User Manual

Modular

Complex Digital Modulation Synthesizer

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Revision 1.0

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Chapter 1
Getting Started

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What's in This Chapter

This chapter contains a general description of the Modular software package. It also provides information on how to install the software on your computer.

NOTE

This software package operates in conjunction with the Tabor line of arbitrary waveform generator. This manual describes the operation of the Modular software package and can be used with any of the following Tabor products: WW5061, WW5062, WW5064, WW1071, WW1072, WW1074, WW2571A, WW2572A, WW2074 and WW1281A.

Introduction

Modular is a software package devoted to synthesizing complex digitally modulated signals to be effectively generated through arbitrary waveform generators (AWG). Among other capabilities, Modular enables the user to:

1. Define baseband I and Q signals.
2. Define multiple RF/IF carriers in a single waveform. Each carrier can independently be defined with parameters such as carrier frequency, symbol rate, modulation type, baseband filtering, data source, etc.
3. Create user defined symbol maps with powerful edition tools.
4. Use a variety of modulation schemes such as BPSK, QPSK, OQPSK, π/4-DQPSK, QAM16, QAM32, QAM64, QAM128, QAM256, QAM1024, 8PSK, O-8PSK, 8-VSB, 16-VSB, GMSK, FSK, AM, FM, and PM.
5. Create DVB-C channel coded signals for component testing and head-end emulation.
6. Create basic Wireless LAN IEEE802.11b signals with DSSS (Barker codes).
7. Synthesize CDMA (IS95) and W-CDMA (IMT2000, UMTS) downlink signals including any number of pilot, user, and synchronization channels. Data, spreading factor, channel number and other parameters are adjustable individually for each channel. Compressed mode emulation is supported for UMTS downlink signals.
8. Use a variety of user-created information such as data, symbol sequences, modulating signals, baseband filters and symbol maps.
9. Linear impairments can be applied to any signal. The

supported impairments include quadrature error, quadrature imbalance, and carrier feed-through.

10. Non-linear impairments may be added to any carrier as well. Amplifier distortions such as AM/AM and AM/PM are easily emulated.
11. Effects of multi-path can be added to every carrier.
12. Analyze frequency, time, statistical, and modulation domain characteristics of the created signals.
13. Support any AWG instrument and communication interface such as GPIB, USB, and Ethernet (TCP/IP) transfers.
14. Export waveform data in delimited ASCII format for external use.

In addition, the software package eliminates all the wrap-around effects found in arbitrary waveform generators and it provides seamless signals that can be continuously played-back without any discontinuity or glitch in the time, frequency, modulation, and channel coding domains.

System Requirements

Minimum requirements for system configuration are described below. These are:

1. PC compatible computer running Windows NT, Windows 2000 and Windows XP and at least 256 Mbytes of RAM.
2. 100 Mbytes of free hard disk space. (More memory will be needed if signals are to be stored in local files).
3. Ethernet, USB and/or GPIB required if a direct connection to the target instrument is planned. The GPIB card must be fully compatible with National Instruments IEEE488.2 function calls.
4. NI-VISA 4.0 or later must be installed in the computer in order to communicate with the target AWG. NI-VISA is available for free on the Tabor web site.

Installation

Installing the Modular software package is very simple. Just insert the supplied CD into the CD drive, click on the setup.exe icon and follow the on-screen instructions. When done, Modular will automatically place an icon on your desktop. To run Modular, just click on the Modular icon and the program will be invoked.

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Chapter 2
Using the Modular Application

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Overview

This chapter contains information about how to use the Modular application. General information on the various commands and design dialog boxes is given first. Included is information how to program carrier options and impairments. The opening screen and its associated commands are described in the following.

To invoke the application click on the Modular icon. The main window, as shown in Figure 2-1 will appear.

The Main Window

Waveforms are defined by adding all the required carriers to the project. The main window provides access to all the editing and configuration functions. The main window is comprised of the following sections:

- Commands Bar
- Tools Bar
- Carrier Worksheet
- Basic Signal Parameters
- Remarks Field

Each of the above sections is described in the following

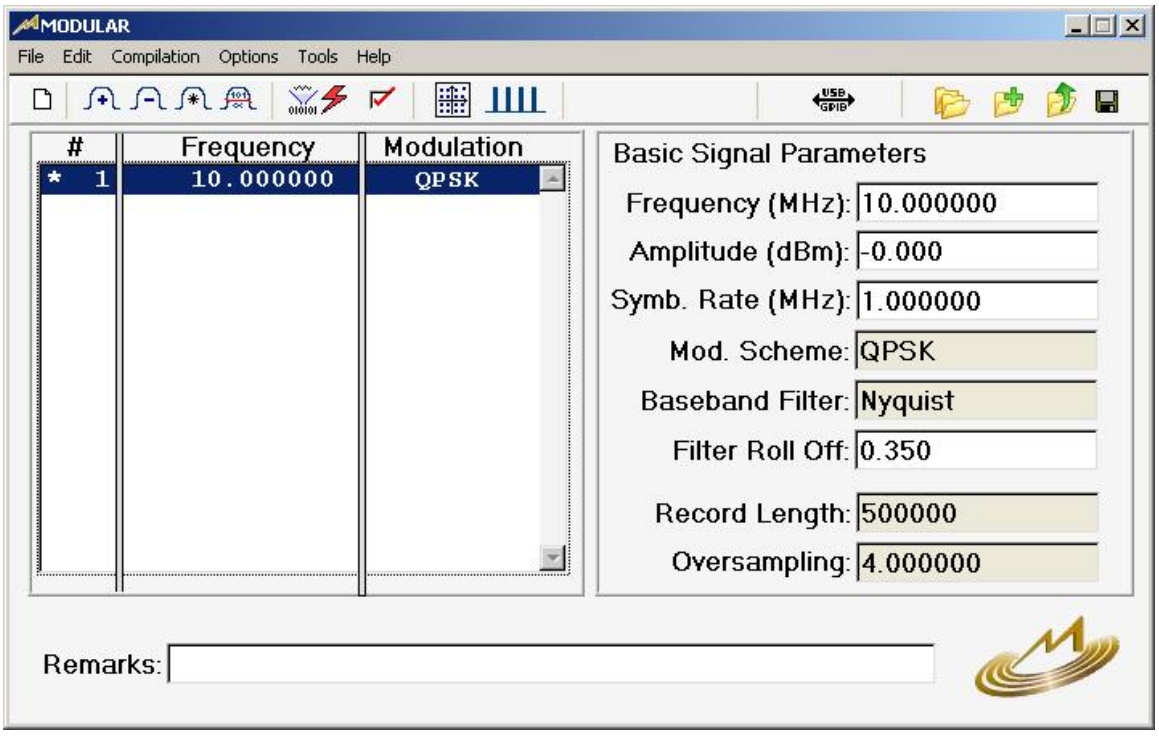


Figure 2-1, The Main Window

The Commands Bar

The Menu Bar is a standard Windows menu bar that contains commands that control the modular application. These commands are: File, Compilation, Options, Tools and Help. Clicking on these commands normally provides access to an array of commands that are associated with the title command. The commands in the Menu Bar are described below.

File Commands

The File commands provide access to all of the application file operations. Figure 2-2 shows the File commands; These are: New Table, Load Table File…, Append Table File…, Load Last Table File…, Save Table File, Save Table File as…, Load Setup File…, Save Setup File as… and Quit. The various file commands are described in the following.

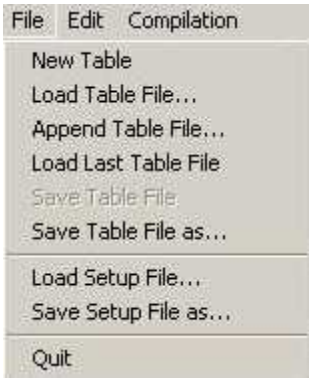


Figure 2-2, the File Commands

New Table - and wipes off the entire work sheet to start creating a new table.

Load Table File… - and displays a window to select a pre-recorded carrier table file. It also deletes any existing information.

Append Table File… - window to select any existing carrier table file. It appends the information contained in the selected file to any existing information in the work sheet.

Load Last Table File - opens the latest file opened or saved by the user.

Save Table File - saves the current table while preserving its name.

Save Table File as… - saves the current table using a different file name.

Load Setup File… - a window to select any existing setup file. It overrides the existing setup information. The software automatically saves the active setup when closing the application and loads it when the application is restarted.

Save Setup File as… - saves the current setup information using a different file name.

Quit - closes the application. The present configuration (setup) is saved automatically when closing the application.

Edit Commands

The Edit commands provide access to all of the application file operations. Figure 2-3 shows the Edit commands; These are: Add Carrier…, Delete Carrier, Set Carrier as Reference and Edit Carrier…. The various file commands are described in the following.

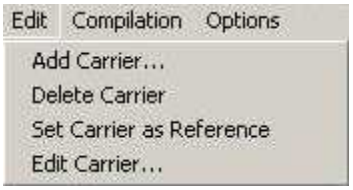


Figure 2-3, the Edit Commands

Add Carrier… – opens the Carrier Editing dialog box. From the Carrier Editing dialog box you can specify the carrier parameters. After you set the various parameters and click on the ok, the carrier frequency and modulation scheme will be added to the carrier list on the main window.

Delete Carrier – deletes the carrier frequency which is highlighted on the main window. Note that the delete action is destructive and thus make sure you really want to delete the carrier before you perform this action.

Set Carrier as Reference – marks the highlighted carrier on the main window as reference. Reference carriers are marked with an asterisk at the left of the carrier index number. Depending on the compilation settings, either the exact carrier frequency or the symbol rate will be preserved even after wrap-around-artifact-free handling, regardless of the record length setting.

Edit Carrier… – opens the Carrier Editing dialog box and allows modification of parameters that are associated with the highlighted carrier frequency in the main window.

Compilation Commands

The Compilation commands provide access to all of the compilation operations. The compilation process consists of a series of steps. The progress for each step is shown at an information window. These steps are:

- FSK preprocessing: FSK type signals (including GMSK) require a preceding process to avoid phase-related wrap-around artifacts. Compilations in this step only involve FSK-like carriers.
- Compilation: The complete output waveform is calculated and normalization values are obtained. After this step the Visualization Window is updated. Compilations are performed for all of the carriers in the list.
- Transfer steps: Depending on the value of the check boxes in the Compilation Options Window, . The number of transfer steps goes from zero to three. Each one involving one of the possible components: Combined Waveform (RF/IF), Baseband I, and Baseband Q. Files are effectively created in the local drive or in the target instrument during these steps.

Figure 2-4 shows the Compilation commands; These are: Compile and download and Compilation Options. The various compilation commands are described in the following.

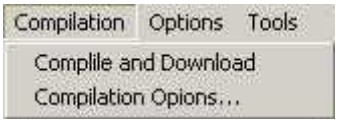


Figure 2-4, The Compilation Commands

Compile and Download - starts the waveform Compilation and downloads the waveform coordinates to the target instrument. It is only active when there is a set of parameter to be compiled.

Compilation Options - opens the Compilation Options window as shown in Figure 2-5. Using the fields in the Compilation Options, one may define a set of compilation parameters that meets with his application requirements. Listed below are the parameters that can be defined using this window.

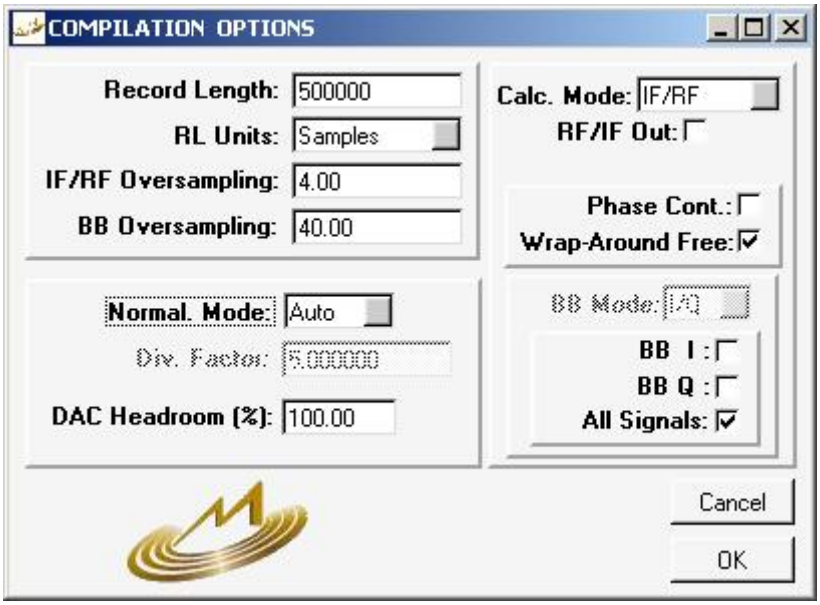


Figure 2-5, The Compilation Options Window

Record Length
This is the time domain length of the resulting waveform. It can be expressed in different units. The actual length will be adjusted depending on the target instrument requirements, such as maximum record length and others (see the Instrument Options section of this manual).

RL Units (Record Length Units)
Record length can be defined in samples, symbols, UMTS frames, or IS95 frames for a specific carrier of the signal called the Anchor Carrier (see the Carrier Table Edition section of this manual).

IF/RF Oversampling
The Modular package will calculate the output clock frequency by using this number. This value is roughly the number of samples per period for the maximum frequency carrier in the table.

BB Oversampling (Baseband Oversampling)
This parameter controls the AWG sample rate as an approximate multiple of the maximum symbol rate that was programmed in the carrier list. It eases the definition of baseband (IQ) signals where the carrier frequency becomes irrelevant.

Normal. Mode (Normalization Mode)
In the Auto mode, the compilation process looks for the maximum values of each of the resulting signals and uses them to normalize all the samples to completely fill the available dynamic range in the target instrument. In the manual mode the user-defined Div. Factor will be used instead. Manual mode is useful when the user plans to create sequences of consistent signals where peak values can be different.

Div. Factor (Division Factor):
Used in conjunction with the Normal Mode. The Manual mode is useful when the user plans to create sequences of consistent signals where peak values can be different.

DAC Headroom
This parameter controls the percentage of the DAC dynamic range being used to generate the final signal. Limiting the range may, in some cases, improve linearity or can help to simulate the behavior of converters with less significant bits.

Compilation Mode
This parameter controls the way the sampling rate is set by the software. If IF/RF is selected the final sampling rate will be approximately the maximum carrier frequency in the carrier list multiplied by the IF/RF Oversampling factor. When Baseband is selected, the final sampling rate will be approximately the maximum symbol rate in the carrier list multiplied by the BB Oversampling.

RF/IF Out
This check box selects the RF/IF waveform to be effectively created in the target instrument or file.

Phase Cont. (Phase Continuity)
This control is active only when the Wrap-Around Free button is not checked. Phase continuity is one of the wrap-around spurious free conditions. In some application (i.e. pulsed RF or single shot signals) wrap around handling may be irrelevant as there is no continuity between the end and the beginning of the waveform. However, some applications may require keeping the phase continuity as it must remain coherent between the different pulses. Phase Continuity button forces the software to keep an integer number of cycles in the available record length and thus making sure that the phase remains coherent when the signal is repeated.

