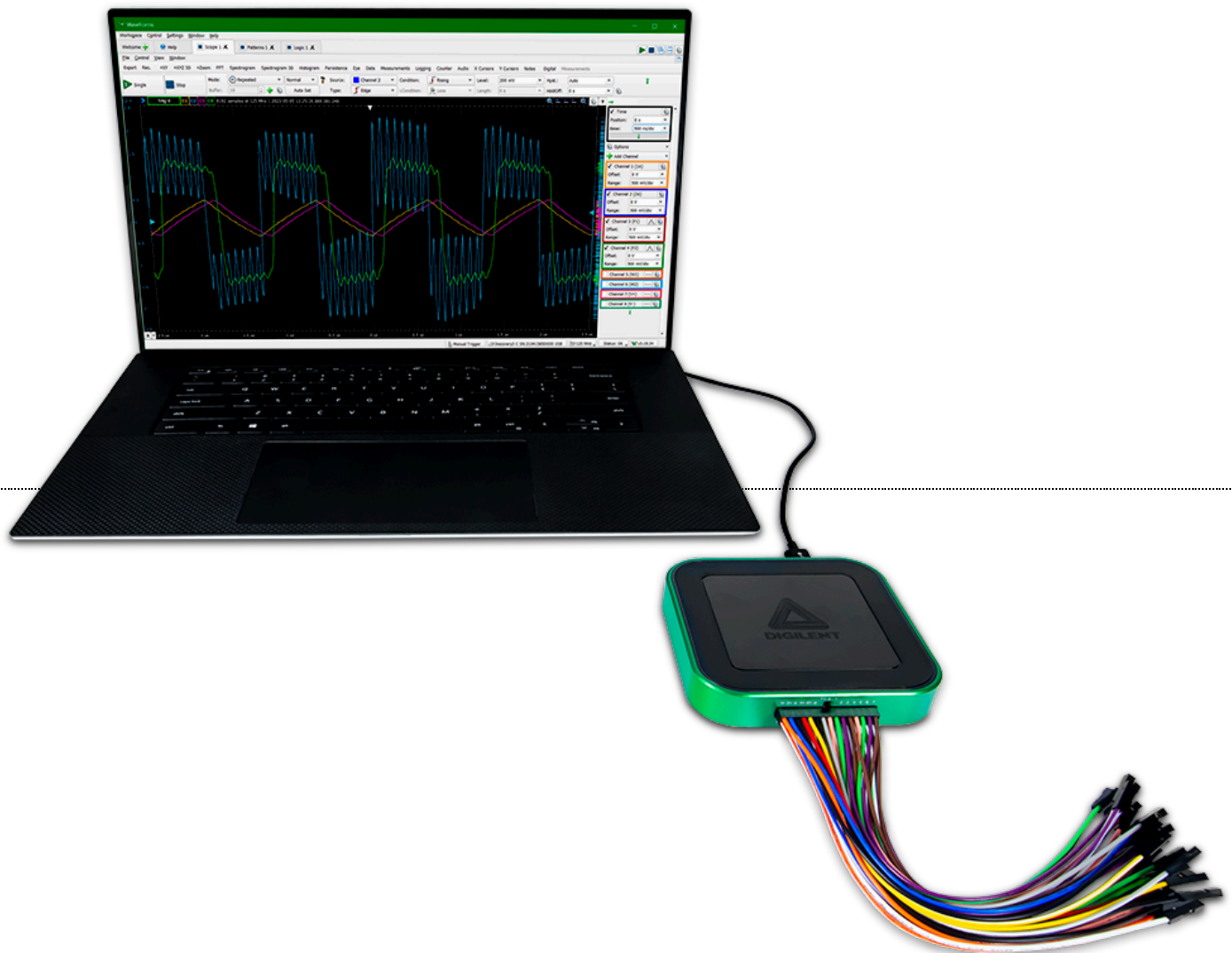
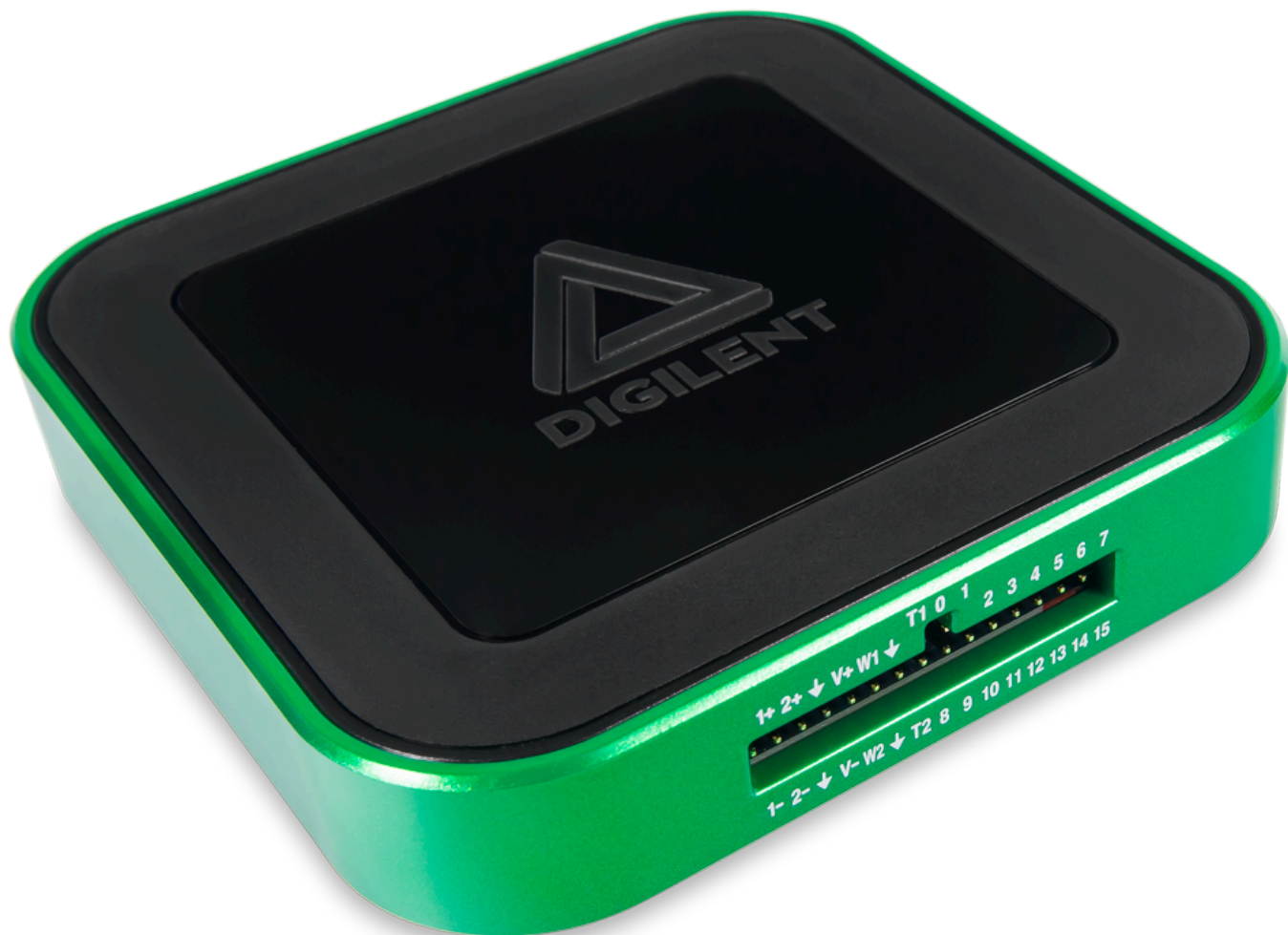


Analog Discovery 3 Reference Manual

The Diligent Analog Discovery 3™, featuring circuitry made by Texas Instruments, is a multi-function test and measurement device that allows users to measure, visualize, generate, record, and control mixed signal circuits of all kinds. The low-cost Analog Discovery 3 is small enough to fit in your pocket, but powerful enough to replace a stack of lab equipment, providing engineering students, hobbyists, and electronics enthusiasts the freedom to work with analog and digital circuits in virtually any environment, in or out of the lab.



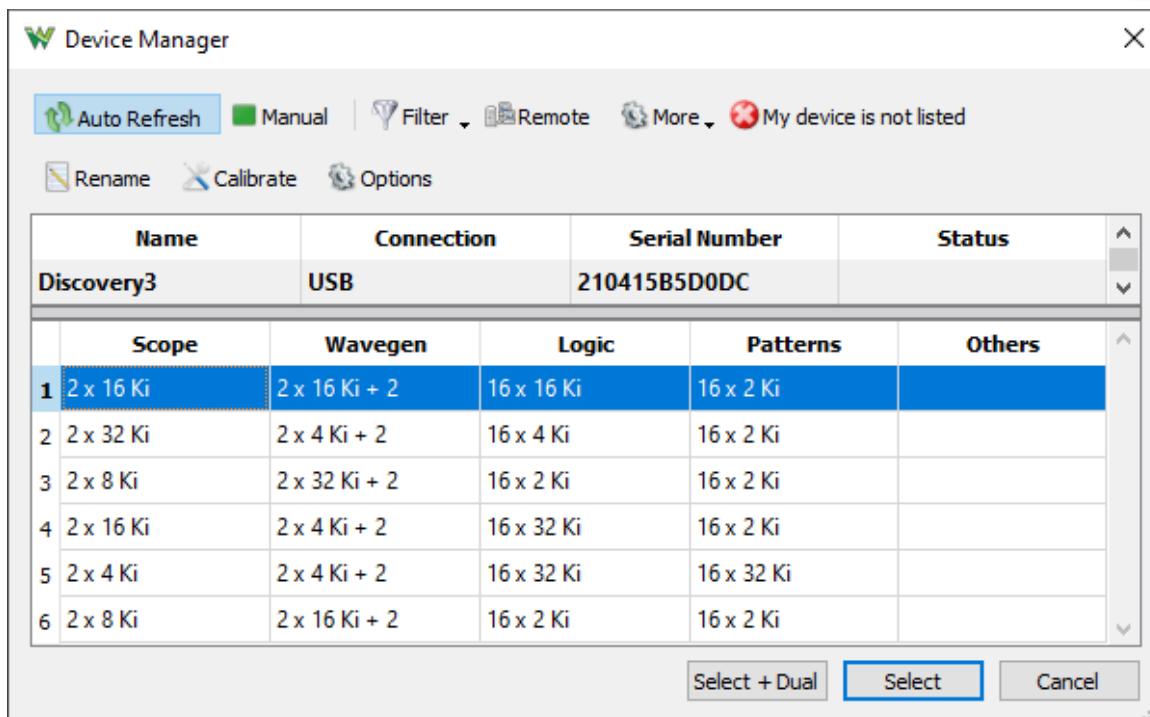
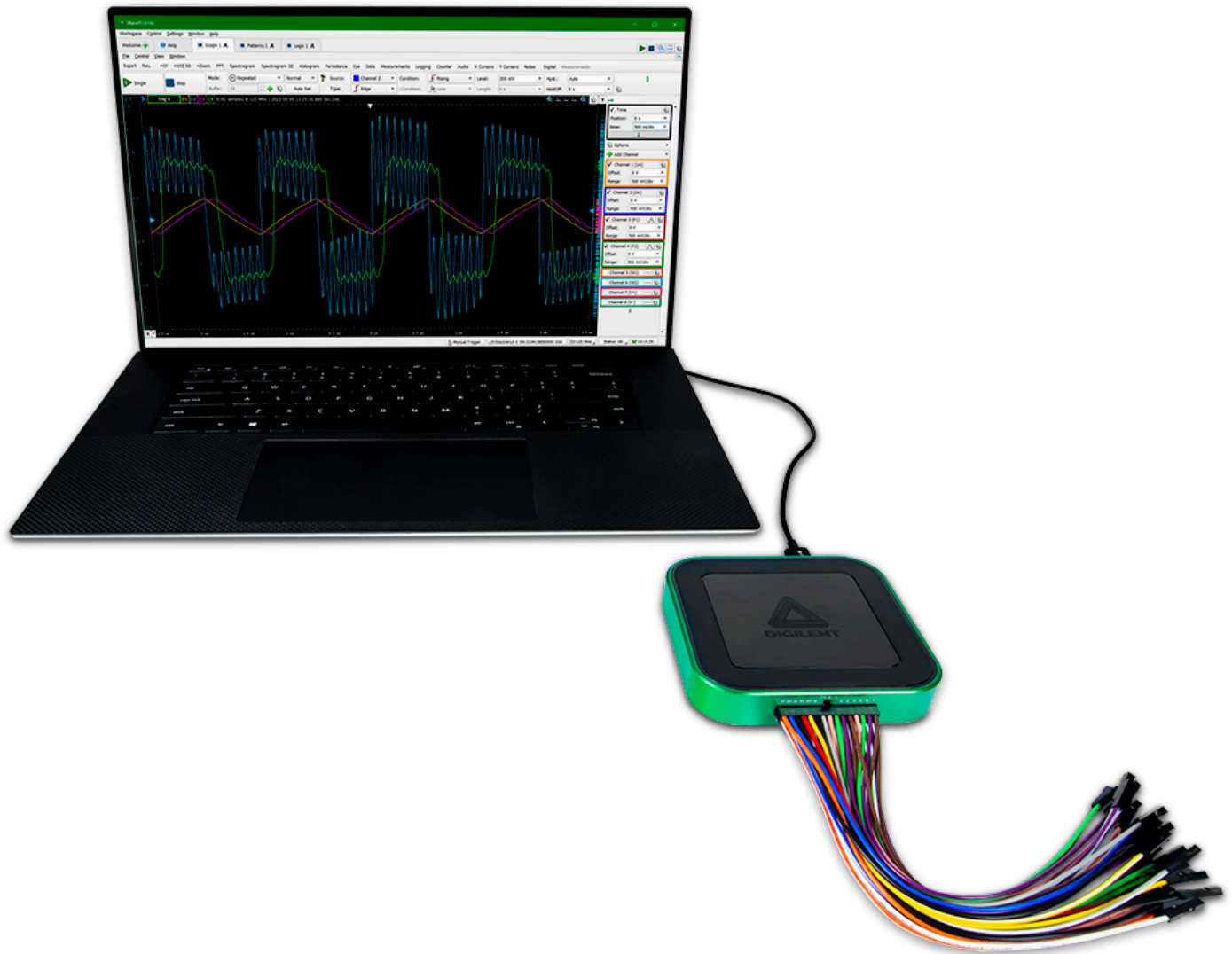
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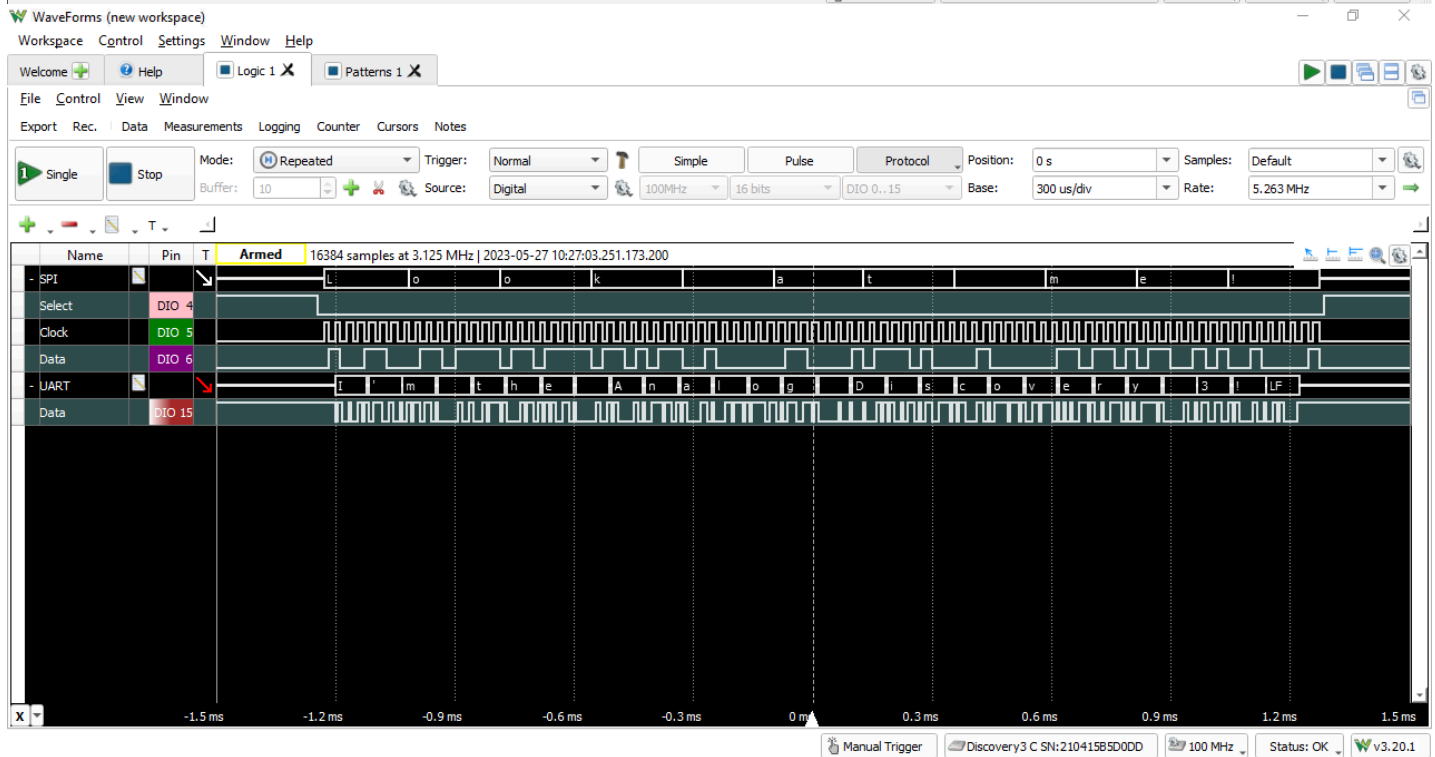
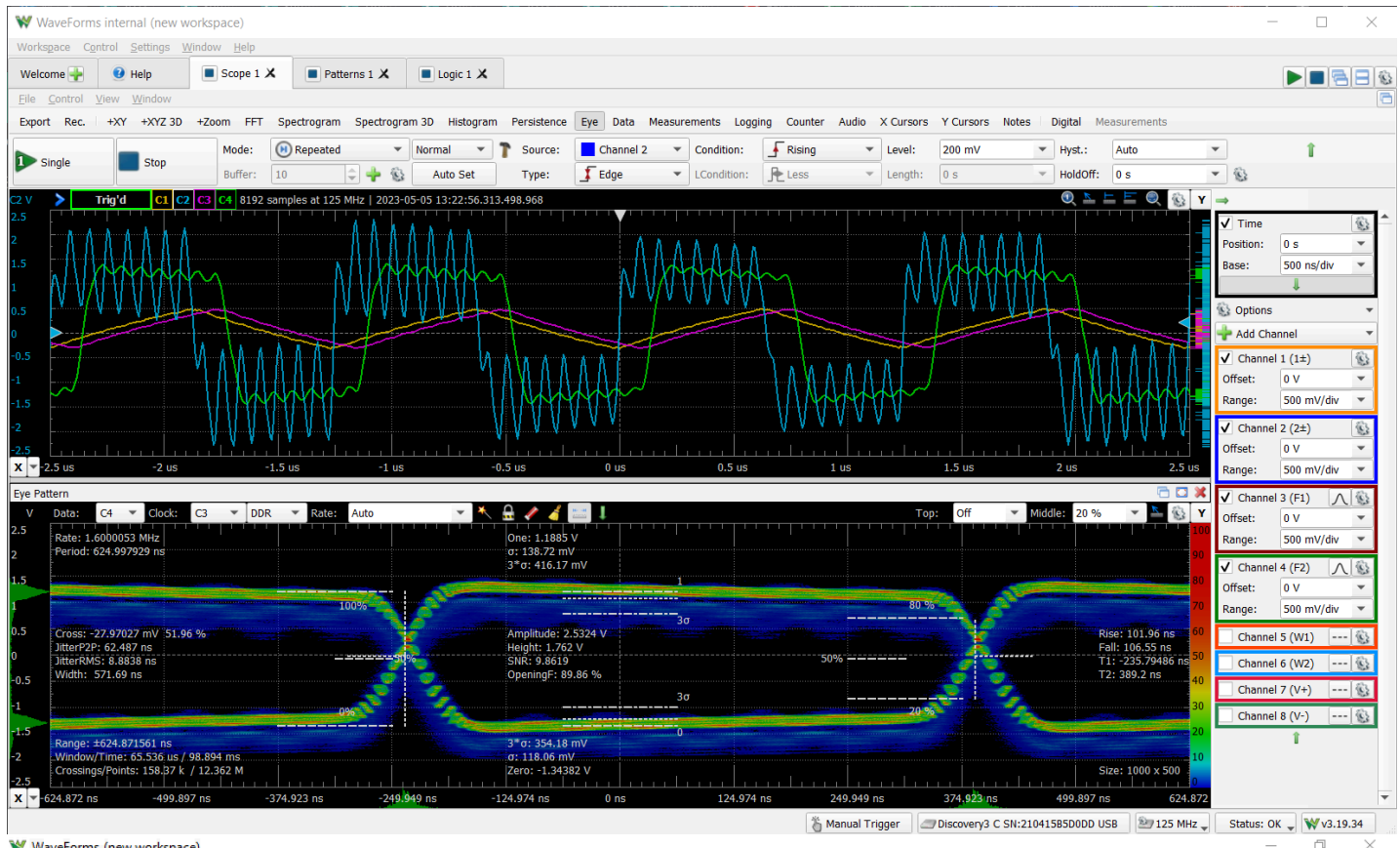


