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A User's Manual for the Functional Relay Operation Monitor (FROM)

Fred R. Gustke

Prepared by Sandia National Laboratories, Albuquerque, New Mexico 87185
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A User's Manual for the Functional Relay Operation Monitor (FROM)

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Abstract

Sandia's Digital Systems Development Division 1521 has developed a new functional relay tester. Capabilities of this tester include the measurement of coil and contact resistance, hipot, operate current, and contact operation and bounce times. The heart of the tester is a Hewlett-Packard 21MX minicomputer that uses BASIC or FORTRAN programming languages. All measurements are made by means of simple program calls, and all measurement standards are traceable to the National Bureau of Standards. Functional relay test data are stored on a disc drive and can be output as hard copy, manipulated in the computer, or sent over a distributed-system link to other Sandia computers.

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FRONTISPIECE
Functional Relay Operation Monitor (FROM)

A User's Manual for the Functional Relay Operation Monitor (FROM)

1. Introduction

The Functional Relay Operation Monitor (FROM) is a new computer-controlled functional relay tester designed and developed by Sandia's Digital Systems Development Division 1521. This tester measures coil resistance of relays with one to four coils, contact resistance of from one to four sets of contacts with any configurations, various hipots, coil operation current, and all contact operation and bounce times. The tester input matrix has 16 test positions for relay connection and a special input port to accept the CHESS relay life tester. All tester internal measurement standards, and therefore tester calibration, are traceable to the National Bureau of Standards.

The heart of the FROM is a Hewlett-Packard (HP) 21MX minicomputer with 128K words of memory and an HP7906 disc drive. The computer operates under the control of RTE4B master-program executive, with many special Sandia drivers, subroutines, and extensions. Relay testing is done by calling the Sandia routines through BASIC or FORTRAN programming languages. Thus someone who is familiar only with the relay to be tested and with a high-level computer language can operate the machine competently. Relay test data stored on the disc can be (a) output as immediate hard copy, (b) manipulated alone or with other data within the computer, and (c) output or sent over a distributed-system link to other Sandia computers. Relay test data or programs may be permanently saved on the disc or on magnetic tape, and some data-plotting capability is provided.

This manual presents a descriptive analysis of the FROM and includes design information on the system. As an operating manual for the tester user, it describes various hardware and software subsystem functions, and specifically covers how to call and implement all Sandia routines. Step-by-step instructions are given for implementing a universal BASIC language test program that is included in the tester for the general case user. This document also contains precise design specifications for duplicating the tester, a delineation of subsystem functions to enhance understanding of the design philosophy, and block diagrams and connector lists to facilitate system applications. The tester calibrations section (Section 6) should be used to verify internal standards before any tests are done. All special software listings are resident on the tester disc drive and are shown only as necessary in this report; however, a complete software index is included.

2. Hardware Description and Capabilities

2.1 General

The FROM, weighing ~800 lb, is housed in a triple-bay electron rack. Powered from 208 V ac, 3-phase at 20 A FROM dissipates ~15,000 Btu of heat. In this report tester hardware is described sequentially from top to bottom, and left bay to right bay. Table 1 lists test relay input connector wiring.

Table 1. Tester Input Connections
(Mating Connector=Amphenol AN-3106-28-21P)

Pin	Designation	Function
A	CONTACT 1 CLOSED VOLTAGE	
B	CONTACT 1 CLOSED CURRENT	
C	CONTACT 1 ARM VOLTAGE	
D	CONTACT 1 ARM CURRENT	
E	CONTACT 1 OPEN VOLTAGE	
F	CONTACT 1 OPEN CURRENT	
G	RESET COIL 1 POSITIVE	
H	RESET COIL 1 NEGATIVE	
J	CONTACT 2 CLOSED VOLTAGE	
K	CONTACT 2 CLOSED CURRENT	
L	CONTACT 2 ARM VOLTAGE	
M	CONTACT 2 ARM CURRENT	
N	CONTACT 2 OPEN VOLTAGE	
P	CONTACT 2 OPEN CURRENT	
R	OPERATE COIL 1 POSITIVE	
S	OPERATE COIL 1 NEGATIVE	
T	CONTACT 3 CLOSED	
U	CONTACT 3 CONTACT 3 CLOSED	
V	CONTACT 3 ARM VOLTAGE	
W	CONTACT 3 ARM CURRENT	
X	CONTACT 3 OPEN VOLTAGE	
Z	CONTACT 3 OPEN CURRENT	
a	RESET COIL 2 POSITIVE	
b	RESET COIL 2 NEGATIVE	
c	CONTACT 4 CLOSED VOLTAGE	
d	CONTACT 4 CLOSED CURRENT	
e	CONTACT 4 ARM VOLTAGE	
f	CONTACT 4 ARM CURRENT	
g	CONTACT 4 OPEN VOLTAGE	
h	CONTACT 4 OPEN CURRENT	
j	OPERATE COIL 2 POSITIVE	
k	OPERATE COIL 2 NEGATIVE	
m	CONTINUITY LOOP SOURCE	
n	CONTINUITY LOOP SOURCE	
p	CONTINUITY LOOP DRAIN	
r	CONTINUITY LOOP DRAIN	
s	TESTER CHASIS, CABINET, RELAY CASE, AND SAFETY GROUND	

Note: One continuity loop source must be connected to one continuity loop drain.

2.2 Disc Controller

The uppermost panel on the viewer's left is an HP/3037A disc-drive controller. This microprocessor-based device translates high-level command words into commands intelligible to the disc drive. The controller also transfers data bidirectionally between the disc drive and the computer, at the same time taking steps to ensure data integrity. The computer is notified of any data transfer or control errors. Many data errors can be corrected by invoking internal microprocessor software routines.

2.3 Input/Output (I/O) Extender

Because the computer mainframe has too few I/O channels, an I/O extender is used to accomodate 16 additional channels as an extension of the HP21MX computer vectored priority-interrupt system. The model used is an HP12979A.

2.4 Computer

The main control computer of the relay tester is an HP21MX with dynamic memory mapping, memory protect, and microprogram capability. The installed system executive is an HPRTE4B with session monitor. This computer performs logical, arithmetic, and data-transfer operations at the command of instructions stored in its main memory.

2.5 Disc Drive

The disc drive, an HP7906, is a high-performance, random-access, mass-storage device designed for peripheral use in a medium-sized system. It has a combination fixed disc and front-loading removable-disc cartridge. The fixed and removable discs each hold 10 million words of data or programs. The drive also contains a sophisticated fault-detection system that senses abnormal conditions and indicates the nature of the fault.

2.6 Reader

The paper tape reader is a Remex Model RR-4501 that uses 8-level tape to convert information stored in the form of punched holes into a usable form for the computer. This reader senses changes in light intensity as perforations in the tape pass over photocells. Tape moves from left to right, with the tape feed-holes in the rear.

2.7 Punch

The paper tape punch, a Remex Model RPM10, perforates 8-level tape and stores data sent from the computer in the form of punched holes. This high-speed unit feeds tape by means of a stepping motor. A tape-feed switch allows the punching of all columns or only of feedholes to allow extra tape leader.

2.8 Electronic Matrix

The electronic matrix subsystem, which is located in the top positions of the center equipment bay, has three functions. First, it formats the contact status of the relay under test as received from the test matrix with its coil status and sends this information to the contact timers. Second, it contains all electronic, nonarc-suppressed, coil drivers. These drivers, powered from the constant voltage source, actuate the relay under test so that the coil-status information sent to the contact times has submicrosecond accuracy. Third, the matrix has a programmable contact status check that, when fulfilled, informs the computer with a program interrupt. Front panel lamps indicate the present mode of operation and status.

2.9 Digital Voltmeter (DVM)

All voltage and current measurements are made with the HP3190 DVM. (Table 2 lists the possible DVM interconnects.) The accuracy of all measurements is affected by the DVM which must be calibrated by a standards organization. Current measurements are made by passing the current through a calibrated resistance and measuring the voltage.

Table 2. DVM Interconnect

Lower + True	Function	DVM J6-50 Pin
1	"1" UNITS	1
2	"2" UNITS	2
3	"4" UNITS	26
4	"8" UNITS	27
5	"1" TENS	3
6	"2" TENS	4
7	"4" TENS	28
8	"8" TENS	29
9	"1" HUNDREDS	5
10	"2" HUNDREDS	6
11	"4" HUNDREDS	30
12	"8" HUNDREDS	31
13	"1" THOUSANDS	7
14	"2" THOUSANDS	8
15	"4" THOUSANDS	32
16	"8" THOUSANDS	33
23	FLAG	43
24	COMMON	50
A	HOLD MODE	22
Z	STC	46
Upper + True	Function	DVM J6-50 Pin
1	"1" TEN THOUSANDS	9
2	"2" TEN THOUSANDS	10
3	"4" TEN THOUSANDS	34
4	"8" TEN THOUSANDS	35
Lower + True	Function	DVM J6-50 Pin
5	OVERRANGE	11
6	COM	12
7	COM	36
8	COM	37
9	"1" RANGE	13
10	"2" RANGE	14
11	"4" RANGE	38
12	COM	39
13	POLARITY	17
14	OVERLOAD	18
15	SAMPLE/HOLD	44
16	STRETCH	J5-10

Table 2. (continued)

Lower + True	Function	DVM J5-36 Pin
23	FLAG	23
24	COM	12
A	"1" RANGE	1
B	"2" RANGE	2
C	"4" RANGE	19
D	AUTO	20
E	FUNCTION	3
F	FUNCTION	4
H	SAMPLE	21
J	TRACK	22
K	REMOTE	6
L	HOLD	29
M	CALL 1	34
N	CALL 2	35
P	CALL 4	15
R	CALL 8	16
S	AC TRIGGER	8
T	DC TRIGGER	9
Z	STC	5
W	EXTERNAL	28

2.10 Contact Timers

Eight identical contact timers operate and communicate under the control of an internal micro-processor. Each timer may be independently programmed to measure contact times for bounce, release bounce, operate, or release. The start of measurement for bounce and release bounce is the first contact operation. The start of measurement for operate or release time is either a coil energize or coil deenergize. During all measurements, the timer is stopped when the last programmed contact function is detected. Front panel lamps display fault conditions, each timer has an auxiliary data readout. The calibration standard for all measurements of time is a 10-MHz quartz-crystal oscillator.

2.11 Terminal

All operator communication with the relay tester control computer is done through the HP2648 terminal. This terminal, which contains two cartridge tape drivers for storing test programs data, is also capable of graphics presentation of test data. During normal operation, test output is depicted on the terminal and is also sent to the disc drive.

2.12 Power Converters

The power-conversion system, located in the bottom of the center equipment rack, converts the 208-V 3-phase power input to 115 V for operating the various tester subsystems. Additionally, 28-V and 5-V dc power supplies are incorporated to operate internal relays and integrated circuits. The main power contactor and input power monitors are also included in this section.

2.13 Test Matrix

The uppermost panel in the equipment rack on the viewer's right is the test matrix, which connects the digital voltmeter, constant-current and constant-voltage sources, hipot programmer, and electronic matrix to the coils and contacts of the relay under test. The test matrix can isolate any coil or contact of the relay under test and connect it to the constant-current source while routing the developed voltage to the DVM, thereby yielding contact or coil resistance measurements. It can also isolate any relay part and connect it to the hipot programmer hi-voltage output while measuring the current in this element, giving hipot data. The test matrix can also connect any relay coil to either the constant-current supply or constant-voltage supply to change the state of the relay under test or measure its operate current. Incorporated into test matrix are two internal current viewing resistors, 1Ω and 100Ω , which are calibrated by using the test matrix $10\text{-}\Omega$ transfer standard resistor. The transfer standard resistor also calibrates the constant-current source. Front-panel lamps indicate the present programmed status of the test matrix. During all contact resistance measurements, a short circuit is placed across the test relay elements until specifically removed by a separate programming command to ensure that no overcurrent glitch is applied to the device under test.

2.14 Input Matrix

The input matrix connects one of 16 possible relays to the test matrix input port. Confirmation of relay connection is sensed with a continuity loop, and the request of a nonoperational channel is detected by the control computer. The proper method of wiring the relays to be tested to the input matrix is shown in Table 1.

2.15 Hard Copy Unit

The hard copy line printer is an HP13246B. Test relay output data are sent directly to this printer, and the contents of the terminal screen can be printed at any time.

2.16 Hipot Programmer

The hipot programmer interfaces between the control computer and the hipot power supply. Hipot voltage can be programmed in $1/2\text{-V}$ steps from 0 to 500V with an internal overcurrent trip-out of $700\text{ }\mu\text{A}$. In the event of a hardware overcurrent protector failure, output current is resistively limited to 2.5 mA. The internal hipot current-viewing resistor is $1000\text{ }\Omega$, and a $100\text{-m}\Omega$ transfer standard resistor is used to ensure hipot calibration. The CHESS relay life tester input port for the test matrix is also routed through the hipot programmer. Activation of the input matrix and the CHESS port are mutually exclusive. In addition, the front panel of the hipot programmer depicts its status and incorporates a PANIC switch. Activating the PANIC switch programs all test power supplies to zero output, programs the tester input to undefined, and returns the control computer to the monitor mode.

