# UHF-AWG
# Arbitrary Waveform Generator

Zurich Instruments

## 2 output channels, 1.8 GSa/s, 14-bit
## 600 MHz, 128 MSa waveform memory

Product Specification
Release date: February 2016

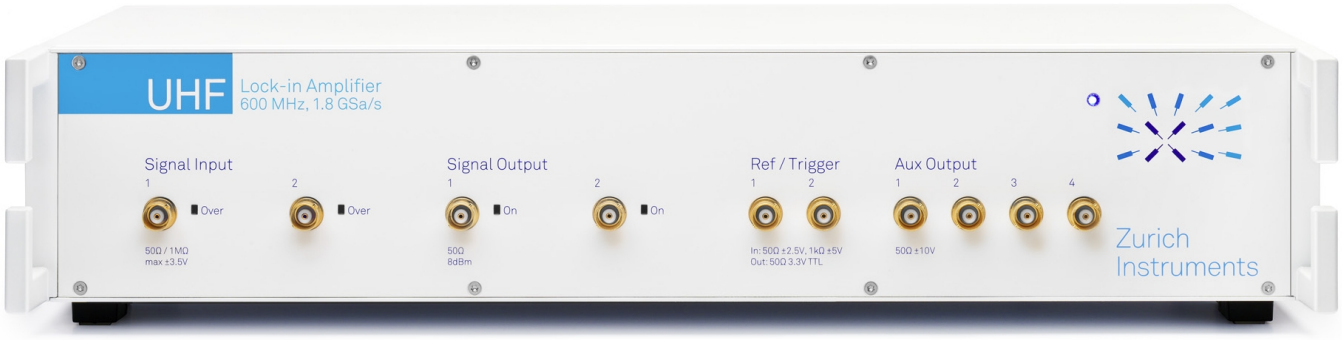
The UHF-AWG Arbitrary Waveform Generator integrates signal generation and detection in a single box providing a complete solution for pulsed measurement protocols. Its state-of-the-art programming concept offers a quick route leading to custom signals on the two 600 MHz output channels. The available detection schemes include high-speed demodulation, pulse counting and a digitizer for time domain analysis. Sequence branching based on internal measurement results enables feed-forward protocols of unparalleled speed, enabling applications like quantum error correction. The modulation capabilities the UHF-AWG are designed to meet the most demanding requirements regarding phase coherence, as required for instance in quantum computing, mixed-signal device testing, NMR spectroscopy and more. The entire functionality is conveniently integrated into the LabOne® software which allows for intuitive and platform-independent control.

## Key Features

- Dual 600 MHz arbitrary waveform generator
- 14-bit resolution, 2 markers per channel
- 128 MSa waveform memory per channel
- Amplitude modulation with internal and external phase reference
- Two 600 MHz signal inputs with oscilloscope and optional demodulation, pulse counter, boxcar averager
- Cross-trigger engine for low-latency triggering and sequence branching

## User Benefits

- Intuitive AWG programming language allows for a quick start and efficient use
- Controlling AWG and detection with a single user interface leads to a significant reduction of setup complexity
- The parametric Sweeper (delay, amplitude, frequency, phase, etc.) provides straightforward measurements automation
- Reduction of waiting times by fast transfer of long phase-coherent patterns thanks to modulation and sequencing
- Simple implementation of fast feed-forward and feedback protocols without FPGA programming



## Highlights

The UHF-AWG can reproduce any waveform from a user-programmable 128 MSa memory on its two 600 MHz output channels. The high-level compiler integrated into the LabOne® user interface centralizes the tools for waveform creation and editing, sequencing, and instrument configuration, ensuring an efficient workflow towards the desired output signal.

Moreover, the UHF-AWG is equipped with two 600 MHz signal inputs and a measurement toolset offering a variety of synchronous and asynchronous detection methods. The cross-trigger engine enables bidirectional triggering between the AWG and the internal detection units, representing a superior replacement of inter-device triggering used in traditional measurement setups. It eliminates complicated synchronization methods between separate instruments for signal detection and signal generation. Instead, the measurement procedure is controlled from a single AWG program as illustrated with the example shown below.

The platform-independent LabOne user interface provides an extensive measurement and analysis toolset. With the parametric Sweeper, dependencies on AWG parameters such as waveform amplitude, delays, or carrier frequency and phase are easily measured. Continuously streamed measurement data are visualized with the Plotter tool and offer a close monitoring of the effect of the AWG signal. Triggered recording is available using either the built-in Scope or the Software Trigger tool to accommodate for the often shot-like character of AWG measurements. The LabOne programming interfaces for Python, LabVIEW, MATLAB, and C allow for quick integration into existing control software.

