CHECKSUM

**Model TR-6
Functional Test System
Visual MDA Manual Supplement**

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Limited Warranty

CheckSum, Inc. products, exclusive of fixturing products, are covered by a one-year limited parts and labor warranty for defects in materials and workmanship from time of original product shipment. Fixturing products (Model TR-3/TR-5/TR-7/TR-9 series and Model GS-850) include a 90-day limited warranty. This warranty extends only to the original purchaser and excludes products or parts that have been subject to misuse, neglect, accident, or abnormal conditions of operations.

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2. Pack the product in its original packing material or suitable equivalent and return it postage-paid to CheckSum, Inc.. Mark the package clearly with the RMA number.

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In the event that expedited repair is necessary, call CheckSum for information. In many cases a replacement module can be provided immediately.

Getting Started

Model TR-6 Documentation Overview

This instruction manual is for use with the CheckSum Model TR-6 Functional Test Electronics used with Visual MDA Software. The Model TR-6 is designed to by used in conjunction with CheckSum Manufacturing Defects Analyzer (MDA) test systems, such as the Model TR-8 MDA System. In some cases it can be used as a stand-alone capability, however, it has been designed to provide the widest range of capabilities by sharing some of the MDA switching and measurement functions in an integrated environment.

This Manual is used in conjunction with the MDA Manual, such as the Model TR-8 MDA Instruction Manual. This manual describes unique installation and use of the Model TR-6. Once you have read this manual to obtain an orientation of the Model TR-6, the MDA manual can be used as a reference. It includes the specifics of the TR-6 Test Types that you will be using as you program the TR-6.

This manual also includes information about several CheckSum options that are used for power-up testing. For example, the Model RM-1 relay module, Model GPIB IEEE-488 interface, and Model G-80 digital I/O module.

Note

This manual refers to MDA systems such as the CheckSum Model TR-4 or Model TR-8 test electronics and software. When MDA switching is mentioned, it refers to the 200-point solid-state multiplexer modules, such as the Model TR-4-1 or TR-8-1.

Model TR-6 Hardware Overview

The TR-6 Functional Test System provides the basic tools used for power-up testing of the unit-under-test (UUT). These tools include a DMM, Function Generator, Digital I/O, Counter/Timer, Fused Power Supplies, Undedicated Relays, and high-voltage/high-current switching.

The basic Model TR-6 System is comprised of a single, full-sized module that contains a DMM, Counter/Timer, Function Generator, Digital I/O, sixteen relay test points, fused power outputs, and four undedicated relays.

The Model TR-6-1 Relay MPX Module expands the relay switching of the Model TR-6 in 50-test-point increments. Relay switch points are used when measuring low resistances or when the test points are subject to voltages greater than +/-12 volts (with respect to the PC chassis).

The Model TR-6-2 Fixture Interface allows you to provide special functions near the UUT to help facilitate functional testing. These functions include switching high power to the UUT, buffering and conditioning of signals (e.g. frequency-dividing and redriving an oscillator signal from the UUT), and switching or disconnecting signals near the UUT to reduce capacitive loading or to support special signal cabling requirements.

The Model-GPIB allows a Model TR-6 to use external IEEE-488 instrumentation to supplement testing operations. The software is designed to support the specific GPIB module supplied by CheckSum.

The Model TR-6 Base System provides eight digital I/O bits that can be used for control of external solid-state relays (such as those produced by Opto-22) for input or output, or for LS-TTL or CMOS-compatible logic for purposes of functional testing of the UUT. The Model TR-6 digital I/O can also directly control relays since it consists of open-collector drivers with pull-ups.

The TR-6 also supports output of DC voltages directly to several simultaneous test points (up to 16) through the MDA solid-state test points. These can also be used to supply digital signals.

If additional digital I/O points are needed, 96 more digital bits can be added with an optional CheckSum Model G-80 Digital I/O Module.

Installation

Overview

There are several steps in the installation process. The first step is installation of the MDA and TR-6 Electronics Modules into your PC. The next step is installation of the Visual MDA Software. Finally, connections are made to the UUT via a CheckSum-supplied or your own fixturing system.

First refer to the MDA Manual for the basic installation instructions. The TR-6 hardware is connected between the MDA System Module (e.g., TR-8) and the MDA switching modules (e.g., TR-8-1).

The System, as shipped, is configured so that the software and hardware jumper configurations match for your particular system. Because of this, you normally will not need to change any of the jumpers. However, if you find conflicts with existing hardware in your computer, it may be necessary to change some jumper positions. Also, you may be installing additional hardware not included with your initial system configuration which will require appropriate jumpering. If changes are necessary, the corresponding changes need to be made both on the hardware and in the software. You may wish to change the software configuration first since it will show you the new jumper positions necessary and show the range of addresses used by the module to help prevent conflicts.

Model TR-6 System Module Installation

Once the MDA system module is installed (refer to the MDA instruction manual), the next step of the installation procedure involves installing the Model TR-6 Functional Test System in the PC. The Model TR-6 System Module can be identified by the different colored connector (typically blue) on the back panel.

Step 1.

Make sure the System Module is jumpered properly. The base address jumpers are installed on JP-4 of the TR-6 Module. As shipped from CheckSum, it is set to base address 816-831(330-33F hex) with jumpers on positions 9, 8, 5 and 4.

Step 2.

Plug the Model TR-6 System module into the PC.

Step 3.

Install a screw through the top of the back panel bracket into the PC chassis to hold the Module in place.

Step 4.

Install a 50-pin ribbon cable in the back panel connector. You may have received a unique cable with the hardware that has different colored connectors (e.g. blue) or labeled as TR-6. If this is the case, use this cable for connection.

Model TR-6-1 Relay MPX Module Installation

The next step of the installation procedure involves installing the Model TR-6-1 Relay MPX Module(s) in the PC. The Model TR-6-1 Relay MPX Modules can be identified by observing a single black 50-pin ribbon cable connector on the back panel.

Step 1.

Make sure the Modules are jumpered properly. The base address jumpers are installed on JP-1 of the TR-6-1 Modules. As shipped from CheckSum, the first module (test points 1651-1700) is jumpered to base address 832-847 (340-34F hex) with jumpers on positions 9, 8 and 6.

The second module (test points 1701-1750) is jumpered to base address 848-863 (350-35F) with jumpers on positions JP-1 9, 8, 6 and 4.

The third module (test points 1751-1800) is jumpered to base address 864-879 (360-36F) with jumpers on positions JP-1 9, 8, 6 and 5.

Subsequent modules are jumpered in a similar sequence.

Step 2.

Plug the Model TR-6-1 Relay MPX modules into the PC.

Step 3.

Install a screw through the top of the back panel bracket into the PC chassis to hold the Modules in place.

Step 4.

Install a 50-pin ribbon cable in the back panel connector of each module.

Model G-80 Installation

If you have purchased a CheckSum Model G-80 Digital I/O Module with your System, it is installed just like the MDA System Module. However, the jumper settings are slightly different. Refer to the Model G-80 Instruction Manual for details.

As the default, the System expects the Model G-80 base address to be 512 (jumpers on position 8, 7, 6 and 5) and module select 1 (jumper on module select 1).

Model TR-6-2 Fixture Interface Installation

If you have purchased a CheckSum Model TR-6-2 Fixture Interface, it will be installed external to the PC (most likely inside your test fixture). Refer to its manual for instructions about how to customize this interface and wire it to your System.

Model-GPIB IEEE-488 Interface Installation

If you have purchased a CheckSum Model-GPIB IEEE-488 Interface Module, it is installed in the System using the default settings as per its instruction Manual. As defaults, the MDA expects the following switch settings on the Model-GPIB:

1. Base address 688 (hex 2B0) - (SW-1 switches OFF for address positions A7, A5, A4 and ON for address positions A8, A6). Note that the actual address space used in this configuration is 688 (2B0 hex) to 703 (2BF hex), but for programming purposes, the usable addresses start at 696 (2B8 hex).

2. Wait states 0 (SW-11 switches W1 and W0 = ON).

3. Firmware address segment setting 53248 (hex D000) - (SW-2 A18, A16 = OFF, SW-2 A17, A15, A14 = ON). Other address segment settings (such as hex E000, E400, E800 or EC00) are also accepted as long as the setting does not conflict with address space selection on other cards.

4. Operating Mode Setting "A" (SW-3 "A").

5. DMA Level Setting DACK 3, DRQ 3 (jumper JP-1 on position 3, jumper JP-2 on position 3).

6. Interrupt Level 7 (jumper on JP-3 position 7)

Model RM-1 Installation/Usage

The CheckSum Model RM-1 Relay Module can be installed into a test system to provide undedicated switching of power or signals. It uses one short PC slot and has interconnections via a d-Sub back panel connector. A mating connector is included with the Model RM-1.

The Model RM-1 is jumpered and installed as described in its individual instruction manual. The default base address of 800 801 (320 - 321 hex) does not conflict with standard addressing of other CheckSum hardware.

As defaults, the MDA expects the following switch settings on the Model RM-1:

1. Base address 800 (320 hex). (SW-1 A8 & A5 = OFF - SW-1 A7 & A6 & A4 & A3 & A2 & A1 =   ON)

2. Other jumpers: don't care - the other jumpers on the module are for setting digital input characteristics and are no-care's as far as the system configuration is concerned. You should set them to meet your testing requirements if you are using the module to do digital input.

To program the Model RM-1 using CheckSum MDA Software, the PORTO command is used. Specify a range that matches the base address of the module (e.g., PORTO 800). The high limit represents the byte of information to send to the module. The high limit value is determined by adding the following values. The specified relays are closed and the remaining relays are opened.

Relay to Close	Range Value to Add
Relay 1	1
Relay 2	2
Relay 3	4
Relay 4	8
Relay 5	16
Relay 6	32
Relay 7	64
Relay 8	128

The RM-1 requires about 8 mSec for switch closure. To ensure that the relays are fully closed, you can use a PAUSE command to delay sufficient time for switch closure.

The Model RM-1 also supports digital input. To access the digital input, use the PORTI command using an address one higher than the base address. For example, if you are set to base address 800, use PORTI 801 in order to read back information from the module.

Completing the Hardware Installation

Next, refer back to the MDA system manual for installation of the remaining MPX modules.

As the final step in the hardware installation process, it is necessary to install the internal bus cabling inside the PC between the various test modules.

With the MDA System, a 16-pin analog bus carries the signals from the System Module to all of the MPX modules.

With the TR-6 System, a 2-wire bus carries the signals from the TR-6 System Module to each of the TR-6-1 Relay MPX modules that are installed.

With a combined MDA/TR-6 System, the 16-pin bus is connected from the MDA System Module to the TR-6, and another bus connects from the Model TR-6 to the MDA MPX Modules.

Step 1.

A short 16-pin bus cable is connected from JP-1 on the MDA System Module to JP-2 on the TR-6 Module. On the TR-6, JP-2 is in the middle top of the module.

Connect the 16-pin bus from JP-1 on each of the MDA MPX modules to JP-3 on the TR-6 Module. JP-3 is just below JP-2 in the center of the Module.

Pin one on the 16-pin connectors JP-2 and JP-3 of the TR-6 Module is towards the front of the computer.

