

# Software Manual



## OFDM VSA PC Software

**R&S<sup>®</sup> FSQ-K96**

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The following abbreviations are used throughout this manual:  
The R&S® FSQ-K96 OFDM-VSA is referred to as OFDM-VSA.  
The R&S® FSQ signal analyzer is referred to as R&S FSQ.  
The R&S® AFQ, AMU, SMATE, SMJ and SMU vector signal generators are referred to as R&S Signal Generator  
R&S® is a registered trademark of Rohde & Schwarz GmbH & Co. KG.  
Trade names are trademarks of the owners.

# Basic Safety Instructions

## Always read through and comply with the following safety instructions!

All plants and locations of the Rohde & Schwarz group of companies make every effort to keep the safety standards of our products up to date and to offer our customers the highest possible degree of safety. Our products and the auxiliary equipment they require are designed, built and tested in accordance with the safety standards that apply in each case. Compliance with these standards is continuously monitored by our quality assurance system. The product described here has been designed, built and tested in accordance with the attached EC Certificate of Conformity and has left the manufacturer's plant in a condition fully complying with safety standards. To maintain this condition and to ensure safe operation, you must observe all instructions and warnings provided in this manual. If you have any questions regarding these safety instructions, the Rohde & Schwarz group of companies will be happy to answer them.

Furthermore, it is your responsibility to use the product in an appropriate manner. This product is designed for use solely in industrial and laboratory environments or, if expressly permitted, also in the field and must not be used in any way that may cause personal injury or property damage. You are responsible if the product is used for any intention other than its designated purpose or in disregard of the manufacturer's instructions. The manufacturer shall assume no responsibility for such use of the product.

The product is used for its designated purpose if it is used in accordance with its product documentation and within its performance limits (see data sheet, documentation, the following safety instructions). Using the product requires technical skills and a basic knowledge of English. It is therefore essential that only skilled and specialized staff or thoroughly trained personnel with the required skills be allowed to use the product. If personal safety gear is required for using Rohde & Schwarz products, this will be indicated at the appropriate place in the product documentation. Keep the basic safety instructions and the product documentation in a safe place and pass them on to the subsequent users.

Observing the safety instructions will help prevent personal injury or damage of any kind caused by dangerous situations. Therefore, carefully read through and adhere to the following safety instructions before and when using the product. It is also absolutely essential to observe the additional safety instructions on personal safety, for example, that appear in relevant parts of the product documentation. In these safety instructions, the word "product" refers to all merchandise sold and distributed by the Rohde & Schwarz group of companies, including instruments, systems and all accessories.

## Symbols and safety labels

							
Notice, general danger location Observe product documentation	Caution when handling heavy equipment	Danger of electric shock	Warning! Hot surface	PE terminal	Ground	Ground terminal	Be careful when handling electrostatic sensitive devices
							
ON/OFF supply voltage	Standby indication	Direct current (DC)	Alternating current (AC)	Direct/alternating current (DC/AC)	Device fully protected by double (reinforced) insulation		

## Tags and their meaning

The following signal words are used in the product documentation in order to warn the reader about risks and dangers.

	indicates a hazardous situation which, if not avoided, will result in death or serious injury.
	indicates a hazardous situation which, if not avoided, could result in death or serious injury.
	indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
	indicates the possibility of incorrect operation which can result in damage to the product. In the product documentation, the word ATTENTION is used synonymously.

These tags are in accordance with the standard definition for civil applications in the European Economic Area. Definitions that deviate from the standard definition may also exist in other economic areas or military applications. It is therefore essential to make sure that the tags described here are always used only in connection with the related product documentation and the related product. The use of tags in connection with unrelated products or documentation can result in misinterpretation and in personal injury or material damage.

## Operating states and operating positions

*The product may be operated only under the operating conditions and in the positions specified by the manufacturer, without the product's ventilation being obstructed. If the manufacturer's specifications are not observed, this can result in electric shock, fire and/or serious personal injury or death. Applicable local or national safety regulations and rules for the prevention of accidents must be observed in all work performed.*

1. Unless otherwise specified, the following requirements apply to Rohde & Schwarz products: predefined operating position is always with the housing floor facing down, IP protection 2X, pollution severity 2, overvoltage category 2, use only indoors, max. operating altitude 2000 m above sea level, max. transport altitude 4500 m above sea level. A tolerance of  $\pm 10\%$  shall apply to the nominal voltage and  $\pm 5\%$  to the nominal frequency.
2. Do not place the product on surfaces, vehicles, cabinets or tables that for reasons of weight or stability are unsuitable for this purpose. Always follow the manufacturer's installation instructions when installing the product and fastening it to objects or structures (e.g. walls and shelves). An installation that is not carried out as described in the product documentation could result in personal injury or death.
3. Do not place the product on heat-generating devices such as radiators or fan heaters. The ambient temperature must not exceed the maximum temperature specified in the product documentation or in the data sheet. Product overheating can cause electric shock, fire and/or serious personal injury or death.

**Electrical safety**

*If the information on electrical safety is not observed either at all to the extent necessary, electric shock, fire and/or serious personal injury or death may occur.*

1. Prior to switching on the product, always ensure that the nominal voltage setting on the product matches the nominal voltage of the AC supply network. If a different voltage is to be set, the power fuse of the product may have to be changed accordingly.
2. In the case of products of safety class I with movable power cord and connector, operation is permitted only on sockets with an earthing contact and protective earth connection.
3. Intentionally breaking the protective earth connection either in the feed line or in the product itself is not permitted. Doing so can result in the danger of an electric shock from the product. If extension cords or connector strips are implemented, they must be checked on a regular basis to ensure that they are safe to use.
4. If the product does not have a power switch for disconnection from the AC supply network, the plug of the connecting cable is regarded as the disconnecting device. In such cases, always ensure that the power plug is easily reachable and accessible at all times (corresponding to the length of connecting cable, approx. 2 m). Functional or electronic switches are not suitable for providing disconnection from the AC supply network. If products without power switches are integrated into racks or systems, a disconnecting device must be provided at the system level.
5. Never use the product if the power cable is damaged. Check the power cable on a regular basis to ensure that it is in proper operating condition. By taking appropriate safety measures and carefully laying the power cable, you can ensure that the cable will not be damaged and that no one can be hurt by, for example, tripping over the cable or suffering an electric shock.
6. The product may be operated only from TN/TT supply networks fused with max. 16 A (higher fuse only after consulting with the Rohde & Schwarz group of companies).
7. Do not insert the plug into sockets that are dusty or dirty. Insert the plug firmly and all the way into the socket. Otherwise, sparks that result in fire and/or injuries may occur.
8. Do not overload any sockets, extension cords or connector strips; doing so can cause fire or electric shocks.
9. For measurements in circuits with voltages  $V_{\text{rms}} > 30 \text{ V}$ , suitable measures (e.g. appropriate measuring equipment, fusing, current limiting, electrical separation, insulation) should be taken to avoid any hazards.
10. Ensure that the connections with information technology equipment, e.g. PCs or other industrial computers, comply with the IEC60950-1/EN60950-1 or IEC61010-1/EN 61010-1 standards that apply in each case.
11. Unless expressly permitted, never remove the cover or any part of the housing while the product is in operation. Doing so will expose circuits and components and can lead to injuries, fire or damage to the product.
12. If a product is to be permanently installed, the connection between the PE terminal on site and the product's PE conductor must be made first before any other connection is made. The product may be installed and connected only by a licensed electrician.
13. For permanently installed equipment without built-in fuses, circuit breakers or similar protective devices, the supply circuit must be fused in such a way that anyone who has access to the product, as well as the product itself, is adequately protected from injury or damage.

## Basic Safety Instructions

14. Use suitable overvoltage protection to ensure that no overvoltage (such as that caused by a bolt of lightning) can reach the product. Otherwise, the person operating the product will be exposed to the danger of an electric shock.
15. Any object that is not designed to be placed in the openings of the housing must not be used for this purpose. Doing so can cause short circuits inside the product and/or electric shocks, fire or injuries.
16. Unless specified otherwise, products are not liquid-proof (see also section "Operating states and operating positions", item 1. Therefore, the equipment must be protected against penetration by liquids. If the necessary precautions are not taken, the user may suffer electric shock or the product itself may be damaged, which can also lead to personal injury.
17. Never use the product under conditions in which condensation has formed or can form in or on the product, e.g. if the product has been moved from a cold to a warm environment. Penetration by water increases the risk of electric shock.
18. Prior to cleaning the product, disconnect it completely from the power supply (e.g. AC supply network or battery). Use a soft, non-linting cloth to clean the product. Never use chemical cleaning agents such as alcohol, acetone or diluents for cellulose lacquers.

**Operation**

1. Operating the products requires special training and intense concentration. Make sure that persons who use the products are physically, mentally and emotionally fit enough to do so; otherwise, injuries or material damage may occur. It is the responsibility of the employer/operator to select suitable personnel for operating the products.
2. Before you move or transport the product, read and observe the section titled "Transport".
3. As with all industrially manufactured goods, the use of substances that induce an allergic reaction (allergens) such as nickel cannot be generally excluded. If you develop an allergic reaction (such as a skin rash, frequent sneezing, red eyes or respiratory difficulties) when using a Rohde & Schwarz product, consult a physician immediately to determine the cause and to prevent health problems or stress.
4. Before you start processing the product mechanically and/or thermally, or before you take it apart, be sure to read and pay special attention to the section titled "Waste disposal", item 1.
5. Depending on the function, certain products such as RF radio equipment can produce an elevated level of electromagnetic radiation. Considering that unborn babies require increased protection, pregnant women must be protected by appropriate measures. Persons with pacemakers may also be exposed to risks from electromagnetic radiation. The employer/operator must evaluate workplaces where there is a special risk of exposure to radiation and, if necessary, take measures to avert the potential danger.
6. Should a fire occur, the product may release hazardous substances (gases, fluids, etc.) that can cause health problems. Therefore, suitable measures must be taken, e.g. protective masks and protective clothing must be worn.
7. If a laser product (e.g. a CD/DVD drive) is integrated into a Rohde & Schwarz product, absolutely no other settings or functions may be used as described in the product documentation. The objective is to prevent personal injury (e.g. due to laser beams).

**Repair and service**

1. The product may be opened only by authorized, specially trained personnel. Before any work is performed on the product or before the product is opened, it must be disconnected from the AC supply network. Otherwise, personnel will be exposed to the risk of an electric shock.
2. Adjustments, replacement of parts, maintenance and repair may be performed only by electrical experts authorized by Rohde & Schwarz. Only original parts may be used for replacing parts relevant to safety (e.g. power switches, power transformers, fuses). A safety test must always be performed after parts relevant to safety have been replaced (visual inspection, PE conductor test, insulation resistance measurement, leakage current measurement, functional test). This helps ensure the continued safety of the product.

**Batteries and rechargeable batteries/cells**

*If the information regarding batteries and rechargeable batteries/cells is not observed either at all or to the extent necessary, product users may be exposed to the risk of explosions, fire and/or serious personal injury, and, in some cases, death. Batteries and rechargeable batteries with alkaline electrolytes (e.g. lithium cells) must be handled in accordance with the EN 62133 standard.*

1. Cells must not be taken apart or crushed.
2. Cells or batteries must not be exposed to heat or fire. Storage in direct sunlight must be avoided. Keep cells and batteries clean and dry. Clean soiled connectors using a dry, clean cloth.
3. Cells or batteries must not be short-circuited. Cells or batteries must not be stored in a box or in a drawer where they can short-circuit each other, or where they can be short-circuited by other conductive materials. Cells and batteries must not be removed from their original packaging until they are ready to be used.
4. Keep cells and batteries out of the hands of children. If a cell or a battery has been swallowed, seek medical aid immediately.
5. Cells and batteries must not be exposed to any mechanical shocks that are stronger than permitted.
6. If a cell develops a leak, the fluid must not be allowed to come into contact with the skin or eyes. If contact occurs, wash the affected area with plenty of water and seek medical aid.
7. Improperly replacing or charging cells or batteries that contain alkaline electrolytes (e.g. lithium cells) can cause explosions. Replace cells or batteries only with the matching Rohde & Schwarz type (see parts list) in order to ensure the safety of the product.
8. Cells and batteries must be recycled and kept separate from residual waste. Rechargeable batteries and normal batteries that contain lead, mercury or cadmium are hazardous waste. Observe the national regulations regarding waste disposal and recycling.

**Transport**

1. The product may be very heavy. Therefore, the product must be handled with care. In some cases, the user may require a suitable means of lifting or moving the product (e.g. with a lift-truck) to avoid back or other physical injuries.

2. Handles on the products are designed exclusively to enable personnel to transport the product. It is therefore not permissible to use handles to fasten the product to or on transport equipment such as cranes, fork lifts, wagons, etc. The user is responsible for securely fastening the products to or on the means of transport or lifting. Observe the safety regulations of the manufacturer of the means of transport or lifting. Noncompliance can result in personal injury or material damage.
3. If you use the product in a vehicle, it is the sole responsibility of the driver to drive the vehicle safely and properly. The manufacturer assumes no responsibility for accidents or collisions. Never use the product in a moving vehicle if doing so could distract the driver of the vehicle. Adequately secure the product in the vehicle to prevent injuries or other damage in the event of an accident.

### **Waste disposal**

1. If products or their components are mechanically and/or thermally processed in a manner that goes beyond their intended use, hazardous substances (heavy-metal dust such as lead, beryllium, nickel) may be released. For this reason, the product may only be disassembled by specially trained personnel. Improper disassembly may be hazardous to your health. National waste disposal regulations must be observed.
2. If handling the product releases hazardous substances or fuels that must be disposed of in a special way, e.g. coolants or engine oils that must be replenished regularly, the safety instructions of the manufacturer of the hazardous substances or fuels and the applicable regional waste disposal regulations must be observed. Also observe the relevant safety instructions in the product documentation. The improper disposal of hazardous substances or fuels can cause health problems and lead to environmental damage.

## Informaciones elementales de seguridad

### **Es imprescindible leer y observar las siguientes instrucciones e informaciones de seguridad!**

El principio del grupo de empresas Rohde & Schwarz consiste en tener nuestros productos siempre al día con los estándares de seguridad y de ofrecer a nuestros clientes el máximo grado de seguridad. Nuestros productos y todos los equipos adicionales son siempre fabricados y examinados según las normas de seguridad vigentes. Nuestro sistema de garantía de calidad controla constantemente que sean cumplidas estas normas. El presente producto ha sido fabricado y examinado según el certificado de conformidad adjunto de la UE y ha salido de nuestra planta en estado impecable según los estándares técnicos de seguridad. Para poder preservar este estado y garantizar un funcionamiento libre de peligros, el usuario deberá atenerse a todas las indicaciones, informaciones de seguridad y notas de alerta. El grupo de empresas Rohde & Schwarz está siempre a su disposición en caso de que tengan preguntas referentes a estas informaciones de seguridad.

Además queda en la responsabilidad del usuario utilizar el producto en la forma debida. Este producto está destinado exclusivamente al uso en la industria y el laboratorio o, si ha sido expresamente autorizado, para aplicaciones de campo y de ninguna manera deberá ser utilizado de modo que alguna persona/cosa pueda sufrir daño. El uso del producto fuera de sus fines definidos o sin tener en cuenta las instrucciones del fabricante queda en la responsabilidad del usuario. El fabricante no se hace en ninguna forma responsable de consecuencias a causa del mal uso del producto.

## Informaciones elementales de seguridad

Se parte del uso correcto del producto para los fines definidos si el producto es utilizado conforme a las indicaciones de la correspondiente documentación del producto y dentro del margen de rendimiento definido (ver hoja de datos, documentación, informaciones de seguridad que siguen). El uso del producto hace necesarios conocimientos técnicos y ciertos conocimientos del idioma inglés. Por eso se debe tener en cuenta que el producto solo pueda ser operado por personal especializado o personas instruidas en profundidad con las capacidades correspondientes. Si fuera necesaria indumentaria de seguridad para el uso de productos de Rohde & Schwarz, encontraría la información debida en la documentación del producto en el capítulo correspondiente. Guarde bien las informaciones de seguridad elementales, así como la documentación del producto, y entréguelas a usuarios posteriores.

Tener en cuenta las informaciones de seguridad sirve para evitar en lo posible lesiones o daños por peligros de toda clase. Por eso es imprescindible leer detalladamente y comprender por completo las siguientes informaciones de seguridad antes de usar el producto, y respetarlas durante el uso del producto. Deberán tenerse en cuenta todas las demás informaciones de seguridad, como p. ej. las referentes a la protección de personas, que encontrarán en el capítulo correspondiente de la documentación del producto y que también son de obligado cumplimiento. En las presentes informaciones de seguridad se recogen todos los objetos que distribuye el grupo de empresas Rohde & Schwarz bajo la denominación de "producto", entre ellos también aparatos, instalaciones así como toda clase de accesorios.

## Símbolos y definiciones de seguridad

							
Aviso: punto de peligro general Observar la documentación del producto	Atención en el manejo de dispositivos de peso elevado	Peligro de choque eléctrico	Advertencia: superficie caliente	Conexión a conductor de protección	Conexión a tierra	Conexión a masa	Aviso: Cuidado en el manejo de dispositivos sensibles a la electrostática (ESD)

					
Tensión de alimentación de PUESTA EN MARCHA / PARADA	Indicación de estado de espera (Standby)	Corriente continua (DC)	Corriente alterna (AC)	Corriente continua / Corriente alterna (DC/AC)	El aparato está protegido en su totalidad por un aislamiento doble (reforzado)

## Palabras de señal y su significado

En la documentación del producto se utilizan las siguientes palabras de señal con el fin de advertir contra riesgos y peligros.



PELIGRO identifica un peligro inminente con riesgo elevado que provocará muerte o lesiones graves si no se evita.



ADVERTENCIA identifica un posible peligro con riesgo medio de provocar muerte o lesiones (graves) si no se evita.



ATENCIÓN identifica un peligro con riesgo reducido de provocar lesiones leves o moderadas si no se evita.



AVISO indica la posibilidad de utilizar mal el producto y, como consecuencia, dañarlo.

En la documentación del producto se emplea de forma sinónima el término CUIDADO.

Las palabras de señal corresponden a la definición habitual para aplicaciones civiles en el área económica europea. Pueden existir definiciones diferentes a esta definición en otras áreas económicas o en aplicaciones militares. Por eso se deberá tener en cuenta que las palabras de señal aquí descritas sean utilizadas siempre solamente en combinación con la correspondiente documentación del producto y solamente en combinación con el producto correspondiente. La utilización de las palabras de señal en combinación con productos o documentaciones que no les correspondan puede llevar a interpretaciones equivocadas y tener por consecuencia daños en personas u objetos.

## Estados operativos y posiciones de funcionamiento

*El producto solamente debe ser utilizado según lo indicado por el fabricante respecto a los estados operativos y posiciones de funcionamiento sin que se obstruya la ventilación. Si no se siguen las indicaciones del fabricante, pueden producirse choques eléctricos, incendios y/o lesiones graves con posible consecuencia de muerte. En todos los trabajos deberán ser tenidas en cuenta las normas nacionales y locales de seguridad del trabajo y de prevención de accidentes.*

1. Si no se convino de otra manera, es para los productos Rohde & Schwarz válido lo que sigue: como posición de funcionamiento se define por principio la posición con el suelo de la caja para abajo, modo de protección IP 2X, grado de suciedad 2, categoría de sobrecarga eléctrica 2, uso solamente en estancias interiores, utilización hasta 2000 m sobre el nivel del mar, transporte hasta 4500 m sobre el nivel del mar. Se aplicará una tolerancia de  $\pm 10\%$  sobre el voltaje nominal y de  $\pm 5\%$  sobre la frecuencia nominal.
2. No sitúe el producto encima de superficies, vehículos, estantes o mesas, que por sus características de peso o de estabilidad no sean aptos para él. Siga siempre las instrucciones de instalación del fabricante cuando instale y asegure el producto en objetos o estructuras (p. ej. paredes y estantes). Si se realiza la instalación de modo distinto al indicado en la documentación del producto, pueden causarse lesiones o incluso la muerte.
3. No ponga el producto sobre aparatos que generen calor (p. ej. radiadores o calefactores). La temperatura ambiente no debe superar la temperatura máxima especificada en la documentación del producto o en la hoja de datos. En caso de sobrecalentamiento del producto, pueden producirse choques eléctricos, incendios y/o lesiones graves con posible consecuencia de muerte.

## Seguridad eléctrica

*Si no se siguen (o se siguen de modo insuficiente) las indicaciones del fabricante en cuanto a seguridad eléctrica, pueden producirse choques eléctricos, incendios y/o lesiones graves con posible consecuencia de muerte.*

1. Antes de la puesta en marcha del producto se deberá comprobar siempre que la tensión preseleccionada en el producto coincida con la de la red de alimentación eléctrica. Si es necesario modificar el ajuste de tensión, también se deberán cambiar en caso dado los fusibles correspondientes del producto.
2. Los productos de la clase de protección I con alimentación móvil y enchufe individual solamente podrán enchufarse a tomas de corriente con contacto de seguridad y con conductor de protección conectado.
3. Queda prohibida la interrupción intencionada del conductor de protección, tanto en la toma de corriente como en el mismo producto. La interrupción puede tener como consecuencia el riesgo de que el producto sea fuente de choques eléctricos. Si se utilizan cables alargadores o regletas de enchufe, deberá garantizarse la realización de un examen regular de los mismos en cuanto a su estado técnico de seguridad.
4. Si el producto no está equipado con un interruptor para desconectarlo de la red, se deberá considerar el enchufe del cable de conexión como interruptor. En estos casos se deberá asegurar que el enchufe siempre sea de fácil acceso (de acuerdo con la longitud del cable de conexión, aproximadamente 2 m). Los interruptores de función o electrónicos no son aptos para el corte de la red eléctrica. Si los productos sin interruptor están integrados en bastidores o instalaciones, se deberá colocar el interruptor en el nivel de la instalación.
5. No utilice nunca el producto si está dañado el cable de conexión a red. Compruebe regularmente el correcto estado de los cables de conexión a red. Asegúrese, mediante las medidas de protección y de instalación adecuadas, de que el cable de conexión a red no pueda ser dañado o de que nadie pueda ser dañado por él, p. ej. al tropezar o por un choque eléctrico.
6. Solamente está permitido el funcionamiento en redes de alimentación TN/TT aseguradas con fusibles de 16 A como máximo (utilización de fusibles de mayor amperaje solo previa consulta con el grupo de empresas Rohde & Schwarz).
7. Nunca conecte el enchufe en tomas de corriente sucias o llenas de polvo. Introduzca el enchufe por completo y fuertemente en la toma de corriente. La no observación de estas medidas puede provocar chispas, fuego y/o lesiones.
8. No sobrecargue las tomas de corriente, los cables alargadores o las regletas de enchufe ya que esto podría causar fuego o choques eléctricos.
9. En las mediciones en circuitos de corriente con una tensión  $U_{\text{eff}} > 30 \text{ V}$  se deberán tomar las medidas apropiadas para impedir cualquier peligro (p. ej. medios de medición adecuados, seguros, limitación de tensión, corte protector, aislamiento etc.).
10. Para la conexión con dispositivos informáticos como un PC o un ordenador industrial, debe comprobarse que éstos cumplan los estándares IEC60950-1/EN60950-1 o IEC61010-1/EN 61010-1 válidos en cada caso.
11. A menos que esté permitido expresamente, no retire nunca la tapa ni componentes de la carcasa mientras el producto esté en servicio. Esto pone a descubierto los cables y componentes eléctricos y puede causar lesiones, fuego o daños en el producto.

