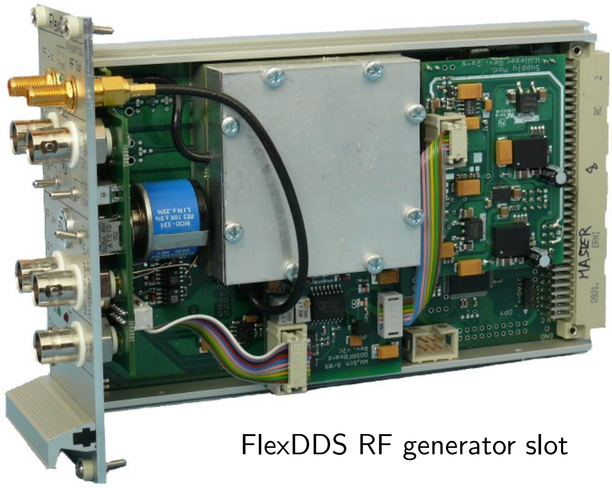
FlexDDS

(Rev. 2c_2, Nov 2011)

Flexible Multi-Channel Phase-Coherent RF Source

Features

- Multi-channel operation with precisely known and adjustable phase relationship between channels
- Real-time control of all signal parameters
- Phase-continuous frequency tuning
- Computer interface (USB 2.0, RS-232)
- Optional per-slot processor (PDCPU add-on)



FlexDDS RF generator slot

Components

- **FlexDDS-Rack:** 19" rack which integrates the computer interface and power supplies. The rack can hold up to 8 independent **FlexDDS** RF generator slots and 1 frontpanel controller slot (**FlexDDS-FPCtl**).
- **FlexDDS:** RF generator slot module
- **FlexDDS-FPCtl:** Slot module for reference clock and trigger.

Full rack

General Description

FlexDDS is a multi-channel phase-coherent RF source. The design deliberately targets the needs of experimental physicists who want to control all signal parameters in real-time from a computer. Initially, a series of actions (like changes in amplitude or frequency, start of frequency sweeps,...) is compiled into commands which are then transferred to the FlexDDS-Rack via the USB link (or via RS-232). Each time a (real-time asynchronious) trigger input is activated, FlexDDS-Rack executes one or several commands and waits for the next trigger event. There is no limit on the number of successive commands as they are loaded continuously from the host computer.

One outstanding feature of FlexDDS is its defined and known phase relationship between channels. For example, two channels can easily be set up to produce an RF output at the same frequency and with equal phase. Slightly detuning the frequency of one channel will then linearly increase the phase difference between the two channels.

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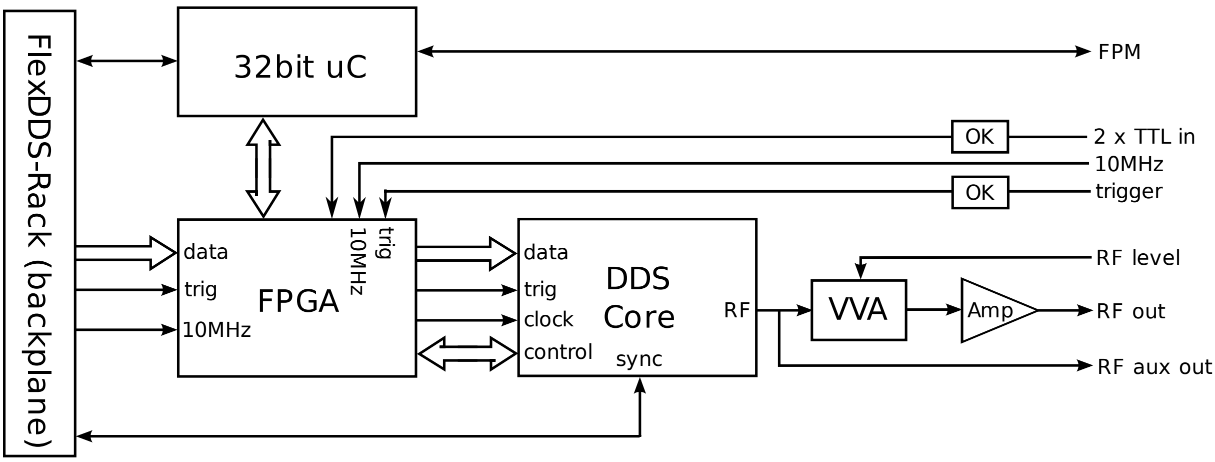
Detailed features of FlexDDS-Rack:

- Up to 8 independent RF generator slots which can be made to run completely synchroniously (phase-coherent).
- Slots can be phase-aligned to each other (e.g. sine waveform on slot 1 and cosine waveform on slot 2). This alignment is a consequence of slot synchronization and is hence completely repeatable, even after power-cycling.
- Separate real-time trigger input to start actions (like frequency changes, sweeps, ...) allows to trigger any combination of up to 8 slots simultaneously.
- 10 MHz reference clock input and separate reference clock output for synchronization.

