

# DTU-315

| All-Standard All-Band Modulator for USB-3



**DATASHEET**

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**DekTec**

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## 1. Introduction

### 1.1. General Description

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 figure below illustrates a typical usage scenario for generating a modulated signal with a laptop and feeding it directly to a device-under-test such as a TV or set-top box. No separate power supply is required: the USB-3 cable supplies power, data and control to the DTU-315.



Figure 1. Typical usage of the DTU-315

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<sup>1</sup>. The maximum modulation bandwidth is 70MHz.

### 1.2. Block Diagram

The figure below shows a functional block diagram of the DTU-315.

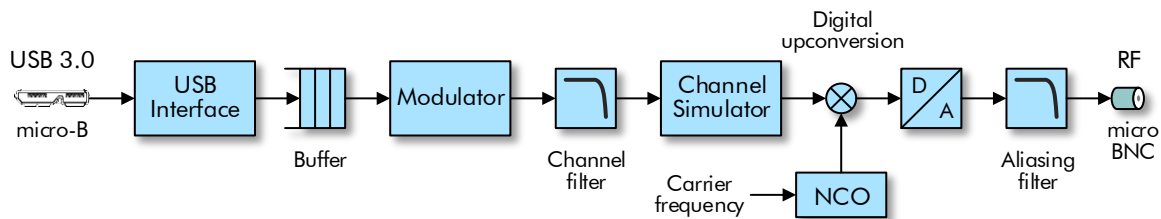


Figure 2. Functional block diagram of the DTU-315

The raw modulation data from the USB bus is received by a USB Interface, then buffered in a FIFO and converted to I/Q samples in the Modulator block. Thereafter a programmable Channel Filter shapes the spectrum in accordance with the selected modulation standard.

The result of the Channel Filter is a modulated baseband signal in the digital domain. A hardware Channel Simulator can be used to add white noise with a programmable level. This way, the Carrier to Noise (CNR) ratio of the modulated signal can be set by the user, e.g. for checking the implementation margin of a receiver.

A quadrature modulator creates a digital RF-signal that is converted to an analog RF-signal with a high performance RF digital-to-analog converter. Finally, the output is filtered for aliases and optionally attenuated within a 20-dB range.

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

### 1.3. Application Support

DekTec offers a number of applications and utilities that fully support the DTU-315.

#### 1.3.1. General-Purpose Applications

The applications in the table below are available for Windows only.

Application	Description
<i>DtInfo</i>	Free Windows utility to list information about DekTec devices. <i>DtInfo</i> can be used to check the status of the DTU-315 and to select the operation mode (see §2.2.1). It can be downloaded from the DekTec website <sup>2</sup> .
<i>StreamXpress</i>	The main application to play out a transport-stream file and modulate. The <i>StreamXpress</i> option is included in DTU-315-SP and DTU-315-GOLD. Channel simulation, which requires the DTC-305-CM option, is controlled from <i>StreamXpress</i> too.
<i>MuxXpert</i>	A general purpose real-time multiplexer. With the DTU-315 it can be used to directly generate a modulated output signal. For more information, please refer to <a href="http://www.dektec.com/Products/Apps/DTC-700">http://www.dektec.com/Products/Apps/DTC-700</a>

#### 1.3.2. Specialized Modulation Applications

A number of applications have been tailored for specific (complex) modulation standards. These applications enable operation and experimentation with virtually all modulation modes and parameters supported by the standard.

Application	Description
<i>C2Xpress</i>	DVB-C2 signal generator software for playing and modulating DVB-C2 signals from file. <i>C2Xpress</i> requires <i>StreamXpress</i> and the DTC-379-C2modulation option.
<i>T2Xpress</i>	DVB-T2 signal generator and gateway software for playing single- and multi-PLP T2 signals from file, or real-time from T2-MI over ASI or IP. <i>T2Xpress</i> requires <i>StreamXpress</i> and the DTC-378-T2 modulation option.
<i>TmmXpress</i>	Signal generator software for ISDB-T <sub>mm</sub> , ISDB-TSB <sub>SB</sub> and ISDB-T. <i>TmmXpress</i> requires <i>StreamXpress</i> and the DTC-382-Tmm <sup>3</sup> modulation option.

<sup>2</sup> *DtInfo* can be downloaded from <http://www.dektec.com/Downloads/Utilities/>

<sup>3</sup> The DTC-382-Tmm option is a combination of DTC-370-ISDB and DTC-380-16MHz.

### 1.3.3. Specialized Modulation Utilities

The following utilities are available to support file generation for specific modulation standards.

Application	Description
<i>DabMux</i>	Command-line utility for multiplexing one or more audio and/or transport-stream files into an ETI (NI) stream that can be played by <i>StreamXpress</i> . <i>DabMux</i> requires the DAB modulation option (DTC-376-DAB).
<i>IsdbsMux</i>	Command-line utility for multiplexing one or more transport-stream files into an ISDB-S stream that can be played by <i>StreamXpress</i> . <i>IsdbsMux</i> requires the ISDB-S modulation option (DTC-373-IS).
<i>IsdbS3Mux</i>	Command-line utility for multiplexing one or more transport-stream and single-TLV-stream files into an ISDB-S3 broadcast-TLV-stream that can be played by <i>DtPlay</i> . <i>IsdbS3Mux</i> requires the ISDB-S3 modulation option (DTC-387-IS3).
<i>L3Mux</i>	Command-line utility for creating L.3 and L.3X baseband frame files that can be played by <i>StreamXpress</i> to modulate DVB-S2 and DVB-S2X baseband frames. <i>L3Mux</i> requires <i>StreamXpress</i> .

### 1.4. SDK Support

The DTU-315 comes with a free SDK that enables you to write custom applications with direct RF output. The SDK contains a device driver and the DTAPI library that provides uniform access to all DekTec hardware.

The DTU-315 is supported for Windows and Linux.

## 1.5. Modulation Options

The table below lists the modulation options that are available for the DTU-315. Some of these options are included in the base products, the other ones have to be purchased separately.

Option	Order code	Remark
ATSC	<i>Included*</i>	
ATSC 3.0	DTC-386-ATSC3	
ATSC-MH	DTC-377-MH	
Channel simulation	DTC-305-CM	White noise (AWGN) insertion and multipath echo
CMMB	DTC-375-CMMB	
DAB	DTC-376-DAB	Enables also DRM(+)
DTMB	DTC-374-DTMB	
DVB-C2	DTC-379-C2	
DVB-CID	<i>Included*</i>	
DVB-S	<i>Included*</i>	
DVB-S2	<i>Included*</i>	
DVB-S2X	DTC-383-S2X	
DVB-T	<i>Included*</i>	
DVB-T2 single-PLP	<i>Included*</i>	
DVB-T2 full	DTC-378-T2	This includes modulation of T2MI
GOLD	GOLD	Enables <b>StreamXpress</b> and all modulation options in this table, as well as any future modulation standard DekTec adds to the DTU-315.
I/Q samples	DTC-371-IQ	
ISDB-S	DTC-373-IS	
ISDB-S3	DTC-387-IS3	
ISDB-T	DTC-370-ISDB	
ISDB-Tmm	DTC-382-TMM	
QAM-A	<i>Included*</i>	ITU J.83 Annex A, also known as DVB-C
QAM-B	<i>Included*</i>	ITU J.83 Annex B
QAM-C	<i>Included*</i>	ITU J.83 Annex C

\* *"Included"* means that the option is included in the base product and that no special license is required.