Step 2.

Connect a 2-wire bus cable from JP-5 on the TR-6 Module to JP-2 on each TR-6-1 board.

Finally, refer to the MDA manual for instructions about installing and configuring the system software.

Model TR-6 Software Configuration/Self-Test

The *Modules* page of the *Configuration* screen described in Chapter 4 of the MDA Manual is used to tell the MDA system what modules are installed, how they are configured, and allow invocation of self-test routines. In addition, it provides for an external calibration of the Model TR-6 System Module.

TR-6 System Self-Test

Selecting self-test, provides two basic functions. First, it optimizes the speed and accuracy of your Test System by performing a self-calibration of the TR-6 System Module installed in your System and functionally tests each I/O test point to verify correct functioning of the MPX Modules.

You should select the TR-6 System Module first, then do each TR-6-1 relay MPX Module. The order is important (especially the first time when you install the System) since the System Module is used to self-test and characterize the MPX modules. After installation, to ensure proper operation, you should run self-test/calibration on every Module in your System. Thereafter, you should run self-test twice a year or if you suspect any problems with the System's operation.

Once self-test has started, follow the prompts until it is completed. It will report any errors that it finds.

<p style="text-align:center"><u>NOTE</u></p>

> *Ensure that no test assemblies are connected during the self-test. Otherwise, you may get incorrect test results.*

In the event that a failure occurs, you are presented with an error message describing the nature of the failure.

When the test is complete, it is important that you save the system configuration data on the disk. When you do this, it saves the newly determined calibration constants on the disk drive so that they will not be lost when you power down the computer or complete your use of the Visual MDA Software.

If you see massive self-test failures, it is likely to be an installation or compatibility problem. If you see one (or a few) repeatable failures, you can suspect a Model TR-6 hardware failure. In this case return the Model TR-6 to CheckSum for checkout or call CheckSum for help.

TR-6 System External Calibration

Selecting *External Calibration* of the Model TR-6 Module invokes an external calibration of the Model TR-6 System Module. This external calibration should be run twice a year to ensure full accuracy.

The external calibration determines calibration offsets and gains to external standards. The external standards are an AC/DC source (e.g., Fluke 5100) and a DMM with current measuring capability (e.g., Fluke 8840). The standards (which include those mentioned) should be at least 4 times the accuracy of the Model TR-6 for the necessary functions. Stimulus points necessary include DCV at .19V, .57V, 1.9V, 5.7V, and 19V, ACV of 5.7V @ 100Hz, and 19V @ 100 Hz and 10 KHz. Measurement capability of 100mA is also necessary.

The calibration display is used for the calibration. It displays the calibration constants that are currently saved. You can manually move to a position and change each number, but you should not do so unless you are restoring values determined earlier for the same hardware. Once you have invoked the calibration sequence the System will guide you through the process, in the correct order to determine the new values. Each time an action is required (e.g., provide a stimulus), the System prompts you accordingly.

When the calibration test is complete, it is important that you save the System configuration data on the disk. When you save the configuration data, it saves the newly determined calibration constants on the disk drive so that they will not be lost when you power down the computer or complete your use of the Visual MDA Software.

Connection to the UUT

Once you have installed the System hardware and software, you are ready to connect your unit-under-test (UUT) to the System. The UUT is connected via the 50-pin ribbon cables from the MDA MPX Modules, the Model TR-6 System Module, and the Model TR-6-1 Relay MPX Modules.

You may choose to obtain a fixturing system directly from CheckSum or design your own.

If you are using a CheckSum Fixturing System, refer to the manual obtained with the Fixturing System for specifics of connection.

If you are connecting to your own fixturing, you need to connect the test points available via the ribbon cables to your UUT.

MDA Test Points

On the MDA MPX Modules, the rightmost 50-pin connector (when facing the component side of the MPX Module) contains test points 1-50, the next connector contains test points 51-100, and so on. The pin-out for test points 1-50 is shown below. The pin-out for the other test points is the same except add 50, 100 or 150 to each test point number shown in the figure as appropriate.

50	49
48	47
46	45
44	43
42	41
40	39
38	37
36	35
34	33
32	31
30	29
28	27
26	25
24	23
22	21
20	19
18	17
16	15
14	13
12	11
10	9
8	7
6	5
4	3
2	1

Figure 2-1 - MDA Test Point Pin-Out (when facing header on MPX Module)

If you have installed the jumpers as suggested, the pin-out will start at test point 1 on the rightmost cable (when facing the back of your computer) and increase by 50 for each cable. If you are confused, use the System's probing feature to probe each cable for identification.

Model TR-6 Test Points

On the Model TR-6 System Module and TR-6-1 Relay MPX Modules, the signals are available from 50-pin connectors on the Module back panels. The TR-6 System Module has a uniquely colored connector (typically blue) so that it can be differentiated from the TR-6-1 modules without removing the PC's cover.

The back panel pin-out for the first Model TR-6-1 is shown in Figure 2-2 below. Add 50 to each test point for each additional TR-6-1 module installed.

TP 1651	TP 1652
TP 1653	TP 1654
TP 1655	TP 1656
TP 1657	TP 1658
TP 1659	TP 1660
TP 1661	TP 1662
TP 1663	TP 1664
TP 1665	TP 1666
TP 1667	TP 1668
TP 1669	TP 1670
TP 1671	TP 1672
TP 1673	TP 1674
TP 1675	TP 1676
TP 1677	TP 1678
TP 1679	TP 1680
TP 1681	TP 1682
TP 1683	TP 1684
TP 1685	TP 1686
TP 1687	TP 1688
TP 1689	TP 1690
TP 1691	TP 1692
TP 1693	TP 1694
TP 1695	TP 1696
TP 1697	TP 1698
TP 1699	TP 1700

Figure 2-2 - Model TR-6-1 Test Point Pin-Out (on first module)

The Model TR-6 has a special pin-out because it mixes power, test points, and other dedicated signals on one connector. The pin-out for the TR-6 System Module is shown in Figure 2-3.

1-TP 1	2-TP 2
3-TP 3	4-TP 4
5-TP 5	6-TP-6
7-TP 7	8-TP 8
9-TP 9	10-TP 10
11-TP 11	12-TP 12
13-TP 13	14-TP 14
15-TP 15	16-TP 16
17-Ground	18-Relay 2 NC
19-Relay 1 NC	20-Relay 2 Com
21-Relay 1 Com	22-Relay 2 NO
23-Relay 1 NO	24-Relay 4 NC
25-Relay 3 NC	26-Relay 4 Com
27-Relay 3 Com	28-Relay 4 NO
29-Relay 3 NO	30-UCT Ch 2 In
31-UCT Gate In	32-UCT Ch 1 In
33-SqrV Out	34-Analog Gnd
35-SineV Out	36-DcV Out
37-DMM In Low	38-DMM In High
39-DigIO 1	40-DigIO 2
41-DigIO 3	42-DigIO 4
43-DigIO 5	44-DigIO 6
45-DigIO 7	46-DigIO 8
47-Ext IO 7	48-(+)5V Pwr
49-(-)12V Pwr	50-(+)12V Pwr

Figure 2-3 - Model TR-6 System Module Pin-Out

Connection Guidelines

When wiring for functional testing, the following guidelines are appropriate. You should also read the Model TR-6 Theory of Operation before wiring the fixture.

1. Use MDA Test points where ever practical since they are the most flexible in use.

2. Use Model TR-6(-1) Relay Test points only when the voltage at the test point will exceed 12 volts from the PC chassis, or when higher current is required (e.g., TR-6 DMM resistance measurements exceed the current-carrying capability of the solid state switches. This is only of concern if you want to measure resistances less than a few ohms).

3. If you want to use the MDA MPX modules digital capability, connect the signals that you want to multiplex between analog and digital to the first 16 test points on each module. Since these two bytes are enabled as inputs and/or outputs as a

whole (see the DIGA test type description), if you are doing both digital input and output arrange your wiring so that the inputs are all on the one byte and the outputs on the other byte. As a general rule, use test points 1-8 as output or input/output points and test points 9-16 as inputs. Points 9-16 can also be configured as outputs, but only when points 1-8 are also configured as outputs.

4. Since there is significant voltage drop when running currents more than a few mA through ribbon cables, use at least two probes on each power supply that you will be connecting to the UUT. If possible use an external cable to plug into the UUT. To minimize voltage drops between the UUT and power supply, use relays and a power supply in close proximity to the UUT and use fairly large wiring. The Model TR-6-2 Fixture Interface Module supports this type of wiring.

Theory of Operation

Overview

The Model TR-6 Functional Test System allows you to power-up your unit-under-test (UUT), then apply stimulus and make measurements to ensure proper UUT operation.

Typically, the Model TR-6 Functional Test System is used in conjunction with a CheckSum MDA System. When this is the case, the MDA system is first used to passively (no UUT power applied) test for proper assembly and no opens or shorts that could cause damage once power is applied. Once this testing has successfully been completed, the Functional Test System can apply power, provide stimulus, and make active measurements.

The combined Systems provide a number of capabilities and shared elements. This section describes various aspects of using the System with respect to common elements. It also describes some global aspects of using the Model TR-6 Functional Test System.

The MDA Manual describes the test step types that are specific to the Model TR-6.

System Switching

System test point switching allows you to use MDA solid state test points (test points 1-1600 and 2001-8400), relay test points on the Model TR-6 (test points 1601-1616) or from the Model TR-6-1 Relay MPX Modules (test points 1651-1950).

The Model TR-6 also allows you to directly use its stimulus or measurement capabilities from its back panel. If you want to use this direct path, specify a "from (-)" test point of 1625. Doing so eliminates any other internal switching that might otherwise be done. Note that the back panel inputs and outputs are always active (not disconnected) regardless of other system activity. Consequently, if you connect them directly to a test point, make sure that stimulus/measurements routed to these points during other parts of the test sequence will not cause problems.

When wiring the test fixture, special care must be used when wiring test points that can exceed plus or minus 12 volts with respect to the controller (PC) chassis when the UUT is powered up. These points must be wired to the Model TR-6(-1) relay test points to prevent erroneous measurements and damage to the test system. However, whenever possible use MDA test points since these are the most flexible. The MDA test points can be used for continuity tests, source, sense and do guarded measurements while the Model TR-6 test points are for basic 2-wire measurements only.

The TR-6 relay switching is also used in place of the MDA switching for taking low resistance measurements with the Model TR-6. Since the TR-6 DMM uses 100 mA, the MDA switching would be damaged by its use and compliance voltages would be exceeded.

System Measurement Switching

Both the relay switching of the Model TR-6(-1) or the solid-state switching of the MDA can be used to make UUT measurements. These measurements can be made with the Model TR-6's DMM or UCT or the MDA's measurement circuitry for resistance, capacitance, inductance or DC voltage measurements.

UUT measurements using the TR-6 switching are 2-wire only. Therefore, guarded or externally sensed measurements can not be performed through these points, although MDA measurements taken through TR-6 test points can be externally sensed through MDA test points.

