Application Note DT-AN-315-1

DTU-315
Verification of Specifications

APPLICATION NOTE

January 2018

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1. Introduction

1.1. General Description of the DTU-315

The DTU-315 is a general-purpose modulator for USB-3 that can be used as a test modulator for generating virtually any DTV modulation standard currently in use around the world. The hardware and firmware are flexible enough to support new standards like ATSC-3.0.

The output frequency of the DTU-315 is agile from 36MHz up to 2150MHz, covering the VHF and UHF bands for terrestrial and cable standards, and the L Band for satellite standards[1]. The maximum modulation bandwidth is 70MHz.

For more information about the DTU-315 and its specifications, please refer to the datasheet of the DTU-315, available on the DekTec website.

1.2. Purpose of this Application Note

This application note provides instructions on measuring the characteristics of the output signal of the DTU-315, and verifying that the modulated signal conforms to the specifications stated in the data sheet.

The DTU-315 covers a wide range of settings including frequency, modulation standard, RF power-level. The settings used in this application note serve as an example and can be modified to accommodate specific application scenarios.

This application note provides measurement- and verification instructions for the following specification items:

- RF power-level accuracy;
- SNR accuracy when using the channel simulator;
- Carrier frequency accuracy;
- Phase noise.

[1] This is not a technical limitation: The DTU-315 can modulate any standard in any band, e.g. OFDM in the L band.

2. Measurements

2.1. Hardware Setup

The measurements for verifying the performance of the DTU-315 with respect to its specifications can all be performed with a DTU-315 connected to a spectrum analyzer. To avoid measurement errors, proper impedance matching with high-quality components is of the utmost importance.

The following hardware setup is required:

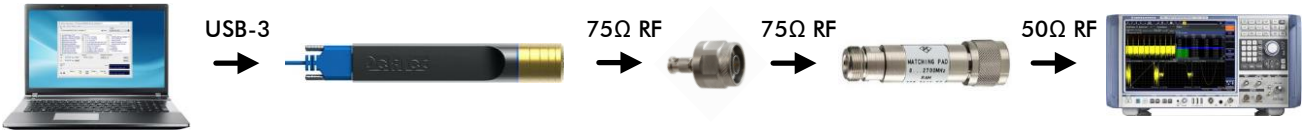

Figure 1. Hardware setup for measuring the performance of the DTU-315.

Recommended hardware setup:

- PC/laptop running the latest version of ***StreamXpress***, DekTec's play-out and modulation software.
- DTU-315, connected to the PC/laptop with a USB-3 cable.
- 75-ohm micro-BNC to 75-ohm N-type RF adapter, e.g. Amphenol APH-NP-HDBNCP.
- Minimum-loss impedance-matching pad.
- The RF adapter and impedance-matching pad should be connected directly without cables.

For power measurements an RF power sensor may also be used instead of a spectrum analyzer. An example of such an RF power sensor is Rohde & Schwarz NRP-Z11.

2.2. Generic Spectrum Analyzer Requirements

	Specification	Remarks
RF Input	50-ohm, preferably N-type due to matching pad	For spectrum analyzers with a native 75-ohm input no matching pad is required
Frequency range	≥ 36 to 2150MHz	
Frequency accuracy	≤ 0.3ppm	
Absolute level uncertainty	≤ 0.5dB	From 36 to 2150MHz
Return Loss	≥ 20dB	From 36 to 2150MHz; Internal attenuation may be required
Channel power measurement	≥ 8MHz bandwidth	
Detector type	RMS	
Compensation	Minimum-loss pad	Nice to have; otherwise add 5.72dB manually

Warm-up time recommended
Allow both the DTU-315 and the spectrum analyzer to warm-up for a period of 30 minutes in full operation, before doing measurements.

3. RF Power-Level

3.1. Relevance

The DTU-315 uses several analog components for generating an RF signal at a specified level. Aging of these analog components may influence the accuracy of the generated RF power-level over time.