## Informaciones elementales de seguridad

12. Si un producto se instala en un lugar fijo, se deberá primero conectar el conductor de protección fijo con el conductor de protección del producto antes de hacer cualquier otra conexión. La instalación y la conexión deberán ser efectuadas por un electricista especializado.
13. En el caso de dispositivos fijos que no estén provistos de fusibles, interruptor automático ni otros mecanismos de seguridad similares, el circuito de alimentación debe estar protegido de modo que todas las personas que puedan acceder al producto, así como el producto mismo, estén a salvo de posibles daños.
14. Todo producto debe estar protegido contra sobretensión (debida p. ej. a una caída del rayo) mediante los correspondientes sistemas de protección. Si no, el personal que lo utilice quedará expuesto al peligro de choque eléctrico.
15. No debe introducirse en los orificios de la caja del aparato ningún objeto que no esté destinado a ello. Esto puede producir cortocircuitos en el producto y/o puede causar choques eléctricos, fuego o lesiones.
16. Salvo indicación contraria, los productos no están impermeabilizados (ver también el capítulo "Estados operativos y posiciones de funcionamiento", punto 1). Por eso es necesario tomar las medidas necesarias para evitar la entrada de líquidos. En caso contrario, existe peligro de choque eléctrico para el usuario o de daños en el producto, que también pueden redundar en peligro para las personas.
17. No utilice el producto en condiciones en las que pueda producirse o ya se hayan producido condensaciones sobre el producto o en el interior de éste, como p. ej. al desplazarlo de un lugar frío a otro caliente. La entrada de agua aumenta el riesgo de choque eléctrico.
18. Antes de la limpieza, desconecte por completo el producto de la alimentación de tensión (p. ej. red de alimentación o batería). Realice la limpieza de los aparatos con un paño suave, que no se deshilache. No utilice bajo ningún concepto productos de limpieza químicos como alcohol, acetona o diluyentes para lacas nitrocelulósicas.

**Funcionamiento**

1. El uso del producto requiere instrucciones especiales y una alta concentración durante el manejo. Debe asegurarse que las personas que manejen el producto estén a la altura de los requerimientos necesarios en cuanto a aptitudes físicas, psíquicas y emocionales, ya que de otra manera no se pueden excluir lesiones o daños de objetos. El empresario u operador es responsable de seleccionar el personal usuario apto para el manejo del producto.
2. Antes de desplazar o transportar el producto, lea y tenga en cuenta el capítulo "Transporte".
3. Como con todo producto de fabricación industrial no puede quedar excluida en general la posibilidad de que se produzcan alergias provocadas por algunos materiales empleados, los llamados alérgenos (p. ej. el níquel). Si durante el manejo de productos Rohde & Schwarz se producen reacciones alérgicas, como p. ej. irritaciones cutáneas, estornudos continuos, enrojecimiento de la conjuntiva o dificultades respiratorias, debe avisarse inmediatamente a un médico para investigar las causas y evitar cualquier molestia o daño a la salud.
4. Antes de la manipulación mecánica y/o térmica o el desmontaje del producto, debe tenerse en cuenta imprescindiblemente el capítulo "Eliminación", punto 1.

5. Ciertos productos, como p. ej. las instalaciones de radiocomunicación RF, pueden a causa de su función natural, emitir una radiación electromagnética aumentada. Deben tomarse todas las medidas necesarias para la protección de las mujeres embarazadas. También las personas con marcapasos pueden correr peligro a causa de la radiación electromagnética. El empresario/operador tiene la obligación de evaluar y señalizar las áreas de trabajo en las que exista un riesgo elevado de exposición a radiaciones.
6. Tenga en cuenta que en caso de incendio pueden desprenderse del producto sustancias tóxicas (gases, líquidos etc.) que pueden generar daños a la salud. Por eso, en caso de incendio deben usarse medidas adecuadas, como p. ej. máscaras antigás e indumentaria de protección.
7. En caso de que un producto Rohde & Schwarz contenga un producto láser (p. ej. un lector de CD/DVD), no debe usarse ninguna otra configuración o función aparte de las descritas en la documentación del producto, a fin de evitar lesiones (p. ej. debidas a irradiación láser).

### **Reparación y mantenimiento**

1. El producto solamente debe ser abierto por personal especializado con autorización para ello. Antes de manipular el producto o abrirlo, es obligatorio desconectarlo de la tensión de alimentación, para evitar toda posibilidad de choque eléctrico.
2. El ajuste, el cambio de partes, el mantenimiento y la reparación deberán ser efectuadas solamente por electricistas autorizados por Rohde & Schwarz. Si se reponen partes con importancia para los aspectos de seguridad (p. ej. el enchufe, los transformadores o los fusibles), solamente podrán ser sustituidos por partes originales. Después de cada cambio de partes relevantes para la seguridad deberá realizarse un control de seguridad (control a primera vista, control del conductor de protección, medición de resistencia de aislamiento, medición de la corriente de fuga, control de funcionamiento). Con esto queda garantizada la seguridad del producto.

### **Baterías y acumuladores o celdas**

*Si no se siguen (o se siguen de modo insuficiente) las indicaciones en cuanto a las baterías y acumuladores o celdas, pueden producirse explosiones, incendios y/o lesiones graves con posible consecuencia de muerte. El manejo de baterías y acumuladores con electrolitos alcalinos (p. ej. celdas de litio) debe seguir el estándar EN 62133.*

1. No deben desmontarse, abrirse ni triturarse las celdas.
2. Las celdas o baterías no deben someterse a calor ni fuego. Debe evitarse el almacenamiento a la luz directa del sol. Las celdas y baterías deben mantenerse limpias y secas. Limpiar las conexiones sucias con un paño seco y limpio.
3. Las celdas o baterías no deben cortocircuitarse. Es peligroso almacenar las celdas o baterías en estuches o cajones en cuyo interior puedan cortocircuitarse por contacto recíproco o por contacto con otros materiales conductores. No deben extraerse las celdas o baterías de sus embalajes originales hasta el momento en que vayan a utilizarse.
4. Mantener baterías y celdas fuera del alcance de los niños. En caso de ingestión de una celda o batería, avisar inmediatamente a un médico.
5. Las celdas o baterías no deben someterse a impactos mecánicos fuertes indebidos.

6. En caso de falta de estanqueidad de una celda, el líquido vertido no debe entrar en contacto con la piel ni los ojos. Si se produce contacto, lavar con agua abundante la zona afectada y avisar a un médico.
7. En caso de cambio o recarga inadecuados, las celdas o baterías que contienen electrolitos alcalinos (p. ej. las celdas de litio) pueden explotar. Para garantizar la seguridad del producto, las celdas o baterías solo deben ser sustituidas por el tipo Rohde & Schwarz correspondiente (ver lista de recambios).
8. Las baterías y celdas deben reciclarse y no deben tirarse a la basura doméstica. Las baterías o acumuladores que contienen plomo, mercurio o cadmio deben tratarse como residuos especiales. Respete en esta relación las normas nacionales de eliminación y reciclaje.

### Transporte

1. El producto puede tener un peso elevado. Por eso es necesario desplazarlo o transportarlo con precaución y, si es necesario, usando un sistema de elevación adecuado (p. ej. una carretilla elevadora), a fin de evitar lesiones en la espalda u otros daños personales.
2. Las asas instaladas en los productos sirven solamente de ayuda para el transporte del producto por personas. Por eso no está permitido utilizar las asas para la sujeción en o sobre medios de transporte como p. ej. grúas, carretillas elevadoras de horquilla, carros etc. Es responsabilidad suya fijar los productos de manera segura a los medios de transporte o elevación. Para evitar daños personales o daños en el producto, siga las instrucciones de seguridad del fabricante del medio de transporte o elevación utilizado.
3. Si se utiliza el producto dentro de un vehículo, recae de manera exclusiva en el conductor la responsabilidad de conducir el vehículo de manera segura y adecuada. El fabricante no asumirá ninguna responsabilidad por accidentes o colisiones. No utilice nunca el producto dentro de un vehículo en movimiento si esto pudiera distraer al conductor. Asegure el producto dentro del vehículo debidamente para evitar, en caso de un accidente, lesiones u otra clase de daños.

### Eliminación

1. Si se trabaja de manera mecánica y/o térmica cualquier producto o componente más allá del funcionamiento previsto, pueden liberarse sustancias peligrosas (polveros con contenido de metales pesados como p. ej. plomo, berilio o níquel). Por eso el producto solo debe ser desmontado por personal especializado con formación adecuada. Un desmontaje inadecuado puede ocasionar daños para la salud. Se deben tener en cuenta las directivas nacionales referentes a la eliminación de residuos.
2. En caso de que durante el trato del producto se formen sustancias peligrosas o combustibles que deban tratarse como residuos especiales (p. ej. refrigerantes o aceites de motor con intervalos de cambio definidos), deben tenerse en cuenta las indicaciones de seguridad del fabricante de dichas sustancias y las normas regionales de eliminación de residuos. Tenga en cuenta también en caso necesario las indicaciones de seguridad especiales contenidas en la documentación del producto. La eliminación incorrecta de sustancias peligrosas o combustibles puede causar daños a la salud o daños al medio ambiente.

### Kundeninformation zur Batterieverordnung (BattV)

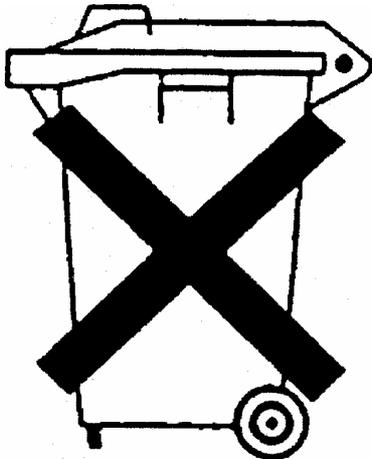
Dieses Gerät enthält eine schadstoffhaltige Batterie. Diese darf nicht mit dem Hausmüll entsorgt werden.

Nach Ende der Lebensdauer darf die Entsorgung nur über eine Rohde&Schwarz-Kundendienststelle oder eine geeignete Sammelstelle erfolgen.

### Safety Regulations for Batteries (according to BattV)

This equipment houses a battery containing harmful substances that must not be disposed of as normal household waste.

After its useful life, the battery may only be disposed of at a Rohde & Schwarz service center or at a suitable depot.



### Normas de Seguridad para Baterías (Según BattV)

Este equipo lleva una batería que contiene sustancias perjudiciales, que no se debe desechar en los contenedores de basura domésticos.

Después de la vida útil, la batería sólo se podrá eliminar en un centro de servicio de Rohde & Schwarz o en un depósito apropiado.

### Consignes de sécurité pour batteries (selon BattV)

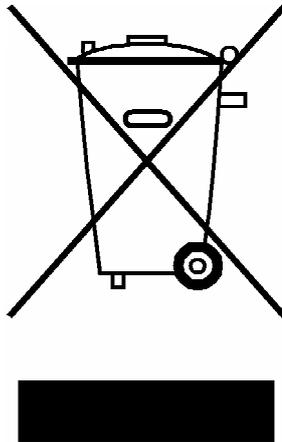
Cet appareil est équipé d'une pile comprenant des substances nocives. Ne jamais la jeter dans une poubelle pour ordures ménagères.

Une pile usagée doit uniquement être éliminée par un centre de service client de Rohde & Schwarz ou peut être collectée pour être traitée spécialement comme déchets dangereux.

# Customer Information Regarding Product Disposal

The German Electrical and Electronic Equipment (ElektroG) Act is an implementation of the following EC directives:

- 2002/96/EC on waste electrical and electronic equipment (WEEE) and
- 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS).



Product labeling in accordance with EN 50419

Once the lifetime of a product has ended, this product must not be disposed of in the standard domestic refuse. Even disposal via the municipal collection points for waste electrical and electronic equipment is not permitted.

Rohde & Schwarz GmbH & Co. KG has developed a disposal concept for the environmental-friendly disposal or recycling of waste material and fully assumes its obligation as a producer to take back and dispose of electrical and electronic waste in accordance with the ElektroG Act.

Please contact your local service representative to dispose of the product.



# Qualitätszertifikat

## Certificate of quality

## Certificat de qualité

Certified Quality System  
**ISO 9001**

Certified Environmental System  
**ISO 14001**

### **Sehr geehrter Kunde,**

Sie haben sich für den Kauf eines Rohde&Schwarz-Produktes entschieden. Hiermit erhalten Sie ein nach modernsten Fertigungsmethoden hergestelltes Produkt. Es wurde nach den Regeln unseres Qualitätsmanagementsystems entwickelt, gefertigt und geprüft. Das Rohde&Schwarz-Qualitätsmanagementsystem ist u.a. nach ISO9001 und ISO 14001 zertifiziert.

### **Der Umwelt verpflichtet**

- ▮ Energie-effiziente, RoHS-konforme Produkte
- ▮ Kontinuierliche Weiterentwicklung nachhaltiger Umweltkonzepte
- ▮ ISO 14001-zertifiziertes Umweltmanagementsystem

### **Dear Customer,**

You have decided to buy a Rohde&Schwarz product. You are thus assured of receiving a product that is manufactured using the most modern methods available. This product was developed, manufactured and tested in compliance with our quality management system standards. The Rohde&Schwarz quality management system is certified according to standards such as ISO9001 and ISO 14001.

### **Environmental commitment**

- ▮ Energy-efficient products
- ▮ Continuous improvement in environmental sustainability
- ▮ ISO 14001-certified environmental management system

### **Cher client,**

Vous avez choisi d'acheter un produit Rohde&Schwarz. Vous disposez donc d'un produit fabriqué d'après les méthodes les plus avancées. Le développement, la fabrication et les tests respectent nos normes de gestion qualité. Le système de gestion qualité de Rohde&Schwarz a été homologué, entre autres, conformément aux normes ISO9001 et ISO 14001.

### **Engagement écologique**

- ▮ Produits à efficience énergétique
- ▮ Amélioration continue de la durabilité environnementale
- ▮ Système de gestion de l'environnement certifié selon ISO 14001

# Customer Support

## Technical support – where and when you need it

For quick, expert help with any Rohde & Schwarz equipment, contact one of our Customer Support Centers. A team of highly qualified engineers provides telephone support and will work with you to find a solution to your query on any aspect of the operation, programming or applications of Rohde & Schwarz equipment.

## Up-to-date information and upgrades

To keep your instrument up-to-date and to be informed about new application notes related to your instrument, please send an e-mail to the Customer Support Center stating your instrument and your wish. We will take care that you will get the right information.

### USA & Canada

Monday to Friday (except US public holidays)  
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- ◆ Sales Locations
- ◆ Service Locations
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# 1 General Information

The OFDM-VSA PC analysis software application uses the I/Q capture functionality of the R&S spectrum analyzer to enable generic OFDM measurements using a PC-based software.

This manual supports the user in working with this software. It describes how to prepare, execute, and evaluate a measurement and gives many helpful hints and examples.

## Introduction – OFDM

In an OFDM (Orthogonal Frequency Division Multiplexing) system, the available spectrum is divided into multiple carriers, called subcarriers, which are orthogonal to each other. Each of these subcarriers is independently modulated by a low rate data stream.

OFDM is used as well in WLAN, WiMAX and broadcast technologies like DVB. OFDM has several benefits including its robustness against multipath fading and its efficient receiver architecture.

Fig. 1 shows a representation of an OFDM signal taken from [1]. Data symbols are independently modulated and transmitted over a high number of closely spaced orthogonal subcarriers. In OFDM-VSA, common modulation schemes as QPSK, 16QAM, and 64QAM can be defined as well as arbitrary distributed constellation points.

In the time domain, a guard interval may be added to each symbol to combat inter-OFDM-symbol-interference due to channel delay spread. The OFDM-VSA requires a cyclic prefix as guard interval which is inserted prior to each OFDM symbol.

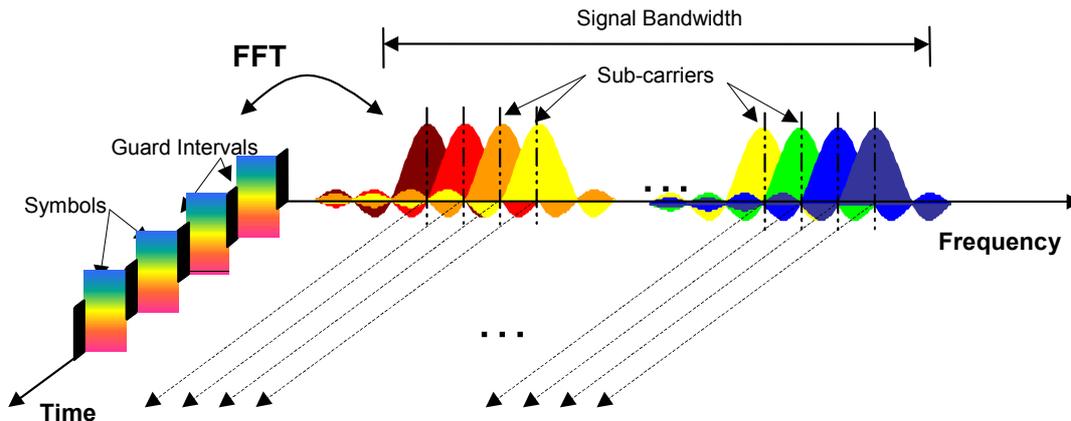


Fig. 1 Frequency-time representation of an OFDM signal

In practice, the OFDM signal can be generated using the inverse fast Fourier transform (IFFT) digital signal processing. The IFFT converts a number  $N$  of complex data symbols used as frequency domain bins into the time domain signal. Such an  $N$ -point IFFT is illustrated in Fig. 2, where  $a(mN+n)$  refers to the  $n^{\text{th}}$  subchannel modulated data symbol, during the time period  $mT_u < t \leq (m+1)T_u$ .

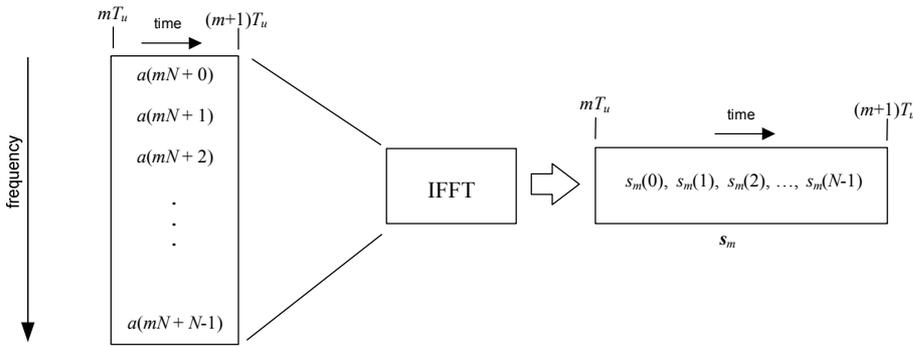


Fig. 2 OFDM useful symbol generation using an IFFT

The vector  $\mathbf{s}_m$  is defined as the useful OFDM symbol. It is the time superposition of the  $N$  narrowband modulated subcarriers. Therefore, from a parallel stream of  $N$  sources of data, each one independently modulated, a waveform composed of  $N$  orthogonal subcarriers is obtained, with each subcarrier having the shape of a frequency *sinc* function (see Fig. 1).

Fig. 3 illustrates the mapping from a serial stream of QAM symbols to  $N$  parallel streams, used as frequency domain bins for the IFFT. The  $N$ -point time domain blocks obtained from the IFFT are then serialized to create a time domain signal. Not shown in Fig. 3 is the process of cyclic prefix insertion.

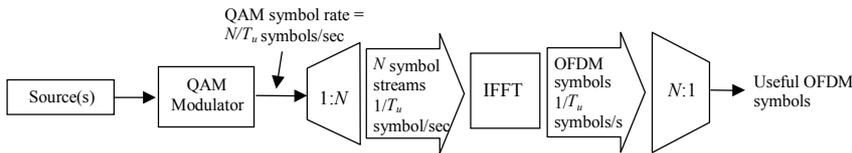


Fig. 3 OFDM signal generation chain

- [1] 3GPP TR 25.892: Feasibility Study for Orthogonal Frequency Division Multiplexing (OFDM) for UTRAN enhancement (Release 6)

## OFDM Parameterization

A generic OFDM analyzer supports various OFDM standards. Therefore a common parameterizing of OFDM systems has to be defined.

### Time Domain Description

The fundamental unit of an OFDM signal in time domain is a ‘Sample’. An ‘OFDM-Symbol’ with a length of  $N_s$  samples consists of a ‘Guard Interval’ of length  $N_G$  and an ‘FFT Interval’ of length  $N_{FFT}$ .

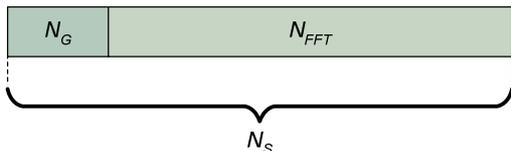


Fig. 4 OFDM symbol in time domain

## Frequency Domain Description

In frequency domain the FFT intervals of the OFDM symbols are transformed into the frequency domain using a discrete fourier transform. The successive symbols of the OFDM signal are displayed in time-frequency matrices. The fundamental unit of an OFDM signal in frequency domain is a 'Cell'. A column of cells at the same frequency is called 'Carrier'. A row of cells at the same time is called 'Symbol'. The carrier number is the column index of a time-frequency matrix. The number '0' is assigned to the so called 'DC-Carrier', which lies at the transmitter center frequency. The total number of carriers is  $N_{FFT}$ . The 'DC-Carrier Offset' determines the position of the DC carrier relative to the lowermost carrier and is an inherent attribute of the FFT algorithm.

FFT Length $N_{FFT}$	DC-Carrier Offset	Range
even	$\frac{N_{FFT}}{2}$	$\left[ -\frac{N_{FFT}}{2}, \frac{N_{FFT}}{2} - 1 \right]$
odd	$\frac{N_{FFT} - 1}{2}$	$\left[ -\frac{N_{FFT} - 1}{2}, \frac{N_{FFT} - 1}{2} \right]$

The symbol number is the row index of a time frequency matrix. The first symbol gets the number '0'. The total area of a time frequency matrix is called 'Frame'. A frame is the highest level unit used in the OFDM-VSA.

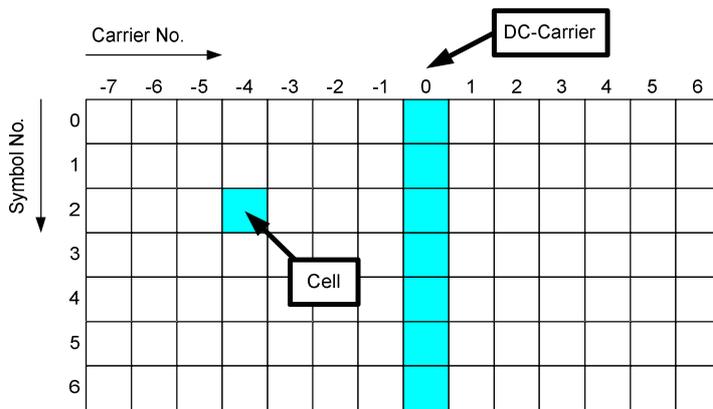


Fig. 5 Time-Frequency matrix

## Structure Matrix

The structure matrix defines the complete frame and subclassifies the OFDM system into

- Pilot cells,
- Data cells,
- Don't Care cells,
- Zero cells.

Pilot cells contain known values and are used for various synchronization and parameter estimation purposes. Data cells contain the user data or "payload" of the transmission. The modulation format of the data cells must be known or can be estimated in a modulation estimation block. "Don't care" regions are cells that aren't evaluated for EVM measurement, but contain signal power. Finally, zero cells contain no signal power at all. Typically these are guard carriers around DC or at the edges of the carrier axis.

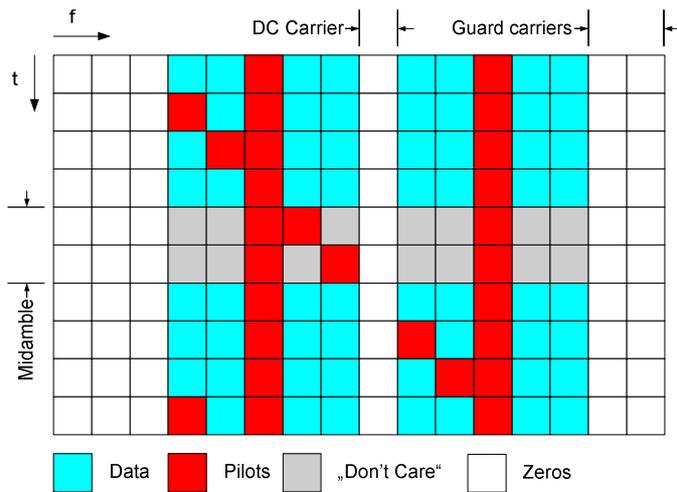


Fig. 6 Example of a structure matrix

### Pilot Matrix

A pilot matrix contains known complex numbers in the matrix cells, which are defined as pilot cells in the structure matrix. Within the analyzer, the pilot matrix is correlated with the received time frequency matrix to get the frame start and the frequency offset of the received signal relative to the given structure matrix.

