Intermodulation Products – Presto Specifications

Updated: 2023-04-05

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.

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

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

Modes of operation

Continuous-wave mode

- Up to 192 generators with programmable frequency, amplitude and phase distributable between 16 output ports
- Up to 192 demodulators with programmable frequency and phase distributable between 16 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 9 GHz carrier (digital up- and down-conversion)

* note: Front-end sets lower analog limit. Custom solutions are possible.

Pulse-sequencing mode

- *Output, at each port (x16)*
  - 16 templates (direct output) or envelopes (multiplied by carrier)
  - Maximum single-template length 1 µs (concatenation and continuous looping possible)
  - Template sampling resolution 500 ps (direct mode) or 1 ns (mixed mode)
  - 2 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 (2^{19} samples)
  - Total sample memory 268 ms (2^{29} samples)
  - Averaging of multiple windows in FPGA, maximum 65k (2^{16}) 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
  - Event coordinator for timing of input and output sequences, 10736 events
  - 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

Specifications

RF inputs

# ports	8	16
Impedance	50 Ω	50 Ω
Coupling	various options	various options
Maximum frequency*	9 GHz	9 GHz
Sampling**	14-bit ADC up to 5 GS/s	14-bit ADC up to 2.5 GS/s
Range***	1 dBm (min range)	1 dBm (min range)
Variable input attenuation (analog)	0 to 27 dB in 1-dB steps	0 to 27 dB in 1-dB steps

* see input noise figure below
** rate selectable at runtime
*** see input range figure below

RF outputs

# ports	8	16
Impedance	50 Ω	50 Ω
Coupling	various options	various options
Maximum frequency*	9 GHz	9 GHz
Sampling	14-bit DAC up to 10 GS/s (selectable at runtime)	14-bit DAC up to 10 GS/s (selectable at runtime)
Range*	6.5 dBm (at max range) < 200 MHz	6.5 dBm (at max range) < 200 MHz
Variable output power (analog)	-18.5 dBm to 6.5 dBm	-18.5 dBm to 6.5 dBm

* see output power versus frequency figure below

RF noise and distortion

Input voltage noise*	10 nV/√Hz, -147 dBm/Hz @ 240 MHz
Input harmonic distortion (typ, from HD2 and HD3)	-75 dBc @ 240 MHz -56 dBc @ 3.5 GHz -46 dBc @ 5.9 GHz
Input intermodulation distortion (typ, from IM3, input at -7 dBFS)	-81 dBc @ 240 MHz -69 dBc @ 3.5 GHz -53 dBc @ 5.9 GHz
Output harmonic distortion (typ, from HD2 and HD3, output at 0 dBFS)	-82 dBc @ 240 MHz -68 dBc @ 3.5 GHz -59 dBc @ 5.9 GHz
Output intermodulation distortion (typ, from IM3, output at -6 dBFS)	-89 dBc @ 240 MHz -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
	-OCXO option: oven-controlled crystal oscillator, frequency stability ±20 ppb
External	Programmable reference input up to 750 MHz and output up to 3 GHz (10 MHz default)

Analog front-end configurations

Configuration	Inputs	Outputs	Description / applications
-8-QC	Port 1 – 4: 3 – 8 GHz Port 4 – 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.

