

Quantum Engineering Toolkit (QET)



The Quantum Engineering Toolkit (QET) integrates the following components:

- PXIe chassis as the framework chosen to integrate the modular QET solution. A single PXIe chassis can support a variety of PXIe arbitrary wave generators (AWG), digitizers (DIG), combined AWG + DIG modules (COMBO), and Dual Direct Digital Synthesizers (DDS).
- Multiple PXIe chassis can be integrated to scale the control system for many qubit experiments. Single and multiple PXIe chassis can be controlled by embedded PXIe controllers, some sort of compact, but powerful PCs, or by external PC servers and supported external PCs.
- PXIe and FPGA based AWG, DIG, and COMBO for DC, baseband, and intermediate frequency In-phase and Quadrature (I/Q) pulse generation and acquisition.
- I/Q Modulators/Demodulators and PXIe DDS modules for upconverting (I/Q pulses generated by the AWG/COMBO modules) to microwave frequencies and downconverting them back to DC, baseband, or intermediate frequencies for the DIG/COMBO acquisition process.

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PXle Chassis

Keysight provides three PXle chassis for use with QET:

- M9010A – a 10-Slot PXI 24 GB/s, Gen 3 chassis
- M9018B – a 18-Slot PXI 8 GB/s, Gen 2 chassis
- M9019A – a 18-Slot PXI 24 GB/s, Gen 3 chassis

Refer to the specifications and comparisons below to determine which chassis is best for your application.



Figure 1: Keysight M9019A PXle Chassis

PXle Chassis Specifications

- 4U chassis with innovative cooling design
- High data bandwidth (max 24 GB/s system and 8 GB/s slot-to-slot when Gen 3 chassis is used)
- Multi-chassis power-sequencing using rear panel RJ-45 connectors
- Front panel external trigger input/output ports
- One common driver supports IVI-C and IVI.NET for all three chassis

PXle Chassis Comparisons

Keysight chassis	Slots	PCIe interface
M9010A	8 hybrid slots, 1 PXIe timing slot, and 1 PXIe system slot	Gen 3 PCIe with a two-link (x8, x16) system slot and x8 links to the hybrid/timing slots
M9018B	16 hybrid slots, 1 PXIe timing slot, and 1 PXIe system slot	Configurable 2-Link (2x8) and 4-Link (4x4) plus M9021A configuration (1x8)
M9019A	16 hybrid slots, 1 PXIe timing slot, and 1 PXIe system slot	Gen 3 PCIe with a two-link (x8, x16) system slot and x8 links to the hybrid/timing slots

More information

For more information about these chassis and help in determining which chassis is best for your application, refer to [“All Chassis Specifications Guide \(M9019-90015\).”](#)

Controllers

Keysight supports multiple embedded PXIe and external PXIe controllers for use with the Quantum Engineering Toolkit (QET).

PXIe embedded controllers	PXIe external controllers	PXIe extension cards
Keysight M9037A	Dell Precision 5810 Desktop Tower Workstation	Keysight M9021A/M9022A /M9023A/M9024A
Keysight M9036A	HP Z8 G4 Workstation	Keysight M9048A/M9048B /M9049A

M9037A PXIe Embedded Controller Specifications

- Intel i7-4700EQ 2.4 GHz processor
- 4-slot PXI controller module
- Front removable 240 GB solid state drive
- Up to 16 GB RAM Memory
- Gen 3 PCIe®, 4- or 2-link (up to x24) configuration providing up to 16 GB/s max data bandwidth from CPU to PXIe backplane
- Front panel connections: four USB 2.0, two USB 3.0, two LAN (10/100/1000), two DisplayPort, one GPIB, one SMB trigger
- x8 Gen 3 PCIe IPASS connector on the front for controlling a second PXIe or AXIe chassis or connection to RAID storage



Figure 2: Keysight M9037A PXIe Embedded Controller

More information

For more information about this product, visit this website: www.keysight.com/find/M9037A

M9036A PXIe Embedded Controller Specifications

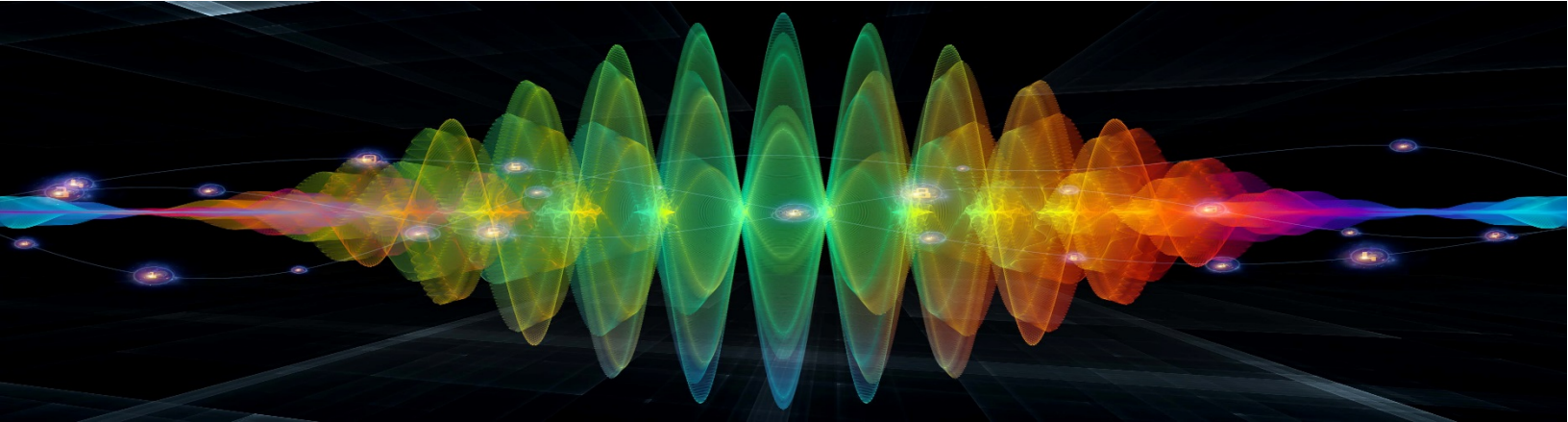
- Intel Core i5-520E 2.4GHz processor – 3-slot PXIe controller module
- 160 GB solid-state drive
- 4 GB RAM memory with 8 GB option
- Gen 2 PCIe®, 4- or 2-link configuration providing up to 4 GB/s max data bandwidth between links
- Front panel connections with USB (4), 10/100/1000 LAN (2), DVI-I, GPIB, ExpressCard 34, and SMB trigger connector
- Support for Microsoft Windows 7 (32 and 64 bit) and Windows 10 (64 bit)

More information

For more information about this product, visit this website: www.keysight.com/find/M9036A

Supported PXIe External Controllers

The PXIe external controllers supported by Keysight are listed in the table, Supported Controllers (Embedded Controllers and External Controllers). For a list of additionally tested external controllers that are compatible with Keysight PXIe chassis, refer to “[Tested PC and PXI/AXIe Chassis Configurations Technical Overview \(5990-7632EN\)](#)”.



