blank = None</td>
<td></td>
</tr>
<tr>
<td>OUTPUT I.C.</td>
<td></td>
</tr>
<tr>
<td>7404, 7406, 8830 etc. (See Table I)</td>
<td></td>
</tr>
<tr>
<td>Followed by &quot;R&quot; = Pull-up Resistor</td>
<td></td>
</tr>
<tr>
<td>ILLUMINATION:</td>
<td></td>
</tr>
<tr>
<td>Blank = Incandescent (Standard)</td>
<td></td>
</tr>
<tr>
<td>LED = Light Emitting Diode (Optional)</td>
<td></td>
</tr>
<tr>
<td>OUTPUT TERMINATION LOCATION:</td>
<td></td>
</tr>
<tr>
<td>E = End</td>
<td></td>
</tr>
<tr>
<td>S = Side</td>
<td></td>
</tr>
<tr>
<td>OUTPUT TERMINATION:</td>
<td></td>
</tr>
<tr>
<td>M16 = MS3102E16S-1P Connector</td>
<td></td>
</tr>
<tr>
<td>M18 = MS3102E18-1P Connector</td>
<td></td>
</tr>
<tr>
<td>S = Special Non-Standard Features specified on purchase order or customer's spec.</td>
<td></td>
</tr>
</tbody>
</table>
## Interface Unit Cannon Plug

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
<th>Pigtail</th>
<th>Cable</th>
<th>Pin</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Output B</td>
<td>Brown</td>
<td>Brown</td>
<td>A</td>
</tr>
<tr>
<td>B</td>
<td>Output A</td>
<td>Red</td>
<td>Red</td>
<td>B</td>
</tr>
<tr>
<td>C</td>
<td>Output (\bar{B})</td>
<td>Orange</td>
<td>Orange</td>
<td>C</td>
</tr>
<tr>
<td>D</td>
<td>V+</td>
<td>Yellow</td>
<td>Yellow</td>
<td>D</td>
</tr>
<tr>
<td>E</td>
<td>Output (\bar{A})</td>
<td>Green</td>
<td>Green</td>
<td>E</td>
</tr>
<tr>
<td>F</td>
<td>V-</td>
<td>Blue</td>
<td>Blue</td>
<td>F</td>
</tr>
<tr>
<td>G</td>
<td>Sen +</td>
<td>White</td>
<td>White</td>
<td>D</td>
</tr>
<tr>
<td>H</td>
<td>Sen -</td>
<td>Black</td>
<td>Black</td>
<td>F</td>
</tr>
<tr>
<td>J</td>
<td>Case Ground</td>
<td>Shield</td>
<td>Shield</td>
<td>G</td>
</tr>
</tbody>
</table>

### Interface Unit and Encoder Connector Terminations.
### HEWLETT-PACKARD 1000 COMPUTER INTERFACE CABLE

<table>
<thead>
<tr>
<th>Edge Connector Pin</th>
<th>D Connector Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Bit 0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Bit 1</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>Bit 2</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>Bit 3</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>Bit 4</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>Bit 5</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>Bit 6</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>Bit 7</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>Bit 8</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>Bit 9</td>
</tr>
<tr>
<td>11</td>
<td>11</td>
<td>Bit 10</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>Bit 11</td>
</tr>
<tr>
<td>13</td>
<td>13</td>
<td>Bit 12</td>
</tr>
<tr>
<td>14</td>
<td>14</td>
<td>Bit 13</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td>Bit 14</td>
</tr>
<tr>
<td>16</td>
<td>16</td>
<td>Bit 15</td>
</tr>
<tr>
<td>Z</td>
<td>22</td>
<td>Command</td>
</tr>
<tr>
<td>AA</td>
<td>23</td>
<td>Device Flag</td>
</tr>
<tr>
<td>BB</td>
<td>24</td>
<td>Ground</td>
</tr>
</tbody>
</table>