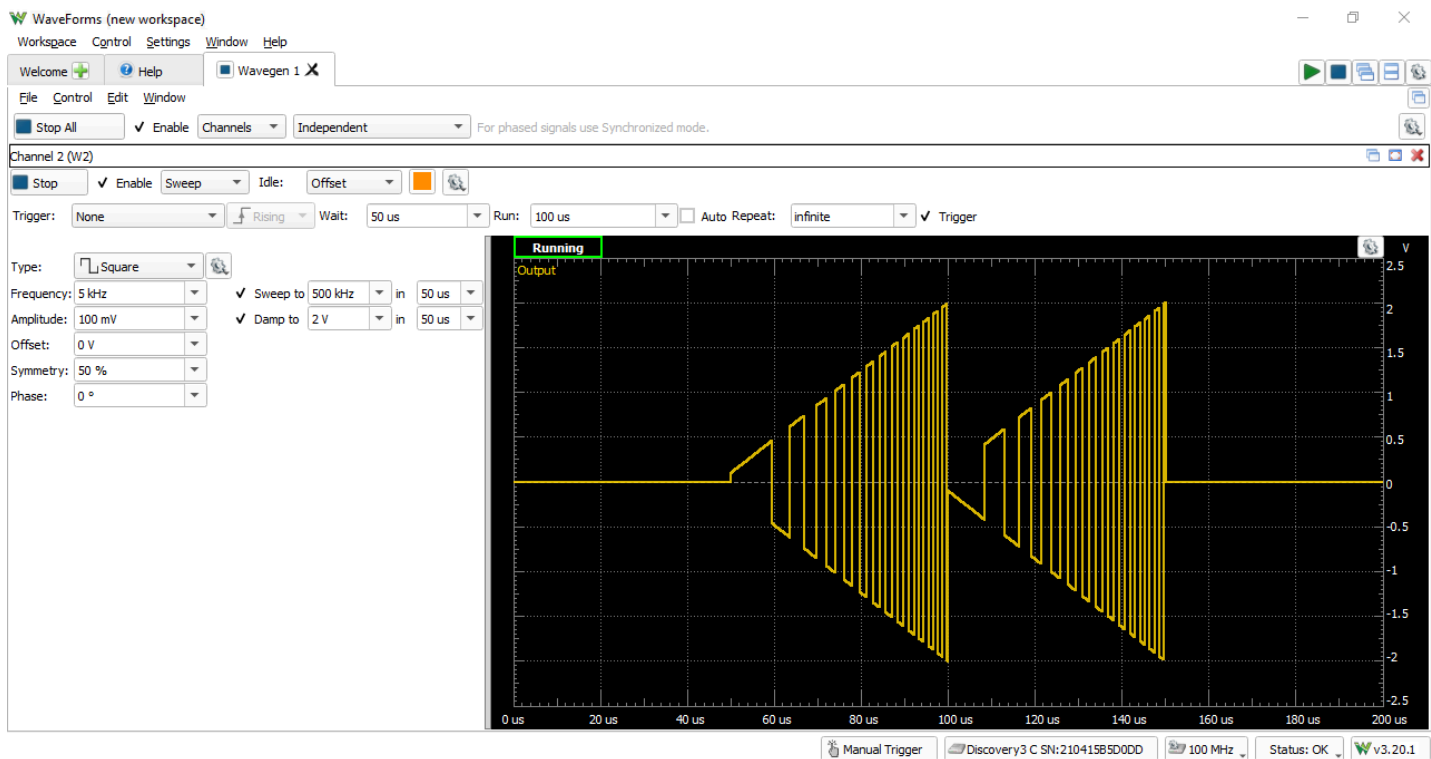




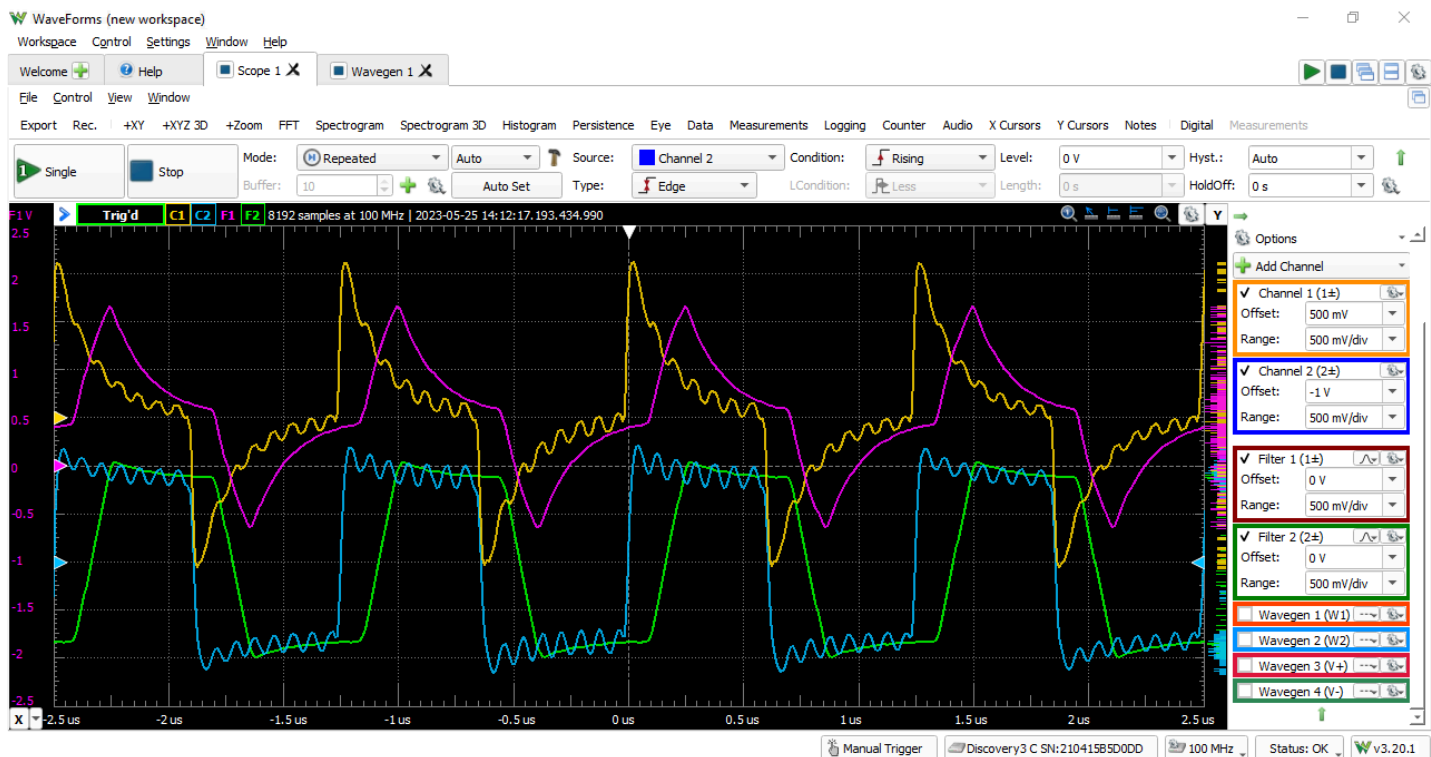








Oscilloscope



Highlighted Features

- Two differential channels with 14-bit resolution at up to 125 MS/s () per channel
- ± 25 V input range, 9 MHz () bandwidth with MTE cables, 30+ MHz () when used with the BNC Adapter
- User-configurable input filters and lock-in amplifier
- FFT, Spectrogram, Eye Diagram, XY Plot views, and more
- Rectangular, Triangular, Hamming, Hann, Cosine, Flat-top, Blackman-Harris, and Kaiser windowing functions
- Triggering: edge, pulse, transition, hysteresis, and many others

- Cross-triggering with Logic Analyzer, Waveform Generator, Pattern Generator, or external trigger
- Digital loopback of analog output channels
- Multiple math channels with complex functions
- Cursors with advanced data measurements
- Captured data files can be exported in standard formats
- Scope configurations can be saved, exported, and imported

The Analog Discovery 3 can be used with WaveForms' Scope instrument to capture analog input data via the analog input channels, using either BNC cables or MTE cables. When this instrument is used, the Analog Discovery 3's analog input channels act as a two-channel oscilloscope with 14-bit resolution at up to 125 MS/s(). The samples themselves are stored in a 16-bit format, so increased resolution is available at lower sample rates with 15-bit resolution available when sampling at half of the system frequency and 16-bit resolution when sampling at one quarter or lower of the Adjustable System Clock Frequency (https://digilent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#adjustable_system_clock_frequency). An increased number of samples beyond what has been set in the Device Configuration (https://digilent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#device_configuration) can be acquired at slower data rates through Record mode. Users can record both directly to file (with optional data compression) or use the host computers RAM() as a buffer to hold the acquisition until complete.

The BNC Adapter (<https://digilent.com/reference/test-and-measurement/bnc-adapter-board/start>) can be used with the Analog Discovery 3 to allow for the use of BNC cables with the oscilloscope to enable substantially higher bandwidth than with MTE cables. Note that when the AD3 is used with the BNC Adapter that the oscilloscope channels on the adapter are single-ended and the circuit under test must still share a common ground with the Analog Discovery 3.

When used with MTE cables, the oscilloscope channels' positive (+) and negative (-) pins are differentially paired. The negative (-) pins can be attached to a non-ground circuit net, but the circuit under test must still share a common ground with the Analog Discovery 3 and continue to respect the ± 25 V input range.

Important Note: Grounding Circuitry

Despite the fact that the Analog Discovery 3 analog input channels are fully differential, a GND() connection to the circuit under test is required to provide a stable common mode voltage.

