

IEEE Recommended Practice for Using IEEE 1671.2™ Instrument Description Templates for Describing Synthetic Instrumentation for Classes of Instruments such as Waveform Generators, Digitizers, External Oscillators, and Up and Down Converters

IEEE Standards Coordinating Committee 20

Sponsored by the

IEEE Standards Coordinating Committee 20 on
Test and Diagnosis for Electronic Systems

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USA

IEEE Std 1871.1™-2014

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Abstract: Instrument Description templates, compliant with IEEE Std 1671.2-2012, that providers of synthetic instruments should use to describe waveform generators, digitizers, external local oscillators, and up and down converters are provided in this recommended practice. These synthetic instruments may be integrated in an automatic test system (ATS) that is to be used to test and diagnose a unit under test (UUT).

Keywords: ATML instance document, ATS, automatic test equipment (ATE), Automatic Test Markup Language (ATML), automatic test system, IEEE 1671.2™, IEEE 1871.1™, instrument, instrumentation, synthetic instrument, XML schema

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Introduction

This introduction is not part of IEEE Std 1871.1™-2014, IEEE Recommended Practice for Using IEEE 1671.2™ Instrument Description Templates for Describing Synthetic Instrumentation for Classes of Instruments such as Waveform Generators, Digitizers, External Oscillators, and Up and Down Converters.

The Synthetic Instrument Working Group (SIWG) was formed, at Department of Defense request, to define synthetic instrumentation and its attributes. The SIWG also developed a framework that balances user and supplier objectives, facilitates rapid technology advancements and adaption throughout the test life cycle, and complements/supports other relevant test and measurement industry activities.

The goals or desired effects of the SIWG activities were to:

- a) Reduce the total cost of ownership of the automatic test system (ATS).
- b) Reduce time to develop and field new or upgraded ATS's.
- c) Provide greater flexibility to the war fighter through the U.S. and coalition partner's interoperable ATS's.
- d) Reduce the ATS's logistics footprint.
- e) Reduce the ATS's physical footprint.
- f) Improve the quality of test.

The SIWG addressed the reductions from the test and measurement perspective. The SIWG efforts resulted in both the definition of synthetic instruments and the specifications of their respective attributes.

Synthetic instruments were originally part of IEEE Std 1671.2-2008, as both an example of *InstrumentDescription* instances as well as to provide a definition of the necessary parameters/attributes to document a synthetic instrument as defined by the SIWG.

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1. Overview

1.1 Scope

This recommended practice provides Instrument Description templates, compliant with IEEE 1671.2, that providers of synthetic instruments should use to describe waveform generators, digitizers, external local oscillators, and up and down converter.

1.2 Purpose

The purpose of this recommended practice is to provide the definition of synthetic instruments as well as identify the following requirements for each of the synthetic instruments:

- a) Input
- b) Output
- c) Time base
- d) Power
- e) Physical
- f) Communications and control
- g) Memory parameter
- h) High-speed data port
- i) Validation

1.3 General

Automatic test markup language (ATML) is a collection of IEEE standards and associated extensible markup language (XML) schemas that allow automatic test system (ATS) and test information to be exchanged in a common format adhering to the XML standard.¹

The ATML framework and the ATML family of standards have been developed and are maintained under the guidance of the Test Information Integration (TII) Subcommittee of IEEE Standards Coordinating Committee 20 (SCC20) to serve as a comprehensive environment for integrating design data, test strategies, test requirements, test procedures, test results management, and test system implementations, while allowing test program (TP), test asset interoperability, and unit under test (UUT) data to be interchanged between heterogeneous systems.

This recommended practice provides both the definition of synthetic instruments as well as the requirements and XML template instance document element descriptions for instrument input/output (I/O), communication ports, internal instrument requirements (time base, power, memory, etc.) and validation requirements.

The synthetic instruments are defined in Clause 4 and consist of the following:

- a) Waveform generator (requirements and XML elements are identified in Clause 5)
- b) Digitizer (requirements and XML elements are identified in Clause 6)
- c) Down converter (requirements and XML elements are identified in Clause 7)
- d) Local oscillator (LO) (requirements and XML elements are identified in Clause 8)
- e) Up converter (requirements and XML elements are identified in Clause 9)

The IEEE 1671.2 XML template instance documents (*SyntheticWaveformGenerator.xml*, *Digitizer.xml*, *DownConverter.xml*, *UpConverter.xml*) provide for the specifications of their respective instrument I/O, communication ports, internal instrument requirements (time base, power, memory, etc.) and validation requirements. These four XML template instance documents are available as described in Annex A.

¹ This information is given for the convenience of users of this standard and does not constitute an endorsement by the IEEE of this consortium standard. Equivalent standards or products may be used if they can be shown to lead to the same results.

1.4 Application of this document's annexes

This document includes three annexes. Annex A, Annex B, and Annex C are informative, and thus are provided strictly as information for users, implementers, and maintainers of this document.

1.5 Usage

This recommended practice (as well as the four XML template instance documents that accompany IEEE Std 1671.2-2012) are intended to be used in documenting synthetic instrument I/O and communication ports, internal instrument requirements (time base, power, memory, etc.) and validation requirements.²

1.6 XML template documents

XML templates are well formed XML instance documents. XML templates provide for a consistent overall look and layout by providing an organized and structured set of contents. The XML templates guide and direct information input by defining which fields are required, which are optional, and what cannot be entered; along with the permissible value sets that may populate each field.

Utilization of XML templates enables faster software development at a reduced cost. Developers can simply insert their data into a copy of the XML template; and do not have to spend time defining the parameters and identifying how they should be specified.

1.7 IEEE 1671.2 XML template documents

IEEE 1671.2 XML template documents' (*SyntheticWaveformGenerator.xml*, *Digitizer.xml*, *DownConverter.xml*, *UpConverter.xml*) contents have been generated by domain experts in the instrumentation field. These templates represent the domain expert's mutual agreement on what parameters need to be defined and how they should be specified.

These XML template instance documents should be used by vendor's either developing or providing synthetic instruments; as the basis for documenting the synthetic instrument's I/O and communication ports, internal instrument requirements (time base, power, memory, etc.) and validation requirements. When the vendor's actual values are incorporated into their XML instance document (which use the XML template instance document as a basis) for a particular synthetic instrument, that XML instance document will be valid against the IEEE 1671.2 XML schemas.

1.8 Application

Synthetic instruments link a series of hardware (HW) and software (SW) components with standardized interfaces, to generate signals or make measurements using algorithmic numeric processing techniques. The goal is to decrease the total cost of ownership of an ATS, to lessen the time to develop and field new or upgraded an ATS, to reduce the test system logistics footprint, and finally, to improve the quality of test.

The information contained in a XML instance document that utilizes a synthetic instrument XML template instance document(s) will be useful to the following:

² Information on references can be found in Clause 2.

- a) Instrument developers
- b) Instrument maintainers
- c) ATE system developers
- d) ATE system maintainers
- e) Developers of ATML-based tools and systems

1.9 Conventions used within this document

1.9.1 General

This recommended practice uses the vocabulary and definitions of relevant IEEE standards. In case of conflict of definitions, except for those portions quoted from standards, the following precedence shall be observed: (1) Clause 3, and (2) *The IEEE Standards Dictionary Online* [B1].³

1.9.2 Precedence

IEEE 1671.2 *InstrumentDescription* schema (InstrumentDescription.xsd) element, child element, and annotation information shall take precedence over the descriptive information contained in Clause 4 through Clause 9.

