Fracture Technology Associates

**Automated Fatigue Crack Growth Testing – G4 Development
Version 3+.15.06**

Users' Multiple Crack Monitor Manual

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1.0   Introduction to FTA's FCGR G4 (V3+) Multiple Crack Monitor Application

1.1   System Concept

Fracture Technology Associates' Multiple Crack Monitor (MM) software provides additional functionality to the standard Fatigue Crack Growth Rate package by allowing the use of multiple and simultaneous crack monitors using compliance and DCPD techniques as outlined below:

- Simultaneous and multiple compliance and DCPD crack monitors (up to ten of each) are available. The total combined compliance/DPCD monitors are limited only by the 16 analog input channels available.

- A hardware configuration file can be created and saved (*.pr8) for the configuration of all 16 analog input channels.

- The analysis files (*.in3) are compatible with the existing version 3 analysis software.

1.2   About This Manual

This document is intended to provide support and background for the use of the software upgrade features only. Full familiarity with the standard system is assumed: readers seeking information on the use of the FCGR package are directed to FTA's steady state reference manual.

2.0   Installation Guide

2.1   Connecting the ADwin to the Controller

The ADwin-Gold is factory-calibrated and configured for differential inputs, although FTA can provide a calibration procedure upon request. The ADwin must be grounded for use in conjunction with a test machine: it should be grounded to the system console or the common ground of the controller (refer to the ADwin hardware manual *Start Up* section for details). The standard manual covers installation not specific to this upgraded software.

2.1.1   ANALOG INPUT AND OUTPUT CONNECTIONS

Sixteen analog input channels are available and can be configured through software. Channels are scanned sequentially starting with **IN 1** and **IN 2.** Therefore, if only eight channels are required, it is advisable to select **IN 1** through **IN 8**. Channels are

multiplexed in pairs, therefore **IN 1** and **IN 2** are simultaneous as are **IN 3** and **IN 4**… etc. It is recommended that the two channels necessary for compliance testing (load and displacement) be assigned according to these pairs (eg **IN 1** = load; **IN 2** = displacement).

2.1.2 DIGITAL INPUT AND OUTPUT CONNECTIONS

A custom cable can be provided, supporting two digital outputs for DCPD current switching and two digital inputs for Run-Stop and Auxiliary Interlocks. This cable connects to **CONN 2** (digital out) of the ADwin. Pins 5 and 13 of this connector monitor the run state of the controller (pin 5 connects to 'high' and pin 13 to 'low/ground' of a digital-in logic signal. Pins 18 and 25 of this connector monitor the auxiliary interlock status of the system (pin 18 connects to 'high' and pin 25 to 'low/ground' of a digital-in logic signal. To allow each digital input to function with relay contacts, pins 5 and 18 are each connected to the 5 volt source from pin12 through a 2K ohm resistor. Therefore a closed relay is low (0 volts) and an open relay is high (5 volts). The RUN-STOP is tripped in the high state (relay open) and the Auxiliary Interlock is tripped in the low state (relay closed).

Pin 1 (red wire) provides a digital output for the forward state of the DCDP current supply and pin 14 (black wire) provides a digital output for the reversed state of the DCDP current supply. The shield provides the ground for each digital output and is connected to pin 25.

3.0 Using FTA's FCGR G4 (V3+) software system

Full familiarity with the Automated Fatigue Crack Growth Testing and Analysis Manual is assumed. For easy cross reference to the standard manual, the section numbering system of the standard manual has been maintained, hence numerous gaps in section numbering will be noted in this supplement.

The following section of this guide outlines the start-up sequence unique to the multiple crack monitor capability. Activation of multiple compliance and DCPD crack monitors is assumed.

1. Turn on power to the Adwin.
2. *Open the FCGR testing program. On the initial **Splash Screen**, choose the crack monitor type (both Compliance and DC Potential Drop) and application (Steady State).*
3. Click **New Test**. Ensure the green light on the Adwin is blinking, which indicates communication with the computer.
4. When the **Main Menu** appears, choose either English or Metric units (English units are assumed here). *If the program is already open from a previous test,*

*ensure the function generator has been reset by clicking **Reset FNG** on the **Full Function Generator Control (FNG)**. This resets the hold level to zero. Also ensure that the frequency is set to 1 Hz and that **FNG shutdown** is ticked.*