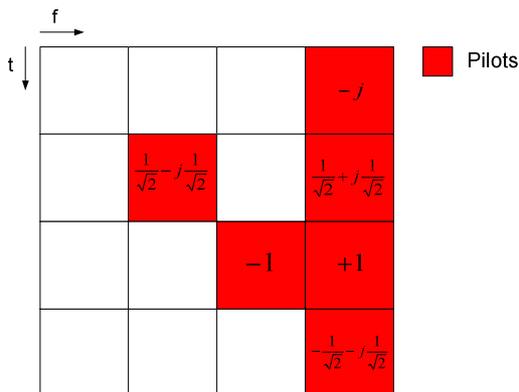


Fig. 7 Example of a pilot matrix

### Constellation Vector

A constellation vector contains all possible numbers in the complex plane, that belong to a specific modulation format. Constellation vectors must be defined for each possible data modulation format. The magnitude within the constellation vectors must be scaled according to the pilot matrix. One entry in the constellation vector is called 'constellation point'.

Differential modulation is not supported. The respective absolute modulation scheme must be used instead (e.g. QPSK instead of DQPSK). Periodically rotated constellations are not supported. The set union of all constellations must be used instead (e.g. 8PSK instead of PI/4-DQPSK).

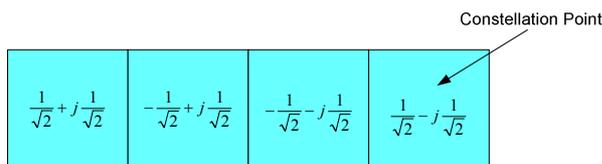


Fig. 8 QPSK constellation vector

### Modulation Matrix

A modulation matrix contains numbers to the underlying constellation vector for each cell, which is defined as data cell in the structure matrix. Clusters of data cells with the same modulation therefore share the same number. A data cell can also contain an unused number, that is a number for which no constellation vector is defined. In this case, all data cells sharing that number are assumed to use one and only one of the valid constellation vectors. This method can be used within the OFDM-VSA to allow an automatic modulation detection.

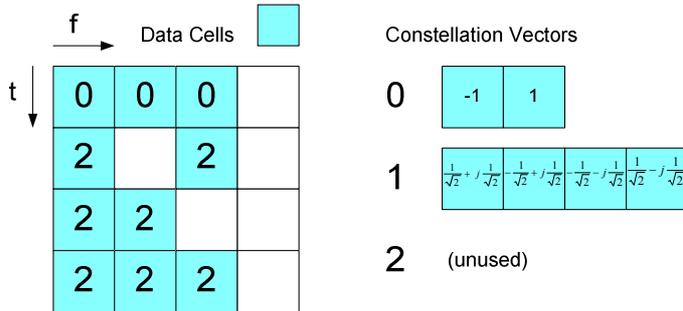


Fig. 9 Example of a modulation matrix

### Preamble Description

The OFDM demodulator shall support synchronization on repetitive preamble symbols. A repetitive preamble contains several repetitions of one time domain block. Fig. 10 shows exemplarily the parameterization of a repetitive preamble symbol, which contains a five times repetition of block T. The structure matrix can have an arbitrary offset to the begin of the preamble symbol. If the offset is zero or negative, the preamble is also contained within the frame and is used for further estimation processes.

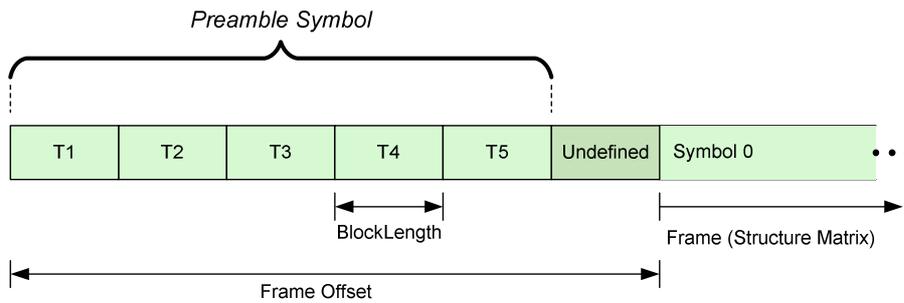


Fig. 10 Description of a repetitive preamble symbol

## **2 Installation and Test Setup**

### **Software Installation**

Please refer to the release notes for detailed instructions on the installation process.

### **Connection to the Instrument**

In order to be able to communicate with the instruments, the PC must be connected to the R&S FSQ using either an IEEE bus or LAN connection. The type of connection and the address can be selected inside the software. Please refer to section "Software Setup" for a detailed description.

Any R&S FSQ with firmware version 4.35 or higher can be used

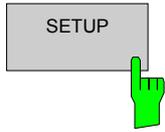
### **Configuration Settings**

The R&S FSQ address (either GPIB or LAN address) has to be set in the R&S FSQ-K96 OFDM-VSA analysis software.

### How to Obtain the GPIB or LAN Address in the R&S FSQ Instrument

In this section it is described how to obtain the GPIB or LAN address of the R&S FSQ instrument.

#### GPIB address



- Press the **[SETUP]** hardkey.  
The *SETUP* menu opens.
- Press the **<GPIB>** softkey.

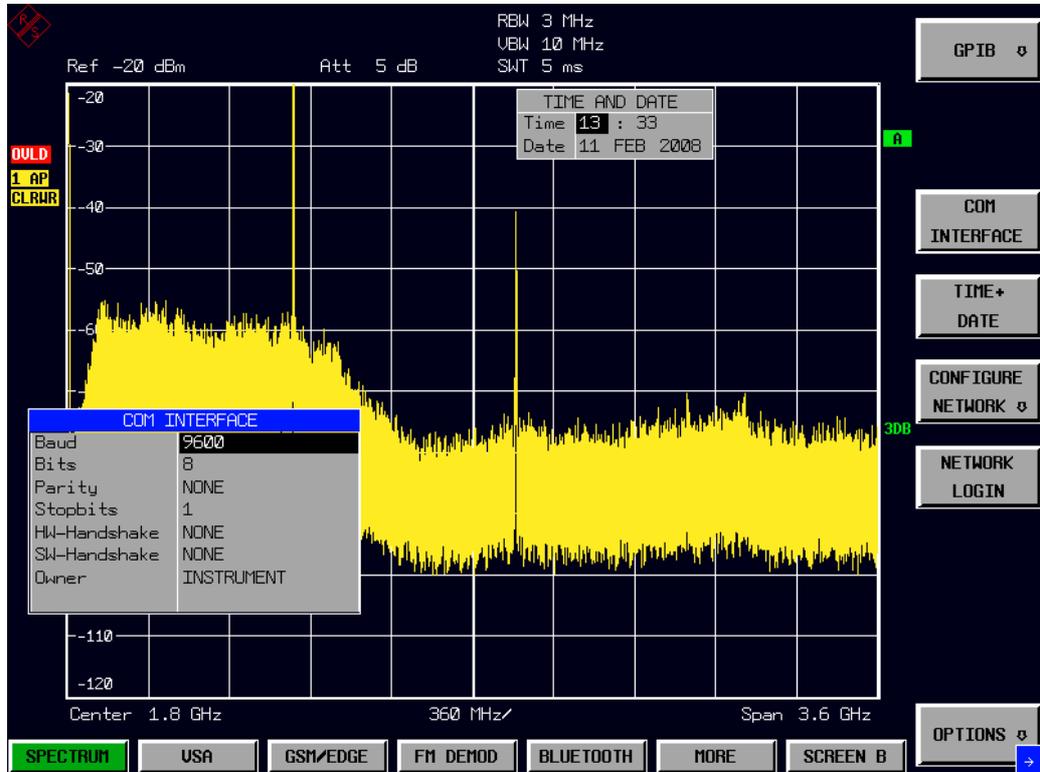
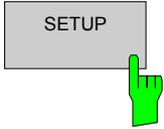


Fig. 11 Softkey: GPIB Address

LAN address



- Press the [SETUP] hardkey.  
The *SETUP* menu opens.

- Press the <CONFIGURE NETWORK> softkey.

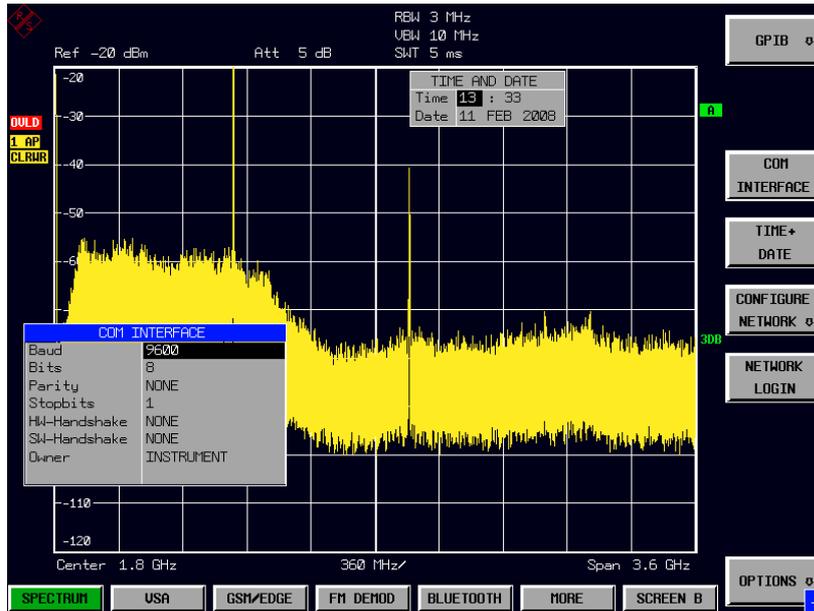


Fig. 12 Softkey: Configure Network

- Select *Local Area Connection* and press Enter.

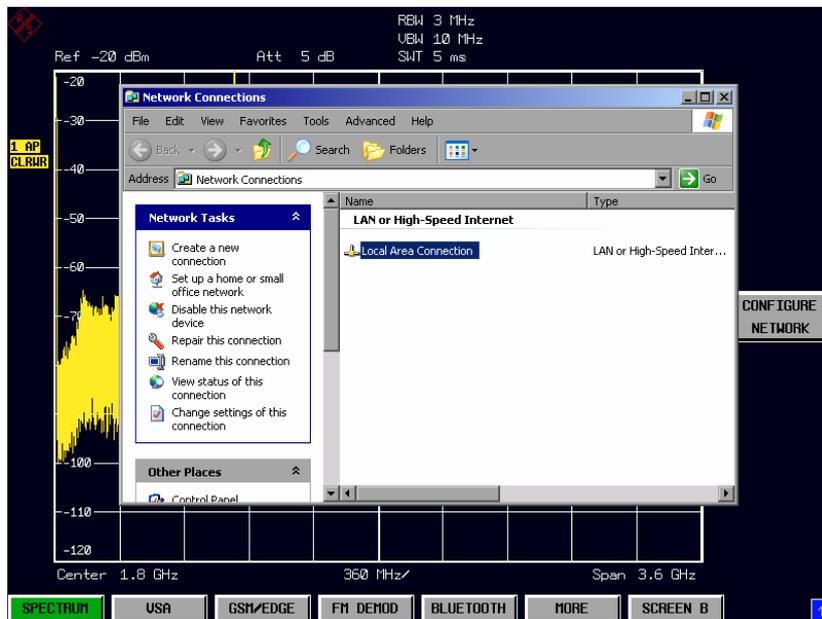


Fig. 13 Local Area Connection

➤ Click on the *Support* tab of the *Local Area Connection Status* dialog.

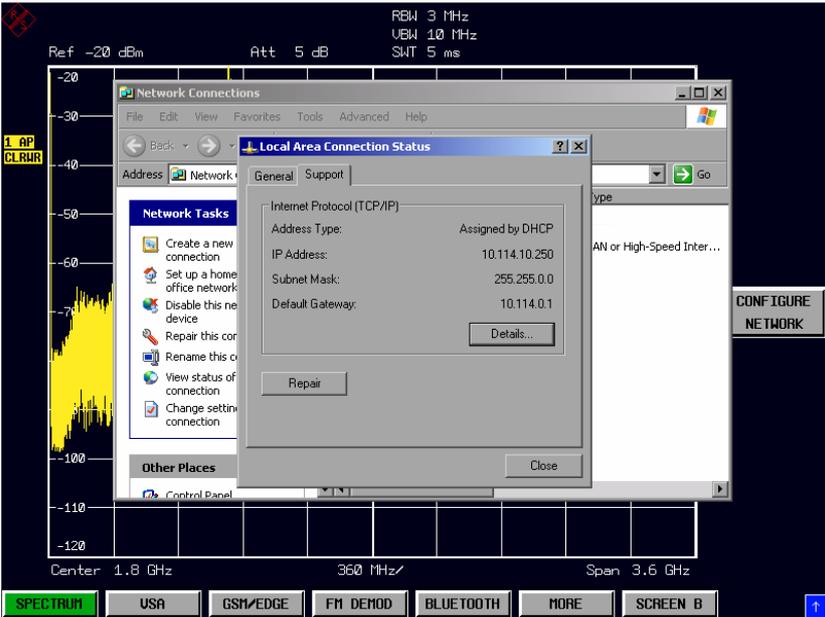


Fig. 14 Local Area Connection: Support tab

# Operating the software

## Starting the software

Use the desktop shortcut or the shortcut from the Start menu to start the OFDM-VSA analysis software. The following window appears:



The software user interface consists of six main elements:

- **Header table (1)**  
Showing basic information such as measurement frequency or capture length.
- **Results display (2)**  
Here, all measurement results are displayed in full or split screen style. Results displays are always separated into
  - Header (showing title, etc) and
  - Display (showing data) section.
- **Status bar (3)**  
The status bar shows "live" information on the measurement progress and displays software messages and errors.
- **Hotkeys (4)**  
The hotkeys control the measurement process (e.g. running a measurement). Pressing a hotkey will be referred to as **<HOTKEY CAPTION>** in this manual, e.g. **<RUN SGL>**.
- **Softkeys (5)**  
The softkeys are used to open configuration windows and to select the desired measurement result style. The softkeys may change when operating the software (e.g. clicking a hardkey). Pressing a softkey will be referred to as **<SOFTKEY CAPTION>** in this manual, e.g. **<SPECTRUM>**.
- **Hardkeys (6)**  
The hardkeys provide the same functions as those known from the R&S FSQ (load/store data, configure the display, etc). Pressing a hardkey will be referred to as **[HARDKEY CAPTION]** in this manual, e.g. **[MAIN]**.

## Quick start guide

This section will help you to quickly become familiar with the OFDM-VSA software (refer to section 3 for detailed operating instructions). As an exemplary signal WLAN 802.11a is used. The analyzer must be connected to the external PC via LAN or IEEE bus.

## Setting up the generator

This example requires an 802.11a or 802.11g-OFDM signal with 64-QAM data modulation. Fig. 15 shows the exemplary settings of an R&S SMU Vector signal generator.

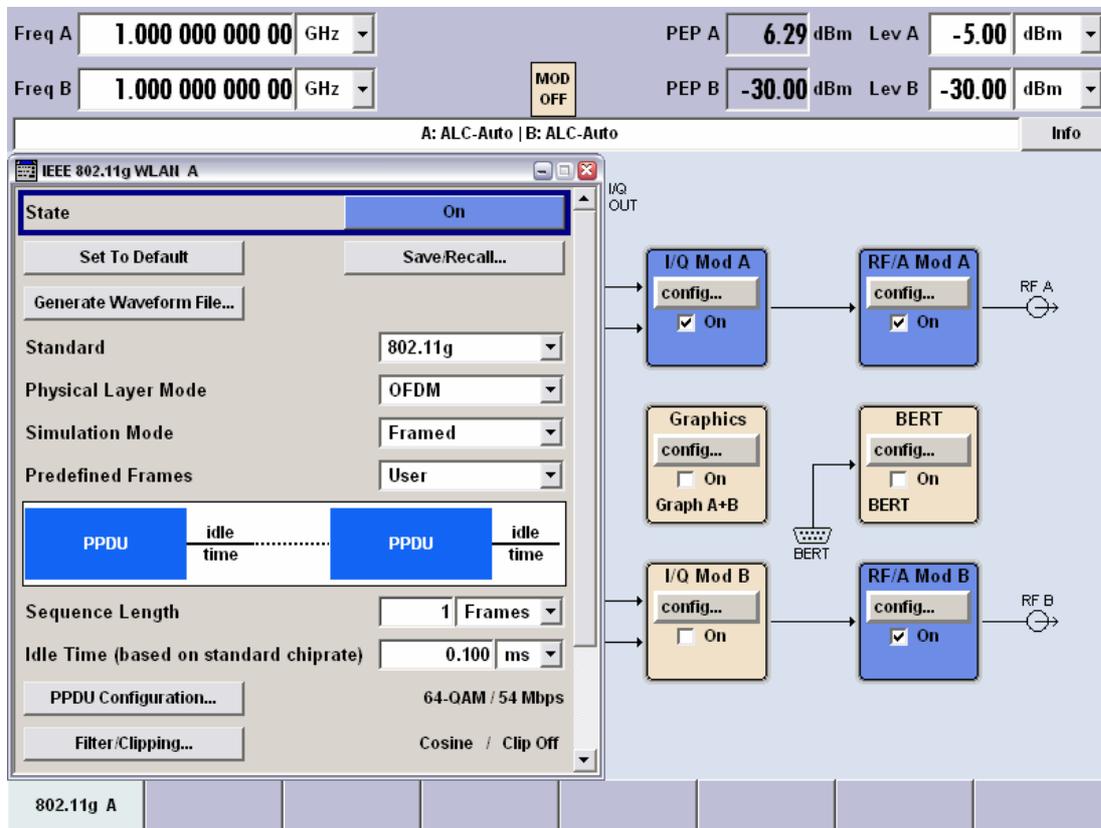
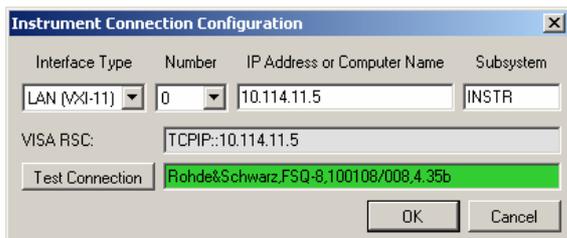


Fig. 15: WLAN settings menu of the R&S SMU Vector Signal Generator

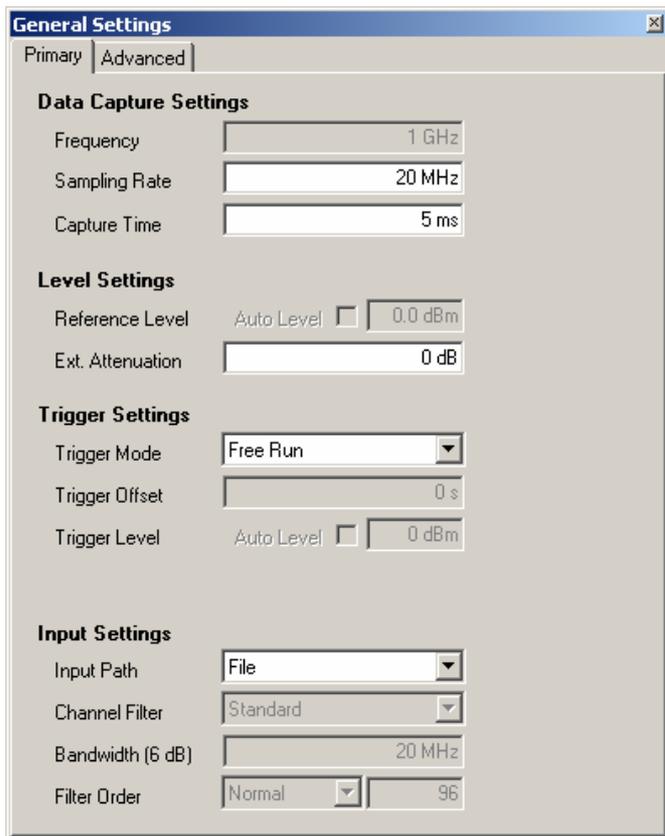
## Setting up the measurement

- Start the OFDM-VSA application and press [PRESET].
- Press [SETUP] and set the data source to instrument via the <DATA SOURCE> softkey.
- Press <CONFIGURE ANALYZER CONNECTION> and set up the instrument connection. Use the 'Test Connection' button to verify the connection settings.



## General setup (frequency, level, etc)

- Press <GENERAL SETTINGS> to open the General Settings panel.

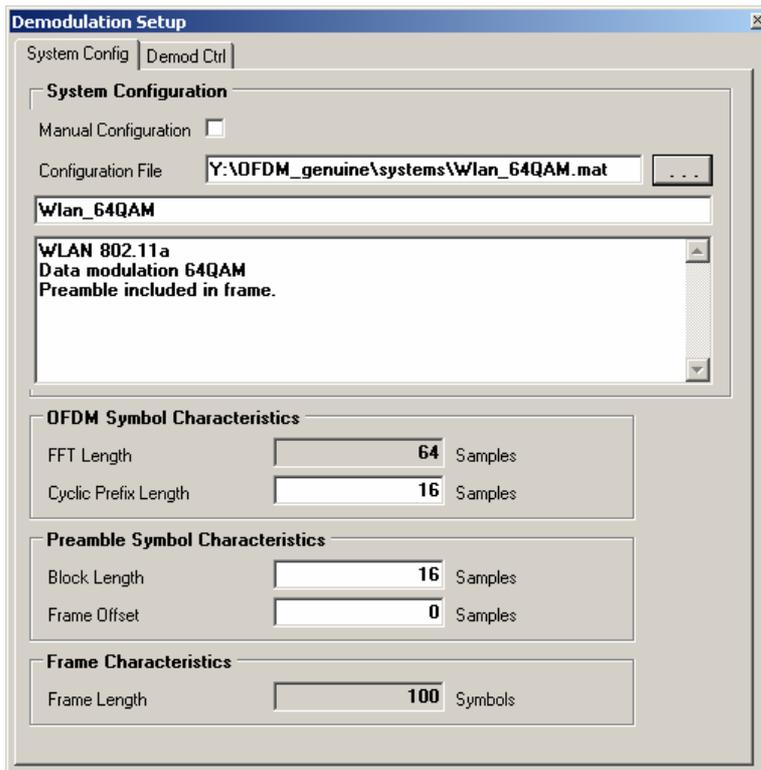


- Enter the desired frequency to measure in the *Frequency* field.
- Enter the 802.11a sample rate of 20 MHz in the *Sampling Rate* field.
- Enter a capture length of 5 ms in the *Capture Time* field.

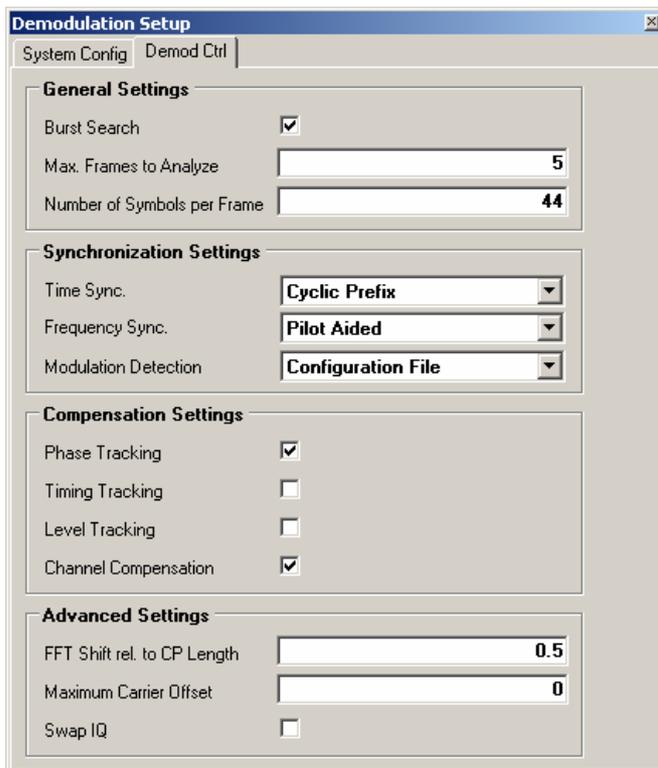
All other settings in this panel are sufficient for this example.

