

USB Control of the AFG31000 Arbitrary Function Generator Using the 4200A-SCS Parameter Analyzer

APPLICATION NOTE



KEITHLEY
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Introduction

The AFG31000 Series Arbitrary Function Generators (AFGs), shown in **Figure 1**, are high-performance instruments with built-in waveform generation applications and real-time waveform monitoring. The AFG31000 Series provide pulse and function generation with arbitrary waveform capability. Depending on the model in the family of function generators, they can be either one or two channels and can range in output frequency from 25 MHz to 250 MHz depending on what mode is used.

To automate waveform generation, the AFG31000 can be remotely controlled via USB. Remote control can be done through sending commands via USB using NI VISA. The

commands for the AFG31000 follow the SCPI standard. For a list of available commands please refer to the *AFG31000 Series Arbitrary Function Generator Programmer's Manual* at tek.com.

Starting with Clarius V1.11, the AFG31000 can now be remotely controlled with the Keithley 4200A-SCS Parameter Analyzer using USB communication and the 4200A-SCS's built-in interactive software, Clarius. Adding an AFG31000 to the system configuration can be useful if a device that is being tested by the Parameter Analyzer may also need to be stimulated by pulsing or other waveform generation. This application note will explain how to set-up and control the AFG31000 with the 4200A-SCS.

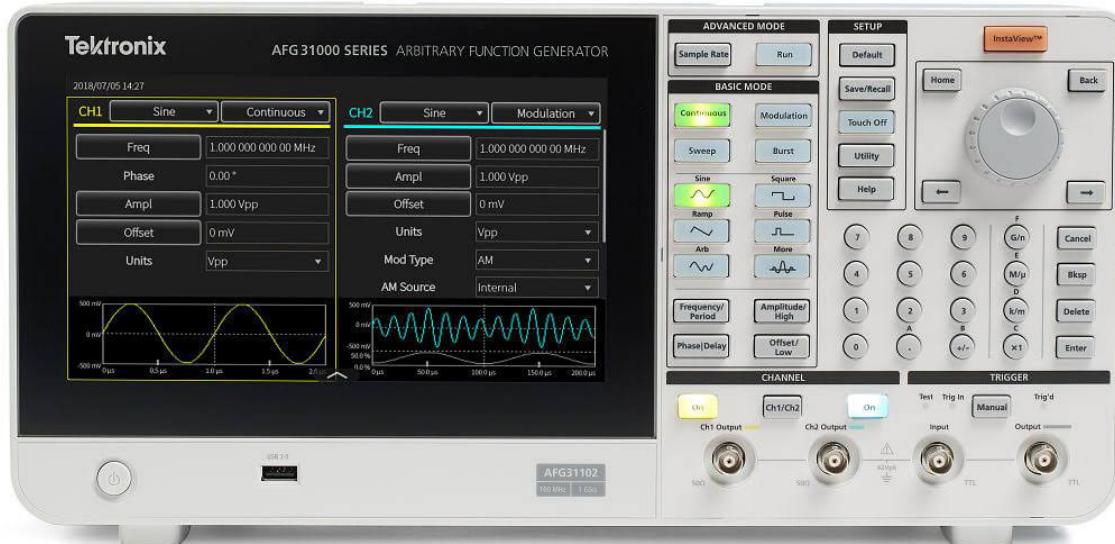


Figure 1. AFG31000 Series Arbitrary Function Generator (AFG31102).

Making Connection from the AFG31000 to the 4200A-SCS

The AFG31000 can be connected to the 4200A-SCS through a USB A to USB B cable. The USB B side of the cable gets connected to the respective port on the rear panel of the AFG31000. The USB A side of the cable is then connected to any of the USB A ports on the 4200A-SCS, which has four USB A ports on the rear panel of the 4200A-SCS and four USB A ports on the front panel of the 4200A-SCS. These USB connections are shown in **Figure 2**.



4200A-SCS Parameter Analyzer Rear Panel



AFG31000 Rear Panel

Figure 2. USB connections from the 4200A-SCS to the AFG31000.

Adding an AFG31000 in the Keithley Configuration Utility, KCon

Once the AFG31000 is connected to the 4200A-SCS via USB, the AFG31000 needs to be added into the Keithley Configuration Utility, or KCon. The KCon application manages the configuration and interconnections between the test system components that are controlled by the Clarius software. The KCon application can be found on the desktop of the 4200A-SCS. To add an AFG31000 in KCon, press the Update button at the top of the screen as highlighted in **Figure 3**.

