DN2.80x/81x - hybridNETBOX up to 125 MS/s: Digitizer and AWG

- **Stimulus-Response, Closed-Loop, Recorder/Replay, Automated Tests, MIMO, ...**
- **2, 4 or 8 channels with 40 MS/s or 125 MS/s in both directions**
- **Simultaneously sampling and generation on all channels**
- **512 MiSample acquisition and 512 MiSample AWG memory**
- **Digitizer: single-ended or differential inputs**
- **Digitizer: separate ADC and amplifier per channel**
- **Digitizer: 6 input ranges: ±200 mV up to ±10 V**
- **Digitizer: programmable input offset of ±100%**
- **AWG: output into 50 Ohm up to ±3 V (8 channels) or ±6 V (2 and 4 channels)**
- **AWG: output into 1 MOhm up to ±6 V (8 channels) or ±12 V (2 and 4 channels)**
- **Streaming, Multiple Recording, Gated Sampling, Timestamps, Sequence Replay**

- Ethernet Remote Instrument
- LXI Core 2011 compatible
- GBit Ethernet Interface
- Sustained streaming mode up to 100 MB/s

- Direct Connection to PC/Laptop
- Connect anywhere in company LAN
- Embedded Webserver for Maintenance/Updates
- Embedded Server option for open Linux platform

Operating Systems	**SBench 6 Professional Included**	**Drivers**
• Windows 7 (SP1), 8, 10, 11 Server 2008 R2 and newer • Linux Kernel 2.6, 3.x, 4.x, 5.x • Windows/Linux 32 and 64 bit	• Acquisition, Generation and Display of analog and digital data • Calculation, FFT • Documentation and Import, Export	• LabVIEW, MATLAB • Python, C/C++, C#, Java, Julia • IVI

General Information

The hybridNETBOX DN2.80/81x series internally consists of a digitizer and an AWG that can run together or independently. That allows simultaneous data generation and data acquisition for stimulus-response tests, ATE applications, MIMO applications or closed-loop applications. Used independently, the digitizer can acquire test data in the field and the AWG can replay this test data in lab. The hybridNETBOX offers 16 bit resolution and is available with sampling rates of 40 MS/s and 125 MS/s and can be installed anywhere in the company LAN and remotely controlled from a host PC.

hybridNETBOX Model	Internal Module	Digitizer				Internal Module	Arbitrary Waveform Generator				Internal Star-Hub
		Single-Ended Inputs		Differential Inputs			Outputs		Output Level		
DN2.813-02	M2p.5931-x4	2 channels	40 MS/s	2 channels	40 MS/s	M2p.6541-x4	2 channels	40 MS/s	±6V (50Ω)	±12V (1MΩ)	yes[1]
DN2.813-04	M2p.5936-x4	4 channels	40 MS/s	4 channels	40 MS/s	M2p.6546-x4	4 channels	40 MS/s	±6V (50Ω)	±12V (1MΩ)	yes[1]
DN2.803-08	M2p.5933-x4	8 channels	40 MS/s	4 channels	40 MS/s	M2p.6533-x4	8 channels	40 MS/s	±3V (50Ω)	±6V (1MΩ)	yes[1]
DN2.816-02	M2p.5961-x4	2 channels	125 MS/s	2 channels	125 MS/s	M2p.6571-x4	2 channels	125 MS/s	±6V (50Ω)	±12V (1MΩ)	yes[1]
DN2.816-04	M2p.5966-x4	4 channels	125 MS/s	4 channels	125 MS/s	M2p.6576-x4	4 channels	125 MS/s	±6V (50Ω)	±12V (1MΩ)	yes[1]
DN2.806-08	M2p.5968-x4	8 channels 4 channels	80 MS/s 125 MS/s	4 channels	125 MS/s	M2p.6568-x4	8 channels 4 channels	80 MS/s 125 MS/s	±3V (50Ω)	±6V (1MΩ)	yes[1]

(1)SBench 6 does not support star-hub for mixed digitizer and AWG. Instead SBench 6 can only operate the cards independently by starting two instances of the program

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Software Support

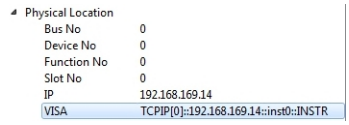
Windows Support

The digitizerNETBOX/generatorNETBOX/hybridNETBOX can be accessed from Windows 7, Windows 8, Windows 10, Windows 11 (either 32 bit or 64 bit). Programming examples for Visual C++, C++ Builder, LabWindows/CVI, Delphi, Visual Basic, VB.NET, C#, Julia, Python, Java and IVI are included.

Linux Support

The digitizerNETBOX/generatorNETBOX/hybridNETBOX can be accessed from any Linux system. The Linux support includes SMP systems, 32 bit and 64 bit systems, versatile programming examples for Gnu C++, Python, Julia as well as drivers for MATLAB for Linux. SBench 6, the powerful data acquisition and analysis software from Spectrum is also included as a Linux version.

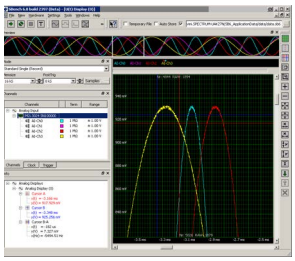
Discovery Protocol



The Discovery function helps you to find and identify any Spectrum LXI instruments, like the digitizerNETBOX and generatorNETBOX, available to your computer on the network. The Discovery function will also locate any Spectrum card products that are managed by an installed Spectrum Remote Server somewhere on the network.

After running the discovery function the card information is cached and can be directly accessed by SBench 6. Furthermore the qualified VISA address is returned and can be used by any software to access the remote instrument.

SBench 6 Professional



The digitizerNETBOX, generatorNETBOX and hybridNETBOX can be used with Spectrum's powerful software SBench 6 – a Professional license for the software is already installed in the box. SBench 6 supports all of the standard features of the instrument. It has a variety of display windows as well as analysis, export and documentation functions.

- Available for Windows Windows 7, Windows 8, Windows 10, Windows 11 and Linux
- Easy to use interface with drag and drop, docking windows and context menus
- Display of analog and digital data, X-Y display, frequency domain and spread signals
- Designed to handle several GBytes of data
- Fast data preview functions
- SBench 6 only supports either AWG or Digitizer in one program
- Star-Hub for mixed mode applications is not supported
- To run AWG and Digitizer with SBench 6, the software needs to be started twice and each instance of the program then operates independetly one device

IVI Driver

The IVI standards define an open driver architecture, a set of instrument classes, and shared software components. Together these provide critical elements needed for instrument interchangeability. IVI's defined Application Programming Interfaces (APIs) standardize common measurement functions reducing the time needed to learn a new IVI instrument.

The Spectrum products to be accessed with the IVI driver can be locally installed data acquisition cards, remotely installed data acquisition cards or remote LXI instruments like digitizerNETBOX/generatorNETBOX. To maximize the compatibility with existing IVI based software installations, the Spectrum IVI driver supports IVI Scope, IVI Digitizer and IVI FGen class with IVI-C and IVI-COM interfaces.

Third-party Software Products

Most popular third-party software products, such as LabVIEW, MATLAB or LabWindows/CVI are supported. All drivers come with examples and detailed documentation.

Embedded Webserver

The integrated webserver follows the LXI standard and gathers information on the product, set up of the Ethernet configuration and current status. It also allows the setting of a configuration password, access to documentation and updating of the complete instrument firmware, including the embedded remote server and the webserver.

General Hardware features and options

LXI Instrument

The digitizerNETBOX and generatorNETBOX are fully LXI instrument compatible to LXI Core 2011 following the LXI Device Specification 2011 rev. 1.4. The digitizerNETBOX/generatorNETBOX has been tested and approved by the LXI Consortium.

Located on the front panel is the main on/off switch, LEDs showing the LXI and Acquisition status and the LAN reset switch.

Chassis features

The chassis is especially designd for usage in different application arreas and has some advanced features for mobile and shared usage:

- stable metal chassis
- 8 bumper edges protect the chassis, the desk and other components on it. The bumper edges allow to store the chassis either vertically or horizontally and the lock-in structure allows to stack multiple chassis with a secure fit onto each other. For 19" rack mount montage the bumpers can be unmounted and replaced by the 19" rack mount option
- The handle allows to easily carry the chassis around in juts one hand.
- A standard GND screw on the back of the chassis allows to connect the metal chassis to measurement ground to reduce noise based on ground loops and ground level differences.

Front Panel

Standard BNC connectors are used for all analog input or output signals and all auxiliary signals like clock and trigger. No special adapter cables are needed and the connection is secure even when used in a moving environment.

Custom front panels are available on request even for small series, be it SMA, LEMO connectors or custom specific connectors.

Ethernet Connectivity

The GBit Ethernet connection can be used with standard COTS Ethernet cabling. The integration into a standard LAN allows to connect the digitizerNETBOX/generatorNETBOX either directly to a desktop PC or Laptop or it is possible to place the instrument somewhere in the company LAN and access it from any desktop over the LAN.

Boot on Power Option

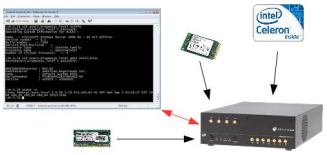
The digitizerNETBOX/generatorNETBOX can be factory configured to automatically start and boot upon availability of the input power rail. That way the instrument will automatically become available again upon loss of input power.

DC Power Supply Option

The digitizerNETBOX/generatorNETBOX/hybridNETBOX can be equipped with an internal DC power supply which replaces the standard AC power supply. This power supply options is available with an input range of nominal 24 V. Contact the sales team if other DC levels are required.

Using the DC power supply the device can be used for mobile applications together with a Laptop in automotive or airborne applications.

Option Embedded Server



The option turns the digitizerNETBOX/generatorNETBOX in a powerful PC that allows to run own programs on a small and remote data acquisition system. The digitizerNETBOX/generatorNETBOX is enhanced by more memory, a powerful CPU, a freely accessable internal SSD and a remote software development access method.