3.2. StreamXpress Settings

Setting	Value
Frequency	36 to 1000MHz, e.g. 474MHz
Modulation standard	DVB-C
Constellation	256-QAM
Symbol rate	6.875MBaud
Channel simulator	Disabled
File	None
Test-signal generator	Enable; Mode PSBS23 / O151 on PID 0x0100
RF output level	-25dBm
Spectral inversion	Disabled
CW	Disabled
RF Enabled on Stop	Disabled
SNR	Disabled

3.3. Spectrum-Analyzer Settings

Setting	Value	Remarks
Frequency	Same as modulator	e.g. 474MHz
Span	16MHz	
Reference level	0dBm	
Attenuation	10dB	Commonly required to achieve return loss ≥ 20dB
Level range	100dB	
Trace mode	Clear write	
Detector	RMS	
Resolution bandwidth	100kHz	
Video bandwidth	300kHz	At least 3 times resolution bandwidth
Sweep time	500ms	Long sweep time usually gives more stable measurements, as the RMS detector averages over this time
Sweep mode	Auto sweep	Auto FFT is not recommended
Measurement mode	Channel power	
Channel bandwidth	8MHz	

3.4. Example

The screenshots below show the configuration described above.

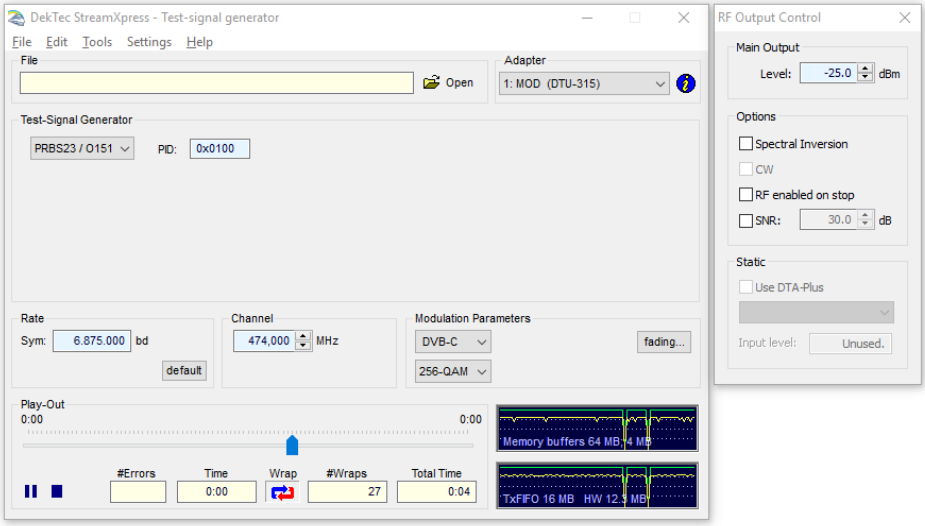

Figure 2. StreamXpress settings.

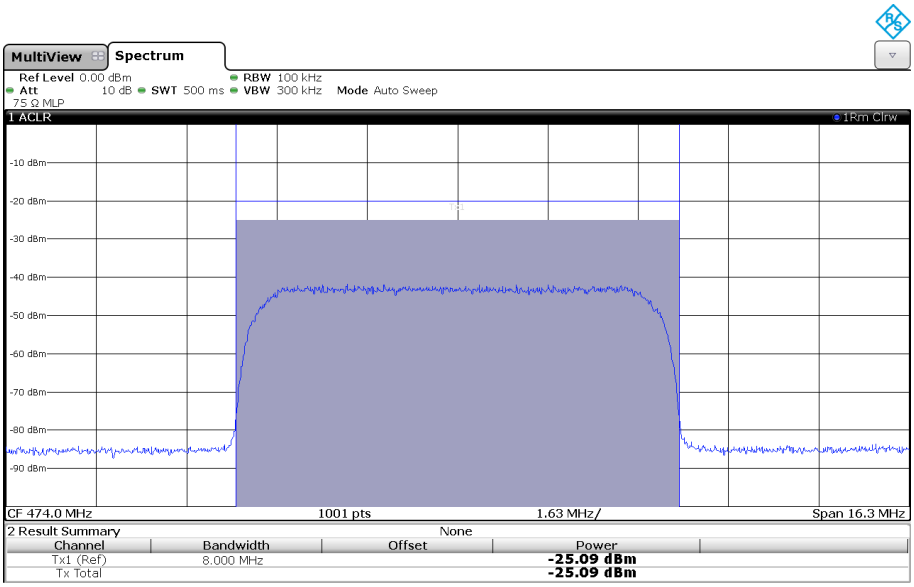

Figure 3. Rohde & Schwarz FSW signal and spectrum analyzer.

