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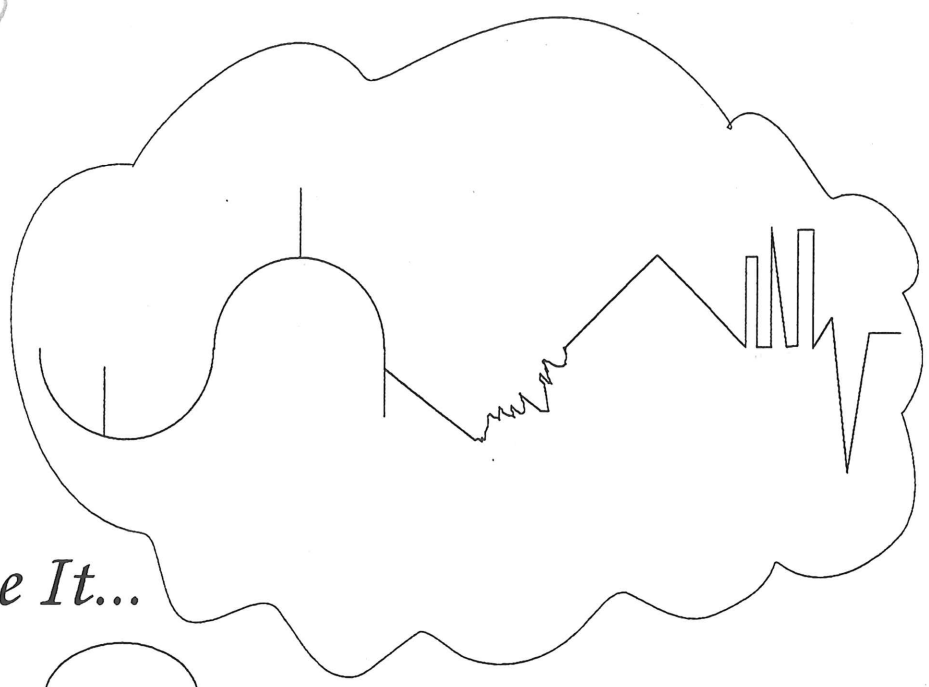
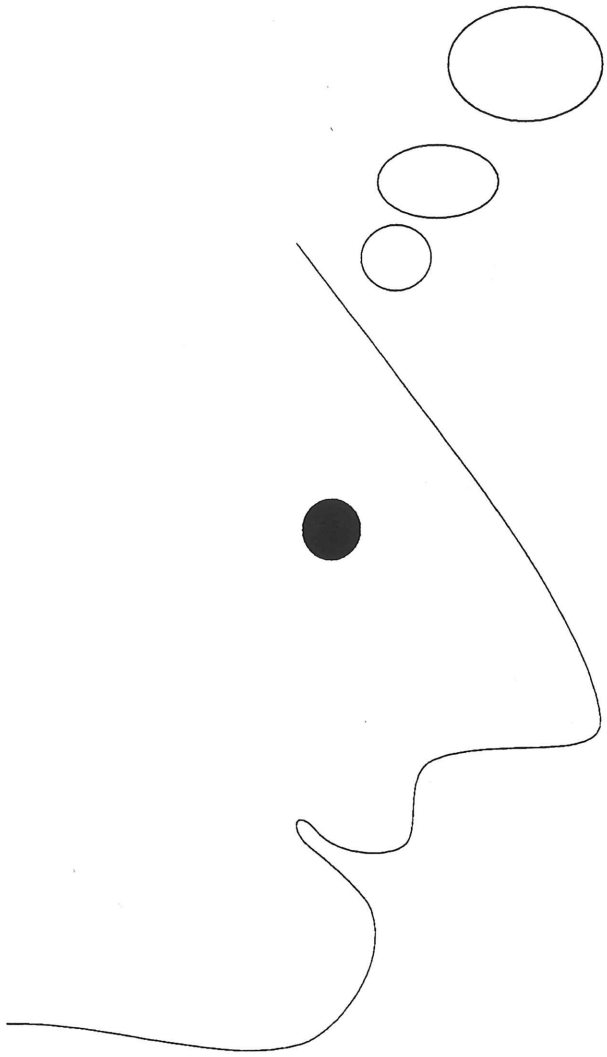


Imagine It...
Define It...
Generate It...



Create Any Waveform You Can Imagine...

Tektronix

Arbitrary Signal Sources Sales Guide

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Bruce Virell, Product Marketing Manager

John McHugh, Marketing Support Manager

Sales Guide Introduction

The world gets more complicated as we find out that the more we know, the more questions we have. The adage ***"Ignorance is bliss and that's all I need to know"*** just doesn't cut it anymore. In the real world, anomalies including glitches, drift, and noise cause devices to work incorrectly. Device failure can be as minor as an annoyance or it can be catastrophic resulting in loss of life or valuable equipment. Using a signal source with it's clean, ideal signal does not simulate what will happen when the device leaves the lab or manufacturing floor. Any customer who has a digital scope (like the TDS series) probably has a signal source near by. This customer is an excellent candidate for an arbitrary generator

That's where Arbitrary generators come in. They bring reality to signal generation by simulating what can happen when things are not ideal. Tektronix has a broad line of arbitrary generators to match the performance requirements of your customers. The recent introduction of the 2000 series Arbs brings industry leading performance with unprecedented ease of capturing and editing arbitrary waveforms.

This sales guide covers the Waveform Simulation solutions available from Tektronix. This guide is broken into four major sections:

Topic	*Answered in:*
What are Waveform Simulators?	**Arbitrary Generators Introduction**
What customers are served by Waveform Simulators?	**Markets & Applications**
What is the competition?	**Competitive Information**
Support material, export control, etc.	**Information on accessories, ordering, etc.**

Arbitrary Generators Introduction

Before arbitrary waveform generators (Arbs for short), designers had to settle for the limited number of waveforms available from function generators or by adding multiple waveforms together to create more realistic signals. Arbs give designers the freedom to test their systems with real world signals. These real world signals have all the complexity and anomalies the system will encounter when it leaves the lab or manufacturing floor and is delivered to their customer.

Even when system input signals are standard waveshapes, an Arb is useful for evaluating the circuit's marginal performance. Margin testing is becoming increasingly important as circuit speeds increase and tolerances get tighter. An Arb is used to modify the standard waveshape and add specific anomalies like phase shift, glitches, runts and other distortions to test the circuit's immunity to the specific anomalies.

Arbs can improve throughput during production testing. An example is testing the frequency response of a filter or IF stage. If a function generator is used, it must sweep through a band of sine waves which takes time. The same test can be accomplished in an Arb with a single Sin(x)/x signal that has a flat spectrum from zero to the upper frequency.

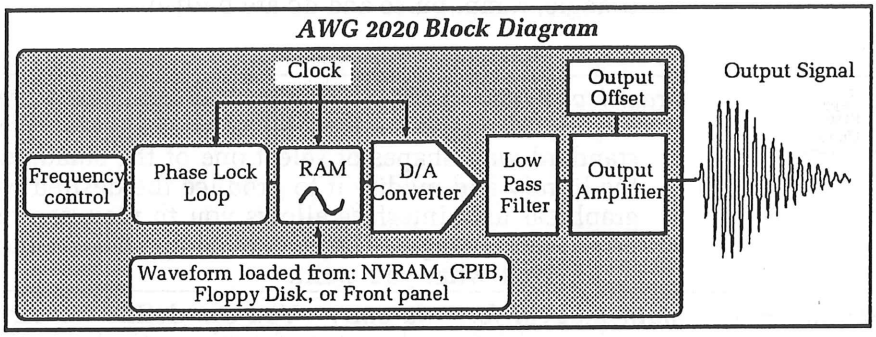
With an Arb, not only can the standard forte of signals be generated, the signal can be manipulated to reflect the real world (noise, glitches, jitter, runt pulses, etc.) with greater accuracy and flexibility than with standard signal sources.

