

DTA-2115

| All-Standard, All-Band Modulator



PCI
EXPRESS®

DATASHEET

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DekTec

Table of Contents

1. Introduction	3
1.1. General Description	3
1.2. Block Diagram	3
1.3. Software Support	4
1.4. Available Options	4
2. Specifications	5
2.1. RF Outputs	5
2.2. Frequency Reference Inputs	5
2.3. RF and Modulation Parameters.....	6
2.4. Miscellaneous Specifications	6
3. Modulation Standards	8
3.1. ATSC	8
3.2. ATSC-MH	8
3.3. CMMB	9
3.4. DAB(+)/T-DMB	9
3.5. DTMB (ADTB-T, DMB-T/H)	10
3.6. DVB-C2	10
3.7. DVB-S	11
3.8. DVB-S2	11
3.9. DVB-S2X	12
3.10. DVB-T/H	13
3.11. DVB-T2	14
3.12. I/Q-samples	14
3.13. ISDB-S	15
3.14. ISDB-T/T _B	16
3.15. ISDB-Tmm	17
3.16. QAM-A (DVB-C)	17
3.17. QAM-B	18
3.18. QAM-C (ISDB-C)	18
4. Performance Measurements	19
4.1. Phase Noise	19
4.2. Return Loss	21
4.3. Adjacent Channel Power	21
4.4. Shoulder Attenuation	22
4.5. Second Harmonic Leakage	23

1. Introduction

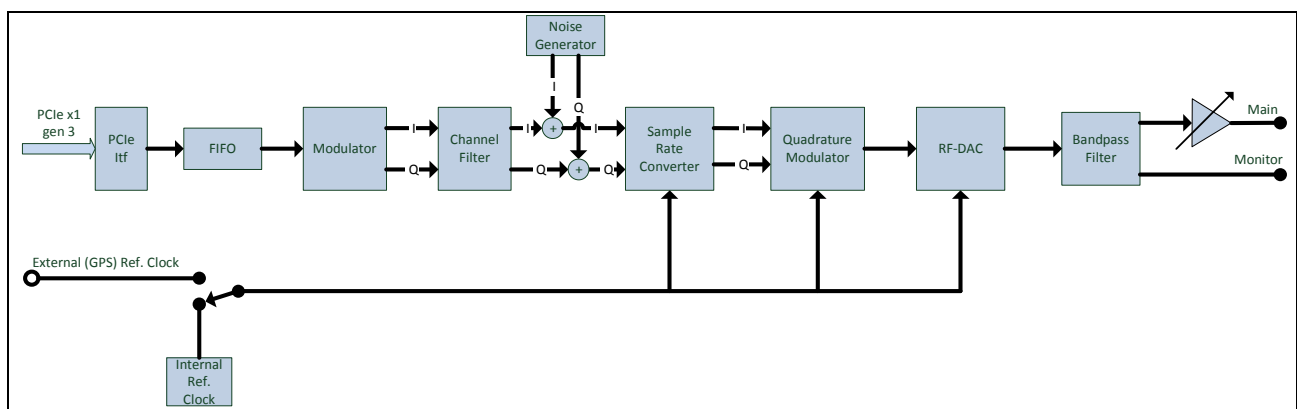
1.1. General Description

The DTA-2115 is a general-purpose modulator on a PCI Express x1 card. It can be used as a test modulator for generating virtually any DTV modulation standard currently in use around the world, including multi-PLP DVB-T2 and DVB-S2X. Advanced features include ultra-low phase noise, GPS synchronization, phase noise emulation and multi-channel modulation.

The output frequency of the DTA-2115 is agile in the range from 32MHz up to 2186MHz, covering VHF/UHF for terrestrial and cable standards, and L-Band for satellite. The maximum modulation bandwidth is 72MHz.

1.2. Block Diagram

The figure below shows a functional block diagram of the DTA-2115.



Functional block diagram of the DTA-2115

The modulation data from the PCI express bus is buffered in the Transmit FIFO. The I/Q Modulator converts this data into I/Q samples. Thereafter the I/Q samples pass the Channel Filter, which is fully programmable and implements the channel filter corresponding with the selected modulation standard.

The result of the Channel Filter is a modulated baseband signal in the digital domain. A hardware Noise Generator with programmable noise level can be used to add simulated noise to the I- and Q-samples. 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.

The next digital processing steps are a Sample Rate Converter and a Quadrature Modulator. They output a digital RF-signal. The high performance RF Digital-to-Analog Converter (RF-DAC) converts this signal in an analog RF-signal.

The sample rate and RF-frequency is synchronized with an accurate internal clock reference or an external clock reference, e.g. a 10MHz and 1pps GPS signals for Single Frequency Network operation.

Finally, the output of the RF-DAC is filtered, amplified and – for the main output – attenuated with a 60-dB range.

