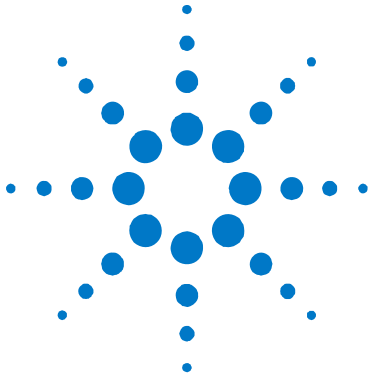

Agilent V2895A MIMO Synchronization Unit

MIMO Application Guide

Agilent Technologies

Notices

Manual Part Number

V2895-90004

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- www.agilent.com/find/V2895A (product-specific information and support)
- www.agilent.com/find/assist (worldwide contact information for repair and service)

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EMC COMPLIANCE:

- Complies with European EMC Directive 2004/108/EC
- IEC/EN 61326-1 or IEC/EN 61326-2-1
- CISPR Pub 11 Group 1, class A
- AS/NZS CISPR 11
- ICES/NMB-001: This ISM device complies with Canadian ICES-001. (Cet appareil ISM est conforme a la norme NMB du Canada.)

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- Complies with European Low Voltage Directive 2006/95/EC
- IEC/EN 61010-1, 2nd Edition
- Canada: CSA C22.2 No. 61010-1-04
- USA: UL std no. 61010-1, 2nd Edition
- This instrument is in conformance with the German Regulation on Noise Declaration for Machines (Laermangabe nach der Maschinenlaermrerordnung -3.GSGV Deutschland).

Acoustic noise emission	Geraeuschemission
LpA < 70 dB Operator position Normal position Per ISO 7779	LpA < 70 dB Am Arbeitsplatz Normaler Betrieb Nach DIN 45635 t.19

Safety Notices

The following safety precautions should be observed before using this product and any associated instrumentation.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the user documentation for complete product specifications.

WARNING If this product is not used as specified, the protection provided by the equipment could be impaired. This product must be used in a normal condition (in which all means for protection are intact) only.

The types of product users are:

- **Responsible body** is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.
- **Operators** use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.
- **Maintenance personnel** perform routine procedures on the product to keep it operating properly (for example, setting the line voltage or replacing consumable materials). Maintenance procedures are described in the user documentation. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

- **Service personnel** are trained to work on live circuits, perform safe installations, and repair products. Only properly trained service personnel may perform installation and service procedures.

Agilent products are designed for use with electrical signals that are rated Measurement Category I and Measurement Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Measurement Category I and must not be directly connected to mains voltage or to voltage sources with high transient over-voltages. Measurement Category II connections require protection for high transient over-voltages often associated with local AC mains connections. Assume all measurement, control, and data I/O connections are for connection to Category I sources unless otherwise marked or described in the user documentation.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000V, no conductive part of the circuit may be exposed.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance-limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, ensure that the line cord is connected to a properly-grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided in close proximity to the equipment and within easy reach of the operator.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

The instrument and accessories must be used in accordance with its specifications and operating instructions, or the safety of the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with the same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

CAUTION

A **CAUTION** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a **CAUTION** notice until the indicated conditions are fully understood and met.

WARNING

A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits – including the power transformer, test leads, and input jacks – must be purchased from Agilent. Standard fuses with applicable national safety approvals may be used if the rating and type are the same. Other components that are not safety-related may be purchased from other suppliers as long as they are equivalent to the original component (note that selected parts should be purchased only through Agilent to maintain accuracy and functionality of the product). If you are unsure about the applicability of a replacement component, call an Agilent office for information.

WARNING **No operator serviceable parts inside. Refer servicing to qualified personnel. To prevent electrical shock do not remove covers. For continued protection against fire hazard, replace fuse with same type and rating.**

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N10149 The C-Tick mark is a registered trademark of the Australian Spectrum Management Agency.

ICES/NMB-001
ISM GRP.1 CLASS A
This symbol indicates product compliance with the Canadian Interference-Causing Equipment Standard (ICES-001). It also identifies the product is an Industrial Scientific and Medical Group 1 Class A product (CISPR 11, Clause 4).

This symbol indicates separate collection for electrical and electronic equipment, mandated under EU law as of August 13, 2005. All electric and electronic equipment are required to be separated from normal waste for disposal (Reference WEEE Directive, 2002/96/EC).

his symbol on an instrument means caution, risk of danger. You should refer to the operating instructions located in the user documentation in all cases where the symbol is marked on the instrument.

This symbol indicates the instrument requires AC input power.

This symbol on the rear panel power switch indicates that power is turned OFF when the rocker switch is push in that direction.

This symbol on the rear panel power switch indicates that power is turned ON when the rocker switch is push in that direction. The rear panel power (LINE) switch disconnects the mains circuits from the mains supply.

This symbol on the front panel power button is illuminated amber if the instrument is in STANDBY power mode, green if the power button is turned on, or OFF (not illuminated) if the rear panel power switch is turned OFF or the mains power is removed to the instrument.

40 This symbol indicates the time period during which no hazardous or toxic substance elements are expected to leak or deteriorate during normal use. Forty years is the expected useful life of the product.

IP20 As defined by IEC 60529, IP20 indicates that the enclosure protects a finger or similar object (12 mm in diameter and 80 mm long) from entering any opening and touching dangerous internal parts, and there is no protection against water intrusion.

C SA US The CSA mark is a registered trademark of the CSA International.

CLEANING PRECAUTIONS:

WARNING To prevent electrical shock, disconnect the Agilent Technologies instrument from mains before cleaning. Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not attempt to clean internally. To clean the connectors, use alcohol in a well-ventilated area. Allow all residual alcohol moisture to evaporate, and the fumes to dissipate prior to energizing the instrument.

Table of Contents

Section 1: MIMO Introduction

Preface

This Agilent Technologies Inc. multiple-in multiple-out (MIMO) Application Guide introduces you to the concepts of MIMO technology with the associated topics: OFDMA, WLAN, and WiMAX.

It also describes how you can configure your Agilent Technologies Inc. software and instrumentation for a complete measurement solution.

- Agilent V2820A VSA
- Agilent V2920A VSG
- Agilent V2895A MIMO Synchronization Unit
- Agilent V2901A SignalMeister RF Communications Test Toolkit

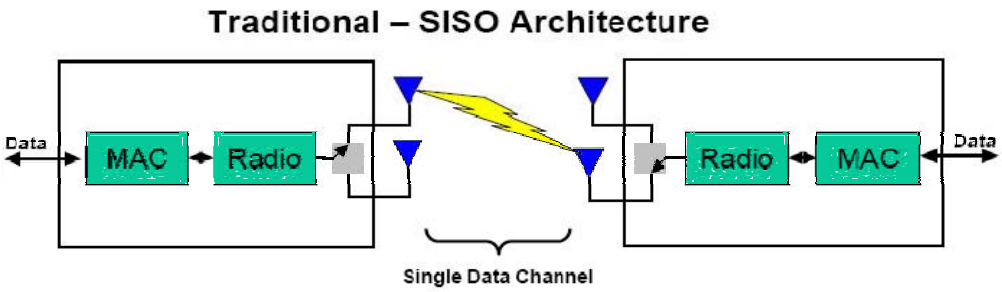
SISO to MIMO

Commercial radio technology has reached a turning point where the move is from single carrier technologies (single-input single-output, SISO) where one digital symbol is transmitted at a time, to a new paradigm, where potentially hundreds of symbols are transmitting simultaneously (multiple-input multiple-output, MIMO). The change has been driven by customer demand for more mobile services, and the decreasing cost of the digital signal processing technology required to deploy high-bandwidth broadband wireless systems. The technology can now be used in a variety of commercial communications devices. For example, phones, PDAs, and the laptops upon which we have become so dependent.

The technology of choice for this broadband connection is based on a modulation scheme called orthogonal frequency division multiplexing (OFDM). OFDM has very good spectral efficiency and is quite tolerant of the ever-present interference in the bands where it is used. One of the key reasons for this is that it transmits hundreds of symbols simultaneously, yet at a low rate per symbol.

SISO: Single-Input Single-Output

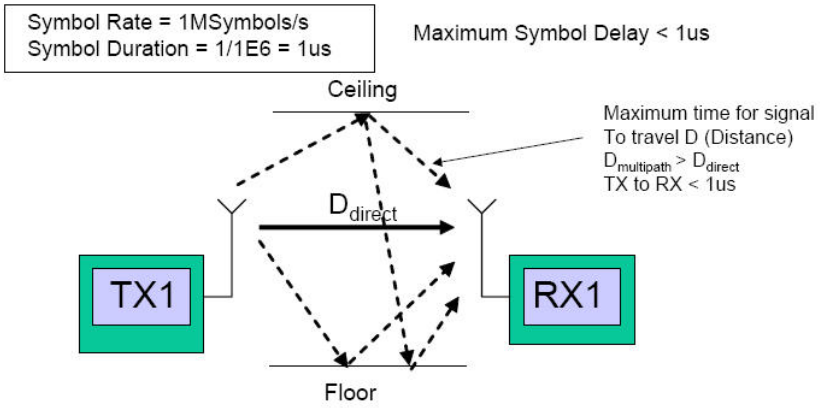
The figure below shows a typical SISO radio with one transmitter and one receiver with information sent over a single data channel. This configuration is used in almost all radio products today. While there may be an extra antenna for spatial diversity (constantly switched for the best signal path), there is a single upconverter and a single downconverter, a single demodulator/modulator in the radio, and a single data stream in the higher levels of the product's communications stack.



- One radio, only one antenna used at a time (e.g., 1 x 1)
- Antennas constantly switched for best signal path
- Only one data "stream" and a single data channel

Multi-Path

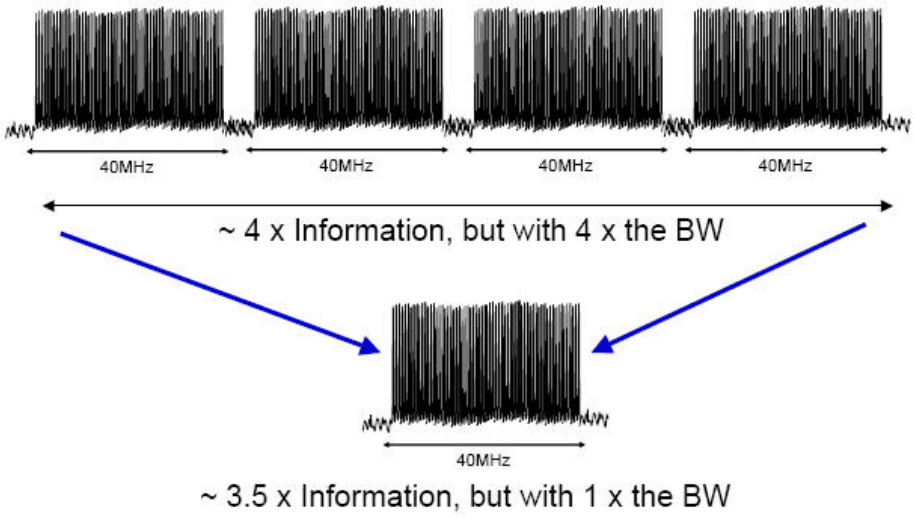
Multi-path architecture adds complexity to the SISO transmission. The figure below shows a Bluetooth signal with a symbol rate of 1M symbols per second. That means that the receiver will expect a specific symbol within a period of one microsecond. If the multi-path architecture delays the signal by more than one microsecond, the receiver will receive the symbol in the next symbol period, causing a significant symbol error.



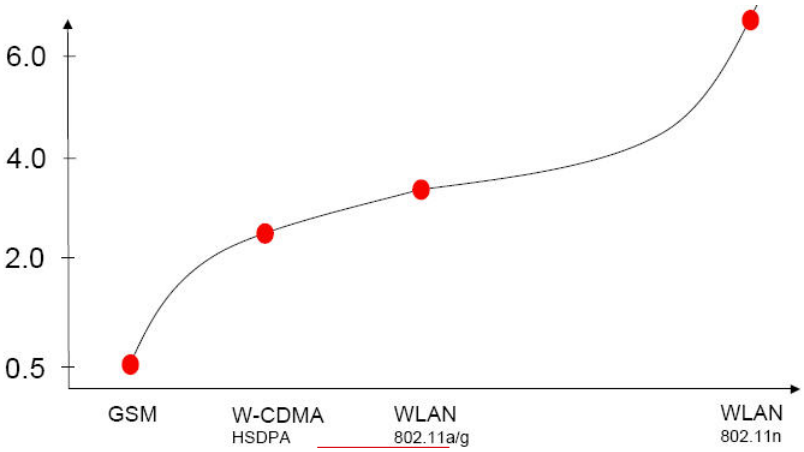
If the difference in path length between direct and reflected paths exceeds 1 ms, the receiver will receive the symbol in the next symbol period.

MIMO: Multiple-Input Multiple-Output

MIMO is the most significant change to radio architecture in radio history. The principle is simple: If you have one transmitter, you can transmit some data from point A to point B; If you have four transmitters (or four carriers) the data is four times more likely to get to its destination, but the transmission would take up four times as much bandwidth. MIMO aligns those four independently modulated OFDM carriers on top of each other resulting in four separate transmissions, sharing a single frequency. It can carry up to 3.5 times as much information in the same bandwidth as a single carrier (see the figure below). The most complex part of this operation is getting the transmission back to four independent radio signals at the receiver. The principle is not new, but the cost of the technology has decreased such that it is now commercially viable.



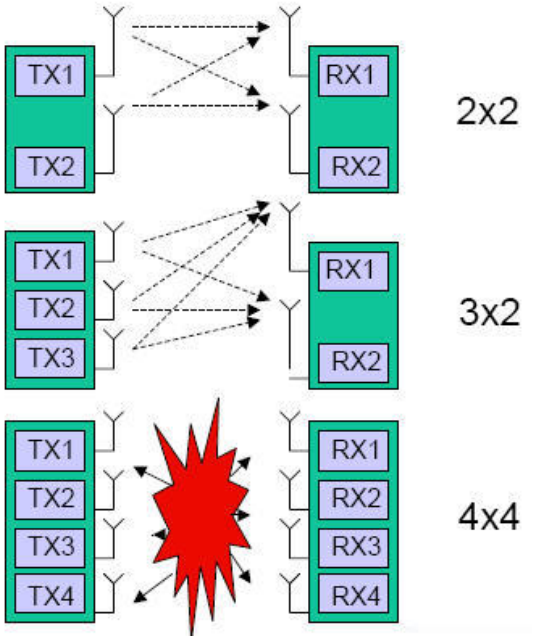
By using somewhere between two and four carriers to transmit the data, and having two and four receivers, the likelihood of receiving everything is much better, so the spectral efficiency rises dramatically, although that efficiency comes with a higher level of complexity.



MIMO Radio Configuration

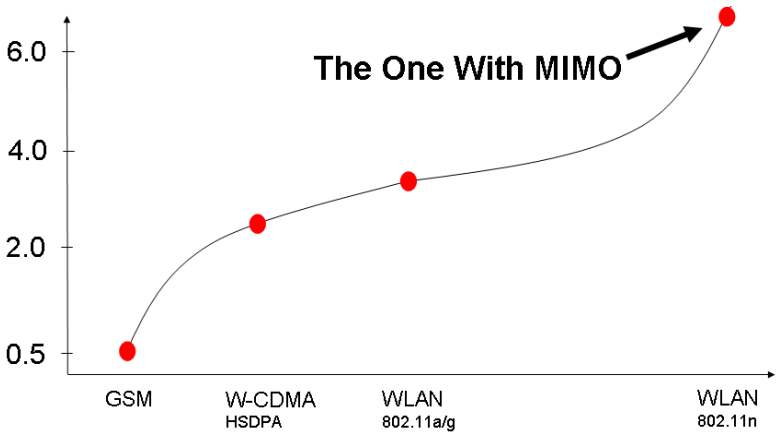
The figure below shows some typical MIMO configurations. A 2×2 system contains two transmitters and two receivers; A 4×4 system has four transmitters and four receivers. Many commercial WLAN devices today employ a 3×2 configuration of three transmitters and two receivers.

Multiple paths degrade the signal quality on SISO systems, but are necessary for MIMO systems. If there are two unknown transmitted signals and two measurements at the receivers, and the two measurements are sufficiently independent, it is possible to identify the transmitted symbols. For example, if a MIMO transmitter transmits two signals on the same frequency, each signal takes a slightly different path to the receiver and each signal's characteristics diverge from the originally transmitted signals (mainly due to multi-path distortion). Both receivers receive a mixture of both the original signals. As the two receivers are independent, you can use simultaneous equations on the two received signals and identify the transmitted symbols.



Spectral Efficiency: SISO versus MIMO

MIMO allows the same bandwidth to be used multiple times, allowing a higher spectral efficiency. You can see that when you compare the efficiency of 802.11a/g wireless LAN signals without MIMO to the 802.11n wireless LAN signals with MIMO.



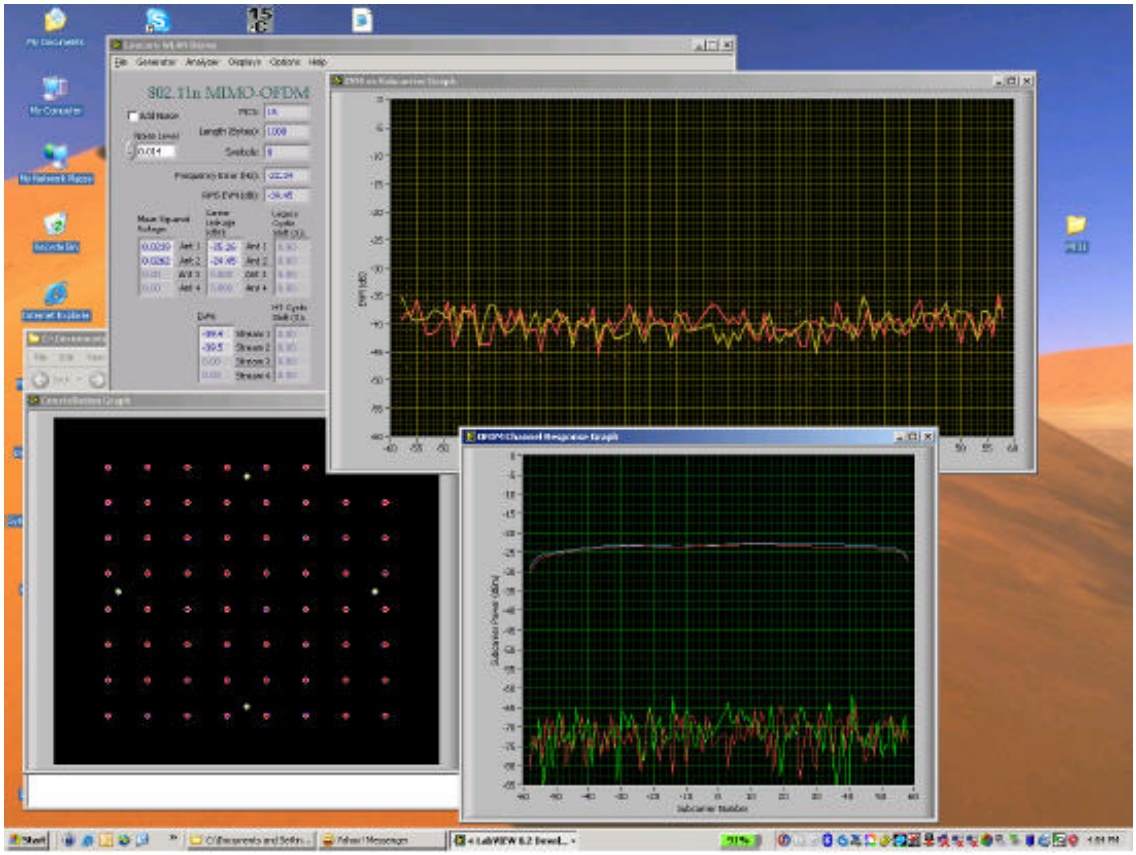
Hardware

To transmit multiple signals you must synchronize the phase and sampling alignment on multiple channels. This can easily be achieved by using two Agilent V2920A Vector Signal Generators (VSGs) with the Agilent V2895A MIMO Synchronization Unit. Conversely, to independently receive MIMO signals, it is necessary to synchronize two Agilent V2820A Vector Signal Analyzers (VSAs). In such a test setup, all V2820As and V2920As are identical standard units. The system also provides the flexibility to use V2920A VSGs as standalone generators.

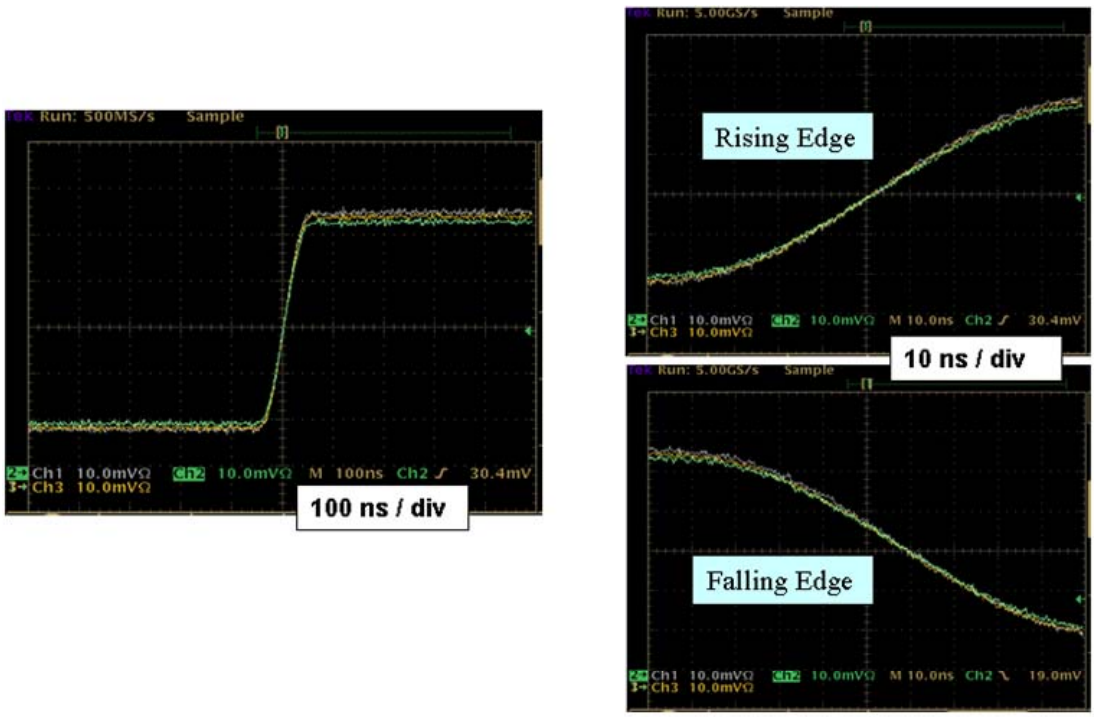
When configured as a system, all the analyzers share common local oscillator and clock signals. The master provides the LO, a 100 MHz digital clock and trigger synchronization to the MIMO Synchronization Unit. The latter unit distributes those signals to all the other units. Signal sampling should be aligned within ±1 ns.

The Agilent second generation MIMO systems are:

- Precise and stable relative to carrier phase
  - Up to ±60 degrees fixed phase offset. This varies with the instrument configuration.
  - <1 degree peak-peak relative phase jitter
- Precise and stable ARB alignment
  - Up to ±1 ns fixed time offset
  - <1 ns peak-peak jitter between the ARB waveforms
- ~60 ns burst rise and fall times (10% to 90%)
- <-90 dBc on-off power ratio between bursts



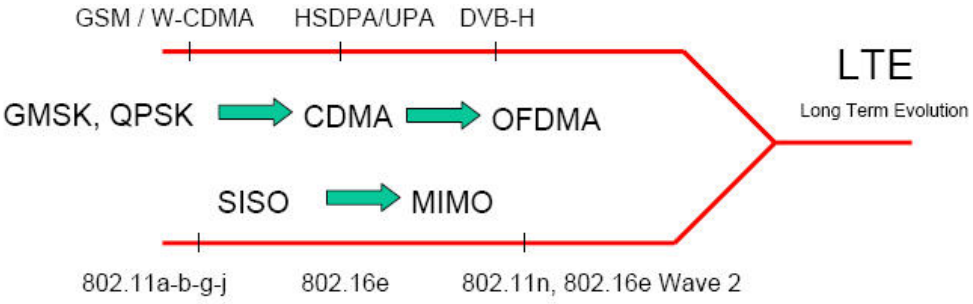
The figure above shows three MIMO measurements on a two-channel system. The upper measurement is an error vector magnitude (EVM) measurement across the OFDM subcarriers on each channel (shown by the yellow and red plots). Underneath that you can see the channel frequency response over 60 subcarriers. Finally, you see the constellation of a channel.



These scope screen shots show that the modulation from all of the RF sources is closely synchronized.

The Long-Term Evolution (LTE) of Wireless

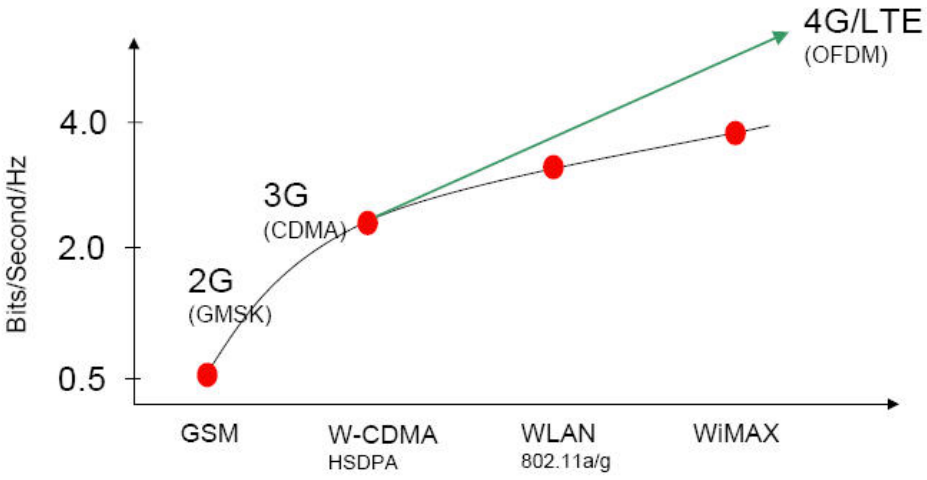
The Long Term Evolution of wireless (LTE), also known as Ultra Mobile Broadband (UMB) for cellular devices (see the figure below), is the migration from 3G technology to 4G technology. Fourth generation technology of radios, cellular phones, cellular data devices, or cellular terminals will be based on OFDM technology and MIMO radio configurations. Right now the commercial application is wireless LAN, which has moved to 4G. When choosing test equipment for testing today's radio standards, it is important to consider the evolution of wireless technology and to ensure that your purchases are forward compatible.



Orthogonal Frequency Division Multiplexing (OFDM)

Orthogonal frequency division multiplexing (OFDM) is a form of digital modulation used in a wide array of communications systems. The following topic will explain what OFDM is, why it is important, where it is used, and what test instrumentation is required to maintain it.

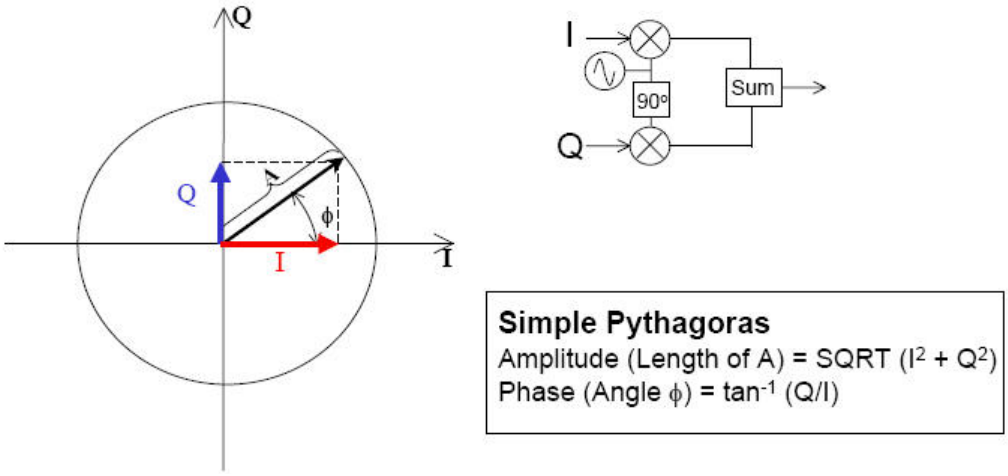
- OFDM is spectrally efficient, carrying more data per unit of bandwidth than such services as GSM and W-CDMA. The figure below shows a comparison of the spectral efficiency of the leading cellular technologies and how they compare to WLAN and WiMAX. Fourth Generation technology, often referred to as the Long Term Evolution of wireless (LTE) and Ultra Mobile Broadband (UMB) for cellular devices, plans to use OFDM or OFDMA.



- OFDM tolerates environments with high RF interference. Some services that use OFDM, such as WLAN, operate in the unregulated Industrial Scientific Medical (ISM) bands, where they must coexist with many unregulated devices, including analog cordless phones (900 MHz), microwave ovens (2.45 GHz), Bluetooth devices (2.45 GHz), digital cordless phones (2.45 GHz or 5.8 GHz) and Wireless LAN (2.45 GHz or 5.8 GHz).

Digital Modulation Overview

Most forms of digital transmission involve modulating a pair of summed sine waves that differ in phase by 90°. The modulation signal can be represented by the vector sum of the in-phase (I) and quadrature (Q) components, as shown in the figure below.

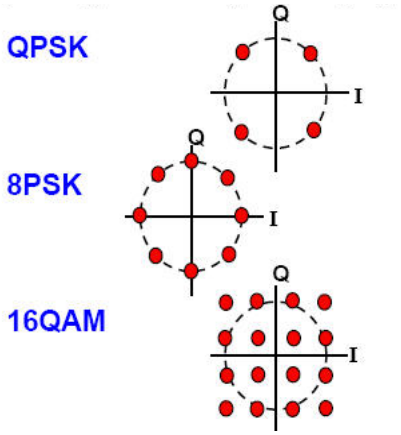


There are many ways to encode digital information. If you change the phase relationships between the two sine waves, the result is called phase shift keying (PSK). A common type of PSK is quadrature phase shift keying (QPSK), which uses four phases; if eight phases are used, the result is 8PSK.

If you vary both the amplitude and phase of the two sine waves, the result is quadrature amplitude modulation (QAM).

The best way to analyze the resulting signals is with a vector signal analyzer (VSA), for example, the Agilent V2820A, which processes all of its data as quadrature pairs in a constellation diagram. The figure below shows constellation diagrams for three types of modulations: QPSK, 8PSK, and 16QAM.

Input Signal Analyzer Display



Modulation Quality Analysis

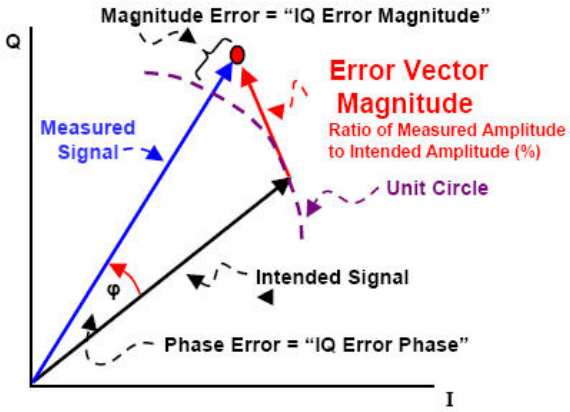
A good measurement of the quality of a received digital signal is error vector magnitude (EVM). This is the ratio of the received signal's amplitude and phase compared to its ideal amplitude and phase. Mathematically, EVM is determined by:

$$\mathrm{EVM}(\%) = \sqrt{\frac{P_{\mathrm{error}}}{P_{\mathrm{reference}}}} * 100\%$$

$$\mathrm{EVM}(\mathrm{dB}) = 10\log_{10}\left(\frac{P_{\mathrm{error}}}{P_{\mathrm{reference}}}\right)$$

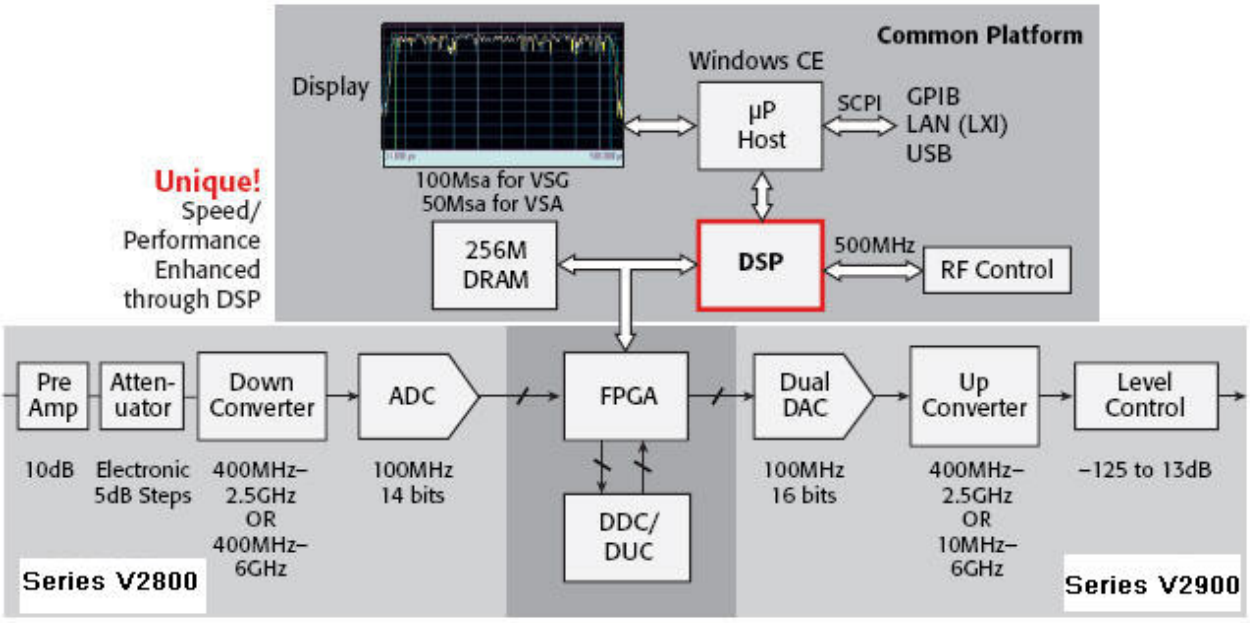
P = RMS Power

Cellular technology specifications are usually stated in percent, while the Wireless LAN industry tends to specify EVM using decibels. The measurement analysis is depicted in the following illustration:



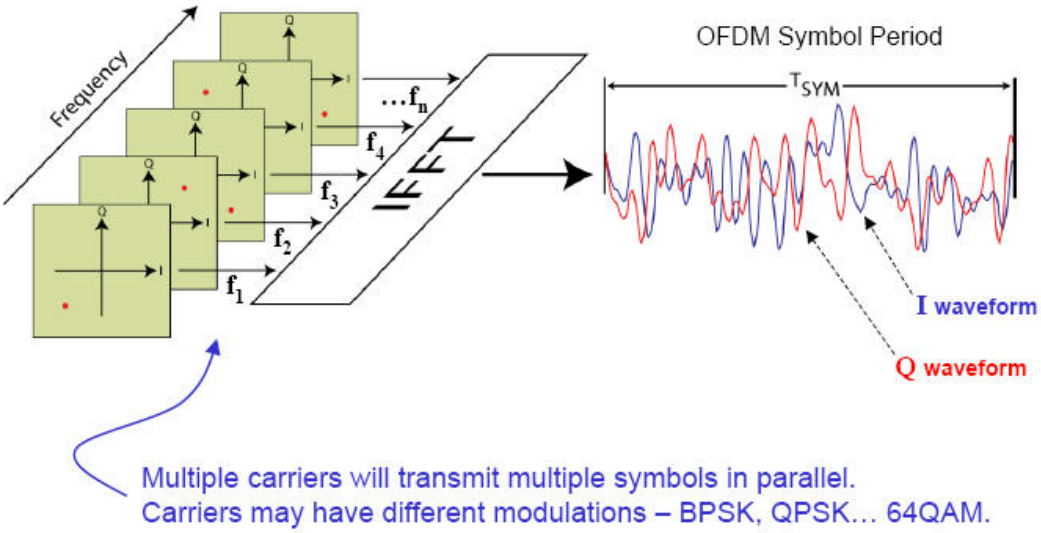
The OFDM Radio

Many conventional instruments lack the signal processing capability to perform MIMO measurements quickly. As shown in the figure below, Agilent Technologies' DSP enhanced architecture makes it possible to perform the analysis very quickly.

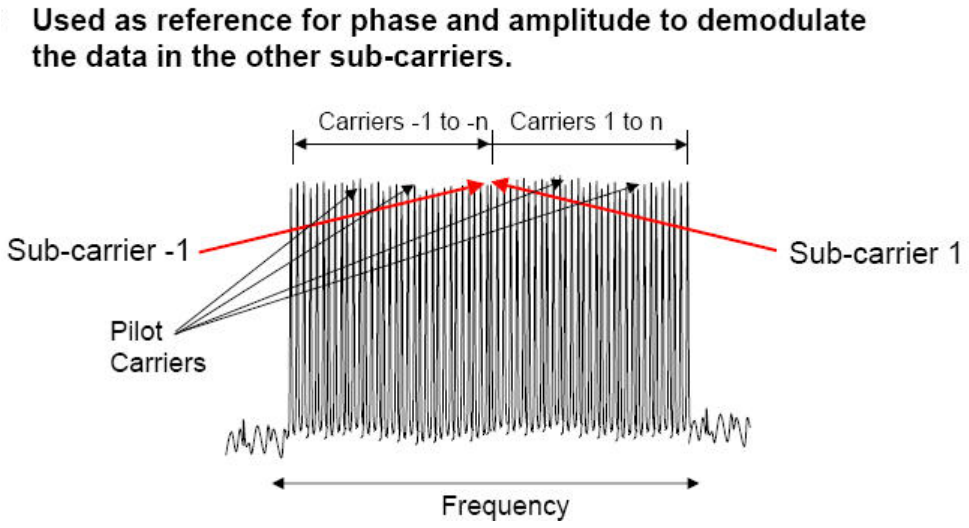


This block diagram shows the digital circuit in the V2820A Vector Signal Analyzer and the V2920A Vector Signal Generator.

OFDM is simple in concept, even though its implementation is complex. Mathematically, it can be implemented by using an Inverse fast Fourier transform (IFFT) in the transmitter and conversely an FFT in the receiver. The figure below shows the parallel symbols being converted to the two modulated sine waves in the output, as if the IFFT is a specialized multiplexer.