3.5. Expected Results

Measurement	Value	Units	Remarks
Channel power (typical)	-24.4 ≥ power ≥ -25.6	dBm	36 to 1000MHz
	-24.3 ≥ power ≥ -25.7	dBm	1000 to 2000MHz
Channel power (maximum)	-23 ≥ power ≥ -27	dBm	36 to 1000MHz
	-22 ≥ power ≥ -28	dBm	1000 to 2000MHz

4. Channel Simulator – SNR

4.1. Relevance

The DTU-315 uses digital signal-processing circuitry to create additive white noise with an accurate SNR level. These digital circuits are not affected by ageing.

4.2. Measurement with Frequency Sweep

This method can be used for values of SNR ≥ 3dB.

4.2.1. StreamXpress Settings

Setting	Value
Frequency	36 to 1000MHz, e.g. 474MHz
Modulation standard	DVB-C
Constellation	256-QAM
Symbol rate	6.875MBaud
Channel simulator	Enabled
AWGN generation	Enabled
SNR	15dB
File	None
Test-signal generator	Enable; Mode PSBS23 / O151 on PID 0x0100
RF output level	-25dBm
Spectral inversion	Disabled
CW	Disabled
RF enabled on stop	Disabled
SNR	Disabled

4.2.2. Spectrum-Analyzer Settings

Setting	Value	Remarks
Frequency	Same as modulator	e.g. 474MHz
Span	16MHz	
Reference level	0dBm	
Attenuation	10dB	Commonly required to achieve return loss ≥ 20dB
Level range	100dB	
Trace mode	Clear write	
Detector	RMS	
Resolution bandwidth	100kHz	
Video bandwidth	300kHz	At least 3 times resolution bandwidth
Sweep time	5s	Long sweep time usually gives more stable measurements, as the RMS detector averages over this time
Sweep mode	Auto sweep	Auto FFT is not recommended
Measurement mode	Frequency sweep	
Marker #1 frequency	474MHz	
Marker #2 frequency	+4.25MHz	Delta marker
Marker #3 frequency	–4.25MHz	Delta marker

4.2.3. Example

The screenshots below are the instrument's main dialog with the configuration as mentioned above applied.

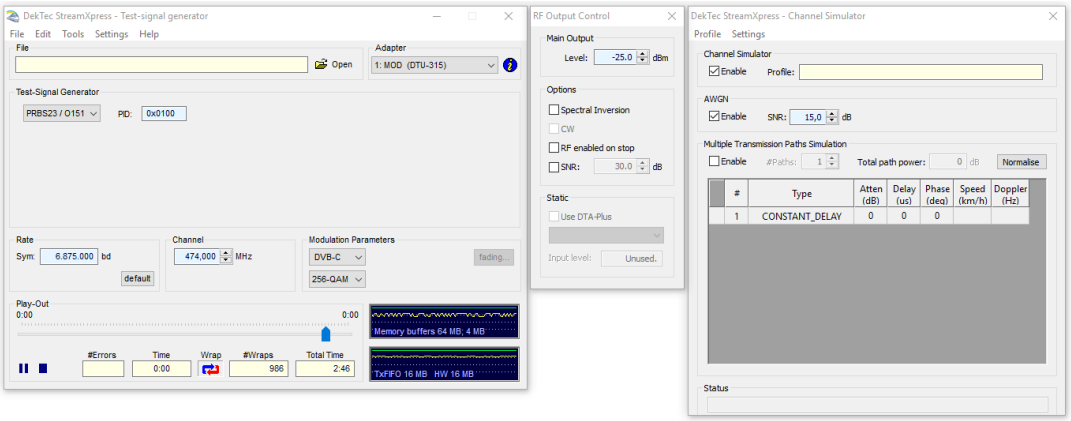

Figure 4. StreamXpress settings.