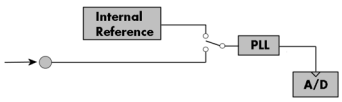
The digitizerNETBOX/generatorNETBOX can either run connected to LAN or it can run totally independent, storing data to the internal SSD. The original digitizerNETBOX/generatorNETBOX remote instrument functionality is still 100 % available. Running the embedded server option it is possible to pre-calculate results based on the acquired data, store acquisitions locally and to transfer just the required data or results parts in a client-server based software structure. A different example for the digitizerNETBOX/generatorNETBOX embedded server is surveillance/logger application which can run totally independent for days and send notification emails only over LAN or offloads stored data as soon as it's connected again.

Access to the embedded server is done through a standard text based Linux shell based on the ssh secure shell.

External clock I/O

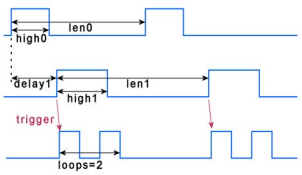
Using a dedicated connector a sampling clock can be fed in from an external system. It's also possible to output the internally used sampling clock to synchronise external equipment to this clock.

Reference clock



The option to use a precise external reference clock (normally 10 MHz) is necessary to synchronize the instrument for high-quality measurements with external equipment (like a signal source). It's also possible to enhance the quality of the sampling clock in this way. The driver automatically generates the requested sampling clock from the fed in reference clock.

Firmware Option Digital Pulse Generator

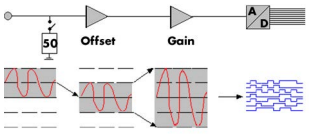


The digital pulse generator option adds 4 internal independent digital pulse generators with programmable duty cycle, output frequency, delay and number of loops. These digital pulse generators can be triggered by software, hardware trigger or can trigger each other allowing to form complex pulse schemes to drive external equipment or experiments. The digital pulse generators can

be output on the existing multi-XIO lines (X0, X1, ...), to trigger other pulse generators or can be used to trigger the instrument's main trigger internally. Time resolution of the pulse generator depends on the cards type and the selected sampling rate and can be found in the technical data section.
The pulse generator option is a firmware option and can be later installed on all shipped cards.

Digitizer Hardware Features and Options

Input Amplifier



The analog inputs can be adapted to real world signals using a wide variety of settings that are individual for each channel. By using software commands the input termination can be changed between 50 Ohm and 1 MOhm, one can select a matching input range and the signal offset can be compensated for.

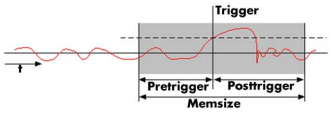
Differential inputs

With a simple software command the inputs can individually be switched from single-ended (in relation to ground) to differential by combining each two single-ended inputs to one differential input. When the inputs are used in differential mode the A/D converter measures the difference between two lines with relation to system ground.

Automatic on-board calibration

All of the channels are calibrated in factory before the board is shipped. To compensate for different variations like PC power supply, temperature and aging, the software driver provides routines for an automatic on-board offset and gain calibration of all input ranges. All the cards contain a high precision on-board calibration reference.

Ring buffer mode



The ring buffer mode is the standard mode of all oscilloscope instruments. Digitized data is continuously written into a ring memory until a trigger event is detected. After the trigger, post-trigger samples are recorded and pre-trigger samples can also be stored. The number of pre-trigger samples available simply equals the total ring memory size minus the number of post trigger samples.

FIFO mode

The FIFO mode is designed for continuous data transfer between remote instrument and PC memory or hard disk. The control of the data stream is done automatically by the driver on interrupt request. The complete installed on-board memory is used for buffer data, making the continuous streaming extremely reliable.

Channel trigger

The data acquisition instruments offer a wide variety of trigger modes. Besides the standard signal checking for level and edge as known from oscilloscopes it's also possible to define a window trigger. All trigger modes can be combined with the pulsewidth trigger. This makes it possible to trigger on signal errors like too long or too short pulses. In addition to this a re-arming mode (for accurate trigger recognition on noisy signals) the AND/OR conjunction of different trigger events is possible. As a unique feature it is possible to use deactivated channels as trigger sources.

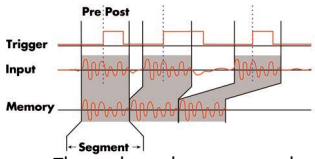
External trigger I/O

All instruments can be triggered using an external TTL signal. It's possible to use positive or negative edge also in combination with a programmable pulse width. An internally recognised trigger event can - when activated by software - be routed to the trigger connector to start external instruments.

Pulse width

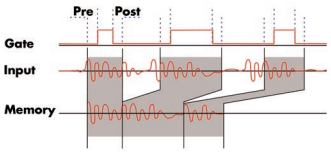
Defines the minimum or maximum width that a trigger pulse must have to generate a trigger event. Pulse width can be combined with channel trigger, pattern trigger and external trigger.

Multiple Recording



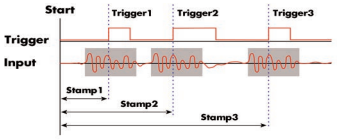
The Multiple Recording mode allows the recording of several trigger events with an extremely short re-arming time. The hardware doesn't need to be restarted in between. The on-board memory is divided in several segments of the same size. Each of them is filled with data if a trigger event occurs. Pre- and posttrigger of the segments can be programmed. The number of acquired segments is only limited by the used memory and is unlimited when using FIFO mode.

Gated Sampling



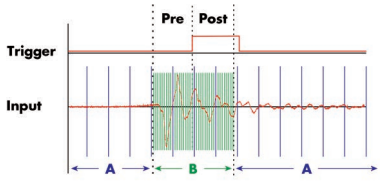
The Gated Sampling mode allows data recording controlled by an external gate signal. Data is only recorded if the gate signal has a programmed level. In addition a pre-area before start of the gate signal as well as a post area after end of the gate signal can be acquired. The number of gate segments is only limited by the used memory and is unlimited when using FIFO mode.

Timestamp



The timestamp function writes the time positions of the trigger events in an extra memory. The timestamps are relative to the start of recording, a defined zero time, externally synchronized to a radio clock, an IRIG-B a GPS receiver. Using the external synchronization gives a precise time relation for acquisitions of systems on different locations.

ABA mode



The ABA mode combines slow continuous data recording with fast acquisition on trigger events. The ABA mode works like a slow data logger combined with a fast digitizer. The exact position of the trigger events is stored as timestamps in an extra memory.

AWG Hardware Features and Options

Singleshot output

When singleshot output is activated the data of the on-board memory is played exactly one time. The trigger source can be either one of the external trigger inputs or the software trigger. After the first trigger additional trigger events will be ignored.

Repeated output

When the repeated output mode is used the data of the on-board memory is played continuously for a programmed number of times or until a stop command is executed. The trigger source can be ei-

ther one of the external trigger inputs or the software trigger. After the first trigger additional trigger events will be ignored.

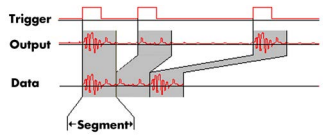
Single Restart replay

When this mode is activated the data of the on-board memory will be replayed once after each trigger event. The trigger source can be either the external trigger or software trigger.

FIFO mode

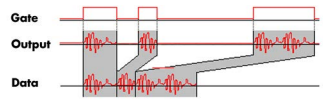
The FIFO mode is designed for continuous data transfer between PC memory or hard disk and the generation board. The control of the data stream is done automatically by the driver on an interrupt request basis. The complete installed on-board memory is used for buffering data, making the continuous streaming extremely reliable.

Multiple Replay



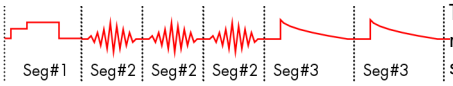
The Multiple Replay mode allows the fast output generation on several trigger events without restarting the hardware. With this option very fast repetition rates can be achieved. The on-board memory is divided into several segments of the same size. Each segment can contain different data which will then be played with the occurrence of each trigger event.

Gated Replay



The Gated Sampling mode allows data replay controlled by an external gate signal. Data is only replayed if the gate signal has attained a programmed level.

Sequence Mode



The sequence mode allows to split the card memory into several data segments of different length. These data segments are chained up in a user chosen order using an additional sequence memory. In this sequence memory the number of loops for each segment can be programmed and trigger conditions can be defined to proceed from segment to segment. Using the sequence mode it is also possible to switch between replay waveforms by a simple software command or to redefine waveform data for segments simultaneously while other segments are being replayed. All trigger-related and software-command-related functions are only working on single cards, not on star-hub-synchrnonized cards.

External trigger input

All boards can be triggered using up to two external analog or digital signals. One external trigger input has two analog comparators that can define an edge or window trigger, a hysteresis trigger or a rearm trigger. The other input has one comparator that can be used for standard edge and level triggers.

hybridNETBOX Technical Data - Digitizer

Only figures that are given with a maximum reading or with a tolerance reading are guaranteed specifications. All other figures are typical characteristics that are given for information purposes only. Figures are valid for products stored for at least 2 hours inside the specified operating temperature range, after a 30 minute warm-up, after running an on-board calibration and with proper cooled products. All figures have been measured in lab environment with an environmental temperature between 20°C and 25°C and an altitude of less than 100 m.

