Waveform Sequencing with the AWG 2000 Series
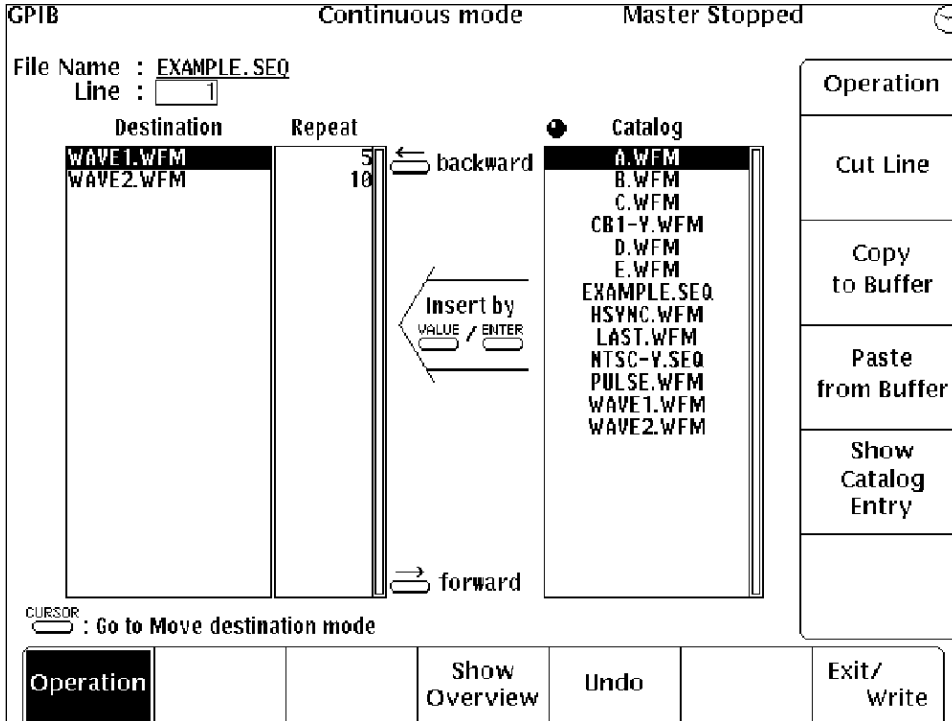

Figure 1. Sequence file (EXAMPLE.SEQ).

- **True "Real Time" Sequencing allows "on-the-fly" sequence editing**

- **Create waveforms which have effective records to over a billion points! (AWG 2021 and AWG 2005)**

- **Interact with the device-under-test to determine precise waveform placement in Waveform Advance and Auto-Step modes**

WAVE1.WFM
- Waveform address
- Data length
- Looping counter value 5

WAVE2.WFM
- Waveform address
- Data length
- Looping counter value 10

Introduction

The advanced waveform sequencing capabilities of the AWG 2000 Series Arbitrary Generators offers users new features not available in any other competitive product. Waveform records of over a billion points can be created by taking advantage of the fact that complex waveforms have portions that repeat. Individual waveforms are linked together to form complex or long duration signals to be used as stimulus to electronic circuits and systems. During design and debug stages of product development, engineers and scientists can quickly identify and correct problems by simulating complex "real world" conditions using "what if" scenarios.

Uses of waveform sequencing are described in this technical brief as it applies to datacom, video/imaging, and magnetic media applications.

Theory of Operation

The sequence control block of the AWG 2000 Series is partitioned into two functional areas. The first area, sequence memory, stores the contents of the sequence control information. It contains the waveform addresses, data lengths, and looping count values for each waveform in the sequence file. Up to 8,192 waveforms can be sequenced together in a sequence file. Figure 1 shows an example sequence file for a sequence named EXAMPLE.SEQ. The sequence memory contains:

