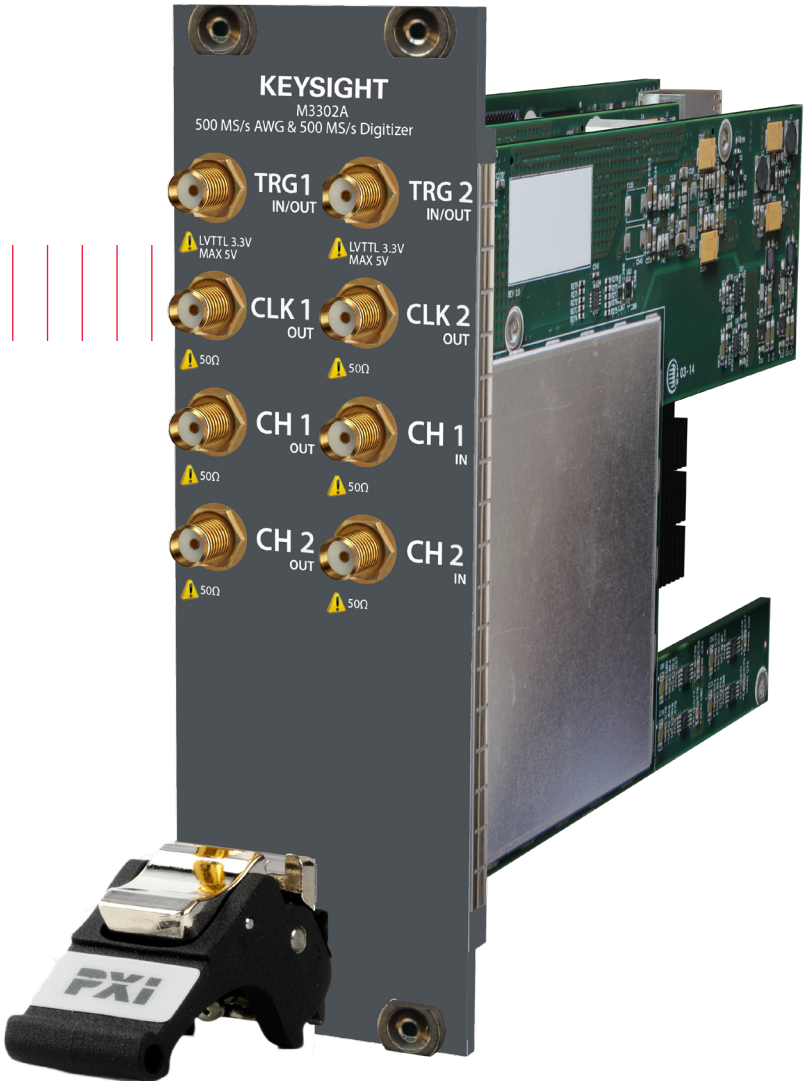
Keysight M3302A

PXIe Arbitrary Waveform Generator and Digitizer with Optional Real-Time Sequencing and FPGA Programming

500 MSa/s, 16 Bits, 2 Channel Arbitrary Waveform Generator

500 MSa/s, 14 Bits, 2 Channel Digitizer

Data Sheet



KEYSIGHT TECHNOLOGIES

Fast, Flexible, High-Performance Control, Testing and Prototyping

The M3302A combines high-performance arbitrary waveform generator channels and digitizer channels in the same module providing the ideal tool for testing and prototyping in control or communications applications. Performance meets simplicity thanks to easy-to-use programming libraries, real-time sequencing technology (Hard Virtual Instrumentation or HVI), and graphical FPGA programming technology.

Features

Outputs (AWG)
- 500 MSa/s, 16 Bits, 2 Channels

Inputs (digitizer)
- 500 MSa/s, 14 Bits, 2 Channels

Output features
- AWGs, function generators, AM/FM/PM modulators
- Advanced triggering and marking functionalities

Input features
- Powerful data acquisition system (DAQ)
- 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)
- Up to 200 MB/s transfer BW with P2P capabilities
- Independent DMA channels for fast and efficient data transfer

Applications

General purpose AWGs & digitizers

High-performance control

Communications: BB/IF SDR, channel emulation, transceiver testing

Aerospace & defense (A/D): RADAR, electronic warfare (EW)

Hardware-in-the-loop (HIL), automated test equipment (ATE)