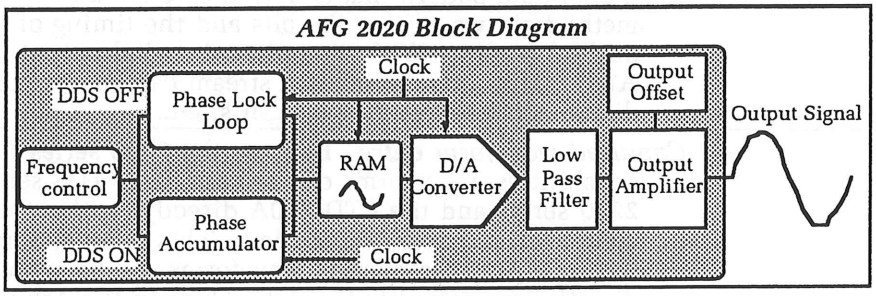
Key Features and Benefits of an Arb

Feature	Benefit
Non-standard user-defined waveforms can be captured or created, edited and stored for later use.	Allows generating signals that reflect the real world. This leads to more accurate assessment of circuit performance after it leaves the lab or manufacturing floor
Built-in function generator waveforms can be used as building blocks for waveform creation, or used as pure standard signals.	An Arb is an excellent standard signal source. Multiple sources like function generators, synthesized generators, etc. can be consolidated into one flexible signal source.
Waveforms with anomalies and aberrations can be created with extremely high resolution.	Since the waveforms are stored in memory, anomalies can be generated each clock cycle, something that is difficult with analog methods.
Captured waveforms from real physical sources can be uploaded from a DSO.	The best source of real world signals is....the real world. A digital storage oscilloscope (DSO) can capture the event and download it to the Arb for generation, storage or modification.
Non-volatile memory provides extensive waveform storage.	The Arb remembers the most commonly used waveforms so they are always available to the user.
Continuous and non-continuous operating modes (trigger, gate, burst) provide unparalleled signal generation and sequencing capabilities.	Arbs have several operating modes that allow the user extreme flexibility with the output of the signal. An example is controlling the output with an external signal to trigger or gate when the Arb output is turned on. Sequencing is an extremely powerful capability that allows creating a long waveform from several smaller waveforms. This allows creating waveforms with many different characteristics easily.

How an Arb works

This section explains how an Arb functions and how complex waveforms are created. The concept of an Arb is quite simple. Individual data points are stored in random access memory (RAM). The Arb addresses (clocks) the user defined waveform data stored in RAM and converts each data point from memory to an analog voltage. Groups of the analog voltage points develop a voltage waveform as a function of time. The waveform is amplified and output through an analog amplifier. This waveform can be replayed continuously or operated as a triggered, gated or burst waveform. By controlling the clock period (sampling frequency) and the total number of points to be cycled, the frequency of the waveform can be increased or decreased. The output amplitude of the waveform can be controlled by setting the waveform data value and the gain and offset of the output amplifier.





If the Arb has direct digital synthesis circuitry (DDS), generation of standard signals, sweeps and modulation are made easier and more accurate by calculating them. A description of direct digital synthesis (DDS) is covered in the section titled "Terms To Know".

Two Types of Arbs

There are two types of Arbs, each optimized for different applications.

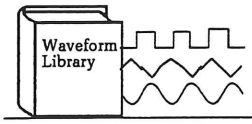
1. AFG (Arbitrary Function Generator) which is a excellent function generator first and an arbitrary generator second. This means that an AFG excels at precise sine, triangle, square wave generation, signal modulation and sweeping. Applications that need this type of product range from general purpose signal source to telecommunications (analog and digital modulation).
2. AWG (Arbitrary Waveform Generator) is a true arbitrary generator. It has more flexibility to generate truly arbitrary or complex waveforms. This is accomplished with long record lengths, flexible operating modes like sequencing, and enhanced waveform editing capabilities. Applications needing an AWG usually require long record length or require the flexibility of the operating capabilities. Examples include automotive design/test and disk drive design/test.

INTRODUCING THE NEW AFG 2020 & AWG 2020

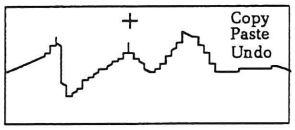
The new AWG 2020 and AFG 2020 combine the functions of an Arbitrary generator with a controller and an icon based graphical user interface. The built-in high resolution monitor and MS-DOS compatible file structure facilitate easy waveform editing and transfer. An external controller is not needed for most operations.

Seven ways of creating and editing waveforms

The built-in waveform editor and the ability to use standard waveforms or waveforms captured from a DSO gives unprecedented flexibility to get the waveshape your customer needs.



Standard waveform library - Standard waveshapes including sine, square, triangle, ramp, pulse and dc are built-in.



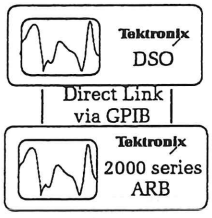
Graphical editor - Unique waveforms can be easily created using the graphic editing features to define waveshapes. You can use one of the standard waveshapes or select one of the standard waveshapes from the library and modify it to produce the desired waveshape. The graphical user interface allows you to view the resultant waveform before outputting it. There is even an UNDO function when the result isn't what you want.

$V(t) = Sin(2*\pi*k) + k2*Sin(5*\pi*x)$

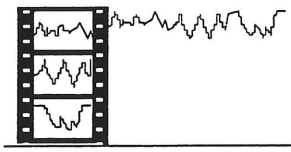
Mathematical formula entry - You can define waveshapes using polynomial formula entry of mathematical equations.

010110100101
101101110101
011101010111

Digital table and timing entry - Every Arbitrary waveform is really a digital data pattern that is output through a D/A converter. This method allows editing the bits and the timing of those bits to get the desired results. With the optional digital output port (Opt. 09 on AWG 2020), this digital data stream can be used to control and test digital circuits like D/A's, ASICs, etc.



Captured waveform entry - Because the 2000 series Arbs have controller capabilities, waveforms can be read from TDS series, 2400 series, 2200 series and the RTD 710A directly, without an external controller and software needed. This is an extremely powerful feature since "real world" waveforms can be captured with a DSO and directly transferred to the Arb. Once in the Arb the waveform can be saved to disk (AWG 2020) and edited using any of the editing features available.

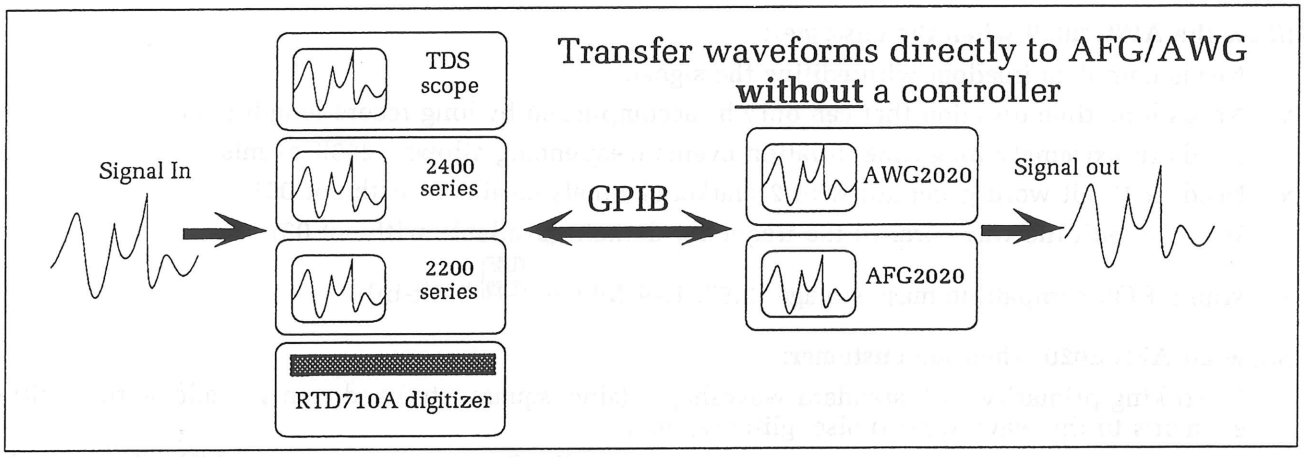


Waveform sequencing (AWG 2020 only) - Different waveshapes can be put together in a continuous stream using the sequencing capability. This allows for extreme flexibility in the type of output and length of the waveshape to get the job done.