### Demodulation setup (System configuration and demodulation control)

- Press <DEMODO SETTINGS> to open the Demodulation Settings panel, and select the *System Config* tab.



- Load the system configuration file 'WlanA\_64QAM.mat'.
- Select the *Demod Ctrl* tab.

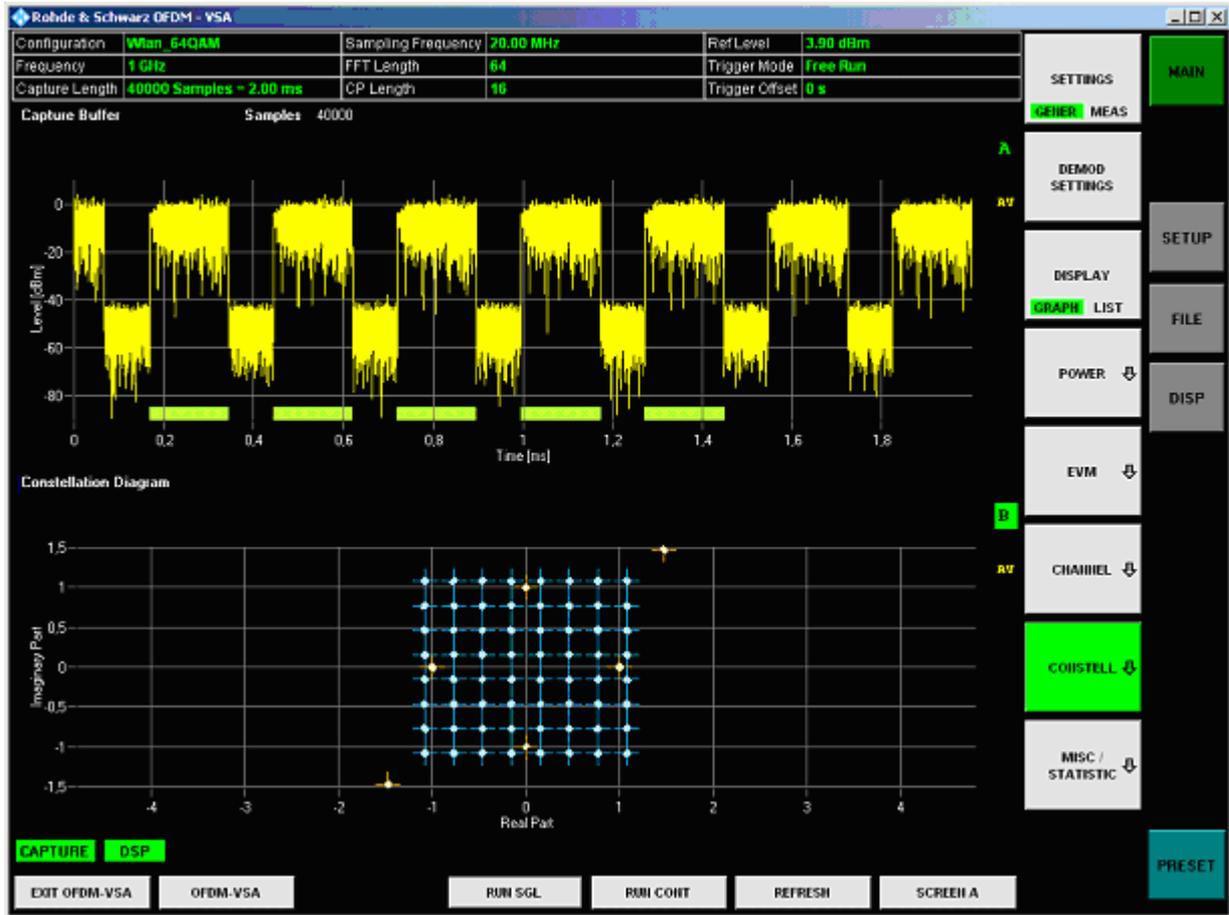


- Set the number of symbols per frame to the number of data symbols per OFDM burst plus 5 (4 preamble symbols + 1 signal field).

### Performing the measurement

- Start the measurement by pressing <RUN SGL>.

Measurement results are updated once the measurement has been completed. The results are displayed in graphical form. The display can be toggled to a tabular list of measurement points by pressing <DISPLAY>.



## 3 Operating the Software

This section contains a detailed description of all measurement modes, settings and results.

### Measurements

#### Numerical results

##### EVM measurements

- *EVM All*  
EVM for all data and all pilot cells of the analyzed frame
- *EVM Data*  
EVM for all data cells of the analyzed frame
- *EVM Pilot*  
EVM for all pilot cells of the analyzed frame.

##### I/Q constellation measurements

- *IQ Offset*  
Power at spectral line 0 normalized to the total transmitted power.
- *IQ Gain Imbalance*  
Logarithm of the 'Q-Channel to I-Channel gain ratio'.
- *IQ Quadrature Error*  
Measure of the 'phase angle between Q-Channel and I-Channel' deviating from the ideal 90 degrees.

##### Frequency measurements

- *Frequency Error*  
Difference between measured and reference center frequency.
- *Sample Clock Error*  
Difference between measured and reference sample clock relative to the system sampling rate.

##### Power measurements

- *Frame Power*  
Average time domain power of the analyzed frame.
- *Crest Factor*  
Peak-to-average power ratio of the analyzed frame.

### Graphical results

#### Power measurements

- *Power vs. Symbol X Carrier*  
Power profile of all cells in the analyzed frame.
- *Power vs. Carrier*  
Power of all carriers in the analyzed frame averaged over the symbols.
- *Power vs. Symbol*  
Power of all symbols in the analyzed frame averaged over the carriers.
- *Capture Buffer*  
Power profile of the capture buffer data being analyzed.

- *Power Spectrum*  
Power density spectrum of the complete capture buffer.

#### **EVM measurements**

- *EVM vs. Symbol X Carrier*  
EVM of all cells in the analyzed frame.
- *EVM vs. Carrier*  
EVM of all carriers in the analyzed frame averaged over the symbols.
- *EVM vs. Symbol*  
EVM of all symbols in the analyzed frame averaged over the carriers.
- *Error Freq / Phase*  
Samplewise Frequency and phase error vs. time.

#### **Channel measurements**

- *Flatness*  
Magnitude of the channel transfer function.
- *Group Delay*  
Relative group delay of each single carrier averaged over all OFDM symbols.
- *Impulse Response*  
Magnitude of the channel impulse response and position within the guard interval.

#### **Constellation measurements**

- *Constellation Diagram*  
Complex constellation diagram of the modulation symbols. The different cell types are assigned to unique colors. With the <CONSTELL SELECTION> softkey it is possible to suppress unwanted information.
- *Constellation vs. Carrier*  
Real and imaginary part of the modulation symbols over all carriers.
- *Constellation vs. Symbol*  
Real and imaginary part of the modulation symbols over all symbols.

#### **Miscellaneous and Statistic**

- *CCDF (complementary cumulative distribution function)*  
Complementary cumulative probability distribution for the capture buffer samples relative to the average power.
- *Signal Flow*  
Detailed description of the current measurement status.
- *Report*  
Detailed list of the demodulation steps.

# Softkey menu

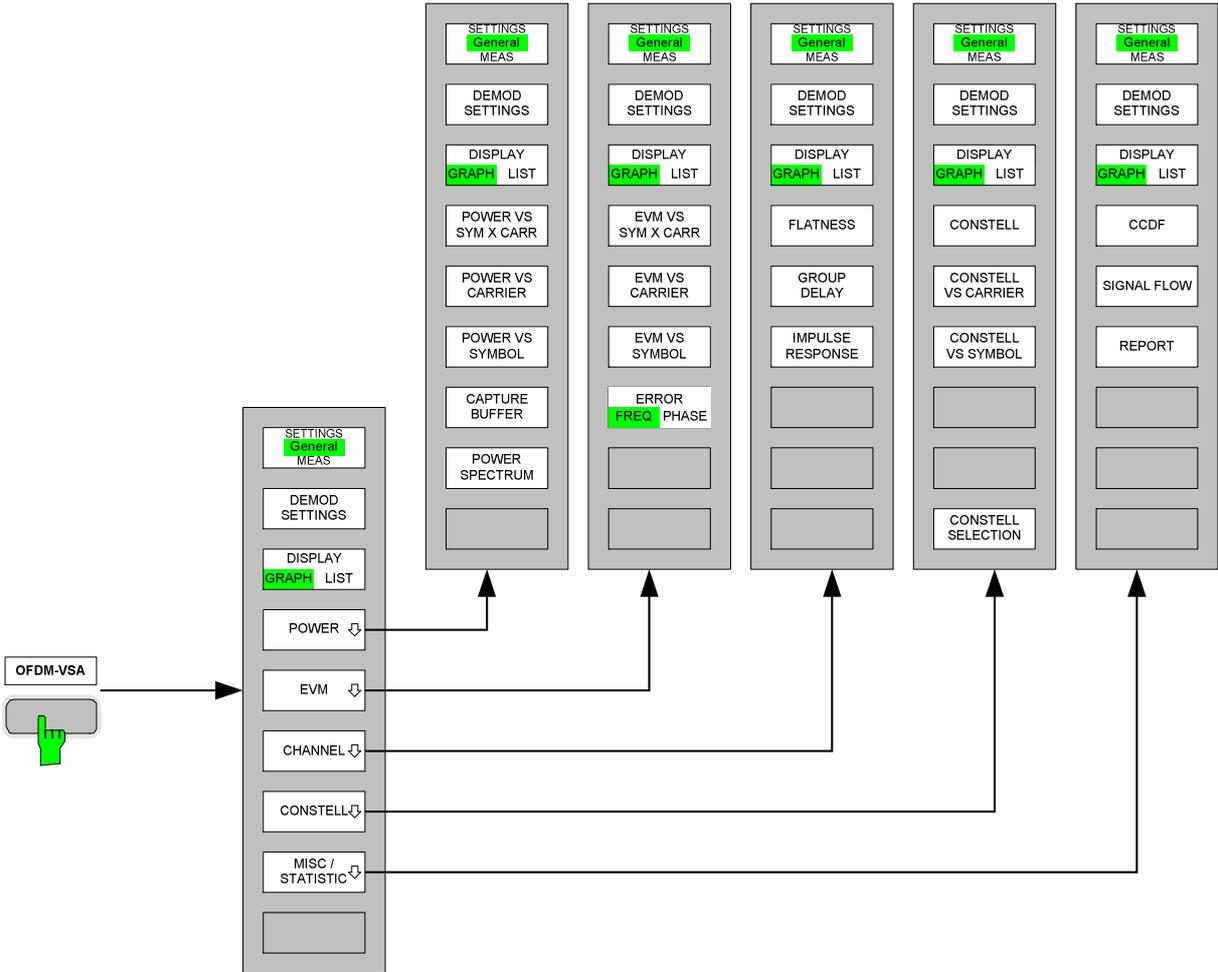


Fig. 16 OFDM-VSA menu structure

## Performing measurements

You can either use the R&S analyzer hardware to capture I/Q data or load the I/Q data from a file. The data source can be switched by using the [SETUP] <DATA SOURCE> keys. Please refer to section 4 “Import and Export of Data” for details on the file format.

### Running the measurement

Use the hotkeys of the OFDM-VSA software displayed at the bottom of the screen to start a single or continuous measurement with newly acquired data or the already captured I/Q data.



- RUN SGL**            Executes a single measurement with data capturing and signal processing and stops after it has finished.
- RUN CONT**        Executes subsequent measurements with data capturing and signal processing until you press <RUN CONT> again.
- REFRESH**         Executes a single measurement as with <RUN SGL>, but using already captured I/Q data for processing. This can be used to e.g. observe the changes of different demodulation settings to the results.

### Events during a measurement

While running the measurement, certain events may cause the measurement execution to fail. The corresponding error message is displayed in the status bar and stored in the error log.

### Measurement header table

The tabular section below the title bar shows the overall measurement settings and specific results used to obtain the current measurement results.

Configuration	<b>Wlan_64QAM</b>	Sampling Frequency	<b>20.00 MHz</b>	Ref Level	<b>0.00 dBm</b>
Frequency	<b>1 GHz</b>	FFT Length	<b>64</b>	Trigger Mode	<b>Free Run</b>
Capture Length	<b>20000 Samples = 1.00 ms</b>	CP Length	<b>16</b>	Trigger Offset	<b>0 s</b>

Fig. 17 Overall measurement settings summary

The settings summary includes the following information:

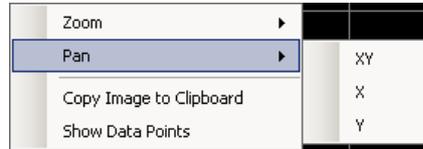
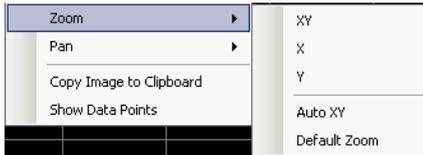
- **Configuration**            Name of the loaded configuration or ‘Manual’.
- **Frequency**                The analyzer RF frequency.
- **Capture Length**        Capture length in number of samples and time.
- **Sampling Frequency**    System sample rate.
- **FFT Length**              Length of the FFT interval in number of samples.
- **CP Length**                Length of Cyclic prefix interval in number of samples.
- **Ref Level**                 Reference level of the analyzer.
- **Trigger Mode**            Trigger condition of the analyzer.
- **Trigger Offset**         Offset of the capture buffer relative to the trigger point.

## Evaluating the results

### Operating the graph

#### Context menu (Zoom, Pan, Copy Image to Clipboard, Show Data Points)

Using the right mouse button on the graphical displays, you can select several options to perform a more detailed measurement on the displayed graphics.



#### Zoom

##### **XY**

Clicking the graph with the left mouse button and holding it down will select an X and Y area to zoom in on.

##### **X**

Clicking the graph with the left mouse button and holding it down will open a range which can be used to select an X area to zoom in on.

##### **Y**

Clicking the graph with the left mouse button and holding it down will open a range which can be used to select a Y area to zoom in on.

##### **Auto XY**

Scales the X and Y axes automatically to display the complete trace data.

The same action can be started by double-clicking on the display area.

##### **Default Zoom**

Scales the X and Y axes to the default axis values.

#### Pan

##### **XY**

Clicking the graph with the left mouse button and holding it down will move the graph in both the X and Y directions.

##### **X**

Clicking the graph with the left mouse button and holding it down will move the graph in the X direction.

##### **Y**

Clicking the graph with the left mouse button and holding it down will move the graph in the Y direction.

#### Copy Image to Clipboard

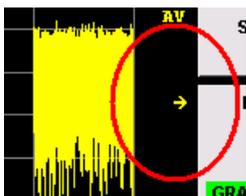
Copies the displayed image to the operating system clipboard.

#### Show Data Points

Displays small dots at each data point of the linear interpolated trace.

### Arrows indicating data out of display range

Parts or all of the data may be out of the display range. For this purpose, arrow indicators on the right side of the graph show a status in each direction (up, down, left, right). The arrow is displayed in yellow if only parts of the data are outside the visual area. If all data is outside the visual area, the arrow turns red.



This yellow arrow indicates that parts of the data are outside to the right of the visible area (arrow points to the right).

## I/Q measurements

This section contains a detailed description of the measurements.

### Power vs. Symbol X Carrier



The Power vs. Symbol X Carrier results are selected by pressing the <POWER> softkey in the main measurement softkey menu followed by the <POWER VS SYM X CARR> softkey.

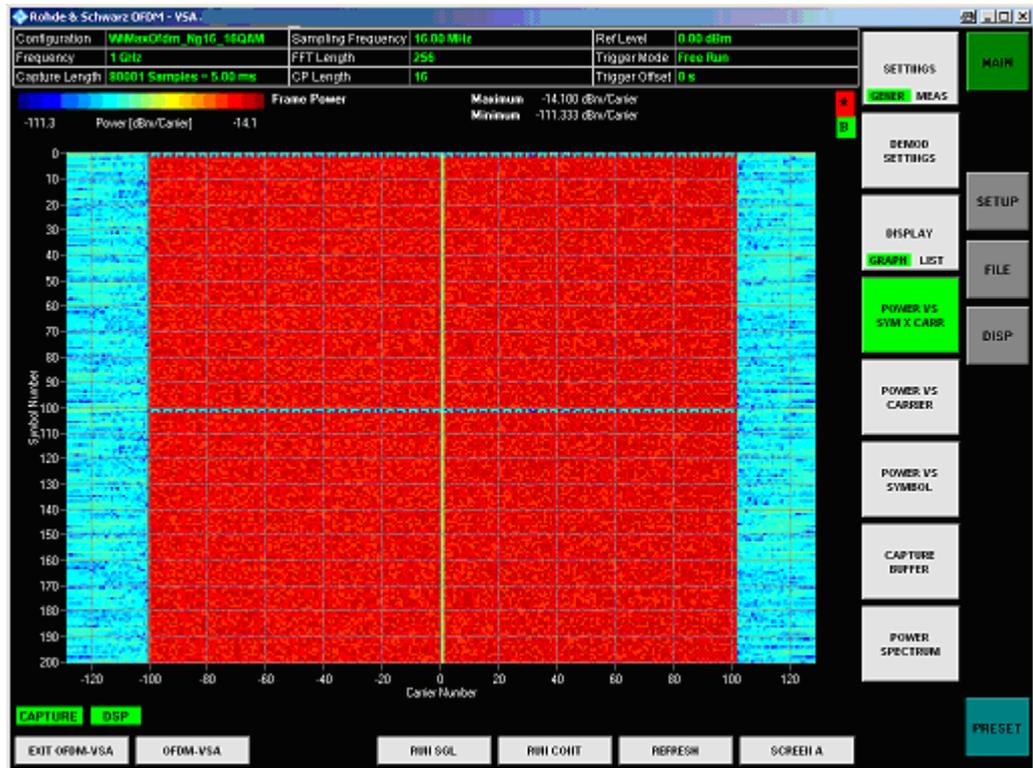


Fig. 18 Power vs. Sym. X Carr. display

The Power vs. Sym. X Carr. display shows the power of each carrier in each symbol of the received signal frames in dBm/Carrier. The values are color-coded using a colormap which is displayed on the top of the measurement window. All analyzed frames are concatenated in symbol direction.

Power vs. Carrier

POWER VS CARRIER



The Power vs. Carrier results are selected by pressing the <POWER> softkey in the main measurement softkey menu followed by the <POWER VS CARRIER> softkey.

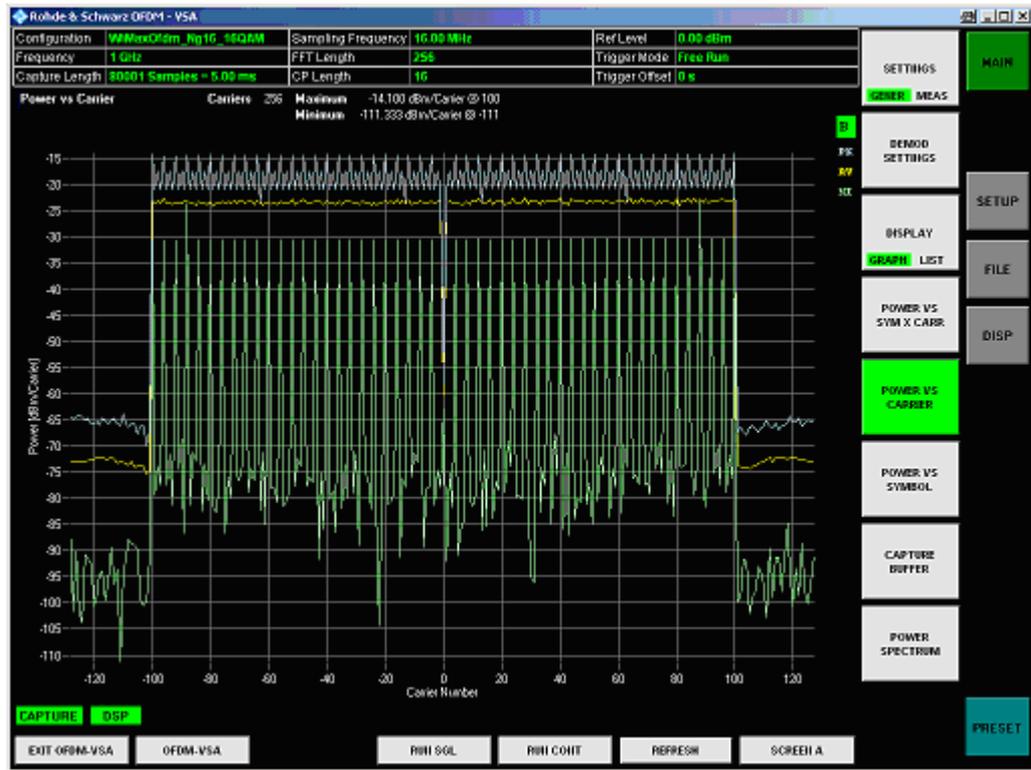
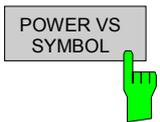


Fig. 19 Power vs. Carrier display

The Power vs. Carrier display shows the power of each carrier of the received signal frames in dBm/Carrier with statistics in symbol direction.

Power vs. Symbol



The Power vs. Symbol results are selected by pressing the <POWER> softkey in the main measurement softkey menu followed by the <POWER VS SYMBOL> softkey.

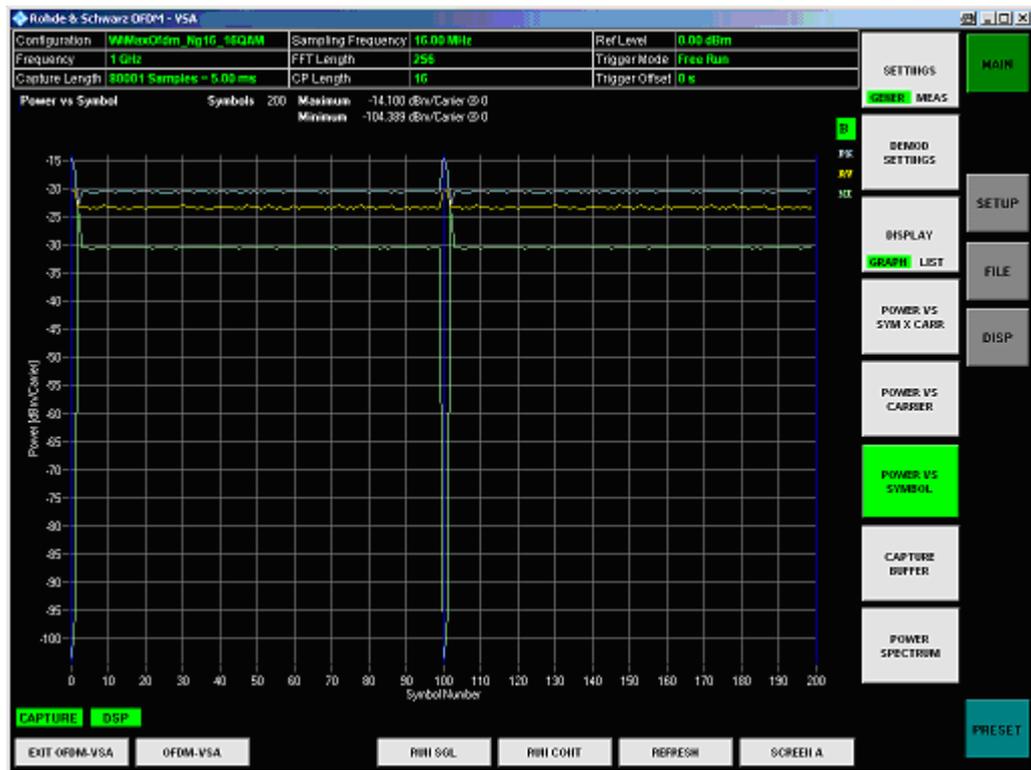
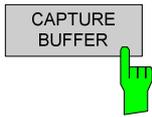


Fig. 20 Power vs. Symbol display

The Power vs. Symbol display shows the power of each symbol of the received signal frames in dBm/Carrier with statistics in carrier direction. All analyzed frames are concatenated in symbol direction with blue lines marking the frame borders. Carriers which contain 'Zero'-cells over the complete symbol range (e.g. guard carriers or DC carrier) are excluded from the statistic.