The second section of the sequence control block is comprised of three counters that read out the contents of the sequence memory and output the waveform addresses. The current waveform address is loaded into the address counter. The size of this waveform is stored in the length counter and the number of repetitions desired is contained in the looping counter. When the count value in the looping counter is reached, the sequence memory address counter is incremented and the contents of the next step are read.
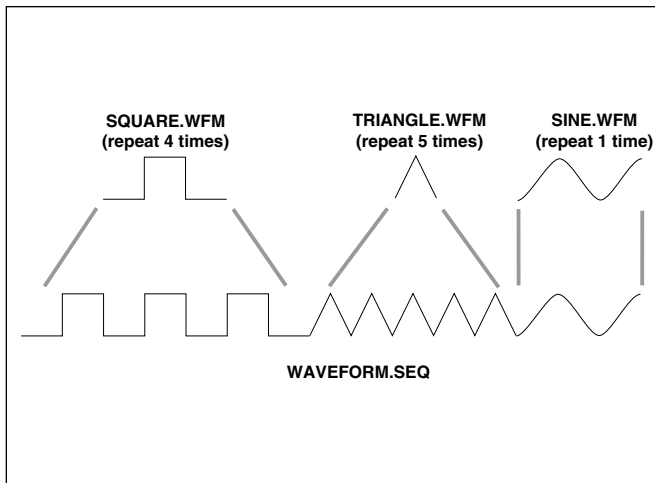
SQUARE.WFM
(repeat 4 times)

TRIANGLE.WFM
(repeat 5 times)

SINE.WFM
(repeat 1 time)

WAVEFORM.SEQ

Figure 2. Graphical representation of waveform sequence to build a complex waveform from three segments.
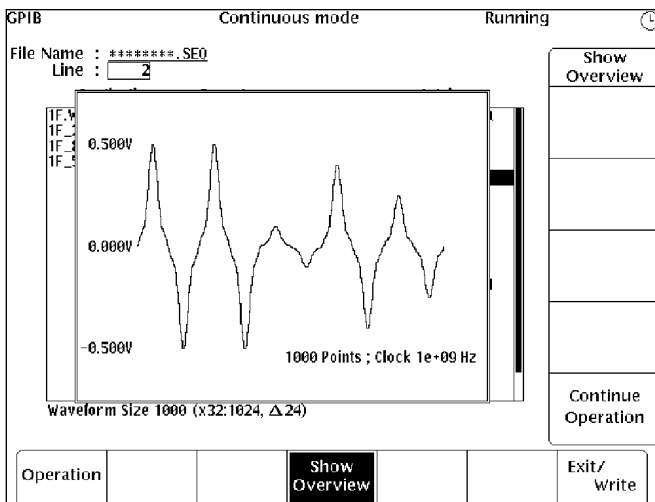

Figure 3. NTSC colorbar composite (NTSC-M.SEQ).

Figure 4. Disk-drive read head height variations.

A graphic illustration of how waveform sequencing works is shown in Figure 2. Small waveform segments are pieced together to form complex signals.

The AWG 2005/AWG 2021 and the AWG 2040 manage their waveform sequence memory differently. The AWG 2005/AWG 2021 can exceed memory length limitations and generate billions of waveform data points. The AWG 2040 uses a sequence compile; the maximum number of data points that can be output using the AWG 2040 waveform sequencer is 1 million points with the standard configuration or 4 million points if Option 01 is installed.

Video/Imaging Example

Video and imaging applications share the need to simulate complex and modulated signals. Arbitrary waveform generators are currently used in research, design, and manufacturing of video and imaging equipment.

While there are lower-cost video generators available to output standard video signals, the AWG 2000 Series can perform these tasks and much more. Arbitrary waveform generators can simulate fault conditions such as missing sync pulses in order to test, characterize, and troubleshoot video circuitry and systems. The AWG 2000 Series can generate standard video formats (i.e., NTSC, SECAM, PAL, and HDTV) as well as non-standard video signals including IR imaging systems which may use raster scan or vector-based synchronizing schemes.

