

Presto microwave platform

Presto is a measurement platform for high frequency signal generation and analysis aimed at emerging applications in quantum technology. It has up to 16 RF input ports, 16 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, either in *Continuous wave mode for multifrequency excitation and demodulation or Pulse sequencing mode* for highly accurate sequencing of pulses and analysis suitable for control and readout of quantum systems.



Functionality overview

Digital up- and down-conversion

Each output and input channel features

- 1 numerically-controlled oscillator (NCO): 48-bit frequency resolution (40 μHz) and 18-bit phase resolution (30 μrad)
- 1 fully-digital IQ mixer: zero local-oscillator (LO) leakage and no amplitude/phase imbalance
- 1 GHz IF bandwidth (-3 dB at 964 MHz)
- Configurable analog bandwidth, see options below.
- Designed to operate in higher Nyqvist bands (analog bandwidth typically larger than Nyqvist frequency)

NCOs and IQ mixers from neighboring channels can be combined into same physical port for multi-band operation

Continuous-wave mode

Frequency based measurement mode in which outputs are defined as continuous tones and inputs are continuously demodulated. Featuring:

- 192 generators with programmable frequency, amplitude and phase distributable between 16 output ports
- 192 demodulators with programmable frequency and phase distributable between 16 input ports
- All modulators locked to single internal or external reference clock

Applications:

Multifrequency lockin detection



- Two-tone spectroscopy
- Frequency multiplexed sensor detection
- Intermodulation spectroscopy
- Non-linear analysis
- Qubit characterization

Pulse-sequencing mode

Measurement mode in which the outputs are defined as a sequence of pulses with very exact timing. Featuring:

- Output, at each port (x16)
 - 16 AWG slots ("templates"). Used as direct output or as envelopes (multiplied by IF carrier)
 - Template length 1 µs (concatenation and continuous looping possible)
 - Template sampling resolution 500 ps (direct mode) or 1 ns (mixed mode)
 - 2 IF carrier-tone generators with user-defined frequency and phase
 - 2 user-defined gain blocks
- Input, resources distributable between 16 input ports
 - Contiguous sampling window, maximum 524 µs (2¹⁹ samples)
 - Total sample memory 268 ms (2²⁹ samples)
 - Averaging of multiple windows in FPGA, maximum 65k (2¹⁶) windows at full-scale input
 - Template matching (state discrimination) in FPGA, 128 templates (max length 1 μs)
- Experiment design: sequencer
 - Stepper with 512 values with 40-bit resolution of frequency (0.9 mHz resolution) and phase (6 prad resolution) per carrier-tone generator
 - Stepper with 512 values (17-bit resolution) of scale per output-gain block
 - Single sequence can contain 10736 events (e.g. start pulse, step frequency)
 - Event time resolution 2 ns
 - Fast feedback from template matching, total latency (analog signal in to analog signal out) between 184 and 254 ns, depending on enabled features
 - Sequences can be repeated for interleaved averaging

Application:

- Qubit control
- Box car averaging

Specifications

RF outputs

	Presto-8	Presto-16
# ports	8	16
Connector	8x SMA	16x SMA
Sampling	14-bit DAC up to 10 GS/s (rate selectable at runtime)	
Variable output power range (analog)	0 to 24 dB	

RF inputs

	Presto-8	Presto-16	
# ports	8	16	
Connector	8x SMA	16x SMA	
Sampling	14-bit ADC up to 5 GS/s	14-bit ADC up to 2.5 GS/s	
Variable input attenuation (analog)	0 to 27 dB in 1-dB steps		

RF output analog options

Each group of 4 ports for Presto-16, or pair of 2 ports for Presto-8 can be individually configured at order to one of the below listed options

Option Name	Frequency range *	Coupling	Impedance	Peak output power	Description
pfe-wide	10 MHz – 10 GHz	AC	50 Ω	+4 dBm	Wide-band balun transformer
pfe-wamp	10 MHz – 10 GHz	AC	50 Ω	+16 dBm	Wide-band balun and amplifier
pfe-low	DC – 500 MHz	DC	50 Ω	+12 dBm	DC-coupled baseband amplifier

* Defined as usable range. Output power is frequency dependent, see performance curves below.

RF inputs analog options

Each group of 4 ports for Presto-16, or pair of 2 ports for Presto-8 can be individually configured at order to one of the below listed options

Option Name	Frequency range	Coupling	Impedance	Max input power *	Description
pfe-wide	10 MHz – 10 GHz	AC	50 Ω	1 dBm	Wide-band balun transformer

* Defined as the power which will saturate the input port. Power is frequency dependent, listed value is for 200 MHz.