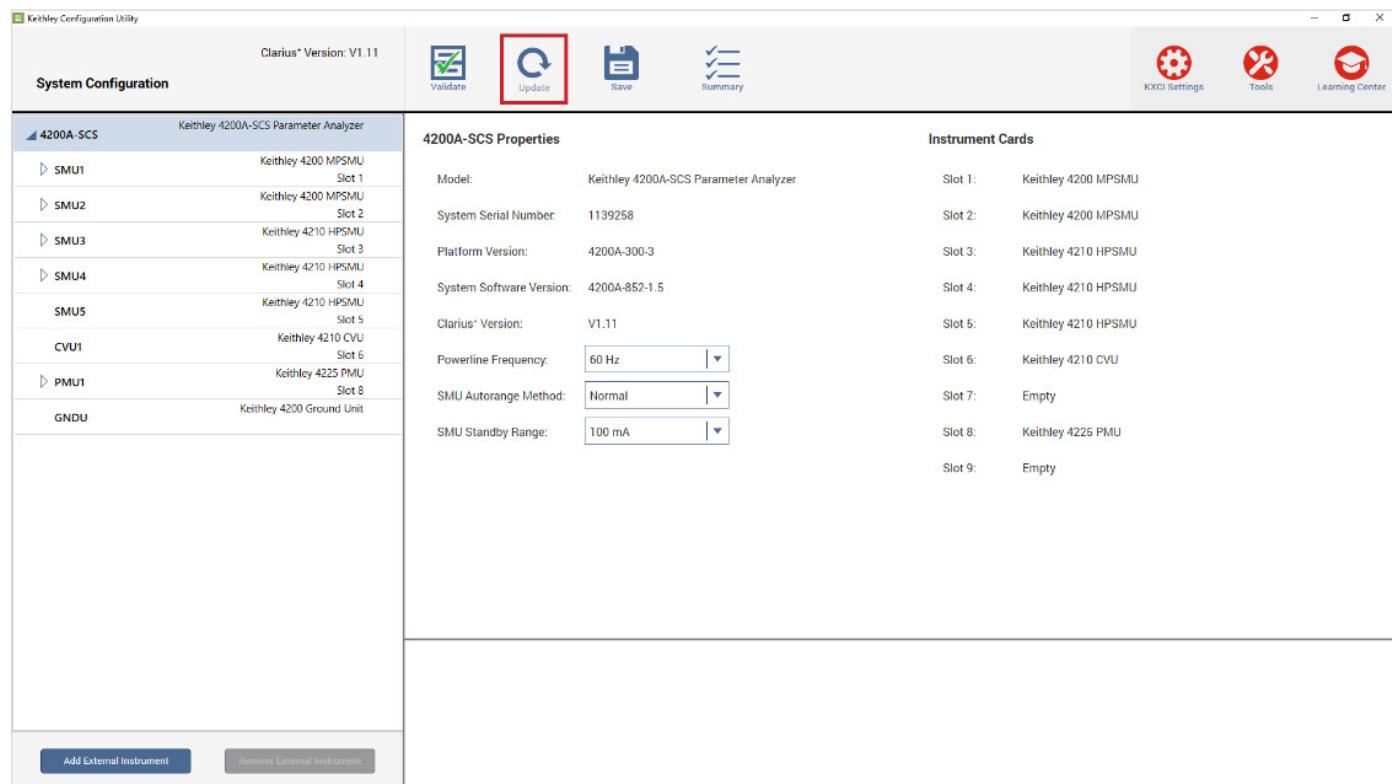


Figure 3. KCon Update button highlighted.

By selecting Update, the AFG31000 will be autodetected and added to the system configuration. If there is only one AFG31000 connected, an instrument named AFG1 will appear as seen in **Figure 4**. KCon supports up to four AFG31000s, so if four AFG31000s are connected AFG1-AFG4 will appear in the system configuration. Once the AFG31000 is added in KCon, it will be available to use remotely through Clarius.

