Atsc3Xpress

ATSC 3.0 Signal Generator

Table of Contents

Revision History

Revision	Date	Changes
v1.21.0.52	2025.06.19	Fixed DTA-2115B outputs not in sync Changed MIMO Cross-Polarization Distortion simulation Fixed AWGN for MIMO Added warnings for MIMO specification violations Fixed L1 detail size computation for L1 detail version 2 Fixed bootstrap and preamble power on polarization #2 when the first sub-frame is SISO Fixed MIMO edge pilots in SBS symbols Fixed MIMO stream combining for QPSK 13/15 Adjusted MIMO preamble and bootstrap power for polarization #2 according to latest specification (29 April 2025)
v1.20.1.46	2025.05.12	Fixed MIMO channel simulation Fixed possible indeterministic MIMO channel start
v1.20.0.44	2025.04.10	Added MIMO Cross-Polarization Interference simulation Added option to output SISO subframes to first output channel or to both Increased maximum PRBS bitrate to 160Mbps Show warning during playout if PCAP bitrate is higher than PLP capacity Fixed number of TI cells shown in Frame Info for HTI configurations Fixed MIMO stream combining for theta=0 Fixed MIMO null pilot pattern (MP32_4) encoding
v1.19.1.43	2025.02.20	Fixed MIMO Pilot parameter setting MIMO configurations output bootstrap and SISO PLPs on both channels
v1.19.0.42	2025.01.27	Added MIMO support
v1.18.0.40	2024.11.21	Enhanced frame information in GUI Improved tooltips in GUI Added no-GUI command line option
v1.17.1.39	2024.03.04	Increased DTA-2116 power level range to -3dBm .. -135dBm Improved Source Selection dialog for small screens
v1.17.0.38	2023.07.06	Added DTA-2116 support Added support for Big-Endian PCAP files Added source-specific multicast source address selection
v1.16.1.37	2022.02.24	Fixed out of band spurs of the DTU-315 modulator Fixed TxID selection
v1.16.0.36	2022.01.10	Increased the number of ROUTE/MMT IP-Addresses in PLP Source Selection Added check on the number of data cells per subframe
v1.15.0.34	2020.06.30	Added IP-filtering option for ROUTE/MMT file input
v1.14.0.33	2019.11.14	Added support for large ALP-packets Removed LLS reference (224.0.23.60:4937) from LMT-table generation
v1.13.0.31	2019.05.22	Added support for PCAP-files with fragmented IP packets
v1.12.1.30	2019.02.22	Improved indication of parameter errors
v1.12.0.29	2019.02.04	Added option to reset time-info generation on input-file wrap. Improved PLP parameter error checking Increased AWGN SNR range to +30dB .. -60dB Fixed MISO signal generation Fixed display of milliseconds component of PTP-time in GUI

v1.11.0.26	2018.07.23	Added support for the "Korean Mode" option, which will generate a LMT (if enabled) according the 2016 specification
v1.10.0.25	2018.05.30	Added support for L1-Detail version 1 Fixed random cell generation with LDM PLPs Fixed LMT-table generation Added new V&V configurations
v1.9.0.23	2018.01.16	Added generation of LMT-table Added support for different types of ALP-packets Extended parameter error checking
v1.7.0.16	2017.09.01	Added support for PCAP-files containing ALP Added MISO support Added display of PCAP-file's first timestamp in PTP time Fixed UTC to PTP time conversion, which caused 10 seconds L-Detail-timestamp difference Fixed PRBS packet length that was not saved
v1.6.0.14	2017.05.22	Added TxID support Added PCAP bitrate estimation Added IP-input adapter selection Reversed AES wakeup bits Improved tolerance against PCAP timestamp jitter Fixed crash with L1 detail mode 1 repetition Fixed buffer overflow in LDPC encoder
v1.5.1.11	2017.03.22	Fixed ROUTE/MMT IP input
v1.5.0.10	2017.03.02	Added ALP-over-IP input Support for PCAP with nanosecond timestamp format Fixed I/Q Float32 output format Fixed Doppler simulation
v1.4.0.9	2016.12.22	Incorporated latest specification updates Added bitrate information Increased the number of IP-inputs per PLP Added IQ over ASI option
V1.3.0.8	2016.10.06	Fixed generation of CTI with LDM Enabled changing parameters without restart
V1.0.0.3	2016.08.22	Initial version

1. Introduction

The DTC-386 ***Atsc3Xpress*** software package is designed to create ATSC 3.0 test signals in the form of I/Q sample files or ATSC 3.0 RF output signals. ***Atsc3Xpress*** can be installed by the user on any qualifying PC, as specified in section 2.

Atsc3Xpress allows you to set the ATSC 3.0 parameters, specify the preamble parameters, subframe parameters, PLP parameters and select the PLP sources, add noise, add multiple channel simulation paths and generate the ATSC 3.0 test signals.

The I/Q sample file can be processed by your application or it can be played out through the ***StreamXpress***.

Note: The ***Atsc3Xpress*** functions depend on the installed options, as specified in section 3.

2. Minimum PC Requirements

Platform	Windows 2k12/2k16/2k19, 7,8,10,11
Processor*	Core i5 minimum Core i7 recommended
RAM	2 GB

* Or equivalent AMD processor

3. Atsc3Xpress Software Options

The ***Atsc3Xpress*** software requires a valid license to be installed. Without a valid ***DTC-386-ATSC3*** license installed, ***Atsc3Xpress*** will operate in demo mode and is not able to generate ATSC 3.0 signals.

The following options are available:

Option	Description
DTC-386-ATSC3	***Atsc3Xpress***: Enables ATSC 3.0 RF output
DTC-371-IQ	Option to enable ATSC 3.0 I/Q sample generation, and playout of I/Q samples through the ***StreamXpress***
DTC-305-CM	Option to enable channel modelling

4. Atsc3Xpress Software Installation

The ***Atsc3Xpress*** software installation and ***Atsc3Xpress*** license installation instructions can be found in the 'DTC-386 Atsc3Xpress Installation' document, which is included in the install package.