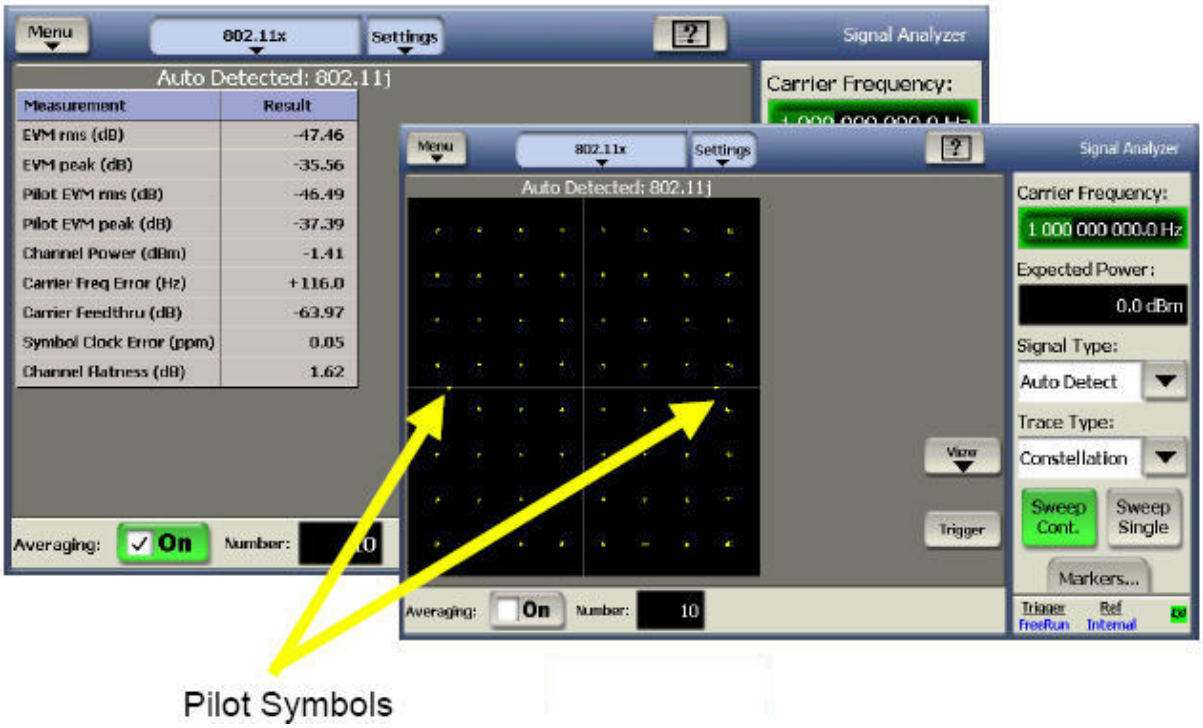


In order to keep things synchronized, an OFDM signal includes several subcarriers (see the figure below) designated as pilot carriers. The pilot carriers are used as reference for phase and amplitude for synchronizing the receiver as it demodulates the data in the other subcarriers.



Key Measurements: Constellation and EVM

The figure below shows the constellation of a WLAN signal conforming to the 802.11j standard. Note that even though the signal has been transmitted using many carriers, it is still essentially a QAM signal. There are also two extra symbols, representing the information modulated on the pilot carriers.



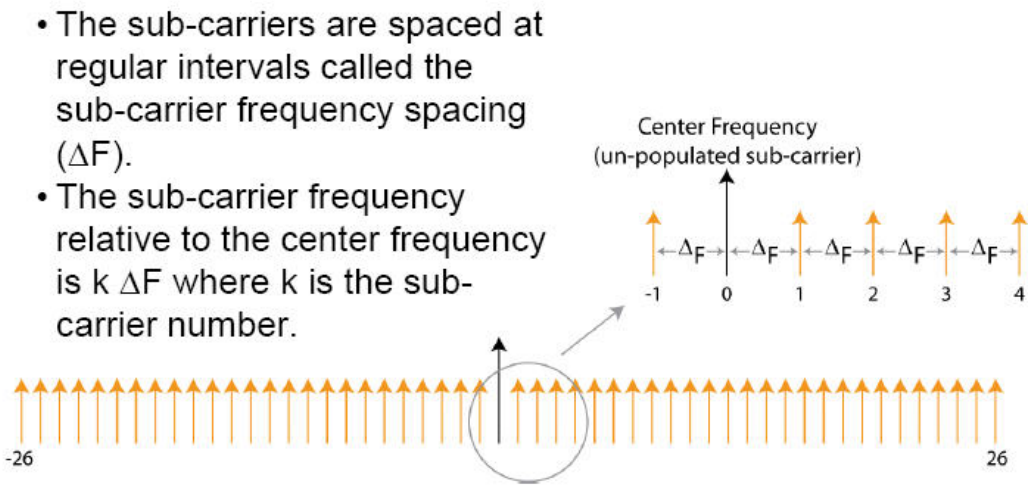
OFDM is very pervasive, as shown in Table 1.

Table 1**: Communication services using OFDM**

Wireless	Wireline
IEEE 802.11a, g, n (WiFi) Wireless LANs	ADSL and VDSL broadband access via POTS copper wiring
IEEE 802.15.3a Ultra Wideband (UWB) Wireless PAN	MoCA (Multi-media over Coax Alliance) home networking
IEEE 802.16d, e (WiMAX), WiBro, and HiperMAN Wireless MANs	PLC (Power Line Communication)
IEEE 802.20 Mobile Broadband Wireless Access (MBWA)	
DVB (Digital Video Broadcast) terrestrial TV systems: DVB-T, DVB-H, T-DMB, and ISDB-T	
DAB (Digital Audio Broadcast) systems: EUREKA 147, Digital Radio Mondiale, HD Radio, T-DMB, and ISDB-TSB	
Flash OFDM cellular systems	
3GPP UMTS and 3GPP@ LTE (Long Term Evolution) and 4G	

WLAN

WLAN is defined by the IEEE 802.11 standard, of which there are several variations, a through g, as shown in Table 2 below. Within a 16.25 MHz bandwidth are 52 carriers, numbered -26 to +26, and spaced 312.5 kHz apart. Carriers 7 and 21 (-21, -7, +7 and +21) are the pilots. The packet structure is Preamble - Header - Data Block, and the subcarrier modulation types are BPSK, QPSK, 16-QAM, or 64-QAM.



Each carrier within the modulation scheme is referred to as a subcarrier. The subcarriers are spaced at regular intervals called the subcarrier frequency spacing (ΔF). The subcarrier frequency relative to the center frequency is kΔF, where k is the subcarrier number.

Table 2: **WLAN Summary**

802.11	Description
a	54 Mbps OFDM, 5.9 GHz Band, 20 MHz channels
b	11 Mbps CCK, 2.4 GHz (Legacy, not OFDM)
g	54 Mbps, 2.4GHz
j	Japanese version of g that uses half the sample rate
n	• Not finished yet, expected to finalize in November 2009 • Like g, but up to 600 Mbps • OFDM • MIMO • 20 and 40 MHz channels

The original WLAN standard is 802.11b, which is not based on OFDM. "a" and "g" are basically the same: "a" works in the 5 GHz ISM band and "g" works in the 2.4 GHz ISM band. "j" is a slower symbol rate version of "g" for the Japanese market, and "n" is based on MIMO technology.

Several organizations are involved with WLAN: WiFi is an industry consortium that defines a required subset of 802.11 to ensure better operation between different vendors' equipment, while EWC is an industry consortium that took the unfinished "n" standard, agreed upon a version, and is attempting to field solutions prior to 802.11N ratification.

Test Equipment Requirements for WLAN

Test equipment for WLAN must have a frequency range up to 6 GHz and be able to modulate or demodulate OFDM signals with a bandwidth of up to 16.25 MHz for all types except for 802.11n, which has a maximum bandwidth of 40 MHz.

WiMAX

The Worldwide Interoperability for Microwave Access (WiMAX) is very similar in concept to 802.11, but the demands of multiple simultaneous users make the implementation much more complex.

There are two major variations of WiMAX: fixed and mobile. The mobile version, 802.16e-2005 (often called 802.16e), facilitates the link between mobile devices. It uses Scalable OFDM Multiple Access (SOFDMA), which interoperates with OFDMA but requires new equipment. 802.16e also adds MIMO.

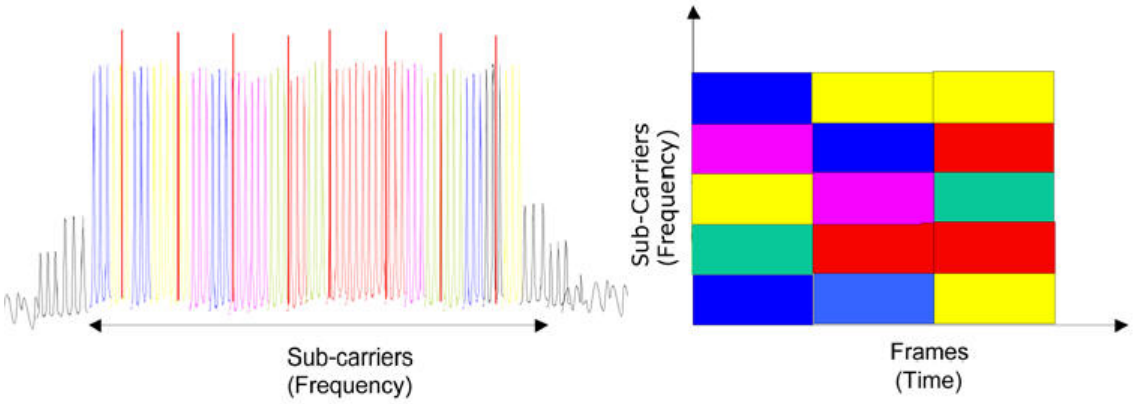
The fixed version of WiMAX, 802.16-2004 (often called 802.16d), uses OFDMA and operates from 2 GHz to 11 GHz (there is no regulatory approval above 5.9 GHz); it delivers a practical data rate of 10 Mbps over 2 km.

The differences are summarized in Table 3.

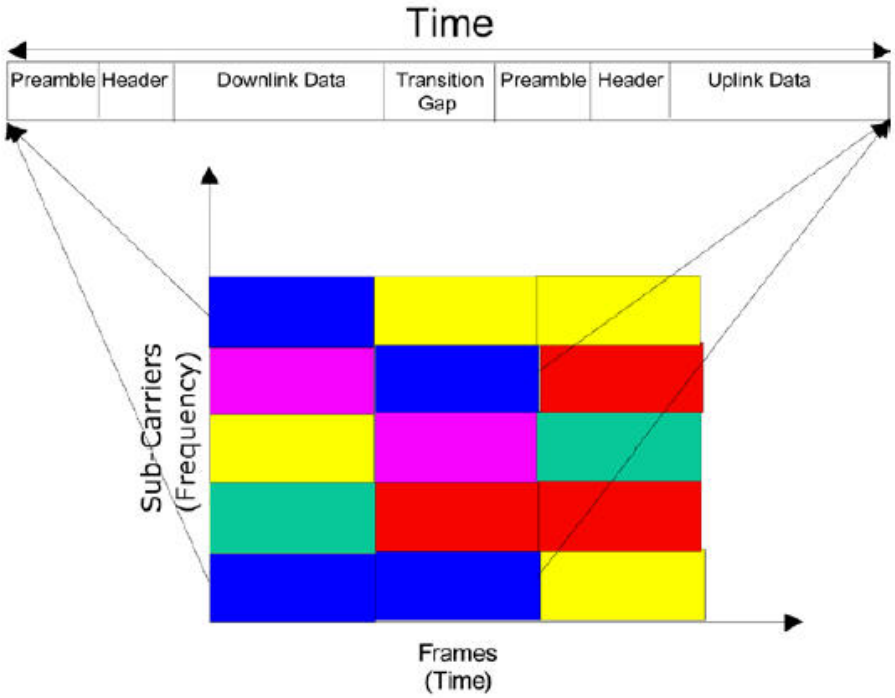
Table 3: **Fixed and Mobile WiMAX**

802.16	Description
802.16-2004 (also know as 802.16d)	Fielded system for fixed-point access (to the home or office)
	OFDMA (OFDM multiple access) 2–11 GHz (no regulatory approval above 5.9 GHz) Practical rate: 10 Mbps over 2 km
802.16e-2005	The current version of the standard, upgraded to include mobile wireless
	SOFDMA interoperates with OFDMA, but requires new equipment. It Adds MIMOs

Fixed WiMAX is similar in some respects to WLAN, that is, it has an OFDM physical layer. Mobile WiMAX is based on an OFDMA physical layer. It uses both frequency division multiplex and time division multiplex. Groups of subcarriers (see figure below) represent individual data streams. Each group of subcarriers also has a frame structure.

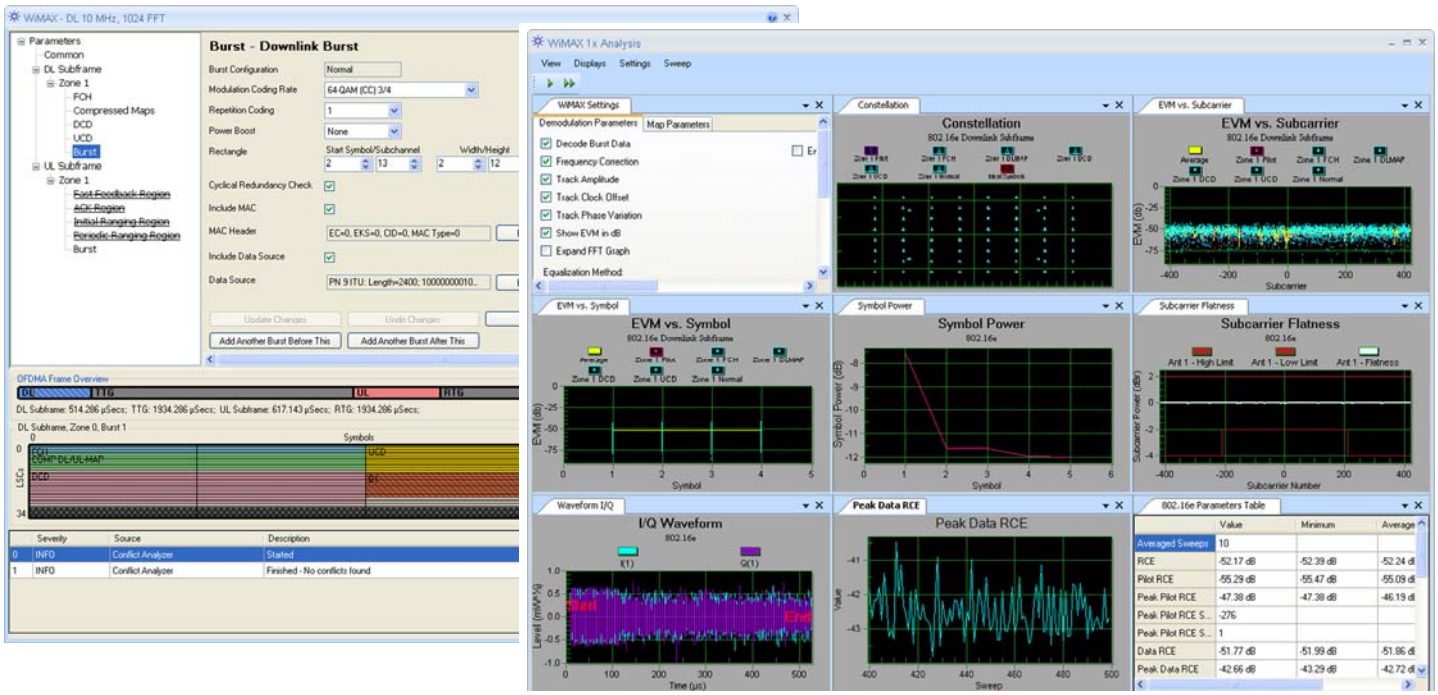


Time division characteristics are shown in the figure below. The frame structure equates to a packet. There is a timing gap between the uplink and downlink called the transition gap.



Mobile WiMAX is a dynamic system. The amount of data transferred is a function of the modulation type and symbol rate on each set of subcarriers. If the link quality is good, a high throughput modulation type such as QAM is used, and most of the bandwidth is consumed, thus limiting the number of users on the system. As a user moves further away from the base station, the signal quality decreases, and with it the ability to maintain a high throughput. A lower throughput modulation scheme such as QPSK would then be employed. This does not require a large group of subcarriers, so the system can support more users.

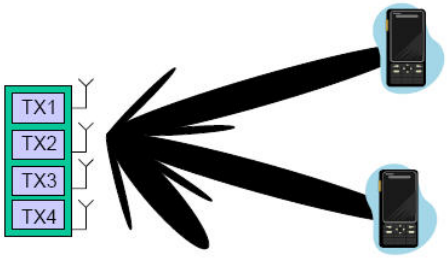
The figure below shows the V2901A SignalMeister 802.16e WiMAX waveform generation and analysis features. You can see (background image) a packet structure containing downlink and uplink data, DL and UL, each separated by a transition gap. The WiMAX analysis (foreground image) shows some of the measurements that can be made for a demodulated waveform. Note that one software application (SignalMeister) includes both the signal generation and analysis, and allows the easy addition of signal impairments.



Beam Forming

Beam Forming is a signal processing technique used in sensor arrays for directional signal transmission or reception. This spatial selectivity is achieved by using adaptive or fixed receive/transmit beam patterns. The improvement compared with an omni-directional reception and transmission is known as the receive and transmit gain (or loss).

One of the key benefits of the Agilent V2820A Vector Signal Analyzer and V2920A Vector Signal Generator is their ability to align RF energy to specific uses by adjusting the phase and amplitude of each coherent transmitter or receiver for beam forming. Beam forming research today is based around developing higher configurations of radios within devices to maximize the amount of services that can be delivered to a customer. Radio configurations of 8×8 and higher are leading the way in broadband radio research. Agilent Technologies offers the industry's only phase-coherent measurement- grade 8×8 system.



Control the directionality and shape of the radiated pattern

Increase range, capacity and throughput

Section 2: Model 2895 MIMO Synchronization Unit

The Agilent Technologies Inc. V2895A MIMO Synchronization Unit provides synchronized signals to MIMO system instruments. This gives the MIMO system a highly precise and stable alignment between up to four signal analyzers or signal generators. The V2895A is designed to be used with the Agilent V2820A Vector Signal Analyzers (VSAs) and V2920A Vector Signal Generators (VSGs).

Key features and benefits

- Synchronization unit creates a MIMO system using standard MIMO-ready Agilent VSAs or VSGs
- Two, three, or four channel configurations
- Very wide bandwidth
- Does not degrade instrument EVM measurements
- Ideal for 802.11 n WLAN and 802.16e WiMAX Wave 2
- Same synchronization unit works with both sources (VSGs) and receivers (VSAs)
- Powerful MIMO signal-analysis software package option

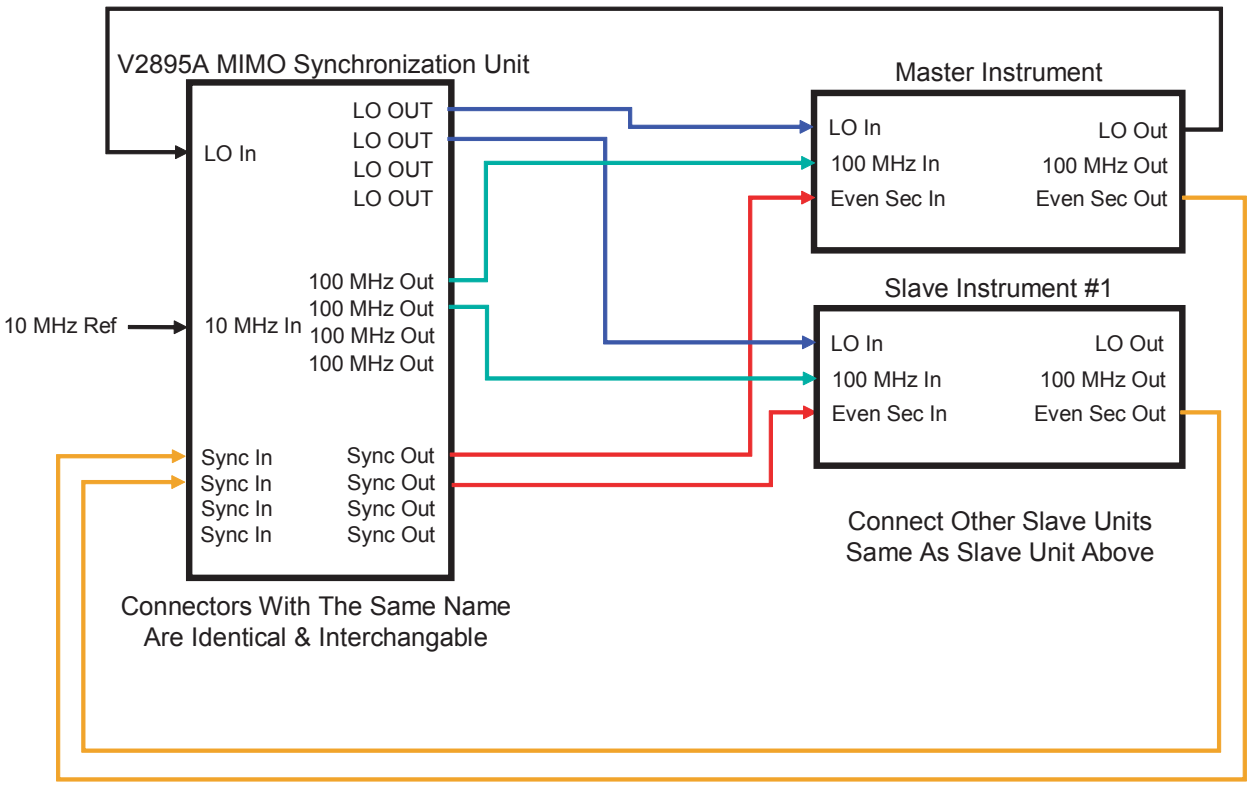
Model 2895 Specifications

To view the latest version of SPEC-2895, go to www.agilent.com/find/V2895A.

Setting up the V2895A

To set up the MIMO system:

1. Connect the system equipment, using the cable configuration shown in the figure below.
    - 100 MHz clock
    - LO signal
    - Sync In signal received from each instrument
    - Sync Out signal sent to each instrument



One instrument acts as the leader (or master), and provides all of the instruments in a MIMO system with a local oscillator (LO) signal. This instrument is identified as the master LO instrument. The MIMO synchronization unit takes the LO signal from the master instrument and distributes it to all the instruments in the group (the slaves).

2. The MIMO system instruments can be powered up at the same time if desired, or individually.

NOTE: If you power up the instruments individually, power them up in the following order:

   a. V2895A Synchronization Unit(s); these units supply the clock signals for the other instruments
   b. All master instruments
   c. All slave instruments

3. On each VSG, set the following parameters:
   a. Selec t RF: **On**.
   b. For the master instrument, select **Menu** > **Global Settings** > **MIMO** > **Mode** > **Master** > **Close**.
   c. For each of the slave instruments, select **Menu** > **Global Settings** > **MIMO** > **Mode** > **Slave** > **Close**.
   d. For master and slave instruments, select **Menu** > **Global Settings** > **Trigger** > **Trigger Mode** > **Trigger start of Arb waveform** > **Close**.

4. On each VSA, set the following parameters:
   a. Select **Spectrum** > **General Purpose** > **Zero Span**.
   b. Select **Sweep Single**.
   c. For the master instrument, select **Menu** > **Global Settings** > **MIMO** > **Mode** > **Master** > **Close**.
   d. For each of the slave instruments, select **Menu** > **Global Settings** > **MIMO** > **Mode** > **Slave** > **Close**.

To Load ARB Waveforms and Synchronize the VSGs

1. Starting with the Master VSG, load the same arbitrary waveform file into each instrument's waveform playback table.
2. Cho ose **Select Modulation** > **Arb** > **Add Arb** > **Add Arb File**.
3. Locate and load the *.arb file:
   - If the file is in the User directory, select the filename and then select **Open** > **Load**.
   - If you do not see the file that you want in the User directory, open the Look in: drop-down menu and select the directory where the file is located. Select the filename and then select **Open.**
4. On each VSG, clear **Modulation On** to turn *off* the modulation.
5. Select **Modulation On** to turn on the modulation for each of the slave VSGs.
6. Select **Modulation On** to turn on the modulation for the master VSG.
7. Select **Menu** > **Global Settings** > **Trigger** > **Trigger Now** on each slave VSG to create a trigger event.
8. Select **Menu** > **Global Settings** > **Trigger** > **Trigger Mode** > **Trigger start of ARB waveform** > **Close** on the master VSG.

To Center the Burst across the VSA Display

On the master VSA, select the following parameters:

1. Select **Menu** > **Global Settings** > **Trigger** > **Trigger Source** > **Video** > **Close**.
2. Clea r the **BW Auto** check box, then double-click **Bandwidth** > **Set to Max**.

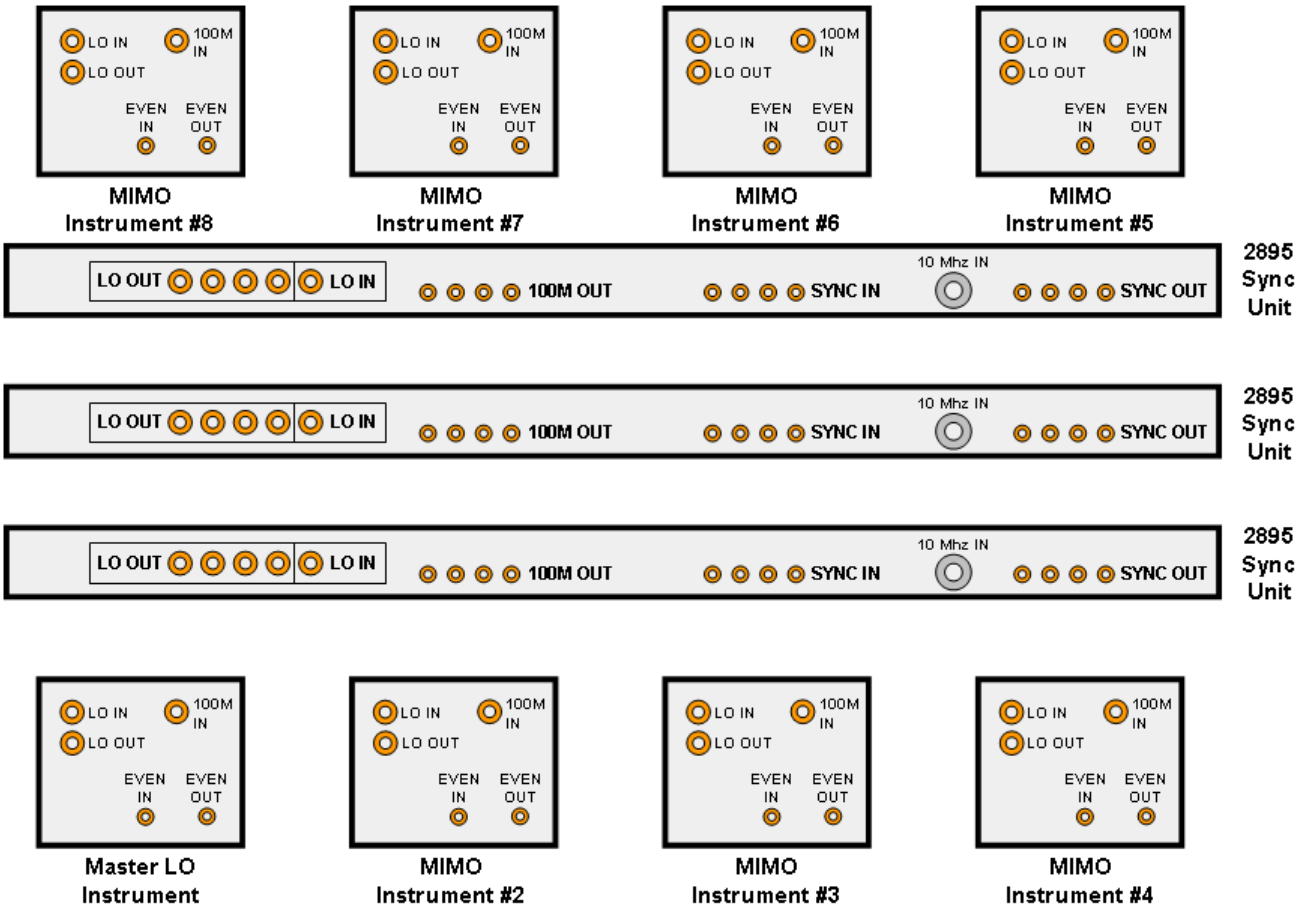
Adjust the Master VSA to view a complete burst on the VSA display

1. Select **Sweep Time** and adjust the value to see a burst on the VSA display.
3. Visually measure the width of the burst on the screen by counting the number of vertical divisions across the displayed burst.
4. Multiply the number of divisions you counted by the scale per division. Then, set the master VSA sweep time to the value calculated in the previous step.
5. Select **Menu** > **Global Settings** > **Trigger** > **Trigger Delay** and adjust the delay value to view the entire burst on the display.
6. Select Close.
7. Select Sweep Single to take a measurement sweep and see if the entire burst is centered on the VSA display. If necessary, adjust the sweep time and trigger delay values.
8. Set the slave VSA's trigger source, sweep time, and trigger delay settings to the same values that you used for the master in the previous steps.

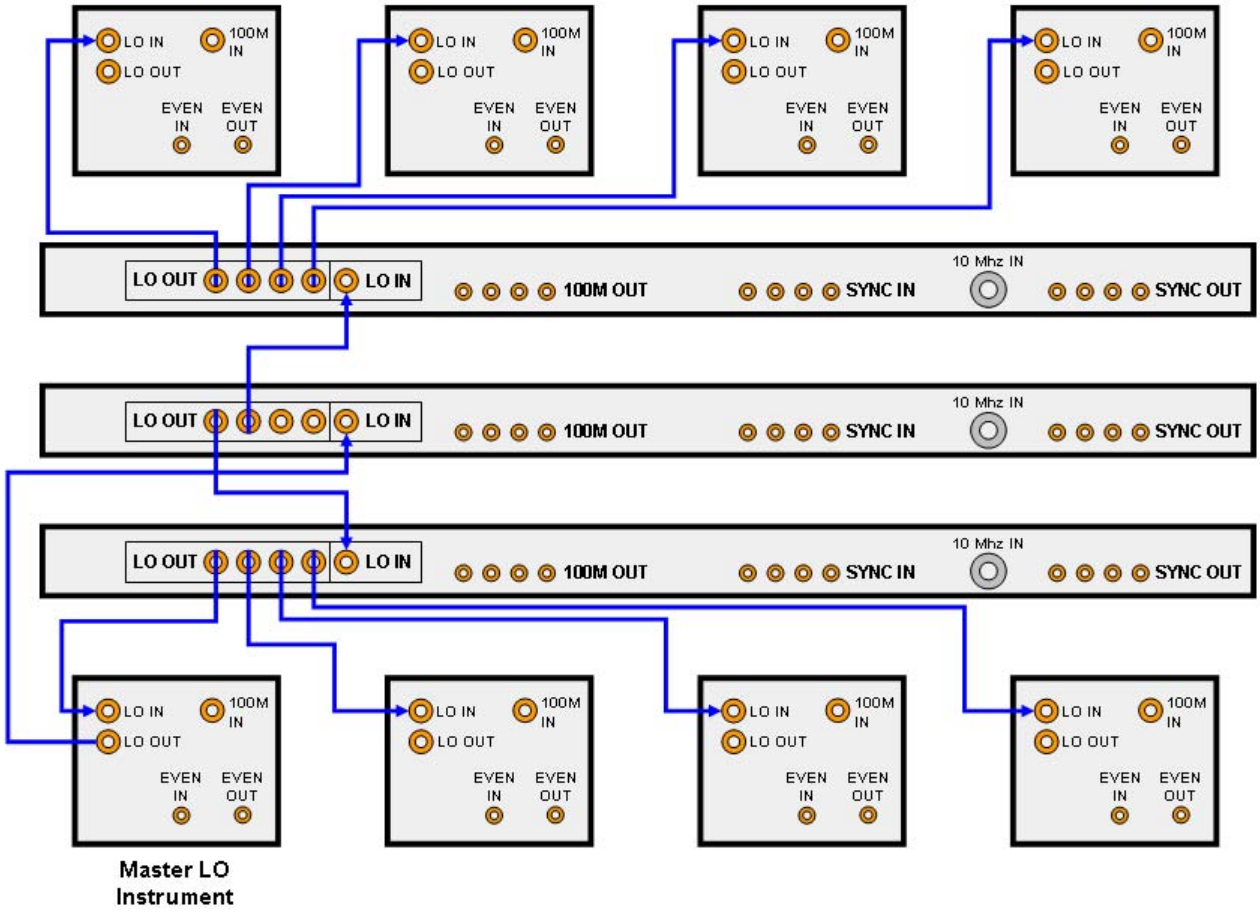
5x5 to 8x8 MIMO Systems

Systems larger than 4x4 need more ports than one V2895A MIMO Synchronization Unit can supply. Consequently, larger systems daisy-chain three synchronization units together. The wiring diagrams for these systems are also different as shown in the following diagrams. Two special length SMB cables are used for the center synchronization unit's Sync In and Sync Out connectors. These cables are identified in purple on the Sync & Trigger Signal Distribution diagram below.

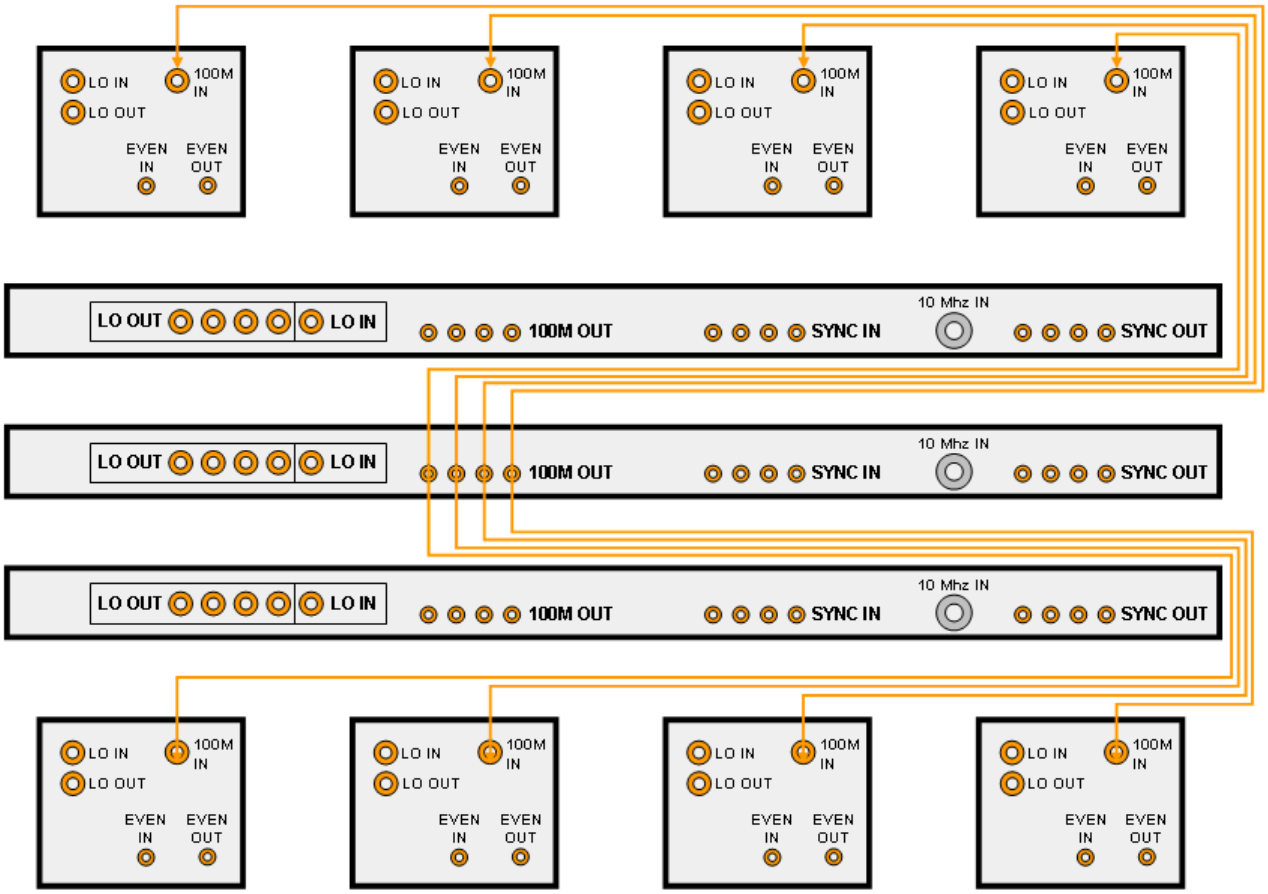
Agilent 8x8 MIMO System Components



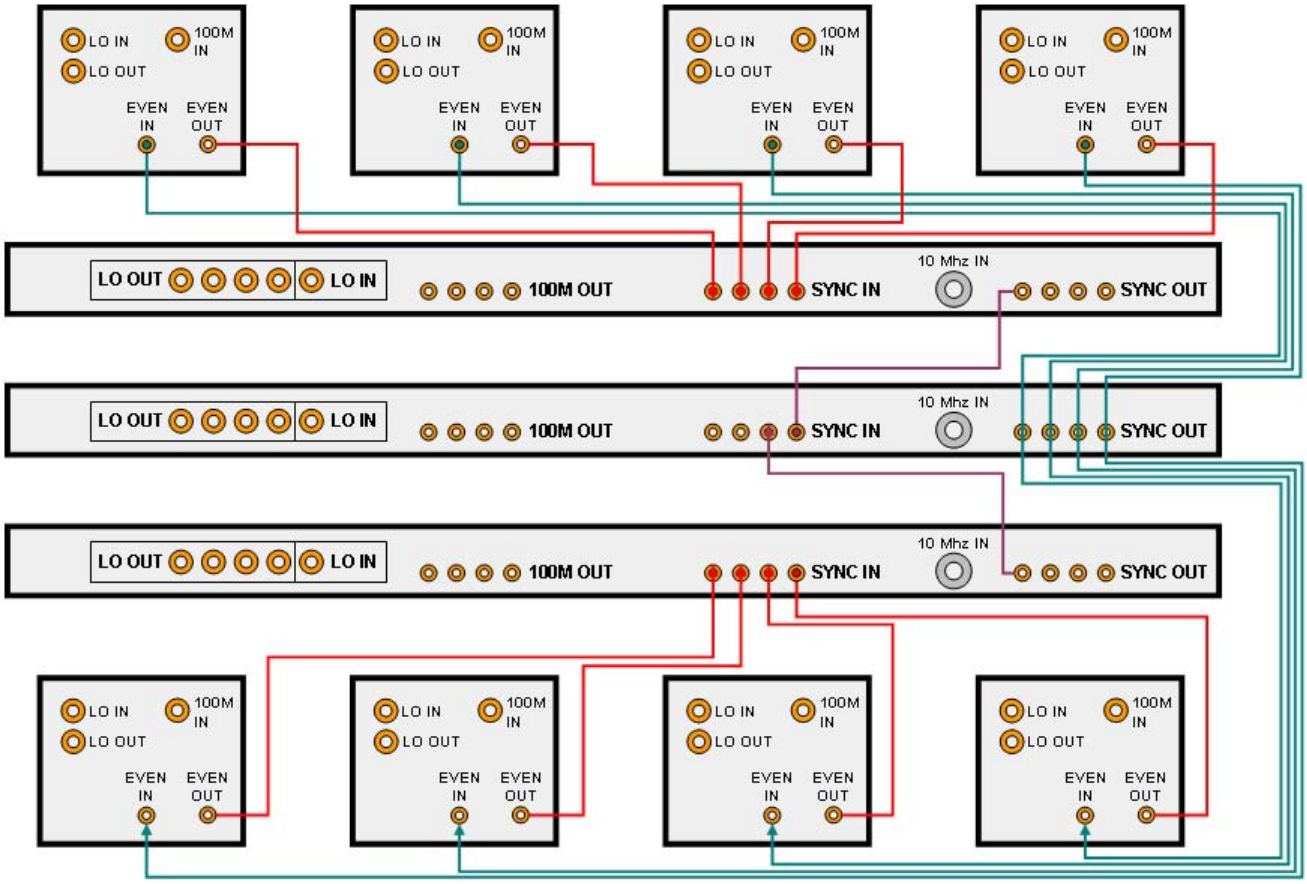
LO Distribution



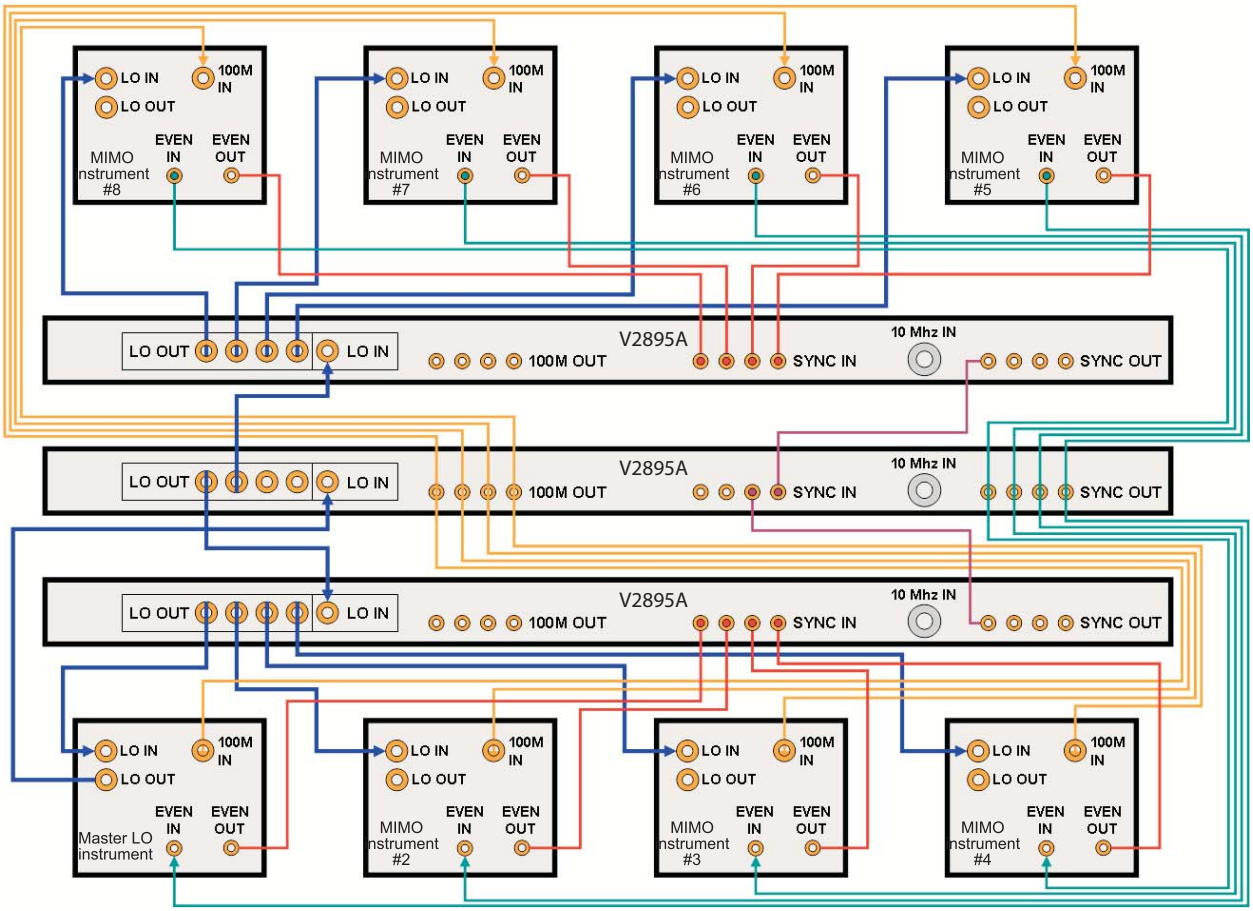
100 MHz Clock Distribution



Sync and Trigger Signal Distribution



Full Connectivity Diagram



Blue lines ..... LO distribution
Orange Lines ..... 100 MHz clock distribution
Green Lines ..... sync and trigger signal distribution
Red Lines ..... trigger signal distribution
Purple Lines ..... sync and trigger signal distribution

MIMO System Manual Test Procedure

For testing purposes, there are three types of MIMO configurations:

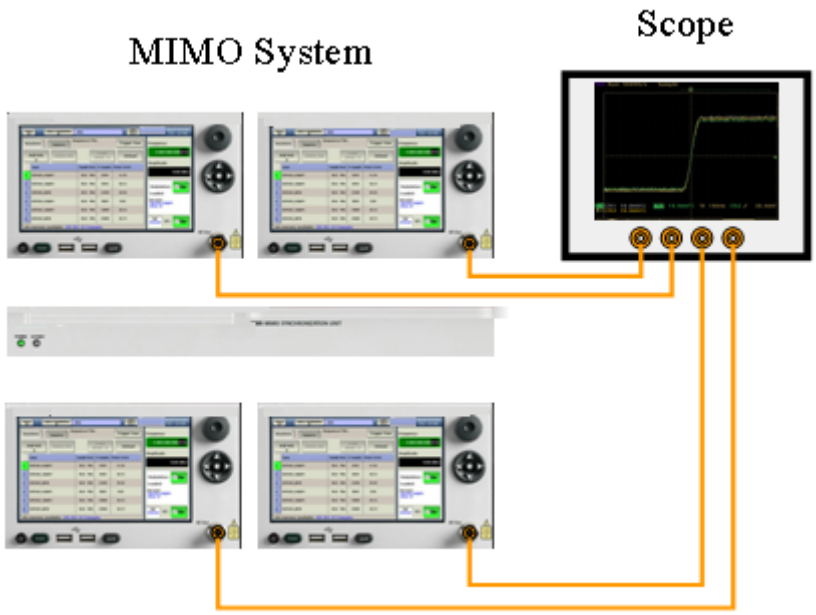
- *V2920A VSG Only Systems*
- *V2820A VSA Only Systems*
- *V2920A VSG and V2820A VSA Systems*

Since a defective cable, miswired connection, or an incorrect setting could prevent a MIMO system from working, it is best to perform a manual system functionality check.