### Capture Buffer



The Capture Buffer PVT (power versus time) results are selected by pressing the <POWER> softkey in the main measurement softkey menu followed by the <CAPTURE BUFFER> softkey.

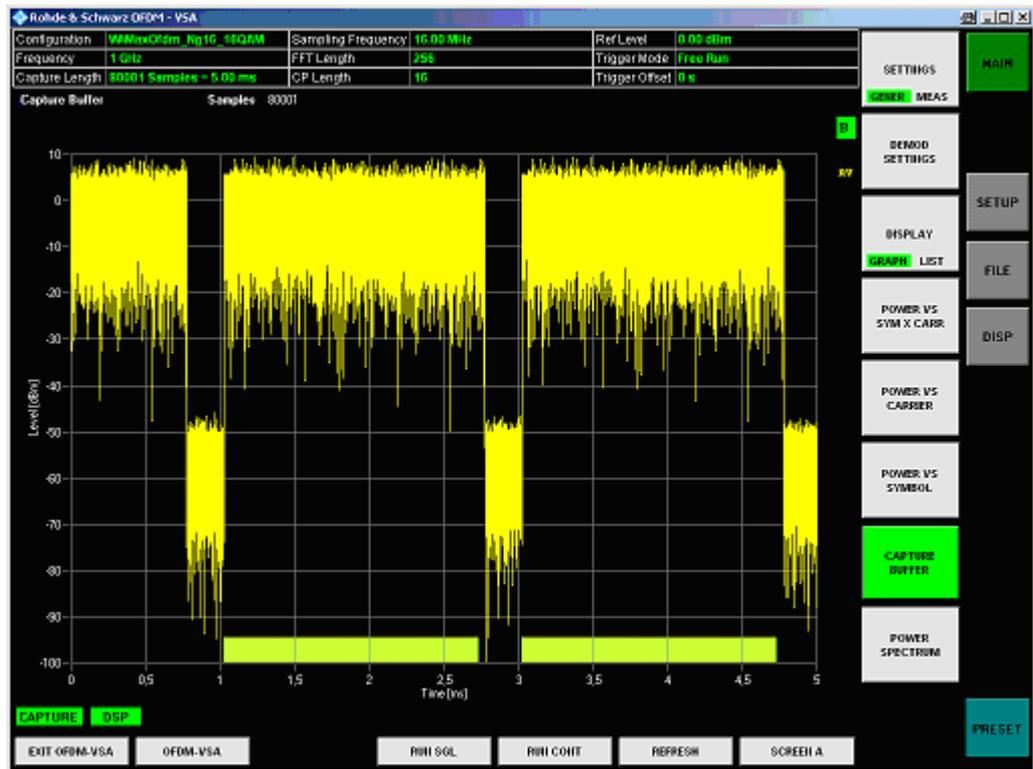
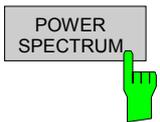


Fig. 21 Capture Buffer display

The capture buffer shows the complete range of captured data for the last sweep. The Capture Buffer display shows the power of the captured I/Q data versus time in dBm. The analyzed frames are identified with a green bar at the bottom of the Capture Buffer display.

All I/Q measurements process the same signal data. Therefore, all I/Q measurement results are available after a single I/Q measurement has been executed. I/Q measurements may be performed for RF or baseband input.

### Power Spectrum



The Power Spectrum is selected by pressing the <POWER> softkey in the main measurement softkey menu followed by the <POWER SPECTRUM> softkey.

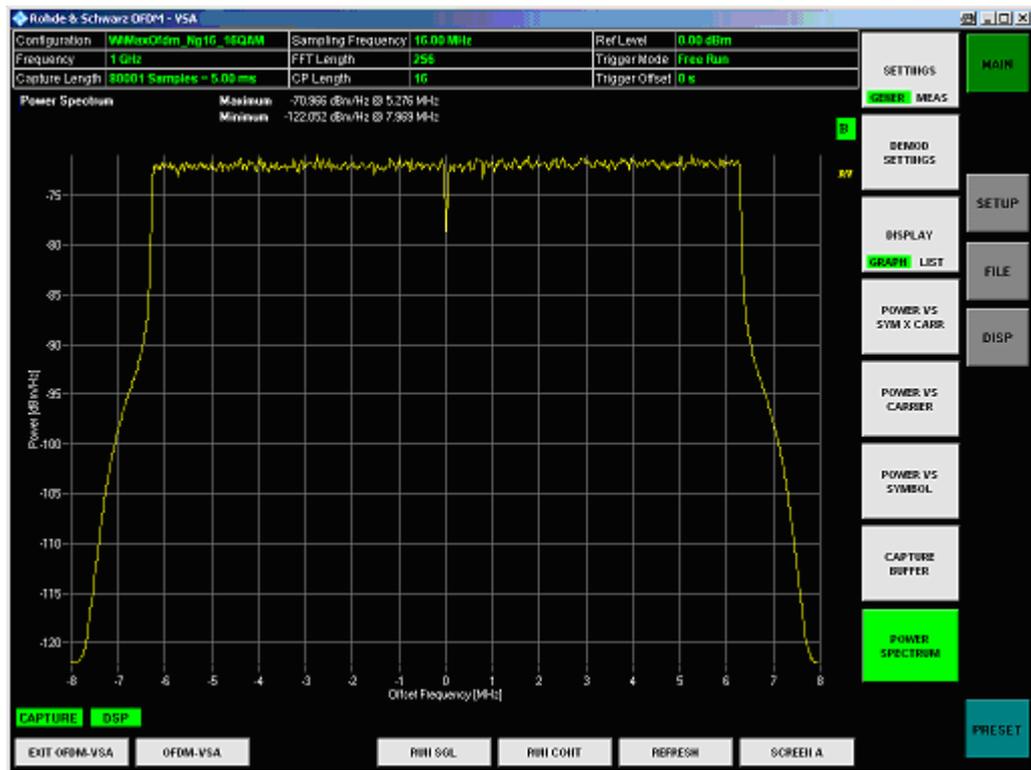
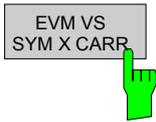


Fig. 22 Power Spectrum display

The Power Spectrum display shows the power density spectrum of the complete capture buffer in dBm/Hz.

### EVM vs. Symbol X Carrier



The EVM vs. Symbol X Carrier results are selected by pressing the <EVM> softkey in the main measurement softkey menu followed by the <EVM VS SYM X CARR> softkey.

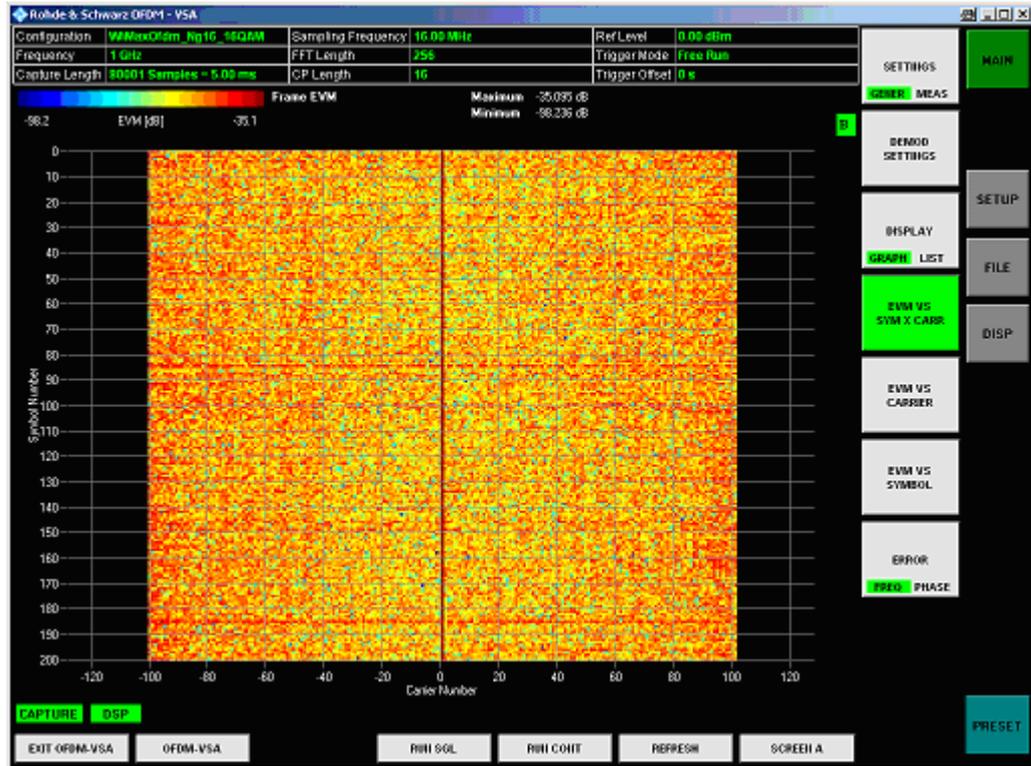
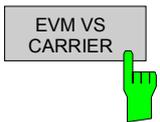


Fig. 23 EVM vs. Sym. X Carr. display

The EVM vs. Sym. X Carr. display shows the EVM of each carrier in each symbol of the received signal frames in dB or %, depending on the unit settings. The values are color-coded using a colormap which is displayed on the top of the measurement window. All analyzed frames are concatenated in symbol direction.

EVM vs. Carrier



The EVM vs. Carrier results are selected by pressing the <EVM> softkey in the main measurement softkey menu followed by the <EVM VS CARRIER> softkey.

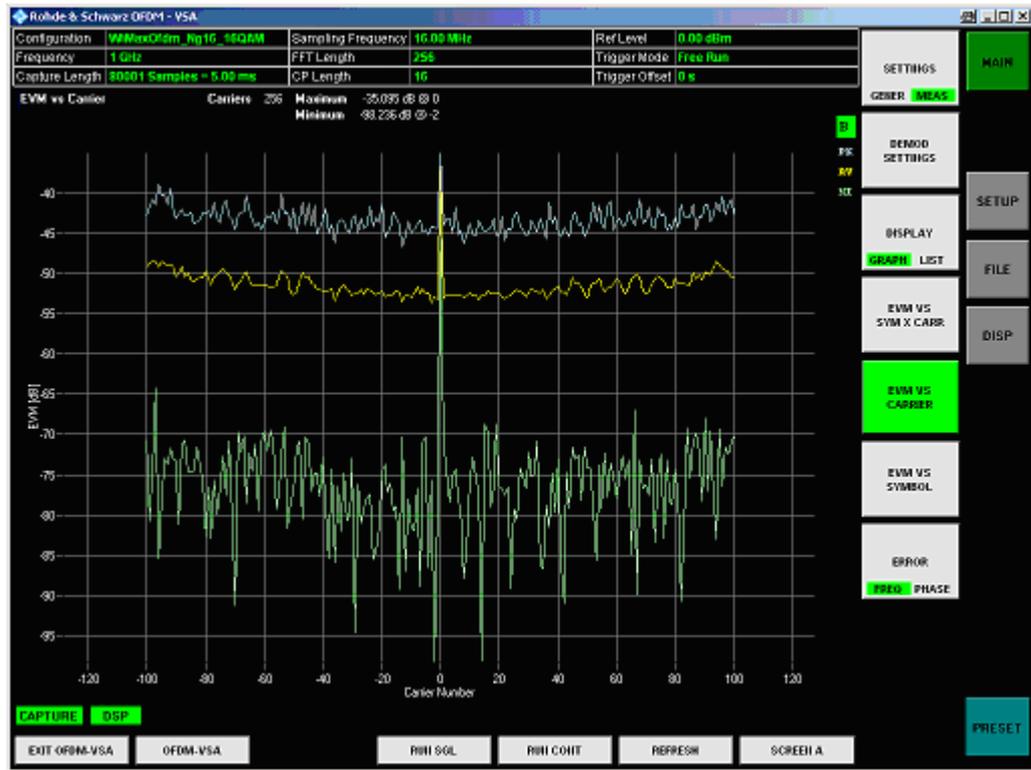
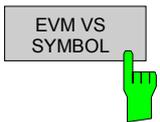


Fig. 24 EVM vs. Carrier display

The EVM vs. Carrier display shows the EVM of each carrier of the received signal frames in dB or %, depending on the unit settings, with statistics in symbol direction.

### EVM vs. Symbol



The EVM vs. Symbol results are selected by pressing the <EVM> softkey in the main measurement softkey menu followed by the <EVM VS SYMBOL> softkey.

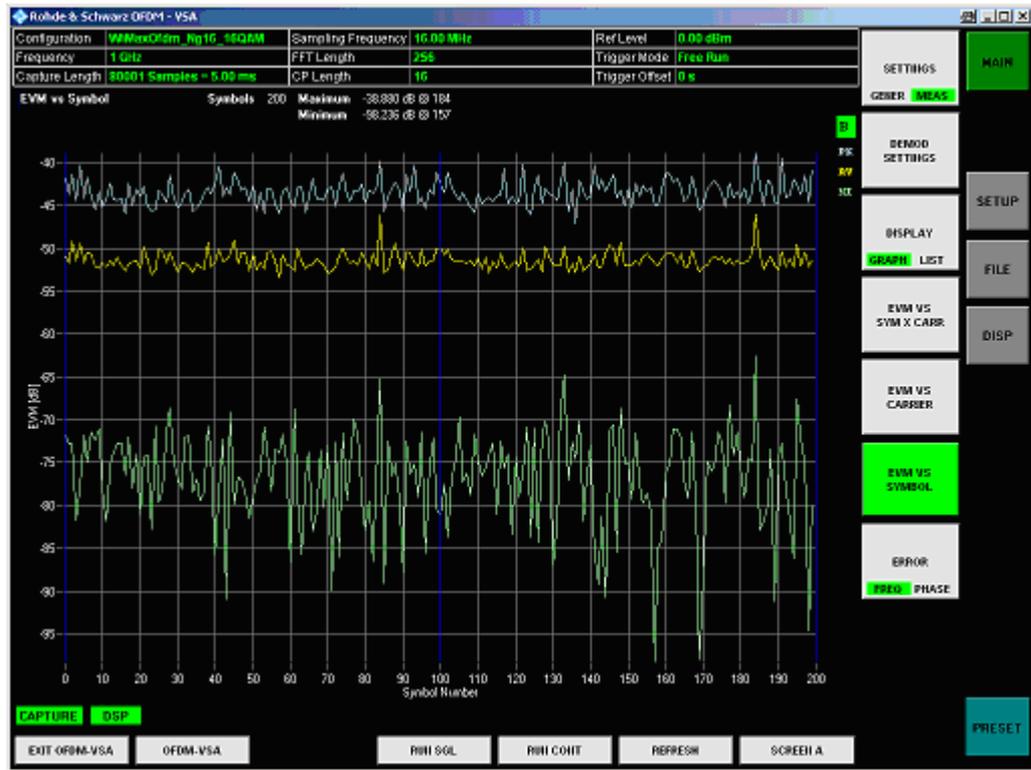
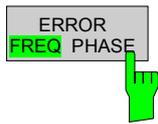


Fig. 25 EVM vs. Symbol display

The EVM vs. Symbol display shows the EVM of each symbol of the received signal frames in dB or %, depending on the unit settings, with statistics in carrier direction. All analyzed frames are concatenated in symbol direction with blue lines marking the frame borders. Carriers which contain 'Zero'-cells over the complete symbol range (e.g. guard carriers or DC carrier) are excluded from the statistic.

### Error Freq. / Phase



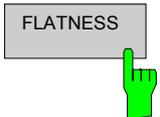
The Error Freq. / Phase results are selected by pressing the <EVM> softkey in the main measurement softkey menu followed by the <ERROR FREQ PHASE> softkey. Successive pressing of the softkey toggles between Frequency and Phase Error.



Fig. 26 Frequency Error display

The Error Frequency display shows the frequency deviations in Hz versus time. The Error Phase display shows the phase deviations in Degree versus time. The evaluation length of this measurement can be set in the measurement setup menu. All analyzed frames are concatenated in time direction with blue lines marking the frame borders.

### Channel Flatness



The Channel Flatness measurement results are selected by pressing the <CHANNEL> softkey in the main measurement softkey menu followed by the <FLATNESS> softkey.



Fig. 27 Channel Flatness display

The Channel Flatness display shows the amplitude of the channel transfer function vs. carrier. The statistic is performed over all analyzed frames.

### Group Delay



The Group Delay measurement results are selected by pressing the <CHANNEL> softkey in the main measurement softkey menu followed by the <GROUP DELAY> softkey.

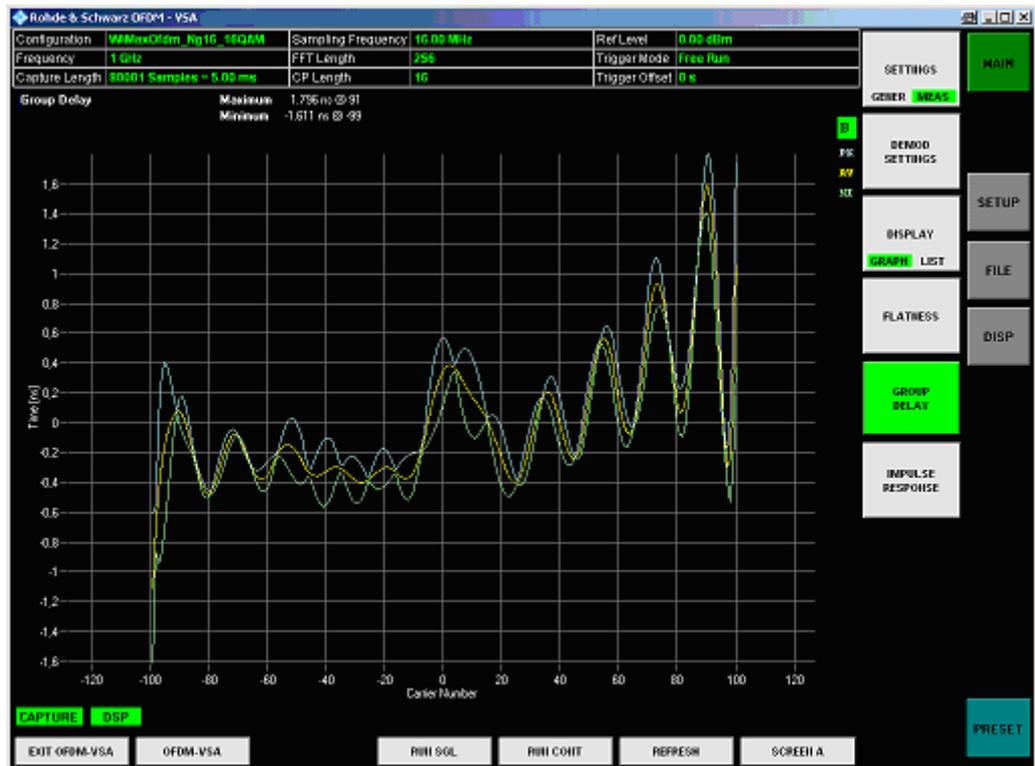
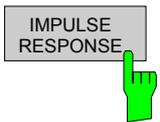


Fig. 28 Group Delay display

The Group Delay display shows the group delay of each single subcarrier. The statistic is performed over all analyzed frames.

### Channel Impulse Response



The Channel Impulse Response is selected by pressing the <CHANNEL> softkey in the main measurement softkey menu followed by the <IMPULSE RESPONSE> softkey.

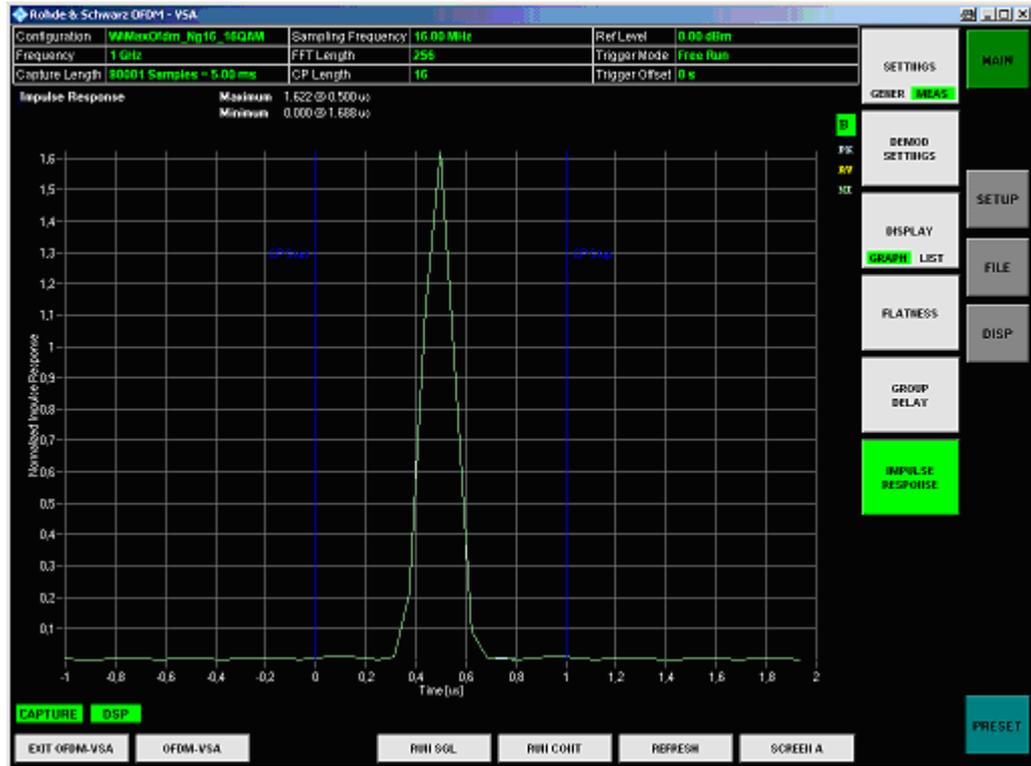
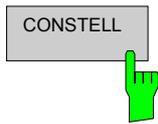


Fig. 29 Channel Impulse Response display

The Channel Impulse Response display shows the impulse response of the channel and its position within the guard interval. The start and the end of the guard interval are marked with blue lines. The statistic is performed over all analyzed frames.

### Constellation Diagram



The Constellation Diagram is selected by pressing the <CONSTELL> softkey in the main measurement softkey menu followed by the <CONSTELL> softkey.

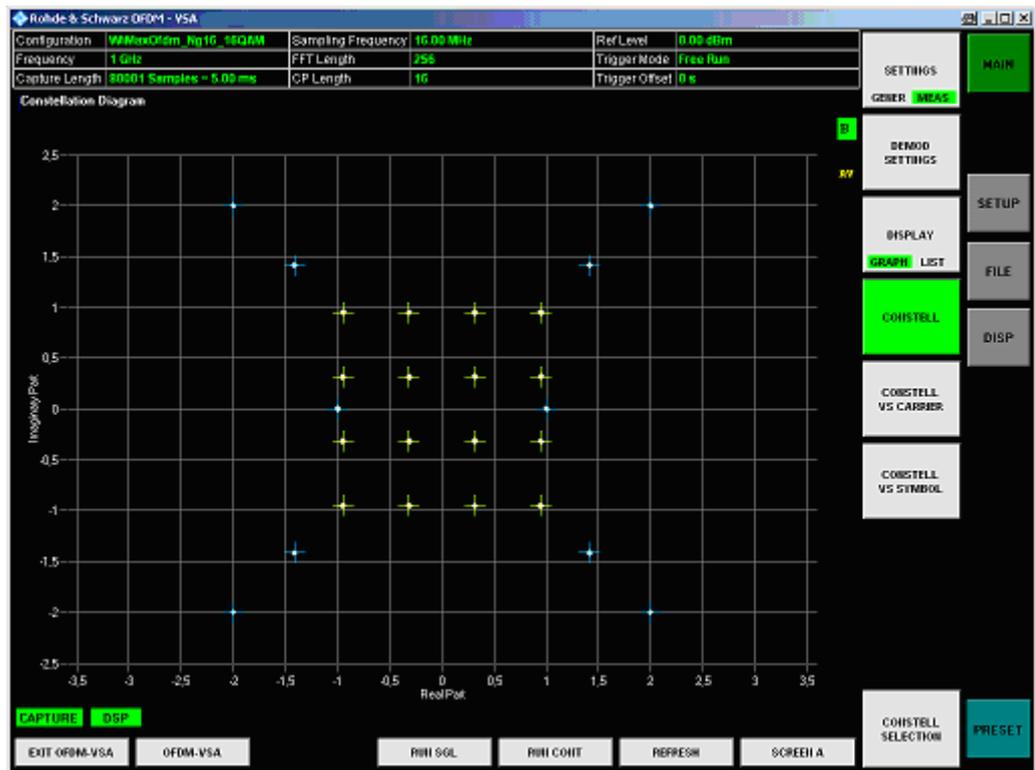
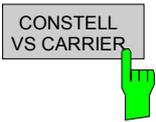


Fig. 30 Constellation Diagram display

The Constellation Diagram display shows the inphase and quadrature phase results over the full range of the measured input data. The ideal points for the selected cell types are displayed for reference purposes.