Scientific research

Quantum computing

Functional Block Diagram

Output - Arbitrary Waveform Generator

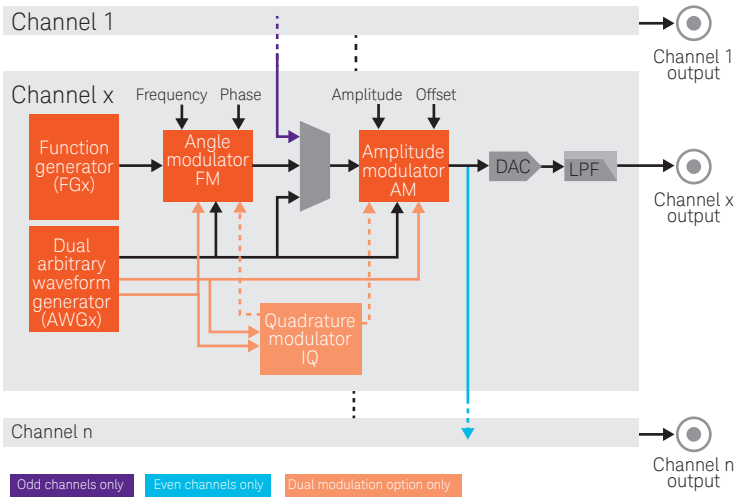


Figure 1. M3302A output functional block diagram, all channels have identical output structure

Input - Digitizer

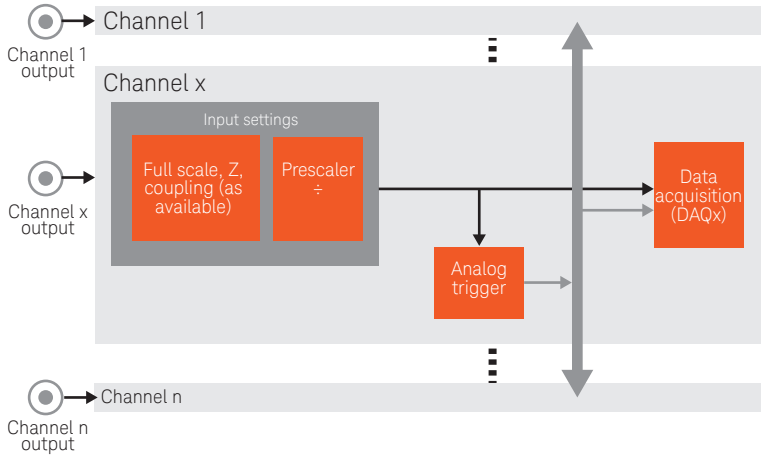


Figure 2. M3302A input functional block diagram, all channels have identical input structure

Programming Technology and Software Tools

Software programming

- Easy-to-use native programming libraries for most common languages: C, C++, Visual Studio, LabVIEW, MATLAB, Python, and more

Hardware programming (optional)

- Real-time sequencing (Hard Virtual Instrumentation or HVI technology)
  - Graphical flowchart-style M3601A design environment (-HV1 option required on HW)
  - Ultra-fast, fully-parallelized, hard real-time execution
  - Ultra-fast, time-deterministic decision-making
  - Off-the-shelf inter-module synchronization & data exchange
- FPGA programming
  - Graphical M3602A FPGA design environment (-FP1 option required on HW)
  - No FPGA know-how required
  - Include high-level to low-level design elements: off-the-shelf DSP blocks, MATLAB/ Simulink designs, Xilinx CORE Generator IP cores, Xilinx VIVADO/ISE projects, VHDL or Verilog code
  - Ultra-fast, one-click compiling and on-the-fly programming

No programming

- Ready-to-use SD1 SPF (software front panels)

PXIe Arbitrary Waveform Generators, Digitizers and Combination Modules

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

AWG Technical Specifications and Characteristics

General characteristics

Parameter	M3302A-C22 Min	Typ	Max	Units	Comments
Inputs and outputs					
Channels (single-ended mode)		2		Out	
Channels (differential mode)		1		Out	Differential uses 2 channels
Reference clock[1]		1		Out	
Reference clock[2]		1		In	
Triggers/markers[1, 3]		1		In/out	Reconfigurable
Triggers/markers[2, 3]		8		In/out	Reconfigurable
Output channels overview					
Sampling rate[4]	0.005		500	MSa/s	
Voltage resolution		16		Bits	
Output frequency	DC		200	MHz	
Real-time BW			200	MHz	
Output voltage	–1.5		1.5	Volts	
Built-in functionalities					
Function generators		2			1 per channel
Dual AWGs		2			1 per channel
IQ modulators		2			1 per channel
Frequency modulators		2			1 per channel
Phase modulators		2			1 per channel
Amplitude modulators		2			1 per channel
DC offset modulators		2			1 per channel
Onboard memory					
RAM memory	16		2048	MBytes	

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

I/O specifications

	M3302A-C22				
Parameter	**Min**	**Typ**	**Max**	**Units**	**Comments**
Output channels					
Sampling rate[1]	100		500	MSa/s	
Output frequency	0		200	MHz	Limited by a reconstruction filter
Output voltage	–1.5		1.5	Volts	On a 50 Ω load
Source impedance		50		Ω	
Reference clock output					
Frequency		10 to 12.5[2]		MHz	Generated from the internal clock, user selectable
Voltage		800		mV_{pp}	On a 50 Ω load
Power		2		dBm	On a 50 Ω load
Source impedance		50		Ω	AC coupled
External I/O trigger/marker					
V_{IH}	2		5	V	
V_{IL}	0		0.8	V	
V_{OH}	2.4		3.3	V	On a high Z load
V_{OL}	0		0.25	V	On a high Z load
Input impedance		10		K Ω	
Source impedance		TTL		–	
Speed		100		MHz	