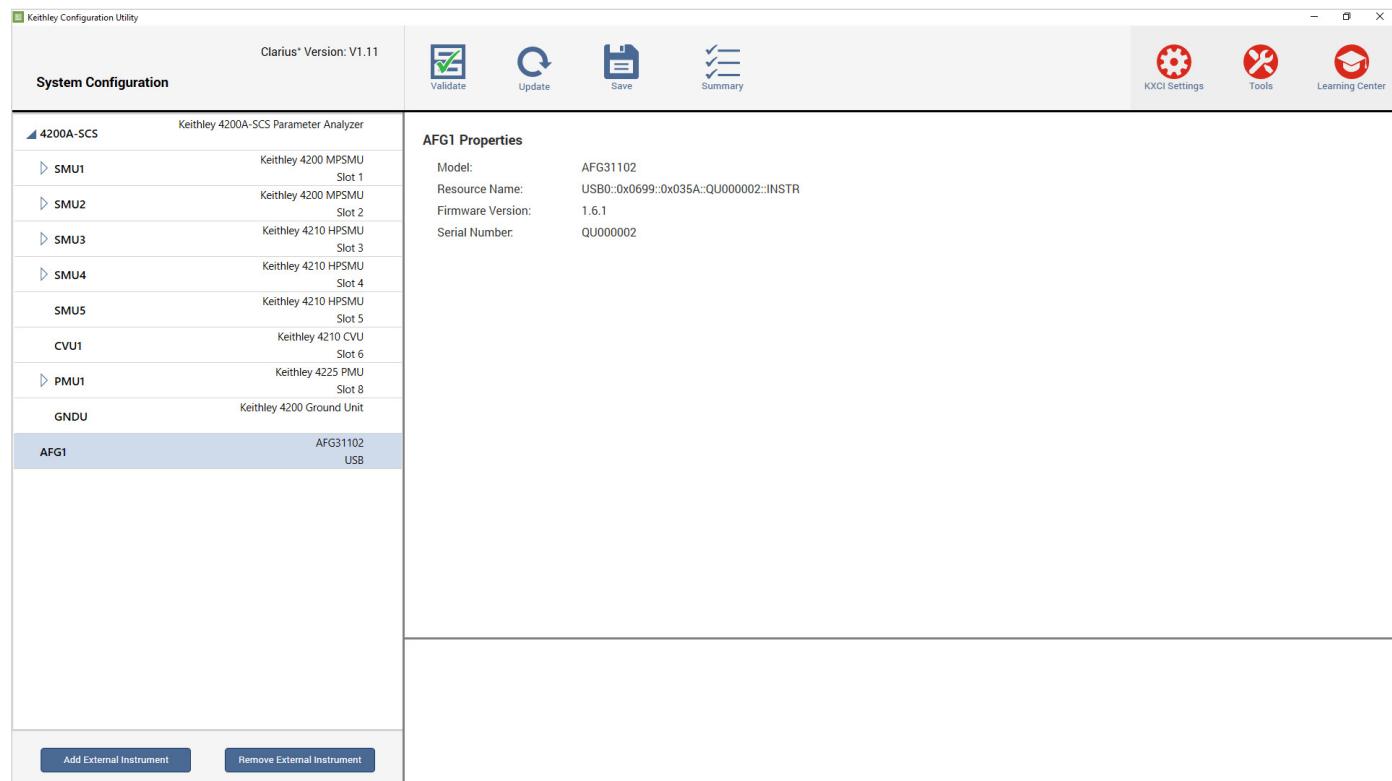


Figure 4. KCon System Configuration with AFG1 present.

Using the AFG31000 user library

An AFG31000 user library was added to Clarius V1.11 to configure the AFG31000 to different waveforms and then output those waveforms. This user library, called *AFG31000_examples_ulib*, provides an example of controlling an AFG31000 through Clarius.

Table 1 shows a description and settable parameters of the four user modules in *AFG31000_examples_ulib*.

User Module	Description	Settable Parameters
afg31000_config_2ch	Configures and outputs an arbitrary waveform to each channel of an AFG31000. Both channels are set to burst mode with both channels being triggered simultaneously. The list of possible arbitrary waveforms to configure and output to each channel are sine, square, ramp, pulse, $\sin(x)/x$, dc, Gaussian, Lorentz, exponential rise, exponential decay, and haversine.	<ul style="list-style-type: none"> • AFG_ID – AFG ID from KCon • Channel1, Channel2 – waveform type for each channel • LoadCh2, LoadCh2 – load for each channel • FrequencyCh1, FrequencyCh2 – frequency for each channel • AmplitudeCh1, AmplitudeCh2 – amplitude for each channel • OffsetCh1, OffsetCh2 – offset for each channel • Num_CyclesCh1, Num_CyclesCh2 – number of cycles to output waveform for each channel • DC_RuntimeCh1, DC_RuntimeCh2 – amount of time to output DC waveform for each channel • SymmetryCh1, SymmetryCh2 – ramp waveform symmetry for each channel • Duty_CycleCh1, Duty_CycleCh2 – pulse waveform duty cycle for each channel
afg31000_config_1ch	Configures and outputs an arbitrary waveform to channel 1 of an AFG31000. Channel 1 is set to burst mode. The list of possible arbitrary waveforms to configure and output to channel 1 are sine, square, ramp, pulse, $\sin(x)/x$, dc, Gaussian, Lorentz, exponential rise, exponential decay, and haversine.	<ul style="list-style-type: none"> • AFG_ID – AFG ID from KCon • Channel1 – waveform type • Load – load for channel 1 • Frequency – frequency for channel 1 • Amplitude – amplitude for channel 1 • Offset – offset for channel 1 • Num_Cycles – number of cycles to output waveform • DC_Runtime – amount of time to output DC waveform • Symmetry – ramp waveform symmetry • Duty_Cycle – pulse waveform duty cycle
afg31000_segarb_file_load_2ch	Configures and outputs created arbitrary waveform files (.twfx), from either the internal storage of an AFG31000 or an USB drive connected to an AFG31000, to each channel of an AFG31000. Both channels of an AFG31000 are set to burst mode with both channels being triggered simultaneously.	<ul style="list-style-type: none"> • AFG_ID – AFG ID from KCon • Channel1, Channel2 – channel on or off • LoadCh1, LoadCh2 – load for each channel • FilenameCh1, FilenameCh2 – filename of the arbitrary waveform file to load for each channel • StorageCh1, StorageCh2 – storage location of file for each channel • FrequencyCh1, FrequencyCh2 – frequency for each channel • Num_CyclesCh1, Num_CyclesCh2 – number of cycles to output waveform for each channel
afg31000_segarb_file_load_1ch	Configures and outputs a created arbitrary waveform file (.twfx), from either the internal storage of an AFG31000 or an USB drive connected to an AFG31000, to channel 1 of an AFG31000. Channel 1 is set to burst mode.	<ul style="list-style-type: none"> • AFG_ID – AFG ID from KCon • Channel1 – channel on or off • Load – load for channel 1 • Filename – filename of the arbitrary waveform file to load to channel 1 • Storage – storage location of file • Frequency – frequency for channel 1 • Num_Cycles – number of cycles to output waveform for channel 1