5. Atsc3Xpress Overview

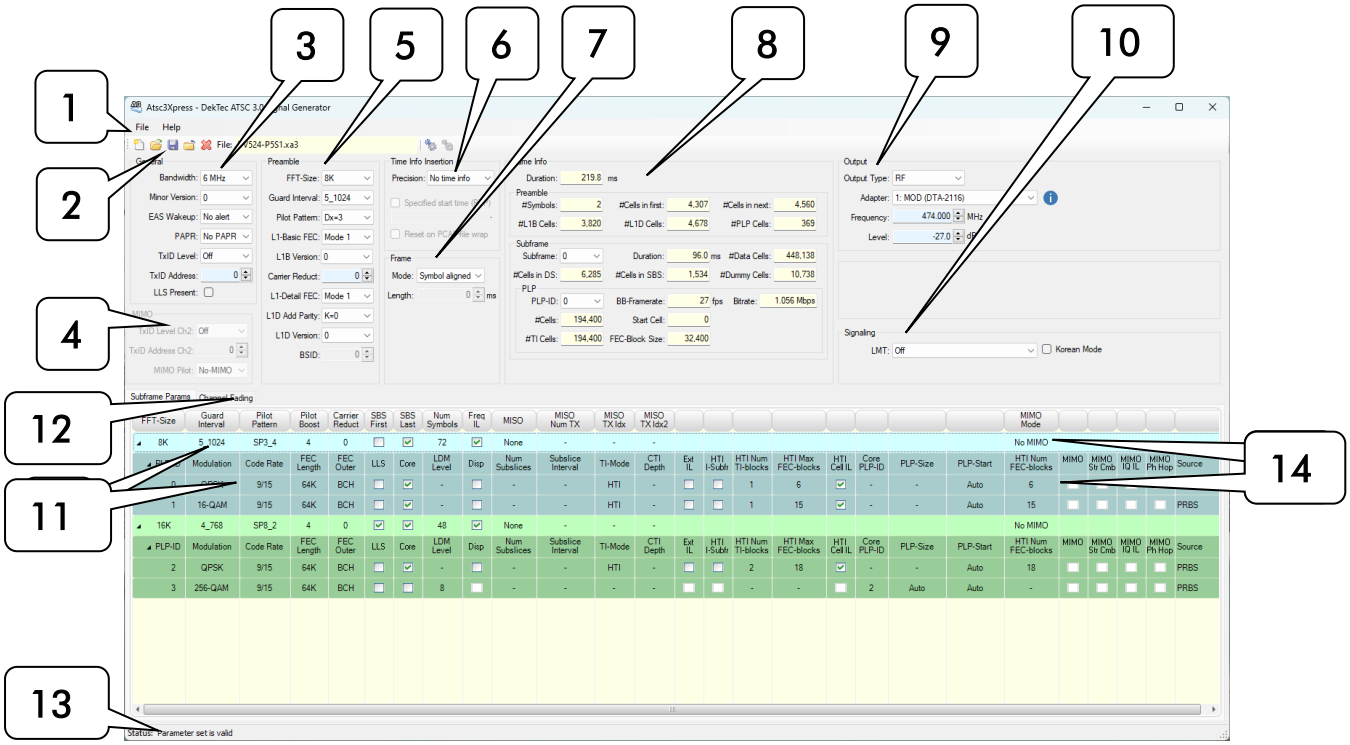
5.1. Launching Atsc3Xpress

The ***Atsc3Xpress*** program can be started by clicking the Windows Start button, type ***Atsc3Xpress***, and press Enter. A dialog appears that allows you to specify all parameters, to save and load parameter sets from file, and to start generation of the ATSC 3.0 signal.

Atsc3Xpress can be started from the command-line. The following command-line options are available:

Option	Description
-f filename	Start signal generation using the configuration file
-stop	Stops the currently running ***Atsc3Xpress***
-nogui	Hides the ***Atsc3Xpress*** application window.

5.2. Atsc3Xpress Application Layout



1. Menu Bar

The top area of the ***Atsc3Xpress*** application contains two menus: File and Help.

2. Tool Bar

This area contains the following commands: New File, Open File, Save File, Close File, Clear, Generate output and Cancel. This area also displays the name of the Atsc3Xpress-settings file.

3. General ATSC 3.0 Parameters

This group of controls allows you to set the general ATSC 3.0 parameters.

4. General MIMO parameters

This group of controls allows you to set parameters that are applicable for MIMO. It is enabled if MIMO is enabled.

5. Preamble Parameters

This group of controls allows you to set the ATSC 3.0 preamble parameters.

6. Time Information Parameters

This group of controls allows you to set the time information insertion parameters.

7. Frame Parameters

This group of controls allows you to set the ATSC 3.0 frame parameters.

8. Frame Information

This area displays information about the ATSC 3.0 frame and subframes.

9. Output Settings
This group of controls allows you to specify the name, location, size and the format for the generated signals.

10. Signaling
This group of controls allows you to specify the LMT-table generation. And whether the LMT-table format is according to the Korean (TTAK.KO-07.0127/R3) or the ATSC A/300 standard.

11. Subframe and PLP Parameters
This group of controls allows you to specify the subframe and PLP parameters and to select the source for each PLP.

12. Channel Fading
This section allows you to add noise to the output signal and to specify multiple simulated fading paths. For each path you can specify the channel-simulation parameters.

13. Status Bar
The status bar shows the validity of the ATSC 3.0 parameter set.

14. Subframe and PLP MIMO Parameters
In this part you can specify the subframe and PLP MIMO specific parameters.

6. Walkthrough: Generation of an ATSC 3.0 RF signal

This walkthrough will guide you through the generation of an ATSC 3.0 RF signal.