IEEE Std 1671™ *Common* schema (Common.xsd) element, child element, and annotation information shall take precedence over the descriptive information contained in Clause 4 through Clause 9.

IEEE Std 1671 *HardwareCommon* schema (HardwareCommon.xsd) element, child element, and annotation information shall take precedence over the descriptive information contained in Clause 4 through Clause 9.

1.9.3 Word usage

In accordance with *the IEEE Standards Style Manual* [B2], the word *shall* is used to indicate mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*). The use of the word *must* is used only to describe unavoidable situations. The use of the word *will* is only used in statements of fact.

The word *should* is used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability (*can* equals *is able to*).

³ The numbers in brackets correspond to those of the bibliography in Annex C.

1.9.4 Units of measure/description

For the purpose of this recommended practice, the term ‘units of measure/description’ should be understood to mean any standard unit(s), system of units for which a quantity can be expressed (for example the dollar is the United States unit of currency), or a textual description.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 1671™-2010, IEEE Standard for Automatic Test Equipment Markup Language (ATML) for Exchanging Automatic Test Equipment and Test Information via XML.^{4, 5}

IEEE Std 1671.2™-2012, IEEE Standard for Automatic Test Equipment Markup Language (ATML) Instrument Description.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* [B1] should be consulted for terms not defined in this clause.⁶ In the event a term is explicitly redefined, or defined in more detail, in an ATML component standard, the component standard’s definition shall be normative for that ATML component standard.

element: A bounded component of the logical structure of an eXtensible Markup Language (XML) document that has a type and that may have XML attributes and content. [adapted from eXtensible Markup Language (XML) 1.0 (Fourth Edition)]

entity: Something that has a distinct separate existence.

eXtensible Markup Language (XML) attribute: Name-value pair associated with an XML element.

eXtensible Markup Language (XML) document: A data object that conforms to the XML requirements for being well formed. In addition, the data object is valid if it additionally conforms to semantic rules of the XML schema.

eXtensible Markup Language (XML) schema: The definition of a class of XML document, typically expressed in terms of constraints on the structure and the content of documents of that class, above and beyond the basic syntax constraints imposed by XML itself.

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⁶ *IEEE Standards Dictionary Online* subscription is available at:
http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html.

instance document: An eXtensible Markup Language (XML) document that conforms to a particular XML schema.

instrument: Devices (chemical, electrical, hydraulic, magnetic, mechanical, optical, pneumatic) that may be utilized to test, observe, measure, monitor, alter, generate, record, calibrate, manage, or control physical properties, movements, or other characteristics. (adapted from MIL-STD-1309D)

synthetic instrument (SI): A series of hardware and software components, with standardized interfaces, to generate signals or make measurements using algorithmic/numeric processing techniques.

virtual instrument: A computer or workstation equipped with application software, instrumentation hardware, and driver software, that together perform the functions of traditional instrument.

3.2 Acronyms and abbreviations

ac	alternating current
ADC	analog-to-digital converter
ALC	automatic level control
AM	amplitude modulation
API	application programming interface
ARB	arbitrary waveform generator
ATE	automatic test equipment
ATML	Automatic Test Markup Language
ATS	automatic test system
BER	bit error rate
BW	bandwidth
CG	conversion gain
CMOS	complimentary metal-oxide semiconductor
COTS	commercial-off-the-shelf
CPU	central processing unit
CW	continuous wave
D/A	digital-to-analog
DA	direct analog
DAC	digital-to-analog converter
dB	decibel
dBc	decibels relative to the carrier
dBm	decibels referenced to one milliwatt (mW)
dc	direct current
DDS	direct digital synthesis
DNL	differential nonlinearity

DOM	depth of modulation
DSP	digital signal processing
ECL	emitter coupled logic
ENOB	effective number of bits
EXT	external
F	noise factor, frequency
FGEN	function generator
FH	frequency-high
FL	frequency-low
FM	frequency modulation
FPGA	field programmable gate array
FR	frequency resolution
FSR	full-scale range
GHz	gigahertz
GPIO	general purpose interface bus
HSD	high-speed data
HW	hardware
Hz	hertz
I	in-phase
I/O	input/output
IBW	instantaneous bandwidth
IF	intermediate frequency
IMD	inter-modulation distortion
INL	integrated nonlinearity
INT	internal
IP3	third-order intercept
IVI™	Interchangeable Virtual Instruments ⁷
kHz	kilohertz
LAN	local area network
lb	pound(s)
LO	local oscillator
LSB	lower sideband, least significant bit
LVDS	low-voltage differential signal
LXI™	LAN-based eXtensions for Instrumentation ⁸

⁷ IVI is a registered trademark of the IVI Foundation.

⁸ LXI is a registered trademark of the LXI Consortium.

MAC	Media Access Control
MHz	megahertz
MPW	minimum pulse width
N/A	not applicable
NF	noise figure
ns	nanosecond
OSI	open system interconnection
P1	low power level
P2	upper power level
PC	personal computer
PCI™	Peripheral Component Interconnect ⁹
PCIe®	PCI Express®
PCI-SIG®	PCI Special Interest Group
PCS	physical coding sublayer
PD	pulse duration
PECL	positive emitter coupled logic
PLL	phase lock loop
PM	pulse modulation
ppm	parts per million
PRF	pulse repetition time
PRT	pulse repetition time, pulse recurrence time
PWRRES	power resolution
PXI™	PCI eXtensions for Instrumentation ¹⁰
PXIe®	PCI eXtensions for Instrumentation Express
Q	quadrature
QPSK	quadrature phase shift keying
RF	radio frequency
RF/UW	radio frequency/microwave
RFI	reference frequency input
RFO	reference frequency output
RL	return loss
rms	root mean square

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SCC20	Standards Coordinating Committee 20
SCPI	standard commands for programmable instrumentation
SFDR	spurious free dynamic range
SHE	stimulus hardware emulator
SI	synthetic instrument
SiNAD	signal to noise and distortion
SIWG	Synthetic Instrument Working Group
SNDR	signal-to-noise and distortion ratio
SNR	signal-to-noise ratio
SW	software
TDMA	Time Division Multiple Access
thd	total harmonic distortion
TII	Test Information Integration
TP	test program
TPS	test program set
TTL	transistor transistor logic
UI	unit interval
UPCONSYN	up converter/synthesizer
USB	upper sideband
UUT	unit under test
UW	microwave
VSWR	voltage standing wave ratio
VXI	VME eXtensions for Instrumentation
WFM	waveform memory
XML	eXtensible Markup Language

4. Synthetic instrumentation

A synthetic instrument (SI) is defined as a reconfigurable system that links a series of “elemental” hardware (HW) and software (SW) components, with standardized interfaces, to generate signals or make measurements using numeric processing techniques. In the context of this definition, a component is defined as a functional HW module (digital-to-analog conversion, radio frequency (RF) Upconversion, RF Downconversion, or analog-to-digital conversion) or SW module (signal generation or analysis algorithm, resource controller, etc.). The term *elemental* pertains to the lowest level building block with standardized I/O definitions.

Within Figure 1, the elemental building blocks (those shaded the darker grey) are the SI targets of interest.

The SI architecture is predicated upon being synthesized utilizing readily available commercial-off-the-shelf (COTS) HW/SW modules and data busses such as VXI, PXI/PXIe, LXI/LAN, and IVI, to name a

few. The architecture is flexible and may be synthesized as a “hybrid” system employing a combination of HW/SW technology standards.

Due to the modularity of the architecture and its compatibility with existing mainstream HW/SW module/standards, technological innovation and upgrade is assured by a broad industrial base of products and processes in both the instrumentation and information technology industries.