Analog Inputs

Resolution		16 bit (can be reduced to acquire simultaneous digital inputs)
Input Range	software programmable	±200 mV, ±500 mV, ±1 V, ±2 V, ±5 V, ±10 V
Input Type	software programmable	Single-ended or True Differential
Input Offset (single-ended)	software programmable	programmable to ±100% of input range in steps of 1%
ADC Differential non linearity (DNL)	ADC only	591x: ±0.2/±0.8 LSB (typ./max.) 592x: ±0.2/±0.8 LSB (typ./max.) 593x, 8x3: ±0.5/±0.9 LSB (typ./max.) 594x: ±0.5/±0.9 LSB (typ./max.) 596x, 8x6: ±0.5/±0.9 LSB (typ./max.
ADC Integral non linearity (INL)	ADC only	591x: ±1.0/±2.3 LSB (typ./max.) 592x: ±1.0/±2.3 LSB (typ./max.) 593x, 803, 813: ±2.0/±7.5 LSB (typ./max.) 594x: ±2.0/±7.5 LSB (typ./max.) 596x, 806, 816: ±2.0/±7.5 LSB (typ./max.)
Offset error (full speed), DC signal	after warm-up and calibration	≤ 0.1% of range
Gain error (full speed), DC signal	after warm-up and calibration	≤ 0.1% of reading
Offset temperature drift	after warm-up and calibration	typical 5 ppm/K of range
Gain temperatur drift	after warm-up and calibration	typical 45 ppm/K of reading
AC accuracy	1 kHz signal	≤ 0.3% of reading
AC accuracy	50 kHz signal	≤ 0.5% of reading
Crosstalk: Signal 1 MHz, 50 Ω	range ≤ ±1V range ≥ ±2V	≤ 95 dB on adjacent channels ≤ 90 dB on adjacent channels
Crosstalk: Signal 10 MHz, 50 Ω	range ≤ ±1V range ≥ ±2V	≤ 87 dB on adjacent channels ≤ 85 dB on adjacent channels
Analog Input impedance	software programmable	50 Ω /1 MΩ || 30 pF
Analog input coupling	fixed	DC
Over voltage protection	range ≤ ±1V	±5 V (1 MΩ), 3.5 Vrms (50 Ω)
Over voltage protection	range ≥ ±2V	±50 V (1 MΩ), 5 Vrms (50 Ω)
Anti-Aliasing Filter (digital filtering active)	591x (5 MS/s)	Digital Anti-Aliasing filter at 40% of sampling rate. Examples: 5 MS/s sampling rate -> anit-aliasing filter at 2 MHz 1 MS/s sampling rate -> anti-aliasing filter at 400 kHz
Anti-Aliasing Filter (standard)	591x (5 MS/s) 592x (20 MS/s) 593x (40 MS/s) 594x (80 MS/s) 596x (125 MS/s)	fixed 2.5 MHz 3rd order butterworth alike fixed 10 MHz 3rd order butterworth alike fixed 20 MHz 3rd order butterworth alike fixed 40 MHz 3rd order butterworth alike fixed 60 MHz 3rd order butterworth alike
CMRR (Common Mode Rejection Ratio)	range ≤ ±1V	100 kHz: 75 dB, 1 MHz: 60 dB, 10 MHz: 40 dB
CMRR (Common Mode Rejection Ratio)	range ≥ ±2V	100 kHz: 55 dB, 1 MHz: 52 dB, 10 MHz: 50 dB
Common Mode Voltage Range Differential Input	Input Range VCM (1 MΩ termination) VCM (50 Ω termination)	±200 mV ±500 mV ±1 V ±2 V ±5 V ±10 V ±900 mV ±2.25 V ±2.25 V ±9 V ±22.5 V ±22.5 V ±900 mV ±2.25 V ±2.25 V ±3.5 V ±3.5 V ±3.5 V
Channel selection (single-ended inputs)	software programmable	1, 2, 4 or 8 channels (maximum is model dependent)
Channel selection (true differential inputs)	software programmable	1, 2 or 4 channels (maximum is model dependent)
Calibration	Internal	Self-calibration is done on software command and corrects against the onboard references. Self-calibration should be issued after warm-up time.
Calibration	External	External calibration calibrates the onboard references used in self-calibration. All calibration constants are stored in nonvolatile memory. A yearly external calibration is recommended.

Trigger

Available trigger modes	software programmable	Channel Trigger, External, Software, Window, Pulse, Re-Arm, Spike, Or/And, Delay
Trigger level resolution	software programmable	14 bit
Trigger edge	software programmable	Rising edge, falling edge or both edges
Trigger pulse width	software programmable	0 to [4Gi - 1] samples in steps of 1 sample
Trigger delay	software programmable	0 to [4Gi - 1] samples in steps of 1 samples
Trigger holdoff (for Multi, ABA, Gate)	software programmable	0 to [4Gi - 1] samples in steps of 1 samples
Multi, ABA, Gate: re-arming time		< 40 samples (+ programmed pretrigger + programmed holdoff)
Trigger input: pipeline delay to internal trigger		43 sample clocks
Trigger input to trigger output delay	Firmware version ≥ V29	45 sample clocks
Pretrigger at Multi, ABA, Gate, FIFO	software programmable	8 up to [32 KiSamples / number of active channels] in steps of 8
Posttrigger	software programmable	8 up to [8Gi - 4] samples in steps of 8 (defining pretrigger in standard scope mode)
Memory depth	software programmable	16 up to [installed memory / number of active channels] samples in steps of 8
Multiple Recording/ABA segment size	software programmable	8 up to [installed memory / number of active channels] samples in steps of 8
Internal/External trigger accuracy		1 sample
Timestamp modes	software programmable	Standard, Startreset, external reference clock on X1 (e.g. PPS from GPS, IRIG-B)
Data format		Std., Startreset: 64 bit counter, increments with sample clock (reset manually or on start) RefClock: 24 bit upper counter (increment with RefClock) 40 bit lower counter (increments with sample clock, reset with RefClock)
Extra data	software programmable	none, acquisition of X1/X2/X3 inputs at trigger time, trigger source (for OR trigger)
Size per stamp		128 bit = 16 bytes

External trigger		**Ext**	**X1, X2, X3**
External trigger type		Single level comparator	3.3V LVTTL logic inputs
External trigger impedance	software programmable	50 Ω / 5 kΩ	For electrical specifications refer to „Multi Purpose I/O lines“ section.
External trigger input level		±5 V (5 kΩ), ±2.5 V (50 Ω),	
External trigger over voltage protection		±20 V (5 kΩ), 5 Vrms (50 Ω)	
External trigger sensitivity (minimum required signal swing)		200 mVpp	
External trigger level	software programmable	±5 V in steps of 10 mV	
External trigger bandwidth	50 Ω 5 kΩ	DC to 400 MHz DC to 300 MHz	n.a. DC to 125 MHz
Minimum external trigger pulse width		≥ 2 samples	≥ 2 samples
Minimum pause between external triggers		≥ 2 samples	≥ 2 samples
Resulting max. detectable trigger frequency		[Current Samplerate]/4	[Current Samplerate]/4

Multi Purpose I/O lines

Number of multi purpose output lines	one, named X0
Number of multi purpose input/output lines	three, named X1, X2, X3

Multi Purpose line		**X0**	**X1, X2, X3**
Input: available signal types	software programmable	n.a.	Synchronous Digital-In, Asynchronous Digital-In, Timestamp Reference Clock, Logic trigger
Input: signal levels		n.a.	3.3 V LVTTL (Low ≤ 0.8 V, High ≥ 2.0 V)
Input: impedance		n.a.	10 kΩ to 3.3 V
Input: maximum voltage level		n.a.	-0.5 V to +4.0 V
Input: maximum bandwidth		n.a.	125 MHz
Output: available signal types	software programmable	Run-, Arm-, Trigger-Output, Asynchronous Digital-Out, ADC Clock Output Digital Pulse Generator (option)	Run-, Arm-, Trigger-Output, Asynchronous Digital-Out Digital Pulse Generator (option)

Output: impedance	50 Ω
Output: drive strength	Capable of driving 50 Ω loads, maximum drive strength ±48 mA
Output: type / signal levels	3.3V LVTTL, TTL compatible for high impedance loads
Output: update rate (synchronous modes)	sampling clock

- The auxiliary I/O lines X0 and X3 for the digitizer module are not available on DN2.80x-08 and DN2.81x-08 models.

Option M2p.xxxx-PulseGen

Number of internal pulse generators	4
Number of pulse generator output lines	4 (Existing multi-purpose outputs X0 to X3)
Time resolution of pulse generator	Selected Sampling Rate, max is 125 MS/s (8 ns)
Programmable output modes	Single-shot, multiple repetitions on trigger, gated
Programmable trigger sources	Software, Card Trigger, Other Pulse Generator, XIO lines.
Programmable trigger gate	None, ARM state, RUN state
Programmable length (frequency)	2 to 4Gi samples in steps of 1 (32 bit)
Programmable width (duty cycle)	1 to 4Gi samples in steps of 1 (32 bit)
Programmable delay	0 to 4Gi samples in steps of 1 (32 bit)
Programmable loops	0 to 4Gi samples in steps of 1 (32 bit) with 0 = infinite loops
Output level of digital pulse generators	Please see section of multi-purpose I/O lines.

Clock

Clock Modes	software programmable	internal PLL, external clock, external reference clock, sync
Internal clock range (PLL mode)	software programmable	see „Clock Limitations and Bandwidth“ table below
Internal clock accuracy	after warm-up	≤ ±1.0 ppm (at time of calibration in production)
Internal clock aging		≤ ±0.5 ppm / year
PLL clock setup granularity (int. or ext. reference)		1 Hz
External reference clock range	software programmable	128 kHz up to 125 MHz
Direct external clock to internal clock delay	single card only	4.3 ns
Direct external clock range		see „Clock Limitations and Bandwidth“ table below
Direct external clock minimum LOW/HIGH time		see „Clock Limitations and Bandwidth“ table below
External clock type		Single level comparator
External clock input level		±5 V (5 kΩ), ±2.5 V (50 Ω),
External clock input impedance	software programmable	50 Ω / 5 kΩ
External clock over voltage protection		±20 V (5 kΩ), 5 Vrms (50 Ω)
External clock sensitivity (minimum required signal swing)		200 mVpp
External clock level	software programmable	±5 V in steps of 1mV
External clock edge		rising edge used
External reference clock input duty cycle		45% - 55%
Clock output electrical specification		Available via Multi Purpose output X0. Refer to „Multi Purpose I/O lines“ section.
Synchronization clock multiplier „N“ for different clocks on synchronized cards	software programmable	N being a multiplier (1, 2, 3, 4, 5, ... Max) of the card with the currently slowest sampling clock. The card maximum (see „Clock Limitations and Bandwidth“ table below) must not be exceeded.
ABA mode clock divider for slow clock	software programmable	8 up to (64Ki - 8) in steps of 8
Channel to channel skew on one card		< 200 ps (typical)
Skew between star-hub synchronized cards		< 100 ps (typical)

- The auxiliary I/O lines X0 for the digitizer module is not available on DN2.80x-08 and DN2.81x-08 models.