2.17 Constant-Current Source

The current source for resistance measurements and coil operate current tests is an HP6140 digital current supply. It can be programmed from the control computer in output steps of $1\text{ }\mu\text{A}$ from 0 to 100 mA. At all times a voltage limit of 2 to 100 V can be imposed.

2.18 Constant-Voltage Source

The voltage source for relay activation during time measurements or open side contact resistance measurements is an HP6130 digital voltage source. This supply can be programmed from 0 to 50-V output in a 1-mV steps. At all times an output current limit from 10 mA to 1 A can be imposed.

2.19 Hipot Supply

The hipot power supply, an electronic measurements Model 236, is totally controlled by the hipot programmer. The left knob should be at the mark or about one-half on; the other control-knob position has no effect.

3. Theory of Operation

3.1 General

This section covers hardware structure and interconnections, beginning with the relays to be tested and continuing through tester circuitry. A test relay is selected by the input matrix and applied to the test matrix input port. The test matrix isolates various contacts or coils and selects appropriate power supplies to measure resistance or hipot. The test matrix can also pass either the test relay contacts or coils through the electronic matrix. If the state of a latching relay is to be changed, the test matrix performs this function. During the measurement of operate current, the test matrix connects the constant-current source to the relay coil and passes the contacts to the electronic matrix for monitoring. When measuring contact times, the electronic matrix operates the relay coil and passes the contact data to the contact timers.

Each relay tester hardware section is individually operated by an interface in the control computer as shown in Table 3. The software control of all hardware is covered in this manual, and block diagrams of all major hardware sections are given. Various commercial power supplies and Hewlett-Packard hardware are fully explained in their literature and are not covered here.

Table 3. Computer I/O Connections

I/O Slot	Card type	Interface
10	12908	CONTROL STORE MODULE 12
11	12908	CONTROL STORE MODULE 13
12	SPECIAL	TIME BASE GENERATOR
13	12566	ELECTRONIC MATRIX
14	12551	HIPOT PROGRAMMER
15	12566	PRIVILEGED I/O FENCE
16	12771	DISTRIBUTED SYSTEM LINK
17	13030	DISC DRIVE
20	59310	HPIB CHANNEL
21	12661	CONSTANT CURRENT SUPPLY
22	12661	CONSTANT VOLTAGE SUPPLY
23	12566-2	DVM LOWER SELECT
24	12566-2	DVM UPPER SELECT
25	12566	CONTACT TIMERS
26	12551	TEST MATRIX
27	12551	INPUT MATRIX
30	12966	TERMINAL
31	12566	READER
32	12566	PUNCH
33	12566-2	CHESS TESTER PLUS
34	SPECIAL	CHESS OVER-RIDE
35	12531	AUXILIARY TERMINAL
36	12566	CHESS TESTER NORMAL
37	12539	AUXILIARY TIME BASE
40	12551	FUTURE MAGNETIC TAPE

3.2 Input Matrix

The input matrix is constructed in two panels numbered 1 through 8 and 9 through 16. Each position has a select confirmation lamp. The computer interface has 18 relays, one connected to each of the 16 computer output bits, one to the device command, and the last to the device flag. When a computer bit is enabled, the corresponding relay is energized and 28-V power is sent to the channel-select relays, continuity-loop-select relays, and indicator lamp. The channel-select relays are 4-pole, 10-A Babcock BR14X units. Eight are used for each test position. The required 32 poles of switching are: normally closed contact, arm, and normally open contact on each of four poles of the relay under test with both a voltage and current connection, and two coil leads for each of a possible four coils. The continuity-loop-select relay connects the computer device command and device flag to the respective input channel position. After the input channel select bit is issued, the computer sends the device command. If the continuity loop is closed, the device flag is sent to the computer. If the device flag is not received by the computer after 1 s, the computer assumes an error has occurred and takes appropriate action.

3.3 Hipot Programmer

The hipot programmer chassis contains one more input matrix test position. The use of this position is mutually exclusive with the use of the normal input matrix. The seventeenth input channel is used with the CHSS relay life tester to allow functional testing of a relay undergoing a life test. Normal computer program hierarchy is used to resolve conflicts between input channel selection.

3.3.1 Hipot Voltage Programming

Hipot voltage is programmed by using 10 computer bits in a binary sequence. These bits select a programming resistance value for the resistively programmed Electronic Measurements power supply. The programming resistance constant is 500 Ω/V . Another computer bit short-circuits the programming resistance and provides a true zero output whenever the hipot system is deselected. Additionally, a computer bit places a 100-M Ω transfer standard resistor across the hipot system output, yielding an accurate system calibration. Indicator lamps for these 12 functions are provided on the front panel.

3.3.2 Overcurrent and Panic

The output of the Electronic Measurements high-voltage power supply is routed to the hipot programmer. A control computer bit controls the hipot current range (see Figure 1). The lower current range has a maximum output of 2.5 mA under any conditions as limited by the 200-k Ω safety resistor.

In the high current range, output can be as high as 50 mA. The current range in use is indicated by a front panel lamp. The current range relay also changes the value of the hipot current viewing resistor. In the low current range the viewing resistor is 1 k Ω , yielding 1 mV/ ΩA sensitivity, and in the high range it is 10 Ω yielding 10 mV/mA. In either range, the value of the resistance undergoing hipot is many times larger than the value of the current viewing resistor, allowing calculation of the unknown resistance to ignore the internal resistance size.

In either current range, the voltage developed across the current viewing resistance is sent to a 700-mV detector. If this circuit senses 700 mV or more, an overcurrent trip is generated. The current trip values are 700 μA on low range and 70 mA on high range. When a trip occurs, logic informs the computer by means of the device flag, a front panel lamp illuminates, and the hipot power supply disconnects. A PANIC switch is also connected to the overcurrent logic. When either an overcurrent or PANIC sends the device flag to the computer, an interrupt is generated, a software routine decides which type of indication was sent, and appropriate action is taken.

In relay testing, because the high current range is never used, normal maximum current to a human load is 700 μA .

Figure 1. Overcurrent and Panic Block Diagram

3.4 Test Matrix

The test matrix has five semiindependent programmable sections. The first controls test type--resistance and hipot measurements or power for the test relay coils. The second controls the removal of a short circuit placed in parallel with the contacts undergoing resistance measurements. The third controls test position (which of the test relay contacts or coils are to be acted upon). The fourth selects the type of power to be applied to the test relay coils. The last section controls placement of the DVM input. All selected modes are shown on front panel lamps.

3.4.1 Coil Resistance

The basic circuit used for coil resistance measurement is shown in Figure 2. The test type is set to resistance, and power is routed from the constant-current supply through a viewing resistor to the coil of interest. The digital voltmeter may be used to view the test current or measure the voltage developed across the relay coil. Because the current source and the voltmeter are both calibrated devices, the accuracy of this measurement is assured.

Figure 2. Coil Resistance

3.4.2 Contact Resistance

The basic circuit used for contact resistance measurement is shown in Figure 3. The test type is set to resistance, and power is routed from the constant-current source through a 1-Ω viewing resistor to the short circuit and the contact to be measured. After all connections have been made and the power supply settles to its final value, the computer removes the short circuit. The DVM may be used to monitor the test current or measure the voltage developed across the contact. The constant-voltage source is routed through the electronic matrix to the coil of the relay under test, to actuate the test relay and allow the measurement of normally open contacts. Because the current source and the voltmeter are both calibrated devices, the accuracy of this measurement is assured.

Figure 3. Contact Resistance

3.4.3 Contact Resistance Check

The normal contact resistance testing mode is used, except when an external transfer standard resistance is measured. This calibration check will catch any mysterious measurement error. The calibration check mode disables the normal contact selection system circuitry.

3.4.4 Hipot Measurement

The basic circuit used for hipot measurement is shown in Figure 4. The test type is set to select either hipot energized or hipot deenergized, and the desired contact is programmed. The voltmeter may measure either the voltage impressed across the test circuit or the current flow. When the energized test type is programmed, the relay arms are connected to and measured with the normally open contacts. The relay coils are routed to the electronic matrix to set the energized condition. When the deenergized test type is selected, the relay arms are connected to and measured with their respective normally closed contacts. All nonselected relay elements and the relay case are connected to the hipot return and safety ground. The relay coils may only be tested in the deenergized move, since floating of the constant-voltage supply is not allowed.

Figure 4. Hipot Measurement

Hipots are done sequentially as follows: The test matrix is programmed; then the hipot programmer is given the desired voltage. After a period of time selectable by the test consultant has elapsed, the DVM measures the hipot circuit current and the hipot programmer is cleared. Finally, the test matrix is set to undefined. Calibration is assured by the measurement of current flowing through a 100-m Ω transfer standard.

3.4.5 Operate Current

The basic circuit used to measure relay operate current is shown in Figure 5. The test type is set to power coils, and the power program is set to connect the constant-current source to the set, reset, or operate coils. The relay contacts are routed to the electronic matrix for monitoring. The current source is started at zero and stepped up in increments requested by the test consultant who also defines the time between increments. Eventually the contacts operate, and the computer records the last current programmed and begins decrementing the current supply to record the relay drop-out current value.

Because the current source is checked as a normal calibration step, accuracy of the measurement is assured.

Figure 5. Operating Current

3.4.6 State Transfer

Latching relay state transfers are normally handled through the electronic matrix, but the test matrix may also be programmed to power any relay coil from either the constant-current source or the constant-voltage source. When either the power coils test type or no test type is programmed, the test relay contacts are routed to the electronic matrix. When any test type other than coil resistance or power coils is programmed, the test relay coils are routed to the electronic matrix. The constant voltage source is not routed to the electronic matrix only when the power coils test type is programmed.

3.5 Electronic Matrix

The electronic matrix has three main functions and sections. The first section powers the test relay coils from the constant-voltage source. The second section monitors test relay contacts during operate current measurements, and the third section formats the test relay contacts for the contact times. Indicator lamps on the front panel of the electronic matrix confirm its present programming.

3.5.1 Coil Power

Figure 6 shows the basic circuit used to power the test relay coils during contact time measurements and normally open contact resistance measurements, or optionally for state transfers. The constant-voltage source positive is sent to four electronic coil drivers, one for each of four possible test relay coils. The electronic coil drivers each has a voltage drop of exactly 2 V. The computer must compensate for this voltage drop by programming the constant-voltage source for 2 V more than the desired test relay coil voltage. Normally, a computer command turns the coil drivers on and off as well as selects which coil drivers are activated. Many times, only a pulse of coil voltage is desired for the operation of latching relay coils. A computer command can enable the coil-pulse mode, wherein the computer command begins the coil-voltage pulse, and an internal 10-ms time ends it.

Figure 6. Power Coils

3.5.2 Contact Monitor

Only the electronic matrix contact monitor mode or the format timers mode may be programmed at any one time: the two modes may not be used simultaneously. Figure 7 shows the basic circuit used in the contact-monitor mode. The test relay arms are connected to +5 V. The eight or less test relay contacts are connected to logic, which determines if the contacts are closed. This logic will draw no more than 1 mA of current through a closed contact. The states of all eight monitors are indicated on the front panel of the electronic matrix. The monitor logic has additional inputs from the control computer. These control commands determine which contacts are to be monitored, whether they should be open or closed, and if the computer should be notified of contract make or break. In measuring operate current, a sample command would be to notify the computer when normally open contact number one makes contact. When all programming commands have been fulfilled, the logic is said to be true, and the computer is notified by means of the electronic matrix device flag.

Figure 7. Monitor Contacts

3.5.3 Format Timers

The electronic matrix format timers mode cannot be programmed at the same time as the contact monitor mode. Although there are only eight contact timers on a four-pole relay, as many as 16 separate measurements may be desired at the same time. For example, during coil energize four each measurements are desired of normally closed release time and release bounce time. For each normally open operate time and bounce time are desired as well. The electronic matrix contact monitor mode will resolve this conflict with one of five formats. Programming and description of the formats are covered with the relay tester software. The presently programmed format is depicted by an electronic matrix front-panel indicator.

3.6 Contact Timers

Eight identical contact times are incorporated in the functional relay test system, each programmable to one of four modes of measurement on either a normally open or a normally closed contact. All subsequent explanations describe only action on a normally open contact since the signal from a normally closed contact is merely inverted. Each contact timer may be programmed to measure with either regular or latching test relay coil signals. All explanations assume the latter since a regular coil signal is merely inverted and used to form a pseudo-reset-coil signal. All contact timers in all modes use the same 10-MHz quartz-crystal time standard.

3.6.1 Operate Time

The basic circuit of a contact timer programmed for operate time measurement is shown in Figure 8. A reset signal has reset the flip-flop, accumulator, a memory to zero; the clock pulses are blocked at the AND gate. The test relay contacts are open, and the standardizer inverts this signal by applying a true input to the accumulator AND gate thereby linking memory to the accumulator.

Figure 8. Operate Time

When the coil is energized, the flip-flop applies a true signal to its AND gate, allowing the clock pulses to be counted in the accumulator. This continues until the test relay contacts close, at which time the memory is unlinked from the accumulator. If the test relay contacts open later, memory is relinked to the accumulator to provide a total time update. This action continues until the test relay contacts remain closed.