PXle Extension Cards

- M9048A PCIe desktop PC adapter: x8, Gen 2
- M9048B PCIe Host Adapter: x8, Gen 3
- M9049A PCIe Host Adapter: Dual x8 or x16, Gen 3

System and Cable Modules for PXle Systems

- M9021A PCIe Cable Interface: x8, Gen 2
- M9022A PXle Single Port Performance System Module: x8, Gen 3
- M9023A PXle Dual Port System Module: dual x8 or x16, Gen 3
- M9024A PXle Dual Port System Module with Connectivity Expansion: two Gigabit LAN, two USB 3.0, four USB 2.0, GPIB, dual x8 or x16, Gen 3



Figure 3: Keysight M9048B PCIe Host Adapter

More information

For more information, refer to [Interface Modules and Adapters for PXle and AXle Systems - Data Sheet \(5992-0377EN\)](#).

DC, Baseband, and Intermediate Frequency

Generating DC, Baseband, and Intermediate Frequency (IF) signals can be accomplished using variations of many Keysight products. Refer to the table below for primary characteristics of each module.

M3xxxA PXle Arbitrary Waveform Generators (AWG), Digitizers, and Combo Modules

Product	Type	Outputs (AWGs)				Inputs (Digitizers)			
		Speed	Bits	Ch	BW	Speed	Bits	Ch	BW
		MSa/s			MHz	MSa/s			MHz
M3202A	AWG	1000	14	2/4	DC-400				
M3201A	AWG	500	16	2/4	DC-200				
M3102A	Digitizer					500	14	2/4	DC-200
M3100A	Digitizer					100	14	4/8	DC-100
M3302A	Combo	500	16	2	DC-200	500	14	2	DC-200
M3300A	Combo	500	16	2/4	DC-200	100	14	4/8	DC-100

Table 1: PXle AWG, Digitizers, and Combination Modules

M3201A/M3202A PXIe AWG Specifications

- M3201A: 500 MSa/s, 16 bits, 2/4 channels, 200 MHz BW (400 MHz In-Phase and Quadrature (IQ))
- M3202A: 1 GSa/s, 14 bits, 2/4 channels, 400 MHz BW (800 MHz In-Phase and Quadrature (IQ))
- Embedded advanced arbitrary waveform generators (AWGs)
 - Advanced triggering and marking (up to 8 reconfigurable I/Os)
 - Waveform queue system with cycles, delays and prescalers
- Embedded high-precision function generators (FGs)
 - Sinusoidal, triangular, square, DC, and more
 - 39-bit frequency resolution (up to $\sim 727.6 \mu\text{Hz}$)
 - 24-bit phase resolution (up to $\sim 21.5 \mu\text{deg}$)
- High-quality output signal with low phase noise
 - M3201A: SFDR: $\sim 64 \text{ dBc}$ at 80 MHz (typical)
 - M3202A: SFDR: $\sim 54 \text{ dBc}$ at 160 MHz (typical)
 - Average noise density: down to -145 dBm/Hz (typical)
 - Low jitter $< 2 \text{ ps}$ (Option CLF)
- Up to 2 GB of onboard RAM ($\sim 1 \text{ Gsamples}$)
- Mechanical/interface
 - 1 slot 3U (PXIe)
 - Up to 1.6 GB/s transfer BW with P2P capabilities (PCIe Gen 2)
 - Independent direct memory access (DMA) channels for fast and efficient data transfer



Figure 4: Keysight PXIe M3201A AWG

M3201A/M3202A PXIe AWG Block Diagram

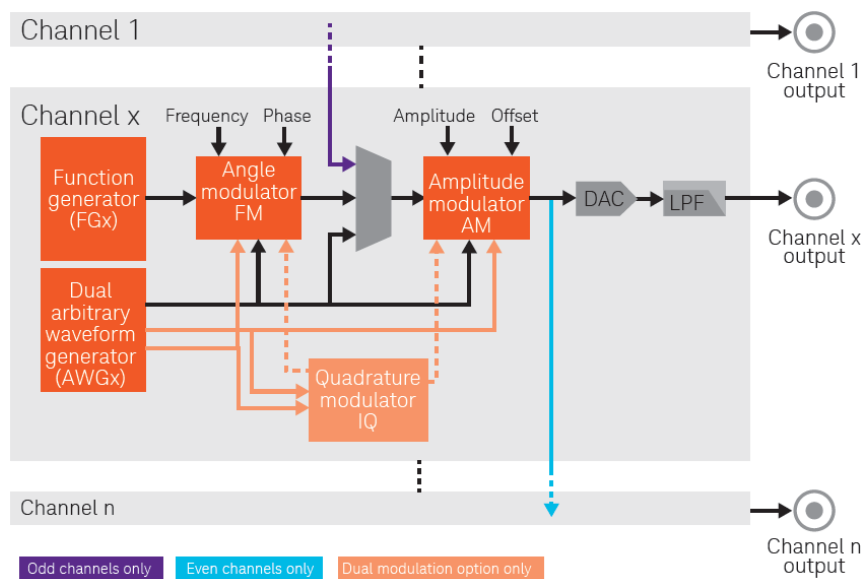


Figure 5: Keysight M3201A PXIe AWG Block Diagram

M3201A/M3202A PXIe AWG General Characteristics Comparison

Parameter	M320xA-CH2			M320xA-CH4			Units	Comments
	Min	Typ	Max	Min	Typ	Max		
Inputs and outputs								
Channels (single-ended mode)	2			4			Out	
Channels (differential mode)	1			2			Out	Differential uses 2 channels
Reference clock ¹	1			1			Out	
Reference clock ²	1			1			In	
Triggers/markers ^{9, 3}	1			1			In/out	Reconfigurable
Triggers/markers ^{10,11}	8			8			In/out	Reconfigurable
Output channels overview								
M3201A Sampling rate ⁴	0.005		500	0.005		500	MSa/s	
M3202A Sampling rate ⁵	400		1000	400		1000	MSa/s	
M3201A Voltage resolution	16			16			Bits	
M3202A Voltage resolution	14			14			Bits	
M3201A Output frequency	DC		200	DC		200	MHz	
M3202A Output frequency	DC		400	DC		400	MHz	
M3201A Real-time BW	200			200			MHz	
M3202A Real-time BW	400			400			MHz	
Output Voltage	-1.5		1.5	-1.5		1.5	Volts	
Built-in functionality								
Function generators	2			4				1 per channel
Dual AWGs	2			4				1 per channel
IQ modulators	2			4				1 per channel
Frequency modulators	2			4				1 per channel
Phase modulators	2			4				1 per channel
Amplitude modulators	2			4				1 per channel
Onboard memory								
RAM memory	16		2048	16		2048	MBytes	

Table 2: AWG General Characteristics Comparison

More information

Refer to these data sheets for details:

- [M3201A - PXIe Arbitrary Waveform Generator with Optional Real-Time Sequencing and FPGA Programming - Data Sheet \(5992-1797EN\)](#)
- [M3202A PXIe Arbitrary Waveform Generator with Optional Real-Time Sequencing and FPGA Programming - Data Sheet \(5992-1798EN\)](#)

¹ At front panel

² At backplane

³ Markers available from firmware version v3.0 or later

⁴ (-CLV) option: DC to 500 MSa/s; (-CLF) option: fixed 500 MSa/s

⁵ (-CLV) option: 400 MSa/s to 1 GSa/s; (-CLF) option: fixed 1 GSa/s

M3100A/M3102A PXIe Digitizer Specifications

- M3100A: 100 MSa/s simultaneous sampling, 14 bits, 4/8 channels, 100 MHz BW⁶,
M3102A: 500 MSa/s simultaneous sampling, 14 bits, 2/4 channel, 200 MHz BW
- Advanced data acquisition system (DAQ)
 - Flexible triggering (HW trigger, HVI trigger, SW trigger)
 - Programmable cycles and data bursts to avoid PC saturation
- Optional HW programming for high-performance applications
 - Real-time sequencing (HVI technology)
 - FPGA programming
 - Xilinx Kintex-7, 325T or 410T FPGA
- Up to 2 GB of onboard RAM (~ 1 Gsamples)