## 2. Operating the DTU-315

### 2.1. USB-3 and Operating System Support

The high bitrate of modulated signals and power consumption makes the DTU-315 a demanding device on the USB-3 bus.

DekTec recommends to use the DTU-315 with Windows 8, 8.1 or 10 (not Windows 7), on a PC with an on-board USB-3 host controller (avoid using a USB-3 PC add-on card).

#### 2.1.1. Host System

As an obvious first step, please ensure that the PC system you want to use has one or more USB-3 ports. The DTU-315 will not work in a USB-2 port. Furthermore a proper USB-3 cable shall be used.

#### 2.1.2. Operating System

The DTU-315 is supported by the following operating systems:

Operating System	Remarks
Windows 8, 8.1, 10 (64 bits <sup>4</sup> )	These OSES have native support for USB 3. Do <u>not</u> install the driver supplied with the USB-3 host controller.
Windows 7 (64 bits <sup>4</sup> )	No native OS support for USB-3, the driver supplied with the USB-3 host controller has to be used.
Other Windows versions (older, server)	Not supported
Linux $\geq$ 2.6.31, 3.x, 4.x	This OS has native support for USB 3.
Mac OS X	Not supported

#### 2.1.3. USB-3 Host Controller

The USB-3 host controller is the device (chip) that manages the USB-3 transfers between host (PC) and USB-3 device, in this case the DTU-315.

The following host controllers have been tested successfully for both Windows 7 and Windows 8:

USB-3 Host Controller	Remarks
Etron USB-3 Extensible Host Controller	Used on motherboards
Intel USB-3 eXtensible Host Controller	Used on motherboards
AS Media eXtensible Host Controller	Used on motherboards
Renesas/NEC D720200	Used on motherboards
Renesas/NEC D720202	Used on PC add-on cards with 2 external USB-3 ports

Note: The Renesas/NEC host controller has been tested on Windows 7 with driver version v2.1.36.0. Older versions of this driver do not run stable.

<sup>4</sup> 32-bit versions of Windows will probably work but have not been validated by DekTec. DekTec recommends using a 64-bit OS to meet the performance requirements for modulating DTV signals.

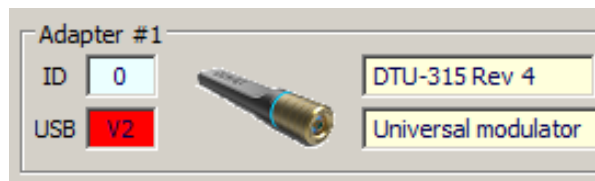
The following USB-3 host controllers are not supported by the DTU-315:

USB-3 Host Controller	Remarks
AS Media ASM1022	Used on PC add-on cards with 2 external USB-3 ports
AS Media ASM1042 1144A/1144B	Used on PC add-on cards with 4/2 external USB-3 ports
Texas Instruments TUSB7340	Used on PC add-on cards with 4 external USB-3 ports
VIA/VLI VL810/VL811	Used on PC add-on cards with 4/5 external USB-3 ports

#### 2.1.4. Troubleshooting USB Problems

A common issue that may prevent proper operation of the DTU-315 is the USB connection operates in USB-2 instead of USB-3 mode.

You can use *DtInfo* to check whether the DTU-315 is operating in USB-2 or in USB-3 mode.



In USB-2 mode, the DTU-315 is visible in *DtInfo* and VPD data can be read, but the DTU-315 cannot transfer DTV signals or other data at all.

If this condition occurs, please first try to fully disconnect the USB-3 connector on both ends of the cable, and reconnect.

If the problem remains, a possible cause for this condition is the quality of the cable, which has to be a good-quality USB-3 cable, preferably a short one. If the DTU-315 still only starts in USB-2 mode, there may be a compatibility problem, see the rest of this document.



## 2.2. Low-Power versus High-Quality Mode

The DTU-315 operates in one of two modes:

- In Low Power mode (*LOWPWR*), a good quality signal is generated at a power level that is very close to the maximum power specified for a USB-3 port<sup>5</sup>.
- In High Quality mode (*MODHQ*), a high quality signal is generated at the cost of extra power consumption. Most USB-3 ports can supply (amply) sufficient power to let the DTU-315 operate in High Quality mode<sup>6</sup>.

The main differences between the two operating modes *LOWPWR* and *MODHQ* are summarized in the table below.

Characteristic	LOWPWR	MODHQ
Carrier frequency range	36 to 2000MHz	36 to 2150MHz
Symbol rate	Up to 43.75MBd	Up to 70MBd
Absolute maximum power consumption	4.69W	5.27W

The mode in which the DTU-315 operates can be selected by using *DtInfo*, see the section below. Programmatically the mode can be changed using the *SetIoConfig* method in the DekTec SDK (DTAPI).

### 2.2.1. Using DtInfo to Select Low-Power or High-Quality Mode

Click the *Change* button for the I/O configuration of the DTU-315. A dialog will pop up that allows you to select between Low-Power and High-Quality mode.

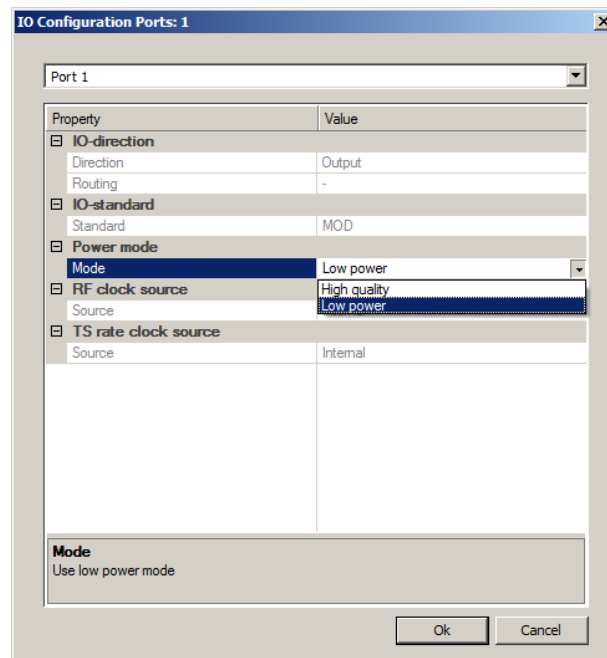


Figure 3. *DtInfo* – Advanced port I/O configuration dialog

<sup>5</sup> Under worst-case conditions the power consumption can be slightly above the maximum specified by USB-3. However, all USB-3 ports tested by DekTec can supply this amount of power with abundant margin.