The operate-time measurement is the time from the first application of test relay coil power until the last closing of the test relay contacts.

3.6.2 Release Time

Measuring release time involves the same series of events as measuring operate time, except that measurement start time is when the test relay reset coil is energized and the test relay contact signal is inverted a second time.

Release time measurement is the time from the first application of test relay reset coil power until the last opening of the test relay contact.

3.6.3 Bounce Time

The basic circuit of a contact timer programmed for bounce-time measurement is shown in Figure 9. This is very similar to operate-time measurement, differing only in that the accumulator start command is changed to the first test relay contact closure.

Figure 9. Bounce Time

The bounce-time measurement is the time from the first test relay contact closure until the last test relay contact closure. If the contacts do not reopen after the first contact closure, the accumulator is never gated into the memory and the resultant data are zero.

3.6.4 Release Bounce Time

Measuring release bounce time involves the same sequence of events as measuring bounce time, except that the contact signal is inverted a second time.

The release-bounce-time measurement is the time from the first test relay contact opening until the last test relay contact opening.

3.6.5 Timer Data Readout

The current load presented to each test relay contact is 1 mA from the contact timer 5-kΩ input resistor. All contact timers are programmed by, and have their memories read by, a microprocessor. When a begin test command is received from the control computer, the microprocessor will reset all flip-flops, accumulators, and memories. After 800 ms, the microprocessor informs the control computer that the test data are ready and whether any errors have occurred. Possible errors, also shown by front panel lamps, are: no accumulator start, no accumulator to memory AND gate turn off or stop, and accumulator overflow. Microprocessor programming activity on the various contact timers is also depicted by front-panel lamps. When the control computer is ready to receive the test data, the microprocessor formats, error-checks, and sends it.

4. Software Description and Use

The FROM incorporates two major classes of software. The first, HPRTE4B, is the operating system. All of its components, consisting of the executive, file manager, session monitor, editor, assembler, loader, FORTRAN compiler, BASIC interpreter, and libraries, are well documented and are not covered herein. The second class of software is Sandia-written and consists of drivers, device subroutines or calling programs, extensions, system subroutines, and test programs. All Sandia software is written in HP assembly code. Sources for Sandia software are stored on the tester disc drive according to the names shown in Table 4 and are located on Cartridge 10010 of Logical Unit 12.

Table 4. Sandia Software

Source Name	Relocatable Name	Function
Device Drivers		
&IMATD	%DVR46	OPERATE INPUT MATRIX
&HIPOD	%DUR47	OPERATE HIPOT PROGRAMMER
&CVOLD	%DUR50	OPERATE CONSTANT VOLTAGE
&CAMPD	%DVR51	OPERATE CONSTANT CURRENT
&CHESD	%DVR52	CHESS TESTER INPUT PORT
&TMATD	%DVR53	OPERATE TEST MATRIX
&DVMD	%DVR54	OPERATE DIGITAL VOLTMETER
&EMATD	%DVR55	OPERATE ELECTRONIC MATRIX
&TBGD	%DVR56	OPERATE AUXILIARY TIME BASE
&TIMED	%DVR57	OPERATE CONTACT TIMERS
Device Subroutines (Calling Programs)		
&IMATC	%IMATC	CALL INPUT MATRIX
&HIPOC	&HIPOC	CALL HIPOT PROGRAMMER
&CVOLC	%CVOLC	CALL CONSTANT VOLTAGE
&CAMPC	%CAMPC	CALL CONSTANT CURRENT
&CHESS	%CHESS	CALL CHESS TESTER INPUT
&TMATC	%TMATC	CALL TEST MATRIX
&DVMC	%DVMC	CALL DIGITAL VOLTMETER
&EMATC	%EMATC	CALL ELECTRONIC MATRIX
&TBGC	%TBGC	CALL AUXILIARY TIME BASE
&TIMEC	%TIMES	CALL CONTACT TIMERS
RTE4B Extensions		
&FR.ED	%FR.ED	PASS TRAP NUMBERS TO BASIC
&BR.BA	%BR.BA	BREAK EXECUTION
&CL.TM	%CL.TM	CLEAR CONTACT TIMERS
&REMEM	%REMEM	ACTIVITY INDICATOR
&&6940	%&6940	NO GENERATION UNDEFINED
&DVA71	%DVA71	DUMMY DRIVER

Table 4. (continued)

Source Name	Relocatable Name	Function
Special Files		
BCALLS	LISTING OF DEVICE CALLS	
HCALLS	LISTING OF SYSTEM CALLS	
ERRORS	LISTING OF SANDIA ERRORS	
System Subroutine		
&SETUP	%SETUP	CONTAIN TEST PARAMETERS
&CHAN	%CHAN	PROGRAM TEST INPUT PORT
&COILR	%COILR	MEASURE COIL RESISTANCE
&CLRCL	%CLRCL	MEASURE CLOSED CONTACT RESISTANCE
&CLROP	%CLROP	MEASURE OPEN CONTACT RESISTANCE
&HPTDE	%HPTDE	MEASURE DEENERGIZED HIPOTS
&HPTEN	%HPTEN	MEASURE ENERGIZED HIPOTS
&STATE	%STATE	SET RELAY STATE
&OPERI	%OPERI	MEASURE OPERATE CURRENT
&TIMES	%TIMES	MEASURE CONTACT TIMES
&OPNCL	%OPNCL	DETERMINE RELAY STATE
&CLRCA	%CLRCA	CALIBRATE CURRENT SOURCE
&HPTCA	%HPTCA	CALIBRATE HIPOT SUPPLY
Operating System		
TRY8AN	GENERATION ANSWER FILE	
&TRY8	GENERATION LISTING	
BMTAB2	BASIC BRANCH TABLE SOURCE	
T2	BASIC TABLE PASSER	
Test Programs		
TEST	GENERAL RELAY TEST PROGRAM	
DATA	GENERAL RELAY TEST DATA PROGRAM	

4.1 General

Sandia software has been segregated into five major types: drivers, subroutines, extensions, device subroutines, and testing programs.

The device drivers become an integral part of the RTE4B operating system during its generation, and actually control the tester hardware. The drivers do almost no error checking and are concerned only with device efficiency.

The device subroutines provide a link with which the high-level language programmer may direct the hardware devices in the tester. These subroutines, or calling programs, also provide extensive error checking and format the programmer's request into one that is understood by its respective driver.

The executive extensions consist of some special programs added to memory during system generation that allow some of the device drivers to interrupt the normal execution sequence of the tester's operating system.

Because all of the device subroutines interface only to a particular device driver, several system subroutines have been provided. These subroutines are oriented to test function and in turn call several of the device subroutines and drivers.

The last type of Sandia software comprises BASIC language test programs that may be modified or completely changed by the tester user. As supplied, the normal test programs fulfill 99% of all relay testing and data logging requirements.

4.2 Drivers

All of the hardware device drivers have been incorporated into the relay tester operating system. This section assumes reader familiarity with the RTE4B operating system, HP assembly language, and RTE driver writing and format. The method by which hardware control is exercised and an outline of each driver are described.

4.2.1 Input Matrix

The input matrix driver consists of both an initiator and a hardware interrupt entered continuator. When the initiator is called with a channel number request between 1 and 16, the channel number is changed into a corresponding bit position, 0 through 15 inclusive. The bit is output to the input matrix hardware, a device command is sent to the hardware, and a 5-s time-out is set. If a zero or a channel number larger than 16 is requested, the driver clears the input matrix and returns to the caller.

Within the input matrix hardware, the device command is routed through the continuity loop of the programmed channel and sends an interrupt command to the operating system. This interrupt runs the input matrix driver continuator and merely cancels the time-out of the driver.

If the continuator is not run and the time-out is cancelled within the 5-s time limit, the operating system sets down the input matrix equipment table entry.

4.2.2 Hipot Programmer

The hipot programmer driver sets the hipot system, voltage, current limit, and calibration status. The driver initiator formats the desired voltage, etc, to an output bit pattern and sends it to the hipot programmer hardware. The initiator waits for 10 ms for an overcurrent flag. After 10 ms, the initiator returns to the caller with overcurrent status information. The initiator also enables the panic switch by sending a device command to the hipot programmer and enabling the panic interrupt.

The hipot driver continuator is entered on either an overcurrent interrupt or operation of the PANIC switch. The continuator interrogates the hipot programmer hardware to determine the reason for its entry. When the continuator is entered because of a hipot supply overcurrent, the supply is reprogrammed to zero output and a program is scheduled to pass TRAP No. 3 to the presently operating program. If the PANIC switch was operated all hardware devices are cleared or programmed to zero, and the operating BASIC program is broken to the command mode.

4.2.3 Constant-Voltage Driver

The initiator of the constant-voltage source driver formats the desired voltage and current limit and passes the information to the power supply. When the power supply is programmed, it is put into the delay mode wherein a device flag is sent to the driver after 10 ms. If this delayed flag is not received by the driver initiator, the power supply is known to be inoperable, and this fact is returned to the caller. After the delayed flag is received, the power supply is checked to see if an overload has occurred. If so, this fact is also returned to the calling program. During proper operation, the power supply is set to the alarm mode and the driver initiator exits to the calling program.

If an overcurrent occurs after the initiator has completed execution, the continuator is entered. The driver continuator schedules a system extension program to pass a TRAP No. 5 to the operating BASIC program and exit.

4.2.4 Constant-Current Driver

The constant-current driver is almost an exact copy of the constant-voltage driver. The only differences are that references to supply voltage and current are transposed, and the TRAP number is 4.

4.2.5 Chess Tester Input Port

The chess tester input port driver has only an immediate completion initiator section. The only control is chess link on or off. The driver interprets a "one" command as on, and all other commands as off. The driver changes only the state of Bit 15 on the hipot programmer hardware to control the access of the auxiliary input port.

Present programming of the hipot programmer hardware is always preserved intact by this driver.

4.2.6 Test Matrix

The test matrix hardware has five subfunctions: test position, test type, DVM, power program, and contact loop resistance (CLR) short circuit. The test position defines which test relay contact or coil is to be acted upon. The test type defines whether the test to be performed is CLR, hipot, or whether the test relay coils are to be powered. The DVM function controls application of the DVM and subsequent data readout to the various power supplies or circuit elements. The power program controls which power supply is connected to the test relay coils and which, if any, current viewing resistor is used. The CLR short circuit is applied whenever a test type of CLR is requested. The CLR short-circuit command will remove it.

All calls made to the test matrix driver are sent to the test matrix hardware exactly as received. Ten milliseconds after the request is sent to the hardware, a valid data bit is added instructing the hardware to accept the request. After another 10 ms, the driver exits to the calling program except when a CLR short removal is desired. If a CLR short removal is requested, the calling program is suspended, the driver sets up a 250-ms time-out, and the initiator exits to the operating system. After 250 ms have elapsed, the driver continuator is entered and the system is returned to normal operation. The purpose of the time-out is to allow the constant-current power supply to settle at a new output voltage, or to generate a TRAP interrupt.

4.2.7 Digital Voltmeter (DVM)

The DVM driver uses two I/O computer select codes. The select codes are referred to as upper or lower, which is determined by the placement of the interface cards in the computer mainframe.

After the driver initiator is entered, the DVM programming command is examined. If it differs from the existing voltmeter setup, the DVM is reprogrammed. To change the voltmeter programming, the new program is output to the upper select code and a device command is sent to the upper select code. The initiator waits 50 ms for the device flag from the upper select code, which signifies that reprogramming is complete, or return to the caller with a device inoperable status. The present state of the DVM programming command is stored, and operation continues the same as when DVM programming is unchanged.

The driver initiator starts a DVM reading by sending a device command on the lower select code. It then sets up a 2-s time-out and returns to the operating system. When the DVM finishes the reading, a device flag is sent to the lower select code. The driver continuator then removes the data from the DVM and sends it to the calling program. The data, as received and sent, are in 1, 2, 4, 8 BCD code containing seven digits of reading plus range, polarity, and overload information.

4.2.8 Electronic Matrix

The electronic matrix driver initiator controls power routing between the constant-voltage source and any test relay coil. Powering of the test relay coil may be set up as a continuous mode or as a pulse, and this function may be used at any time without regard to other electronic matrix functions.

The format of the interface between the test relay contacts and the contact timers is also controlled by the electronic matrix driver initiator. Because both this function and the contact monitor function switch the test relay contacts, they are mutually exclusive.

The electronic matrix driver initiator may also set up a contact monitor, which constantly examines the status of all the contacts of the relay under test and produces an interrupt to set up a TRAP 2 when it is fulfilled.

The requests to the driver initiator perform their required functions and delay 10 ms except for commands affecting the test relay coils, which do not delay. The commands then perform an immediate completion exit.

The only function of the driver-continuator is to vector the electronic matrix hardware interrupt and set up the BASIC TRAP.

Communications between the electronic matrix driver and the calling program is maintained with a four-word buffer. The first word is the electronic matrix request command to be set up or executed. The second word is a binary image of the bit pattern to be sent to, added to, or deleted from the electronic matrix hardware. The third word is a binary image of the bit pattern last known to exist on the electronic matrix hardware. The fourth word is a representation of the present state of the test relay contacts, if they are capable of being monitored.