Clock Limitations and Bandwidth

	M2p.591x, DN2.591-xx DN6.591-xx	M2p.592x, DN2.592-xx DN6.592-xx	M2p.593x DN2.593-xx DN6.593-xx DN2.803-xx DN2.813-xx	M2p.594x	M2p.596x DN2.596-xx DN6.596-xx DN2.806-xx DN2.816-xx
max internal clock (non-synchronized cards)	5 MS/s	20 MS/s	40 MS/s	80 MS/s	125 MS/s
min internal clock (non-synchronized cards)	1 kS/s	1 kS/s	1 kS/s	1 kS/s	1 kS/s
max internal clock (cards synchronized via star-hub)	5 MS/s	20 MS/s	40 MS/s	80 MS/s	125 MS/s
min internal clock (cards synchronized via star-hub)	128 kS/s	128 kS/s	128 kS/s	128 kS/s	128 kS/s
max direct external clock	5 MS/s	20 MS/s	40 MS/s	80 MS/s	125 MS/s
min direct external clock	1 MS/s	1 MS/s	1 MS/s	1 MS/s	1 MS/s
min direct external clock LOW time	25 ns	25 ns	4 ns	4 ns	4 ns
min direct external clock HIGH time	25 ns	25 ns	4 ns	4 ns	4 ns
-3 dB analog input bandwidth	> 2.0 MHz	> 10 MHz	> 20 MHz	> 40 MHz	> 60 MHz
-3 dB analog input bandwidth, digital filter de-activated	> 2.5 MHz	n.a.	n.a.	n.a.	n.a.

RMS Noise Level (Zero Noise), typical figures

M2p.591x, DN2.591-xx, DN6.591-xx digital filtering active

Input Range	±200 mV		±500 mV		±1 V		±2 V		±5 V		±10 V	
Voltage resolution	6.1 µV		15.3 µV		30.5 µV		61.0 µV		152.6 µV		305.2 µV	
50 Ω	<1.5 LSB	<10 µV	<1.2 LSB	<19 µV	<1.0 LSB	<31 µV	<3.0 LSB	<183 µV	<1.6 LSB	<245 µV	<1.2 LSB	<367 µV
1 MΩ	<1.5 LSB	<10 µV	<1.2 LSB	<19 µV	<1.0 LSB	<31 µV	<3.0 LSB	<183 µV	<1.6 LSB	<245 µV	<1.2 LSB	<367 µV

M2p.592x, DN2.592-xx, DN6.592-xx

Input Range	±200 mV		±500 mV		±1 V		±2 V		±5 V		±10 V	
Voltage resolution	6.1 µV		15.3 µV		30.5 µV		61.0 µV		152.6 µV		305.2 µV	
50 Ω	<4.0 LSB	<25 µV	<2.6 LSB	<40 µV	<2.1 LSB	<65 µV	<4.3 LSB	<263 µV	<2.6 LSB	<397 µV	<2.1 LSB	<641 µV
1 MΩ	<4.5 LSB	<28 µV	<3.0 LSB	<46 µV	<2.5 LSB	<107 µV	<4.5 LSB	<275 µV	<3.0 LSB	<458 µV	<2.5 LSB	<763 µV

M2p.593x, DN2.593-xx, DN6.593-xx, DN2.803-xx, DN2.813-xx

Input Range	±200 mV		±500 mV		±1 V		±2 V		±5 V		±10 V	
Voltage resolution	6.1 µV		15.3 µV		30.5 µV		61.0 µV		152.6 µV		305.2 µV	
50 Ω	<6.0 LSB	<37 µV	<5.0 LSB	<77 µV	<4.5 LSB	<138 µV	<6.5 LSB	<397 µV	<5.0 LSB	<763 µV	<4.5 LSB	<1.4 mV
1 MΩ	<6.5 LSB	<40 µV	<5.0 LSB	<77 µV	<4.5 LSB	<138 µV	<6.5 LSB	<397 µV	<5.0 LSB	<763 µV	<4.5 LSB	<1.4 mV

M2p.594x

Input Range	±200 mV		±500 mV		±1 V		±2 V		±5 V		±10 V	
Voltage resolution	6.1 µV		15.3 µV		30.5 µV		61.0 µV		152.6 µV		305.2 µV	
50 Ω	<7.0 LSB	<43 µV	<5.5 LSB	<85 µV	<4.5 LSB	<138 µV	<7.5 LSB	<458 µV	<5.5 LSB	<840 µV	<4.5 LSB	<1.4 mV
1 MΩ	<7.5 LSB	<46 µV	<5.8 LSB	<89 µV	<4.5 LSB	<138 µV	<7.7 LSB	<470 µV	<5.8 LSB	<886 µV	<4.5 LSB	<1.4 mV

M2p.596x, DN2.596-xx, DN6.596-xx, DN2.806-xx, DN2.816-xx

Input Range	±200 mV		±500 mV		±1 V		±2 V		±5 V		±10 V	
Voltage resolution	6.1 µV		15.3 µV		30.5 µV		61.0 µV		152.6 µV		305.2 µV	
50 Ω	<9.0 LSB	<55µV	<6.8 LSB	<104 µV	<5.5 LSB	<168 µV	<9.0 LSB	<550 µV	<6.8 LSB	<1.1 mV	<5.5 LSB	<1.7 mV
1 MΩ	<9.5 LSB	<58µV	<7.1 LSB	<109 µV	<5.5 LSB	<168 µV	<9.5 LSB	<580 µV	<7.1 LSB	<1.1 mV	<5.5 LSB	<1.7 mV

Dynamic Parameters, typical figures

M2p.591x, DN2.591-xx, DN6.591-xx digital filtering active

Test - sampling rate	5 MS/s							
Input Range	±200 mV		±500 mV		±1 V		±2 V	
Test Signal Frequency	20 kHz	1 MHz	20 kHz	1 MHz	20 kHz	1 MHz	20 kHz	1 MHz
SNR (typ)	≥ 83.5 dB	≥ 82.8 dB	≥ 85.0 dB	≥ 84.9 dB	≥ 86.2 dB	≥ 85.7 dB	n.a.	n.a.
THD (typ)	(≤ 84.4 dB)	≤ -93.5 dB	(≤ 86.3 dB)	≤ -93.1 dB	(≤ 86.9 dB)	≤ -91.8 dB	n.a.	n.a.
SFDR (typ), excl. harm.	≥ 103.0 dB	≥ 103.0 dB	≥ 104.0 dB	≥ 107.0 dB	≥ 103.0 dB	≥ 107.0 dB	n.a.	n.a.
ENOB (based on SNR)	≥ 13.6 LSB	≥ 13.4 LSB	≥ 13.8 LSB	≥ 13.8 LSB	≥ 14.0 LSB	≥ 13.9 LSB	n.a.	n.a.
ENOB (based on SINAD)	≥ 13.1 LSB	≥ 13.4 LSB	≥ 13.4 LSB	≥ 13.7 LSB	≥ 13.6 LSB	≥ 13.8 LSB	n.a.	n.a.

M2p.591x, DN2.591-xx, DN6.591-xx digital filtering active

Test - sampling rate	3 MS/s		1 MS/s		500 kS/s		200 kS/s	
Input Range	±200 mV	±1 V	±200 mV	±1 V	±200 mV	±1 V	±200 mV	±1 V
Test Signal Frequency	20 kHz		20 kHz		20 kHz		20 kHz	
Input bandwidth due to digital filter	1.2 MHz		400 kHz		200 klHz		80 kHz	
SNR (typ)	≥ 85.3 dB	≥ 86.6 dB	≥ 87.2 dB	≥ 89.1 dB	≥ 86.2 dB	≥ 89.7 dB	≥ 86.4 dB	≥ 89.4 dB
THD (typ)	(≤ 88.9 dB)	(≤ -88.5 dB)	(≤ 86.4 dB)	(≤ -88.6 dB)	(≤ 86.9 dB)	(≤ -90.8 dB)	(≤ 89.7 dB)	(≤ -93.8 dB)
SFDR (typ), excl. harm.	≥ 103.1 dB	≥ 103.6 dB	≥ 102.8 dB	≥ 105.6 dB	≥ 103.1 dB	≥ 103.1 dB	≥ 103.1 dB	≥ 103.5 dB
ENOB (based on SNR)	≥ 13.9 LSB	≥ 14.1 LSB	≥ 14.2 LSB	≥ 14.5 LSB	≥ 14.0 LSB	≥ 14.6 LSB	≥ 14.1 LSB	≥ 14.6 LSB
ENOB (based on SINAD)	≥ 13.5 LSB	≥ 13.7 LSB	≥ 13.6 LSB	≥ 14.0 LSB	≥ 13.6 LSB	≥ 14.2 LSB	≥ 13.8 LSB	≥ 14.3 LSB

(20 kHz measurements are missing the correct bandpass filter and therefore show a larger THD that is coming from the generator)

	M2p.592x, DN2.592-xx, DN6.592-xx							
Test - sampling rate	20 MS/s							
Input Range	±200 mV		±500 mV		±1 V		±2 V	
Test Signal Frequency	1 MHz	n.a.	1 MHz	n.a.	1 MHz	n.a.	1 MHz	n.a.
SNR (typ)	≥ 77.2 dB	n.a.	≥ 79.8 dB	n.a.	≥ 81.0 dB	n.a.	≥ 75.0 dB	n.a.
THD (typ)	≤ 92.5 dB	n.a.	≤ -92.8 dB	n.a.	≤ -89.5 dB	n.a.	≤ -76.5 dB	n.a.
SFDR (typ), excl. harm.	≥ 103.0 dB	n.a.	≥ 103.0 dB	n.a.	≥ 105.0 dB	n.a.	≥ 93.0 dB	n.a.
ENOB (based on SNR)	≥ 12.5 LSB	n.a.	≥ 13.0 LSB	n.a.	≥ 13.2 LSB	n.a.	≥ 12.2 LSB	n.a.
ENOB (based on SINAD)	≥ 12.5 LSB	n.a.	≥ 13.0 LSB	n.a.	≥ 13.1 LSB	n.a.	≥ 11.8 LSB	n.a.