1.3. Software Support

The DTA-2115 comes with a free SDK that is available for both Windows and Linux. The SDK contains a device driver and the DTAPI library that provides uniform access to any DekTec hardware. The SDK enables you to write custom applications with direct RF output.

The device driver implements low-level operations that require direct access to the DTA-2115 hardware, such as initiation and coordination of DMA transfers, the handling of interrupts and reading and writing of Vital Product Data (VPD).

DekTec provides a number of standard (chargeable) applications for the DTA-2115:

- StreamXpress: Play out a transport-stream file and modulate;
- MuxXpert: Real-time multiplexing with modulated output;
- C2Xpress: DVB-C2 signal generator software;
- T2Xpress: DVB-T2 signal generator software;
- TmmXpress; ISDB-Tmm signal generator software.

1.4. Available Options

The table below lists the options that are available for the DTA-2115.

Option	Order code	Remark
ATSC	Included*	
ATSC-MH	DTC-377-MH	
Channel simulation	DTC-305-CM	AWGN and multipath emulation
CMMB	DTC-375-CMMB	
DAB	DTC-376-DAB	
DTMB	DTC-374-DTMB	
DVB-C2	DTC-379-C2	
DVB-S	Included*	
DVB-S2	Included*	
DVB-S2X	DTC-383-S2X	
DVB-T	Included*	
DVB-T2 full	DTC-378-T2	
DVB-T2 single-PLP	Included*	
GOLD	GOLD	Enables all current and future modulation options
I/Q samples	DTC-371-IQ	
ISDB-S	DTC-373-IS	
ISDB-T	DTC-370-ISDB	
ISDB-Tmm	DTC-382-TMM	
QAM-A	Included*	ITU J.83 Annex A, also known as DVB-C
QAM-B	Included*	ITU J.83 Annex B
QAM-C	Included*	ITU J.83 Annex C

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

2. Specifications

2.1. RF Outputs

The modulated signal is available on two output connectors:

- On a 50-Ω main output with programmable RF level;
- On a 75-Ω monitor output with fixed RF level.

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

	Qualification	Min	Typ	Max	Unit
MAIN OUTPUT					
Connector type		SMA, female			
Impedance		50			Ω
Level (programmable)	DVB-S(2), ISDB-S, QAM	-60		0	dBm
	DVB-S2 32APSK, DVB-S2X	-61		-1	dBm
	OFDM-based standards	-63		-3	dBm
Level, step size		0.1			dB
Return loss	32 to 1000MHz	-12			dB
	1000 to 2186MHz	-10			dB
MONITOR OUTPUT					
Connector type		F-type, female			
Impedance		75			Ω
Level (fixed)		-50	-45	-40	dBm
Return loss	32 to 1000MHz	-12			dB
	1000 to 2186MHz	-10			dB

2.2. Frequency Reference Inputs

The frequency reference inputs can be used to lock the DTA-2115 modulator to an external GPS source. Applications include SFN operation and experiments or operation of transmit diversity systems (MIMO, MISO).

	Qualification	Min	Typ	Max	Unit
1PPS					
Connector type		BNC, female			
Impedance		High impedance			
Standard	Schmitt trigger	Low Voltage CMOS (LVC)			
Vin	High level	1.6			V
	Low level			0.5	V
10MHz					
Connector type		BNC, female			
Impedance		50			Ω
Amplitude		10		1000	mVpp

2.3. RF and Modulation Parameters

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

	Qualification	Min	Typ	Max	Unit
RF FREQUENCY					
Range	Min/max frequency	32		2186	MHz
Initial accuracy	25°C	-0.5		+0.5	ppm
Aging in first year				1	ppm
Stability	0 to 40°C ambient	-0.5		+0.5	ppm
Step size				1	Hz
Phase noise	2186MHz, 10kHz offset			-116	dBc
MODULATION					
Bandwidth				72	MHz
MER	Equalised	48	50		dB
	Unequalised	38	42		dB
SIGNAL PURITY					
Spectral purity	32 to 1000MHz	50			dB
	1000 to 2186MHz	45			dB
Adjacent channel power				-60	dB
Shoulder attenuation				-50	dB

* These are the minimum and maximum frequencies of the generated spectrum. The carrier frequency range is less, depending on the modulation bandwidth.

2.4. Miscellaneous Specifications

	Qualification	Min	Typ	Max	Unit
POWER					
Supply rails used			3.3, +12		V
Power consumption		8.5		17.2	W
	Card is idle		8.7		W
	Modulating		16.9		W
PCI EXPRESS BUS					
Label			PCIe3 x1		
Profile			Standard profile		
MECHANICAL					
Dimensions	W x H x D		162.65 x 106.65 x 16.20		mm
Weight			325		g
ENVIRONMENTAL					
Operating temperature		0		+45	°C

	Qualification	Min	Typ	Max	Unit
COMPLIANCY	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			
FCC – Class		B			
Safety		UL 1419, IEC60065			