4.2.9 Contact Timers

The contact timer hardware contains an integral microprocessor, and communication requires only one command word. The functions of the command word are: reset, program, perform test, or return the data. The driver initiator is first called to clear old data from the timers and reprogram the system. All timers will be cleared, and the programming information contained within the command word will be executed. The initiator then performs an immediate completion.

The driver initiator is again called to start the test, and the timers open an 880-ms test window during which the test relay must be activated and perform another immediate completion. The test programmer must now operate the test relay. After the test window closes, an interrupt is generated to the driver continuator to inform that the test data are ready.

The contact timer driver initiator is called for a last time to get the test data. This request is passed to the driver continuator where the test program is suspended until the data are ready. If the timers have data that have not been removed, BASIC will perform a TRAP 7.

The contact timer hardware always requires a valid data bit, which is sent by the driver initiator only after all request parameters are examined and set. The contact timer hardware runs asynchronously with the main computer hardware and uses the device flag to signal its wait state. The device flag remains set until the contact timers are instructed to clear it. The device command from the main computer interrupts the contact timer to inform it that the main computer has a request to be performed. This method synchronizes the system elements during passage of programming commands or test data because it allows the driver initiator, running in the main computer, to finish execution in a very short time.

4.2.10 Auxiliary Time Base

The auxiliary time-base driver operates a time-base generator that is not affiliated with the RTE4B operating system. When it is called, the driver initiator resets any existing TRAPs to 6 and sets up the driver continuator to count the number of time-base generator interrupts specified in the call. It then performs an immediate completion exit. Each time-base generator interrupt causes the driver continuator to be entered and the count incremented. When the count of interrupts equals the request to the driver initiator, an operating system extension is used to enable BASIC TRAP 6.

4.3 Subroutines

The subroutines, or calling programs, are integral extensions of the BASIC interpreter. As installed in the functional relay tester the subroutines are also FORTRAN-callable. These calling programs provide a link between the high-level language programmer and the hardware drivers. They also do extensive error-checking, thereby preventing any harm to hardware devices or inaccurate data.

This section outlines the calling sequence for each hardware device and explains the device action. If a hardware device such as the electronic matrix or contact timers requires multiple calls, the sequence and reasons are covered. Command or execution errors and recovery from them are explained and each subroutine capable of producing them is listed.

4.3.1 Input Matrix

CALL FORMAT = INMAT (CHANNEL NUMBER)

The channel number may be a constant or integer variable, and the input matrix sets the channel number requested while resetting all others. If a channel number of zero (or less or larger than 16) is requested, all channels are cleared. If the continuity loop in the requested channel is not closed, the terminal produces the error message IOTO 12,0. To recover, first ensure the continuity loop is closed. Then press any key on the terminal, press carriage return, press the key again, and the terminal shows an asterisk. Type UP,12 and the subroutine tries to fulfill the request again.

4.3.2 Hipot Programmer

CALL FORMAT = HIPOT (VOLTAGE, FUNCTION, STATUS)

The desired hipot voltage may be any value between 0 V and 510 V. The function command must be an integer between 0 and 3. A function of 0 turns off the output of the hipot supply and disconnects the calibrate resistor. A function of 1 turns on the output of the hipot power supply and enables the low-current, 700- μ A range. A function of 2 turns the output of the hipot power supply on and enables the high-current, 70-mA range. A function of 3 is the same as 1, except the calibrate resistor is placed across the output of the hipot programmer.

The status is a number returned to the programmer. If the status is -2, an overcurrent trip-off has occurred. If the status is -1, there was no response from the hipot power supply. If the status is zero, the request was performed. If the status is 1, the request was in error.

The PANIC switch is enabled only after the first request to the hipot programmer has been granted. When a call for output from the hipot programmer is requested, a check for an overcurrent condition is made. If an overcurrent is detected at this time, a -2 status is returned and the hipot power supply is set to zero.

If an overcurrent occurs sometime later, TRAP-3 is set and the hipot system is set to zero. The PANIC switch, if operated, sets all power systems to zero and puts BASIC into the command mode of execution.

4.3.3 Constant-Voltage Source

CALL FORMAT = VOLTS (VOLTAGE, LIMIT, STATUS)

The desired constant voltage may be any value between -50 and + 50 V with a resolution of ~ 1 mV. The constant, or integer variable, placed in "limit" sets the maximum output current and TRAP-5 trigger level as shown below.

Limit Value		Maximum Output Voltage (V)
1	-	2
2	-	5
3	-	7
4	-	10
5	-	20
6	-	50
7	-	70
8	-	100

Limit Value		Maximum Output Current
1	-	20 mA
2	-	50 mA
3	-	70 mA
4	-	100 mA
5	-	200 mA
6	-	500 mA
7	-	700 mA
8	-	1 A

The status return value is shown below.

Status	Meaning
-2	Current limit exceeded during call
-1	No response
0	Action performed
1	Command error

4.3.4 Constant-Current Source

CALL FORMAT = AMPS (CURRENT, LIMIT, STATUS)

The desired constant current may be any value between -150 and +150 mA, with a resolution of ~1 mA. The constant or integer variable placed in "limit" sets the maximum output voltage and TRAP -4 trigger level as shown below

Limit Value		Maximum Output Voltage (V)
1	-	2
2	-	5
3	-	7
4	-	10
5	-	20
6	-	50
7	-	70
8	-	100

The value of status returned is shown below.

Status	Meaning
-2	Voltage limit exceeded during call
-2	No response
0	Action performed
1	Command error

4.3.5 Chess Tester Input Port

CALL FORMAT = CHESS (FUNCTION)

If the function is equal to 1, the chess relay life tester is connected to the functional relay tester input port. If the function is equal to any number other than 1, the chess tester input port is disconnected.

4.3.6 Test Matrix

The test matrix has four input formats.

Format	Use
CHECK	To measure internal values
RESIS	To measure contact resistance measurements
INSUL	To measure hipot current
POWER	To power the test relay coils for relay state transfer or operate current measurements

CALL FORMAT = CHECK (FUNCTION)

Function Value	Data Sent to DVM
0	Turn test matrix off (clear)
1	Open circuit voltage of current supply
2	Standard 1 V
3	Open circuit voltage of voltage supply

CALL FORMAT = RESIST (FUNCTION, CHANNEL)

Function, Channel	Action, Measurement by DVM
0,0	CLEAR TEST MATRIX
1,1	NC-A CONTACT RESISTANCE SETUP
1,2	NO-A CONTACT RESISTANCE SETUP
1,3	NC-B CONTACT RESISTANCE SETUP
1,4	NO-B CONTACT RESISTANCE SETUP
1,5	NC-C CONTACT RESISTANCE SETUP
1,6	NO-C CONTACT RESISTANCE SETUP
1,7	NC-D CONTACT RESISTANCE SETUP
1,8	NO-D CONTACT RESISTANCE SETUP
2,0	CONTACT CURRENT INTO SHORT CIRCUIT
2,1	CONTACT CURRENT INTO NC-A
2,2	CONTACT CURRENT INTO NO-A
2,3	CONTACT CURRENT INTO NC-B
2,4	CONTACT CURRENT INTO NO-B
2,5	CONTACT CURRENT INTO NC-C
2,6	CONTACT CURRENT INTO NO-C
2,7	CONTACT CURRENT INTO NC-D
2,8	CONTACT CURRENT INTO NO-D
3,0	MEASURE RESISTANCE OF STANDARD

4,0	COIL RESISTANCE APPLIED VOLTAGE
4,1	COIL RESISTANCE MEASUREMENT OF RESET 1
4,2	COIL RESISTANCE MEASUREMENT OF RESET 2
4,3	COIL RESISTANCE MEASUREMENT OF SET 1
4,4	COIL RESISTANCE MEASUREMENT OF SET 2
5,1	COIL RESISTANCE APPLIED CURRENT RESET COIL-1
5,2	COIL RESISTANCE APPLIED CURRENT RESET COIL-2
5,3	COIL RESISTANCE APPLIED CURRENT SET COIL-1
5,4	COIL RESISTANCE APPLIED CURRENT SET COIL-2
6,0	Remove short circuit in parallel with the test relay contacts that were enabled with the last setup call.

CALL FORMAT = INSUL (FUNCTION, CHANNEL) FUNCTION, CHANNEL ACTION,
MEASURE BY DVM 0,0 CLEAR TEST MATRIX

The following commands are used with the test relay in the set or coil energized state.

- 1,0 HIPOT VOLTAGE OPEN CIRCUIT
- 1,1 HIPOT VOLTAGE NC-A
- 1,2 HIPOT VOLTAGE NO-A AND A ARM
- 1,3 HIPOT VOLTAGE NC-B
- 1,4 HIPOT VOLTAGE NO-B AND B ARM
- 1,5 HIPOT VOLTAGE NC-C
- 1,6 HIPOT VOLTAGE NO-C AND C ARM
- 1,7 HIPOT VOLTAGE NC-D
- 1,8 HIPOT VOLTAGE NO-D AND D ARM
- 2,0 HIPOT CURRENT OPEN CIRCUIT
- 2,1 HIPOT CURRENT NC-A
- 2,2 HIPOT CURRENT NO-A AND A ARM
- 2,3 HIPOT CURRENT NC-B
- 2,4 HIPOT CURRENT NO-B AND B ARM
- 2,5 HIPOT CURRENT NC-C
- 2,6 HIPOT CURRENT NO-C AND C ARM
- 2,7 HIPOT CURRENT NC-D
- 2,8 HIPOT CURRENT NO-D AND D ARM

The following commands are used with the test relay in the reset or relaxed state.

- 3,0 HIPOT VOLTAGE OPEN CIRCUIT
- 3,1 HIPOT VOLTAGE NC-A AND A ARM
- 3,3 HIPOT VOLTAGE NC-B AND B ARM
- 3,2 HIPOT VOLTAGE NO-A
- 3,4 HIPOT VOLTAGE NO-B
- 3,5 HIPOT VOLTAGE NC-C AND C ARM
- 3,6 HIPOT VOLTAGE NO-C
- 3,7 HIPOT VOLTAGE NC-D AND C ARM
- 3,8 HIPOT VOLTAGE NO-D
- 3,9 HIPOT VOLTAGE RESET COIL 1

- 3,10 HIPOT VOLTAGE RESET COIL 2
- 3,11 HIPOT VOLTAGE SET COIL 1
- 3,12 HIPOT VOLTAGE SET COIL 2
- 4,0 HIPOT CURRENT OPEN CIRCUIT
- 4,1 HIPOT CURRENT NC-A AND A ARM
- 4,2 HIPOT CURRENT NO-A
- 4,3 HIPOT CURRENT NC-B AND B ARM
- 4,4 HIPOT CURRENT NO-B
- 4,5 HIPOT CURRENT NC-C AND C ARM
- 4,6 HIPOT CURRENT NO-C-
- 4,7 HIPOT CURRENT NC-D AND D ARM
- 4,8 HIPOT CURRENT NO-D
- 4,9 HIPOT CURRENT RESET COIL 1
- 4,10 HIPOT CURRENT RESET COIL 2
- 4,11 HIPOT CURRENT SET COIL 1
- 4,12 HIPOT CURRENT SET COIL 2

CALL FORMAT = POWER (FUNCTION)

Function	Action and DVM Measurement
0	CLEAR TEST MATRIX
1	ACTIVATE TEST RELAY COIL RESET 1 FROM VOLTAGE SUPPLY
2	ACTIVATE TEST RELAY COIL RESET 2 FROM VOLTAGE SUPPLY
3	ACTIVATE TEST RELAY COIL SET 1 FROM VOLTAGE SUPPLY
4	ACTIVATE TEST RELAY COIL SET 2 FROM VOLTAGE SUPPLY
5	ACTIVATE TEST RELAY COILS RESET 1 & 2 FROM VOLTAGE SUPPLY
6	ACTIVATE TEST RELAY COILS SET 1 & 2 FROM VOLTAGE SUPPLY
7	ACTIVATE TEST RELAY COIL RESET 1 FROM CURRENT SUPPLY
8	ACTIVATE TEST RELAY COIL RESET 2 FROM CURRENT SUPPLY
9	ACTIVATE TEST RELAY COIL SET 1 FROM CURRENT SUPPLY
10	ACTIVATE TEST RELAY COIL SET 2 FROM CURRENT SUPPLY
11	ACTIVATE TEST RELAY COILS RESET 1 & 2 FROM CURRENT SUPPLY
12	ACTIVATE TEST RELAY COILS SET 1 & 2 FROM CURRENT SUPPLY
13	ACTIVATE TEST RELAY COIL RESET 1 FROM VOLTAGE MEASURE CURRENT
14	ACTIVATE TEST RELAY COIL RESET 2 FROM VOLTAGE MEASURE CURRENT
15	ACTIVATE TEST RELAY COIL SET 1 FROM VOLTAGE MEASURE CURRENT
16	ACTIVATE TEST RELAY COIL SET 2 FROM VOLTAGE MEASURE CURRENT
17	ACTIVATE TEST RELAY COILS 1 & 2 FROM VOLTAGE MEASURE CURRENT
18	ACTIVATE TEST RELAY COILS 1 & 2 FROM VOLTAGE MEASURE CURRENT

A command error, or a command not herein listed, sent to the test matrix subroutine produces a BASIC ERR value as shown below.