### Constellation vs. Carrier



The Constellation vs. Carrier diagram is selected by pressing the <CONSTELL> softkey in the main measurement softkey menu followed by the <CONSTELL VS CARRIER> softkey.

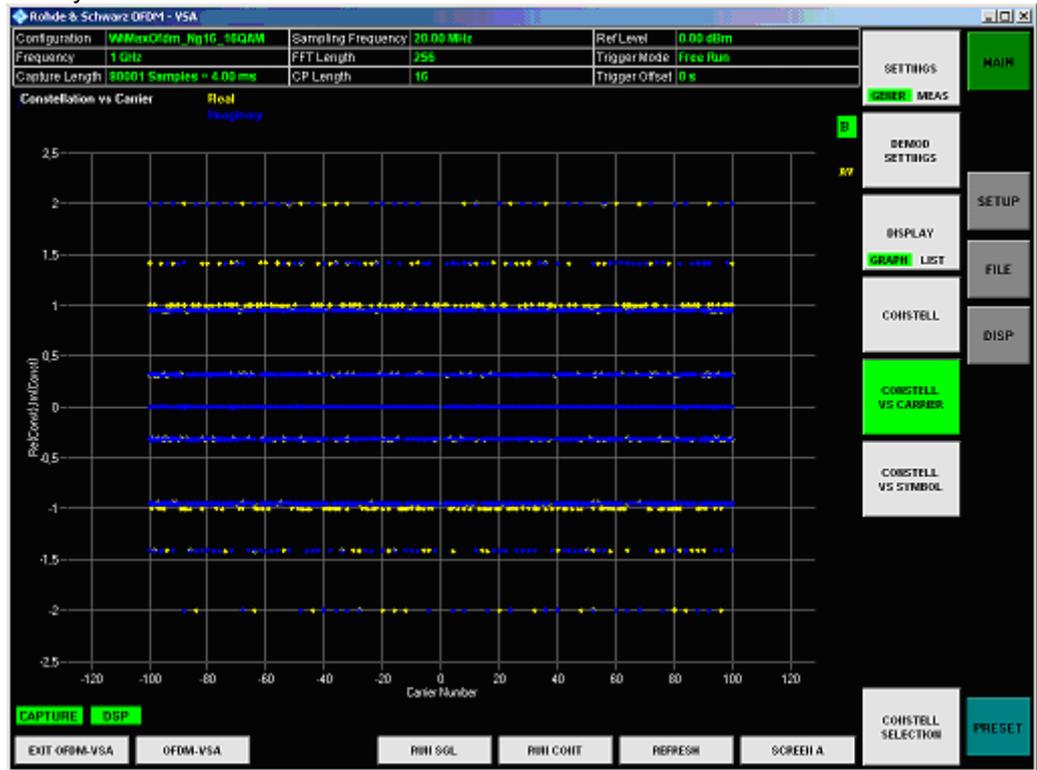
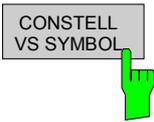


Fig. 31 Constellation vs. Carrier display

The Constellation vs. Carrier display shows the inphase and quadrature magnitude results of all symbols over the respective carriers. The inphase-values are displayed as yellow dots, the quadrature-values are displayed as blue dots.

### Constellation vs. Symbol



The Constellation vs. Symbol diagram is selected by pressing the <CONSTELL> softkey in the main measurement softkey menu followed by the <CONSTELL VS SYMBOL> softkey.

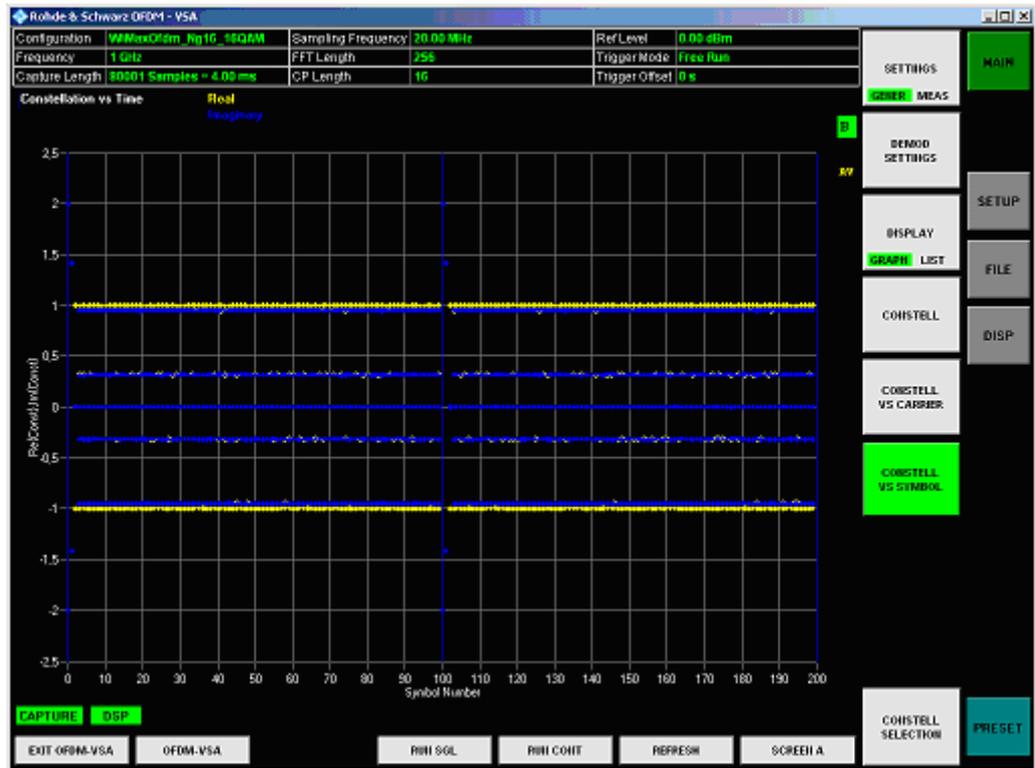
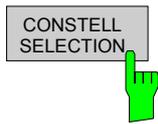


Fig. 32 Constellation vs. Symbol display

The Constellation vs. Symbol display shows the inphase and quadrature magnitude results of all carriers over the respective symbols. The inphase-values are displayed as yellow dots, the quadrature-values are displayed as blue dots. All analyzed frames are concatenated in symbol direction with blue lines marking the frame borders.

### Constellation SELECTION



The <CONSTELL SELECTION> softkey displays a pop-up dialog that allows the displayed results to be filtered. The results may be filtered by any combination of cell type, modulation, symbol, or carrier. The results are updated as soon as any change to the constellation selection parameters is made.

(Please note that if you use a split screen and have the constellation display on each of these screens, it is not possible to have two different filters for the different screens.)

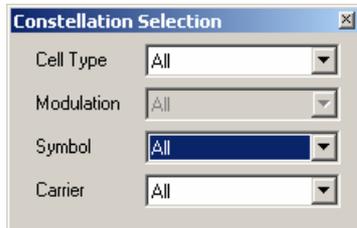
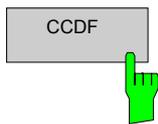


Fig. 33 Constellation Evaluation Filter panel

### CCDF (complementary cumulative distribution function)



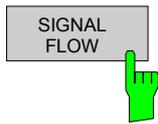
The CCDF measurement results are selected by pressing the <MISC / STATISTIC> softkey in the main measurement softkey menu followed by the <CCDF> softkey.



Fig. 34 CCDF display

The CCDF results display shows the probability of an amplitude exceeding the mean power. The X axis displays power relative to the measured mean power.

### Signal Flow



The Signal Flow display is selected by pressing the <MISC / STATISTIC> softkey in the main measurement softkey menu followed by the <SIGNAL FLOW> softkey.

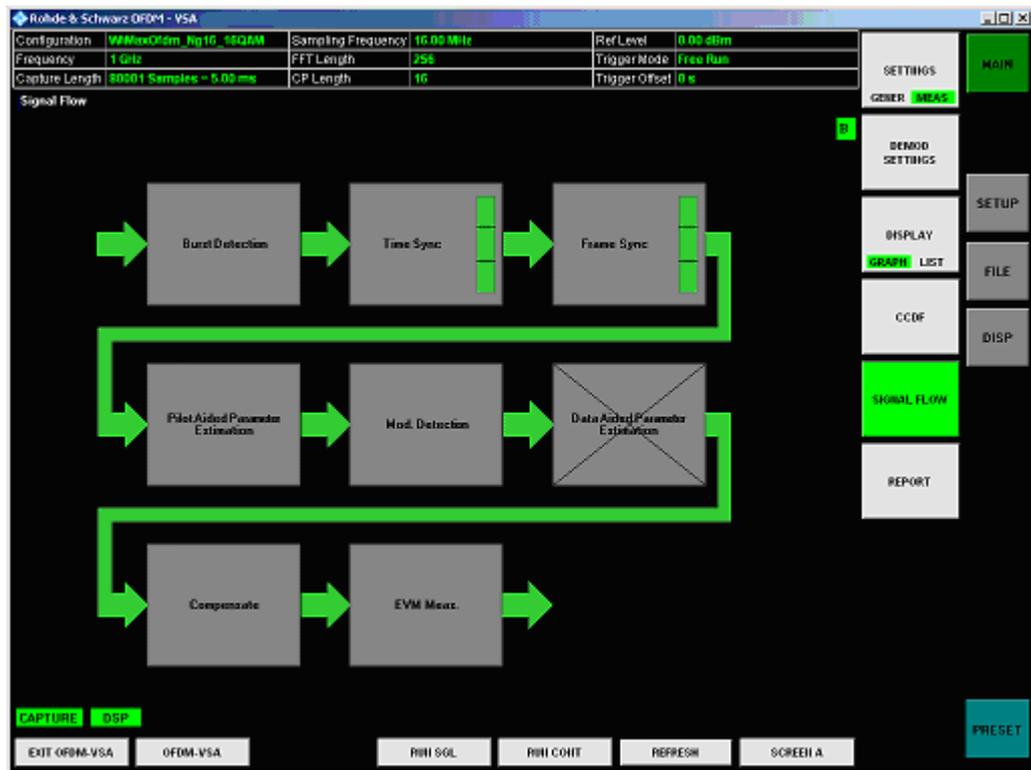


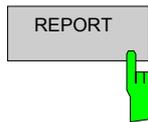
Fig. 35 Signal Flow display

The Signal Flow display shows a detailed description of the current measurement status. It provides additional hints on what is going wrong within the signal analysis. Unused blocks are crossed out.

For the synchronization blocks, a bar is shown giving information about the reliability of the synchronization result. If the level in the bar falls below the thresholds indicated by the horizontal line, the color of the bar changes from green to yellow and finally to red. When the synchronization of the block fails, the complete block changes its color and all succeeding arrows change their color too.

For detailed information about the complete synchronization process, please refer to section 6.

## Demodulation Report



The demodulation report is selected pressing the *<MISC / STATISTIC>* softkey in the main measurement softkey menu followed by the *<REPORT>* softkey.

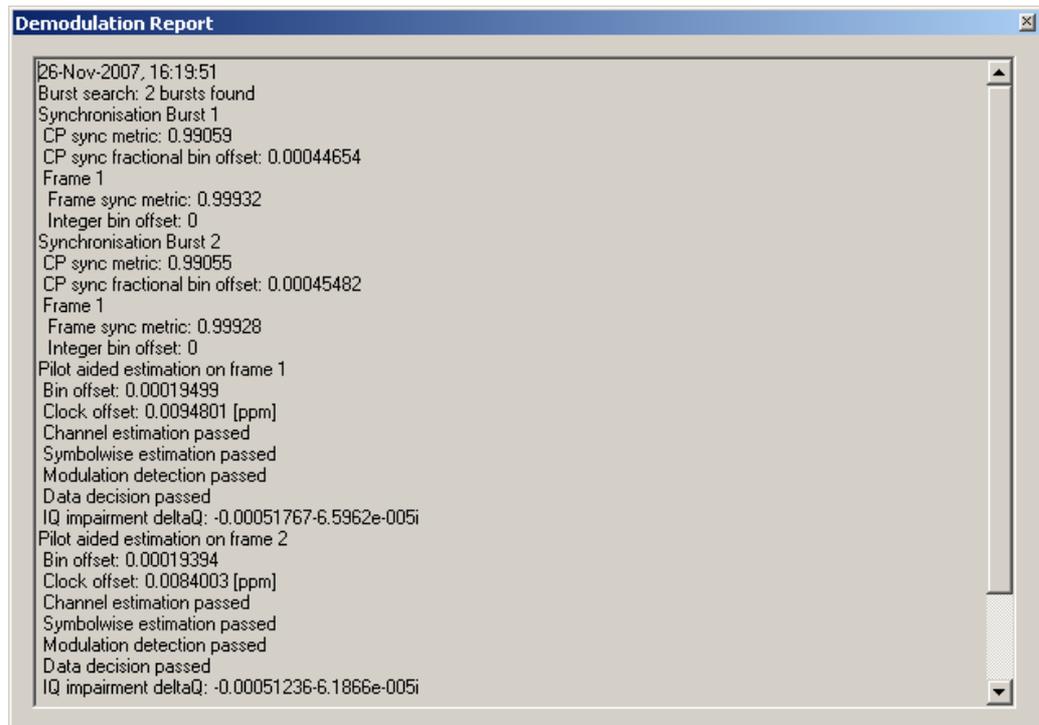


Fig. 36 Demodulation Report

The demodulation report lists messages generated by the signal processing kernel. It can give additional hints about the signal processing chain.

## Result summary

The Result Summary table is displayed for I/Q measurements when the display mode is set to LIST. This table shows the overall scalar measurement results. The statistic is performed over all analyzed frames within the capture buffer.



Fig. 37 Result Summary display

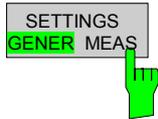
The Result Summary display is selected by pressing the <DISPLAY – LIST> softkey, which is available in all main measurement menus and submenus.

## Automatic level detection

Automatic level detection allows the Signal Level and Reference Level settings to be adjusted to the input signal. Automatic level detection can be performed by setting *Auto Level* in the General Settings panel to ON. Running the automatic level detection means that an automatic level detection measurement is executed before each measurement sweep.

## General settings

This section describes the General Settings panel, where all settings related to the overall measurement (i.e. Data Capture, Trigger and Input settings) can be modified. It is divided into a primary part, which will be sufficient for most measurement purposes, and an advanced part for specific manual settings.



The <GENERAL SETTINGS> softkey opens the General Settings panel.

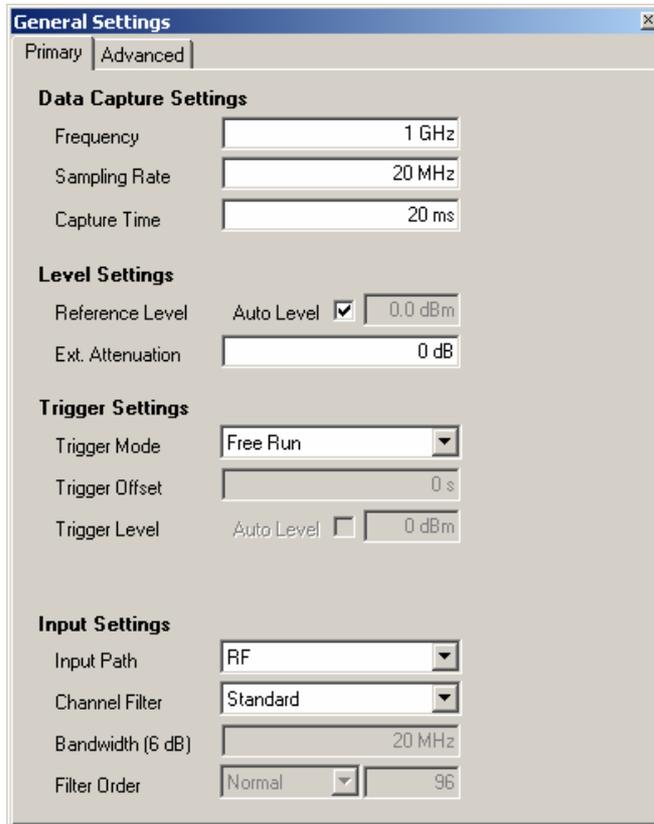


Fig. 38 Primary Tab of the General Settings Menu

## Data Capture Settings

The Data Capture Settings are the general settings concerning the physical attributes of the signals to be measured.

### Frequency

Frequency

Specifies the *Center Frequency* of the signal to be measured. The maximum frequency depends on the hardware configuration of the R&S analyzer.

### Sampling Rate

Sampling Rate

Specifies the *System Sampling Rate* of the OFDM signal to be measured.

The maximum sampling rate depends on the hardware configuration of the R&S analyzer.

### Capture Time

Capture Time

Specifies the *Capture Time* which is stored in the capture buffer and analyzed within one sweep.

The maximum capture time depends on the hardware configuration of the R&S analyzer and the memory of the external PC.

## Level Settings

The Level Settings are the general settings concerning the power leveling of the R&S analyzer.

### Reference Level

Reference Level  Auto Level

Specifies the *Reference Level* to use when running measurements, or displays the reference level when *Auto Level* is enabled.

The *Reference Level* parameter is editable only when RF input is selected and *Auto Level* is disabled.

When Auto Level is set to ON, the OFDM-VSA analysis software will measure the reference level automatically at the start of each measurement sweep. This ensures that the reference level is always set at the optimal level for obtaining accurate results but will lead to slightly increased measurement times.

The *Auto Level* setting is only available for RF input.

### External Attenuation

Ext. Attenuation

Specifies an *External Attenuation* to be considered in the power results of the R&S FSQ-K96 OFDM-VSA analysis software.

## Trigger Settings

The Trigger Settings group contains all the settings related to the triggering of a measurement sweep.

### Trigger Mode

Trigger Mode

*Trigger Mode* is the source of the trigger for the measurement sweep.

The possible values for the *Trigger Mode* are:

- Free Run** – The measurement sweep starts immediately.
- External** – The measurement sweep starts when the external trigger signal meets or exceeds the specified external trigger level at the input connector *EXT TRIGGER/GATE* on the rear panel.
- IF-Power** – The measurement sweep starts when the IF power meets or exceeds the specified trigger level.

### Trigger Offset

Trigger Offset

*Trigger Offset* specifies the time offset between the trigger signal and the start of the sweep. A negative value indicates a pre-trigger.

The *Trigger Offset* parameter is not editable when *Trigger Mode* is set to Free Run because this indicates that the measurement sweep should trigger immediately and as such a trigger delay or pre-trigger would not be appropriate.

### Trigger Level

Trigger Level  Auto Level

*Trigger Level* specifies the threshold of the External- or the IF-Power trigger.

If Auto Level is selected, this trigger threshold is determined automatically by the R&S FSQ-K96 OFDM-VSA analysis software before each sweep.

## Input Settings

The Input settings group contains settings related to the input source of the signal to be measured.

### Input Path

Selects whether the RF input or Baseband (BB) input is used.

### Channel Filter

*Channel Filter* selects the input filter preceding the OFDM demodulator. The *Standard* setting uses the default filter of the connected instrument. *Adjustable* allows the design of a lowpass filter with adjustable bandwidth and filter order.

### Bandwidth 6 dB

The *Bandwidth* of the channel filter is defined as two times the 6 dB cutoff frequency. It can be chosen between 0 Hz and the sample rate. Choosing a bandwidth near the sample rate can lead to backfolding of higher frequency signal parts.

### Filter Order

The *Filter Order* determines the slope characteristics of the channel filter. Three predefined filter orders, *Low*, *Normal* and *High* are available. Additionally, the filter order can be set manually. Odd filter orders are rounded to the next higher even number.

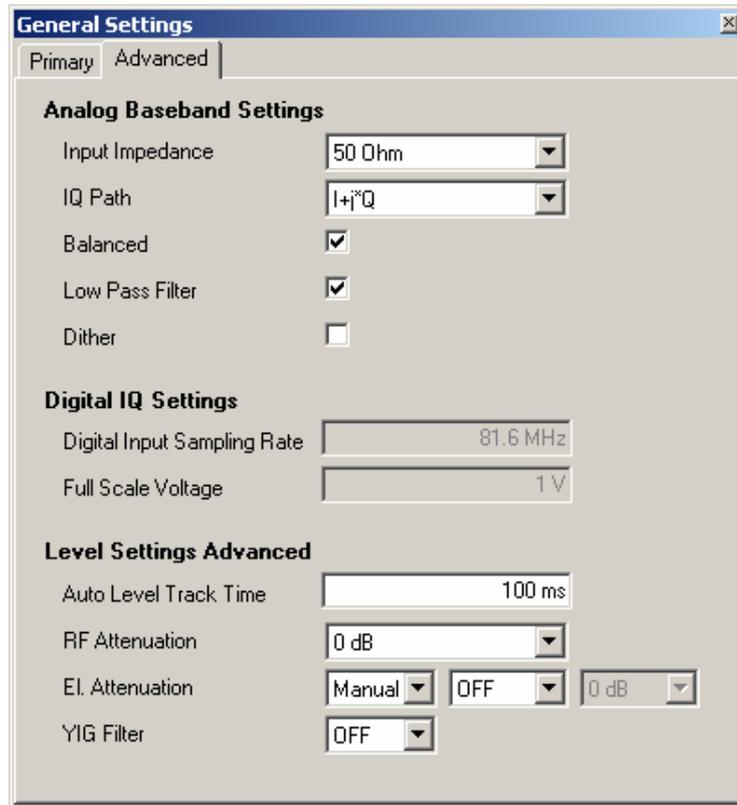


Fig. 39 Advanced Tab of the General Settings Menu

## Analog Baseband Settings

The Analog Baseband Settings group contains settings related to the baseband input source.

### Input Impedance

Input Impedance

*Input Impedance* allows the selection of the impedance of the Baseband inputs. The selection depends on the instrument configuration.

The *Input Impedance* parameter is editable only when Baseband input is selected.

### Balanced

Balanced

*Balanced* switches the Baseband inputs between symmetrical (balanced) and asymmetrical (unbalanced).

The *Balanced* parameter is editable only when Baseband input is selected.

### Lowpass

Low Pass Filter

When enabled, the *Lowpass* parameter inserts a 36 MHz lowpass filter into the I and Q parts of the baseband input.

## Dither

Dither

When enabled, the *Dither* parameter specifies that a 2 MHz-wide noise signal at 42.67 MHz is injected into the signal path of the Baseband input. It appears in the spectrum at 38.92 MHz.

The *Dither* parameter is editable only when Baseband input is selected.

## Digital IQ Settings

The Digital IQ Settings group contains settings related to the digital IQ input source.

### Digital Input Sampling Rate

Digital Input Sampling Rate

*Digital Input Sampling Rate* defines the sampling rate of the data signal at the digital IQ input.

The *Digital Input Sampling Rate* parameter is editable only when Baseband input is selected.

### Full Scale Voltage

Full Scale Voltage

*Full Scale Voltage* defines the voltage corresponding to the maximum input value of the digital baseband input ( value 7FFF hex).

The *Full Scale Voltage* parameter is editable only when Baseband input is selected.

## Level Settings Advanced

The Level Settings Advanced group contains settings related to the leveling of the R&S analyzer.

### Auto Level Track Time

Auto Level Track Time

*Auto Level Track Time* specifies the sweep time used for the auto level measurements.

This parameter is editable only when RF input is selected and *Auto Level* is enabled.