V2920A VSG Only Systems

Use a oscilloscope to check the RF signals and signal alignment. For a basic functionality check, a 400 MHz or better oscilloscope is sufficient.

1. Connect the VSG RF outputs to the oscilloscope inputs as shown.
2. Turn on all of the oscilloscope channels that are being used.
3. Perform the tests as follows. If any of the tests fail, refer to *Troubleshooting Tips*.



VSG Only Systems Step 1

1. Cycle the power on all instruments.
2. Check that there are no error messages on the VSG displays.
3. Press the RF On button on each VSG.
4. Verify that every VSG is generating a signal.
5. If any problems are found, go to *Troubleshooting Tips for VSG Systems Step 1*.

VSG Only Systems Step 2

1. On each unit create a distinctive waveform so that the signal alignment can be displayed.
2. On the VSG select Modulation > Digital > ASK > Load.
3. If ASK is not available you can use Analog > Pulse. You can also use ARB to load a waveform and then set the highest possible sample or pulse rate.
4. Select Edit > Symbols/s > Press the Middle Puck Button to open the number pad > Set to Max > Load > Close.
5. All VSGs should be generating waveforms that are out of synchronization with each other. If not, go to *Troubleshooting Tips for VSG Systems Step 2.*

VSG Only Systems Step 3

Perform the following sequence on each VSG.

1. Select **Menu** > **Global Settings** > **MIMO**.
2. Set the master LO VSG to **Master** and the other VSGs to **Slave** and then select **Close**.
3. Select **Menu** > **Global Settings** > **Trigger** > **Trigger Mode** > **Trigger start of arb waveform** to setup the trigger state.
4. Turn **Modulation** to off by clearing the checkbox and then select the checkbox to turn Modulation back On again.
5. Once steps 1 through 4 have been done for each VSG, select **Trigger Now** on each unit.

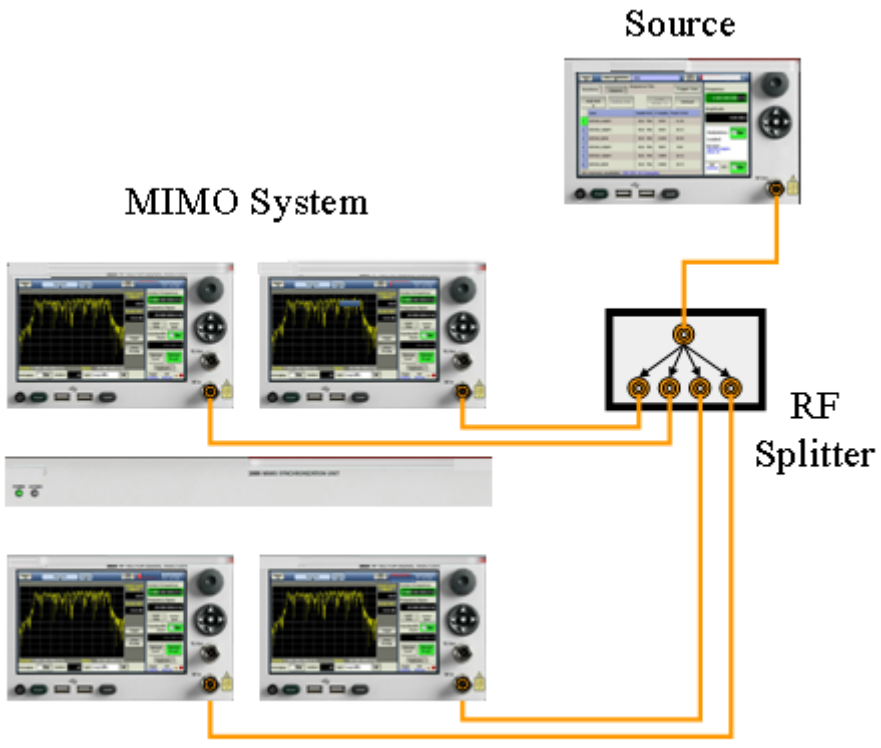
All VSGs should start generating waveforms that are in synchronized with each other as shown on the oscilloscope, if not go to *Troubleshooting Tips for VSG Systems Step 3*.

V2820A VSA Only Systems

A VSG with an RF splitter can be used to create identical RF signals that are fed to each of the VSAs.

Note: A 1 x 4 splitter is shown in the diagram. If you only have a 1 x 2 splitter available, you can verify two units at one time.

1. Connect the VSG RF Out to the RF Splitter In.
2. Connect the RF Splitter outputs to the VSAs as shown.
3. Perform the following tests.
4. If any of the tests fail, refer to *Troubleshooting Tips*.



VSA Only Systems Step 1

1. Power cycle all VSAs
2. Check that there are no error messages on the VSA displays.
3. Set the source to generate a signal where the alignment can be easily measured. For example,
   - Set RF On.
   - Selec t Modulation > Digital > ASK > Load.
   - Selec t **Edit** > Press the **Middle Puck Button** to open the numeric keypad > **Symbols/s** > **Set to Max** > **Load** > **Close**.
4. .Check that each VSA is receiving the VSG signal.
5. If any problems are found go to *VSA Only Systems Step 1*.

VSA Only Systems Step 2

1. Select **Spectrum** > **General Purpose** > **Zero Span**. To set all of the VSAs to zero span.
2. Enter a sweep time of 4 ms.
3. Set the maximum bandwidth (40 MHz).
4. Select **Single Sweep**.

All VSAs should see pulses in the ASK signal, however, the displayed waveforms probably will not be aligned. If a problem is encountered, go to Troubleshooting Tips for VSA Systems Step 2.

VSA Only Systems Step 3

On each unit:

1. Select **Menu** > **Global Settings** > **MIMO**.
   - for the master LO VSA, select **Master**.
   - for all other VSAs select **Slave**.
2. Select Close.
3. Set all units to Sweep Cont.
4. On the master VSA only, select **Single Sweep**.

Every time you press the master's Single Sweep button you should see the exact same waveform on all the VSAs. If the units freeze or are not synchronized, go to *Troubleshooting Tips for VSA Systems Step 3* for help.

VSA Only Systems Step 4

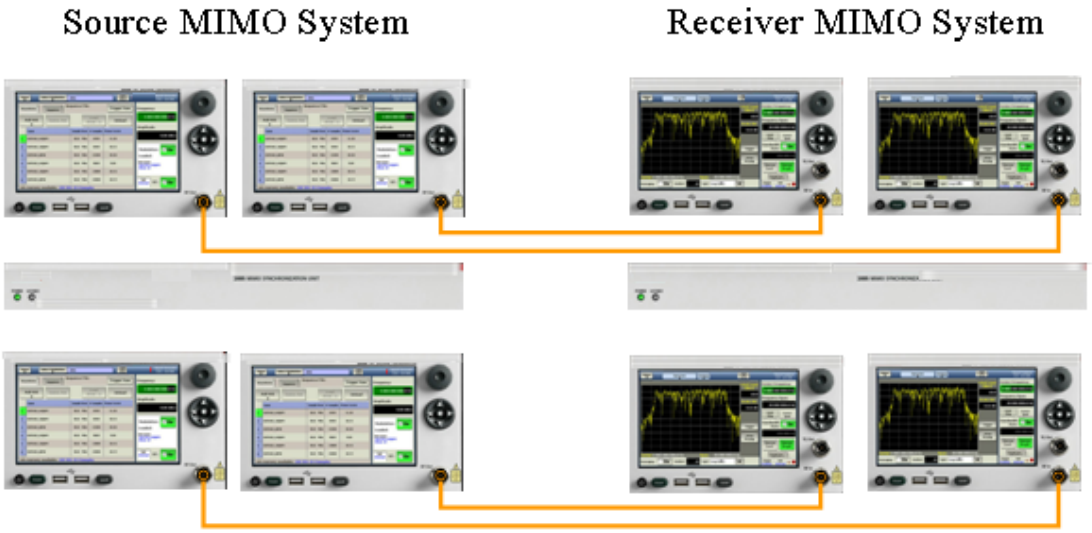
1. Enable triggered measurements on all VSAs by selecting **Trigger** > **Trigger Source** > **Video** > **Close**.

   With all the slave instruments set to Sweep Cont., every press of the master's Sweep Single button should cause all of the units to take a new triggered trace.
2. Verify that all waveforms display the exact waveform with identical alignment. If not, go to *VSA Only Systems Step 4.*

V2920A VSG and V2820A VSA Systems

A Combination VSG and VSA system use the VSAs to view the waveforms to verify if both sides of the MIMO system are properly aligned.

1. Connect each VSG to one of the VSAs. The order does not matter.
2. Go to *V2920A VSG Only Systems* test procedure to set up the VSGs
3. Go *to V2820A VSA Only Systems* to setup the VSAs.



After performing both the VSG only and VSA only setup procedure, all VSAs should display the exact waveform with identical alignment. If you experience problems, go to *Troubleshooting Tips*.

Troubleshooting Tips

Troubleshooting Tips for VSG Systems Step 1

Problem	Possible Causes	Possible Solutions
At power up the VSG reports "Could not init RF Hardware".	The VSG's rear panel 100 MHz clock is not properly connected to the V2895A Synchronization unit.	Check the cable connections.
	The V2895A is not turned on.	Check the power light.
	The V2895A was turned on later (after instruments were turned on.	The sync unit should be powered on before or at the same time as the instruments. The instruments need the 100 MHz clock supplied from the V2895A to be already running when they are powered-on. If the V2895A is turned on after the instruments are turned on the instruments will not start up correctly.
	The VSG's 100 MHz input/outputs are swapped or mislabeled.	Check the cable connections.
	There is a bad 100 MHz cable.	Replace with a known good cable.
No signal appears at the VSA output when MIMO sync is not turned on.	The VSG LO In is missing.	Make sure the VSAs rear panel LO In signal is properly connected to one of the V2895A LO Out connectors. Note: On the bottom of the MIMO menu, a LO power indicator is displayed to detect when the LO power is too low.
	The master VSG LO Out is missing.	Make sure the master's VSG rear panel LO Out signal is properly connected to the V2895A LO In connector.
	The V2895A is not turned on.	Check the power light.
	The VSG LO inputs/outputs are swapped or mislabeled.	Check the cable connections.

Troubleshooting Tips for VSG Systems Step 2

Problem	Possible Causes	Possible Solutions
The VSG RF output or modulation does not start up as expected when MIMO is enabled.	The Front Panel RF button must be On.	
	For modulation, the Modulation button must be On.	
	One of the VSGs is waiting for one of the other VSGs to be triggered.	Trigger all instruments. (That is, if Trigger Source is set to "SCPI or front Panel Trigger") select **Trigger Now** on each VSG then enable **Trigger start of ARB waveform**.
	One of the VSGs does not have MIMO Sync turned on.	Select **Menu** > **Global Settings** > **MIMO**. Set each instrument to either master or slave. Then turn RF modulation on and trigger all instruments.
	One of the V2895As Sync Out lines might not be properly connected.	Make sure all of the VSGs have EVEN Sync In connected to the V2895A Sync Out.
	One of the V2895As Sync In lines might not be properly connected.	Make sure all of the VSGs have EVEN Sync Out connected to the V2895A Sync In.
	One of the Sync cables might be bad or shorted.	Swapping the Sync cables with a known good cable is an option. Another option is removing all of the slave units Even Sec Out to Sync In cable connections; this will disconnect the slave units from the handshaking chain and prevent them from holding up a sweep. Then the master can be run to see if it will sweep correctly by itself. If it works, then add the slave units back in one by one. This can determine if one of these units or its cables is causing the problem.

Troubleshooting Tips for VSG Systems Step 3

Problem	Possible Causes	Possible Solutions
The VSG outputs are not synchronized.	The VSGs might have different firmware revisions.	Load identical firmware into all instruments.
	MIMO sync might not be enabled.	Select **Menu** > **Global Settings** > **MIMO**. Set each VSG to either master or slave as applicable.
	Triggering might not be turned on.	Select **Menu** > **Global Settings** > **Trigger > Trigger start of arb waveform**. Trigger each VSG to start synchronize the outputs.

Troubleshooting Tips for VSA Systems Step 1

Problem	Possible Causes	Possible Solutions
At power up the VSA reports "Could not init RF Hardware".	The VSA's rear panel 100 MHz clock is not properly connected to the V2895A Synchronization unit.	Check the cable connections.
	The V2895A is not turned on.	Check the power light.
	The V2895A was turned on later (after instruments were turned on.	The V2895A should be powered on before or at the same time as the other instruments. The VSAs need the 100 MHz clock supplied from the V2895A to be already running when they are powered-on. If the V2895A is turned on after the VSAs are turned on they will not start up correctly.
	The VSA's 100 MHz input/outputs are swapped or mislabeled.	Check the cable connections.
	There is a bad 100 MHz cable.	Replace with a known good cable.
No signal appears on the VSA display.	The VSA LO In is missing.	Make sure the VSAs rear panel LO In signal is properly connected to one of the V2895A LO Out connectors. Note: On the bottom of the MIMO menu, a LO power indicator is displayed to detect when the LO power is too low.
	The master VSA LO Out is missing.	Make sure the master's VSA rear panel LO Out signal is properly connected to the V2895A LO In connector.
	VSA LO inputs/outputs are swapped or mislabeled.	Check the cable connections.
	There is a bad 100 MHz cable.	Replace with a known good cable.

Troubleshooting Tips for VSA Systems Step 2

Problem	Possible Causes	Possible Solutions
The VSAs hang up and do not sweep.	One of the V2895A Sync Out lines might not be properly aligned.	Make sure all of the V2895A “Sync Out” connectors are properly connected to each VSA EVEN SEC In connectors.
	One of the V2895A Sync In lines might not be properly aligned.	Make sure all of the VSAs have the “Sync Out” connector properly connected to each V2895A “EVEN SEC In" connectors.
	The VSA might be waiting for the master to trigger with either a video or external trigger.	Check if either external or video trigger is set on the master. If it is set to external trigger, verify that an external trigger is being provided. If it is set to video trigger, verify that the video trigger level is set properly, or if an input signal that would provide a trigger is being input.
	One of the VSAs might not have MIMO Sync enabled.	Select **Menu** > **Global Settings** > **MIMO**. Set the VSA to either master or slave as applicable.
	The VSA setup might not be correct.	Try switching the master VSA out of MIMO mode to see if it will operate and trigger on its own. When the setup is corrected go back into MIMO mode.
	One of the Sync cables might be bad or shorted.	Swapping the Sync cables with a known good cable is an option. Another option is removing all of the slave unit's Even Sec Out to Sync In cable connections; this will disconnect the slave units from the handshaking chain and prevent them from holding up a sweep. Then the master can be run to see if it will sweep correctly by itself. If this works, the slave units can be added back in one by one. This can be done to determine if one of these units or cables is causing the problem.

Troubleshooting Tips for VSA Systems Step 3

Problem	Possible Causes	Possible Solutions
The instruments are not synchronized.	The instruments might have different firmware revisions.	Load identical firmware into all instruments.
	MIMO sync might not be enabled.	Turn on under **Menu > Global Settings > MIMO**. While all instruments are in "hold" (not sweeping), set to either master or slave as applicable.
	Triggering might not be set to the exact same mode on all instruments.	Set all instruments to the same triggering mode. Select **Menu** > **Global Settings** > **Trigger**. Note that instruments configured as a slave will ignore this setting and obtain their triggering from the master, but this trigger setting still needs to be set to the same selection on all instruments.
	One of the V2895A sync units "Sync Out" lines might not be properly connected.	Make sure all of the V2895A Sync Out connectors are properly connected to each receiver's EVEN SEC IN connectors.
	MIMO mode might have been enabled when the receivers were in different states.	Switching receivers in MIMO mode while some receivers are sweeping or in different instrument states may put the instrument out of synchronization with each other. To fix this, place all of the instruments in hold (Sweep Single). Next, place all of the receivers into the same instrument state, and then switch all receivers into MIMO mode.

Troubleshooting Tips for VSA Systems Step 4

Problem	Possible Causes	Possible Solutions
The instruments are not synchronized.	Triggering might not be set to the exact same mode on all instruments.	Set all instruments to the same triggering mode. Select **Menu** > **Global Settings** > **Trigger**. Note that instruments configured as a slave will ignore this setting and obtain their triggering from the master, but this trigger setting still needs to be set to the same selection on all instruments.

MIMO Debugging for Control Software

Problem	Possible Causes	Possible Solutions
One or more instruments do not respond to remote commands.	Instrument address is incorrect	With multiple instruments it is easy to have one instrument address wrong. Use the instrument front panels to bring up the addresses and make sure they match the addresses entered into the control software.
	Cables are not properly connected	Ensure that all communications cables are present, fully inserted, and latched or fastened.
	Bad cable	Try swapping cables with an instrument that is able to communicate to see if the cable is defective.
	Instruments do not respond	Cycle the power on all instruments.
MIMO decoding software cannot detect all of the MIMO channels.	The sources are transmitting a non-MIMO ARB file.	A MIMO ARB file contains channel information for each source/antenna, but that information is missing from a non-MIMO ARB file.
	Some sources have been loaded with the same MIMO ARB file.	To emulate multiple MIMO transmit channels, or antennas, it is necessary to use unique ARB files in each source. MIMO ARB files contain channel information and each source must use an ARB file that broadcasts different channel information.

MIMO Signal Descriptions and Troubleshooting Tips

Signal Descriptions	Troubleshooting Tips
The 100 MHz clock is used to run the instrument's internal hardware. This is provided so the clocks in every instrument in a MIMO group will run in synchronization.	Since this clock runs the instrument's internal hardware, if this signal is not connected to the instrument (or if the v2985A is turned off) the instrument will not run and display the error "Could Not Init RF Hardware".
The common LO Carrier signal is provided by the "master LO" instrument, and is distributed back to all instruments so every instrument's carrier phase is synchronized exactly and does not deviate or jitter.	If this signal is not correctly connected, an instrument will not generate a signal at its RF output port. On the V2895A menu, a LO power indicator is displayed to detect when the LO power is missing. Since the LO signal is common to all of the instruments, "slave" instruments must be set to the identical instrument configuration settings as the "master" instrument, or "slave" instruments will not use this LO signal correctly.
The V2895A's "Sync In" input signal informs the V2895A when an instrument is ready to proceed. The signal runs from an instrument's "Even Sec Out" port to one of the V2895A's "Sync In" ports.	If an instrument is not in MIMO mode, or if the instrument is not programmed correctly, then this "ready to proceed" signal might be in the wrong state, which could prevent the MIMO group from starting.
The V2985A's "Sync Out" signal tells the instruments when to start generating signals (for VSGs), or when to start or end measurements (for VSAs). It connects to the instrument's "Even Sec In" port.	An instrument might freeze and refuse to trigger in MIMO mode if this signal is not properly connected.

Section 3: Using SignalMeister™

Introduction to SignalMeister™

The Agilent V2901A SignalMeister RF Communications Test Toolkit is a PC-based software tool that allows you to easily create and analyze complex signals used in advanced wireless transmission protocols.

SignalMeister software works seamlessly with Agilent Series V2900 Vector Signal Generators, Series V2800 Vector Signal Analyzers, and MIMO test systems.

Using a waveform file created with SignalMeister software requires one or more Series V2900 VSGs equipped with an arbitrary waveform generator (ARB) option and a SignalMeister license option that matches the waveform signal standard of the file being used.

Analyzing the signals created by the waveform files requires a Series V2800 VSA equipped with the appropriate license options, or a SignalMeister Signal Analysis license. There are two SignalMeister signal analysis software licenses available: The WLAN Analysis license (V2901A-WLN) and the WiMAX Analysis License (V2901A-WMX).

Supported Wireless Transmission Formats

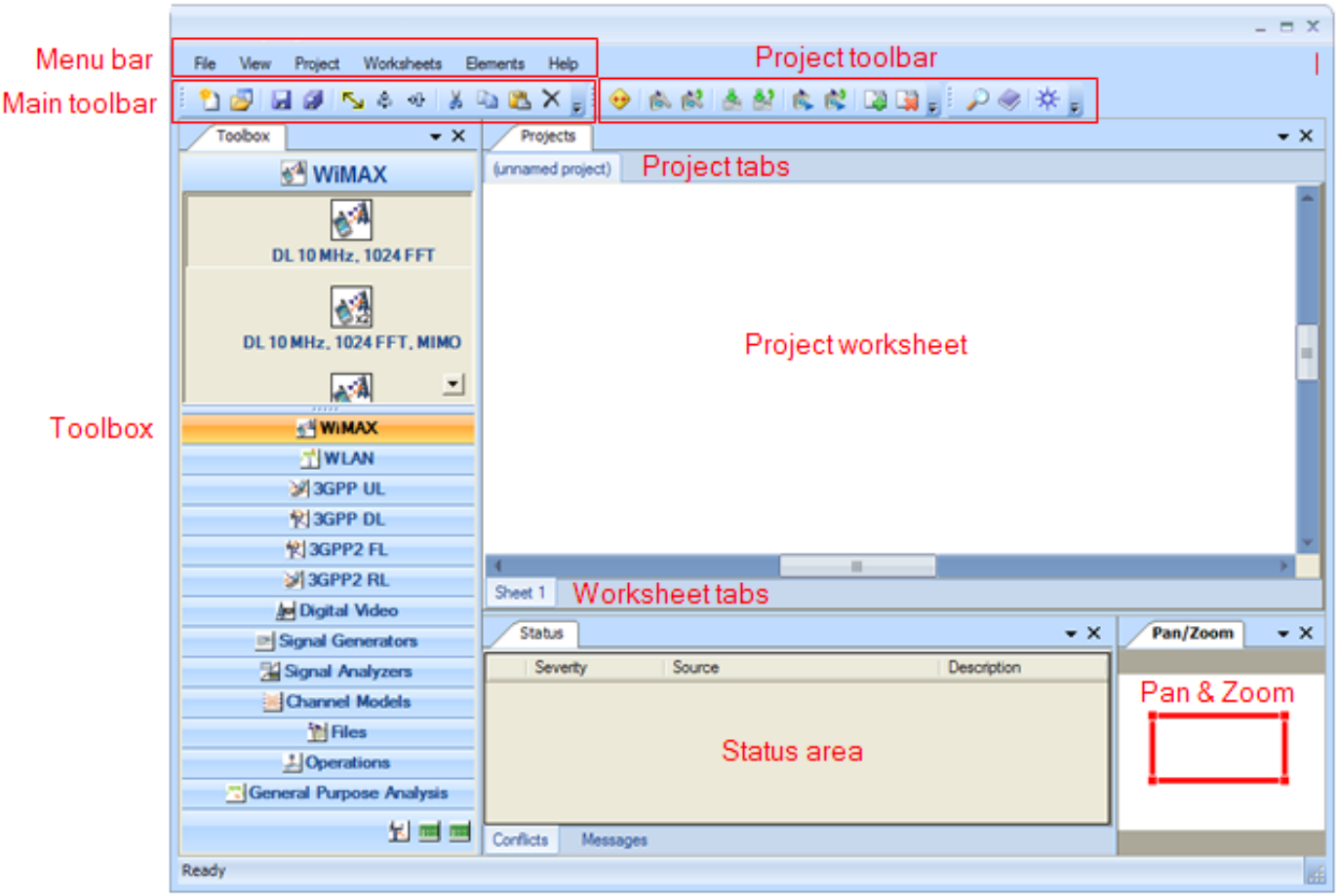
WLAN	802.11a/g/j/pj 802.11b 802.11n MIMO 802.11n SISO
WiMAX®	802.16e OFDMA
3GPP	W-CDMA HSDPA HSUPA
3GPP2	cdma2000® cdmaOne® 1xEV-DV
DVB	DVB-T DVB-H

Note: All Agilent Series V2900 vector signal generators require firmware revision 3.11 or higher to be compatible with Agilent V2901A SignalMeister RF Communications Test Toolkit.

To learn more detail about using SignalMeister software, refer to the SignalMeister Help system.

Application Interface Overview

When the Agilent V2901A SignalMeister RF Communications Test Toolkit is first launched, the user interface displays the default docking station layout shown below.



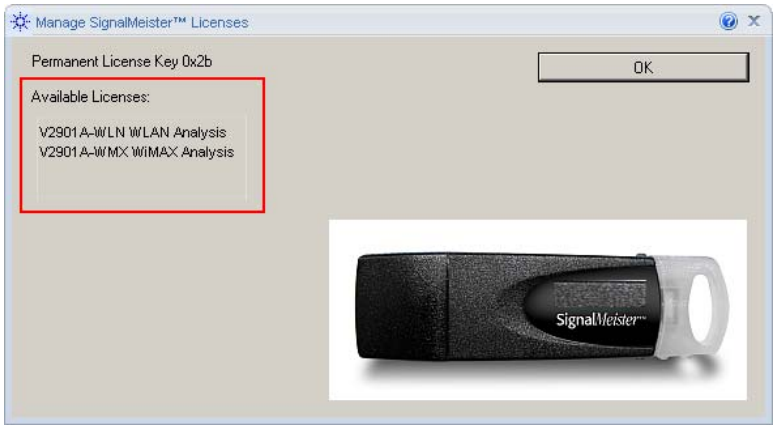
Each of the windows has a docking function, allowing each of the windows to be docked in a new location, hidden from view, or “floating” allowing them to be moved to any convenient location on the screen.

NOTES:

- To restore the default docking layout to the application interface, select **View > Restore Docking Layout** from the Menu Bar. You can also restore the layout for individual windows from the View menu.
- SignalMeister’s analysis feature cannot be operated using Desktop Control Panel.

SignalMeister licenses

Displays the licenses available on your <SM> RF Communications Test Toolkit. The SignalMeister permanent license key serial number is also displayed. If you are using an evaluation license key, the expiration date of the key is displayed. Contact your <company> representative about adding other licenses.



Signal Generation Software Licenses

The Series V2900 Vector Signal Generators can play back waveforms that are generated from the SignalMeister RF Communications Test Toolkit when the correct licenses are installed. To play back a SignalMeister software-generated waveform with a specific channel added and "Enabled" in the SignalMeister signal definition dialog box, you will need to have both the correct type of waveform playback license and a valid arbitrary waveform generator license loaded on your Series V2900 VSG.

To view the current instrument option licenses on the Agilent Series V2800 VSA and the Series V2900 VSG, select **Menu > Utilities > Licensing** from the front panel of the instrument.

To view the current SignalMeister licenses select **File > Manage Licenses** from the SignalMeister main menu.

See the following tables for available licensing options.

WLAN Licensing

License Model Number	License Identifier	Waveform Types	Additional Licenses Required
V2900A-205	802.11a/b/g/j Signal Generation	802.11a, b, g, j	V2920A-B20 *
V2900A-206	802.11N Signal Generation (MIMO and SISO)	802.11n	V2920A-B40 * V2900A-205
V2900A-207	802.11N Channel Modules A through F	WLAN	V2920A-B40 *

* Minimum ARB generator bandwidth. The ARB number may be larger, for example, V2920A-B20 may use V2920A-B40 or V2920A-B80.

WiMAX® Licensing

License Model Number	License Identifier	Waveform Types	Additional Licenses Required
V2900A-208	802.16E Signal Generation	802.16e-2005	V2920A-B40 *
V2900A-209	802.16E Channel Model Signal Generation	802.16e-2005	

* Minimum ARB generator bandwidth. The ARB number may be larger, for example, V2920A-B40 may use V2920A-B80.

3GPP Licensing

License Model Number	License Identifier	Waveform Types	Additional Licenses Required
V2900A-202	WCDMA Signal Generation	WCDMA	V2920A-B20 *
V2900A-204	3GPP Channel Model Signal Generation		
V2900A-203 **	HSPA Plus Signal Generation (uplink and downlink)	HSDPA HSDPCCH HSDPAFRC HSUPA HSUPAFRC EHICH ERGCH EAGCH	V2920A-B20 * V2900A-202 V2900A-105

* Minimum ARB generator bandwidth. The ARB number may be larger, for example, V2920A-B20 may use V2920A-B40 or V2920A_B80.

** If you have the previous HSPA licenses, 2900-HSDPA-PC and 2900-HSUPA-PC, either one of these will enable the same functionality as V2900A-203.

3GPP2 Licensing

License Model Number	License Identifier	Waveform Types	Additional Licenses Required
V2900A-201	CDMA Signal Generation	cdmaOne cdma2000 1xEV-DV	V2920A-B20 * V2900A-104

* Minimum ARB generator bandwidth. The ARB number may be larger, for example, V2920A-B20 may use V2920A-B40 or V2900A_B80.

Multi-Purpose Licensing

License Model Number	License Identifier	Waveform Types	Additional Licenses Required
V2900A-213	DVB Signal Generation	DVB-H DVB-T	V2920A-B20 *

* Minimum ARB generator bandwidth. The ARB number may be larger, for example, V2900A-B20 may use V2900A-B40 or V2920A_B80.

Signal Analysis Software Licenses

The V2901A SignalMeister RF Communications Test Toolkit software can be used to perform signal analysis functions when the correct licenses are installed in SignalMeister. The signal analysis licenses reside in the V2901A SignalMeister USB license key.

License Model Number	License Identifier	Waveform Types	Additional Licenses Required
V2901A-WLN	WLAN Analysis	802.11a,b,g,j,n-SISO 802.11n-MIMO	none
V2901A-WMX	WiMAX Analysis	802.16e-2005	none

For more information about purchasing SignalMeister licenses, please visit the SignalMeister support page at http://www.agilent.com/find/V2901A.

Basic SignalMeister Tasks

Working with Elements

NOTE: The elements provided in the Toolbox groups are samples that you can use as they are, or you can customize them for your particular testing needs. When viewing elements in the toolbox, remember that an element's label only indicates its present configuration. You can place an element on your worksheet and modify its properties as you see fit. If you modify an element, we suggest you *edit the element's label* so that it more accurately indicates how you have customized it or its relevance to your project.

The elements in the SignalMeister toolbox are the building blocks used to:

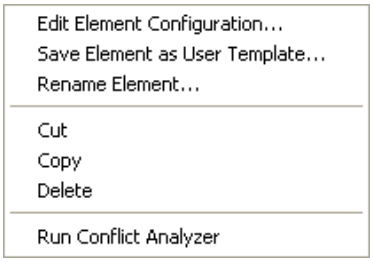
- Define and process an arbitrary waveform file in one of the several available signal formats,
- create a waveform file based on your configuration;
- download that waveform file to a signal generator to be played back and analyzed.

Each element, or icon, represents a specific function, or portion, of the waveform creation and playback process, and has a configuration dialog associated with it that allows you to set the parameters for that particular element, based on what the element represents. For example, the FFT size, bandwidth, guard interval, and so on, in a WiMAX® waveform can be configured for your specific waveform design, renamed to easily identify that particular configuration, and then saved to be used again to create other ARB files using a WiMAX element from the Toolbox.

To access the configuration dialog of any element, either double-click the element icon or right-click the element icon then select **Edit Element Configuration...** from the pop-up menu (below).

Other items from the right-click menu include:

Menu Item	Function
Edit Element Configuration...	Opens the configuration dialog window of the selected element.
Save Element as User Template...	Opens a dialog window that allows you to save the selected element as a user template. The dialog window provides you the opportunity to specify a template name and location for the saved element. The template is displayed in the My Templates toolbox with the icon of the selected element. **NOTE:** If the user template is stored in any location other than C:\Program Files\Agilent Technologies\Agilent SignalMeister\Item Templates\User Templates, it will function as a template, but will not be shown in the My Templates toolbox.
Rename element...	Opens the Rename dialog that allows you to change the name of the selected element.
Cut	Removes the selected element from the worksheet and places it on the system clipboard.
Copy	Places a copy of the selected element on the system clipboard.
Delete	Deletes the selected element.
Run conflict analyzer	Runs the conflict analyzer only on the selected element, not the entire worksheet. This is particularly valuable when checking for channel and code conflicts.

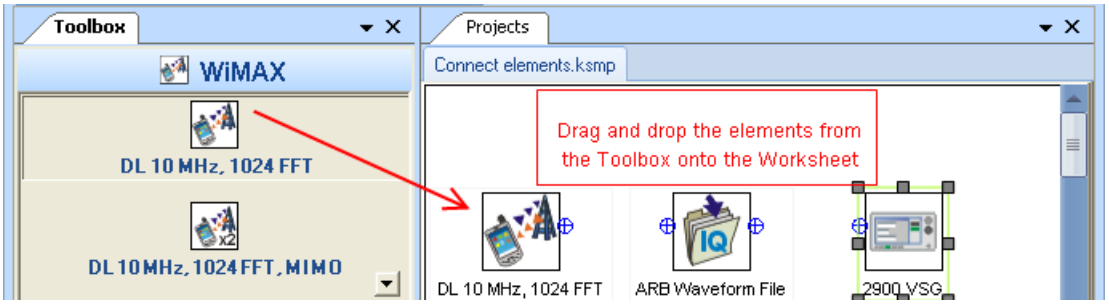


Connecting Elements

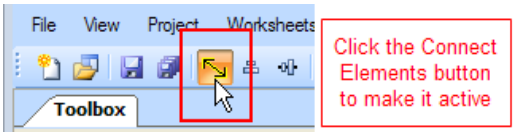
Select the **Connect Elements** icon in the tool bar to begin the sequence of connecting one or more elements together in your project. When **Connect Elements** is active , begin by selecting the sink element, then select the source element to connect the two items. You can drag and drop multiple elements onto your worksheet, then connect them all as one step.

For example, to connect a WiMAX element, an **ARB File** element, and a **2900 VSG** element together you would:

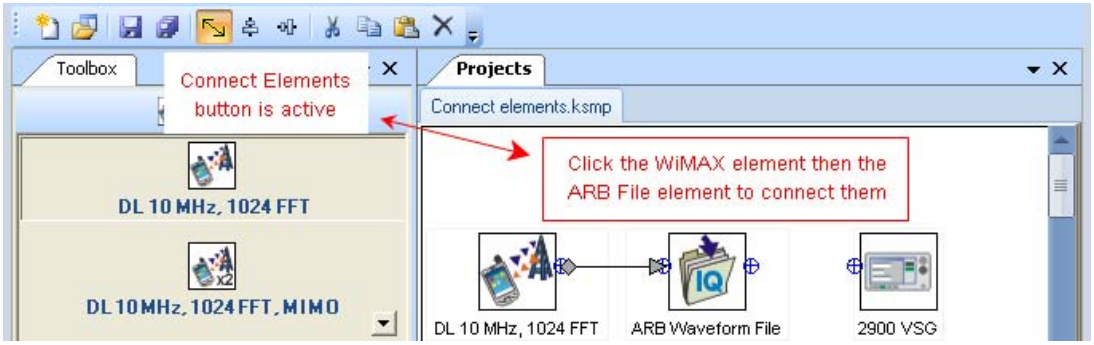
1. Drag and drop the elements from the Toolbox to the Projects worksheet.