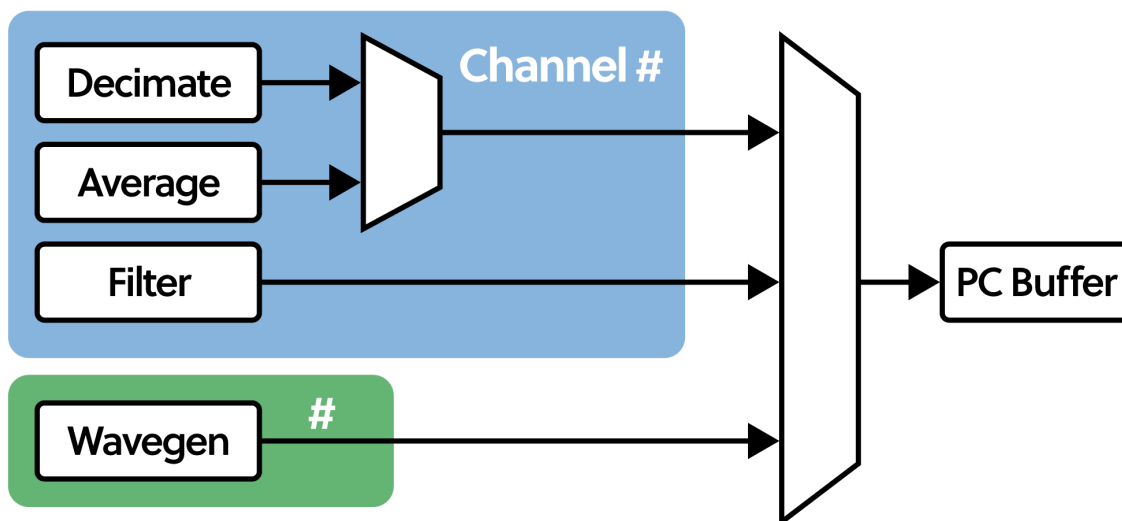
The Analog Discovery 3's GND() reference is connected to the USB GND(). Depending on the PC powering scheme, and other PC connections (Ethernet, audio, etc. – which might also be grounded) the Analog Discovery 3 GND() reference might be connected to the whole GND() system and ultimately to the power network protection (earth ground). The circuit under test might also be connected to earth or possibly floating.

For safety reasons, it is the user's responsibility to understand the powering and grounding scheme and to make sure that there is a common GND() reference between the Analog Discovery 3 and the circuit under test. For distortion-free measurements, the common mode and differential voltages need to meet and not exceed the Specifications (<https://digilent.com/reference/test-and-measurement/analog-discovery-3/specifications>).

Since the Analog Discovery 3's analog input channels are shared between instruments, the Oscilloscope instrument cannot be used at the same time as other instruments including the Voltmeter, Data Logger, Spectrum Analyzer, Network Analyzer, Impedance Analyzer, or Tracer instruments.

The Analog Discovery 3 has a separate small noise buffer that stores minimum and maximum sample values collected during data acquisition and represented on screen as a semi-transparent band in the background of the plot in order to indicate glitches or higher frequency components while running at a lower sample rate than the system frequency. The noise acquisition can be disabled for a faster acquisition rate.

In addition to the two physical analog input channels, the Analog Discovery 3 supports digital loopback of the data sent to the Wavegen and Power Supplies to display the configured outputs as traces on the on the Scope plot view. This allows idealized reference signals of the outputs to be easily viewed and used for in-app calculations and filters.

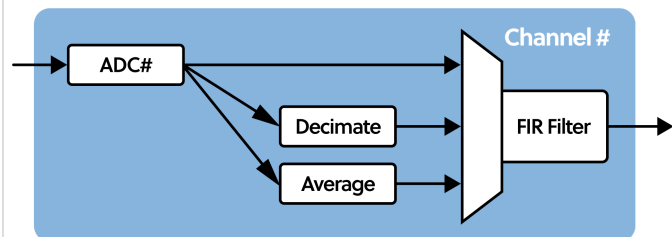


(https://diligent.com/reference/_detail/test-and-measurement/analog-discovery-3/diagrams-scope-plot-view.png?id=test-and-measurement%3Aanalog-discovery-3%3Areference-manual)

Figure 1. Available sources of hardware data to display on the Scope plot view.

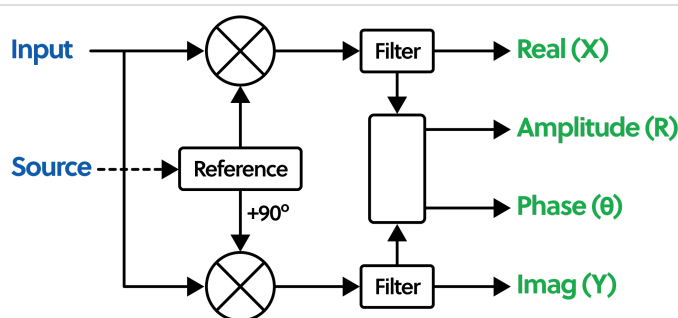
Hardware and software filters are available within the Scope instrument as additional channels to be shown on the viewing plot. A hardware FIR filter with different windowing functions is available for each of the two analog inputs on the Analog Discovery 3 as additional channels. Each hardware filter can be configured to use the averaged, decimated, or raw ADC() data from its associated oscilloscope input.

Software channels, which are calculated by the WaveForms software on the host computer, can also be added as visible channels to the viewing plot. These software channels and filters include straightforward arithmetic operations such as calculating the total amount of power consumed by a system, Butterworth and Chebyshev IIR filters for signal processing, Lock-in amplifiers to extract a signal from surrounding noise, and scriptable math functions. Each software channel can use any of the existing hardware or software channels as the source for their inputs.



(https://diligent.com/reference/_detail/test-and-measurement/analog-discovery-3/diagrams-fir-filter-tall.png?id=test-and-measurement%3Aanalog-discovery-3%3Areference-manual)

Figure 2. Oscilloscope hardware data acquisition and filter diagram.

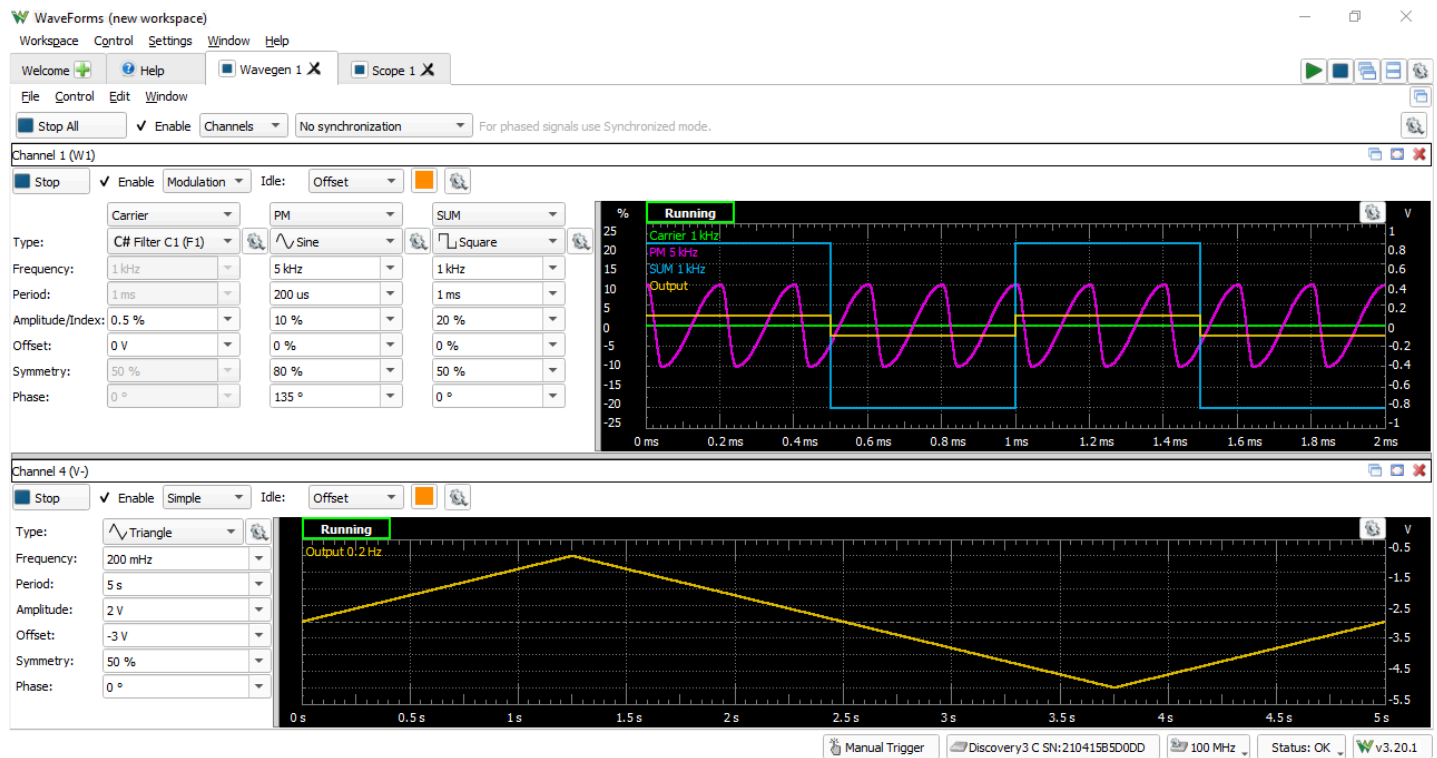


(https://diligent.com/reference/_detail/test-and-measurement/analog-discovery-3/diagrams-lock-in-amplifier.png?id=test-and-measurement%3Aanalog-discovery-3%3Areference-manual)

Figure 3. Oscilloscope Lock-in Amplifier diagram.

For more information on the analog input channels, please visit the Analog Discovery 3 Specifications (<https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications>). For a walkthrough of the different features of WaveForms' Scope instrument, please visit the Using the Oscilloscope (<https://diligent.com/reference/test-and-measurement/guides/waveforms-oscilloscope>) guide. Information on the Adjustable System Clock Frequency (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#adjustable_system_clock_frequency) and the Trigger System (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#trigger_system) can be found in their respective sections within this document.

Waveform Generator



Highlighted Features

- Two channels with 14-bit resolution at up to 125 MS/s,() per channel
- ± 5 V output range, 9 MHz,() bandwidth with MTE cables, 12 MHz,() when used with the BNC Adapter
- Standard waveforms: sine, triangle, sawtooth, noise, ramp up, ramp down, DC voltage, and more
- Advanced waveforms: Sweep, Modulation and summing (phase, AM, FM), custom math, and play mode
- Digital loopback of raw, averaged, or filtered analog input data as waveform outputs
- User-defined arbitrary waveforms: defined within WaveForms software user interface or using standard tools (e.g. Excel)
- Optional standard waveforms control over the two programmable supplies

The Analog Discovery 3 can be used with WaveForms' Wavegen instrument to output analog voltage waves through either BNC cables or MTE cables. When the Wavegen is used, the Analog Discovery 3's analog output channels act as a two-channel arbitrary waveform generator with 14-bit resolution at up to 125 MS/s,(). Additional separate buffers are allocated towards modulation for frequency or phase modulation (FM/PM) or amplitude and summation (AM/SUM) for complex signals to be generated on each of the analog output channels. The size of the sample buffers for both the primary AWG channels and the modulation parameters can be set through the [Device Configuration \(https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#device_configuration\)](https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#device_configuration).

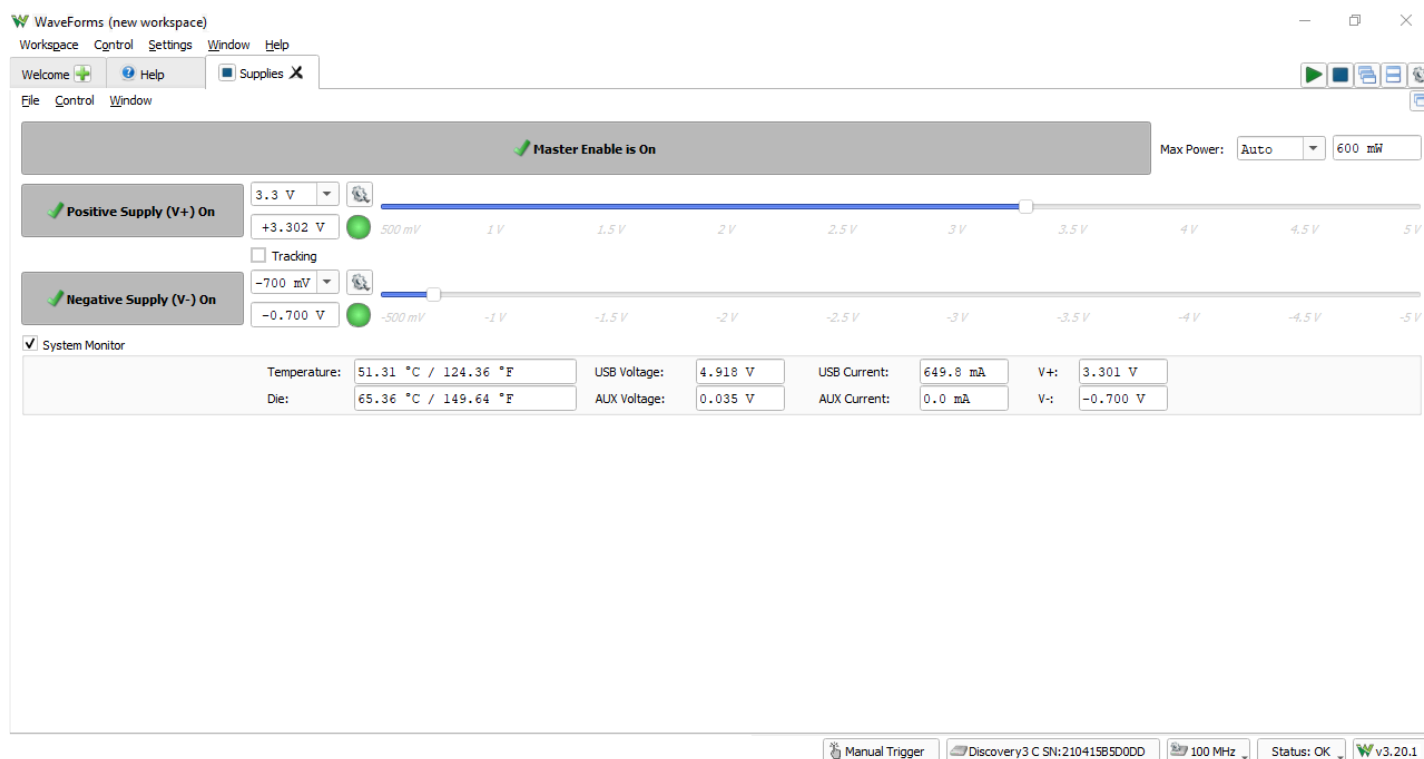
If highly capacitive loads are attached to the analog outputs, ringing or overshoot may be observed in signals that have abrupt edges. This can be mitigated with the [BNC Adapter \(https://diligent.com/reference/test-and-measurement/bnc-adapter-board/start\)](https://diligent.com/reference/test-and-measurement/bnc-adapter-board/start) by positioning the jumper to the 50 Ω of impedance selection rather than the default 0 Ω impedance (not precisely controlled) used by the Analog Discovery 3. The BNC Adapter can be used to allow for the use of BNC cables with the arbitrary waveform generator to enable higher output bandwidth than the MTE cables.

In addition to controlling the two single ended outputs as standard or advanced types of waveforms, the Analog Discovery 3 features digital loopback paths that allow the analog output channels to directly use raw, averaged, or filtered analog input data from the Scope instrument. Both programmable power supplies can also be separately controlled as slow, 2.5 Hz,() or less, standard waveform generators.

Since the Analog Discovery 3's analog output channels are shared, the Wavegen instrument cannot be used at the same time as the Network Analyzer or Impedance Analyzer instruments. If the two primary analog outputs or the programmable power supplies are being controlled directly from the Scope instrument (<https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#oscilloscope>), the associated channels cannot be simultaneously controlled through the Wavegen instrument.

For more information on the analog output channels, please visit the [Analog Discovery 3 Specifications](https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications) (<https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications>). For a walkthrough of the different features of WaveForms' Wavegen instrument, please visit the [Using the Waveform Generator](https://diligent.com/reference/test-and-measurement/guides/waveforms-waveform-generator) (<https://diligent.com/reference/test-and-measurement/guides/waveforms-waveform-generator>) guide. Information on the [Adjustable System Clock Frequency](https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#adjustable_system_clock_frequency) (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#adjustable_system_clock_frequency) and the [Trigger System](https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#trigger_system) (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#trigger_system) can be found in their respective sections within this document.

