



## ***Fracture Technology Associates***



**Automated Fatigue Crack Growth Testing – G4 Development  
Version 3+.15.06  
Supplement to Variable Amplitude Manual**

**June 2015**

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## **1.0 Supplement to Variable Amplitude Manual**

The following are upgrades to the Variable Amplitude (VA) software.

- A custom waveform sequence allows unique time based ramps and holds between specified end levels. Enhanced waveform integration is included to minimize the risk of underload/overload.
- The 'Matrix' has been enhanced to allow activating and changing the waveform sequence according to the event table.

## **1.2 About This Manual**

This document is intended to provide temporary support of upgrades that have not yet been incorporated in FTA's variable amplitude reference manual.

## 4.1 Splash Screen

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# Automated Fatigue Crack Growth

*V3+. 15.04 (45)*

**Crack Monitor**

- Compliance
- DC Potential Drop
- Multiple Monitors

**Application**

- Steady State
- Variable Amplitude

**New Test**      **Resume**      **Exit**

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. If a different crack monitor type is required for subsequent tests, the program must be shut down completely and restarted.

The **Application** is also selected at this point. Options are **Steady State** or **Variable Amplitude**. For the **Custom Waveform Sequence**, the **Steady State** selection must be used.

#### 4.4.1.1 Initialize

**Data Input**

Test ID: test

Force Compliance Storage Limits

Initialize Calibration Coefficients Dimensions

Test ID: test

Start Log File

Load Test Parameters

Save Test Parameters

Clear Correction

Cycle Count Preset: 0

Initialize

Clear Data Buffer

Clear Cycle Count

Clear Elapse Timer

Restore Data Buffer

Specify Data Buffer Size

1

Data Buffer

% Used

Data storage path

I:\Software Development\FCGR ADBasic development for G4 Software\Version 44

Receive from ADwin Send to ADwin Print to Log

New screen showing **Clear Correction** check box.

#### 4.4.1.6 Force

Data Input

Test ID: test

Initialize	Calibration	Coefficients	Dimensions
<b>Force</b>	Compliance	Storage	Limits

Maximum Load (lbs) 2000.0

Stress Ratio (R) 0.00

Load Decrease Only

**Control Type**

- Constant Load
- K Control - (Constant C)
- K Control - (Look-up Table)

**K Control Mode**

- Fixed Stress Ratio
- Constant Kmax

**K Control Parameters**

Initial a (in)	0.00	1.04004
Initial Kmax (ksi sqrt[in])	0.0	29.09
K-Gradient (1/in)	0.00	
Initial Delta K (ksi sqrt[in])	0.0	
<input type="checkbox"/> Enable K-Gradient Calculation		
Final a (in)	0.00	
Final Kmax (ksi sqrt[in])	0.0	

Receive from ADwin Send to ADwin Print to Log

New screen showing Stress Ratio is grey out.

## 4.5 Control

### 4.5.1 FULL FUNCTION GENERATOR CONTROL (VARIABLE AMPLITUDE)

**Full Function Generator Control**

DAC Rate: 400    Data Sync: 68,334    Circular Buffer: 68,353

**Waveform**  
 Sine  
 Triangle

**Response Rate**  
 5x  
 Standard  
 1/5

**Command Control**  
 Standard  
 1/2  
 1/4

**Control Status**  
 FNG Shutdown  
 Command Control  
 Slope Analysis  
 Data Storage

**Clear Message**    **Reset FNG**

**Raise Rate**    **Raise Hz(max)**    **Raise Hz(min)**    **Raise Hold**  
 1000    10.0    0.100    0

**Lower Rate**    **Lower Hz(max)**    **Lower Hz(min)**    **Lower Hold**

**Pre Load**  
 0

Coarse Adjustment  
 Fine Adjustment  
 Ramp to Hold Level

**Load Rate (units/sec)**  
 1000

**Frequency (Hz)**  
 0.612

**Cycle Count**  
 1,227

**Pass Count**

**Display**  
 Volts  
 Engr.

**IN 2** ▾

**Run**    **STOP**

End Point Status		Load (lb)	FNG Out (lb)	Load (lb)	Disp (in)
Error (lb)	3DCF (lb)				
0	0	0	1,017	1,015	0.00406
Max	0	202	284	529	0.00212
Min	0	1,019	1,019	283	0.00113

**No FNG shutdown conditions**

New screen showing variable amplitude FNG.