Detailed features of each FlexDDS RF generator slot:

- DDS (direct digital synthesis) core operating at 1GSps with 14 bit output DAC
- Output frequency range 0.3 MHz to 400 MHz (sine wave)
- 32bit frequency tuning word (resolution 0.23 Hz)
- 16bit phase offest word (0.0055° resolution)
- Analog amplitude attenuator with >35dB dynamic range (ext. level input or potentiometer)
- Additionally, output amplitude digitally controllable with 14bit resolution (linear scale)
- Fast digital RF switch with >60dB attenuation of the output frequency (OSK); optionally allows to linearly ramp down/up the RF output power.
- Less than 2μs per update of frequency + phase + amplitude (per channel)
- Up to 8 independently programmable profiles for frequency, phase and amplitude which can be selected/switched even faster
- Linear phase, frequency and amplitude sweeps (see below)
- Up to 1024 words (32bit) internal RAM for storage and playback of complex output sequences
- Maximum RF output level +10dBm into 50 ohm
- Separate auxiliary RF output for monitoring (-5dBm into 50 ohm)



Structure of a FlexDDS RF slot attached to the backplane (left). OK=Optocoupler, VVA=voltage variable attenuator

Features of the integrated ramp generator

FlexDDS integrates a 32bit ramp generator which allows to sweep either frequency, phase or amplitude from a defined start point to a defined end point. The RF output stays phase-continuous before, during and after the ramp.

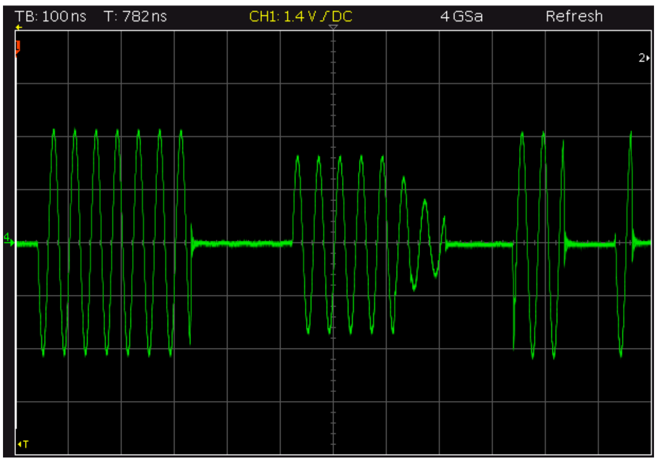
- Precisely selectable start and end points (frequency: 0.23Hz resolution)
- Selectable ramp step size (e.g. frequency: 0.23Hz resolution)
- Selectable ramp speed (16 bit resolution): 4ns to 260μs per ramp step
- Independent control of ramp speed and step size for both the positive and negative slope
- Configurable ramp end behavior:
  - Keep end value (normal)
  - Jump back to the start value
  - Change direction and ramp back again
- Optional external ramp hold input to temporarily freeze the ramp generator
- Optional external ramp direction input

Optional Add-On: High speed reconfiguration (PDCPU)

Optionally, a firmware add-on allows to switch DDS parameters much faster: The add-on consists of a simple processor ("CPU") with an own RAM storage of 8192 words all built into the FPGA in the DDS slot. The processor runs at 31.25 MHz (1 GHz/32) and can execute the following commands:

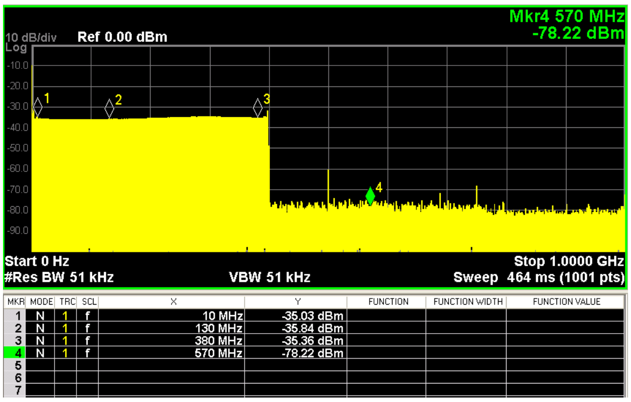
- Write into DDS core via parallel data bus (either frequency or or phase with 16 bits accuracy or amplitude or "polar mode" which sets phase and amplitude with 8 bit resolution each).
- Change DDS profile (one out of 8 profiles).
- Change DDS ramp direction, hold DDS ramp, switch on/off DDS output (OSK).
- Wait for event (trigger, input activity).
- Wait for some amount of time (32ns to 2 minutes).
- Change DDS registers (e.g. to re-program the ramp generator)
- Jump to specified address in RAM and resume there.
- Conditional jump if a certain condition is true (external input, ramp status) allows to implement loops.