Hewlett-Packard 1000 Computer Interface Connector Terminations

B-13

(Page B-14 Blank)
APPENDIX C - SOFTWARE LISTINGS

0001 FTN4
0002 PROGRAM RCOIL( ), REV A 2NOV83 CLF
0003
0004 *********************************************************
0005 C**********************************************************
0006 C THIS PROGRAM ALLOWS RECOIL TRAVEL DATA TO BE TAKEN USING A SHAFT
0007 C ENCODER, COUNTER CIRCUIT AND 12566B/C COMPUTER INTERFACE. THE
0008 C PROGRAM USES OFF-LINE DRIVER PROGRAM READY TO TAKE THE SAMPLES
0009 C FROM THE COUNTER CIRCUIT AND STORE THEM IN COMPUTER MEMORY. A
0010 C SOFTWARE TIMING LOOP IS USED TO MAKE MEASUREMENTS AT 1.28 MILLI-
0011 C SECOND INTERVALS. THE BUFFER SIZE IS 1K-12K IN 1K INCREMENTS.
0012 C DATA ACQUISITION IS INITIATED UNDER OPERATOR CONTROL. WHEN THE
0013 C BUFFER HAS BEEN FILLED THE DATA IS TRANSFERRED TO DISC BY SERTN
0014 C RTRAN. RTRAN PLACES THE DATA IN AN ADCHK FORMAT III DATA FILE.
0015 C IN ADDITION THE VELOCITY IS CALCULATED BY DIFFERENCING THE
0016 C DISPLACEMENT DATA.
0017 C
0018 C TO USE THE PROGRAM THE FOLLOWING STEPS SHOULD BE FOLLOWED:
0019 C
0020 C 1. USING THE PA COMMAND MAKE APPROPRIATE ENTRIES FOR PARAMETERS
0021 C 1? - GAGE FACTOR<DISANCE/COUNT>
0022 C 20 - UNITS
0023 C 22 THRU 24 - TRANSCUER DESCRIPTION
0024 C 25 THRU 27 - PLOT LABELS & REMARKS
0025 C WHEN FINISHED, SET PARAMETER 1 (SELECTED) TO NO.
0026 C
0027 C 2. AFTER COMPLETING LO % AR FOR THE ASRD CHANNELS, RU.RCOIL
0028 C ENTER THE DATA SIZE DESIRED, WHEN READY TO TAKE DATA, HIT
0029 C CARRIAGE RETURN. IF NECESSARY TO GET OUT TYPE EX.
0030 C
0031 C 3. WHEN DATA ACQUISITION IS COMPLETED, DETERMINE IF DATA IS TO
0032 C BE SAVED.
0033 C
0034 C RU.RCOIL.INTRCTV LU(DFLT=1),DATA DISC LU(DFLT=19),
0035 C DATA START TRACK(DFLT=DIRECTORY)
0036 C
0037 C REV A 2MAR83 CLF ORIGINAL.
0038 C 2NOV83 CLF ADD CHECKS FOR EXIT & SAVING DATA.
0039 C
0040 C******************************************************************************
0041 C
0042 C DIMENSION IPRM(5)
0043 C COMMON IBUF(12288)
0044 C ***** GET RUN TIME PARAMETERS
0045 C CALL RMPAR(IPRM)
0046 C IF(LU.EQ. 0)LU=1
0047 C IF(LUDK.EQ. 0)LUDK=19
0048 C IF(IDTRK.EQ. 0)IDTRK=1
0049 C ***** SET OPERATOR ENTRIES
0050 C WRITE(1,100)
0051 C 100 FORMAT("ENTER NO OF K-WORDS OF DATA TO TAKE: ")
0052 C READ(I,*NWORD)
0053 C IF(NWORD.EQ. 1 OR. NWORD .GT. 12)GO TO 200
0054 C NWORD=NWORD+1024
0055 C ***** CHECK IF READY FOR DATA OR EXIT
0056 C WRITE(LU,120)
0057 C 120 FORMAT("ENTER CARRIAGE RETURN TO TAKE DATA - EX TO TERMINATE")
0058 C READ(LU,140)IANS
0059 C 140 FORMAT(2A)
0060 C IF(IANS.EQ.3)THEN GO TO 200
0061 C ***** READ DATA
0062 C CALL READ(1,IBUF,NWORD)
0063 C ***** CHECK IF DATA IS TO BE SAVED
0064 C 160 WRITE(LU,150)
0065 C 150 FORMAT("SAVE DATA IN MEMORY OR DISC YE OR NO? ")
0066 C READ(LU,140)IANS
0067 C IF(IANS.EQ.1 OR. IANS .EQ. 2)NWORD=1024
0068 C IF(IANS.EQ. 3)THEN GO TO 200
0069 C ***** WRITE DATA TO DISC
0070 C CALL RTRAN(LU,LUDK, IDTRK,NWORD)
0071 C ***** DONE
0072 C 200 END
0073 C END$
** T=00000 IS ON LU 08