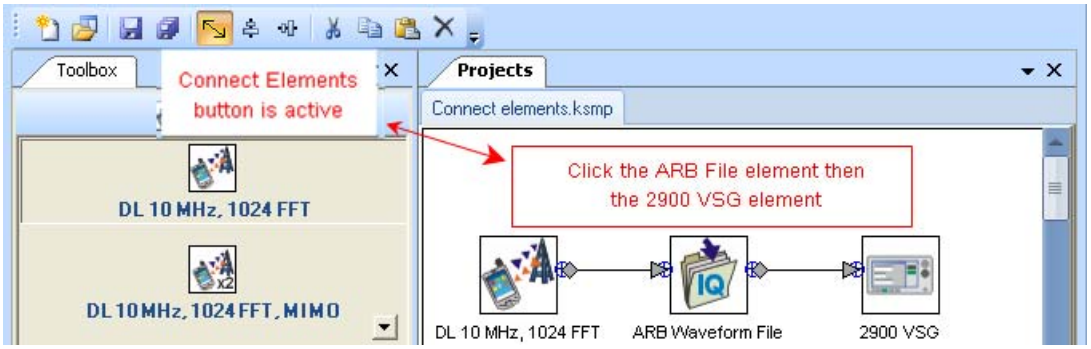
4. Select the **Connect Elements** button to make it active.



5. Click the WiMAX® element.
6. Click the ARB file element (these are now connected).



7. Click the ARB file element again.
8. Click the signal generator element (all three elements are now connected).



Renaming Elements

NOTE: The elements provided in the toolboxes are samples that you can use as they are, or customize for your particular needs. When viewing elements in the toolbox, remember that an element's label only indicates its present configuration. You can place an element on your worksheet and modify its properties as you see fit. If you modify an element, we suggest you *edit the element's label* so that it more accurately indicates how you have customized it or its relevance to your project.

Select **Rename Element** to assign a unique, easy to remember name for your element. This is particularly useful after you have customized the settings for any element, and want to save those changes for future use.

Creating an Element Shortcut

1. In the Worksheet, click on a element or a group of elements to highlight
2. Right-click on the element and select **Copy** from the shortcut menu.
3. From the main menu, click **Worksheets** > **Paste as Shortcut**.

Notice that the new element or group of elements has a yellow boarder identifying it as a shortcut.

Using the Frequency Shift Element

SignalMeister generates signals at the baseband frequency. When they are played back on the V2900 Vector Signal Generator (VSG), their frequency spectrum is centered on the carrier frequency of the VSG.

Ideally, to generate interferer or jamming signals, you would use multiple VSG instruments. However, if you have only a single VSG you can generate a single ARB file with both a desired signal and an interferer, with some limitations. The jamming signal can only be a maximum of half the ARB generation bandwidth away from the carrier frequency. Additionally, you will run into resolution issues of the DAC, impairing the signal quality.

Example project

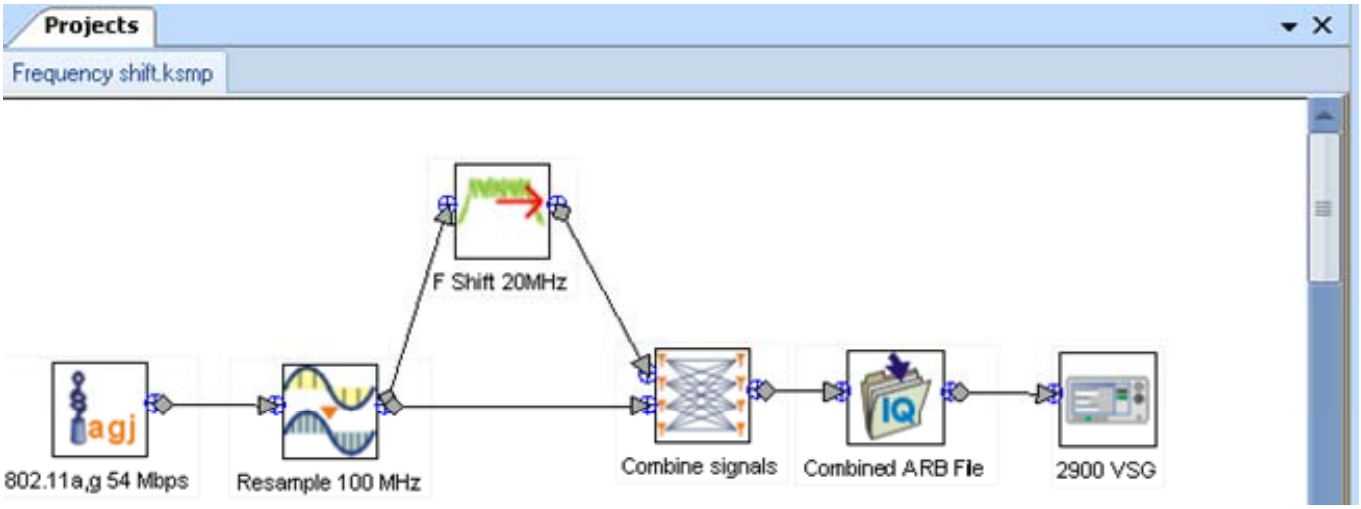
The following example uses an 802.11 WLAN signal in the presence of an identical 802.11 WLAN signal on an adjacent channel 50 MHz away.

Start with an 802.11a,g signal object that is shifting by 20 MHz. This signal must be unsampled, because at the default 50 Msample/s rate used for two 802.11 signals, you are limited to a 40 MHz bandwidth. Shifting a 20 MHz wide 802.11 waveform by 20 MHz would not be possible, because you would be bandwidth limited (20 MHz offset + 20 MHz BW/2 = 50 MHz). Unsampling to 100 Msamples/s allows you to generate waveforms with bandwidth up to 80 MHz total. (That is, 40 MHz offset from each side of the carrier.

Next, the interferer is generated. A frequency shift element with a 20 MHz value is inserted. The output of the resampler is connected to both the frequency shift element and to the channel model element. The channel model element allows you to combine both the frequency-shifted and original 802.11 a,g signals into a single ARB file.

Step 1

Build the project using an 802.11a,g 54Mbps signal with the other elements as shown below.

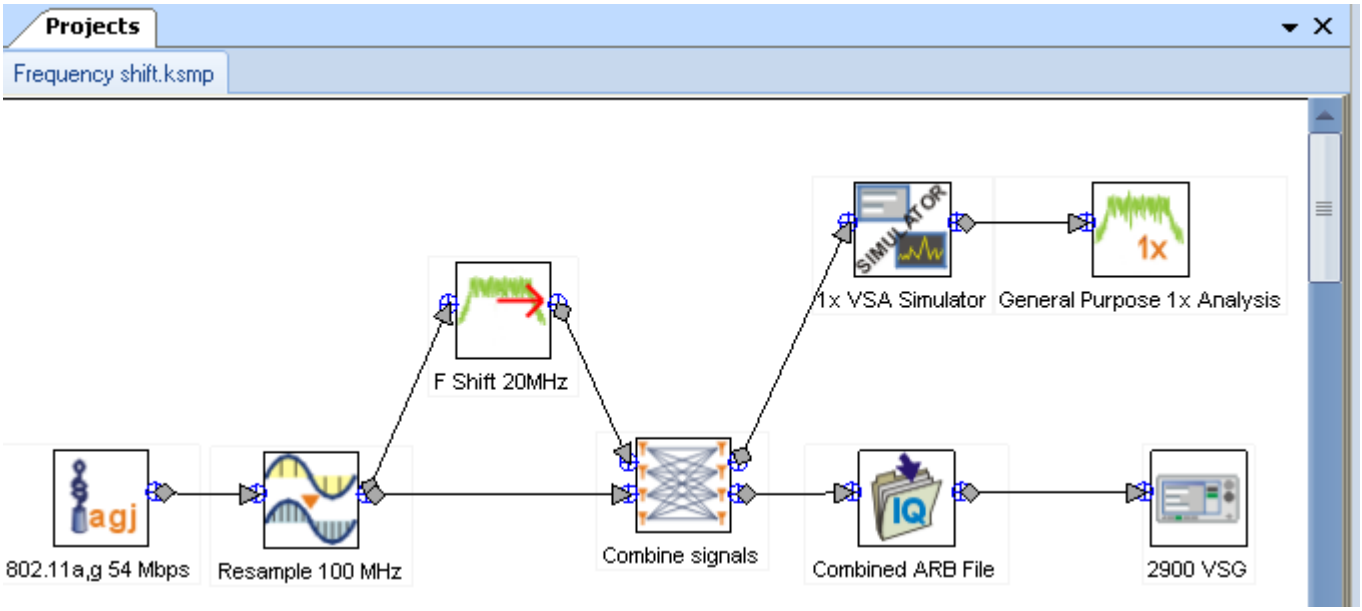


Step 2

Use the Channel Model Configuration to combine main signal with the frequency shift module (3 dB down).

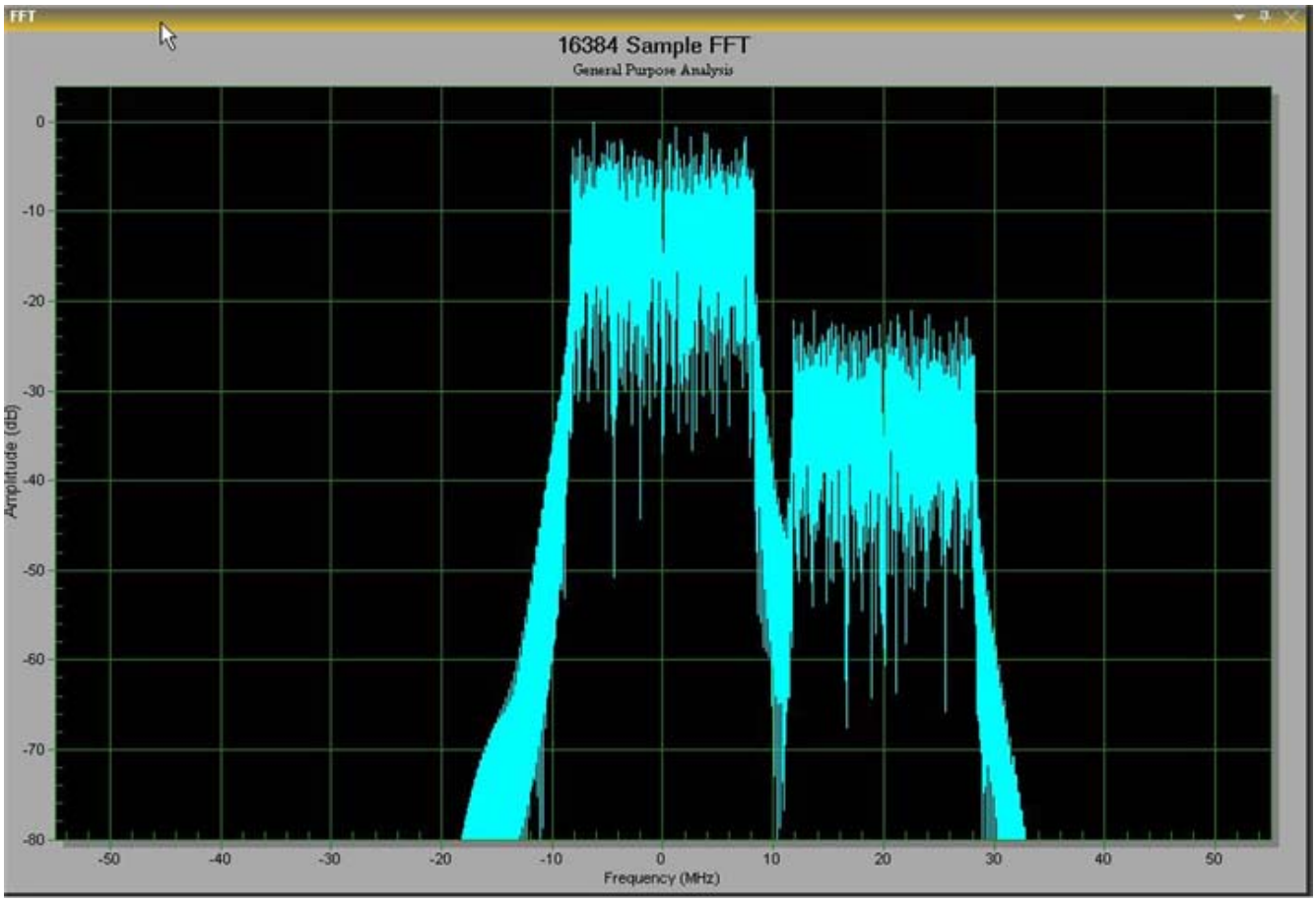
Step 3

Add a VSA Simulator and General Purpose Analysis elements to the project as shown below.



Step 4

Use the General Purpose Analysis element to view the results.



Managing Project Files

SignalMeister uses various file types when creating and executing projects. For example:

- **Project files** (*.ksmp)
- **Component files**, such as ARB files, map files, IQ files, bit reference files, and other data files. These can be a combination of files generated or referenced relative to the project directory, or referenced from an external source (for example, residing on another part of the hard drive, on a network drive, etc.).

IMPORTANT:

If you intend to share or move your SignalMeister projects (for example, email or move them to another computer), be sure to keep all the files located in the same directory as the project (*.ksmp) file, or a subdirectory of the project.

Regardless of how a project is saved or the component files are specified, if all the files are in the same directory as the project, or in a subdirectory of the project, then you can copy that directory (and subdirectory) to any other location and successfully open and use the project from the new location, including a different computer.

However, if a SignalMeister project uses any component file (ARB file, map file, etc.) that is specified in a location other than the project's directory (or subdirectory), then that file must exist in that exact absolute path for that project to be opened and used successfully.

For example, if you save a project in C:\MyProject and it specifies that the component files also reside in C:\MyProject\components, you can compress/zip the entire MyProject directory and move/send it to another computer, where it can be uncompressed/unzipped and used in any location.

Conversely, if you save a project in C:\MyProject and it specifies a user file in your computer's My Documents directory (for example, c:\documents and settings\johndoe\My Documents\) and you send all the files to another computer, the project will report a conflict because the specified user file cannot be found (c:\documents and settings\johndoe\My Documents\ does not exist on the other computer).

Renaming Project Worksheets

There are three ways available to rename the project worksheets; from the Worksheets menu in the menu bar, double-click the worksheet tab to highlight the worksheet name and type in the new name, or right-click the worksheet tab and select Rename Worksheet from the drop-down menu. The following steps explain how to rename a worksheet from the menu bar.

1. From the main menu, select **Worksheets** > **Rename Worksheets**.
2. In the Rename dialog box, enter a new name for the current worksheet.
3. Select **OK**.

Creating Project Templates

Any portion of a SignalMeister project can be saved as a user template allowing easy reuse of project elements. For example, after you have entered the communication addresses for the signal generator and signal analyzer, you could save this to reuse in future projects.

As you configure different test setups, you can save any element, group of elements or complete project as a template. When you first open the SignalMeister software, the My Templates category is not immediately available in the Toolbox, and there are no templates available for use. As soon as you save either a project or an element as a template, the My Templates category is displayed with the saved template available to use in your project.

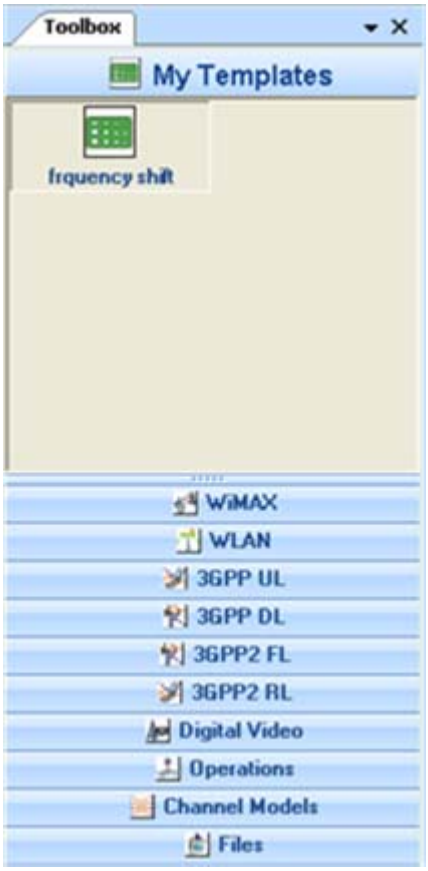
There are two types of templates for use in SignalMeister; a project template (*.ksmp), and an element template (*ksmt):

- A project template is made up of two or more individual elements, and is identified by a green, template icon, as shown in the figure below.
- An element template is a single element that has been configured for your specific needs, and has been saved with that configuration. It is identified by the element icon from which it was created, as shown in the figure below.

NOTE: Only single elements can be saved as an element template. If you want to save more than one element as a template, it must be saved as a project template with the project (*.ksmp) file extension.

Saving a template

1. To save an existing project as a template, right-click anywhere in the Projects worksheet and select Save Project as Template… from the context menu. Alternately, from the main menu select **Projects > Save Project as Template....**
2. To save an existing element (configured for future use), right-click on the element and select Save Element as User Template… from the context menu. Alternately, from the main menu select **Elements > Save element as User Template...**.
3. After the template is saved, SignalMeister automatically creates a "My Templates" group in the Toolbox and places the template in it. In the Toolbox select **My Templates** to view the new user-saved project template or element template.

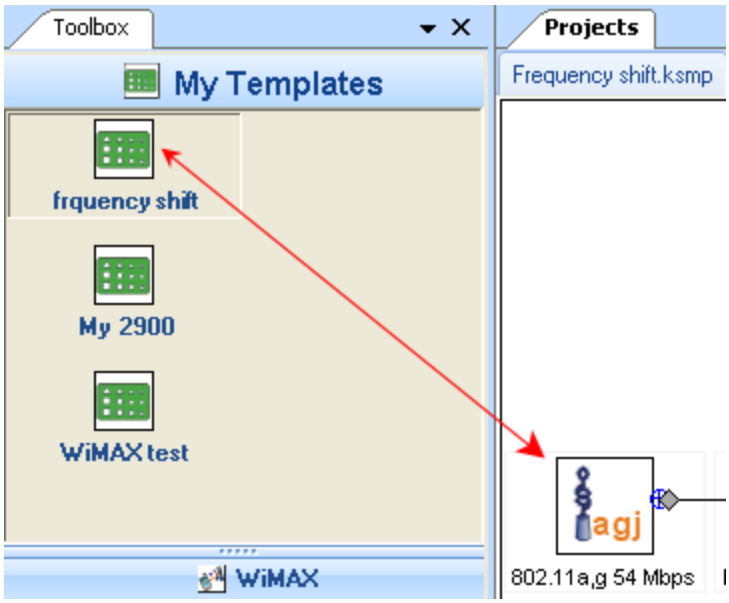


Adding a template to a project

User template elements can be added to projects like any other elements. Once the user template is placed in a project, it will expand into all of the individual elements included in the template. To demonstrate this feature:

1. From the main menu, select Worksheets > Add Worksheet to add a new worksheet into the existing project.
2. Right-click on the Sheet 2 tab and select Rename Worksheet. You rename the worksheet for easy identification of the signal types and ARB file configurations.
3. In the Toolbox, select the template element from the My Templates folder and click and drag it across to the new worksheet.

Notice how the project element expands back into the three individual elements that were saved as the project template.



Deleting a template

To delete a user template, perform the following steps:

1. From the main menu bar, select Elements > Delete User Templates.
2. From the submenu, select the name of the user template you want to delete.
3. As soon as you click the name of the template you want to delete, it will be removed from the My Template category.

Printing a Worksheet

1. From the main menu, select **File** > **Print Worksheet...**
2. From the Print dialog box, select the printer name and specify the **Properties** if needed.
3. Select **OK**.

Tip: You can add descriptive text to a worksheet prior to printing.

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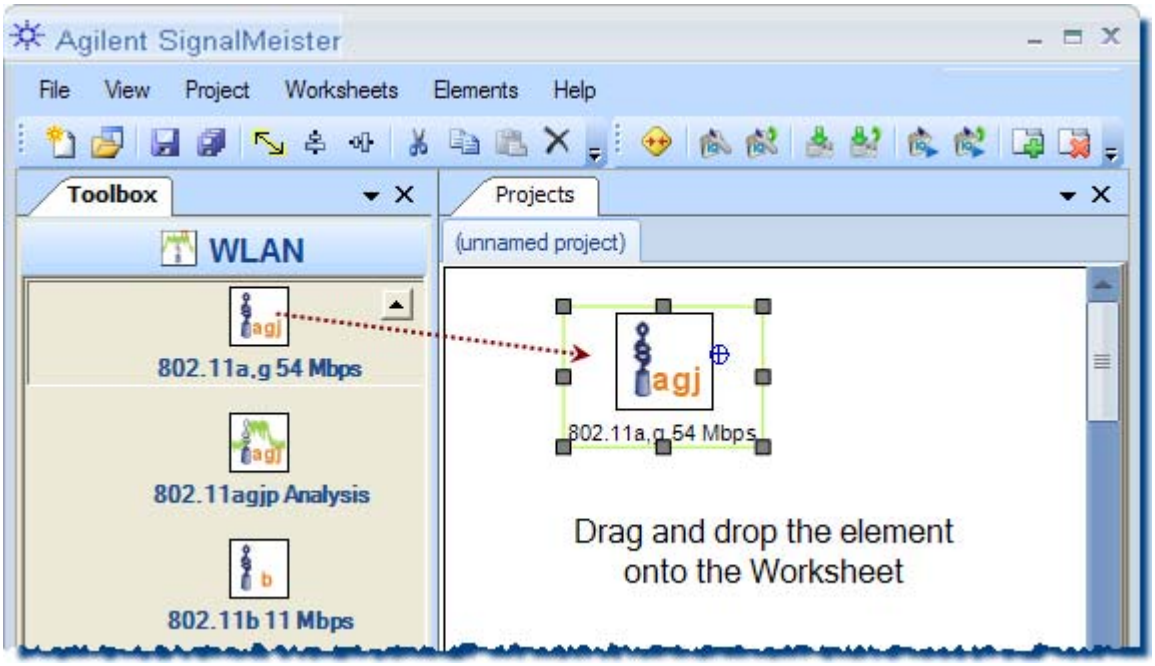
1. From the main menu, select **Elements** > **Add Text Block**.
2. An editable text box appears in the center of the worksheet.
3. Double-click inside the text box to open the **Text Block Editor**.
4. Enter the desired text and then select **OK**.
5. In the **Worksheet,** click and drag the text box to the desired location.

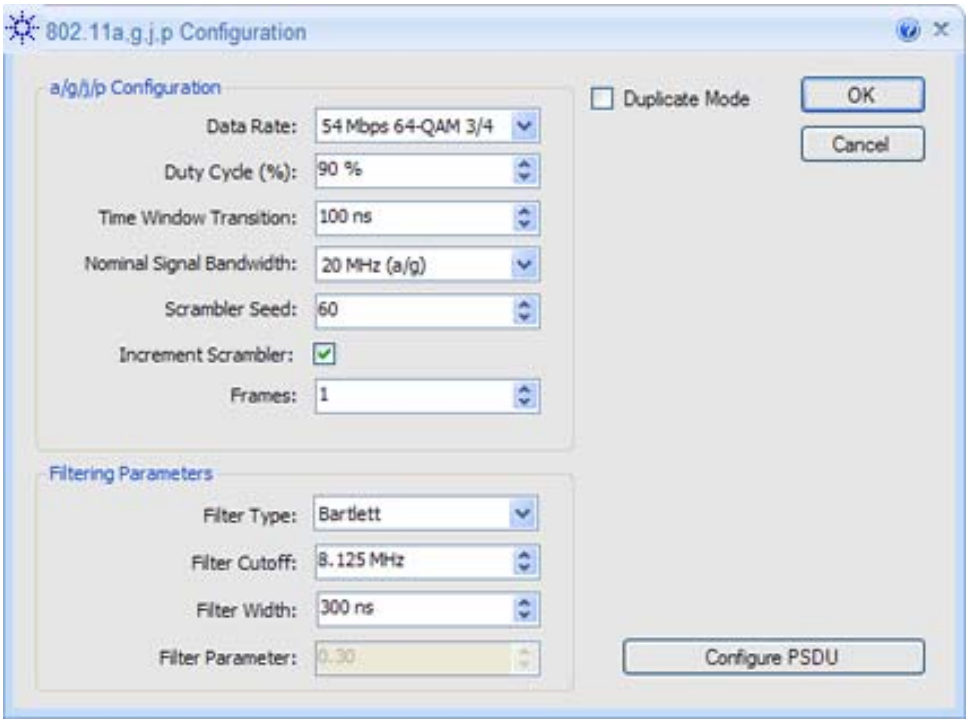
Generating ARB Files

The basic process for creating waveforms is described below.

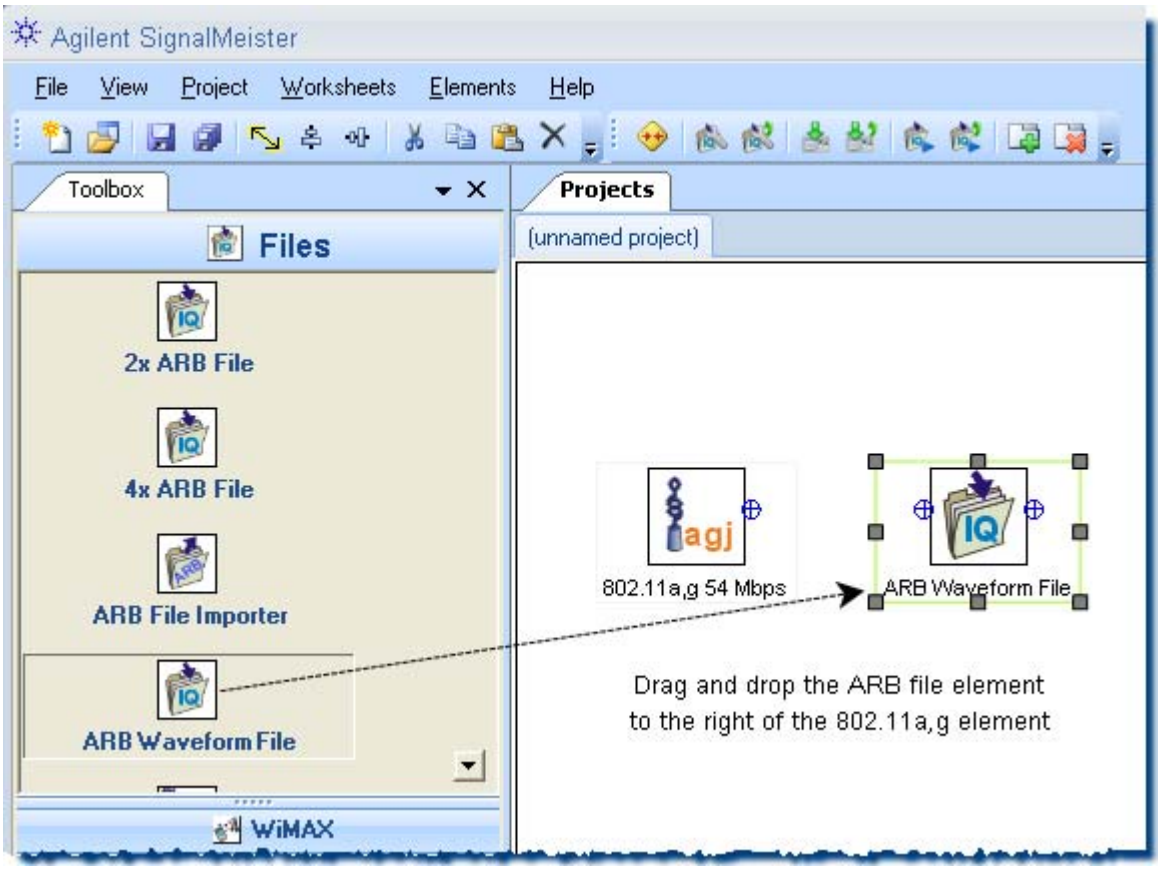
1. Drag and drop a signal generation element from the Toolbox onto the Projects worksheet. Choose from one of the available technologies, such as WLAN, WiMAX, 3GPP, 3GPP2, Digital Video, and so on.For this example, the WLAN 802.11a, g 54 Mbps is used.



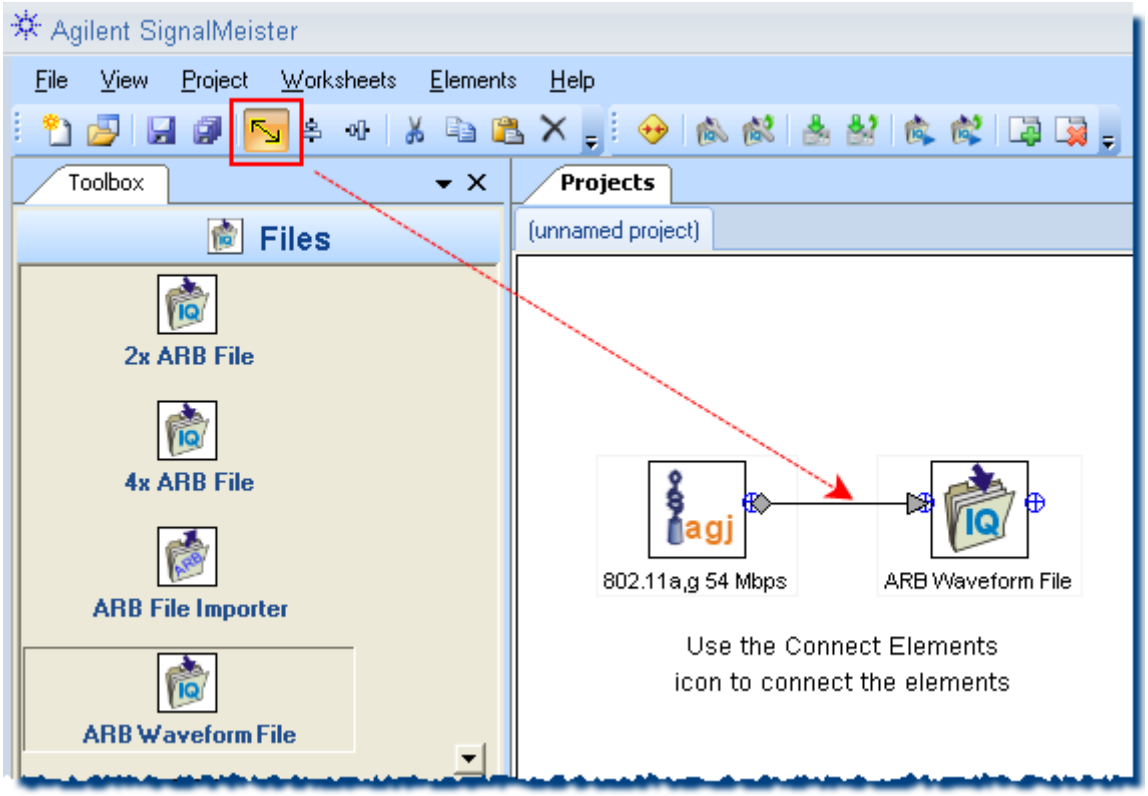
2. Double-click the element or right-click on the element and select **Edit Element Configuration…** from the context menu to set the waveform parameters. The 802.11a,g,j,p Configuration dialog is displayed.



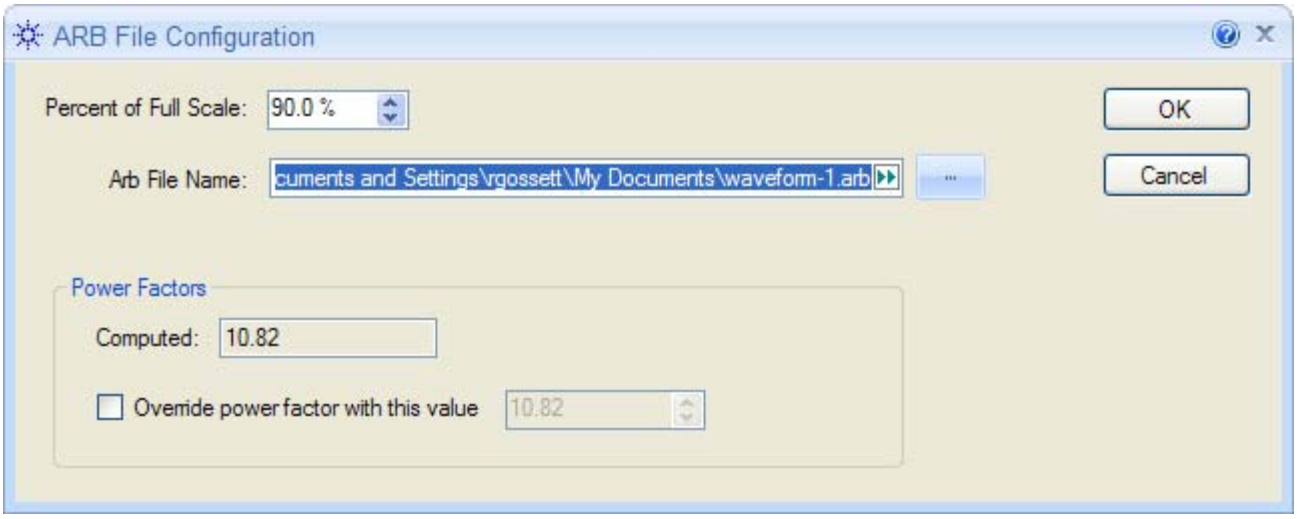
3. From the **Files** section of the Toolbox, click and drag an **ARB File** element onto the Projects worksheet.



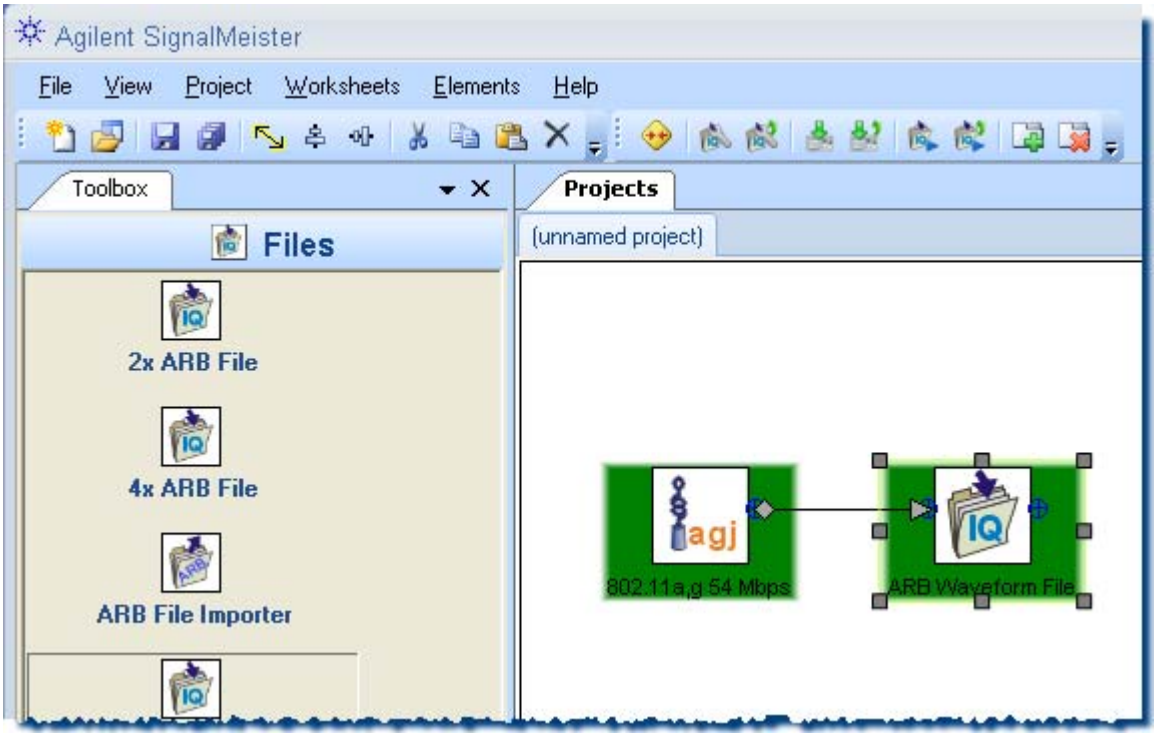
4. Use the **Connect Elements** icon (shown in the tool bar as a line with arrow heads on both ends) to connect the output of the waveform element to the input of the ARB file element. To do this, first click the source element then click the sink element to automatically connect them. In this step the source element is the WLAN element, and the sink element is the ARB File.



5. Double-click the ARB File element to open the ARB File Configuration dialog and enter the ARB file name and storage location on the PC.



6. From the main menu, select **Project** > **Build All** to build the ARB file. When the build is complete, the Status area displays a results message. Notice that the elements in the worksheet turn color. In this case, the background color changes to green, indicating that the element ran without any errors or warnings. Yellow indicates that the element ran with warnings; Red indicates that the element had errors and the build was halted.



At this point, the ARB file is generated and can be loaded into the Series V2900 vector signal generator (VSG). The file can be manually moved using a USB memory device or you can use SignalMeister to copy the ARB file to the VSG.

7. To save the project select **File** > **Save Project As**. You can reload saved projects into SignalMeister at a later time.

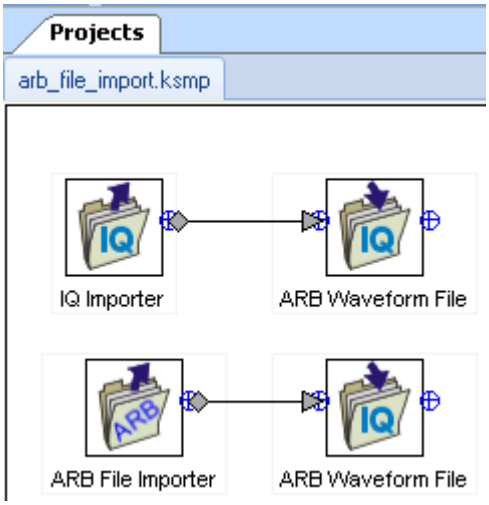
Importing ARB and IQ Files (user-provided files)

SignalMeister can import a double- or single-precision IQ file and convert it into an ARB file for use with the Agilent Series V2900 Vector Signal Generators, as well as importing ARB files that were previously created and saved. The following instructions show how to import an IQ file, convert it to an ARB file that is saved to a file for future use, then import that ARB file into a project.