FFT editor (AWG 2020 only) - Certain customers want to edit waveforms in the frequency domain along with the time domain. This allows for generating signals that comply with test or design standards. The optional FFT editor allows modifying the signal in the frequency domain as easily as in the time domain.

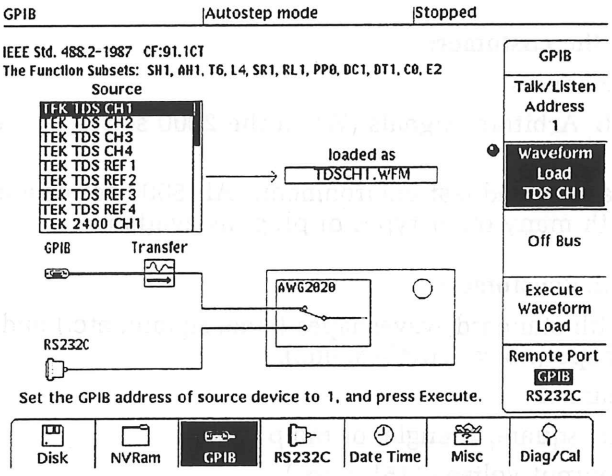
Direct link with Tektronix digital storage scopes

The AWG 2020 and AFG 2020 have built-in controller capabilities so waveforms can be read directly from a TDS series, 2400 series, 2200 series and the RTD 710A, without an external controller and software needed.



This is an extremely powerful feature since "real world" waveforms can be captured with a DSO and directly transferred to the Arb. Once in the Arb the waveform can be saved to disk (AWG 2020) and edited using any of the editing features available.

An example screen for the AWG 2020 is shown below.



INTRODUCING THE AWG 5105, AWG 5102, AND AFG 5102

The 5000 series Arbs are a modular, low cost Arbitrary generators that fit well in benchtop or manufacturing testing applications with signals less than 50 MHz and cost is an issue. These arbitrary generators are available as plug-ins for TM5000 mainframes or monolithic. Refer to the next section titled "Which Arb do I show?" to determine the best choice to show to the customer.

WHICH ARB DO I SHOW?

Arbitrary Function Generators and Arbitrary Waveform Generators (AWG) are intended for different application requirements. Here are some performance differences between the Arbs we sell:

Show the AWG 2020 when the customer:

- √ Needs complete freedom with editing the signal.
- √ Needs long time duration that can only be accomplished by long record length (256K)
- √ Needs to extremely long time duration events (sequencing allows >256K events)
- √ Needs a 12 bit word generator with 2 marker channels (available with opt 09)
- √ Wants to edit the waveform in the frequency domain (available with opt 03)
- √ Wants DOS compatible mass storage (3.5", 1.44 Mbyte  built-in)

Show an AFG 2020 when the customer:

- √ Is working primarily with standard waveshapes (sine, square, etc.) and wants to add some Arbitrary elements to the waveshape (noise, glitches, etc.).
- √ Primarily needs to generate Sine waves up to 100 MHz, Square waves up to 50 MHz, Triangle, Ramp or Pulse waves up to 31.2 MHz.
- √ Is modulating the signal (AM, FM, PSK and FSK). These functions are built-in to the AFG.
- √ Needs very accurate frequencies. The AFG 2020 frequency accuracy with DDS is 50 times (1 ppm vs. 50 ppm) more accurate than the AWG 2020.
- √ Needs to sweep a signal for tests like frequency response.

Show an AWG 5105 when the customer:

- √ Needs up to 2 output channels
- √ Needs less than 50 MHz Arbitrary signals (When the 2000 series is overkill and the 5102 series is not enough)
- √ Is using the Arb in an automated test environment. All 5000 series are modular, have minimal front panels, expandable, with many other types of plug-ins available.

Show an AFG 5102 when the customer:

- √ Is working primarily with standard waveshapes (sine, square, etc.) and wants to add some Arbitrary elements to the waveshape (noise, glitches, etc.).
- √ Needs single output channel
- √ Needs ≤ 20 MHz of sine, square, triangle, or ramp signal
- √ Needs more than 10V output voltage (15V max.)
- √ Is using the Arb in an automated test environment. All 5000 series are modular, have minimal front panels, expandable, with many other types of plug-ins available.
- √ Requires choice of Linear/Log/Arbitrary sweeps

Show an AWG 5102 when the customer:

- √ Needs single output channel
- √ Needs ≤ 1 MHz of sine, square, triangle, or ramp signal
- √ Is using the Arb in an automated test environment. All 5000 series are modular, have minimal front panels, expandable, with many other types of plug-ins available.
- √ Lowest cost alternative

TERMS TO KNOW

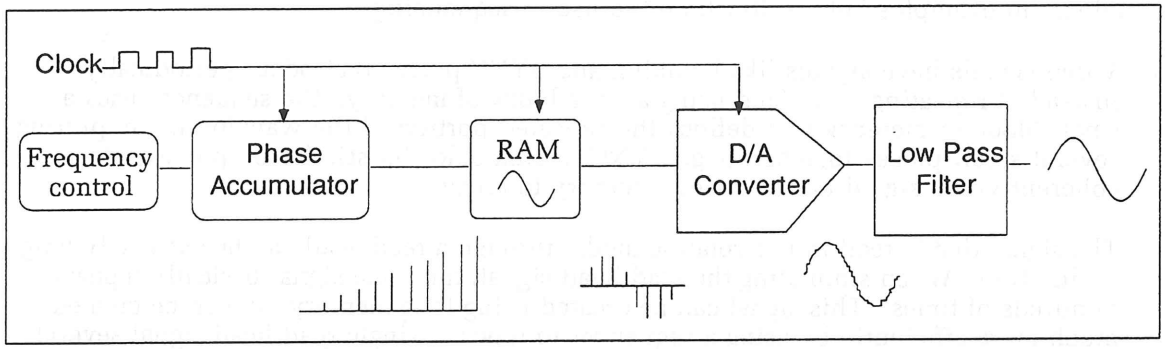
There are several terms used when talking about arbitrary generators that are unique to. This section discusses these terms and describes how they pertain to Arbs. The terms covered are:

- Direct Digital Synthesis (DDS)
- FSK and PSK modulation
- Sequencing

DDS (Direct Digital Synthesis)

The AFG with DDS differs from an AWG because the AWGs waveform is stored entirely in RAM while the DDS output is computed in real time. The DDS output signals, usually a sinewave carrier with optional amplitude, phase and frequency modulation. While an AWG can be programmed to produce things like amplitude, phase, and frequency modulation or a swept waveform, it requires programming each individual point. DDS assists the user by computing these instead of having the user compute them.

DDS allows generation of waveforms with a variety of frequencies using one very accurate reference frequency. The block diagram shows the DDS process.



The frequency control sets the increment of the phase accumulator for each clock cycle. The phase accumulator addresses a signal (e.g., Sine) stored in RAM at each clock cycle. The D/A converter reads this value from RAM and converts it into an analog level. The D/A output is low pass filtered (to remove quantization levels) and amplified.

PSK (Phase Shift Key) and FSK (Frequency Shift Key)

PSK and FSK are popular modulation schemes for putting digital information on an RF carrier used in modems, faxes, cellular telephones and any other transmission that transmits digital information. This allows for packing more digital information in a narrow bandwidth. An example is sending modem information on a 3 KHz phone line at 9600 bits per second (which would take 10 KHz bandwidth without modulation).

PSK and FSK are two of many different schemes for modulating digital information. The one your customer uses will depend on their application.

Waveform Sequencing

Waveform sequencing is an extremely powerful capability that is unique to arbitrary generators. In a nutshell, sequencing takes advantage of the fact that even complex waveforms (for example, video) have portions that repeat. Sequencing conserves memory when the desired waveform has one or more repeating segments. Having to define these segments more than once eats up memory, which may not be available if the user must also insert relatively large segments in between. Sequencing also helps users by allowing them to break up their waveform into several smaller sections and create them separately.

Some application examples help to illustrate the use of sequencing.

Video — Video signals have signals like blanking and SYNC pulses that occur periodically. Instead of repeating them (and using a large block of memory), the sequencer uses a small block of memory that defines the repeated portion of the waveform. By putting several small pieces together, (e.g., SYNC, blank, color burst), the output waveform is a coherent video signal but takes less memory to create.