1. (-CLV) option: 100 to 500 MSa/s; (-CLF) option: fixed 500 MSa/s
2. CLF option is set to 10 MHz while with CLV option varies from 12.5 MHz to 10 MHz

Function generators (FGs) specifications

Parameter	M3302A-C22 Min	Typ	Max	Units	Comments
General specifications					
Function generators		2		–	1 per channel
Waveform types		4		–	Sinusoidal, triangular, square and DC
Frequency range	0		200	MHz	
Frequency resolution		45		Bits	
Frequency resolution		5.7		µHz	
Phase range	0		360	Deg	
Phase resolution		24		Bits	
Phase resolution		21.5		µdeg	
Speed performance					
Frequency change rate		100		MChanges/s	With HVI technology
Frequency modulation rate		500		MSamples/s	With AWGs and angle modulators
Phase change rate		100		MChanges/s	With HVI technology
Phase modulation rate		500		MSamples/s	With AWGs and angle modulators

Amplitude and offset specifications

Parameter	M3302A-C22 Min	Typ	Max	Units	Comments
General specifications					
Amplitude/offset range	–1.5		1.5	Volts	Amplitude + offset values
Amplitude/offset resolution		16		Bits	
Amplitude/offset resolution		45.8		µV	
Speed performance					
Amplitude/offset change rate		500		MChanges/s	With HVI technology
Amplitude/offset modulation rate		500		MSamples/s	With AWGs and amplitude modulators

Arbitrary waveform generators (AWGs) specifications

Parameter	M3302A-C22 Min	Typ	Max	Units	Comments
General specifications					
Dual AWGs		2			1 Dual AWG per output channel
Aggregated speed (16 bits)			2000	MSa/s	For all onboard waveforms combined
Aggregated speed (32 bits)			1000	MSa/s	For all onboard waveforms combined
Waveform multiple		5		Samples	Waveform length must be a multiple of this value
16-bit waveform length	15		957M	Samples	Maximum depends on onboard RAM
32-bit waveform length	10		478M	Samples	Maximum depends on onboard RAM
Waveform length efficiency		93.5		%	Effic. = waveform size/waveform size in RAM
Trigger		Selec.			External Trigger (input connector, backplane triggers), software trigger
AWG specifications (16-bit single waveform)					
Speed			500	MSa/s	Per AWG
Resolution		16		Bits	
AWG destination		Selec.			Amplitude, offset, frequency or phase
AWG specifications (16-bit dual waveform)					
Speed (waveform A)			500	MSa/s	Per AWG
Speed (waveform B)			500	MSa/s	Per AWG
Resolution (waveform A)		16		Bits	
Resolution (waveform B)		16		Bits	
AWG destination (waveform A)		Selec.			Amplitude, offset or I
AWG destination (waveform B)		Selec.			Frequency, phase or Q
AWG specifications (32-bit single waveform)					
Speed			100	MSa/s	Per AWG, minimum prescaler: 1
Resolution		32		Bits	
AWG destination		Selec.			Amplitude, offset, frequency or phase
AWG specifications (32-bit dual waveform)					
Speed (waveform A)			100	MSa/s	Per AWG, minimum prescaler: 1
Speed (waveform B)			100	MSa/s	Per AWG, minimum prescaler: 1
Resolution (waveform A)		32		Bits	
Resolution (waveform B)		32		Bits	
AWG destination (waveform A)		Selec.			Amplitude or offset
AWG destination (waveform B)		Selec.			Frequency or phase

Angle modulators specifications

Parameter	M3302A-C22 Min	Typ	Max	Units	Comments
General specifications					
Frequency modulators		2			1 per output channel
Phase modulators		2			1 per output channel
Carrier signal source		FGs			Table 3 on page 8
Modulating signal source		AWGs			Table 5 on the 9
Frequency modulators (16-bit modulating waveform)					
Deviation	–Dev. gain		+Dev. gain	MHz	
Modulating signal resolution		16		Bits	AWG waveform
Modulating signal BW	0		250	MHz	AWG Nyquist limit
Deviation gain	0		200	MHz	
Deviation gain resolution		16		Bits	
Frequency modulators (32-bit modulating waveform)					
Deviation	–Dev. gain		+Dev. gain	MHz	
Modulating signal resolution		32		Bits	AWG waveform
Modulating signal BW	0		50	MHz	AWG Nyquist limit
Deviation gain	0		200	MHz	
Deviation gain resolution		16		Bits	
Phase modulators (16-bit modulating waveform)					
Deviation	–Dev. gain		+Dev. gain	Deg	
Modulating signal resolution		16		Bits	AWG waveform
Modulating signal BW	0		250	MHz	AWG Nyquist limit
Deviation gain	0		180	Deg	
Deviation gain resolution		16		Bits	~ 5.5 mdeg
Phase modulators (32-bit modulating waveform)					
Deviation	–Dev. gin		+Dev. gain	Deg	
Modulating signal resolution		16		Bits	AWG waveform is truncated
Modulating signal BW	0		50	MHz	AWG Nyquist limit
Deviation gain	0		180	Deg	
Deviation gain resolution		16		Bits	~ 5.5 mdeg