- **Start Atsc3Xpress application**
  Atsc3Xpress can be started from the start menu or using the desktop shortcut.
  After start-up all ATSC 3.0 parameters are set to default values.
- **Set general ATSC 3.0 parameters**
- **Set preamble, subframe and PLP Parameters**
  Modify the subframe and PLP parameters and optionally add more subframes and/or PLPs.
  To add more subframes right-click the mouse in the subframe and PLP parameter area and select: Add subframe. Alternatively, the Insert key can be used.
  To add more, select the subframe to which the PLP must be added then right-click the mouse and select: Add PLP. Alternatively, the Insert key can be used.
  To remove a complete Subframe or a PLP or, select the subframe or PLP then right-click the mouse and select: Remove subframe or Remove PLP. The shortcut key in this case is Delete.
  To navigate through the subframe and PLP parameters, use the arrow keys. After selection you can press the Enter key to modify the parameter. When done, press the Enter key for further navigation.
  To modify the PLP's source, double click on the PLP's source parameter and select PRBS test pattern, IP-capture file or live-IP streams.
- **Set Output Type**
  Set the Output Type to *RF,* thereafter you can specify the output adapter, RF frequency and RF level.
- **Check Status Bar**
  The status bar should indicate: *Parameter set is valid*. If otherwise, correct the settings.
- **Save Atsc3Xpress-Settings**
  Optionally save the current Atsc3Xpress settings to file by pressing the save button in the toolbar or selecting Save File in the menu bar.

- Generate RF signal

  The generation of the RF signal can be started by pressing the Generate output button  in the toolbar or selecting Generate output in the menu bar.

  The generation can be stopped by pressing the Cancel generation button  in the toolbar or selecting Cancel generation in the menu bar.

7. Atsc3Xpress Application GUI

The following sections describe the parameter groups and areas in the GUI of the ***Atsc3Xpress*** application.

7.1. Menu Bar

The menu bar contains two menus:

- File Menu

Submenu	Description
New	Create a new Atsc3Xpress-settings file; Settings are set to default
Open …	Open an existing Atsc3Xpress-settings file
Save	Save the current Atsc3Xpress-settings to file
Save As …	Save the current Atsc3Xpress-settings to file using a different file name
Close	Close the current file
Clear	Clear the current settings. All settings are set to default
Generate output	Start the generation of the ATSC 3.0 signal
Cancel generation	Cancel the generation of the ATSC 3.0 signal

- Help Menu

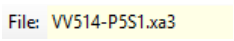
Submenu item	Description
About	Provide information about the current ***Atsc3Xpress*** version

7.2. Tool Bar

- Toolbar buttons

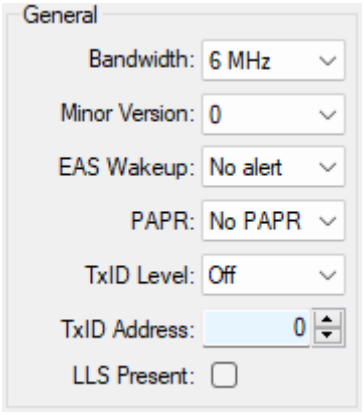
Toolbar button	Description
	Create a new Atsc3Xpress-settings file; Settings are set to default
	Open an existing Atsc3Xpress-settings file
	Save the current Atsc3Xpress-settings to file
	Close the current file
	Clear the current settings; All settings are set to default
	Start the generation of the ATSC 3.0 signal
	Cancel the generation of the ATSC 3.0 signal

- Additional information

Toolbar info	Description
	The name of the current Atsc3Xpress-settings file.
	During the generation of the output file(s) the progress is displayed.

7.3. General ATSC 3.0 Parameters

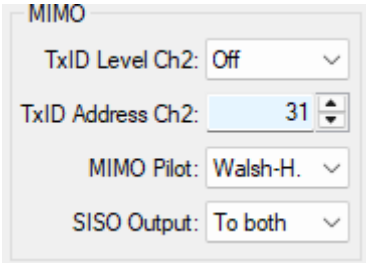
This group of parameters allows you to specify the general ATSC 3.0 parameters.



Parameter	Description
Bandwidth	Channel raster bandwidth: 6, 7 or 8 MHz
Minor Version	Bootstrap minor version: 0 .. 7
EAS Wakeup	Emergency Alert System wake-up information: 0 .. 3
PAPR	The PAPR reduction used: No PAPR, ACE only, TR only or both ACE and TR
TxID Level	The TxID injection level, specified in dBs.
TxID Address	Unique identification of the transmitter in an SFN: 0 .. 8191
LLS Present	Low Level Signaling (LLS) Present flag. If checked, indicates low levelling signalling is present in one of the PLPs.

7.4. General MIMO parameters

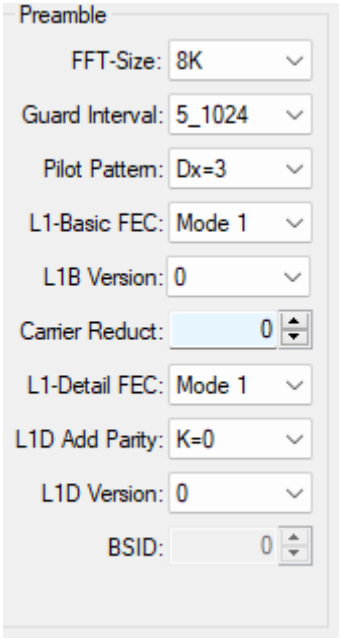
This group of parameters allows you to specify the general MIMO ATSC 3.0 parameters. It is available if MIMO is enabled.



Parameter	Description
TxID Level Ch2	The TxID injection level in MIMO channel 2, specified in dBs.
TxID Address Ch2	Unique identification of the transmitter in MIMO channel 2: 0 .. 8191
MIMO Pilot	Walsh-H (Walsh-Hadamard) or Null Pilots MIMO pilot encoding
SISO Output	SISO subframes output for mixed MIMO/SISO configurations: to both channels or to channel 1 only

7.5. Preamble Parameters

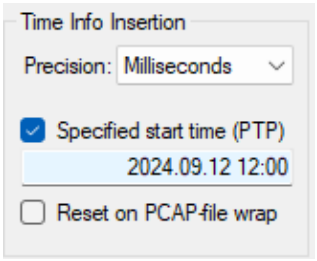
This group of parameters allows you to specify the preamble parameters.