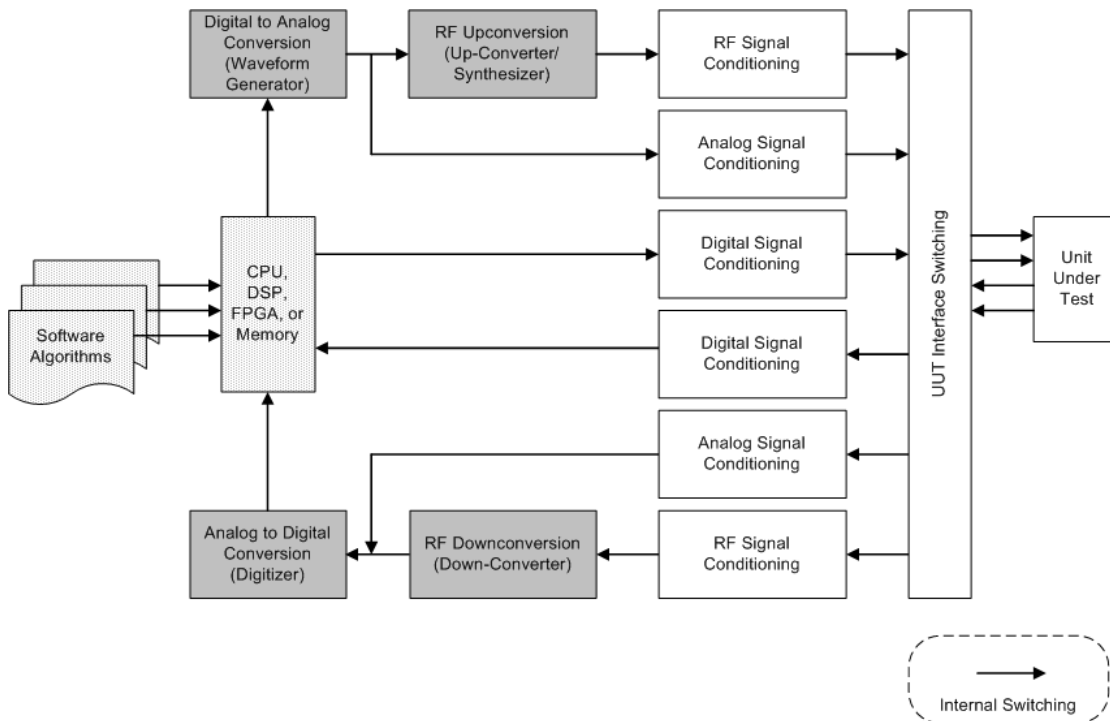


Figure 1—High-level synthetic instrument model

4.1 Digital-to-analog conversion

A critical SI component is the *waveform generator*.

By definition, the primary function of a SI waveform generator is “digital-to-analog conversion.”

Waveform generators come in many different types of instantiations that may employ similar or different circuit topologies/interconnection schemes, form factors, and specification behaviors; Clause 5 focuses only on the essential and therefore common attributes of all SI waveform generators regardless of implementation as well as those attributes unique to *function generators* (FGEN) and *arbitrary waveform generators* (ARB). When contemplating the replacement of a waveform generator in a SI context, it is important for the SI user to consider the selection/design of a replacement unit based on satisfying the triad of requirements of the existing waveform generator.

The intent of Clause 5 is to provide “best specification practices” and guidance to the user in specifying/characterizing waveform generator parameters, for use in a SI context, for new development and/or replacement purposes.

Each specification parameter or group of specification parameters specified in Clause 5 may or may not be applicable in support of a particular application. Also, different waveform generators available in the marketplace may or may not possess all of the features or functionalities specified and described in

Clause 5. The defined ports and associated functionality may or may not be required based on the use case or application for which a waveform generator is intended.

4.2 Analog-to-digital conversion

A critical SI component is the *digitizer*.

By definition, the primary function of an SI digitizer is “analog-to-digital conversion by means of sampling.”

Digitizers come in many different types of instantiations that may employ similar or different circuit topologies/interconnection schemes, form factors, and specification behaviors; Clause 6 focuses only on the essential and therefore common attributes of all SI digitizers regardless of implementation. When contemplating the replacement of a digitizer in a SI context, it is important for the SI user to consider the selection/design of a replacement unit based on satisfying the triad of requirements of the existing digitizer.

The intent of Clause 6 is to provide “best specification practices” and guidance to the user in specifying/characterizing digitizer parameters, for use in a SI context, for new development, and/or replacement purposes. Each specification parameter or group of specification parameters specified in Clause 6 may or may not be applicable in support of a particular application. Also, different digitizers available in the marketplace may or may not possess all of the features or functionalities specified and described in Clause 6. The defined ports and associated functionality may or may not be required based on the use case or application for which a digitizer is intended.

It should be noted that the following four variants of SI digitizer are addressed within the context of Clause 6:

- a) Base digitizers
- b) Digitizer with on board signal processing
- c) Digitizers with high-speed streaming data port(s)
- d) Digitizers with both high-speed ports and on board processing

4.3 RF downconversion

A critical SI component is the *downconverter*.

The primary function of a downconverter is to translate a frequency or group of frequencies from a higher frequency, usually in the GHz range, to a lower or intermediate frequency (IF) where the signal may be more readily digitized and processed.

Downconverter’s come in many different types of instantiations that may employ similar or different circuit topologies/interconnection schemes, form factors, and specification behaviors. When contemplating the replacement of a downconverter in a SI context, it is important for the SI user to consider the selection/design of a replacement unit based on satisfying the triad of requirements of the existing Down-Converter.

The intent of Clause 7 is to provide “best specification practices” and guidance to the user in specifying/characterizing down-converter parameters, for use in a SI context, for new development and/or replacement purposes. Each specification parameter or group of specification parameters specified in Clause 7 may or may not be applicable in support of a particular application. Also, different Down-

Converter's available in the marketplace may or may not possess all of the features or functionalities specified and described in Clause 7.

Clause 8 provides “best specification practices” and guidance to the user in specifying/characterizing the down converter's external local oscillator (LO) parameters, for use in a SI context, where the down converter is to utilize an external LO.

It should be noted that two distinct flavors or variants of a down converter are addressed within the context of Clause 7, as follows:

- a) A down converter employing an embedded LO
- b) A down converter employing an external LO

4.4 RF upconversion

A critical SI component is the *up converter/synthesizer* (UPCONSYN).

The stimulus or digital to radio frequency/microwave (RF/UW) path/functionality (see Figure 1) of an SI is often referred to as a *stimulus hardware emulator* (SHE) and is comprised of digital-to-analog converter (DAC) or arbitrary waveform generator (ARB), frequency UPCONSYN, and signal conditioning functional blocks. In many instances, the UPCONSYN may incorporate signal conditioning circuitry within its functionality. In a SI context, the primary function of this SI component is to either generate a continuous wave (CW) or modulated (RF/UW) signal or translate a frequency or group of frequencies from a lower frequency, usually in the MHz range, to a higher frequency CW or modulated signal to support the testing of communications systems. Minimal or no spurious stimuli should be generated along with the desired/programmed CW or modulated output signal.

UPCONSYN designs employ similar but different circuit topologies/interconnection schemes, form factors, and specification behaviors. When contemplating the replacement of an UPCONSYN in an SI context, it is important for the SI user to consider the selection/design of a replacement unit based on satisfying the triad of requirements of the existing up converter.