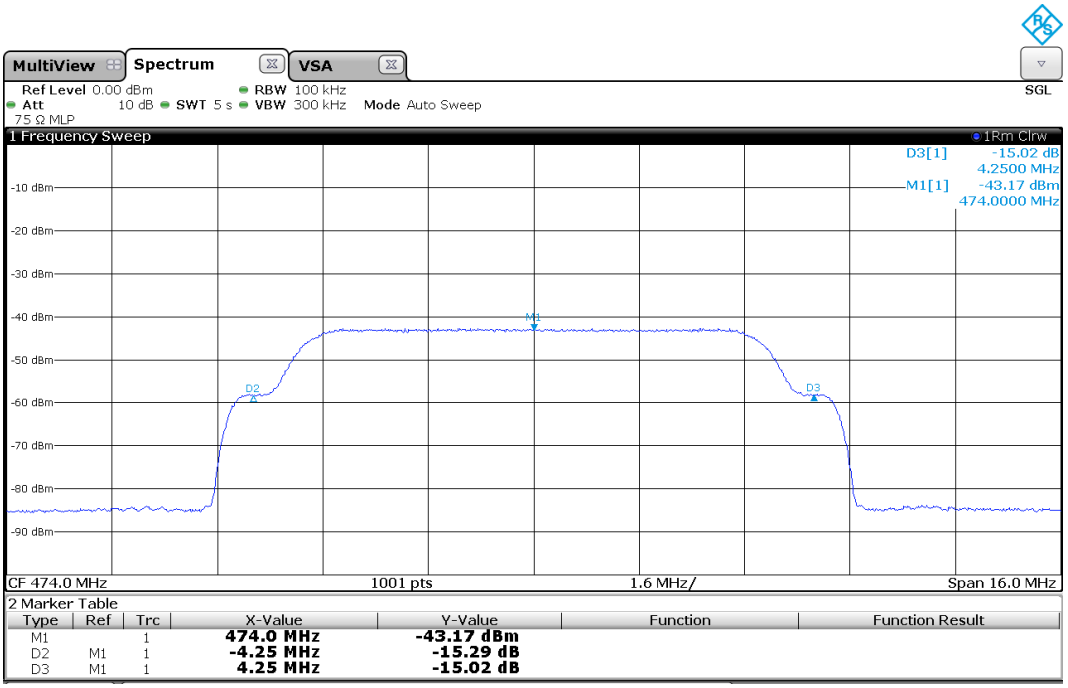

Figure 5. Rohde & Schwarz FSW signal and spectrum analyzer.

4.2.4. Expected Results

Measurement	Value	Units	Remarks
Signal Level Delta +4.25MHz	-14 ≥ Level ≥ -16	dB	
Signal Level Delta –4.25MHz	-14 ≥ Level ≥ -16	dB	

4.3. Measurement with Vector Signal Analyzer

This method can be used for values of SNR ≥ theoretical minimum MER for given constellation[2].

4.3.1. StreamXpress Settings

Setting	Value
Frequency	36 to 1000MHz, e.g. 474MHz
Modulation standard	DVB-C
Constellation	256-QAM
Symbol rate	6.875MBaud
Channel simulator	Enabled
AWGN generation	Enabled
SNR	25dB
File	None
Test-signal generator	Enable; Mode PSBS23 / O151 on PID 0x0100
RF output level	-25dBm
Spectral inversion	Disabled
CW	Disabled
RF enabled on Stop	Disabled
SNR	Disabled

4.3.2. Spectrum-Analyzer Settings

Setting	Value	Remarks
Frequency	Same as modulator	e.g. 474MHz
Reference level	0dBm	
Attenuation	10dB	Commonly required to achieve return loss ≥ 20dB
Measurement mode	Vector signal analyzer	
Modulation type	QAM	
Modulation order	256-QAM	
Mapping	DVB-C	
Symbol rate	6.875MBaud	
Transmit filter type	RRC	
Transmit filter alpha	0.15	
Equalizer	Disabled	
Impedance-matching type	75-ohm minimum-loss pad	Nice to have

[2] For 256-QAM this value is approximately 17dB. For more information on how a receiver computes MER, please refer to chapter 3 of DT-AN-2137-2 RF measurements with the DTA-2137(C).
Link: https://www.dektec.com/products/PCIe/DTA-2137C/downloads/DT-AN-2137-2.pdf

4.3.3. Example

The screenshots below are the instrument's main dialog with the configuration as mentioned above applied.