Wrap-Around Free
The Wrap-Around Free button activates the wrap-around handling procedure in the software. It assures continuity of the signal at all levels (carrier, symbol, modulation, and baseband filtering) when cycling from the end to the initial sample on repeated records and thus assures that no spurious at any level are produced. Meeting the wrap-around free criteria requires a series of minor adjustments in the frequency and symbol rate of the waveforms which are normally not necessary when the signal is pulsed and the initial and final segments of the waveform are at zero level.

Baseband I Out
This check box selects the “I” (In-phase) baseband waveform to be effectively created in the target instrument or file. If there is more than one carrier in the carrier table, the Anchor carrier I baseband signal will be created.

Baseband Q Out
This check box selects the Q (Quadrature) baseband waveform to be effectively created in the target instrument or file. If there is more than one carrier in the carrier table, the Anchor carrier Q baseband signal will be created.

All Signals
This check box enables the creation of a combined baseband signal made of the combination of all baseband signals in the carrier list. This is especially useful for CDMA/W-CDMA signals, where multiple channels share the same carrier. All the information shown in the Visualization Display will reflect this combined waveform.

All parameters contained in the Compilation Window belong to the Modular setup information, so they will be affected by the Load Setup and Save Setup actions.

When no check boxes are ticked off the compilation will take place without creating any waveform file in the target. It is useful only for visualization or analysis purposes.

Options Commands

The Options commands provide access to programming general environment parameters and target instrument settings.

Figure 2-6 shows the options commands; These are: Data Path and Instrument Options. The various options commands are described in the following.

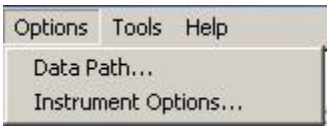


Figure 2-6, The Options Commands

Data Path – opens the Environment window and provides access to programming the general environment settings. The Environment window is shown in Figure 2-7 and its settings options are described hereinafter.

Instrument Options - opens the Instrument Options window and provides access to setting up the target instrument and the communication options. The Instrument Options window is shown in Figure 2-8 and its setting options are described hereinafter.

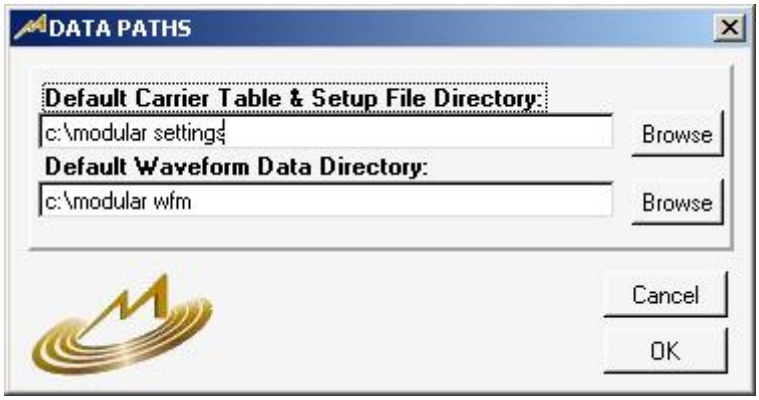


Figure 2-7, The General Options Window

The Data Path Window parameters are: Default Carrier Table & Setup File Directory and Default Waveform Data Directory, The Data Path Window parameters are described below.

NOTE

The programmed settings that are embedded in the Data Path menu pertain to the Modular setup information and hence will be affected by the Load Setup and Save Setup actions.

Default Carrier Table & Setup File Directory
Modular will launch the program setting for the Data and Setup files using the directory as set in this field

Default Waveform Data Directory
Modular will retrieve waveform files using the directory as set in this field

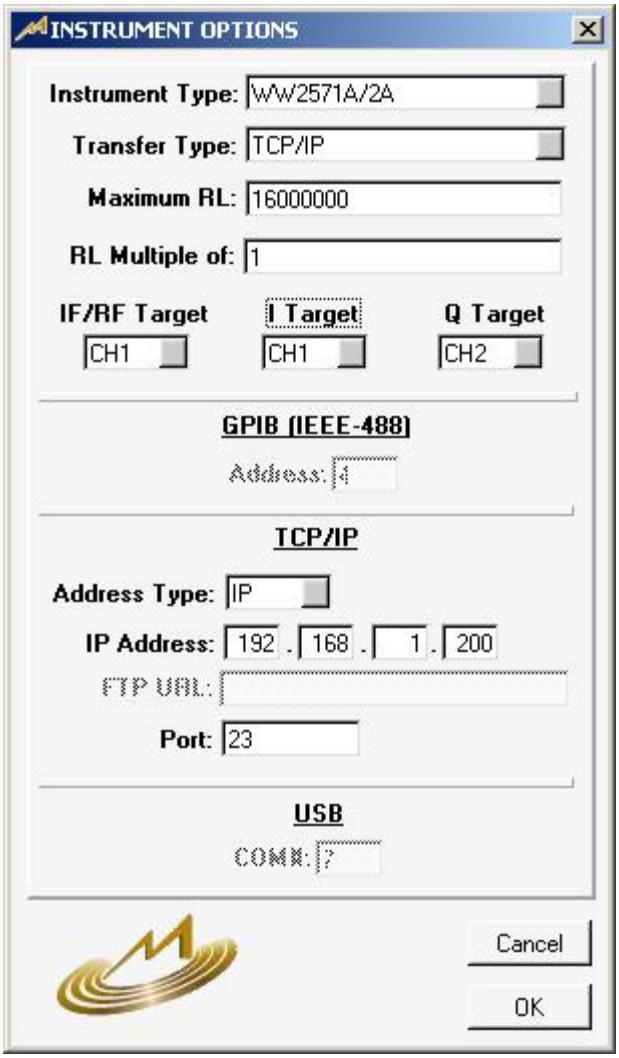


Figure 2-8, The Instrument Options Window

The Instrument Options Window parameters are: Instrument Type, Transfer Type, Maximum RL, RL Multiple of, GPIB Setting and TCP/IP Setting The instrument Options Window parameters are described below.

NOTE

The programmed settings that are embedded in the Instrument Options menu pertain to the Modular setup information and hence will be affected by the Load Setup and Save Setup actions.

Instrument Type
Use this field to select the target for the calculated waveforms. You can choose from a variety of arbitrary waveform generators and generic files. Generic files can be used to export results to other tools, such as spreadsheets or mathematical analysis packages

Transfer Type
Use this field to select an appropriate interface to communicate with the target device. The following options prevail:

> ***GPIB*** – IEEE488.2 compatible standard interface. Using this option, the computed waveform will be downloaded to the instrument through the GPIB interface. If you select this option, make sure that the GPIB address agrees with that programmed on your target device.
>
> ***Network*** - Using this option, the computed waveform will be downloaded to the instrument through the LAN interface. If you select this option, make sure that the LAN address agrees with that programmed on your target device.

Maximum RL (Maximum Record Length)
This is the maximum record length available in the target instrument. This parameter is not being set automatically. Also, t defined when the user chooses a given instrument, so it can be changed to any desired value.

RL Multiple of (Record Length Multiple of)
Defines the multiplicity (interlace multiple) required by the target instrument. This parameter is not being set automatically. Also, t defined when the user chooses a given instrument, so it can be changed to any desired value.

IF/RF Target
Selects the target channel on the instrument where the waveform coordinates will be downloaded. If you have only one channel then the waveform coordinates will be downloaded to this channel as a default. Other instruments, for example, the model 2074 have four channels with the default channel being channel 1 so if you want to download to another channel, use this pull down menu to select the active channel for the download process.

I Target
Selects the target channel on the instrument where the “I” (In-phase) waveform coordinates will be downloaded. You need to have an instrument that has at least two channels if you want to download I and Q waveforms.

Q Target
Selects the target channel on the instrument where the “Q” (Quadrature) waveform coordinates will be downloaded. You need to have an instrument that has at least two channels if you want to download I and Q waveforms.

GPIB
Use this field to program the primary address on the target instrument. This field is required only if you are using the GPIB interface option.

TCP/IP
Use these fields to program the LAN settings for the target instrument. These fields are required only if you are using the NETWORK interface option in the Transfer Type pull down menu. If you tick the Anonymous field, you allow access to anyone that has an access to your computer. The User name and Password assures that no one but yourself will have an access to your files.

USB
If you do not know which comm. port is available, the software will assign a default port number for you. Use this field to change the port setting if you are not satisfied with the automatic default ASLR number selection.

Tools Command

The Tools command provides an access to the Edit Map Symbol dialog box.

Figure 2-9 shows the Tools command and the following paragraph describes the Edit Map Symbol command.

Figure 2-9, The Tools Command

Edit Map Symbol…
Use this command to open the Symbol Map Editing tool. For detailed information, read the Symbol Map Editing Tool section of this manual.

Multi-Carrier Assistance…
This will open the Multi-Carrier Assistance dialog box which allows simultaneous design of multiple carriers from one source.

The Tools Bar

The Tools Bar contains icons which provide extremely convenient shortcuts to access commands and actions without the need to go through multiple mouse search and clicks in the Commands Bar. The tools bar is shown in Figure 2-10 and the various tool bar icons are described in the following. Notice that if you place your mouse cursor over one of these icons, a tool tip is automatically turned on with the information on the action that this icon will do.

In general, the tools bar icons are divided to logical groups of which the right icons are used for standard Windows operations such as save, open and file path and on the left there are icons that are used for specific operations such as table editing, compilation etc.

The tool bar icons are described below.

Figure 2-10, The Tools Bar

This icon clears the current working table and prepares a blank carrier table. If you have not saved your table work, all information will be lost.

Press this icon to add a new carrier to the carrier table. After you click on this icon, the Carrier Editing window, as shown in Figure 2-12, will open and allow the creation of a new carrier.

Use this icon to remove a carrier from the table. The removal of carrier definition is permanent.

Click on this icon to anchor a carrier. Anchored carrier is marked by an asterisk at the left of the carrier index number. Anchored carrier shall retain its parameters as reference and without modification when the wrap-around spurious-free option is selected.

Use this icon to access the advanced setting. You do not need to access advanced settings if you are content with the parameters that are set in the Basic Signal Parameters section of the main window. This icon will open the Carrier Editing window for the carrier that was highlighted on the main window.

Click on this icon to calculate and download the data to the waveform generator. Notice the lightning arrow in this icon, it warns against accidental operation because downloading new data to the generator will overwrite waveforms that were previously downloaded to the AWG.

Use this icon to access the Compilation Options dialog box. The Compilation options dialog box is shown in Figure 2-4.

Clicking on this icon will open the Symbol Map Editing. Information on the symbol map editing is given later in this manual.

Use this icon to access the Multi-Carrier Assistant dialog box. The multi-Carrier assistant dialog box allows definition of multiple carriers from one dialog box.

Use this icon to access the Communication Options dialog box. From this dialog box you can select an interface to communicate with the AWG and program the parameters that are associated with the selected interface option.

Use this icon to specify the path to your data and setup files. Pay special attention to this path setting in case you intend to use the calculated data in other applications.

You can add carriers from table files that were already stored on your computer. Use this icon to append the current list from a stored file. You can add carriers which were stored in file with *.mcp extension only. These can be found if you follow the path as specified in the data path box.

This icon loads a carrier list from files that were previously stored on your computer. Open files that have *.mcp extension only. These can be found if you follow the path as specified in the data path box.

Similar to any other Windows program, click on this icon to save carrier list files in a know folder. If you want to change the path, use the data path icon to create another path for your data files.

The Carrier Worksheet

The Carrier Worksheet is shown in Figure 2-11. The carrier list worksheet shows the current contents of the carrier table, visualize the progress of the project, edit existing carrier parameters, and define the Anchor Carrier.

Double clicking on existing line will open the Carrier Settings dialog box with the current parameters for this line, allowing visualizing all the details about a given carrier and editing them if necessary.

The scroll bar becomes active when the amount of carriers overflows the available visible area in the carrier worksheet.

There are a number of ways to add carriers to the carrier worksheet:

1) Load a list from a file that was already stored from previous sessions.
2) Append a list from a file that was already stored from previous sessions, or

3) Clicking on the Add Carrier icon in the Tools Bar. This will in turn open the Carrier Editing dialog box and allow you to set the carrier parameters as required by your application.

The carrier worksheet is comprised of three fields as described below.

 # (Index Number)
This is an index field that lists the carriers in ascending order. An Asterisk on the left of the index number designates a reference carrier.

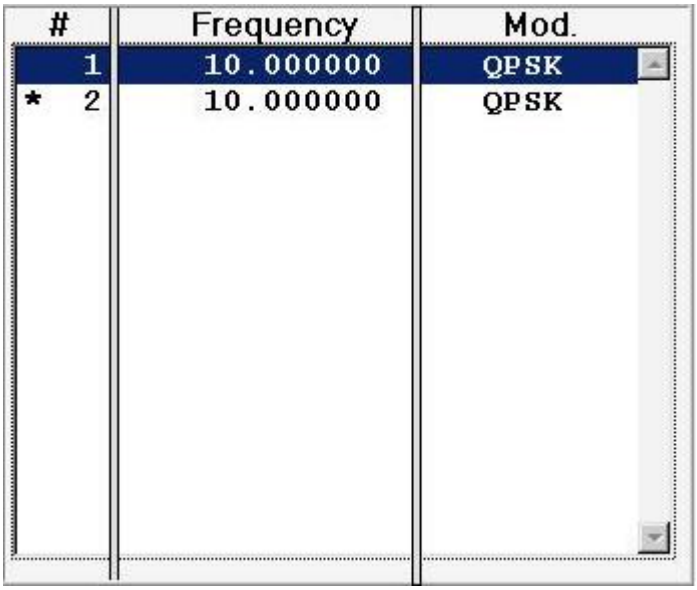


Figure 2-11, The Carrier Worksheet

Frequency
This field indicates the carrier frequency that is associated with the index number.

Mod. (Modulation)
This field indicates the modulation scheme that was selected for the carrier. The various modulation schemes are listed in the Carrier Editing dialog box.

The Basic Signal Parameters Work Area

The Basic Signal Parameters work area is shown in Figure 2-12. This area contains an abbreviated list of carrier parameters, which are the most prominent for setting up the carrier. As you can see from the picture, there are some fields that are grayed; These fields are blocked for direct access from the work area. On the other hand, some of the parameters are available for modification from the work area. These are: Frequency, Amplitude, Symbol Rate and

Filter Roll Off. When you modify one of these fields from the work area, it automatically updates the fields in the Carrier Editing dialog box and visa versa.

Note that when the program is first turned on, the fields in the basic signal parameters appear blank. As soon as a carrier is added to the carrier list, the blank fields are updated with parameter values as were programmed in the Carrier Editing dialog box. Notice that some of the parameters are grayed out in the basic signal parameters fields, indicating that modification of these parameters is possible from the carrier editing window only. For ease of accessibility and operability the Frequency, Amplitude, Symbol Rate and Filter Roll off parameters can be modified without the need to access the carrier editing window.