RF option "QC" (discontinued)

Prior to the configurable front-end described above Presto has the following fixed analog configuration:

Configuration	Inputs	Outputs	Description / applications
-8-QC	Port 1 – 4: 3 – 8 GHz Port 5 – 8: 10 MHz – 3 GHz	Port 1 – 4: 3 – 8 GHz Port 5 & 6: 10 MHz – 3 GHz Port 7 & 8: DC – 500 MHz	Mixture of multiple ranges.
-16-QC	Port 1 – 8: 3 – 8 GHz Port 9 – 16: 10 MHz – 3 GHz	Port 1 – 8: 3 – 8 GHz Port 9 – 12: 10 MHz – 3 GHz Port 13 – 16: DC – 500 MHz	Mixture of multiple ranges.

RF noise and distortion

Input voltage noise*	10 nV/√Hz, -147 dBm/Hz @ 240 MHz
Input harmonic distortion	-75 dBc @ 240 MHz
(typ, from HD2 and HD3)	-46 dBc @ 5.9 GHz
Input intermodulation distortion	-81 dBc @ 240 MHz
(typ, from IM3, input at -7 dBFS)	-69 dBc @ 3.5 GHz
	-53 dBc @ 5.9 GHz
Output harmonic distortion	-82 dBc @ 240 MHz
(typ, from HD2 and HD3, output at 0 dBFS)	-68 dBc @ 3.5 GHz
	-59 dBc @ 5.9 GHz
Output intermodulation distortion	-89 dBc @ 240 MHz
(typ, from IM3, output at -6 dBFS)	-73 dBc @ 3.5 GHz
	-71 dBc @ 5.9 GHz
Cross-talk isolation between channels	-70 dBc @ 0 – 6 GHz
Output noise floor (typ)	3 nV/√Hz, -158 dBm/Hz @ 240 MHz
Output phase noise (typ)	-125 dBc/Hz at 10 kHz offset, 1 GHz carrier
	-115 dBc/Hz at 10 kHz offset, 3 GHz carrier
	-109 dBc/Hz at 10 kHz offset, 6 GHz carrier
Output phase jitter (12 kHz – 20 MHz)	105 fs rms @ 3 GHz

* see noise figure below

Digital markers / triggers

# input ports	4
Input impedance	10 kΩ
# output ports	4
Output impedance	50 Ω
Output voltage	3.3 V
Output rise time*, 10-90%	820 ps
Output rise time*, 20-80%	470 ps
Output fall time*, 90-10%	1060 ps
Output fall time*, 80-20%	620 ps

* typical, into 50 ohm

HF outputs

Presto provides two high-frequency outputs for continuous-wave operation. These outputs are frequency locked to all other clocks in Presto, but lack a flexible phase synchronization. Ideal applications include generating pump tones for parametric amplifiers in phase-insensitive (phase-preserving) mode.

# ouput ports	2
Output inpedance	50 Ω
Frequency range	10 MHz – 15 GHz
Output power	8 dBm @ 8 GHz
	5 dBm @ 15 GHz

Clock reference

Internal	temperature-compensated crystal oscillator (TCXO), frequency stability ±50 ppb
External	Programmable reference input up to 750 MHz and output up to 3 GHz (10 MHz default)

DC bias output

Additional output ports for DC biasing (voltage source).

Number of channels	16
Connectors	4x SMA, 1x DSub-25
Software-selectable	0-3.33 V, 0-6.67 V, ±3.33 V, ±6.67 V, ±10 V, independent on each channel
ranges	
Resolution	16 bit
Output noise	60 nV/√Hz @ 1 kHz
	45 nV/√Hz @ 10 kHz
	1.7 μV rms 0.1 Hz to 10 Hz
Voltage accuracy	±250 ppm max
Temperature stability	2 ppm/°C
Output impedance	1 κΩ
Compliance current	10 mA

General

Connectors	Signal ground isolated from enclosure / PE
Communication	Gigabit Ethernet. The device is fully computer controlled from Python API (Windows, Mac and Linux compatible).
Power supply	100-250 V, 50-60 Hz
Country of origin	Sweden
Classifications	HS 9030.84.00, ECCN 3A002.h (note, export control may apply)
Dimensions	428 mm x 403 mm x 88 mm (W x D x H). Mountable in 2 U, 19" rack with brackets.
Weight	6 kg



Performance characteristics

Output power range

Maximum output power is measured with a Rohde & Schwarz FSW spectrum analyzer, a calibrated cable. Outputs are driven at full power (0 dBFS amplitude, DAC current set to 40 500 μ A). For comparison, output-power curves are plotted alongside measurements on the XM655 breakout board with just a DC block (no balun transformers).







Output power range: QC option (discontinued)

Phase noise







Input noise