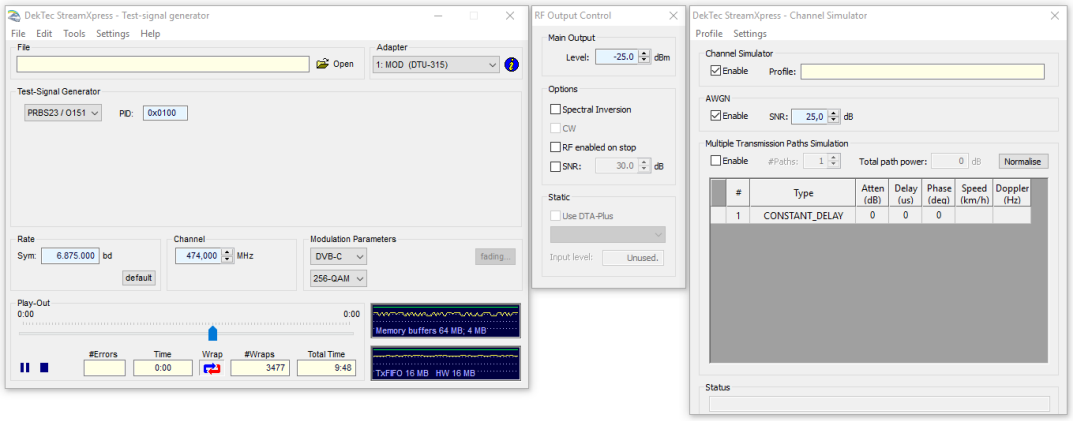

Figure 6. StreamXpress settings.

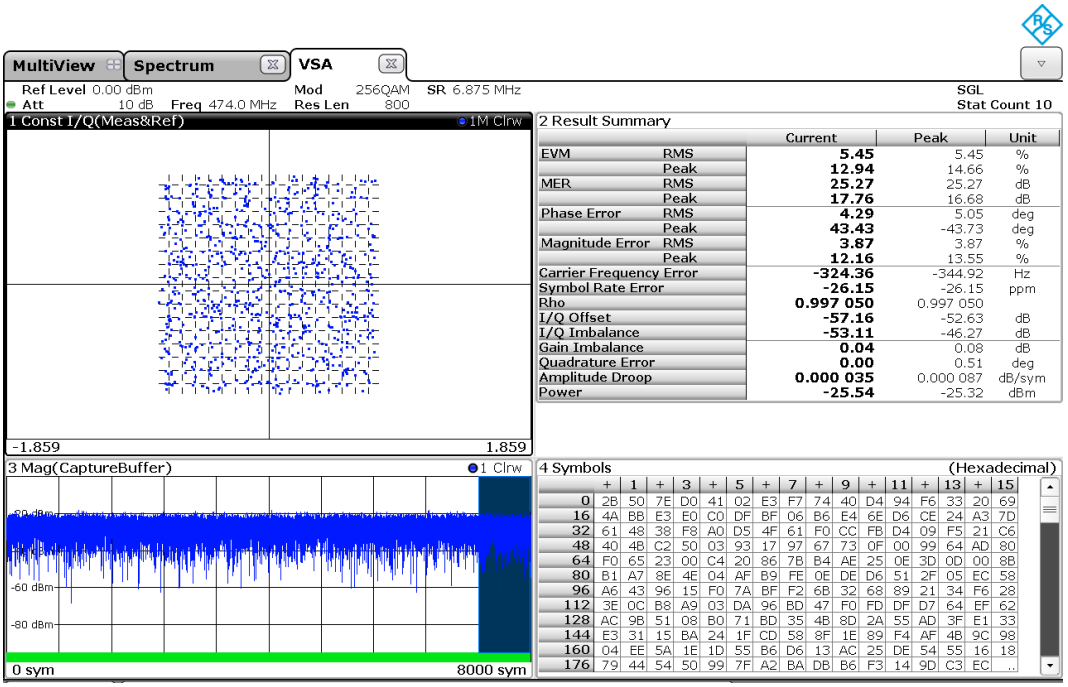

Figure 7. Rohde & Schwarz FSW signal and spectrum analyzer.

