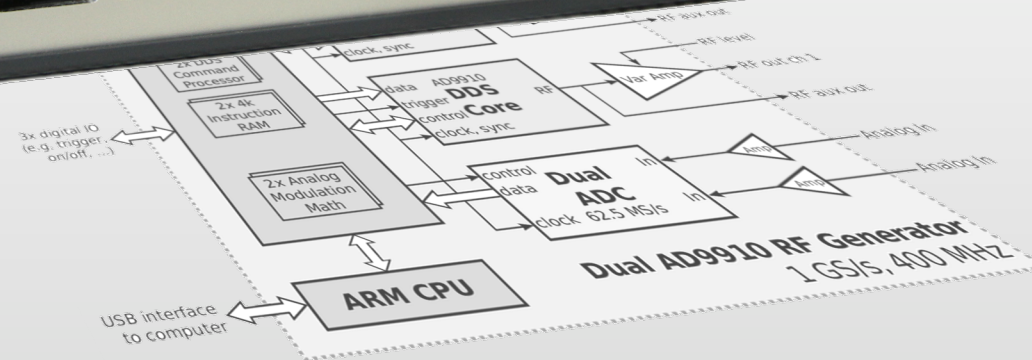# FlexDDS-NG DUAL

Dual-Channel 400 MHz Agile Waveform Generator

- ✓ Excellent signal quality
- ✓ Rapid parameter changes
- ✓ Phase-continuous sweeps
- ✓ High speed analog modulation

FlexDDS-NG DUAL: Front View

- **Two independent digitally synthesized RF outputs** covering a frequency range of 0.3 to 400 MHz; with up to +10 dBm you can drive e.g. mixers directly
- DDS technology guarantees **precisely controlled phase, amplitude and frequency** and enables many more advanced features like agile frequency hops, phase-continuous frequency sweeps or known phase relationships

- **Two dedicated analog inputs for analog modulation**: These inputs are digitally sampled and allow you to perform amplitude/phase/ frequency or even polar I/Q modulation at a rate of 62.5 MS/s with 12 to 14 bits resolution
- Modulation gain and offset are programmed digitally and can be tuned on the fly without the need to change any analog circuits

- **Auxiliary RF outputs** for monitoring (-5 dBm)

- **RF output full-scale power adjustment**. This sets the amplifier gain covering a full scale RF output power range from below -40 dBm to +10 dBm
- **Scale the RF level to your needs** without loosing any bit of resolution in the DDS

- **RF output on/off master switch**, one for each channel

- **Configurable LEDs** enable you to immediately see the signal states so you spend less time debugging

- **Three digital IOs can be configured for various functions** including fast on/off, triggering, changing sweep direction, interrupting sweeps, quickly switching output profiles or as outputs e.g. to control post amplifiers or get notified of end-of-sweep

- The FlexDDS-NG has an **internal reference with 2.5ppm over a -30 to +75°C** temperature range that can be digitally tuned. For higher stability or to phase-lock multiple devices you can use the external 10 MHz input

- **USB interface to computer:** Easy access as virtual COM port, no special drivers needed, no baud rate configuration(any Windows version since XP and Linux)

FlexDDS-NG DUAL: Dual-Channel 400 MHz Agile Waveform Generator

FlexDDS-NG DUAL is a dual-channel phase continuous direct digital signal synthesizer. 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 which deliberately targets the needs of experimental physicists.

Main 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 V$_{pp}$) 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; coherent atom manipulation

- BEC evaporation ramps

FlexDDS-NG DUAL: Digital Command Processor

Overview

The FlexDDS-NG DUAL is a dual-channel waveform generator. Each RF generator 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. A 120 MHz ARM processor handles the USB connection.

Firmware updates for new features are performed over the USB link by the customer without the need to remove the FlexDDS-NG DUAL from the setup.