#### 4.5.1 FULL FUNCTION GENERATOR CONTROL (CUSTOM WAVEFORM SEQUENCE)

The screenshot displays the 'Full Function Generator Control' software interface. The 'Custom Sequence' mode is selected, with parameters for Index (3), Segment (13), Time (.3 sec), and Level % (15.0). The waveform is set to 'Custom Sequence' with a 'Rising' start-stop mode. The frequency is 0.250 Hz with a cycle count of 187. The interface includes buttons for 'Run' and 'STOP', and a 'Reset Waveform' button. A table at the bottom shows target load and FNG output values for Max and Min settings.

	Target Load (lb)	FNG Out (lb)	Load (lb)	Disp (in)
Max	2,000	2,001	2,001	0.00800
Min	200	201	216	0.00086

The above display shows features for the **Custom Waveform Sequence** mode.

A **Reset Waveform** button has been added to allow restarting at the beginning of the waveform.

The following features have been added or modified as follows:

- Across the top of the form are useful tracking parameters as follows:
  - DAC Rate – Analog input data acquisition rate in readings per second.
  - Data Sync. – Starting location of data acquisition cycle in 100,000 word circular buffer.
  - Buffer. – Current location of data acquisition cycle in 100,000 word circular buffer.
  - Custom Sequence (waveform)
    - Index # – Current Index
    - Segment # – Current Segment
    - Time (sec) – Elapse time in current segment.
    - Level % – Level in current segment.
  
- **Reset Max/Min** – Pressing this button resets the maximum and minimum to the **Set Point** value but does not reset the hold value.
  
- **Reset Hold** – Pressing this button resets the hold value to the **Set Point** value.
  
- **Waveform: Sine, Triangle, Custom Shape (previously called User Defined) or Custom Sequence** can be selected. The **Custom Shape** mode allows construction of waveforms, such as saw-tooth and trapezoid. The **Custom Sequence** mode provides greater flexibility. The **Custom Shape** or the **Custom Sequence** mode cannot be activated until the corresponding form is selected from the **Control** menu and the corresponding waveform created or loaded (discussed in Section 4.5.3, below). The default mode is **Sine**. It is possible to change the waveform while the function generator is running. It is also possible to automatically change the waveform from the **Matrix** form. The upper right corner of the **FNG** display includes useful status information when the **Custom Sequence** waveform option is selected
  
- When the **Custom Waveform Sequence** is selected, the targeted **FNG** command signal is output regardless of the status of the **Command Control**. If **Command Control** is enabled, then the **FNG** output is adjusted to compensate for loading errors.
  
- The **Command Control option** adjusts the aggressiveness of the function generator compensation in response to errors between the target maximum and minimum loads and the actual maximum and minimum loads. When the **Custom Waveform Sequence** is selected, the waveform compensation works differently to account for the relatively slow frequency associated with typical custom waveform sequences. In this mode of operation, waveform compensation is continuous rather than based on historical maximum and minimum response.



Ramp rates and limits as well as integration rates and limits can be set by the user in the **Custom Waveform Sequence Control** form.

### 4.5.3 WAVEFORM

#### 4.5.3.2 Custom Waveform Sequence

A **Custom Waveform Sequence** form has been added under the **Control** menu for creating user-defined waveforms sequences (.dat files). Custom waveform sequences of up to 1000 data entries may be generated. Multiple waveform sequences may be created, each uniquely defined by the index number. Entries within a unique waveform sequence are defined by the segment number. Waveforms can be created using the form shown below, or in a text editor.

Segment #	Time (seconds)	Level (0 to 100%)
1	0.0	0.00

One display and three text boxes appear at the top of the **Custom Waveform Sequence** form.