Table 1. User modules in the *AFG31000_examples_ulib* User Library.

The *afg31000_segarb_file_load_Xch* user modules both take filenames as inputs for the arbitrary waveform files to load to the AFG31000 and output. To see the available files on the internal or USB drive storage of the AFG31000, go to the ArbBuilder app from the home screen of the AFG31000 as seen in the blue highlighted icon in **Figure 5**.



Figure 5. AFG31000 Home Screen ArbBuilder highlighted.

Once in the ArbBuilder app, select open located in the bottom left corner, and all the available files, on both the internal storage and the USB drive attached to the AFG31000, will appear on the screen of the AFG31000 as seen in **Figure 6**. Available files stored on a USB drive can also be seen by connecting the USB drive to a computer and looking for files with the *tfwx* file extension.

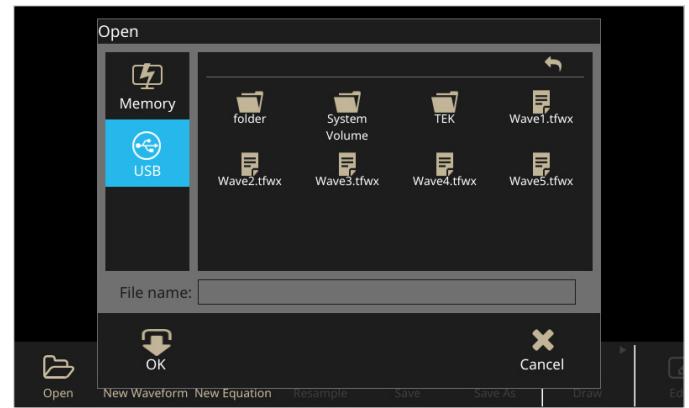
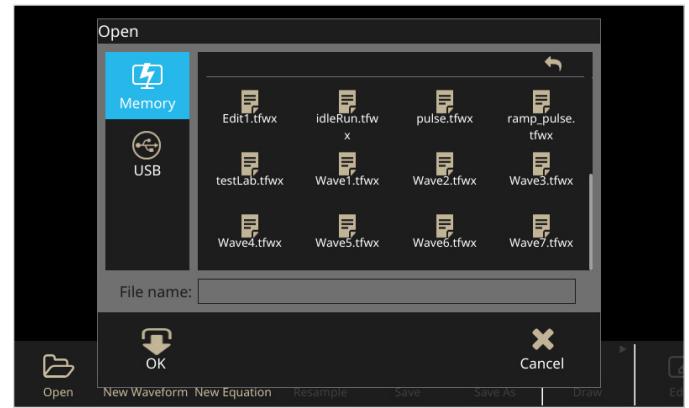


Figure 6. View of available files in Internal Storage (top), and USB storage (bottom).

To create and save arbitrary waveform files to use with the *afg31000_segarb_file_load_Xch* user modules, the ArbBuilder app can also be used. For instructions on how to use the ArbBuilder app to create arbitrary waveforms, please refer to the *AFG3100 Series Arbitrary Function Generator User's Manual* at tek.com.

Using the built-in library tests and project

For convenience, four AFG31000 tests and a project have been added to Clarius' extensive built-in Library. These tests were created using the *AFG31000_examples_plib* user library. The project, called *afg31000-config-output*, has four tests with each test corresponding to one of the four user modules previously described. **Table 2** shows the user modules used for each test in the project.

Test	User Module
afg31000-config-2ch	afg31000_config_2ch
afg31000-config-1ch	afg31000_config_1ch
afg31000-segarb-2ch	afg31000-segarb_file_load_2ch
afg31000-segarb-1ch	afg31000-segarb_file_load_1ch

Table 2. User Modules for each test.

These tests and the project can easily be found in their respective sections of the Select view by entering the keywords AFG31000, AFG, 31000, Arbitrary Function Generator, Arbitrary Waveform, or Function Generator into the search bar as seen in **Figure 7**.