The intent of Clause 9 is to provide “best specification practices” and guidance to the user in specifying/characterizing UPCONSYN parameters, for use in an SI context, for new development and/or replacement purposes. Each specification parameter or group of specification parameters specified in Clause 9 may or may not be applicable in support of a particular application. Also, different UPCONSYNs available in the marketplace may or may not possess all of the features or functionalities specified and described in Clause 9.

The core UPCONSYN (ARB/EXT IF input and an RF/UW output) with auxiliary/extension I/O functionality may or may not be required based on the use case or application for which an UPCONSYN is intended. It is the responsibility and purview of the user to determine which extensions to employ in a new development or replacement situation based on a particular use case/application.

4.5 CPU, DSP, FPGA, memory

The lighter grey shaded building blocks within Figure 1 are the purview of the user and are highly dependent on both the SW and HW architectures of the implementation.

4.6 Signal conditioning and switching

The building blocks within Figure 1 that are not shaded are the purview of the user and are highly dependent on the architecture and signal characteristics of the UUT.

5. Waveform generator requirements and XML template instance

5.1 Synthetic instrument waveform generator requirements

This clause covers the SI waveform generator I/O ports in detail. There are subclauses for each I/O port illustrated in Figure 2. In each case the controls/settings are outlined, followed by a listing of the applicable performance parameters. Where necessary additional information is provided, including parameter specification definitions, conventions, recommendations on test/validation conditions and reporting.

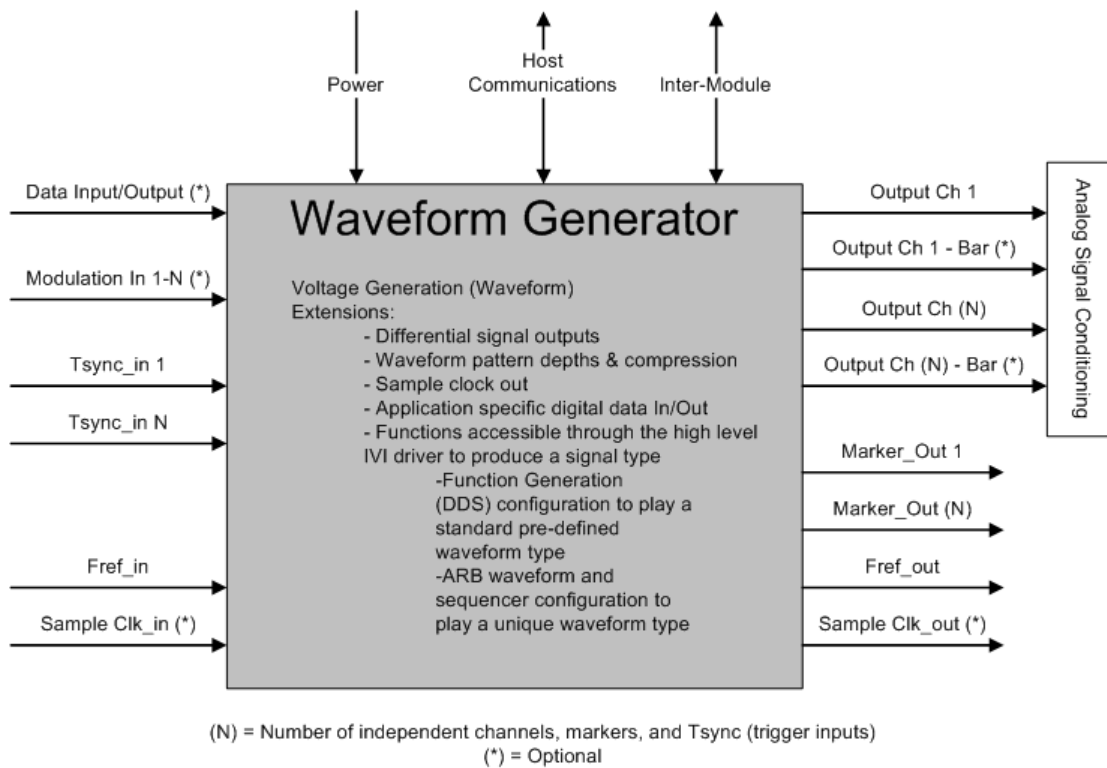


Figure 2—Waveform generator baseline model

The ports defined in Figure 2 are representative of the accepted minimum functional interface. The specific behavior and performance associated with the ports is application driven. With this in mind, the following conventions have been established:

- a) SI waveform generators with common functionality operate in the same manner
- b) The settings/controls associated with a particular functionality are common
- c) Performance is described by measured parameters with common definitions
- d) The measurement of performance parameters shall be according to “best specification practices” as described within this clause

This clause outlines the functional attributes, parameters, and figures of merit associated with a waveform generator intended for use in SI systems.

5.1.1 Input requirements

None.

5.1.2 Output requirements

5.1.2.1 Programmable settings (Channel 1-N)

Identification of the settings/controls associated with the SI waveform generator. These are broken down into those functions common to both the FGEN and the ARB.

5.1.2.1.1 Common programmable settings (Channel 1-N)

5.1.2.1.1.1 Operating mode

This shall control the “play mode” of the SI waveform generator. Operating mode specifies how the instrument will produce output waveforms on a specified channel, either “continuous” or “burst.” It does not define whether the unit is acting as a FGEN or ARB. In “continuous” mode the unit will produce an output indefinitely until stopped by operator intervention regardless of the manner in which the output is produced internally. In “burst” mode the unit will produce an output in accordance with the appropriate settings and then terminate without operator intervention.

5.1.2.1.1.1.1 Units of measure/description

None.

5.1.2.1.1.1.2 Notes

None.

5.1.2.1.1.2 Output enable

This shall be a global control. It shall control whether the output signal is connected to the specified output port. It is independent of all other settings that control the output.

5.1.2.1.1.2.1 Units of measure/description

None.

5.1.2.1.1.2.2 Notes

- a) An output will be present at the specified output port if it is enabled and triggered.
- b) The value of this setting is binary; it is either “on” (1) or “off” (0).

5.1.2.1.1.3 Output mode

This shall define the mechanism through which the unit produces an output signal on the specified port. It can be thought of as the operating mode because it defines how the unit will operate.

5.1.2.1.1.3.1 Units of measure/description

None.

5.1.2.1.1.3.2 Notes

- a) This setting has three possible values: “standard function,” “arbitrary waveform,” and “arbitrary sequence.”
- b) The FGEN functions only apply when the output mode is set to “standard function.”
- c) The ARB functions only apply when the output mode is set to either “arbitrary waveform” or “arbitrary sequence.”
- d) This setting enables and disables large portions of the application programming interface (API).

5.1.2.1.1.4 Output impedance

This shall define the output impedance of the specified channel.

5.1.2.1.1.4.1 Units of measure/description

Ohms or equivalent (to define the mode).

5.1.2.1.1.4.2 Notes

- a) This can be thought of as output impedance mode.
- b) If the unit has more than one output impedance (a variable output impedance), then this setting will have a value that defines the output impedance. Examples are 600 Ω , 50 Ω , 1 k Ω , etc.

5.1.2.1.1.5 Burst count

This shall specify the number of waveform cycles that the generator produces.

5.1.2.1.1.5.1 Units of measure/description

None.

5.1.2.1.1.5.2 Notes

None.

5.1.2.1.1.6 AM enabled

This shall specify whether the generator applies AM to the signal the generator is producing (if there is an AM function). AM enabled shall be either “on” or “off.”

5.1.2.1.1.6.1 Units of measure/description

None.