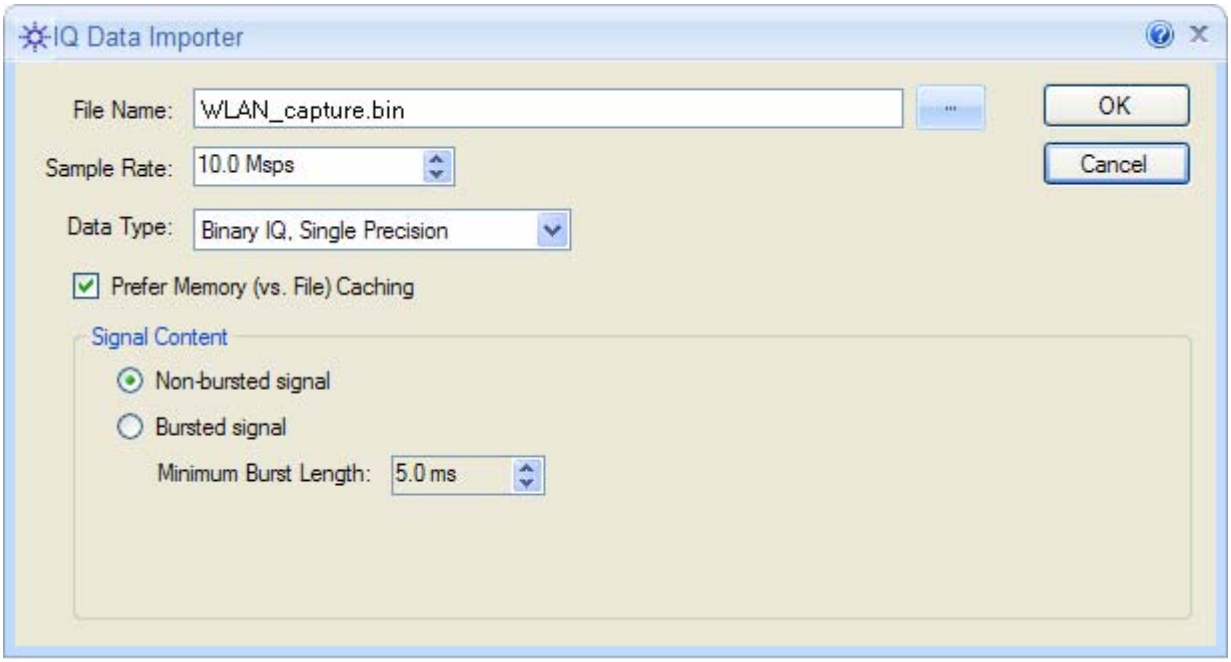
IMPORTANT: ***To play the ARB files created in this process, you must have a V2920A-Bxx ARB file playback license, either V2920A B20, V2920A B40 or V2920A B80, based on the sample rate. Less than 50 Msps requires a 20 MHz license, 50 Msps to 99 Msps requires a 40 MHz license and 100 Msps or greater requires an 80 MHz license. See Managing Licenses for more information on obtaining and installing licenses.***

---

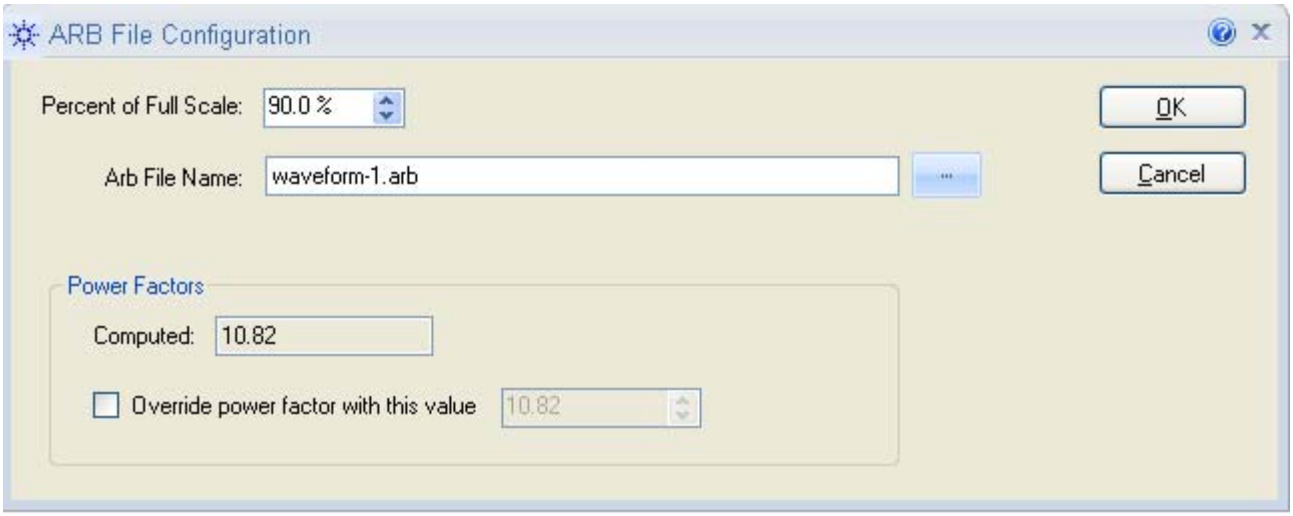
1. Drag and drop the elements shown in the diagram below onto a project worksheet and connect them as shown. See *Connecting Elements*.



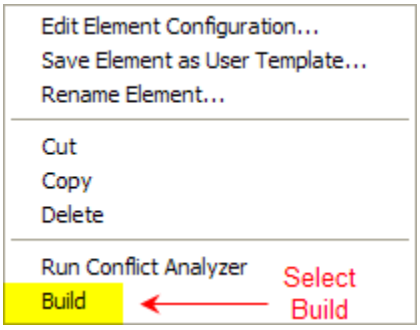
2. Double-click the DP IQ Import element to open the dialog, then enter the information about the file you want to import.



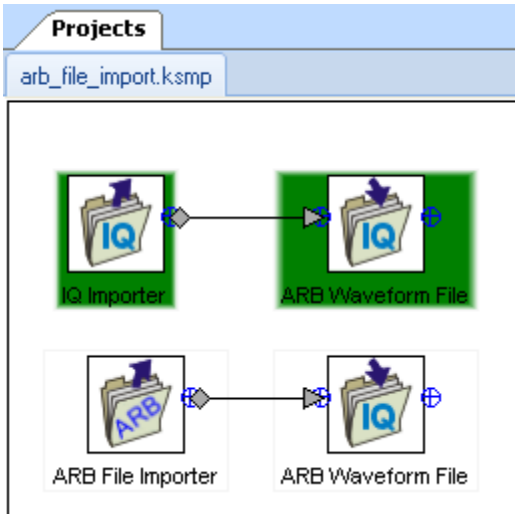
3. Right-click on the first instance of the ARB File element, select **Edit Element Configuration** from the popup menu, then enter a name for the ARB file and the location where you would like to save the file in the **Arb File Name** field. Click **OK**



4. Right-click on the first instance of the ARB File element and select **Build** from the popup menu.

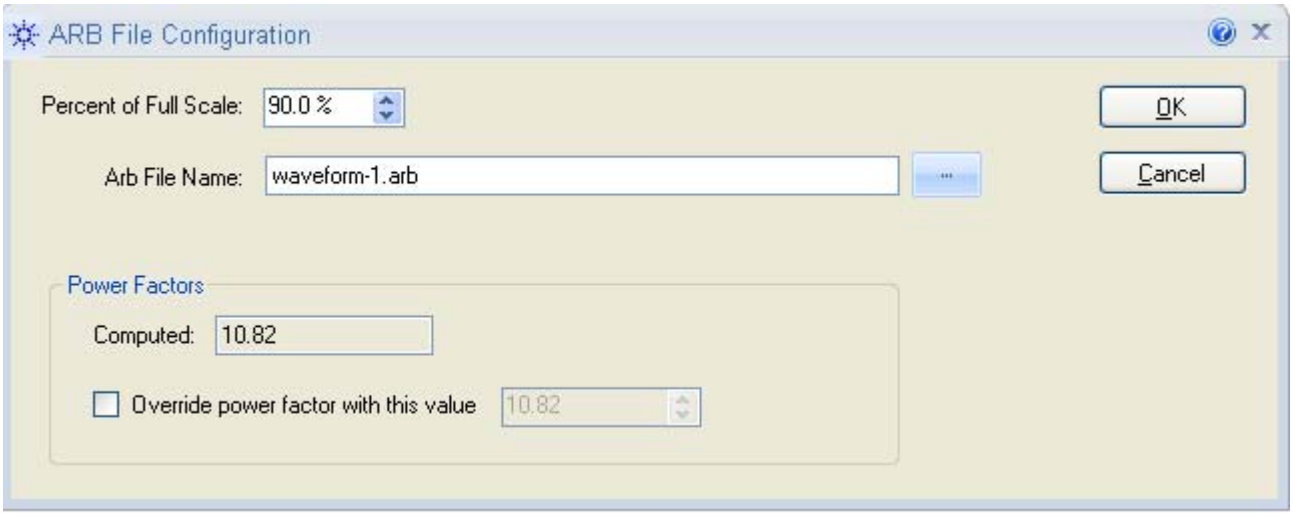


5. When the build is finished, the IQ Import and ARB File elements become green in color, indicating the .bin file has been converted into an .arb file without errors.

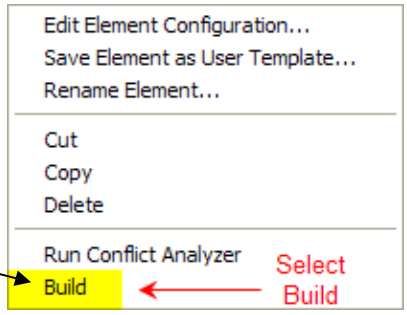


6. Double-click the ARB File Importer to open the dialog, then enter the Arb File Name and location of the ARB file you saved in Step 3

7. Right-click on the second instance of the ARB File element, select **Edit Element Configuration** from the popup menu, then enter a name for the ARB file and the location where you would like to save the file in the **Arb File Name** field. Click **OK**.

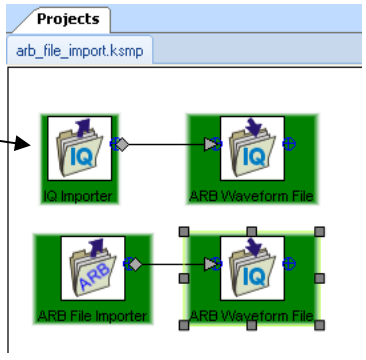


8. Right-click on the second instance of the ARB File element and select Build from the popup menu.



9. When the build is finished, the ARB File Importer and ARB File elements become green in color, indicating the .arb file was imported without errors.

10. The ARB file is now ready to use in other projects.



Downloading ARB files to a Series V2900 VSG

The Agilent V2901A SignalMeister RF Communications Test Toolkit allows you to create arbitrary waveform files (ARB) for Agilent Series V2900 signal generators and play them on Series V2800 vector signal generators.

1. To copy the arb file automatically, add a signal generator element to your project by dragging and dropping a signal generator element from the Toolbox to the Project worksheet.
2. Enter the LAN or GPIB address for the instrument. To open the configuration dialog window, use either of the two methods below:
    - Right-click the signal generator element and select Edit Element Configuration from the context menu.
    - Double-click the selected signal generator element.
3. Select the **VISA Resource** tab, and then select the **Configure** button. If you are using a LAN connection, select the LAN/TCPIP tab. If you are using a GPIB connection, select the GPIB tab.
4. Enter the TCP/IP address of the signal generator. The LAN/GPIB addresses for the <Series> Vector Signal Generators are viewed or set from the Utilities menu of the signal generator. From the front panel of the signal generator select **Menu > Utilities > Ethernet Settings...** to view the IP address.
5. After the IP address has been configured, connect the Signal Generator element by selecting the **Connect Element** icon in the toolbar, then select the arb file and the signal generator on the worksheet.
6. The arb file can now be downloaded and played by the signal generator using one of the methods shown below.
    - Select **Project > Load All** from the main menu
    - Select the **Load All** button from the Project toolbar
    - Right-click the signal generator element and then select **Load Arb File** from the context menu. This method allows you to update only one arb file if you have several configured in a large project.

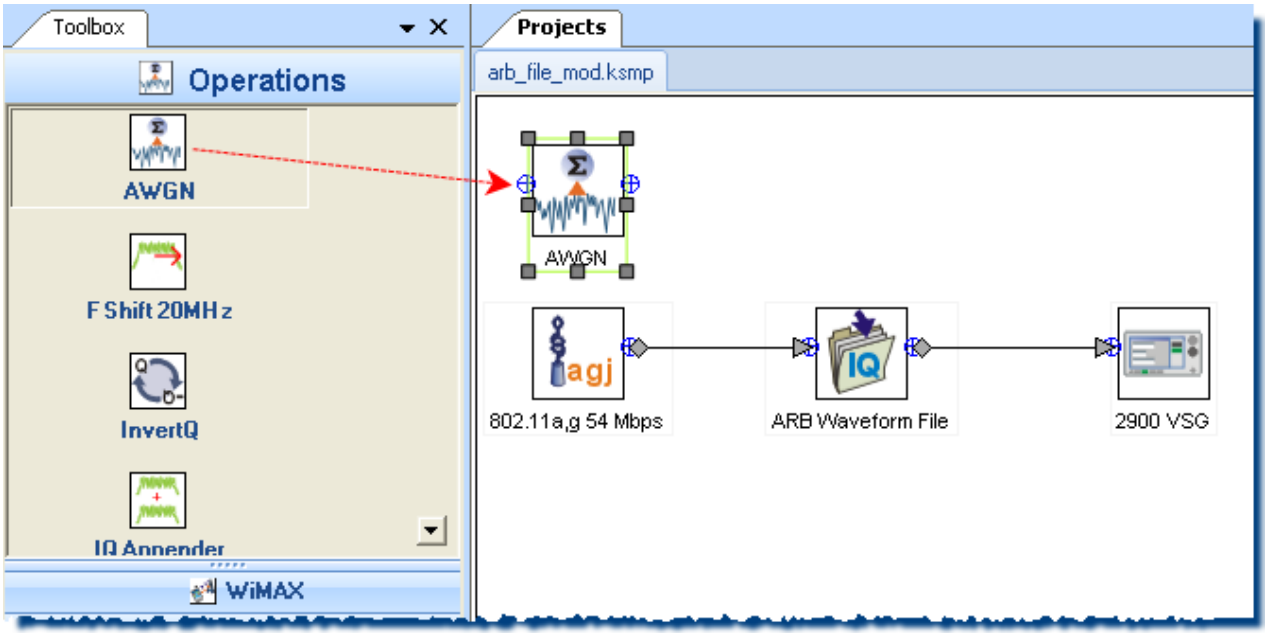
Adding Modifications and Impairments to ARB Files

Modifications and impairments can be added to any type of ARB file by sending the output or the waveform generation element to an operation element before sending it to the ARB file element. Multiple modifications can be added to the same signal. Modification and impairment elements are contained in the Operations section of the toolbox. The available waveform operations include:

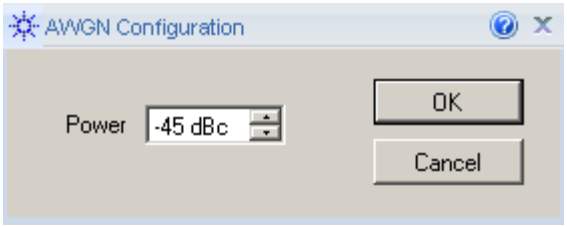
- AWGN
- IQ gain imbalance
- IQ offset
- Invert Q signal
- Resample to a different sample rate
- Apply a channel matrix to a MIMO signal

As an example, an AWGN will be added to the signal in the existing WLAN project.

1. From the **Toolbox,** select the **Operations** tab and click and drag the **AWGN** element to the project.



2. Use the **Connect Elements** icon to connect the 802.11 signal element to the AWGN element.
3. Double-click on the AWGN element to set the noise level.

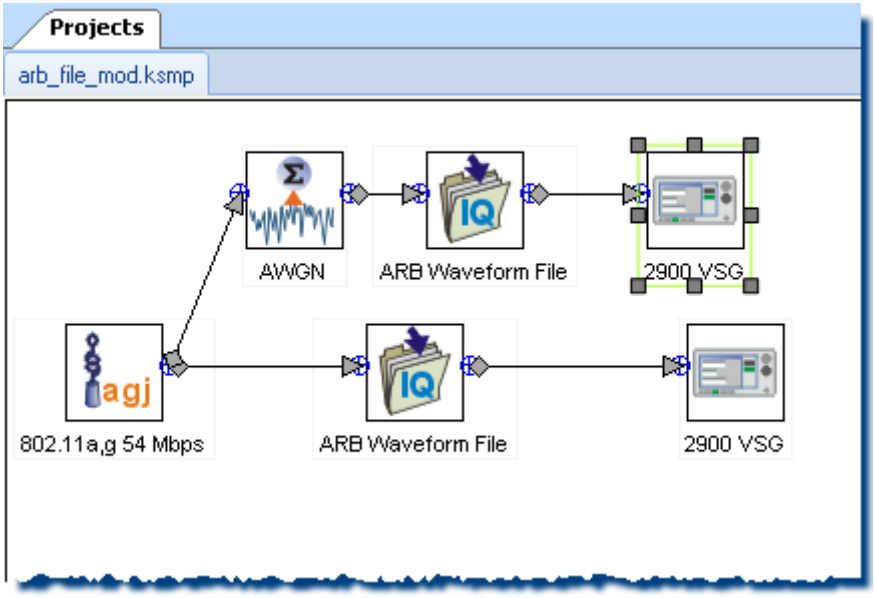


At this point, there are two options.

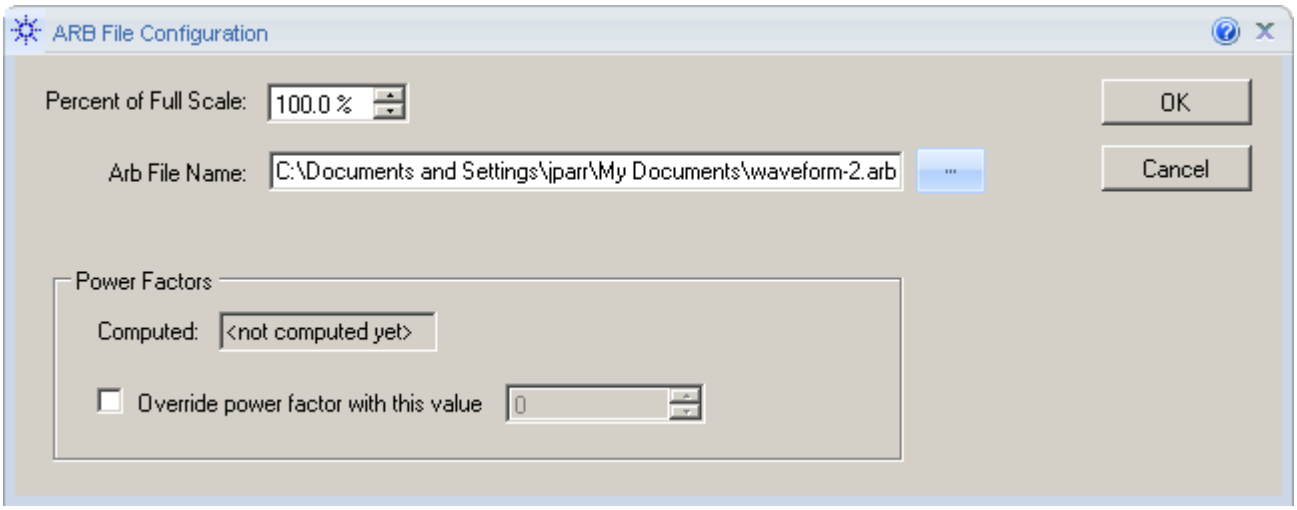
- First you can disconnect the output of the 802.11 signal generation element from the ARB file element and connect the output of the AWGN element to the ARB file input.
- Or, you can create a second ARB file for the impaired waveform. The ARB file and signal generator elements can be added to the project from the toolbox, as shown earlier, or you can select the existing ARB file and signal generator elements in the project and copy them.

4. To do this, on the worksheet click and drag a rectangle over the ARB file and signal generator elements to select.

5. From the main menu, select **Elements** > **Copy** then **Worksheet** > **Paste as New**.



6. Use the **Connect Elements** icon to connect the output of the AWGN element to the new ARB file as shown in the figure above.
7. Double click on the new **ARB File** element to open the ARB File Configuration dialog, and then enter a file name.



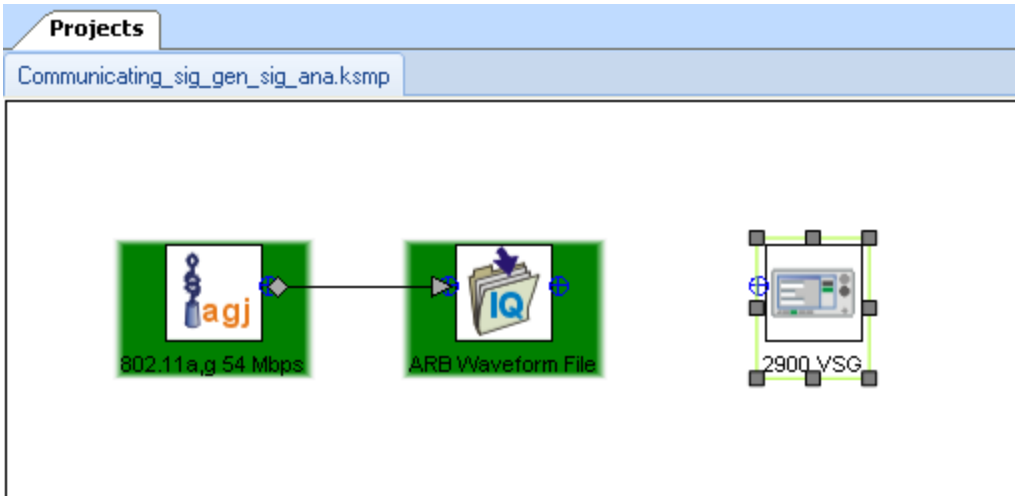
8. Double-click on the signal generator element and configure the communications settings for the signal generator communications type used.

The project now illustrates the two methods for generating and downloading the ARB files. If you select **Project** > **Force Load All**, both files will be generated and loaded. If you right click on the new source element and select **Load ARB File**, only this file will be downloaded.

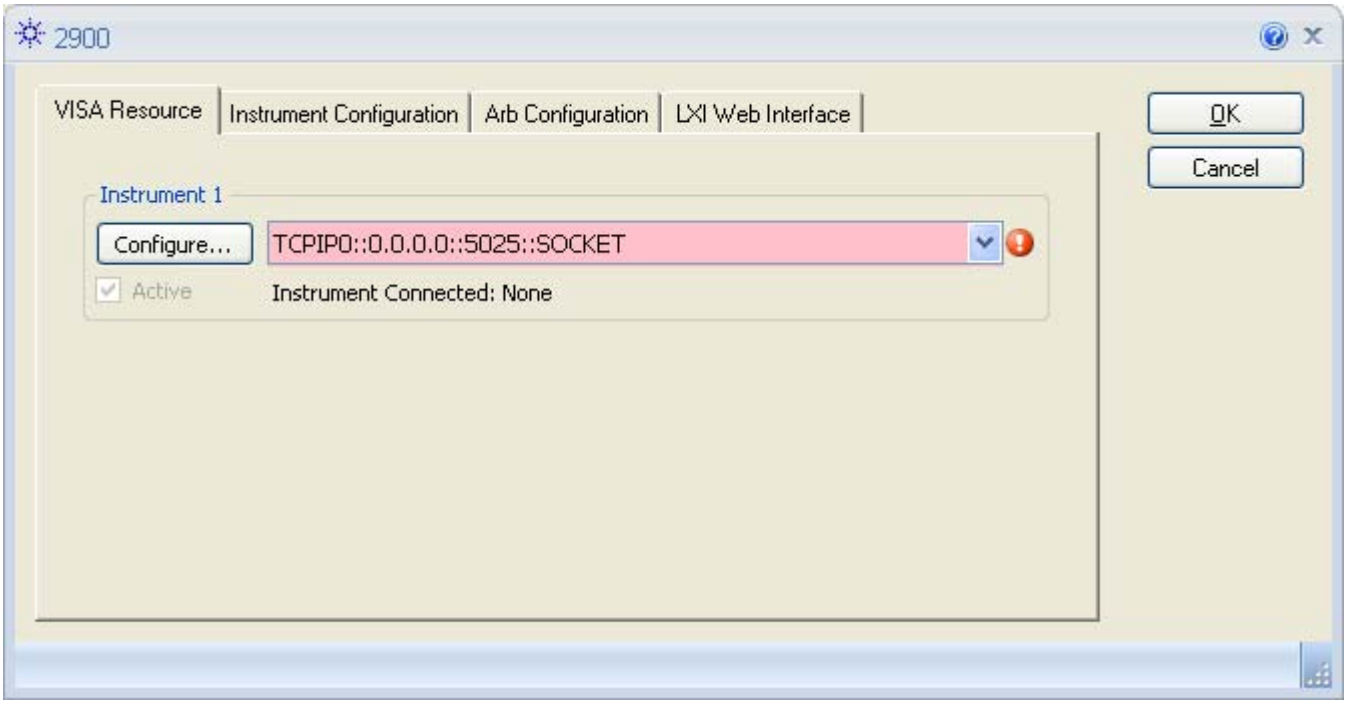
Communicating with Signal Generators and Signal Analyzers

Refer to *Generating ARB Files* for details on how to create an ARB file.

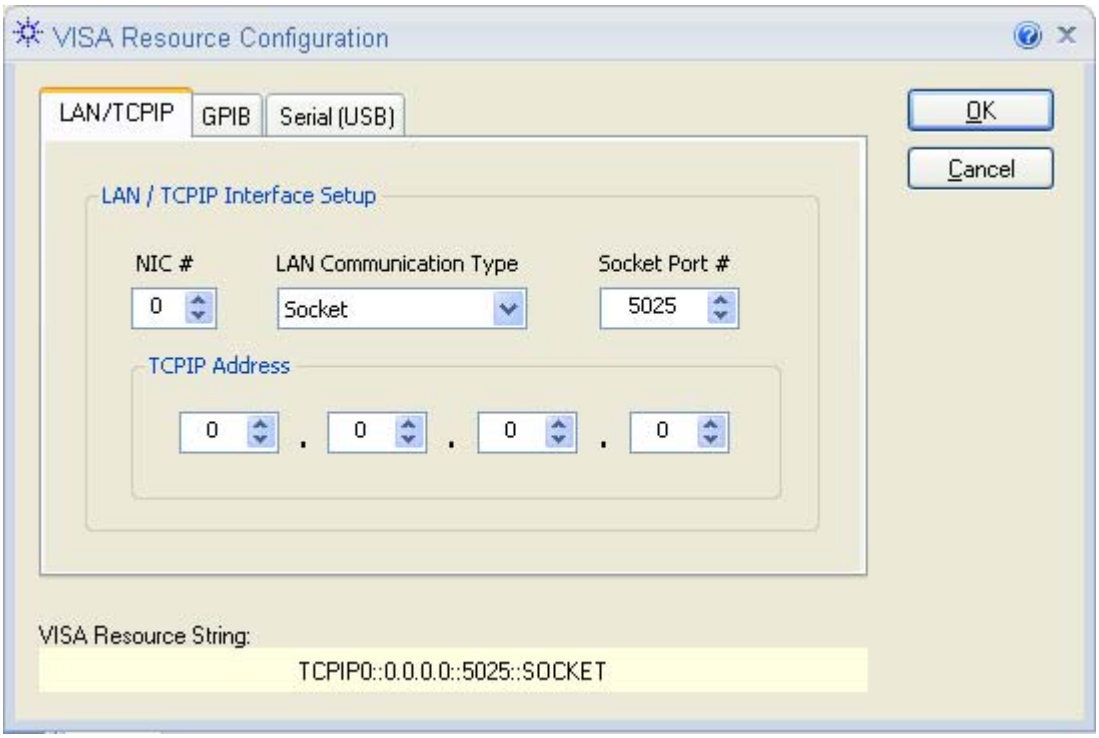
1. To Copy an ARB file automatically, add a signal generator to the project. Note this topic continues with th e802.11a,g 54 Mbps setup described in Generating ARB files.



2. Either double-click on the signal generator element, or right-click and select **Edit Element Configuration**, to open a dialog window where you enter the LAN or GPIB address, configure the Arb file, or start the LXI Web Interface for that signal generator.

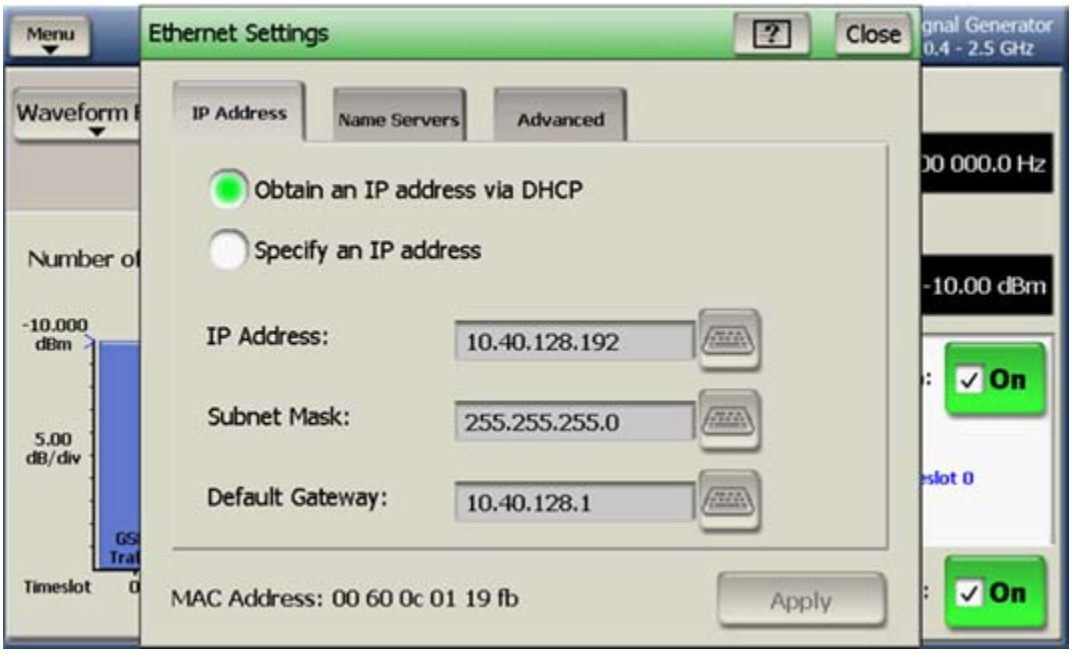


3. Select the VISA Resource tab, and then click **Configure**.

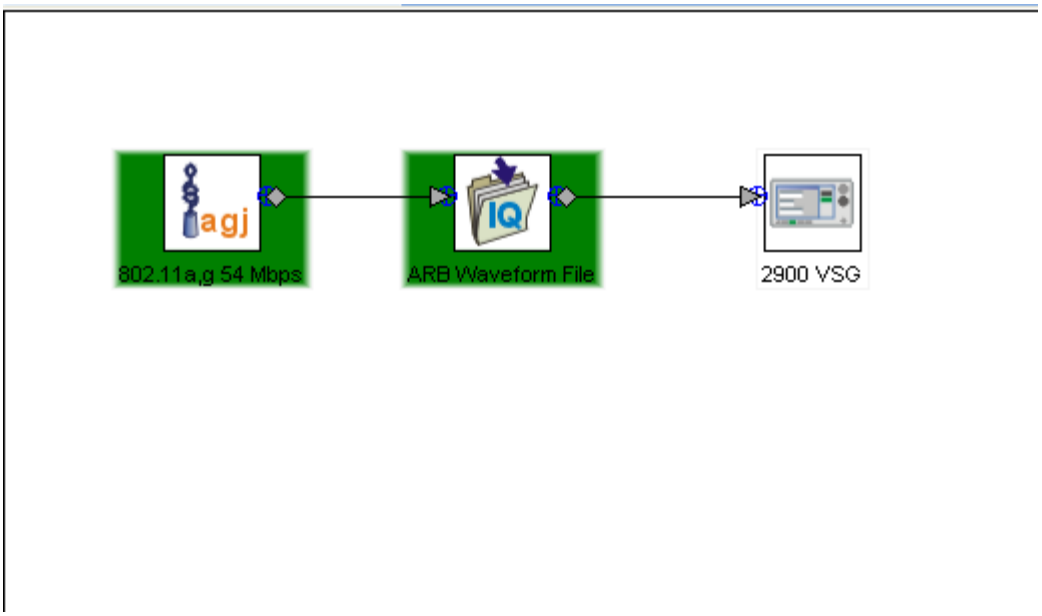


4. Select either the **LAN/TCPIP** or **GPIB** tab as applicable, then configure your interface setup. Click **OK** when you have finished..

   The GPIB and LAN addresses for the Series V2900 Vector Signal Generator or the Series V2800 Vector Signal Analyzer are s obtained from the Utilities menu of the instrument to which you want to connect. The following screen capture shows the LAN setup screen for the instrument. The instruments allow static and dynamically allocated LAN addresses.



5. Now that the communications address is configured, use the **Connect Elements** icon to connect the Signal Generator element to the output of the ARB file.



The ARB file can now be downloaded and played by the VSG using two different methods.

- From the main menu, select **Project** > **Reload All**. This will regenerate the ARB files and then load them to the VSG.
- Right-click on the Signal Generator element and select **Load ARB File** from the context sensitive menu.

For this simple project, there is no difference between these methods. However, SignalMeister allows the creation of a large project that can produce multiple ARB files. For these projects, the second method allows you to update one file without regenerating all of the files in the project.

6. When you select either method a dialog will be presented asking you to load or overwrite the existing files. Select **OK** to these dialogs to load the new file. The Signal Generator element will also turn color after the above process. A green background indicates that the operation completed successfully.

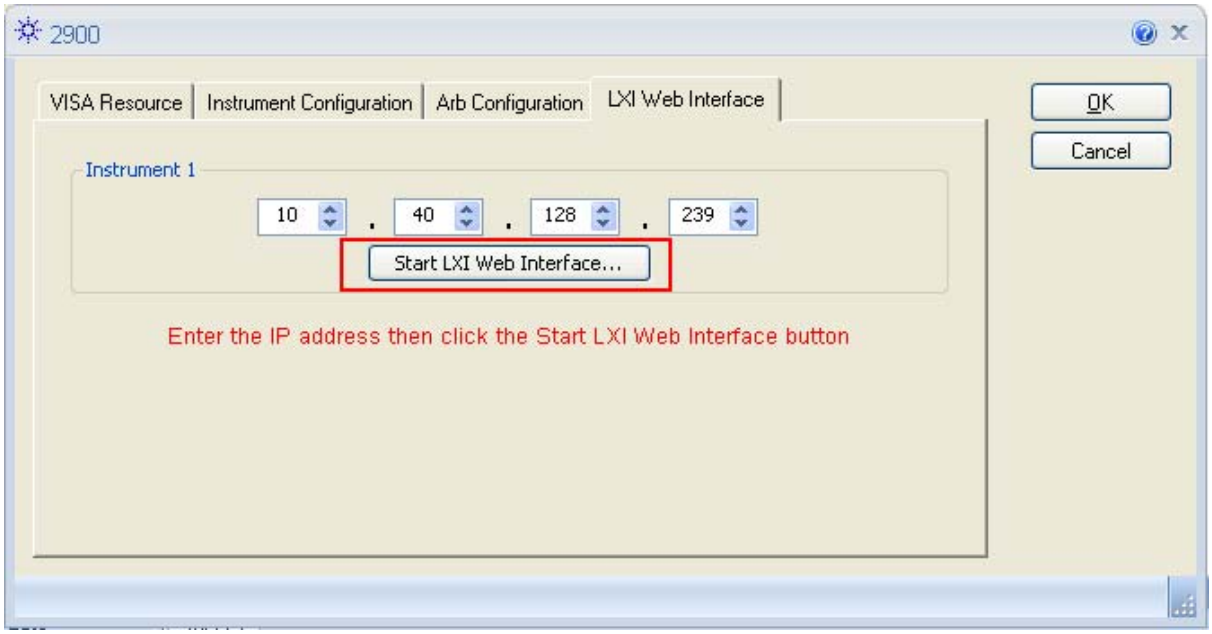
USB memory device

1. Insert a USB memory device into a USB port on your computer.
2. Copy the generated waveform file (*.arb) to the memory device from the storage location of your PC.
3. Remove the USB memory device from the computer and insert it into the Series V2900 VSG front panel USB port.
4. From the Series V2900 VSG front panel, choose **Select Modulation > Arb > Add Arb > Add Arb File**.
5. In the Open Arb dialog box, select the **Look in:** drop-down arrow and select **USB**.
6. Select the *.arb file from the scroll list and select **Open**. The file is now loaded in the arbitrary waveform playback table.
7. Select the row of the playback table containing the file that you just downloaded, then select **Load Row#**.
8. Select **RF: On** to switch on the RF output.

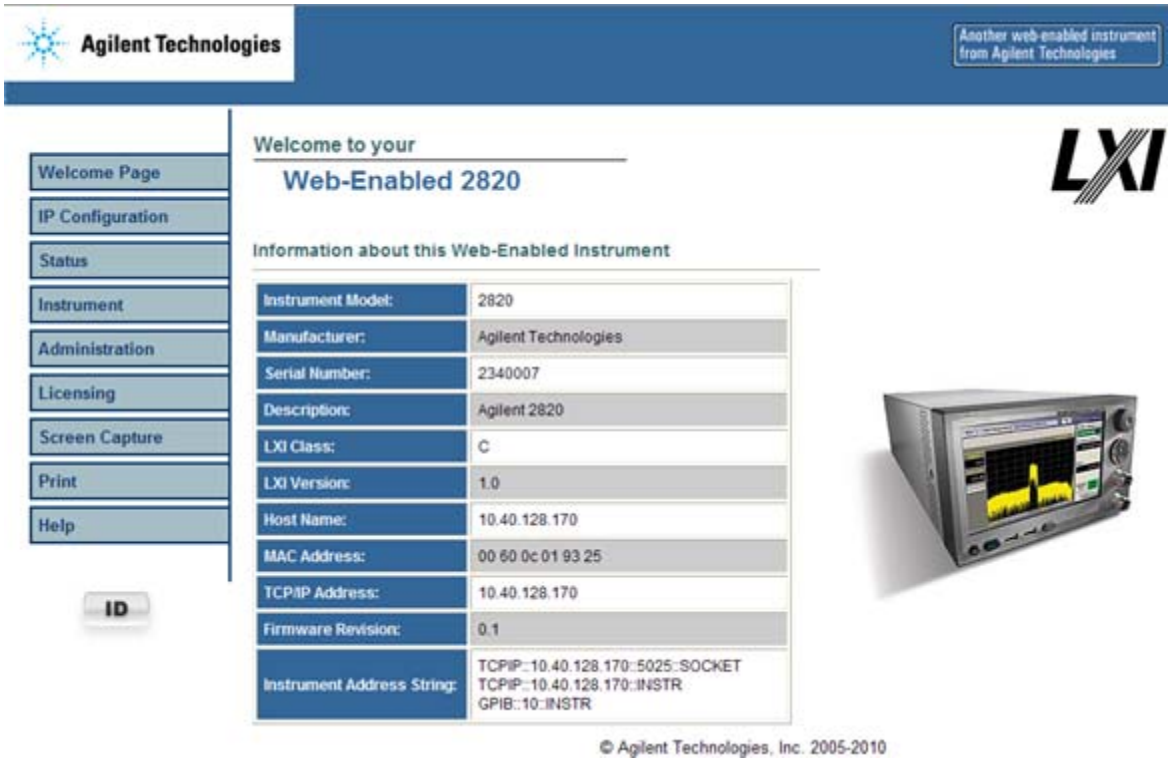
For more information on signal control and playback, refer to the Series V2900 VSG help topics. See **Arbitrary waveform > Arbitrary waveform procedure**s for detailed information.

Using the LXI Web Interface

SignalMeister also allows a convenient method to access the LXI Web Interface for Agilent RF instruments. To access the LXI interface, double-click the source element (refer to *Communicating with Signal Generators and Signal Analyzers* select the **LXI Web Interface** tab and then select **Start LXI Interface**.



The Agilent LXI interface has two very useful operations in this mode. First you can select a live display of the instrument. The following figure shows the vector signal analyzer welcome screen.



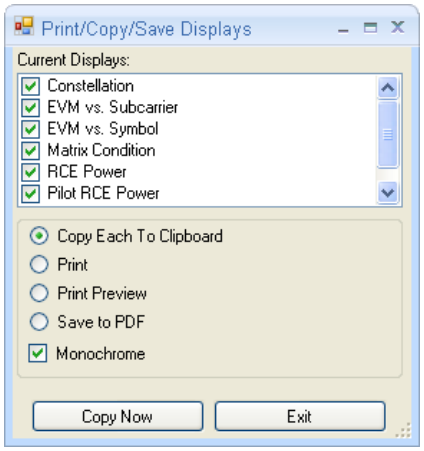
The LXI interface screen capture can also be useful to copy the instrument display for report and data sheet generation.

Working with Analysis Elements

Print/Copy/Save Analysis Elements

This menu is specific to the analysis elements (**Displays > Print/Copy/Save Displays**), and provides access to the Print/Copy/Save commands for each of the active displays.

As displays are made active or are disabled, such as the parameters table, burst data table, and graph or strip chart displays, the list of Current Displays is updated as each is added or removed. Use the check-box(es) to select the items you wish to Print/Copy/Save.



Command	Description
Copy Each To Clipboard	Copy each of the selected displays to the clipboard. **NOTE:** When the contents of the Parameters Table is copied to the clipboard, it can be pasted as tab delimited text into applications such as Notepad®, or it can be pasted as comma separated values (CSV) into applications such as Excel®.
Print	Choose this to print the selected displays.
Print Preview	Select this to preview the current print job.
Save to PDF	Select this to save the selected displays to a PDF file.
Monochrome	Select this check-box to have each selected display shown in monochrome (black and white). De-select this check-box to show the displays in color.