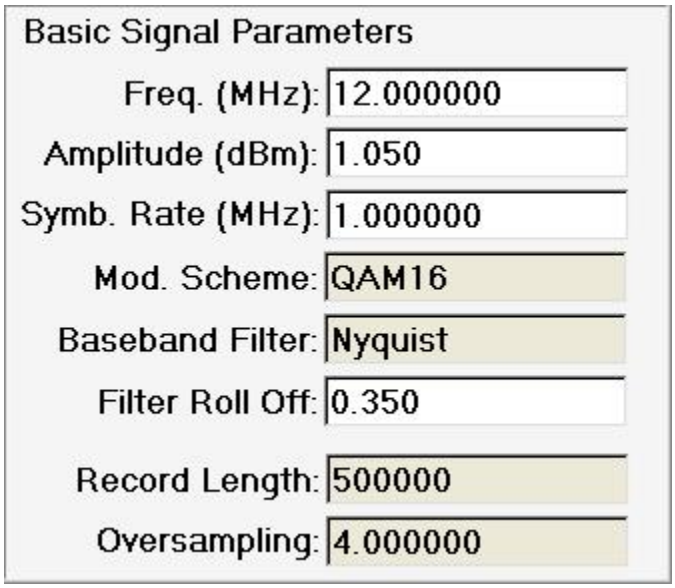


Figure 2-12, The Basic Signal Parameters Dialog Box

Creating a Carrier Table

To create a carrier table, just add lines to the carrier list work area. To do so, use the Add Carrier icon or alternatively the Multi Carrier Assistant icon. The Add Carrier command will create a single line while the Multi-Carrier Assistant will create a collection of similar carriers in one action. The icon commands are also available as Edit commands. Click on Edit and select the required action. From the Edit command you can select: Add Carrier, Delete Carrier, Set Carrier as Reference and Edit Carrier Settings. The Multi-Carrier Assistant can be accessed from the Tools command.

Adding a Carrier

The Carrier Settings dialog box will open after hitting the Add Carrier icon (a new line will be created) or after double clicking one of the existing lines in the Carrier List work area.

The Carrier Settings dialog box shows all the information related to a specific carrier. All of the carrier parameters are logically grouped in different areas of the dialog box however, access to certain groups and fields is provided only when an appropriate selection is made in certain fields. Accessing such fields shall be discussed in the following paragraphs.

Figure 2-13 shows the Carrier Settings dialog box and its various groups are described in the following paragraphs.

The Carrier Group

The Carrier Group has four fundamental parameters: Amplitude, Carrier Frequency, Phase and Frequency Offset. These parameters are defined below.

Amplitude
This parameter programs the amplitude for the carrier. Amplitude is a dimensionless linear number used to adjust the relative amplitude of the carriers. Actual amplitude for each carrier depends on the Div. Factor, the output amplitude in the target instrument and its frequency response. The amplitude usually refers to the level of the projection of the highest symbol in one of the axis. The amplitude is specified in units of dBm.

Carrier Freq. (Carrier Frequency)
This parameter programs the carrier's frequency in units of MHz. It can be defined with one hertz resolution. The compilation process will define the actual frequency in order to avoid any wrap-around artifact. See the Anchor Carrier discussion in this section for details.

Phase
This parameter sets the initial phase of the carrier expression in units of degrees.

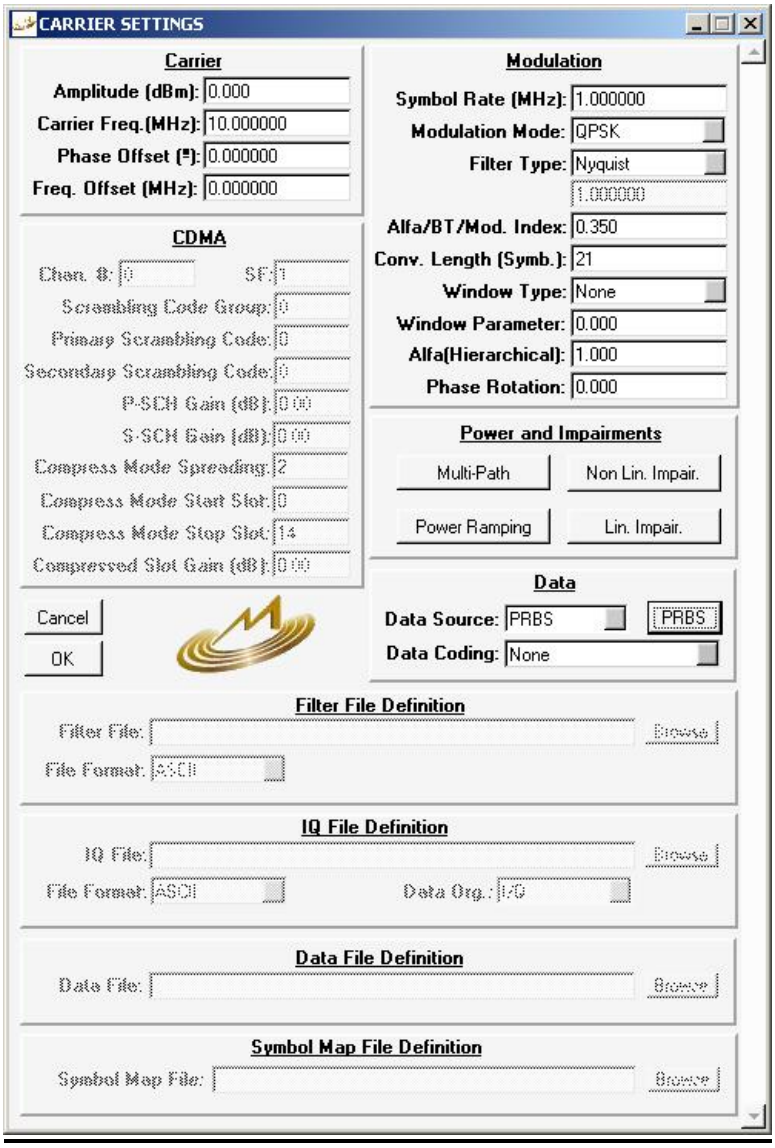


Figure 2-13, the Carrier Settings Dialog Box

Freq. Offset (Frequency Offset)

This parameter programs the frequency offset of the carrier in units of MHz. Frequency offset controls the location of the signal relative to the carrier frequency. As an example if a 10 MHz carrier is modulated by a QPSK baseband signal with a +5 MHz offset then the effective carrier frequency will be 15 MHz (and 5MHz if the offset is set to -5MHz). It looks like a redundant control as you could get the same result by just typing directly this number at the carrier frequency field while keeping the offset at zero. In fact this is the best way to proceed for IF/RF signals but you need this control if you want to create baseband signals that when applied to an external IQ modulator result in a multi-carrier signal. Even simple situations like generating an interfering tone located at just one

frequency other than the center frequency for a baseband signal requires this control. Physically, frequency offset is implemented by rotating the “I”, “Q” vector clockwise (for negative offsets) or counterclockwise (for positive offsets) at a pace equal to the offset frequency.

The Modulation Group

The Data Group has ten programmable parameters: Symbol Rate, Modulation Mode, Filter Type, FSK Peak Deviation/ASK Modulation Index, Alfa/BT/Modulation Index, Convolution Length, Window Type, Window Parameter, Alfa and Phase Rotation. These parameters are described below.

Symbol Rate
The Symbol Rate for the selected carrier is expressed in MBauds (MSymbols/S). For analog modulations (AM, FM, and PM) it contains the frequency of the modulating signal. For external envelope files (FILE1) it expresses the sampling frequency for the input data. It can be defined with one hertz resolution. The compilation will define the actual frequency process to avoid any wrap-around artifact. See the Anchor Carrier discussion later in this section for details.

Modulation Mode
This provides an access to a list of internally-defined modulation schemes or to a list of externally-defined files.

External files can be defined for three different scenarios: samples (FILE1), symbols (FILE2), and symbol maps (FILE3). Samples consist in the time-domain, baseband envelope for the carrier. The Modular package interpolates the required time samples based on the input sampling rate (defined in the symbol rate field) and using an ideal interpolator (sync, sin x / x). Symbols are provided in a file containing a symbol amplitude list.

The actual time domain baseband signal will be created by the Modular package based on the Symbol Rate and the Baseband Filter selected for this carrier. Symbol Map uses a user-defined file, which contains any symbol map required for the application. Using this information along with the Data, Filter Type, and Symbol Rate Parameters will generate the actual waveform data. Selecting any file-based mode activates the corresponding file selection area in the Symbol Editing Window.

Filter Type
This provides an access to a list of internally-defined baseband filters or to a list of externally-defined filters.

This field inactive when analog or FILE1 (samples) modulation modes are selected. It is automatically programmed to Gaussian when GMSK is selected. Filter types available are NONE (no filtering), RAISED COSINE, SQUARE ROOT OF RAISED COSINE, GAUSSIAN 1 (Input for the filter is a square pulse), GAUSSIAN 2

(Input for the filter is a Dirac's Delta), TRIANGULAR, HALF-SINE, EDGE, RTIME and FILE. Selecting FILE activates the corresponding file selection area in the Symbol Editing Window.

FSK Peak Deviation (ASK Modulation Index)
This field serves dual purpose. It programs the peak deviation in units of kHz for FSK modulation schemes. The title is changing to ASK Modulation Index and programs the modulation index for the ASK modulation scheme in units of %. When neither the ASK nor FSK functions are selected, this field is grayed out and no title is shown in this group.

Alfa/BT/Mod. Index (Alfa/Bandwidth/Modulation Index)
This field serves three parameters, depending on the modulation mode, filter type and values. For Raised Cosine and Square Root of Raised Cosine filters, it contains the alpha parameter of the filter. For Gaussian filters it contains the BT (Bandwidth*Symbol Period) products for the filter. For analog modulations, it contains the modulation index (% for AM, Peak Deviation for FM in kHz, and Peak Deviation for PM in degrees). For RTIME filter, it specifies the rise and fall times in fractions of a symbol or UI.

Convolution Length (Symbols)
This field programs the convolution length expressed in symbol periods. This parameter is used to control the quality of the Compilation performed to obtain the baseband signals. The bigger the number of consecutive symbols used for convolution the better the quality of the signal. This parameter also has an effect on the compilation time, so usually the user must make a trade off between compilation speed and quality. This parameter must be an odd integer. If an even number is typed, the software will automatically assign the closest larger odd integer for this parameter.

Window Type
This provides an access to a list of pre-defined time domain window to apply to the filter impulse response. It is specifically useful for limiting the spectral leakage, especially when short convolution length is being used. It also improves the spectral behavior of the signal however, deteriorating the EVM (Error Vector Magnitude) parameter.

Window Parameter
This field allows for the definition of the alpha parameter for the Kaiser window and the lobe ratio (dB) for the Chebyshev window.

Alfa (Hierarchical)
This parameter allows the definition of non-uniform QAM constellations used in hierarchical modulation schemes. Alfa=1 results in a uniform constellation.

Phase Rotation
This parameter defines the rotation of the constellation from one symbol to the next.

The Power and Impairments Group

The Power and Impairments group has four buttons: Multi-Path, Power Ramping, Non Linear Impairments and Linear Impairments. Introduction to impairments, multi-path and power ramping is given later in this chapter.

The Data Group

The Data Group has two programmable parameters: Data Source and Data Coding. These parameters are defined below. This group also provides access to the PRBS editor.

Data Source
This selection list let the user select between internally generated pseudo random binary sequences (PRBS), “all 1s”, “all 0s”, user-defined patterns and externally defined data files. Data source is no active when external files (FILE1 and FILE2) are selected as the Modulation Mode. See the Data File Definition section for further details on the supported formats.

Data Coding
This selection list let the user select between internally generated pseudo random binary sequences (PRBS), “all 1s”, “all 0s”, user-defined patterns and externally defined data files. Data source is no active when external files (FILE1 and FILE2) are selected as the Modulation Mode. See the Data File Definition section for further details on the supported formats.

PRBS
This button invokes the PRBS Editor window. This button is active only when the selected Data Source option is PRBS. Introduction to PRBS and the PRBS Editing window is described later in this manual.

The CDMA Group

The CDMA area groups all the parameters needed for the definition of the downlink CDMA (IS95) and the W-CDMA (IMT2000, UMTS) signals. These parameters are activated or deactivated depending on the modulation scheme selected by the user. There are three different modulation schemes influencing this area: IS95 DL, DPCH DL (UMTS), DPCH DL (Compressed mode, UMTS), HSDPA (UMTS), and C-CCPCH/SCH DL (UMTS).

The CDMA Group has eleven programmable parameters: Channel #, SF, Scrambling Code Group, Primary Scrambling Group, Secondary Scrambling Group, P-SCH Gain, S-SCH Gain, Compress Mode Spreading, Compress Mode Start Slot, Compress Mode Stop Slot and Compressed Slot Gain. These parameters are defined below.

Chan. # (Channel Number)
This field codes the desired channel number for the target carrier by assigning the corresponding Walsh Code (IS95) or OVSF (UMTS) channelization code. Ranges are 0-63 for IS95 DL and 0-511 (depending on the spreading factor) for DPCH DL (UMTS).

SF (Spreading Factor)
This field specifies the spreading factor. It is active only for DPCH DL (UMTS). It ranges from 2 to 512.

Scrambling Code Group
This field contains the scrambling code group number for the target carrier. It is used only with UMTS modulation schemes. It ranges from 0 to 63.

Primary Scrambling Code
This field defines the specific primary scrambling code within the previously defined scrambling code group. It is used only in conjunction with UMTS modulation schemes. It ranges from 0 to 7. To Compilation the absolute primary scrambling code just use the following formula:

$$SC_{abs}=8xSCG+PSC.$$

Secondary Scrambling Code
This field defines the specific secondary scrambling code which is associated with the previously-defined primary scrambling code. It is used only with UMTS modulation schemes. It ranges from 0 to 15. To calculate the absolute scrambling code just use the following formula:

$$SC_{abs}=(8xSCG+PSC)x16+SSC.$$

P-SCH Gain (Primary Synchronization Gain)

This field is active only when the C-CCPCH/SCH DL (UMTS) is selected as the modulation scheme. This parameter controls the amplitude of the Primary Synchronization Code relative to the C-CCPCH portion of the time slot. It is expressed in dB.

S-SCH Gain (Secondary Synchronization Gain)
This field is active only when the C-CCPCH/SCH DL (UMTS) is selected as the modulation scheme. This parameter controls the amplitude of the Secondary Synchronization Code relative to the C-CCPCH portion of the time slot. It is expressed in dB.

Compressed Mode Spreading
This field sets the relative spreading factor of the boundary slots. The higher the number the lower the spreading factor relative to the channel's origin.

Compressed Mode Start Slot
This field sets the time slot where the transmission gap starts.

Compressed Mode Stop Slot
This field sets the time slot where the transmission gap ends.

Compressed Mode Slot Gain
This field sets the relative amplitude of the boundary slots relative to the channel's origin. It is expressed in units of dB.

NOTE

Refer to Appendix 3 for detailed discussion on WCDMA and compressed mode configuration.

The File Definition Group

There are four sub-groups in the file definition group of which provide a path to setup files that were pre-recorded for a specific application. These are: Filter File Definition, IQ File Definition, Data File Definition and Symbol Map File Definition. Normally, the fields in these sub-groups are disabled and require certain conditions to be become active. These file definitions are discussed below.