<sup>6</sup> If all else fails a powered USB-3 hub can be used to boost the power of a USB-3 port.

### 2.2.2. Using the SDK to Select Low-Power or High-Quality Mode

The *DtDevice::SetIoConfig* or *DtOutpChannel::SetIoConfig* method can be used to change the operational mode of the DTU-315 programmatically. Please refer to the DTAPI Core Classes reference manual for details on these functions.

A code example to select the mode is provided below:

```
-- Select low-power mode
Dtu315Dvc.SetIoConfig(1, DTAPI_IOCONFIG_PWRMODE, DTAPI_IOCONFIG_LOWPWR);

: : :

-- Select high-quality mode
Dtu315Dvc.SetIoConfig(1, DTAPI_IOCONFIG_PWRMODE, DTAPI_IOCONFIG_MODHQ);
```

### 3. Specifications

#### 3.1. RF Output

The characteristics of the output are specified in the table below.

	Qualification	Min	Typ	Max	Unit
Connector type		Micro-BNC, female			
Impedance		75			$\Omega$
Level (programmable)	36 to 2000MHz *	-45		-25	dBm
	2000 to 2150MHz **	-45		-25	dBm
Level, step size		0.5			dB
Level, accuracy	36 to 1000MHz		0.6	$\pm 2$	dB
	1000 to 2150MHz		0.7	$\pm 3$	dB
Return loss	36 to 1000MHz		-24	-17	dB
	1000 to 2150MHz		-15	-12	dB

\* For OFDM standards: up to 1GHz; for single-carrier standards up to 2GHz

\*\* Above 2GHz the output level is max. 5dB lower.

### 3.2. RF and Modulation Parameters

The characteristics of the modulated signal are specified in the table below.

	Qualification	Min	Typ	Max	Unit
<b>RF FREQUENCY</b>					
Center frequency	In LOWPWR mode	36		2000	MHz
	In MODHQ mode	36		2150	MHz
Initial accuracy	25°C	-0.5		+0.5	ppm
Aging in first year				1	ppm
Stability	0 to 45°C ambient	-0.5		+0.5	ppm
Step size				1	Hz
Phase noise	36MHz, 10kHz offset			-125	dBc
	500MHz, 10kHz offset			-117	dBc
	1500MHz, 10kHz offset			-108	dBc
	2000MHz, 10kHz offset			-105	dBc
<b>MODULATION</b>					
Bandwidth	In LOWPWR mode			43.75	MBd
	In MODHQ mode			70	MBd
MER			40		dB
<b>SIGNAL PURITY</b>					
Spectral purity			50		dB
Adjacent channel power				-50	dB
Shoulder attenuation				-50	dB
<b>CHANNEL SIMULATOR</b>					
SNR, range	DVB-S, DVB-S2, ISDB-S, ISDB-S3	3		30	dB
	DVB-S2X	-10		30	dB
	All other standards	-10		100	dB
SNR, step size			0.1		dB
SNR, accuracy		±1			dB

### 3.3. Miscellaneous Specifications

	Qualification	Min	Typ	Max	Unit
<b>USB</b>					
Connector type		USB 3 Micro-B			
Generation		USB 3.2 Gen 1 Also called USB 3.0 or USB 3.1 Gen 1 or SuperSpeed USB			
Link speed		5			Gbit/s
<b>POWER</b>					
Voltage		4	5	5.25	V
Power consumption	Overall range	0.5		5.27	W
	Device is idle		0.6		W
	Modulating in LOWPWR		4.57	4.69	W
	Modulating in MODHQ		5.17	5.27	W
<b>MECHANICAL</b>					
Dimensions	W x H x D	154 x 30 x 30			mm
Weight		146			g
<b>ENVIRONMENTAL</b>					
Operating temperature		0		+45	°C
<b>COMPLIANCY</b>					
	In compliant PC				
CE – Emission		EN 55022:2011			
		EN 61000-3-2:2006/A1:2009			
		EN 61000-3-3:2006/A2:2010			
CE – Immunity		EN 55024:2010			
ESD		8kV (IEC61000-4-2)			
FCC – Class		B			
Safety		UL 1419, IEC60065			

## 4. Modulation Standards

This section provides features, specifications and software support per modulation standard.

### 4.1. ATSC

Parameter / Feature	Value / Comment
STANDARD	ATSC A/53E
MODULATION PARAMETERS	
Mode	8VSB, 16VSB
Roll-off	0.115, programmable
FEATURES	
Input format	MPEG-2 transport stream
Channel simulation	AWGN insertion with adjustable SNR, multipath fading, Rayleigh channels and Doppler simulation
SOFTWARE SUPPORT	
<i>StreamXpress</i>	Application for playing transport-stream files and modulating in ATSC
DTAPI SDK	SDK for creating custom applications that generate ATSC directly

### 4.2. ATSC 3.0

Parameter / Feature	Value / Comment
STANDARD	ATSC 3.0
MODULATION PARAMETERS	
Channel raster bandwidth	6MHz, 7MHz, 8MHz
Bootstrap minor version	0 to 7
EAS wakeup	0 to 3
PARP reduction	None, ACE only, TR only, both ACE and TR
LLS present flag	On, off
Number of PLPs	Up to 64
PLP payload	PRBS, IP-capture file, live IP-input
Other ATSC 3.0-parameters	All ATSC 3.0 defined parameters
FEATURES	
Input format	PRBS IP-capture file Live IP-input
Channel simulation	AWGN insertion with adjustable SNR, multipath fading, Rayleigh channels and Doppler simulation
SOFTWARE SUPPORT	
<i>Atsc3Xpress</i>	For playing and modulating single-PLP and multi-PLP ATSC 3.0 streams with full control over the entire ATSC 3.0 parameter set
DTAPI SDK	SDK for creating custom applications that generate ATSC 3.0 directly

### 4.3. ATSC-MH

Parameter / Feature	Value / Comment
STANDARD	ATSC A/153
MODULATION PARAMETERS	
Mode	8VSB
Roll-off	0.115, programmable
FEATURES	
Input format	ATSC M/H transport stream
Channel simulation	AWGN insertion with adjustable SNR, multipath fading, Rayleigh channels and Doppler simulation
SOFTWARE SUPPORT	
<b>StreamXpress</b>	Applications for playing transport-stream files and modulating in ATSC-MH
DTAPI SDK	SDK for creating custom applications that generate ATSC-MH directly