Parameter	Description
FFT-Size	FFT size used for the preamble: 8K, 16K or 32K
Guard Interval	Guard interval between preamble symbols (GI): 1_192, 2_384, 3_512, 4_768, 5_1024, 6_1536, 7_2048, 8_2432, 9_3072, 10_3648, 11_4096, 12_4864
Pilot Pattern	Preamble pilot pattern Dx: Dx=3, Dx=4, Dx=6, Dx=8, Dx=12, Dx=16, Dx=24, Dx=32
L1-Basic FEC	L1-Basic FEC mode: Mode 1 .. Mode 5
L1B Version	L1-Basic version : 0 or 1
Carrier Reduct	Preamble carrier reduction: 0 .. 4
L1-Detail FEC	L1-Detail FEC mode: Mode 1 .. Mode 7
L1D Add Parity	Additional parity for L1-Detail: K=0, K=1, K=2
L1D Version	L1-Detail version: 0, 1 or 1
BSID	Broadcast Stream ID: 0 .. 65535

7.6. Time Information Parameters

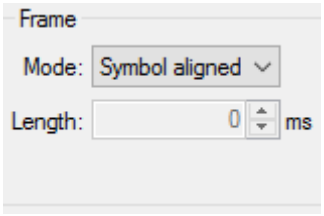
This group of parameters allows you to specify the time information insertion parameters.



Parameter	Description
Precision	Specifies the presence or absence of timing information and the precision (time info flag): No time info, Milliseconds, Microseconds, Nanoseconds
User specified start time (PTP)	If not checked, the current PTP-time is included in the frame. If checked, the user specified PTP-time is used as starting time for the first frame. Thereafter the time increments in the succeeding frames. Format: yyyy.mm.dd hh:mm:ss.SSS Examples: - 11:00 - 13:20:30:500 - 2016-01-01 8:00:50 Note that the time can be copied from PCAP start time in PLP Source Selection.
Reset on PCP-file wrap	If not checked, the PTP-time increments in the generated frames. If checked, the PTPtime to the specified start time when the PCAP file playback wraps.

7.7. Frame Parameters

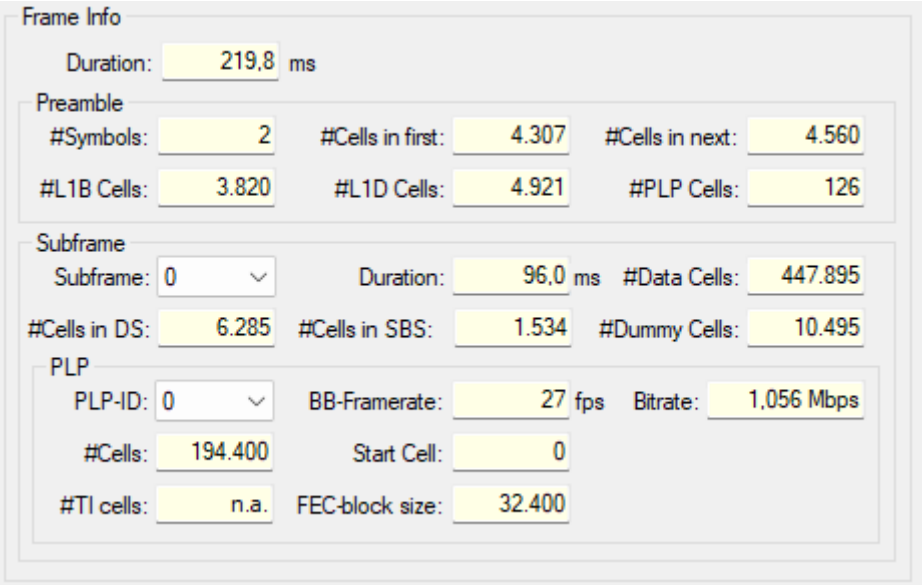
This group of parameters allows you to specify the frame parameters.



Parameter	Description
Mode	Frame length mode: Symbol aligned or Time aligned
Length	Frame length in milliseconds. Can only be specified if time aligned frames are configured: 5ms .. 5000ms in steps of 5ms

7.8. ATSC 3.0 Frame Information

This group shows information on the ATSC 3.0 frame and subframe structure.



If the ATSC 3.0 parameter set is valid, this area displays the derived frame information.

Parameter	Description
Duration	The duration of an ATSC 3.0 frame in milliseconds (including bootstrap and preamble and data symbols)
Preamble #Symbols	The number of preamble symbols
Preamble #Cells in first	The number of cells in the first preamble symbol
Preamble #Cells in next	The number of cells in the next preamble symbol(s)
Preamble #L1B Cells	The number of data cells in L1-Basic signaling
Preamble #L1D Cells	The number of data cells in L1-Detail signaling
Preamble #PLP Cells	The number of PLP data cells available in the final preamble symbol
Subframe	Selected subframe (0 is the first subframe, 1 the second, and so on)
Subframe Duration	Duration of the selected subframe in milliseconds
Subframe #Data Cells	Total number of data cells available for the PLP, including the preamble PLP cells for the first subframe
Subframe #Cells in DS	The number of data cells in each data symbol
Subframe #Cells in SBS	The number of cells in each Subframe Boundary Symbol
Subframe #Dummy cells	The number of dummy cells in each subframe
PLP-ID	Selected PLP ID
BB-Framerate	The number of baseband-frames (data + FEC) per second
Bitrate	The maximum payload data bitrate capacity of the PLP
#Cells	The total number of data cells contained by the PLP
Start cell	The index of the first PLP data cell
#TI cells	The number of Time Interleaver memory cells
FEC-block size	The number of cells in a FEC block

7.9. Output settings

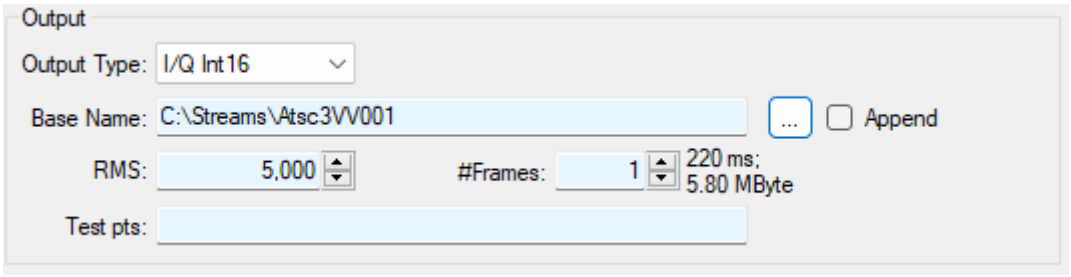
This area allows you to specify the output settings. Depending on the selected output type, other selection fields are shown in this area.