Power Supplies



Highlighted Features

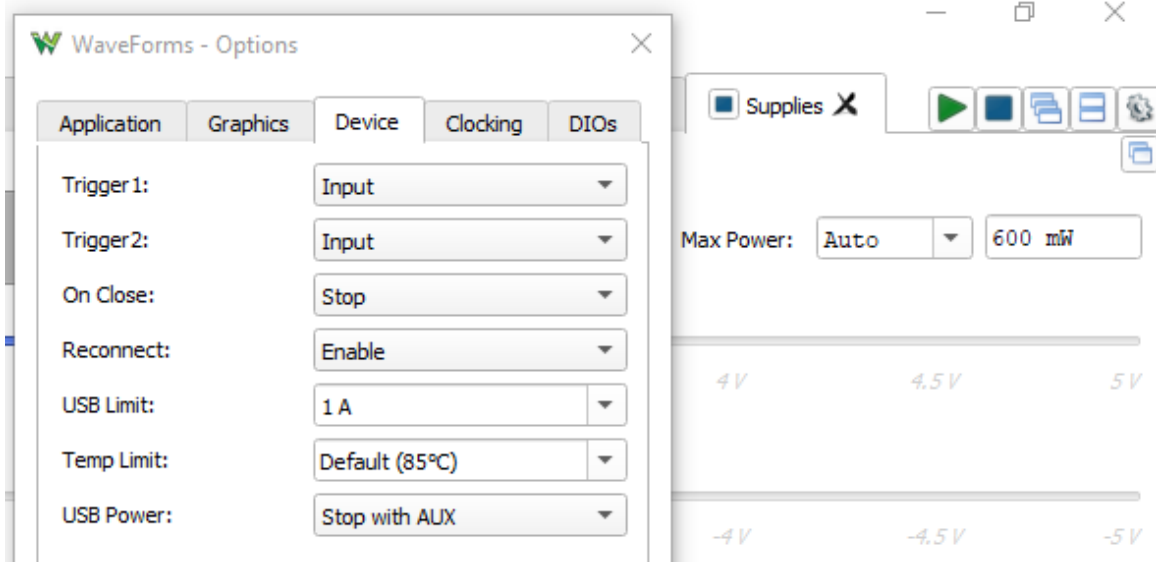
- Two programmable power supplies (0.5 V to 5 V , -0.5 V to -5 V)
- Optional tracking between the two programmable power supplies
- Integrated readback of system temperature, voltage rail outputs, and amount of current drawn from source
- Configurable power limitations to prevent system damage

The Analog Discovery 3 has two variable power supply rails that can be used to power external circuits under test. These rails can be set to voltage levels between 0.5 V to 5 V and -0.5 V to -5 V respectively, through the use of WaveForms' Supplies instrument. Direct integrated readback of the supplied host voltage and current, power supply voltage outputs, and system temperature is also present in this instrument.

The maximum available output current and power depend on how the Analog Discovery 3 is powered. When powered over USB, the Analog Discovery 3 draws up to 700 mA (~3.5 W) with no instruments running. The two variable power supplies can be used until the recommended USB overall operating wattage of 5.5 W is reached.

When using a 5 V_{DC} auxiliary power supply with a recommended current rating of 3.1 A or higher, each programmable power supply rail can provide up to 800 mA, with a wattage limit of 2.4 W per channel to prevent the internal components of the power supplies from overheating. The point at which the device becomes at risk for overheating is at 10 W or higher.

Users can set their own preferred device temperature limit and power limit for the Analog Discovery 3 to further restrict the recommended conditions. The Max Power setting configures the total amount of power provided to the hardware circuitry behind the user supplies; the amount of power able to be sourced from the two supplies will be less than this setting and is dependent on the voltage requested by the user, the load, and the duty cycle of the internal hardware needed to maintain the requested voltage output, among other factors. The Auto option dropdown for the Max Power settings has WaveForms automatically set the allowed power based on the USB capabilities or the presence of an auxiliary power supply.

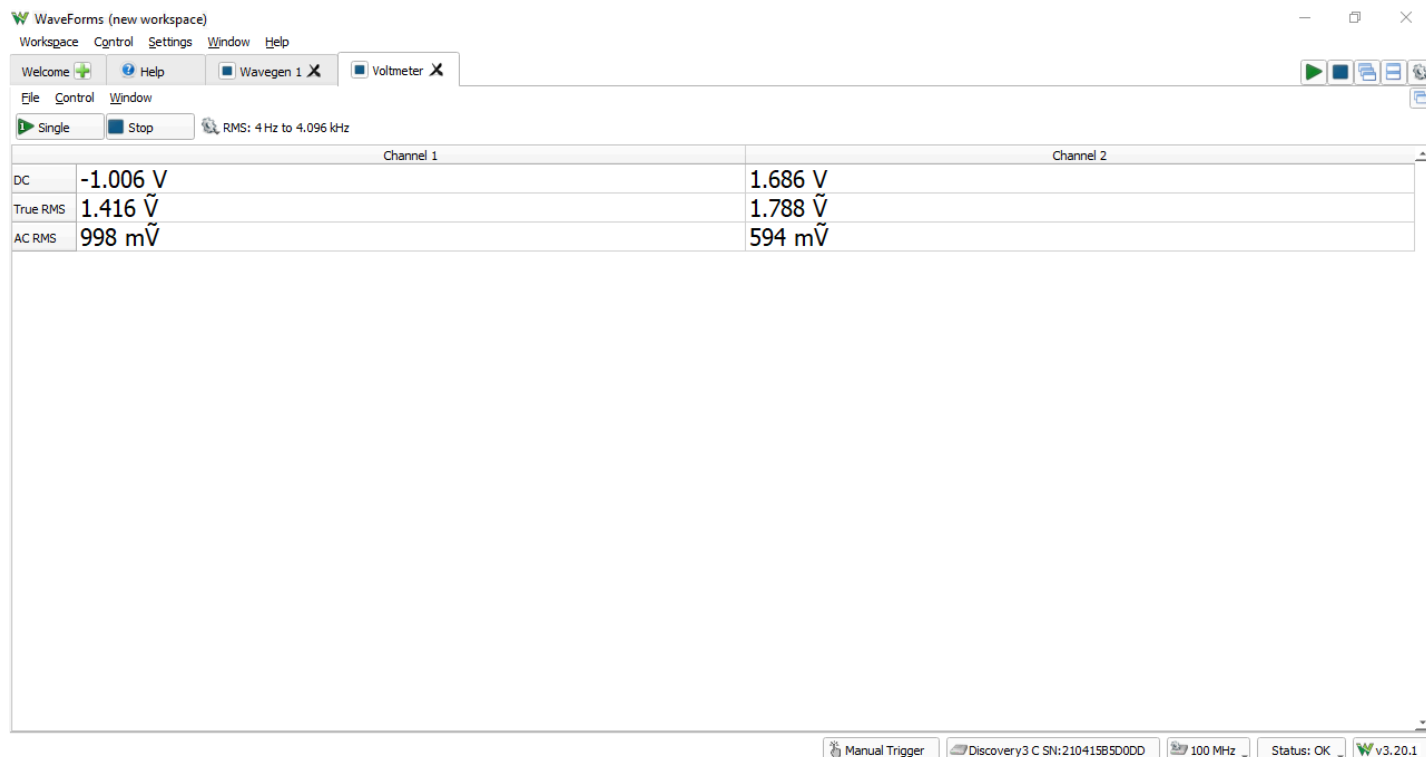


(https://digilent.com/reference/_detail/test-and-measurement/analog-discovery-3/supplies-power-temp-limits.png?id=test-and-measurement%3Aanalog-discovery-3%3Areference-manual)

Figure 4. Power Supplies and temperature limit settings

For more information on the programmable power supplies, please visit the [Analog Discovery 3 Specifications](https://digilent.com/reference/test-and-measurement/analog-discovery-3/specifications) (<https://digilent.com/reference/test-and-measurement/analog-discovery-3/specifications>). For a walkthrough of the different features of WaveForms' Power Supplies instrument, please visit the [Using the Power Supplies](https://digilent.com/reference/test-and-measurement/guides/waveforms-supplies) (<https://digilent.com/reference/test-and-measurement/guides/waveforms-supplies>) guide.

Voltmeter



Highlighted Features

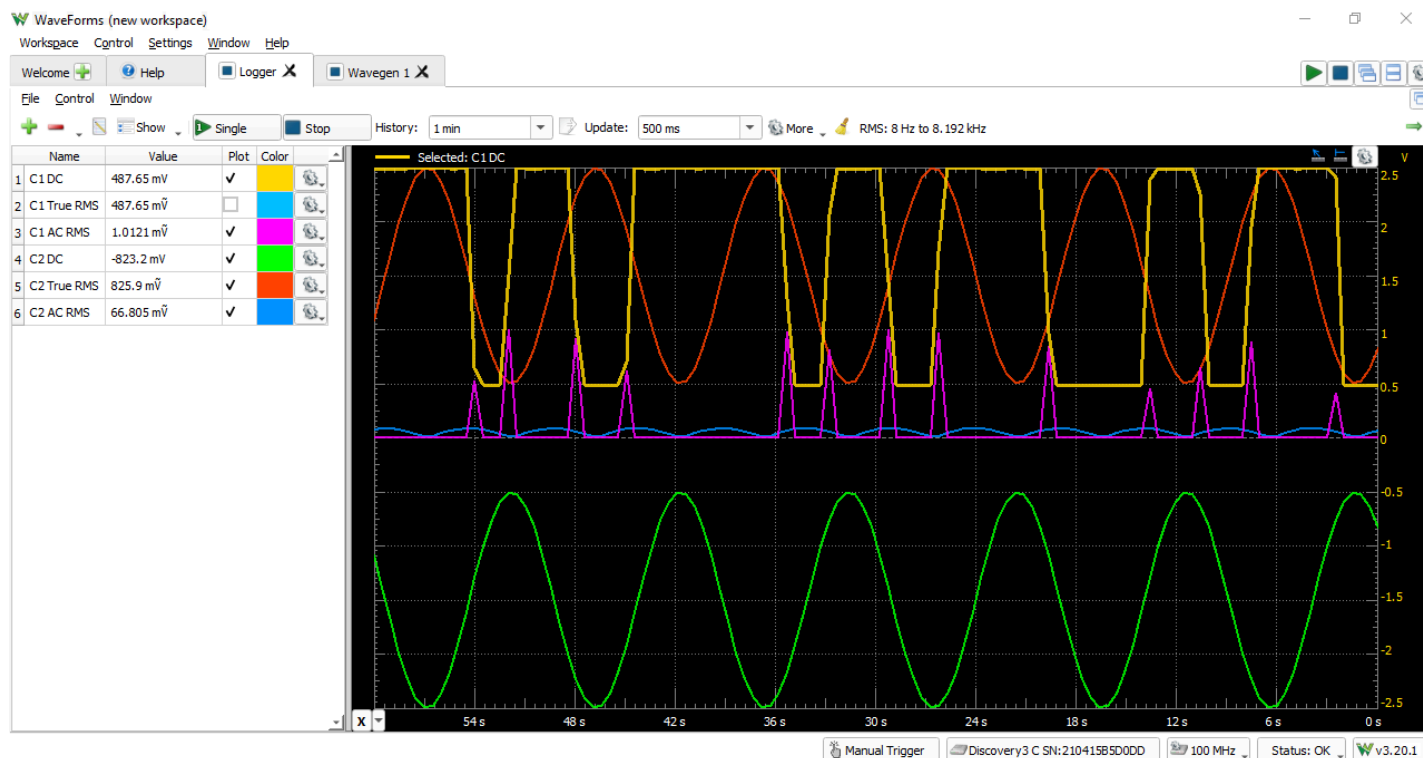
- DC, AC RMS, and True RMS measurements

The Analog Discovery 3's analog inputs can be used with WaveForms' Voltmeter instrument to act as a simple voltmeter. DC voltages, AC RMS voltages, and True RMS voltages can be viewed for each of the two Scope channels.

Since the Analog Discovery 3's analog input channels are shared, the Voltmeter instrument cannot be used at the same time as the Oscilloscope, Data Logger, Spectrum Analyzer, Network Analyzer, or Impedance Analyzer instruments.

For more information on the analog input (“Scope”) channels, please visit the [Analog Discovery 3 Specifications](https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications) (<https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications>). For a walkthrough of the different features of WaveForms' Voltmeter instrument, please visit the [Using the Voltmeter](https://diligent.com/reference/test-and-measurement/guides/waveforms-voltmeter) (<https://diligent.com/reference/test-and-measurement/guides/waveforms-voltmeter>) guide.

Data Logger



Highlighted Features

- DC, AC RMS, and True RMS measurements
- Capable of logging continuously for 60 days
- Scriptable custom measurements

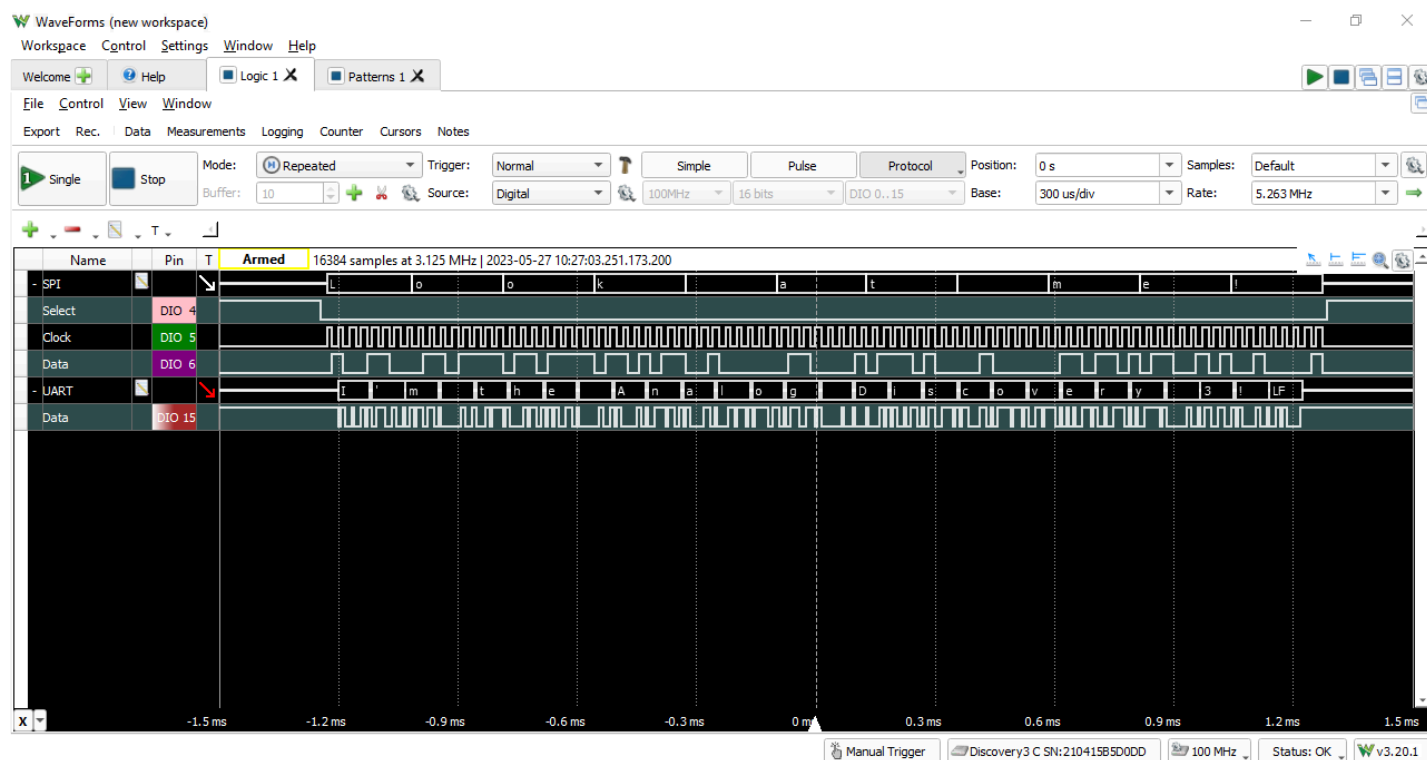
The Analog Discovery 3 can be used with WaveForms' Logger instrument in order to capture analog input data for a long period of time.