System Source Switching

The Model TR-6 has internal sources for generating sine waves (SINEV), square waves (SQRV) and dc voltages (DCV). In addition, there are provisions for switching an external signal (EXTIO) for sourcing or measuring with an external device. These sources are available at the TR-6 back panel, or they can be switched into the MDA solid state switching. They are not available at the Model TR-6(-1) relay switching. If it is necessary to apply one of these sources to a test point that cannot be wired into the MDA, you can provide wiring for the source to the UUT point through one of the Model TR-6's undedicated relays.

The Model TR-6 sources are ground-referenced. The ground is ultimately connected to the chassis of the controller (PC). The "from (-)" test point used for supplying sources are connected back to this ground.

System sources are disconnected when the source test title is specified as RESET (in either upper or lower case), or when the same source is connected to another destination. The System can provide each source to multiple destinations if the test program uses a FLAGS (8) command to enable multiple sourcing or a FLAGS (4) to disable multiple sourcing. The sources are all reset when the system is powered up, when a CONT or ICS test is performed, and before and after each complete test program is executed.

The MDA allows up to six guard points at one time (each of which can be remotely sensed. When one or more sources are programmed (and not reset), only three guard points can be active simultaneously. The software automatically ignores the last three guard points if present.

UUT Power Switching

The Model TR-6 has the ability to apply power to the UUT. Applying power can be accomplished in several ways depending on the requirements of the UUT.

For low-power UUTs that require +12 V or +5 V (up to 1A) or -12V (up to 100mA), the System provides fused outputs from the controller's (PC's) power supply. These can be connected to the Model TR-6's undedicated switching for connecting power and ground to the UUT.

For medium power UUTs (those requiring up to about 1 amp), the System's undedicated relays can be used to switch the power to the UUT via an external power supply. There are several ohms of internal resistance present in this switching, so some voltage drop will occur when switching more than a few milliamps.

For higher power UUTs, the TR-6's digital output capability can be used to directly switch external power relays. The open-collector digital outputs sink up to 100 mA and, as such, can power fairly large power relays.

As a final method of switching higher UUT power, the Model TR-6-2 Fixture Interface contains power switching relays that are suitable for UUTs requiring up to 10 amps.

Note that you should switch both power and ground to the UUT since the MDA System relies on the UUT to be floating during MDA testing operations.

- WARNING -

Because of the extreme hazard to operators, you should avoid applying line power and other high voltages to the UUT during test. As an alternate, switch DC into the output of the AC power supply on the UUT.

System Source Interdependency

The Model TR-6 has the ability to provide simultaneous stimulus channels, however, there are some interdependencies. In the case of interdependencies, the last programmed value has priority. These include:

1. There is one DCV output dedicated to generating square waves. In most cases, square waves are generated between this voltage and ground. However, if you would like both amplitudes of the square wave to be non-zero, the other DCV output (normally used for DC output) can be used as the other square wave amplitude.

To accomplish this, specify a square wave (SQRV) with a non-zero low-limit. The DC voltage (DCV) output is used as the lower value. Therefore, the stimulus value for the first voltage of the square wave and the DCV output will be the same. If the alternate DCV output (range = 2) is used, it disables the square wave output entirely and replaces it with the specified DC voltage signal.

2. The square and sine wave generation (SINEV/SQRV) use the same frequency generation circuitry, therefore the frequency must be the same for both if they are simultaneously used.

AC Source Frequencies Available

The following frequencies are available when generating sine and square waves:

40KHz, 20KHz, 13.3KHz, 10KHz, 8KHz, 6.67KHz, 5.71KHz, 5KHz, 4.44KHz, 4KHz, 3.64KHz, 3.33KHz, 3.08KHz, 2.85KHz, 2.67KHz, 2.5KHz, 2KHz, 1.33KHz, 1KHz, 800Hz, 667Hz, 571Hz, 500Hz, 444Hz, 400Hz, 364Hz, 333Hz, 308Hz, 285Hz, 267Hz, 250Hz, 200Hz, 133Hz, 100Hz, 80Hz, 67Hz, 57Hz, 50Hz, 44Hz, 40Hz, 36Hz, 33Hz, 31Hz, 29Hz, 27Hz, 25Hz, 20Hz, 13Hz, 10Hz, 8Hz, 7Hz, 6Hz 5Hz, 4Hz, 3Hz.

Digital Input/Output

The Model TR-6 directly accommodates eight bits of digital I/O via its System Module. The eight bits consist of open-collector drivers that can be used to control external relays that require currents of up to 100 mA. The module supports the installation of on-board pull-up resistors that make the digital byte appear as + 5V or + 12V digital logic. Alternatively you can use an external pull-up source. Digital input signals of up to 12 volts can also be read back (at TTL logic thresholds). This digital I/O is controlled with the DIGI and DIGO test types (see Chapter 11).

Note that the TR-6 digital outputs are relay-driver open-collector outputs. Because of this, the low logic level is somewhat higher than typical TTL/CMOS parts - usually about 1 volt. If your UUT is sensitive to the low logic level, considerer redriving the digital output through another driver in the test fixture, or use an alternate digital output source such a the Model G-80 or MDA System Module digital output.

When used with an MDA System, an additional byte of digital data on the MDA System module is also available. MDA digital I/O is controlled with the DIGA, DIGI and DIGO test types.

The TR-6 DCV command can be used to provide logic levels to several test points simultaneously. The (-) test point serves as a digital low and the (+) test point, when programmed to + 5V serves as a digital high level. Up to 16 simultaneous source points can be used. Under normal circumstances, the System disconnects previous test points connected to the same source (e.g. DCV) when a new stimulus is applied. However, with use of the FLAGS test step, you can have the System allow multiple stimulus points from the same source (FLAGS range = 8). The FLAGS test type with a range of 4 sets the System back to single source mode. The source can be disconnected with a RESET of the desired source.

Note

When using the DCV command for digital control, be advised that the System will disconnect the stimulus for short periods of time between tests as part of the hardware reset process. Because of this you should not use DCV stimulus to digital points that are clocks or are edge-sensitive.

When the System is configured with MDA MPX modules, you can multiplex the first 16 test points per MDA MPX module between standard analog I/O and digital I/O under software control. These points can be wired into digital nodes on the UUT to supply digital testing. These test points are configured as analog or digital inputs and outputs with the DIGA test type. Use the DIGO and DIGI test types to then change the bits.

A G-80 Overdrive Module (G80-ODM) is an available accessory for overdrive of signal and control lines to extend the LOGIC test capability of a system. The overdrive module provides high current drivers useful to temporarily force a logic level on a net which also is driven by another active output. The automatic use of overdrive is included in the LOGIC test. The G80-ODM can be controlled by TTL outputs and can be directly connected to a G80 cable.

Grounding

The Model TR-6 provides two grounds, analog and chassis. These are connected together internally in the Model TR-6 module. During fixturing, you will normally leave both grounds   separated.

For analog sourcing and measuring, the analog ground is used. By being separated from the chassis ground, noise and ground loops are minimized.

Model TR-6 analog sources and digital I/O are referenced to the computer chassis ground. DMM inputs are floating (to within 8 volts of computer chassis) for the lower ranges (up to 6 V), and referenced to PC chassis for higher ranges. UCT inputs are with respect to ground.

MDA measurements require the UUT to be floating with respect to the controller, consequently when applying power to the UUT you should switch both power and ground. Signal inputs to the MDA test points should never exceed 12 volts from the PC chassis. Doing so will damage the System.

Fixturing

When the Model TR-6 is shipped from CheckSum with bed-of-nails fixturing, a particular convention is used. The MDA test point switching starts from the left and work to the right. The functional test system is connected starting at the right (with the Model TR-6) and working left (with the Model TR-6-1 modules). Using this convention provides an easy way to separate the two functions and allows for systematic increases in the test point-count if expansion is desired.

Refer to the test fixture instruction manual for specific conventions based on the type of fixturing - mechanical, pneumatic, or vacuum.

Functional Test Programming

Overview

TR-6 programming is fully integrated with MDA test programming. In fact, often the MDA and functional tests are combined into a single program. Functional programming is basically an extension of the MDA programming environment by including additional commands.

The TR-6 is programmed with use of test-types as described in Appendix I of the MDA system manual. The test-types used for functional programming include: DMM, UCT, UCTTR, DIGA, DIGO, DIGI, LOGIC, SINEV, SQRV, DCV, EXTIO, and RELAY. There are also associated jump test types for the measurement commands, for example JMPDM for jump based on a DMM measurement.

Refer to these commands in the MDA manual for details of programming the TR-6.

There are special screens that emulate instrument front panels for interactive control of the hardware during programming. These are present for the digital multi-meter (DMM) the counter-timer (UCT), and for performing digital I/O. The use of these screens is included in this chapter.

DMM Interactive Control

Selection of *Step Analysis*, from the *Edit* screen while a DMM test type is highlighted allows you to interactively control the DMM. Interactive control is similar to observing the display and pressing the buttons on the front panel of a standard bench-top DMM. With use of this display you can perform debug on the test program or do UUT repair operations. You can also use it to automatically determine the range value without referring to the instruction manual for the details of the range code assignment.

The *DMM Interactive Control* Screen, *Front Panel* page, is shown in Figure 4-1. The various menu items are discussed below.
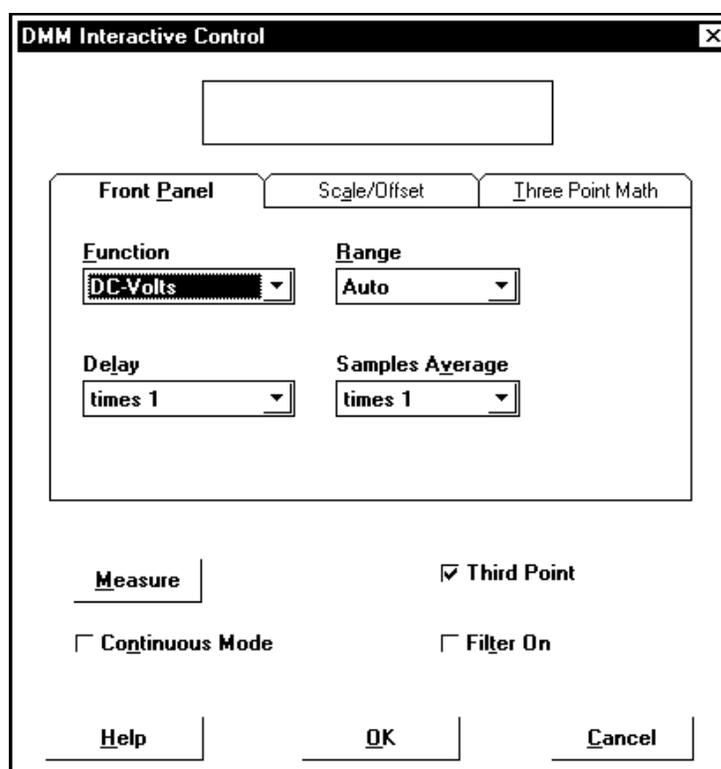
Figure 4-1 - DMM Interactive Control Screen, Front Panel Page

- **Function**   is used to assign the function for the DMM. You can choose between AC volts, DC volts, and Resistance. Note that resistance is for low value resistance measurements only, such as when measuring trace resistance. To make these low value measurements it uses high current (100mA) that cannot be routed through the MDA solid-state test points (1-1600) without damage. Unless a special requirement exists, resistance measurements should be taken with the MDA resistance measurement capabilities. AC voltage measurements are true-RMS, unless AC-coupling is selected.

