Introduction

Vivace is a measurement platform for high frequency signal generation and analysis, aimed at emerging applications in quantum technology. It has 8 RF input ports, 8 RF output ports, 4 digital input and 4 digital output ports, all synchronized to one very stable clock. Two branches of firmware provide a highly configurable platform for complex experiments with rigid timing constraints on multiple phase-coherent signals. *Continuous wave mode* is a microwave big-brother to our 3rd generation Multifrequency Lockin Amplifier (MLA-3). *Pulse sequencing mode* is our new approach to timed pulse generation and analysis for control and readout of quantum systems.

Modes of operation

Continuous wave mode

- Up to 192 generators with programmable frequency, amplitude and phase distributable between 8 output ports
- Up to 192 demodulators with programmable frequency and phase distributable between 8 input ports
- All modulators locked to single internal or external reference clock
- Direct mode operation: DC* up to 1000 MHz
- Mixed mode operation: Up to +- 500 MHz band around 0 to 6 GHz carrier (digital up- and down-conversion)

* note: Front-end sets lower analog limit, e.g. 3 MHz. Custom solutions are possible.

Pulse sequencing mode

- *Output, at each port (x8)*
  - 16 templates (direct output) or envelopes (multiplied by carrier)
  - Maximum single-template length 1 us (concatenation and continuous looping possible)
  - Template sampling resolution 500 ps
  - 2 carrier-tone generators with user-defined frequency and phase
  - 2 user-defined scaling factors
- *Input, resources distributable between 8 input ports*
  - Continuous sampling window, maximum 524 us
  - Averaging of multiple windows in FPGA, maximum 65k windows at full-scale input
  - Template-matching (state discrimination) in FPGA, 128 templates (max length 1 us)
- *Experiment design*
  - Stepper with 512 values (40 bit resolution) of frequency and phase per carrier-tone generator.
  - Stepper with 512 values (17 bit resolution) of scale per output scaler.
  - Event coordinator for timing of input and output sequences, 10736 events
  - Event time resolution 2 ns
  - Fast feedback from template matching, total latency typical 200 ns

Specifications

RF inputs

# ports	8
Impedance	50 ohm
Coupling	AC, 3 MHz cut-off
Maximum frequency*	6 GHz
Sampling	12 bit ADC up to 4096 MSample/s
Range**	6 dBm (0.6 V_{peak}) @ 100 MHz

* see input noise figure below
** see input range figure below

RF outputs

# ports	8
Impedance	50 ohm
Coupling	AC, 3 MHz cut-off + bias
Maximum frequency*	6 GHz
Sampling	14 bit DAC up to 6554 MSample/s
Range*	0.5 dBm (0.3 V_{peak}) @ 100 MHz
Bias	Built-in bias tee for DC offset,16 bit DAC, ±1.25 V

* see output power versus frequency figure below

Noise and distortion

Input voltage noise*	10 nV/sqrtHz, -147 dBm/Hz @ 100 MHz
Output-input total harmonic distortion**	- 52 dBc at 100 MHz
Output-input intermodulation distortion***	- 83 dBc at 100 MHz
RF signals cross talk	- 95 dBc at 100 MHz

* see noise figure below
** THD from 2nd and 3rd harmonic at 50% of DA
*** IMD from 3rd and 5th order at 50% of DA

Digital markers / triggers

# input ports	4
Input impedance	10 kohm
# output ports	4
Output impedance	50 ohm
Output voltage	3.3 V
Output rise time, 10-90%	670 ps
Output rise time, 20-80%	440 ps
Output fall time, 90-10%	570 ps
Output fall time, 80-20%	360 ps