The Data Logger can capture buffers of data at update rates of up to 10 samples per second. The maximum duration of a log is dependent on the update rate, but at the extreme, can run for over a thousand hours. Additional logging configurations and options are available via the Record mode of the Scope instrument (<https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#oscilloscope>).

Since the Analog Discovery 3's analog input channels are shared, the Data Logger instrument cannot be used at the same time as the Oscilloscope, Voltmeter, Spectrum Analyzer, Network Analyzer, or Impedance Analyzer instruments.

For more information on the analog input channels, please visit the [Analog Discovery 3 Specifications](https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications) (<https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications>). For a walkthrough of the different features of WaveForms' Logger instrument, please visit the [Using the Data Logger](https://diligent.com/reference/test-and-measurement/guides/waveforms-data-logger) (<https://diligent.com/reference/test-and-measurement/guides/waveforms-data-logger>) guide.

Logic Analyzer



Highlighted Features

- Interpreters for SPI, I2C, UART, CAN, I2S, 1-Wire, PS/2, HDMI CEC, Manchester codes, JTAG, GPIB, SWD, and parallel buses
- Scripted custom protocols
- Multiple trigger options including pin change, bus pattern, and many others
- Cross-triggering between Analog input channels, Logic Analyzer, Pattern Generator, or external trigger
- Data file import/export using standard formats

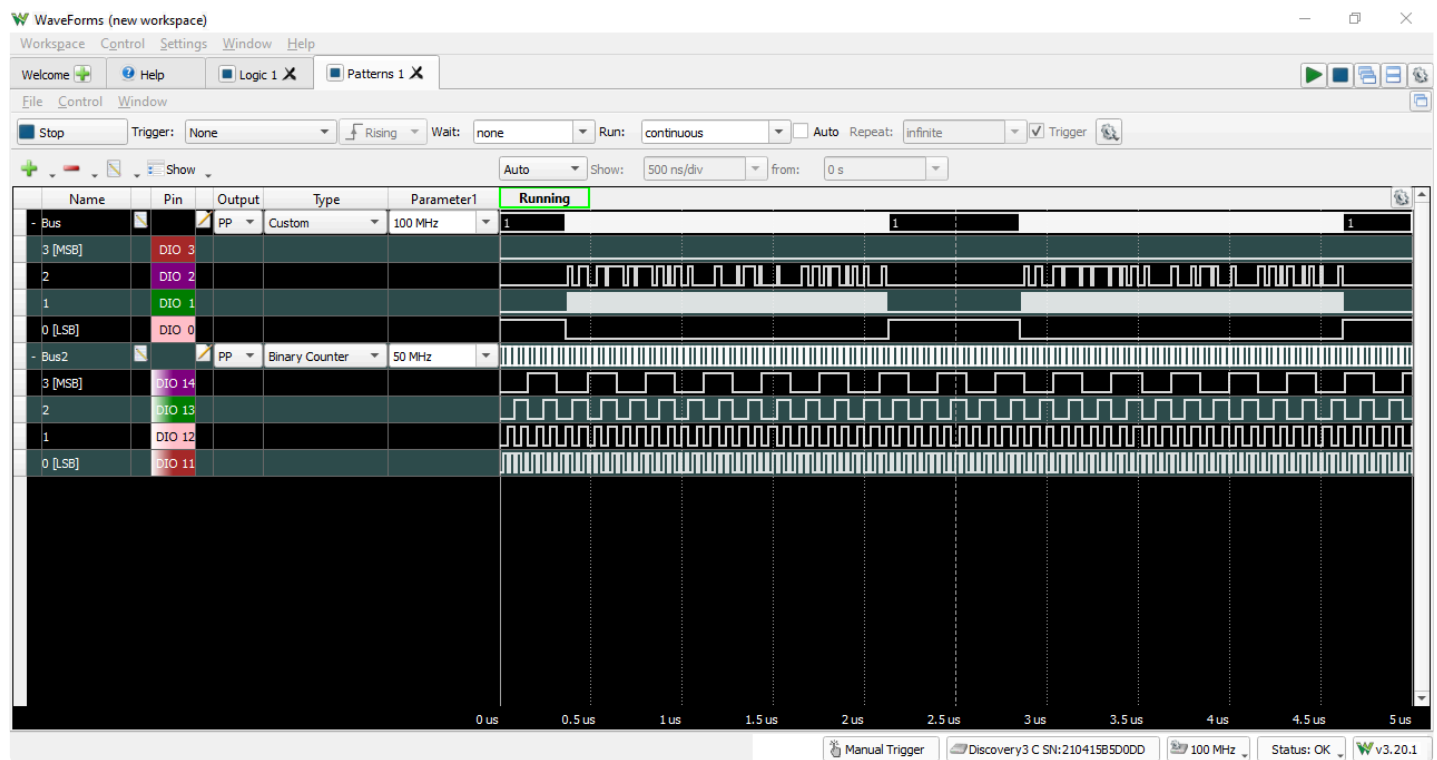
The Analog Discovery 3 can be used with WaveForms' Logic instrument to act as a Logic Analyzer. When used this way, the 16 digital input/output channels are configured to capture high/low logic states on connected pins and are capable of interfacing with 3.3 V CMOS logic signals and are tolerant to voltages of up to 5 V. An increased number of samples beyond what has been set in the Device Configuration (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#device_configuration) can be acquired at slower data rates through Record mode. Users can record both directly to file (with optional data compression) or use the host computers `RAM()` as a buffer to hold the acquisition until complete.

Individual input/output channels can be grouped as buses and protocols. Protocol groups can be used to view the decoded contents of packets of many common communications protocols, including SPI, I2C, UART, CAN, and I2S. Signal states, decoded bus values, and decoded protocols can be used to trigger a Logic Analyzer capture. Protocol triggers include protocol-specific events, like start of transmission, end of transmission, or packet contents matching a value.

Digital input/output channels used by the Logic Analyzer instrument can still be used by other instruments using the same digital input/output channels. Additionally, the drive strength and internal pull resistors can be changed in the [Digital I/O Settings](https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#digital_io_settings) (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#digital_io_settings).

For more information on the digital input/output channels, please visit the [Analog Discovery 3 Specifications](https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications) (<https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications>). For a walkthrough of the different features of WaveForms' Logic Analyzer instrument, please visit the [Using the Logic Analyzer](https://diligent.com/reference/test-and-measurement/guides/waveforms-logic-analyzer) (<https://diligent.com/reference/test-and-measurement/guides/waveforms-logic-analyzer>) guide. Information on the [Adjustable System Clock Frequency](https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#adjustable_system_clock_frequency) (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#adjustable_system_clock_frequency) and the [Trigger System](https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#trigger_system) (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#trigger_system) can be found in their respective sections within this document.

Pattern Generator



Highlighted Features

- Multiple preset patterns including Clock, Pulse, Binary Counter, Grey Counter, Johnson Counter, Walking 0/1, Decimal Counter, and Noise
- Custom user defined patterns and truth table ROM logic supported
- Data file import and export using standard formats
- Cross-triggering between Analog input channels, Logic Analyzer, Pattern Generator, or external trigger

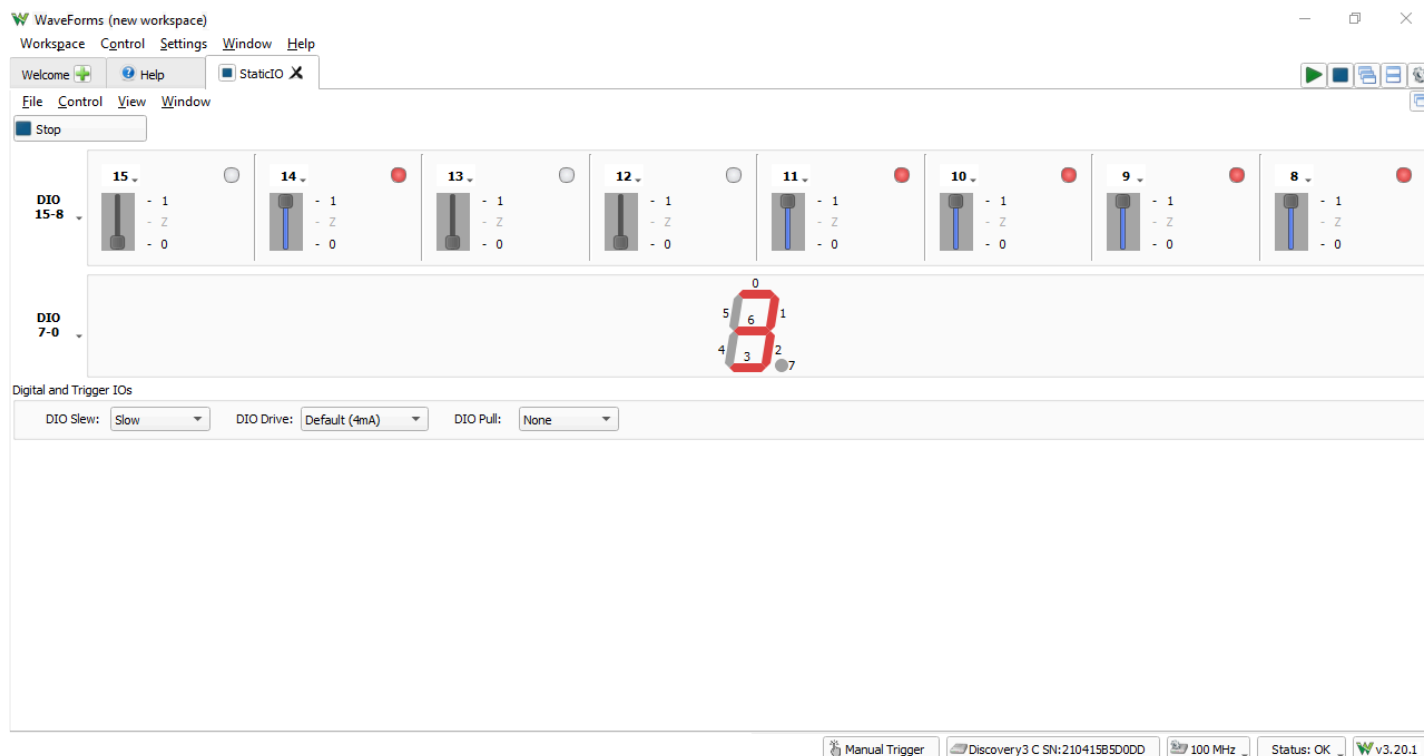
The Analog Discovery 3 can be used with WaveForms' Patterns instrument to generate logic signal sequences on the 3.3 V CMOS digital input/output pins at sample rate of up to 125 MS/s. Each individual pin or user defined groups of pins can be configured to be push/pull, open drain, open source, or tri-state logic.

Preset patterns such as a clock pulse or a Johnson counter can be selected as the desired pattern type, along with user defined custom patterns for more unique systems. Simple state machines can be created through the ROM logic option for groups of digital pins.

Individual digital input/output channels used by the Pattern Generator instrument can still be used by other instruments, however, other instruments can only use these shared channels as inputs. Additionally, the drive strength, slew rate, internal pull resistors can be changed in the Digital I/O Settings (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#digital_io_settings).

For more information on the digital input/output channels, please visit the Analog Discovery 3 Specifications (<https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications>). For a walkthrough of the different features of WaveForms' Pattern Generator instrument, please visit the Using the Pattern Generator (<https://diligent.com/reference/test-and-measurement/guides/waveforms-pattern-generator>) guide. Information on the Adjustable System Clock Frequency (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#adjustable_system_clock_frequency) and the Trigger System (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#trigger_system) can be found in their respective sections within this document.

Static I/O



Highlighted Features

- Virtual I/O devices (LEDs, buttons, switches, and displays)
- Easy control over DIO electrical characteristics

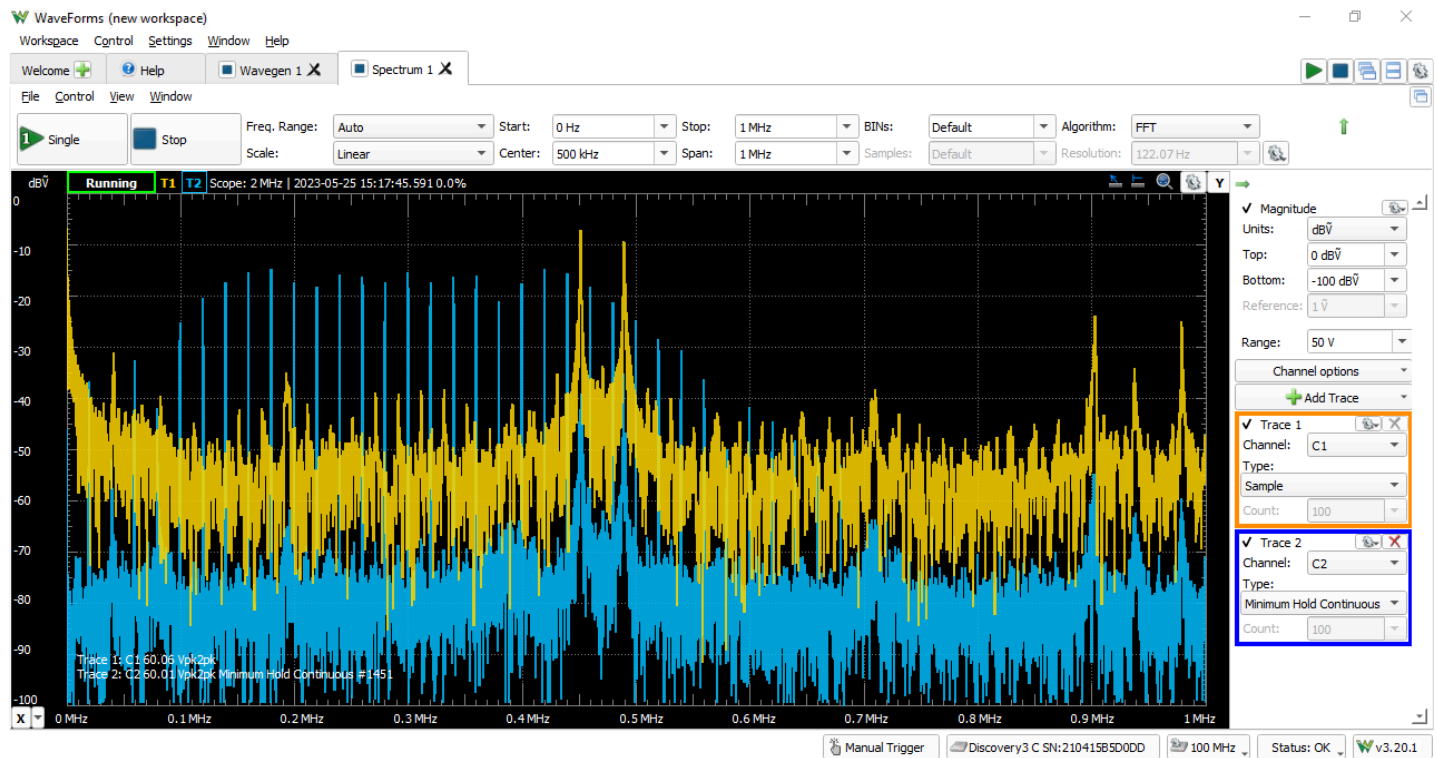
The Analog Discovery 3 can be used with WaveForms' Static I/O instrument to emulate a variety of user input/output devices on the digital input/output pins. Virtual LEDs, buttons, switches, sliders, and displays can be assigned to specific digital I/O pins, and interacted with within the WaveForms user interface.