0001 ASMB NAM READR REV B 05JAN84 CLF
0002 *
0003 **************************************************************
0004 * THIS SUBROUTINE READS THE OPTICAL SHAFT ENCODER RECOIL TRAVEL
0005 * TRANSDUCER AND FILLS A BUFFER WITH THE READINGS.
0006 *
0007 * A SOFTWARE TIMING LOOP IS USED TO GENERATE THE TIMING INTERVAL
0008 * FOR TAKING THE READINGS. IT IS SET TO TAKE A READING EVERY
0009 * 1280 MICROSECONDS (RATE 5 OF THE ASRD).
0010 *
0011 * THE 12566B 12566C CARD MUST BE JUMPERED TO PROVIDE:
0012 * W1 = B B POSITIVE TRUE COMMAND
0013 * W2 = A A CLEAR DEVICE FF ON POSITIVE EDGE OF FLAG
0014 * W3 = A A STROBE DATA IN ON POSITIVE EDGE OF FLAG
0015 * W4 = DONT CARE
0016 *
0017 * W5= IN OUT LATCH INPUTS ON FLAG
0018 *
0019 * W9= DONT CARE
0020 *
0021 * W10= B 12566B COMPATIBILITY
0022 *
0023 * W11= OUT POSITIVE TRUE
0024 *
0025 *
0026 *
0027 * REV B 05JAN84 CLF ADD OUTPUT ON BIT 0 TO START EXTERNAL CHANNEL.
0028 *
0029 * REV A 28MAR83 CLF ORIGINAL.
0030 *
0031 **************************************************************
0032 *
0033 *
0034 *
0035 *
0036 *
0037 * THE MICROCIRCUIT REGISTER SELECT CODE MUST
0038 * BE SET CORRECTLY BELOW FOR THIS SUBROUTINE TO WORK
0039 MCKT EDU 21B
0040 *
0041 **************************************************************
0042 *
0043 STOR BSS 2
0044 READR NOP
0045 JSB ENTR
0046 DEF STOR
0047 LDA STOR GET BUFFER ADDRESS
0048 STA IBUF A SAVE ADDRESS
0049 LDA STOR+1,I GET WORD COUNT
0050 CHA, INA NEGATE COUNT
0051 STA COUNT SAVE WORD COUNT
0052 JSB #$LIBR SHUT OFF INTERRUPTS
0053 NOP
0054 *
0055 ***** OUTPUT A LOW TO BIT 0
0056 *
0057 CLA CLEAR A
0058 OUT MCKT SEND TO MCKT CARD
0059 *
0060 *
0061 ***** START DATA ACQUISITION LOOP
0062 *
0063 LOOP LDA DELAY LOAD SOFTWARE DELAY LOOP VALUE
0064 STA DELWD SAVE DELAY
0065 IS2 DELWD INCREMENT DELWD
0066 JMP ++-1 WAIT
0067 NOP KILL 1 MICROSECOND
0068 STC MCKT,C SET COMMAND & CLEAR FLAG
0069 SPS MCKT,C CHECK IF DATA IS READY
0070 JMP ++-1 IF NOT WAIT
0071 LIA MCKT GET READING
0072 STA IBUF A,I SAVE IT
0073 IS2 IBUF A INCREMENT ADDRESS
0074 IS2 COUNT INCREMENT COUNT
0075 JMP LOOP CONTINUE IF NOT DONE
0076 *
0077 +++++ RESTORE A ONE TO BIT 0 OUTPUT REGISTER
0078 *
0079  CLA             CLEAR A
0080  INA             SET A TO 1
0081  OTA MCKT       SEND TO MCKT CARD
0082  *               DONE
0083  *               CLF MCKT       PREVENT ILL INT
0084  *               CLC MCKT       PREVENT ILL INT
0085  JSB #LIBX       TURN INT SYSTEM ON
0086  DEF ++1          
0087  DEF ++1          
0088  JMP READR,1      
0089  *               DEFINE CONSTANTS
0090  *               ISUFA BSS 1
0091  *               DELW' BSS 1
0092  *               DELWD BSS 1
0093  *               DELAY DEC -542
0094  END

C-3
FUNCTION JBCD(IWORD), REV A 15SEP82 CLF

THIS FUNCTION TAKES A FOUR DIGIT BINARY CODED DECIMAL (BCD) INPUT
AND RETURNS THE INTEGER VALUE OF THE FOUR BCD DIGITS.