- **AC Coupling**   is available when the AC Voltage function is selected. AC coupling eliminates or reduces the DC component of the input signal by routing the input signal through a capacitor. If AC Coupling is not selected, the measured signal is directly DC coupled into the DMM.

- **Range**   is used to set the range of the measurement. The allowed ranges are different based on the function selected using *Function*. Autorange allows the System to change ranges during the measurement. It is helpful during interactive use, but test programs will operate more quickly if a fixed range is chosen.

- **Measure**   is used to make a DMM measurement and display it at the top of the display.   If you select *Continuous Mode*, the DMM shifts into continuous measurement mode. In this mode the System continues to take readings until the screen is exited or other selected DMM settings are changed.

- **Delay**   is used to set the measurement delay. You can increase or decrease the standard measurement settling delay to improve speed or accuracy. You can select from normal delay (times 1), one-half delay (divided by 2), double delay (times 2) or ten times the standard delay (times 10).

- **Samples Averaged**   is used to set the samples averaged. You can increase the number of samples averaged by a factor of 10 or 100. Doing so increases the stability of the readings (by filtering noise) at the expense of some test speed. Use of extra samples averaged is normally only necessary if the source being measured is noisy.

- **Filter On**   allows you to set the filter on or off. The filter selection is available when the DC or Resistance function is selected. It is used to filter out noise in the measurements. The filter significantly reduces measurement speed and should not be used unless necessary.

- **Third Point**   can be used for Resistance, AC-Volts or DC-Volts readings. When the box is checked, measurements are made from a "Third Point" to the selected "From Point" and the "To Point" that are specified in the Bus Connection page. See the following Three Point Math page section for more information.

- **Cancel**   allows you to exit back to the *Edit* screen without altering the test program to reflect the DMM settings that have been changed during use of this screen.

- **OK**   exits back to the *Edit* screen. A new range value is computed for the test program that reflects the DMM settings at the time [ESC] is selected.

Other options are available with the *Scale/Offset* page of the *DMM Interactive Delay* screen shown in Figure 4-2.
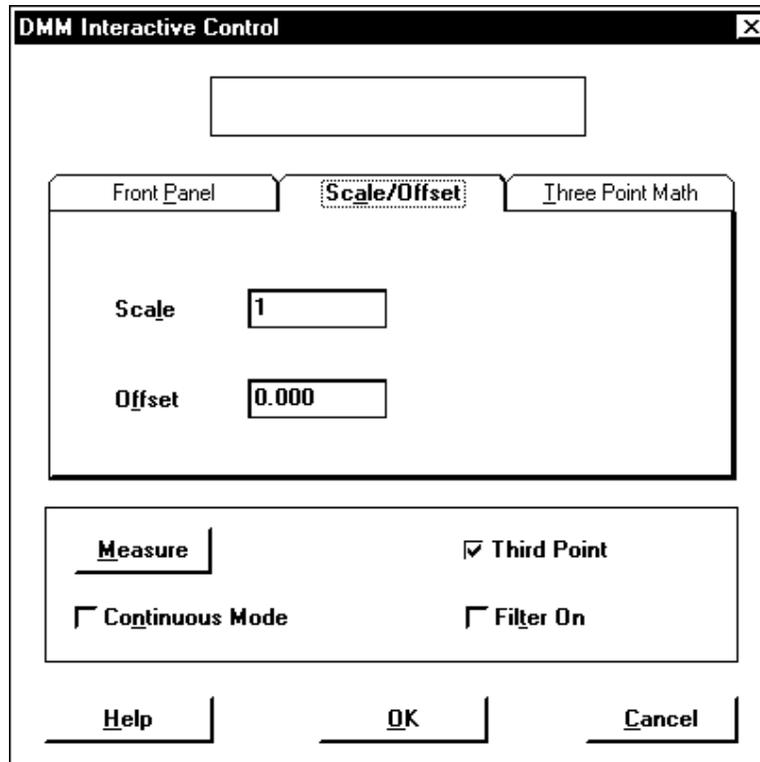
Figure 4-2 - DMM Interactive Control Screen, Scale/Offset Page

WARNING

With the scale or offset values, the operator could be mislead into believing less voltage is present at the input to the DMM than is actual present. For safety purposes you should not scale or offset hazardous voltages so that lower values are displayed.

- **Scale**   is used to specify a scale factor. The scale factor is multiplied by the DMM reading before display. It can be used in conjunction with external dividers to display the proper value. Offset is applied before the scale factor.

- **Offset**   is used to specify an offset that is added to the DMM measurement prior to display to the operator or making test evaluations. It can be used to correct a reading for offsets in the measurement such as path resistance. Offset is applied before the scale factor.

Other options are available with the *Third Point Math* page of the *DMM Interactive Delay* screen shown in Figure 4-3.
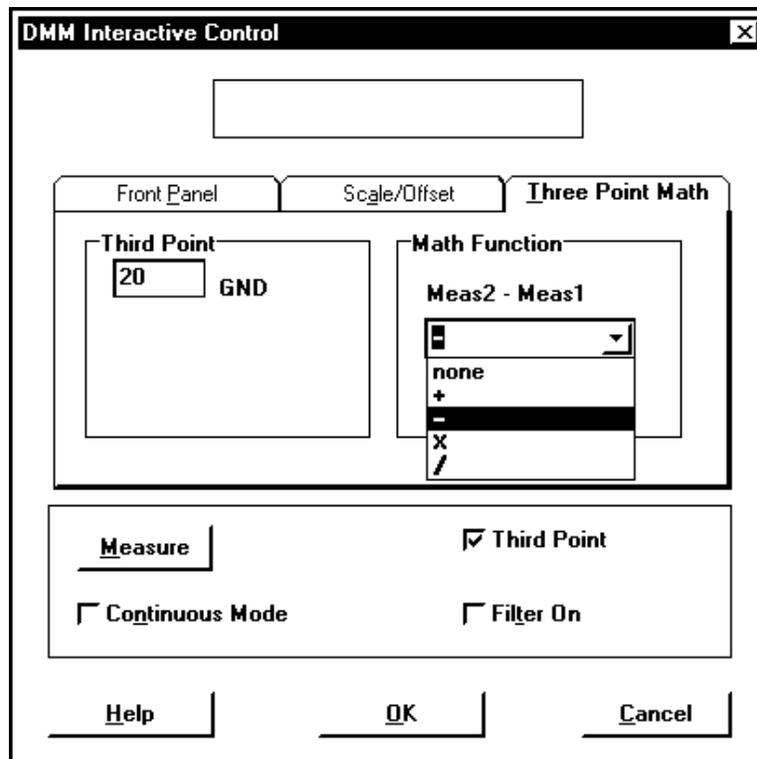
Figure 4-3 - DMM Interactive Control Screen, Third Point Math Page

- **Third Point**   is used to specify the reference test point used to measure the "*From Point*" and "*To Point*" for the Three Point Math.

- **Math Function**   selections are none, add, subtract, multiply, or divide.

The DMM three point math feature makes two measurements. First, a DMM measurement from the specified "*Third Point*" to the specified "*From Point*" is made (call it Meas1). Then, a DMM measurement from the specified "*Third Point*" to the specified "*To Point*" is made (Meas2). Finally, a math function is performed, Meas2 **math** Meas1, on these two measured values. The math function can be none, add, subtract, multiply, or divide. The result of this math operation creates the measured value for the test step.

UCT Interactive Control

Selection of *Step Analysis*, from the *Edit* screen while a UCT test type is highlighted allows you to interactively control the UCT. Interactive control is similar to observing the display and pressing the buttons on the front panel of a standard bench-top counter/timer. With use of this display you can perform debug on the test program or do UUT repair operations. You can also use it to automatically determine the range value without referring to the instruction manual for the details of the range code assignment.

The *UCT Interactive Control, Front Panel Page* screen is shown in Figure 4-4 below.
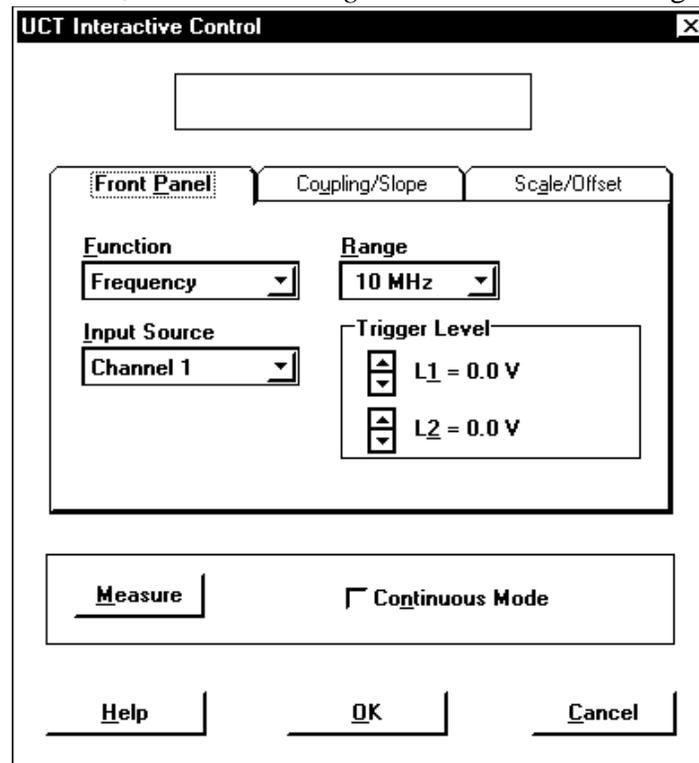
Figure 4-4 - UCT Interactive Control Screen, Front Panel Page

- **Function**   is used to assign the function for the UCT. You can choose between frequency, time, and count. Frequency measures the frequency of the input signal by counting the number of trigger transitions during a selected period. Period measurements are made by counting an internal clock between trigger transitions of the input signal. On the lowest ranges, the internal clock is measured for several input periods for more accuracy. Counts are measured by opening the gate for an amount of time specified under *Range*, and measuring the trigger transitions of the input signal.

- **Range** is used to set the range of the measurement. The allowed ranges are different based on the function selected using *Range*. Ranges for period are from 12.8 uS to 128 S. Frequency ranges are from 5 KHz to 10 MHz full-range. Counts are measured during gate times of 12.8 mS to 12.8 Sec. The range affects the measurement resolution and speed. You should select the range with the minimum resolution necessary in order to optimize speed.

- **Measure** is used to make a UCT measurement and display it at the top of the display. If you select *Continuous Mode*, the UCT shifts into continuous measurement mode. In this mode the System continues to take readings until the screen is exited or other selected UCT settings are changed.

- **Input Source** is used to set the input source(s). You can choose between channel 1, channel 2, channel 1 to 2, channel 2 to 1, or the DMM input (and its associated full range value). Normal measurements are taken with channel 1. Channel 2 is only available at the TR-6 rear panel connector. If you want to measure a higher voltage or need differential input, use the DMM input. The DMM input is usable to about 50 KHz. Period measurements can be measured as starting and ending on the same channel or on different channels (e.g. channel 1 to 2 or 2 to 1).