## Description

### Waveform generation and modulation

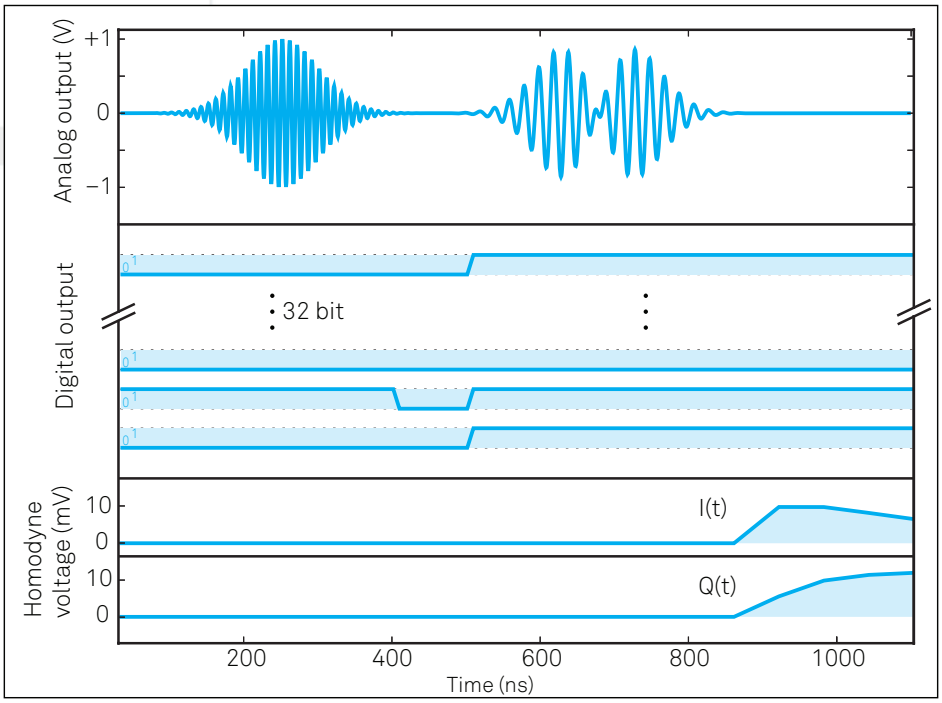
The UHF-AWG can operate in direct output mode or in amplitude modulation mode. In direct output mode, the waveforms are routed directly to the DC-coupled signal outputs. The 128 MSa waveform memory and 14-bit, 1.8 GSa/s D/A conversion enable generation of high-resolution pulse shapes to reproduce a wide range of device testing conditions or to compensate for distortions occurring in the signal path. In amplitude modulation mode, each AWG channel shapes a sinusoidal signal generated by an internal oscillator. This optimizes the generation of phase-coherent pulse patterns using the sequencer and generic pulse envelopes, where otherwise the entire waveform needed to be uploaded. This saves time and increases throughput. Variation of carrier parameters helps in cases where frequent tuning of

Sequence Editor

```
1  string gauss = generate("gauss", 512, 1, 50, 100);
2  string drag = generate("drag", 512, 1, 50, 100);
3
4  const CONFIG_A = 0;
5  const CONFIG_B = 1;
6
7  repeat (1000) {
8      setInt("demods/0/oscsel", 0);
9      playWave(1, gauss);
10     setDIO(CONFIG_A);
11     wait(100);
12     setDIO(CONFIG_B);
13     setInt("demods/0/oscsel", 1);
14     playWave(1, drag);
15     setTrigger(1);
16     wait(400);
17     setTrigger(0);
18 }
```

LabOne sequence editor window with AWG program featuring waveform generation, control of multi-bit digital output, and dynamic change of carrier frequency.

Analog and digital AWG signals generated by the program on the left. Data acquisition (here: homodyne detection) is performed synchronously with signal generation.



phase or frequency is required. In applications such as NMR spectroscopy that require long patterns at the full 600 MHz bandwidth, the user can reduce waveform size by specifying envelopes with a lower sampling rate than the final signal. The UHF-AWG's sine wave generators serve as a reference both for the signal generation and the signal detection, which enables measurement of the phase in applications such as pulsed radar. Two digital marker signals per channel can be generated with the same time resolution as the analog signal both in direct output mode and amplitude modulation mode.

### Detection schemes

The UHF-AWG can be combined with a range of detection units in the same instrument:

- The Demodulator allows for phase-sensitive detection with a best-in-class 5 MHz measurement bandwidth for pulsed RF measurements.
- The Pulse Counter conveniently processes PMT or similar pulse-like signals with rates up to 200 MHz.
- The Scope and Digitizer allow direct visualization of the system response to a waveform stimulus.
- The Spectrum Analyzer provides the high frequency resolution required e.g. in NMR spectroscopy.