Amplitude modulators specifications

Parameter	M3302A-C22 Min	Typ	Max	Units	Comments
General specifications					
Amplitude modulators		2			1 per output channel
Offset modulators		2			1 per output channel
Carrier signal source		FGs			Table 3 on page 8
Modulating signal source		AWGs			Table 5 on page 9
Amplitude & offset modulators (16-bit modulating waveform)					
Deviation	–Dev. gain		+Dev. gain	V_p	
Modulating signal resolution		16		Bits	AWG waveform
Modulating signal BW	0		250	MHz	AWG Nyquist limit
Deviation gain	0		1.5	V_p	
Deviation gain resolution		16		Bits	Limited by the output DAC
Amplitude & offset modulators (32-bit modulating waveform)					
Deviation	–Dev. gain		+Dev. gain	Vp	
Modulating signal resolution		16		Bits	AWG waveform is truncated
Modulating signal BW	0		50	MHz	AWG Nyquist limit
Deviation gain	0		1.5	V_p	
Deviation gain resolution		16		Bits	Limited by the output DAC

IQ modulators specifications

Parameter	M3302A-C22 Min	Typ	Max	Units	Comments
General specifications					
IQ modulators		2			1 per output channel
Carrier signal source		FGs			Table 3 on page 8
Modulating signal source		AWGs			Table 5 on page 9
External I/O trigger/marker					
Amplitude deviation	–1.5		1.5	Vp	
Phase deviation	–180		180	Deg	
I modulating signal resolution		16		Bits	AWG waveform
I modulating signal BW	0		250	MHz	AWG Nyquist limit
Q modulating signal resolution		16		Bits	AWG waveform
Q modulating signal BW	0		250	MHz	AWG Nyquist limit

Clock system specifications

Parameter	M3302A-C22 Min	Typ	Max	Units	Comments
General specifications					
Clock frequency[1]	> 100		500	MHz	

1. (-CLV) option: 100 to 500 MSa/s; (-CLF) option: fixed 500 MSa/s

AC performance

Parameter	M3302A-C22 Min	Typ	Max	Units	Comments
General characteristics					
Analog output jitter		< 2		ps	RMS (cycle-to-cycle)
AWG trigger to output jitter		< 2		ps	RMS (cycle-to-cycle) for any trigger referenced to the chassis clock; independent of input trigger jitter if input jitter < 4nS peak-to-peak
Trigger resolution		10		ns	
Channel-to-channel skew		< 20		ps	Between ch 0 & ch 1, and ch 2 & ch 3
		< 50		ps	Between any channel
		< 150		ps	Between modules, chassis dependant[2]
Clock output jitter		< 2		ps	RMS (cycle-to-cycle)
Clock accuracy and stability		100		ppm	PXIe, cPCIe versions; chassis dependent[1].
AC characteristics					
Spurious-free dynamic range (SFDR)					P_{out} = 4 dBm, measured from DC to max frequency
f_{out} = 10 MHz		68		dBc	
f_{out} = 80 MHz		64		dBc	
f_{out} = 120 MHz		57		dBc	
f_{out} = 160 MHz		54		dBc	
Crosstalk (adjacent channels)					
f_{out} = 10 MHz		< –105		dB	
f_{out} = 80 MHz		–75		dB	
f_{out} = 120 MHz		–88		dB	
f_{out} = 160 MHz		–73		dB	
Crosstalk (non-adjacent channels)					
f_{out} = 10 MHz		< –105		dB	
f_{out} = 80 MHz		–78		dB	
f_{out} = 120 MHz		< –105		dB	
f_{out} = 160 MHz		–92		dB	
Phase noise (SSB)					
offset = 1 KHz		< –127		dBc/Hz	
offset = 10 KHz		< –133		dBc/Hz	
offset = 100 KHz		< –138		dBc/Hz	
Average noise power density		< –145		dBm/Hz	

1. This value corresponds to a M9505A chassis. This value can be improved with an external chassis clock or a system timing module.
2. This value corresponds to a M9005A PXIe chassis.