Typical video signals such as horizontal and vertical sync pulses, colorbars, etc. can easily be generated and quickly modified using the AWG. Error conditions such as noise, interference, missi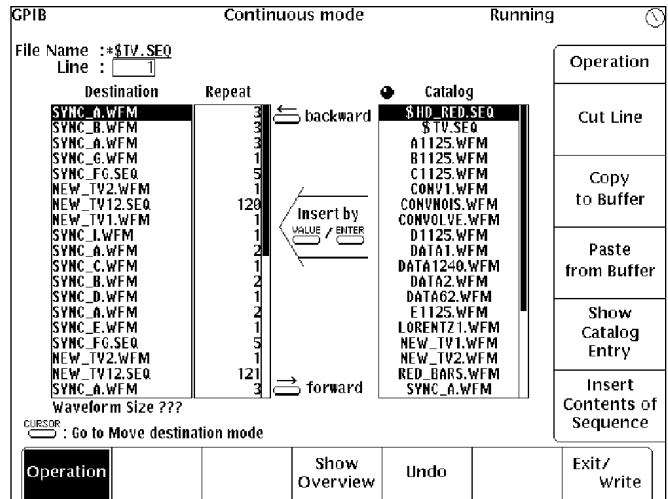ng sync pulses, etc. can be used to characterize video circuits and systems. Entire video lines can be generated using the large waveform and sequencing memories.

An example NTSC TV signal sequence (NTSC-M.SEQ colorbar composite) is shown in Figure 3. Note that parts of the sequence are repeated more than once.

Magnetic Media Testing Example

The increasing performance demands on magnetic media with faster access times and larger storage capacities requires accurate simulation of operating signals to test the performance of disk-drive circuitry. This is especially true with channel and servo control signals.

A wide variety of testing techniques are encountered in magnetic media testing. The most frequently encountered waveform is the Lorentzian pulse (see Figure 4) which occurs simultaneously with the magnetic states written onto the media. These pulses vary in shape and complexity proportional to the speed, density, and quality of the data written on the media.

The AWG 2000 Series waveform sequencer is ideally suited to simulate channel signals including missing bits, extra bits, varying flying heights of read head, peak shift, noise, and glitches.
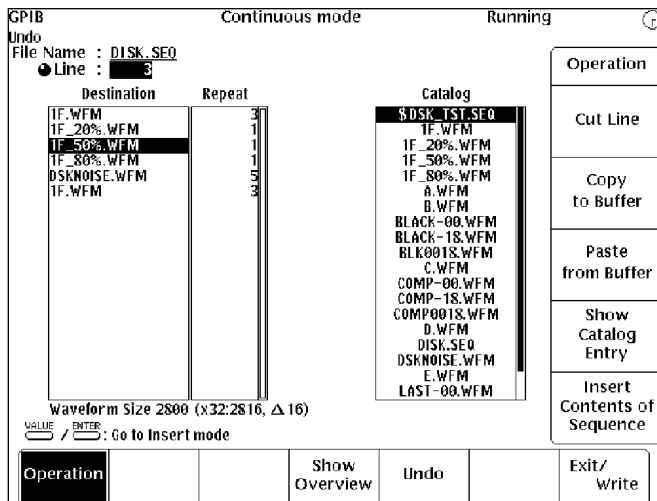
Undo
File Name : DISK.SEQ
   Line :   3

Destination	Repeat	Catalog
1F.WFM	3	$DSK_TST.SEQ
1F_20%.WFM	1	1F.WFM
1F_50%.WFM	1	1F_20%.WFM
1F_80%.WFM	1	1F_50%.WFM
DSKNOISE.WFM	5	1F_80%.WFM
1F.WFM	3	A.WFM
		B.WFM
		BLACK-00.WFM
		BLACK-18.WFM
		BLK001S.WFM
		C.WFM
		COMP-00.WFM
		COMP-18.WFM
		COMP001S.WFM
		D.WFM
		DISK.SEQ
		DSKNOISE.WFM
		E.WFM
		LAST-00.WFM

Waveform Size 2800 (x32:2816, △16)
VALUE / ENTER : Go to Insert mode

Operation

Cut Line

Copy
to Buffer

Paste
from Buffer

Show
Catalog
Entry

Insert
Contents of
Sequence

Operation   Show Overview   Undo   Exit/Write

Figure 5. Disk-drive waveform sequence DISK.SEQ.