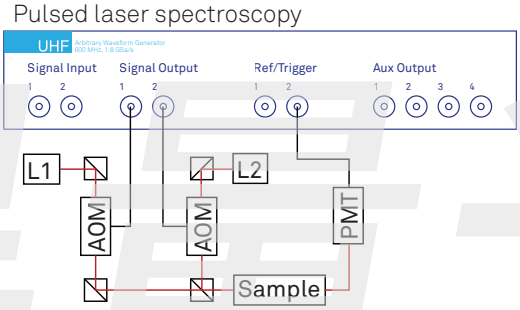
The setup schematics below and the options table on the following page can serve as an inspiration on how the UHF-AWG can meet your measurement needs.

### Sequence branching and feed-forward

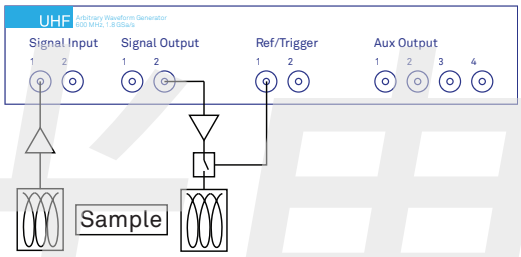
Using its branching capabilities, the UHF-AWG can select the next waveform based on external conditions such as the state of the 32-bit digital input, or internal conditions such as the value of a demodulated signal quadrature. The flow diagram at the bottom of the page illustrates the flexibility in defining branching conditions for different applications. Achieving sub-microsecond feed-forward times is a matter of a few sequencer commands and there is no need for dealing with low-level digital signal processing.

Typical applications of the UHF-AWG Arbitrary Waveform Generator

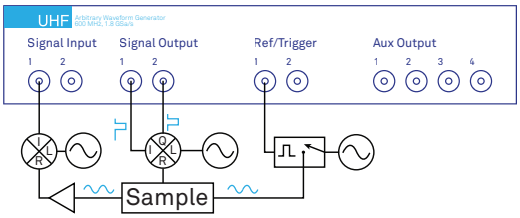
Trapped Ion Quantum Computing:
Pulsed laser spectroscopy



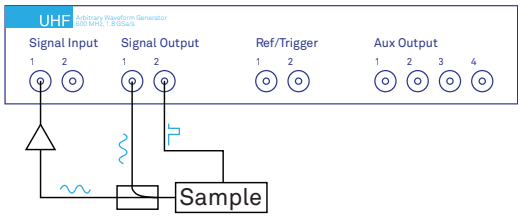

NMR/EPR Spectroscopy:
RF transmission



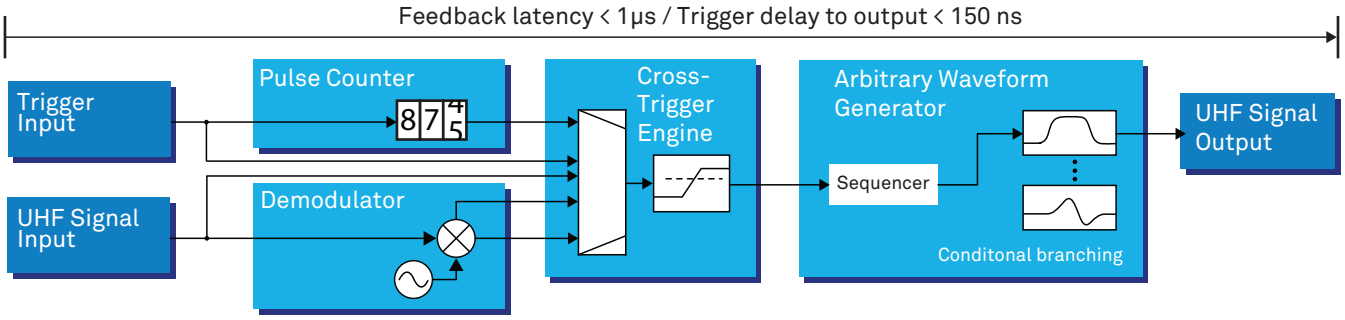

Circuit Quantum Electrodynamics:
Microwave transmission




Quantum Dots:
RF reflection




Flow diagram of the signal path for a fast feedback protocol. A feedback latency below 1 µs is reached for a protocol including demodulation and conditional branching. Direct AWG trigger delay is less than 150 ns.