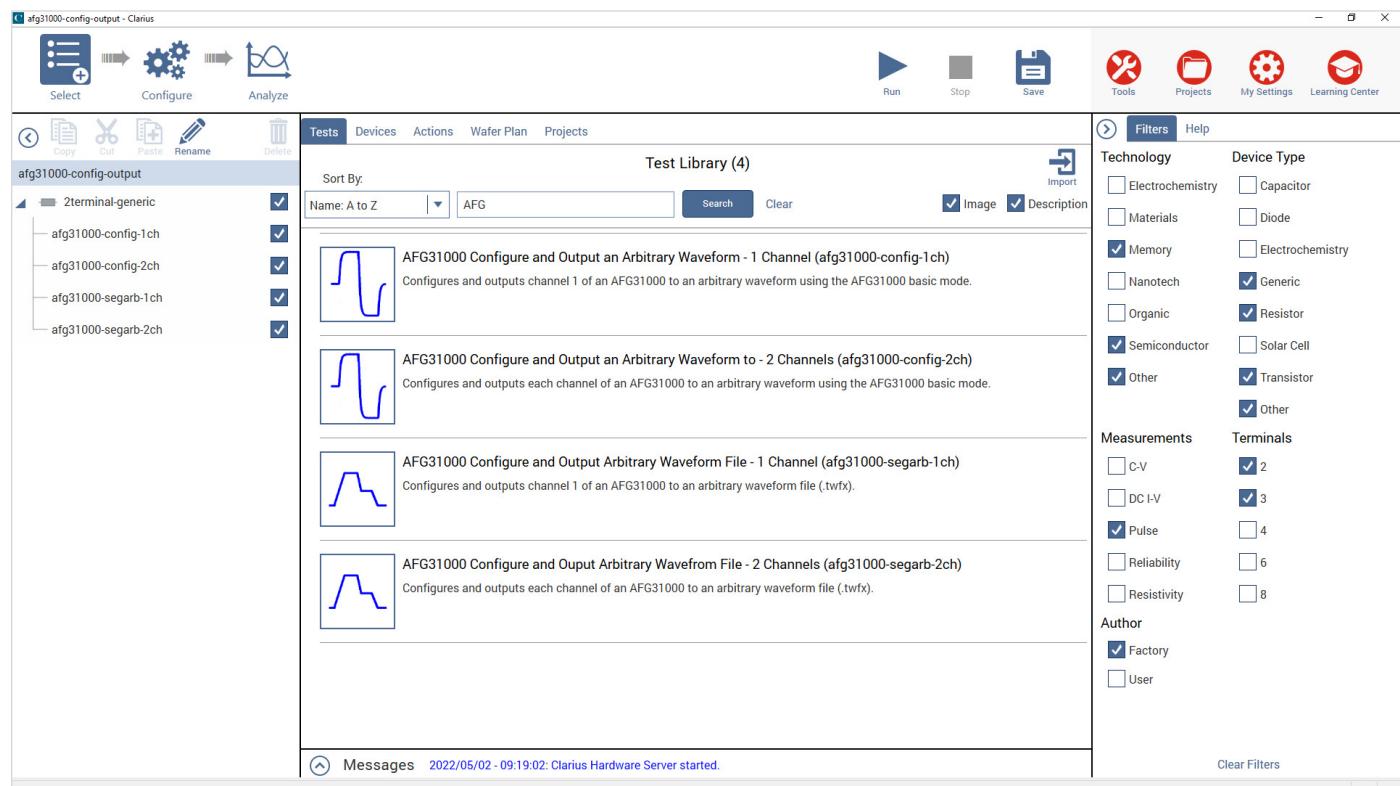


Figure 7. AFG test search.

The default view of the *afg31000-config-2ch* test's Configure view in the *afg31000-config-output* project can be seen in

Figure 8. The settable parameters that apply for each channel are shown in groups labeled after their respective channel. The available AFGs, as configured in KCon, can be selected under the Instrument group.