Setting Up the Analysis Window

From the Analysis Window, individual windows can be selected from both the **Displays Menu** and the **Settings Menu**. Once selected, the positioning and some properties of the window can be set up using the **View Menu**.

Set Up Windows

To set up a window in Analysis Window element, do the following:

1. Launch the Analysis Window.
2. Select either **Displays Menu** or **Settings Menu**.
3. Select a window from the menu.

Example: **Displays > Graphs > Constellation, or Settings > Instrument Control**

NOTE: The selected window opens in accordance to the settings in the View Menu with regard to position and size.

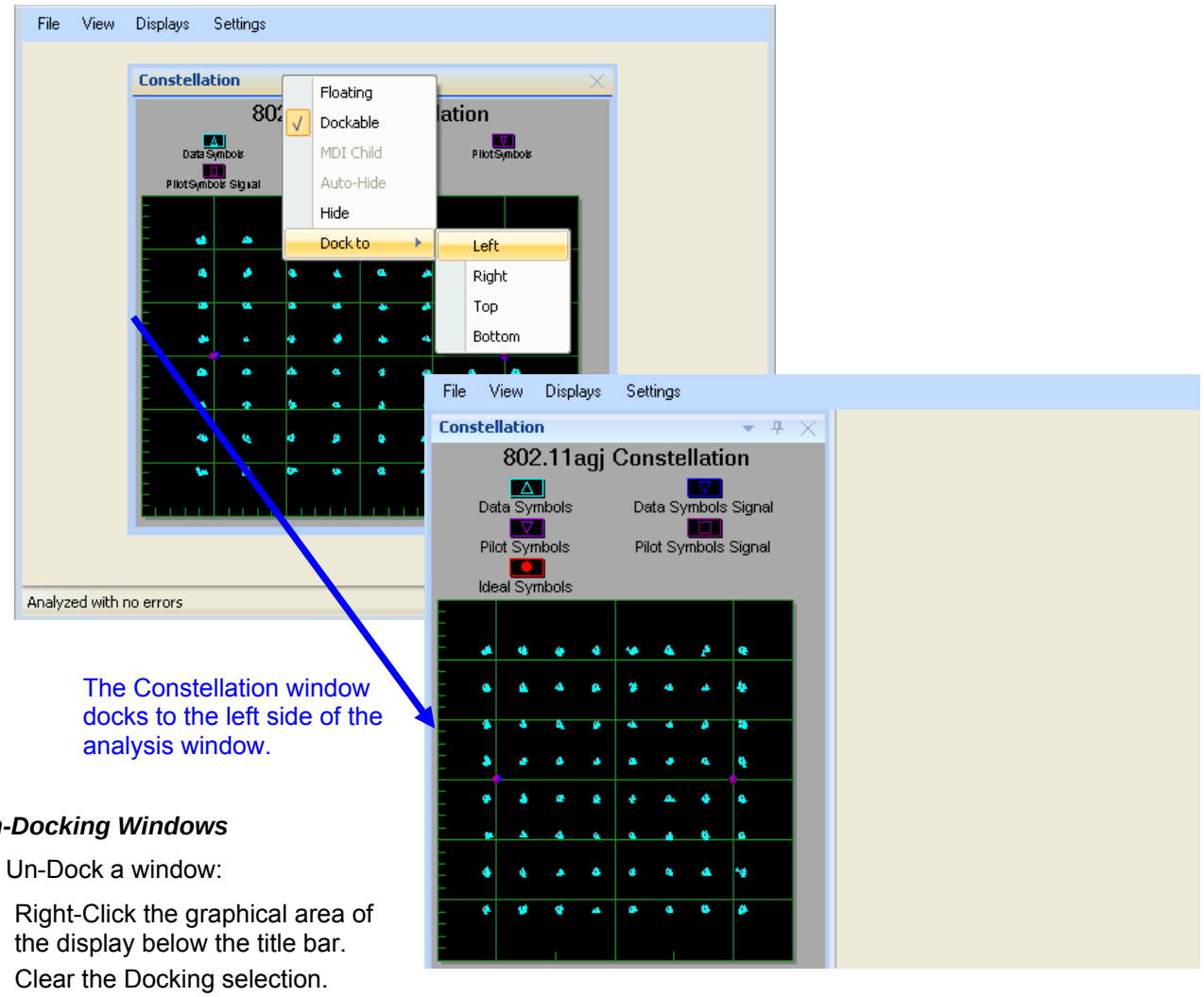
Arranging Windows

If the windows are docked, there are several methods of arranging them.

Docking Windows

To dock a window:

1. Right-click the graphical area of the display below the title bar.
2. Select Dock to.
3. Select either Left, Right, Top, or Bottom as the edge of the graph to dock to.



The Constellation window docks to the left side of the analysis window.

Un-Docking Windows

To Un-Dock a window:

1. Right-Click the graphical area of the display below the title bar.
2. Clear the Docking selection.
3. The window is now free to be moved by dragging.

Hiding Windows

To hide a window:

1. Right-click the graphical area of the display below the title bar.
2. Selec t Hide.
3. The window now disappears from view.

Signal Generation

The input parameter requirements for different communication standards vary significantly. As such, the displays for inputting this data in SignalMeister also vary significantly. The SignalMeister waveform parameter input screens are formatted in a manner that allows data entry consistent with the terminology of the standards.

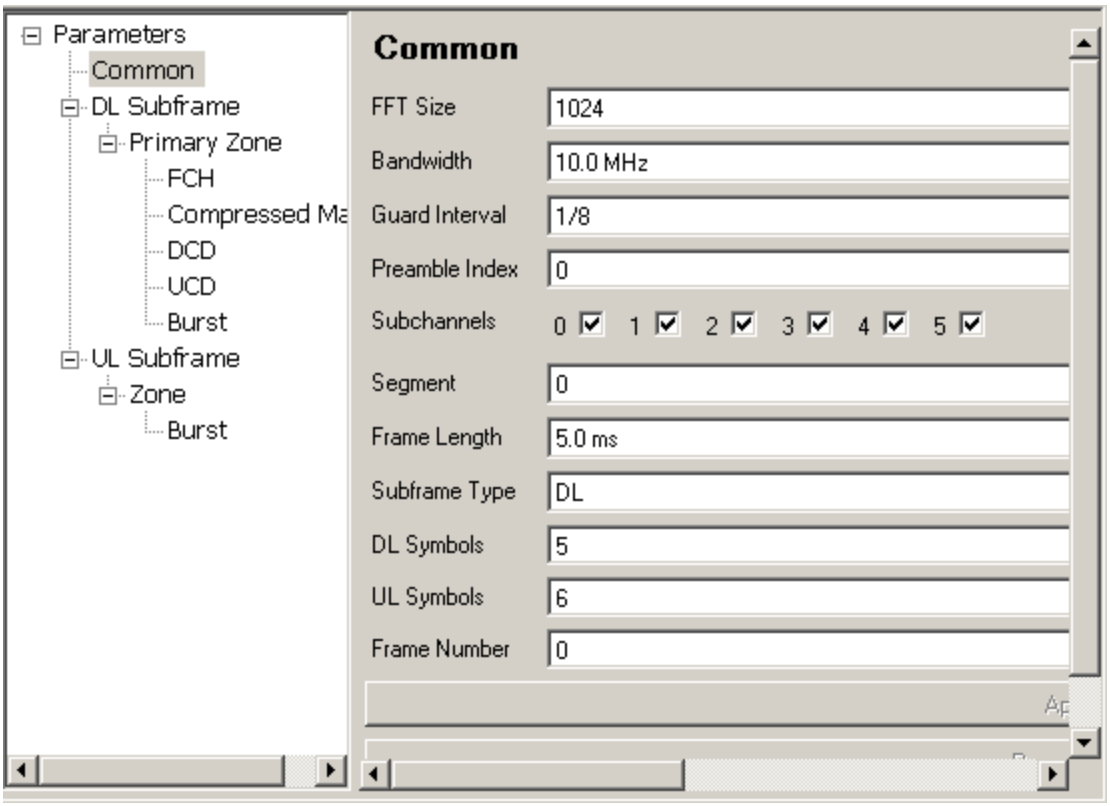
- WiMAX
- WLAN
- 8 x MIMO Signal Generation – IQ files
- 3GPP and 3GPP2

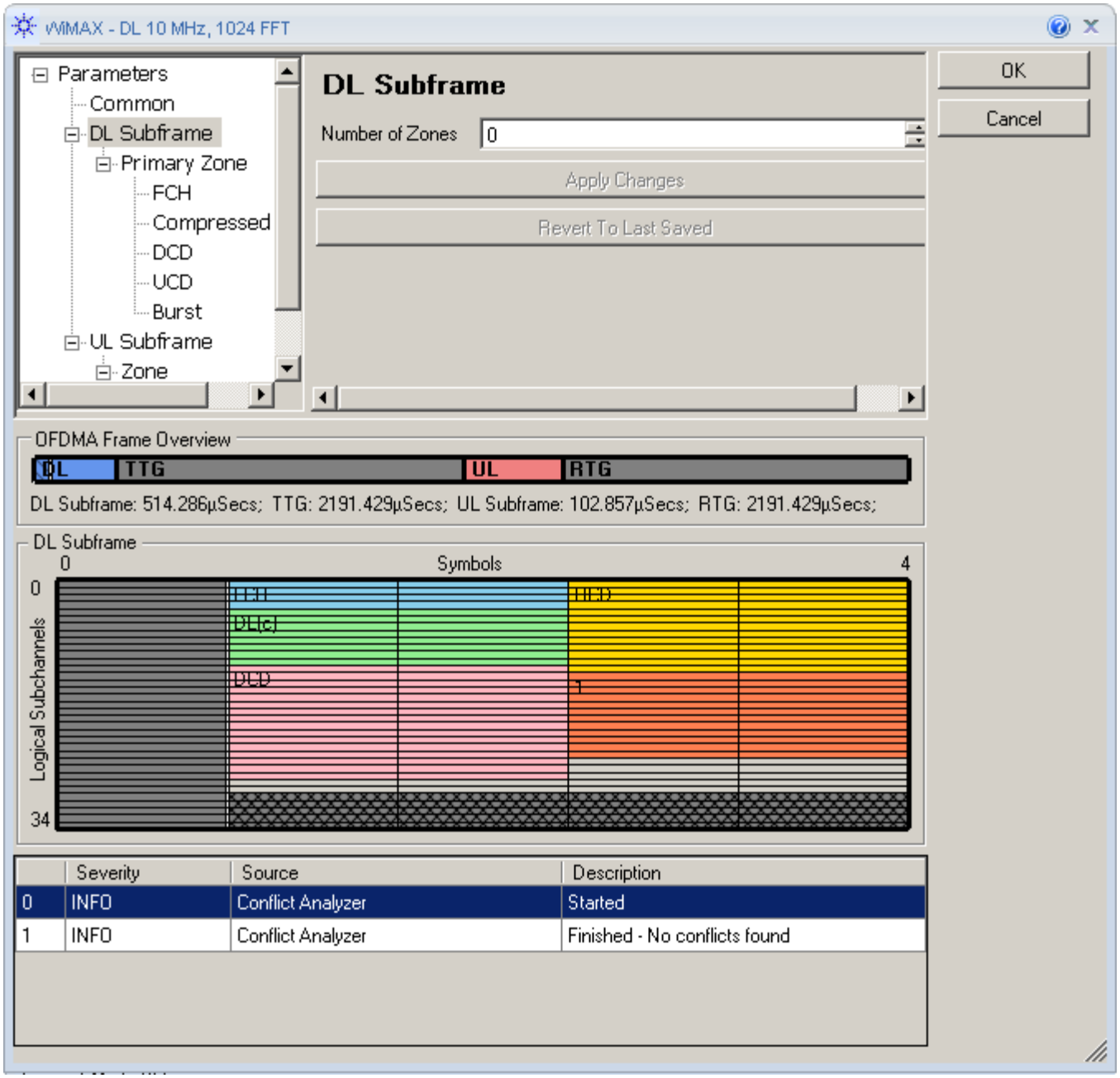
NOTE: For more detailed information on signal generation refer to the V2901A SignalMeister Help system.

WiMAX

The 802.16e WiMAX standard allows for a very high degree of flexibility. The SignalMeister parameter window for WiMAX also allows this level of flexibility. There are three major sections of the WiMAX setup:

- **Common Parameters**: Specifies the input parameters such as FFT size, number of symbols, length of frame, It also allows you to create the uplink or downlink signal.
- **DL subframe**: Specifies the zone and burst parameters for the downlink subframe.
- **UL subframe**: Specifies the zone and burst parameters for the uplink subframe.





Because of the complexity of the WiMAX map configuration, SignalMeister can save the map configuration into a file that can be loaded into the signal analyzer. The WiMAX Map file element is located in the Files folder of the toolbox. The output of the Map File element can be connected to a signal analyzer element and is loaded into the VSA WiMAX measurement when the project is run. The following examples show this setup.

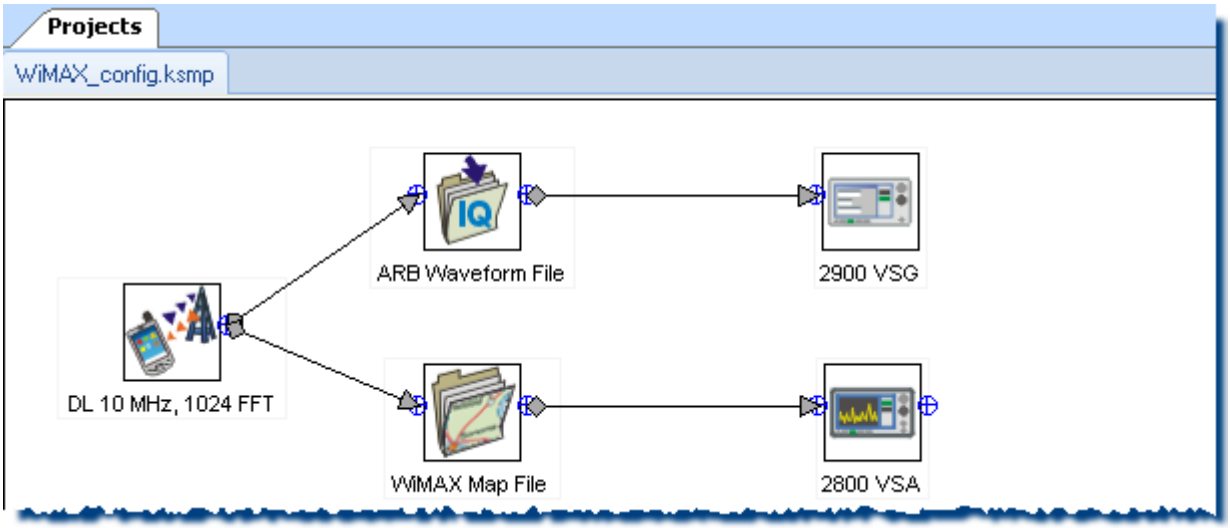
Generating a WiMAX SISO Signal

Put Elements in the Project View

1. In the SignalMeister Toolbox, select the **WiMAX** folder to display the list of WiMAX elements.
2. Drag and drop **DL 10 MHz, 1024 FFT** into the Projects view.
3. In the Toolbox, select the **Files** folder to display the list of Files elements.
4. Drag and drop the **ARB File** and **WiMAX Map File** elements into the Projects view.
5. In the Toolbox, select the **Signal Generators** folder to display the list of signal generator elements.
6. Drag and drop a **2900 VSG** element into the Projects view.
7. In the Toolbox, select the **Signal Analyzers** folder to display the list of signal analyzer elements.
8. Drag and drop a **2800 VSA** into the Projects view.

Connect the Elements and Run the Project

1. Use the **Connect Elements** icon to connect the output of the **DL 10 MHZ, 1024 FFT** element to the **ARB File** input.
2. Connect the output of the **ARB File** element to the input of the **2900 VSG** element.
3. Connect the output of the **DL 10 Mhz, 1024 FFT** element to the input of the **WiMAX Map File** element.
4. Connect the output of the **WiMAX Map File** element to the input of the **2800 VSA** element.
5. From the main menu, select **File** > **Save Project As...** and then save the project.



Verify the Signals on the VSA

1. Connect the output of the VSG to the input of the VSA.
2. On the VSA, select **Preset** > **Spectrum** > **Standards** > **802.16x** to view the constellation diagram and other parameters.

Generating a WiMAX MIMO Signal

WiMAX MIMO, also known as Wave 2, supports space-time coding (STC) and spatial multiplexing (SM) in WiMAX signals. STC uses Alamouti scheme (Matrix A) to provide transmit diversity as shown in Figure 1. Spatial multiplexing is also referred to as MIMO and uses Matrix B, as shown in Figure 2. STC/MIMO is often used to indicate WiMAX MIMO mode.

In WiMAX downlink, both STC and SM are used. In WiMAX uplink, collaborative spatial multiplexing is used. Two users, each only has one antenna, can transmit collaboratively in the same slot as if two streams are spatially multiplexed from two antennas of the same user.

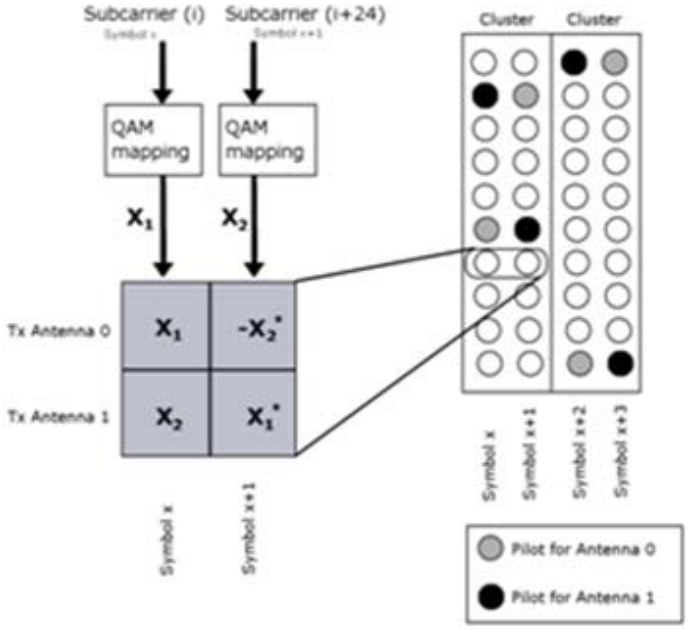


Figure 1: Space-Time Coding Diagram

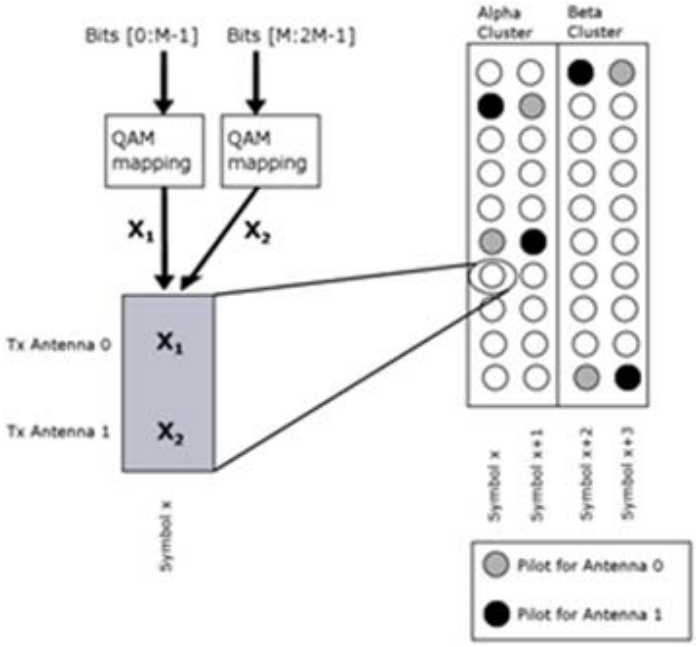


Figure 2: Spatial Multiplexing

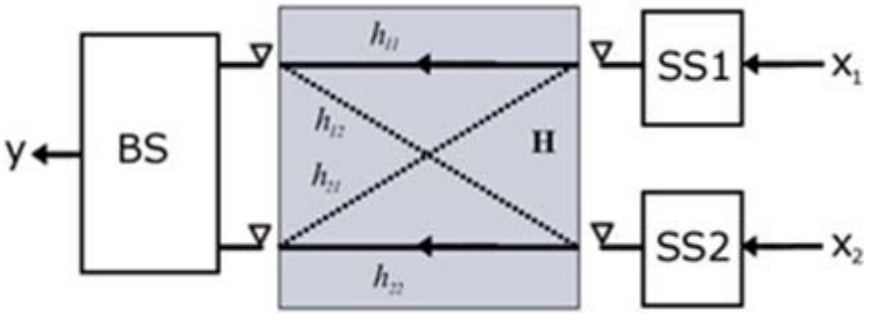
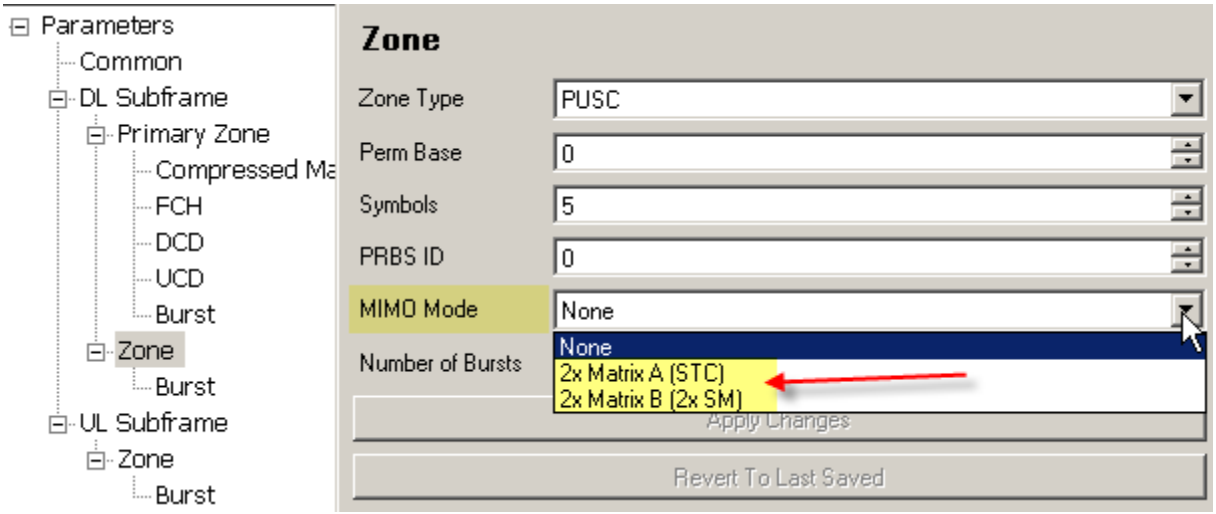
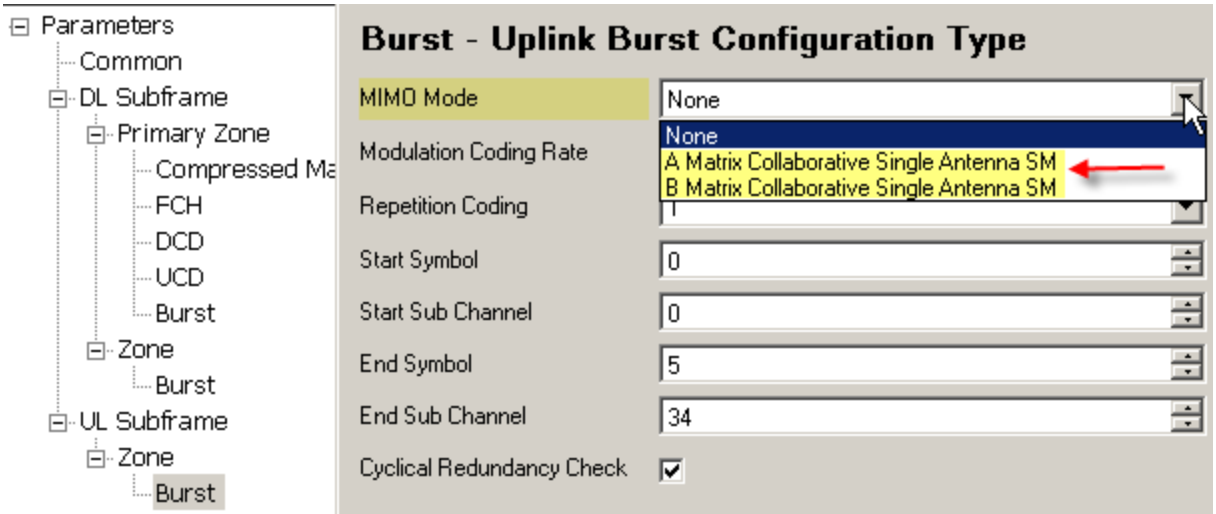


Figure 3: Collaborative Spatial Multiplexing for Uplink

In SignalMeister, the MIMO mode offers WiMAX MIMO selection. There are two options: 2x Matrix A (STC) and 2x Matrix B (SM) in the downlink. MIMO mode is found in **DL Subframe** >**Zone**.



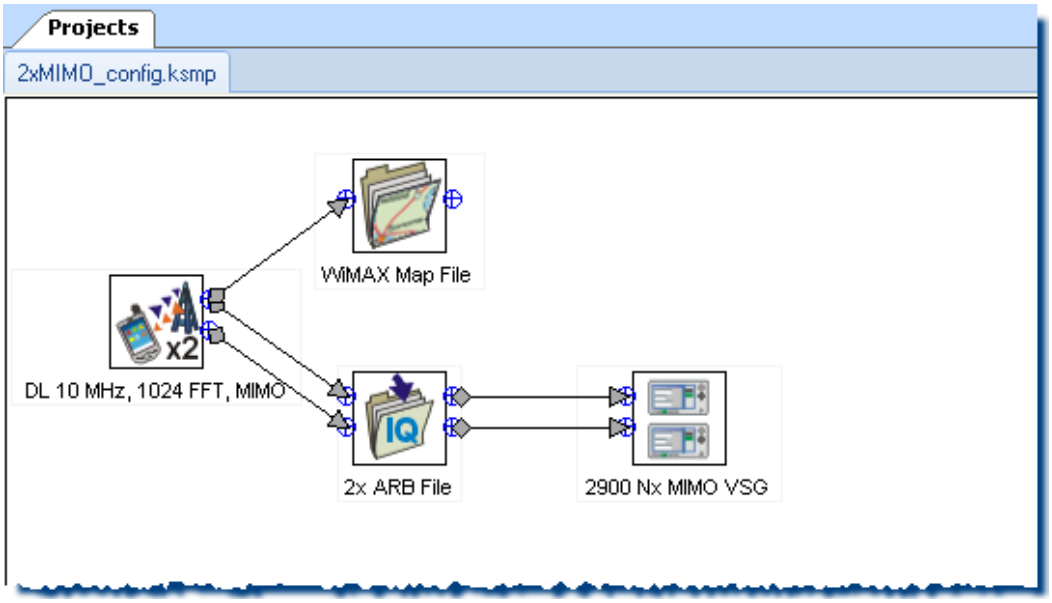
In uplink, MIMO mode is found in the **UL Subframe** > **Zone > Burst**.



Generating WiMAX MIMO signals follows the same steps as in *Generating a WLAN SISO Signal and Analyzing it on a VSA*. Here, WiMAX downlink MIMO is used as an example. However, the WiMAX files are *not* downloaded into the Series V2800 VSAs because the VSAs will be used for data collection in MIMO mode and the analysis will be done on the PC in SignalMeister. This is different from WiMAX SISO signal analysis which can be done in the embedded WiMAX analysis of the Series V2800 VSA.

Put Elements into the Projects View and Connect the Elements

1. In the SignalMeister Toolbox, select the **WiMAX** folder to display the list of WiMAX elements.
2. Drag and drop the **DL 10 MHz, 1024 FFT 2xMIMO** element into the Projects view.
3. In the Toolbox, select the **Files** folder to display the list of Files elements.
4. Drag and drop the **2x ARB File** and **WiMAX Map File** elements into the Projects view.
5. In the Toolbox, select the **Signal Generators** folder to display the list of signal generator elements.
6. Drag and drop the signal generator **2900 Nx MIMO** element into the Projects view.
7. Double-click the element to open the **How Many Instruments** dialog.
8. Select the number of instruments in your configuration (in this example it is 2).
9. Connect the elements as shown below.



Run the Project

1. Configure each element appropriately by double-clicking on the element.
2. From the main menu, select **File** > **Save Project As...** then save the project.
3. Select **Projects** > **Load All** to download the file to the specified location in the VSA, and load it into the ARB memory.

   The elements will turn green to show a successful build.

Verify Signals on the VSAs

1. Place both the Series V2800s and Series V2900s into MIMO mode.
2. Load the corresponding ARB file into the Series V2900 ARB memory and load it.
3. Configure the frequency and power level, then turn the RF to On.
4. On the Series V2900s
   - Set the master to **Trigger Now**.
   - Set the slave to **Trigger Now**.
5. On the Series V2800s
   - Set the Frequency and Reference Level as appropriate.
   - Place both Series V2800s into Zero-Span mode.
   - Set the Sweep Time appropriately.
   - Set the Trigger Source to either Free Run or Video Trigger. If Video Trigger is selected, set the Trigger Level as well.

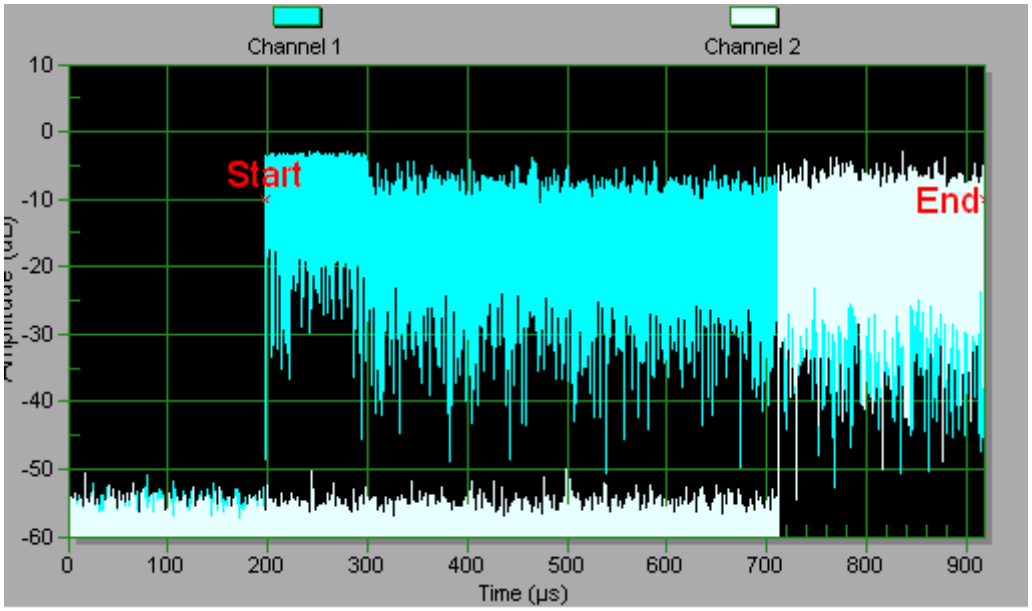
By now, waveforms should be displayed on the analyzers. If not,

1. Connect the output of the VSG to the input of the VSA.
2. On the VSA, select **Preset** > **Spectrum** > **Standards** > **802.16x** to view the constellation diagram and other parameters.
3. Then load the testing signals again for verification.

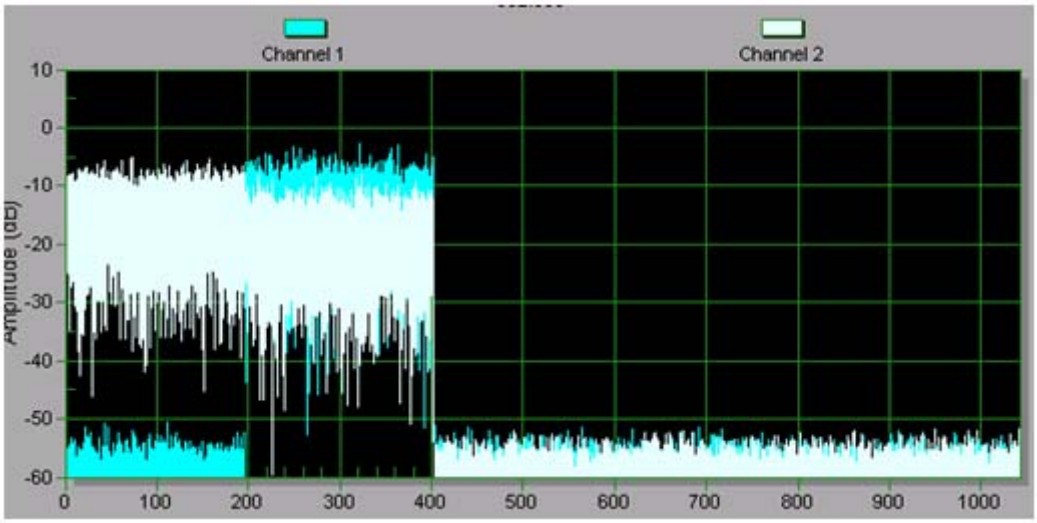
Successfully Triggering WiMAX MIMO Signals

WiMAX MIMO signals pose an interesting challenge to video triggering. Most OFDM MIMO standards have all of the transmitters come on synchronously, so you can choose a specific transmitter and successfully trigger a signal.

WiMAX, however, only uses MIMO as part of the data region. When the signal first comes on, only the master transmitter sends out the header information. Shown below is an example of a 2x2 WiMax MIMO transmission:

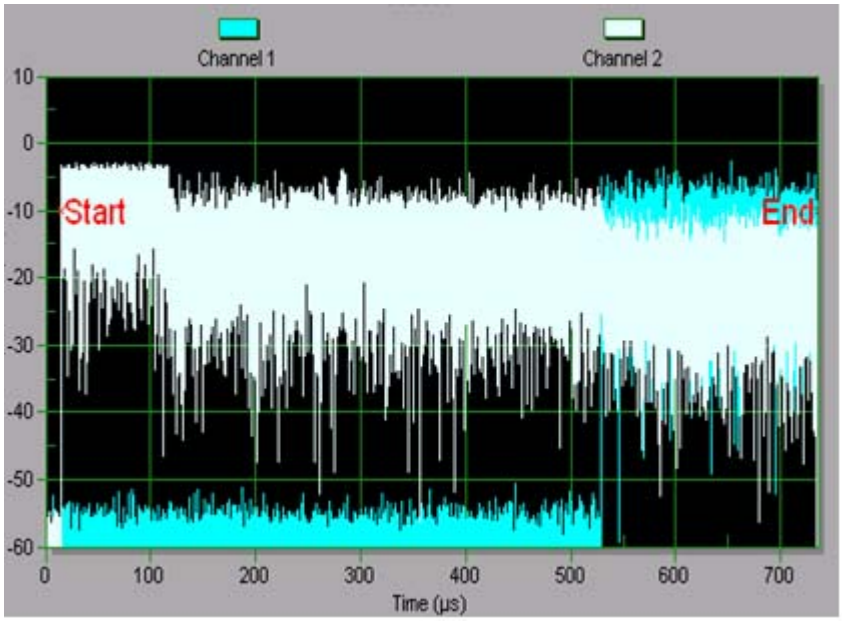


Note that the master transmitter (Channel 1) comes on approximately 500 µsec prior to the slave transmitter (Channel 2). The problem can be described as such; a MIMO system must choose a single input from which to derive the video trigger. By convention, the master receiver is used. If you cable the slave transmitter to the master receiver, you get the situation shown below:



Channel 1 (the blue trace) is the signal received at the master receiver. The video trigger from the blue trace did not occur until 500 µsec after Channel 2 (the white trace) became active (you can only see about 200 µsec in this graph). Since the trigger was so late, the WiMax header was missed, and the signal was not demodulated.

Knowing that this situation exists, you have to decrease the video trigger delay by 500 µsec, so acquisition begins in time to capture both pulses in their entirety, as is shown in the figure below:



In this case, the trigger delay was reduce from 322 µsec to -20 µsec. Determining the required trigger delay can be done from the SignalMeister analysis window. If you place SignalMeister in a Continuous sweep, display the IQ Amplitude graph, and begin reducing the video trigger delay, you can see when you are capturing enough of the signal to successfully demodulate.

In summary, there are 3 choices to get reliable acquisitions of WiMAX MIMO:

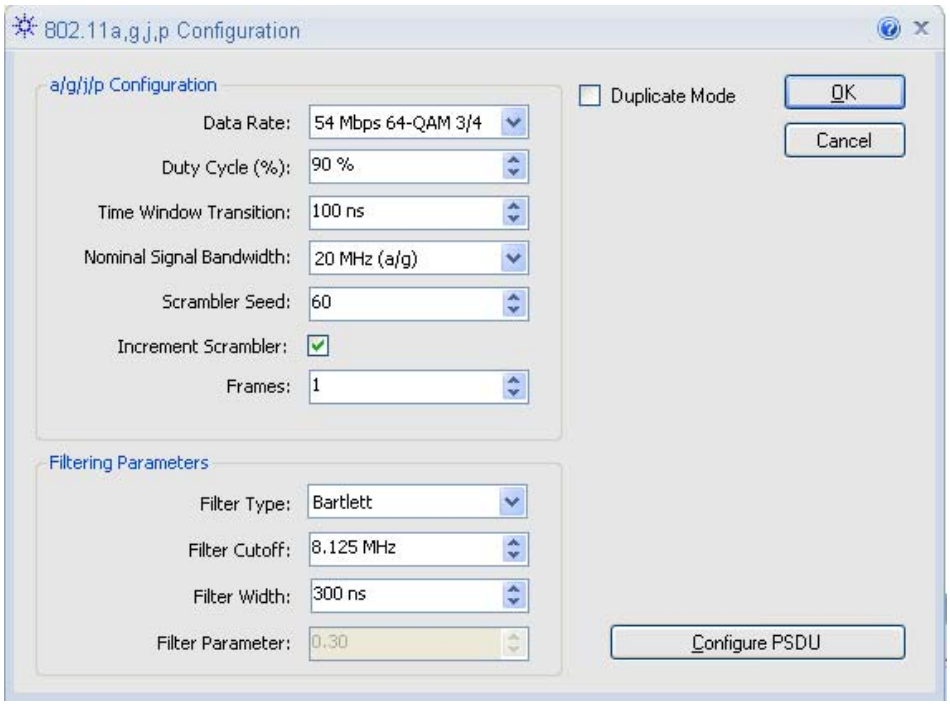
- Always ensure that the master transmit goes to the master receive
- Look for the case where the video trigger needs negative delay and add the delay when needed.
- Use free run trigger, and an acquisition time long enough to always get a complete burst. This is typically twice the WiMAX frame time.