4.3.4. Expected Results

Measurement	Value	Units	Remarks
MER	24 ≥ Level ≥ 26	dB	

5. Carrier Frequency

5.1. Relevance

The DTU-315 uses several analog components for generating an RF signal at a specified carrier frequency. Aging of these analog components may influence the frequency accuracy of the generated RF carrier over time.

5.2. StreamXpress Settings

Setting	Value
Frequency	36 to 1000MHz, e.g. 474MHz
Modulation standard	DVB-C
Constellation	256-QAM
Symbol rate	6.875MBaud
Channel simulator	Disabled
RF output level	-25dBm
Spectral inversion	Disabled
CW	Enabled
RF enabled on stop	Disabled
SNR	Disabled

5.3. Spectrum-analyzer settings

Setting	Value	Remarks
Frequency	Same as modulator	e.g. 474MHz
Span	5kHz	
Reference level	0dBm	
Attenuation	10dB	Commonly required to achieve return loss ≥ 20dB
Level range	140dB	
Trace mode	Clear write	
Resolution bandwidth	100Hz	
Video bandwidth	300Hz	At least 3 times Resolution bandwidth
Sweep time	5s	Long sweep time usually gives more stable measurements, as the RMS detector averages over this time
Sweep mode	Auto sweep	Auto FFT is not recommended
Marker #1 frequency	Peak search	

5.4. Example

The screenshots below are the instrument's main dialog with the configuration as mentioned above applied.

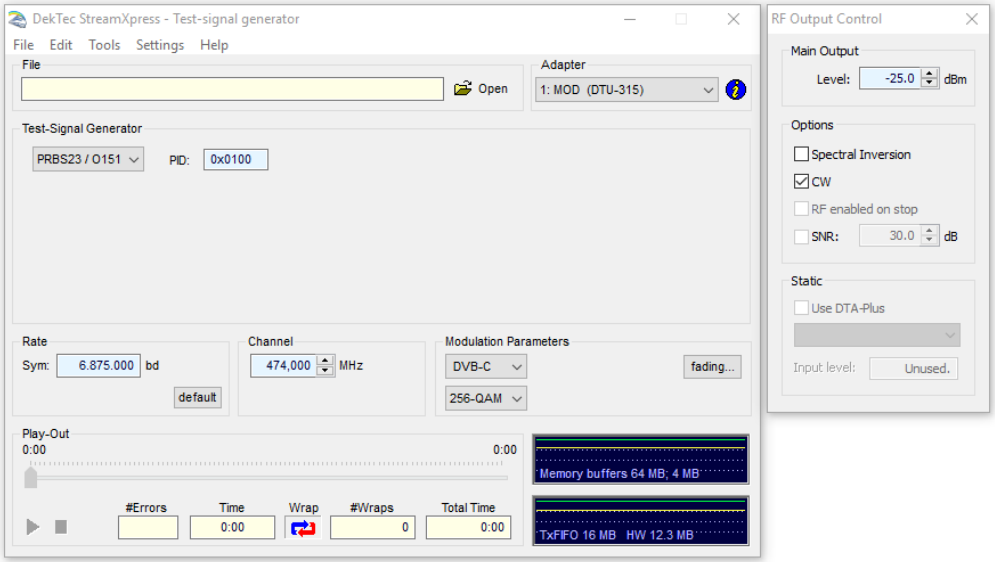

Figure 8. StreamXpress settings.