Disk Drive — The signal that is read from a rotating media through a read head can be extremely long in duration. When simulating the read head signal, the same signal basically repeats hundreds of times. This signal can be created using long memory but can be created much more efficiently by using a sequencer to repeat a single read head signal several times. It is very easy to add anomalies like varying head height by inserting a small waveform that simulates this event somewhere in the sequence.

Digital pulses — Digital pulses can have relatively long gaps between the pulses. A sequencer can output the pulse and then repeat a short waveform that represents the gap. This creates a very flexible pulse train with potentially long gaps between pulses if desired while using little memory.

MARKETS & APPLICATIONS

This sales guide presents two perspectives about AWG/AFG markets and applications;

1. Reasons to use an Arb
2. Customer profiles

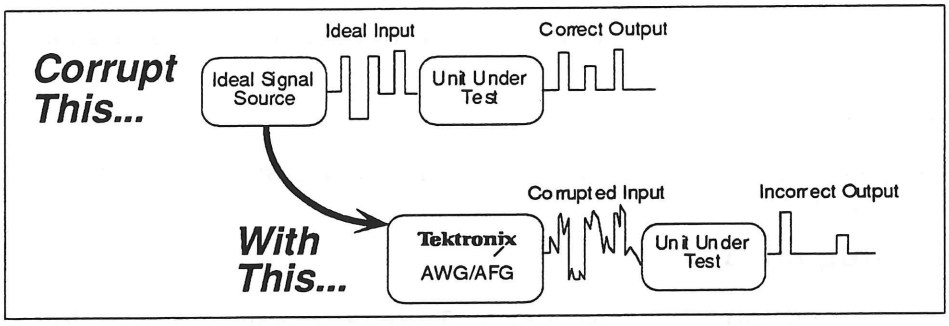
These two perspectives are complimentary. When talking to a customer who is using a signal source, at least one of these strategies will apply.

Benefits of Using an Arb

There are four fundamental reasons for using Arbs. These reasons stem from the fact that Arbs are so flexible and are capable of generating real world signals. Identify which reason(s) apply with your customer and convert them into Arbitrary Generator opportunities! The four benefits are:

Benefit	Examples
Replace conventional waveform generators	Function generators, pulse generators, sweepers, synthesizers
Replace specialized instrumentation	Custom circuits, fixtures
Corrupt ideal waveforms	Noise susceptibility, power supply failure conditions
Simulate transducers	Pressure, velocity, acceleration, temperature

Corrupt ideal waveforms and generate signal anomalies

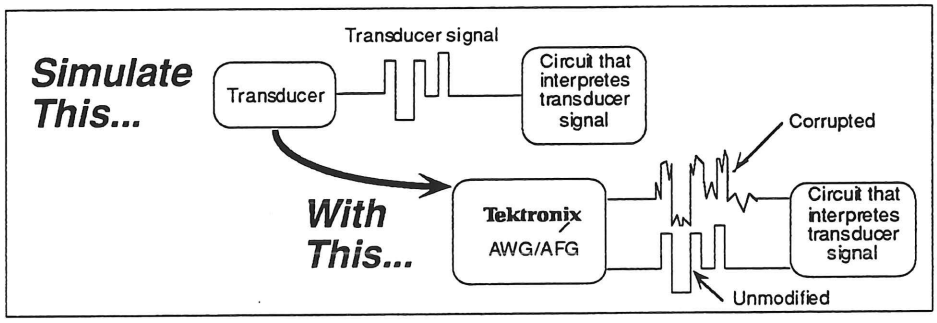


Corruption of ideal waveforms is paramount to perform margin or susceptibility testing of circuits. An Arb can generate signal anomalies to "'stress" circuits or devices under test (DUT). Susceptibility testing determines the ability of circuitry to reject anomalies contained in an incoming waveform can be tested with an Arb. Current techniques generally involve multiple generators or custom test circuitry intended to develop anomalies and test DUTs within specified limits.

Advantages of an Arb:

- Vary "ideal" input signals easily.
- Replace custom signal sources that lack flexibility or performance.
- Create library of corrupted signals for repeatable tests.
- Capture real world corrupted signals on digital oscilloscope and download to Arb to test susceptibility.

Simulate transducers

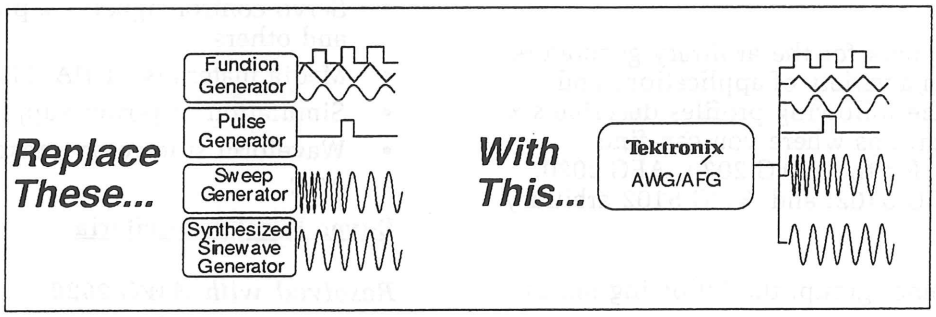


Simulation eliminates the need to have the actual event available (which in many cases is impractical) as stimulus when designing or testing the processing electronics. Computer drive signals can be simulated as input to the drive's read back electronics. Or the multi-path return signal from a pulse-response system (e.g., radar, sonar, LIDAR) can be simulated as input to the echo processing electronics.

Advantages of an Arb:

- Test anywhere without the need to use the transducer as the signal source.
- It's easy to corrupt the transducer signal for margin testing.
- Provides repeatable signal generation for production testing.
- Capture transducer signal on digital oscilloscope and store in Arb for long term generation.

Replace conventional waveform generators

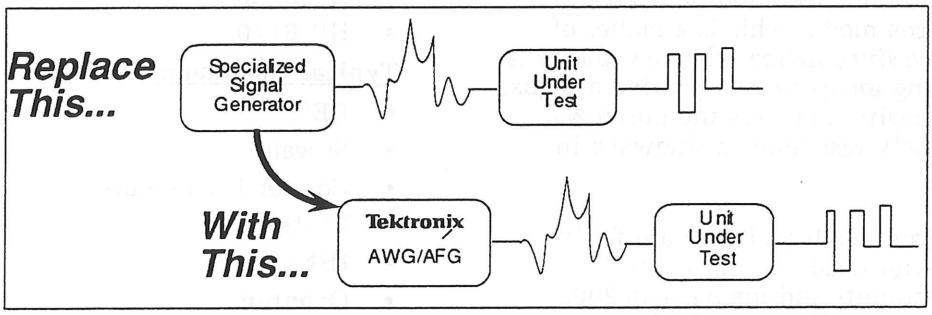


Since AWGs can generate synthesized signals, they can easily generate conventional signals (e.g., sinusoids, triangles, pulses, modulated sines). It's like having several signal generators in one box! The arbitrary function generator has built-in sweep and modulation along with arbitrary capability.

Advantages of an Arb:

- Consistent interface so it's easier to change from one operation to another.
- Takes less bench space so there is room for all the other equipment needed to do the job.
- Portable signal generation in one rugged package.
- Lower cost with one instrument instead of several.
- Single GPIB address frees the bus to add other instruments.

Replace specialized instrumentation



Custom waveform generators have been developed to generate specialized real-world signals. These specialized products offer dedicated, application-specific complex or mixed signal waveforms such as Composite Video Generators, T-Carrier.

The fundamental weakness of custom signal generators is lack of flexibility. If they are a "one-of-a-kind" generator, then support is also an issue.

Advantages of an Arb:

- Extreme flexibility to handle changing requirements.
- Standard off-the-shelf instrument so replacement, service and upgrading are simpler.
- Reduced cost since one signal source replaces several specialized sources.

Customer Profiles

Potential customers for the arbitrary generators can be found in a variety of applications and companies. The following profiles describe six key customer groups where you can find potential sales for the AWG 2020, AFG 2020, AWG 5105, AFG 5102, and AWG 5102 arbitrary generators.