AC performance, typical

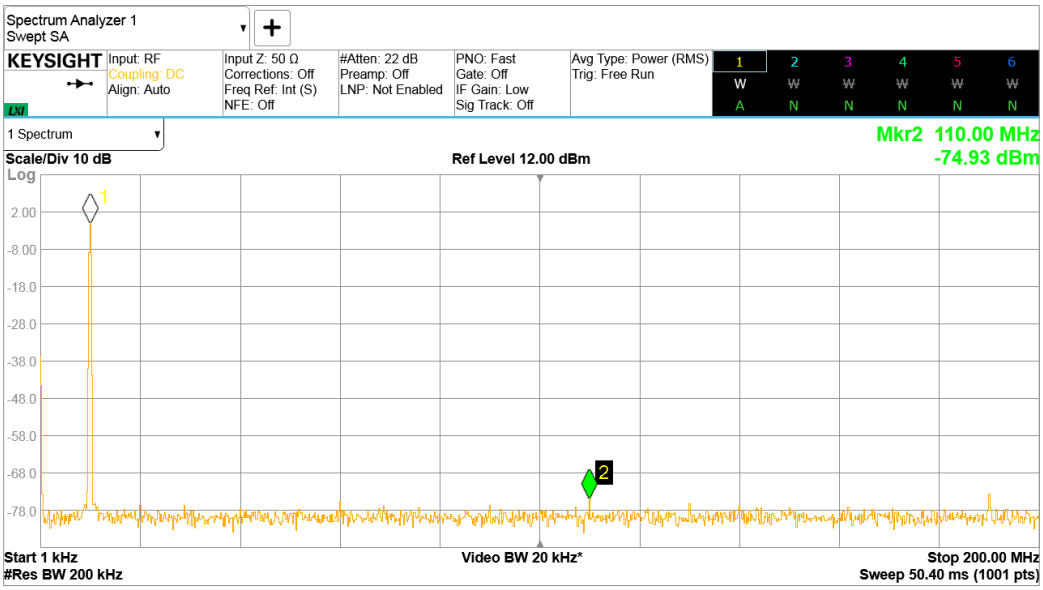


Figure 3. Single-tone spectrum @ f_{out} = 10 MHz

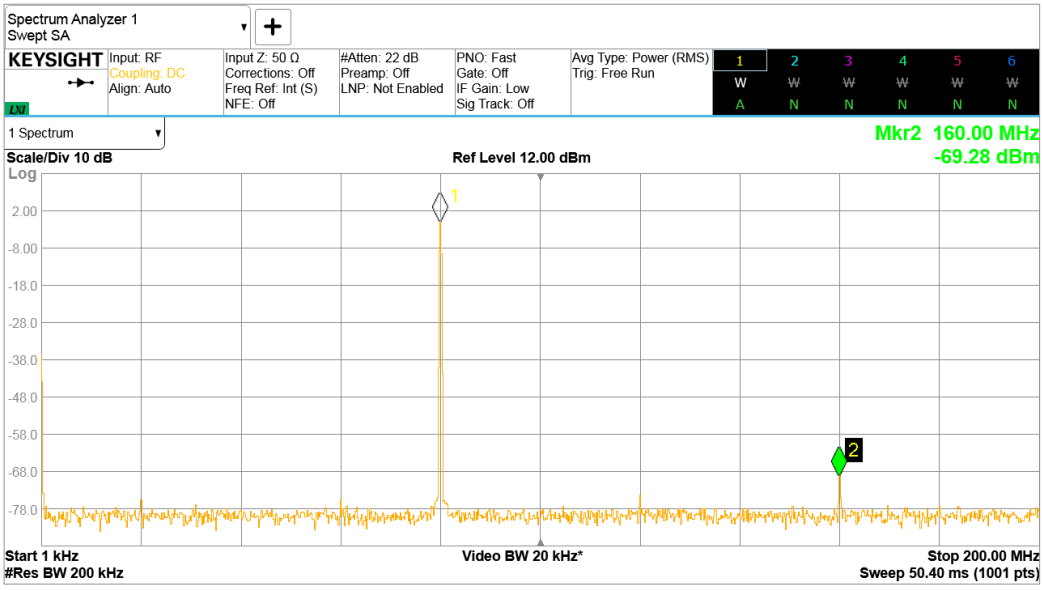


Figure 4. Single-tone spectrum @ f_{out} = 80 MHz

AC performance, typical

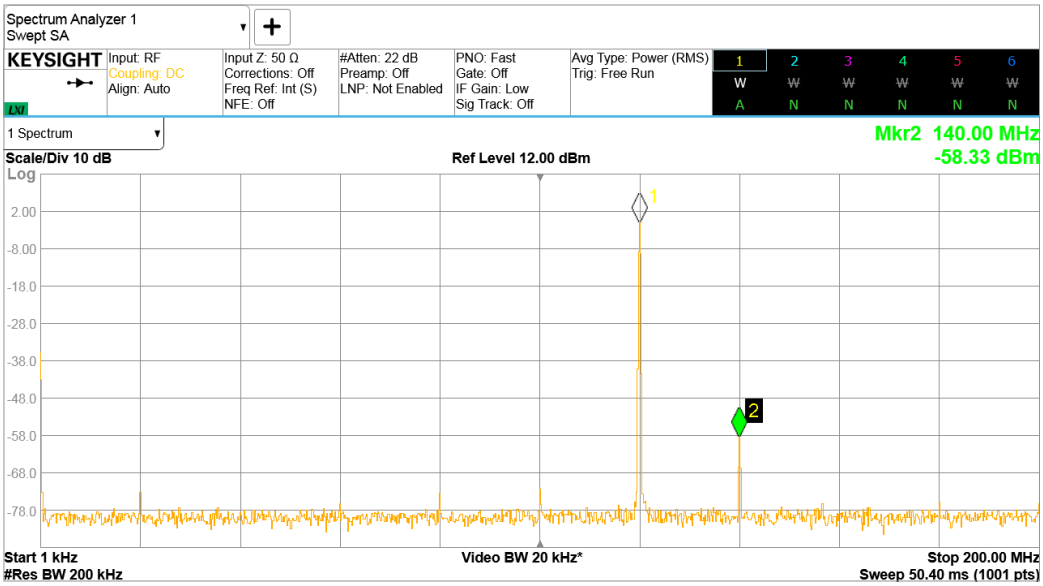


Figure 5. Single-tone spectrum @ f_{out} = 120 MHz

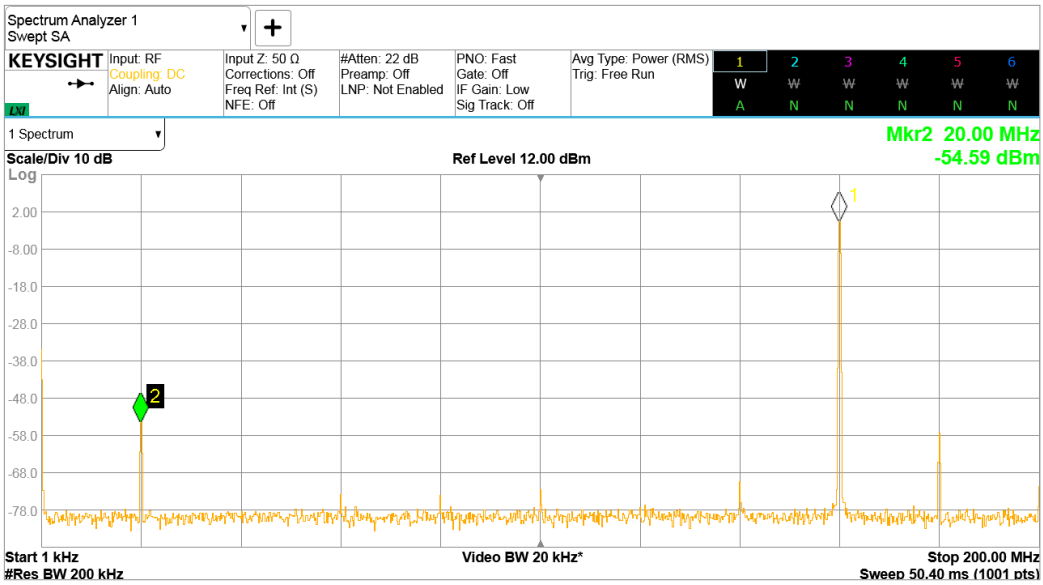


Figure 6. Single-tone spectrum @ f_{out} = 160 MHz

Digitizer Technical Specifications and Characteristics

General characteristics

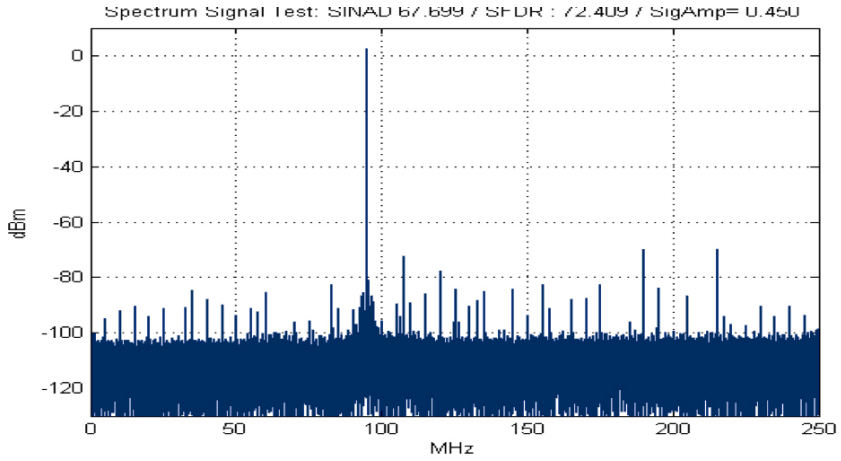
Parameter	M3302A-C22 Min	Typ	Max	Units	Comments
Inputs and outputs					
Channels		2		Out	
Reference clock[1]		1		Out	
Reference clock[2]		1		In	
Triggers/markers[1, 3]		1		In/out	Reconfigurable
Triggers/markers[2, 3]		8		In/out	Reconfigurable
Input channels overview					
Sampling rate[4]		500		MSa/s	
Voltage resolution		14		Bits	
Input frequency	0		200	MHz	
Real-time BW		200		MHz	
Time skew		< 50		ps	Between channels
Built-in functionalities					
Input conditioning blocks		2			1 per channel
Analog trigger processors		2			1 per channel
Data acquisition blocks		2			1 per channel
Onboard memory					
RAM memory	16		2048	MBytes	