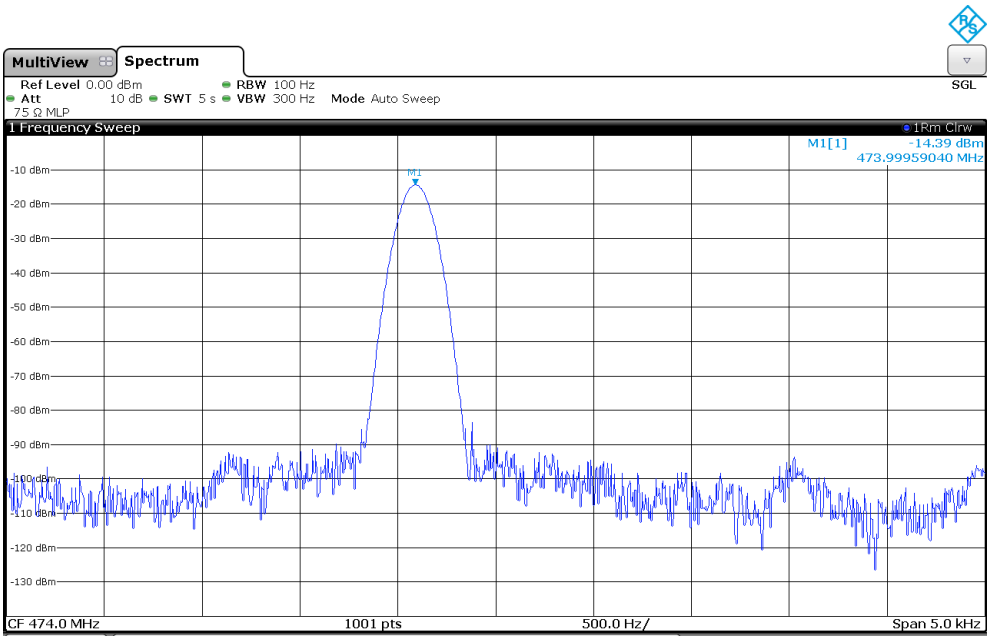

Figure 9. Rohde & Schwarz FSW signal and spectrum analyzer.

5.5. Expected Results

Measurement	Value	Units	Remarks
Marker frequency	473.999526 ≥ Frequency ≥ 474.000474	MHz	Initial accuracy incl. stability over temperature range
	473.999289 ≥ Frequency ≥ 474.000711	MHz	Including aging in first year

6. Phase Noise

6.1. Relevance

The DTU-315 uses several analog components for generating an RF signal at an accurate carrier frequency with excellent phase noise performance. Aging of these analog components may influence the phase-noise performance of the generated RF carrier over time.

6.2. Specific Spectrum-Analyzer Requirements

	Specification	Remarks
Frequency accuracy	≤ 0.3ppm	
Phase noise @ 10kHz offset	≤ 135dBc	Up to 500MHz
	≤ 120dBc	Up to 1GHz
	≤ 115dBc	Up to 2GHz
Return loss	≥ 20dB	For above frequency range; Internal attenuation might be required
Measurement mode	Phase noise	

6.3. StreamXpress Settings

Setting	Value
Frequency	36 to 1000MHz, e.g. 474MHz
Modulation standard	DVB-C
Constellation	256-QAM
Symbol rate	6.875MBaud
Channel simulator	Disabled
RF output level	-25dBm
Spectral inversion	Disabled
CW	Enabled
RF enabled on stop	Disabled
SNR	Disabled

6.4. Spectrum-Analyzer Settings

Setting	Value	Remarks
Frequency	Same as modulator	e.g. 474MHz
Attenuation	10dB	Commonly required to achieve return loss ≥ 20dB
Measurement mode	Phase noise	
Nominal level	-25dBm	
Verify frequency	Enabled	
Verify level	Enabled	
Track frequency	Disabled	Only necessary for unstable DUTs
Track level	Disabled	Only necessary for unstable DUTs
Range	100Hz to 1MHz	
Trace mode	Clear write	
Trace smoothing	Enabled; 1%	
Spur removal	Disabled	

6.5. Example

The screenshots below are the instrument's main dialog with the configuration as mentioned above applied.