	M2p.593x, DN2.593-xx, DN6.593-xx, DN2.803-xx, DN2.813-xx							
Test - sampling rate	40 MS/s							
Input Range	±200 mV		±500 mV		±1 V		±2 V	
Test Signal Frequency	1 MHz	10 MHz	1 MHz	10 MHz	1 MHz	10 MHz	1 MHz	10 MHz
SNR (typ)	≥ 73.0 dB	≥ 72.6 dB	≥ 74.6 dB	≥ 74.4 dB	≥ 75.3 dB	≥ 75.3 dB	≥ 71.9 dB	≥ 71.8 dB
THD (typ)	≤ -87.8 dB	≤ -67.0 dB	≤ -89.0 dB	≤ -67.0 dB	≤ -86.1 dB	≤ -67.2 dB	≤ -79.0 dB	≤ -67.2 dB
SFDR (typ), excl. harm.	≥ 98.3 dB	≥ 96.5 dB	≥ 98.8 dB	≥ 99.5 dB	≥ 101.0 dB	≥ 100.0 dB	≥ 81.7 dB	≥ 91.3 dB
ENOB (based on SNR)	≥ 11.8 LSB	≥ 11.8 LSB	≥ 12.1 LSB	≥ 12.0 LSB	≥ 12.2 LSB	≥ 12.2 LSB	≥ 11.7 LSB	≥ 11.6 LSB
ENOB (based on SINAD)	≥ 11.8 LSB	≥ 10.7 LSB	≥ 12.1 LSB	≥ 10.7 LSB	≥ 12.2 LSB	≥ 10.8 LSB	≥ 11.6 LSB	≥ 10.7 LSB

	M2p.594x							
Test - sampling rate	80 MS/s							
Input Range	±200 mV		±500 mV		±1 V		±2 V	
Test Signal Frequency	1 MHz	10 MHz	1 MHz	10 MHz	1 MHz	10 MHz	1 MHz	10 MHz
SNR (typ)	≥ 70.6 dB	≥ 70.5 dB	≥ 72.9 dB	≥ 72.8 dB	≥ 74.2 dB	≥ 74.2 dB	≥ 69.8 dB	≥ 69.8 dB
THD (typ)	≤ -87.3 dB	≤ -76.9 dB	≤ -86.6 dB	≤ -76.3 dB	≤ -84.8 dB	≤ -70.1 dB	≤ -79.0 dB	≤ -77.9 dB
SFDR (typ), excl. harm.	≥ 97.5 dB	≥ 105.0 dB	≥ 101.0 dB	≥ 104.0 dB	≥ 100.0 dB	≥ 100.0 dB	≥ 96.9 dB	≥ 96.6 dB
ENOB (based on SNR)	≥ 11.4 LSB	≥ 11.4 LSB	≥ 11.8 LSB	≥ 11.8 LSB	≥ 12.0 LSB	≥ 12.0 LSB	≥ 11.2 LSB	≥ 11.2 LSB
ENOB (based on SINAD)	≥ 11.4 LSB	≥ 11.3 LSB	≥ 11.8 LSB	≥ 11.5 LSB	≥ 12.0 LSB	≥ 11.1 LSB	≥ 11.2 LSB	≥ 11.2 LSB

	M2p.596x, DN2.596-xx, DN6.596-xx, DN2.806-xx, DN2.816-xx											
Test - sampling rate	125 MS/s											
Input Range	±200 mV			±500 mV			±1 V			±2 V		
Test Signal Frequency	1 MHz	10 MHz	40 MHz	1 MHz	10 MHz	40 MHz	1 MHz	10 MHz	40 MHz	1 MHz	10 MHz	40 MHz
SNR (typ)	≥ 68.1 dB	≥ 66.2 dB	≥ 65.5 dB	≥ 70.5 dB	≥ 69.9 dB	≥ 68.7 dB	≥ 73.3 dB	≥ 72.7 dB	≥ 71.5 dB	≥ 67.8 dB	≥ 65.8 dB	≥ 65.1 dB
THD (typ)	≤ -81.5 dB	≤ -74.5 dB	≤ -53.7 dB	≤ -82.5 dB	≤ -77.6 dB	≤ -55.3 dB	≤ -83.3 dB	≤ -68.9 dB	≤ -57.3 dB	≤ -78.0 dB	≤ -75.6 dB	≤ -53.7 dB
SFDR (typ), excl. harm.	≥ 95.0 dB	≥ 93.4 dB	≥ 92.3 dB	≥ 97.5 dB	≥ 96.8 dB	≥ 94.0 dB	≥ 98.5 dB	≥ 98.1 dB	≥ 96.4 dB	≥ 91.5 dB	≥ 89.0 dB	≥ 89.0 dB
ENOB (based on SNR)	≥ 11.0 LSB	≥ 10.7 LSB	≥ 10.6 LSB	≥ 11.4 LSB	≥ 11.3 LSB	≥ 11.1 LSB	≥ 11.8 LSB	≥ 11.8 LSB	≥ 11.6 LSB	≥ 11.0 LSB	≥ 10.6 LSB	≥ 10.5 LSB
ENOB (based on SINAD)	≥ 11.0 LSB	≥ 10.6 LSB	≥ 8.6 LSB	≥ 11.4 LSB	≥ 11.1 LSB	≥ 8.9 LSB	≥ 11.7 LSB	≥ 11.0 LSB	≥ 9.2 LSB	≥ 10.9 LSB	≥ 10.6 LSB	≥ 8.6 LSB

Dynamic parameters are measured at ±1 V input range (if no other range is stated) and 50 Ω termination with the samplerate specified in the table. Measured parameters are averaged 20 times to get typical values. Test signal is a pure sine wave generated by a signal generator and a matching bandpass filter. Amplitude is >99% of FSR. SNR and RMS noise parameters may differ depending on the quality of the used PC. SNR = Signal to Noise Ratio, THD = Total Harmonic Distortion, SFDR = Spurious Free Dynamic Range, SINAD = Signal Noise and Distortion, ENOB = Effective Number of Bits.

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Connectors

Analog Inputs or Outputs		9 mm BNC female (one for each single-ended Ch.)	Cable-Type: Cab-9m-xx-xx
Trigger Input		9 mm BNC female	Cable-Type: Cab-9m-xx-xx
Clock/Reference Clock Input		9 mm BNC female	Cable-Type: Cab-9m-xx-xx
Clock Output, Multi-Purpose X0		9 mm BNC female	Cable-Type: Cab-9m-xx-xx
Multi-Purpose I/O X1, X2, X3	Programmable Direction	9 mm BNC female	Cable-Type: Cab-9m-xx-xx

Connection Cycles

All connectors have an expected lifetime as specified below. Please avoid to exceed the specified connection cycles or use connector savers.

BNC connector	500 connection cycles
Power connecctor	500 connection cycles
LAN connector	750 connection cycles

- The auxiliary I/O lines X0 and X3 for the digitizer module are not available on DN2.80x-08 and DN2.81x-08 models.

hybridNETBOX Technical Data - Arbitrary Waveform Generator

Only figures that are given with a maximum reading or with a tolerance reading are guaranteed specifications. All other figures are typical characteristics that are given for information purposes only. Figures are valid for products stored for at least 2 hours inside the specified operating temperature range, after a 30 minute warm-up, after running an on-board calibration and with proper cooled products. All figures have been measured in lab environment with an environmental temperature between 20°C and 25°C and an altitude of less than 100 m.

Analog Outputs

Resolution		16 bit	
D/A Interpolation		no interpolation	
Output amplitude	software programmable	653x and 656x:	±1 mV up to ±3 V in 1 mV steps into 50 Ω termination (resulting in ±2 mV up to ±6 V in 2mV steps into high impedance loads)
		653x and 656x	Gain values below ±300 mV into 50 Ω are generated by reduction of digital samples
		654x and 657x:	±1 mV up to ±6 V in 1 mV steps into 50 Ω termination (resulting in ±2 mV up to ±12 V in 2mV steps into high impedance loads)
		654x and 657x:	Gain values below ±300 mV and between ±1000 mV and ±2000 mV into 50 Ω are generated by reduction of digital samples
Output Amplifier Path Selection	automatically by driver	Low Power path:	Selected Gain of ±1 mV to ±960 mV (into 50 Ω)
		High Power path:	653x and 656x: Selected Gain of ±940 mV to ±3 V (into 50 Ω) 654x and 657x: Selected Gain of ±940 mV to ±6 V (into 50 Ω)
Output Amplifier Setting Hysteresis	automatically by driver	940 mV to 960 mV (if output is using low power path it will switch to high power path at 960 mV. If output is using high power path it will switch to low power path at 940 mV)	
Output amplifier path switching time		1.2 ms (output disabled while switching)	
Output offset Low Power Path	software programmable	±960 mV in 1 mV steps into 50 Ω (±1920 mV in 2 mV steps into 1 MΩ)	
Output offset High Power Path	software programmable	653x and 656x: ±3 V in 1 mV steps into 50 Ω (±6V in 2 mV steps into 1 MΩ) 654x and 657x: ±6 V in 1 mV steps into 50 Ω (±12V in 2 mV steps into 1 MΩ)	
Filters	software programmable	One of 4 different filters (refer to „Bandwidth and Filters" section)	
DAC Differential non linearity (DNL)	DAC only	±2.0 LSB typical	
DAC Integral non linearity (INL)	DAC only	±4.0 LSB typical	
Output resistance		50 Ω	
Output coupling		DC	
Minimum output load		653x and 656x: 0 Ω (short circuit safe by design) 654x and 657x: 50 Ω (short circuit safe by hardware supervisor, outputs will turn off)	
Max output swing in 50 Ω		653x and 656x: ±3.0 V (offset + amplitude) 654x and 657x: ±6.0 V (offset + amplitude)	
Max output swing in 1 MΩ		653x and 656x: ±6.0 V (offset + amplitude) 654x and 657x: ±12.0 V (offset + amplitude)	
Max output current		653x and 656x: ±100 mA 654x and 657x: ±200 mA	
Slewrate (using Filter 0)		Low power path (0 to 900 mV): 250 mV/ns 653x and 656x: High power path (0 to 3000 mV): 850 mV/ns 654x and 657x: High power path (0 to 6000 mV): 1700 mV/ns	
Rise/Fall time 10% to 90% (using Filter 0)		653x and 656x: ±3 V square wave: 5.3 ns 654x and 657x: ±3 V square wave: 5.4 ns 654x and 657x: ±6 V square wave: 5.4 ns	
Crosstalk @ 1 MHz signal ±3 V	1 to 4 ch standard AWG	95 dB (M2p.6530, M2p.6531, M2p.6536, M2p.6560, M2p.6561, M2p.6566)	
Crosstalk @ 1 MHz signal ±3 V	8 channel AWG	84 dB (M2p.6533, M2p.6568)	
Crosstalk @ 1 MHz signal ±6 V	1 to 4 ch high-voltage AWG	99 dB (M2p.6540, M2p.6541, M2p.6546, M2p.6540, M2p.6541, M2p.6546)	
Output accuracy		±1 mV ±0.5 % of programmed output amplitude ±0.1 % of programmed output offset	
Calibration	External	External calibration calibrates the on-board references. All calibration constants are stored in non-volatile memory. A yearly external calibration is recommended.	