### 4.4. CMMB

Parameter / Feature	Value / Comment
STANDARD	GY/T 220.1/2-2006
MODULATION PARAMETERS	
Bandwidth	2MHz, 8MHz
Identification	Transmitter Identification and Area Identification are freely settable
FEATURES	
Input format	CMMB-PMS stream
Channel simulation	AWGN insertion with adjustable SNR, multipath fading, Rayleigh channels and Doppler simulation
SOFTWARE SUPPORT	
<b>StreamXpress</b>	For playing and modulating CMMB-PMS files
DTAPI SDK	For creating custom applications that generate CMMB directly

#### 4.5. DAB(+)/T-DMB

Parameter / Feature	Value / Comment
STANDARD	EN 300 401, TS 102 563 and TS 102 427
MODULATION PARAMETERS	
Modes	I, II, III, IV
FEATURES	
Input format	ETI(NI) stream according to EN 300 799
Channel simulation	AWGN insertion with adjustable SNR, multipath fading, Rayleigh channels and Doppler simulation
SOFTWARE SUPPORT	
<i>DabMux</i>	For multiplexing one or more audio and/or transport-stream files into an ETI(NI) stream
<i>StreamXpress</i>	For playing transport-stream files and modulating in DAB(+) or T-DMB
DTAPI SDK	For creating custom applications that generate DAB(+) or T-DMB directly

#### 4.6. DRM(+)

Parameter / Feature	Value / Comment
STANDARD	ETSI ES 201 980
MODULATION PARAMETERS	
Robustness modes	A, B, C, D, E
FEATURES	
Input format	Application Framing (AF) packets according ETSI TS 102 821 section 6
Channel simulation	AWGN insertion with adjustable SNR, multipath fading, Rayleigh channels and Doppler simulation
Number of channels	Up to eight channels
SOFTWARE SUPPORT	
<i>DtPlay</i>	Application for playing DCP-files according ETSI TS 102 821 Annex B.3
DTAPI SDK	SDK for creating custom applications that generate DRM(+) directly



#### 4.7. DTMB (ADTB-T, DMB-T/H)

Parameter / Feature	Value / Comment
STANDARD	GB 20600-2006
MODULATION PARAMETERS	
Bandwidth	5, 6, 7, 8 MHz
Constellation	4QAM-NR, 4QAM, 16QAM, 32QAM, 64QAM
Code rate	0.4, 0.6, 0.8
Guard interval	PN420, PN595, PN945
Interleaving	Mode1 (B=54,M=240), mode2 (B=54,M=720)
Frame numbering	On, off
Pilots	On, off
FEATURES	
Input format	MPEG-2 transport stream
Channel simulation	AWGN insertion with adjustable SNR, multipath fading, Rayleigh channels and Doppler simulation
SOFTWARE SUPPORT	
<i>StreamXpress</i>	For playing transport-stream files and modulating in DTMB
DTAPI SDK	For creating custom applications that generate DTMB directly

#### 4.8. DVB-C2

Parameter / Feature	Value / Comment
STANDARD	EN 302 769
MODULATION PARAMETERS	
Channel raster bandwidth	6MHz, 8MHz
C2-system bandwidth	Up to 32MHz completely filled; up to 64MHz partly filled
Number of PLPs	Up to 255
PLP bundling	Fully supported
Number of data slices	Up to 255
PAPR reduction	None, TR
Other DVB-C2-parameters	All DVB-C2 defined parameters
FEATURES	
Input format	MPEG-2 transport stream
Special simulation features	ACM and L1-update simulation
Channel simulation	AWGN insertion with adjustable SNR, multipath fading, Rayleigh channels and Doppler simulation
SOFTWARE SUPPORT	
<i>C2Xpress</i>	For playing and modulating single-PLP and multi-PLP DVB-C2 streams with full control over the entire DVB-C2 parameter set
DTAPI SDK	SDK for creating custom applications that generate DVB-C2 directly; The DTAPI supports "Multi-PLP Extensions" to easily create multi-PLP applications.

#### 4.9. DVB-CID

Parameter / Feature	Value / Comment
STANDARD	ETSI TS 103 129 v1.1.2
MODULATION PARAMETERS	
Constellation	BPSK
Roll off	0.35
FEATURES	
Input format	DVB-CID Global Unique Identifier
SOFTWARE SUPPORT	
<b>StreamXpress</b>	For playing transport-stream files or L3 baseband frame files, and modulating in DVB-S2/S2X, including DVB-CID
DTAPI SDK	SDK for creating custom applications that generate DVB-S2/S2X, including DVB-CID directly

#### 4.10. DVB-S

Parameter / Feature	Value / Comment
STANDARD	EN 300 421
MODULATION PARAMETERS	
Symbol rate	0.088MBd to 70MBd
Constellation	QPSK
Code rate	1/2, 2/3, 3/4, 5/6, 7/8
Roll off	0.35, programmable
FEATURES	
Input format	MPEG-2 transport stream
Channel simulation	AWGN insertion with adjustable SNR
SOFTWARE SUPPORT	
<b>StreamXpress</b>	For playing transport-stream files and modulating in DVB-S
DTAPI SDK	SDK for creating custom applications that generate DVB-S directly

#### 4.11. DVB-S2

Parameter / Feature	Value / Comment
STANDARD	EN 302 307-1
MODULATION PARAMETERS	
Symbol rate	0.088MBd to 70MBd
Constellation	QPSK, 8PSK, 16APSK, 32APSK
Constellation amplitude	E=1, R=1 (for 16APSK, 32APSK)
Code rate	All DVB-S2 defined code rates
FEC-frame size	Normal, short
Pilots	On, off
Roll-off	0.20, 0.25, 0.35, programmable
CCM	Default modulation mode
VCM, ACM, multiple streams, generic streams, null-packet deletion	Supported through L.3 baseband frames. The frames specify the transmission format and the user data. Baseband frames can be created with a custom mode-adaptation application or through DekTec's L3Mux utility. The resulting L.3 file can be played using the StreamXpress player or using a custom application via the DekTec DTAPI.
FEATURES	
Input format	MPEG-2 transport stream L.3 baseband frames
Channel simulation	AWGN insertion with adjustable SNR
SOFTWARE SUPPORT	
L3Mux	Utility for creating L.3 baseband frame files
<b>StreamXpress</b>	For playing transport-stream files or L.3 baseband frame files, and modulating in DVB-S2
DTAPI SDK	SDK for creating custom applications that generate DVB-S2 directly