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)
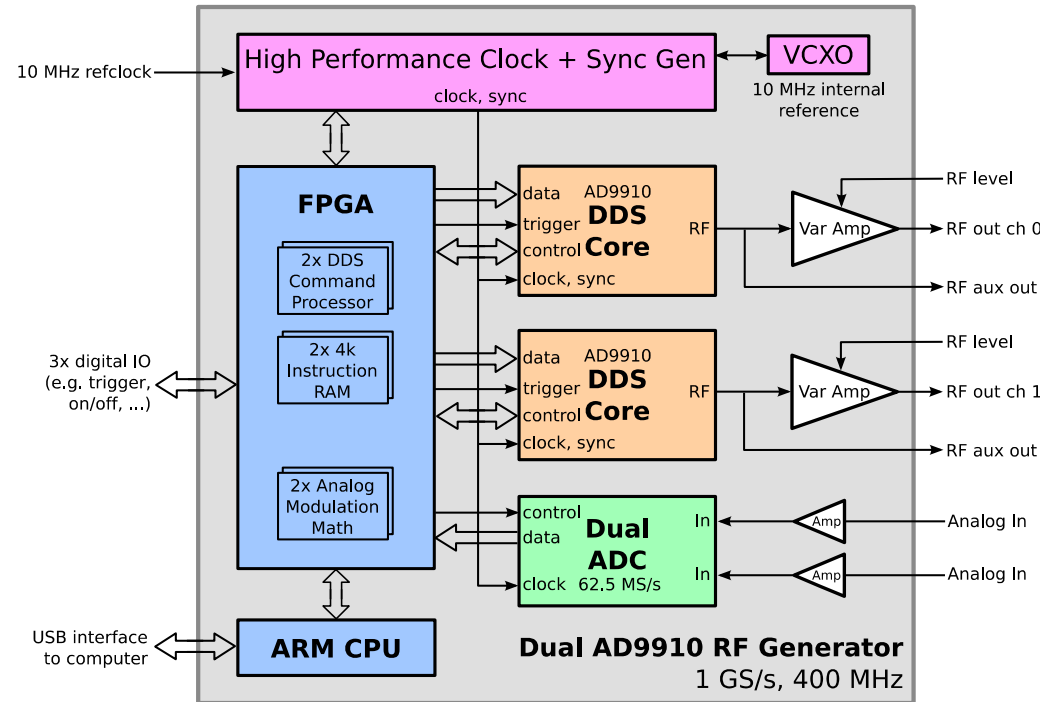
Simplified schematic of the FlexDDS-NG DUAL

Waveform Generation Features

- Linear phase, frequency and amplitude **sweeps** (phase-continuous)

- Up to 1024 words (32bit) internal RAM (inside DDS core AD9910) for storage and playback of complex output sequences

- **Analog modulation:** Phase, frequency, amplitude, polar

- **Precision:** 16 bit phase offset word (0.005° resolution), 14 bit amplitude scaling (0.006%) , 32 bit frequency tuning (0.23 Hz)

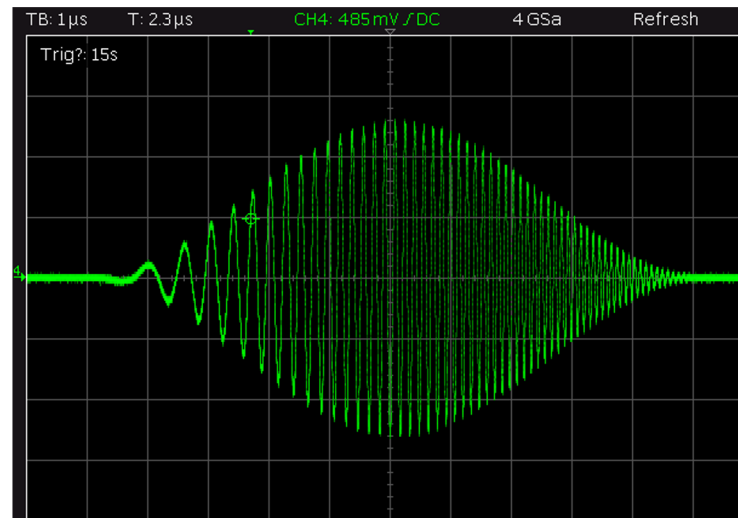- Output frequency range **0.3 to 400 MHz,** output power up to **+10 dBm**