Filter File Definition
This area becomes active when FILE is selected in the Filter Type field. The user can select between ASCII and binary formats in the file format selection list. The Browse button opens a standard file selection window to follow a path to an existing file. Filters must be defined with 50 samples per symbol period as the software will take care of re-sampling and interpolating the signal to the resolution required by a specific settings.

IQ File Definition
This area becomes active when FILE1 or FILE2 are selected in the Modulation Mode field. The user can select between ASCII and binary formats in the file format selection list. It is also possible to define the way data is organized inside the file by selecting the appropriate format in the Data Organization selection list. If different files have been defined for the "I" and "Q" components, the user must define two carriers in the list with the same basic parameters and must select the corresponding component in the Data Organization field. The Browse button opens a standard file selection window to follow a path to an existing file.

Data File Definition
This area becomes active when USER FILE is selected in the Data Source field. The Browse button opens a standard file selection window to follow a path to an existing file. Any ASCII file may be used as the data source and it can use any format, delimited or not. The next bit will be generated by reading the file until a '0', a '1', an 'x', or an 'X' character is found. '0' and '1' will add the corresponding bit to the sequence while the 'x' and 'X' characters will add a new PRBS sequence bit as defined in the PRBS Sequence Editing window. Any other intermediate character will be ignored. Once the end of the file has been reached, the file is read again from the beginning.

Symbol Map File Definition
This area becomes active when FILE3 is selected in the Modulation Mode field. The Browse button gives access to the Symbol Map Editing Tool (see section 4 of this manual for details) where a new map can be created or an existing one can be loaded.

Deleting a Carrier

Deleting a carrier from a carrier list work area is simply a matter of marking a carrier line and clicking on the delete Carrier icon however, bear in mind that this action is irreversible and therefore, before you decide to click on an icon, make sure you really do not need the data that you programmed for the selected carrier.

Setting a Carrier as Reference

Arbitrary waveform generators requires the the same basic signal is recycled, again and again, to obtain a continuous output. In order to avoid discontinuities at the transition between the end of the waveform and the beginning of the next segment, special care must be taken to avoid “wrap-around” artifacts. For modulated carriers certain conditions must be met by the signal; These are:

1. The waveform must contain an integer number of carrier cycles.
2. The carrier must contain an integer number of symbols.

In general, it is impossible to meet these criteria for any given set of carriers if the record length in the target instrument is a finite and integer number which implies that some rounding must be performed in order to adhere to the above two conditions. In this case, the user can select one of the carriers to act as a reference. The output clock will be calculated in order to preserve some of the frequency characteristics of the carrier. If record length is expressed in samples then the carrier frequency will be preserved. If record length is expressed in symbols then the symbol rate will be the preserved parameter. The actual clock output will be also influenced by the maximum carrier frequency in the list and by the oversampling factor.

The actual values for carrier frequencies and symbol rates will be shown in the carrier list window after compilation. The previous values will be overwritten, so the carrier table must be stored before compiling if these values must be reused in the future.

Editing a Carrier

The basic signal parameters are shown on the main window but many other parameters are not available there. In case you want to view or change the carrier parameters, highlight the carrier in the carrier list worksheet and either double-click on it or select the Edit Carrier icon from the toolbar. The Carrier Settings dialog box will open allowing access to all of the carrier parameters.

The Multi-Carrier Assistance

At times, user applications require a collection of similar carriers. For example, in CATV head-end or return-path emulation, where equally spaced, similar carriers (same modulation scheme, baseband filtering and symbol rate) are transmitted together to the network. The standard way to create this set up is by adding such carriers to the carrier list worksheet one at a time.

The Multi-Carrier Assistance is a great tool to simultaneously create multiple carriers, simpler and faster, from one dialog box.

The multi-carrier dialog box, as shown in Figure 2- 14, looks very similar to the regular Carrier Settings dialog box with some added extensions to define a complete set of carriers simultaneously, instead of only just one. Notice that some features that exist on the Carrier Setting dialog box were removed from the Multi-Assistance dialog box because they are not relevant for multiple carrier signals. The parameters that are available in this dialog box are described below.

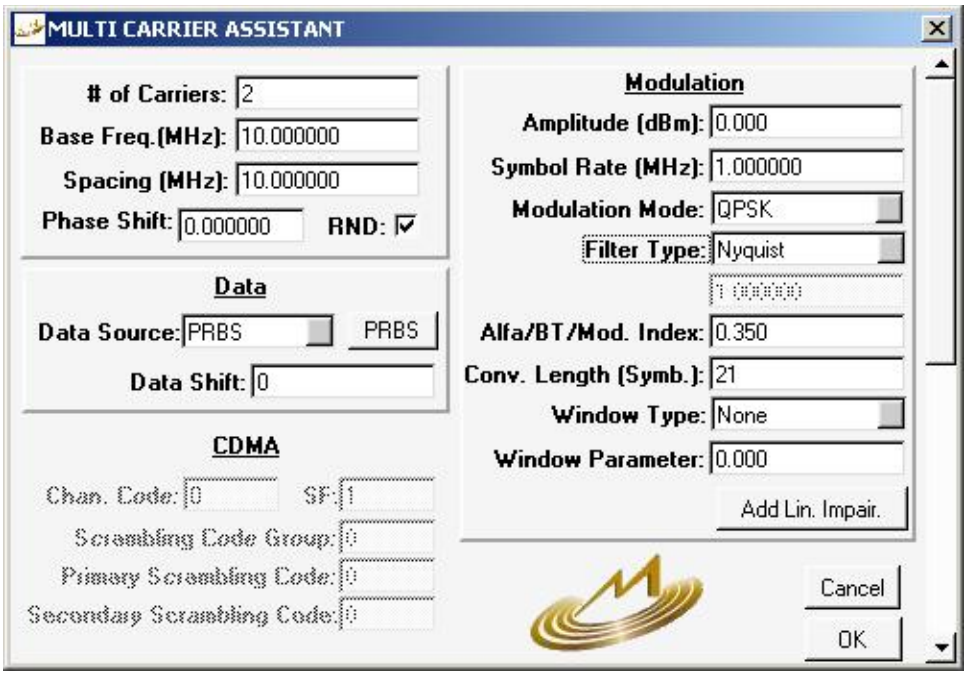


Figure 2-14, The Multi-Carrier Assistance Dialog Box

# of Carriers (Number of Carriers)
It defines the total amount of carriers to be created.

Base Freq. (Base Frequency)
This is the carrier frequency for the first carrier in the list. The frequency is defined in units of MHz.

Spacing)
Frequency distance between consecutive carriers. The frequency spacing is defined in units of MHz.

Phase Shift
Incremental phase shift applied to each carrier. The phase shift is defined in units of degrees.

RND (Random Phase)
This check box activates the assignment of a random phase to each carrier. This assignment helps to reach lower peak to average power ratios, thus improving the linearity and the dynamic range of the resulting signal.

Another extension can be found in the Data Area of the assistant:

Data Shift
Incremental shift applied to the PRBS generator for each carrier. This feature allows the creation of uncorrelated carriers even if they share the same PRBS polynomial. Uncorrelated data sequences provide a better PAPR (Peak to average power ratio) and a more realistic behavior of the resulting signal.

Once you hit the **OK** button, the software will automatically create all the required lines in the Carrier List worksheet area. After that, each carrier in the list becomes a regular carrier and it can be edited independently or deleted by using the standard methods described in this manual.

Introduction to PRBS

Digitally modulated, real world signals usually appear as random sequences. This is done on purpose and by doing so, a better performance transmission system can be obtained, even though the underlying data is not at all statistically random. Pseudo random binary sequences provide a good simulation of real-world signals and make bit error rate testing easier. Using the PRBS Editor, Modular allows the user the freedom of defining the desired PRBS for each carrier, including the PRBS polynomial and the initial value of the shift register (“seed”).

Some arbitrary waveform generators allow the creation of virtually infinite length signals by using a feature called sequencing. Sequencing consists of creating waveform segments that will be replayed in a pre-defined sequence in the target instrument.

Defining different contents for each segment and designing an appropriate sequence may result in a very long repetition time, far beyond the memory capability of the generator. The resulting signals will behave more realistically and will have a denser (noise-like) spectrum. Sequencing digitally modulated data requires special care to preserve time domain consistency and spectral quality.

In order to have consistent segments which can be seamlessly sequenced it is necessary to insure their convolution continuity. To do so, segments have to use the same initial symbols, what implies the use of the same initial bits. This can be accomplished by using the same PRBS at the beginning of each segment while using different ones for the rest of the segment.

The Initial PRBS field in the PRBS Editor window was specifically designed for this purpose and will be activated when the check box Equal is disabled. It is advisable that the initial polynomial be of lower or equal order to avoid any chance of having an “all zeros” seed value for the rest of the sequence. Also, bear in mind that in order to keep the consistency of the amplitude, all segments must use the same Division Factor. Compiling all the segments, obtaining the worst-case division factor, and then recompiling all the segments using this worst-case factor in “Force” mode can do this.

The PRBS Editor is invoked after you click on the PRBS button in the Data Group. The PRBS Editor window is shown in Figure 2-15 and its various fields are described below.

Using the PRBS Editor

The PRBS (Pseudo Random Binary Sequences) Editor is invoked after you click on the PRBS button in the Data Group. The PRBS Editor window is shown in Figure 2-15 and its various fields are described below.

Polynomial Definition

The correct notation to write the desired polynomial consists of typing the terms in the format XY, where X (character ‘X’ or ‘x’) represents the variable and Y the power applied to this value, separated with the ‘+’ character. The final term +1 is optional and, if not added, the software will automatically add it at the endof the string. The order of which the terms are entered is not important. If repeated terms are typed, only one will take effect. Below you may find some examples of polynomial definitions:

X31+X30+1=0	**$X^{31}+X^{30}+1=0$**
X15+X14=0	**$X^{15}+X^{14}+1=0$**
X14+x15+1=0	**$X^{15}+X^{14}+1=0$**
X15+X14+X15+1=0	**$X^{15}+X^{14}+1=0$**

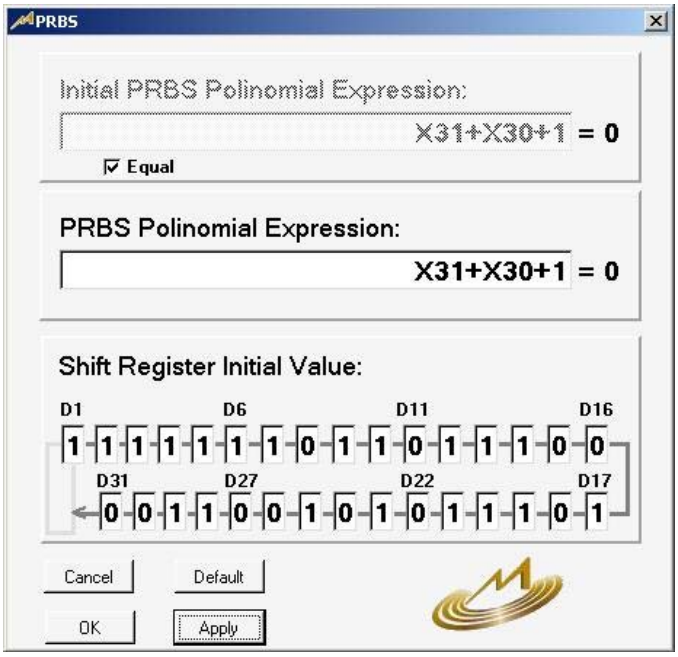


Figure 2-15, the PRBS Editor

Seed Definition
Bit values for the initial contents of the PRBS generator can be defined individually by typing the desired values. Depending on polynomial order, the unused bits will be hidden to avoid confusion. Keep in mind that an “all zeros” seed value will create an “all zeros” sequence.

Adding Impairments

The Modular software calculates near-perfect waveforms which are ideal for accurate simulation of wireless equipment however, some tests require that the signals be distorted and impaired for testing edge limits of equipment or for simulating real-life transmission traffic. Modular software package has the ability to add multiple impairments to the waveform and hence simulate more closely real-life wireless signals. There are two impairment tools that can be used, linear and non-linear. The impairment tools are selected from the Carrier Settings dialog box.

Linear Impairments

The Linear Impairments dialog box, as shown in Figure 2-16, is accessed after you click on the Lin. Impair. (Linear Impairments) button in the Power and Impairment group of the Carrier Settings dialog box. Linear impairments are set up and processed in three blocks of which can add serial impairment to the calculation process. Use these blocks as necessary. If you do not need more than one or two impairments, select the No Impairment options for the rest of the blocks. The various impairment options are described below.

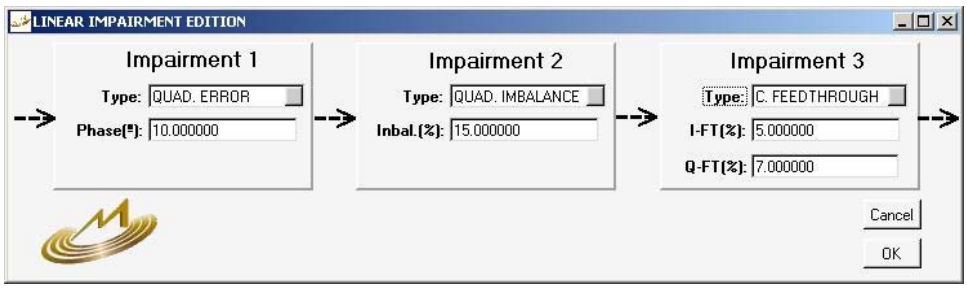


Figure 2-16, The Linear Impairments Dialog Box

No Impairments

The No Impairments option leaves the waveform undistorted after its original calculation. If this option is selected for all three blocks, the resulted waveform will look as shown in Figure 2-17.

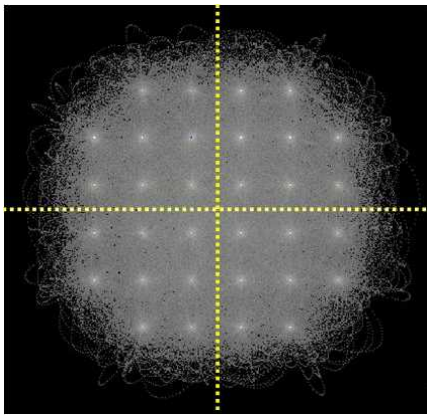


Figure 2-17, No Impairments Added to the Calculations

Quadrature Error

The Quadrature Error refers to the phase deviation between the “I” and “Q” axes relative to the ideal phase (90^{o}). The associated parameter Phase is expressed in degrees. Calculation consists of adding half the deviation to each axis but in opposite direction. If this option is selected, the resulted waveform will look as shown in Figure 2-18.