#### 4.12. DVB-S2X

Parameter / Feature	Value / Comment
STANDARD	EN 302 307-2
MODULATION PARAMETERS	
Symbol rate	0.088MBd to 70MBd
Constellation	QPSK, 8PSK(-L), 16/32/64/128/256APSK(-L)
Constellation VL-SNR	QPSK, BPSK(-S)
Code rate	All DVB-S2X defined code rates
FEC-frame size	Normal, medium, short
Pilots	On, off
Roll-off	0.05, 0.10, 0.15, 0.20, 0.25, 0.35, programmable
CCM	Default modulation mode
VCM, ACM, multiple streams, generic streams, null-packet deletion	Supported through L.3 baseband frames. The frames specify the transmission format and the user data. Baseband frames can be created with a custom mode-adaptation application or through DekTec's L3Mux utility. The resulting L.3 file can be played using the StreamXpress player or using a custom application via the DekTec DTAPI.
Channel bonding	Not supported
FEATURES	
Input format	MPEG-2 transport stream L.3X baseband frames
Channel simulation	AWGN insertion with adjustable SNR
SOFTWARE SUPPORT	
<b>L3Mux</b>	Utility for creating L.3X baseband frame files
<b>StreamXpress</b>	For playing transport-stream files or L.3X baseband frame files, and modulating in DVB-S2X
DTAPI SDK	SDK for creating custom applications that generate DVB-S2X directly

### 4.13. DVB-T/H

Parameter / Feature	Value / Comment
STANDARD	EN 302 769-2
MODULATION PARAMETERS	
Bandwidth	5, 6, 7, 8 MHz
Constellation	QPSK, 16QAM, 64QAM
Code rate	1/2, 2/3, 3/4, 5/6, 7/8
FFT mode	2k, 4k, 8k
Interleaving	Native, in-depth
Guard interval	1/32, 1/16, 1/8, 1/4
TPS format	DVB-T, DVB-H
FEATURES	
Input format	MPEG-2 transport stream
Channel simulation	AWGN insertion with adjustable SNR, multipath fading, Rayleigh channels and Doppler simulation
SOFTWARE SUPPORT	
<i>StreamXpress</i>	For playing transport-stream files and modulating in DVB-T
DTAPI SDK	SDK for creating custom applications that generate DVB-T directly

#### 4.14. DVB-T2

Parameter / Feature	Value / Comment
STANDARD	EN 302 755 v1.1.1, v1.2.1, v1.3.1
MODULATION PARAMETERS	
Bandwidth	1.7, 5, 6, 7, 8, 10 MHz
T2 version	1.1.1, 1.2.1, 1.3.1
T2 profile	Base, lite, base+lite
Number of PLPs	Single-PLP: 1 Multi-PLP: up to 255
PLP payload	Transport stream (TS), Generic Stream Encapsulation (GSE)
PAPR reduction	None, ACE, TR, ACE+TR
Transmitter signature	Through auxiliary-streams or FEFs
Other DVB-T2-parameters	All DVB-T2 defined parameters
FEATURES	
Input format	MPEG-2 transport stream GSE packets T2 Modulator Interface (T2-MI)
Channel simulation	AWGN insertion with adjustable SNR, multipath fading, Rayleigh channels and Doppler simulation MISO simulator, generating both MISO transmitter signals
SOFTWARE SUPPORT	
<i>T2Xpress</i>	For playing and modulating single-PLP and multi-PLP DVB-T2 streams with full control over the entire DVB-T2 parameter set
<i>StreamXpress</i>	Application for playing transport streams or T2-MI files and modulating in DVB-T2
DTAPI SDK	SDK for creating custom applications that generate DVB-T2 directly; The DTAPI supports "Multi-PLP Extensions" to easily create multi-PLP applications.

#### 4.15. I/Q-samples

Parameter / Feature	Value / Comment
STANDARD	DekTec proprietary
MODULATION PARAMETERS	
Sample rate	0.088Msps to 70Msps
Roll off	None, 0.05, 0.10, 0.15, 0.20, 0.25, 0.35, programmable
FEATURES	
Input format	I/Q samples as pairs of 16-bit signed integers in I, Q order
Channel simulation	AWGN insertion with adjustable SNR, multipath fading, Rayleigh channels and Doppler simulation
SOFTWARE SUPPORT	
<i>StreamXpress</i>	For playing I/Q-sample files
DTAPI SDK	SDK for creating custom applications that play out I/Q samples

#### 4.16. ISDB-S

Parameter / Feature	Value / Comment
STANDARD	ARIB STD-B20
MODULATION PARAMETERS	
Symbol rate	0.088MBd to 70MBd
Number of layers	1 when using transport stream input Up to 4 when using ISDB-S streams input
Modulation and code rate	BPSK 1/2, QPSK 1/2, QPSK 2/3, QPSK 3/4, QPSK 5/6, QPSK 7/8, 8PSK 2/3
Roll off	0.35, programmable
FEATURES	
Input format	ISDB-S stream: Transport streams with TMCC encoded in SYNC bytes
Channel simulation	AWGN insertion with adjustable SNR
SOFTWARE SUPPORT	
<i>IsdbsMux</i>	Utility for multiplexing one or more transport-stream files into an ISDB-S stream
<i>StreamXpress</i>	Application for playing transport-stream files and modulating in ISDB-S
DTAPI SDK	SDK for creating custom applications that generate ISDB-S directly

#### 4.17. ISDB-S3

Parameter / Feature	Value / Comment
STANDARD	ARIB STD-B44
MODULATION PARAMETERS	
Symbol rate	0.088MBd to 85MBd (default 33.7561MBd)
Modulation	BPSK, QPSK, 8PSK, 16APSK, 32APSK
Code rate	1/3, 2/5, 1/2, 3/5, 2/3, 3/4, 7/9, 4/5, 5/6, 7/8, 9/10
Roll off	0.03
FEATURES	
Input format	Broadcast-TLV-stream packets: UDP-packets with TMCC information (5810 byte payload)
Channel simulation	AWGN insertion with adjustable SNR
Number of channels	Maximum one channel
SOFTWARE SUPPORT	
<i>IsdbS3Mux</i>	Utility for multiplexing one or more transport-stream and single-TLV-stream files into a broadcast-TLV-stream pcap-file.
<i>DiPlay</i>	Application for playing broadcast-TLV-stream pcap-files and modulating in ISDB-S3
DTAPI SDK	SDK for creating custom applications that generate ISDB-S3 directly

#### 4.18. ISDB-T/T<sub>SB</sub>

Parameter / Feature	Value / Comment
STANDARD	ARIB STD-B31 and ARIB STD-B29
MODULATION PARAMETERS	
Bandwidth	5, 6, 7, 8 MHz
Number of segments	ISDB-T: 13 ISDB-T <sub>SB</sub> : 1, 3
Constellation	DQPSK, QPSK, 16QAM, 64QAM
Code rate	1/2, 2/3, 3/4, 5/6, 7/8
FFT mode	Mode 1 (2k), mode 2 (4k), mode 3 (8k)
Guard interval	1/4, 1/8, 1/16, 1/32
Interleaving	0, 1, 2, 4, 8, 16
IIP PID	Selectable
Partial reception	On, off
Emergency broadcasting	On, off
FEATURES	
Input format	MPEG-2 transport stream 204-byte transport stream with TMCC encoded in the last 16 bytes of the 204-byte transport packets
Channel simulation	AWGN insertion with adjustable SNR, multipath fading, Rayleigh channels and Doppler simulation
SOFTWARE SUPPORT	
<b>StreamXpress</b>	Application for playing transport-stream files and modulating in ISDB-T. For ISDB-T, StreamXpress includes a hierarchical multiplexer.
DTAPI SDK	SDK for creating custom applications that generate ISDB-T directly. Includes a hierarchical multiplexer API.