5. From the **Main Menu**, go the **Input** dropdown menu and choose **Hardware Configuration** to open the **Hardware Configuration** form. *Note that the form has four tabs, which are typically addressed from left to right.* Note that the crack monitors are numbered 1-10 for compliance and 11-20 for DCPD. Select the **Activation** tab. Use the blue button to **Load [a] Hardware Configuration** file (.pr8). Inspect and/or modify the contents of the **Activation, Allocation, Calibration and Configuration** tabs to conform to the analog input requirements (see section 4.4.1.a for details about these tabs). Once properly configured, press **Send to ADwin** button. Use the **Save Hardware Configuration** button to save modifications to the original hardware configuration file. Once configured, the **Enable** check box should be un-checked to prevent accidental modification of the configuration parameters. In this mode, activation of the crack monitors and the selection of the Master monitor is still enabled but all other changes are locked out.

6. From the **Main Menu**, go the **Input** dropdown menu and choose **Data** to open the **Data Input** form. *Note that the form has six tabs, which are typically addressed from left to right.* Select the **Initialize** tab. Enter the Test ID.

7. **Start Log File** by pressing the blue button and establish the correct file path.

8. A test parameter file must be loaded for each crack monitor. The software default is **Comp 1.** Use the blue button to **Load [a] Test Parameter** file. Then press **Send to ADwin**. Press **Comp** to increment to the next compliance monitor. Repeat the **Load [a] Test Parameter** file and **Send to ADwin** processes for each compliance crack monitor. For DCPD crack monitors, press **DCPD** and **Load [a] Test Parameter** file and **Send to ADwin** for each DCPD crack monitor.

   NB **Send to ADwin** *must* be pressed for each crack monitor, whenever its parameter file has been created or changed.

9. Now go to each tab to confirm correct values. Values in white data input boxes are common to all crack monitors. Light blue boxes contain values unique to each individual compliance crack monitor and light green boxes are unique to each DCPD crack monitor. Darker shades of blue or green must be manually updated by pressing the **Receive from ADwin** button. Inactive text boxes and labels are grayed out.

10. **Send to ADwin** and **Print to log**.

11. **Save Test Parameter[s]** file (blue button on the **Initialize** tab) for each crack monitor for future use. Press **Comp** or **DCPD** to select crack monitor type and number.

12. Return to the **Input** dropdown list on the **Main Menu**, and select the **General Information** form. Load a previous form or input new values and save file for future use.

13. Go to the **Control** dropdown list, and open the **Full Function Generator Control (FNG).**
14. From the **Display** dropdown list, open **Compliance Status, DCPD Status, Load-Displacement, Load-DCPD** and **da/dN-dK** displays. These overlapping forms are arranged on the screen so that bringing any of them to the foreground can be done with a single mouse click on the exposed part of the form. Pressing **Crack Monitor** toggles through the available crack monitors. If the monitor is active, then the adjacent crack monitor number is bold, otherwise it is grayed-out. Pressing either **Comp** or **DCPD** on the **da/dN-delta K** form highlights data associated with the appropriate crack monitor.
15. Refer to the standard manual or specific application notes for continuation of this start-up procedure. However, it is recommended that the **FNG** be started at 1 Hz and the sample cycled at low load to test the functionality of all crack monitors.

Important Application Notes:

Most data entries and test modifications can be performed 'on the fly' while the test is running without unintended consequences. However, this degree of flexibility should be used with caution.

In particular, it is recommended, but not required, that the function generator be stopped when changing waveforms or while modifying the hardware configuration.

Disabling **Command Control** on the **FNG** form is recommended prior to any data entry that could affect the calculated load (such as modifying K-control parameters). It should also be noted that modification of the command signal is not disabled when using the **Custom Waveform Sequence** or when using the **Variable Amplitude Application** (selected during initial program loading).

4.0 FTA's FCGR G4 (V3+) software system: Description of Menus and Tabs

The following section offers a description of the display forms and input parameters associated with using the Version 3+.14.12 (V44) software application. Please refer to the Steady State Reference Manual for descriptions common to both standard testing and these advanced concepts.