- Output Type

Type	Description
I/Q Float32	Pairs of 32-bit floats in I, Q order
I/Q Int16	Pairs of signed 16-bit integers in I, Q order, little Endian: Byte #0: Least-significant byte I Byte #1: Most-significant byte I Byte #2: Least-significant byte Q Byte #3: Most-significant byte Q Etc.
I/Q Text	Text (ASCII)-based format consisting of pairs of four-character hexadecimal values with 0x prefix in I, Q order. The I and Q values are separated by a TAB and I/Q pairs are separated by a linefeed. Example: 0x2b45<TAB>0x1c3f<LF> 0xfeA9<TAB>0x0073<LF>
RF	ATSC 3.0 RF output through the selected ATSC 3.0 modulator port

7.9.1. I/Q Output Settings

In case the output type I/Q samples is selected (I/Q Float32, I/Q Int16 or I/Q Text), this area allows the selection of the location and the base name of the generated I/Q sample file and test point data files.



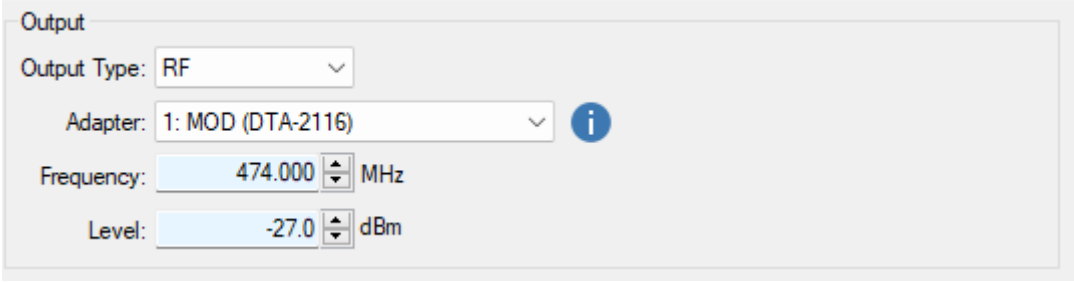
I/Q samples file settings

- Append files
  If not checked, Atsc3Xpress overwrites the previously generated file. If checked, the Atsc3Xpress appends the new generated data to the end of the existing file. It allows you to create IQ-files with dynamically changing ATSC 3.0 parameters.
- RMS
  The Root Mean Square (RMS) of the complex samples. This value should be set as large as possible to have the largest SNR, but small enough to avoid saturation. When a DekTec card is used for play-out of the I/Q samples, the value 5000 is a good value.
- #Frames
  The number of ATSC 3.0 frames to be generated. The resulting file length and size are displayed.
- Test pts
  Enables the generation of test point data files according to the generation of ATSC 3.0 reference

streams document (S32-XXXrx-V&V_Detailed_Explanation-201y-mm-dd.docx). Test points must be separated by commas. The following test points are supported: 4, 5, 6, 7, 8, 9, 10, 14, 15, 21, 22, 26, 30, 31, 32, 34, 37, 39, 40, 42, 43, 45, 48 and 50.

7.9.2. RF Output settings

In case the output type ATSC 3.0 RF is selected this area allows the selection of the ATSC 3.0 capable modulator card and the RF parameters.

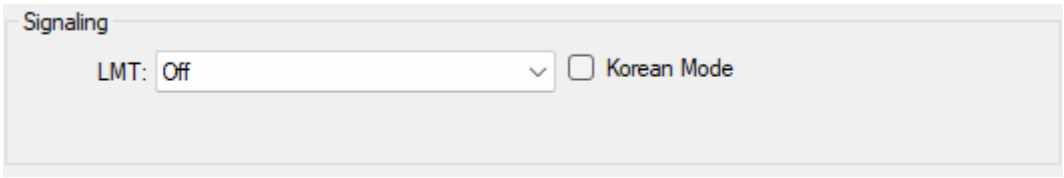


ATSC 3.0 RF output settings

- **Frequency**
  Carrier frequency for the RF signal.
- **Level**
  Level (in dBm) of the output signal.

7.10. Signaling

This area allows you to specify the LMT-table generation. If enabled, the LMT-table is included in the PLP(s) where the LLS checkbox is checked.



LMT-table generation

LMT	Description
Off	No LMT-table is included in the output signal
From config file	An LMT-table is included in the output signal. The <Signaling> section (directly following the <Subframe> section) of the configuration file specifies the LMT-table content. For example: <Signaling> <Lmt cycle_time="1" gen_mode="from_config_file" /> <Plp plp_id="0"> <Multicast> <Src ip0="192" ip1="168" ip2="0" ip3="3" port="53010" /> <Dst ip0="224" ip1="0" ip2="23" ip3="60" port="4937" /> </Multicast> <Multicast> <Src ip0="0" ip1="0" ip2="0" ip3="0" port="24576" /> <Dst ip0="236" ip1="249" ip2="153" ip3="118" port="0" /> </Multicast> </Plp> </Lmt> </Signaling>
Derived from plp sources	An LMT-table is included in the output signal. The LMT-table is derived from the selected PLP-sources.

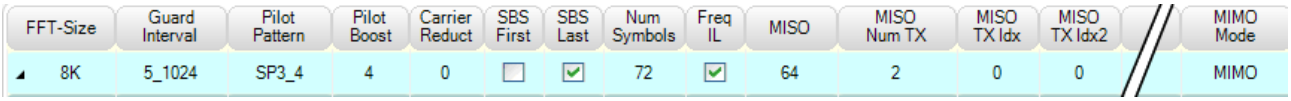
- Korean Mode
  If checked the ALP-encapsulation of the generated LMT (if enabled) is according to the Korean TTAK.KO-07.0127/R3 specification which is commonly used in Korea. Otherwise, the ALP-encapsulation is according to the ATSC A/300 standard.

7.11. Subframe and PLP Parameters

The Subframes Params tab allows you to specify the subframe parameters and the PLP parameters. The light-coloured rows specify the parameters of the subframes. Each Subframe can contain one or more PLPs. The parameters of the PLPs within a Subframe are specified in the slightly darker coloured rows below the subframe parameters.

7.11.1. Subframe Parameters

Each light coloured row specifies the parameters for a Subframe.