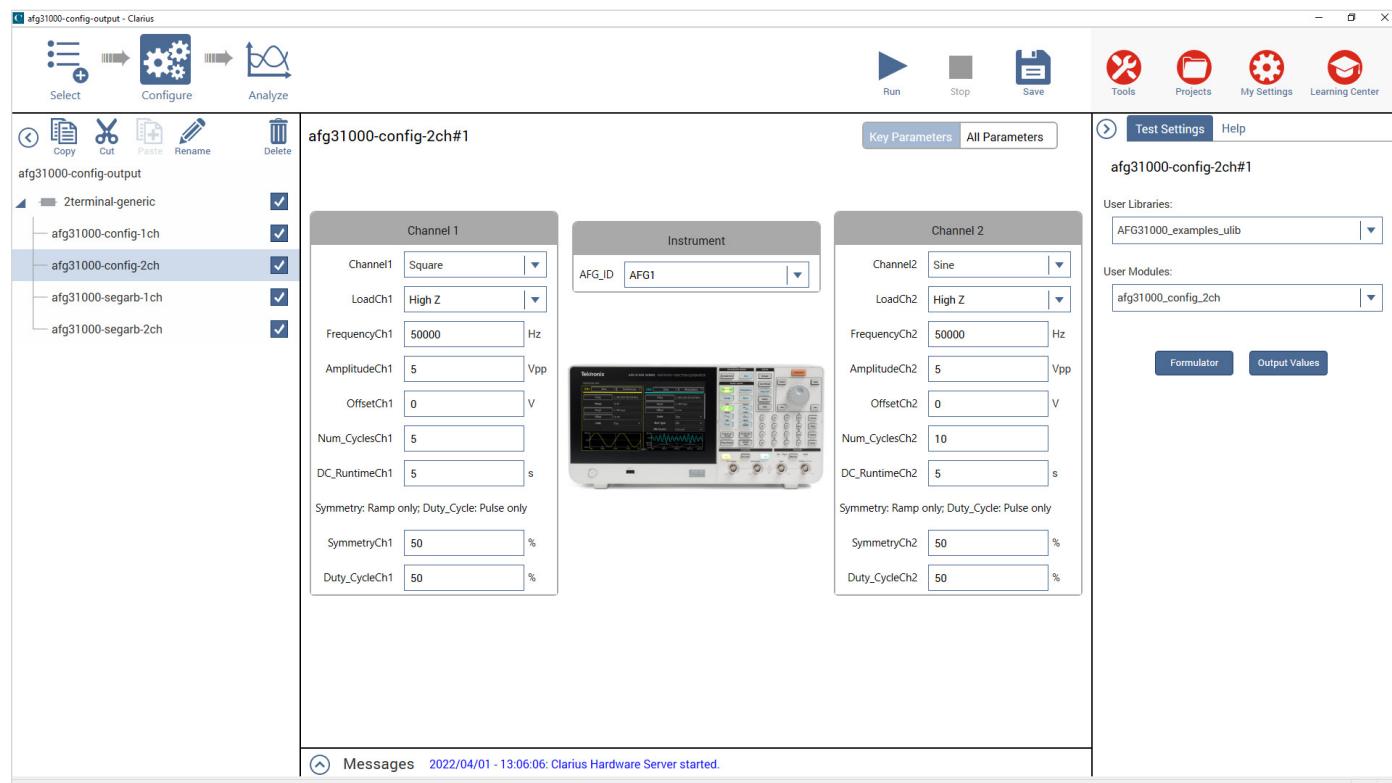


Figure 8. *afg31000-config-2ch* Test Configure view.

After you Run one of these tests, a return value of 0 is returned to the Clarius sheet in the Analyze view, if the test ran successfully. If any other value is returned, then the test failed to send the waveforms as set up in the Configure view of the selected test. **Figure 9** shows the results after a successful output from the AFG31000.

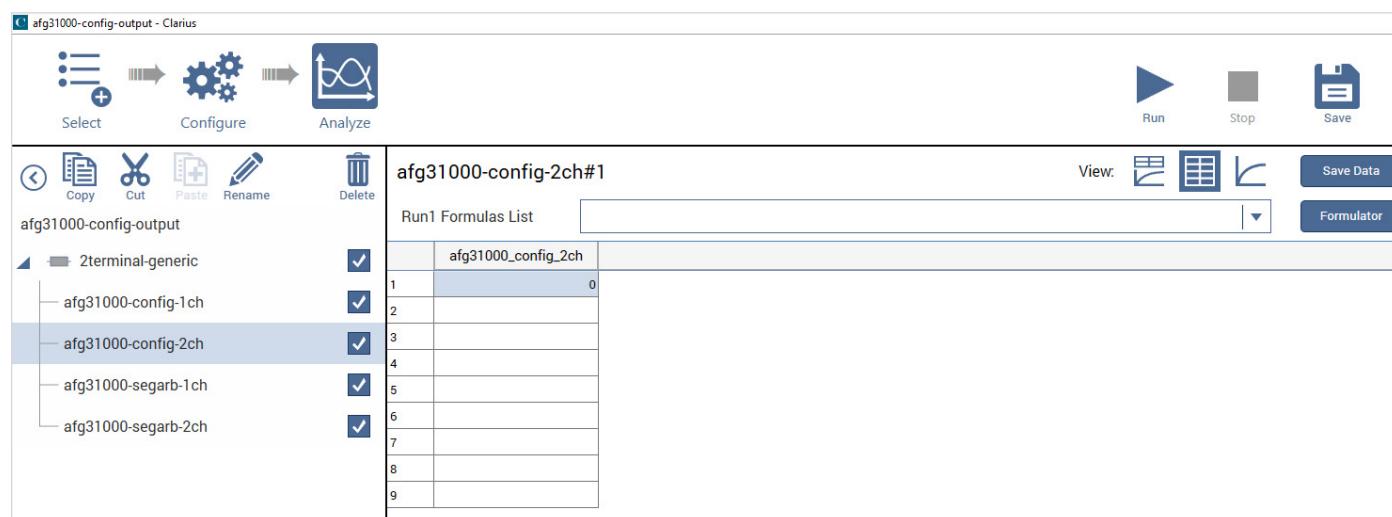


Figure 9. Return value after successful test.