5.1.2.1.1.6.2 Notes

None.

5.1.2.1.1.7 AM internal depth

This shall specify the extent of the modulation that the generator applies to the carrier waveform when the AM source is set to “AM internal” (if there is an internal AM function).

5.1.2.1.1.7.1 Units of measure/description

Percent.

5.1.2.1.1.7.2 Notes

None.

5.1.2.1.1.8 AM internal frequency

This shall specify the frequency of the internal modulating waveform source (if there is an internal AM function).

5.1.2.1.1.8.1 Units of measure/description

Hertz.

5.1.2.1.1.8.2 Notes

None.

5.1.2.1.1.9 AM internal waveform

This shall specify the waveform of the internal modulating waveform (if there is a choice). The waveform shall be specified as either: “sine,” “square,” “triangle,” or “ramp.”

5.1.2.1.1.9.1 Units of measure/description

None.

5.1.2.1.1.9.2 Notes

None.

5.1.2.1.1.10 AM source

This shall specify the source of the modulating waveform (if applicable). AM source shall be specified as either “internal” or “external.”

5.1.2.1.1.10.1 Units of measure/description

None.

5.1.2.1.1.10.2 Notes

None.

5.1.2.1.1.11 FM enabled

This shall specify whether the generator applies FM to the signal the generator is producing (if there is an FM function). FM enabled shall be either “on” or “off.”

5.1.2.1.1.11.1 Units of measure/description

None.

5.1.2.1.1.11.2 Notes

None.

5.1.2.1.1.12 FM internal deviation

This shall specify the maximum frequency deviation that the generator applies to the carrier waveform when the FM source is set to “FM internal” (if there is an internal FM function).

5.1.2.1.1.12.1 Units of measure/description

Hertz.

5.1.2.1.1.12.2 Notes

None.

5.1.2.1.1.13 FM internal frequency

This shall specify the frequency of the internal modulating waveform source (if there is an internal FM function).

5.1.2.1.1.13.1 Units of measure/description

Hertz.

5.1.2.1.1.13.2 Notes

None.

5.1.2.1.1.14 FM internal waveform

This shall specify the waveform of the internal modulating waveform (if there is a choice). The waveform shall be specified as either: “sine,” “square,” “triangle,” or “ramp.”

5.1.2.1.1.14.1 Units of measure/description

None.

5.1.2.1.1.14.2 Notes

None.

5.1.2.1.1.15 FM source

This shall specify the source of the modulating waveform (if applicable). FM source shall be specified as either “internal” or “external.”

5.1.2.1.1.15.1 Units of measure/description

None.

5.1.2.1.1.15.2 Notes

None.

5.1.2.1.2 Unique ARB programmable settings (Channel 1-N)

5.1.2.1.2.1 Arbitrary gain

This channel-based attribute shall specify the factor by which the signal generator scales the arbitrary waveform data. When you create arbitrary waveforms, you must first normalize the data points to the range -1.0 to $+1.0$. Use this attribute to scale the arbitrary waveform to other ranges.

5.1.2.1.2.1.1 Units of measure/description

Unitless or decibel (dB).

5.1.2.1.2.1.2 Notes

None.

5.1.2.1.2.2 Arbitrary dc offset

This channel-based attribute shall specify the value that the signal generator adds to the arbitrary waveform data. When you create arbitrary waveforms, you must first normalize the data points to the range -1.0 to $+1.0$. Use this attribute to shift the arbitrary waveform range.

5.1.2.1.2.2.1 Units of measure/description

Volts.

5.1.2.1.2.2.2 Notes

None.

5.1.2.1.2.3 Arbitrary sample rate

This channel-based attribute shall specify the rate at which the signal generator outputs the points in arbitrary waveforms.

5.1.2.1.2.3.1 Units of measure/description

Samples per second.

5.1.2.1.2.3.2 Notes

None.

5.1.2.1.3 Unique FGEN programmable settings (Channel 1-N)

5.1.2.1.3.1 Amplitude

This channel-based attribute shall control the amplitude of the standard waveform that the signal generator produces. This value is the amplitude at the output terminal.

5.1.2.1.3.1.1 Units of measure/description

Volts peak-to-peak.

5.1.2.1.3.1.2 Notes

- a) The voltage swing should be specified into characteristic impedance.
- b) This attribute applies to standard waveforms (e.g., sine wave, square wave, triangular wave) within the frequency range of the FGEN.

5.1.2.1.3.2 Offset

This channel-based attribute shall specify the dc offset applied to the waveform being generated.

5.1.2.1.3.2.1 Units of measure/description

Volts.

5.1.2.1.3.2.2 Notes

None.

5.1.2.1.3.3 Duty cycle high

This channel-based attribute shall control the duty cycle of the square wave the signal generator produces. Specify this attribute as a percentage of the time the square wave is high in a cycle.

5.1.2.1.3.3.1 Units of measure/description

Percent.

5.1.2.1.3.3.2 Notes

None.

5.1.2.1.3.4 Frequency

This channel-based attribute shall control the frequency of the standard waveform that the signal generator produces.

5.1.2.1.3.4.1 Units of measure/description

Hertz.

5.1.2.1.3.4.2 Notes

None.

5.1.2.1.3.5 Start phase

This channel-based attribute shall control the horizontal offset of the standard waveform the signal generator produces. Specify this attribute in degrees of one waveform cycle.

5.1.2.1.3.5.1 Units of measure/description

Degrees.

5.1.2.1.3.5.2 Notes

None.

5.1.2.1.3.6 Waveform

This channel-based attribute shall specify which standard waveform the signal generator produces. The waveform shall be specified as either: “sine,” “square,” “triangle,” “ramp-up,” “ramp-down,” or “dc.”

5.1.2.1.3.6.1 Units of measure/description

None.

5.1.2.1.3.6.2 Notes

None.

5.1.2.2 Output parameters (Channel 1-N)

This shall be the identification of the input related measurement parameters. They collectively define the operation and performance of the SI waveform generator.

5.1.2.2.1 Bandwidth (–3 dB)

This shall be the guaranteed minimum –3 dB BW of the output channel(s).

5.1.2.2.1.1 Units of measure/description

Hertz.

5.1.2.2.1.2 Notes

- a) This shall be defined for each reconstruction filter setting.
- b) The type of filter utilized (Bessel, Chebyshev, etc.) shall be indicated.
- c) The test/validation conditions should be provided by the supplier.

5.1.2.2.2 Bandwidth (–3 dB) without reconstruction filter

This shall be the maximum DAC BW of the output channel(s) without a reconstruction filter.

5.1.2.2.2.1 Units of measure/description

Hertz.

5.1.2.2.2.2 Notes

This represents the frequency sample clock max divided by 2.

5.1.2.2.3 Frequency response (plot)

This shall be a typical plot of the output channels frequency response.

5.1.2.2.3.1 Units of measure/description

Decibel as a function of frequency in hertz.

5.1.2.2.3.2 Notes

- a) Plots are the recommended means of reporting the influence that different settings, or operating modes have on the frequency response, of the SI waveform generator.
- b) Frequency response plots are normally reported as typical.
- c) The test/validation conditions should be provided by the supplier.

5.1.2.2.4 Output impedance

This shall be the channel output impedance.

5.1.2.2.4.1 Units of measure/description

Ohms.

5.1.2.2.4.2 Notes

- a) Report the value type typical or worst case.
- b) The test/validation conditions should be supplied by the supplier.

5.1.2.2.5 Pulsed transition time

This shall be a measurement of the 10% to 90% points of the FGEN output.