# FlexDDS-NG DUAL: Versatile Waveform Generation

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 stays 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

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

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
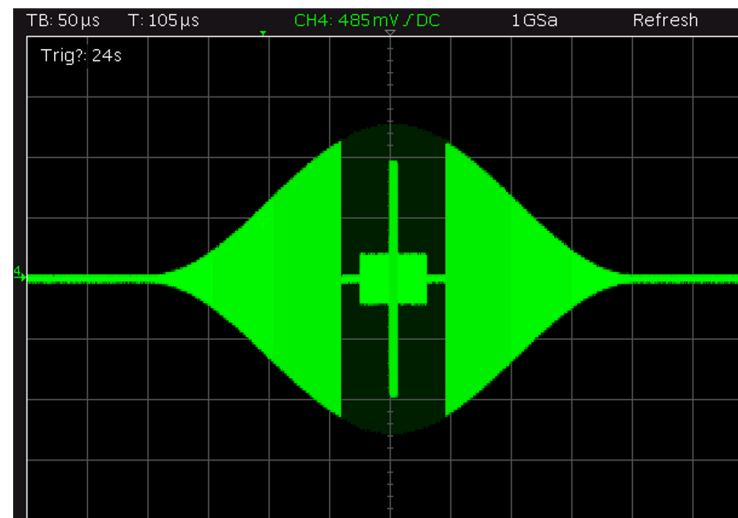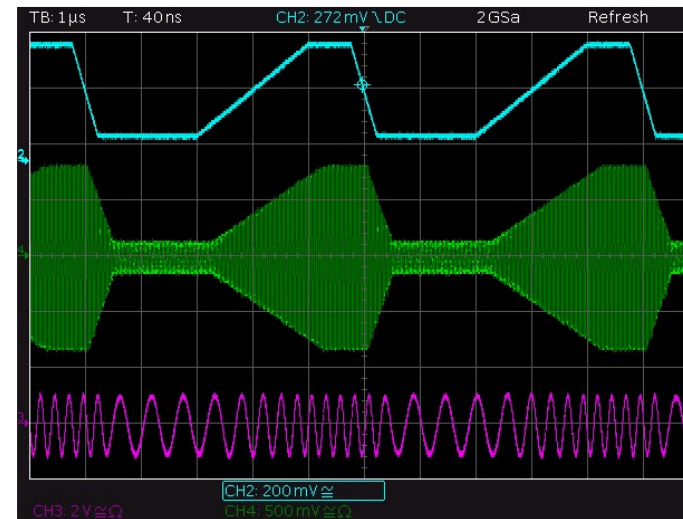

Oscilloscope trace showing the output of the FlexDDS-NG: RAM playback / modulation can be used to create arbitrary shapes, not only in amplitude (as shown here)
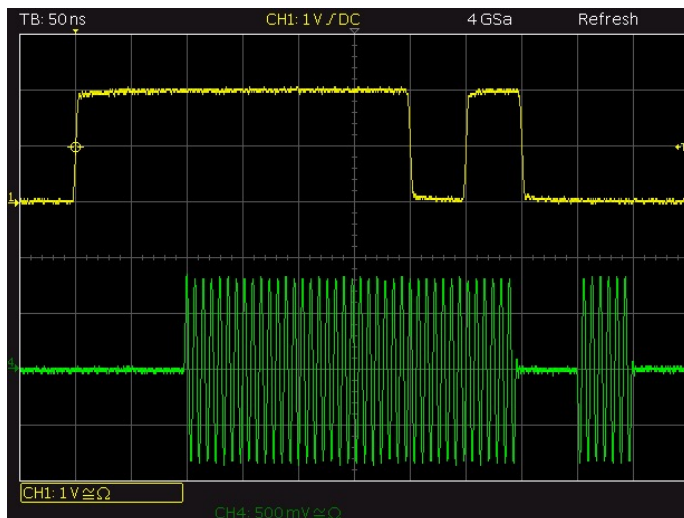
FlexDDS-NG DUAL: Features