Subroutine Name	ERR Value
CHECK	101
RESIS	102
INSUL	103
CHECK	104

These errors cause BASIC to terminate unless the programmer has specified the subroutine fail option.

FORTTRAN programmers must define and check an internal integer variable named ERRCD, which has been placed in the RTE4B subsystem global area.

4.3.7 Digital Voltmeter (DVM)

CALL FORMAT = DVM (RANGE, DATA)

The DVM may be commanded to use a specific input voltage range, automatic control of input voltage range, or local control mode. The range request may be a constant or an integer variable as shown below.

Range Value	DVM Function
0	LOCAL MODE
1	AUTO RANGE
2	0.1-V RANGE
3	1-V RANGE
4	10-V RANGE
5	100-V RANGE
6	1000-V RANGE
7	TRACK AND HOLD (FOR COMMAND 8)
8	GET VOLTAGE AT TIME OF CALL

DATA is a simple variable where the DVM reading is placed. When the DVM is called, the caller is suspended until the reading is complete and the data have been returned.

If the range value is invalid or the DVM is overloaded, the ERR (error) location of BASIC is set to 200.

4.3.8 Electronic Matrix

The electronic matrix has five input formats.

Format	Use
CONTT	To connect the test relay contacts to the contact timers
CONTM	To set up the test relay contact monitor mode
COILS	To control which coils of the relay under test are activated
EMATF	To command the start of execution of other electronic matrix set-ups
EMATS	To read the contact status of the relay under test

CALL FORMAT = CONTT (MODE)

The CONTT and CONTM commands are mutually exclusive; any call to either one sets the other to undefined. The five allowed mode commands may be a constant or integer variable; they control the connection of the test relay contacts to the contact timers as shown below.

MODE	TIMER =	CONTACT,	TIMER =	CONTACT,	TIMER =	CONTACT,	TIMER =	CONTACT
0	1	NC-A	2	NO-A	3	NC-B	4	NO-B
	5	NC-C	6	NO-C	7	NC-D	8	NO-D
1	1	NC-A	2	NC-A	3	NC-B	4	NC-B
	5	NC-C	6	NC-C	7	NC-D	8	NC-D
2	1	NO-A	2	NO-A	3	NO-B	4	NO-B
	5	NO-C	6	NO-C	7	NO-D	8	NO-D
3	1	NC-A	2	NC-A	3	NO-A	4	NO-A
	5	NC-B	6	NC-B	7	NO-B	8	NO-B
4	1	NC-C	2	NC-C	3	NO-C	4	NO-C
	5	NC-D	6	NC-D	7	NO-D	8	NO-D

An error in or out of the mode call to CONTT, or a call that is out of range, sets the ERR value to 300.

CALL FORMAT = CONTM (TYPE, ACTION, CONTACTS)

The CONTM command merely sets up the contact monitor mode; an EMATF command is required to enable the TRAP interrupt. TYPE is the contact type to be monitored where zero is specified for normally open contacts and one is specified for normally closed contacts. ACTION is the state or change or state required by the test relay contacts to produce an electronic matrix true state and the TRAP interrupt. A zero is specified for broken or on-contact break, and a one is specified for make or on-contact make. The value placed in CONTACTS controls that test relay contacts are monitored as shown below.

Contacts Value	Contacts Monitored
0	Exit Monitor Mode
1	A
2	B
3	A and B
4	C
5	A and C
6	B and C
7	A and B and C
8	D
9	A and D
10	B and D
11	A and B and D
12	C and D
13	A and C and D
14	B and C and D
15	A and B and C and D

All CONTM data inputs are constants or simple integer variables, and an input command that is out of range to any of them sets the ERR value to 301.

CALL FORMAT = COILS (WHICH)

This command merely sets up which coils are acted upon; the EMATF command controls all coil energization. An out-of-range input command sets ERR to 302. Legal input requests are shown below.

Value in WHICH	Coils Acted Upon
0	None
1	Reset 1
2	Reset 2
3	Set 1
4	Set 2
5	Reset 1 and 2
6	Set 1 and 2

CALL FORMAT = EMATF (FUNCTION)

A FUNCTION command of 0 clears all existing commands and setups from the electronic matrix hardware.

A FUNCTION command of 1 enables the TRAP 2 interrupt to execute when the test relay contacts set up with the CONTM command achieve the status declared in the command. If this function is called and the CONTM command has not been executed, an error is produced.

A FUNCTION command of 2 sends power from the constant-voltage power source to the test relay coils defined in the COILS command. If this function is called and the COILS command has not been executed, an error is produced.

A FUNCTION command of 3 sends power from the constant-voltage power source to the test relay coils defined in the COILS command, but the power will only be a 10-ms pulse.

A FUNCTION command of 4 cancels the FUNCTION of 2 and deenergizes the test relay coils.

An out-of-range FUNCTION command or other error sets the ERR value to 303. The electronic matrix hardware has a 2-V loss during operation of the test relay coils from the constant-voltage power supply. Care must be taken to ensure that the constant-voltage supply is programmed for 2V in excess of the desired test relay coil voltage.

CALL FORMAT = EMATS (CONTACTS, MONITOR)

The EMATS command reads the present status of the relay contacts under test. The CONTM command with a contact value of 15 must have been previously executed to enable the monitor mode on all contacts, or an ERR value of 304 will be sent to BASIC. The value returned in CONTACTS depicts the present status of the test relay contacts in binary form. This number should be examined by trial subtraction of the contact identifier numbers shown below from largest to smallest.

Integer Number To Be Subtracted	Contact Closed If Subtractions Successful
1	NC-A
2	NO-A
4	NC-B
8	NO-B
16	NC-C
32	NO-C
64	NC-D
128	NO-D

The value returned in MONITOR is odd if the CONTM status is fulfilled, or even if the status is not fulfilled. The value in MONITOR is zero or one if the TRAP interrupt is not enabled, and two or three if the TRAP interrupt is enabled.

1.3.9 Contact Timers

The contact timers have three input command formats.

Format	Use
TIMEP	To program the timer
TIMER	To read the data taken by the timers
TIMEC	To control the contact timers

CALL FORMAT = TIMEP (CHANNEL, STATE, ACTION, TYPE, TEST)

The integer value placed in CHANNEL is the channel number (from 1 to 8) of the contact timer being programmed. The integer value placed in STATE depicts the initial or present status of the test relay contact. A zero placed in STATE indicates an initial status of open, and one indicates an initial status of closed. This does not mean the normal status of the test relay contact, but rather the start of time-test state.

The integer value placed in ACTION depicts the action occurring on the coil of the test relay during the time test. A zero is placed in ACTION when the coil is deenergized or a latching relay's reset coil is pulsed. A one is placed in ACTION when the test relay is operated or a latching relay is set.

The integer number placed in TYPE depicts the type of coils of the test relay. A zero placed in TYPE indicates a standard relay and a one placed in TYPE indicates a latching relay.

The integer number placed in TEST indicates the type of test to be performed. A zero placed in TEST programs the measurement of bounce time. Bounce time is the time from the first contact indication to the last contact indication of the state opposite to the state declared as initial. A one placed in TEST programs the measurement of operate time. Operate time is defined as the time from operation of the test relay coil until the last contact state opposite to the state declared as initial.

Any out-range inputs to the TIMEP format produces an ERR value of 501.

CALL FORMAT = TIMER (CHANNEL, DATA, BAD)

The integer value placed in CHANNEL is the channel number (from 1 to 8) of the contact timer being read.

The value of the simple variable returned in BAD depicts the quality of the test data as shown below.

BAD Value	Meaning
-1	Timer failure
0	Good test and data
1	No test start detected
2	No test stop detected
3	Neither start nor stop detected
4	Timer overflow
5	No test programmed

An out-of-range command to the TIMER format produces an ERR value of 502.

CALL FORMAT = TIMEC (FUNCTION)

The integer value placed in FUNCTION controls all of the contact timers.

A FUNCTION value of -1 presets the contact timers and blanks all of the data displays.

A FUNCTION value of 0 resets all of the contact timer internal clocks and flags.

A FUNCTION value of 1 sends all of the commands set up with the TIMEP format to the contact timers. All channels to be used should be programmed with the TIMEP format before the function of one is requested.

A FUNCTION value of 2 will get the test data from the contact timer memory to be accessed by the TIMER format. If the FUNCTION value of 2 is commanded and no test has been run, an ERR value of 504 is set. The FUNCTION value of 2 must be used before calling the TIMER format to update the TIMER program.

A FUNCTIONS value of 3 starts the 880-ms time out of the contact timers and enables the contact timers to begin a test measurement. The TIMEC function of 3 will immediately return to the programmer to allow calling and EMATF function to operate the test relay.

A FUNCTION value of 4 is used to wait for the completion of a contact timer measurement. When the FUNCTION of 4 is called, the operating program is suspended until the contact timer hardware has completed test relay contact time data measurement. If a FUNCTION of 4 is requested and a FUNCTION of 3 has not been previously requested, an ERR value of 505 is set.

An out-of-range function request causes an ERR value of 503 to be set.

The recommended programming sequence for the contact timers is as follows.

Step	Format and Request
1	TIMEC(0) RESET TIMERS
2	TIMEP PROGRAM TIMERS
3	TIMEC(1) SEND PROGRAMMING COMMANDS
4	TIMEC(3) START TEST
5	EMATF OPERATE TEST RELAY
6	TIMEC(4) COMPLETE TEST
7	TIMEC(2) GET TEST DATA
8	TIMER READ TEST DATA

4.3.10 Auxiliary Time Base

CALL FORMAT = CLOCK (NUMBER OF SECONDS)

The integer value placed in NUMBER OF SECONDS is the elapsed time between the programming of the auxiliary time base and the activation of TRAP-6. If the integer is zero or less than zero, a pending TRAP is cancelled and the interrupt is disabled.

4.4 Executive Extensions

The executive extensions are special programs or files used in the operating system execution of the functional relay tester. This section describes the various extensions and explains their use.

4.4.1 FR.ED

FR.ED is a special program that is scheduled by any driver to pass a TRAP interrupt to the BASIC interpreter. When FR.ED is run, it determines the program that scheduled its execution, retrieves the TRAP number, and places it in the execution sequence processor of the BASIC interpreter.

4.4.2 BR.BA

BR.BA is a special program that stops execution of the BASIC interpreter and places BASIC in the command input mode.

4.4.3 CL.TM

CL.TM is a special program that presets the contact timer hardware when the functional relay tester is powered up.

4.4.4 REMEM

REMEM is a special program that increments the display register of the main computer in accordance with the level of activity. When the main computer is fully applied (as during coil operate current measurement), the main computer display register freezes.

4.4.5 %&6940

%&6940 is a special relocatable file that is used during RTE4B system generation to correct a bug in the HP software.

4.4.6 %DVA71

%DVA71 is a dummy driver that controls the CHESS relay life tester through the KIWI interface.

4.5 Special Files

The special files are all stored on the system disc and are ASC-II.

4.5.1 BCALLS

The BCALLS file lists all the device-oriented subroutine or calling-program calling sequences.

4.5.2 HCALLS

The HCALLS file lists all the test-function-oriented, system-subroutine calling sequences.

4.5.3 ERRORS

The ERRORS file lists all the ERR values and their meanings. The system subroutines may call several of the device subroutines, and some errors can be difficult to trace. The ERRORS file contains an origin of error table to simplify error removal.

4.6 System Subroutines

The system subroutines are high-level calling programs that are oriented to relay test functions. These subroutines may call several devices, one or more times in the execution of a relay test, and are the normal method of conducting testing. This section outlines the calling sequence for each system subroutine and explains the action of the hardware devices. Command or execution errors are explained with each subroutine capable of producing them. All of these subroutines have a variable-length calling sequence wherein a default value is used if a parameter is not specified.

All legal parameters are define with each system subroutine, and any out-of-range request is rejected. The ERR values are shown below.

Subroutine	ERR Value
SETUP	600
CHAN	601
COILR	602
CLRCL	603
CLROP	604
HPTDE	605
HPTEN	606
STATE	607
OPER1	608
OPNCL	609
TIMES	610

4.6.1 SETUP

The SETUP subroutine is used to define and contain parameters for the other system subroutines required during a relay test. These parameters, such as the number or form of test relay contacts, must be defined before the system subroutine that uses them may be called, or an error will result. The SETUP subroutine also enables the front panel PANIC switch and prevents overlaying of the operating system subroutine area by new copies of the system subroutines. When a relay test program is modified or written, the SETUP subroutine must be the first system subroutine called.

CALL FORMAT = SETUP (ARMS, FORM, CONT, COIL, TYPE, VOLTS)

The integer number placed in ARMS is the number of contact poles of the relay under test. This number may be from 1 to 4, and the default value is 2.