5.1.2.2.5.1 Units of measure/description

Seconds.

5.1.2.2.5.2 Notes

- a) Typically used for generating digital signals, specified with the reconstruction filter in or out.
- b) The test/validation conditions should be provided by the supplier.

5.1.2.2.6 Absolute maximum output or short circuit protection

This shall be the damage current (short circuit) of each output channel setting and coupling range (ac or dc). An overload of an output channel could automatically disable the main output.

5.1.2.2.6.1 Units of measure/description

Amperes peak or amperes rms.

5.1.2.2.6.2 Notes

The calculated value shall be provided by the supplier.

5.1.2.2.7 Maximum reverse power

This shall be the maximum reverse power reflecting back into the ARB or FGEN for each output channel. An overload of an output channel could automatically disable the main output.

5.1.2.2.7.1 Units of measure/description

Decibel referenced to one milliwatt (dBm) or volts.

5.1.2.2.7.2 Notes

- a) Not commonly specified for an ARB.
- b) May be typical or characteristic to the design.
- c) The calculated value shall be provided by the supplier.

5.1.2.2.8 DC offset resolution (ability to be set)

This shall be a specification of the offset resolution within the settable range.

5.1.2.2.8.1 Units of measure/description

Volts.

5.1.2.2.8.2 Notes

None.

5.1.2.2.9 DC offset accuracy

This shall be the accuracy of dc signals.

5.1.2.2.9.1 Units of measure/description

Percent of full scale.

5.1.2.2.9.2 Notes

- a) DC accuracy shall be specified with the offset set to zero.
- b) Specify the applicable temperature range, with and/or without self-calibration.

5.1.2.2.10 DC offset accuracy temperature coefficient

This shall be the amount of dc accuracy change due to changes in temperature.

5.1.2.2.10.1 Units of measure/description

Percent of full scale (drift) per degrees centigrade.

5.1.2.2.10.2 Notes

- a) This is a change in dc gain accuracy without recalibration over the applicable temperature range.
- b) The test/validation conditions should be provided by the supplier.

5.1.2.2.11 Output (ac) resolution (ability to be set)

This shall be the resolution of the ac component of the output waveform.

5.1.2.2.11.1 Units of measure/description

Bits or volts.

5.1.2.2.11.2 Notes

If a DAC resolution varies over sample clock range then it shall specified.

5.1.2.2.12 Output (ac) accuracy

This shall be the accuracy of ac signals.

5.1.2.2.12.1 Units of measure/description

Percent of full scale.

5.1.2.2.12.2 Notes

- a) Specify the applicable temperature range, with and/or without self-calibration.
- b) Recommend 10 kHz and 50 kHz be used for low-frequency converters.
- c) The test/validation conditions should be provided by the supplier.

5.1.2.2.13 Output (ac) accuracy temperature coefficient

This shall be the amount of ac accuracy change due to changes in temperature.

5.1.2.2.13.1 Units of measure/description

Percent of full scale (drift) per degrees centigrade.

5.1.2.2.13.2 Notes

- a) This is a change in ac accuracy without recalibration over the applicable temperature range.
- b) The test/validation conditions should be provided by the supplier.

5.1.2.2.14 Signal-to-noise ratio

This shall be the measured SNR over all applicable input settings. More precisely, the SNR is as shown in Equation (1):

$$\text{SNR} = 10\log (\text{power of the signal} / \text{power of the noise}) \quad (1)$$

where

<i>power of the signal</i>	is the input power root mean square (rms) value
<i>power of the noise</i>	is the noise power rms value (excluding harmonic distortion)

The noise measured in an SNR calculation does not include harmonic distortion but does include quantization noise (an artifact of quantization error of the DAC) and all other sources of noise (for example, thermal noise or the broadband noise floor of the sample clock). For a given DAC resolution, the DAC quantization noise or effective number of bits (ENOB) is what limits DAC to its theoretical best SNR because quantization error is the only error in an ideal DAC.

5.1.2.2.14.1 Units of measure/description

Decibels.

5.1.2.2.14.2 Notes

The test/validation conditions should be provided by the supplier.

5.1.2.2.15 Noise floor

This shall be the broadband noise floor of the waveform generator. The waveform generator noise floor shall be the composite of the thermal noise generated plus the noise figure (NF) artifacts of the signal generation path, which include the combination of the DAC quantization noise, sample clock noise floor, plus the signal amplification NF, and the reconstruction filter characteristics of the output signal path.

5.1.2.2.15.1 Units of measure/description

dBc per hertz.

5.1.2.2.15.2 Notes

The noise floor measurement is typically accomplished by a measurement receiver device with a low noise amplifier on the RF front end if required to maintain a 20 dB signal to noise margin between the UUT and the measurement device. The measurement device is typically a spectrum analyzer with a pre-amp utilizing a noise marker function measurement that compensates for the resolution BWs filter response and normalizes the measurement to a 1 Hz BW.

5.1.2.2.16 Harmonics

This shall be the signal impurities that occur at integer multiples of a generated signal's fundamental frequency (e.g., 2, 3, 4, N). Harmonics are residual frequency artifacts that result from the nonlinear

properties of internal components in the digital-to-analog signal generation path while generating a sinusoid waveform in the ARB. This specification parameter is usually specified at a prescribed signal frequency and voltage output level (harmonics at the carrier frequency at a specified output level).

5.1.2.2.16.1 Units of measure/description

dBc.

5.1.2.2.16.2 Notes

- a) The maximum level should be specified.
- b) The test/validation conditions should be provided by the supplier.

5.1.2.2.17 Spurious free dynamic range

This shall provide the SFDR over the operating frequency ranges and settings. SFDR is the difference between the magnitude of the measured signal and its highest spur peak within the output frequency range. The nonharmonic related spurs are typically related to the intermixing of the data as a function of submultiples per Equation (2):

$$(1 / n) \times (\text{sample clock}) \quad (2)$$

where

n is an integer between 2 and 10

5.1.2.2.17.1 Units of measure/description

dBc.

5.1.2.2.17.2 Notes

- a) To insure that spurs are not masked, test SFDR using a single tone sine wave.
- b) Discrete spurs should be observed as indicated in Table 1.
- c) The clock rate should be set to the minimum and maximum value expected to be used.
- d) Spurious signals are typically measured with a spectrum analyzer.

Table 1—Discrete spurs

Signal frequency	Spur frequency
Approximately $F_{clk}/4$	$F_{clk} \pm 3 F_{sig}$, $F_{clk} \pm 5 F_{sig}$, $2 F_{clk} \pm 7 F_{sig}$, etc.
Approximately $F_{clk}/3$	$F_{clk} - 2 F_{sig}$
Approximately $F_{clk}/5$	$F_{clk} \pm 4 F_{sig}$
Approximately $F_{clk}/4$	$F_{clk} / 2 - F_{sig}$
Approximately $F_{clk}/10$	$F_{clk} / 4 - F_{sig}$

5.1.2.2.18 System phase noise

This shall be the short-term frequency stability containing all the elements causing frequency changes about the nominal frequency of less than a few seconds of duration. Mathematically, an ideal sine wave can be described by Equation (3):

$$V(t) = V_o \sin (2 \Pi F_o t) \quad (3)$$

where

V_o is the nominal amplitude
 $2 \Pi F_o t$ is the linearly accumulation phase component
 F_o is the nominal frequency

But an actual signal is better described by Equation (4):

$$V(t) = [V_o + \Sigma(t)] \sin [2 \Pi F_o t + \Delta\Theta(t)] \quad (4)$$

where

$\Sigma(t)$ is the amplitude fluctuations
 $\Delta\Theta(t)$ is the randomly fluctuating phase term or phase noise
 F_o is the nominal frequency

This randomly fluctuating phase term $\Delta\Theta(t)$ could be observed on an ideal spectrum analyzer (one which had no sideband noise of its own). There are two types of fluctuating phase terms. The first, deterministic, are discrete signals appearing as distinct components in the spectral density plot. These signals, commonly called *spurious*, can be related to known phenomena in the signal output such as power line frequency, power supply frequency, vibration frequency, or mixing products. The second type of phase instabilities are random in nature due to the sample clock oscillator noise components, which include the composite of the thermal noise, shot noise, and flicker noise being induced onto the output of the DAC.