The Analog Discovery 3's digital input/output channels use 3.3 V CMOS logic standard for input and output, and are tolerant to input signals up to 5 V. The drive strength, internal pull resistors, and slew can be changed directly changed in this instrument. Additional information about this can be found in the [Digital I/O Settings \(https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#digital_io_settings\)](https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#digital_io_settings) section.

Digital input/output channels used by the Static I/O instrument can still be used by other instruments using the same digital input/output channels, however, other instruments can only use these shared channels as inputs.

For more information on the digital input/output channels, please visit the [Analog Discovery 3 Specifications \(https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications\)](https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications). For a walkthrough of the different features of WaveForms' Static I/O instrument, please visit the [Using the Static I/O \(https://diligent.com/reference/test-and-measurement/guides/waveforms-static-io\)](https://diligent.com/reference/test-and-measurement/guides/waveforms-static-io) guide.

Spectrum Analyzer



Highlighted Features

- FFT and CZT power spectrum algorithms
- Adjustable frequency range modes: center/span, start/stop
- Linear or logarithmic scaling
- Multiple vertical axis options: voltage-peak, voltage-RMS, dBV, dBu, dBVS, and more
- Rectangular, Triangular, Hamming, Hann, Cosine, Flat-top, Blackman-Harris, and Kaiser windowing functions
- Sample, Peak Hold, Minimum Hold Continuous, Linear RMS Average, and more viewing options for each trace
- Data file import/export using standard formats

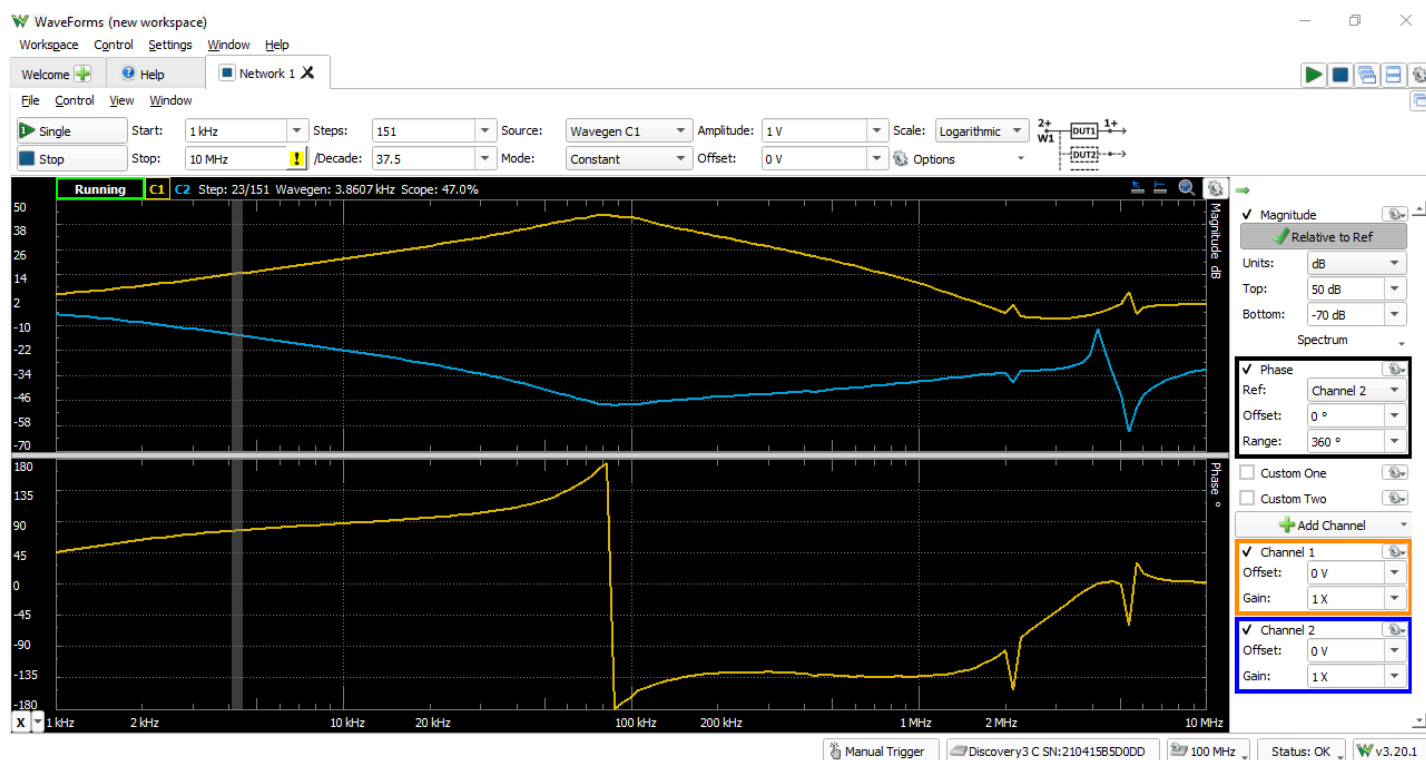
The Analog Discovery 3 can be used with WaveForms' Spectrum instrument to view the power of frequency-domain components of analog signals captured on the analog input channels. A Fast Fourier Transform or chirp Z-transform (Bluestein's algorithm) can be used as the discrete Fourier transform of choice.

The maximum number of samples and correspondingly number of frequency bins is dependent on the buffer size of the Scope selected in the WaveForms Device Manager and the chosen algorithm. The Spectrum instrument can have a maximum frequency of half of the Adjustable System Clock Frequency (https://digilent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#adjustable_system_clock_frequency).

Because the Analog Discovery 3's analog input channels are shared, the Spectrum instrument cannot be used at the same time as the Oscilloscope, Voltmeter, Data Logger, Network Analyzer, or Impedance Analyzer instruments.

For more information on the analog input channels, please visit the [Analog Discovery 3 Specifications](https://digilent.com/reference/test-and-measurement/analog-discovery-3/specifications) (<https://digilent.com/reference/test-and-measurement/analog-discovery-3/specifications>). For a walkthrough of the different features of WaveForms' Spectrum Analyzer instrument, please visit the [Using the Spectrum Analyzer](https://digilent.com/reference/test-and-measurement/guides/waveforms-spectrum-analyzer) (<https://digilent.com/reference/test-and-measurement/guides/waveforms-spectrum-analyzer>) guide.

Network Analyzer



Highlighted Features

- Bode, Nichols, Nyquist, and FFT diagrams
- Settable input gain and offset
- Selectable Wavgen channel or external signal as the frequency source
- Configurable samples, settle time, and averaging options for each frequency step
- Custom traces and calculations available
- Rectangular, Triangular, Hamming, Hann, Cosine, Flat-top, and Blackman-Harris windowing functions

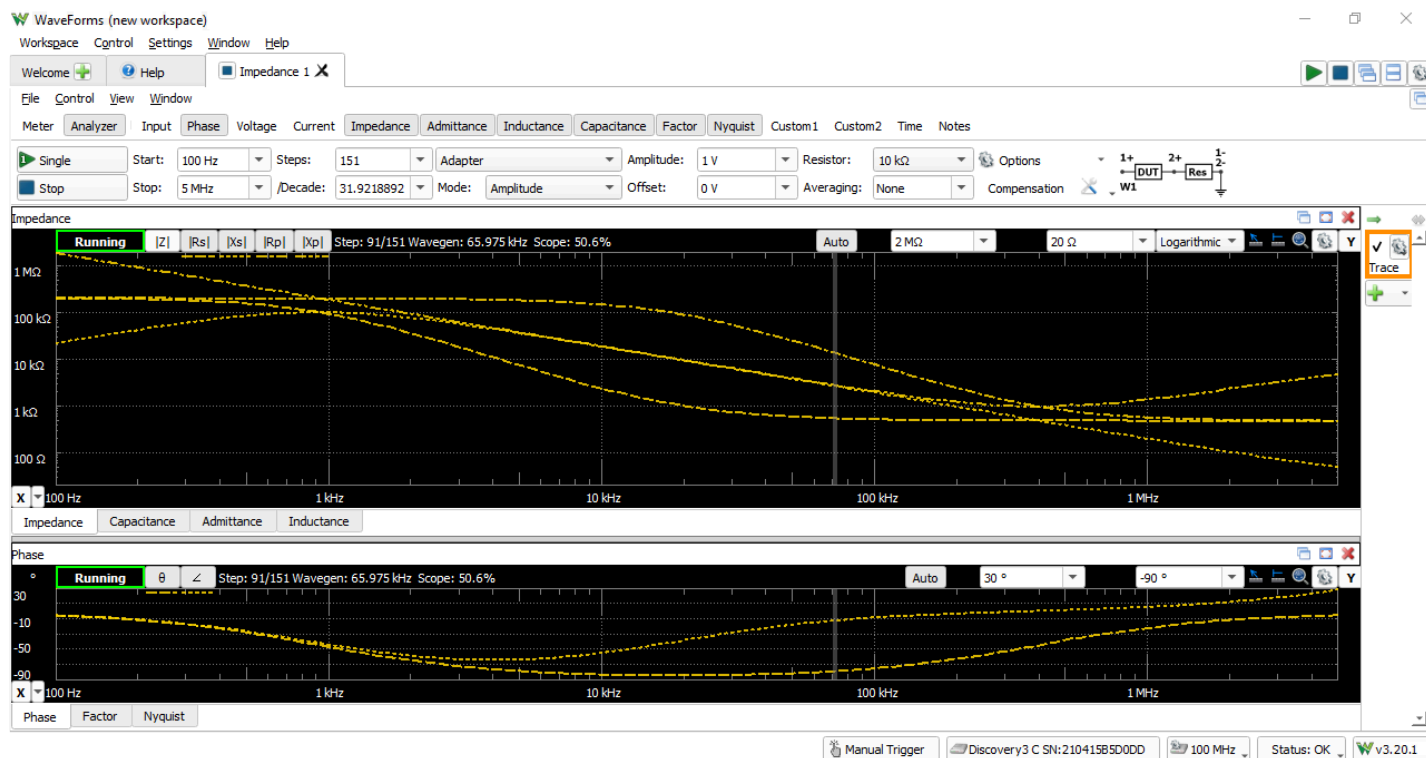
The Analog Discovery 3 can be used with WaveForms' Network instrument to view the amplitude and phase response of a circuit under test. Nichols and Nyquist plots can also be viewed with this instrument. The wave used to perform this sweep can be customized and uses the same resources as the Waveform Generator instrument, but can also be configured to use an external signal to provide input to the circuit under test rather than using the analog output channels.

A sweep is performed in order to test the response of the circuit at a range of frequencies from as low as 20 μ Hz and as high as one quarter of the Adjustable System Clock Frequency (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#adjustable_system_clock_frequency). The accurate upper end of the frequency range is dependent on the bandwidth of the frequency signal source, whether generated directly by the Analog Discovery 3 or an external system, as well as the bandwidth of the analog inputs of the Analog Discovery 3. Using an adapter like the BNC Adapter (<https://diligent.com/reference/test-and-measurement/bnc-adapter-board/start>) with Analog Discovery 3 can greatly improve the achievable upper bandwidth.

Since the Analog Discovery 3's analog input and output channels are shared, the Network Analyzer instrument cannot be used at the same time as the Oscilloscope, Waveform Generator, Voltmeter, Data Logger, Spectrum Analyzer, or Impedance Analyzer instruments.

For more information on the analog output and analog input channels, please visit the [Analog Discovery 3 Specifications](https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications) (<https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications>). For a walkthrough of the different features of WaveForms' Network Analyzer instrument, please visit the [Using the Network Analyzer](https://diligent.com/reference/test-and-measurement/guides/waveforms-network-analyzer) (<https://diligent.com/reference/test-and-measurement/guides/waveforms-network-analyzer>) guide.

Impedance Analyzer



Highlighted Features

- Plot views for Input Gain, Voltage, Current, Impedance, Admittance, Inductance, Capacitance, Nyquist, Custom, and more
- Alternative simple Meter view
- Selectable external compensation circuit topographies
- Data file export using standard formats

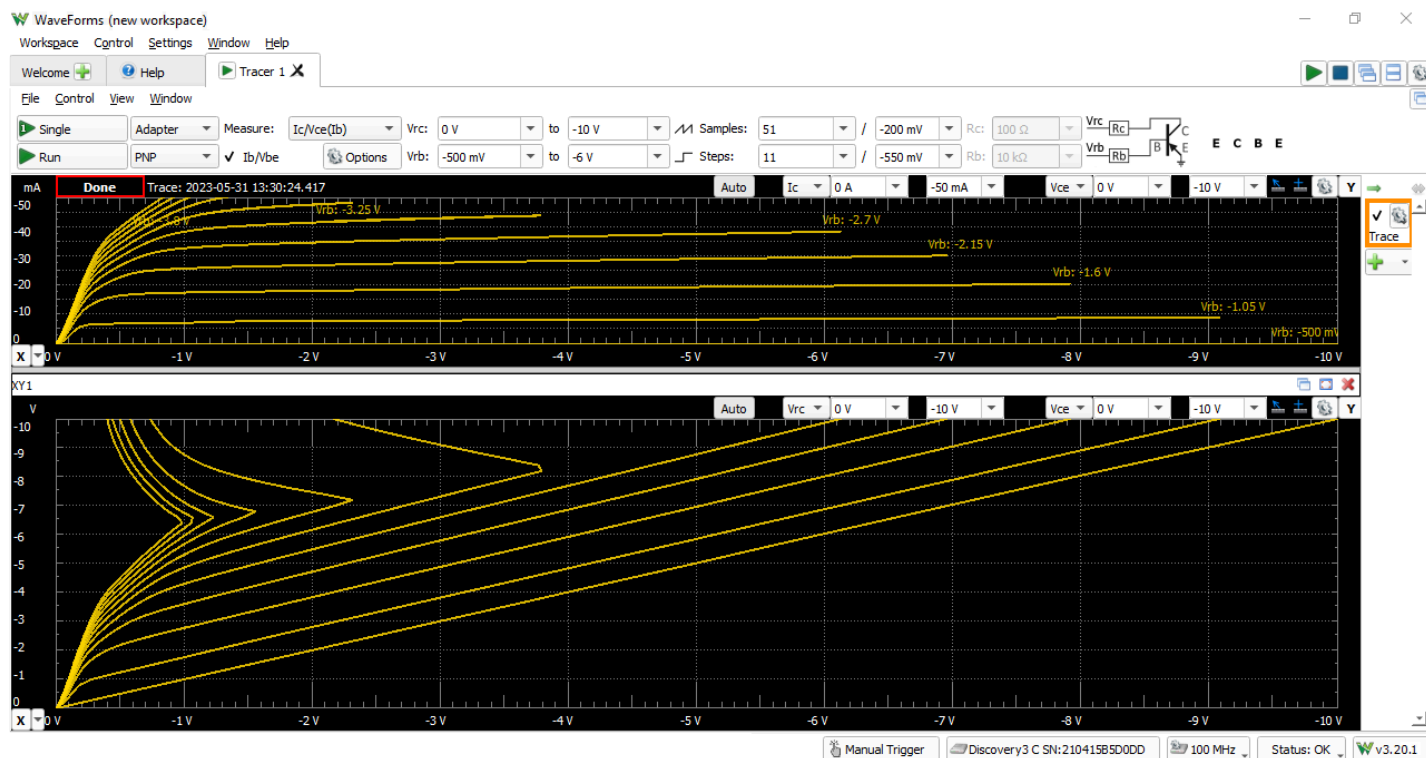
The Analog Discovery 3 can be used with WaveForms' Impedance instrument to view a wide variety of frequency response characteristics of a circuit under test. Predefined and custom plots can be used to present the results of a wide variety of different mathematical operations on buffered data.

A sweep from the Analog Discovery 3 analog outputs is performed in order to test the response of the circuit at a range of frequencies from 20 μ Hz to one quarter of the Adjustable System Clock Frequency (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#adjustable_system_clock_frequency). Different topographies of the DUT (device under test) can be selected from a variety of presets, with configurable amplitude and offset. An Impedance Analyzer Adapter (<https://diligent.com/reference/add-ons/impedance-analyzer/start>) with precise 0.1% resistors can be used to simplify the circuit setup.