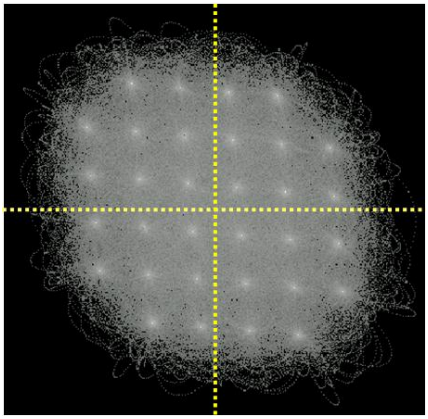


Figure 2-18, Quadrature Error Added to the Calculations

Quadrature Imbalance

The Quadrature Imbalance refers to the amplitude deviation between the “I” and “Q: components of the signal relative to the ideal one (same amplitude). The associated parameter – Quad. Imbalance (Quadrature Imbalance) is expressed as percentage of the amplitude and reflects the desired difference between both es. Calculation consists in incrementing and decrementing the “I” and “Q” components of such a way that the resulting waveform shows the required imbalance. If this option is selected, the resulted waveform will look as shown in Figure 2-19.

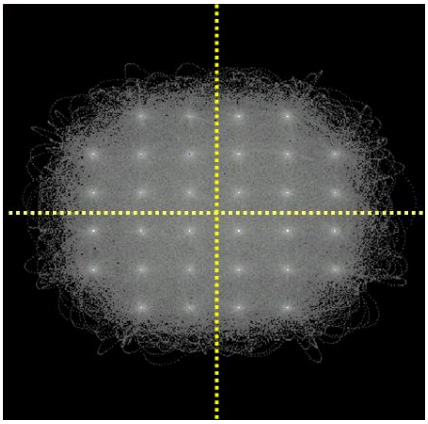


Figure 2-19, Quadrature Imbalance Added to the calculations

Carrier Feedthrough

The Carrier feed through consists in adding a DC component to the baseband signals. The associated parameters I-FT (“I” Feedthrough) and Q-FT (“Q” Feedthrough) allow controlling of both the amplitude and phase of the remaining carrier. They are expressed as percentage of the signal basic amplitude, which is related with the maximum value for a symbol in one of the axes. If this option is selected, the resulted waveform will look as shown in Figure 2-20.

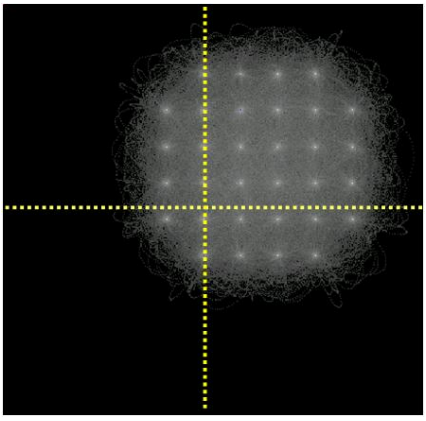


Figure 2-20, Carrier Feedthrough Added to the calculations

Non-Linear Impairments

The Non-Linear Impairments dialog box is accessed after you click on the Non Lin. Impair. (Non-Linear Impairments) button in the Power and Impairment group of the Carrier Settings dialog box. Non-Linear impairments are set up and processed in the Non-Linear Impairments dialog box. The various non-linear parameter options are described below.

Amplifier Distortion

Amplifier nonlinearities cause modulation errors and generate signal components outside the used channel. Nonlinearities can be simulated in this program using the Amplifier Distortion dialog box as shown in Figure 2-21.

Three amplifier models are available: Nonlinear, Hard Limited and Soft Limited. Since the amplifier distortions are simulated, a gain factor of one is assumed for all models. This means that in the ideal case, the output voltage of the amplifier is identical to the input voltage.

Amplifier distortions can be turned on and off using the check box next to the Apply Amplifier Distortion, as shown in Figure 2-21. Information on the Amplifier Distortion parameters is given in the following paragraphs.

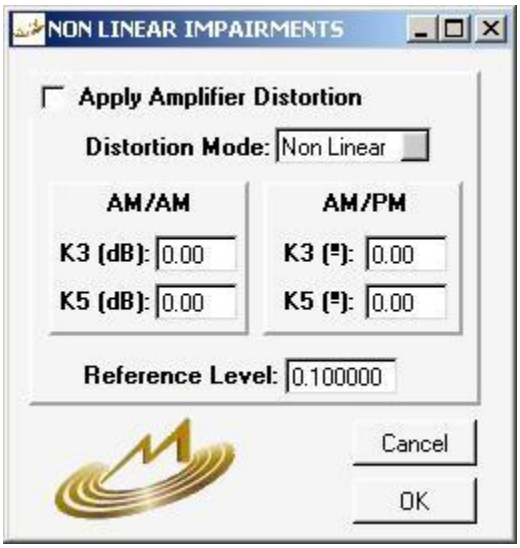


Figure 2-21, Adding Amplifier Distortion

Distortion Mode
Three options are available in this selection box:

Non-Linear – simulates distortions that are attributed to amplifier nonlinearity. Such nonlinearities cause modulation errors and generate signal components outside the used channel.

Soft Limited – simulates distortions that are caused by limiting effects. This means that the output voltage follow exactly the input voltage up to a certain value. Above this value, the output voltage remains constant at a level close to the power supply rails, when the input is further increased. By selecting the soft limited option, the ideal gain is limited to an amplifier input level of Limiting level, which means that input values between –Limiting Level and +Limiting Level are ideally amplified and input values below or above the Limiting Level are forced to ±1.

Hard Limited – simulates a special model of the soft limited amplifier where the limit for the ideal gain is at an input of 0. For all input values below and above 0, the output level is forced to -1 and +1, respectively.

AM/AM
The AM/AM group has two parameters: K3 and K5 are the polynomial coefficient of the third and fifth order, respectively, expressed in units of dB. These expressions describe the relationship between the output and the input amplitude and can be set within the range of -3 dB to +3 dB. The fields will also accept negative coefficients which are automatically linearized and entered in the calculations fully processed.

AM/PM
The AM/PM group has similar parameters: K3 and K5 are the polynomial coefficient of the third and fifth order, respectively, expressed in units of degrees. These expressions describe the relationship between the output phase and the input voltage and can be set in the range of -30° to +30°.

Reference Level
The Reference Level specifies the operating point of the nonlinear amplifier. The minimum value for the reference level is 0.1 and all amplitudes of the input signal are normalized to the level as set in this field.

Figure 2-22 shown an example of the constellation display that simulates amplifier distortions

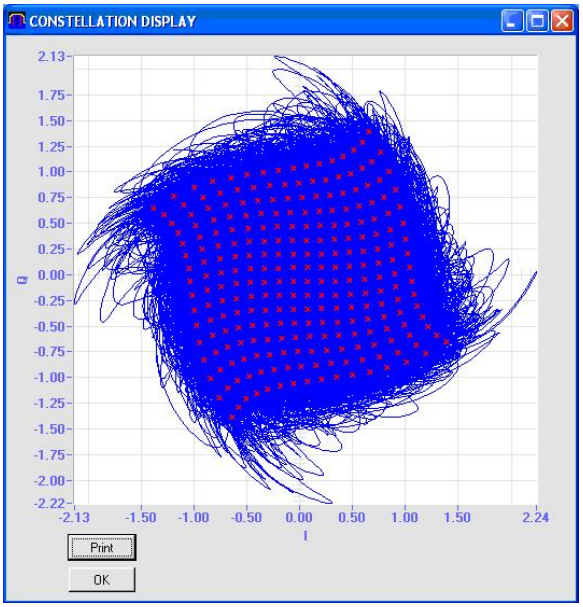


Figure 2-22, Constellation Display Simulates Amplifier Distortion

Multi-Path Distortion

Multi-path is a distortion caused by the signal arriving at the receiver's antenna through more than one path (and hence – multi-path). It is extremely important in today's wireless communication systems as a lot (if not most) of the design complexity comes from the fact receivers have to deal with this problem. Adaptive equalization, channel estimators, receiver architecture (i.e. Rake Receivers) and even modulation schemes (OFDM was created to deal gracefully with multi-path) are just examples of the impact of multi-path. Modular can simulate Multi-path distortions by defining different path entries to a list and hence stressing the receiver to its limits to test its operating margins.

Multi-Path Editing

Multi-path is recreated by processing the signal through the channel impulse response which is comprised of a series of complex (magnitude and phase) peaks. All that the user has to do is type multiple paths to the list window.

The Multi-Path editing dialog box is shown in Figure 2-23 and the various parameters that can be defined in this dialog box for each path are described in the following. Multi-Path distortion is added to the calculation when you select the Apply in the Multi-Path selection field at the upper left corner of the dialog box.

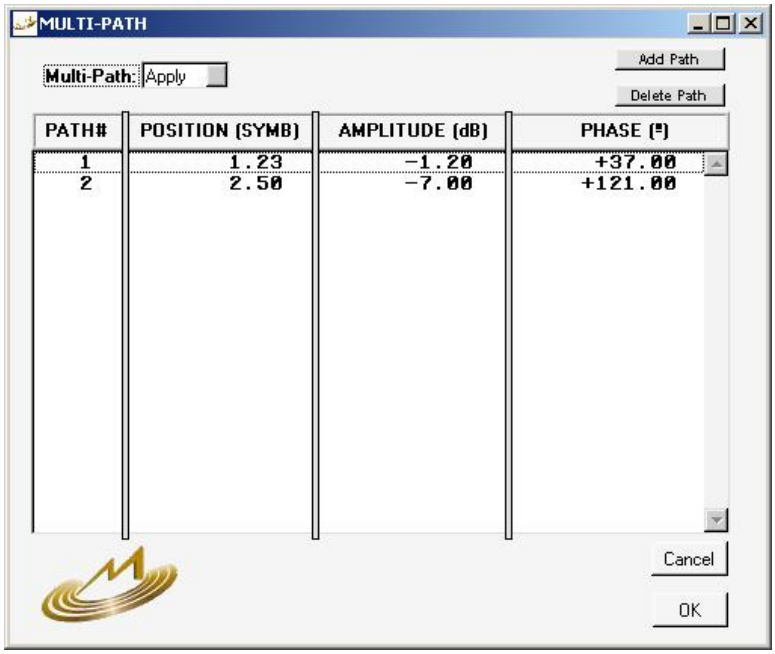


Figure 2-23, The Multi-Path Dialog Box

The following parameters may be defined for each path:

Position
This parameter is defined in UI (symbol times) and may have either positive or negative values that do not exceed one half of the convolution length. This means that any multi-path situation with delays up to the convolution length may be defined for a given carrier.

Amplitude
It is expressed in dB. Typically, 0 dB should be applied to the direct path and the remaining paths should be in reference to the direct path.

Phase
Carrier phase shift induced by the path, expressed in units of degrees.

Multi-path distortion is added by modifying the isolated pulse. The isolated pulse will show then real and imaginary parts as shown in the analysis window – Figure 2-24.

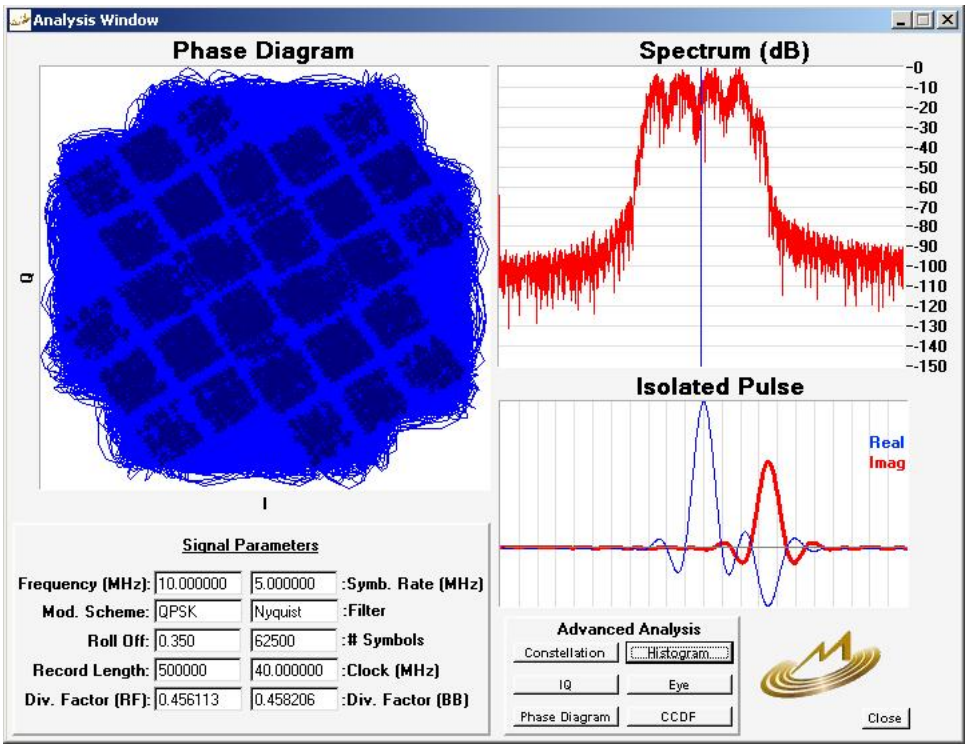


Figure 2-24, Multi-path Distortion Visualized on the Analysis Window

Power Ramping

Power ramping functionality allows for the emulation of power changes of any carrier over time. Power may change due to the pulsed or burst nature of the signal being created (i.e. RADAR or TDMA signals) or to simulate sudden changes in the signal power due to desired (i.e. power control in CDMA signals) or undesired effects (i.e. Quick fading) at the receiver's side.

Modular can simulate power ramping by defining different instantaneous ramp up or ramp down entries for each carrier in the carrier list and hence stressing the receiver to test its operating margins.

Power Ramping Editing

Power ramping is created by processing each symbol through the ramping mode, ramping time and ramping cycle(s). All that the user has to do is select the position location and its associated power transition in the power ramping position list.

The Power Ramping dialog box is shown in Figure 2-25 and the various parameters that can be defined in this dialog box for each path are described in the following. Power ramping distortion is added to the calculation when you select the Linear or Cosine options in the Ramping Mode selection field at the upper corner of the dialog box.

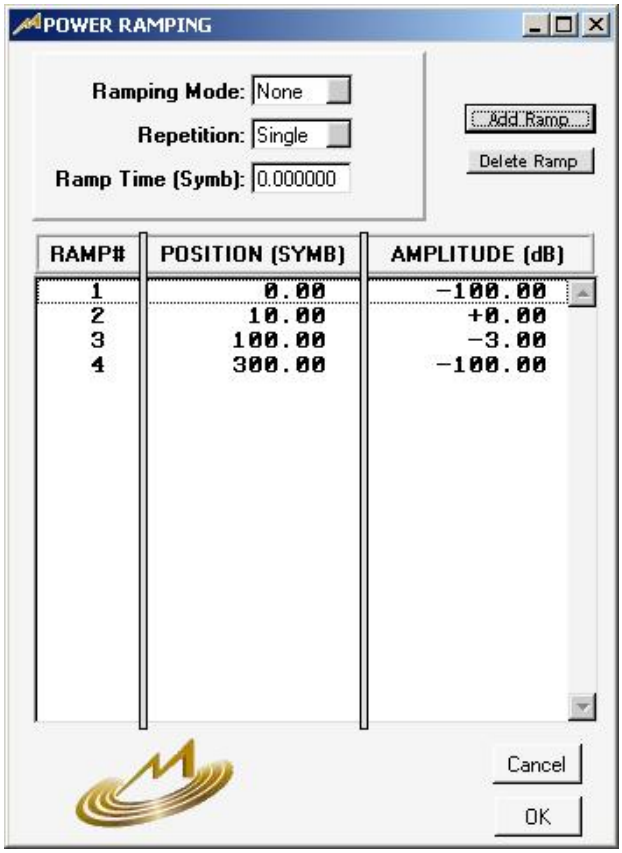


Figure 2-25, The Power Ramping Dialog Box

There are three basic parameters that define the power ramping characteristics: Ramping Mode, Repetition and Ramp Time. These should be defined prior to adding lines to the power ramping list. These parameters are described below.