Figure 6: Keysight PXIe M3100A Digitizer

PXIe Digitizer Mechanical/Interface

- 1 slot 3U (PXIe)
- M3100A: Up to 1.6 GB/s transfer BW with P2P capabilities (PCIe Gen 2)
M3102A: Up to 200 MB/s transfer BW with P2P capabilities
- Independent DMA channels for fast and efficient data transfer

M3100A/M3102A PXIe Digitizer Block Diagram

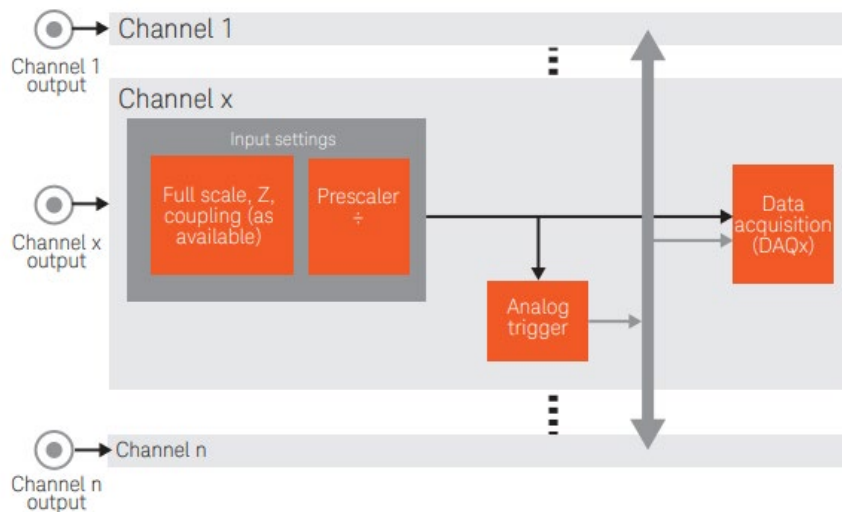


Figure 7: Keysight M3100A/M3102A PXIe Digitizer Block Diagram

⁶ 100 MHz refers to the front-end bandwidth. This digitizer can operate in 1st and 2nd Nyquist zones (using under-sampling technique), but its real-time BW is limited by Nyquist to some 50 MHz. As an example, for a band-limited signal of 70 MHz with a 10 MHz signal bandwidth the aliased component will appear between 25 to 35 MHz (30 ± 5 MHz).

M3100A/M3102A PXIe Digitizer General Characteristics Comparison

Parameter	M310XA-CH4			M310XA-CH8			Units	Comments
	Min	Typ	Max	Min	Typ	Max		
Inputs and outputs								
M3100A Channels		4			8		Out	
M3102A Channels		2			4		Out	
Reference clock ⁷		1			1		Out	
Reference clock ⁸		1			1		In	
Triggers/markers ^{15, 9}		1			1		In/out	Reconfigurable
Triggers/markers ^{16,17}		8			8		In/out	Reconfigurable
Input channels overview								
M3100A Sampling rate		100			100		MSa/s	
M3202A Sampling rate ¹⁰		500			500		MSa/s	
Voltage resolution		14			14		Bits	
M3100A Input frequency	DC		100	DC		100	MHz	
M3102A Input frequency	0		200	0		200	MHz	
M3100A Real-time BW		50			50		MHz	
M3102A Real-time BW		200			200		MHz	
Time skew		< 50			<50		ps	Between channels
Built-in functionality								
M3100A Input conditioning blocks		4			8			1 per channel
M3102A Input conditioning blocks		2			4			1 per channel
M3100A analog trigger processors		4			8			1 per channel
M3102A analog trigger processors		2			4			1 per channel
M3100A data acquisition blocks		4			8			1 per channel
M3102A data acquisition blocks		2			4			1 per channel
Onboard memory								
RAM memory	16		2048	16		2048	MBytes	

Table 3: M3100A/M3102A PXIe Digitizer General Characteristics Comparison

⁷ At front panel

⁸ At backplane

⁹ Markers available from firmware version v3.0 or later

¹⁰ 100 to 500 Msa/s (-CLV) option with variable sampling clock

More information

Refer to these data sheets for details:

- [M3100A PXIe Digitizers with Optional Real-Time Sequencing and FPGA Programming - Data Sheet \(5992-1806EN\)](#)
- [M3102A PXIe Digitizers with Optional Real Sequencing and FPGA Programming - Data Sheet \(5992-1805EN\)](#)

M3300A/M3302A PXIe AWG and Digitizer Combo Specifications

- Outputs (AWGs)
 - M3300A: 500 MSa/s, 16 bits, 2/4 channels
 - M3302A: 500 MSa/s, 16 bits, 2 channels
- Inputs (digitizers)
 - M3300A: 100 MSa/s, 14 bits, 4/8 channels
 - M3302A: 500 MSa/s, 16 bits, 2 channels
- Input Features
 - Powerful data acquisition system (DAQ)
 - Advanced triggering and marking functionalities
- Output Features
 - AWGs, function generators, AM/FM/PM modulators
 - Advanced triggering and marking functionalities
- Less than 400 ns input to output latency
- Optional HW programming for high-performance applications
 - Real-time sequencing (HVI technology)
 - FPGA programming
 - Xilinx Kintex-7 325T or 410T FPGA
- Up to 2 GB of onboard RAM (~ 1 Gsamples)
- Mechanical Interface
 - 2 slots 3U (PXIe)
 - M3300A: Up to 1.6 GB/s transfer BW with P2P capabilities (PCIe Gen 2)
 - M3302A: Up to 200 MB/s transfer BW with P2P capabilities
 - Independent DMA channels for fast and efficient data transfer



Figure 8: Keysight M3302A PXIe Combo

M3300A/M3302A PXIe AWG and Digitizer Combo Block Diagrams

The M330xA combo modules have combined technology of the M320xA and the M310xA in one module. The block diagrams are identical to those shown above:

- M3201A/M3202A PXIe AWG Block Diagram
- M3100A/M3102A PXIe Digitizer Block Diagram

M3300A/M3302A PXIe AWG and Digitizer Combo General Characteristics Comparison

Parameter	M3300A-C24/ M3302A-C22 ⁵			M3300A-C48			Units	Comments
	Min	Typ	Max	Min	Typ	Max		
Inputs and outputs								
Channels (single-ended mode)	2			4			Out	
Channels (differential mode)	1			2			Out	Differential mode uses 2 channels
Reference clock ¹¹	1			1			Out	
Reference clock ¹²	1			1			In	
Triggers/markers ^{19, 13}	1			1			In/out	Reconfigurable
Triggers/markers ^{20,21}	8			8			In/out	Reconfigurable
Output channels overview								
M3300A Sampling rate	500			500			MSa/s	Fixed sampling clock
M3302A Sampling rate ^{14, 15}	0.005	500					MSa/s	
Voltage resolution	16			16			Bits	
Output frequency	DC	200		DC	200		MHz	
Real-time BW	200			200			MHz	
Output voltage	-1.5	1.5		-1.5	1.5		Volts	
Built-in functionality								
Function generators	2			4				1 per channel
Dual AWGs	2			4				1 per channel
IQ modulators	2			4				1 per channel
Frequency modulators	2			4				1 per channel
Phase modulators	2			4				1 per channel
Amplitude modulators	2			4				1 per channel
DC offset modulators	2			4				
Onboard memory								
RAM memory	16	2048		16	2048		MBytes	