- **Delay** is available for Counts and Period measurements. This delay has one millisecond resolution and is used to control the maximum Counts measurement time or the time the Period measurement waits before timing out while looking for a measurement pulse. The minimum delay time is one millisecond. Entering a value of 0 for delay causes the delay to be set to its default value. For Counts measurements the delay default value is slightly more than the full count down time of the internal timer used to gate Counts measurements. For Period measurements the default delay equals to twice the product of the number of periods averaged and the range value.

- **[Arrow Keys]** are used to set the trigger levels. Pressing the up and down arrow keys change the trigger level number displayed. There are separate arrow keys for each trigger level. L1 is used for the UCT starting event, and L2 is used for the UCT ending event.

- **Cancel** allows you to exit back to the *Edit* screen without altering the test program to reflect the UCT settings that have been changed during use of this screen.

- **OK** exits back to the *Edit* screen. A new range value is computed for the test program that reflects the UCT settings at the time [ESC] is selected.

The *UCT Interactive Control, Coupling/Slope Page* screen is shown in Figure 4-5 below.
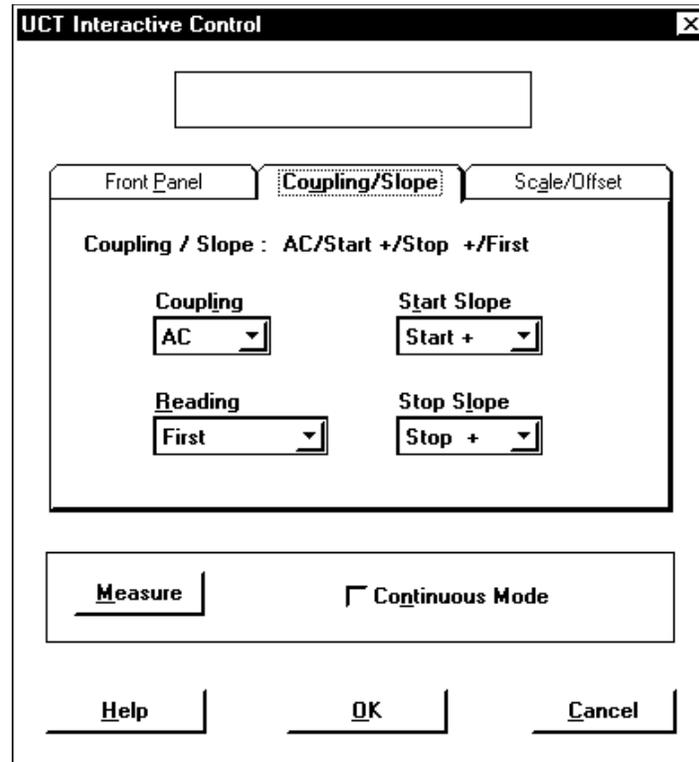
Figure 4-5 - UCT Interactive Control Screen, Coupling/Slope Page

- **Coupling**   is used to set the input signal coupling. AC coupling eliminates the DC
  component of the measurement and can help eliminate noise in the
  measurement, but reduces the signal amplitude for low frequencies (less than
  about 30 Hz). AC coupling can be used to make input signals that have DC
  offset fall within the trigger level range.

- **Start/Stop Slope**   is used to set the triggering slope. The slope specifies the start
  and stop trigger slopes. Normally, + to + is used unless you want to
  measure pulse width.

- **Reading**   is used take more than one reading. You can either use the first reading
  that the UCT takes, or take another reading, ignoring the first. Often better
  measurements can be taken by ignoring the first one, but for lengthy
  measurements, the first may be most expedient.

The *UCT Interactive Control, Scale/Offset Page* screen is shown in Figure 4-6 below.
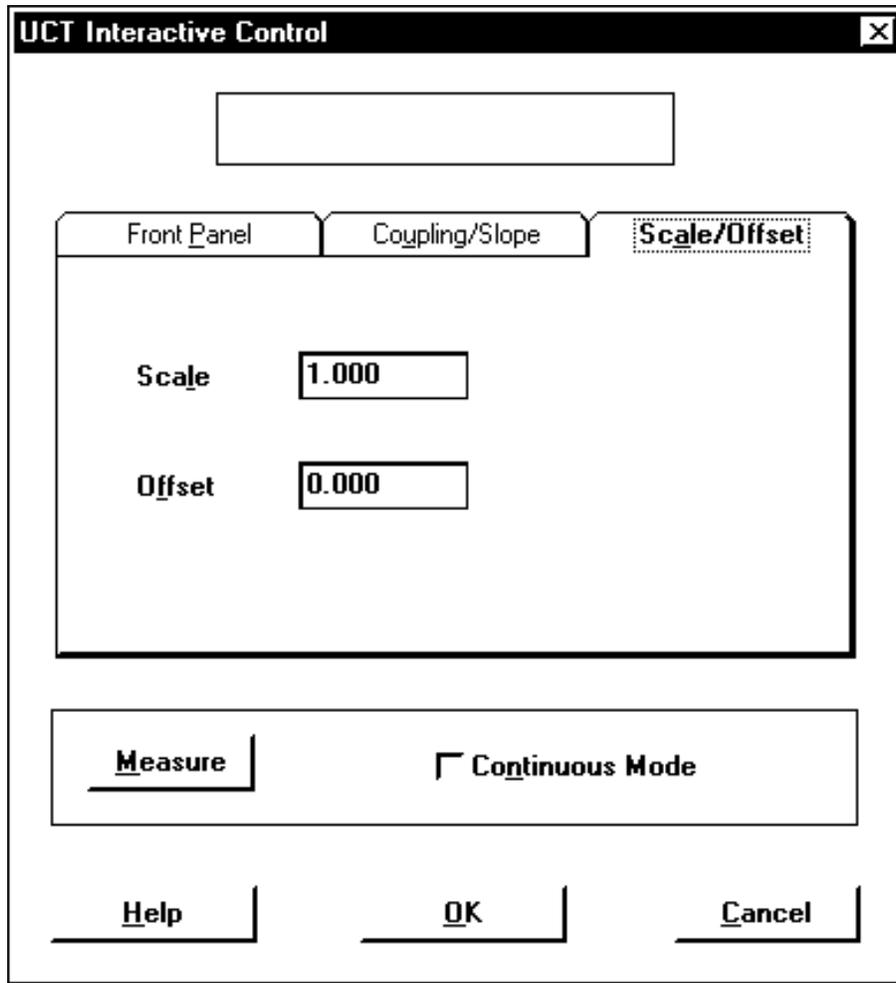
Figure 4-6 - UCT Interactive Control Screen, Scale/Offset Page

- **Scale**   is used to specify a scale factor. The scale factor is multiplied by the UCT reading before display or test evaluation. It can be used in conjunction with external dividers (e.g., Model TR-6-2 Fixture Interface) to display the proper value before division takes place. The Offset value is applied to the measurement before applying the Scale factor.

- **Offset**   is used to specify an offset that is added to the UCT measurement prior to display to the operator or making test evaluations. The Offset value is applied to the measurement before applying the Scale factor.

Digital Testing Overview

The digital test types allow you to input and output digital data from within a test program.

PORTx Test Types

The PORTx test types do I/O to the PC's internal I/O bus (the 16/32 bit PC bus). PORTI and PORTO do input and output (respectively) to this bus allowing you to communicate with plug-in cards, peripherals and other I/O-mapped devices.

DIGx Test Types

The DIGx test types perform input and output via the CheckSum MDA System Module (8 bits), Model TR-6 System Module (8 bits), MDA MPX Modules (16 bits each) and a CheckSum Model G-80 Digital I/O Module that can provide an additional 96 bits.

LOGIC Test Type

For digital I/O, the LOGIC test type can use one or more types of CheckSum hardware, including the MDA System Module, the MDA MPX modules, Model TR-6 Functional Test Module, Model G-80 Digital I/O Module and/or Model G-80 Overdrive Module. This combined software/hardware can be used to do in-circuit testing of digital hardware combinational logic and transceivers. Refer to the following section for more details and examples of LOGIC test use.

MDA System Module/G-80 Characteristics

On the Model G-80 Digital IO Module and on the Model TR-4 MDA System Module, each bit is an individually bi-directional digital TTL I/O line which can source 2.5 mA or sink up to 24 mA. Since a pull-up resistor is in place (10 KΩ), the bits are also compatible with most CMOS logic families. On the TR-8 System Module, the outputs are totem-pole CMOS with 10 KΩ pull-ups.

Note

> *Reset Conditions: Between test program executions, the bits are all set to high impedance (tri-state). Since each line has a 10 KΩ resistor to + 5 V, this results in a logic one. Each line that you would like to use for output from the System needs to be set active using the DIGA test type. In the reset mode, the outputs are set to tri-stated zeros, so that when you activate an output it will immediately go to a zero. You can first perform a DIGO to set the bits to ones prior to the activate if you so desire.*

TR-6 System Module Digital I/O

The Model TR-6 directly accommodates eight bits of digital I/O via its backpanel connector. The eight bits consist of open-collector drivers that can be used to control external relays requiring currents of up to 100 mA. The module supports the installation of on-board pull-up resistors that make the digital byte appear as 5V or 12V digital logic. Input signals of up to 12 volts can also be read back (at TTL logic thresholds).

The TR-6 System is shipped with a 10 KOhm pullup resistor network connected to + 5V. This resistor network can also be jumpered on the Model TR-6 Module to + 12V. The resistor network (socketed) can be removed to eliminate inter-bit impedance or to allow connection to external pull-up sources such as when you are directly driving external relays with the System. The digital input always uses TTL-level inputs, although it can be used with inputs of up to +12 volts without damage.

Since the Model TR-6 digital IO consists of open collector relay drivers, its logic low is somewhat higher than standard TTL/CMOS logic. Typical logic low output is about one volt. If your UUT is sensitive to its logic low level, consider using a different digital output (such as a Model G-80), or redrive the output through another IC in the test fixture.

Because the Model TR-6 has open-collector output, it does not need the DIGA command to set it to high impedance for input. On the TR-6, just make sure that any bits you are using for input are not set to output a logic low, since this will override any logic high inputs.

MDA MPX Module Digital I/O

With the MDA MPX modules, you can multiplex 16 test points per module between standard analog I/O and digital I/O under software control. These points can be wired into digital nodes on the UUT to supply digital testing.

On each MDA MPX Module, the first 16 test points can be changed to digital I/O points. The points can be set as input or output on a byte-by-byte basis. When these points are used, they should be specially wired to the test points on the UUT requiring digital control. As a general rule, use test points 1-8 as output or input/output points and test points 9-16 as inputs (although these points can also be configured as outputs, but only when points 1-8 are also configured as outputs.)

To use the digital capabilities on the MDA MPX modules, after completion of MDA testing and application of power to the UUT, first connect the digital bytes to the test points and configure them as inputs or outputs as necessary with the DIGA command. Then use DIGO to do output or DIGI to do input. These digital bytes are accessed by test range values that apply to a byte on each module.