Ramping Mode
If None is selected, the power ramping options will be disabled. Selecting Linear or Cosine defines the basic shape of the power ramp.

Repetition
Repetition defines if power ramping will occur once or periodically. The Single option will ramp the power once; Repetitive will cause the ramping sequence to repeat itself, provided that the interval of the signal is longer than ramping sequence.

Ramp Time
Ramp Time defines time in UI (Unit Interval or symbol time) for the ramps in the sequence.

Entries in the table are done one-at-a-time. Click on the Add Ramp button and add the Start Symbol and Amplitude parameters for each ramp line, as shown in Figure 2-26. Once you press the OK button, the list will be updated with the new ramp parameters. The same window will open if you highlight and click on a programmed line, which allows modification of present setting. Delete a line by highlighting it and clicking the Delete Ramp button.

There are two parameters that define a specific power ramping line: Position and Amplitude. These parameters are described below.

Position
The position is in symbols in reference to the start position of the waveform. It is imperative that the initial power level is entered with its corresponding value at position “0”.

Amplitude
Amplitude defines the relative power in reference to the power level of the initial symbol. The amplitude is programmed in units of dB.

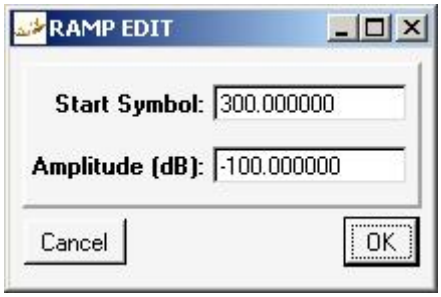


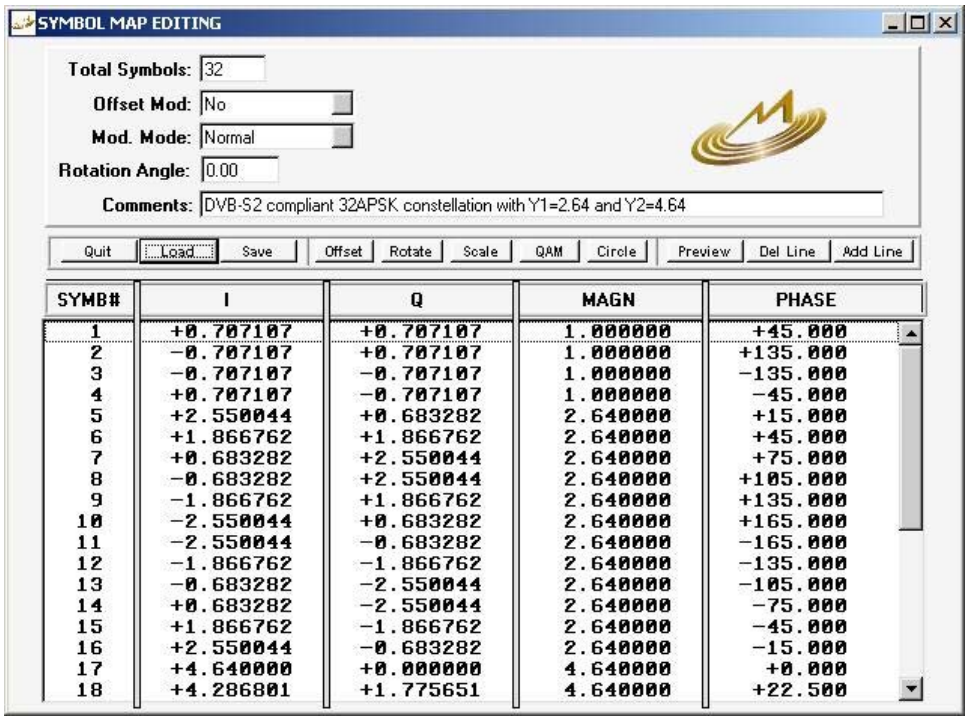
Figure 2-26, Power Ramp Entry and Editing Dialog Box

Symbol Map Editing Tool

Most of the popular modulation schemes and impairments are native in the Modular software however, some applications require the creation of custom modulation schemes or the simulation of impairments within the resulting waveform.

Modular has a built-in Symbol Map Editing tool that simplifies the task of creating custom modulation and impairments. Invoke the symbol map editing tool from either the main window icon or from the Edit command in the commands bar.

The Symbol Map Editing tool is shown in Figure 2-27. Three areas compose the symbol map editing window: Header, Toolbar and Symbol Table. These features are described in the following paragraphs.



SYMB#	I	Q	MAGN	PHASE
1	+0.707107	+0.707107	1.000000	+45.000
2	−0.707107	+0.707107	1.000000	+135.000
3	−0.707107	−0.707107	1.000000	−135.000
4	+0.707107	−0.707107	1.000000	−45.000
5	+2.550044	+0.683282	2.640000	+15.000
6	+1.866762	+1.866762	2.640000	+45.000
7	+0.683282	+2.550044	2.640000	+75.000
8	−0.683282	+2.550044	2.640000	+105.000
9	−1.866762	+1.866762	2.640000	+135.000
10	−2.550044	+0.683282	2.640000	+165.000
11	−2.550044	−0.683282	2.640000	−165.000
12	−1.866762	−1.866762	2.640000	−135.000
13	−0.683282	−2.550044	2.640000	−105.000
14	+0.683282	−2.550044	2.640000	−75.000
15	+1.866762	−1.866762	2.640000	−45.000
16	+2.550044	−0.683282	2.640000	−15.000
17	+4.640000	+0.000000	4.640000	+0.000
18	+4.286801	+1.775651	4.640000	+22.500

Figure 2-27, The Symbol Map Editing Tool

Header

The header area includes the basic information on the symbol map. It has five fields: Total Symbols, Offset Mode, Modulation Mode, Rotation Angle and Comments. These fields are described below.

Total Symbols
It shows the total number of symbols in the table. It is automatically updated and cannot be modified by the user.

Offset Mode
It allows the user to create modulation schemes with half symbol time delay between the “I” and the “Q” components as in the OQPSK modulation scheme. Offset Mode options are Yes (offset mode on) or No (offset mode disabled).

Mod. Mode (Modulation Mode)
This option is used to create differential modulation schemes (such as DQPSK or O-8PSK) without having to take into consideration all the constellations. The user must create only the basic constellation (i.e. QPSK for the D-QPSK modulation scheme, 8PSK in O-8PSK) and then define the angle of rotation for each symbol transition.

Modulation mode can be Normal (no rotation), Diff (Continuous) and Diff. (Alternate). The difference between Continuous and Alternate modes is the way the phase rotation is added for each symbol transition. The Continuous mode adds the phase entered in the Rotation Angle field for each transition. The Alternate mode adds and subtracts alternatively the rotation angle.

Rotation Angle
Sets the rotation angle for the Differential Continuous and Alternate modes in units of degrees.

Comments
Users can use this field to type helpful comments up to 200 characters. This field is informative only and will not be used to store, setup or calculate symbols.

Toolbar

The toolbar area contains buttons that control the symbol map editing tool. The buttons are combined in three groups: File Operation, Symbol Calculation and Symbol Editing. These buttons are described in the following.

File Operation
The File Operation group has three buttons.

Quit – use this button to close the Symbol Map Editing however, bear in mind that this action is destructive to information that was added to the table. If you plan to save the data in the table for future use, make sure you save it first.

Load – use this button to access a file selection dialog box where the user can select an existing symbol map file to be opened for editing. If the symbol map editing tool has been opened from the Carrier Editing window the file name will be copied to the Symbol Map File field.

Save – opens a file selection dialog box where the user can define a new name or select an existing symbol map file name to save the edited data. If the symbol map editing tool has been opened from the carrier editing window, the file name will be copied to the Symbol Map File field.

Symbol Calculation
The Symbol Calculation group has five buttons.

Offset – use this button to add a DC offset to the "I" and/or "Q" components of the current constellation. It opens a dialog box where both offset levels can be independently defined, as shown in Figure 2-28. The offset will be added to the "I" and/or "Q" component after you press the OK button.

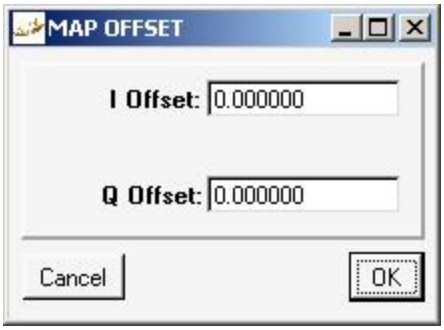


Figure 2-28, Add DC Offset Dialog Box

Rotate – use this button to define the angle between the "I" and "Q" axes. It opens a dialog box, as shown in Figure 2-29, where the user can define the desired angle of rotation. The default rotation is 0° (no impairment). It is useful to create signals that show Quadrature errors and hence the usage of the rotate feature.

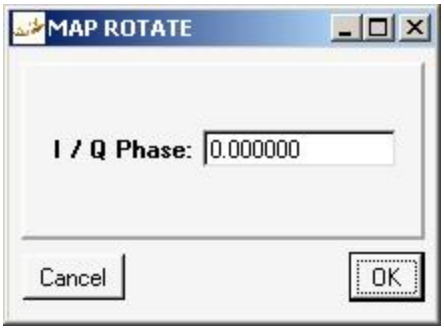


Figure 2-29, Add Rotation Angle Dialog Box

Scale – use this button to apply a scale factor to the "I" and "Q" components of the current constellation. It opens a dialog box, as shown in Figure 2-30, where the user can scale both factors independently. The scale factors are expressed as percent of the original size. The default value is 100%.

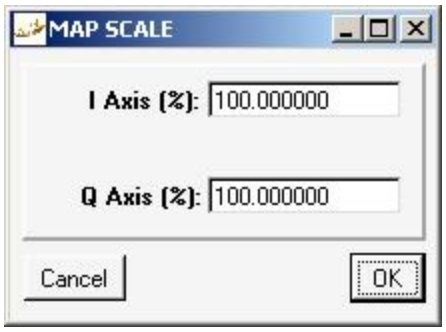


Figure 2-30, Add Scale Factors Dialog Box

QAM – use this button to quickly and automatically create standard and popular symbol tables. It opens a dialog box, as shown in Figure 2-31, where the user can select one of the following modulation schemes: BPSK, QPSK, QAM16, QAM32, QAM64, QAM128, or QAM256 and hence save valuable time that would otherwise take to create such tables from scratch.

Circle – use this button to open a circle constellation definition dialog box that allows the creation of equally spaced symbols in a circle of a given radius. The dialog box has three fields:

# of symbols, defines how many symbols will be created simultaneously.

Radius, defines the radius of the circle. The largest radius for a given circle determines the scale limits.

Phase Offset, defines the phase rotation of a given circle.

Using the same tool repeatedly with different number of symbols, phase offset, and radius allows the easy creation of APSK modulation schemes. The '**+**' and '**x**' buttons control the phase offset value to be 0 or half the angle between consecutive symbols respectively.

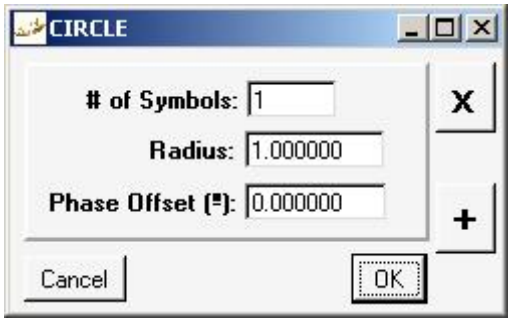


Figure 2-31, Add Circle Dialog Box

Symbol Editing
The Symbol Editing group has three buttons.

Preview – use this button to open a symbol map visualization window where the symbols in the current table can be seen in a graphical way. A preview example is shown in Figure 2-32.

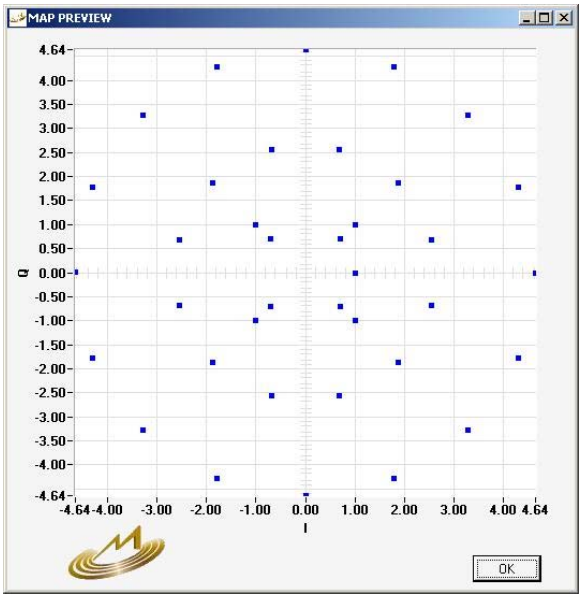


Figure 2-32, Symbol Map Visualized

Delete Line – use this button to delete a highlighted line in the Symbol Map Table area.

Add Line – will open the Symbol Editing dialog Box, as shown in Figure 3-33, and will provide access to line-by-line programming of table entries. There are five parameters that can be programmed in this dialog box: Symbol #, "I" Component, "Q" Component, Magnitude and Phase. These parameters are discussed below.

Symbol #, designates the number of the symbol that will be added to the table. If you select an existing entry, the parameters that are associated with the selected symbol will be modified in the table.

"I" Component, defines the relative location of the "I" component. This value will be updated in the symbol map table

after you hit the OK button.

"Q" Component, defines the relative location of the "Q" component. This value will be updated in the symbol map table after you hit the OK button.

Magnitude, programs the magnitude of the entire symbol in reference to the origin (0,0).

Phase, programs the phase rotation for the programmed symbol.

The Symbol Map Table is updated with the programmed parameters and the dialog box will close as soon as the OK button is pressed. The Cancel button terminates the editing process and does not change the table entries.

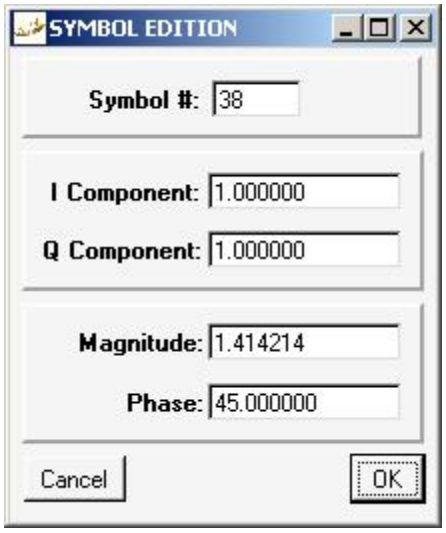


Figure 2-33, Symbol Editing Dialog Box

The Symbol Table

The Symbol Table area shows the current symbol values and can be used to access individual symbols for editing or deletion actions. As shown in Figure 2-34, there are five fields in the symbol area table: Symbol #, I Component, Q Component, Magnitude and Phase. These buttons are described in the following.