4.1 Splash Screen
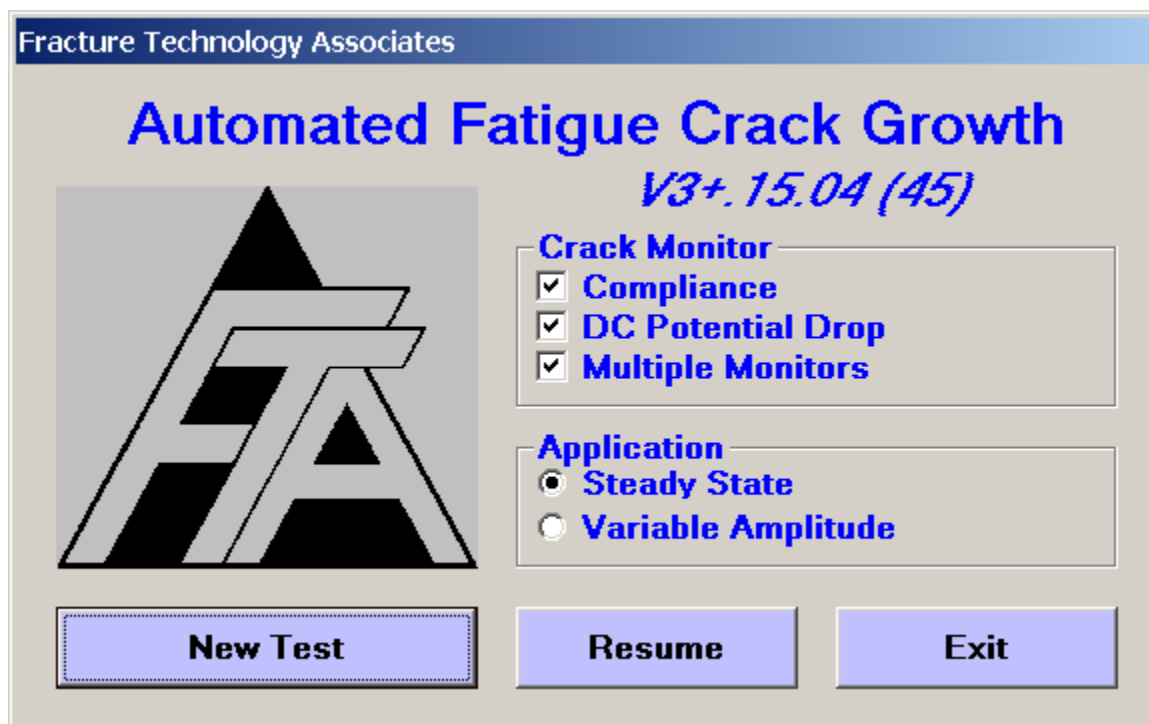
When the FCGR testing program is first opened, the **Splash Screen** is displayed. The application title and version number are identified at the top of this form.

From this form the **Crack Monitor** type (**Compliance** and/or **DC Potential Drop)** is selected. The **Multiple Monitor** check box must also be selected to utilize the features of this software upgrade.

4.2   Main Menu
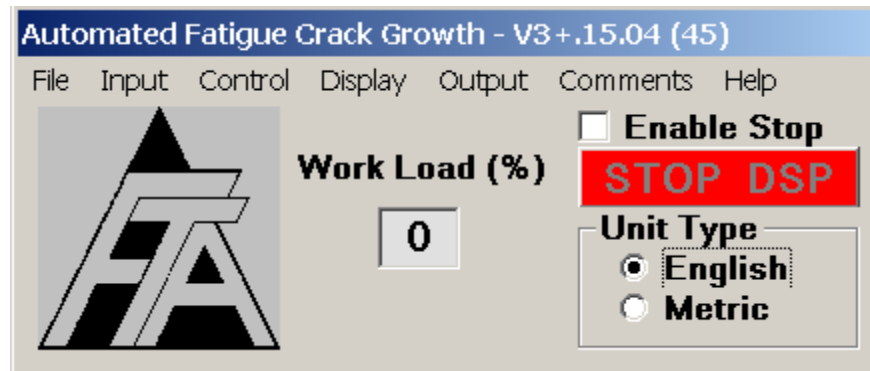
The **Main Menu** is always displayed while the program is running: its default position is in the upper left-hand corner of the computer screen.

4.3   File

4.3.1   SAVE ANALYSIS FILE …

For multiple crack monitors, the file being stored corresponds to the active monitor of the **Data Input** form. For analysis and data storage, each crack monitor is considered a separate test. Each monitor's .in3 file *must* be saved individually. The crack monitor number is automatically appended to the file name. A **Save Multiple Analysis Files** menu option simplifies the storage of multiple crack monitors.