Other Digital Methods (TR-6)

The Model TR-6 DCV command can be used to provide logic levels to several test points simultaneously. The (-) test point serves as a digital low and the (+) test point, when programmed to + 5V, serves as a digital high level. Up to 16 simultaneous source points can be used.

The System does interrupt these analog voltages during reset operations so DCV sourcing should only be used on level-sensitive digital bits.

Under normal circumstances, the System disconnects previous test points connected to the same source (e.g., DCV) when a new stimulus is applied. However, with use of the FLAGS test step, you can have the System allow multiple stimulus points from the same source (FLAGS range = 8). The source can be disconnected with a RESET of the desired source.

General Programming

When reading a test program, the numbers used with the digital test types are all decimal. As such, if you would like to send a byte of all ones, you would specify 255. A byte of all zeros is 0. Individual bits (which can be added) are 1, 2, 4, 8, 16, 32, 64, and 128.

The System programs the bits in byte increments. Byte number 0 refers to the MDA System Module bits, bytes 1-12 refer to the Model G-80 bits, byte 13 refers to the Model TR-6 System Module bits, bytes 14-29 refer to the MDA MPX Module bits.

While doing a digital input from the UUT, a mask can be used to ignore specific bits. Any 1 in the mask is used to mask out the specified bit (ignore it). For example, if you want to mask out the two least significant bits, specify a 3. Test results are presented after the masking operation.

After you have inserted a digital testing test step, you can select *Step Analysis* (or press [F6]) to obtain an interactive programming screen. On the following pages, the screens for selecting pin direction (input vs output): DIGA, performing output to the UUT: DIGO, and reading the UUT digital output: DIGI, are discussed.

Digital Control Programming Screens

Digital Active Screen

The *Digital Active (DIGA) Interactive Display Screen* is shown in Figure 4-7 below.
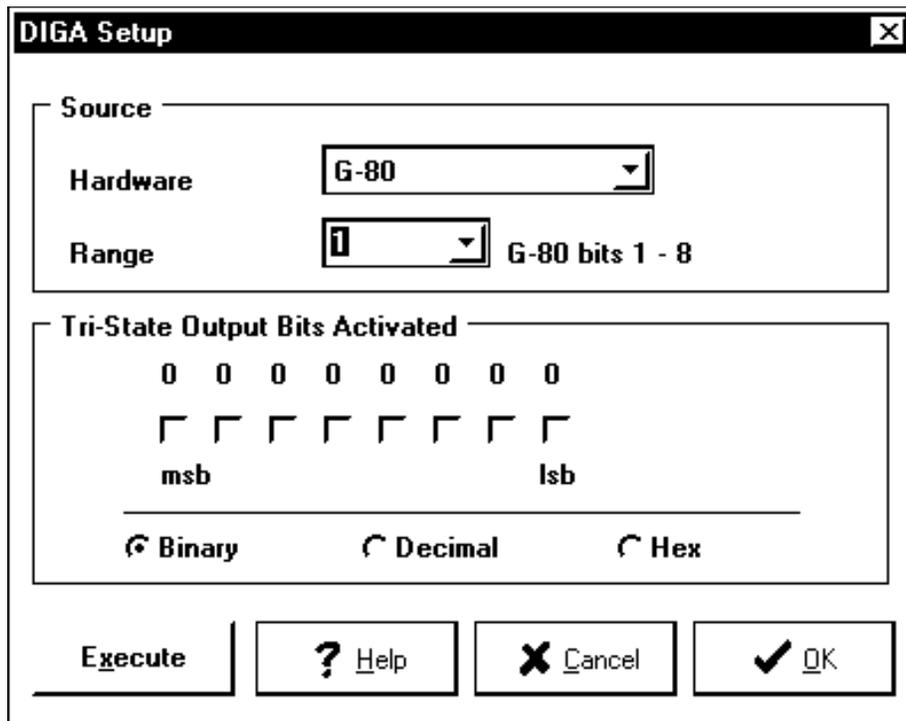
Figure 4-7 - Digital Active (DIGA) Interactive Control Screen

The *Digital Active (DIGA) Interactive Display Screen* is used to set the direction of digital IO. If a tester digital bit is tri-stated (high-impedance), it is set for doing input to the test system. If the tester digital bit is not tri-stated (i.e., active), it is low-impedance and able to send out highs and lows to the UUT. Bits that are tri-stated are in the logic high state when the controller is turned on. The default for digital output (see DIGO) is low for each pin. Because of this, as soon as you make the pin active for output, it will go low. You can precede the DIGA command with a DIGO command to set the pin high if you want it to stay in the high state.

Note

The Model TR-6 Module has open-collector output so it does not need to be set active for output. However, to be active for input, it's output bits need to be set to the high state so that they can assume a logic high, or be pulled down to the low state by the UUT.

To use the *Digital Active (DIGA) Interactive Display Screen*:

1. Select the output device to be used. To do this, use the **Hardware** list box. Select the hardware module to be used for output.

2. Select the byte (8-bits) to be controlled. To do this, use the **Range** list box. The range values will be different for each byte that you will be controlling with this test step. When you have selected a byte, the screen shows you the bit numbers being controlled.

3.   For each bit to be set active for output, click on the corresponding box. When the box is selected, the associated bit will be set low-impedance (non-tri-stated) in preparation to do output to the UUT.

You can select to enter the byte data in binary (the default), hex (base 16), or Decimal (base 10). When you read a test program, you will see the active byte specified in decimal.

The 'Execute' button can be selected to cause the test type to be executed with the hardware. This causes the same action as when the when the program is later run.   This can be helpful for interactive debugging.

Digital Output Screen

The *Digital Output (DIGO) Interactive Display Screen* is shown in Figure 4-8 below.

Figure 4-8 - Digital Output (DIGO) Interactive Control Screen

The *Digital Output (DIGO) Interactive Display Screen* is used to send a logic state to the UUT. Before you use this command, you need to use the DIGA command to prepare the test system to do output (see above).

To use the *Digital Output (DIGO) Interactive Display Screen*:

1. Select the output device to be used. To do this, use the **Hardware** list box. Select the hardware module to be used for output.

2. Select the byte (8-bits) to be controlled. To do this, use the **Range** list box. The range values will be different for each byte that you will be controlling with this test step. When you have selected a byte, the screen shows you the bit numbers being controlled.

3. For each bit to be set as a logic high for output, click on the corresponding box. When the box is selected, the associated bit will be set high.

You can select to enter the byte data in binary (the default), hex (base 16), or Decimal (base 10). When you read a test program, you will see the output byte specified in decimal.

The 'Execute' button can be selected to cause the test type to be executed with the hardware. This causes the same action as when the when the program is later run. This can be helpful for interactive debugging.

Digital Input Screen

The *Digital Input (DIGI) Interactive Display Screen* is shown in Figure 4-9 below.
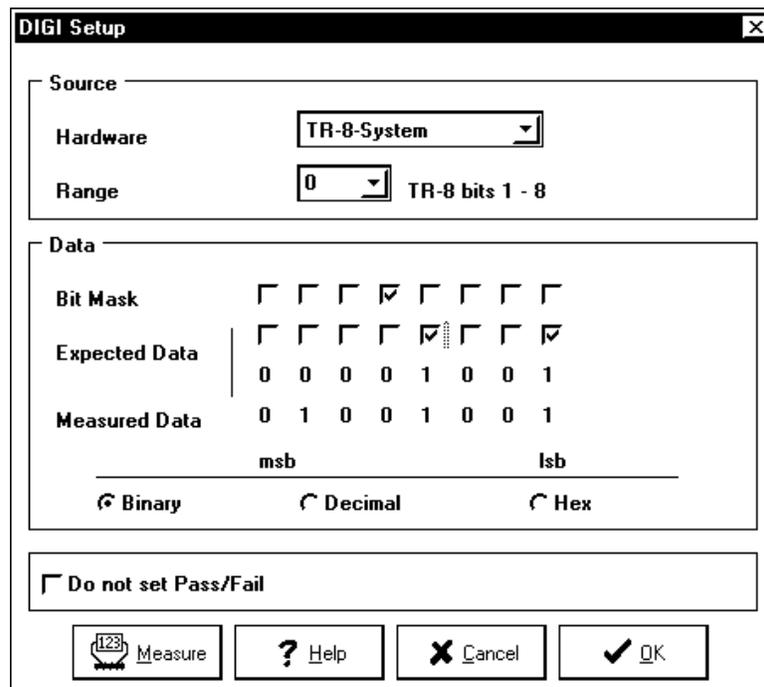
Figure 4-9 - Digital Input (DIGI) Interactive Control Screen

The *Digital Input (DIGI) Interactive Display Screen* is used to read a logic state from the UUT.

To use the *Digital Output (DIGO) Interactive Display Screen*:

1. Select the output device to be used. To do this, use the **Hardware** list box. Select the hardware module to be used for input.

2. Select the byte (8-bits) to be read. To do this, use the **Range** list box. The range values will be different for each byte that you will be controlling with this test step. When you have selected a byte, the screen shows you the bit numbers being controlled.

3.   For each bit that you expect to be a logic high after input, click on the corresponding box for *Expected Data*.

4.   For each bit that you want to ignore (you don't care whether it is a one or zero), click on the corresponding box for *Bit Mask*.

You can select to enter the byte data in binary (the default), hex (base 16), or Decimal (base 10). When you read a test program, you will see the expected data and mask bits specified in decimal.

The 'Measure' button can be selected to cause the test type to be executed with the hardware. This causes the same action as when the when the program is later run. This can be helpful for interactive debugging. After pressing 'Measure', the data read from the hardware is displayed on the screen.

You can opt to not generate pass or fail test result while doing a DIGI test. To do so, select the 'Do not set pass/fail' box. This allows you to read patterns, then make decisions later in the test program with use of the MEMI test type.

Using the Logic Test-Type

The Logic test type is used for functionally testing digital hardware logic. Test vectors from an ASCII test file are applied to the UUT. Test vector input/output speed is limited paced by hardware and software and typically operates at speeds lower than when the UUT is in operation. A single Logic test references a sub-test within a test file which may contain multiple lines. The test file is ASCII for ease in editing. Function declarations have commonly used logic syntax.

Logic Test File Syntax

The LOGIC test file contains three elements: signal declarations, logic sub-tests and comments:

1. Signal declarations are enclosed by lines beginning with "#define:" and "#end".

2. Logic sub-tests are enclosed by lines beginning with "#test:" <name_list>" and "#end".

3. Any text outside these blocks and any lines within the blocks beginning with a "#" mark are treated as comments.

Signal Declarations

Test Point Names used for MDA testing are automatically recognized by the Logic test. Signals used only during a Logic test need only be declared in the LOGIC test file signal declarations.

Within the signal declaration block each non-comment line declares a digital signal for use in the sub-tests of that file. UUT Logic input signals declared in the Logic test file override declarations of signals with the same name in the MDA test program. If a stimulus can be driven by either a digital source or as an analog test point it is driven digitally. Conversely, if a UUT output is wired to both a digital input and as an analog test point it will be measured as analog. This rule for measuring an output wired both ways allows tri-state and floating outputs to be detected as well as true logic high and logic low levels.