INPUT ARGUMENT: IWORD - 16 BIT INTEGER WORD CONTAINING FOUR BCD
DIGITS. IWORD IS NOT CHANGED. THE BCD FORMAT IS:

\[
\begin{array}{cccccc}
\text{BIT} & 8 & 4 & 2 & 1 \\
\text{WEIGHT} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 8 & 4 & 2 & 1 \\
\end{array}
\]

REV A 15SEP82 CLF ORIGINAL

ISIGN=0
IF(IWORD,LT.0)ISIGN=1
JBCD=IAND(IWORD,17B) + 10*(IAND(IWORD,360B)/16) +
* 100*(IAND(IWORD,7400B)/256) + 1000*(IAND(IWORD,70000B)/4096)
* + 9000*ISIGN
RETURN
END
END$
**FTN4**

SUBROUTINE RTRAN(LU,LUDK,IDTRK,NWORDS), REV A 2NOV83 CLF

**THIS SUBROUTINE TRANSFERS THE DATA STORED IN CPU MEMORY BY SUBROUTINE READR TO DISC. THE DATA IS STORED ON A BTST DATA LU IN ADOC FORMAT III AS CHANNEL 30. IN ADDITION, THE VELOCITY IS CALCULATED FROM THE DATA IN THE BUFFER AND STORED AS CHANNEL 31.**

**SUBROUTINE ARGUMENTS:**
- LU - LOGICAL UNIT OF OPERATOR TERMINAL
- LUDK - DISC LU WHERE DATA IS TO BE STORED
- IDTRK - DISC TRACK WHERE DATA IS TO BE STORED IF -1, DIRECTORY WILL BE USED TO FIND LOCATION
- NWORDS - NUMBER OF WORDS OF DATA STORED IN MEMORY

---

The general sequence of the file is as follows:

- ROUND HEADER
- CHANNEL POINTERS
- FILE COMMENTS
- SPARE
- DOCUMENTATION INFORMATION FOR CHANNEL 30
- DOCUMENTATION INFORMATION FOR CHANNEL 31
- DATA WORDS FOR CHANNEL 30
- DATA WORDS FOR CHANNEL 31
- REMAINDER OF TRACK IS FILLED WITH ZEROES

---

**ROUND HEADER FORMAT - SECTOR 0 OF DATA FILE:**

<table>
<thead>
<tr>
<th>Word</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 &amp; 2</td>
<td>This is a floating point number which is a count of the number of words in the file including round header, channel pointers, channel documentation and channel data.</td>
</tr>
<tr>
<td>3,4</td>
<td>Not used - set to 0.</td>
</tr>
<tr>
<td>5</td>
<td>ROUND HEADER information in ASCII format taken from sector 6 thru sector 56 of track 1 of the data lu. See program HDR for specific usage of these words. This information can be read using the RH command of ADOC.</td>
</tr>
</tbody>
</table>

---

**CHANNEL POINTERS FORMAT - SECTOR 1 OF DATA FILE:**

<table>
<thead>
<tr>
<th>Word</th>
<th>Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 &amp; 2</td>
<td>The pointer contains a real word which is the location of the start of the channel data. If the channel is selected but no data was taken, its value is -1.0.</td>
</tr>
<tr>
<td>3,4</td>
<td></td>
</tr>
<tr>
<td>63,64</td>
<td>31</td>
</tr>
</tbody>
</table>

---

**FILE COMMENTS - SECTOR 2 OF DATA FILE:**

This sector is filled with blanks by TRAN. After the data file is created, this sector can be used to record comments on the file.
This sector is filled with zeroes by TRANS. It is available for future expansion if necessary.

---

### CHANNEL DOCUMENTATION FORMAT - 4 SECTORS FOR EACH SELECTED CHANNEL:

<table>
<thead>
<tr>
<th>sector</th>
<th>words</th>
<th>usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2</td>
<td>1-128</td>
<td>Setup parameters taken directly from track 0. TRANS makes no changes in any of these values.</td>
</tr>
</tbody>
</table>

**Channel No.**

- **2**-22: Not used - set to 0.
- **31**: Channel No.
- **23**: Base rate.
- **34-35**: Scale factor.
- **37**: Baseline count (set to -4096 by TRANS).
- **38**: Maximum count (set to -4096 by TRANS).
- **39**: Minimum count (set to -4096 by TRANS).
- **40**: Not used = 0.
- **41-42**: Stop word number (set to 0 by TRANS).
- **43-64**: Not used = 0.

