WIESERLABS
Electronics

Precision Optoelectronics, Advanced RF Generation and Cutting-Edge Mixed Analog/Digital Solutions

WL-FlexDDS-NG-1GS

Dual-Channel 1 GS/s Radio Frequency Waveform Generator Slot

Main Features

- Extensible Platform for Multi-Channel Signal Synthesis
- Power, Reference Clock and Synchronization for up to 6 Slots
- Real Time Control and Predictable Timing

FlexDDS-NG-1GS is a dual-channel phase-continuous direct digital signal synthesizer designed for integration into the FlexDDS-NG rack mainframe. Based on the successful design of the FlexDDS multi-channel RF source developed for the Max Planck Institute for Quantum Optics, FlexDDS-NG is the next generation waveform generator created to address the specific requirements of experimental physicists.

Features

- Direct digital synthesis (DDS) at 1 GS/s and 14 bit resolution enables highly configurable and precisely repeatable signal generation with a frequency range from 0.3 to 400 MHz (resolution 0.23 Hz)
- Two independent output channels with **precisely known phase relationship**
- One **DDS Command Processor (DCP)** per channel with 8 ns timing resolution and separate instruction cache (4096 entries) enables **fast real-time control** of all signal parameters and execution of complex sequences with **deterministic timing**
- **Versatile signal generation**: Phase-continuous linear frequency/amplitude sweeps with external hold and direction inputs, phase ramps, fast profile switching, RAM playback, separate amplitude sweep generator, delay/timing generator
- Two independent high speed **analog modulation inputs**: Amplitude, phase, frequency or polar modulation from analog signal sources with up to **20 MHz bandwidth**; slope and intercept of the transfer function can be digitally set
- **Excellent signal quality** (low phase noise, spurs, harmonics) with an RF output level **up to +10 dBm** (2 Vpp) into 50 Ω e.g. to drive mixers directly
- Fast output on/off functionality; no signal leakage in off state
- Three real-time **digital IOs** for **external triggering** and other functions

Typical Applications

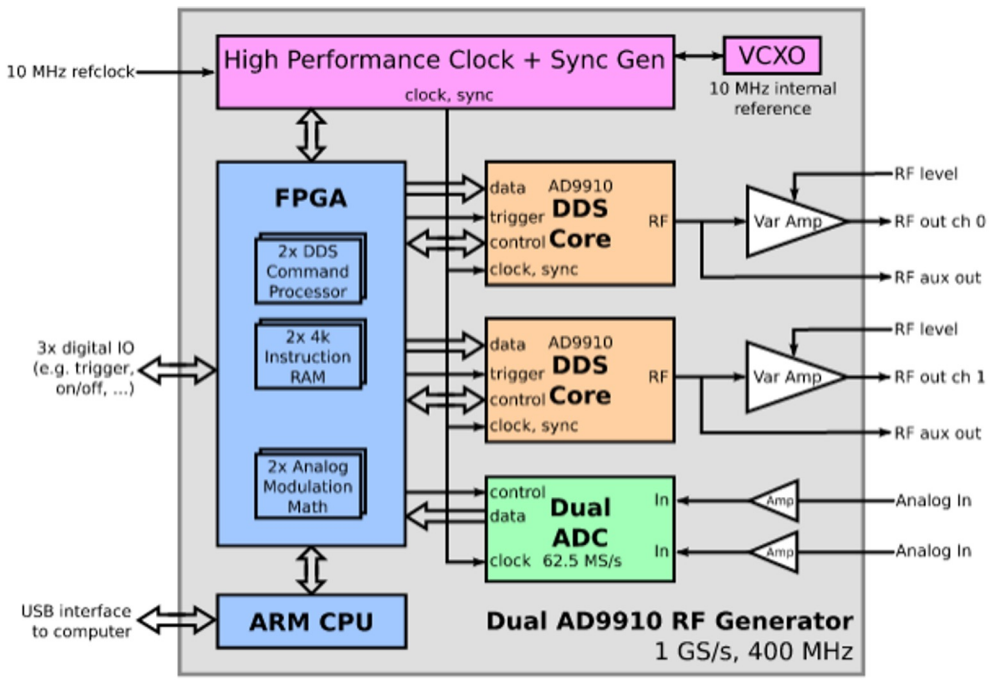
- Driving AOMs (acousto-optic modulators)
- Ultra-cold atom experiments and coherent atom manipulation
- BEC evaporation ramps
- Quantum computing and Q-bit manipulation