The signal declaration syntax is: "signal_name = io_byte, io_bit" or "signal_name = io_byte, io_bit, cntrl_byte, cntrl_bit" or "signal_name.od = io_byte, io_bit". Io_byte, io_bit mask, cntrl_byte and cntrl_bit mask have the same byte and bit format as used in the DIGx commands. The last two formats identify signals that have corresponding overdrive control lines such as BANK0~ in Figure 4-10.

There are two ways to specify a signal that has overdrive (through a G80-ODM module). If the G80-ODM is wired directly to the Model G-80 using normal wiring conventions (see Figure 4-10), simply add .od to the signal name (e.g., "signal_name.od"). When control and signal bit ordering is not the same as the G80-ODM then the control bit needs to be declared explicitly. An io_bit value of 0 indicates the use of overdrive for a signal already declared in the pin names list.

Test Declarations

The sub-test "name list" contains at least one test name following "#test:" that is preceded by at least one space. The Logic Test Step can use any of the sub-test names to identify the test declared.

There are eight types of actions within the test declaration block. They are: set, set immediately, reset, reset immediately, clock, sequential, output enable (.oe), and Sum-Of-Product (SOP) declarations. One of the following declaration types are allowed within a sub-test:

    SET   implicant;
    SETI   implicant;
    RESET   implicant;
    RESETI   implicant;
    input.clk = compound_name;
    [!]{name|(dddd)} := expression;
    [!]{name|(dddd)}[.oe] = SOP expression;

A SET declaration specifies that a signal is to be held high or low until the sub-test ends, the signal is reset to tri-state via RESET or RESETI, or has its level changed by a later SET operation within the sub-test. One or more consecutive lines of SET operations are executed together without regard to ordering of the lines. The set immediate (SETI) operates like SET except that each line is executed immediately. The RESET and RESETI operations return any tri-statable signals that were previously SET back to the tri-state condition. SETI, RESETI and CLK declarations are generally intended for use with digital signals. LOGIC test control of voltage levels on analog channels can not rule out transients that could violate the test program sequence defined by SETI, RESETI and CLK declarations. The syntax to hold a signal high is "SET signal_name;". The syntax to hold a signal low is "SET !signal_name;".

The clock declaration identifies a digital signal to be used as the clock for an immediately following sequential output test. Each sequential test must be preceded by a clock declaration which declares the clock signal for the sequential test output. The sequential output is treated as rising-edge triggered if its clock signal declaration has no inversion, negative-edge triggered otherwise. If multiple signal edges must be sequenced before testing a sequential output then SETI commands can be used to specify sequencing of the additional edges before the clock and sequential declarations.

The last definition shown defines both SOP and output enable expressions. The square braces indicate an optional field. The curly braces indicates where the choice of one option is required. The vertical bar indicates a choice. The exclamation mark indicates negation. Following are definitions of terms used above:

implicant = input[*input]...[*input]

input = compound_name|(dddd)

(dddd) is a positive decimal number up to 4 digits in length.

   This number indicates the testpoint number of a UUT input instead of the
   testpoint name.

compound_name = !name|name

name begins with an alpha character.

expression = constant;|implicant;

constant = '1'| '0'

SOP   expression   =   constant;|implicant[+implicant]...[+implicant];

When an individual output to be tested has a group of setup signals to enable the output, use an output enable declaration. The output enable declaration for a signal should precede the SOP expression for a combinatorial output or the CLK declaration for a sequential output. Figure 4-12 provides some SOP expression examples. A SOP expression can consist of several lines of implicants by ending each line except the last with either a plus sign character or an asterisk. The last line needs to end in a semi-colon.

Example Logic Test

Figure 4-10 shows a schematic example and Figure 4-11 and 4-12 a corresponding Logic test file.
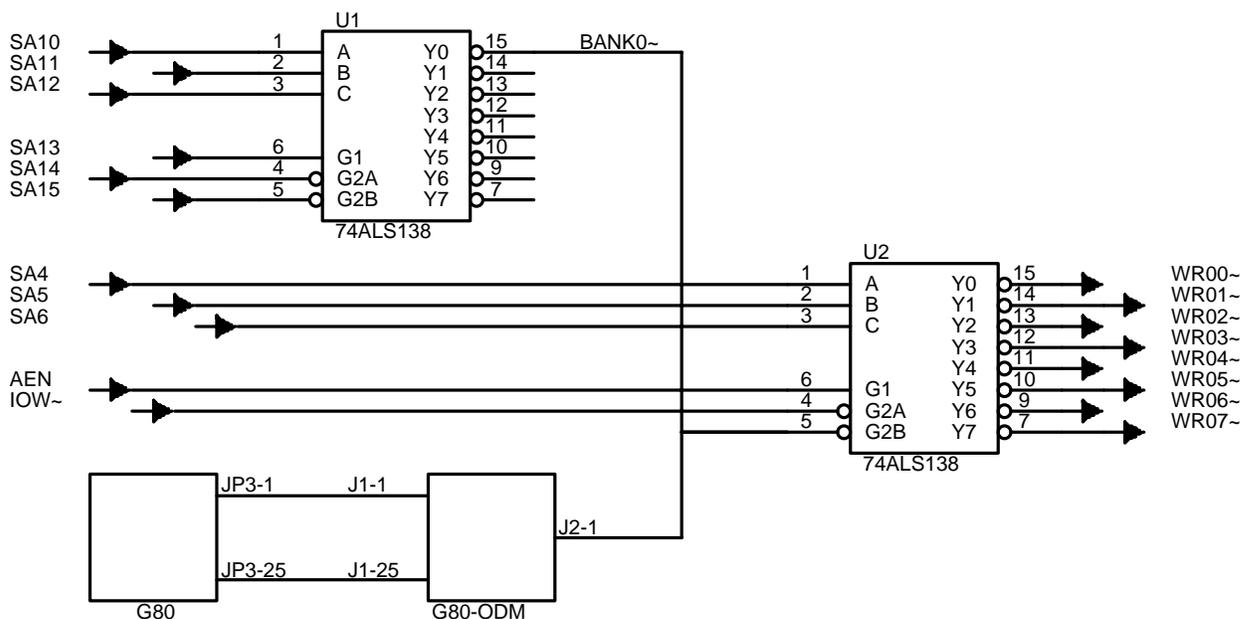

Figure 4-10 - Example Circuit for Logic Test

Figure 4-11 contains a listing of an example LOGICDEMO test program containing Logic test steps. Figure 4-12 shows the PG1.TST file used by these steps for testing U2 of the Figure 4-10 schematic. The test setup uses a Model G-80 with a G80-ODM to provide overdrive of the BANK0~ signal. Overdriving BANK0~ allows U1 to be ignored during testing of U2. Note that the signal names may be entered with upper and/or lower case characters.

```
=============================================================================

                          Test Specification Report

        Testing Facility:   HiTechTest

        Assembly ID:        LogicBoard

        File Name:          LOGICDEMO

        Report Date:        Sep 16, 1994
                Time:       13:21

        Test System:        CheckSum Model TR-4/6 Test System


=============================================================================

   ---From---    ----To----    ----------Test----------    --Limits--   --Nom--
Port    Name  Port    Name   Type   Range      Title       Low    High

                             Logic    32     PG1 U2-15  0.000   5.000
                             Logic    32        PG1 U2  0.000   5.000

     End of data
```

Figure 4-11 - Example Logic Test Steps

```
#define:
select~.od = 1, 1
#end

#test: u2-15
set !select~;
SA4 = SA4;
SA5 = SA5;
SA6 = SA6;
AEN = AEN;
IOW~ = IOW~;
BANK0~ = 0;
WR00~.oe = AEN * !IOW~;
!WR00~   = !SA6 * !SA5 * !SA4;
#end

#test: u2
set !select~;
set AEN;
set !IOW~;
wr00~  =  sa6 +  sa5 +  sa4;
!wr01~ = !sa6 * !sa5 *  sa4;
!wr02~ = !sa6 *  sa5 * !sa4;
!wr03~ = !sa6 *  sa5 *  sa4;
!wr04~ =  sa6 * !sa5 * !sa4;
!wr05~ =  sa6 * !sa5 *  sa4;
!wr06~ =  sa6 *  sa5 * !sa4;
wr07~  = !sa6 + !sa5 + !sa4;
#end

EOF
```

Figure 4-12 - Example Logic Test in ASCII Format

The PG1.TST logic test file contains two sub-tests. The U2-15 sub-test checks pin 15 output of the 74LS138 decoder after first verifying that the decoder inputs SA4, SA5, SA6, AEN and IOW~ can be toggled. This sub-test uses the set command to hold select~ (and thus the BANK0~ overdrive output) low during the entire sub-test. It also checks that the BANK0~ overdrive output is indeed held low. The sub-test calls for AEN to be held high and IOW~ low during testing of the WR00~ output on pin 15.

The U2 sub-test checks all eight decoder outputs. It uses the set command to hold BANK0~ low, IOW~ low and AEN high during the entire sub-test. This sub-test has examples of decoder outputs represented by active high (WR00~ and WR07~) and active low expressions (WR01~ through WR06~).

G80 JP3 to G80-ODM J1		
Data Location	Control Byte Location	Output Bits
DIGIO Byte 1	DIGIO Byte 4	G80-ODM J2: 01-08
DIGIO Byte 2	DIGIO Byte 5	G80-ODM J2: 09-16
DIGIO Byte 3	DIGIO Byte 6	G80-ODM J2: 17-24

G80 JP4 to G80-ODM J1		
Data Location	Control Byte Location	Output Bits
DIGIO Byte 7	DIGIO Byte 10	G80-ODM J2: 01-08
DIGIO Byte 8	DIGIO Byte 11	G80-ODM J2: 09-16
DIGIO Byte 9	DIGIO Byte 12	G80-ODM J2: 17-24

Figure 4-13 - G80-ODM Input/Output Pin Mapping When Connected to a Model G-80

Logic Test Error Logging

The MDA command line option of "*/log <file_name>* " specifies that all Logic errors are appended to a file of the specified name. Information on the Logic error detected, the specific test step number, and the date and time of step execution are included in the log file. This summary line is followed by a blank separator line and preceded by failure-specific details. The first line of an entry specifies the error type including unrecognized pin or file names, test file format errors or actual hardware logic failures. Logic failures specify the output signal name/test point and measured value. They are followed by one or more lines indicating the state of the Logic inputs when the failure was

detected. Input pin numbers are shown as negative numbers if the signal pin was forced to a logic low and as positive numbers for a logic high level.

The Logic error log file may be viewed from the Edit Screen by selecting a Logic test step then *Step Analysis*. This screen allows you to select by name another file for viewing, e.g., such as a Logic test file.

Logic Test Coverage

Each product term in the SOP expression is called an implicant of the output (which is a signal or its inverted form declared on the left of the equals sign in the signal declaration). The Logic test checks that the output goes low for one combination of inputs and that it is high for each of its implicants. If you want to test all implicants of both the signal and its complement you need to declare a SOP expression for both.