File Name : *$DSK_TST.SEQ
   Line :   1

0.500V

0.000V

-0.500V

2800 Points ; Clock 1e+08 Hz

Waveform Size 2800 (x32:2816, △16)

Show
Overview

Continue
Operation

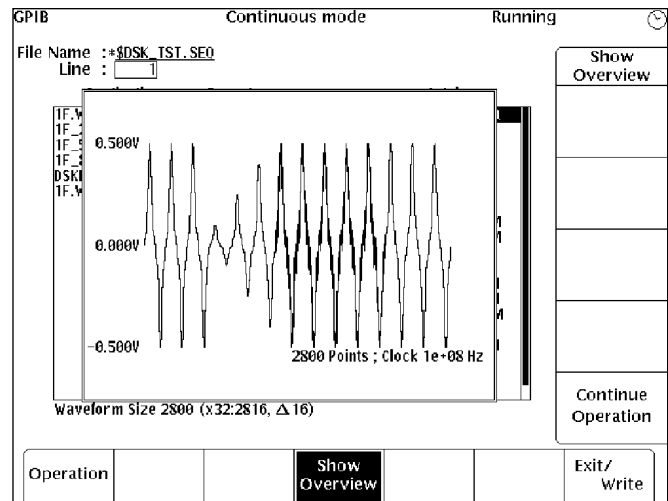Operation   Show Overview   Exit/Write

Figure 6. Disk-drive waveform sequence overview.

Anomalies can be inserted into the sequence to simulate marginal conditions and characterize the performance and tolerances of the electronic circuitry.

Some key specifications of the AWG2000 Series that make these products well suited for test applications are:

- Deep waveform sequencing buffer (8K waveforms) with 64K segment looping
- Fast-point-rate clock speed, high accuracy and resolution (i.e., 1 ns, 1 ppm, 7 digits)
- Digital output and digital editing capability (ECL, Option 03; TTL, Option 04)
- FFT and convolution editing (with Option 09)
- Long record length
- Dynamic triggering
- Direct waveform transfer from a digital storage oscilloscope

Creating a Sequence

The following basic steps illustrate how to create a sequence file using the sequence editor:

LOAD WAVEFORM

1. Insert the Waveform Library diskette into the AWG floppy disk drive. From the power-up screen (SETUP menu displayed), press the LOAD/SAVE button on the side menu.

2. Use the front-panel knob to highlight the sub-directory DISKDRV and select CHANGE DIRECTORY on the side menu. Push OK on the side menu. The waveforms from the disk drive should now be displayed on the bottom of the screen.

3. Select LOAD ALL on the side menu.

CREATE THE SEQUENCE

1. Press the EDIT button on the side menu.

2. Select NEW SEQUENCE on the side menu.

3. Use the general-purpose knob to highlight the specific files shown in Figure 5 from the Catalog. Waveforms in the Catalog could have been previously created or acquired from a digital storage oscilloscope or digitizer.[1] Press the front-panel VALUE or ENTER button; the selected file will be inserted into the Destination list. Repeat until the Destination list matches Figure 5. Sequences may be up to 8,192 lines long.

4. Use the ← and → keys on the front panel (below the CURSOR, VALUE keys) to select the file for the repetition count.

5. Use the numeric keys to input the repetition count; then press the

ENTER button to enter the values. When completed, the screen should match Figure 5. The default value for repetition count is 1. The maximum value for the repetition count is 65,535. To view the sequence file at any point, press the SHOW OVERVIEW button from the bottom menu. Figure 6 shows the resultant sequence waveform.

6. To save the waveform sequence, select WRITE and EXIT on the side menu. Using the general-purpose knob, move the cursor to highlight the first letter of the name you want to call the file (in this example, DISK SEQ); press the VALUE button to load this letter into the Sequence Name input box. Repeat this process until the file name DISK.SEQ has been entered.