Since the Analog Discovery 3's analog input and output channels are shared, the Impedance Analyzer instrument cannot be used at the same time as the Oscilloscope, Waveform Generator, Voltmeter, Data Logger, Spectrum Analyzer, or Network Analyzer instruments. If using the Impedance Analyzer Adapter, the digital channels and power supplies are also used to control the on-board relays.

For more information on the analog output and analog input channels, please visit the [Analog Discovery 3 Specifications](https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications) (<https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications>). For a walkthrough of the different features of WaveForms' Impedance Analyzer instrument, please visit the [Using the Impedance Analyzer](https://diligent.com/reference/test-and-measurement/guides/waveforms-impedance-analyzer) (<https://diligent.com/reference/test-and-measurement/guides/waveforms-impedance-analyzer>) guide.

Curve Tracer



Highlighted Features

- Works with diodes, NPN and PNP transistors, and P- and N-Type FETs
- Performs a variety of selectable measurements depending on the device under test, covering many combinations of base/collector/emitter and drain/gate/source voltage and current calculations
- Settable voltage sweep ranges and step sizes

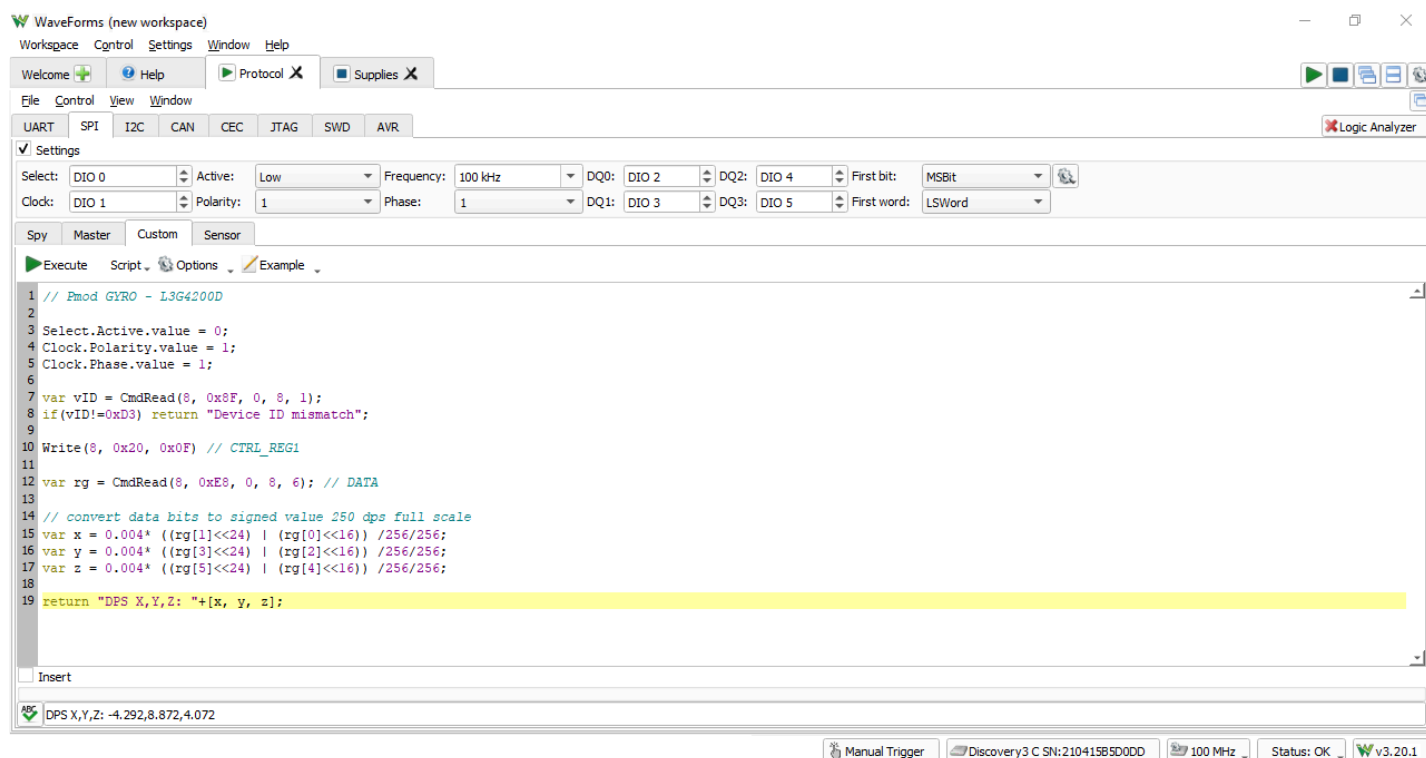
The Analog Discovery 3 can be used with WaveForms' Tracer instrument to plot the characteristic I-V curves of devices like diodes, NPN and PNP transistors, and both P- and N-type FETs.

The Transistor Tester Adapter (<https://digilent.com/reference/test-and-measurement/transistor-tester-adapter/start>) provides the required reference circuit or users can create their own external circuit. Reference circuit diagrams are provided in WaveForms, regardless of whether the Transistor Tester Adapter is used or not, indicating how each leg of the device under test is to be connected to the Analog Discovery 3 or the adapter.

Since the Analog Discovery 3's analog input and output channels are shared, the Curve Tracer instrument cannot be used at the same time as the Oscilloscope, Waveform Generator, Voltmeter, Data Logger, Spectrum Analyzer, or Network Analyzer instruments. Similarly, while using the Transistor Test Adapter, the Analog Discovery 3 is limited to the DC Current Drive limit of the analog output channels.

For more information on the analog output channels, please visit the [Analog Discovery 3 Specifications](https://digilent.com/reference/test-and-measurement/analog-discovery-3/specifications) (<https://digilent.com/reference/test-and-measurement/analog-discovery-3/specifications>). For more information on constructing a reference circuit and using the Tracer more generally, check out the [Using the WaveForms Curve Tracer](https://digilent.com/reference/test-and-measurement/guides/waveforms-curve-tracer) (<https://digilent.com/reference/test-and-measurement/guides/waveforms-curve-tracer>) guide.

Protocol Analyzer



Highlighted Features

- Supports UART, SPI, I2C, CAN, HDMI CEC, JTAG, SWD, and AVR protocols
- Scriptable transaction sequences for SPI, I2C, and SWD
- Configurable data rates, modes, polarity, and more
- Save logged transactions to data files

The Analog Discovery 3 can be used with WaveForms' Protocol instrument to work with common communications protocols. UART, SPI, I2C, CAN, CEC, SWD, and AVR transactions can have data transmitted and received by the Analog Discovery 3 and all protocols spied upon using any of the digital input/output channels. Custom scripts can be written within the Protocol Analyzer instrument to generate sequences of SPI or I2C transactions. The Logic instrument (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#logic_analyzer) can optionally be used to directly receive and debug incoming digital data.

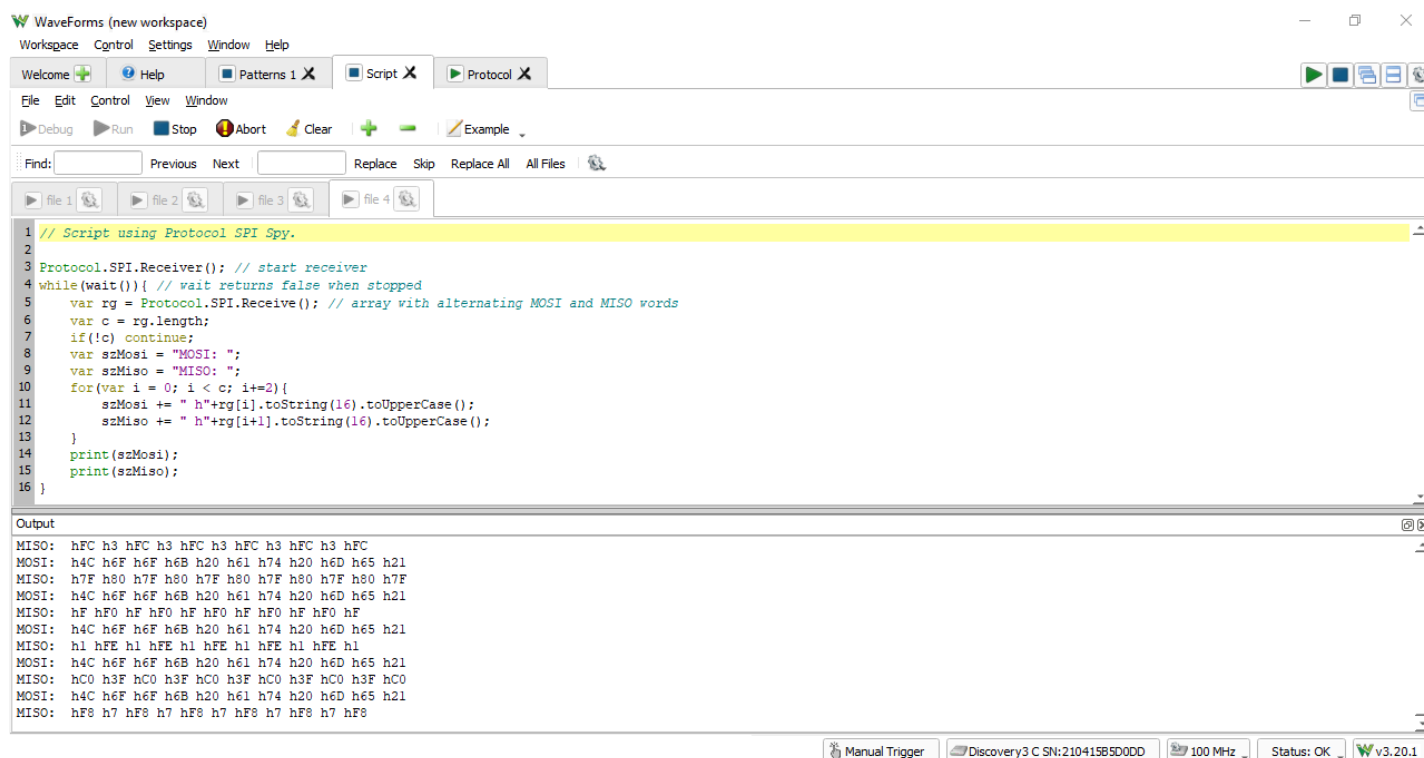
The Scripts instrument (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#waveforms_script_editor) can be used to support multiple protocols in one test by opening and closing different protocols. Alternatively, the Patterns instrument (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#pattern_generator) can be used to simulate a custom pattern that simulates a predetermined protocol output.

Because the Protocol instrument uses the same hardware resources as the Logic Analyzer and Pattern Generator instruments, the Protocol Analyzer cannot be used at the same time as these instruments and can only control a single protocol engine at a time.

The Analog Discovery 3's digital input/output channels use 3.3 V CMOS logic standard for input and output, and are tolerant to input signals up to 5 V. The drive strength, internal pull resistors, and slew can be changed directly changed in this instrument. Additional information about this can be found in the Digital I/O settings (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#digital_io_settings) section.

For more information on the digital input/output channels, please visit the [Analog Discovery 3 Specifications](https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications) (<https://diligent.com/reference/test-and-measurement/analog-discovery-3/specifications>). For a walkthrough of the different features of WaveForms' Protocol Analyzer instrument, please visit the [Using the Protocol Analyzer](https://diligent.com/reference/test-and-measurement/guides/waveforms-protocol-analyzer) (<https://diligent.com/reference/test-and-measurement/guides/waveforms-protocol-analyzer>) guide.

WaveForms Script Editor



Highlighted Features

- Available directly within the WaveForms application
- Simultaneous control of all instruments through JavaScript
- Automatable `GUI()` actions
- Custom data analysis and manipulation functions

Each of WaveForms' instruments can be controlled through scripts within the WaveForms application itself. The Script instrument allows the user to write and run JavaScript code (based on the [EMCAScript](https://digilent.com/reference/lib/exe/fetch.php?tok=20800c&media=https%3A%2F%2Fdoc.qt.io%2Fqt-5%2Fecmascript.html) (<https://digilent.com/reference/lib/exe/fetch.php?tok=20800c&media=https%3A%2F%2Fdoc.qt.io%2Fqt-5%2Fecmascript.html>) and ECMA-262 (<https://digilent.com/reference/lib/exe/fetch.php?tok=c80cf5&media=http%3A%2F%2Fwww.ecma-international.org%2Fpublications%2Fstandards%2FEcma-262.htm>) specification) that can control the rest of the WaveForms application through an extensive API, allowing the user to configure and run many instruments at the same time, in an easily repeatable way. Hovering over different scriptable actions within the GUI shows the corresponding Script function in the lower left hand corner of WaveForms.

The Script instrument is intended to enable users to automate some features available within different instruments, such as changing a PWM frequency over a preset number of runs. Other features such as setting up channels, naming individual traces, and static configuration are far easier to configure from within that particular instrument's GUI rather than from the Script instrument. As each WaveForms workspace saves both the Script and individual instrument settings, users can define different configurations of an instrument from within its own GUI and the Script tool without needing to manually define and setup everything in a single location.

For a walkthrough of the different features of WaveForms' Script instrument, please visit the [Using Scripts](https://digilent.com/reference/test-and-measurement/guides/waveforms-script-editor) (<https://digilent.com/reference/test-and-measurement/guides/waveforms-script-editor>) guide.

Additional Features

First Party Software Support

WaveForms

WaveForms is Diligent's free Test and Measurement software application compatible with all of Diligent's Discovery family devices. With support for Mac, Linux, and Windows operating systems, users can easily configure and control all of the virtual instruments offered by the Analog Discovery 3.

More information about WaveForms including a getting started guide and examples can be found in the [WaveForms Resource Center \(https://diligent.com/reference/software/waveforms/waveforms-3/start\)](https://diligent.com/reference/software/waveforms/waveforms-3/start).

WaveForms Software Development Kit (SDK)

WaveForms SDK is a set of software libraries and examples included with WaveForms that can be used to develop custom applications that can control Diligent Test and Measurement devices outside of the WaveForms application. With support for a variety of languages including C/C++, C#, MATLAB, Python, and Visual Basic, users can easily control hardware channels and virtual instruments of multiple devices without ever needing to open WaveForms itself.

More information about WaveForms SDK including a getting started guide and examples can be found in the [WaveForms SDK Resource Center \(https://diligent.com/reference/software/waveforms/waveforms-sdk/start\)](https://diligent.com/reference/software/waveforms/waveforms-sdk/start).

Third Party Software Support

The Analog Discovery 3 has support for third party applications including MATLAB and LabVIEW.

A guide for using WaveForms with LabVIEW can be found in [Diligent's Getting Started with LabVIEW guide \(https://diligent.com/reference/test-and-measurement/guides/getting-started-with-labview\)](https://diligent.com/reference/test-and-measurement/guides/getting-started-with-labview) and a similar guide for MATLAB can be found in Diligent's [Getting Started with MATLAB guide \(https://diligent.com/reference/test-and-measurement/guides/matlab-getting-started\)](https://diligent.com/reference/test-and-measurement/guides/matlab-getting-started).

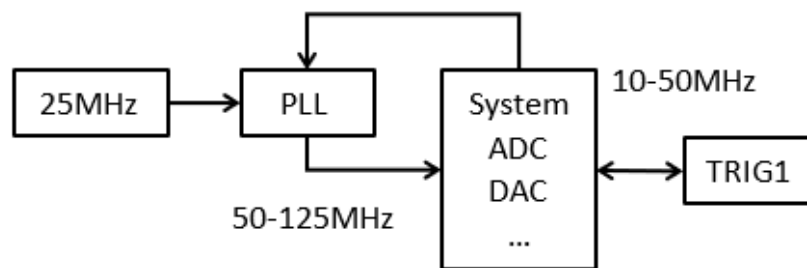
Adjustable System Clock Frequency

Each of the primary systems of the AD3 — the analog inputs, analog outputs, and digital I/O pins — have their sample rate controlled by an adjustable system clock from rates ranging between 50 [MHz \(\)](#) up to 125 [MHz \(\)](#) with a default rate of 100 [MHz \(\)](#). Users can change the system frequency through the WaveForms Device options; if a manually selected frequency is not achievable, the actual frequency achieved by the FPGA will be listed.