NCI=NOT CURRENTLY IMPLEMENTED

---

**CHANNEL DATA WORDS FORMAT:**

The first selected channels data words follow the notes sector. The location is obtained from the channel pointers in sector 1 of the first track of the data file. The number of words that a channel can take varies from 1024-12289 in 1024 steps.

The data values in memory are in BCD format. Function JBCO is used to convert the values to integer and they are stored in the data file on disk in integer format. The memory values range from 0-9999 but are offset and limited to -2048 to 4047. The rate is added to produce a data word format identical to a standard A/D CHK data word (FORMAT III).

---

### REV A 2N9083 CLE ORIGINAL

### REV A 2N9083 CLE MODIFIED FOR FORMAT III TO GET ADDED RANGE.

---

**DOCUMENTATION FORMAT**

- **1024-1030:** CHANNEL DATA WORDS FORMAT:
  - The first selected channels data words follow the notes sector.
  - The location is obtained from the channel pointers in sector 1 of the first track of the data file. The number of words that a channel can take varies from 1024-12289 in 1024 steps.
  - The data values in memory are in BCD format. Function JBCO is used to convert the values to integer and they are stored in the data file on disk in integer format. The memory values range from 0-9999 but are offset and limited to -2048 to 4047. The rate is added to produce a data word format identical to a standard A/D CHK data word (FORMAT III).

---

**REV A 2N9083 CLE ORIGINAL**

**REV A 2N9083 CLE MODIFIED FOR FORMAT III TO GET ADDED RANGE.**

---

**DOCUMENTATION FORMAT**

- **1024-1030:** CHANNEL DATA WORDS FORMAT:
  - The first selected channels data words follow the notes sector.
  - The location is obtained from the channel pointers in sector 1 of the first track of the data file. The number of words that a channel can take varies from 1024-12289 in 1024 steps.
  - The data values in memory are in BCD format. Function JBCO is used to convert the values to integer and they are stored in the data file on disk in integer format. The memory values range from 0-9999 but are offset and limited to -2048 to 4047. The rate is added to produce a data word format identical to a standard A/D CHK data word (FORMAT III).

---

**REV A 2N9083 CLE ORIGINAL**

**REV A 2N9083 CLE MODIFIED FOR FORMAT III TO GET ADDED RANGE.**

---

**DOCUMENTATION FORMAT**

- **1024-1030:** CHANNEL DATA WORDS FORMAT:
  - The first selected channels data words follow the notes sector.
  - The location is obtained from the channel pointers in sector 1 of the first track of the data file. The number of words that a channel can take varies from 1024-12289 in 1024 steps.
  - The data values in memory are in BCD format. Function JBCO is used to convert the values to integer and they are stored in the data file on disk in integer format. The memory values range from 0-9999 but are offset and limited to -2048 to 4047. The rate is added to produce a data word format identical to a standard A/D CHK data word (FORMAT III).
I. IF (LUDK .EQ. 18) .AND. ISTRK .LT. 196) GO TO 120
   120 IF (IDTRK .GE. 2) GO TO 220
   WRITE (LU, 140)
   WRITE (LU, 140)
   WRITE (LU, 140)

   IF (LUDK .EQ. 18) NLEFT = 202 - ISTRK + 1
   ELSE NLEFT = 1023 - ISTRK1

   WRITE (LU, 60) NLEFT

   FORMAT ("ONLY ", 4, " TRACKS REMAIN--CONTINUE(Y OR N)??")

   READ (LU, 80) I
   FORMAT (A1)

   IF (I .NE. 1) RETURN

   120 IF (LUDK .GE. 19) NLEFT = 1023 - ISTRK1
   ELSE NLEFT = 202 - ISTRK + 1

   WRITE (LU, 140)

   IF (LUDK .EQ. 18) NLEFT = 202 - ISTRK + 1

   WRITE (LU, 60) NLEFT

   FORMAT ("ONLY", 14, " TRACKS REMAIN--CONTINUE(Y OR N)??")