Table 4: M3300A/M3302A PXIe AWG and Digitizer Combo General Characteristics Comparison

More information

Refer to these data sheets for details:

- [M3300A PXIe Arbitrary Waveform Generator and Digitizer Combo with Optional Real-Time Sequencing and FPGA Programming - Data Sheet \(5992-1809EN\)](#)
- [M3302A PXIe Arbitrary Waveform Generator and Digitizer Combo with Optional Real-Time Sequencing and FPGA Programming - Data Sheet \(5992-1808EN\)](#)

¹¹ At front panel

¹² At backplane

¹³ Markers available from firmware version v3.0 or later

¹⁴ (Option CLV): DC to 500 MSa/s; (Option CLF): fixed 500 MSa/s

¹⁵ This is the only characteristic of the M3302A-C22 that is different from the M3300A-C24 module.

Microwave Frequency Local Oscillator

M9347AH01 PXIe Dual Direct Digital Synthesizer (DDS) General Characteristics

- Inputs
 - Clock In (SMA (f) Connector, 2nd from the Top)
 - Ref In (SMP (m) Connector, 2nd from the Bottom)
 - Link In (USB-mini, Middle-Right)
- Outputs
 - Synth Out 2 (SMA (f) Connector, Top)
 - Ref Out (SMA (f) Connector, 3rd from the Top)
 - Synth Out 1 (SMA (f) Connector, Bottom)
 - Link Out (USB-mini, Bottom-Right)



Figure 9: Keysight M9347AH01 PXIe Dual DDS

Frequency and phase characteristics			
Frequency range	50 MHz to 12 GHz	Units	Comments
Frequency resolution (spec.)	80	bits	
	20	fHz	From 50 MHz to 6 GHz
	40	fHz	From 6 MHz to 12 GHz
Phase resolution (spec.)	32	bits	
	$\sim 84 \cdot 10^{-9}$	degrees	
Analog output power characteristics		Units	Comments
Synth Out 1 and 2 (nom.)	-10 to 0	dBm	50 MHz to 12 GHz
Synth Out 1 and 2 Deviation (meas.)	± 1 (from RF Output Power = 0 dBm)	dBm	50 MHz to 12 GHz
Synth Out 1 and 2 SFDR (meas.)	> 75 (from RF Output Power = 0 dBm)	dBc	50 MHz to 12 GHz
Ref Out (100 MHz) (nom.)	+14	dBm	
Ref Out (4.8 GHz) (nom.)	-10 (from Input Clock Power)	dB	
Ref Out (19.2 GHz) (nom.)	+10 (from Input Clock Power)	dB	
Analog input power characteristics			
Clock In 4.8 GHz and 19.2 GHz	0 to +20	dBm	
Ref In 100 MHz	0 to +14	dBm	

Table 5: M9347AH01 PXIe Dual Direct Synthesizer General Characteristics

NOTE The recommended warm up time is 30 minutes.

NOTE Characteristics and Specifications are subject to change without notice.

M9347AH01 PXIe Dual DDS SSB Phase Noise Measurements

SSB Phase Noise (meas.) (dBc/Hz)	RF Output Frequency				
	3.2 GHz	5 GHz	7 GHz	9 GHz	11.5 GHz
Offset frequency					
10 Hz	-90	-87	-86	-79	-79
100 Hz	-104	-99	-96	-93	-90
1 kHz	-122	-120	-115	-114	-112
10 kHz	-130	-127	-123	-122	-121
100 kHz	-135	-132	-128	-127	-125
1 MHz	-148	-144	-141	-140	-137
10 MHz	-155	-153	-149	-149	-146
Noise floor	-151	-150	-149	-149	-147

Table 6: M9347AH01 PXIe Dual DDS SSB Phase Noise Measurements

NOTE

Characteristics and Specifications are subject to change without notice.

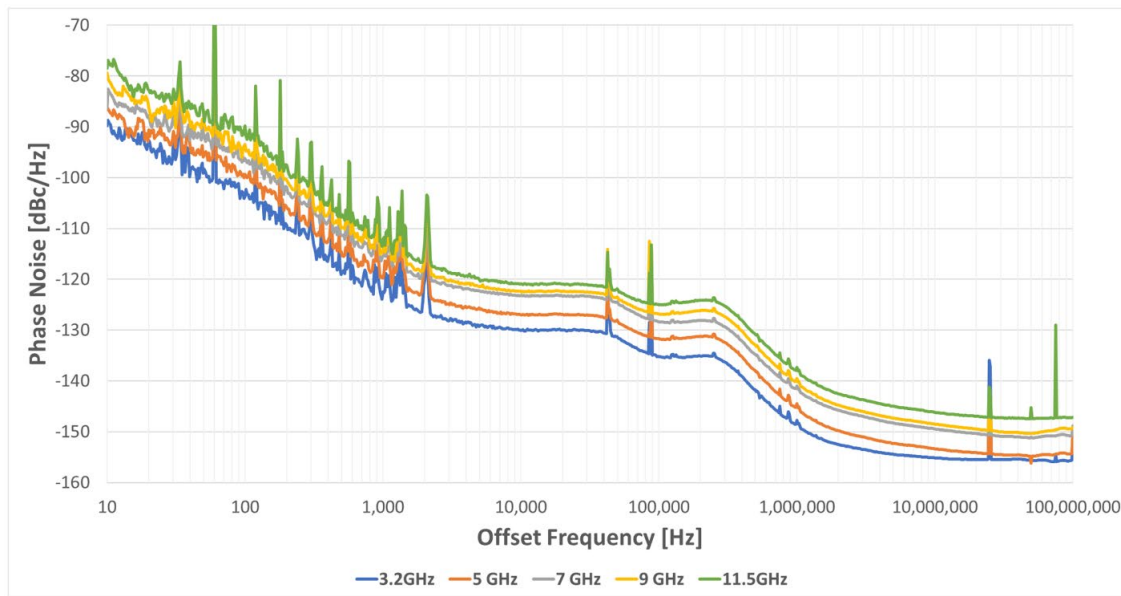


Figure 10: M9347AH01 PXIe Dual DDS SSB Phase Noise (with E8267D-UNY as Clock In)



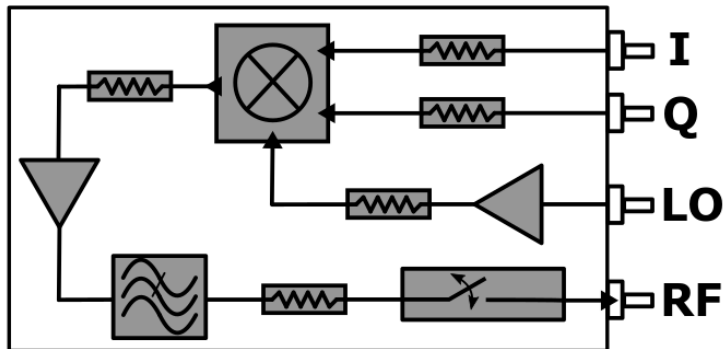
U3022AH37 I/Q Modulator/Demodulator

- I/Q Modulator
 - I In (SMA (f) Connector, Top)
 - Q In (SMA (f) Connector)
 - RF Out (SMA (f) Connector)
 - Pin Sw (SMB (m) Connector)
 - LO In (SMA (f) Connector, Bottom)
- I/Q Demodulator
 - I Out (SMA (f) Connector, Top)
 - Q Out (SMA (f) Connector)
 - RF In (SMA (f) Connector)
 - LO In (SMA (f) Connector, Bottom)