Overview

The FlexDDS-NG-1GS radio frequency waveform generator slot provides two independent waveform outputs. Each output channel features a 1 GS/s DDS synthesizer (AD9910) followed by a variable, highly linear output amplifier. A dual-channel analog-to-digital converter (ADC) can capture analog modulation signals at 62.5 MS/s. All components are controlled by an FPGA that implements, for each channel, a Digital Command Processor (DCP) and the analog sample rescaler. Communication is performed mainly via the FlexDDS-NG rack mainframe and its Gbit Ethernet interface. Furthermore, a 120 MHz ARM processor on each waveform generator slot provides a USB connection for debugging and – although it is not recommended – sending commands. Firmware updates for new features are also performed centrally via the FlexDDS NG rack. The rack further provides the reference clock for all generator slots as well as two independent trigger buses that can be used to synchronize multiple slots.

The Digital Command Processor enables real-time signal control

- Each output channel features a dedicated Digital Command Processor (DCP) with deterministic timing that controls the 1 GS/s DDS generator (AD9910)
- The FlexDDS-NG can execute signal updates either self-timed (timing resolution 8 ns) or by waiting for external trigger events from the digital IOs
- Each DCP has a high speed memory holding up to 4096 instructions (more can be loaded via the USB on the fly)
- Less than 2 µs per update of frequency + phase + amplitude together
- Up to 8 independently programmable profiles for frequency, phase and amplitude which can be switched within nanoseconds
- The digital IOs can also be used as outputs to perform real-time control tasks (e.g. switching attached amplifiers)



Simplified schematic of the FlexDDS-NG DUAL

Waveform Generation Features

Waveform Sweeps	Linear Phase, Frequency and Amplitude (Phase-continuous)
Internal RAM Capacity	Up to 1024 words (32bit) internal RAM (inside DDS core AD9910) for storage and playback of complex output sequences
Analog Modulation Options	Phase, Frequency, Amplitude, Polar
Precision	Phase Offset: 16-bit Word (0.005° Resolution) Amplitude Scaling: 14-bit (0.006%) Frequency Tuning: 32-bit (0.23 Hz)
Output Frequency Range	0.3 to 400 MHz
Output Power	Up to +10 dBm

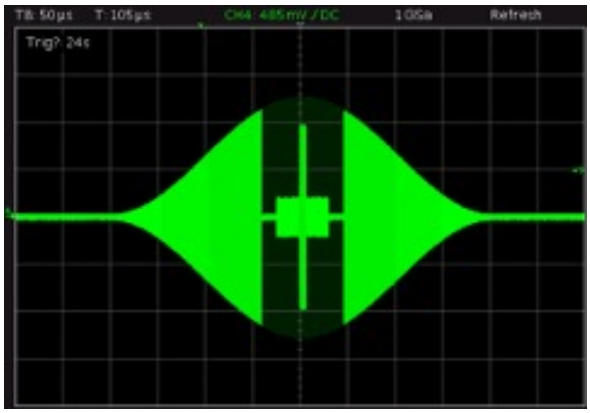
RAMP/SWEEP GENERATOR

- Each channel has an integrated **32 bit ramp generator** which allows to sweep either **frequency, phase or amplitude** from a defined start point to a defined end point;
  the RF output remains phase-continuous before, during and after the ramp
- External digital inputs allow to **temporarily freeze the ramp generator** (ramp hold) or to change the direction at any time
- New ramps can be triggered from the completion of the previous ramp allowing **piece-wise linear ramps**
- Precisely selectable start and end points (frequency: 0.23 Hz resolution)
- Selectable ramp step size (e.g. frequency: 0.23 Hz resolution)
- Selectable ramp speed (16 bit resolution): 4 ns to 260 µs per ramp step
- Independent control of ramp speed and step size for both positive and negative slopes
- Configurable **ramp end behavior**:

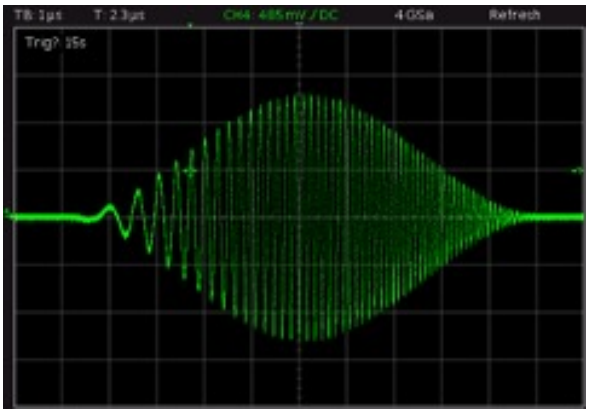
  Keep end value (normal)
  Jump back to the start value
  Change direction and ramp back again

VERSATILE SIGNAL GENERATION

- RF signal generation is **fundamentally phase-continuous** due to the DDS design
- **Precise and known phase relationship between the output channels** can be established if desired



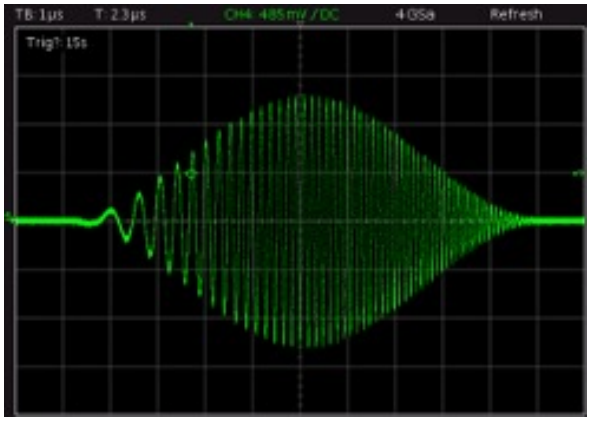
Oscilloscope trace showing the output of the FlexDDS-NG:
Hann shaped chirped pulse using the ramp generator to change the frequency while the amplitude is controlled from the RAM playback



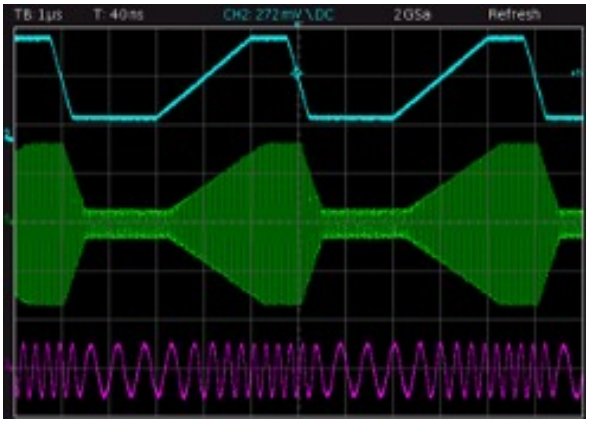
Oscilloscope trace showing the output of the FlexDDS-NG:
RAM playback /modulation can be used to create arbitrary shapes, not only in amplitude (as shown here)

HIGH SPEED ANALOG MODULATION

- **Two independent analog inputs** allow you to modulate the generated RF signal
- **Amplitude, frequency, phase** (16 bit) and **polar** (2 x 8 bit) modulation formats supported
- **Fully digital design**: The analog modulation input is digitized at a sample rate of 62.5 MHz (12 or 14 bit resolution). The modulation parameters are then **computed** from these sample values with **adjustable coefficients** (offset and slope) and fed into the DDS core at a rate of 62.5 MHz.
- A **short latency** of 0.3 µs allows you to implement fast analog control loops
- Input specs: **±1 V** range, 50 Ω termination**, 20 MHz** bandwidth