Many terms exist to quantify the characteristic randomness of phase noise. Essentially, all methods measure frequency or phase deviations of the source under test in either the frequency or time domain. Since frequency and phase are related to each other, all terms that characterize phase noise are also related.

One of the fundamental descriptions of phase instability, or phase noise is the spectral density of the phase fluctuations on a per hertz basis. The term *spectral density* describes the energy distribution as a continuous function, expressed in phase variance per unit BW. Thus $S_{\Theta}(F_m)$ is represented by Equation (5):

$$S_{\Theta}(F_m) = \Delta\Theta^2_{rms}(F_m) / \text{BW used to measure } \Delta\Theta_{rms} \quad (5)$$

where

BW is negligible with respect to changes in S_{Θ} versus the Fourier frequency or offset frequency F_m

Another useful measure of noise energy is $L(fm)$, which is directly related to $S \Theta (Fm)$ by a simple approximation that has generally negligible error if the modulation sidebands are such that the total phase deviations are much less than 1 radian ($\Delta\Theta_{pk} \ll 1$ radian). Thus $L(fm)$ is represented by Equation (6):

$$L(fm) \approx \frac{1}{2} S \Theta (Fm) \quad (6)$$

$L(fm)$ is an indirect measure of the noise energy easily related to the RF power spectrum observed on a spectrum analyzer. $L(fm)$ is the ratio of power in one phase modulation sideband to the total signal power at an offset fm hertz away from the carrier. The phase modulation sideband is based on per hertz of BW spectral density and fm equals the Fourier frequency or offset frequency. Thus $L(fm)$ is represented by Equation (7), Equation (8), and Equation (9):

$$L(fm) = \text{Power density (in one-phase modulation sideband)} / \text{total signal power} \quad (7)$$

$$L(fm) = P_{ssb} / P_s \quad (8)$$

$$L(fm) = \text{Single sideband (SSB) phase noise to carrier ratio per hertz} \quad (9)$$

where

P_{ssb} is one phase modulation sidebands power density
 P_s is the signal power

$L(fm)$ is usually presented logarithmically as a spectral density of the phase modulation sidebands in the plot of the frequency domain, expressed in dB relative to the carrier per hertz (dBc/Hz).

5.1.2.2.18.1 Units of measure/description

None.

5.1.2.2.18.2 Notes

The test/validation conditions should be provided by the supplier.

5.1.2.2.19 System jitter

This shall be defined as the random statistical time variance of a signal relative to the ideal period of the output signal of the DAC. Both jitter and phase noise can be related mathematically since jitter is measured in the time domain and phase noise is measured in the frequency domain.

There are a few different ways to look at phase noise. However, each way of looking at phase noise is derived from a common spectral density distribution plot $S_{phi}(f)$. This is due to the random nature of instabilities that does not allow discrete measurement. The term *spectral density* describes the power distribution (mean square deviation) as a continuous function, expressed in units of energy within a given BW. Phase jitter is just another way of interpreting the information from a spectral density plot.

By integrating the plot of $S_{phi}(f)$ from f_1 to f_2 and then taking the square root, one is able to obtain the total rms phase deviation within a specified BW in radians. This then can be converted to phase jitter in dB with respect to 1 radian or phase jitter in degrees by Equation (10):

$$L(f) = \text{Phi}(f) / 2 \quad (10)$$

The jitter measurements can be derived from the single sideband spectral density phase noise measurement described in 5.1.2.2.18. The $L(f)$ plot gives the sideband noise distribution in the form of a power spectral density function in units of dBc. The power level of the carrier is not important, since jitter reflects only the relative levels of phase noise (modulation) when compared to the “pure” carrier. The total noise power of the sidebands can be determined by integrating the $L(f)$ function over the band of interest $f1$ to $f2$ per Equation (11). This is the total area under the phase noise plot from $f1$ to $f2$.

$$N = \int_{f2}^{f1} L(fm) df \quad (11)$$

where

N is noise power

These calculations yield the power level of the phase modulating (jitter producing) noise in this band. From this, we can determine the rms jitter. The definite integral used is per Equation (12):

$$\text{Phase jitter} = \text{SQRT} (10^N / (10 \times 2)) \quad (12)$$

Equation (13) can be used to determine the rms jitter caused by this noise power:

$$\text{Jitter rms} = \text{Jitter (radians)} / 2 \pi F_0 \quad (13)$$

This can be expressed in other units, such as unit interval (UI) or time. To convert to time, divide Equation (13) by the frequency of the carrier in radians, per Equation (14):

$$\text{Output carrier frequency } F1 - Fn \text{ and Integration BW } F1 - F2 \text{ determined by vendor} \quad (14)$$

5.1.2.2.19.1 Units of measure/description

None.

5.1.2.2.19.2 Notes

The test/validation conditions should be provided by the supplier.

5.1.2.2.20 Frequency switching time

This shall be defined as the time it takes for the ARB to change from one frequency (e.g., $F1$) to another frequency (e.g., $F2$) within the operating frequency and settle to within a specific frequency from the desired final frequency (e.g., $F2$) or within 1 dB of the final amplitude. This time shall be defined under the worst-case conditions where two preloaded waveforms are switched within one sample of each other.

5.1.2.2.20.1 Units of measure/description

Seconds.

5.1.2.2.20.2 Notes

a) Example ARB

- 1 giga sample per second 1 ns clock rate
- Using the spectrally useable Nyquist divisor of 2.5 (40% of F_{max}) 400 MHz output
- Maximum RF frequency out of 400 MHz 2.5 ns time period
- 1) From trigger, t_0 measure 5 time periods, or 2.5 full cycles
- 2) Frequency switching time equals 2.5 times the time period, 6.25 ns

Thus, frequency switching time is specified at the maximum frequency or the maximum sample rate using Equation (15) and Equation (16):

$$\text{Switching time} = 2.5 / \text{Maximum output frequency} \quad (15)$$

$$\text{Switching time} = 6.25 / \text{Sample rate} \quad (16)$$

where

<i>Maximum output frequency</i>	is in hertz (Hz)
<i>Sample rate</i>	is in samples per second

b) The test/validation conditions should be provided by the supplier.

5.1.2.2.21 AM input sensitivity

This shall be the gain of the external AM circuit.

5.1.2.2.21.1 Units of measure/description

Volts per volt, percent per volt, volt per percent, or percent per percent.

5.1.2.2.21.2 Notes

The test/validation conditions should be provided by the supplier.

5.1.2.3 Output related parameters (data input/output)

These shall be the parameters related to the data I/O port found on some ARBs. This port provides a digital output of the data being sent to the D/A in the ARB. This port is optional. If provided these are the parameters required.

5.1.2.3.1 Signal type

This shall be the type of logic of the signal, specified as either: “TTL,” “ECL,” “PECL,” or “LVDS.”