DC bias output

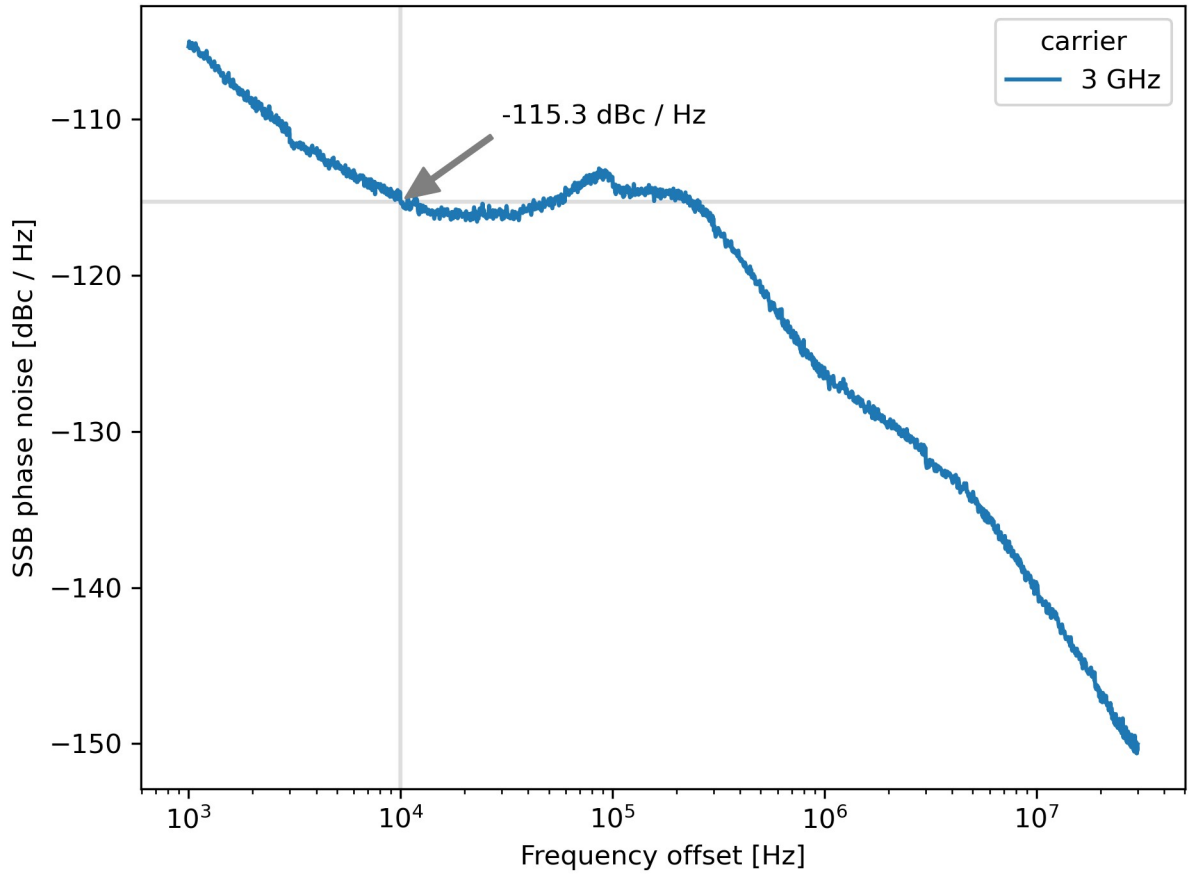
Additional output ports for DC biasing (voltage source) can be added with option “-DC”.

Number of channels	16
Connectors	4 SMA, 1 DSub-25
Software-selectable ranges	0–3.33 V, 0–6.67 V, ±3.33 V, ±6.67 V, ±10 V, independent on each channel
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 kΩ
Compliance current	10 mA