7. Press the OK button on the side menu to save the sequence in the instrument's internal memory.

You should now see the sequence file displayed in

---

[1] **Waveforms can be acquired directly from a variety of digital storage oscilloscopes or digitizers by simply connecting a GPIB cable between the AWG2000 Series and the scope. No controller or software is required.**
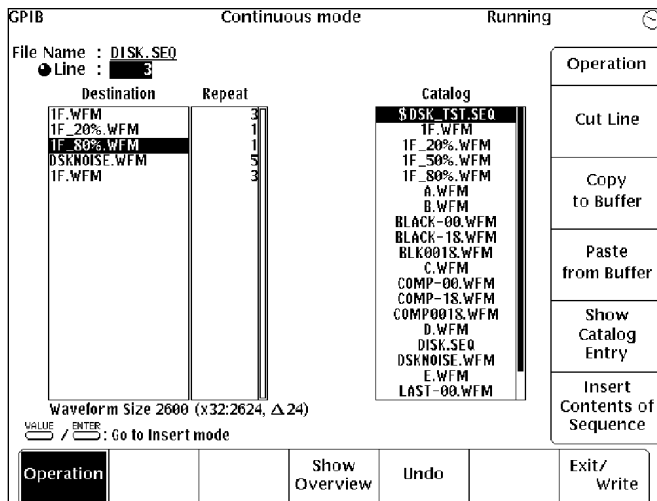
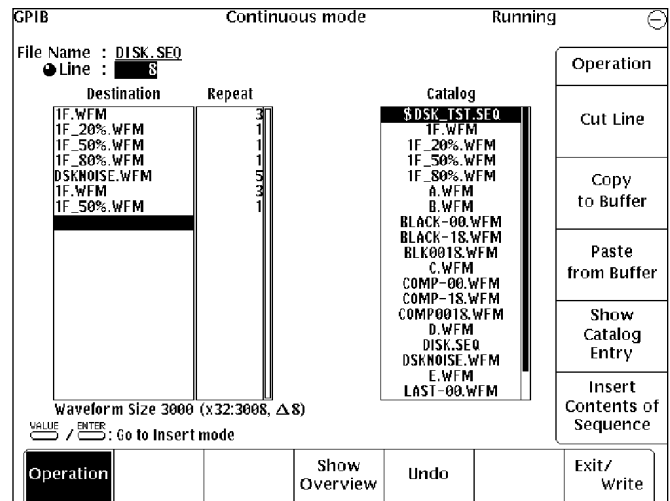Figure 7. Disk-drive waveform sequence DISK.SEQ with line 3 cut.

Figure 8. Disk-drive waveform sequence DISK.SEQ with line 3 copied and pasted to line 7.

alphabetical order in the file list.

Editing a Sequence

To edit a sequence file, perform these steps (this example uses the DISK.SEQ file created in the previous example):

CUTTING A LINE

1. From the power-up screen (SETUP menu displayed), press the EDIT button on the side menu.

2. Use the general-purpose knob to select the sequence file DISK.SEQ and push the EDIT button on the side menu.

3. Press the front-panel CURSOR button. Use the general-purpose knob to highlight line 3 on the Destination list.

4. Select CUT LINE on the side menu. The screen should look like Figure 7. When CUT LINE is selected, the highlighted line 3 in the Destination list is deleted and put into the paste buffer.

5. To return the Destination list to its original state, select UNDO on the bottom menu.

COPYING /PASTING A LINE

1. Press the front-panel CURSOR button. Use the general-purpose knob to highlight line 3 on the Destination list.

2. Select COPY TO BUFFER from the side menu. When COPY TO BUFFER is selected, the highlighted line 3 in the Destination list is copied to the paste buffer. This operation does not affect the display on the CRT.

3. Use the general-purpose knob to specify line 7 as the location to paste the copied line. The position for pasting is directly before the inverted display cursor in the Destination list.

4. Select PASTE FROM BUFFER on the side menu. The screen should look like Figure 8. Each time PASTE FROM BUFFER is selected, the line stored in the paste buffer is pasted into the location you select.

Conclusion

The AWG 2000 Series Arbitrary Generators are powerful tools for engineers and scientists. The waveform sequencing capabilities of these instruments allow quick characterization and debug of circuits and systems by simulating faults that can occur in actual operation.

Waveform sequencing allows the simulation of complex, long-duration signals that occur in video, magnetic media, radar, telecommunications, and other applications.

By using the advanced tools available in the Tektronix 2000 Series Arbitrary Generators, product development time and related costs can be reduced, resulting in a competitive advantage in the marketplace.

For further information, contact:

Printed on recycled paper

12/94   TD   5M   76W-10373-0

Tektronix