Symbol # (Symbol Number)
This shows the position of the symbol in the list. The fields on the right show the corresponding data values. By highlighting a specific position, you can either access the Symbol Editing dialog box, as described above, or marking a line to be deleted when you click on the Delete button.

"I"
Shows the linear magnitude of the "I" component in reference to the

"Q" axis.

"Q"
Shows the linear magnitude of the "Q" component in reference to the "I" axis.

MAGN (Magnitude)
Shows the magnitude of the vector from the origin (0,0) to the symbol.

Phase
Shows the phase of the vector from the origin (0,0) to the symbol.

SYMB#	I	Q	MAGN	PHASE
1	+0.707107	+0.707107	1.000000	+45.000
2	-0.707107	+0.707107	1.000000	+135.000
3	-0.707107	-0.707107	1.000000	-135.000
4	+0.707107	-0.707107	1.000000	-45.000
5	+2.550044	+0.683282	2.640000	+15.000
6	+1.866762	+1.866762	2.640000	+45.000
7	+0.683282	+2.550044	2.640000	+75.000
8	-0.683282	+2.550044	2.640000	+105.000
9	-1.866762	+1.866762	2.640000	+135.000
10	-2.550044	+0.683282	2.640000	+165.000
11	-2.550044	-0.683282	2.640000	-165.000
12	-1.866762	-1.866762	2.640000	-135.000
13	-0.683282	-2.550044	2.640000	-105.000
14	+0.683282	-2.550044	2.640000	-75.000
15	+1.866762	-1.866762	2.640000	-45.000
16	+2.550044	-0.683282	2.640000	-15.000
17	+4.640000	+0.000000	4.640000	+0.000
18	+4.286801	+1.775651	4.640000	+22.500

Figure 2-34, Symbol Map Table Entries

To navigate through the symbol map table just use the mouse, arrow keys and scrolling bar (in case all the symbols do not fit the viewing area) to highlight a specific symbol. Double click on the highlighted symbol to open the Symbol Editing dialog box (see the Add Line section above).

The Analysis Window

The Analysis Window is available for graphical representation of the compiled waveform. It can be used to visualize, monitor, validate and document the results. The analysis window encompasses five sections: Phase Diagram, Spectrum, Isolated Pulse, Signal Parameters and Advance Analysis buttons.

The Analysis Window, as shown in Figure 2-35, is invoked automatically after you click on the Compile and Download icon in the toolbar, or select the equivalent command from the commands bar. The Analysis Window and its various sections are described in the following paragraphs.

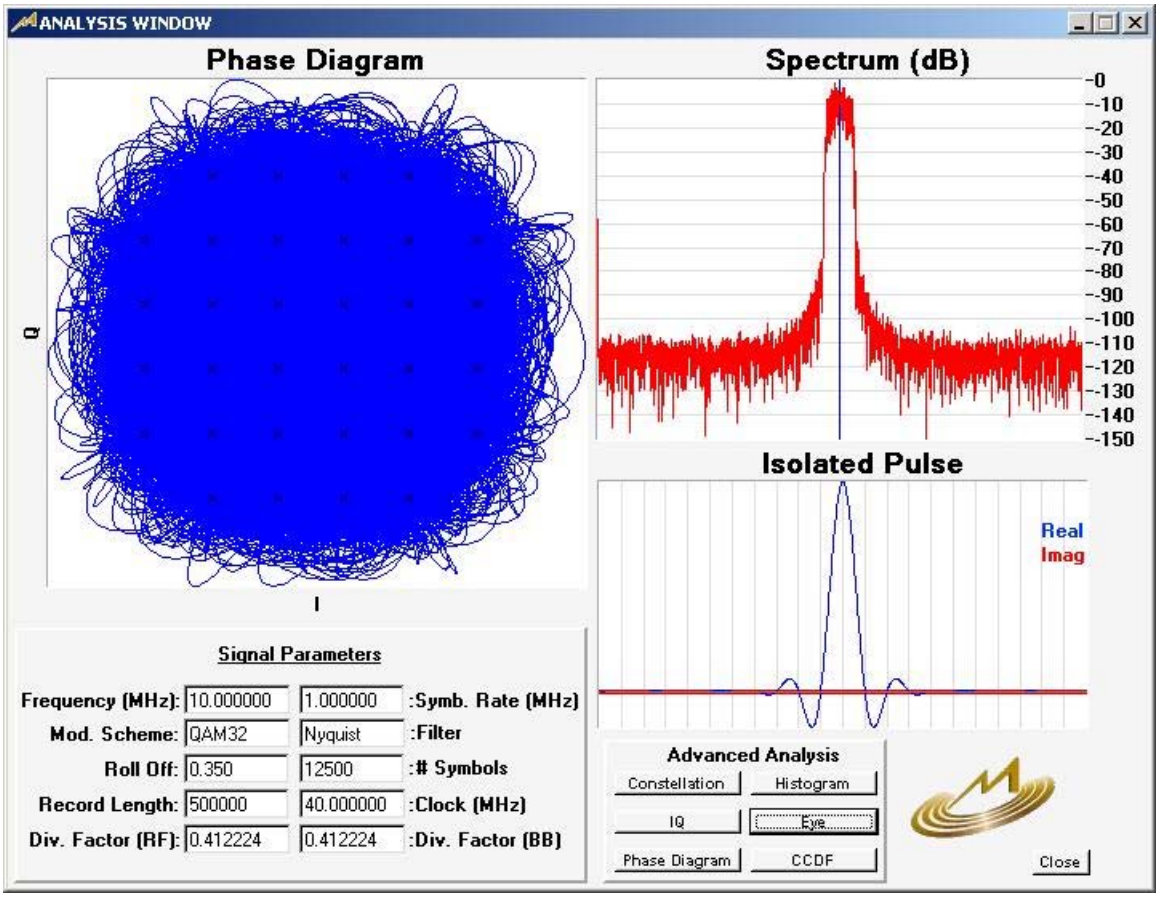


Figure 2-35, The Analysis Window

Phase Diagram

The Phase Diagram section shows a graphical presentation of the phase diagram for the anchor carrier. Interfering signals or filters placed at the output of the target instrument do not affect its shape.

Spectrum (dB)

The Spectrum section is an FFT presentation corresponding to the first 8192 samples of the combined output waveform. A blue vertical cursor shows the location of the carrier. This spectrum display is not affected by the analog frequency response of the target instrument. Sample data has been previously quantized depending on the target instrument to give an idea of the ideal level of quantization noise. It can help to select appropriate calculation parameters to limit processing time while preserving signal integrity and quality.

Isolated Pulse

The Isolated Pulse section shows a graphical presentation of the baseband pulse shape for the anchor carrier.

Signal Parameters

The Signal Parameters section shows numerical and textual information pertaining to both the anchor carrier and the combined output waveform. Parameters in the Signal Parameters fields are shown for reference only and cannot be modified directly from these fields.

Advanced Analysis

The Advanced Analysis section provides access to additional analysis and display of advanced data. There are six buttons grouped together in this section: Constellation, IQ, Phase Diagram, Histogram, Eye and CCDF. These operations are described in the following.

Constellation

The Constellation Display, as shown in Figure 2-36, will be computed and displayed after you click on the Constellation button. The window shows a zoomed view on the constellation diagram that pertains to the anchor carrier.

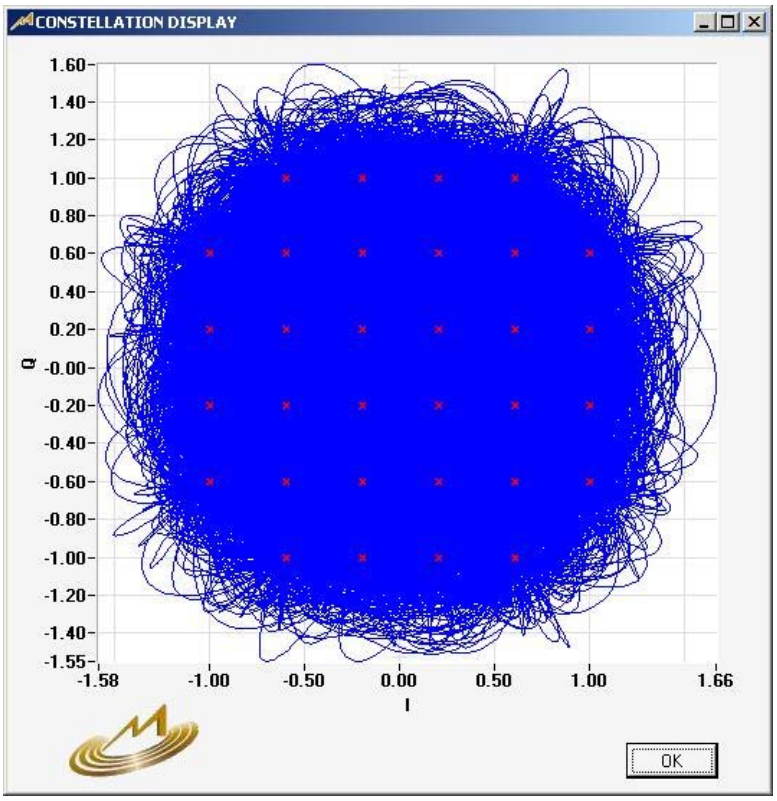


Figure 2-36, Advanced Analysis - Constellation Display

IQ

The IQ Vs. Time display, as shown in Figure 2-37, will be computed and displayed after you click on the IQ button. The window shows the first 8192 time domain samples of the “I” and “Q” components of the carrier.

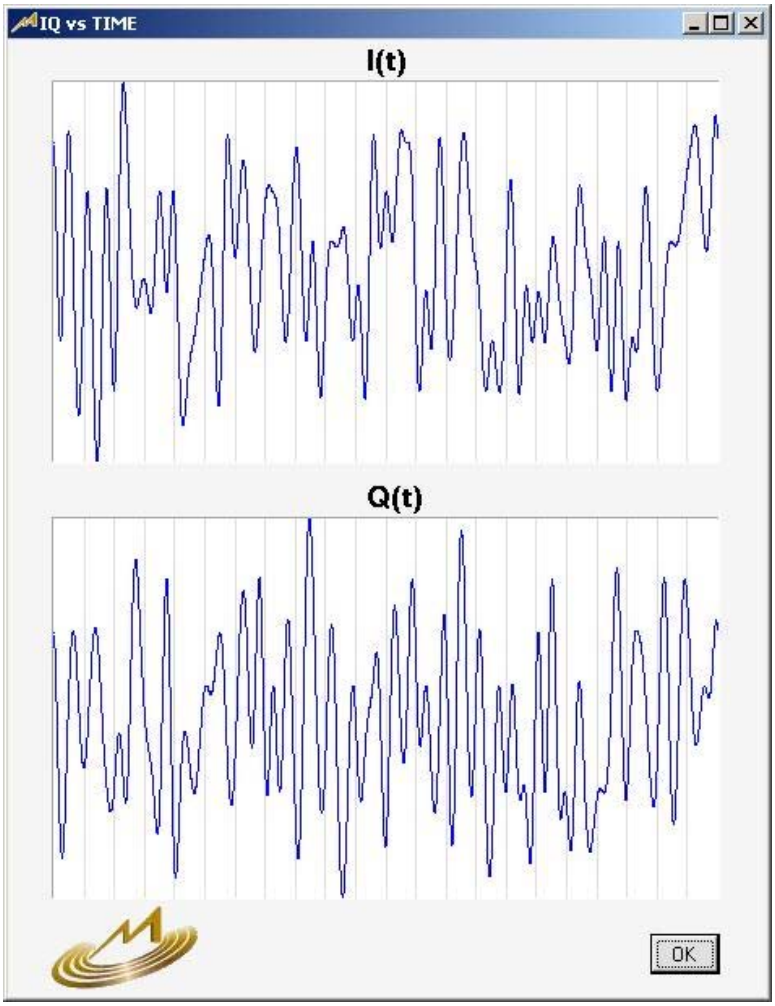


Figure 2-37, Advanced Analysis - IQ vs. Time Display

Phase Diagram

The Phase Diagram display, as shown in Figure 2-38, will be computed and displayed after you click on the Phase Diagram button. The window zooms in on the Phase Diagram section of the Analysis Window.

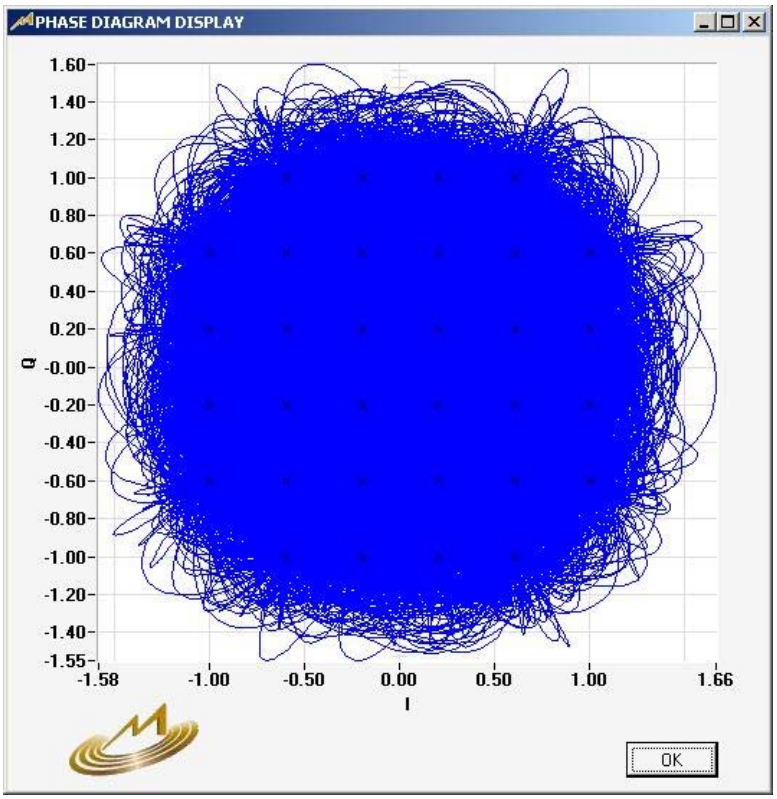


Figure 2-38, Advanced Analysis – Phase Diagram Display

Histogram

The Histogram display, as shown in Figure 2-39, will be computed and displayed after you click on the Histogram button.

The histogram window shows a gray scale graphical display. The purpose of such a display is to give a qualitative visualization of the statistical distribution of the signal. This is especially useful in very complex signals such as multi-channel W-CDMA downlink signals.

It is also possible to obtain horizontal (I axis), and vertical (Q axis) histograms by placing the two available XY cursors at different location. To move the cursors, click and hold on one of the cursors and drag it to the desired location.