For each customer group, the following topics are covered:

- Applications
- Buyer purchase criteria
- Competition
- Typical companies or customer types

Magnetic Media Testing

A wide variety of testing techniques are encountered in magnetic media testing. The most frequently encountered waveform is the Lorentzian pulses which occur coincidentally with the magnetic states written onto the media. These pulses vary in shape and complexity proportionally to the speed and density of the data written to the media. This is a matter of great significance since increased data capacity is one of the driving forces in newer drive designs. As the signal density increases the Lorentzian shape more closely resembles a sinewave in appearance.

The types of products tested here are fairly limited, read/write heads, motor control circuitry, logic circuits and media. The 2000 series Arbs are especially powerful in these applications through their ease of use, advanced waveform sequencing, dynamic triggering (marker outputs) and direct DSO transfers.

It is difficult to generalize the requirements of this industry, but several features of the AWG 2020 are beneficial in simulation of typical waveforms encountered here. In fact, we have discovered that some customers who have standardized on a "form factor" such as VXI, are willing to consider a AWG 2020 since it provides the right feature set for an excellent price.

Applications

- Disc flying height
- Peakshift
- Noise immunity testing
- Missing/extra bit patterns
- Evaluation of Read/Write heads
- Servo control signals - 2 phase di-bit pattern and others
- Media materials - HDA, Floppy, Tape, etc.
- Simulation of power supply conditions
- Waveform storage or transportation
- ATE

Buyer Purchase Criteria

Resolved with AWG 2020

- Point rate clock speed, accuracy and resolution - (i.e., 4 ns, 50 ppm, 4 digits to 100 ps resolution)
- Phase coherent multi-channel outputs
- Digital output and digital editing capability (option 03)
- Waveform sequencing
- Dynamic triggering
- Digital signal processing (FFT)
- System configurability

Competition

- LeCroy 9109
- Analogic 2045
- HP 8770

Typical Customers

- DEC
- Seagate
- Connor Peripherals
- Dastek
- IBM
- Quantum
- Exabyte
- Maxtor
- Storagetek
- Micro Motion
- Fujitsu
- Western Digital
- Crystal Semiconductor
- National Semiconductor
- Megatape Corp.
- Masstor Systems Corp.
- Laser Magnetic storage
- HP
- Applied Magnetics
- Fujitsu America
- Bose

Telecommunications/Data Communications

Communications products testing share a general need to simulate a variety of modulation signals. The use of Arbs is required in research, design, and manufacturing of low, medium or high speed communications equipment and network transmission equipment. The products tested may reside in the world of consumer products, industrial, or government/contractor markets. Jitter modulations are easily created with either the AWG or AFG 2020.

Applications

- Modems/Fax/Telex machines
- TTY machines
- Cellular/Digital phone testing
- Nyquist filter response
- Antenna Test
- Telephone network
- Mobile communications
- IF, QAM, FSK, PSK and other modulated signals
- CCIR, CCITT, SONET, DTMF

Buyer Purchase Criteria

Resolved with AFG 2020

- Direct internal modulation capabilities AM/FM/PSK/FSK
- Jitter modulation through FSK sequencer
- High need for accuracy, stability and resolution
- Requires only 1 or 2 independent, phase coherent channels
- Primarily synthesizer users

Resolved with AWG 2020

- High variety of Arb signals requiring long records (256K) with reduced requirements for clock accuracy stability and resolution (unless an external system clock is provided)
- Internal AM/FM/PSK/FSK/jitter modulation through Equation or Sequence editors
- Jitter modulation through sequencer
- Reduced frequency and precision (THD <60 dB @ 250 KHz)content sinewaves
- FFT editor
- Digital logic testing

Resolved with AWG 5105

- Reduced requirements for clock accuracy stability and resolution (unless an external system clock is provided)
- Reduced point resolution 20 ns/ point (50 MHz)
- Reduced frequency (5 MHz) and precision THD content sinewaves
- More than two independent phase coherent channels required
- High variety of Arb signals requiring long records (256K)
- Lowest cost

Competition

- LeCroy 9109
- Analogic 2045
- HP 8770

Typical Customers

- Allied Signal
- AT&T
- Argosystems
- Micro Linear
- Bell Northern
- Bell Core
- Bose Corp.
- Commercial Telecom
- Delta USA
- Eaton Corp.
- Fujitsu
- Hughes
- NIST
- ITT Hancock
- IBM
- Indonesian Telecom
- GEC/Marconi Motorola
- Metracom
- Micromotion
- Northern Telecom
- Rockwell International
- Telecom Techniques
- United Technologies

Video/Imaging

Video/Imaging applications share the need to simulate complex and modulated signals. The use of Arbs is required in research, design, and manufacturing of low, medium or high speed video and imaging equipment. The products tested may reside in the world of consumer products, industrial, or government production test systems.

Applications

- IR imaging systems
- Machine imaging systems
- Television & VCR manufacturers
- Antenna test
- Television network
- Mobile imaging systems
- Multiple black bursts
- Digital and analog test outputs
- SMPTE, PAL, NTSC, CCIR
- Other modulated signal applications

Buyer Purchase Criteria

Resolved with AWG 2020

- A variety of Arb signals requiring long records (256K)
- Waveform sequencer to build complex video signals. These signals that have portions that repeat, an ideal situation for the sequencer
- Clock accuracy stability and resolution (Additional precision added with external system clock)
- 12 bit vertical resolution is highly desirable
- May require more than two independent, phase coherent channels
- Digital logic testing

Resolved with AWG 5105

- High variety of Arb signals requiring long records (256k)
- Reduced requirements for clock accuracy stability and resolution (unless an external system clock is provided)
- Reduced point resolution 20 ns/ point (50 MHz)
- Reduced frequency (5 MHz) and precision THD content sinewaves
- More than two independent phase coherent channels required
- Lowest cost

Competition

- Analogic 2000 series
- LeCroy 9000 series
- Wavetek 295

Typical Customers

- Boeing
- Lockheed
- General Dynamics
- North American

Computer Peripherals (except disk drive)

The types of products tested are fairly broad in nature but share a general need to simulate modulation signals. The use of Arbs is required in research, design, and manufacturing of low, medium or high speed communications equipment and network transmission equipment. The products tested may reside in the world of consumer products, industrial, or government

Applications

- Computer Power supply
- Keyboard test
- Modem test
- Terminal tests
- LAN Card manufacturing

Buyer Purchase Criteria

Resolved with AFG 2020

- Direct internal modulation capabilities AM/FM/PSK/FSK
- High need for accuracy, stability and resolution
- 12 bit vertical resolution (4096 levels)
- Requires fast 100 MHz, precise low THD content sinewaves
- Requires only 1 or 2 independent, phase coherent channels
- Limited variety of Arb signals requiring only 1 k records
- Direct waveform period readout
- Primarily synthesizer users
- Lowest cost GUI Arb

Resolved with AWG 2020 (external system clock provided)

- When used in these applications the internal memory and/or sequence editor of the AWG is used to simulate the various modulation techniques
- Reduced requirements for clock accuracy stability and resolution (unless an external system clock is provided)
- More than two independent, phase coherent channels required
- High variety of Arb signals requiring long records (256K)
- Digital logic testing

Competition

- Analogic 2000 series
- LeCroy 9000 series
- Wavetek 295

Typical Customers

- Apple
- Fujitsu
- Cirrus logic
- Cray
- Colorado Memory Systems
- IBM
- Compaq
- Data General
- Data Metrics
- DEC
- Emulex
- Fairchild Weston Systems
- HP
- Leading Edge
- MiniScribe
- Microtech
- Mountain Computer
- Nashua Corp.
- National Semiconductor
- Prime Computer
- RadiSys
- Syncom Techs Inc.
- Solectron Corp.
- Tandem
- Unisys Corp.

Radar/Sonar

These systems are constructed with a variety of modulating sources, RF Sources, modulators, mixers/combiners. The types of products tested share a need to simulate a wide variety of modulation signals. The use of Arbs is required in research, design, and manufacturing of low, medium or high frequency equipment where they typically provide the modulating signals and supply circuit power. On the high end, the Arbs are unable to simulate carrier frequencies but are valuable as the modulation source. On the low end, the Arbs may simulate both carrier and modulation signals.