5.1.2.3.1.1 Units of measure/description

None.

5.1.2.3.1.2 Notes

- a) The output related parameters should include the output voltage swing for each logic family. For example: 3.3 V for the complementary metal-oxide semiconductor (CMOS) logic family.
- b) The test/validation conditions should be provided by the supplier.

5.1.2.3.2 Synchronization type

This shall be the synchronization for data input, specified as either: “TTL,” “ECL,” “PECL,” or “LVDS.”

5.1.2.3.2.1 Units of measure/description

None.

5.1.2.3.2.2 Notes

The test/validation conditions should be provided by the supplier.

5.1.2.3.3 Number of channels

This shall be the number of channels.

5.1.2.3.3.1 Units of measure/description

None.

5.1.2.3.3.2 Notes

The test/validation conditions should be provided by the supplier.

5.1.2.3.4 Number of bits

This shall be the bits per channel.

5.1.2.3.4.1 Units of measure/description

None.

5.1.2.3.4.2 Notes

The test/validation conditions should be provided by the supplier.

5.1.2.3.5 Output modes

This shall be the possible output combinations, specified as either: “digital only,” “digital and analog,” or “off.”

5.1.2.3.5.1 Units of measure/description

None.

5.1.2.3.5.2 Notes

The test/validation conditions should be provided by the supplier.

5.1.2.3.6 Output termination requirements

This shall be the termination required for logic type.

5.1.2.3.6.1 Units of measure/description

None.

5.1.2.3.6.2 Notes

The test/validation conditions should be provided by the supplier.

5.1.2.3.7 Max sample rate

This shall be the maximum sustainable data rate.

5.1.2.3.7.1 Units of measure/description

Hertz.

5.1.2.3.7.2 Notes

The test/validation conditions should be provided by the supplier.

5.1.2.3.8 Min sample rate

This shall be the minimum sustainable data rate.

5.1.2.3.8.1 Units of measure/description

Hertz.

5.1.2.3.8.2 Notes

The test/validation conditions should be provided by the supplier.

5.1.3 Time base requirements

5.1.3.1 Time base programmable settings

The programmable settings facilitate the following time base configurations or cases.

Case	Frequency reference	Sample clock
1	INT	INT
2	EXT	INT
3	<i>X</i>	EXT

5.1.3.1.1 Reference selection

This shall allow an “internal” or “external” time base reference to be selected. This external reference is applied exclusively to the Fref_in port on the SI waveform generator.

5.1.3.1.1.1 Units of measure/description

None.

5.1.3.1.1.2 Notes

None.

5.1.3.1.2 Time base selection

This shall allow an “internal” or “external” time base reference to be selected. This external reference would be input to Clk_in.

5.1.3.1.2.1 Units of measure/description

None.

5.1.3.1.2.2 Notes

None.

5.1.3.2 General time base parameters

The parameters related to the sampling clock including the frequency reference. These shall be required for the definition and characterization of the time base associated with a SI waveform generator.

5.1.3.2.1 Sample clock range

This shall provide the sample clock or time base range.

5.1.3.2.1.1 Units of measure/description

Hertz.

5.1.3.2.1.2 Notes

- a) This applies to ARBs only.
- b) Specify the minimum and maximum for each time base case

5.1.3.2.2 Sample clock resolution

This shall provide the sample clock or time base setting resolution for each applicable time base case.

5.1.3.2.2.1 Units of measure/description

Hertz or steps.

5.1.3.2.2.2 Notes

This applies to ARBs only.

5.1.3.2.3 Sample clock frequency accuracy

This shall provide the absolute sample clock accuracy for each applicable time base case.

5.1.3.2.3.1 Units of measure/description

Parts per million (ppm).

5.1.3.2.3.2 Notes

- a) If using a test method that relies on captured signal analysis, the time record has to be as long as possible with enough resolution to reduce the effects of sample jitter and quantization.
- b) The test/validation conditions should be provided by the supplier.

5.1.3.2.4 Reference long-term drift

This shall be the change in time base frequency (usually given in ppm) over a specified period of time at a specified sampling rate.

5.1.3.2.4.1 Units of measure/description

Parts per million, per unit time.

5.1.3.2.4.2 Notes

- a) The drift shall be specified over a period of one year minimum.
- b) The manufacturer shall describe the measurement method used to establish the drift specification.
- c) The test/validation conditions should be provided by the supplier.

5.1.3.2.5 Sample clock phase noise

This shall provide the single sideband phase noise of the internal sample clock at a range of offsets from 100 Hz to 1 MHz.

5.1.3.2.5.1 Units of measure/description

dBc per hertz.

5.1.3.2.5.2 Notes

See 5.1.2.2.18.

5.1.3.2.6 Sampling jitter

This shall provide the uncertainty or jitter for a sample. This parameter is directly related to the sample clock phase noise.

5.1.3.2.6.1 Units of measure/description

Seconds.

5.1.3.2.6.2 Notes

- a) The low-end test should be made at 100 Hz and the high-end test should be made at the Nyquist frequency.
- b) Specify the sample clock frequency being tested.
- c) Refer to 5.1.2.2.19.

5.1.3.3 Time base input port parameters

5.1.3.3.1 Port type (Fref_in)

The frequency reference input signal port shall have its type defined.

5.1.3.3.1.1 Units of measure/description

None.

5.1.3.3.1.2 Notes

None.

5.1.3.3.2 Signal type (Fref-in)

This shall be the type of logic the signal requires, specified as either: “TTL,” “ECL,” “PECL,” or “LVDS.”

5.1.3.3.2.1 Units of measure/description

None.

5.1.3.3.2.2 Notes

The test/validation conditions should be provided by the supplier.

5.1.3.3.3 Signal type (Clk-in)

This shall be the type of logic the signal requires, specified as either: “TTL,” “ECL,” “PECL,” or “LVDS.”

5.1.3.3.3.1 Units of measure/description

None.

5.1.3.3.3.2 Notes

The test/validation conditions should be provided by the supplier.

5.1.3.3.4 Duty cycle tolerance

This shall be the tolerable deviation from a 50% duty cycle. Within this tolerance, the Clk_in or Fref_in circuitry shall operate properly.

5.1.3.3.4.1 Units of measure/description

Percent.

5.1.3.3.4.2 Notes

- a) This shall be reported as worst-case deviation from ideal clock symmetry.
- b) Fref_in and Clk_in are assumed to have different duty cycle tolerances. Duty cycle tolerance shall be identified for both the Fref_in and Clk_in circuits.
- c) Vary the duty cycle of the input and measure the performance of the waveform generator. SiNAD, SFDR, and long-time interval sampled signal frequency are the most relevant parameters. Assume that performance will degrade before catastrophic failure when clocks with non-ideal clock duty cycle are applied to the UUT.

5.1.3.3.5 Input frequency range

This shall provide the frequency range of the Clk_in or Fref_in signals. Identify the minimum and maximum allowable input frequencies. For example, Fref_in is typically specified as 10 MHz $\pm$ 5%. Clk_in typically has a range that is equal or representative of the sample clock range provided by the internal time base.

5.1.3.3.5.1 Units of measure/description

Hertz.

5.1.3.3.5.2 Notes

None.

5.1.3.3.6 Input frequency lock BW (Fref_in)

This shall provide the frequency tolerance to maintain frequency lock.

5.1.3.3.6.1 Units of measure/description

Hertz.

5.1.3.3.6.2 Notes

The test/validation conditions should be provided by the supplier.

5.1.3.3.7 Input impedance

This shall include resistance and capacitance, if applicable, measured between the input port and ground.