3. Modulation Standards

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

3.1. 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	
StreamXpress	Application for playing transport-stream files and modulating in ATSC
DTAPI SDK	SDK for creating custom applications that generate ATSC directly

3.2. 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	
StreamXpress	Applications for playing transport-stream files and modulating in ATSC-MH
DTAPI SDK	SDK for creating custom applications that generate ATSC-MH directly

3.3. 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	
StreamXpress	For playing and modulating CMMB-PMS files
DTAPI SDK	For creating custom applications that generate CMMB directly

3.4. 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	
DabMux	For multiplexing one or more audio and/or transport-stream files into an ETI(NI) stream
StreamXpress	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

3.5. 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	
StreamXpress	For playing transport-stream files and modulating in DTMB
DTAPI SDK	For creating custom applications that generate DTMB directly

3.6. 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	
C2Xpress	For playing and modulating single-PLP and multi-PLP DVB-C2 streams with full control over the entire DVB-C2 parameter set
DTAPI	SDK for creating custom applications that generate DVB-C2 directly; The DTAPI supports “Multi-PLP Extensions” to easily create multi-PLP applications.

3.7. DVB-S

Parameter / Feature	Value / Comment
STANDARD	EN 300 421
MODULATION PARAMETERS	
Symbol rate	0.088MBd to 85MBd
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	
StreamXpress	For playing transport-stream files and modulating in DVB-S
DTAPI	SDK for creating custom applications that generate DVB-S directly

3.8. DVB-S2

Parameter / Feature	Value / Comment
STANDARD	EN 302 307-1
MODULATION PARAMETERS	
Symbol rate	0.088MBd to 85MBd
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 L3 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 L3 file can be played using the StreamXpress player or using a custom application via the DekTec DTAPI.
FEATURES	
Input format	MPEG-2 transport stream L3 baseband frames
Channel simulation	AWGN insertion with adjustable SNR
SOFTWARE SUPPORT	
L3Mux	Utility for creating L3 baseband frame files
StreamXpress	For playing transport-stream files or L3 baseband frame files, and modulating in DVB-S2
DTAPI	SDK for creating custom applications that generate DVB-S2 directly

3.9. DVB-S2X

Parameter / Feature	Value / Comment
STANDARD	EN 302 307-2
MODULATION PARAMETERS	
Symbol rate	0.088MBd to 85MBd
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 L3 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 L3 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 L3X baseband frames
Channel simulation	AWGN insertion with adjustable SNR
SOFTWARE SUPPORT	
L3Mux	Utility for creating L3X baseband frame files
StreamXpress	For playing transport-stream files or L3X baseband frame files, and modulating in DVB-S2X
DTAPI	SDK for creating custom applications that generate DVB-S2X directly

3.10. 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	
StreamXpress	For playing transport-stream files and modulating in DVB-T
DTAPI	SDK for creating custom applications that generate DVB-T directly

3.11. 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	
T2Xpress	For playing and modulating single-PLP and multi-PLP DVB-T2 streams with full control over the entire DVB-T2 parameter set
StreamXpress	Application for playing transport streams or T2-MI files and modulating in DVB-T2
DTAPI	SDK for creating custom applications that generate DVB-T2 directly; The DTAPI supports “Multi-PLP Extensions” to easily create multi-PLP applications.

3.12. I/Q-samples

Parameter / Feature	Value / Comment
STANDARD	DekTec proprietary
MODULATION PARAMETERS	
Sample rate	0.088Msps to 85Msps
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	
StreamXpress	For playing I/Q-sample files
DTAPI	SDK for creating custom applications that play out I/Q samples

3.13. ISDB-S

Parameter / Feature	Value / Comment
STANDARD	ARIB STD-B20
MODULATION PARAMETERS	
Symbol rate	0.088MBd to 85MBd
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	
IsdbsMux	Utility for multiplexing one or more transport-stream files into an ISDB-S stream
StreamXpress	Application for playing transport-stream files and modulating in ISDB-S
DTAPI	SDK for creating custom applications that generate ISDB-S directly

3.14. ISDB-T/T_{SB}

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 _{SB} : 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	
StreamXpress	Application for playing transport-stream files and modulating in ISDB-T. For ISDB-T, StreamXpress includes a hierarchical multiplexer.
DTAPI	SDK for creating custom applications that generate ISDB-T directly. Includes a hierarchical multiplexer API.

3.15. 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	
TmmXpress	Application for playing and modulating an ISDB-Tmm signal with full control over the ISDB-Tmm parameters.
DTAPI	SDK for creating custom applications that generate ISDB-Tmm directly.

3.16. 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	
StreamXpress	Application for playing transport-stream files and modulating in DVB-C
DTAPI SDK	SDK for creating custom applications that generate DVB-C directly

3.17. 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	
StreamXpress	Application for playing transport-stream files and modulating in QAM-B
DTAPI SDK	SDK for creating custom applications that generate QAM-B directly

3.18. 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	
StreamXpress	Application for playing transport-stream files and modulating in QAM-C
DTAPI SDK	SDK for creating custom applications that generate QAM-C directly

4. Performance Measurements

4.1. Phase Noise

The figures below show the phase noise of a CW signal generated by the DTA-2115, measured at different RF frequencies: 32, 500, 1500 and 2186MHz.