In Radar and EW applications the 2000 series Arbs offer excellent frequency agility. These applications rely heavily on Doppler or phase shift waveform simulations. Developers of Radar/Sonar products gain significantly from a signal source which previously required full scale field testing to obtain the unique waveforms. Agility refers to the instruments ability to change from one selected frequency to another, referred to a hopping in these markets. In the case of the 2000 series we enjoy a large advantage over most competition with 4 ns agility.

Applications

- Chirp, Hop, Skip
- Barker-coded pulses
- Burst echo
- Target simulation
- Sea floor topography simulation
- Guidance system testing
- Location detection
- Other exotic modulation signals

Buyer Purchase Criteria

Resolved with AFG 2020

- Direct internal modulation capabilities AM/FM/PSK/FSK
- High need for accuracy, stability and resolution. Typically an AFG customer but may prefer the flexibility of an AWG
- 12 bit vertical resolution (4096 levels)
- Requires fast 100 MHz, precise low THD content sinewaves
- Requires only 1 or 2 independent, phase coherent channels
- Limited variety of Arb signals requiring only 1 k records
- Primarily synthesizer users
- Lowest Cost GUI Arb

Resolved w/ AWG 2020 (external system clock provided)

- When used in these applications the internal memory and/or sequence editor of the AWG is used to simulate the various modulation techniques
- Reduced requirements for clock accuracy stability and resolution (unless an external system clock is provided)
- Modulation capabilities including AM/FM/PSK/FSK/PWM
- More than two independent, phase coherent channels required
- High variety of signals requiring long records (256k)
- Digital logic testing with option 03
- Direct DSO transfer

Sonar Resolved with AWG 5105

- Reduced requirements for clock accuracy stability and resolution (unless an external system clock is provided)
- 12 bit vertical 4096 points
- Reduced point resolution @ 20 ns/ point
- Reduced frequency and precision THD content sinewaves
- More than two independent phase coherent channels required
- High variety of Arb signals requiring long records (256K)
- Lower Cost

Competition

- Analogic 2000 series
- LeCroy 9000 series
- Wavetek 295

Typical Customers

- Government Agencies & Contractors
- NIST
- NCAR - National Center for Atmospheric Research
- E-Systems
- Boeing
- Hughes
- Metricom
- Digicourse

Biomedical

Biomedical applications share a need to simulate the signals developed by the human body. Arbs offer a significant productivity enhancement in these applications by simulating both normal and abnormal physiological waveforms required in product testing. Arbs excel at simulation of real heartbeats, systolic pressure, respiration and other conditions of the human body which would otherwise be impossible. The use of Arbs is required in research, design, and manufacturing of high-speed Biomedical electronics.

Pacemaker testing is but one of many applications for Arbs in medical testing. Pacemakers are designed to detect a patients abnormal heart condition and provide electrical impulses to keep the heart beating normally. To assure pacemaker reliability and prevent the accidental death of the pacemaker wearer, the FDA has developed very strict test requirements for manufacturers of these products. The 2000 series Arbs are powerful in these applications through their ease of use, advanced sequencing, dynamic triggering (marker outputs) and direct DSO transfers.

Applications

- Heart monitors
- Pacemakers
- Defibrillators
- MR imaging systems
- Blood gas analyzers
- Infusion pumps
- Flow/Pressure monitors
- Patient simulator
- Education
- Camac standards

Buyer Purchase Criteria

Resolved with AFG 2020

- Direct internal modulation capabilities AM/FM/PSK/FSK
- High need for accuracy, stability and resolution. Typically an AFG customer but may prefer the flexibility of an AWG
- Requires fast 100 MHz, precise low THD content sinewaves
- Requires only 1 or 2 independent, phase coherent channels
- 12 bit vertical 4096 points
- Limited variety of Arb signals requiring only 1 k records
- Direct waveform period readout
- Ease of use - GUI & graphical editing techniques
- Lowest cost GUI Arb

Resolved with AWG 5105

- Reduced requirements for clock accuracy stability and resolution (unless an external system clock is provided)
- 12 bit vertical 4096 points
- Reduced point resolution 20 ns/ point (50 MHz)
- Reduced frequency (5 MHz) and precision THD content sinewaves
- More than two independent phase coherent channels required
- High variety of Arb signals requiring long records (256K)

Resolved with AFG 5102/5502

- Reduced requirements for clock accuracy stability and resolution (unless an external system clock is provided)
- Reduced point resolution 50 ns/ point (20 MHz)
- Built-in full analog generator
- Swept Arb waveforms is unique to AFG 5102
- Reduced frequency and precision THD content sinewaves
- Single channel only. Two Arbs can provide independent phase coherent channels
- Lowest Cost

Typical Customers

- Isamatec
- Intermedics
- Dynatech Nevada
- Medtronic
- Cardiac Pacemaker

Avionics/Navigation

Avionics/Navigation products share a general need to simulate a variety of non-standard signals. The use of Arbs is required in research, design, and manufacturing of low, medium or high speed equipment. The products tested may reside in the world of industrial or government applications.

Solutions tend to be VXI based in field applications but not necessarily so for research, design, or stationary depot test platforms. In any case, the performance of the monolithic 2000 series exceeds any VXI solution to date.

Applications

- ABS
- Flight pattern simulation
- ILS/MLS
- VOR
- Flight simulation
- Imagining systems
- LANSAT
- NAVSTAR
- Automotive navigation systems
- ARINC
- Other complex signal applications

Buyer Purchase Criteria

Resolved with AFG 2020

- Direct internal modulation capabilities including AM/FM/PSK/FSK/PWM
- Direct waveform period readout
- High need for accuracy, stability and resolution
- 12 bit vertical 4096 points
- Limited need for Arb signals
- Direct DSO transfers
- Ease of use
- Lowest cost GUI Arb

Resolved with AWG 2020

- Reduced requirements for clock accuracy stability and resolution (unless external system clock is provided)
- Independent, phase coherent channels required
- High variety of Arb signals requiring long records (256K)
- 12 bit vertical 4096 points
- Direct DSO transfers
- Digital logic testing with option 03
- Ease of use - GUI & preference for up to 7 editing techniques

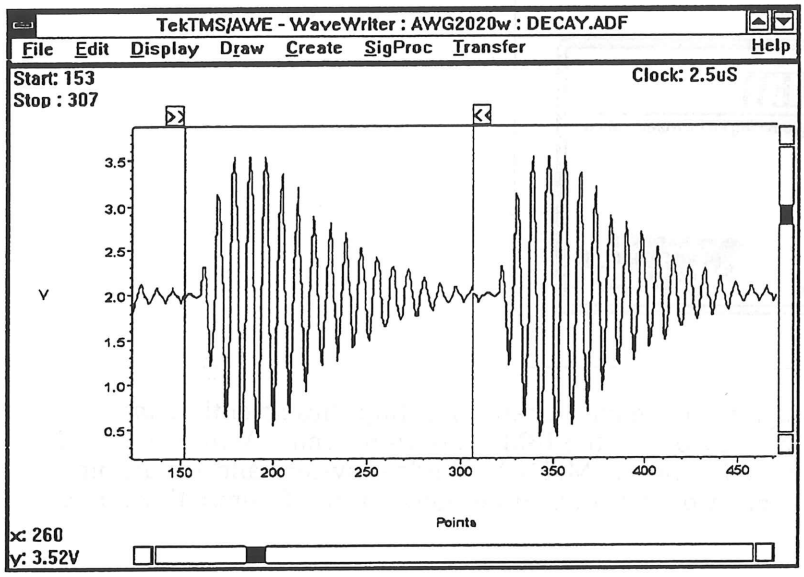
Typical Customers

- Boeing
- Martin Marietta
- Lockheed
- General Dynamics
- North American
- Delta
- United
- Hamilton Standard American

SOFTWARE SOLUTIONS

While the AWG/AFGs have many powerful features, adding an external computer and software extends the functionality of the solution by adding enhanced waveform editing capability, manufacturing test program development, etc.