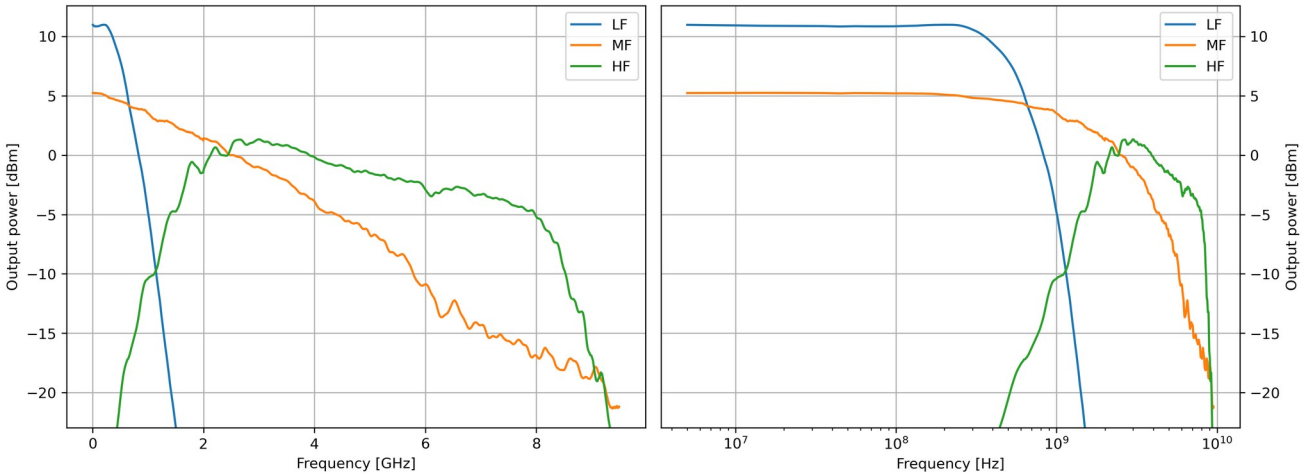
General

Connectors	SMA, 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

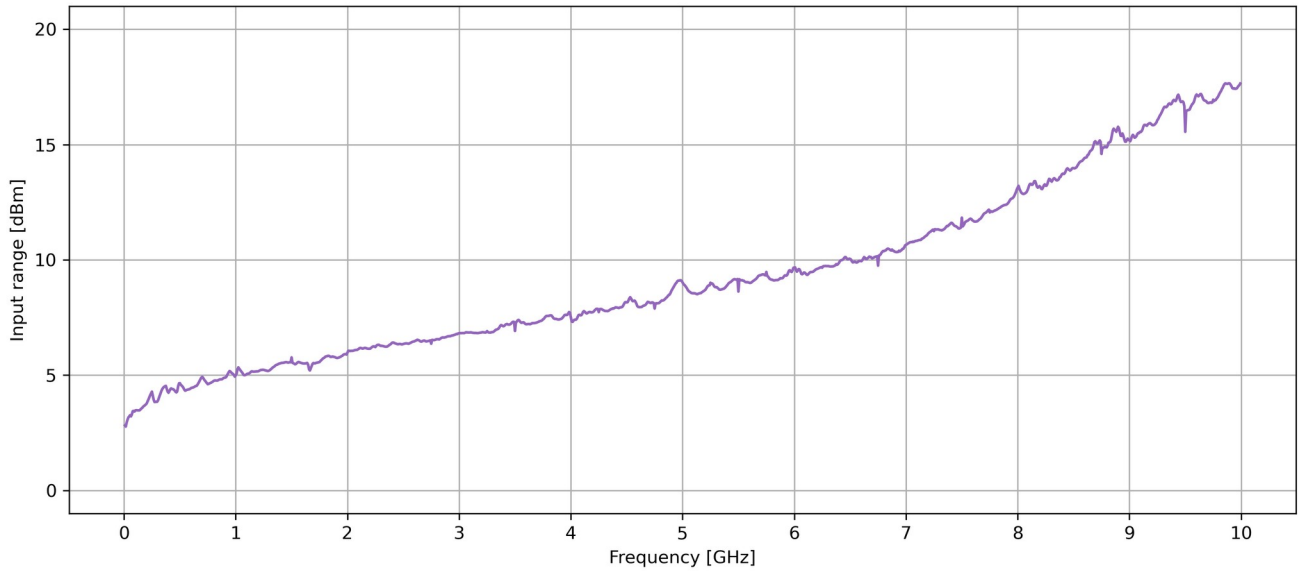
Typical output phase noise



Output range vs frequency



Input range versus frequency



Input noise versus frequency