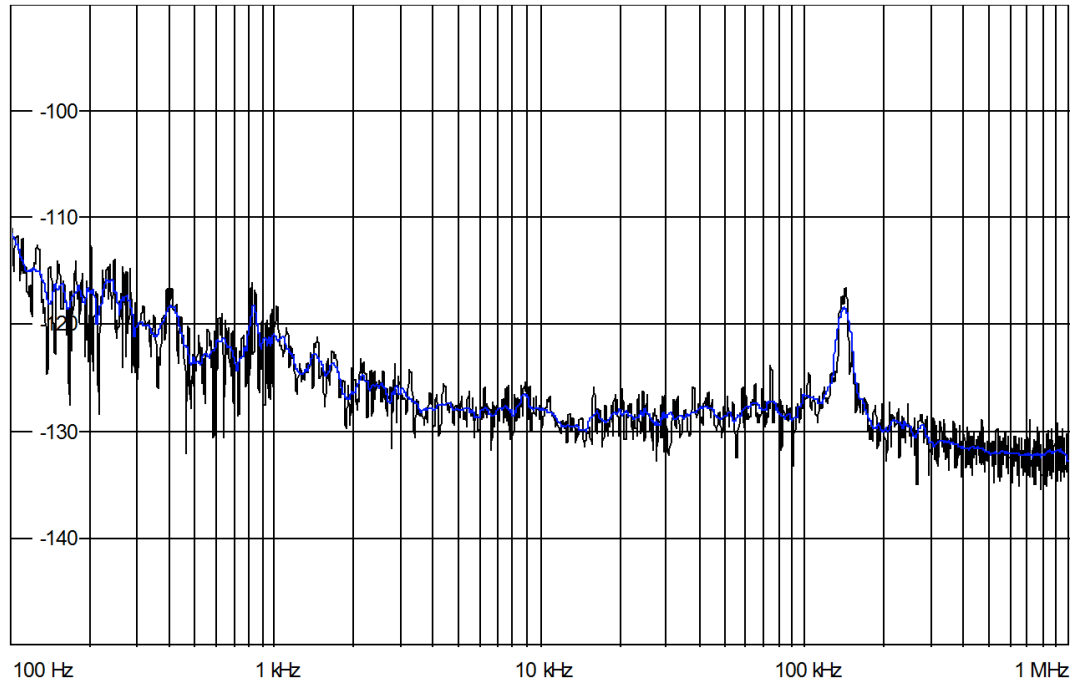


Figure 1. Phase noise @ 32MHz.

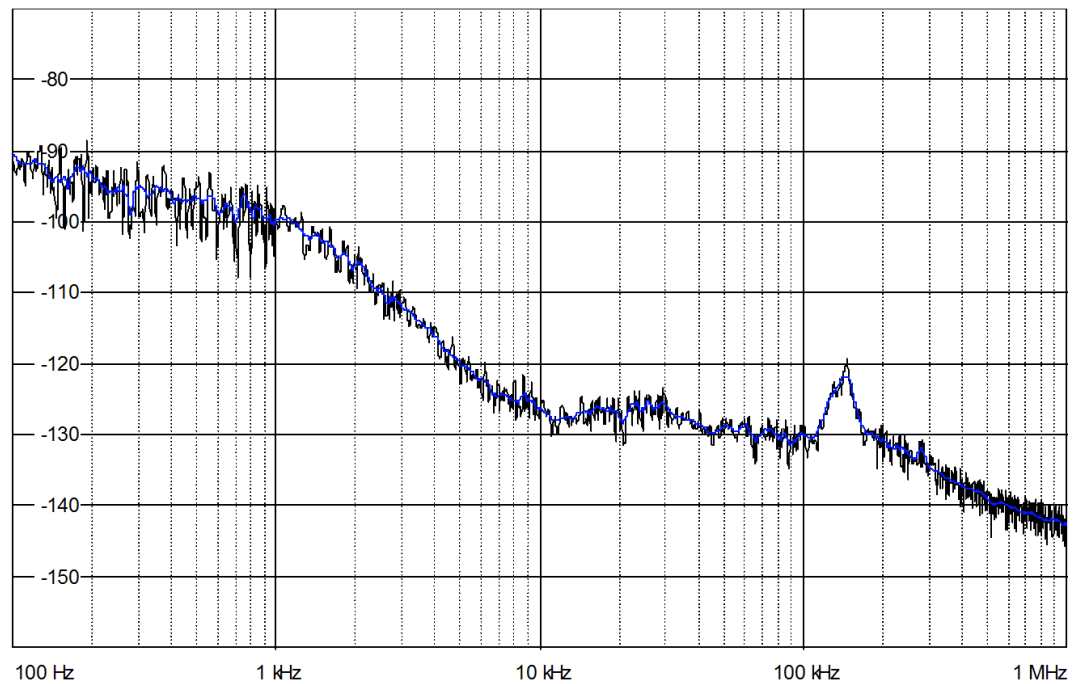


Figure 2. Phase noise @ 500MHz.