An example of the *afg31000-config-2ch* test being run can be seen below. The configure view of the *afg31000-config-2ch* test running can be seen in **Figure 10**. The waveform configured to channel 1 is a square wave with a frequency of 50 kHz, an amplitude of 5 Vpp, and an offset of 0 V. This waveform is set to output for 5 cycles. The waveform configured to channel 2 is a sine wave with a frequency of 50 kHz, an amplitude of 5 Vpp, an offset of 0 V. This waveform is set to output for 10 cycles.

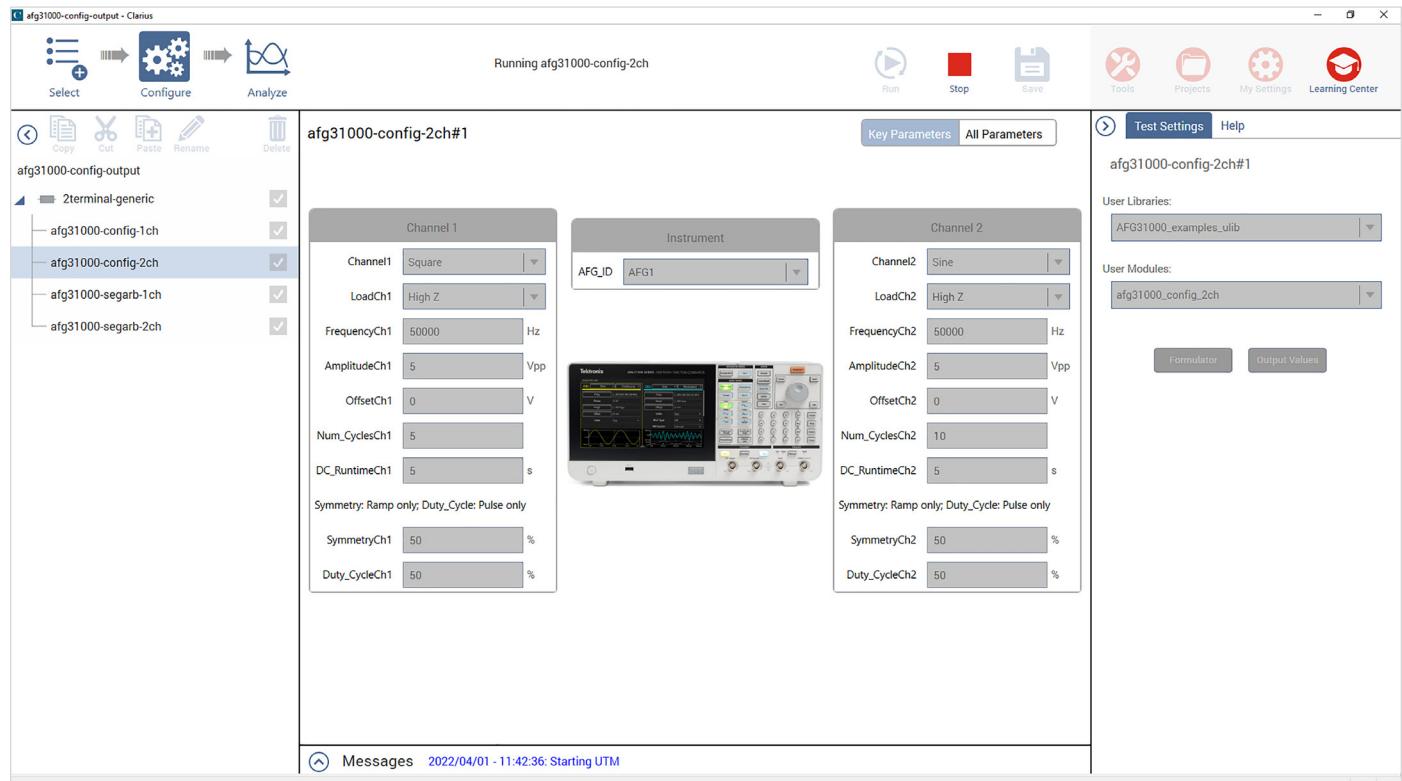


Figure 10. Configure view of *afg-config-2ch* test running.

When the test runs, the settings are sent to the AFG31000 channels by SCPI commands through NI Visa via USB. The result of the setup seen in **Figure 10** can be seen on the AFG31000's screen in **Figure 11**.

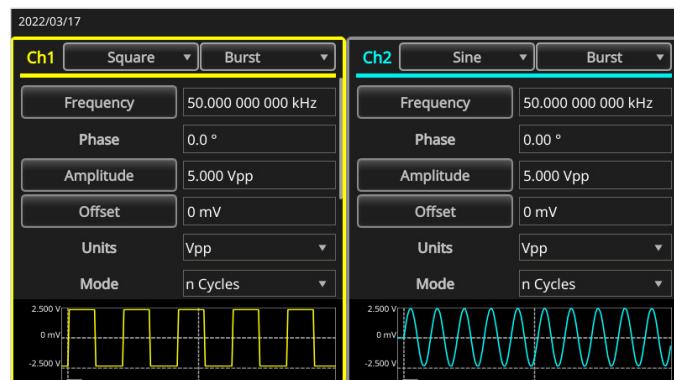


Figure 11. AFG31000 Basic Mode after settings sent.