FFT-Size	Guard Interval	Pilot Pattern	Pilot Boost	Carrier Reduct	SBS First	SBS Last	Num Symbols	Freq IL	MISO	MISO Num TX	MISO TX Idx	MISO TX Idx2		MIMO Mode
8K	5_1024	SP3_4	4	0	☐	☑	72	☑	64	2	0	0		MIMO

Subframe parameter	Description
FFT-Size	FFT size of the subframe: 8K, 16K or 32K
Guard Interval	Guard interval of the subframe (GI): 1_192, 2_384, 3_512, 4_768, 5_1024, 6_1536, 7_2048, 8_2432, 9_3072, 10_3648, 11_4096, 12_4864
Pilot Pattern	Subframe pilot pattern (SP): 3_4, 4_2, 4_4, 6_2, 6_4, 8_2, 8_4, 12_2, 12_4, 16_2, 16_4, 24_2, 24_4, 32_2, 32_4
Pilot Boost	Scattered pilot boost factor: 0 .. 4
Carrier Reduct	Subframe carrier reduction: 0 .. 4
SBS First	If checked, the first symbol of the subframe is a subframe boundary symbol
SBS Last	If checked, the last symbol of the subframe is a subframe boundary symbol

Num Symbols	The total number of data payload OFDM symbols, including any subframe boundary symbol(s)
Freq IL	If checked, the frequency interleaver is enabled. Otherwise, the frequency interleaver is bypassed and not used.
MISO	MISO option: No MISO, MISO with 64 coefficients, MISO with 256 coefficients
MISO Num TX	The number of transmitters in a MISO transmission: 0 (No MISO), 2, 3 or 4
MISO TX Idx	The index of the transmitter in a MISO transmission: 0 .. MISO Num TX -1
MISO TX Idx2	The index of the transmitter for MIMO channel 2 in a MISO transmission: 0 .. MISO Num TX -1
MIMO Mode	MIMO mode option: - No MIMO: all PLPs in this subframe use SISO. - MIMO: all PLPs in this subframe use MIMO. - Mixed: PLPs of both types in this subframe.

To add more subframes, right-click the mouse in the subframe and PLP parameter area and select: *Insert subframe*. Alternatively, the Insert key can be used.

To remove a subframe, select the subframe then right-click the mouse and select: *Remove subframe*. The shortcut key in this case is Delete.

To navigate through the subframe parameters, use the arrow keys. After selection you can press the Enter key to modify the parameter. When done, press the Enter key for further navigation.

7.11.2. PLP Parameters

Each dark coloured row below the Subframe parameters specifies the parameters for a PLP.

PLP parameter	Description
PLP ID	Unique identification of a PLP: 0 .. 63
Modulation	Modulation type used by the PLP:16-QAM, 64-QAM, 256-QAM, 1024-QAM or 4096-QAM
Code Rate	Code rate used by the PLP: 2/15, 3/15, 4/15, 5/15, 6/15, 7/15, 8/15, 9/15, 10/15, 11/15, 12/15, 13/15
FEC Length	FEC code length: 16K LDPC or 64K LDPC
FEC Outer	FEC outer code: BCH, CRC or None
LLS	If checked, indicating that the current PLP contains low level signaling information
Core	Core or enhanced layer. If checked, the PLP belongs to the core layer.
LDM Level	The enhanced PLP's injection level relative to the core PLP. Value: 0 .. 10 => Value/2.0 dB Value: 11 .. 30 => Value – 5.0 dB
Disp	PLP type: non-dispersed or dispered. If check, the PLP is dispersed. Note: only used for core PLPs.

Num Sublices	The number of subslices used for the current PLP: 1...16384. Note: only used for core PLPs where the PLP type is dispersed.
Subslice Interval	The subslice interval: 1 .. 2^24-1. Note: only used for core PLPs where the PLP type is dispersed.
TI-Mode	Time interleaver mode: None, Convolutional time interleaving (CTI) mode, Hybrid time interleaving (HTI) mode. Note: only used for core PLPs.
CTI Depth	The number of rows used in the convolutional time interleaver: 512, 724, 887 (1254 extended interleaving), 1024 (1448 extended interleaving). Note: only used for core PLPs where the time interleaver mode is CTI.
Ext IL	If checked, extended interleaving is used for this PLP. Note: only used for core PLPs where the time interleaver mode is CTI or HTI.
HTI I-Subfr	The hybrid time interleaving mode. If not checked, inter-subframe interleaving is not used (i.e. only intra-subframe interleaving is used). If checked, interleaving is used with one TI block per interleaving frame spread over multiple subframes. Note: only used for core PLPs where the time interleaver mode is HTI.
HTI Num TI-blocks	The number of TI blocks per interleaving frame: 1 .. 16. If HTI I-Subfr checkbox is not checked, the number of TI blocks per interleaving frame. If HTI I-Subfr checkbox is checked, the number of subframes over which cells from one TI block are carried. Note: only used for core PLPs where the time interleaver mode is HTI.
HTI Max FEC-blocks	The maximum number of FEC blocks per interleaving frame: 1.. 4096. Note: only used for core PLPs where the time interleaver mode is HTI.
HTI Cell IL	If checked, the cell interleaver is enabled. Note: only used for core PLPs where the time interleaver mode is HTI.
Core PLP-ID	Used for enhanced PLPs, the PLP ID of the corresponding core layer. The enhanced layer is scheduled with the same number of cells as the core layer.
PLP-Size	For core PLPs: the number of cells per subframe, Auto means to use the full subframe. For enhanced PLPs: the number of cells of the enhanced layer PLP, Auto means the complete size of the core layer PLP. Note: only used if the time interleaver mode is None or CTI.
PLP-Start	PLP starting cell, if set to Auto, the PLP-start is automatically determined by allocating PLPs by increasing PLP index assuming each PLP uses PLP-size cells (for non-dispersed PLPs) or ceil(PLP-size/number of subslices) cells (for dispersed PLPs). For complex FDM allocations the previous algorithm is not sufficient and PLP-start must be set manually. For core PLPs: the index of the starting cell of the PLP in the current subframe. For enhanced PLPs: the index of the starting cell of the PLP counting from the start of the corresponding core PLP.
HTI Num FEC-blocks	The number of FEC blocks per subframe: 1 .. HTI Max FEC-blocks. Note: only used for core PLPs where the time interleaver mode is HTI.