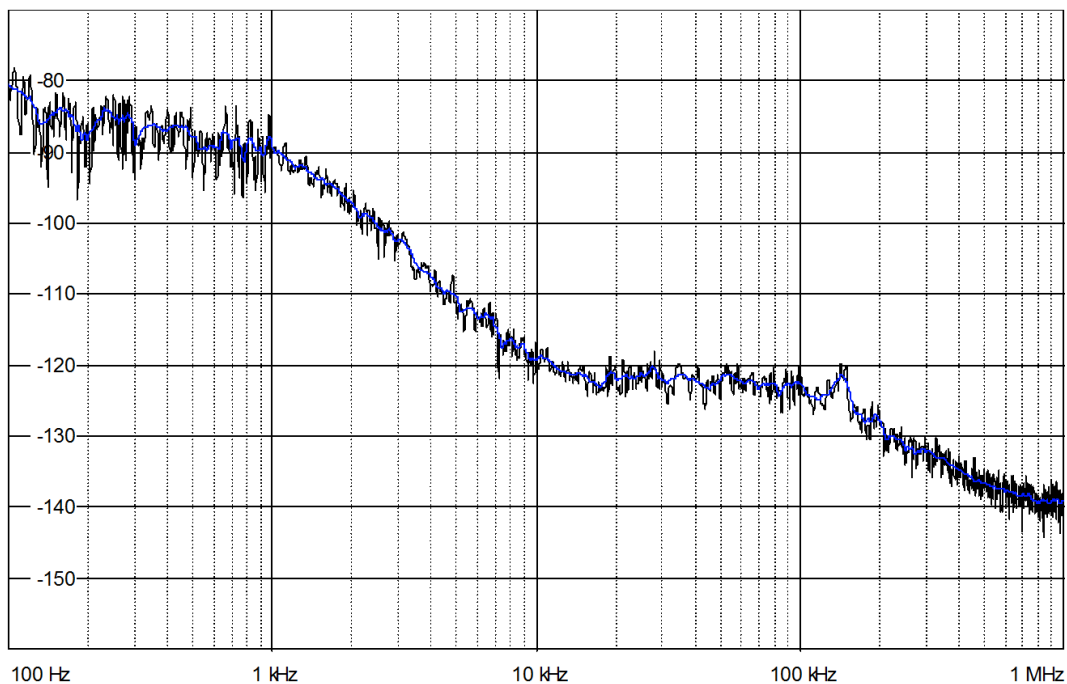


Figure 3. Phase noise @ 1500MHz.

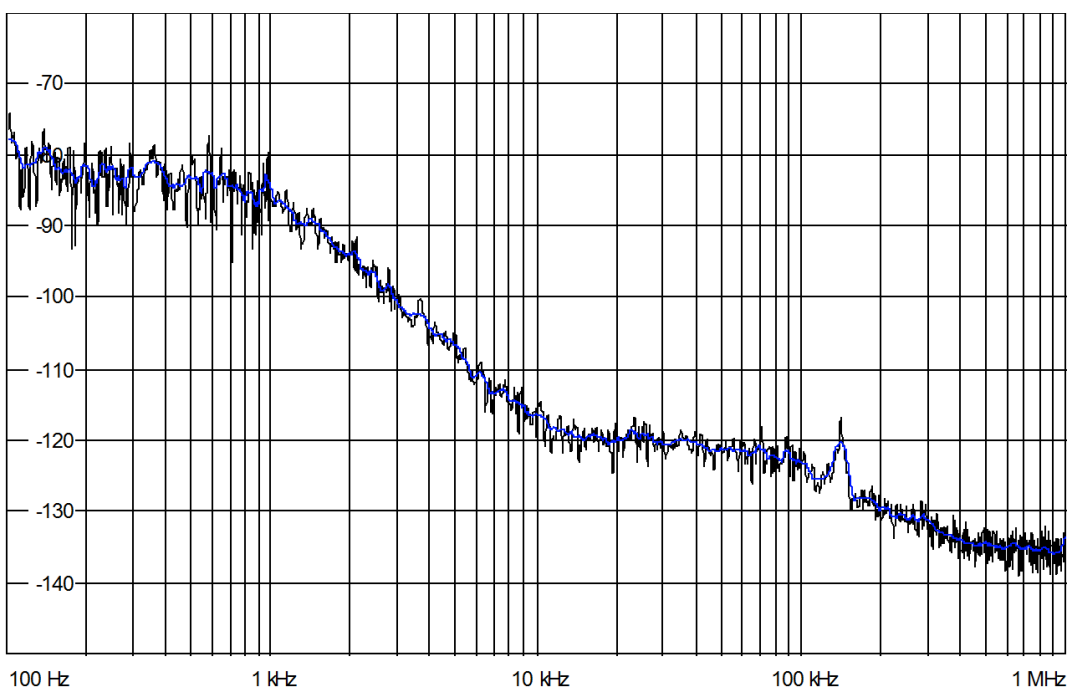


Figure 4. Phase noise @ 2186MHz.