The integer number placed in FORM depicts the contact configuration of the relay under test:

Integer	Relay Contact Configuration
1	Normally open contacts only
2	Normally closed contacts only
3	Both normally open and normally closed contacts

The default value used is 3 or form C. The integer number placed in CONT controls which poles of the relay under test define the state of the relay as shown below.

CONT Value	Poles Used
1	A
2	B
3	A and B
4	C
5	A and C
6	B and C
7	A and B and C
8	D
9	A and D
10	B and D
11	A and B and D
12	C and D
13	A and C and D
14	B and C and D
15	A and B and C and D

The CONT value can be changed to delete a nonfunctioning test relay pole and the default value is 1 A only.

The integer number placed in COIL defines the number of coils incorporated in the relay under test. The number may range from 1 to 4, and a default value of 1 is used.

The integer number placed in TYPE tells the functional relay tester if the test relay is of standard or latching coil configuration. If a standard relay is to be tested, enter 1. For a latching type of test relay, enter 2. The default value used is 1 or standard.

The floating point number placed in VOLTS commands the value of the coil voltage used to operate the test relay. The default voltage is 24.

4.6.2 CHAN

CALL FORMAT = CHAN (CHANNEL NUMBER)

The integer constant or simple variable placed in CHANNEL NUMBER controls test relay input channel number and the CHESS tester input. A zero turns off all channels and clears the contact timers. Numbers from 1 to 16 call in the respective test channels, and an input value of 17 activates the CHESS tester input port.

4.6.3 COILR

This system subroutine measures the coil resistance of the relay under test.

CALL FORMAT = COILR (DATA, BAD, I, E)

The coil resistance values in ohms, are returned in the array data. The array DATA must be dimensioned and has a maximum length of four locations, depending on the number of test relay coils. The array element specified in DATA is used as the first location for the values returned as shown below.

Number of Coils	Array Element			
	1	2	3	4
1	Set	-	-	-
2	Reset	Set	-	-
4	Reset 1	Reset 2	Set 1	Set 2

The numeric values returned in the array BAD relate to the same array elements in DATA, and these values are defined below.

Value	Definition
-2	Open coil circuit or insufficient coil voltage specified
-1	No response from constant current source
0	DATA value is correct
1	Command error
2	No reading was taken

The value placed in I is the current magnitude in milliamperes used in the coil resistance tests. The default value is 1 mA.

The value placed in E is the maximum allowed coil voltage during a coil resistance test. The default value is 20 V.

4.6.4 CLRCL

This system subroutine measures the resistance of the normally closed contacts of the relay test.

CALL FORMAT = CLRCL (DATA, BAD, I,E)

The normally closed contact resistance values in ohms are returned in the array DATA. The array DATA must have been dimensioned and has a maximum length of four locations, depending on the number of test relay poles. The array element specified in DATA is used as the first location for the resistances returned as shown below.

	Number of Contacts	Array Element			
		1	2	3	4
	1	A	-	-	-
	2	A	B	-	-
	3	A	B	C	-
	4	A	B	C	D

The numeric values returned in the array BAD relate to the same array elements in DATA, and these values are shown below:

Value	Definition
-2	Open contact circuit or insufficient contact voltage specified
-1	No response from constant-current source
0	DATA value is correct
1	Command error
2	No reading was taken

The value placed in I is the current magnitude in milliamperes to be used in the contact resistance tests. The default value is 100 mA.

The value placed in E is the maximum allowed open circuit voltage, and the default value is 5 V.

4.6.5 CLROP

This system subroutine measures the resistance of the normally open contacts of the relay under test. Subroutine STATE must be called before using this subroutine to energize the test relay.

CALL FORMAT = CLROP (DATA, BAD, I, E)

The normally open contact resistance values in ohms, are returned in the array DATA. The array DATA must have been dimensioned and has a maximum length of four locations, depending on the number of test relay poles. The array element specified in DATA is used as the first location for the contact resistance returned as shown below.

	Number of Contacts	Array Element			
		1	2	3	4
	1	A	-	-	-
	2	A	B	-	-
	3	A	B	C	-
	4	A	B	C	D

The numeric values returned in the array BAD relate to the same array elements in DATA, and these values are shown below:

Value	Definition
-2	Open contact circuit or insufficient contact voltage specified
-1	No response from constant-current source
0	DATA value is correct
1	Command error
2	No reading was taken

The value placed in I is the current magnitude in milliamperes to be used in the contact resistance tests. The default value is 100 mA.

The value placed in E is the maximum allowed open-circuit contact voltage, and the default value is 5 V.

4.6.6 HPTDE

This system subroutine measures the hipot resistance of the contacts and coils of the relay under test in the realized or reset state. The resistance readings in megohms, are taken from the element specified to all other elements and the relay case. The test relay arms are tested with their respective normally closed contacts.

CALL FORMAT = HPTDE (DATA, BAD, T,I,E,)

The relaxed, reset, or deenergized test relay state hipot resistance values are returned in the array DATA. The array DATA must have been dimensioned and has a maximum length of 12 locations, depending on the number of test relay poles and coils. The array element specified in DATA is used for the first location of the hipot resistance returned as shown below.

Number of Contacts	Number of Coils	Data Location											
		1	2	3	4	5	6	7	8	9	10	11	12
1	1	CLA	OPA	SET	-	-	-	-	-	-	-	-	-
2	1	CLA	CLB	OPA	OPB	SET	-	-	-	-	-	-	-
3	1	CLA	CLB	CLC	OPA	OBP	OPC	SET	-	-	-	-	-
4	1	CLA	CLB	CLC	CLD	OPA	OPB	OPC	OPD	SET	-	-	-
1	2	CLA	OPA	R	SET	-	-	-	-	-	-	-	-
2	2	CLA	CLB	OPA	OPB	R	SET	-	-	-	-	-	-
3	2	CLA	CLB	CLC	OPA	OPB	OPC	R	SET	-	-	-	-
4	2	CLA	CLB	CLC	CLD	OPA	OPB	OPC	OPD	R	SET	-	-
1	4	CLA	OPA	R1	R2	SET1	SET2	-	-	-	-	-	-
2	4	CLA	CLB	OPA	OPB	R1	R2	S1	S2	-	-	-	-
3	4	CLA	CLB	CLC	OPA	OPB	OPC	R1	R2	S1	S2	-	-
4	4	CLA	CLB	CLC	CLD	OPA	OPB	OPC	OPD	R1	R2	S1	S2

CLA = Normally closed contact A and A arm

OPA = Normally open contact A

SET = Set coil

R = Reset coil

The DATA order is:

- All of the normally closed contacts with their respective arms
- The normally open contacts
- The coils with the reset coils first

The numeric values returned in the array BAD relate to the same array elements in DATA, and these values are shown below:

Value	Definition
-2	Overcurrent trip-out of hipot power supply occurred
-1	No response from hipot programmer
0	DATA value is correct
1	Command error to hipot programmer
2	No reading taken

The value placed in T is the amount of time for applying the hipot voltage before measuring hipot current. This time may be specified from 0.1 to 10 s, and the default time is 0.1 s.

The value placed in I controls the overcurrent trip-off of the hipot power supply as shown below:

I Value	Hipot Maximum Current
0	None allowed
1	700 μ A
2	70 mA "Caution"

The default value is 1 (700 μ A maximum)

The value placed in E is the hipot-voltage to be used, the default value is 500 V, and the maximum allowed is 510 V.

4.6.7 HPTEN

This system subroutine measures the hipot resistance of the contacts of the relay under test in the activated or set state. The resistance measurement readings in megohms, are taken from the relay element specified to all other elements and the relay case. The test relay arms are connected to, and measured with, the normally open contacts.

CALL FORMAT = HPTEN (DATA, BAD, T,I,E)

The activated, set, or energized test relay state hipot resistance values are returned in the array DATA. The array DATA must have been dimensioned and has a maximum length of 8 locations, depending on the number of test relay poles. The array element specified in DATA is used for the first location of the hipot resistances returned as shown below.

Number of Contacts	Data Location							
	1	2	3	4	5	6	7	8
1	CLA	OPA		-	-	-	-	-
2	CLA	CLB	OPA	OPB	-	-	-	-
3	CLA	CLB	CLC	OPA	OPB	OPC	-	-
4	CLA	CLB	CLC	CLD	OPA	OPB	OPC	OPD

CLA = Normally closed contacts A

OPA = Normally open contacts A and A arm

The information order DATA is:

- All of the normally closed contacts
- All of the normally open contacts with their respective arms

The numeric values returned in the array BAD relate to the same array elements in DATA, and these values are shown below.

Value	Definition
-2	Overcurrent trip-off of hipot power supply occurred
-1	No response from hipot programmer
0	DATA value is correct
1	Command error to hipot programmer
2	No reading taken

The value placed in T is the amount of time for applying the hipot voltage before measuring hipot current. This time may be specified from 0.1 to 10 s and the default time delay is 0.1 s.

The value placed in I controls the overcurrent trip-off current of the hipot power supply as shown below.

I Value	Hipot Maximum Current
0	None allowed
1	700 mA
2	70 mA "Caution"

The default value is 1 (700 μ A maximum).

The value placed in E defines the hipot voltage to be used; the default value is 500 V, and the maximum allowed is 510 V.

4.6.8 STATE

This system subroutine powers the coils of the relay under test. The call to this subroutine may exit with the test relay set or reset, and the coil of the test relay powered or nonpowered. Unless the pulse mode of output is used, a power coil command to STATE leaves the coil of the test relay energized indefinitely.

CALL FORMAT = STATE (ACTION, VOLTAGE)

The integer value placed in ACTION and the result are shown below.

Action Value	Result
0	All coils are turned off
1	Power Reset Coil 1
2	Power Reset Coil 2
3	Power Set Coil 1
4	Power Set Coil 2
5	Power Reset Coils 1 and 2
6	Power Set Coils 1 and 2

To use a 10-ms pulse of power on any of the above ACTION commands, add 10 to the ACTION command.

VOLTAGE is the coil voltage used in this command. The default value is the voltage specified in the SETUP system subroutine.

The 2-V drop of the electronic matrix hardware is accounted for within this subroutine, and the specified voltage is that which is applied to the relay under test.

4.6.9 OPERI

This system subroutine measures the pull-in and drop-out coil currents of a standard test relay, or the latch and reset currents of a latching type test relay. This subroutine may be called with the test relay in any state. After this subroutine completes, the test relay is in the relaxed or reset state.

CALL FORMAT = OPERI (DATA, BAD, TIME, I, E)

The coil-operate currents in milliamperes, are returned in the array DATA. The array DATA must have been dimensioned and has a maximum length of four locations, depending on the number of test relay coils. The array element specified in DATA is used for the first location of the current measurements as shown below.

Number of Coils	Data Location			
	1	2	3	4
1	OPERATE	RELEASE	-	-
2	RESET	LATCH	-	-
4	RESET-1	RESET-2	LATCH-1	LATCH-2

The numeric values returned in the array BAD relate to the same array elements in the array DATA, and these values are shown below:

Value	Definition
-2	Insufficient coil voltage allowed or no closure
-1	No response from constant current source
0	DATA value is correct
1	Command error to constant current source
2	No reading taken
3	Maximum coil current cut-off, 100 mA

The integer value placed in TIME is used as an extra pause time at each value of coil current programmed. The time normally spent at each value of coil current programmed to check for relay operation is 20 ms. The additional TIME value from 1 to 100 ms is also delayed. The default value is 1 ms.

The value placed in I is added to the existing coil current at each step and becomes the new programmed test relay coil current. During standard relay test drop-out current measurement, this value is subtracted from the existing programmed coil current. The coil current step size may be specified from 10 μ A to 10 mA, and the default I value is 0.1 mA.

The value placed in E is the test stop maximum coil voltage. The OPERI test terminates if this value of coil voltage occurs.

The system subroutine OPERI resets the relay under test and sets the current source to zero. Then use of the current step size commanded in I increments the test relay coil current by I every T plus 20 ms, or until 100 mA is reached. The coil current of the test relay is then reprogrammed to 150% of the value at which activation occurred. The test relay coil current is then lowered by I every T plus 20 ms until relay deactivation occurs. For tests of a latching relay, only the increasing current mode is used on the various coils.

If the test relay coil voltage equals the value placed in E or the coil current exceeds 100 mA, the subroutine is terminated and the ERR location is set to 1000. The ERR location will also be set to 2000 if the coil current of a standard relay reaches zero and a drop-out has not been detected.

4.6.10 TIMES

This subroutine measures the operate, bounce, release, and release bounce times test relay contacts. The time measurement readings are in microseconds to an accuracy of $\pm 0.2 \mu$ s.

The definitions of the test relay times are explained in Section 3.6.

When a three- or four-pole relay is tested, the A&B poles are measured and on a second coil sequence the C&D poles are measured.

CALL FORMAT = TIMES (DATA, BAD, VOLTS)

The contact activation time measurements are returned in the array DATA. The array DATA must have been dimensioned and has a maximum length of 32 locations, depending on the number and form of the relay poles. The array element specified in DATA is used for the first location of the contact time measurement returned as shown below.