Trigger

Available trigger modes	software programmable	External, Software, Pulse, Or/And, Delay	
Trigger edge	software programmable	Rising edge, falling edge or both edges	
Trigger pulse width	software programmable	0 to [4Gi - 1] samples in steps of 1 sample	
Trigger delay	software programmable	0 to [4Gi - 1] samples in steps of 1 samples	
Trigger hold-off (for Multi, Gate)	software programmable	0 to [4Gi - 1] samples in steps of 1 samples	
Multi, Gate: re-arming time		< 24 samples (+ programmed hold-off)	
Trigger input to output delay	Firmware version ≥ V30	63 sample clocks + 7 ns (valid for all modes except SPCSEQ_ENDLOOPONTRIG)	
Trigger input: pipeline delay to internal trigger		22 sample clocks	
Trigger input to trigger output delay	Firmware version ≥ V30	63 sample clocks	
Memory depth	software programmable	16 up to [installed memory / number of active channels] samples in steps of 8	
Multiple Replay segment size	software programmable	16 up to [installed memory / number of active channels] samples in steps of 8	
External trigger accuracy		1 sample	
External trigger		**Ext**	**X1, X2, X3**
External trigger type		Single level comparator	3.3V LVTTL logic inputs
External trigger impedance	software programmable	50 Ω / 5 kΩ	For electrical specifications refer to „Multi Purpose I/O lines" section.
External trigger input level		±5 V (5 kΩ), ±2.5 V (50 Ω),	
External trigger over voltage protection		±20 V (5 kΩ), 5 Vrms (50 Ω)	
External trigger sensitivity (minimum required signal swing)		200 mVpp	
External trigger level	software programmable	±5 V in steps of 10 mV	
External trigger bandwidth	50 Ω 5 kΩ	DC to 400 MHz DC to 300 MHz	n.a. DC to 125 MHz
Minimum external trigger pulse width		≥ 2 samples	≥ 2 samples

Multi Purpose I/O lines

Number of multi purpose output lines		one, named X0	
Number of multi purpose input/output lines		three, named X1, X2, X3	
Multi Purpose line		**X0**	**X1, X2, X3**
Input: available signal types	software programmable	n.a.	Asynchronous Digital-In, Logic trigger
Input: signal levels		n.a.	3.3 V LVTTL (Low ≤ 0.8 V, High ≥ 2.0 V)
Input: impedance		n.a.	10 kΩ to 3.3 V
Input: maximum voltage level		n.a.	-0.5 V to +4.0 V
Input: maximum bandwidth		n.a.	125 MHz
Output: available signal types	software programmable	Run-, Arm-, Trigger-Output, Marker-Output, Synchronous Digital-Out, Asynchronous Digital-Out ADC Clock Output,	Run-, Arm-, Trigger-Output, Marker-Output, Synchronous Digital-Out, Asynchronous Digital-Out,
Output: impedance		50 Ω	
Output: drive strength		Capable of driving 50 Ω loads, maximum drive strength ±48 mA	
Output: type / signal levels		3.3V LVTTL, TTL compatible for high impedance loads	
Output: update rate (synchronous modes)		sampling clock	

Sequence Replay Mode

Number of sequence steps	software programmable	1 up to 4096 (sequence steps can be overloaded at runtime)
Number of memory segments	software programmable	2 up to 64Ki (segment data can be overloaded at runtime)
Minimum segment size	software programmable	32 samples in steps of 8 samples.
Maximum segment size	software programmable	512 MiS / active channels / number of sequence segments (round up to the next power of two)
Loop Count	software programmable	1 to (1Mi - 1) loops
Sequence Step Commands	software programmable	Loop for #Loops, Next, Loop until Trigger, End Sequence
Special Commands	software programmable	Data Overload at runtime, sequence steps overload at runtime, readout current replayed sequence step
Limitations for synchronized products		Software commands changing the sequence as well as „Loop until trigger" are not synchronized between cards. This also applies to multiple AWG modules in a generatorNETBOX.

Clock

Clock Modes	software programmable	internal PLL, external clock, external reference clock, sync
Internal clock range (PLL mode)	software programmable	see „Clock Limitations" table below
Internal clock accuracy	after warm-up	≤ ±1.0 ppm (at time of calibration in production)
Internal clock aging		≤ ±0.5 ppm / year
PLL clock setup granularity (internal reference)		1 Hz
External reference clock range	software programmable	128 kHz up to 125 MHz
Direct external clock to internal clock delay		4.3 ns
Direct external clock range		see „Clock Limitations and Bandwidth" table below
External clock type		Single level comparator
External clock input level		±5 V (5 kΩ), ±2.5 V (50 Ω),
External clock input impedance	software programmable	50 Ω / 5 kΩ
External clock over voltage protection		±20 V (5 kΩ), 5 Vrms (50 Ω)
External clock sensitivity (minimum required signal swing)		200 mVpp
External clock level	software programmable	±5 V in steps of 1mV
External clock edge		rising edge used
External reference clock input duty cycle		45% - 55%
Clock output electrical specification		Available via Multi Purpose output X0. Refer to „Multi Purpose I/O lines" section.
Synchronization clock multiplier „N" for different clocks on synchronized cards	software programmable	N being a multiplier (1, 2, 3, 4, 5, ... Max) of the card with the currently slowest sampling clock. The card maximum (see „Clock Limitations and Bandwidth" table below) must not be exceeded.
Channel to channel skew on one card		< 200 ps (typical)
Skew between star-hub synchronized cards		< 100 ps (typical)

Clock Limitations

	M2p.653x DNx.653-xx M2p.654x DNx.654-xx DNx.803-xx DNx.813-xx	M2p.656x DNx.656-xx M2p.657x DNx.657-xx DNx.806-xx DNx.816-xx
max internal clock (non-synchronized cards)	40 MS/s	125 MS/s
min internal clock (non-synchronized cards)	1 kS/s	1 kS/s
max internal clock (cards synchronized via star-hub)	40 MS/s	125 MS/s
min internal clock (cards synchronized via star-hub)	128 kS/s	128 kS/s
max direct external clock	40 MS/s	125 MS/s
min direct external clock	DC	DC
min direct external clock LOW time	4 ns	4 ns
min direct external clock HIGH time	4 ns	4 ns

Bandwidth and Filters

	Filter	- 3dB bandwidth	Filter characteristic
Analog bandwidth does not include Sinc response of DAC	Filter 0	70 MHz	third-order Butterworth
	Filter 1	20 MHz	fifth-order Butterworth
	Filter 2	5 MHz	fourth-order Bessel
	Filter 3	1 MHz	fourth-order Bessel

Dynamic Parameters

	M2p.653x/DNx.653-xx/DNx.803-xx			
Test - Samplerate	40 MS/s		40 MS/s	
Output Frequency	800 kHz		4 MHz	
Output Level in 50 Ω	±900mV	±3000mV	±900mV	±3000mV
Used Filter	1 MHz		5 MHz	
NSD (typ)	-142 dBm/Hz	-132 dBm/Hz	-142 dBm/Hz	-132 dBm/Hz
SNR (typ)	90.7 dB	91.1 dB	83.7 dB	84.1 dB
THD (typ)	-74.0 dB	-74.0 dB	-70.5 dB	-70.5 dB
SINAD (typ)	73.9 dB	73.9 dB	69.8 dB	69.8 dB
SFDR (typ), excl harm.	97.0 dB	95.0 dB	88.0 dB	88.0 dB
ENOB (SINAD)	12.0	12.0	11.3	11.3
ENOB (SNR)	14.7	14.8	13.5	13.6

	M2p.654x/DNx.654-xx/DNx.813-xx			
Test - Samplerate	40 MS/s		40 MS/s	
Output Frequency	800 kHz		4 MHz	
Output Level in 50 Ω	±900mV	±6000mV	±900mV	±6000mV
Used Filter	1 MHz		5 MHz	
NSD (typ)	-138 dBm/Hz	-129 dBm/Hz	-142 dBm/Hz	-126 dBm/Hz
SNR (typ)	86.7 dB	88.1 dB	83.7 dB	84.2 dB
THD (typ)	-74.0 dB	-74.0 dB	-74.0 dB	-74.0 dB
SINAD (typ)	73.8 dB	73.8 dB	73.6 dB	73.6 dB
SFDR (typ), excl harm.				
ENOB (SINAD)	12.0	12.0	11.9	11.9
ENOB (SNR)	14.1	14.3	13.6	13.7

	M2p.656x/DNx.656-xx/DNx.806-xx					
Test - Samplerate	125 MS/s		125 MS/s		125 MS/s	
Output Frequency	800 kHz		4 MHz		16 MHz	
Used Filter	1 MHz		5 MHz		20 MHz	
Output Level in 50 Ω	±900mV	±3000mV	±900mV	±3000mV	±900mV	±3000mV
NSD (typ)	-142 dBm/Hz	-132 dBm/Hz	-142 dBm/Hz	-132 dBm/Hz	-142 dBm/Hz	-132 dBm/Hz
SNR (typ)	90.7 dB	91.1 dB	83.7 dB	84.1 dB	77.7 dB	78.1 dB
THD (typ)	-74.0 dB	-74.0 dB	-70.5 dB	-70.5 dB	-66.0 dB	-61.9 dB
SINAD (typ)	73.9 dB	73.9 dB	69.8 dB	69.8 dB	65.7 dB	60.9 dB
SFDR (typ), excl harm.	97.0 dB	95.0 dB	88.0 dB	88.0 dB	90.0 dB	89.0 dB
ENOB (SINAD)	12.0	12.0	11.3	11.3	10.6	9.8
ENOB (SNR)	14.7	14.8	13.5	13.6	12.5	12.6