- **Index #** is the unique waveform identifier allowing multiple custom waveform sequences to be stored in a single file.
- **Segment #** is associated with each unique waveform sequence. A minimum number of four segments is required for each waveform sequence, even if the sequence can be defined with less than four. The **Segment #** is not user selectable and cannot be reset for each **Index #**.
- **Time (seconds)** is elapsed time to get to the specified level from the previous level. The time associated with Index 1 is zero, which defines the starting point.
- **Level (0 – 100%)** is targeted endpoint in % of upper and lower limits.
- **Active Index** specifies which waveform sequence (Index) is active. This value must always correspond to one of the available indexes in the waveform sequence file.

The following table defines two simple waveform sequences

<u>Index</u>	<u>Segment</u>	<u>Time (sec)</u>	<u>Level (%)</u>
1	1	0.0	0.00
1	2	5.0	100.00
1	3	50.0	100.00
1	4	5.0	0.00
2	5	0.0	0.00
2	6	50.0	100.00
2	7	10.0	0.00
2	8	0.0	0.00

The first waveform sequence (index 1) is a trapezoidal waveform starting at minimum load with a rise time to maximum load in 5 seconds; a hold at maximum load for 50 seconds; followed by a return to minimum load in 5 seconds.

The second waveform sequence (index 2) is a saw-tooth waveform starting at minimum load with a rise time to maximum load in 50 seconds; followed by a return to minimum load in 10 seconds, The fourth segment is a dummy entry since a minimum of four segments are required.

For each waveform sequence, the first segment defines the initial endpoint level. The time for this segment must be zero. The last segment in the sequence must have the same level as the first segment.

*NB It is recommended that the number of points for A/D Data Acquisition (Options tab) be set to the maximum of 5000 when using this option (See Section 4.4.2).*

#### 4.5.3.3 Custom Waveform Sequence Control

A **Custom Waveform Sequence Control** form has been added under the **Control** menu for establishing ramp rates and limits as well as integration rates and limits when using the **Custom Waveform Sequence** features of the software.

Parameter	Value
Stop Ramp Rate (units/second)	500
Run Ramp Rate Limit (units/second)	5000
Integration Rate 1 (units/second)	2.5
Integration Rate 2 (units/second)	2.5
Integration Limit (units)	100
Integration Value (1)	0.0
Integration Value (2)	0.0

Four text boxes appear in the **Custom Waveform Sequence Control** form.

- **Stop Ramp Rate** – This variable specifies the ramp rate (units/second) to the hold level when the function generator is stopped.
- **Run Ramp Rate Limit** – This variable specifies the maximum ramp rate allowable (units/second) when the function generator is running. If a segment in **Custom Waveform Sequence** file exceeds this rate, the green **Run** button on the function generator turns yellow.
- **Integration Rate** – This variable specifies the integration rate (units/second) for load error compensation while the function generator is running. No integration takes place while the function generator is stopped. For the dual integration mode, two integration rates can be provided.

- **Integration Limit** – This variable specifies the integration limit for load error compensation.
- **Integration Reset** – This button sets the integration value to zero.
- **Integration Mode** – This option selects either a single parameter or dual parameter integration mode. In the dual parameter mode, separate integration terms are used for the minimum and maximum level. In that way, the system can be tuned for a non-linear response between minimum and maximum load.
- **Display Units** – This option chooses between volts and force units.

The default settings for these control parameters are as follows (in volts):

**Stop Ramp Rate** – 1.0 volts/second  
**Run Ramp Rate Limit** – 10.0 volts/second  
**Integration Rate** – 0.005 volts/second  
**Integration Limit** – 0.2 volts

For overload protection, the instantaneous load is scanned 500 times per second. As overload or underload conditions are approached, the rate of ramp rise or fall is limited to 1 volt/sec within 50 mvolts of limit, 0.2 volts/second within 25 mvolts of limit and 0.02 volts second within 5 mvolts of limit. If the limit is reached prior to reaching the upper and lower level of the waveform (100% or 0%), the waveform rise or fall is momentarily halted, to prevent overload or underload, although integration and command compensation continue.

During transition to or from the **Custom Waveform Sequence** mode to the **Sine**, **Triangle** or **Custom Shape** waveforms, the ramp rate is limited to ~0.3 volts/second until the existing function generator output coincides with the new waveform output.