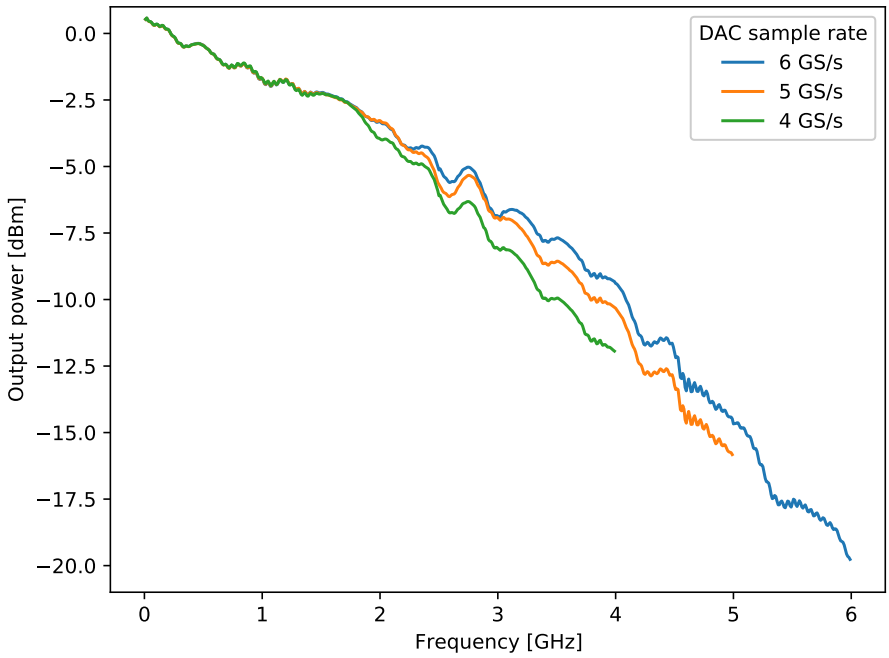
Clock reference

Internal	oven-controlled crystal oscillator, ±10ppb frequency stability
External	programmable, default 10 MHz reference input and output

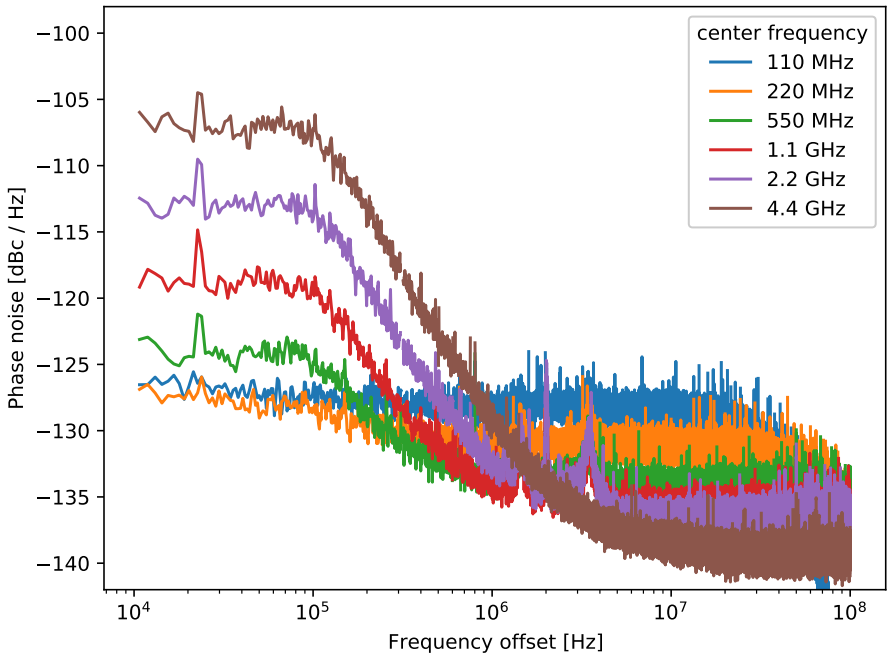
General

Size and weight	430 mm x 450 mm x 89 mm (2U, 19 inch rack), 5 kg
Connectors	SMA, signal ground isolated from enclosure / PE
Communication	Gigabit Ethernet. The device is fully computer controlled (Windows, Mac and Linux compatible).
Power supply	100-250 V, 50-60 Hz