Form A Relay

Data Location	1 Pole	2 Poles	3 Poles	4 Poles
1	NO-OP	ANO-OP	ANO-OP	ANO-OP
2	NO-BO	ANO-BO	ANO-BO	ANO-BO
3	NO-RE	ANO-RE	ANO-RE	ANO-RE
4	NO-RB	ANO-RB	ANO-RB	ANO-RB
5	-	BNO-OP	BNO-OP	BNO-BO
6	-	BNO-BO	BNO-BO	BNO-BO
7	-	BNO-RE	BNO-RE	BNO-RE
8	-	BNO-RB	BNO-RB	BNO-RB
9	-	-	CNO-OP	CNO-OP
10	-	-	CNO-BO	CNO-BO
11	-	-	CNO-RB	CNO-RB
12	-	-	VNO-TB	CNO-RB
13	-	-	-	DNO-OP
14	-	-	-	DNO-BO
15	-	-	-	DNO-RE
16	-	-	-	DNO-RB

Form C Relay

1	ANO-OP	ANO-OP	ANO-OP	ANO-OP
2	ANO-BO	ANO-BO	ANO-BO	ANO-BO
3	ANO-RE	ANO-RE	ANO-RE	ANO-RE
4	ANO-RB	ANO-RB	ANO-RB	ANO-RB
5	ANC-OP	ANC-OP	ANC-OP	ANC-OP
6	ANC-BO	ANC-BO	ANC-BO	ANC-BO
7	ANC-RE	ANC-RE	ANC-RB	ANC-RB
8	ANC-RB	ANC-RB	ANC-RB	ANC-RB
9	-	BNO-OP	BNO-OP	BNO-OP
10	-	BNO-BO	BNO-BO	BNO-BO
11	-	BNO-RE	BNO-RE	BNO-RE
12	-	BNO-RB	BNO-RB	BNO-RB
13	-	BNC-OP	BNC-OP	BNC-OP
14	-	BNC-BO	BNO-BO	BNC-BO
15	-	BNC-RE	BNC-RE	BNC-RE
16	-	BNC-RB	BNC-RB	BNC-RB
17	-	-	CNO-OP	CNO-OP
18	-	-	CNO-OP	CNO-OP
19	-	-	CNO-RE	CNO-RE
20	-	-	CNO-RB	CNO-RB
21	-	-	CNC-OP	CNC-OP
22	-	-	CNC-BO	CNC-BO
23	-	-	CNC-RE	CNC-RE
24	-	-	CNC-RB	CNC-RB
25	-	-	-	DNO-OP
26	-	-	-	DNO-BO
27	-	-	-	DNO-RE

28	-	-	-	DNO-RB
29	-	-	-	DNC-OP
30	-	-	-	DNC-BO
31	-	-	-	DNC-RE
32	-	-	-	DNC-RB

The order of time measurements in the array DATA is by:

- a. Test relay pole
- b. Open contact data or closed contact data
- c. Operate time (OP), bounce time (BO), release time (RE), and release bounce time (RB)

Operate and bounce time are measured when the test relay contacts close, regardless of normal state; release and release bounce time are measured when the test relay contacts break.

The numeric values returned in the array BAD relate to the same array elements in DATA, and these values are shown below.

Value	Definition
-2	Constant voltage power supply current overload
-1	No response from constant voltage source
0	DATA value is correct
1	No timer start
2	No timer stop
3	Neither timer start nor stop
4	Bad data

The value placed in VOLTS is the test relay coil voltage to be used. The default voltage is the voltage specified in the SETUP system subroutine.

4.6.11 OPNCL

The system subroutine OPNCL determines the state of a latching relay.

CALL FORMAT = OPNCL (CLOSED, OPEN, ARM)

The value returned in CLOSED is zero if the normally closed contact is open, and one if the normally closed contact is closed. The value returned in OPEN is zero if the normally open contact is open, and one if the normally open contact is closed.

The integer value placed in ARM is the number of the test relay arm to be evaluated, from 1 to 4.

4.6.12 CLRCA

The CLRCA system subroutine verifies the calibration of the constant current source and ensures the accuracy of coil resistance, contact resistance, and test relay coil operate current measurements. The constant-current source is programmed with 10 current magnitudes, chosen so as to require the significant programming bits to be both on and off. This subroutine requires a calibrated 10- Ω standard resistor that must be installed at the standard terminals of the test matrix.

CALL FORMAT = CLRCA (PASS, ACTUAL)

The value returned in PASS equals zero if all current readings are within $0.1\% \pm 0.01$ mA.

The value returned in PASS equals one if one or more current measurements are out of tolerance. The currents programmed in the test are: 1.0, 1.3, 2.2, 4.1, 8.2, 10, 21, 41, 82, and 100 mA. Actual currents measured are returned in the array ACTUAL. The array ACTUAL must have been dimensioned and has a length of 10 locations, one for each programmed current value. The array element specified in ACTUAL is used to store the first current measurement.

6.13 HPTCA

The HPTCA system subroutine verifies the calibration of the hipot system and ensures the accuracy of hipot measurements. The hipot supply is programmed with the specified voltage. The output voltage of the hipot supply and the current through the standard resistor are then measured and checked. This subroutine requires a calibrated 100-M Ω standard resistor that must be installed in the hipot programmer.

CALL FORMAT = HPTCA (PASS, DELAY, E, ACTUAL)

The numeric value returned in PASS is shown below.

Value	Definition
-2	Hipot supply had an overcurrent trip off
-1	All measurements are within 2% accuracy
0	Measured current is within 2% accuracy for measured voltage
1	Measured current is out of tolerance

The value placed in DELAY is the amount of time for applying hipot voltage to the standard resistor before measuring the hipot current. This time may be specified from 0.1 to 10 s, and the default time delay is 0.1 s.

The value placed in E defines the hipot voltage to be programmed and measured. The default voltage is 500 V, and a maximum of 510 V is allowed.

The results of measurements made during hipot calibration are returned in the array ACTUAL. The array ACTUAL must have been dimensioned and has a length of three locations, one for each measurement. The array element specified in ACTUAL is used to store the first hipot calibration measurement. The array definition and values returned are shown below.

Array, Actual Location	Data
1	OPEN CIRCUIT HIPOT SUPPLY VOLTAGE
2	VOLTAGE IMPRESSED ACROSS STANDARD
3	CURRENT THROUGH STANDARD

4.7 Operating System

The operating system of the functional relay tester is HPRTE4B with the addition of special assembly-level Sandia software. All HP-RTE features are incorporated, and HP DS1000 was included to permit the direct transfer of relay test data to other Sandia computers.

4.7.1 TRY8AN

TRY8AN is the answer file used to generate the functional relay tester operating system. It is stored on the disc drive along with all the other software.

4.7.2 &TRY8

&TRY8 is the generation listing file of the functional relay tester operating system produced during the operating system generation.

4.7.3 BMTAB2

BMTAB2 is a disc file containing the source commands to generate the BASIC interpreter overlay. The overlay contains all information necessary for the BASIC interpreter to execute device and system subroutines.

4.7.4 T2

T2 is a BASIC command file used to load the functional relay tester branch and mnemonic tables. These tables contain the links between BASIC and the overlay. T2 is used in the BASIC interpreter run command as RU,BASIC, T2.

4.8 Test Programs

The test programs provided as part of the functional relay tester are written in BASIC. They will handle ~99% of all relay testing and are especially targeted toward the casual user. No knowledge of the functional relay tester except as given in the step-by-step general operation Section 5.1 of this manual as required.

4.8.1 TEST

The general relay test BASIC program TEST can measure functional relay data on any of any type of relay. This program leads the user by the hand through all test relay description and initialization phases. Relay test data are output to the tester terminal and stored in a permanent disc file. The TEST program may be easily modified to customize it for a specific relay or application.

4.8.2 DATA

The general relay test BASIC program DATA can output functional relay test data. This program outputs the data contained in the permanent relay test disc file to the line printer. It also calculates test relay transfer times and outputs them. The DATA program may be easily modified to customize it for a specific number of relays or number of test data files.

5. Operating Instructions

The functional relay operation monitor is intended for operation or programming from one of three levels. The first level merely involves connecting the relay to be tested and following a step-by-step procedure through data printout. The second level entails the use of device and system subroutines to generate a specific relay test program in the BASIC language. The third level programmer uses assembly language calls to the device drivers and BASIC or FORTRAN language control to test almost any device.

5.1 General Test Program, Step By Step

This section is intended for use by someone who is unfamiliar with the functional relay tester, computers, or computer programming. The steps are rigid, and following them exactly produces good data for the test relays.

Step

- 1 Find the tester. Hint: use the picture that is the frontispiece.
- 2 Verify the proper "on" state of the tester. The main power switch at the top of the machine between the first and second equipment bays should be up or on. Also be sure the two switches on the hipot power supply at the lower right of the tester are up or on.
- 3 If the disc-ready lamp on the disc drive is on, or comes on following 1 min after turning the tester on, skip Step 4.
- 4 A disc platter must be inserted in the disc drive. Any HP7906-type disc will do. After inserting a disc platter, turn the disc-drive switch to RUN or up. Be sure the door is fully closed.
- 5 If the computer front panel lamps are counting, skip Step 6.
- 6 Rotate the key switch on the computer front panel as far counterclockwise as possible. Then place the key switch in the "operate" position. Depress the right-hand side of the only horizontally mounted computer button twice, or until the lamp labeled "S" illuminates. Depress the computer button labeled CLEAR DISPLAY. Press the top portion of computer buttons 14, 12, 9, 8, 7, 6, and 1. The lamps above the switches confirm that octal 051702 is entered.
Press STORE
Press PRESET
Press IBL
Press RUN
Wait about 2 minutes, and the terminal then prints an initialization message.
- 7 Press the space bar on the terminal and note what is printed. If nothing, press carriage return and skip the rest of this step. The message PLEASE LOG ON should have been printed, and must be answered with: RELAY.GENERAL/NONE--that is, relay, period, general, slash, none, and carriage return.
- 8 A colon should now appear on the terminal. Type RU,BASIC, T2--that is, RU, comma, BASIC, comma, T2, and carriage return.
- 9 The terminal will say BASIC READY. Type LOAD TEST.
- 10 Type "CREATE@@@@@,N" where the six characters following the word CREATE will be the name of the data file for this test. If the file already exists, you will be informed. To recover, input CREATE again, with a different six characters. Remember the file name; it will be asked for. The value to be placed at N is the number of relays to be tested plus one.
- 11 Type RUN TEST, and the TEST program requests the file name, file header, and test relay parameters. The file header is merely one line in which any identifying statements may be made.
The relay test is run after all questions are answered.
NOTE: Pressing the control key and the letter "Q" in response to any question causes a return to the start of Step 11. Turning on the PANIC switch also results in a return to the start of Step 11. Be sure to turn the PANIC switch off after BASIC READY is printed. When the tester has measured all the relays connected to it, the terminal asks if more testing is to be done. When the answer is no, the program TEST terminates and data reduction may begin.
- 12 After BASIC READY is printed, type RUN DATA. The data reduction program requests the file name given in Step 10 and begins printing the test data on the line printer.

5.2 Specific Test Program Development

A specific relay test program may be developed by loading and modifying the general relay testing program, or by starting anew. The system subroutine section of this manual describes all the relay testing software. The BASIC command SAVE followed by a file name will make a permanent copy of the developed program on the disc drive.

5.3 Custom Test Program Development

All of the device and system subroutines are both assembly language and FORTRAN-callable. A special test program for any device may be developed through the use of these subroutines or direct call to the device drivers. Most of the subroutines have an error return exit. This exit will place a decimal number in the BASIC interpreter INTERNAL named ERRCD. To check for subroutine errors, the assembly language programmer must declare the EXTERNAL ERRCD, clear it, and check it. The FORTRAN programmer must write a function to interrogate and clear the EXTERNAL ERRCD if subroutine errors are to be recognized or logged.

6. Calibration

The calibrations of all test measurements made by the functional relay tester are traceable to the National Bureau of Standards. This section describes the procedure necessary to keep all measurements in certification. The functional relay tester derives all test measurements from four standards:

a) The digital voltmeter, b) A 10- Ω resistor, c) A 100-M Ω resistor, and d) A crystal oscillator. The standards should be sent to the Sandia National Laboratories Standards Division for certification every 6 months.

6.1 Digital Voltmeter (DVM)

The DVM must be certified on all ranges to 0.1% or better. The accuracy of the digital voltmeter is reflected in all measurements except that of contact time.

6.2 Constant-Current Supply

The calibration accuracy of the constant-current supply is certified during each test by use of the DVM, the 10- Ω resistor, and the system subroutine CLRCA. Ten currents are programmed, checked for accuracy, and optionally printed. The currents were chosen to provide a worst-case activation of the current supply programming bits as output from the control computer. Certification of the digital voltmeter and current supply ensures the accuracy of coil resistance, contact resistance, and coil operate current test measurements. Both coil and contact resistances are measured by sending a known current through the resistance and measuring the developed voltage. Coil operate current is measured by incrementing the current supply output upward and by using the current value last programmed when the test relay contacts operated.