MIMO	If checked, MIMO is enabled for this PLP. Note: only used if the current subframe uses MIMO-Mode Mixed.
MIMO Str Cmb	If checked, the stream combining option of MIMO precoding is enabled.
MIMO IQ IL	If checked, the IQ polarization interleaving option of MIMO precoding is enabled.
MIMO Ph Hop	If checked, the phase hopping option of MIMO precoding is enabled.
Source	Displays the selected source. When double clicking on the source, a dialog is opened that allows you to select the source. The source of a PLP can be: (a) PRBS O515 PRBS test pattern. The bitrate and the packet length must be specified. (b) PCAP IP-capture input file. The path of the IP-capture file can be selected. The PCAP file may contain ROUTE/MMT-packets or ALP-packets. If the IP-address filtering option is enabled, up to 20 IP-addresses can be selected. When the option is disabled, all IP-addresses are passed. (c) ALP over UDP A live IP-input stream carrying ALP-packets. d) ROUTE/MMT Live IP-input streams. Up to 20 IP-input streams can be selected. Optionally a new IP source address can be specified.

To add more PLPs, right-click the mouse in PLP parameter row below the subframe to which the new PLP will be added and select: *Insert PLP*. Alternatively, the Insert key can be used.

To remove a PLP, select the PLP then right-click the mouse and select: *Remove PLP*. The shortcut key in this case is Delete.

To navigate through the PLP parameters, use the arrow keys. After selection, you can press the Enter key to modify the parameter. When done, press the Enter key for further navigation.

7.12. Channel Fading

The channel-fading tab allows you to specify the parameters for the channel simulator:
- White noise
- Reflections (multipath echo's)
- Doppler effects because of a moving receiver

In case MIMO transmission is enabled, two channel-tabs are available, one for MIMO channel 1 and one for MIMO channel 2 channel simulation parameters.

7.12.1. Channel Simulator

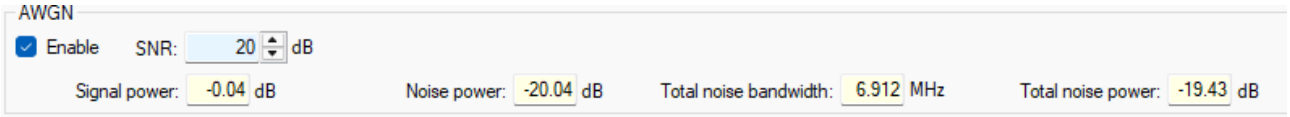
The Channel-Simulator group contains the overall enable box.

If checked, channel simulation is enabled, noise, MIMO cross-polarization interference, and fading-path parameters can be specified. If unchecked, no channel simulation is applied.

The File Open button enables you to load a previously saved set of channel-simulation settings. The File Save button allows you to save the current settings.

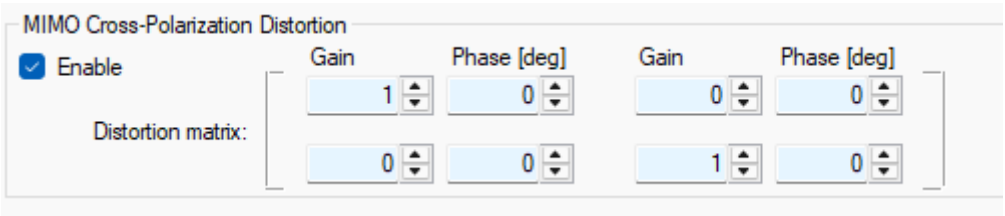
7.12.2. AWGN

The AWGN group enables you to specify parameters for the addition of Gaussian-distributed noise to the I/Q samples. If the Enable box is checked, the signal-to-noise ratio relative to the original signal can be specified.



7.12.3. MIMO Cross-Polarization Distortion

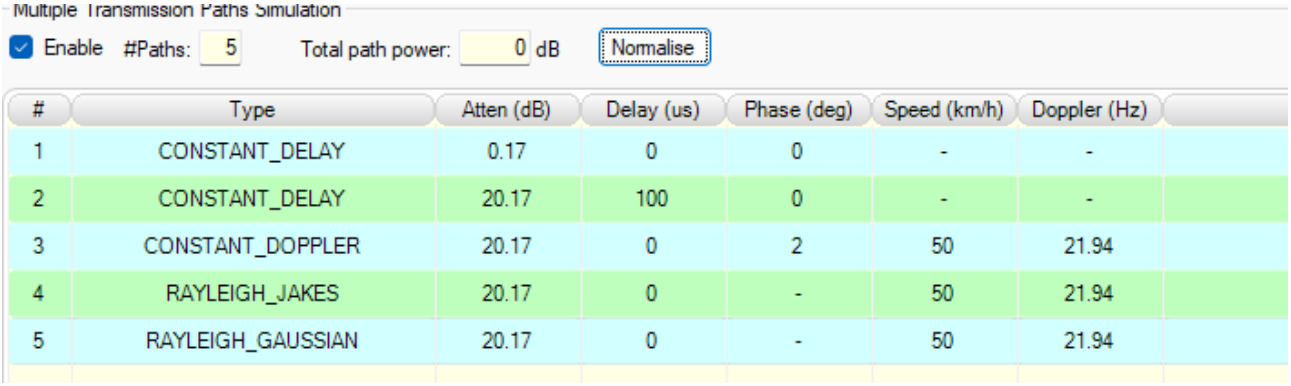
In case of MIMO configurations, MIMO Cross-Polarization Distortion can be enabled. If the Enable box is checked, the cross-distortion can be specified in a matrix.



Note: If MIMO Cross-Polarization Distortion is enabled, the Multiple Transmission Paths simulation is automatically disabled. Currently, both features cannot be simulated simultaneously.

7.12.4. Multiple Transmission Paths Simulation

This group allows you to specify up to 32 transmission paths.