4.2. Return Loss

The figures below show the return loss measured at the main- and monitor outputs of the DTA-2115.

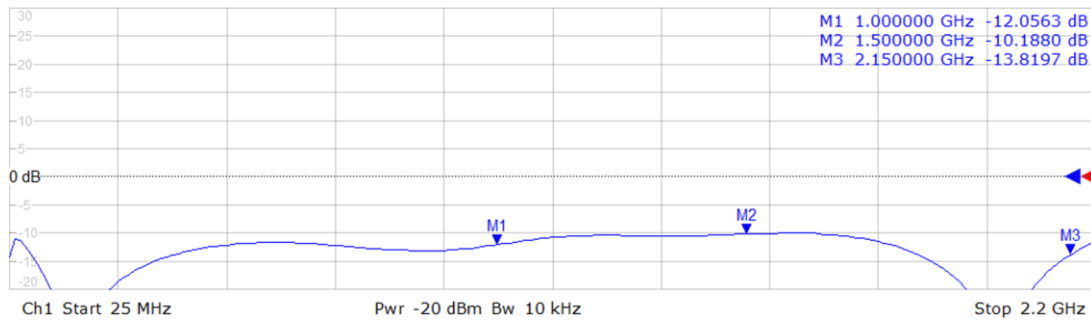


Figure 5. Return loss measurement of the main output.

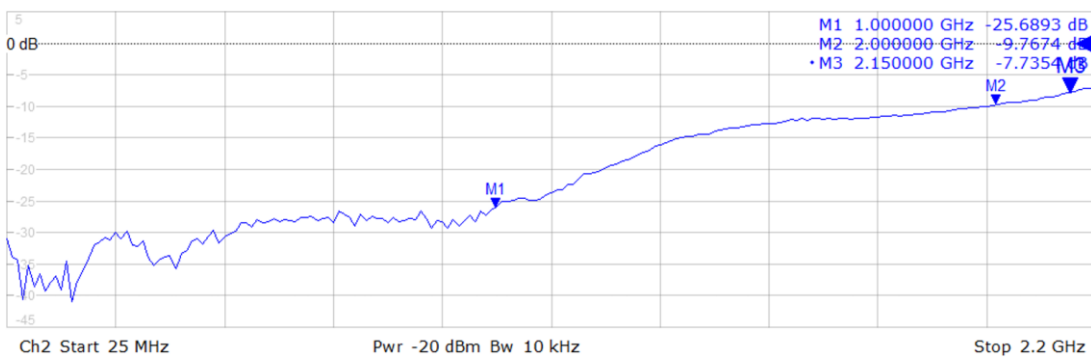


Figure 6. Return loss measurement of the monitor output.

4.3. Adjacent Channel Power

The graph below shows the power level of adjacent channels (ACP) at different RF frequencies when generating a DVB-C 256QAM signal at 0dBm.