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

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.)**

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

FlexDDS-NG DUAL: Signal Quality

Signal Quality

- Internal **low jitter** 1 GHz sample 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)

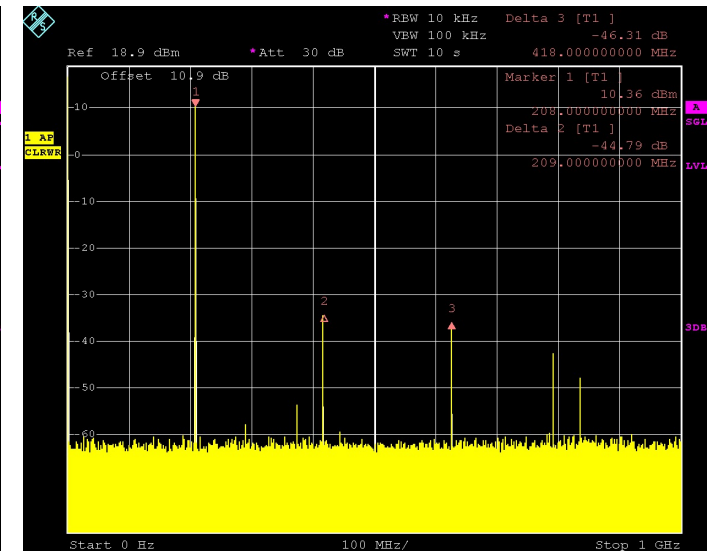- **Very low crosstalk:** Channel-to-channel isolation better than 100 dB
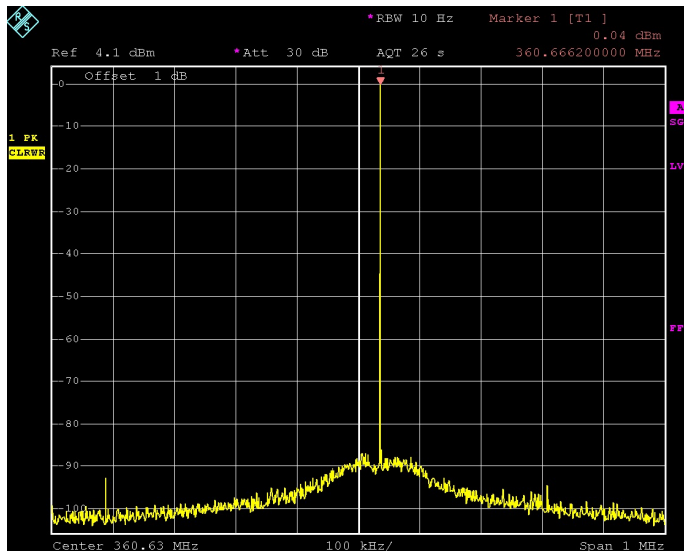
Narrow band phase noise at 360 MHz:
-100 dBc at 300 kHz offset measured in a 10 Hz RBW corresponds to -110 dBc/Hz phase noise (at 300 kHz from carrier)
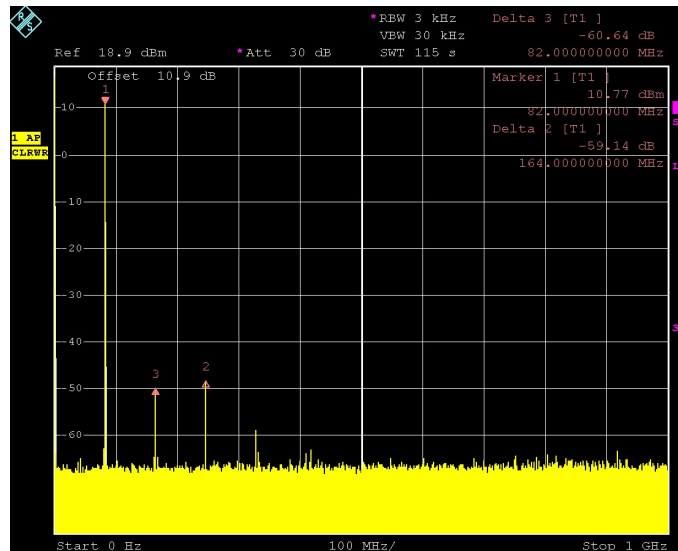
Harmonics at 82 MHz and +10 dBm output power:
Harmonics at ~-60 dBc for 2nd and 3rd, ~-70 dBc for 4th; non-harmonic spurs below -75 dBc (barely visible)
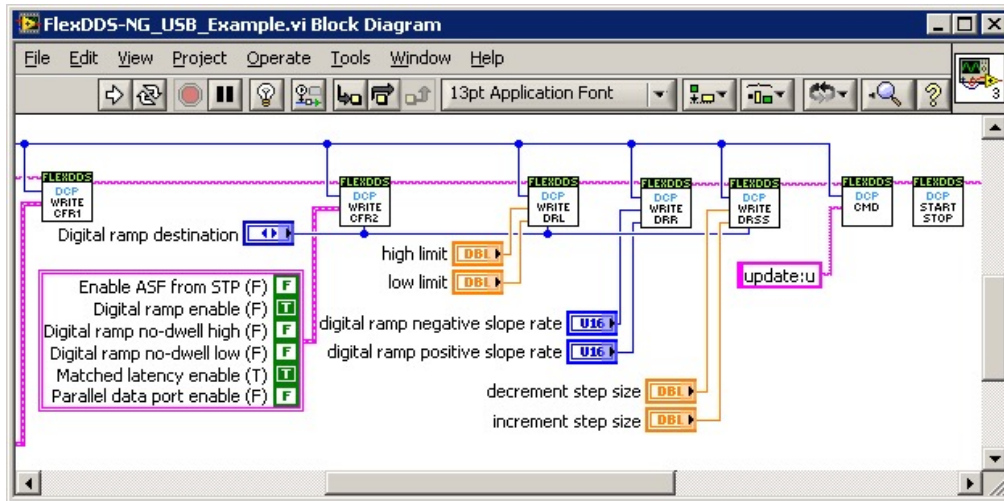