   READ (LU, 80) I
   FORMAT (A1)

   IF (I .NE. 1) RETURN

   C. BEGIN TRANSFER PROCEDURE

   200 WRITE (LU, 220)
   FORMAT ("BEGIN TRANSFER.")

   CALL EXEC (IREAD, LUDK, MBUF, 64, 1, 6)

   300 IF (LUDK .EQ. 18) NLEFT = 202 - ISTRK + 1
   ELSE NLEFT = 1023 - ISTRK1

   WRITE (LU, 60) NLEFT

   FORMAT ("ONLY", 14, " TRACKS REMAIN--CONTINUE(Y OR N)??")

   READ (LU, 80) I
   FORMAT (A1)

   IF (I .NE. 1) RETURN

   120 IF (IDTRK .GE. 2) GO TO 220

   220 WRITE (LU, 140)

   IF (LUDK .EQ. 18) NLEFT = 202 - ISTRK + 1
   ELSE NLEFT = 1023 - ISTRK1

   WRITE (LU, 60) NLEFT

   FORMAT ("ONLY", 14, " TRACKS REMAIN--CONTINUE(Y OR N)??")

   READ (LU, 80) I
   FORMAT (A1)

   IF (I .NE. 1) RETURN

   C. READ HEADER

   CALL EXEC (IREAD, LUDK, MBUF, 64, 1, 6)

   400 C. SET WORDS 1 & 2 TO TOTAL WORD COUNT

   COUNT = 768 + FLOAT (NWORDS + 2 - 1)

   MBUF (1) = ICOUNT (1)
   MBUF (2) = ICOUNT (2)

   C. SET CHANNEL 30 ADDRESS TO 769

   COUNT = 769

   MBUF (125) = ICOUNT (1)
   MBUF (126) = ICOUNT (2)

   C. ZERO WORDS 3 & 4

   MBUF (3) = 0
   MBUF (4) = 0

   C. SET FIRST 30 ADDRESSES STORED IN SECTOR 1 TO -1

   COUNT = -1
   DO 260 J = 1, 31

   MBUF (J - 1) = ICOUNT (1)
   MBUF (J) = ICOUNT (2)

   CONTINUE

   C. SET CHANNEL 30 ADDRESS TO 769

   COUNT = 769

   MBUF (125) = ICOUNT (1)
   MBUF (126) = ICOUNT (2)

   C. SET CHANNEL 31 ADDRESS

   COUNT = COUNT + FLOAT (NWORDS)

   MBUF (127) = ICOUNT (1)
   MBUF (128) = ICOUNT (2)

   C. INSERT DATA FILE NOTES SECTOR (ALL BLANKS)

   DO 280 J = 129, 192

   MBUF (J) = IBLNK

   280 C. INSERT SPARE SECTOR FOR FUTURE EXPANSION (ALL ZEROES)

   DO 300 J = 193, 256

   MBUF (J) = 0

   300 C. WRITE FIRST FOUR SECTORS TO DISC

   CALL EXEC (IRINT, LUDK, MBUF, 256, IDTRK, 0)

   C. INSERT CHANNEL DOCUMENTATION FOR RECOIL TRAVEL (CH 30)

   C. GET CHANNEL SETUP PARAMETERS

   ISCTR = 3 * ICHAN
   ICHAN

   CALL EXEC (IREAD, LUDK, MBUF, 128, 0, ISCTR)

   C. SET CHANNEL 30 TO SELECTED

   MBUF (1) = 1318
   MBUF (129) = ICHAN

   DO 320 J = 2, 64

   MBUF (128 + J) = 0

   320 C. GET SCALE FACTOR (= GAGE FACTOR)

   MBUF (163) = MBUF (17)
   MBUF (164) = MBUF (18)
   MBUF (165) = -4096
   MBUF (166) = -4096
   MBUF (167) = -4096

   C. INSERT NEXT SECTOR WITH BLANKS

   DO 340 J = 193, 256

   MBUF (J) = IBLNK

   340 C. WRITE NEXT SECTOR TO DISC

   CALL EXEC (IRINT, LUDK, MBUF, 256, IDTRK, 4)