### RF Attenuation

RF Attenuation

*RF Attenuation* specifies the mechanical attenuation to be applied to the input RF signal.

Available values:  
*0 dB to 75 dB in steps of 5 dB.*

The *RF Attenuation* parameter is editable only when RF input is selected and *Auto Level* is disabled.

### EI. Attenuation

EI. Attenuation

*EL Attenuation* specifies the electrical attenuation to be applied to the input RF signal.

Available values:  
*0 dB to 30 dB in steps of 5 dB.*

The electrical attenuator can be switched off completely.

### YIG Filter

YIG Filter

*YIG Filter* specifies the state of the YIG filter in the R&S Analyzer.

## Measurement settings

This section describes the Measurement Settings panel, where all settings related to the measurement result displays can be modified. The first tab allows to specify units of the result axes. The following tabs offer specific settings for the different measurements.



The <MEAS SETTINGS> softkey opens the Measurement Settings panel.

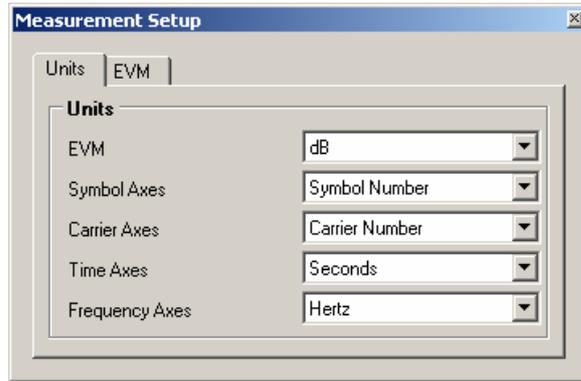


Fig. 40 Units Tab of the Measurement Settings Menu

### Units

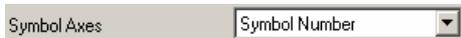
The Units group contains settings regarding the axes units of the different result displays.

#### EVM



*EVM* specifies the unit of EVM results.  
Available values: *dB* or *%*

#### Symbol Axes



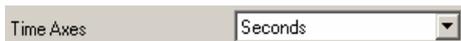
*Symbol Axes* specifies the unit of time axes representing symbol numbers.  
Available values: *Symbol Number* or *Seconds*

#### Carrier Axes



*Carrier Axes* specifies the unit of frequency axes representing carrier numbers.  
Available values: *Carrier Number* or *Hertz*

#### Time Axes



*Time Axes* specifies the unit of general time axes  
Available values: *Seconds*, *Sample Time* or *Symbol Time*

## Frequency Axes

Frequency Axes

*Frequency Axes* specifies the unit of general frequency axes

Available values:

Hertz, Sample Rate or Subcarrier Spacing

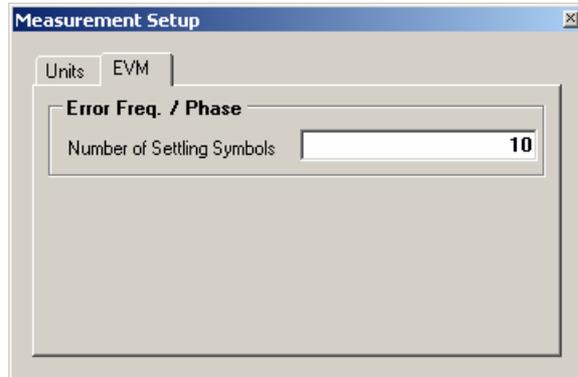


Fig. 41 EVM Tab of the Measurement Settings Menu

## Error Freq. / Phase

The Error Freq. / Phase group contains settings regarding the Error Freq. / Phase measurement within the EVM measurement group.

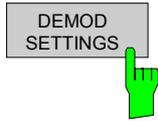
## Number of Settling Symbols

Number of Settling Symbols

*Number of Settling Symbols* specifies the number of symbols per frame used for the evaluation of the samplewise frequency and phase error calculation.

## Demodulation settings

This section describes the demodulation settings of the software for running a correct measurement by means of OFDM system configuration and demodulation control options.



The <DEMOM SETTINGS> softkey opens the Demodulation Settings panel.

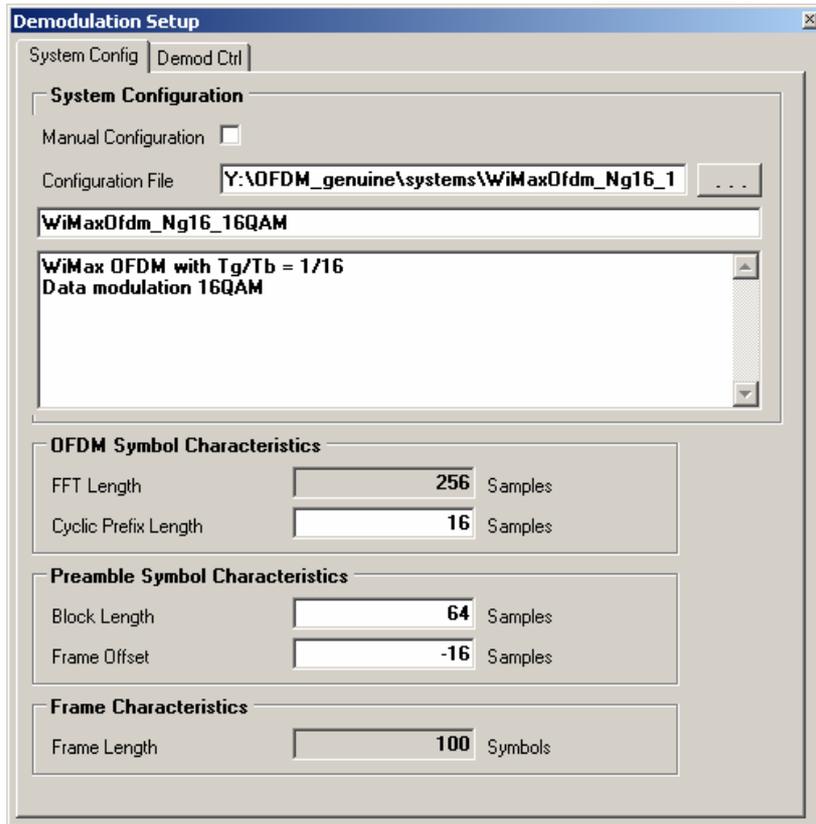


Fig. 42 System configuration tab of the Demodulation Setup menu

## System Configuration

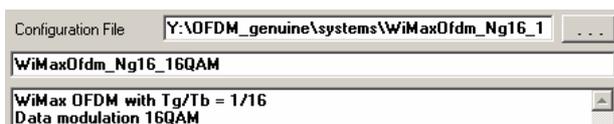
The System Configuration group contains general settings to specify the OFDM system.

### Manual Configuration



*Manual Configuration* allows to specify an OFDM system without using a system configuration file. The basic OFDM parameters can be entered manually. If manual configuration is enabled, no frame synchronization can be performed. EVM or Channel measurements are not available. The constellation diagram will still show a rotation.

### Configuration File



*Configuration File* allows to load a configuration file which defines the specific OFDM system. Pressing ‘...’ opens a file manager. The configuration file contains the system name and a system description, which are displayed within the text fields.

## OFDM Symbol Characteristics

The OFDM Symbol Characteristics group contains settings to specify the OFDM symbol in time domain.

### FFT Length

FFT Length  Samples

*FFT Length* specifies the length of the FFT area of an OFDM symbol in time domain in number of samples. This parameter is editable only when manual configuration is selected.

### Cyclic Prefix Length

Cyclic Prefix Length  Samples

*Cyclic Prefix Length* specifies the length of the Cyclic Prefix area of an OFDM symbol in time domain in number of samples.

## Preamble Symbol Characteristics

The Preamble Symbol Characteristics group contains settings to specify the preamble symbol in time domain. These parameters are used only if 'Preamble Synchronisation' is selected in the Demod Control settings tab.

### Block Length

Block Length  Samples

*Block Length* specifies the length of one data block within the repetitive preamble in number of samples.

### Frame Offset

Frame Offset  Samples

*Frame Offset* specifies the time offset from the preamble start to the actual frame start in number of samples.

## Frame Characteristics

The Frame Characteristics group contains settings to specify the complete OFDM frame.

### Frame Length

Frame Length  Symbols

*Frame Length* displays the length of the configured OFDM frame. This is the maximum evaluation length for which a configuration exists. The parameter has no meaning in manual mode.

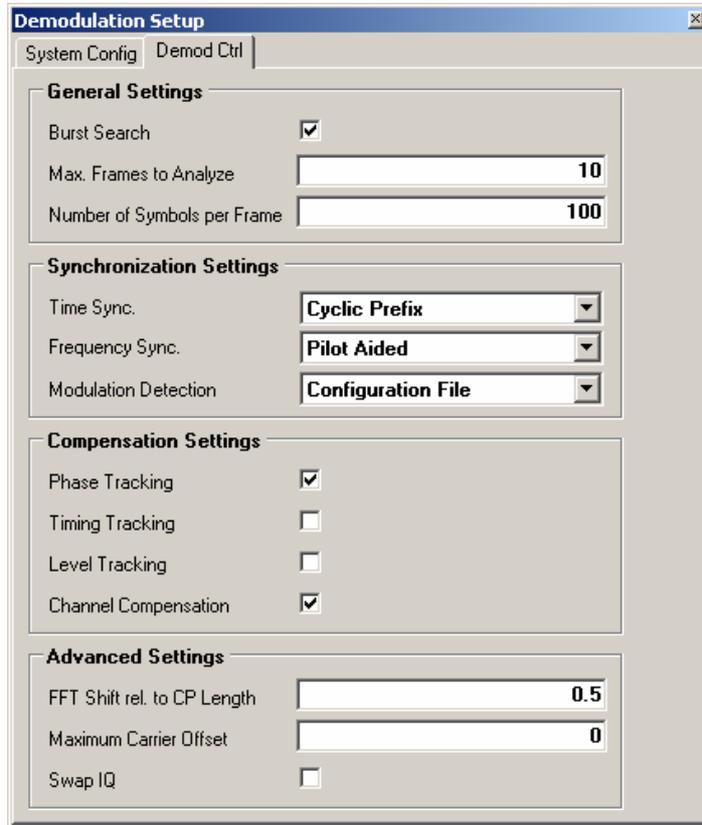


Fig. 43 Demodulation Control Tab of the Demodulation Setup Menu

## General Settings

The General Settings group contains basic settings about the position and length of the OFDM frame within the capture buffer.

### Burst Search

Burst Search

*Burst Search* specifies whether the demodulator shall search for power bursts before time synchronization. If enabled, the successive demodulation steps are restricted to the signal areas which contain significant power. For continuous signals this parameter has to be disabled.

### Maximum Frames to Analyze

Max. Frames to Analyze

*Max. Frames to Analyze* specifies the maximum number of frames which are analyzed within one capture buffer.

### Number of Symbols per Frame

Number of Symbols per Frame

*Number of Symbols per Frame* specifies the number of analyzed symbols in one frame. This number must be equal or lower than the Frame Length specified in the System Config menu.

## Synchronization Settings

The Synchronization Settings group contains settings which control the synchronization steps of the demodulation.

### Time Synchronization

Time Sync.

*Time Sync.* specifies the synchronization method in time domain. The *cyclic prefix* method performs a correlation of the cyclic prefix with the end of the FFT interval. The *preamble* method searches for the repetitive preamble blocks.

### Frequency Synchronization

Frequency Sync.

*Frequency Sync.* specifies the synchronization steps in frequency domain. If *NONE* is selected, the received data stays unsynchronized and EVM and channel results are not available. This setting is mandatory for manual configuration without a configuration file. The *Pilot Aided* synchronization uses the predefined pilot cells as reference signal. The *Data Aided* synchronization uses both pilots and decided data cells for an additional synchronization step.

### Modulation Detection

Modulation Detection

*Modulation Detection* specifies the operation mode of the automatic modulation detection for the data cells. If *Configuration File* is selected, the modulation matrix within the system configuration file is evaluated. The *symbolwise* modulation detection determines a common modulation format for all data cells within one OFDM symbol. The *carrierwise* modulation detection determines a common modulation format for all data cells within one OFDM carrier.

## Compensation Settings

The Compensation Settings group allows a detailed choice of channel and synchronization parameters to be compensated before the EVM measurement.

### Phase Tracking

Phase Tracking

*Phase Tracking* specifies whether or not the measurement results should be compensated for common phase error. The compensation is done on a per-symbol basis.

### Timing Tracking

Timing Tracking

*Timing Tracking* specifies whether or not the measurement results should be compensated for sample clock deviations. The compensation is done on a per-symbol basis.

### Level Tracking

Level Tracking

*Level Tracking* specifies whether or not the measurement results should be compensated for power level deviations. The compensation is done on a per-symbol basis.

### Channel Compensation

Channel Compensation

*Channel Compensation* specifies whether or not the measurement results should be compensated for the channel transfer function. The compensation is done on a per-carrier basis.

## Advanced Settings

The Advanced Settings group contains settings which control certain signal processing steps within the OFDM-VSA analysis software application.

### FFT Shift relative to Cyclic Prefix Length

FFT Shift rel. to CP Length

*FFT Shift rel. to CP length* allows to shift the FFT start sample within the guard interval. This is useful if relevant parts of the channel impulse response fall outside the cyclic prefix interval.



### Maximum Carrier Offset

Maximum Carrier Offset

*Maximum Carrier Offset* defines the search range of the frame synchronization in frequency direction. If set to zero, the center frequency offset must be less than half the carrier distance. Higher values allow higher frequency offsets, but slow down the measurement time.

### Swap IQ

Swap IQ

*Swap IQ* interchanges the I channel and the Q channel.

## Display settings

The layout of the display can be controlled using the display menu.



The **[DISP]** hardkey opens the display softkey menu. It also closes any settings panels that are open.

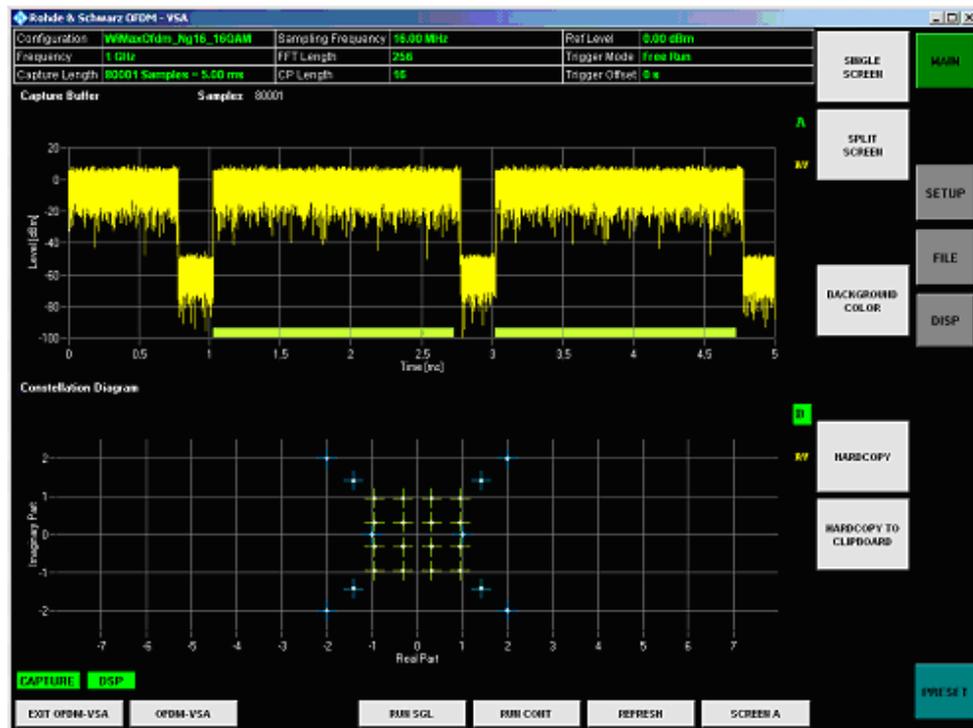


Fig. 44 Display menu

The display menu allows the display to be changed between split and full screen for I/Q measurement results.

I/Q measurements can be run in split screen or in full screen mode.

The active screen can be selected by pressing the **<SCREEN A / SCREEN B>** hotkey. In full screen mode the **<SCREEN A / SCREEN B>** hotkey also toggles which screen is displayed.

The background color of the software can be changed by pressing the **<BACKGROUND COLOR>** softkey and selecting a color in the color selection dialog.

The **<HARDCOPY>** softkey saves a screenshot of the application window in the following formats:

- *BMP*: Uncompressed pixel format
- *GIF*: Color compressed pixel format with 256 colors (platform independent)
- *JPEG*: Compressed pixel format
- *PNG*: Lossless compressed pixel format
- *TIFF*: Format for high color depth images

The **<HARDCOPY TO CLIPBOARD>** softkey sends a screenshot of the application window to the operating system clipboard.

## File management

This section describes the file management of demodulation settings, global settings and I/Q data.



The **[FILE]** hardkey opens the file management softkey menu.



Fig. 45 File management menu

Use **<SAVE>** to open a standard file dialog to save the current settings of the OFDM-VSA software application.

Use **<RECALL>** to open a standard file dialog to load and apply a previously saved setting file.

Use **<SAVE IQ DATA>** to open a standard file dialog to save the current I/Q data in the capture buffer.

Use **<SAVE DEMOD DATA>** to open a standard file dialog to save the processed and demodulated data in a time-frequency matrix.

Please refer to section 4 “Import and Export of Data” for details on the file format.

# Software Setup

This section describes the setup of the OFDM-VSA software application and the connected R&S analyzer.



The **[SETUP]** hardkey opens the software setup softkey menu. It also closes any settings panels that are open.

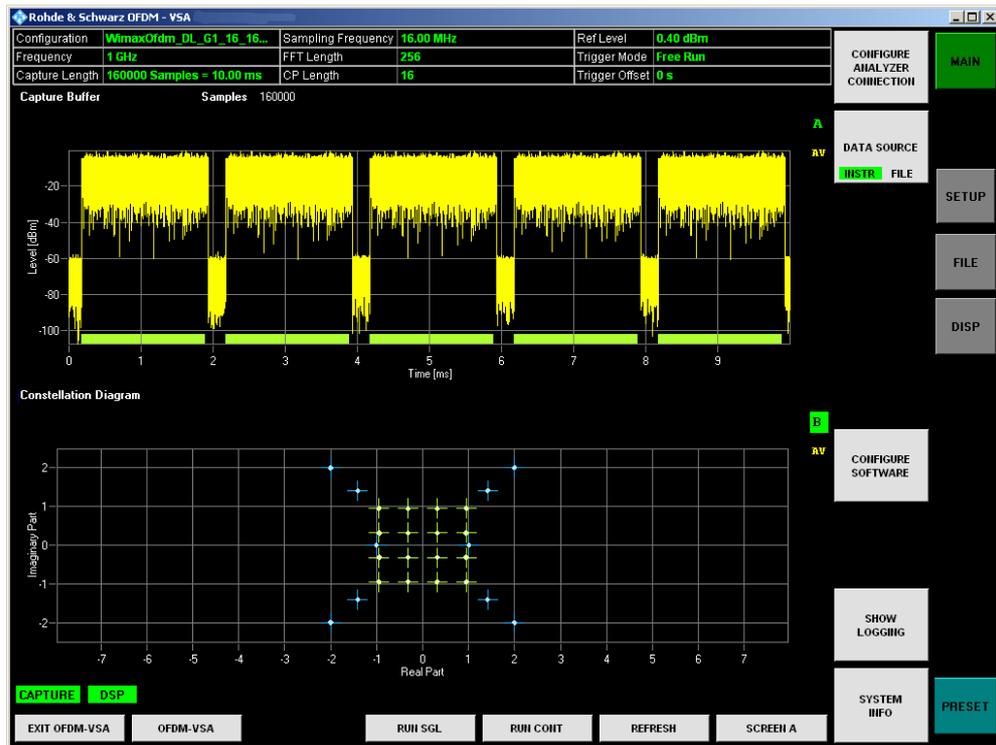
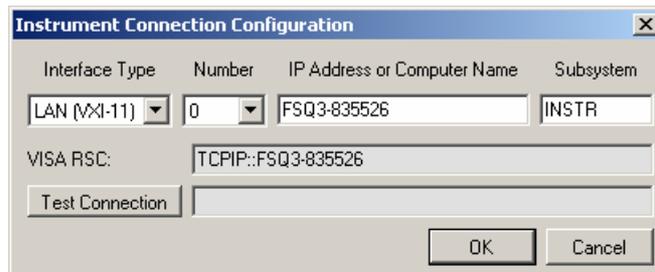


Fig. 46 Software setup menu

## Configure Analyzer Connection



In order to be able to communicate with the instruments, the R&S analyzer must be connected with the PC using either an IEEE bus or LAN connection. The type of connection and the address can be selected by the `<CONFIGURE ANALYZER CONNECTION>` softkey:

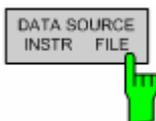


If more than one interface is available on the PC (e.g. because two LAN cards are installed), please select the appropriate interface *Number*. The *Subsystem* does not need to be changed.

Depending on the *Interface Type*, different types of addresses must be entered:

Interface	Description	Address equivalent to ...
GPIB Instrument	IEEE bus system using the IEEE 488 protocol	Instrument primary GPIB address (0...31). Default value is 20 for the FSQ.
LAN <i>VXI-11 protocol</i>	LAN bus system using the VXI-11 protocol (supported with FSQ firmware version 3.65 or later)	Host address as TC/IP address or computer name. Contact your local IT support if you are not sure what to enter here.
LAN <i>RSIB protocol</i>	LAN bus system using a Rohde & Schwarz-specific protocol (supported with all R&S FSQ firmware versions)	Host address as TC/IP address or computer name. Contact your local IT support if you are not sure what to enter here.

## Data Source (Instrument or File)



The `<DATA SOURCE>` softkey is used to specify the I/Q data source. Data can either be captured from the R&S analyzer (*INSTR* is selected) or read from file (*FILE* is selected). If *FILE* is selected, each time the user presses the `<RUN SGL>` or `<RUN CONT>` hotkey, a dialog is shown where the user can specify the full name and path of the I/Q data file to be used. Pressing ENTER loads the specified I/Q data file and displays the results.

If the specified file cannot be found or is not a valid I/Q data file, an error message will be displayed indicating that the I/Q data could not be imported.

## Configure Software

CONFIGURE  
SOFTWARE



Pressing the <CONFIGURE SOFTWARE> softkey opens the following pop-up dialog:

The dialog is divided into a debugging and a remote control section. In the debugging section it can be chosen whether to store debug information each time data is analyzed. The path where the debug information is stored can be selected as well as whether the input, the output, or both debug files shall be stored.

**Note:** *The creation of the debug files takes some time and will slow down the measurement, so this feature should not be activated unless it is necessary.*

The debug files contain all the necessary information (e.g. I/Q data, settings) to reproduce a measurement. These files may be sent back to Rohde & Schwarz together with possible support questions.

The remote control section allows to enable or disable the remote control functionality of the OFDM-VSA. Disabling of the remote control needs a restart of the software.

## Show Logging

SHOW  
LOGGING

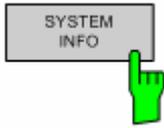


The <SHOW LOGGING> softkey is used to display an error messages history.