4.4   Input

From the **Main Menu**, the **Input** dropdown menu accesses the **Hardware Configuration** form, the **Data Input** form; and the **General Information** form. All data entry except function generation and control is carried out from the **Input** menu. Data are transferred between the PC and the ADwin when the **Send to ADwin** and **Receive from ADwin** buttons are pressed. When a change is made to the input data, the **Send to ADwin** button will flash indicating that the change has not yet been sent to the ADwin. When the **Receive from ADwin** button is pressed, the user will notice that all fields in cyan, darker shaded blue and darker shaded green will be updated with the latest information from the ADwin. Pressing **Receive from ADwin** does not alter test conditions and may be done at any time during a test. All data contained in the **Data Input** form can be dumped to the .log file using the **Print to Log** button.

*NB When you enter data in a text box, it is not transferred to the corresponding variable until you click on another text box or command button such as **Send to Adwin**.*

4.4.1A HARDWARE CONFIGURATION

The **Hardware Configuration** form consists of four tabs: **Activation**, **Allocation**, **Calibration**, and **Configuration**. These tabs are organized in the logical order in which data would be entered to configure the hardware. If a hardware configuration file exists, it should be loaded (.pr8 extension). Otherwise the hardware can be configured with the form and its contents saved for future access. Hardware configuration entries are not transferred to the ADwin until the **Send to ADwin** button is pressed. The **Receive from ADwin** button may be pressed to retrieve the current hardware configuration status from the Adwin.

4.4.1a.1 Activation
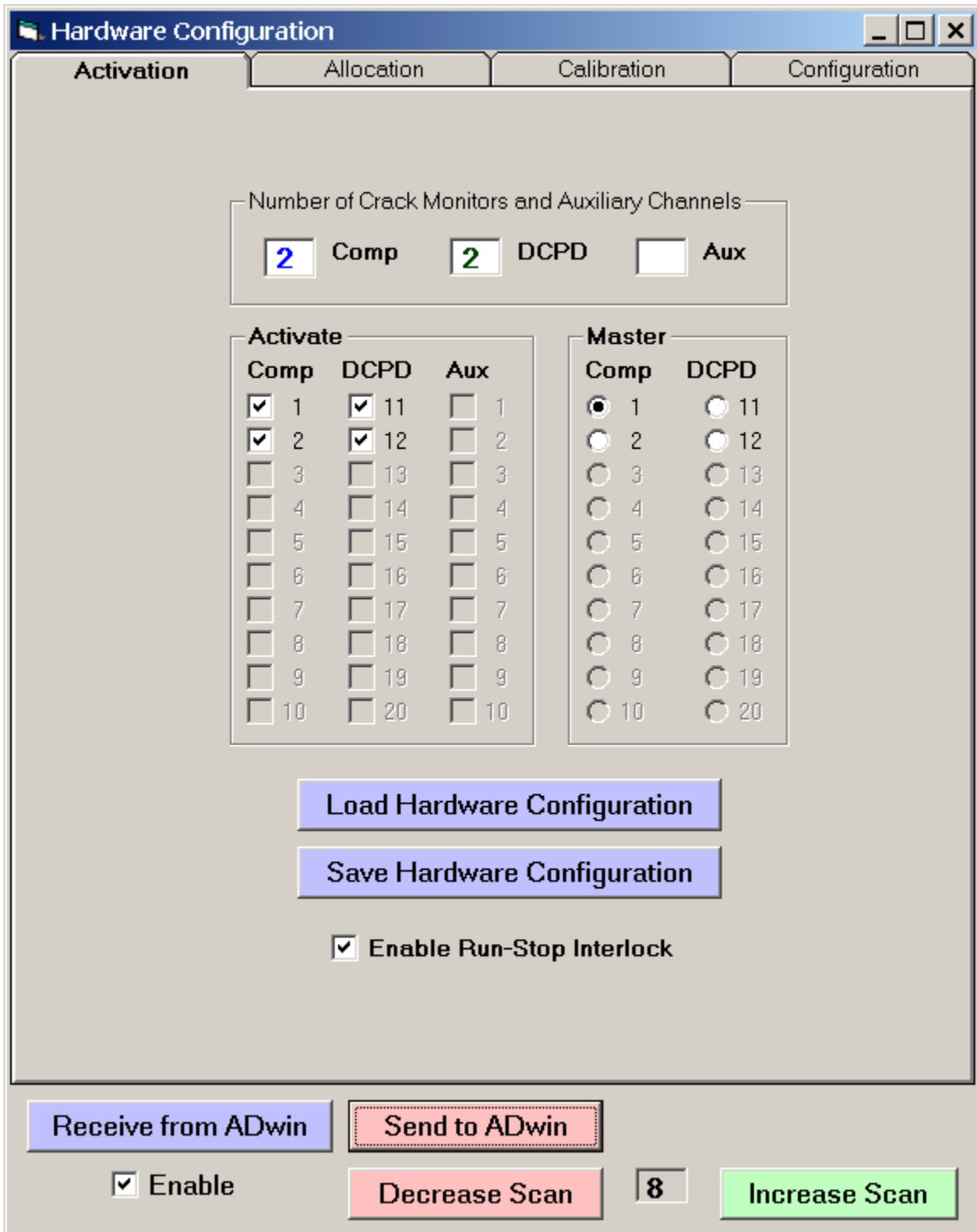
The **Activation** tab allows selection of the number of compliance and DCPD crack monitors and auxiliary channels, activation of each crack monitor, and selection of the master monitor for K-control tests. This tab also allows loading and saving of hardware configuration files. Note that **Enable Run-Stop Interlock** has been added to this tab.