#### 4.19. ISDB-Tmm

Parameter / Feature	Value / Comment
STANDARD	ARIB STD-B46
MODULATION PARAMETERS	
Channel raster bandwidth	6, 7, 8 MHz
Total bandwidth	Up to 14.5 MHz
Number of segments	Up to 33, with any combination of 13-, 3- and 1-segment signals
Constellation	DQPSK, QPSK, 16QAM, 64QAM
Code rate	1/2, 2/3, 3/4, 5/6, 7/8
FFT mode	Mode 1 (2k), mode 2 (4k), mode 3 (8k)
Guard interval	1/4, 1/8, 1/16, 1/32
Interleaving	0, 1, 2, 4, 8, 16
IIP PID	Selectable
Partial reception	On, off
Emergency broadcasting	On, off
FEATURES	
Input format	MPEG-2 transport stream 204-byte transport stream with TMCC encoded in the last 16 bytes of the 204-byte transport packets
Channel simulation	AWGN insertion with adjustable SNR, multipath fading, Rayleigh channels and Doppler simulation
SOFTWARE SUPPORT	
<i>TmmXpress</i>	Application for playing and modulating an ISDB-Tmm signal with full control over the ISDB-Tmm/T <sub>SB</sub> /T parameters.
DTAPI SDK	SDK for creating custom applications that generate ISDB-Tmm directly.

#### 4.20. QAM-A (DVB-C)

Parameter / Feature	Value / Comment
STANDARD	ITU-T J.83 Annex A and EN 300 429
MODULATION PARAMETERS	
Constellation	16QAM, 32QAM, 64QAM, 128QAM, 256QAM
Roll off	0.15, programmable
FEATURES	
Input format	MPEG-2 transport stream
Channel simulation	AWGN insertion with adjustable SNR, multipath fading, Rayleigh channels and Doppler simulation
SOFTWARE SUPPORT	
<i>StreamXpress</i>	Application for playing transport-stream files and modulating in DVB-C
DTAPI SDK	SDK for creating custom applications that generate DVB-C directly

#### 4.21. QAM-B

Parameter / Feature	Value / Comment
STANDARD	ITU-T J.83 Annex B
MODULATION PARAMETERS	
Constellation	16QAM, 256QAM
Roll-off	0.18 (64QAM), 0.12 (256QAM), programmable
Interleaving	All ITU-T J.83.B defined interleaving modes
FEATURES	
Input format	MPEG-2 transport stream
Channel simulation	AWGN insertion with adjustable SNR, multipath fading, Rayleigh channels and Doppler simulation
SOFTWARE SUPPORT	
<i>StreamXpress</i>	Application for playing transport-stream files and modulating in QAM-B
DTAPI SDK	SDK for creating custom applications that generate QAM-B directly

#### 4.22. QAM-C (ISDB-C)

Parameter / Feature	Value / Comment
STANDARD	ITU-T J.83 Annex C
MODULATION PARAMETERS	
Constellation	16QAM, 32QAM, 64QAM, 128QAM, 256QAM
Roll off	0.13, programmable
FEATURES	
Input format	MPEG-2 transport stream
Channel simulation	AWGN insertion with adjustable SNR, multipath fading, Rayleigh channels and Doppler simulation
SOFTWARE SUPPORT	
<i>StreamXpress</i>	Application for playing transport-stream files and modulating in QAM-C
DTAPI SDK	SDK for creating custom applications that generate QAM-C directly

## 5. Performance Measurements

The sections below show some measurements that are indicative for the performance of the DTU-315. Most measurements have been obtained with an R&S FSW Signal and Spectrum Analyzer.

### 5.1. Phase Noise

The figures below show the phase noise of the DTU-315, measured at four RF frequencies: 36, 500, 1500 and 2150MHz.