Once the settings are applied to the AFG31000's channels and the outputs are turned on, the channels are triggered simultaneously. The resulting output of these waveforms, from the AFG31000, can be seen in the scope screen capture in **Figure 12**. A Tektronix MSO56 oscilloscope was used to capture the arbitrary waveforms.

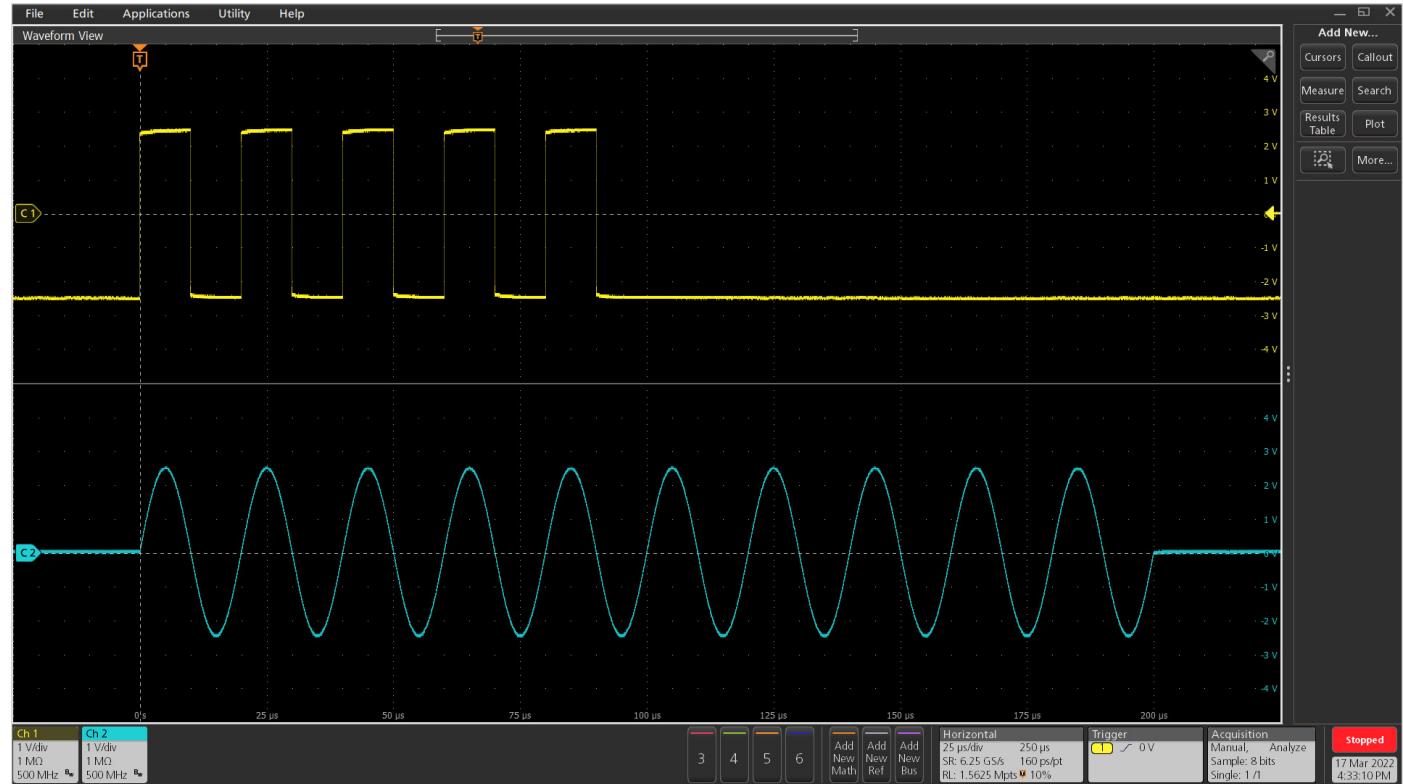


Figure 12. MSO56 Oscilloscope capture of waveforms output by the AFG31000.

Each channel of the AFG31000's output is shut off, once the channel is done sending its configured waveform. Once each channel output of the AFG31000 is shut off after a successful run, a 0 is returned to the Clarius sheet as shown earlier in **Figure 9**. The Help pane lists descriptions of Returned Values for numbers other than 0.

Conclusion

Using Clarius V1.11 or higher, the 4200A-SCS can remotely control an AFG31000 through USB communication via NI VISA. A new user library has been created to enable the Clarius software to easily control the AFG31000. Tests have been added to the Library that can be added to a project to automate waveform generation.

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