Note that the default number of active ADwin channels is six (**IN 1** through **IN 6**). However, additional channels may be activated by pressing the **Increase Scan** button on any of the four tabs. Channels are increased sequentially. These channels are allocated by the user on the next tab of the hardware configuration form.

4.4.1a.2   Allocation

The **Allocation** tab allows selection of analog input channels associated with each crack monitor. Different crack monitors can share the same analog input channel as long as the channel designation is common. For example, multiple DCPD monitors

might share the same DCPD reference channel and multiple compliance monitors might share a common force channel.

In the above example, the compliance crack monitor #1 is associated with ADwin channels **IN 1** (force) and **IN 2** (displacement). Compliance crack monitor #2 is associated with ADwin channels **IN 5** (force) and **IN 6** (displacement). Two potential drop monitors, # 11 and #12, are associated with ADwin channels **IN 3** and **IN 7** (DCPD active) and **IN 4** and **IN 8** (DCPD reference), respectively.

4.4.1a.3 Calibration

The **Calibration** tab allows selection of calibration factors for each analog input. The **Channel Designation** and the **Units** are automatically defined by the contents of the **Allocation** Tab.

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4.4.1a.4 Configuration

The **Configuration** tab allows selection of the **Polarity**, programmable **Gain**, and **Rolling Average** for peak reading of analog input signals. The standard **Gain** of x1 provides + to -10 volt inputs. However, lower level signals could benefit from gains of x2, x4 or even x8. For peak reading of sine waves, the three point rolling average is

suggested to get the most accurate noise free peaks. However, for triangle waveforms, a one-point rolling average would provide a more accurate representation of a peak. Note that **Normal Command Polarity** has been added to this tab.

It is essential that if load cell polarity is reversed (for compressive loading on bend bars, for example), then the command signal polarity is also reversed.

4.4.1 DATA

The **Data Input** form consists of ten tabs: **Initialize, Calibration, Coefficients, Dimensions, Force, Compliance, DCPD, Storage and Limits.** These tabs are organized in the logical order in which data would be entered to start a test. Inactive data fields are displayed in gray.

Data entries are not transferred to the ADwin until the **Send to Adwin** button is pressed.

Cyan, darker shaded blue, or green fields are not updated on the computer screen until the **Receive from ADwin** button is pressed, thus retrieving the current data from the ADwin.

*NB Once a test has been started, it is important to **Receive from ADwin** before pressing the **Print to File** button or changing test conditions.*

4.4.1.1 Initialize

At the bottom of the form are **Comp** and **DCPD** command buttons allowing the selection of individual crack monitors.

A **Load Multiple Parameters** command button has been added to simplify the process of loading multiple parameter files.

A **Save Multiple Parameters** command button has been added to simplify the process of saving multiple parameter files.

Three blue buttons at the top of the tab allow the creation and saving of parameter and log files:

- **Start Log File**: prompts the user to specify the storage path for the log file, which is saved automatically. The log file may then be viewed under **Recent**

Documents on the Windows **Start** menu. Note that all crack monitor data are recorded in a single log file.