WaveWriter



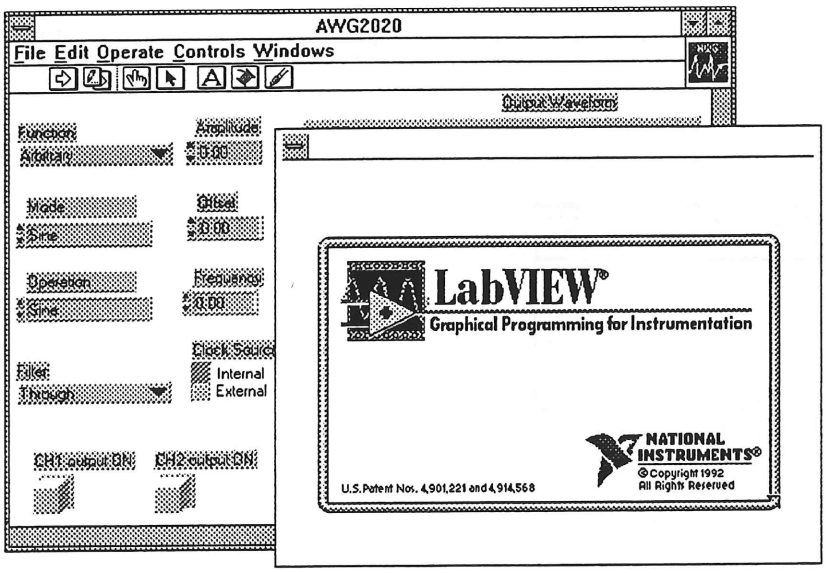
WaveWriter is a stand alone software productivity tool which gives Tektronix an extreme competitive advantage when coupled with our Arbitrary Generators and Digital Oscilloscopes. WaveWriter is a Windows-based applications package which derives its capability with the use of a mouse or keyboard operation.

WaveWriter allows display of multiple waveforms simultaneously with file manipulation provided within the software environment. Template generation is provided in WaveWriter to allow creation of complex templates for use on all Tektronix "Save on Delta" featured DSOs 2400, TDS series etc.

WaveWriter extends the flexibility of Arbs and allows creation of waveforms or modification of existing waveforms by:

- Polynomial Equation (Mathematical Equation Entry)
- "Paint Brush" fashion drawing in:
  - Freehand Mode
  - Point-to-Point Mode (Specify the endpoints)
  - Vertical or Horizontal Mode
- Standard Functions (Sine, Square, Triangle, Pulse)
- Adding offset
- Attenuate or Amplify by Multiplying all or a Portion of a Waveform with a scalar value or the data points of another waveform.

Lab View PC



Lab View PC is an icon-based graphical programming environment that simplifies scientific and engineering programming. LabView is now available on the IBM PC running under Windows 3.1, Sun Microsystems SPARCstations running open Windows or MIT's X-Window system and the Apple Macintosh. LabView allows quick development of test procedures, generation of simulations, etc.

Key capabilities include:

- Virtual Instrument front panels
- Graphical icon program generation and flow
- Multitasking
- Compiler
- Hundreds of advanced analysis routines

Lab Windows

LabWindows is a software development environment for building test and measurement applications. LabWindows gives Microsoft QuickBASIC and C programmers a set of development tools that provides user interface, instrument I/O, waveform display, and analysis routines built-in. The programmer can focus on the test to be made.

There are four parts to LabWindows:

1. Standard package - Provides the base environment that contains the user interface, waveform graphics, and GPIB and RS-232 instrument support.
2. Advanced analysis library - Provides over 125 functions including signal generation, FFT, inverse FFT, integration, differentiation, pulse analysis and more.
3. VXI library - Provides compete interface to VXI instrumentation.
4. Runtime library - Allows generating standalone DOS applications that contain the same flexible and powerful user interface.

COMPETITIVE INFORMATION

There are a number of competitors for AWG/AFGs. They include LeCroy, Fluke, HP and WaveTek. Minor players include Yokogawa, Pragmatic, Stanford Research, Rhode & Swartz (primarily in Europe). This section describes who you will likely encounter and how to win against them. Two tables shown in appendix A compare the major capabilities of Tek products compared with our competitors. The first table covers competitors of the 2000 series Arbs and the second table compares TM5000 competitors. You will notice holes in some of the tables (designated with ??). If you can get information to make these tables more complete, give Bruce Virell a call.

Listed below are specific competitors instruments with their strengths and weaknesses and how you can win with the Tektronix solution.

LeCroy

LeCroy 9100 Series Arb w/ 9000 Series DSO	Tektronix AWG 2020 Arb w/TDS 500 DSO
+ 3 Year Established market in disk drive testing	+ Higher Performance Arb (12 Bit/250 MHz)
+ Higher DSO Record Length (1 Mbyte)	+ Higher Performance Scope
+ "WAVE" software has greater performance/ reliability than AWE	+ Designed for Benchtop or System Applications
- Higher System Cost	+ Integrated Benchtop Solution Package with direct link with TDS scope
- Reduced Flexibility (No Front Panels)	+ Graphical User Interface GUI
- Doesn't Link to Tek Scopes	+ Enhanced AWG Features
+/- New Arbs & PGs are moving LeCroy away from Niche	• Waveform Sequencing
+/- Designed Exclusively for Systems	• Mass Data Storage (3 1/2" DD)
	• 12 Bit Digital Out (opt 03)
	• DSP (opt 09)
	+/- WaveWriter AWE

HP

HP 8770 Complex Waveform Simulator	Tektronix AWG 2020 Arb w/ RIC 386/WaveWriter/Lab View (No DSO)
+ 4 Year Established market in Telecom and disk drive testing	Enhanced Editing Features
+ Higher Arb Record Length (1 MByte)	+ Higher Performance Arb (12 Bit/250 MHz)
+ HP Enjoys an established System & Sources Offering	+ Higher Performance Scope
+/- Designed Exclusively for Systems	+ Designed for Benchtop or System Applications
- Reduced Flexibility (No Front Panels)	+ Integrated Benchtop Solution Package with direct link with TDS scope
- Higher System Cost	+ Graphical User Interface GUI
- Uses Non-Standard Controller	+ Enhanced AWG Features
	• Waveform Sequencing
	• Mass Data Storage (3 1/2" DD)
	• 12 Bit Digital Out (opt 03)
	• DSP (opt 09)
	+/- WaveWriter AWE

Fluke

Fluke Series	Tektronix AWG 2020 Arb w/TDS 500 DSO
+ Shares Most GUI Benefits + Protect Customer Investment (By linking with their DSOs) + Has waveform Solution SW +/- Sources Offering with Arbs & PGs is moving away from Niche - Higher Box Cost	+ Higher Performance Arb (12 Bit/250 MHz) + Higher Performance Scope + Designed for Benchtop or System Applications + Integrated Benchtop Solution Package with direct link with TDS scope + Graphical User Interface GUI + Enhanced AWG Features • Waveform Sequencing • Mass Data Storage (3 1/2" DD) • 12 Bit Digital Out (opt 03) • DSP (opt 09) +/- WaveWriter AWE

INFORMATION ON SUPPORT, ACCESSORIES, ORDERING, ETC.

Ordering Information

Listed below is the order information for the different Arbs available from Tektronix. Please refer to the PAL for up to date information about delivery and prices.

Ordering information choices

Description	Order Information	USDC Price
AFG 2020 250 MHz Arbitrary Function Generator	AFG2020	$7,995
Add second channel	02	$2,950
Rackmount kit	1R	$550
AWG 2020 250 MHz Arbitrary Waveform Generator	AWG2020	$11,995
Add second channel	02	$4,250
12 bit digital word generator	03	$1,000
FFT editing option	09	$1,500
Rackmount kit	1R	$655
AWG 5105 50 MHz Arbitrary Waveform Generator	AWG5105	$5,995
Add second channel	02	$2,000
AWG 5102 20 MHz Arbitrary Waveform Generator plug-in	AWG5102	$2,995
Warranty plus - Calibration for 2nd and 3rd years	M7	$215
Warranty plus - 3 year warranty	M9	$235
AWG 5502 20 MHz Arbitrary Waveform Generator	AWG5502	$3,795
Warranty plus - Calibration for 2nd and 3rd years	M7	$250
Warranty plus - 3 year warranty	M9	$270
AFG 5102 20 MHz Arbitrary Function Generator plug-in	AFG5102	$3,995

Customer technical support

The first line of support for Arbitrary Waveform & Arbitrary Function Generators including WaveWriter should be the local Field Applications Engineer. Customer technical support is available by calling our Applications Support HOT LINE at 1-800-TEK-WIDE, extension: WAVE or by calling the SE support center at 1-503-627-2400.