Figure 11: Keysight U3022AH37 I/Q Modulator/Demodulator

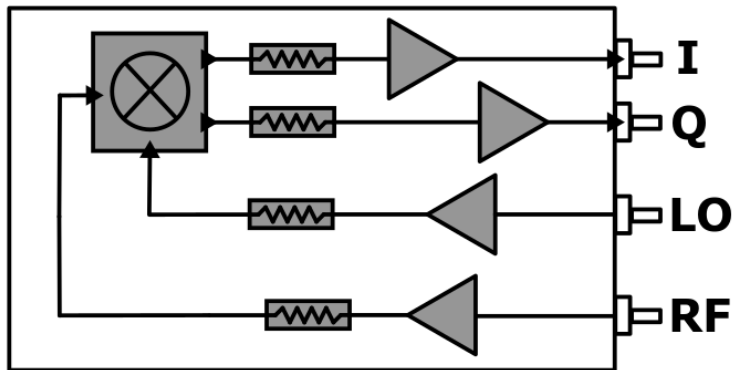
U3022AH37 I/Q Modulator Setup



U3022AH37 I/Q Modulator Options

Option	Description
M00	No Modulator Sections
M01	4 Channel 3 to 7 GHz Modulator Section
M02	8 Channel 3 to 7 GHz Modulator Section
M03	4 Channel 5 to 9 GHz Modulator Section
M04	8 Channel 5 to 9 GHz Modulator Section
M05	4 Channel 6 to 18 GHz Modulator Section
M06	8 Channel 6 to 18 GHz Modulator Section
M99	2 Channel 3 to 7 GHz, 2 Channel 5 to 9 GHz 4 Channel 6 to 18 GHz Modulator Sections

U3022AH37 I/Q Demodulator Setup



U3022AH37 I/Q Demodulator Options

Option	Description
D00	No Demodulator Sections
D01	4 Channel 3 to 7 GHz Demodulator Section
D02	8 Channel 3 to 7 GHz Demodulator Section
D03	4 Channel 5 to 9 GHz Demodulator Section
D04	8 Channel 5 to 9 GHz Demodulator Section
D05	4 Channel 6 to 18 GHz Modulator Section
D06	8 Channel 6 to 18 GHz Modulator Section

U3022AH37 I/Q Operational Characteristics

General specifications		Environmental specifications	
Nominal Voltage/Frequency	100/120 V, 50/60 Hz 220/240 V, 50/60 Hz	Operating environment	Indoor use only
Power	350 Watts	Operating temperature	5 to 40 °C
Dimensions	14.4 x 42.9 x 57.6 cm (5.7 x 16.9 x 22.7 in)	Altitude	2,000 meters
Weight	11.3 kg (25 lbs.)	Storage temperature	-40 to +70 °C
The instrument can operate with mains supply voltage fluctuations up to $\pm 10\%$ of the nominal range.		Humidity	80% maximum relative humidity, non-condensing up to 31 °C and decreasing linearly to 50% relative humidity at 40 °C.

NOTE

The recommended warm up time is 30 minutes.

U3022AH37 I/Q Modulator Characteristics

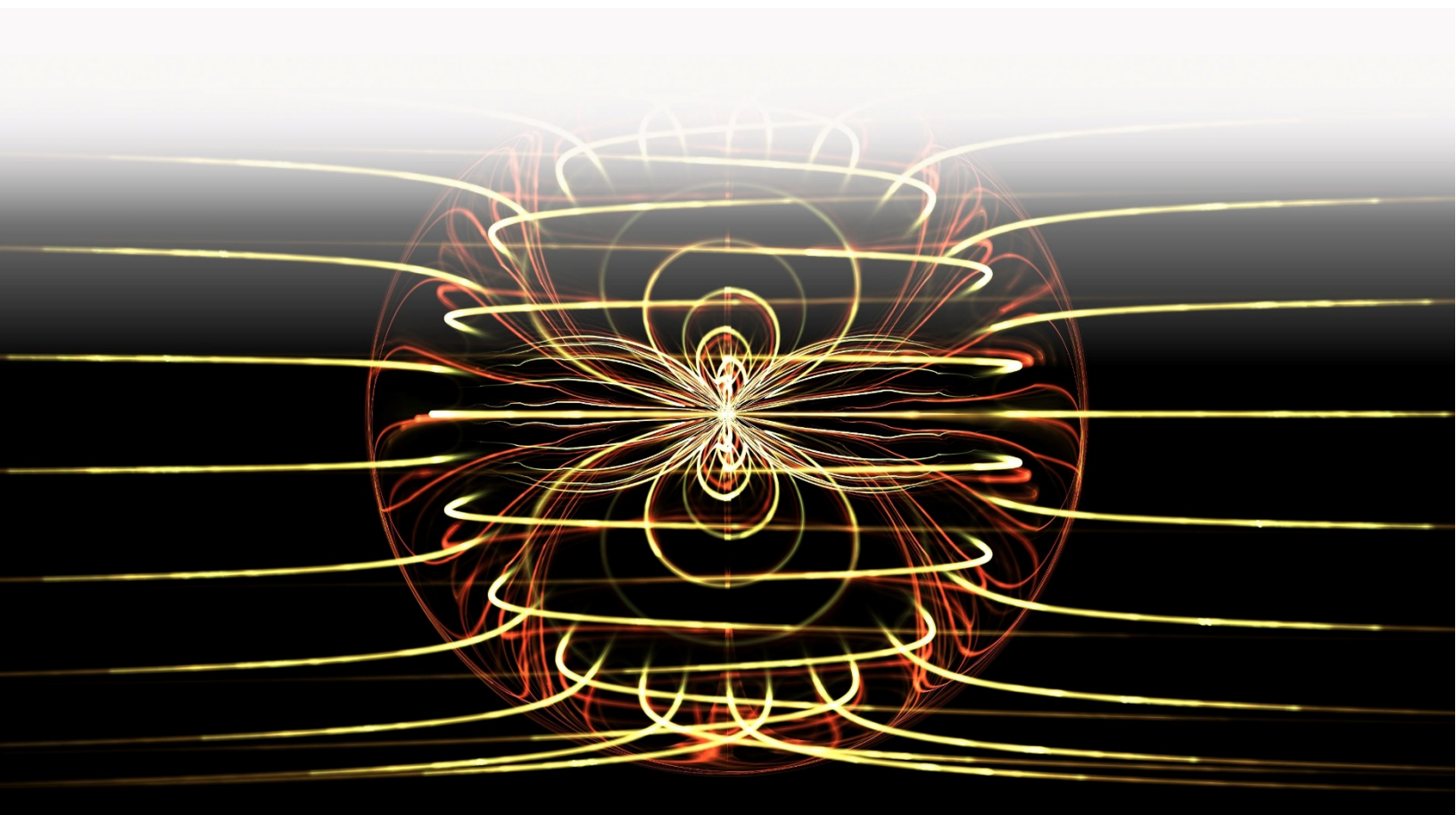
Modulator Characteristics					
Modulator Sections	RF & LO 3 to 7 GHz IF 10-500 MHz	RF & LO 5 to 9 GHz IF 10-500 MHz	RF & LO 6 to 18 GHz IF 10-500 MHz	Units	Comments
Measured Conversion Gain	> +6	> +10	> +7	dB	At IF 100 MHz
I or Q in 1 dB Compression	≥ 2	≥ -3	≥ -1	dBm	
RF Out 1 dB Compression	≥ 9	≥ 8	≥ 8	dBm	
Maximum I or Q in Power	+20	+20	+20	dBm	
Max LO in Power	+10	+10	+10	dBm	
RF Output Power	Refer to Figure 12 through Figure 14 for graphical data of Pin vs Pout.				
Port Match					
RF Out	< -10	< -10	< -10	dB	
LO In	< -10	< -10	< -10	dB	
I/Q In	< -10	< -10	< -10	dB	
Output Switch					
On/Off ratio	> 70	> 70	> 70	dB	
Switching Speed	30	30	30	ns	
Pin SW Input	> 0.6 ON < 0.3 OFF	> 0.6 ON < 0.3 OFF	> 0.6 ON < 0.3 OFF	Vdc	0 or ground = OFF, 1 or 5 Vdc = On