	M2p.657x/DNx.657-xx/DNx.816-xx					
Test - Samplerate	125 MS/s		125 MS/s		125 MS/s	
Output Frequency	800 kHz		4 MHz		16 MHz	
Used Filter	1 MHz		5 MHz		20 MHz	
Output Level in 50 Ω	±900mV	±6000mV	±900mV	±6000mV	±900mV	±6000mV
NSD (typ)	-138 dBm/Hz	-129 dBm/Hz	-142 dBm/Hz	-126 dBm/Hz	-142 dBm/Hz	-127 dBm/Hz
SNR (typ)	86.7 dB	88.1 dB	83.7 dB	84.2 dB	77.7 dB	79.1 dB
THD (typ)	-74.0 dB	-74.0 dB	-74.0 dB	-74.0 dB	-70.5 dB	-63.1 dB
SINAD (typ)	73.8 dB	73.8 dB	73.6 dB	73.6 dB	69.7 dB	63.0 dB
SFDR (typ), excl harm.						
ENOB (SINAD)	12.0	12.0	11.9	11.9	11.3	10.2
ENOB (SNR)	14.1	14.3	13.6	13.7	12.6	12.8

THD and SFDR are measured at the given output level and 50 Ohm termination with a high resolution M3i.4860/M4i.4450-x8 data acquisition card and are calculated from the spectrum. Noise Spectral Density is measured with built-in calculation from an HP E4401B Spectrum Analyzer. All available D/A channels are activated for the tests. SNR and SFDR figures may differ depending on the quality of the used PC. NSD = Noise Spectral Density, THD = Total Harmonic Distortion, SFDR = Spurious Free Dynamic Range. Phase Noise and Jitter is measured with a Holzworth HA7062C Phase Noise Analyzer.

Connectors

Analog Inputs or Outputs		9 mm BNC female (one for each single-ended Ch.)	Cable-Type: Cab-9m-xx-xx
Trigger Input		9 mm BNC female	Cable-Type: Cab-9m-xx-xx
Clock/Reference Clock Input		9 mm BNC female	Cable-Type: Cab-9m-xx-xx
Clock Output, Multi-Purpose X0		9 mm BNC female	Cable-Type: Cab-9m-xx-xx
Multi-Purpose I/O X1, X2, X3	Programmable Direction	9 mm BNC female	Cable-Type: Cab-9m-xx-xx

Connection Cycles

All connectors have an expected lifetime as specified below. Please avoid to exceed the specified connection cycles or use connector savers.

BNC connector	500 connection cycles
Power connecctor	500 connection cycles
LAN connector	750 connection cycles

hybridNETBOX Technical Data - General

Option digitizerNETBOX/generatorNETBOX embedded server (DN2.xxx-Emb, DN6.xxx-Emb)

CPU	Intel Quad Core 2 GHz	
System memory	4 GiByte RAM	
System data storage	Internal 128 GByte SSD	
Development access	Remote Linux command shell (ssh), no graphical interface (GUI) available	
Accessible Hardware	Full access to Spectrum instruments, LAN, front panel LEDs, RAM, SSD	
Integrated operating system	OpenSuse 12.2 with kernel 4.4.7.	
Internal PCIe connection (PCIe bus connection is shared amongst all internal digitizer/generator modules)	DN2.20, DN2.46, DN2.47, DN2.49, DN2.60, DN6.46, DN6.49:	PCIe x1, Gen1
	DN2.59, DN2.65, DN2.80, DN2.81, DN6.59, DN6.65:	PCIe x1, Gen1
	DN2.22, DN2.33, DN2.44, DN2.63, DN2.66, DN2.96, DN2.82:	PCIe x1, Gen2
	DN6.22, DN6.33, DN6.44, DN6.63, DN6.66, DN6.96:	PCIe x1, Gen2

Ethernet specific details

LAN Connection		Standard RJ45	
LAN Speed		Auto Sensing: GBit Ethernet, 100BASE-T, 10BASE-T	
LAN IP address	programmable	DHCP (IPv4) with AutoIP fall-back (169.254.x.y), fixed IP (IPv4)	
Sustained Streaming speed		DN2.20, DN2.46, DN2.47, DN2.49, DN2.60 DN6.46, DN6.49	up to 70 MByte/s
		DN2.59, DN2.65, DN2.22, DN2.33, DN2.44, DN2.63, DN2.66, DN6.59, DN6.65, DN6.22, DN6.33, DN6.44, DN6.63, DN6.66	up to 100 MByte/s
Used TCP/UDP Ports		Webserver: 80 VISA Discovery Protocol: 111, 9757 Spectrum Remote Server: 1026, 5025	mDNS Daemon: 5353 UPNP Daemon: 1900

AC Power connection details (default configuration)

Mains AC power supply	Input voltage: 100 to 240 VAC, 50 to 60 Hz
AC power supply connector	IEC 60320-1-C14 (PC standard coupler)
Power supply cord	power cord included for Schuko contact (CEE 7/7)

DC 24 V Power supply details (option DN2.xxxx-DC24)

Input Voltage	18 V to 36 V
Power supply connector	screw terminal
Power supply cord	no cord included

Serial connection details (DN2.xxx with hardware ≥ V11)

Serial connection (RS232)	For diagnostic purposes only. Do not use, unless being instructed by a Spectrum support agent.

Certification, Compliance, Warranty

Conformity Declaration	EN 17050-1:2010	General Requirements
EU Directives	2014/30/EU	EMC - Electromagnetic Compatibility
	2014/35/EU	LVD - Electrical equipment designed for use within certain voltage limits
	2011/65/EU	RoHS - Restriction of the use of certain hazardous substances in electrical and electronic equipment
	2006/1907/EC	REACH - Registration, Evaluation, Authorisation and Restriction of Chemicals
	2012/19/EU	WEEE - Waste from Electrical and Electronic Equipment
	2006/66/EC	On batteries and accumulators and waste batteries and accumulators
Compliance Standards	EN 61010-1: 2010	Safety regulations for electrical measuring, control, regulating and laboratory devices - Part 1: General requirement
	EN 61187:1994	Electrical and electronic measuring equipment - Documentation
	EN 61326-1:2021	Electrical equipment for measurement, control and laboratory use
	EN 61326-2-1:2021	EMC requirements - Part 1: General requirements EMC requirements - Part 2-1: Particular requirements - Test configurations, operational conditions and performance criteria for sensitive test and measurement equipment for EMC unprotected applications
	EN IEC 63000:2018	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances
Product warranty	5 years starting with the day of delivery	
Software and firmware updates	Life-time, free of charge	

DN2 specific Technical Data

Environmental and Physical Details DN2.xxx

Dimension of Chassis without connectors or bumpers	L x W x H	366 mm x 267 mm x 87 mm
Dimension of Chassis with 19" rack mount option	L x W x H	366 mm x 482.6 mm x 87 mm (2U height)
Weight (1 internal acquisition/generation module)		6.3 kg, with rack mount kit: 6.8 kg
Weight (2 internal acquisition/generation modules)		6.7 kg, with rack mount kit 7.2 kg
Weight (DN2.33x or DN2.63x)		5.9 kg, with rack mount kit 6.4 kg
Warm up time		20 minutes
Operating temperature		0°C to 40°C
Storage temperature		-10°C to 70°C
Humidity		10% to 90%
Dimension of packing (single DN2)	L x W x H	470 mm x 390 mm x 180 mm
Volume weight of Packing (single DN2)		7.0 kg