# Specifications

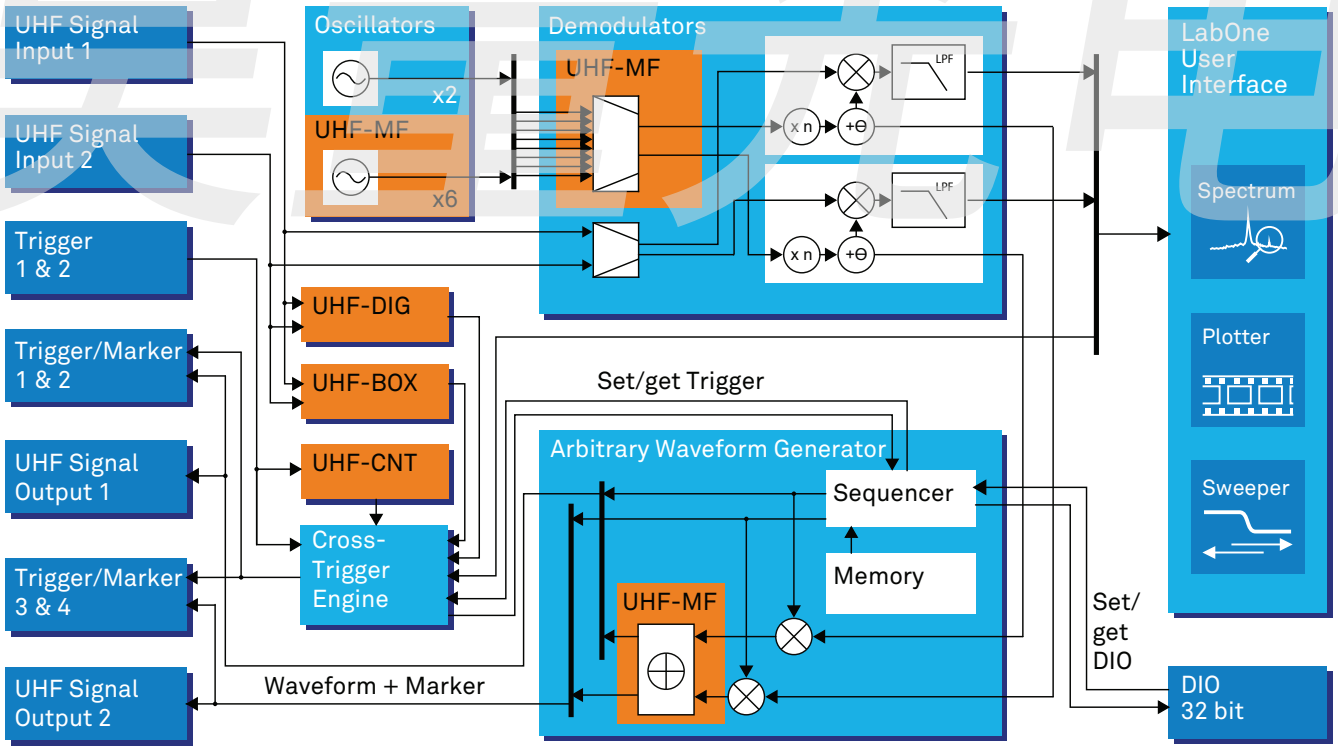
| General | |
|---|---|
| dimensions | 45 × 35 × 10 cm (19” rack)<br>18 × 14 × 4 inch |
| weight | 6.4 kg; 14.1 lbs |
| power supply | AC: 100 – 240 V; 50/60 Hz |

| UHF Signal Output | |
|---|---|
| frequency range | DC – 600 MHz |
| output ranges | ±150 mV, ±1.5 V (DC 50 Ω) |
| number of oscillators | up to 8 |
| phase noise | –120 dBc/Hz (10 MHz, offset 100 Hz) |

| Arbitrary Waveform Generator | |
|---|---|
| channels | 2 |
| D/A conversion | 14 bit, 1.8 GSa/s |
| waveform memory | 128 MSa/channel (main)<br>32 kSa/channel (cache) |
| sequence length | 1024 instructions |
| markers | 2/channel |
| output modes | amplitude modulation, direct, 4-channel aux |
| conditional branching inputs | 32-bit digital input, trigger input, internal data (scope, demodulator, counter) |
| trigger delay to output | <150 ns |
| trigger uncertainty | 2.2 to 4.4 ns |
| feedback latency | <1 µs |

# Upgrade Options

| Option | Main added functionality | Applications |
|---|---|---|
| UHF-MF | 6 additional oscillators for signal generation and detection, I/Q modulation | Trapped ion quantum computing, circuit QED, frequency multiplexing |
| UHF-CNT | Pulse counting at up to 200 MHz frequency | Trapped ion quantum computing, photon counting |
| UHF-DIG | Dual-channel 12-bit, 1.8 GSa/s digitizer | Circuit QED, pulsed radar |
| UHF-BOX | Analysis of periodic signals with Boxcar Averager and Periodic Waveform Analyzer (600 MHz) | Pulsed laser spectroscopy, electrical pump-and-probe, time-domain reflectometry |




Orange color in the diagram indicates optional upgrades. The UHF-AWG Arbitrary Waveform Generator is available both as a stand-alone instrument and as an upgrade option to the UHFLI Lock-in amplifier.

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