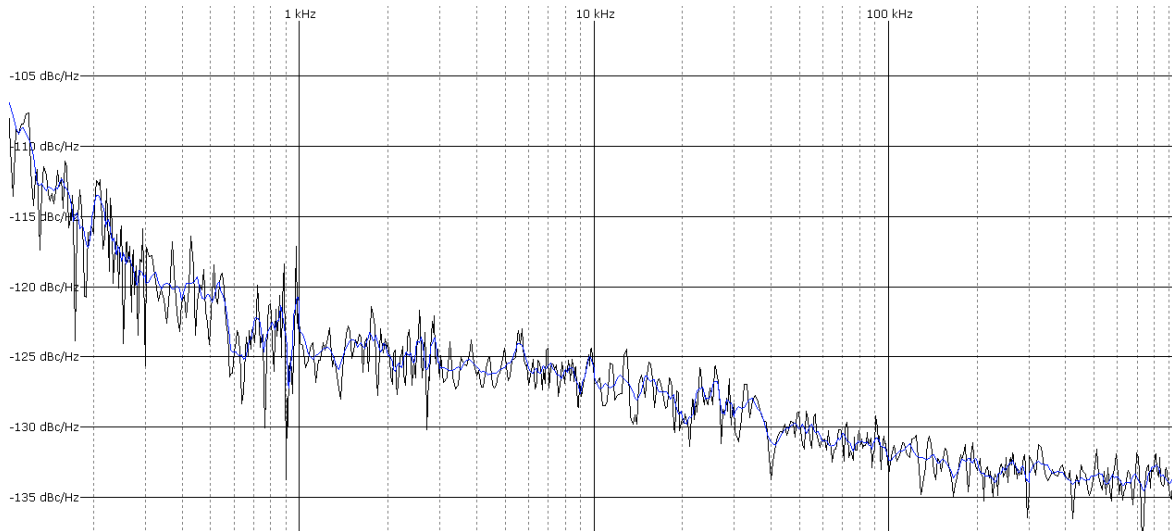


Figure 4. Phase noise @ 36MHz

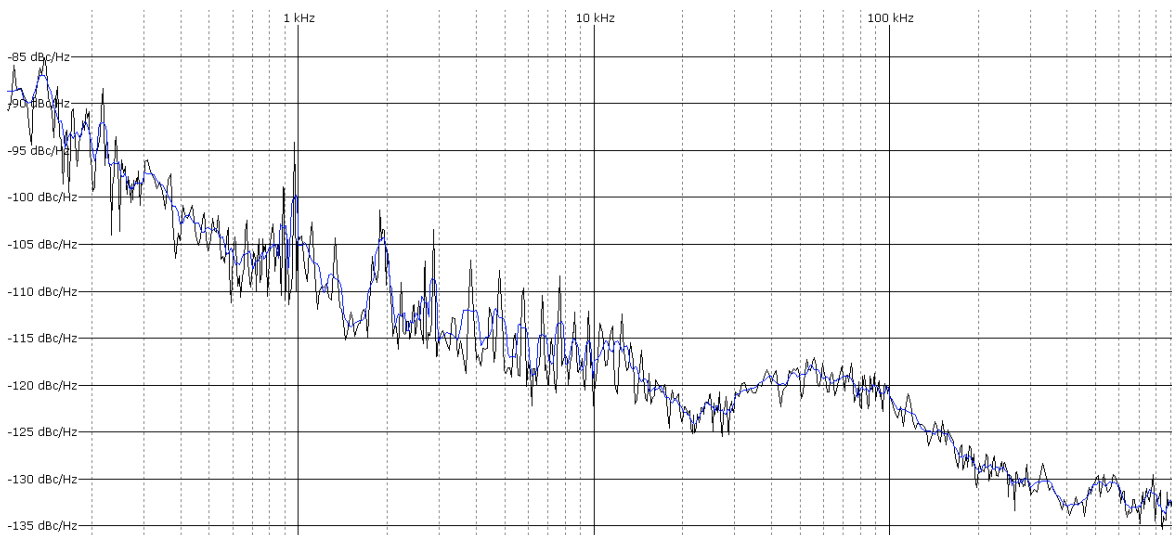


Figure 5. Phase Noise @ 500MHz

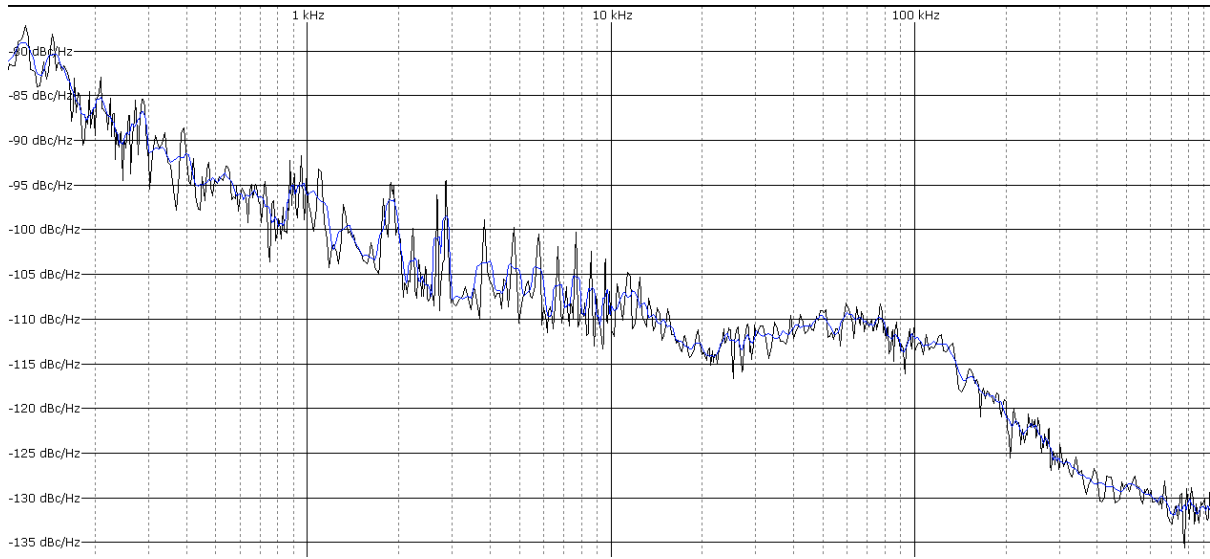


Figure 6. Phase Noise @ 1500MHz

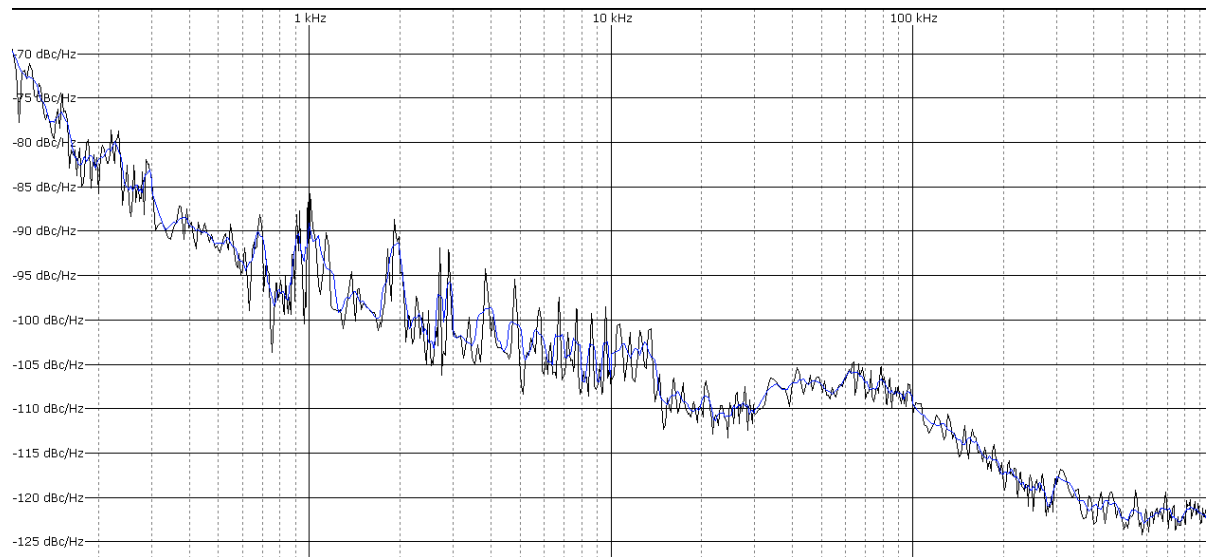


Figure 7. Phase Noise @ 2150MHz

### 5.2. Return Loss

The figures below show the return loss measured at the output of the DTU-315.