#### 4.5.4 THE MATRIX

The **Matrix** has been modified to include automatic changing of the waveform (1 = Sine, 2 = Triangle, 3 = Custom Shape, 4 = Custom Sequence). If the **Custom Sequence** option has been selected, then the **Waveform Sequence Index** must also be defined.

See standard manual for more detail on the use of the **Matrix**.

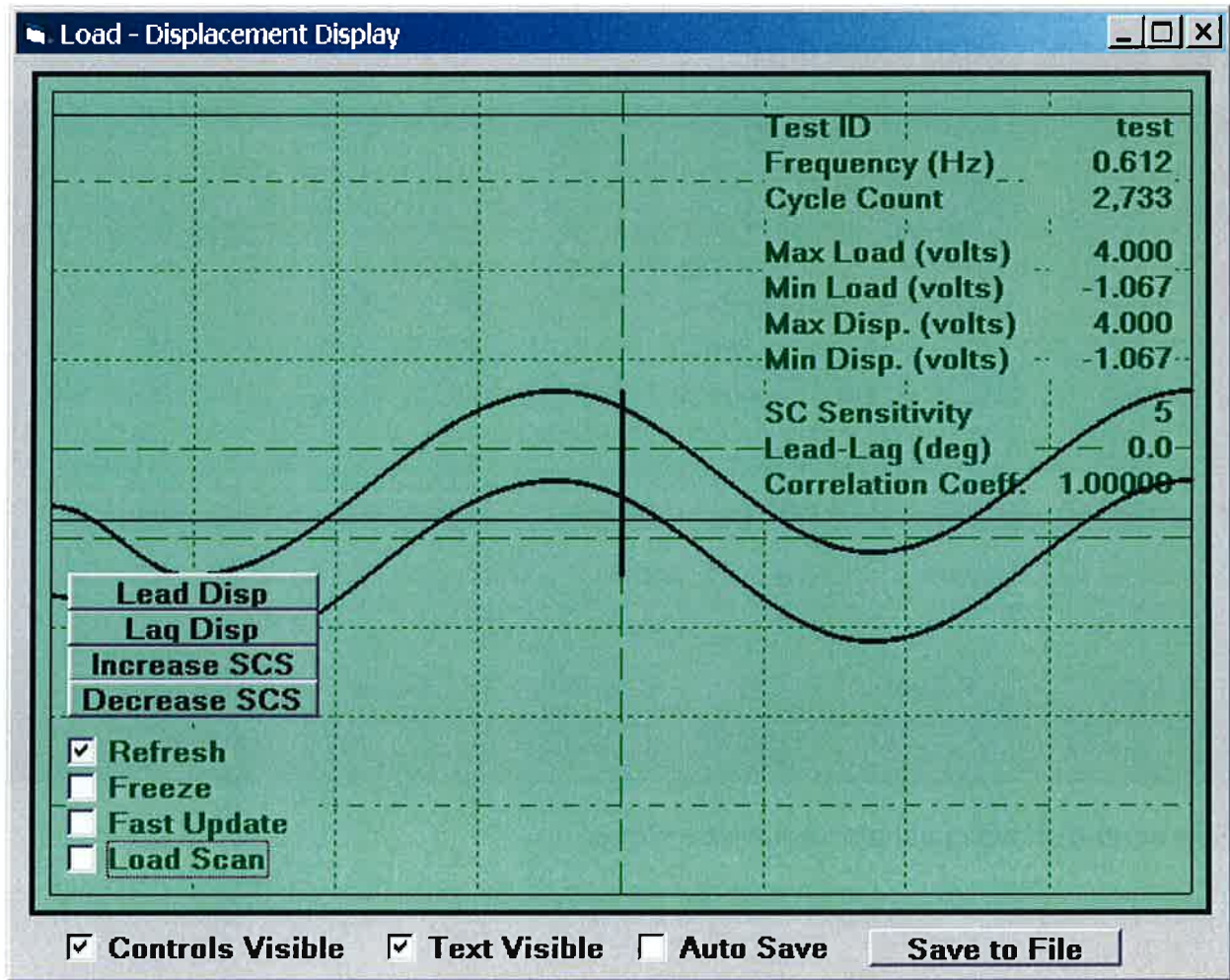
## 4.6 Display

### 4.6.1 STATUS: VARIABLE AMPLITUDE

Status - Compliance										
Test ID: <input type="text" value="test"/>										
Target Load		Command Signal		Actual Load		Clip Gage				
lb	%	lb	%	lb	%	in	%			
Max	<input type="text" value="283.8"/>	<input type="text" value="5.7"/>	<input type="text" value="447.3"/>	<input type="text" value="8.9"/>	<input type="text" value="938.0"/>	<input type="text" value="18.8"/>	<input type="text" value="0.00375"/>	<input type="text" value="18.8"/>		
Min	<input type="text" value="1101.1"/>	<input type="text" value="22.0"/>	<input type="text" value="1101.0"/>	<input type="text" value="22.0"/>	<input type="text" value="446.6"/>	<input type="text" value="8.9"/>	<input type="text" value="0.00179"/>	<input type="text" value="8.9"/>		
a/W	a	Last a	Next a	Count	Time	Date				
<input type="text" value="0.5201"/>	<input type="text" value="1.04019"/>	<input type="text" value="1.04000"/>	<input type="text" value="1.05000"/>	<input type="text" value="2.421"/>	<input type="text" value="11:49:53"/>	<input type="text" value="3/21/2015"/>				
					<input type="text" value="0.53"/>	<input type="text" value="0.02"/>				
Slope #	Slope#	Corr	Kmax	Delta K	da/dN	Damage				
<input type="text" value="20"/>	<input type="text" value="3"/>	<input type="text" value="1.00000"/>	<input type="text" value="29.10"/>	<input type="text" value="29.10"/>	<input type="text" value="1.970E-7"/>	<input type="text" value="1.0021"/>				
						<input type="text" value="1.0024"/>				
EvB/P	Count	a	EvB/P	Count	a					
<input type="text" value="59.9833"/>	<input type="text" value="2.418"/>	<input type="text" value="1.04019"/>	<input type="text" value="59.9985"/>	<input type="text" value="271"/>	<input type="text" value="1.04030"/>					

New screen showing variable amplitude status.

### 4.6.3 LOAD – DISPLACEMENT DISPLAY



New screen showing variable amplitude load-displacement display.