Harmonics and spurs at 208 MHz and +10 dBm output power:
2nd and 3rd harmonic at ~-45 dBc
The two peaks on the right are the 4th harmonic and the mirror frequency at 1 GHz-208 MHz (both below -50 dBc)

FlexDDS-NG DUAL: Connectivity and Remote Control

FlexDDS-NG_USB_Example.vi Block Diagram

A simple USB link connects your computer to the FlexDDS-NG DUAL. The device automatically registers itself as a virtual COM port (VCP)

- Easy to use
- **Text-based command protocol** can be accessed easily from nearly any programming environment
- **LabView** support routines help you to get started quickly
- Operating system support: All Windows versions from XP to 10 as well as any recent Linux (no extra drivers needed)

```
dds reset
dcp 0 spi:STP0=0x3FFF0000028F5C29
dcp 1 spi:STP0=0x3FFF0000028F5C29
dcp 0 spi:DRL=0x147C0118147BC1DB
dcp 0 spi:DRSS=0xFFFFFFFF00000003
dcp 0 spi:DRR=0x2D3E
dcp update:u-d
dcp wait:10000:DROVER
dcp start
```

Digital IOs and LEDs

- Three configurable digital IOs (3.3V or 5V logic, TTL compatible)
- Configurable for diverse functions, e.g. trigger input, RF on/off, ramp/sweep direction selection, ramp/sweep hold or fast profile switching
- Can be used as digital output to e.g. control external amplifiers or monitor internal states
- Several LEDs on the front panel can be configured to reflect a variety of functions/signals to help you set up your experiment

Questions?

Require extra features or more than two channels?

Want to discuss your requirements?

Contact us!

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