NOTE

Maximum input powers are de-rated linearly by 3 dBm at ± 50 °C.

NOTE

Characteristics and Specifications are subject to change without notice.



U3022AH37 I/Q Modulator, RF Output Power vs Input Power Option 3 to 7 GHz

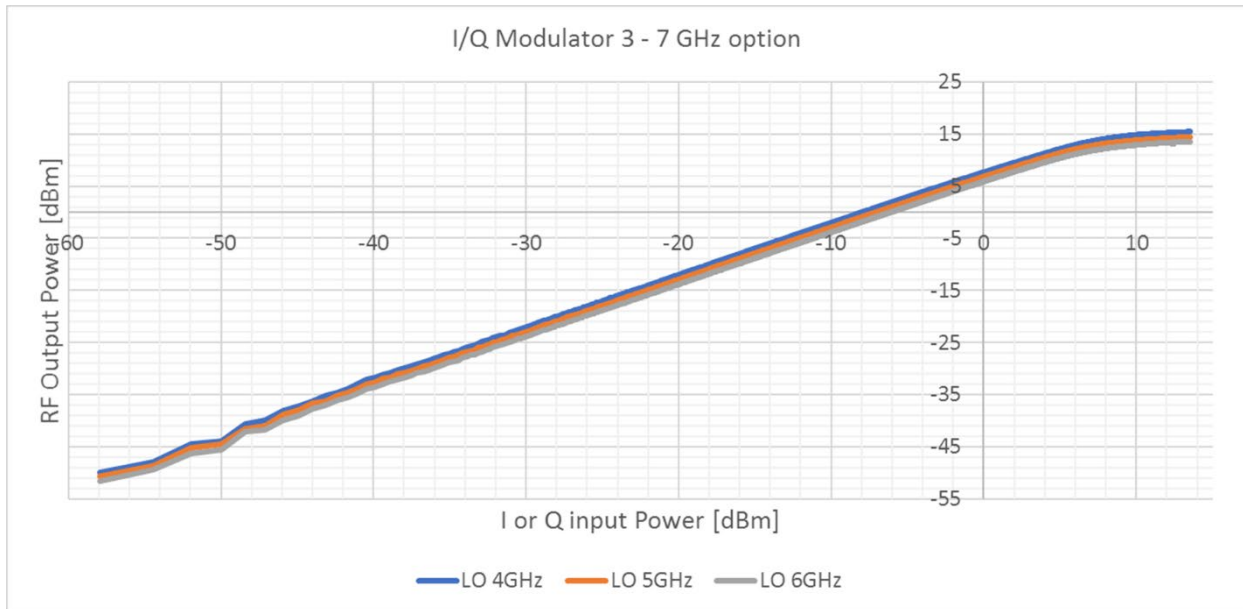


Figure 12: Linearity Performance of the U3022AH37 RF & LO Frequency 3 to 7 GHz

U3022AH37 I/Q Modulator, RF Output Power vs Input Power Option 5 to 9 GHz

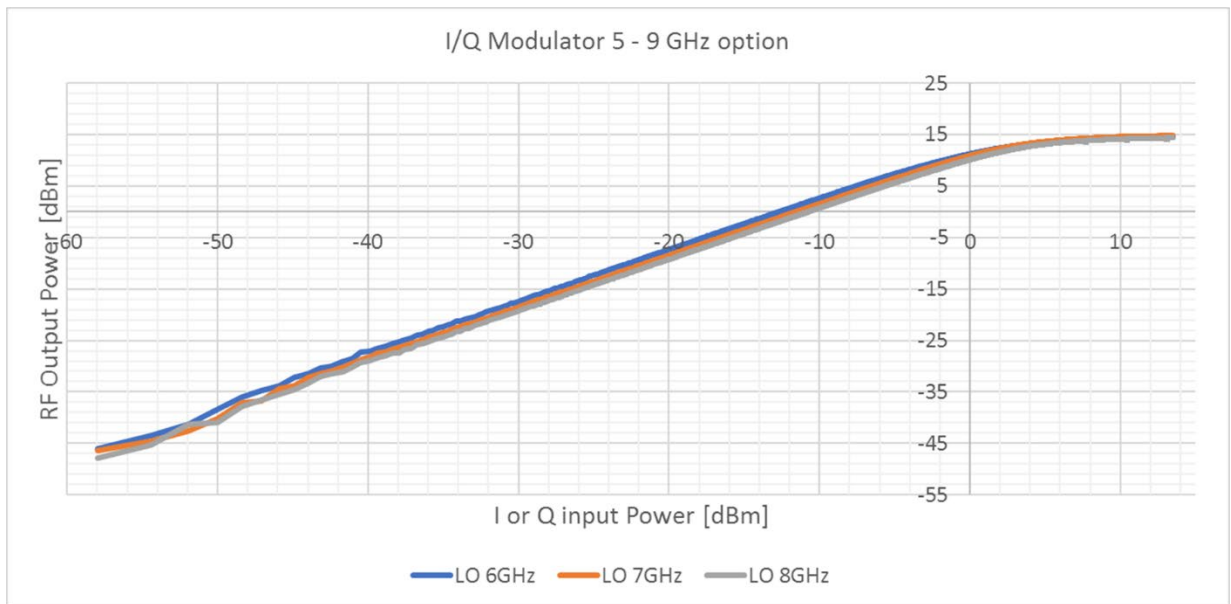


Figure 13: Linearity Performance of the U3022AH37 RF & LO Frequency 5 to 9 GHz

U3022AH37 I/Q Modulator, RF Output Power vs Input Power Option 6 to 18 GHz

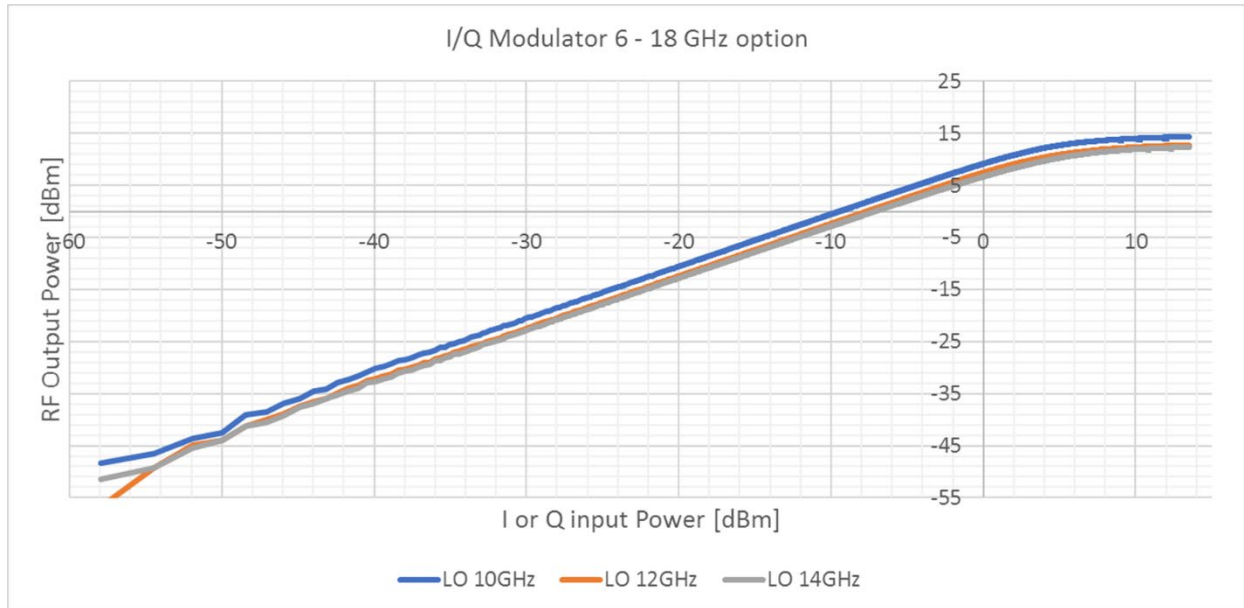


Figure 14: Linearity Performance of the U3022AH37 RF & LO Frequency 6 to 18 GHz

U3022AH37 SSB Phase Noise

Frequency Offset		Single Side Band Phase Noise (dBc/Hz)							Noise Floor (dBc/Hz)
		1 Hz	10 Hz	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz	
RF & LO 3 to 7 GHz	At 3 GHz	-62	-93	-103	-122	-128	-134	-147	-150
	At 5 GHz	-65	-89	-100	-120	-129	-132	-144	-147
IF 10-500 MHz	At 7 GHz	-57	-86	-96	-116	-124	-129	-142	-147
	At 5 GHz	-62	-89	-100	-117	-129	-132	-142	-145