Each of the commands is single-cycle. Each instruction consumes exactly one word of memory. Below is a screen shot of a waveform generated with this mode:



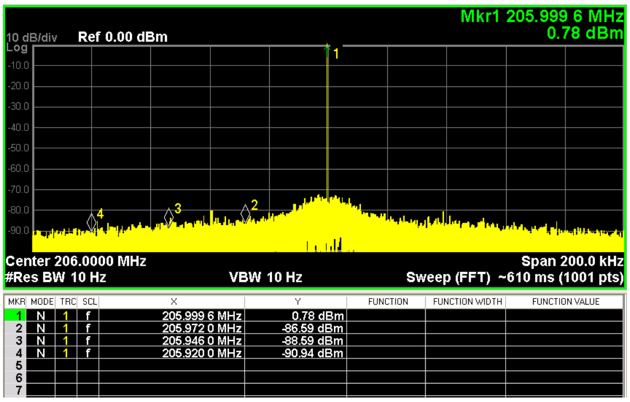
FlexDDS output generated with the high speed reconfiguration (PDCPU add-on) and one single DDS profile, no other features in use (no external gating,...). Amplitude and phase specified via "polar mode". First pulse has 180°, second pulse has reduced amplitude and 270°, third pulse is the shortest one possible. Time scale: one box is 100 ns.

Output power versus frequency



Output power level measured with spectrum analyzer while rapidly sweeping the output frequency from 300kHz to 400MHz. Observed power level variation is 1dB.

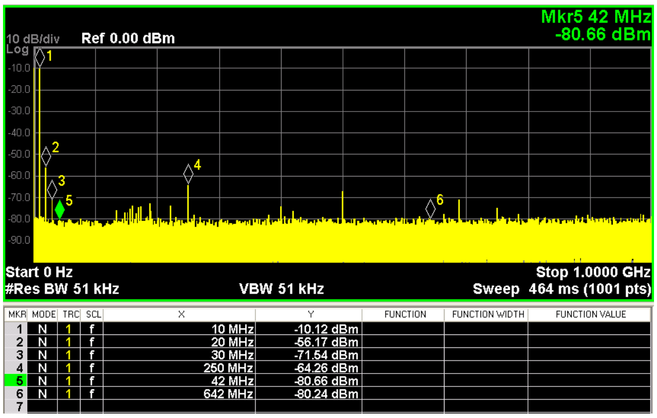
Narrowband SFDR at +10dBm

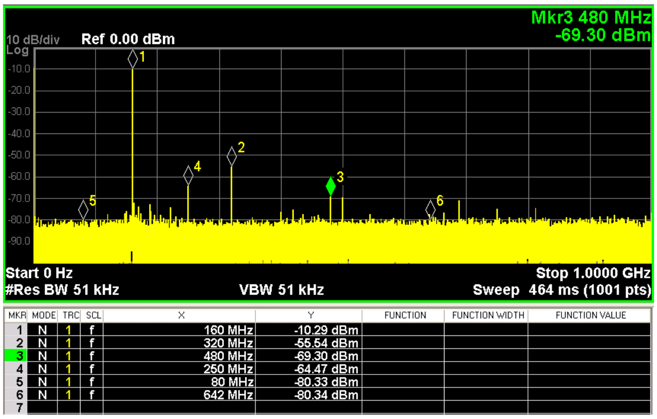


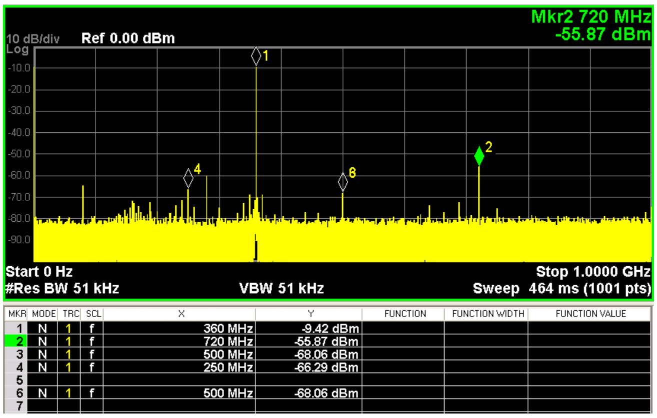
The noise "foot" around the primary output frequency is below -70dBc when measuring with 10Hz resolution. This corresponds to a narrowband noise power density of -80dBc/Hz.

Wideband SFDR

The new improved amplifier design features a 2nd and 3rd harmonic below -45dBc for output power levels up to +10dBm. Harmonics are even lower for reduced output power. The wideband **spurious free dynamic range (SFDR)** is better than -45dBc over most of the frequency range.







Wideband SFDR for 10 MHz, 160 MHz and 360 MHz output at +10dBm output power level. A 20dB input attenuator makes displayed power levels 20dB smaller than real.

Please note that the information provided in this data sheet is preliminary. Final specifications are believed to be similar or in some cases even better than specified here, although degradation of parameters in future revisions cannot be ruled out for certainty.