   C. INSERT CHANNEL DOCUMENTATION FOR RECOIL VELOCITY (CH 31)

   C. INSERT CHANNEL DOCUMENTATION FOR RECOIL VELOCITY (CH 31)
C ***** USE SAME VALUES AS CH 30 EXCEPT CHANGE PLOT LABELS AND SCALE FACTOR
C ***** CHANGE PLOT LABEL
DO 360 I=37,53
360 MBUF(I)=ILBL(I-36)
C ***** SET PLOT UNITS
ICHNT=1
CALL LOOKS(MBUF(54),ICHNT,15)
IF(ICHNT.GT.9)ICHNT=9
DO 360 I=1,15-ICHNT
360 MBUF(53+ICHNT+I)=UNITS(I)
C ***** BLANK REMARKS
DO 400 I=69,102
400 MBUF(I)=IBLNK
C ***** SET CHANNEL NO
MBUF<128>=ICHAN+1
MBUF<129>=ICHAN+1
C ***** SET SCALE FACTOR
ICOUNT<1>=MBUF<163>
ICOUNT<2>=MBUF<164>
COUNT=COUNT/0.60028
MSUF<163>=ICOUNT<1>
MSUF<164>=ICOUNT<2>
C ***** WRITE NEXT FOUR SECTORS TO DISC
C ***** PROCESS DATA FROM MEMORY - CONVERT BCD TO INTEGER
DO 500 I=1,NWORDS
IBUF(I)=JBCD(IBUF(I))-2048
IF(IBUF(I).GT.2047)IBUF(I)=2047
IF(IBUF(I).LT.-2048)IBUF(I)=-2048
IBUF(I)=IBUF(I)+RATE
500 CONTINUE
C ***** TRANSFER DATA TO DISC
ISCTR=12
INDEX=1
KAMT=5376
IBAL=NWORDS
SWITCH=0
520 IF(IBAL.LT.KAMT)KAMT=IBAL
CALL EXEC(IWRT,LUDK,MBUF,256,IDTRK,8)
523 C ***** PROCESS DATA TO GET VELOCITY
C ***** REMOVE RATE CODE AND CONVERT BACK TO INTEGER
DO 620 I=1,NWORDS-1
620 IBUF(I)=IBUF(I)+16)/16
C ***** GENERATE DIFFERENCE AND CONVERT BACK TO ADCHK FORMAT
DO 640 I=1,NWORDS-1
640 IBUF(I)=IBUF(I-1)-IBUF(I)
C ***** SET LAST WORD TO ZERO TO KEEP BUFFER SIZE IN 1K INCREMENTS
IBUF(NWORDS)=0
C ***** SET UP TO TRANSFER DATA TO DISC
ISCTR=KAMT/4+ISCTR
INDEX=1
IF(KAMT.LE.644)IDTRK=IDTRK+1
IBAL=NWORDS
ISWITCH=1
GO TO 520
C-8
**** ZERO REMAINDER OF TRACK
0309 C
0310 IF(KAMT .EQ. 6144) GO TO 800
0311 IBAL=6144-KAMT-64*ISCTR
0312 DO 720 I=1,IBAL
0313 720 IBUF(I)=0
0314 ISCTR=KAMT/64+ISCTR
0315 CALL EXEC(IWRT,LUDK,IBUF,IBAL,IDTRK,ISCTR)
0316 C
0317 **** TELL OPERATOR WHERE DATA WENT
0318 800 KAMT=IDTRK-ISTRK+1
0319 NWORDS=768+2*NWORDS-1
0320 WRITE(LU,820)NWORDS,LUDK,ISTRK,KAMT
0321 820 FORMAT(15," WORDS TRANSFERRED TO DISK L",13," TRACK",15/
0322 $ 10X,13," TOTAL TRACKS UTILIZED")
0323 C
0324 **** CHECK IF DIRECTORY WAS USED
0325 IF(KDIR .EQ. 0) RETURN
0326 C
0327 **** UPDATE THE DIRECTORY
0328 C
0329 **** READ EXISTING DIRECTORY
0330 CALL EXEC(IREAD,LUDK,MBUF,256,1,0)
0331 C
0332 **** MODIFY ENTRIES
0333 NFILE=NFILE+1
0334 MBUF(1)=ISTRK
0335 MBUF(2)=NFILE
0336 MBUF(NFILE*2+1)=ISTRK
0337 MBUF(NFILE*2+2)=KAMT
0338 C
0339 **** WRITE TO DIRECTORY
0340 CALL EXEC(IWRT,LUDK,MBUF,256,1,0)
0341 RETURN
0342 END$
APPENDIX D - REFERENCES