# ***Fracture Technology Associates***



**Automated Fatigue Crack Growth Testing and Analysis – Series 2001  
Version 3.12**

**Users' Variable Amplitude Manual**

**April 2012**

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## **1.0 Introduction to Fracture Technology Associates' Variable Amplitude Software**

### **1.1 System Concept**

Fracture Technology Associates' Variable Amplitude (VA) software provides additional functionality to the standard Fatigue Crack Growth Rate package by allowing the use of user-generated waveforms far more complex than those permitted by the basic application.

The software is characterized by five unique features:

- A waveform output having a constant loading rate with upper and lower frequency limits.
- A command correction compensation based on endpoint errors: each endpoint error is associated with the unique combination of the previous, current and next endpoint.
- A real time damage parameter used to estimate the success in attaining peak loads in a spectrum test.
- The storage of command correction factors unique to each spectrum and test conditions so that endpoint errors can be minimized at the beginning of duplicate tests.
- A validation log for cataloguing 'missed endpoints' beyond a user -specified error threshold.

The software supports a wide variety of file types, including spectra characterized by load peaks and valleys (end-point files); repetitive load peak and valley test sequences (block files); and customized waveform shapes that allow computation of crack size within one cycle and more flexibility than the custom waveform feature of the steady-state application (segment files). A fourth category, flight mix files, is not recommended for most users (contact FTA for details, if required). In-depth discussion of these files (including instructions for their construction and issues arising) begins on page 17 of this manual.

### **1.2 About This Manual**

This document is intended to provide support for the use of FTA's VA software only, particularly as it differs from the standard FCGR package. Full familiarity with the standard system (such as software/hardware setup and the use of sine and other simple waveforms) is assumed. Readers seeking such background information are directed to FTA's steady state reference manual.