Support material

AFG 5102/5502 data sheet	65W-8781-1
AWG 5102/5502 data sheet	75W-8496-0
AWG 5105/5505 data sheet	65W-8714-1
AWG 2020 data sheet	85W-8895-0
AFG 2020 data sheet	85W-8896-0
Waveform Simulation color brochure	65W-8813-0

Terms, Export Control, Warranty Information

	Terms	Combinability	Export control	Warranty
AWG 5105 AWG 5102 AWG 5502 AFG 5102	Exhibit A1, Discount Table X applies	None	Schedule B: 8543.20.0000.3 ECCN: 3A93F County of origin: Israel	1 year, Corporate warranty #2
AFG 2020 AWG 2020	Exhibit A1, Discount Table X applies	None	Schedule B: 8543.20.0000.3 ECCN: 3A02A County of origin: Japan	1 year, Corporate warranty #2

WHO TO CALL

Function	Name	Phone	FAX	Del Station
T&M Sales support	SE Support Center	503 627-2400	503 627-5695	39-519
National Marketing Center	Hal Bates Lisa Herring Jurgen Krannich	800 424-2200	503 690-3959	94-860
2000 Series Marketing	Bruce Virell	503 627-1191	503 627-3838	39-353
Demo Instrument Coordinator	Molly Hall	503 629-3135	503 629-5559	94-886
Scheduling/Order processing	Mary Ann Hanson	503 627-1789		19-163
Service support	Bill LaRue	503 627-6571		19-083
Engineering	Mike Roy	503 629-1573	503 629-5613	92-820

JPMcHugh, 7/21/93

Appendix A- 2000 Series Competitive Comparison

NA= Not Available, ?? = Don't know

Vendor/Model	Tektronix AWG 2020	Tektronix AFG 2020	Wavetek Model 295	LeCroy 9101/9100	LeCroy 9109	LeCroy 9112	Yokogowa AG2200	Yokogowa AG2100A	Analogic 2020-100	HP 8770	HP 8175A	Pragmatic 2205
Sample Rate	250 MS/s	250 MS/s	50 MS/s	200 MS/s	200 MS/s	50 MS/s	200 MS/s	100 MS/s	100 MS/s	50 MS/s	50 MS/s	50 MS/S
Time Base Accuracy	50 ppm	1 ppm	1 ppm	2 ppm	2 ppm	2 ppm	3 ppm	3 ppm	100 ppm	.0005 ppm	.5% +/-2.5ns	50 ppm
Vertical Res)	12	12	12	8	8	12	8	10	12	12	10	12
Sine,Sqr,Tri	Yes	DDS Synthesized	Synthesized	Yes	Yes	Yes	Yes	Yes	Synthesized	Synthesized	24 Data 2 Arb	Yes
Ramp, DC	Yes	Yes	20 MHz	1 MHz	Yes (1MHz)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Execution Memory	256k pts/Chan	1k pts/Chan	32k pts (EM opt 128K)	64K pts	64k pts	32k pts	128k	128k	64k(512k)	512k pts	1k pts	250K/Ch
Non-Volatile Memory	160K	16k/16 Settings	128k pts	350k pts	350k	175k pts	128k	128k	128k pts	??	??	175k pts
Sequencing Memory	Yes, 8k pt Wfm	16k/16 Settings	Yes	Yes	Yes	Yes	675	682	NA	NA	Yes	??
Waveform Editing	Equation, Std,Draw, Timing, Table, (FFT)	Std, Draw	Mouse, Equation,	Line Draw,Pre Def, Equation	Line Draw,Pre Def, Equation	Line Draw,Pre Def, Equation	Line Draw,Pre Def, Equation	Line Draw,Pre Def, Equation	Mouse, Equation,	Line Draw,Pre Def, Equation	Line Draw,Pre Def, Equation	Scope Draw
Output Channels	1	1	1	1	2	2	1	1	2	1	2	2
Additional channels option	1	1	up to 4	1	NA	NA	1	1	NA	NA	NA	NA
Ampl Vpp into 50Ω	5v p-p	10v p-p	15v p-p	10v p-p	10v p-p	10v p-p	10v	10v	10v p-p	2v	16v	10mv-10v
Package Format	Monolithic	Monolithic	Monolithic & plugins	19" Monolithic	19" Monolithic	19" Monolithic	19" Monolithic	19" Monolithic	19" Monolithic	19"x 12" Syst	19" Monolithic	19" Monolithic
Ext Clock	Clk IN/OUT	Ref Clk IN/Out	Clk Out/(In	Clk Out/In	Clk Out	Clk Out/In	Clk Out/In	Clk Out/In	Clk In	NA	Clk Out/In	In/Out &Ref
Modulation	AM	AM/FM/ PSK/FSK/ ØM	AM/SCM	NA	NA	NA	NA	NA	NA	AM, FM, ØM, Chirp, Pulse, Digital	NA	AM
Built-in Sweep Gen	Yes w/ equation edirot	Linear/Log	Linear/Log	NA	NA	NA	Yes w/ equation editor	Yes w/ equation editor	Linear/Log	NA	NA	NA
Media Storage	3 1/2" Floppy	NA	3 1/2" Floppy	NA	NA	NA	3 1/2" Floppy	3 1/2" Floppy	NA	NA	NA	NA
Direct DSO Transfer	2200/2400/TDS / RTD710A	2200/2400/TDS / RTD710A	Yes, limited choices	NA	NA	NA	Yes, limited choices	Yes, limited choices	Yes, limited choices	NA	NA	NA
Digital Out	12 bit + 2 markers	NA	NA	NA	8 or 16 Bit	12 Bit	8 bit	10 bit	16 bit (Std)	12 bit	24 bit	12 bit
Price	$11,995	$7,995	$5,995; $6790EM	$10,900; $13,900	$15,900	$15,900	$19,950	$17,990	??	$28,500	$17,200	$10,985
Add one Channel	$4,250	$2,950	$2,995;$3790 EM	??	NA	NA	$5,550	$5,510	NA	NA	NA	NA
FFT	$1,500	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Digital Output	$1,000	NA	NA	NA	STD	STD	Optional	Optional	STD	$790	STD	NA

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Appendix A - TM5000 Competitive Comparison

NA= Not Available, ?? = Don't know

Vendor/Model	Tektronix AWG 5105	Tektronix AFG 5102/5502	Tektronix AWG 5102/5502	Wavetek Model 95 AFG	Wavetek Model 275 AFG	HP 3314 AFG	HP 3245 AFG
Sample/Clock Rate	50MS/s	20MS/s	20MS/s	20MS/s	3.75MS/s	20MS/s	4.3MS/s
Vertical Res.(bits)	12	12	12	12	12	12	12
Sine,Sqr,Tri,Ramp,DC	NA	20MHz Analog	1MHz Synth	20MHz Synth	12MHz Analog	20MHz Analog	1Mhz Analog
Execution Memory	64k pts/Chan	32k pts/Chan	32k pts	32k pts	2k; 8k opt	160 pts	2k
Non-Volatile Memory	256k pts	32k	32k pts	32k pts	2k; 8k opt	??	??
Memory Sequencing	NA	NA	NA	NA	NA	NA	NA
Output Channels Std	1	1	1	1	1	1	1
Additional channels option	1	NA	NA	NA	NA	NA	Yes
Amplitude Vpp, 50Ω	15v	15V	10mv-10v	1mv-15v	10v	10mv-10v	.1mv-10v
Package Format	TM 5000	TM5000	TM5000 or Mono	Mono 19"	Mono 9"	Mono 19"	Mono 9"
Ext Clock	Clk In	Clk In/Out ea Chan	Clk In/Out	Clk In	NA	NA	NA
Modulation	AM(FM var clk)	AM/FM	AM(FM var clk)	AM/FM	NA	AM/FM	NA
Built-in Sweep Gen	NA	Lin/Log/Arb	NA	??	Lin/Log	Lin/Log	NA
Stored Settings	98	79	98	10	75	NA	14
Price	$5,995	$3,995/$4,795	$3,495/$4,295	$4,595	$4,995	$4,950	$4,550
Add Chan Opt	$2,000	NA	NA	NA	NA	NA	$3,000