The γ parameter helps the user to obtain the desired gray level range for comfortable visualization. Some information about the number of samples used in the histogram calculation is shown in non-accessible fields at the bottom of the window.

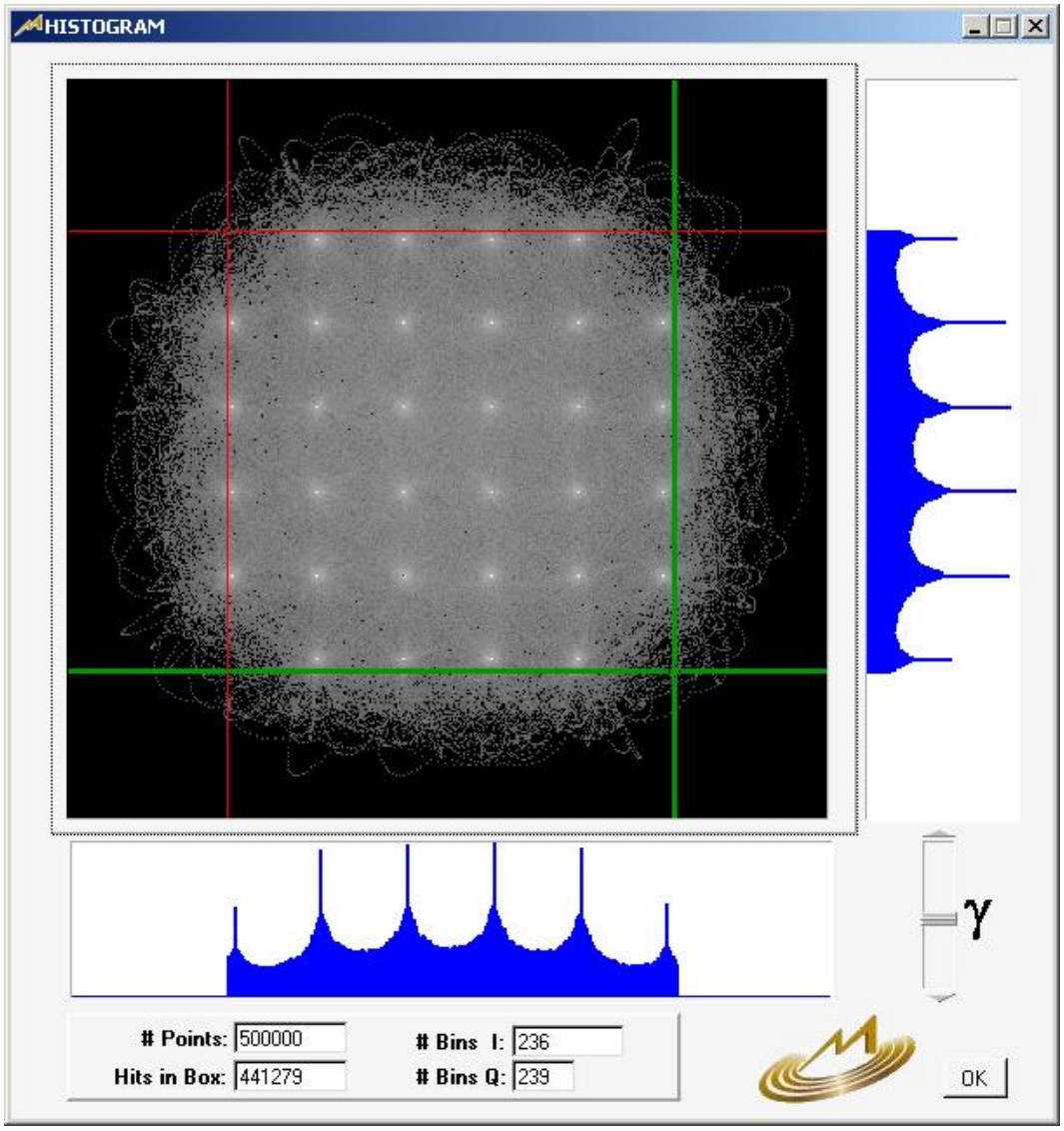


Figure 2-39, Advanced Analysis – Histogram Display

Eye

The Eye display, as shown in Figure 2-40, will be computed and displayed after you click on the Eye button.

The Eye Diagram displays the “I” and “Q” eye diagram for the anchor carrier

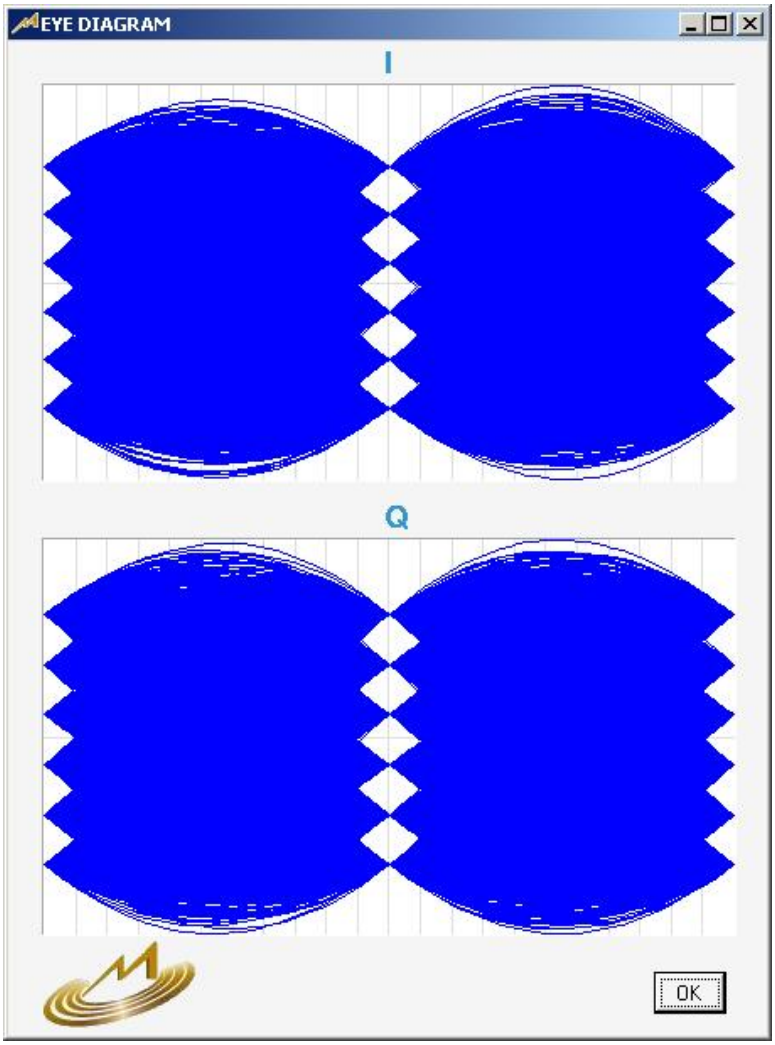


Figure 2-40, Advanced Analysis – Eye Diagram Display

CCDF

The CCDF display, as shown in Figure 2-41, will be computed and displayed after you click on the CCDF button.

The CCDF displays the Complementary Cumulative Distribution Function window where the statistical power distribution of the carrier, or the combined baseband signal (if the “all signals” check box was selected in the Compile Options window).

Crest Factor (also know as PAPR, Peak to Average Power Ratio) is shown in addition to the CCDF graphical display. A cursor is available to accurately determine specific values of the CCDF function. To invoke the cursor, click anywhere on the CCDF window and drag the cursor to the required location.

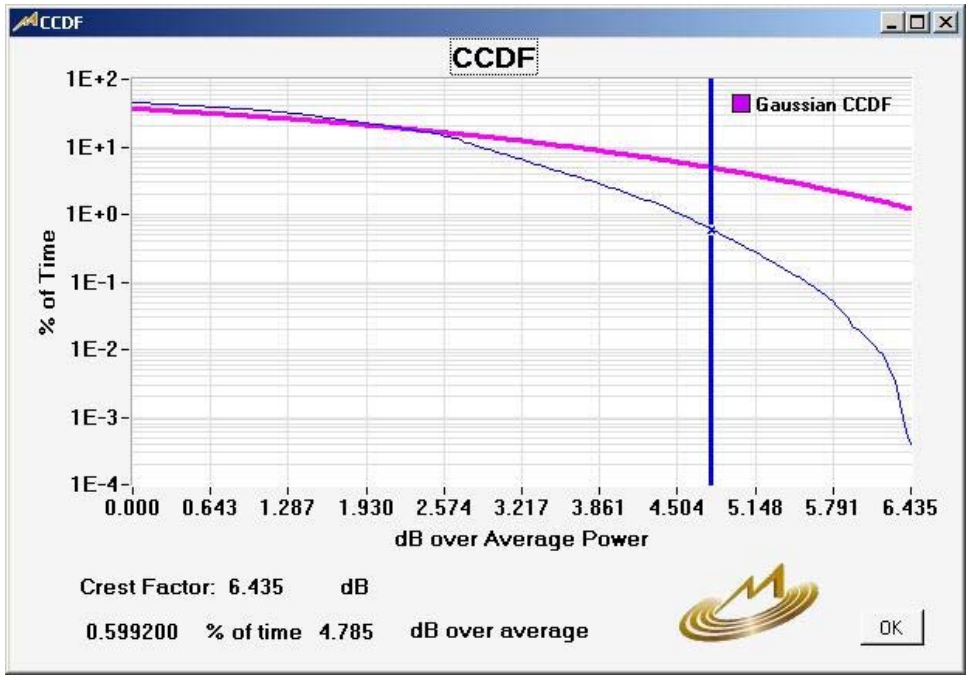


Figure 2-41, Advanced Analysis – CCDF Display

Appendices

Appendix	Title	Page
A	Specifications	A-1

Appendix A
Specifications

Modulation Scheme Support

QAM	QAM16, QAM32, QAM64, QAM128, QAM256, QAM512, QAM1024 with hierarchical modulation support.
PSK	BPSK, QPSK, OQPSK, π/4-QPSK, 8PSK, O-8PSK (EDGE)
ASK	Binary ASK with settable modulation index
FSK	2-FSK, 4-FSK, 8-FSK, 16-FSK, 32-FSK, MSK
Analog	AM, FM, PM. Sinusoidal modulation. Settable modulation index / frequency or phase peak deviation.
VSB	8-VSB, 16-VSB
OFDM	User definable OFDM characteristics including number of carriers, carrier spacing and pilot set-up
Other	Low-jitter clock generation
User Defined	Symbol Map, Symbol List, I/Q time-domain

Modulation Parameters

Base Band Filter	Raised Cosine, Root Raised Cosine, Gaussian (δ Dirac Input), Gaussian (Pulse Input), Rectangular, Triangular, EDGE, Half-sine, Butterworth, User Defined
Time Domain Windowing	None, Triangular, Hamming, Hanning, Blackman, Blackman-Harris, Exact Blackman, Kaiser, Tapered Cosine, Flat Top
Filter Parameters	α, BT
Convolution Length	Minimum 3 Symbols, Maximum 201 Symbols, independently defined for each carrier
FSK Modulation	Peak Frequency Deviation

Signal Impairments

Linear Impairments	Quadrature Error, Quadrature Imbalance, Carrier Feed-through
Non-Linear Impairments	AM/AM, AM/PM for base band (IQ) and amplifier non-linear behavior simulation. Hard and soft clipping simulation.
~~General~~	Impairments are defined independently for each carrier.

Power Ramping

Power Ramping Shapes	Linear, Cosine
Profiling	Power profiles are defined in a carrier-by-carrier basis based in a user-defined transition table.
~~Periodicity~~	Single or cyclic.

Multi-Path

Type	Up to 10 different paths independently set for each carrier.
Control Parameters	Delay (positive or negative) and phase
Delay Range	+- (Convolution length)/2
Phase Range	+- 180^{o}

Channel Coding

DVB-C	Internally defined TS (“all zeros”+ sync byte), sync byte inversion, Reed-Solomon, scrambling, interleaving, and differential coding
IS95 (CDMAOne) Downlink	Channelization/Spreading (Walsh Codes), scrambling
IMT2000 (UMTS) Downlink	3GPP R5 support with channelization/Spreading (OVSF Codes), complex scrambling, C-CCPCH/SCH synthesis and time multiplexing, P-SCH and S-SCH relative power control, compressed mode and HSDPA (QAM16)support.
IEEE-802.11b	Spreading: Barker codes and CCK based modulations.

Payload Data

Data Source	Internal “all zeros”, Internal “all ones”, Internal PRBS, User-editable pattern, User defined
Internal PRBS	Any generation polynomial and seed up to 31 bits long
User-Defined Pattern	Any bit sequence up to 256 bits long. Sequence states may be '1', '0' or 'x' (internal PRBS).
Data Coding	None, Gray, Differential, Gray Differential

Symbol Map Edition

Maximum Symbol Number	Up to 1024 symbols may be defined.
Symbol Definition	I/Q or Magnitude/Phase pairs.
Predefined Maps	QPSK, 16QAM-1024QAM, Symbol in a circle.
Additional Settings	Time-domain Q samples may be delayed by half a symbol time (offset modulations). Constellations may be rotated symbol to symbol by a user defined angle.
Edition Tools	Offset addition, Phase Rotation, Scaling.
Analysis Tools	Edited map graphic preview (constellation display).

Multi-Carrier Assistant

Maximum Number of Carriers	512
Functionality	Any number of carriers with similar characteristics can be defined at once.
Carrier Frequency Parameters	Base and spacing frequencies.
Carrier phase control	Fixed or random (low correlation)
PRBS control	PRBS polynomial is common but seed value may be sequenced to avoid data sequence related correlation problems resulting in high Crest Factor values.

Waveform Compilation Control

Record Length	Record Length may be defined in samples, symbols or DVB-C/IS-95/UMTS frames
Sampling Rate	Sampling rate is automatically set based on the maximum carrier frequency or symbol rate and a user-defined oversampling factor.
Amplitude Control	Amplitude is automatically adjusted to use the complete

	AWG dynamic range or it can be manually set to any value.
Wrap-around Control	None or automatic. Automatic carrier phase consistency.

Analysis Tools

Spectrum	FFT (8192 samples) of the combined signal. Quantization noise based in actual performance of the target instrument' DAC.
Phase Diagram	Selected or combined (for CDMA) signal. Symbols position shown in low intensity mode.
Constellation Diagram	Selected or combined (for CDMA) signal. Phased diagram shown in low intensity mode.
CCDF	For selected or combined signal. Cursor linked to the curve.
Histogram Display	Phase diagram gray scale display with control showing up to 500,000 samples. I and Q histograms for user defined areas.
I, Q	Time domain I,Q displays
Eye Diagram	I and Q eye diagrams showing 2 bit intervals
Magnitude	Power vs Time display

Data Communication and Export

Instruments supported	WW5061/2/4, WW1071/2/4, WW2571/2A, WW2074, WW1281, WW1282
Instrument formats	Direct and Native file transfers.
Communication interfaces	GPIB (IEEE-488), Ethernet 10/100 Mb/s (TCP/IP), USB
Export File Format	ASCII delimited (comma, LF, CR/LF, TAB)

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