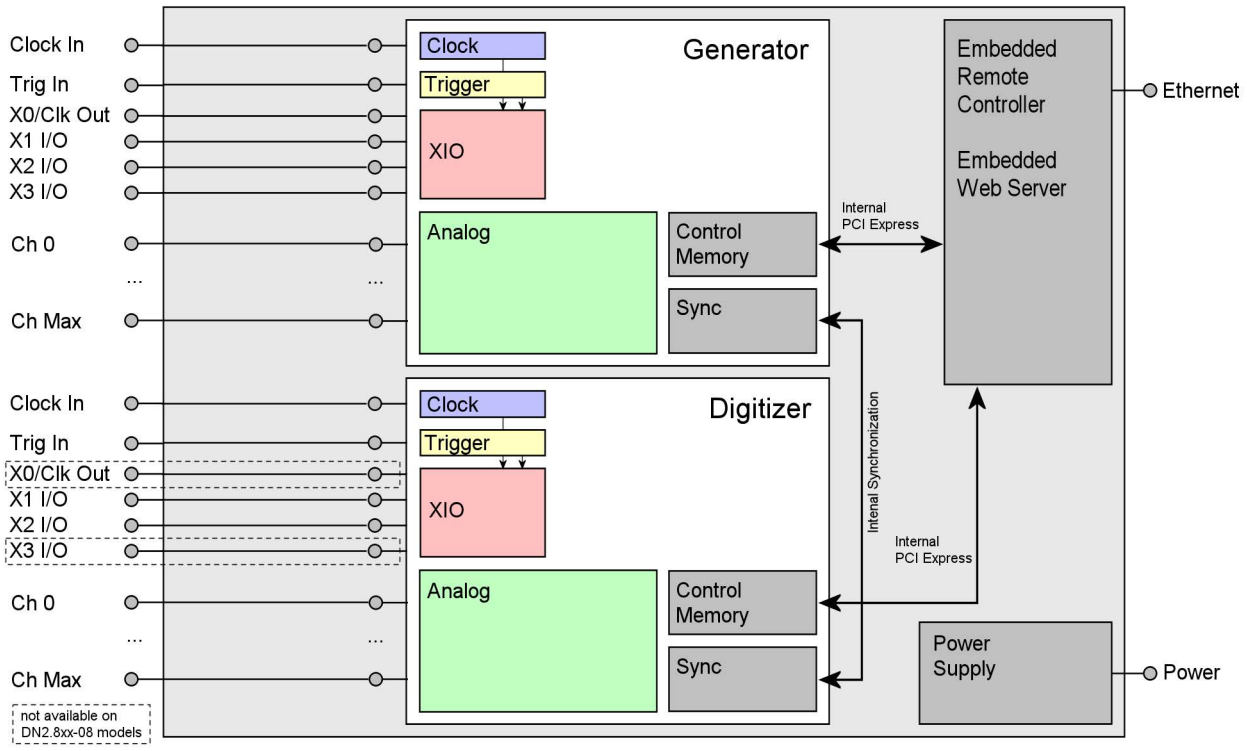
Power Consumption

	230 VAC	12 VDC	24 VDC
2 + 2 channel versions			
4 + 4 channel versions			
8 + 8 channel versions			

MTBF

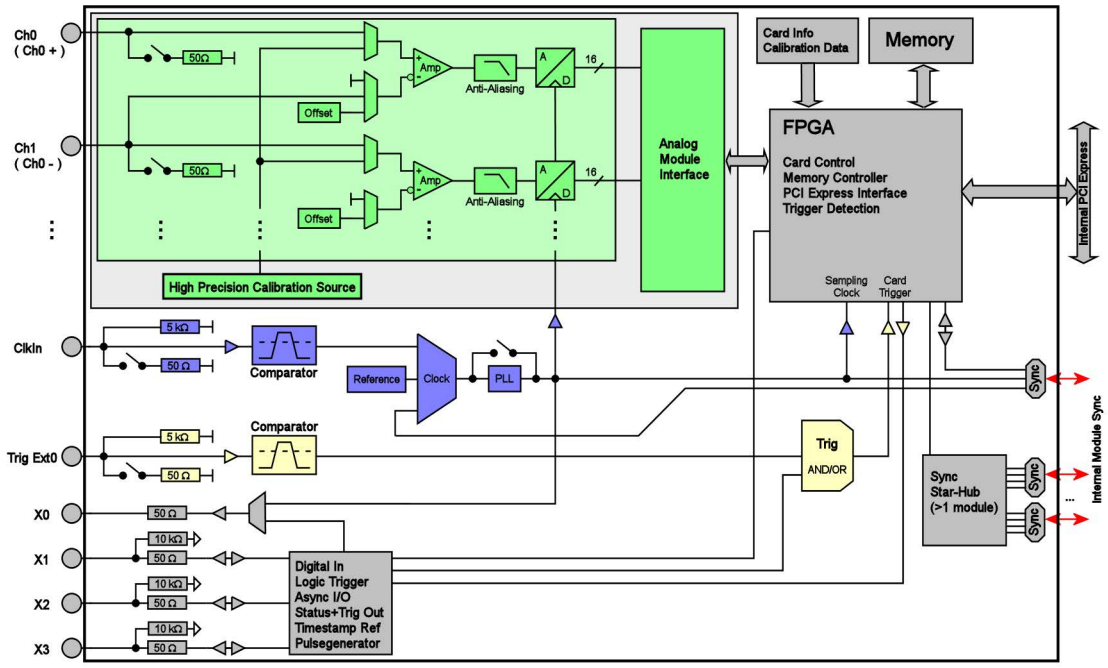
MTBF	100000 hours

Block diagram of hybridNETBOX DN2



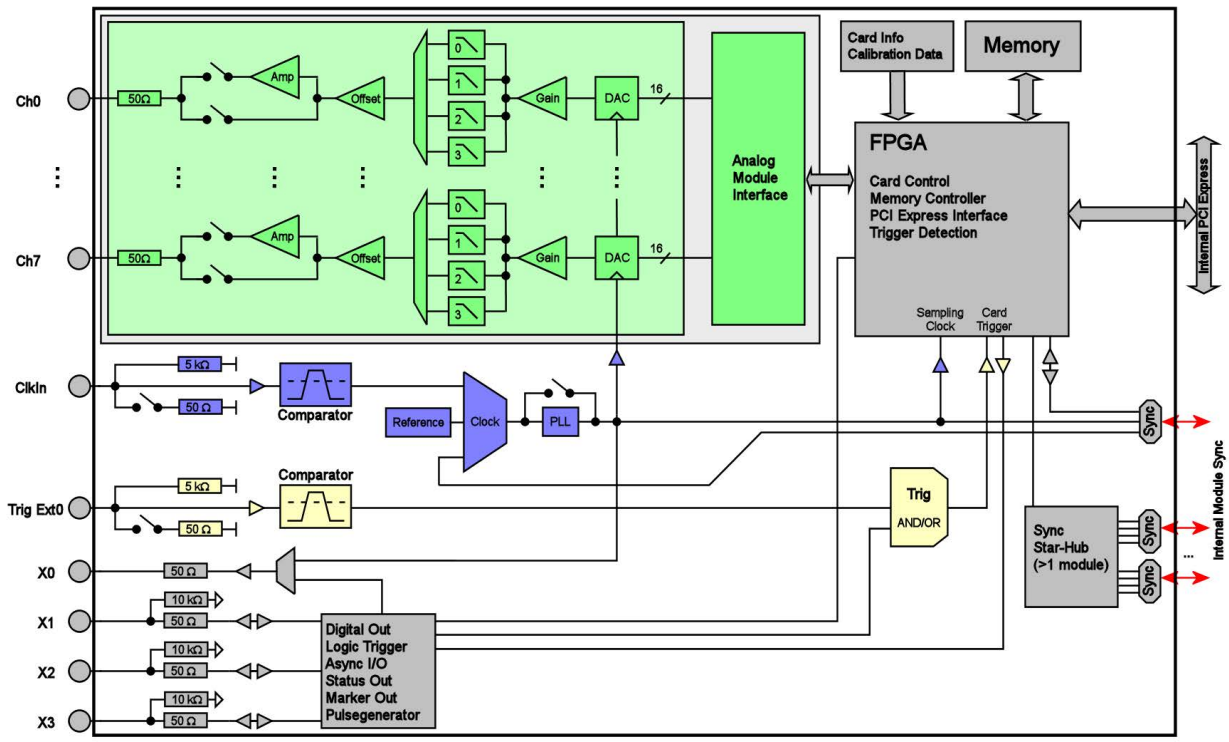
- The number of maximum channels is model dependent.
- The auxiliary I/O lines X0 and X3 for the digitizer module are not available on DN2.80x-08 and DN2.81x-08 models.

Block diagram of Digitizer Module hybridNETBOX DN2.80x/81x



- The auxiliary I/O lines X0 and X3 for the digitizer module are not available on DN2.80x-08 and DN2.81x-08 models.

Block diagram of AWG Module hybridNETBOX DN2.80x/81x



Order Information

The hybridNETBOX is equipped with a large internal memory for data storage and data replay. The internal digitizer supports standard acquisition (Scope), FIFO acquisition (streaming), Multiple Recording, Gated Sampling, ABA mode and Timestamps. Then internal AWG supports standard replay, FIFO replay (streaming), Multiple Replay, Gated Replay, Continuous Replay (Loop), Single-Restart as well as Sequence. Operating system drivers for Windows/Linux 32 bit and 64 bit, drivers and examples for C/C++, IVI (Scope, Digitizer and Function Generator class), LabVIEW (Windows), MATLAB (Windows and Linux), .NET, Delphi, Java, Python, Julia and a Professional license of the oscilloscope software SBench 6 are included.

The system is delivered with a connection cable meeting your countries power connection. Additional power connections with other standards are available as option.

hybridNETBOX DN2 - Ethernet/LXI Interface

		Inputs		Outputs			
Order no.	Memory	Single-Ended	Differential	Channels	Level@50Ω	Level@1MΩ	
DN2.813-02	2 x 512 MiSamples	2 x 40 MS/s	2 x 40 MS/s	2 x 40 MS/s	±6 V	±12 V	
DN2.813-04	2 x 512 MiSamples	4 x 40 MS/s	4x 40 MS/s	4x 40 MS/s	±6 V	±12 V	
DN2.803-08	2 x 512 MiSamples	8 x 40 MS/s	4 x 40 MS/s	8 x 40 MS/s	±3 V	±6 V	
DN2.816-02	2 x 512 MiSamples	2 x 125 MS/s	2 x 125 MS/s	2 x 125 MS/s	±6 V	±12 V	
DN2.816-04	2 x 512 MiSamples	4 x 125 MS/s	4 x 125 MS/s	4 x 125 MS/s	±6 V	±12 V	
DN2.806-08	2 x 512 MiSamples	4 x 125 MS/s 8 x 80 MS/s	4 x 125 MS/s	4 x 125 MS/s 8 x 80 MS/s	±3 V	±6 V	

Options

Order no.	Option
DN2.xxx-Rack	19" rack mounting set for self mounting
DN2.xxx-Emb	Extension to Embedded Server: CPU, more memory, SSD. Access via remote Linux secure shell (ssh)
DN2.xxx-DC12	12 VDC internal power supply. Replaces AC power supply. Accepts 9 V to 18 V DC input. Screw terminals.
DN2.xxx-DC24	24 VDC internal power supply. Replaces AC power supply. Accepts 18 V to 36 V DC input. Screw terminals
DN2.xxx-BTPWR	Boot on Power On: the digitizerNETBOX/generatorNETBOX/hybridNETBOX automatically boots if power is switched on.

Firmware Options

Order no.	Option
M2p.xxxx-PulseGen	Firmware Option: adds 4 freely programmable digital pulse generators that use the XIO lines for output (later installation by firmware - upgrade available)

Calibration

Order no.	Option
DN2.xxx-Recal	Recalibration of complete digitizerNETBOX/generatorNETBOX/hybridNETBOX DN2 including calibration protocol

BNC Cables

The standard adapter cables are based on RG174 cables and have a nominal attenuation of 0.3 dB/m at 100 MHz.

for Connections	Connection	Length	to SMA male	to SMA female	to BNC male	to SMB female	
All	BNC male	80 cm	Cab-3mA-9m-80	Cab-3fA-9m-80	Cab-9m-9m-80	Cab-3f-9m-80	
All	BNC male	200 cm	Cab-3mA-9m-200	Cab-3fA-9m-200	Cab-9m-9m-200	Cab-3f-9m-200	

Technical changes and printing errors possible