Hardware Requirements

Logic testing requires both UUT stimuli and the ability to measure UUT outputs. Stimuli can be provided by a TR-6 and TR-8-1 combination or by using digital outputs from the TR-8-1 or G-80. UUT outputs can be measured as voltages using the MDA system module or MDA MPX module or as logic levels using inputs to the MDA MPX module or G-80.

Specifications

Digital Multimeter

The DMM is used to make voltage and resistance measurements on the UUT. It can make voltage measurements through the TR-6 test points (up to $\pm$ 250 volts) or through the MDA test points (up to $\pm$ 12 volts). Low resistance measurements, through the back panel or TR-6 test points, augment the MDA resistance measurement capabilities.

DC Voltage Measurement

- Ranges: 200 mV, 600 mV, 2V, 6V, 20V 60V, 200V, 600V (max input 250V), autorange

- Accuracy: 0.5% of range

- Resolution: .05% of range

AC Voltage Measurement

- Ranges: 200 mV, 600 mV, 2V, 6V, 20V, 60V, 200V, 600V (max input 250V RMS), autorange

- Accuracy: 2% of range (40 Hz to 1 KHz)
                                   5% of range (1 KHz to 10 KHz)

- Resolution: 0.05% of range

- Input: AC or AC+DC Coupled

Resistance Measurement
- Ranges: 2, 6, 20 Ω, autorange (including lead resistance)

- Resolution: .05% of range

- Accuracy: 3% of range ($\pm$ 2 Ω)

- Ohms Source: 100 mA

DMM General
- Voltage levels: The DMM can take fully floating differential measurements on ranges up to 6V. Neither input can exceed $\pm$ 8 from the computer chassis. On the 20V and higher ranges, measurements are ground-referenced.

- Measurement Speed: ~60mSec (AC readings and filtered DC readings ~500mSec)

Counter/Timer

The counter/timer is used to measure frequencies and periods. It is typically used to measure UUT oscillator frequency and other UUT signal frequencies. Inputs can be taken from the unswitched back panel connector, the TR-6 switching, or through the MDA test points. The DMM input (usable to 50 KHz) can be accessed for low-level differential inputs through the TR-6 test points. The optional Model TR-6-2 Interface can be used to buffer, and divide frequency signals in close proximity to the UUT.

- Frequency range: DC to 10 MHz (higher frequencies can be prescaled by Model TR-6-2 in fixture - see accessories)

- Channels: 2 plus DMM input

- Triggering: Programmable threshold -2.2 V to +2.2 V

- Input Level: 300 mV to 5 V (60 mV to 250 V through DMM channel)

- Coupling: AC/DC

- Common: Ground-referenced (except on differential input ranges of DMM)

- Frequency
    Ranges: 5 KHz, 50 KHz, 500 KHz, 5 MHz, 10 MHz
    Resolution: .0015% of range
    Accuracy: .01% ± 2 counts

- Period:
    Range: 12.8 µS - 128 Sec
                  (in 8 decade ranges)
    Resolution: .0015% of range
    Accuracy: .01% ± 2 counts

- Totalize:
    Range: 1 to 65,535 counts
                  (up to 5MHz input)

- Pulse Width:
    Specifications   Same as period
    Function: Start and stop slope-selectable

Function Generator

The Function Generator is used to provide UUT stimulus. It can provide DC-V, sine and square waves. Both square wave output levels are separately programmable to provide full flexibility.

The stimulus is available at unswitched Model TR-6 back panel outputs, or at MDA test points. All three stimuli are available simultaneously with some limitations (sine and square frequencies must match, square wave must be ground-referenced). When switched through the MDA test points, the total path resistance is 1 Kohm or less. Each function generator output can source up to 10mA into low impedances, but the current/voltage is limited by the switch resistance.

- Functions: DC Voltage / Sine Wave / Square Wave

- Frequency Range: DC, 3 Hz - 40 KHz in 55 discrete steps

- Common: Ground-referenced

- Frequency Accuracy: .01%

- Harmonic Distortion: 1%

- Amplitude Accuracy: 1% of scale (DC)
                                 5% of scale (20 Hz to 1 KHz)
                                 10% of scale (1 KHz to 20 KHz)

- Sine Amplitude: 100 mV to 20 Vpp (.1dB steps)

- Square Wave Amplitude: Each level programmable from -10V to +10V (5mV steps)

- DC V Amplitude: Programmable from -10V to +10V (5mV steps)

Power Outputs

The Model TR-6 makes PC-power available at the back panel connector. Each supply is fused on the TR-6 with a plug-in fuse. Fuse status is determined by system self-test.

The power outputs can be used to power UUTs with limited current requirements. The power outputs can be switched to the UUT with use of the undedicated relay switches on the Model TR-6.

- Fixed outputs: +12V fused at 1A
                                 -12V fused at .1A
                                 +5V fused at 1A
                                 GND unfused

Digital I/O

The Model TR-6 provides digital capabilities which allow you to perform low-speed digital input and output for test of UUT functionality. The digital I/O capability can also be used to drive relays or send and receive digital signals and switch closures controlling test flow.

The standard Model TR-6 includes eight bits of digital I/O capabilities. These bits are available at the TR-6 back panel. Open-collector outputs can directly control external relays requiring up to 100mA when used with an external source. The digital outputs can be left floating, or jumper-connected on the TR-6 through pull-ups to either +5V or + 12V. The status of the eight bits can be read back by the system.

The digital I/O capability of the system can be expanded by 96 non-multiplexed bits with the addition of a Model G-80 Digital I/O Module. Each bit on this module is individually bidirectional and can sink up to 24mA.

When used in conjunction with MDA MPX modules (such as the Model TR-8-1), the system provides an additional 16-bits of digital I/O per MPX module. On these modules, the first sixteen test points can be switched from general purpose analog MPX points to digital I/O points when performing power-on testing. These points can source up to 2 mA and sink up to 24 mA.

Basic TR-6 Digital I/O

- Bits: 8
- Direction: Output   w/readback
- Logic Family: 5V   TTL/LS/HC-MOS
- Outputs: Open-collector   w/pull-up
- Distribution: Back panel connector only
- Sink/Source: Sink 100 mA. Source determined by pull-up resistor
- Pull-ups: 10K socketed pull-up to +5V or +12V

Undedicated Switching

The Model TR-6 provides four undedicated relays, available at the back panel, that can be used for various testing needs such as switching power or other signals to the UUT. Typically, all of the signals from the Model TR-6 back panel connector are available inside the test fixture. When a test fixture is built for a particular UUT, other TR-6 signals and UUT test points can be connected to the undedicated relay connections for use during the power-up tests.

In addition, an accessory 16-pin ribbon cable header on each Model TR-6-1 MPX Module provides four relays for custom use.

- Undedicated Switches: 4 SPDT relays hardwired to back panel (12 connections)

- Contact Rating: 250V, 1A, 30 VA resistive switched

- Isolation: 250V RMS

Test Point Switching

The Model TR-6 provides 16 relay-switched test points at its back panel. These test points can be expanded in 50-point increments by adding Model TR-6-1 Relay Modules (up to 6 TR-6-1 modules can be configured into a system).

The relay test points are used for UUT connections that exceed ± 12 volts with respect to the computer chassis when power is applied to the UUT. The Model TR-6 can make DMM and Counter/Timer measurements at these points. In addition, unguarded 2-wire MDA measurements (e.g. resistance, capacitance and inductance) can be made through these points.

- TR-6 Test Point Matrix: 16 relay-switched test points. Each TR-6 relay test point may be specified as a high or low for DMM measurement.

- Relay Expansion: The matrix may be expanded in 50-point increments with the Model TR-6-1 Relay Expansion Module. Each TR-6-1 module uses one full-length/full-height PC slot.

- MDA Test Points: 2-wire measurements from the MDA test points can be made through the Model TR-6 matrix. TR-6 source and measurement capability (except high-voltage & resistance measurement) is available from all MDA

test points. Multiple sources can be active at MDA test points while making measurements.

Fixture Interface Module

The Model TR-6-2 Fixture Interface Module is designed to be used inside or near the UUT fixture to help support functional test operations. Connecting to the Model TR-6, it provides a number of special capabilities with wire-wrap terminals for connection to the UUT and test point electronics. The basic module contains fundamental capabilities, and by setting jumpers and adding components as necessary, you can perform a number of specialized functions.

Under automated control of the Model TR-6, it provides power relays that can be used to switch power supplies or other signals to the UUT, an interface to the counter/timer that allows you to redrive or frequency-divide low-level UUT oscillator signals, dual instrumentation amplifiers that can buffer and differentially amplify low level signals for the DMM, two shunt locations for current monitoring and a bread-board area for custom circuitry.

The Fixture Interface includes stand-offs for easy mounting inside the fixture or on any flat surface. The 50-pin ribbon cable from the Model TR-6 back panel can be directly plugged into the Fixture interface, or when used inside a Model TR-3 vacuum test head, the special Model TR-6-3-THC plugs directly from the Fixture Interface to the inside of the fixture wiring block connected to the Model TR-6.

The basic Fixture Interface contains two power relays, connectors and interface circuits. You can install your own components to tailor it to your application or purchase kits from CheckSum to populate it as necessary. The Model TR-6-RLY is an additional power relay (up to 8 can be installed), the Model TR-6-CT is the counter/timer interface, the Model TR-6-2-DMM is the DMM signal conditioner interface parts, and the Model TR-6-2-SWO allows change-over of test points from one source to another (or isolation of the test points to eliminate loading).

Mechanical

- Size: 8" x 6.9" x 3"H (with relays installed).

- Mounting: 8 - 3/4" x #6 screws (not included)

Relay Switching

- Provisions for up to 8 DPDT (2 form-C) relays

- Contact rating 10A, 250VAC, 240VA

- Remotely controlled by Model TR-6

Counter/Timer Interface

- Inputs: 2 via wire-wrap or SMA connectors
- Frequency divider ratios: 2, 4, 8, 16
- Sensitivity: 100 mV
- Frequency response: 50 MHz

DMM Signal Conditioner Interface

- Dual 2-input buffer amplifiers
- Amplification ratios: 1 to 1000
- Max input voltage: ± 6 volts, differential

Switch-Over Module

The Model TR-6-2-SWO modules install in the Model TR-6 Fixture Interface Module allowing test points (close to the UUT) to be switched from one source to another (e.g. digital to analog) or to isolate pins to reduce capacitive loading.

- Each switch-over module installs in 2-power relay positions (for a maximum of 4 switch-over modules with no power relays installed).
- Provides 17 ganged test point switch-overs per module.

Model RM-1 Relay Module

The Model RM-1 Relay Module general purpose Relay Module can be installed in an unused short 8-bit controller (PC) slot. It provides eight (four form-C and four form-A) undedicated relays rated at 1A (up to 250VAC) for switching UUT power and signals. It includes a backpanel 37-pin D-sub mating connector to accept your custom wiring. It is controlled by the System's 'PortO' test step type.

Model-GPIB IEEE-488 Interface

The Model GPIB provides IEEE-488 interface capabilities for the test system. The GPIB module installs in an 8-bit PC short slot. It comes with a 2-meter cable for connection to

the first GPIB device, embedded firmware and software support, and drivers for other languages.