The following parameters can be specified for each fading path:

PLP parameter	Description
Type	Echo Type: Constant Delay, Constant Doppler, Rayleigh fading with Gaussian spectrum or Rayleigh fading with Jakes spectrum
Atten (dB)	Attenuation of the path in dB
Delay (us)	Delay of the path in microseconds
Phase (deg)	Phase shift of the path in degrees. Only for Constant Delay and Constant Doppler path types
Speed (km/h)	Speed of the simulated moving receiver in km per hour. The resulting Doppler frequency in Hz is displayed. Only for Constant Doppler, Rayleigh Jakes and Rayleigh Gaussian path types.

If the Multiple Transmission Paths Simulation is disabled, it acts as a single path without attenuation and without delay. If the Multiple Transmission Paths Simulation is enabled and no paths are defined, it acts as a pure noise generator.

The sum of path power is displayed. The normalize button allows you to normalize the attenuation of the paths such that the total power is 0dB again.

7.13. Status Bar

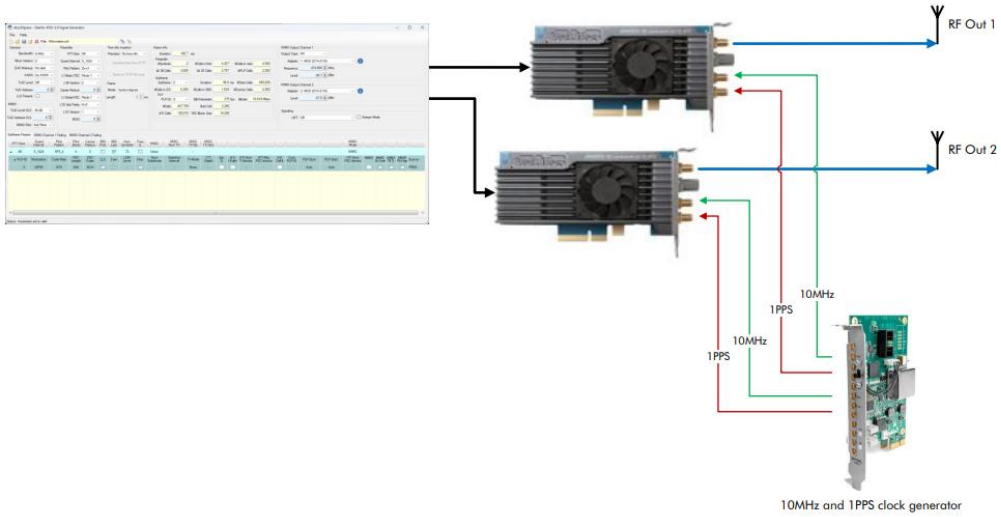
The Status Bar appears in the lower left corner of the *Atsc3Xpress* application. The Status Bar indicates whether the combination of current ATSC 3.0 parameters is valid.

8. Generating ATSC 3.0 MIMO RF Signals

The *Atsc3Xpress* supports the generation of MIMO transmission.

Multiple-Input, Multiple-Output (MIMO) is a transmission technique that uses multiple transmit and receive antennas to improve spectrum efficiency and data throughput. *Atsc3Xpress* achieves this by transmitting the different data streams over different modulator outputs. The modulator outputs must be synchronized to a common timing source with high precision. This can be achieved by utilizing two DTA-2115B cards (1x72MHz firmware variant), two DTA-2116 cards, or a combination of these two card types and an external reference clock generator providing 10MHz and 1pps synchronization signals (e.g. Safran CDM-7). The two modulator cards must be installed in one PC.

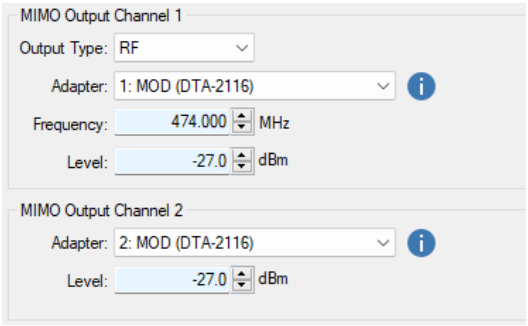
The picture below shows such a MIMO setup.



8.1. Creating a MIMO configuration

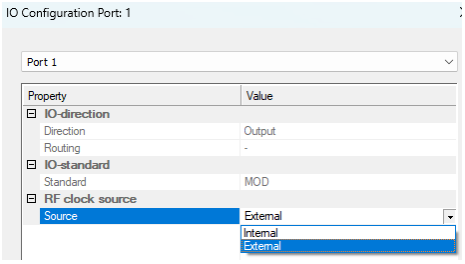
MIMO is enabled if one or more Subframes are configured for MIMO mode **MIMO** or **Mixed**. Thereafter, the GUI allows the selection of two output adapters. Two different output adapters must be selected. The adapters use the same output frequency but can have a different output level.

Also, the General MIMO parameters can be set see section 7.4. And the fading parameters for each MIMO output channel can be set, see section 7.12.



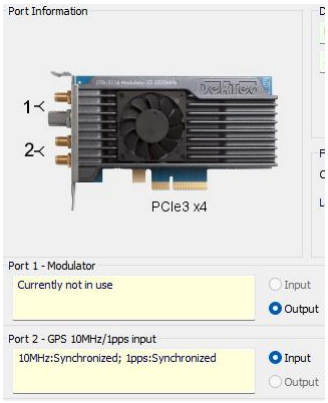
8.2. Synchronizing to an External Clock Source

The modulator outputs must be synchronized to a common timing source. To select the clock source for the DTA-2115B and DTA-2116 on Windows, you can use the DtInfo utility. In the main window, click Change for the target device, then go to Advanced and choose Internal or External as the RF clock source.



When selecting the clock source in DtInfo, the SetIoConfig function is used to persist the chosen setting. This ensures that the reference clock source is maintained even when the system is rebooted or power is lost.

The status of the 10MHz and1pps are shown in DtInfo. In the main window, click Change for the target device. Both 10MHz and 1pps input must indicate they are synchronized.



8.3. Generating the RF Signals

Just as in a SISO configuration the generation of the RF signal can be started by pressing the Generate output button in the toolbar or selecting Generate output in the menu bar. Both outputs start generating the MIMO signals at the same moment. An error message pops up if one of the boards is not properly synchronized to the external clock source.

The generation of the RF signal can be stopped by pressing the Cancel generation button in the toolbar or selecting Cancel generation in the menu bar.