RF & LO 5 to 9 GHz	At 7 GHz	-60	-84	-97	-114	-124	-129	-140	-145
	At 9 GHz	-56	-84	-95	-111	-123	-127	-139	-144
RF & LO 6 to 18 GHz	At 6 GHz	-69	-86	-99	-114	-131	-131	-142	-145
	At 12 GHz	-60	-80	-93	-109	-126	-125	-139	-145
IF 10-500 MHz	At 18 GHz	-49	-76	-90	-107	-120	-123	-134	-139

NOTE

The M9347AH01 was used as the LO (with E8267D-UNY as Clock In) for the Options 3 to 7 GHz and 5 to 9 GHz measurements and only the E8267D-UNY as the LO for the 6 to 18 GHz measurements. In all cases, the M3202A was used as the AWG with an intermediate frequency of 100 MHz.

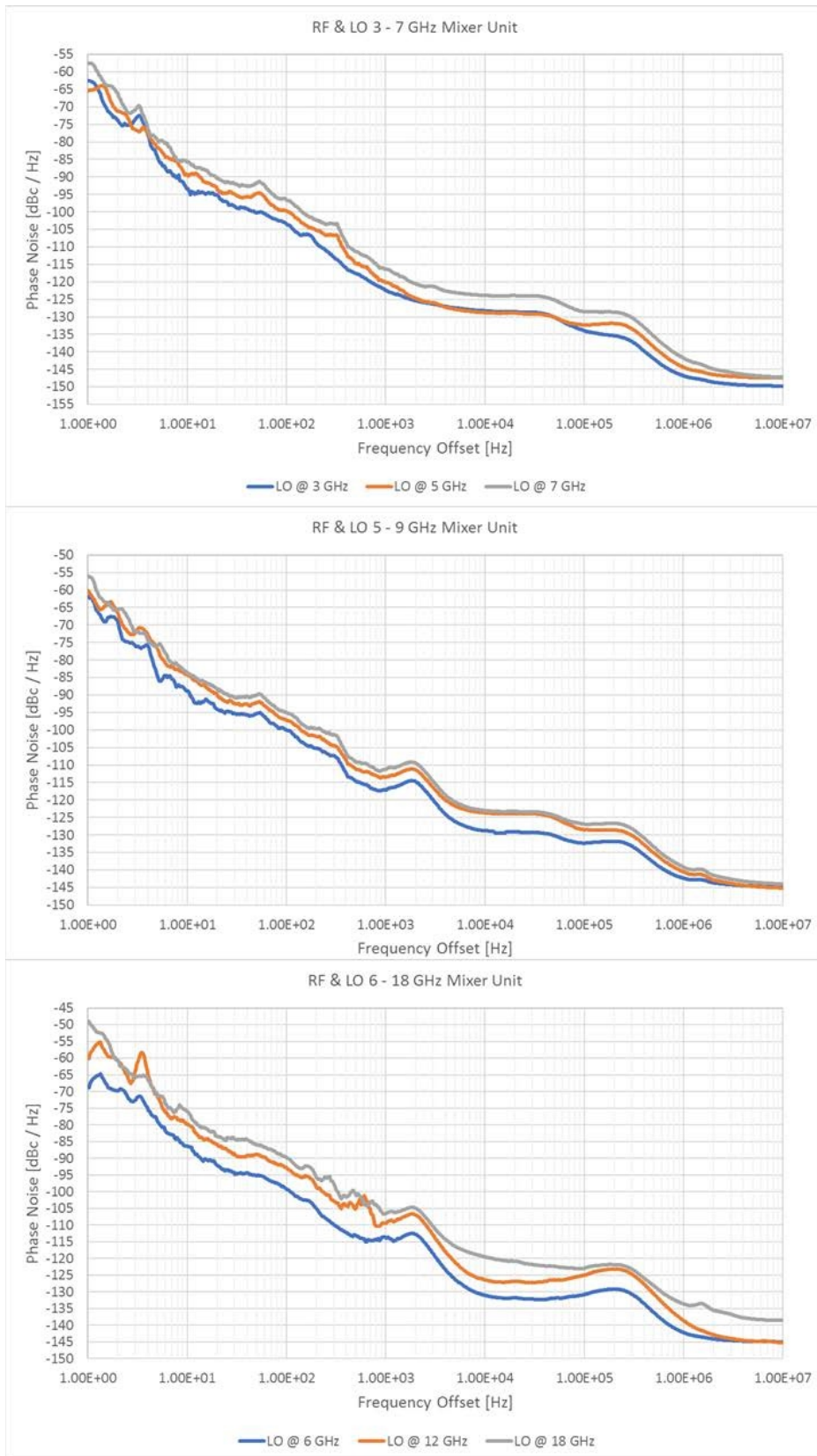


Figure 15: Phase Noise of the three modulator options in the U3022AH37

U3022AH37 I/Q Demodulator Characteristics

Demodulator Sections	RF & LO 3 to 7 GHz IF 10-500 MHz	RF & LO 5 to 9 GHz IF 10-500 MHz	RF & LO 6 to 18 GHz IF 10-500 MHz
Conversion Gain (dB)	> 25	> 36	> 30
RF in 1 dB Compression (dBm)	≥ -22	≥ -28	≥ -29
I or Q Output 1 dB Compression (dBm)	≥ +6	≥ +8	≥ +9
Maximum RF in Power (dBm)	0	0	0
Max LO in Power (dBm)	+10	+10	+10
Port Match (dB)			
RF Out	< -10	< -10	< -10
LO In	< -10	< -10	< -10
I/Q Out	< -20	< -20	< -20

NOTE Maximum input powers are de-rated linearly by 3 dBm at ± 50°C.