1. At front panel
2. At backplane
3. Markers available from firmware version v3.0 or later
4. (-CLV) option: 100 to 500 MSa/s; (-CLF) option: fixed 500 MSa/s

I/O specifications

Analog input characteristics	
Number of channels	C22
Sampling rate	500 MSa/s option -CLF variable rate option -CLV
Configurable inputs: impedance	50 Ω or 1 MΩ (HiZ)
Configurable inputs: Coupling	AC or DC
Input voltage range (50 Ω)	125 mVpp to 8 Vpp (7 scales: 0.125, 0.25, 0,5, 1, 2, 4, 8 Vpp)
Input voltage range (HiZ)	200 mVpp to 16 Vpp (7 scales: 0.2, 0.4, 0.8, 2, 4, 8, 16 Vpp)
Bandwidth limit filters	200 MHz
Effective number of bits (ENOB)[1]	10.6 bits @ 95 MHz (typical)
Noise floor[1]	-146 dBm/Hz
SINAD[1]	66 dB @ 95 MHz (typical)
Spurious free dynamic range (SFDR) + Total Harmonic Distorsion[1]	71 dBc @ 95 MHz (typical)

1. measured at -1 DBFS input signal with 1 Vpp 50 Ω



Parameter	M3302A-C22 Min	Typ	Max	Units	Comments
Reference clock output					
Frequency		10 to 12.5[2]		MHz	Generated from the internal clock. User selectable
Voltage		800		mVpp	On a 50 Ω load
Power		2		dBm	On a 50 Ω load
Source impedance		50		Ω	AC coupled
External I/O trigger/marker					
V_{IH}	2		5	V	
V_{IL}	0		0.8	V	
V_{OH}	2.4		3.3	V	On a high Z load
V_{OL}	0		0.25	V	On a high Z load
Input impedance		10		KΩ	
Source impedance		TTL		-	
Speed		100		MHz	

2. CLF option is set to 10 MHz while with CLV option varies from 12.5 MHz to 10 MHz

Data acquisition blocks (DAQs) specifications

Parameter	M3302A-C22 Min	Typ	Max	Units	Comments
General specifications					
DAQs		2			1 per channel
Aggregated speed			1000	MSa/s	For all onboard DAQs combined
Acquisition burst multiple		5		Samples	Burst length must be a multiple of this value
Acquisition RAM capacity	15		957M	Samples	Maximum depends on onboard RAM
Acquisition RAM capacity effic.		93.5		%	Effic. = waveform size/waveform size in RAM
Trigger		Selec.			Hardware trigger (analog channels, input trigger, backplane triggers), Software trigger
DAQ specifications					
Speed			500	MSa/s	Per DAQ
Resolution		14		Bits	

Clock system specifications

Parameter	M3302A-C22 Min	Max	Units	Comments
General specifications				
Clock frequency (-CLF)	500	500	MHz	Fixed clock
Clock frequency (-CLV)	100	500	MHz	Variable clock

System Specifications

Environmental specifications (PXI Express)

Parameter	M3302A-C22 Min	Typ	Max	Units	Comments
System bus					
Slots		2		Slots	PXI Express (CompactPCI Express compatible)
PCI Express type	Gen 1		Gen 2	–	Automatic gen negotiation, chassis dependent
PCI Express link	1		4	Lanes	Automatic lane negotiation, chassis dependent
Power dissipation					
3.3 V PXIe power supply		3		A	~ 10 W
12 V PXIe power supply		3.5		A	~ 40 W

Environmental [1]		
Temperature range	Operating Non-operating	0 to +55°C (10,000 feet) -40 to +70 °C (up to 15,000 feet)
Max operative altitude		4000 m (10,000 feet)
Operating Humidity range (%RH)		10 to 95% at 40 °C
Non-operating Humidity range (%RH): 5 to 95		5 to 95%
Calibration interval		1 year
EMC		Complies with European EMC Directive – IEC/EN 61326-1 – CISPR Pub 11 Group 1, class A This ISM device is in compliance with Canadian ICES-001 Cet appareil ISM est conforme à la norme NMB-001 du Canada. This ISM device is in compliance with Australian and New Zealand RCM This ISM device is in compliance with South Korea EMC KCC

1. Samples of this product have been type tested in accordance with the Keysight Environmental Test Manual and verified to be robust against the environmental stresses of Storage, Transportation and End-use; those stresses include but are not limited to temperature, humidity, shock, vibration, altitude and power line conditions. Test Methods are aligned with IEC 60068-2 and levels are similar to MIL-PRF-28800F Class 3.