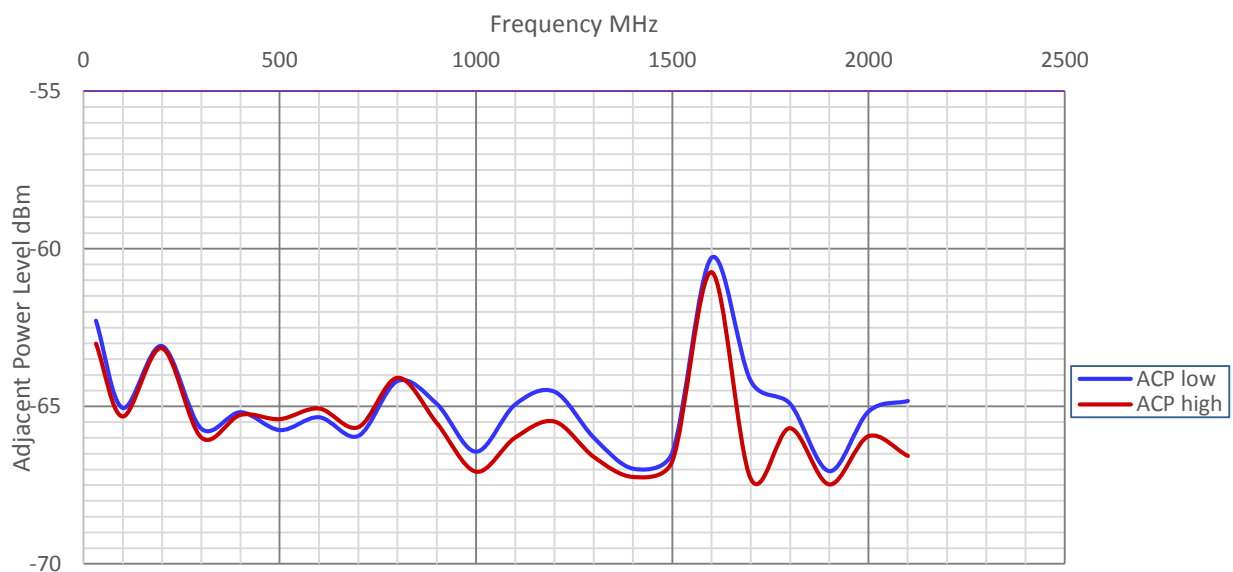


Figure 7. Power of lower and upper adjacent channel.

4.4. Shoulder Attenuation

The figures below show the shoulder attenuation, measured according to ETSI TR 101 290, using DVB-T 8MHz signal at 682MHz centre frequency.

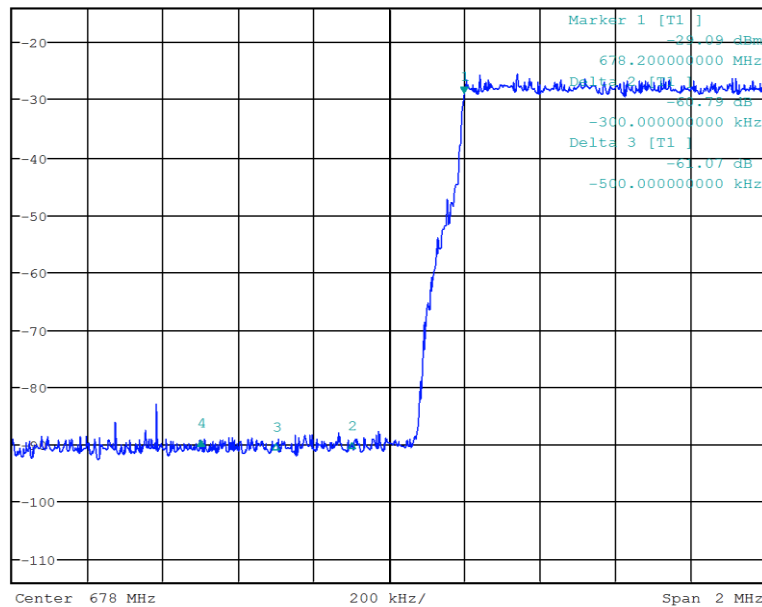


Figure 8. Left shoulder attenuation.

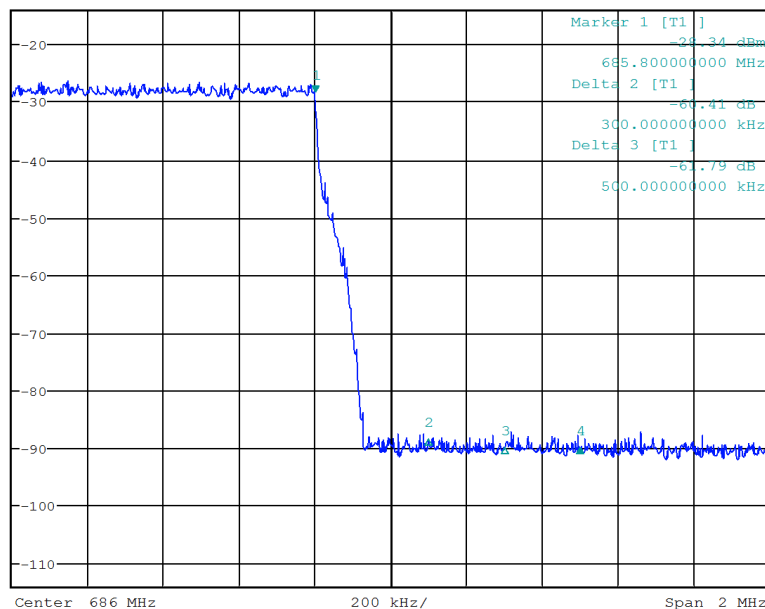


Figure 9. Right shoulder attenuation.

4.5. Second Harmonic Leakage

An undesirable side effect of digital-to-analog conversion on the DTA-2115 is that small “second-harmonic” signals are generated. The table below shows the frequency of the second-harmonic signals as a function of the carrier frequency. Depending on the band, one or two spurious signals are generated.

Band	Frequency	Second harmonic #1	Second harmonic #2
Band I	32 to 1000MHz	$2 * f$	
Band II	1000 to 1400MHz	$2 * f - 1600\text{MHz}$	$3200\text{MHz} - 2 * f$
Band III	1400 to 2186MHz	$2 * f - 2400\text{MHz}$	$4800\text{MHz} - 2 * f$

The measurement of the level of the second-harmonic signals is shown in the graph below.