NOTE Characteristics and specifications are subject to change without notice.

U3022AH37 I/Q Demodulator, I or Q Output Power vs. RF input Power Option 3 to 7 GHz¹⁶

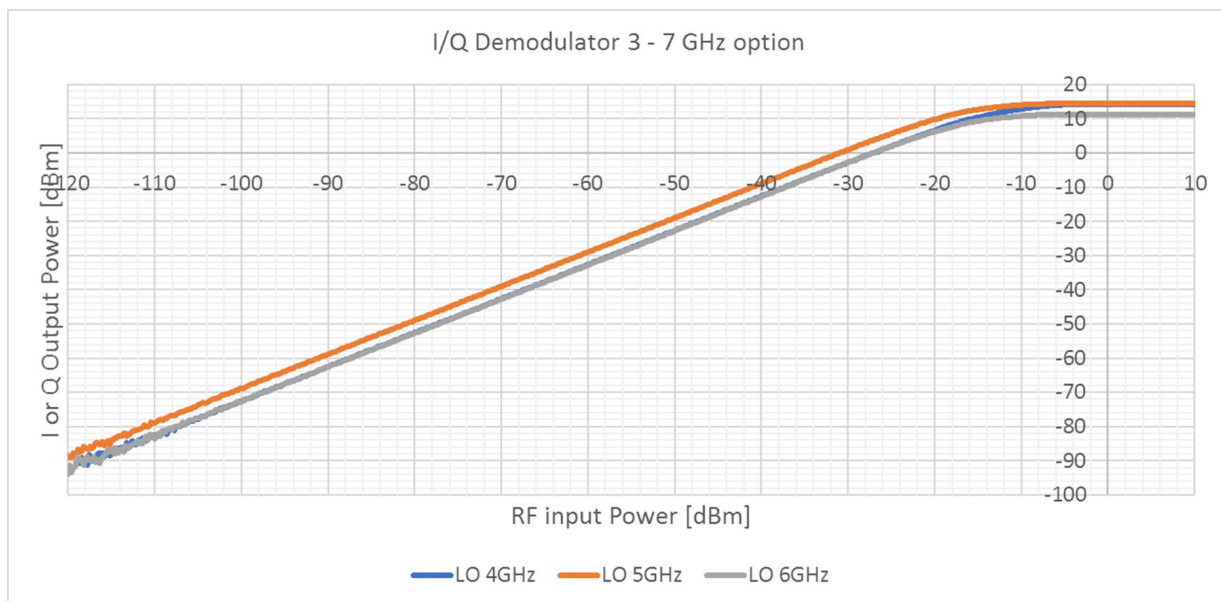


Figure 16: I or Q Output Power vs. RF input Power Option 3 to 7 GHz

¹⁶ This is the I/Q Demodulator Option 3 GHz to 7 GHz Power Output – Power Input response.

U3022AH37 I/Q Demodulator, I or Q Output Power vs. RF input Power Option 5 to 9 GHz

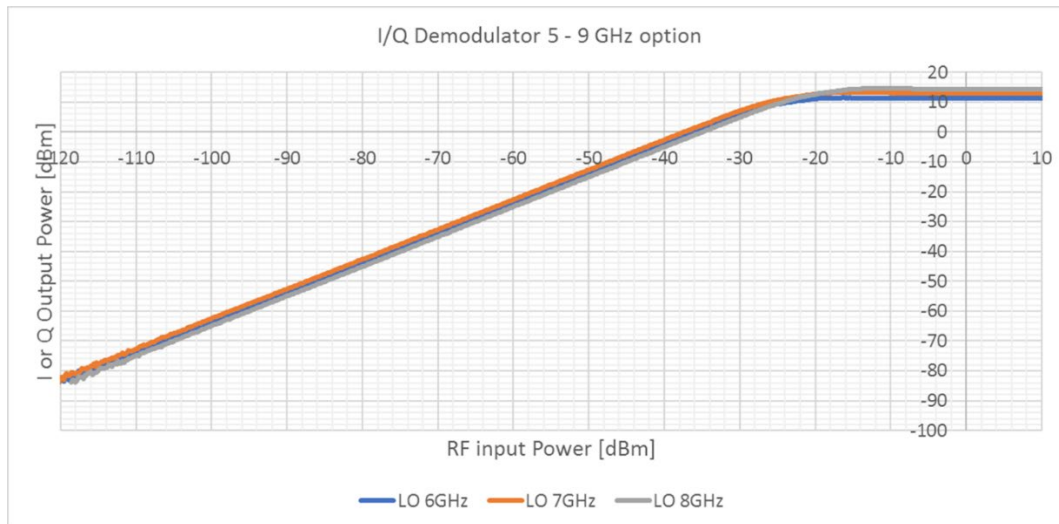


Figure 17: I or Q Output Power vs. RF Input Power Option 5 to 9 GHz

U3022AH37 I/Q Demodulator, I or Q Output Power vs. RF input Power Option 6 to 18 GHz

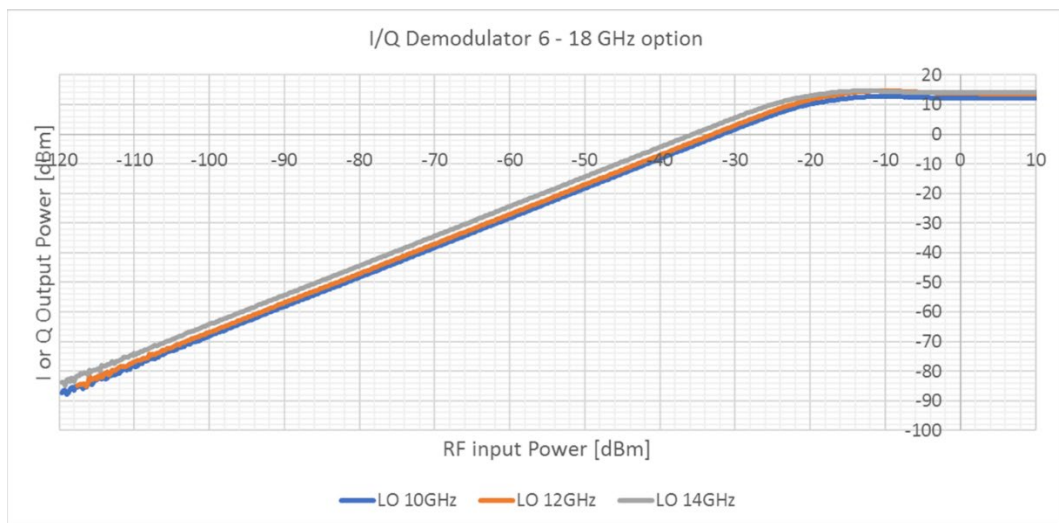


Figure 18: I or Q Output Power vs. RF input Power Option 6 to 18 GHz

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