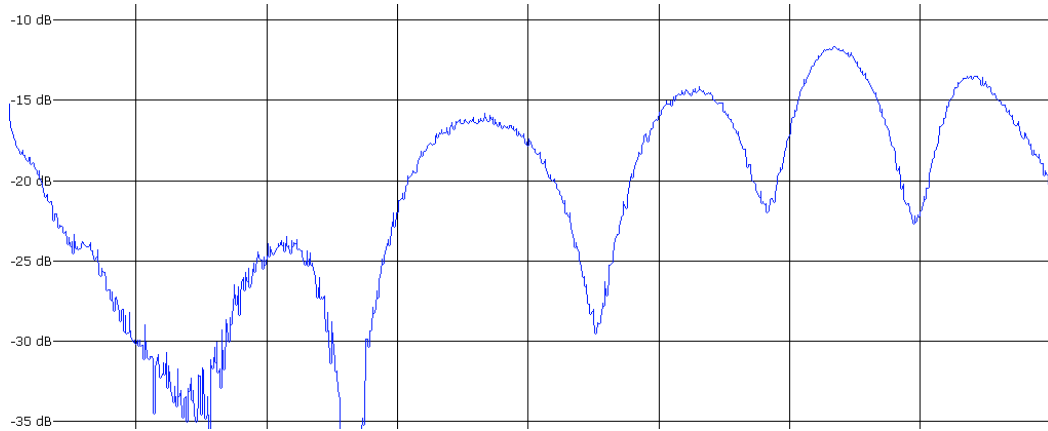


Figure 8. Return loss measurement at the highest output level

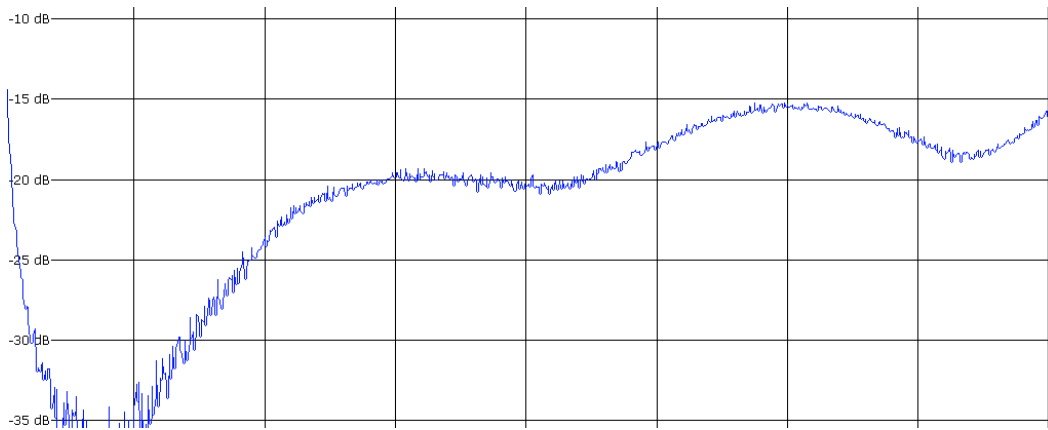


Figure 9. Return loss measurement at the lowest output level

### 5.3. MER

#### 5.3.1. Equalised MER

The figures below show the equalised MER measured for several modulation standards.

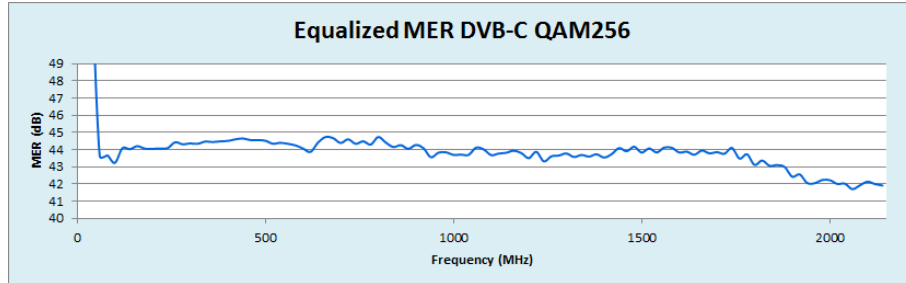


Figure 10. MER at DVB-C QAM256 6.875MBd

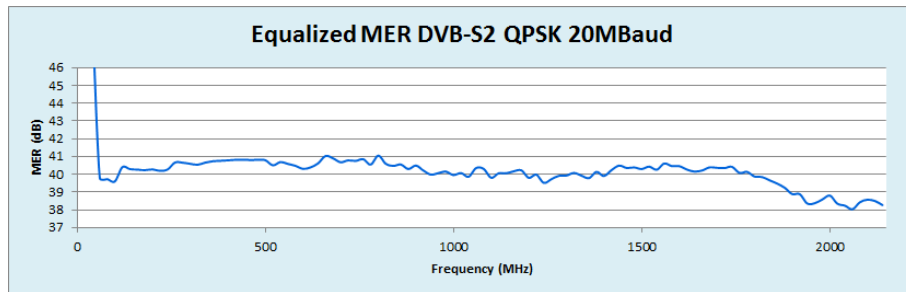


Figure 11. MER at DVB-S2 QPSK 20MBd

#### 5.3.2. Unequalised MER

The figures below show the unequalised MER measured for several modulation standards.

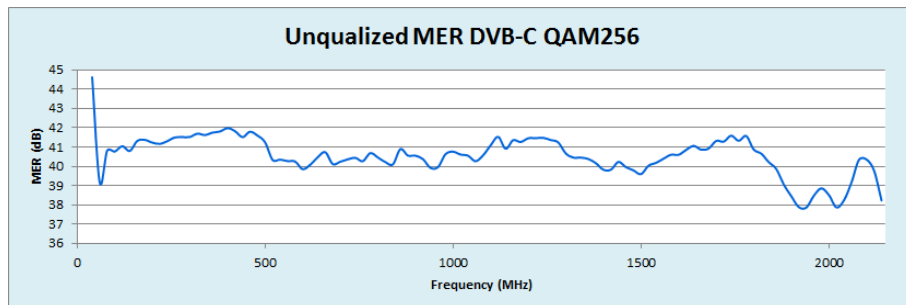


Figure 12. MER at DVB-C QAM256 6.875MBd

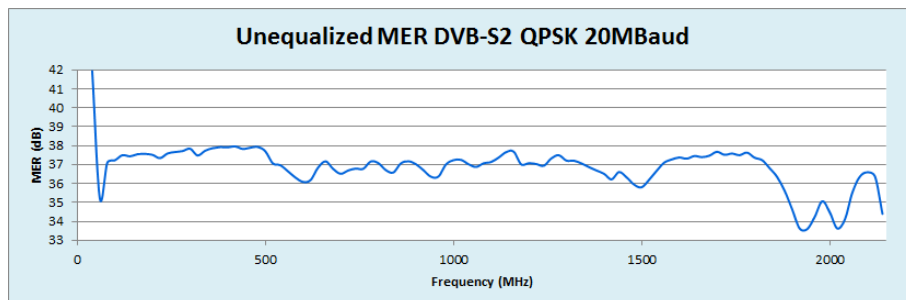


Figure 13. MER at DVB-S2 QPSK 20MBd