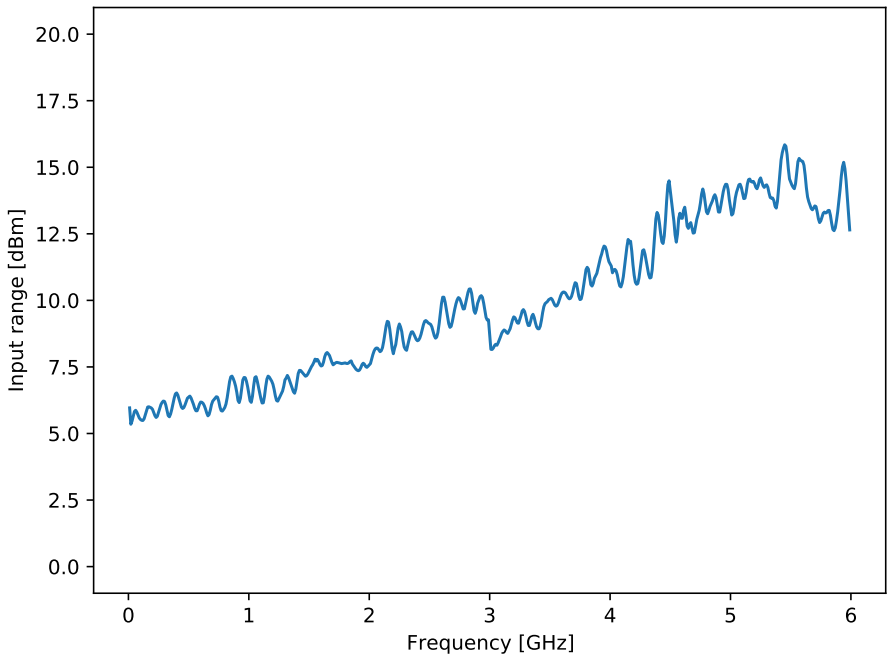
Output power versus frequency



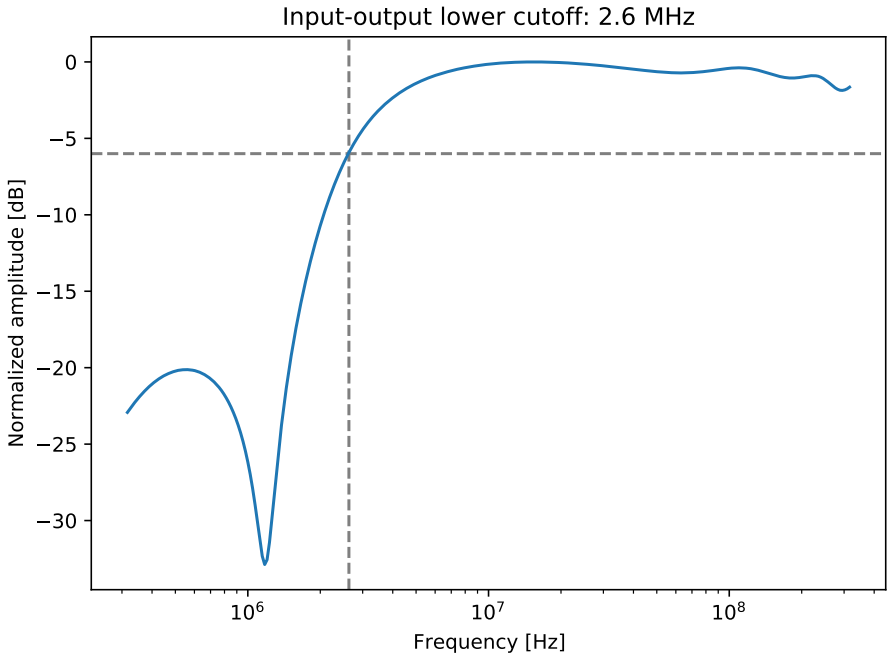
Phase noise at select frequencies (preliminary)



Input range versus frequency



Low-frequency cut-off



Input noise versus frequency