Ordering Information [1]

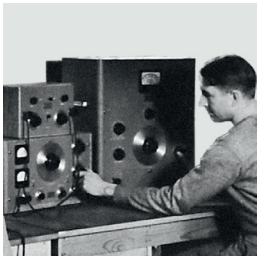
Product	Description
M3302A	Arbitrary waveform generator: 500 MSa/s, 16 Bits + digitizer: 500 MSa/s, 14 Bits
Options	**Description**
M3302A-C22	Two channels AWG + Two channels DIG [2]
M3302A-CLV / -CLF	Variable sampling clock [2] / fixed sampling clock, low jitter
M3302A-DM1	Dual modulation capability for the AWG (amplitude and angle simultaneously)
M3302A-M01 / -M12 / -M20	Memory 16 MB, 8 MSamples [2] / 128 MB, 60 MSamples / 2 GB, 1 GSamples
HW programming options	**Description**
M3302A-HVI	Enabled HVI programming, requires an HVI design environment license (M3601A)
M3302A-FP1	Enabled FPGA programming, requires -K32 or -K41 option and an FPGA design environment license (M3602A)
M3302A-K32 / -K41	FPGA, Xilinx 7K325T / 7K410T, required for -FP1 option only (needs memory option -M20)

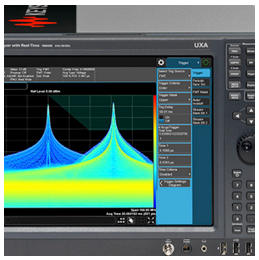
Related software	Description
M3601A	HVI design environment
M3602A	FPGA design environment

1. All options must be selected at time of purchase and are not upgradable
2. These options represent the standard configuration

Evolving Since 1939

Our unique combination of hardware, software, services, and people can help you reach your next breakthrough. We are unlocking the future of technology.
From Hewlett-Packard to Agilent to Keysight.





myKeysight

myKeysight
www.keysight.com/find/mykeysight
A personalized view into the information most relevant to you.

http://www.keysight.com/find/emt_product_registration
Register your products to get up-to-date product information and find warranty information.

PXI

www.pxisa.org
PCI eXtensions for Instrumentation (PXI) modular instrumentation delivers a rugged, PC-based high-performance measurement and automation system.

KEYSIGHT SERVICES
Accelerate Technology Adoption.
Lower costs.

Keysight Services
www.keysight.com/find/service
Keysight Services can help from acquisition to renewal across your instrument's lifecycle. Our comprehensive service offerings—one-stop calibration, repair, asset management, technology refresh, consulting, training and more—helps you improve product quality and lower costs.

CALIBRATION WARRANTY UP TO 10 YEARS
ASSURANCE PLANS

Keysight Assurance Plans
www.keysight.com/find/AssurancePlans
Up to ten years of protection and no budgetary surprises to ensure your instruments are operating to specification, so you can rely on accurate measurements.

Keysight Channel Partners
www.keysight.com/find/channelpartners
Get the best of both worlds: Keysight's measurement expertise and product breadth, combined with channel partner convenience.

www.keysight.com/find/m3302a

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at:
www.keysight.com/find/contactus

Americas

Canada	(877) 894 4414
Brazil	55 11 3351 7010
Mexico	001 800 254 2440
United States	(800) 829 4444

Asia Pacific

Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 11 2626
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 6375 8100

Europe & Middle East

Austria	0800 001122
Belgium	0800 58580
Finland	0800 523252
France	0805 980333
Germany	0800 6270999
Ireland	1800 832700
Israel	1 809 343051
Italy	800 599100
Luxembourg	+32 800 58580
Netherlands	0800 0233200
Russia	8800 5009286
Spain	800 000154
Sweden	0200 882255
Switzerland	0800 805353 Opt. 1 (DE) Opt. 2 (FR) Opt. 3 (IT)
United Kingdom	0800 0260637

For other unlisted countries:
www.keysight.com/find/contactus
(BP-9-7-17)

DEKRA Certified
ISO9001 Quality Management System

www.keysight.com/go/quality
Keysight Technologies, Inc.
DEKRA Certified ISO 9001:2015
Quality Management System

Published in USA, February 20, 2018
5992-1808EN
www.keysight.com

KEYSIGHT TECHNOLOGIES