Optimizing WiMAX MIMO Signals

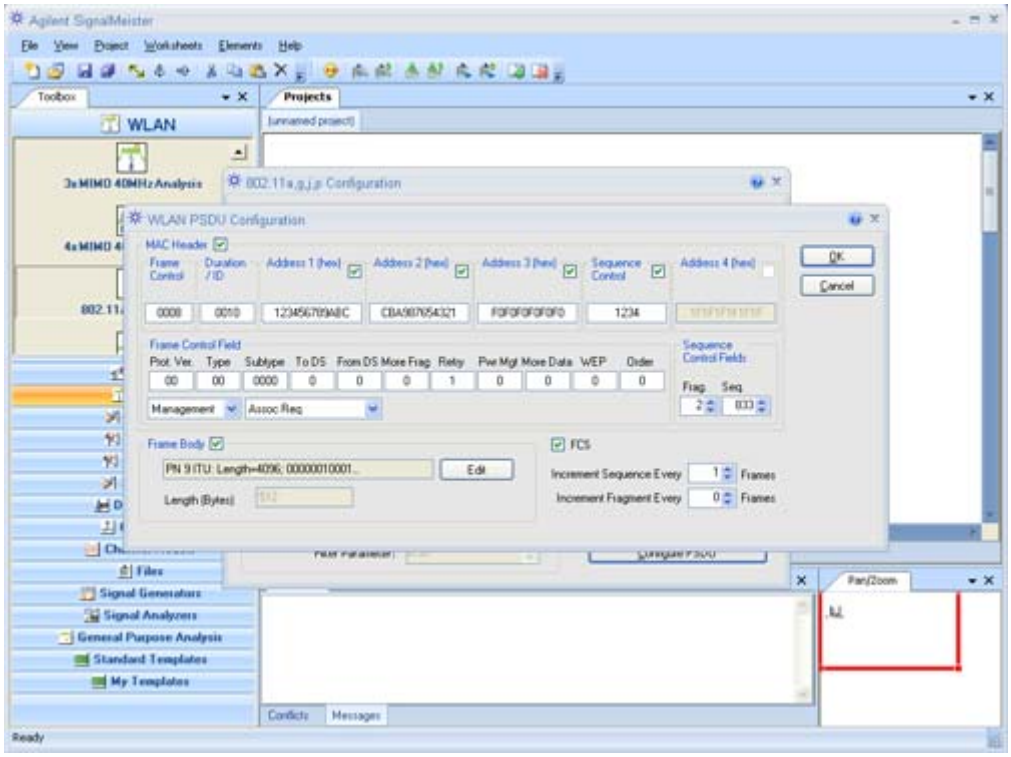
The SignalMeister optimize function assumes that the master transmitter is cabled to the master receiver. The Optimize function will fail in any other configuration, as it attempts to use video triggering. In order to use the Optimize function, you must ensure that the master transmitter output is connected to the master MIMO receiver. If the device being measured does not have the transmitter outputs labeled, it may take some trial and error to find the right connections.

WLAN

The configuration dialog windows for 802.11a/b/g/j all have a similar format. There are a relatively small number of parameters required for these standards. The basic parameters are entered on the following screen. These parameters either have a valid range of numbers from which to choose or an item to select from a drop down list.



The specific payload data can be entered by selecting **Configure PSDU** (see the figure above) and entering values in the WLAN PSDU Configuration dialog (see figure below).

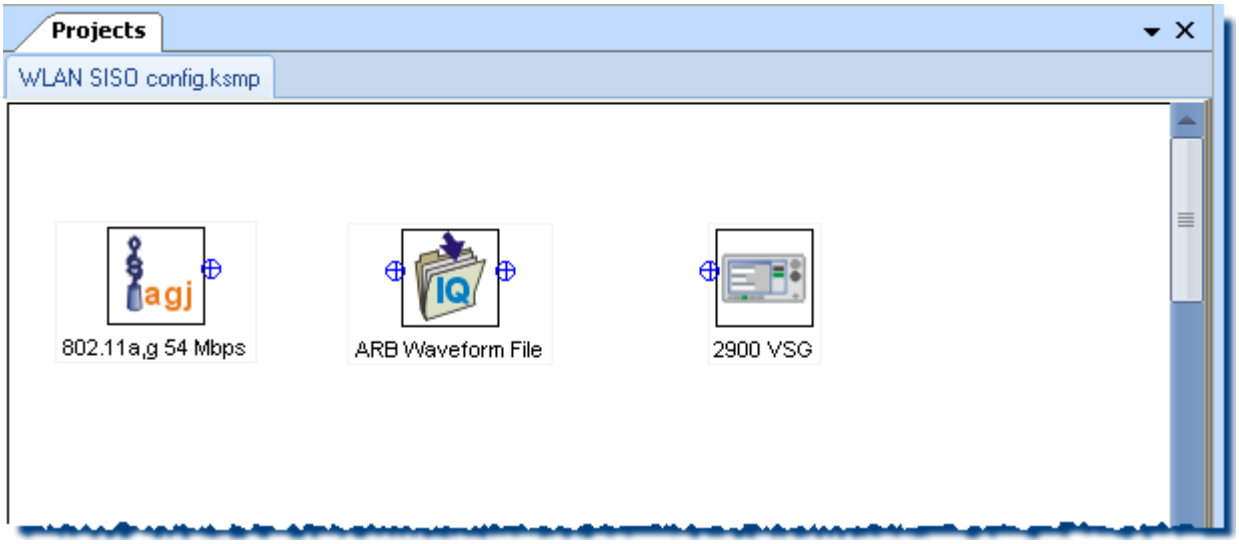


Generating a WLAN SISO Signal

In this section, a SISO 802.11 a/g signal is generated step by step. Then the Series V2800 VSA embedded WLAN option will be used to analyze and verify the generated signal.

Put Elements into the Projects View

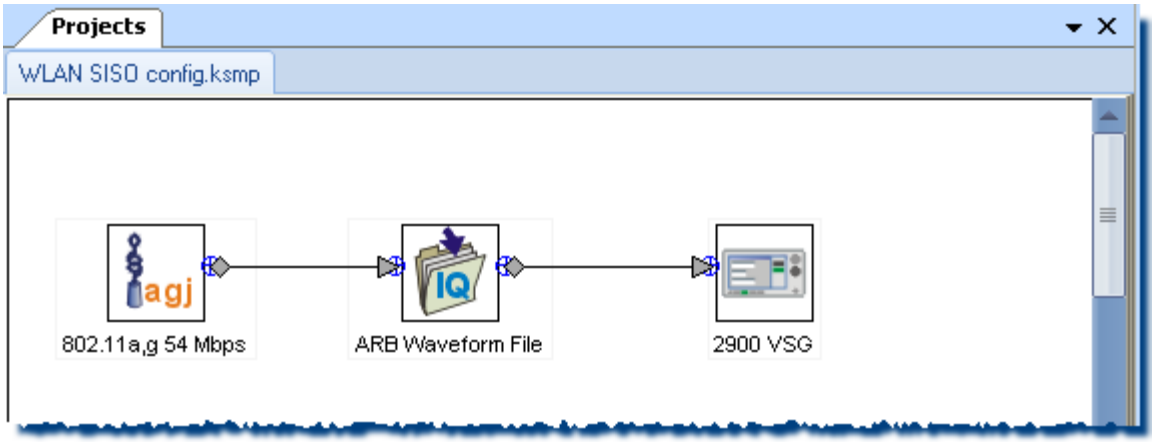
1. In the SignalMeister Toolbox, select the **WLAN** folder to display the list of WLAN elements.
2. Drag and drop a WLAN element (for example, the 802.11a, g 54 Mbps) into the Projects view.
3. In the Toolbox, select the **Files** folder to display the list of File elements.
4. Drag and drop the **ARB File** element into the Projects view.
5. In the Toolbox, select the **Signal Generators** folder to display the list of signal generator elements.
6. Drag and drop the **2900 VSG** element into the Projects view.
7. The three elements should be configured as shown in the figure below.



Connect the Elements

1. Use the **Connect Elements** icon to connect the output of the **802.11a,g 54 Mbps** element to the **ARB File** input.
2. Connect the output of the **ARB File** element to the input of the **2900 VSG**.
3. Click and drag a rectangle to enclose all three elements.
4. From the main menu, select **Worksheets** > **Align Horizontal** (alternately, you can select the Align Horizontal icon from the toolbar).

   Now the elements are connected together and aligned as shown below.



Configure the Elements

1. Double-click each element to configure the parameters of each element. Refer to *WLAN signal generation* for more information. If you need more information regarding each individual parameter refer to the SignalMeister Help. Refer to *Basic SignalMeister Tasks* for information on ARB file and instrument configurations.
2. From the main menu, select **File** > **Save Project...** to save the project.

To run the project

There are four options to run the project from SignalMeister's Projects menu.

- **Run Conflict Analyzer**: Displays any errors or conflicts in the current configuration in the Status area.
- **Build All**: Builds an ARB file that contains all of the elements of the project including the elements on multiple worksheets. The ARB file is created and stored on your PC.
- **Download All**: Downloads the ARB files from your PC to the signal generator memory.
- **Load All**: Loads all of the ARB files in the current project to the signal generator that is configured in your project. This selection makes the ARB file ready to play in the signal generator.

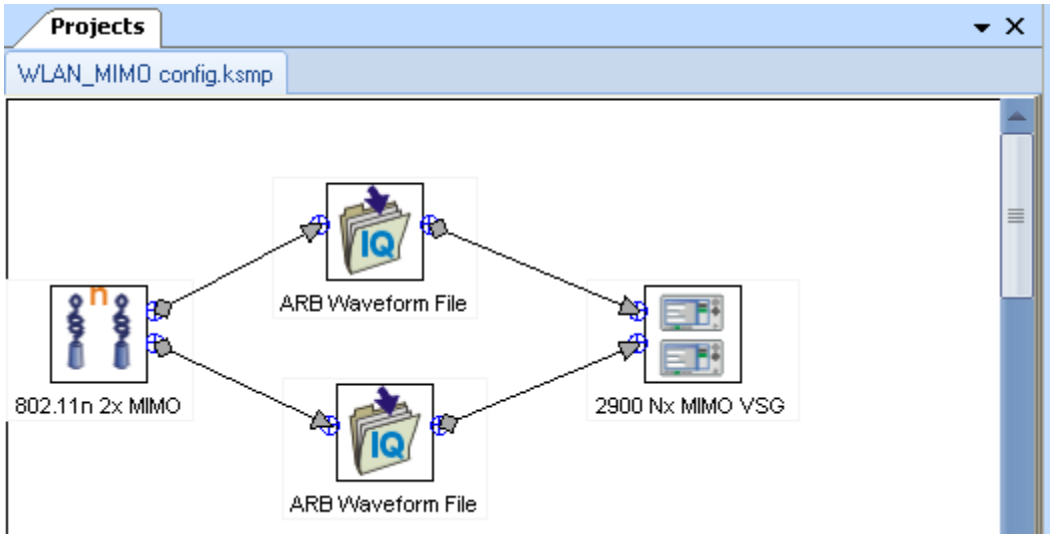
From the main menu, select **Projects** > **Build All** to build the ARB file.

– or –

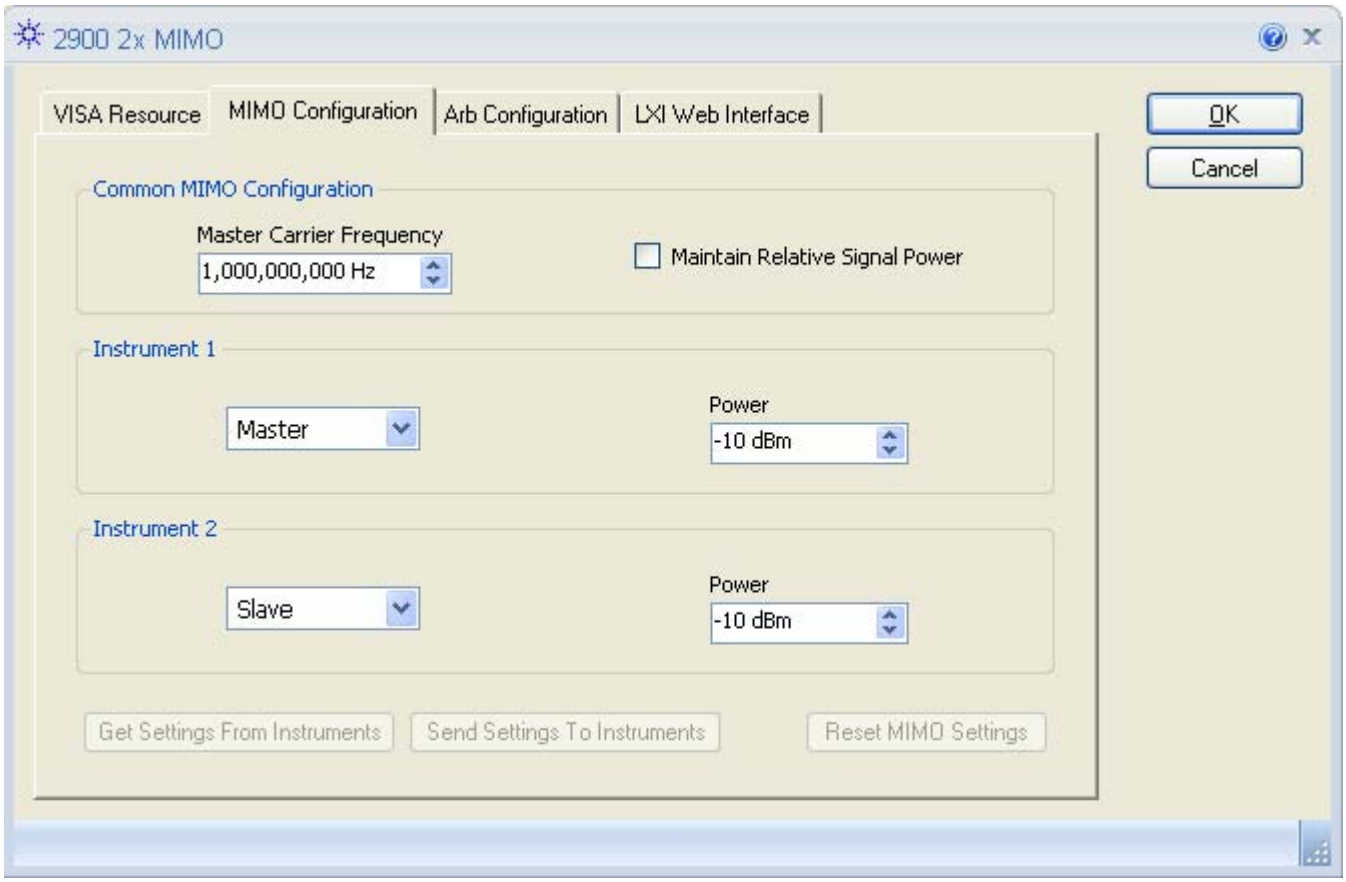
Select **Projects** > **Load All** to download the ARB file to the specified location in the VSA, and load it into the ARB memory.

Generating WLAN MIMO Signals

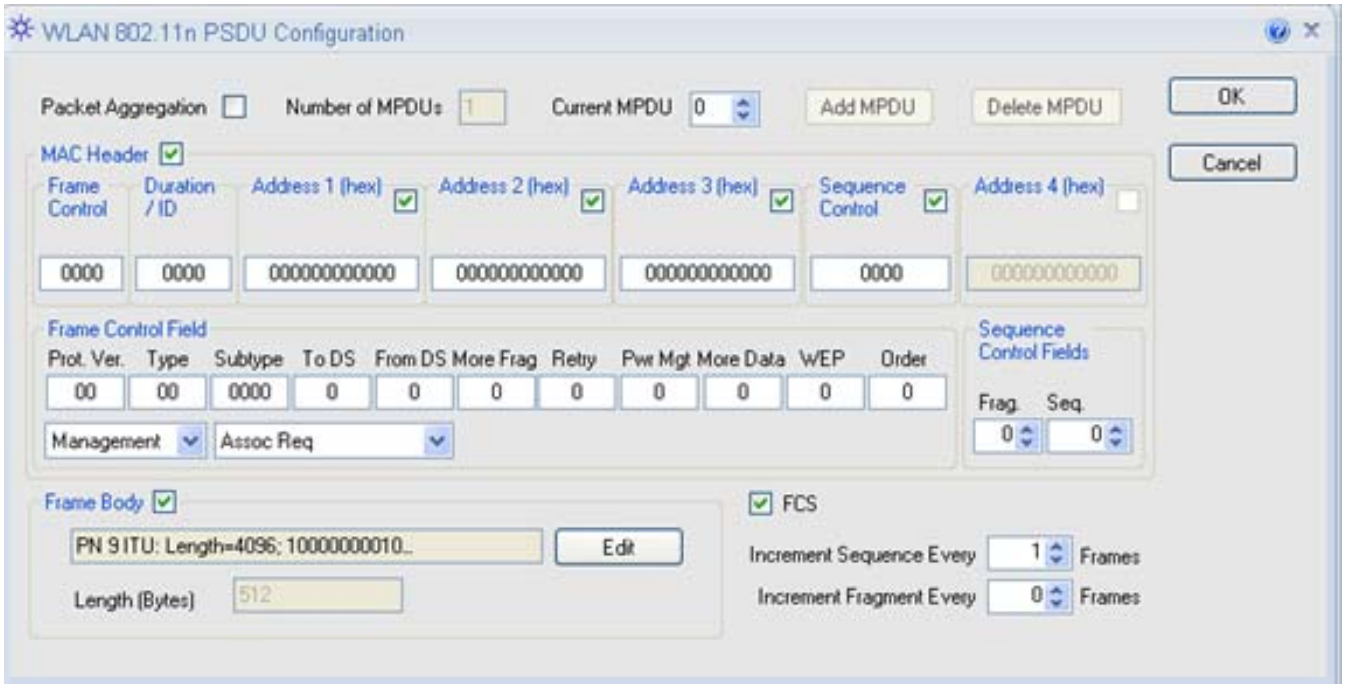
The input parameters for 802.11n are similar to *Generating a WLAN SISO Signal and Analyzing it on a VSA*. However, there is an additional parameter called the MCS number. The MCS number of an 802.11n signal will determine the modulation format, coding scheme, and also the number of MIMO output streams in the waveform data. For example, MCS 15 has two output streams. The following figure shows how to generate the 2x2 MIMO setup for MCS-15.



In this example, the two ARB file elements would have different file names. The 2x2 MIMO signal source object allows the input of communication addresses for both signal sources and configures the MIMO parameters for the system.

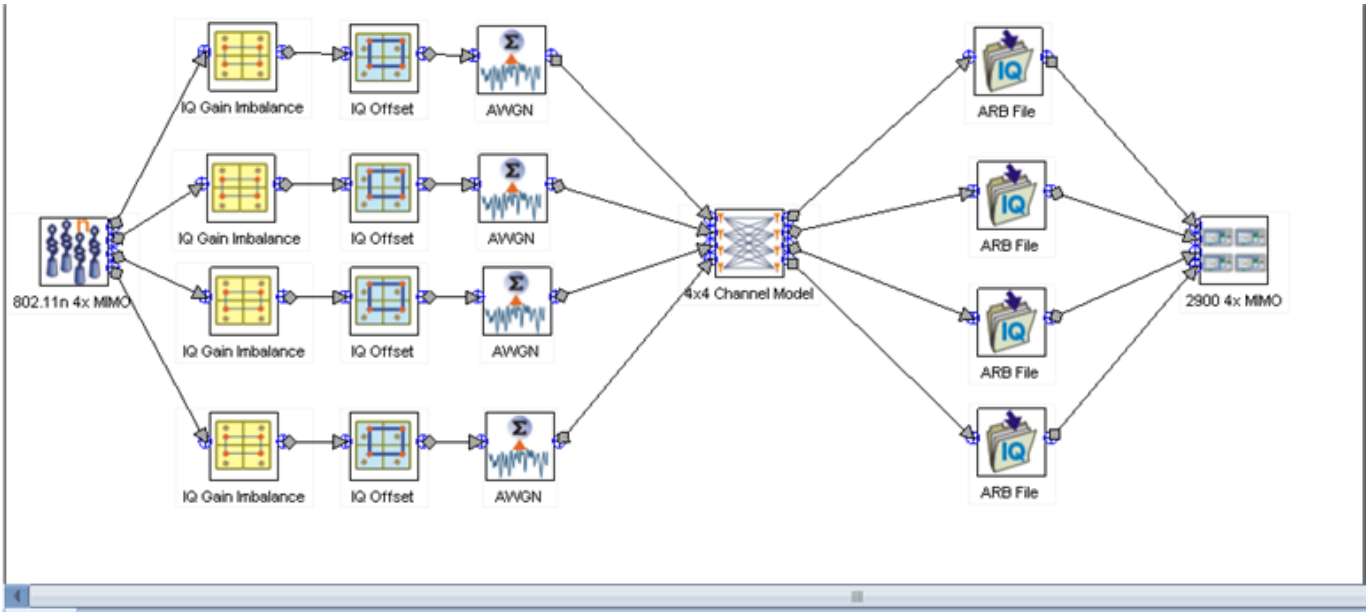


The PSDU configuration for 802.11n also contains additional controls, as shown below.



There are two default standard templates in the Toolbox under the Standard Templates folder. Use them as an example to customize your own project.

From the Toolbox, select the **Standard Template** folder and click and drag the **4xMIMO Complex Impairments** element to the Projects worksheet. Notice how the element automatically opens itself when it is placed on the worksheet.

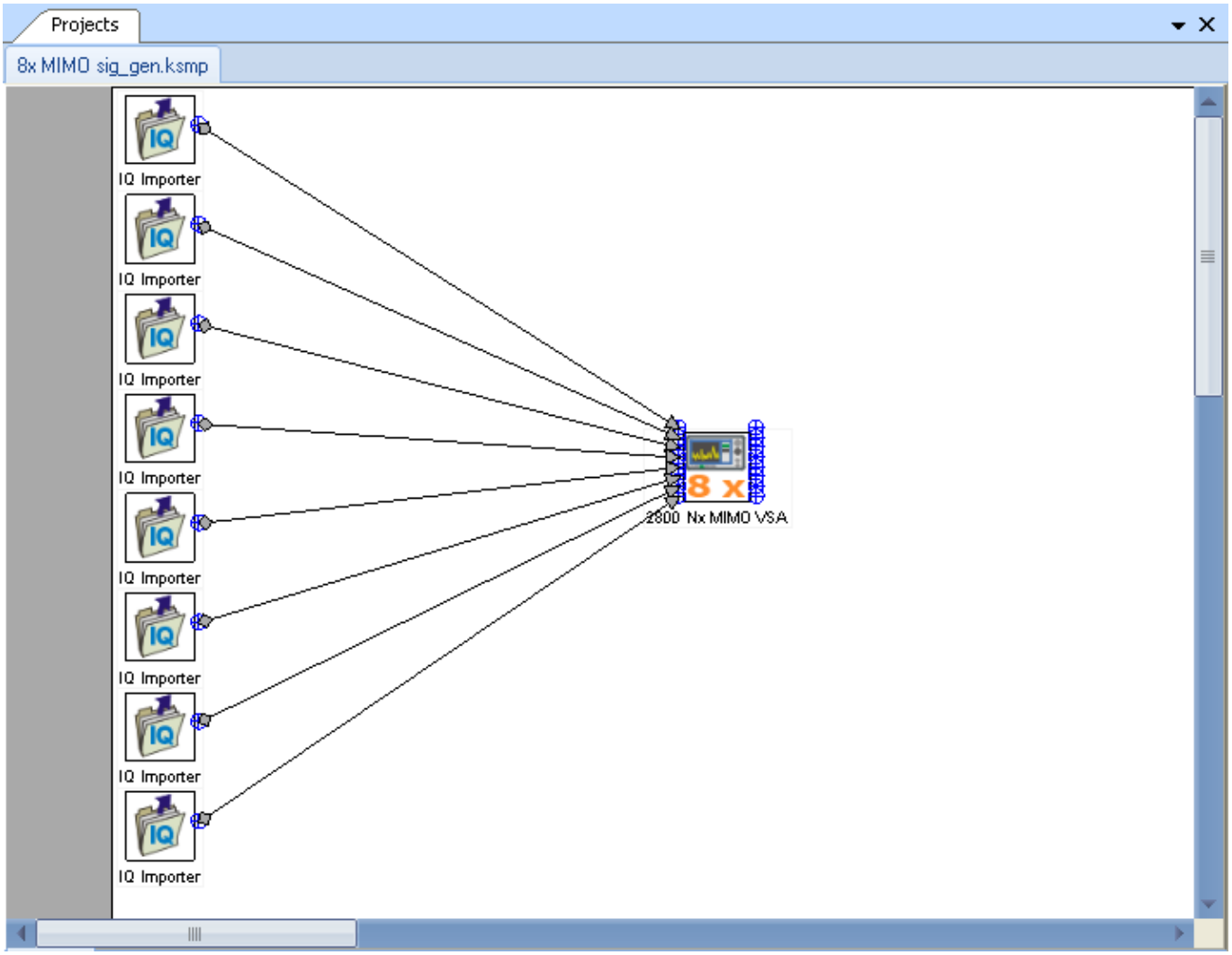


8 x MIMO Signal Generation – IQ Files

This procedure shows MIMO signal generation capability for eight Series V2800s. There is no specific supported standard in SignalMeister to generate 8x MIMO signals. In the case that you would like to develop your own 8x MIMO system, user-defined IQ data sources are used as the following example

Put Elements in Projects View and Connect them

1. From the Toolbox, open the **File** folder and drag and drop the **IQ Importer** element (eight times) onto the Projects view.
2. Open the Signal Analyzers folder and drag and drop **2800 Nx MIMO VSA** to the Projects view.
3. Connect the IQ Importer elements to the **2800 Nx MIMO VSA** elements as shown below.



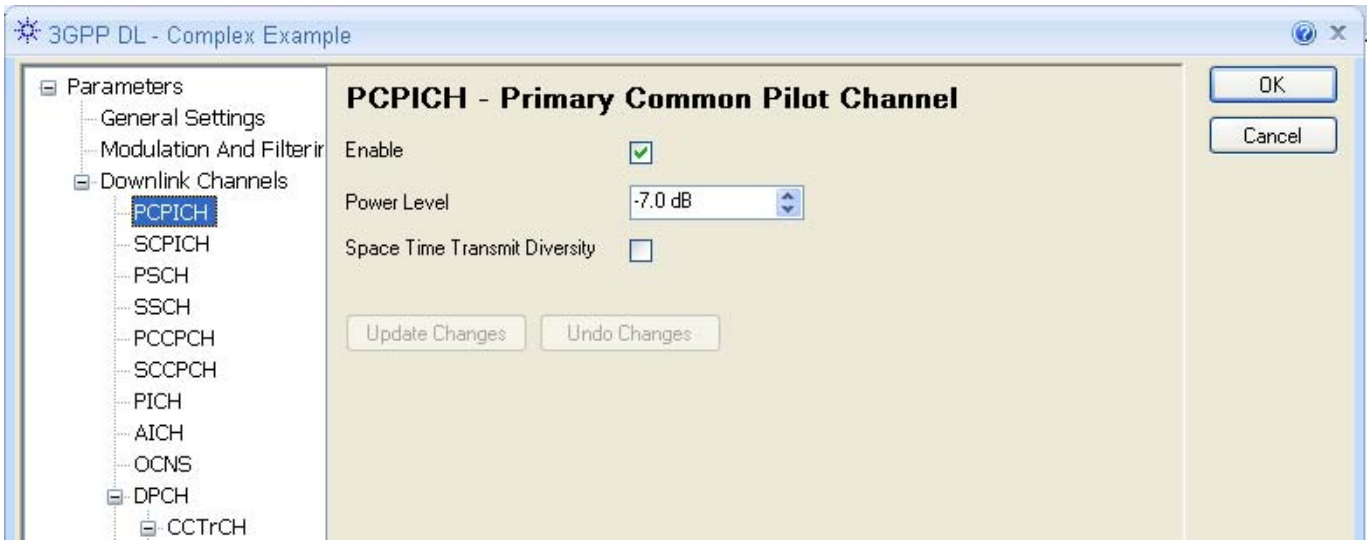
Configure the Elements and Run the Project

1. Configure each user-defined data source in the DP IQ Importer appropriately.
2. The Configuration window of the Series V2800 8X MIMO is similar to other Series V2800 MIMO configurations. It supports eight Series V2800s in VISA Resource, MIMO configuration, ARB configuration, and LXI Web Interface as shown below.


2800 8x MIMO
VISA Resource
MIMO Configuration
LXI Web Interface
OK
Cancel
Instrument 1
Configure...
TCPIP0::0.0.0.0::5025::SOCKET
Active
Instrument Connected: None
Instrument 2
Configure...
TCPIP0::0.0.0.0::5025::SOCKET
Active
Instrument Connected: None
Instrument 3
Configure...
TCPIP0::0.0.0.0::5025::SOCKET
Active
Instrument Connected: None
Instrument 4
Configure...
TCPIP0::0.0.0.0::5025::SOCKET
Active
Instrument Connected: None
Instrument 5
Configure...
TCPIP0::0.0.0.0::5025::SOCKET
Active
Instrument Connected: None
Instrument 6
Configure...
TCPIP0::0.0.0.0::5025::SOCKET
Active
Instrument Connected: None
Instrument 7
Configure...
TCPIP0::0.0.0.0::5025::SOCKET
Active
Instrument Connected: None
Instrument 8
Configure...
TCPIP0::0.0.0.0::5025::SOCKET
Active
Instrument Connected: None

3GPP and 3GPP2

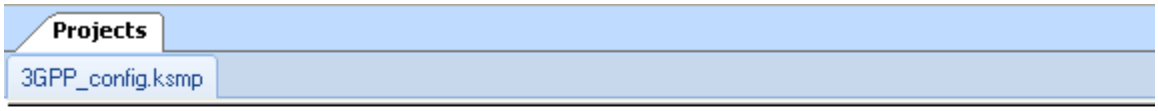
The 3GPP (WCDMA/HSPA) and 3GPP2 (cdmaOne/cdma2000/EV-DV) waveform parameters include a number of general parameters, a list of channels to include, and specific parameters for each channel. This complex data structure is displayed in a tree structure. This provides a quick view of the channel configuration and easy navigation to the specific channel parameters. Several default templates are provided for these standards, covering simple and complicated configurations. In addition, specific parameters (not all parameters) from anywhere in the tree can be defined as “Favorites” giving a quick way to change the most common parameters. This feature is shown in the following screen shots.

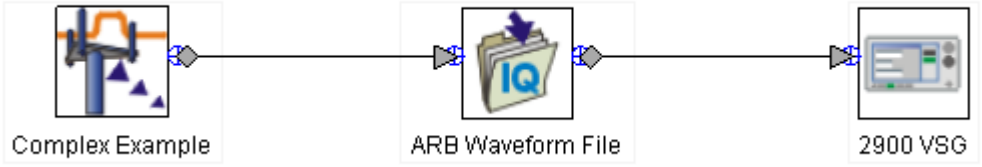


Building 3GPP and 3GPP2 signals is the same as building other signals in SignalMeister. Use the following steps to build a 3GPP downlink signal as shown. Default parameters will be used in this example.

1. Put elements in Project View.
2. Con nect elements.
3. Config ure elements.
4. Save and Run the Project.

Refer to Generating WiMAX MIMO Signals and Analyzing them on a VSA for similar steps for the procedures above.



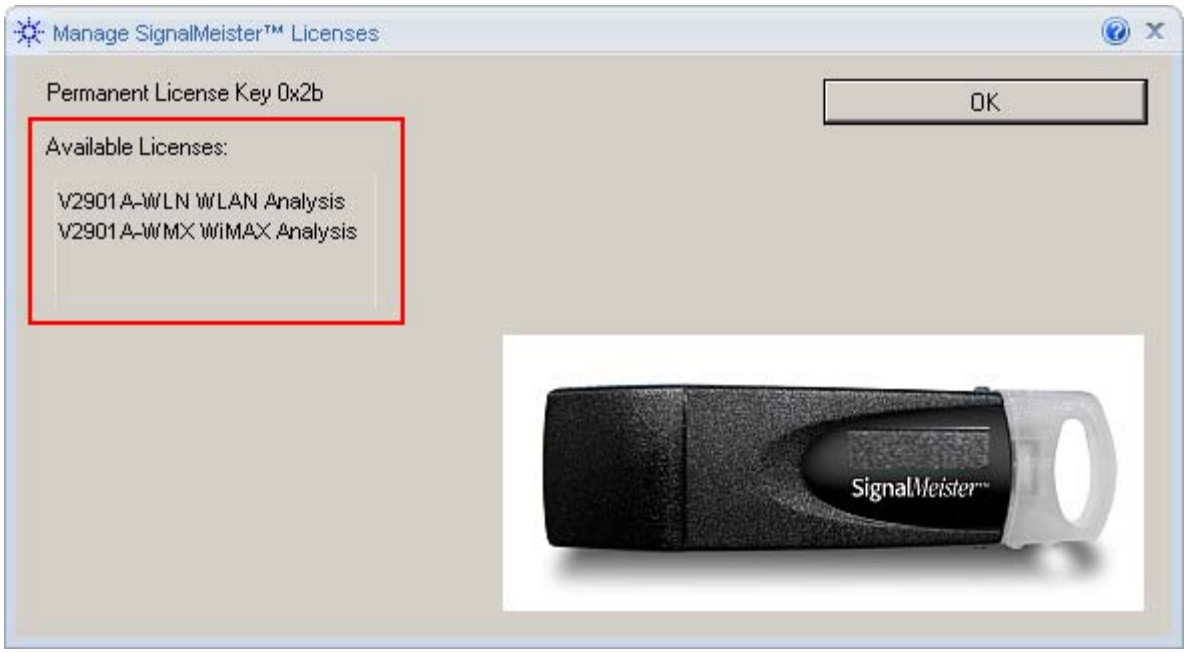


5. Verify Signals on the VSA and VSG.
6. After building the ARB file and loading it into the VSG ARB memory, connect the VSG to the VSA.
7. Use the WCDMA Downlink personality to analyze the signal.

Signal Analysis

SignalMeister supports analyzing WiMAX and WLAN signals in both SISO and MIMO. SISO analysis is similar to the corresponding embedded analysis, but it provides more ways of displaying measurement data, reporting more measurement results, and offers easier and quicker transporting measurement results to the PC. However, SISO analysis in SignalMeister is slower than embedded SISO analysis as it has to go through data collection over GPIB/LAN/USB.

MIMO analysis can only be done in SignalMeister. In this fashion, VSAs are used to collect IQ data, and all analysis are done in SignalMeister. No specific license is needed on the VSAs. Unlike the license for signal generation residing in signal generator, the licenses for signal analysis are residing in the SignalMeister USB license key. With the license key connected, the valid licenses are displayed from the SignalMeister **File** > **Manage Licenses** window.

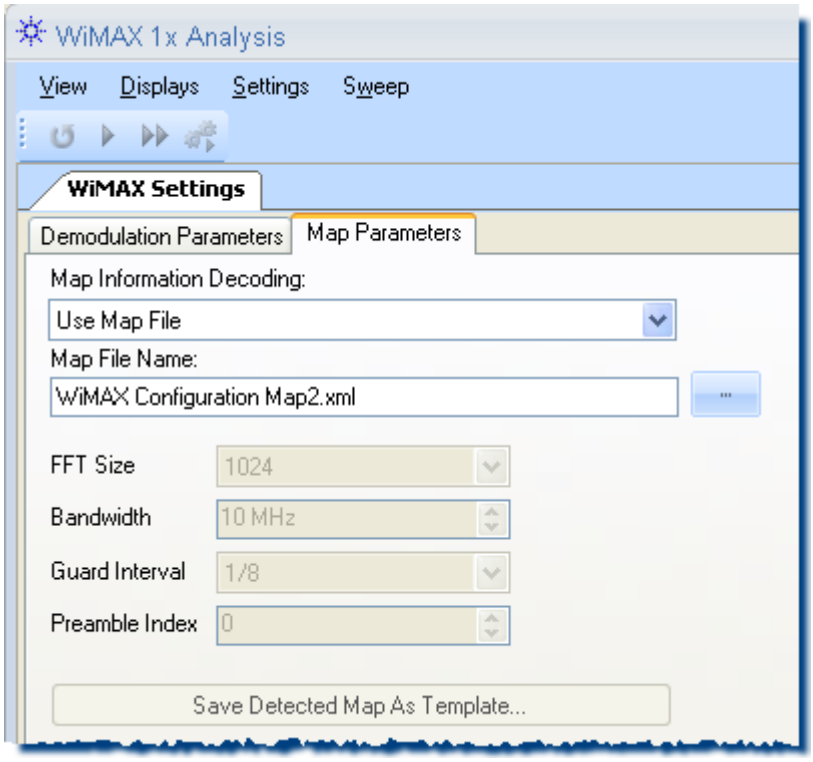


NOTE: SignalMeister's analysis features cannot be operated using remote computer access tools (for example, while the Desktop Control Panel is running).

WiMAX Analysis

WiMAX® signal analysis requires use of the Map file that is generated with the ARB file. The Map file is stored on the PCs hard drive in the My Documents folder, and can be downloaded into the Agilent Series V2800 VSA using the SignalMeister application or a USB device.

To open a WiMAX Map file, select **Use Map File** from the **Map Information Decoding** drop-down menu, then either type in the location and file name of the Map file in the **Map File Name** text box, or click the **More** button ... to open a dialog that allows you to navigate to the Map file location.



Analyzing a SISO WiMAX Signal in SignalMeister

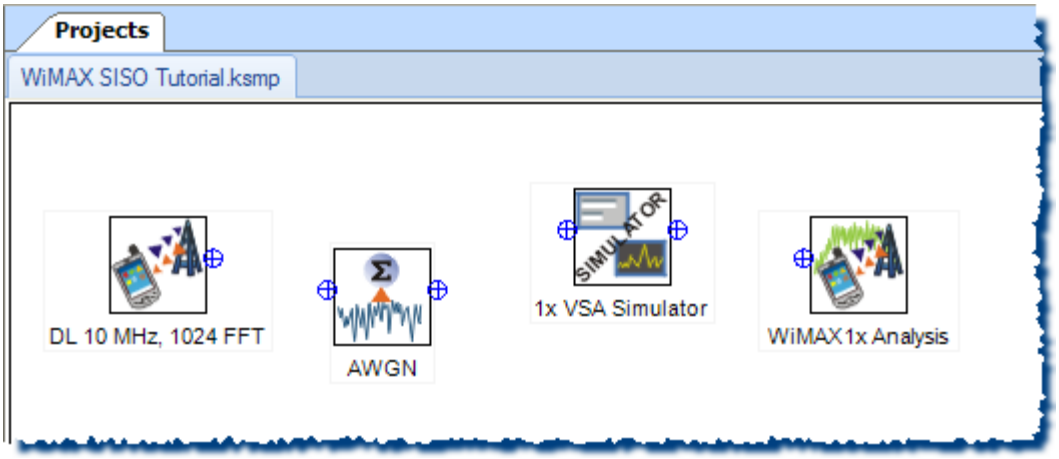
This tutorial demonstrates how to use SignalMeister's simulation mode to create a WiMAX® SISO downlink signal, add AWGN noise to the signal, and then demodulate the received transmission. The simulated analyzer displays both the graphical data and computed parameters. The final steps of the tutorial show you how to increase the noise power, then view the degraded signal.

Hint:	This tutorial can be used for signal types other than WiMAX as the steps in building a project and analyzing a waveform are the same for all signal types. Simply follow each of the steps while substituting the appropriate elements for the type of waveform analysis you wish to perform.

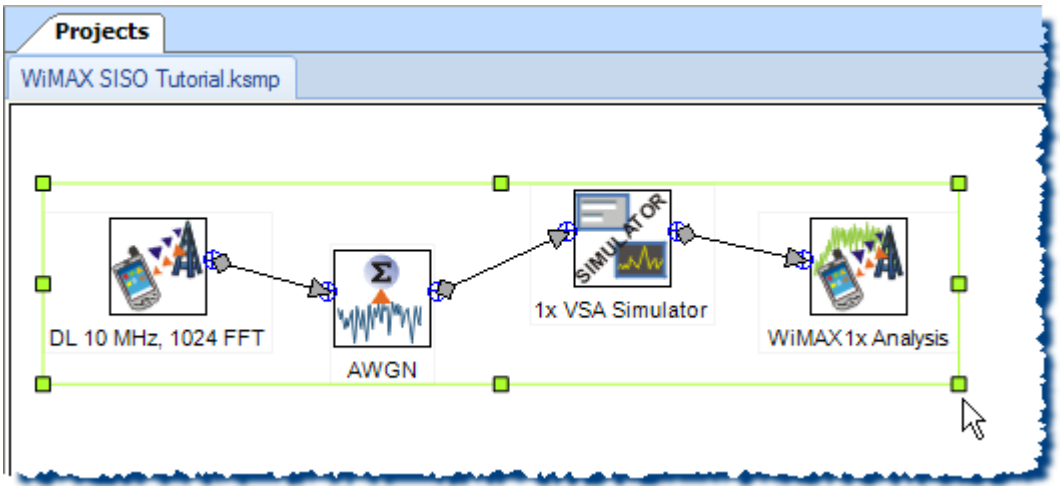
Part 1 – Build the waveform

1. Click the WiMAX button on the Toolbox to display the available elements.
2. Drag and drop the DL 10 MHz, 1024 FFT signal element from the **WiMAX** tool set onto the Projects worksheet.
3. Click the **Operations** button on the Toolbox, then drag and drop the AWGN (Additive White Gaussian Noise) element to the right-hand side of the WiMAX signal element.
4. Click the **Signal Analyzers** button on the Toolbox, then drag and drop the 1x VSA Simulator element to the right-hand side of the AWGN element.