RF output on/off:
Top: externally provided digital signal
Bottom: RF output



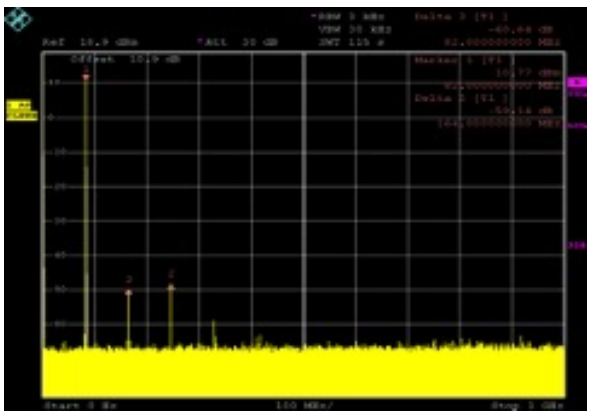
Oscilloscope trace showing the analog modulation:
Top: externally provided analog modulation signal
Center: Channel 0 configured for analog amplitude modulation
Bottom: Channel 1 set to analog frequency modulation

RF OUTPUTS WITH ADJUSTABLE LEVEL AND FAST ON/OFF

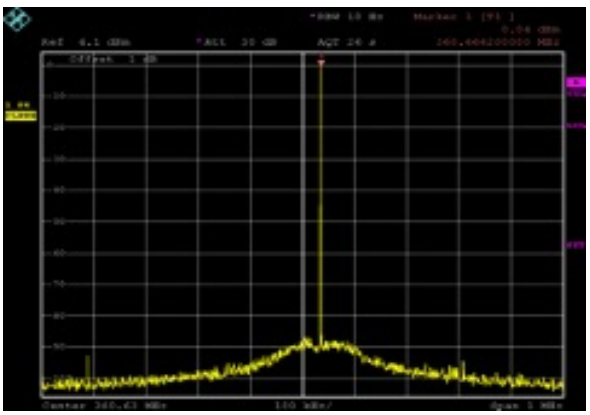
- **A variable output amplifier** with a full-scale output from **-40 to +10 dBm** allows you to scale the RF level to your needs without loosing any bit of resolution in the DDS
- **Fast transition:** Less than **4 ns** from on to off; pulse length down to 12 ns
- **No signal leakage** in off state: The on/off functionality stops waveform generation itself rather than merely attenuating the synthesized RF output
- **External on/off** via digital BNC inputs (0.1 µs response delay, see image)
- Separate „RF kill" switches to manually suppress off RF output at the amplifier, independent of the DDS waveform generator
- Dedicated **amplitude ramp generator** to linearly sweep up/down the amplitude in 8 µs to 4 s
- Output power variation **below ±0.8 dB over full frequency range** (typ.)

Signal Quality

Sample clock:	Internal low jitter 1 GHz clock generator
Low RF output phase noise (see figure below):	At 200 MHz: -100 dBc/Hz @ 3 kHz offset from carrier (typ.) < -110 dBc/Hz @ 300 kHz offset
Frequency stability:	Built-in reference oscillator with 2.5 ppm drift over -30 to +75°C temperature range
Very low harmonics and spurs can be important, e.g. when driving mixers:	A new improved amplifier design features a 2nd and 3rd harmonic below -45 dBc for output power levels up to +10 dBm. Harmonics are even lower for reduced output power and low frequencies, e.g. -60 dBc at 80 MHz and full output power (see figures below)
Very low crosstalk:	Channel-to-channel isolation better than 100 dB



Narrow band phase noise at 360 MHz:
-100 dBc at 300 kHz offset measured in a 10 Hz RBW corresponds to -110 dBc/Hz phase noise (at 300 kHz from carrier)



Harmonics at 82 MHz and +10 dBm output power:
Harmonics at ~-60 dBc for 2nd and 3rd, ~-70 dBc for 4th;
Non-harmonic spurs below -75 dBc (barely visible)

Specifications

	Min	Typ	Max	Unit
Main RF Output				
Frequency range	0.3		400	MHz
Output power level (level adjust set to max.)		+13		dBm
Aux RF Output				
Output power level		0	+3	dBm
Analog Inputs				
Full scale voltage range		± 1		V
Analog bandwidth		20		MHz
Internal reference				
Tolerance		± 1.5		ppm
Digital IOs				
Logic voltage level (configurable via Jumper, default 5 V)	3.3		5.0	V
Trigger input pulse width	100			ns

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Learn more at:
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