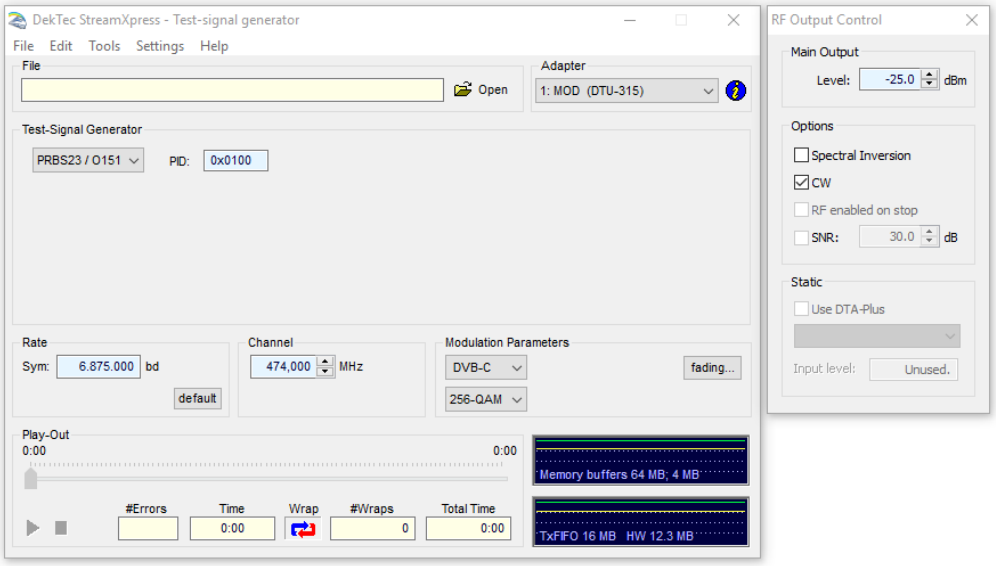

Figure 10. StreamXpress settings for phase-noise measurements.

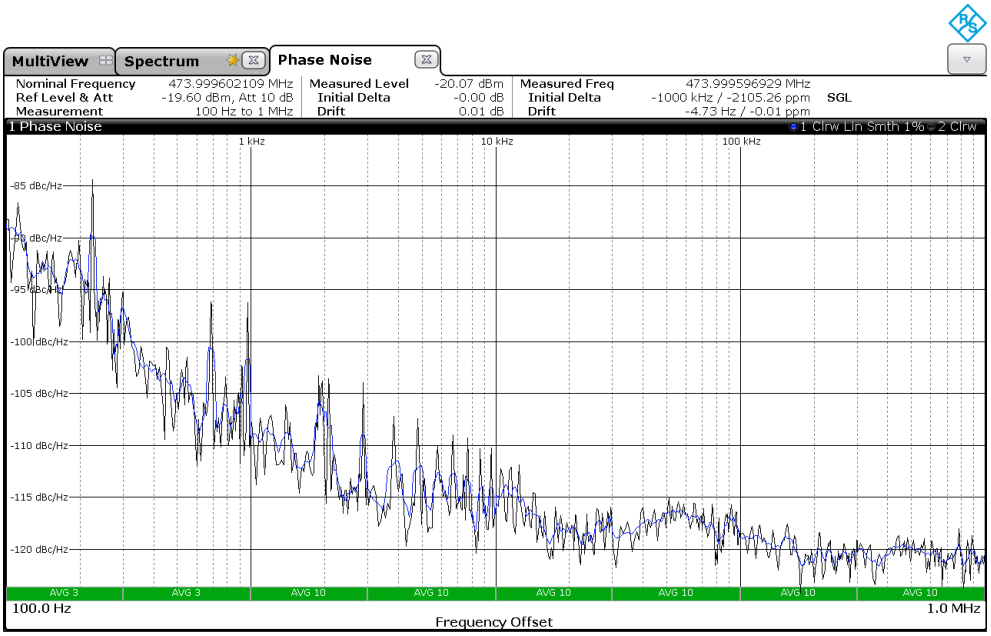

Figure 11. Rohde & Schwarz FSW signal and spectrum analyzer.

6.6. Expected Results

Measurement	Value	Units	Remarks
Phase Noise	Level ≤ -125	dBc/Hz	36MHz; 10kHz offset
	Level ≤ -117	dBc/Hz	500MHz; 10kHz offset
	Level ≤ -108	dBc/Hz	1.5GHz; 10kHz offset
	Level ≤ -105	dBc/Hz	2GHz; 10kHz offset