### APPENDIX B - DISTRIBUTION LIST

**TECOM Project No. 7-GO-ILA-API-001**

<table>
<thead>
<tr>
<th>Address</th>
<th>No. of Copies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commander US Army Test and Evaluation Command</td>
<td></td>
</tr>
<tr>
<td>ATTN: AMSTE-AD-M</td>
<td>2</td>
</tr>
<tr>
<td>AMSTE-CM</td>
<td>1</td>
</tr>
<tr>
<td>AMSTE-CM-R</td>
<td>1</td>
</tr>
<tr>
<td>Aberdeen Proving Ground, MD 21005-5055</td>
<td></td>
</tr>
<tr>
<td>Commander White Sands Missile Range</td>
<td></td>
</tr>
<tr>
<td>ATTN: STEWS-CG</td>
<td>2</td>
</tr>
<tr>
<td>STEWS-ME-D/ID</td>
<td>1</td>
</tr>
<tr>
<td>White Sands, NM 88002</td>
<td></td>
</tr>
<tr>
<td>Commander US Army Cold Regions Test Center</td>
<td></td>
</tr>
<tr>
<td>ATTN: STECR-DT</td>
<td>1</td>
</tr>
<tr>
<td>STECR-RD</td>
<td>1</td>
</tr>
<tr>
<td>APO Seattle 98733</td>
<td></td>
</tr>
<tr>
<td>Commander US Army Yuma Proving Ground</td>
<td></td>
</tr>
<tr>
<td>ATTN: STYMP-MDP</td>
<td>2</td>
</tr>
<tr>
<td>Yuma, AZ 85364</td>
<td></td>
</tr>
<tr>
<td>Commander US Army Jefferson Proving Ground</td>
<td></td>
</tr>
<tr>
<td>ATTN: STJEFP-TD-I</td>
<td>1</td>
</tr>
<tr>
<td>Madison, IN 47251</td>
<td></td>
</tr>
<tr>
<td>Commander US Army Dugway Proving Ground</td>
<td></td>
</tr>
<tr>
<td>ATTN: DTDMP-PC</td>
<td>1</td>
</tr>
<tr>
<td>Dugway, UT 84022</td>
<td></td>
</tr>
<tr>
<td>Commander US Army Tropic Center</td>
<td></td>
</tr>
<tr>
<td>ATTN: STETC-RD-T</td>
<td>1</td>
</tr>
<tr>
<td>APO Miami 34004</td>
<td></td>
</tr>
<tr>
<td>Commander US Army Training and Doctrine Command</td>
<td></td>
</tr>
<tr>
<td>ATTN: ATCD-T</td>
<td>1</td>
</tr>
<tr>
<td>Fort Monroe, VA 23651</td>
<td></td>
</tr>
<tr>
<td>Addressee</td>
<td>No. of Copies</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Director</td>
<td></td>
</tr>
<tr>
<td>US Army Ballistic Research Laboratory</td>
<td></td>
</tr>
<tr>
<td>ATTN: AMXDR-OB-CT (Technical Reports)</td>
<td>2</td>
</tr>
<tr>
<td>Aberdeen Proving Ground, MD 21005-5066</td>
<td></td>
</tr>
<tr>
<td>Commander</td>
<td></td>
</tr>
<tr>
<td>US Army Combat Systems Test Activity (Provisional)</td>
<td></td>
</tr>
<tr>
<td>ATTN: STECS-MT</td>
<td>1</td>
</tr>
<tr>
<td>STECS-SA</td>
<td>1</td>
</tr>
<tr>
<td>STECS-AP-A</td>
<td>1</td>
</tr>
<tr>
<td>STECS-MA</td>
<td>2</td>
</tr>
<tr>
<td>STECS-MA-B (Mr. Betsold)</td>
<td>10</td>
</tr>
<tr>
<td>STECS-AU</td>
<td>1</td>
</tr>
<tr>
<td>STECS-NT-S</td>
<td>1</td>
</tr>
<tr>
<td>STEAP-SA</td>
<td>1</td>
</tr>
<tr>
<td>STEAP-MA-I (Mr. Francis)</td>
<td>3</td>
</tr>
<tr>
<td>Aberdeen Proving Ground, MD 21005-5059</td>
<td></td>
</tr>
<tr>
<td>Administrator</td>
<td></td>
</tr>
<tr>
<td>Defense Technical Information Center</td>
<td></td>
</tr>
<tr>
<td>ATTN: DDA</td>
<td>2</td>
</tr>
<tr>
<td>Cameron Station</td>
<td></td>
</tr>
<tr>
<td>Alexandria, VA 22314</td>
<td></td>
</tr>
</tbody>
</table>

Secondary distribution is unlimited.