6.3 Hipot System

The calibration accuracy of the hipot system is certified during each test by use of the DVM, the 100-M Ω resistor, and the system subroutine HPTCA. The same high voltage as that used in the hipot test measurements is programmed and checked by the DVM. If the hipot supply output voltage is incorrect, the programming constant may be adjusted by removing the cap and setting the front panel control on the hipot power supply.

The hipot power supply output voltage is sent to the 100-M Ω standard resistor and the hipot current viewing resistor in series. The current viewing resistor is only 1 k Ω and has not appreciable effect on the flowing current. The voltage developed across the current viewing resistor is measured by the DVM, checked for accuracy, and optionally printed. The current viewing resistor is located in the hipot programmer chassis and maybe adjusted if necessary.

6.4 Contact Timers

All contact time measurements are made by counting the oscillations of a quartz crystal. Two 10-MHz crystal oscillators are supplied along with a test box. One oscillator should be placed in the test box and sent to Standards for certification while the other is in use. The oscillators should be traded every 6 months.

6.5 Constant-Voltage Supply

Calibration of the constant-voltage power supply is necessary to ensure the application of specified coil voltage. However, no measurements are made where constant-voltage power supply is a factor.

To calibrate the constant-voltage supply, use the device subroutine CHECK (3); that is, CHECK with a parameter of three, and read the present voltage supply output on the DVM. Each coil voltage used in testing should be checked by this method every 6 months.

APPENDIX A

System Schematic Drawings

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LOW RUE
To
COMPUTER

LOWER WORD BITS 0-15
UPPER WORD BITS 0-11
BIT FUNCTION
12 - NO START
13 - NO CLOSE
14 - OVERFLOW
15 - TIME OUT

TRI-STATE
BUSS

FLAG &
DATA READY

04, 00, Vcc-14
COM-7

LOW TRUE
FROM
COMPUTER

BIT FUNCTION

1- RESET
ALL CHANNELS

2- L0 - BOUNCE
HL - OPERATE

3- L0 - OPERATE
HL - RELEASE

4- L0 - STU
HL - LATCH

5- RESERVED

6- RESERVED

7- RESERVED

8- CHAN NO.
BIT A

9- CHAN NO.
BIT B

10- CHAN NO.
BIT C

11- L0 - H0 WORD
H - L0 WORD

12- TEST

13- PROGRAM
SYSTEM

14- VALID
COMMAND

15- RETURN
INPUT

STC - START
TIMES

PROGRAM

Vcc

15V A

15V B

15V C

15V D

15V E

15V F

15V G

15V H

15V I

15V J

15V K

15V L

15V M

15V N

15V O

15V P

15V Q

15V R

15V S

15V T

15V U

15V V

15V W

15V X

15V Y

15V Z

HIGH TO PGM
TRUE
LATCH

CHAN 1-4
RESET

CHAN 5-8
RESET

HL - NO
LU - NL

HL - BOUNCED
LU - OPERATE

HL - OPERATE
LU - RELEASE

HL - STU
LU - LATCH

HL - BOUNCED
LU - OPERATE

HL - OPERATE
LU - RELEASE

HL - STU
LU - LATCH

HL - BOUNCED
LU - OPERATE

HL - OPERATE
LU - RELEASE

HL - STU
LU - LATCH

HL - BOUNCED
LU - OPERATE

HL - OPERATE
LU - RELEASE

HL - STU
LU - LATCH

HL - BOUNCED
LU - OPERATE

HL - OPERATE
LU - RELEASE

HL - STU
LU - LATCH

HL - BOUNCED
LU - OPERATE

HL - OPERATE
LU - RELEASE

HL - STU
LU - LATCH

HL - BOUNCED
LU - OPERATE

HL - OPERATE
LU - RELEASE

HL - STU
LU - LATCH

HL - BOUNCED
LU - OPERATE

HL - OPERATE
LU - RELEASE

HL - STU
LU - LATCH

HL - BOUNCED
LU - OPERATE

HL - OPERATE
LU - RELEASE

HL - STU
LU - LATCH

HL - BOUNCED
LU - OPERATE

HL - OPERATE
LU - RELEASE

HL - STU
LU - LATCH

HL - BOUNCED
LU - OPERATE

HL - OPERATE
LU - RELEASE

HL - STU
LU - LATCH

HL - BOUNCED
LU - OPERATE

HL - OPERATE
LU - RELEASE

HL - STU
LU - LATCH

HL - BOUNCED
LU - OPERATE

HL - OPERATE
LU - RELEASE

HL - STU
LU - LATCH

HL - BOUNCED
LU - OPERATE

HL - OPERATE
LU - RELEASE

HL - STU
LU - LATCH

HL - BOUNCED
LU - OPERATE

800 PGM
ON
TO LATCH

15V A

15V B

15V C

15V D

15V E

15V F

15V G

15V H

15V I

15V J

15V K

15V L

15V M

15V N

15V O

15V P

15V Q

15V R

15V S

15V T

15V U

15V V

15V W

15V X

15V Y

15V Z

15V A

15V B

15V C

15V D

15V E

15V F

15V G

15V H

15V I

15V J

15V K

15V L

15V M

15V N

15V O

15V P

15V Q

15V R

15V S

15V T

TRI-STATE
CONTROL

15-7400
1-74500
7-7404
1-7410
7-74LS90
2-74154

15V A

15V B

15V C

15V D

15V E

15V F

15V G

15V H

15V I

15V J

15V K

15V L

15V M

15V N

15V O

15V P

15V Q

15V R

15V S

15V T

15V U

15V V

15V W

15V X

15V Y

15V Z

15V A

15V B

15V C

15V D

15V E

15V F

15V G

15V H

15V I

15V J

15V K

15V L

15V M

15V N

15V O

15V P

15V Q

15V R

15V T

INTERFACE
HP - GNU TRUE

DATE		
ONE CLASSIFICATION LEVEL		
FUNCTIONAL RELAY TESTER		
SIZE	CODE IDENT NO	ONE NUMBER
C	FRG 29	CONTACT TIME
SCALE		COMPUTER LINK
		SHEET
		OF

CD - TEST RELAY COIL DRIVER

ICD - INTERNAL COIL DRIVER

M - CONTACT MONITOR

NAME		DATE CLASSIFICATION LEVEL	
FUNCTIONAL RELAY TESTER			
ITEM	CODE IDENT NO	DATE NUMBER	REVISION
C	FRG-79		
ELECTRONIC MATRIX		CONTACT CONTROL	
SCALE	SHEET		

COMPUTER CONNECTOR

GND TRUE CARD - P100A-16-285

- A - BIT 0 MONITOR "A"
- B - BIT 1 MONITOR "B"
- C - BIT 2 MONITOR "C"
- D - BIT 3 MONITOR "D"
- E - BIT 4 LO MAKE
- F - BIT 5 LO N CLOSED
- H - BIT 6 USE COIL R1
- J - BIT 7 USE COIL R2
- K - BIT 8 USE COIL S1
- L - BIT 9 USE COIL S2
- M - BIT 10 LOW USE FUSE
- N - BIT 11 TIMERS CLOSED
- P - BIT 12 TIMERS OPEN
- R - BIT 13 TIMERS AQB
- S - BIT 14 TIMERS C&D
- T - BIT 15 COILS ON
- Z - STC ENABLE INTERRUPT
- 1 - BIT 0 FLAG TRUE
- 2 - BIT 1 No A CLOSED
- 3 - BIT 2 No A CLOSED
- 4 - BIT 3 No B CLOSED
- 5 - BIT 4 No B CLOSED
- 6 - BIT 5 No C CLOSED
- 7 - BIT 6 No C CLOSED
- 8 - BIT 7 No D CLOSED
- 9 - BIT 8 No D CLOSED
- 23 - FLAG STATUS TRUE
- 24 - COMMON

82a INPUT CONNECTOR AN 3102-28-21S

CONTACT FORM FUNCTION

FIRST CLOSED VOLTAGE
FIRST CLOSED CURRENT
FIRST ARM VOLTAGE
FIRST ARM CURRENT
FIRST OPEN VOLTAGE
FIRST OPEN CURRENT
RESET COIL 1 POSITIVE
RESET COIL 1 NEGATIVE
SECOND CLOSED VOLTAGE
SECOND CLOSED CURRENT
SECOND ARM VOLTAGE
SECOND ARM CURRENT
SECOND OPEN VOLTAGE
SECOND OPEN CURRENT
SET COIL 1 POSITIVE
SET COIL 1 NEGATIVE
THIRD CLOSED VOLTAGE
THIRD CLOSED CURRENT
THIRD ARM VOLTAGE
THIRD ARM CURRENT
THIRD OPEN VOLTAGE
THIRD OPEN CURRENT
RESET COIL 2 POSITIVE
RESET COIL 2 NEGATIVE
FOURTH CLOSED VOLTAGE
FOURTH CLOSED CURRENT
FOURTH ARM VOLTAGE
FOURTH ARM CURRENT
FOURTH OPEN VOLTAGE
FOURTH OPEN CURRENT
SET COIL 2 POSITIVE
SET COIL 2 NEGATIVE
LOOP SOURCE
LOOP DRAIN
LOOP DRAIN
COMMON

RUSS TO ALL CHANNELS AND OUTPUT CONNECTOR

COMPUTER & CHANNELS CONNECTOR

PTDCA 16 16 PGS

1. RELAY CARD

ONLY ONE SET OF RELAYS FOR
ONE CHANNEL IS SHOWN (GAL CIRCUITS
ALL DIODES 1 AMP 50 VOLT

THE FIRST PART OF THE
CIRCUIT IS SHOWN IN THE
CIRCUIT

KA THROUGH KH RELAY BOARD 26V SW-211889
1. RELAY BOARD 211889-1 N-179324

THIS CLASSIFICATION LEVEL	
1. INITIAL RELAY TESTER	
SIZE CODE IDENTIFY NO	QOS NUMBER
C 16-79	INPUT MATRIX
SCALE	SHEET OF

RELAY CARD

COMPUTER
CONNECTOR
ATDCA-14-18'S

A BIT 0 +5 VOLT
B BIT 1 1 VOLT
C BIT 2 2 VOLTS
D BIT 3 4 VOLTS
E BIT 4 8 VOLTS
F BIT 5 16 VOLTS
H BIT 6 32 VOLTS
J BIT 7 64 VOLTS
K BIT 8 128 VOLTS
L BIT 9 256 VOLTS
M BIT 10 CALIBRATE
N BIT 11 NOT USED
P BIT 12 OUTPUT ON
R BIT 13 HI-I RANGE
S BIT 14 RESET
T BIT 15 CHASS ON
V FLAG ATTENTION
1 THRU 18 +24

JONES STRIP

HIPOUT OUT + TO TMAT
HIPOUT OUT - TO TMAT
HIPOUT SUPPLY +
HIPOUT SUPPLY -
HIPOUT SUPPLY PROGRAM
HIPOUT SUPPLY PROGRAM
E OUT + TO TMAT
E OUT - TO TMAT
I OUT + TO TMAT
I OUT - TO TMAT
+24 FROM SUPPLY
SYSTEM COMMON

TMAT = TEST MATRIX

UNMARKED DIODES
1 AMP 50 VOLT

TESTER CHASSIS

ISSUE		CLASSIFICATION LEVEL	
FUNCTIONAL RELAY TESTER			
SIZE	CODE IDENT NO	DATE NUMBER	
C	FBS-79	HIPOUT PROGRAMMER	
SCALE	SHEET		OF

RELAY
CARD

COMPUTER
CONNECTOR
PTODA 16-26S

DVM & PWR PROG
DECODERS

DVM CONTROL

BUSSES

A BIT 0 POSITION "1"
B BIT 1 POSITION "2"
C BIT 2 POSITION "4"
D BIT 3 POSITION "8"
E BIT 4 TYPE "1"
F BIT 5 TYPE "2"
H BIT 6 TYPE "4"
J BIT 7 REMOVE CLR SHUNT
K BIT 8 DVM FUNC "1"
L BIT 9 DVM FUNC "2"
M BIT 10 DVM FUNC "4"
N BIT 11 DVM FUNC "8"
P BIT 12 PWR PROG "1"
R BIT 13 PWR PROG "2"
S BIT 14 PWR PROG "4"
T BIT 15 VALID DATA
V FLAG CLR READY
18424 COM
1 THRU 17 +24
U STC INTERRUPT ON

A
B
C
D
E
F
G
H
J
K
L
M
N
P
R
S
T
U
X
Z

JONES
STRIP

HIPOT IN + FROM HPROG
HIPOT IN - FROM HPROG
HIPOT E+ FROM HPROG
HIPOT E- FROM HPROG
HIPOT I+ FROM HPROG
HIPOT I- FROM HPROG
CV+ VOLTAGE SUPPLY
CV- VOLTAGE SUPPLY
CC+ CURRENT SUPPLY
CC- CURRENT SUPPLY
DVM+ TO DVM
DVM- TO DVM

HPROG = HIPOT PROGRAMMER

ISSUE		CLASSIFICATION LEVEL	
UNIT NAME		POLA, TESTER	
SERIAL	CODE IDENT NO	DWG NUMBER	TEST MATRIX
FRG-77			MEASUREMENT
SCALE	SHEET OF

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