The system clock can be changed to use an external reference clock ranging between 10 [MHz \(\)](#) and 50 [MHz \(\)](#) that is provided as an input to the Trigger 1 signal pin.

External Clocking

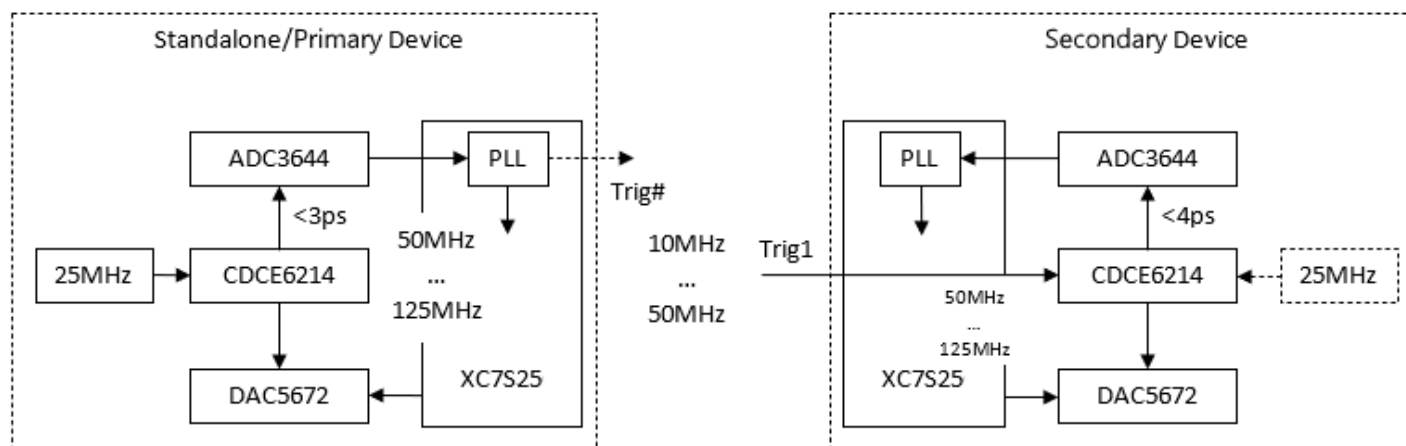
By default, when the Analog Discovery 3 is used as a standalone device or is producing an external clock, a local oscillator provides a clock signal to a dedicated low-jitter PLL to drive the [ADC \(\)](#) and [DAC \(\)](#) clocks. A PLL within the FPGA is used to generate internal clocks as well as a low frequency clock ranging between 10 [MHz \(\)](#) and 50 [MHz \(\)](#) that can be optionally output on the two Trigger I/O pins.



(https://digilent.com/reference/_detail/test-and-measurement/analog-discovery-3/standard_clock_source.png?id=test-and-measurement%3Aanalog-discovery-3%3Areference-manual)

Figure 5. AD3 Default Clocking Setup

The AD3, and correspondingly the Adjustable System Clock Frequency (https://diligent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#adjustable_system_clock_frequency), can also be used with an external reference clock ranging between 10 MHz() and 50 MHz() applied to Trigger 1 (T1). The FPGA directly forwards the reference clock from T1 to the dedicated PLL instead of using the 25 MHz() oscillator. With a 10 MHz() external reference clock, less than 4 ps of jitter was observed on the ADC() clock relative to the local oscillator.



(https://digilent.com/reference/_detail/test-and-measurement/analog-discovery-3/ad3-external-clock-topology.png?id=test-and-measurement%3Aanalog-discovery-3%3Areference-manual)

Figure 6. AD3 External Clock Topology

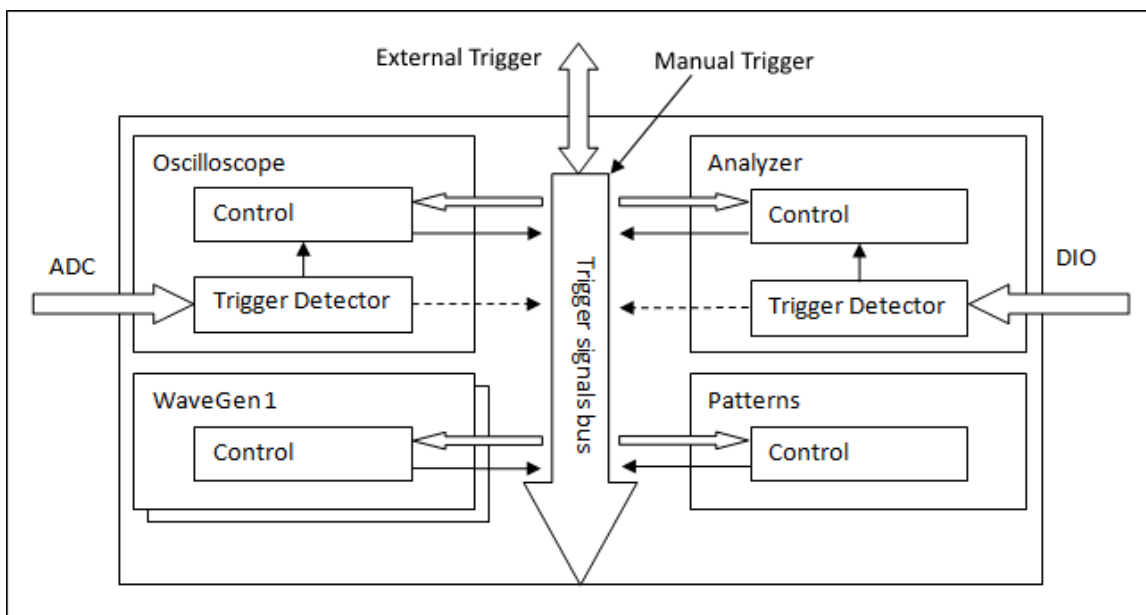
Additional information about the trigger pin can be found in the [Trigger System \(https://digilent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#trigger_system\)](https://digilent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#trigger_system) and the [Analog Discovery 3 Specifications \(https://digilent.com/reference/test-and-measurement/analog-discovery-3/specifications\)](https://digilent.com/reference/test-and-measurement/analog-discovery-3/specifications).

Trigger System

Each primary system of the AD3 — the analog inputs, analog outputs, and digital I/O pins, controlled by the Scope, Wavegen, Logic and Patterns instruments respectively — has its own trigger logic, which has access to the two physical trigger pins and the central trigger bus. Each of the instruments can be triggered by trigger conditions it generates itself, or by any other instrument. For example, a Logic Analyzer acquisition could be triggered to on the known starting value of an error code. The start of the Logic acquisition could then be routed through the trigger bus to the Scope instrument and cause it to be collecting analog data to observe how the external system is reacting to the error code.

The two physical trigger pins by default are set to receive an external signal. They can also output a trigger from generated any instrument on the trigger bus. The trigger pins can also uniformly have their slew, drive, and pull type set by the Digital I/O Settings (https://digilent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#digital_io_settings).

The trigger type can be set to “Auto” (the default setting) where if the trigger condition is not detected within a maximum two seconds (minimum of holdoff plus specified time span) the acquisition will start automatically, “Normal” where the system waits to start the acquisition until the condition is met, and “None” where the acquisition starts immediately.



(https://digilent.com/reference/_detail/test-and-measurement/analog-discovery-3/main-trigger.png?id=test-and-measurement%3Aanalog-discovery-3%3Areference-manual)

Figure 5. Trigger System Overview

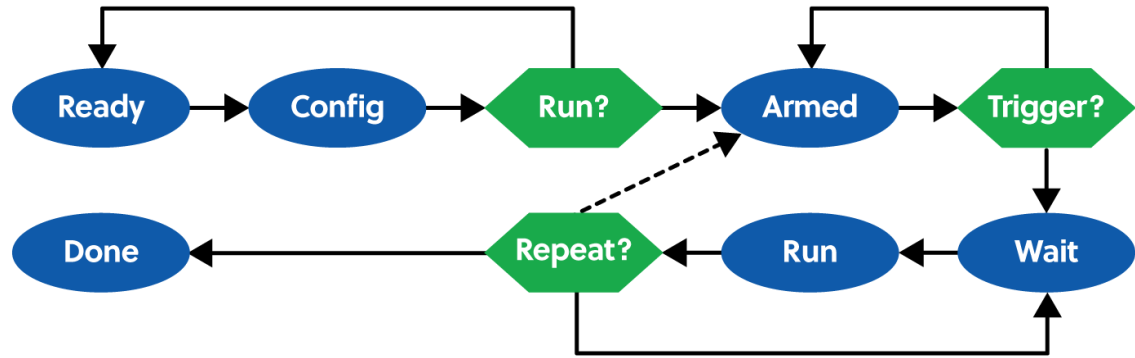
Each of these active systems will step through different states while acquiring or generating a signal. If multiple instances or instruments of the same type are opened, the last used instance (determined by pressing Run or Stop for an individual instrument) will control the state that the Analog Discovery 3 is in. Other instruments sharing the same hardware resources will display a Busy status.

Different states of the systems include:

- Ready - The instrument is not running and ready to be configured
- Config - The instrument is being configured and the acquisition buffer is prefilled with data
- Armed - The instrument is armed and waiting for the user specified trigger event to occur. The acquisition buffer is prefilled with data
- Trig'd - The acquisition is triggered based on a predefined condition in the trigger system
- Auto - The trigger condition timed out and the acquisition started automatically
- Wait - The instrument waits a predefined amount of time before starting its process (known as Holdoff for the Oscilloscope and Logic Analyzer)
- Done - The acquisition was completed
- Stop - The instrument was stopped and is effectively reset to the ready state
- Scan - The instrument is running in scan screen or shift mode
- Error - Something went wrong, such as if the device was disconnected from the host computer

Systems that generate a signal, such as the Waveform Generator (https://digilent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#waveform_generator) and Pattern Generator (https://digilent.com/reference/test-and-measurement/analog-discovery-3/reference-manual#pattern_generator), have options implement wait time, run time, and repeat parameters to easily generate short, precise sequences known as burst signals.

Figure 7 shows a state diagram for one of the generator instruments showing the flow of the system starting out in Ready, becoming configured, checking to see if the user has requested to start the generation, then arming system with the desired trigger, waiting the specified amount of time before starting the signal generation, generating the signal for the requested amount of time (staying in the Run state if the continuous option was specified), then checking to see if the requested number of signal repetitions has been completed. If more repetitions remain or the infinite repetition option was set, the system then either goes back to the Armed state to await for another trigger or to the Wait state if a trigger source of 'None' was selected, before eventually proceeding to the Done state. If the user stops the generator before the Done state is reached, the “Stop” state will be indicated and the instrument will be ready to be reconfigured or start again.



(https://digilent.com/reference/_detail/test-and-measurement/analog-discovery-3/diagrams-generator-state-diagram.png?id=test-and-measurement%3Aanalog-discovery-3%3Areference-manual)

Figure 7. Example state diagram of a Generator instrument

Additional information about the Trigger system and the physical trigger electrical characteristics can be found in the [Analog Discovery 3 Specifications](https://digilent.com/reference/test-and-measurement/analog-discovery-3/specifications) (<https://digilent.com/reference/test-and-measurement/analog-discovery-3/specifications>).

Device Configuration

The Analog Discovery 3 has multiple device configuration options to allocate different predefined buffer sizes to each of the primary systems. A summary of the different configuration options for the Analog Discovery 3 to choose from in the WaveForms Device Manager is available in Table 1.

Table 1: Analog Discovery 3 Configuration Options

Configuration Number	Oscilloscope	Waveform Generator	Logic Analyzer	Pattern Generator
1	16 KiS 16-bit sample buffer 1 KiS 14-bit noise buffer	16 KiS 14-bit carrier, 2 KiS 16-bit AM and FM buffers; two 2 KiS Power Supply Waveform Generator sample buffers	16 KiS 16-bit sample buffer	2 KiS 16-bit sample buffer
2	32 KiS 16-bit sample buffer 1 KiS noise buffers	4 Kis 14-bit carrier, 2 KiS 16-bit AM and FM buffers; two 1 KiS Power Supply Waveform Generator sample buffers	4 KiS 16-bit sample buffer	2 KiS 16-bit sample buffer
3	8 KiS 16-bit sample buffer 1 KiS 14-bit noise buffers	32 KiS 14-bit carrier, 2 KiS 16-bit AM and FM buffers; two 2 KiS Power Supply Waveform Generator sample buffers	2 KiS 16-bit sample buffer	2 KiS 16-bit sample buffer
4	16 KiS 16-bit sample buffer 1 KiS noise buffers	4 Kis 14-bit carrier, 2 KiS 16-bit AM and FM buffers; two 2 KiS Power Supply Waveform Generator sample buffers	32 KiS 16-bit sample buffer	2 KiS 16-bit sample buffer

Configuration Number	Oscilloscope	Waveform Generator	Logic Analyzer	Pattern Generator
5	4 KiS 16-bit sample buffer 1 KiS 14-bit noise buffers	4 KiS 14-bit carrier, 2 KiS 16-bit AM and FM buffers; two 1 KiS Power Supply Waveform Generator sample buffers	32 KiS 16-bit sample buffer	32 KiS 16-bit sample buffer
6	8 KiS 16-bit sample buffer 1 KiS noise buffers	16 KiS 14-bit carrier, 8 KiS 16-bit AM and FM buffers; two 4 KiS Power Supply Waveform Generator sample buffers	2 KiS 16-bit sample buffer	2 KiS 16-bit sample buffer

Digital I/O Settings

The slew rate, drive strength, and pull type for the 18 digital I/O pins on the Analog Discovery 3, including both the 16 I/O pins shared between the Logic Analyzer and Pattern Generator and the two Trigger I/O pins, can be set by the user within the Device Options setting or the Logic Analyzer Instrument.

Slew can be set to slow (the default value) or fast. Drive can be set to 4 mA (the default value), 8 mA, 12 mA, or 16 mA. The pulltype can be set to none (the default value), pulldown, pullup, or keeper. The selected setting will applied to all of the digital I/O pins on the Analog Discovery 3.

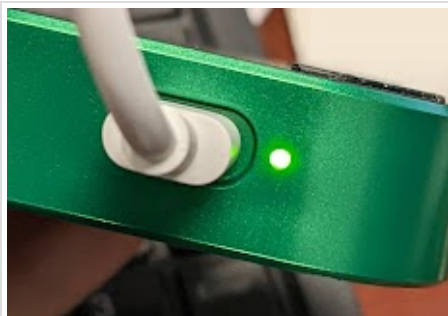
Additional information about these settings can be found in Xilinx's 7 Series FPGA SelectIO Resources User Guide, UG471 (https://digilent.com/reference/lib/exe/fetch.php?tok=d2dffc&media=https%3A%2F%2Fdocs.xilinx.com%2Fv%2Fu%2Fen-US%2Fug471_7Series_SelectIO), in the 7 Series FPGA SelectIO Attributes/Constraints section.

MTE Header

The Analog Discovery 3 provides access to its analog inputs and outputs, digital and trigger I/Os, and programmable power supplies through a 2×15 100 mil spaced header. Users can easily access these pins through the provided color-coded MTE cable set or through one of the compatible adapters.

LED States

The power LED on the back of the Analog Discovery 3 has four different states: fully lit to indicate when both the analog and digital rails are active and powered, dimly lit to indicate when the digital rails are powered but the device is not active, blinking when there is a fault condition with the power supplies (not pictured), and off when the device is not powered.



(https://digilent.com/reference/_media/test-and-measurement/analog-discovery-3/ad3-led-bright.png)

Figure 8. A fully bright LED when the digital and analog rails are active.



(https://digilent.com/reference/_media/test-and-measurement/analog-discovery-3/ad3-led-dim.png)

Figure 9. A dim LED when only the digital rails are enabled but the device is not active.



(https://digilent.com/reference/_media/test-and-measurement/analog-discovery-3/ad3-led-off.png)

Figure 10. A fully off LED for visual comparison.

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