- **Load Test Parameters**: loading a parameter (.par) file populates the **Data Input** form with all the information necessary to start a test (except the **Test ID)**, edited as required. Parameter files contain geometry designations, calibration constants, and other specific test information. Use of parameter files can save time and reduce the risk of errors when entering repetitive information such as coefficient values. Parameter files must match the crack monitoring choice made at the bottom of the **Input Form** (**Comp or DCPD**). A test parameter file must be loaded for each crack monitor type and number.

- **Save Test Parameters**: pressing this button saves the current information with the Test ID for future reference and/or loading.

After a box is ticked, the **Send to ADwin** button must be pressed to communicate the change to the ADwin. The box is then cleared automatically so the action is not repeated accidentally. All of these selections may be made without stopping a test and may be carried out individually or in combination.

4.4.1.2 Calibration
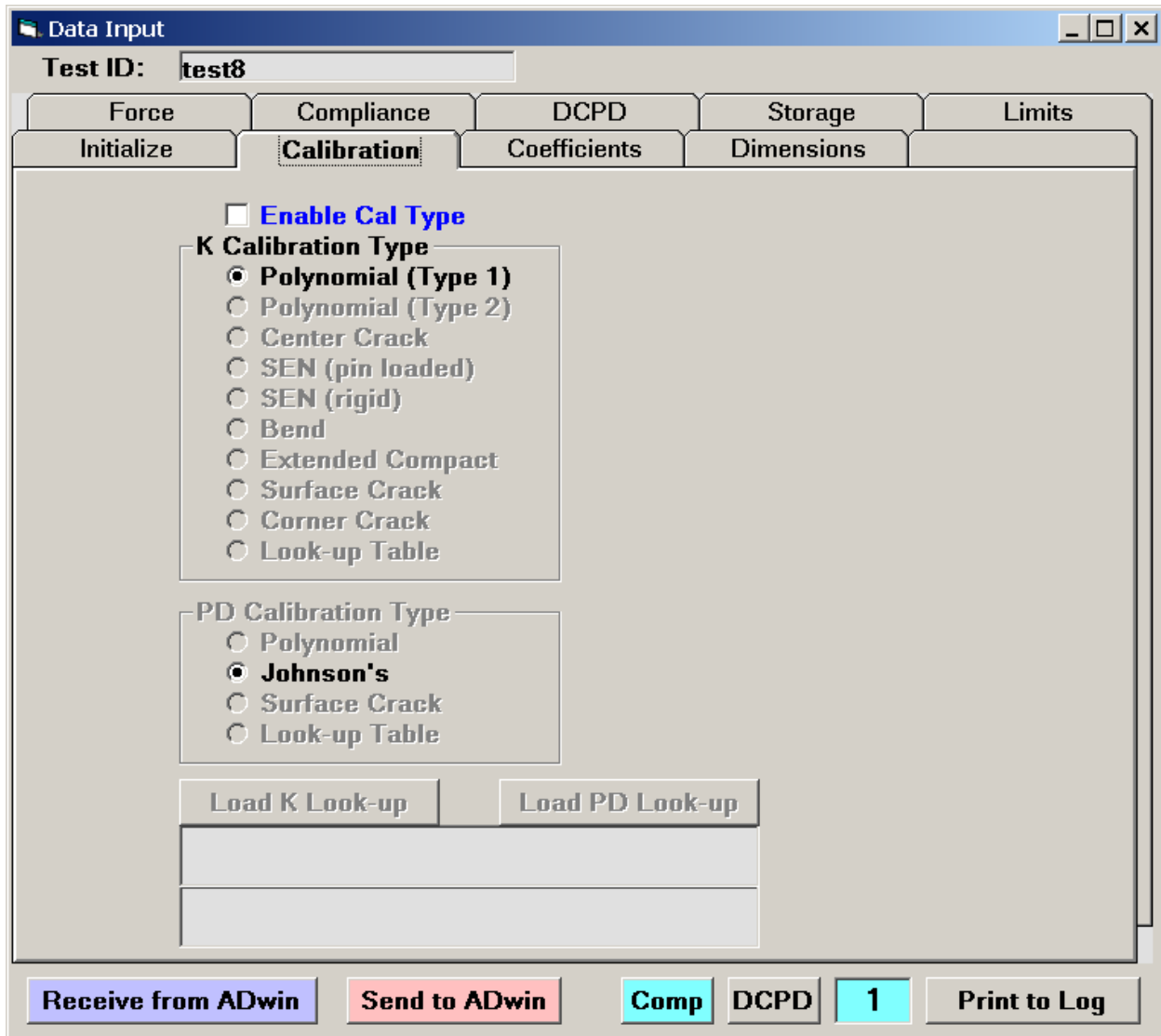
This tab displays the stress intensity and DCPD calibration options selected.