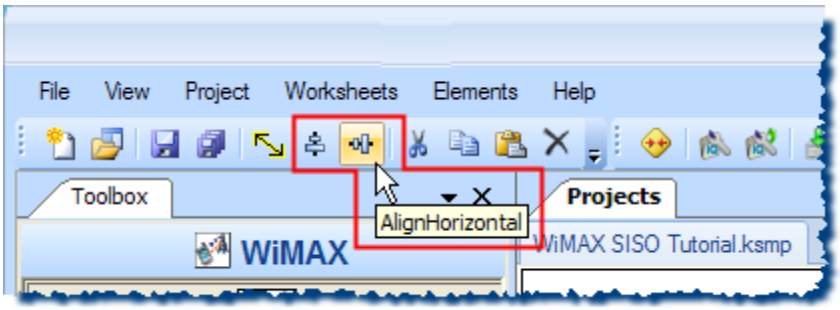
5. Re-open the WiMAX tool set, then drag and drop the WiMAX 1x Analysis element to the right-hand side of the 1x VSA Simulator.
6. Your project should look like something like this so far:



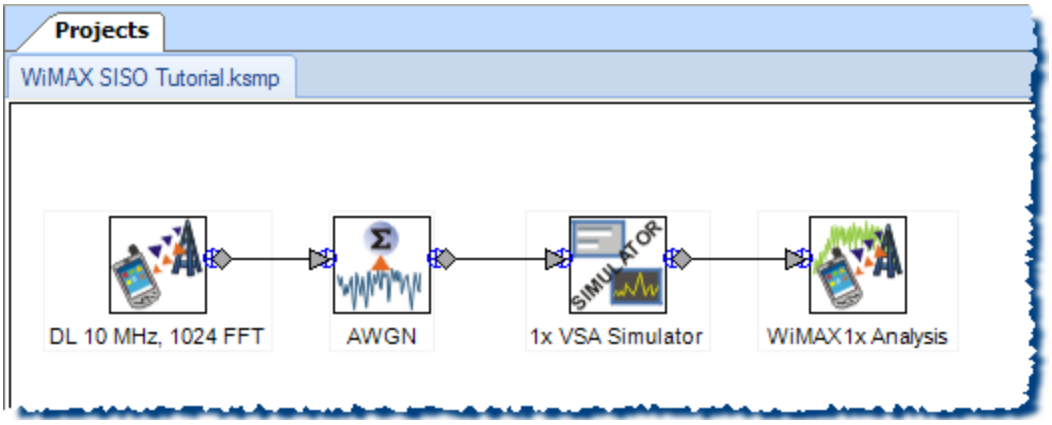
7. Click the **Connect Elements** button on the Main toolbar to make it active.
8. Beginning with the DL 10 MHz, 1024 FFT WiMAX element (far left), click on that element then click the AWGN element to connect them.
9. Click the AWGN element then click the 1x VSA Simulator element to connect them.
10. Repeat this until all elements are connected and a path exists from the signal element to the analysis function.
11. Using the mouse (or the touchpad), left-click, hold and drag across all the elements to create a box around the project.



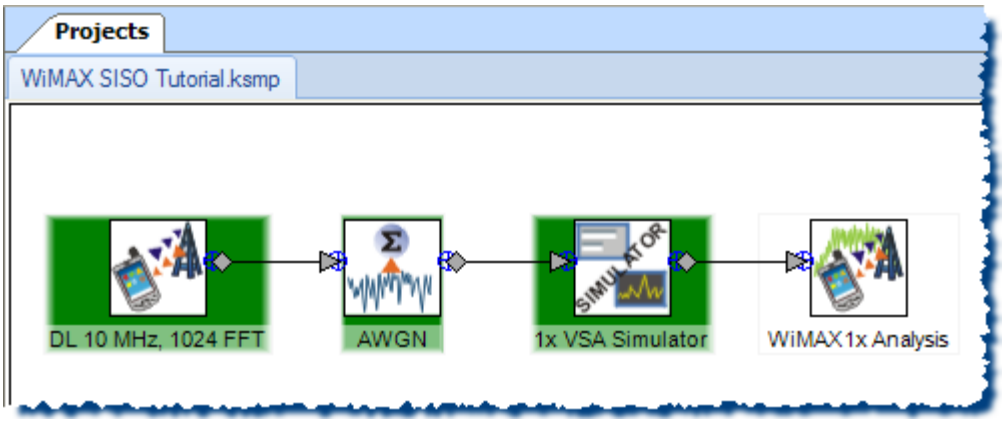
12. Click the **Align Horizontal** icon on the main toolbar to align the elements horizontally.



13. Your project should look like this:



14. On the main toolbar, select **Project > Build All** from the Project menu. If all of the files are built correctly, and there are no errors or conflicts, then the WiMAX signal, AWGN and VSA Simulator elements all become green in color. The Status window displays a message that no errors or conflicts were found.

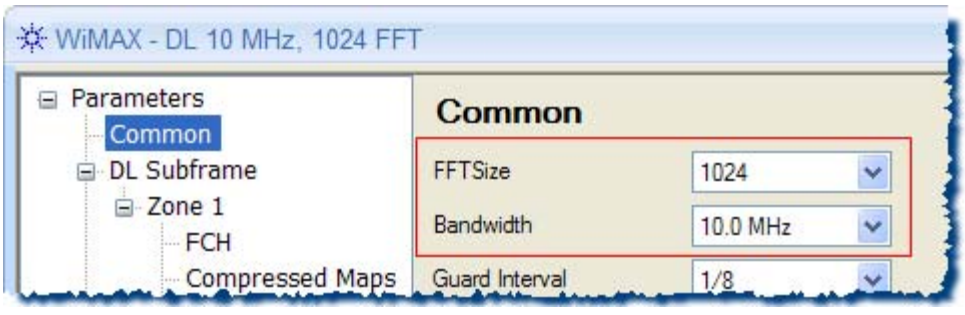


15. The WiMAX downlink signal has been created, Gaussian white noise has been added to it, and the VSA simulator is set to demodulate, display and compute parameters on the signal.

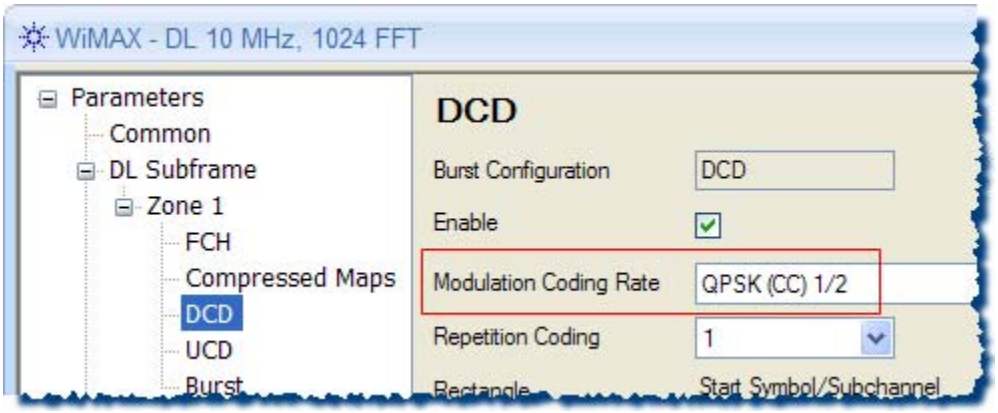
Part 2 – Analyze the signal

NOTE: The waveforms in the toolbox are example waveforms and are starting points for the creation of user-defined waveforms. Numerous parameters are programmable.

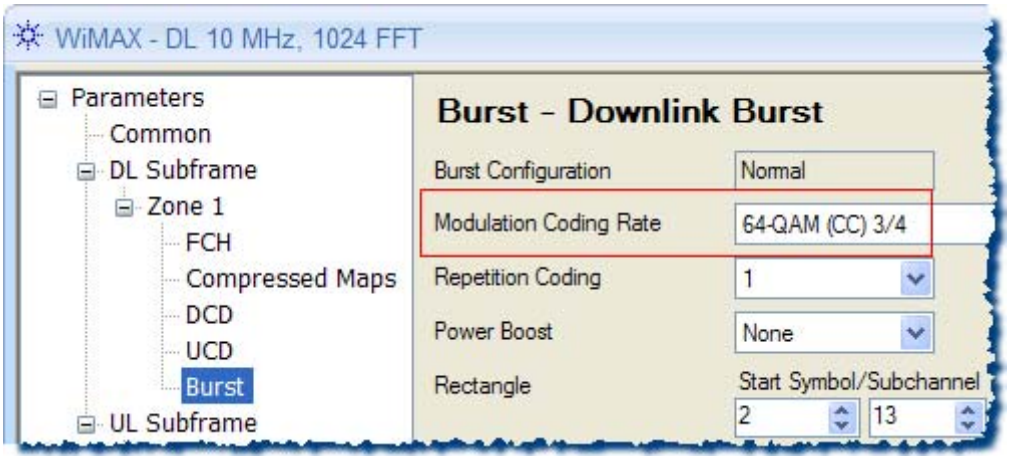
1. Double-click the DL 10 MHz 1024 FFT signal element to open the WiMAX configuration dialog.
2. Select **Common** from the tree view to see that the default parameters are:
   - FFT Size: 1024
   - Bandwidth: 10 MHz (the subcarriers are less than 10 kHz apart)



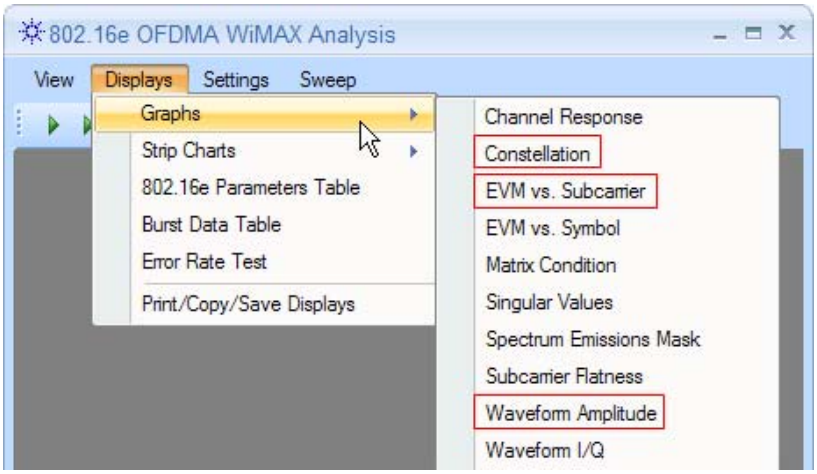
3. Select **DCD** from the tree view to see that the DCD (Downlink Channel Descriptor), that defines channel structure details, uses QPSK modulation.



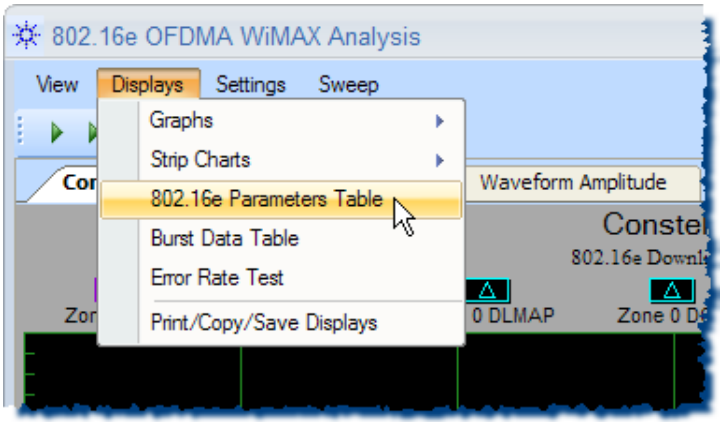
4. Select **Burst** from the tree view to see that the data is transmitted with 64QAM modulation.



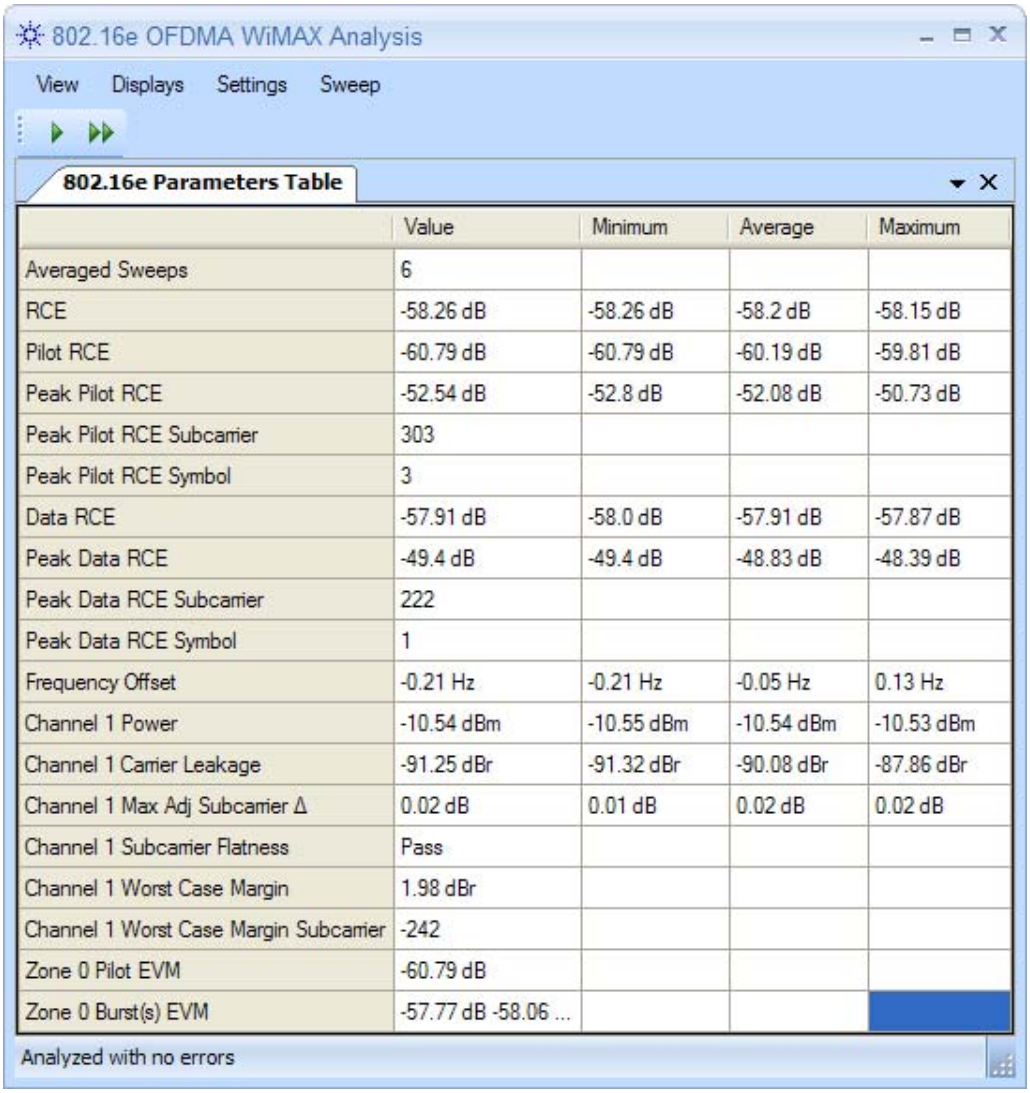
5. Now the WiMAX 1x Analysis element can plot, graph and perform computations on the received signal. This tutorial displays the constellation of the signal, the EVM vs. Subcarrier plot, a waveform amplitude plot (power vs. time), a table of computed parameters and a single-sweep/continuous-sweep instrument control function.
6. Dou ble-click the **WiMAX 1x Analysis** element to open the 802.16e OFDMA WiMAX Analysis window.
7. Select **Displays > Graphs**, then click **Constellation.** Repeat this to also add the **EVM vs. Subcarrier** and **Waveform Amplitude** graphs. The EVM vs. Subcarrier graph shows the EVM for each carrier and the Waveform Amplitude graph shows the power vs. time plot of the 500 µs transmission burst.



8. Select **Displays > 802.16e Parameters Table** to display Relative Constellation Error (RCE) parameters, channel power and other computations.



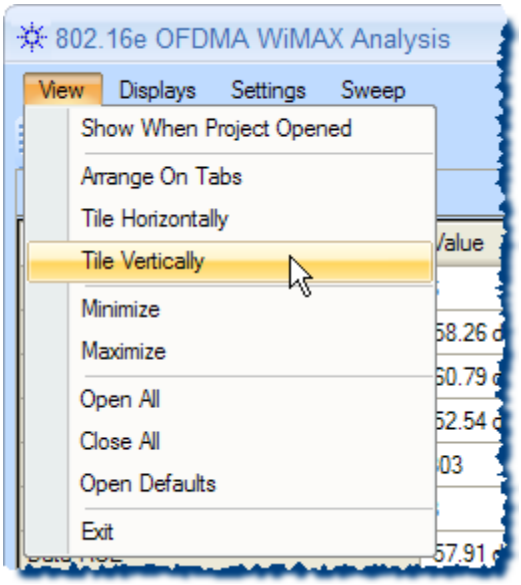
9. Note that the 802.16e Parameters Table shows the number of sweeps and the minimum, maximum and average values for each of the parameters.

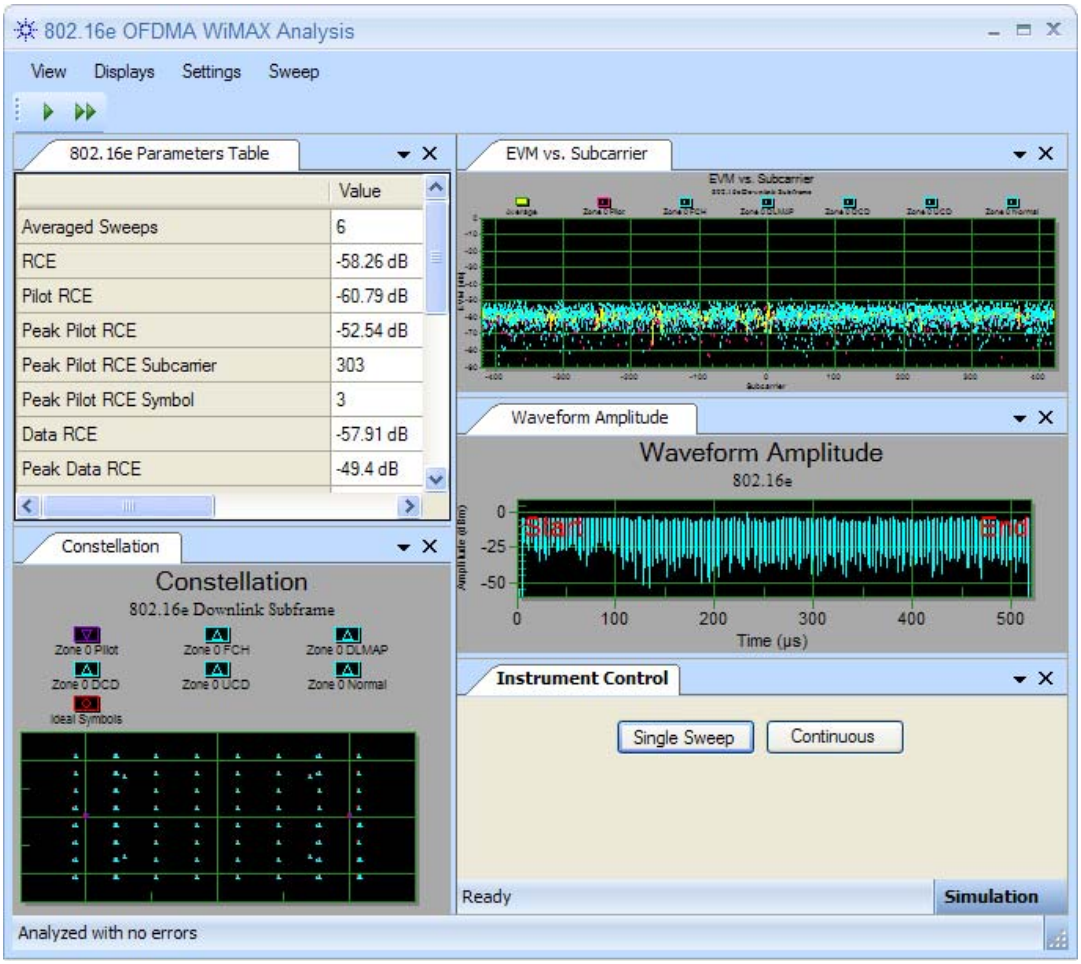


	Value	Minimum	Average	Maximum
Averaged Sweeps	6			
RCE	-58.26 dB	-58.26 dB	-58.2 dB	-58.15 dB
Pilot RCE	-60.79 dB	-60.79 dB	-60.19 dB	-59.81 dB
Peak Pilot RCE	-52.54 dB	-52.8 dB	-52.08 dB	-50.73 dB
Peak Pilot RCE Subcarrier	303			
Peak Pilot RCE Symbol	3			
Data RCE	-57.91 dB	-58.0 dB	-57.91 dB	-57.87 dB
Peak Data RCE	-49.4 dB	-49.4 dB	-48.83 dB	-48.39 dB
Peak Data RCE Subcarrier	222			
Peak Data RCE Symbol	1			
Frequency Offset	-0.21 Hz	-0.21 Hz	-0.05 Hz	0.13 Hz
Channel 1 Power	-10.54 dBm	-10.55 dBm	-10.54 dBm	-10.53 dBm
Channel 1 Carrier Leakage	-91.25 dBr	-91.32 dBr	-90.08 dBr	-87.86 dBr
Channel 1 Max Adj Subcarrier Δ	0.02 dB	0.01 dB	0.02 dB	0.02 dB
Channel 1 Subcarrier Flatness	Pass			
Channel 1 Worst Case Margin	1.98 dBr			
Channel 1 Worst Case Margin Subcarrier	-242			
Zone 0 Pilot EVM	-60.79 dB			
Zone 0 Burst(s) EVM	-57.77 dB -58.06 ...			

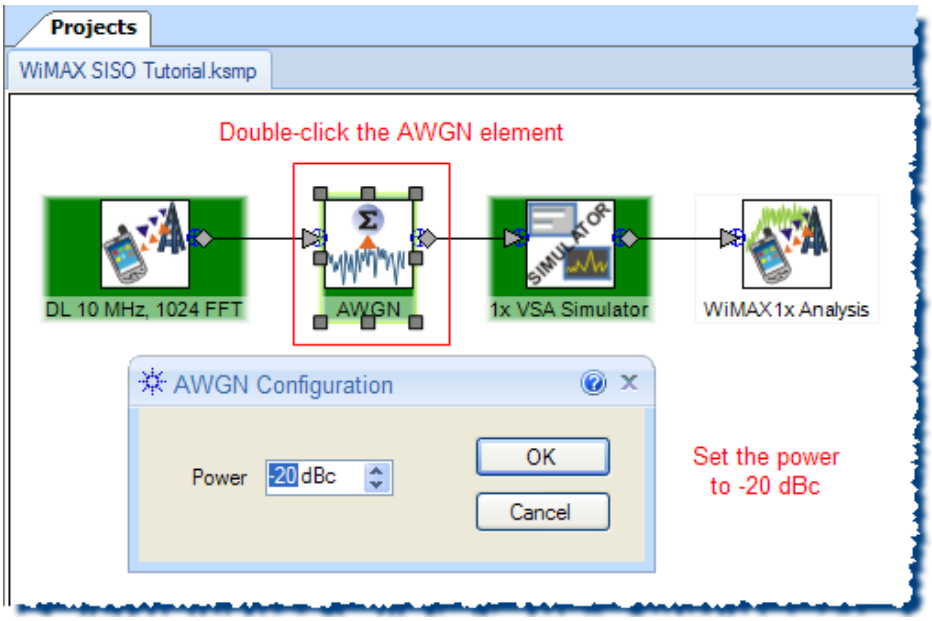
10. Select Settings > Instrument Control to display the control window for the WiMAX Analysis that allows you to select either a Single Sweep or Continuous Sweep.

11. Select **View > Tile Vertically** to see a display of all the open windows.





12. **Select View > Minimize** to return to the SignalMeister project window.
13. Double-click on the AWGN element, then raise the noise Power to -20 dBc and click OK.

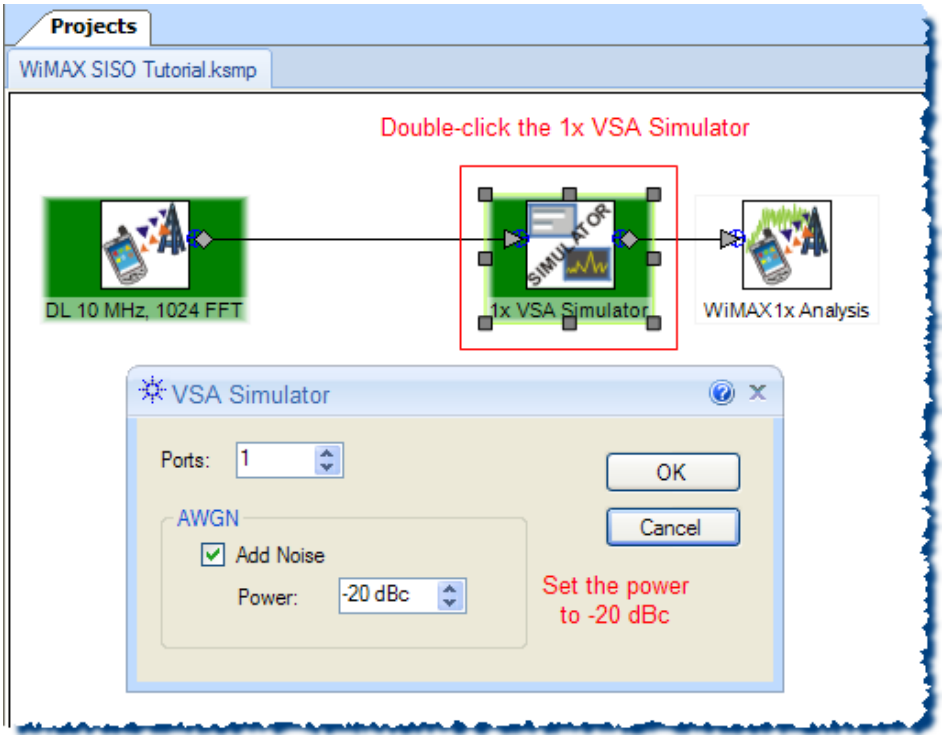


14. Return to the Instrument Control window and click **Single Sweep**. Note that the Constellation is less precise, the EVM vs. Subcarrier is higher (not as good), and the RCE is higher.

Part 3 – Optional steps for a more dynamic display

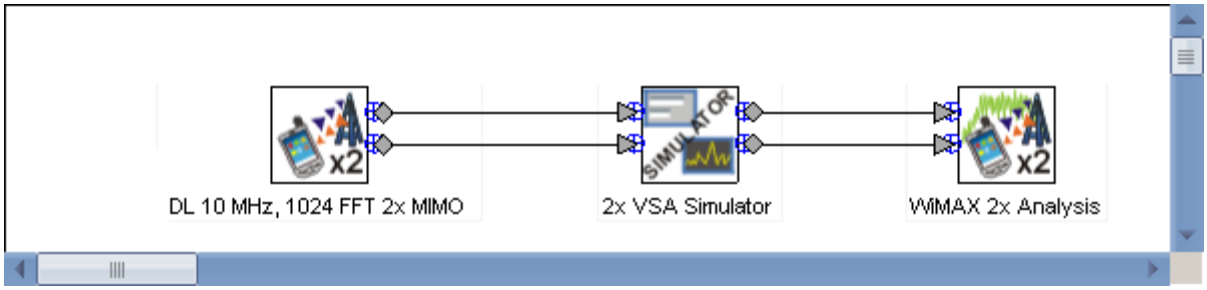
Additive White Gaussian Noise (AWGN) can be added to the VSA simulator to display more realistic data even if the AWGN element is not used. The noise in the VSA simulator is randomized so that it changes with each sweep, so using the VSA's internal noise source creates a changing and more realistic display.

1. Minimize the Analysis window and return to the Projects window.
2. Remove the AWGN element from your project, and remove one of the connectors.
3. Connect the DL 10 MHz, 1024 FFT signal element to the 1x VSA Simulator element.
4. Double-click on the 1x VSA Simulator.
5. Select the **Add Noise** check-box and increase the power to -20 dBc, then click **OK**.

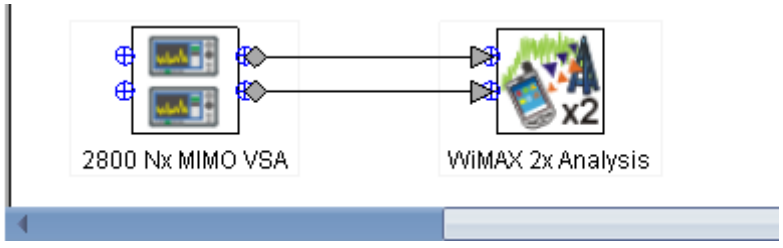


6. Return to the Analysis window and click **Continuous Sweep** from the Instrument Control panel. Note the changing displays. The update rate is a function of your PC speed.
7. Now check the 802.16e Parameters table, the Constellation and EVM vs. Subcarrier graphs to view the changes due to the addition of noise at the 1x VSA Simulator element.

Analyzing MIMO WiMAX Signals in SignalMeister



WiMAX MIMO Analysis Simulation



WiMAX MIMO Analysis using an Instrument

WLAN Analysis Using SignalMeister

Analyzing a SISO Signal in SignalMeister

Following the example in Generating a WLAN SISO Signal and Analyzing it on a VSA, now SignalMeister is used to analyze the same signals.

There are two ways to do this:

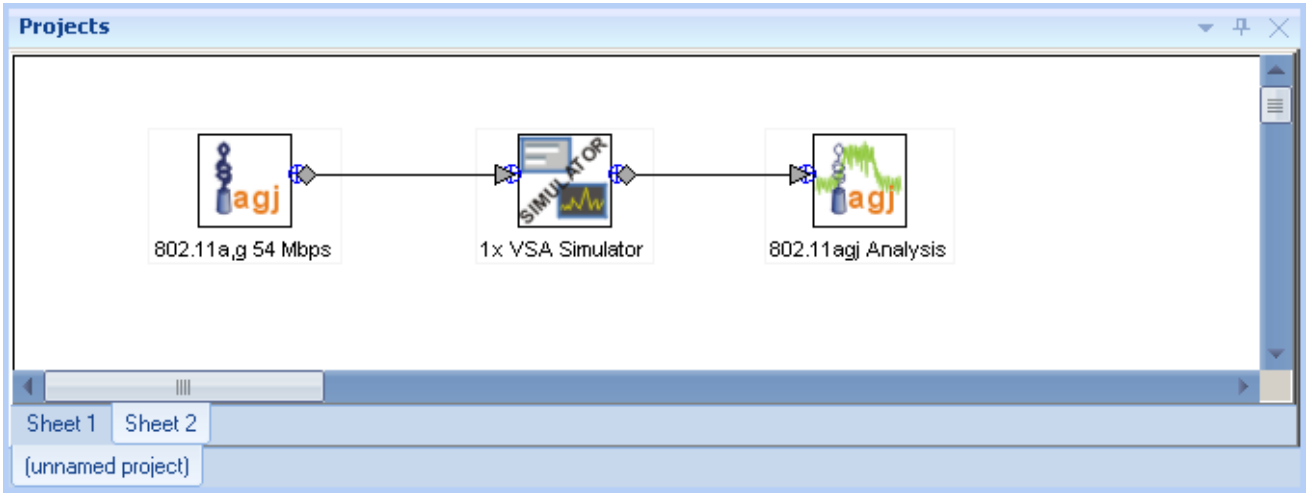
- Use the SignalMeister built-in Series V2800 simulator
- Use the Series V2800 VSA hardware with SignalMeister

The first method does not involve any hardware. It can be used for demonstration purposes and to verify the signal generated from SignalMeister in the baseband (IQ) level. A signal generation element is used as the starting point, which is the same as generating an ARB file. Instead of putting an ARB file element at the output of the signal generation element, a VSA simulator element is connected instead.

Using the Simulation Method

Put Elements in Projects View and Connect Them Together

1. From the Toolbox, select the **WLAN** folder and drag and drop the **802.11 a, g 54 Mbps** on to the Projects view.
2. From the Toolbox, select the **Signal Analyzer** folder and drag and drop the **1x VSA Simulator** element on to the Projects view.
3. From the Toolbox, select the **WLAN** folder and drag and drop the **802.11 agj** element on to the Projects view.
4. Connect the elements together.



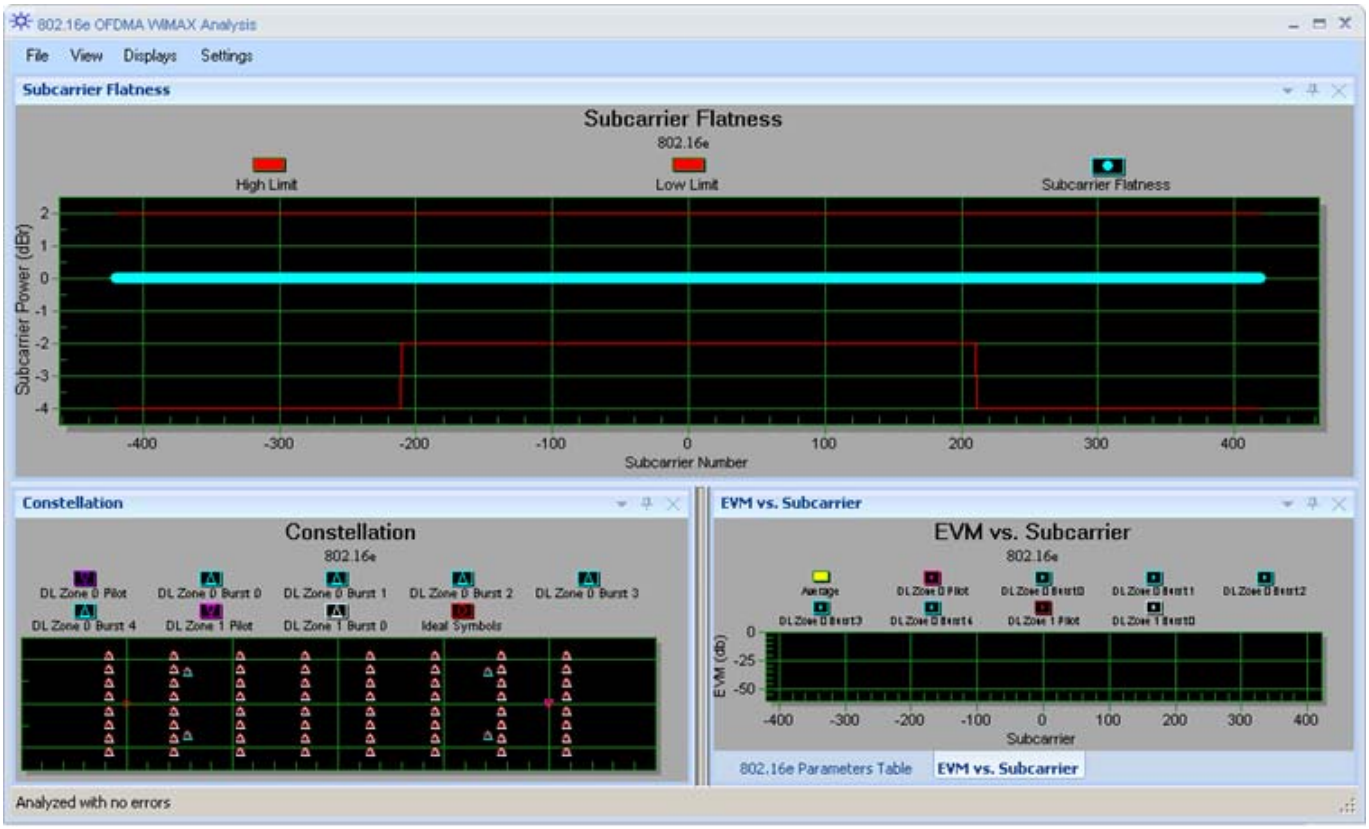
Configure the Elements, Save and Run the Project

1. Configure 802.11 a, g 54 Mbps for the signal you want to analyze.
2. Double click 802.11 agj Analysis. The 802.11 agj SISO analysis window is displayed.

   The startup window will be empty if it has never been configured before. The menu bar has four menus: **File, View, Displays**, and **Settings**.

   - The File menu is used to exit the Analysis window.
   - The View menu is used to globally maintain the Settings and Displays. You can open all of the windows from Settings and Displays and then rearrange them automatically.
   - The Settings Menu supports instrument control, IQ capture settings, specific settings for the type of to-be-analyzed signal, in this case, WLAN settings.
   - The Displays Menu supports various graphs, charts and a parameters reporting table.

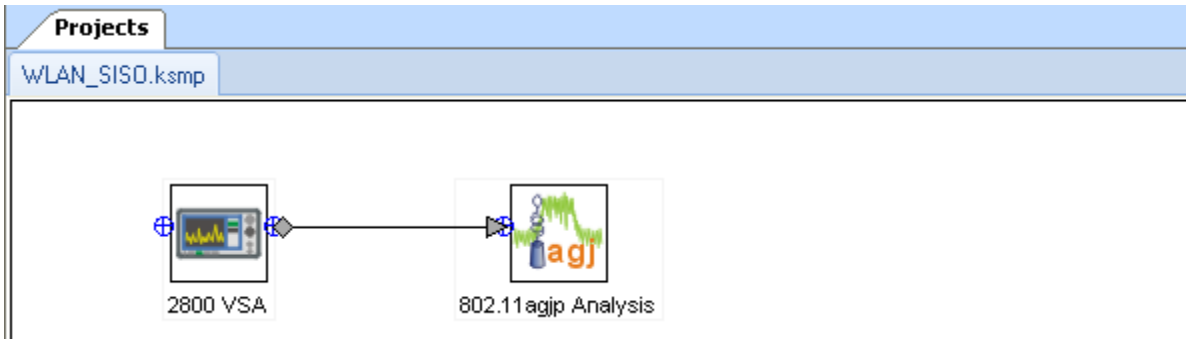
The following figure shows how an analysis window may look like after opening and customizing sub-windows.



3. Go back to the main SignalMeister window and select **Projects** > **Build All** to generate fresh data for analysis.

Using the Hardware Method

The second method uses instruments to do the SISO analysis. This is a little different from simulation mode. Here, it is assumed that a 802.11 a/g signal is fed into a Series V2800 VSA. In our case, such a signal is generated in the previous session of *Generating a WLAN SISO Signal and Analyzing it on a VSA*. It is output from the Series V2900 VSG and directly fed into the Series V2900 VSG. From here, there are only two elements needed as shown below.



Similar to the first example (the Simulation method), you need to configure instrument control and WLAN settings (such as sweep time and type of trigger source). What is different from the simulation method is that the control buttons in the Instrument Control sub-window are activated. The Initialize button allows initialization of the VSA as specified by the settings in this window. Single Sweep or Continuous Sweep offer two types of sweeping for your convenience. The Optimize button offers automatic optimization based on the existing settings.

Analyze MIMO WLAN Signals in SignalMeister

Analyzing a MIMO 802.11n signal is similar to SISO analysis. Both simulation and non-simulation modes are available.

The following figures show a project that simulates 2x 802.11n MIMO analysis. Refer to Analyzing a SISO Signal in SignalMeister for the steps to build and run the project.