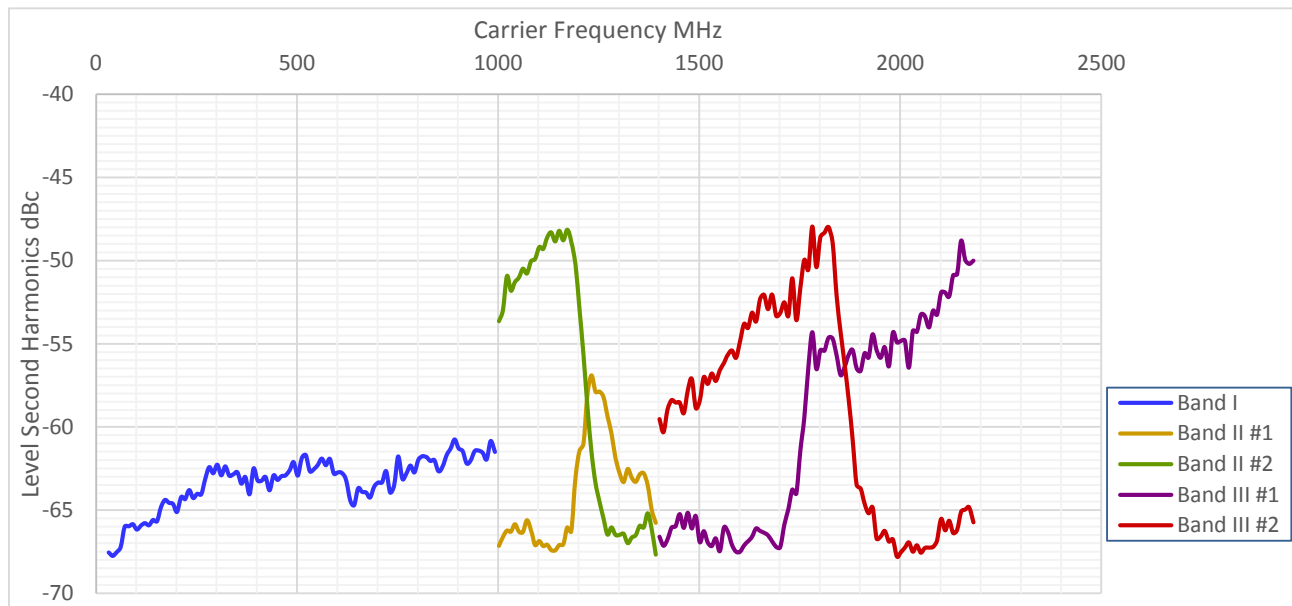


Figure 10. Level of the second-harmonic spurious signal.

An example of the level of the main and second-harmonic signal is shown in the graph below. A main signal at 1830MHz gives a second-harmonic signal at 1260MHz ($= 2 * 1830\text{MHz} - 2400\text{MHz}$) and another at 1140MHz ($= 4800\text{MHz} - 2 * 1830\text{MHz}$).

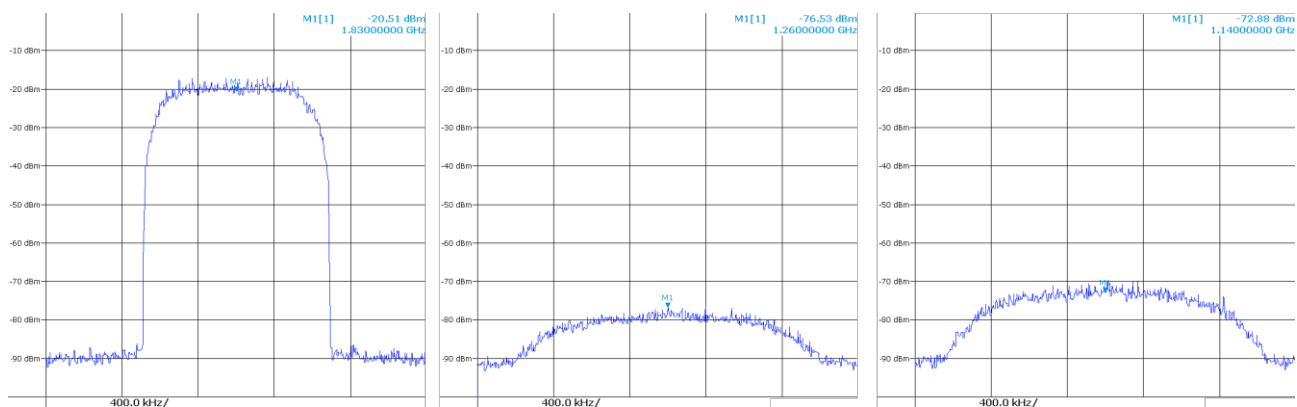


Figure 11. Level of the main signal at 1830MHz and the second-harmonics at 1260MHz and 1140MHz.