4.4.1.3 Coefficients

Data Input

Test ID: test8

| Force | Compliance | DCPD | Storage | Limits |
| Initialize | Calibration | **Coefficients** | Dimensions | |

Stress Intensity		**Compliance**		**DC Potential Drop**	
K0	0.886	C0	1.00098	PD0	0.0
K1	4.64	C1	-4.66951	PD1	0.0
K2	-13.32	C2	18.4601	PD2	0.0
K3	14.72	C3	-236.825	PD3	0.0
K4	-5.6	C4	1214.88	PD4	0.0
K5	0.0	C5	-2143.57	PD5	0.0

Type 1: $K = (P / (B * W^{0.5})) * ((2 + a/W) / (1 - a/W)^{1.5}) * f(a/W)$

Type 2: $K = (P / (B * W)) * (PI * a)^{0.5} * f(a/W)$

	Stress Intensity		**Compliance**		**DC Potential Drop**	
	a/W	f(a/W)	a/W	f(a/W)	a/W	f(a/W)
I	0.002	1.810	0.002	10.235	0.044	-0.211
F	0.998	4120.580	0.998	8776.000	0.998	6.230

Receive from ADwin | **Send to ADwin** | **Comp** | **DCPD** | 1 | **Print to Log**

This tab displays the coefficients of fifth-order polynomial expressions used to calculate stress intensity and crack length.

4.4.1.4 Dimensions

This tab displays the specimen dimensions.

4.4.1.5 Force

This tab displays the force parameters. K-control is based on the master monitor only

4.4.1.6　Compliance

Data Input

Test ID:　test8

| Initialize | Calibration | Coefficients | Dimensions | |
| Force | Compliance | DCPD | Storage | Limits |

Number of Slopes　　　　　　　　　　20.　　　10

☑ **Enable Slope Number Adjustment**

Modulus of Elasticity (Msi)　　　　30.0

Crack Length

Slope Measurement　　　　　☑ **Enable Auto E**　1.04026
　☑ **Data on Loading**
　☑ **Data on Unload**　　　　**Auto E Adjust**　0.0

Minimum and Maximum Slope Level (%)　50.0　　99.0

Minimum Correlation Coefficient　　0.99

Upper Pop Limit (%)

☑ **Enable Crack Closure Measurement**　85.0

Initial EvB/P for ACR　　　　　0.000

Initial CR　　　　　　　　　1.000

☐ **Calculate Kres and Save Disp @ P0**　☑ **Enable ACR Initialize**
　　　　　　　　　　　　　　　ACR Initialize

Receive from ADwin　　**Send to ADwin**　　**Comp** **DCPD** 1　**Print to Log**

Toggle through compliance crack monitors using the blue **Comp** button. In the above example, values for compliance crack monitor #1 are displayed. Note that values in active white boxes apply to all crack monitors.

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4.4.1.7   DCPD

Toggle through DCPD crack monitors using the green DCPD button. In the above example, values for DCPD crack monitor #11 are displayed. Note that values in active white boxes apply to all crack monitors.

4.4.1.8   Storage

The storage tab displays unique information for each crack monitor. Toggle through these using the **Comp** and **DCPD** buttons at the bottom of the tab.

4.4.1.9   Limits

The limits tab displays various limit conditions for test termination. Upon reaching a limit condition the function generator is stopped. Toggle through these using the **Comp** and **DCPD** buttons at the bottom of the tab.

The **Save Multiple Parameters** command button has been added to this tab.

4.5   Control

4.5.1 FULL FUNCTION GENERATOR CONTROL (FNG)

See standard manual for details.

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4.5.4 THE MATRIX

For multiple crack monitor applications, the **Matrix** applies to the master monitor only.

See standard manual for details.

4.6   Displays

The displays are identical to single monitor applications except that **Crack Monitor** command buttons have been added to change the monitor that is actively displayed.