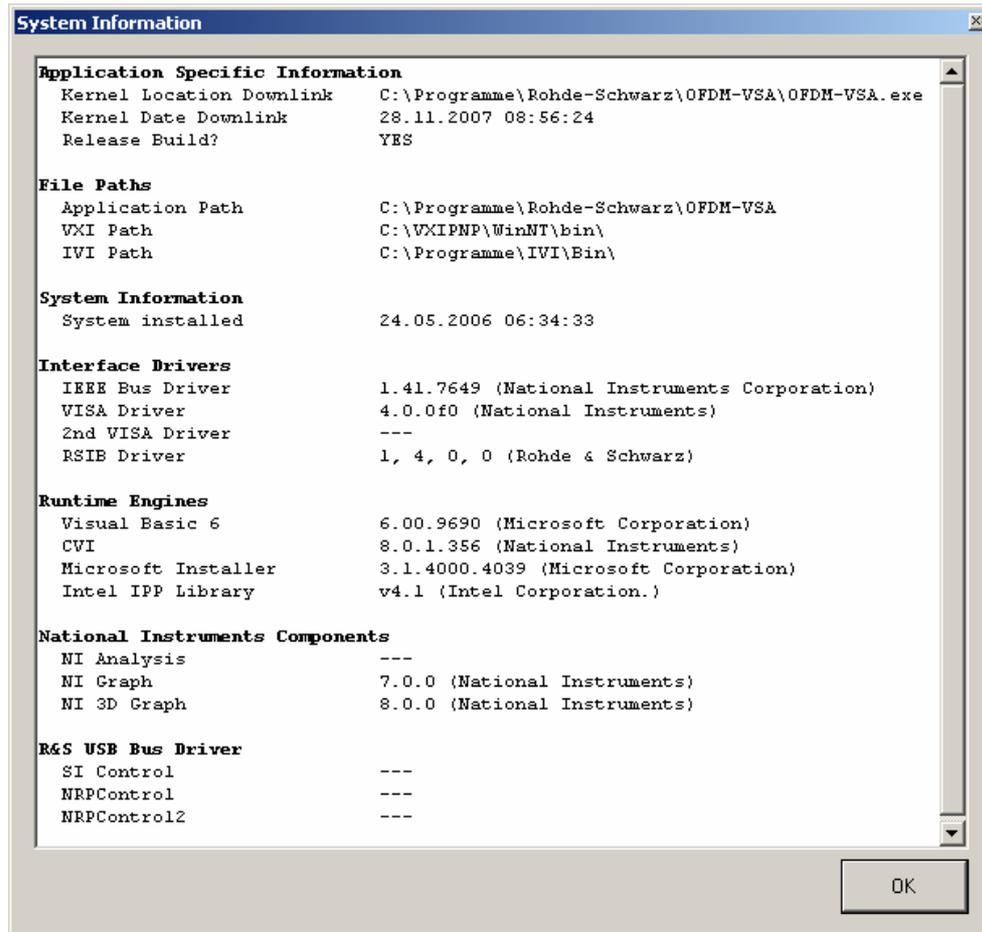
TYPE	TIME	CONTEXT	DESCRIPTION
Fatal	17.07.2007 13:44:00:848	Instrument Link	Cancel selected while trying to read the IQ d

The message history can be refreshed and cleared, and the contents can be copied to the operating system clipboard.

## System Info



The <SYSTEM INFO> softkey opens a dialog containing system information about the version numbers of used drivers and utility software. This information can be useful in case the analyzer software does not work properly.



## 4 Import and Export of Data

This section describes how to import and export data from and to the OFDM-VSA software.

The software will process the following types of data files the user may manipulate:

- I/Q data
- Demodulation data
- Limits

### I/Q data

#### Purpose

The OFDM-VSA software is able to process I/Q data from a file rather than from the R&S FSQ instrument hardware. Captured I/Q data can also be stored in various formats for e.g. processing with other external tools or for support purposes.

#### Format

I/Q data can be formatted either in binary form or as ASCII files. The data is linearly scaled using the unit Volt (if a correct display of e.g. Capture Buffer power is required).

- For **binary format**, data is expected as 32-bit floating point data, Little Endian format (also known as LSB Order or Intel format).  
(EXAMPLE: 0x1D86E7BB in hexadecimal notation will be decoded to -7.0655481E-3.)  
The data order can be either IQIQIQ or II..IQQ..Q.
- For **ASCII format**, data is expected as I and Q values in alternating rows, separated by new lines:  
<I value 1>  
<Q value 1>  
<I value 2>  
<Q value 2>  
...

#### Usage – Import

To use externally stored data, switch to the data source file using **[SETUP] <DATA SOURCE FILE>**. Each time you start a new measurement, you will be prompted for the file name.

#### Usage – Export

To export captured I/Q data, select **[FILE] <SAVE IQ DATA>**.

## Demodulation data

### Purpose

The demodulated data at the end of the signal processing chain can be saved for further evaluation in Matlab. The data is stored in a time frequency matrix representing the analyzed OFDM frames.

### Format

The demodulation data is stored in a Matlab \*.mat file. This file contains one matrix named 'mfcRlk'. The matrix size is 'Number of Symbols' X 'FFT Length'.

The following example code shows how to load the demodulation data in Matlab and plot the constellation diagram:

```
% load file
s = load('mydata.mat', '-mat')

% show constellation
plot(real(s.mfcRlk), imag(s.mfcRlk), 'o');
```

### Usage – Export

To export the demodulation data, select **[FILE]** <SAVE DEMOD DATA>.

## Limits

### Purpose

The limit definition is used to specify user-defined limits. Currently, limits are only used in the Result Table ([**MAIN**] <DISPLAY LIST>).

### Format

The limit definition can be provided as XML. An example, including comments on how to use the definition, is shown below:

```
<Limits>
  <EVMA11/><!--Unit: dB-->
  <EVMDATA/><!--Unit: dB-->
  <EVMPilot/><!--Unit: dB-->
  <IQOffset/><!--Unit: dB-->
  <IQGainImbalance/><!--Unit: dB-->
  <IQQuadratureError/><!--Unit: deg-->
  <FrequencyError/><!--Unit: Hz-->
  <SampleClockError/><!--Unit: ppm-->
  <FramePower/><!--Unit: dBm-->
  <CrestFactor/><!--Unit: dB-->
</Limits>

<!--Example
<Limits>
  <EVMA11 Mean="-40" Max="-30"/>
</Limits>
-->
```

Limit definitions which are not required may be skipped by making no entries or by deleting the complete tag.

### Usage – IMPORT

The limit definition file must be placed in the same folder as the OFDM-VSA application binary ("%Program folder%\Rohde-Schwarz\OFDM-VSA" by default). The file name must be limits.xml. The file is read once during the start-up process of the software.

## 5 System Configuration File

This section describes the format and generation of the OFDM system configuration file. The system configuration file contains the complete description of the OFDM system. It is loaded within the system configuration tab of the demodulation setup window.

### Configuration file format

The OFDM configuration is stored in a Matlab \*.mat format which contains the structure 'stOfdmCfg'. The following table lists the elements of the structure and the sub-structures.

**Instead of manual generation of the configuration structure it is recommended to use the additionally provided OFDM system class and its methods!**

Structure: stOfdmCfg			
Parameter	Type	Meaning	Example
sVersion	string	Version identifier of the interface format.	'R&S_OVSA_IFC_V0.1'
sSystem	string	Identifier of the OFDM system.	'Wimax IEEE 802.16-2004'
sDescription	string	Additional information about the OFDM system.	'Uplink with subchannelisation 8, 20 symbols, special 17QAM modulation'
stPreamble	structure	Optional definition of a repetitive preamble symbol for time synchronization.	
iNfft	int32	Number of samples in one FFT block.	256
iNg	int32	Number of samples in the cyclic prefix block.	16
iNoSymbols	int32	Number of symbols described by this system definition. This is also the maximum result range.	100
meStructure	[iNoSymbols X iNfft] matrix of int8	Time-Frequency matrix containing the type of each cell in the OFDM system. 0: Zero 1: Pilot 2: Data 3: Don't Care	[0,0,1,1,1,1,1,1,1,0,0; 0,0,2,2,1,2,2,1,2,2,0,0]
vstDataConst	Array of stConstellation	Array of constellation structures; one constellation structure for each data constellation.	
viDataConstPtr	Vector of uint8	For each 'Data' entry in meStructure this vector contains the number of the constellation used for the data cell. meStructure is evaluated row wise.	[0,0,1,1,2,2]
vfcPilot	Vector of complex float32	For each 'Pilot' entry in meStructure this vector contains the complex pilot value. meStructure is evaluated row wise.	[1+j,-1-j,-1+j,1-j,1+j,-1-j,-1+j,1-j,1+3j,-1-j]

Structure: stPreamble			
Parameter	Type	Meaning	Example
iBlockLength	int32	Length of the repetitive block.	16
iFrameOffset	int32	Offset of the first sample of the preamble symbol to the first sample of the first symbol defined in the structure matrix.	0

Structure: stConstellation			
Parameter	Type	Meaning	Example
sName	string	Constellation name.	'QPSK'
vfcValue	Vector of complex float32	Vector of complex valued constellation points.	[-1-j, -1+j, 1+j, 1-j]

## OFDM System class

The fundamental system description class is a Matlab class which stores the OFDM system parameterization and offers access to the different parameters. The following member functions are provided:

Member Function	Description
c = OfdmSys() c = OfdmSys(iNOFSymbols, iNfft, iNg)	Default Constructor and parameterized constructor
c = Init(c, iNOFSymbols, iNfft, iNg)	Initialize a new system description
c = SetSystem(c, sSystem)	Set the system name
c = SetDescription(c, sDescription)	Set the description of the system
c = SetCell(c, viSymbol, viCarrier, 'Zero') c = SetCell(c, viSymbol, viCarrier, 'Pilot', vfcValue) c = SetCell(c, viSymbol, viCarrier, 'Data', sConstName) c = SetCell(c, viSymbol, viCarrier, 'DontCare')	Define a specific cell of the OFDM system
c = SetConstellation(c, sName) c = SetConstellation(c, sName, vfcValue)	Add a constellation
c = SetPreamble(c, iBlockLength, iFrameOffset)	Define a repetitive preamble symbol
SaveConfigFile(c, sFileName)	Save the system description file
c = LoadConfigFile(c, sFileName)	Load parameters from a system description file

## 6 Measurements in Detail

This section provides a detailed explanation of the measurements provided by the OFDM-VSA and provides help to measure the characteristics of specific types of DUT.

### Signal processing

#### Data capturing

The analyzer software runs on an external PC and operates a signal analyzer by remote control via LAN or GPIB. Several mixer stages convert the RF signal to an intermediate frequency (IF), which is digitized by an A/D converter. The signal processing following the A/D converter is implemented in digital hardware with ASICs and FPGAs. A numerically controlled oscillator shifts the signal from IF to complex baseband, followed by a halfband filter and a fractional resampler. Arbitrary output sample rates can be set by programming the resampler combined with a subsequent decimation filter.

Alternatively to the use of the RF input, analog baseband signals can be digitized directly (R&S FSQ-B71). Additionally, a digital I/Q interface R&S FSQ-B17 is available to analyze digital baseband signals without having to make use of analog components. The block diagrams in Fig. 47 and **Fehler! Verweisquelle konnte nicht gefunden werden.** show the R&S analyzer hardware from the IF section to the processor running the OFDM-VSA downlink measurement application.

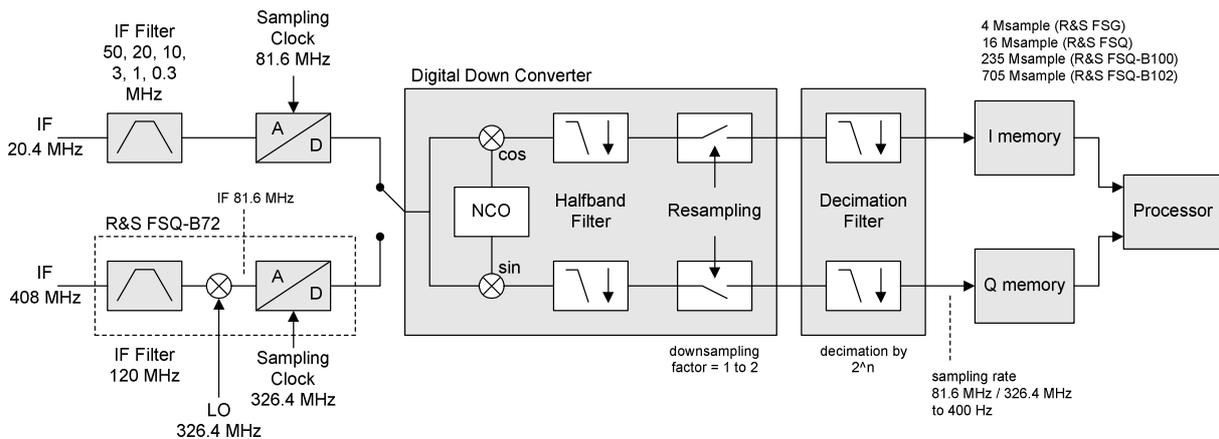


Fig. 47 Data capturing mechanism of the R&S FSQ

## Channel filter

The OFDM-VSA can use the internal channel filter of the instrument or apply an adjustable lowpass filter. Table 1 lists the filter bandwidths of the internal channel filter, which are fully equalized within the digital hardware.

Table 1 Internal analyzer bandwidth depending on the target sampling rate

	sampling rate	bandwidth	max. bandwidth
R&S FSQ	400 Hz to 81.6 MHz	0.8 x sampling rate	28 MHz w/o R&S FSQ B72
	81.6 MHz to 326.4 MHz with R&S FSQ B72	0.68 x sampling rate	120 MHz with R&S FSQ B72

Alternatively to the internal filters, a lowpass filter with adjustable bandwidth and slope characteristics can be applied to the input signal. A window-based finite impulse response filter is designed. The bandwidth is defined as two times the 6 dB cutoff frequency and the filter order determines the slope characteristics. Three predefined filter slopes and a manual input of the filter order are available. Choosing the correct filter order is a trade-off between selectivity and filter impulse response length. A high filter order leads to superior selectivity between adjacent channels. On the other hand, such a filter has a long channel impulse response, which can produce intersymbol interference if used in systems with small guard intervals. Low filter orders require a higher distance between channels and will possibly attenuate the outer carriers of the signal. In contrast, the channel impulse response is short and suited for systems with short guard intervals.

The adjustable lowpass filter performs a decimation by 2 at its output. So the maximum output sample rate, which can be set in the General Settings menu, is reduced by a factor of 2 compared to the internal filter setting.

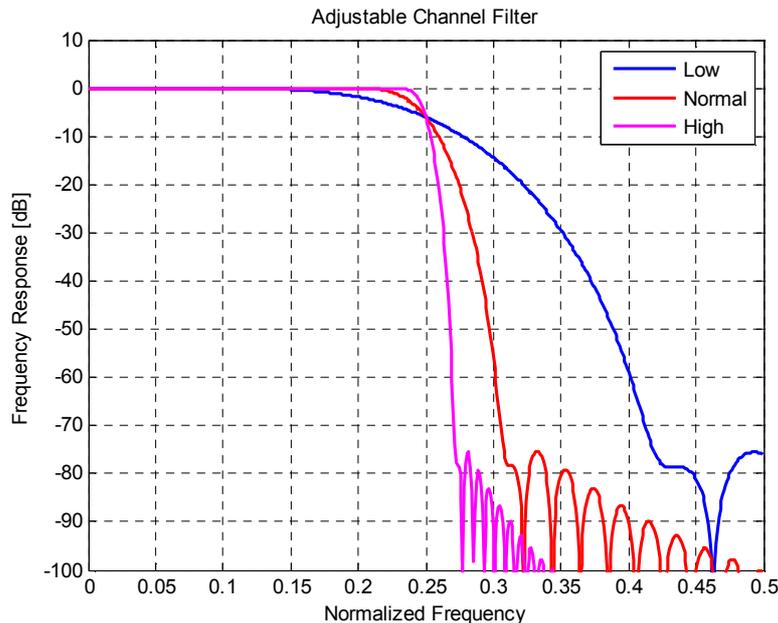


Fig. 48 Channel filter frequency responses depending on the filter order

## OFDM-VSA measurement application

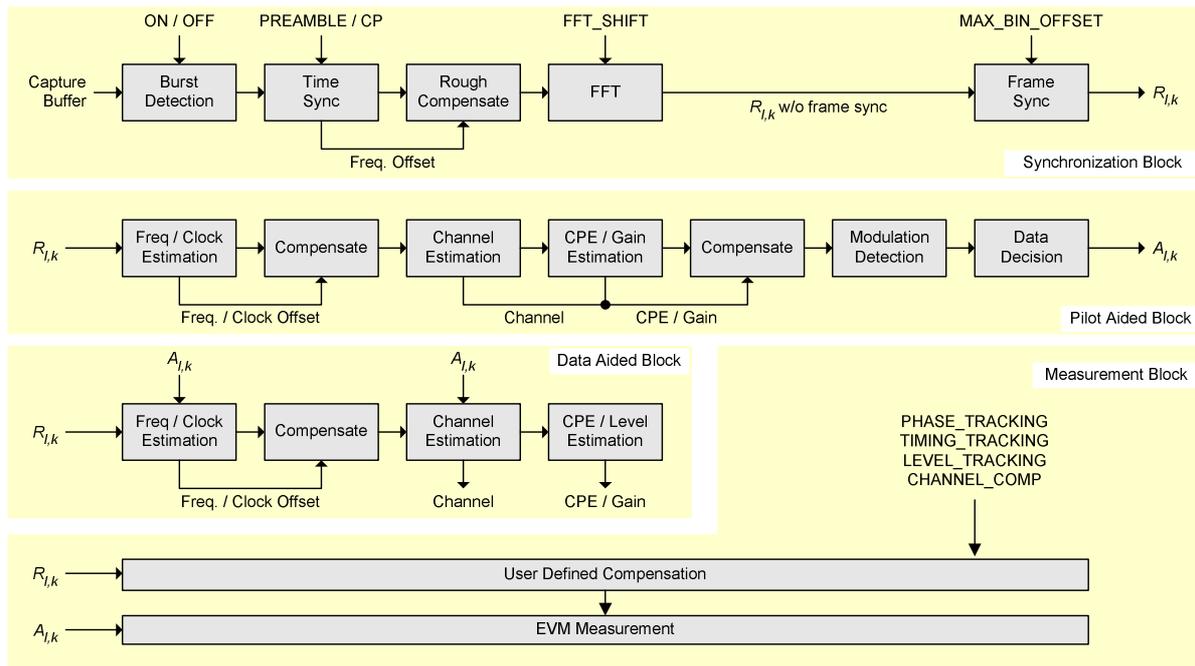


Fig. 49 Block diagram of the OFDM-VSA measurement application

The block diagram in Fig. 49 shows the OFDM-VSA measurement application from the capture buffer containing the I/Q data to the actual analysis block. The signal processing chain can be divided in four major blocks:

- Synchronization Block
- Pilot Aided Block
- Data Aided Block
- Measurement Block

### Synchronization Block

The synchronization starts with a burst detection that extracts transmission areas within a burst signal by a power threshold. For seamless transmission, as is the case in most broadcast systems, it is possible to bypass this block. The following time synchronization uses either the preamble or the cyclic prefix of each OFDM symbol to find the optimum starting point for the FFT by a correlation metric. If preamble synchronization is selected, the correlation is done between successive blocks of a repetitive preamble structure. Alternatively, the cyclic prefix synchronization correlates the guard interval of each symbol with the end of the FFT part. Both methods additionally return an estimation of the fractional frequency offset by evaluating the phase of the correlation maximum. This frequency offset has to be compensated before the FFT to avoid intercarrier interference.

By default, the FFT starting point is put in the center of the guard interval assuming a symmetric impulse response, but it can optionally be shifted within the guard interval. After performing the FFT for each available OFDM symbol, a time-frequency matrix  $R_{l,k}$  with symbol index  $l$  and subcarrier index  $k$  is available.

The following frame synchronization determines the frame start within this matrix and the integer carrier frequency offset. This is done by a two dimensional correlation of  $R_{l,k}$  with the known pilot matrix from

the configuration file. To avoid unnecessary computing time for signals with low frequency offset, the search length in the frequency direction can be limited by a control parameter.

### Pilot Aided Block

The pilot aided block within the signal processing chain uses the predefined pilot cells for parameter estimation and subsequent compensation of the signal impairments. It starts with maximum likelihood estimation of the remaining frequency error and sample clock offset. While a frequency error leads to a phase offset linearly increasing with time, the clock offset introduces an additional phase error linearly increasing with frequency. The estimator determines the most probable parameters that lead to the phase offsets observed on the pilot cells. The resulting offset values are compensated in the frequency domain by re-rotating the phase of the  $R_{l,k}$  matrix. However, for severe clock offsets it can be necessary to resample the received signal in the time domain and repeat the FFT stage.

The subsequent channel estimator determines the channel transfer function at the known pilot positions and uses interpolation to get a complete frequency response vector for all subcarriers. Since the presented measurement system is intended for stationary channels, the interpolation is performed along the frequency direction only. The node values on the frequency axis are determined by averaging all available pilots of each subcarrier over time. Depending on the layout of the pilots on the frequency axis, an interpolation filter bank with optimum Wiener filter coefficients is calculated in advance. The Wiener filter is designed under the assumption that the maximum impulse response length does not exceed the cyclic prefix length.

Although the channel is assumed to be stationary, common phase error and power level variations are estimated symbol by symbol over the complete frame. This takes settling effects of oscillators and power amplifiers into account. All estimated impairments are fully compensated to get an optimum signal for the subsequent modulation-detection and data decision stage.

The modulation-detection block determines the modulation type of the data cells. Either each carrier or each symbol can be assigned to one specific constellation. Alternatively, the modulation information provided in the configuration file is evaluated to extract clusters of data cells with consistent modulation. The estimator uses a maximum likelihood approach, where each cluster of data cells is compared with all possible modulation hypotheses and the most probable constellation for each cluster is used for the subsequent data decision. The data decision block finally outputs a reference signal matrix  $A_{l,k}$  which is an optimum estimate of the actual transmitted OFDM frame.

### Data Aided Block

The data aided block can be activated optionally to refine the parameter estimations with the help of the reference signal. Whereas the previous stages could only include pilot cells for the estimation algorithms, the data aided part can treat data cells as additional pilots. This increases the accuracy of the estimates in good signal to noise environments without data decision errors. However, if the reference signal matrix  $A_{l,k}$  contains falsely decided data cells, the data aided estimation part can corrupt the results and should be omitted.

### Measurement Block

The last part of the signal processing chain comprises the user defined compensation and the measurement of modulation quality. The measurement block takes the received OFDM symbols  $R_{l,k}$  and the previously determined reference OFDM symbols  $A_{l,k}$  to calculate the error vector magnitude (EVM). The received OFDM symbols can optionally be compensated by means of phase, timing and level deviations as well as the channel transfer function.

## Measurement result definitions

### Error vector magnitude (EVM)

The EVM of a cell (symbol number  $l$ , carrier number  $k$ ) is defined as

$$EVM_{l,k} = \sqrt{\frac{|r_{l,k} - a_{l,k}|^2}{\frac{1}{N_{used}} \sum_{l,k} |a_{l,k}|^2}}$$

where

- $r_{l,k}$  is the received symbol point in the complex plane of symbol number  $l$  and carrier number  $k$ .  
The received symbol point is compensated by phase and clock errors as well as channel transfer function according to the user settings.
- $a_{l,k}$  is the ideal symbol point in the complex plane of symbol number  $l$  and carrier number  $k$ .
- $N_{used}$  is the number of used cells, i.e. all cells with  $a_{l,k} \neq 0$ .

### IQ Impairments

The I/Q imbalance can be written as

$$r(t) = G_I \cdot \Re\{s(t)\} + j \cdot G_Q \cdot \Im\{s(t)\}$$

where  $s(t)$  is the transmit signal,  $r(t)$  is the received signal, and  $G_I$  and  $G_Q$  are the weighting factors.

Variable	Meaning	Definition from Transmitter Model
$G_I$	Gain I-branch	1
$G_Q$	Gain Q-branch	$1 + \Delta Q$ (complex)

$$\text{Gain-Imbalance} = 20 \log \left( \frac{|G_Q|}{|G_I|} \right) \text{dB}$$

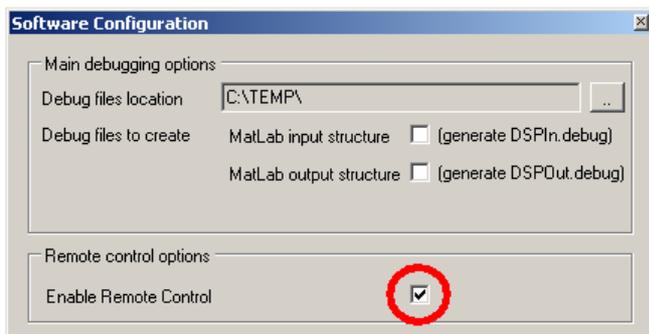
$$\text{Quadrature-Error} = \arctan \left( \frac{\text{Im}\{G_Q\}}{\text{Re}\{G_Q\}} \right) \cdot 180^\circ / \pi$$

## 7 Remote Control

### Enabling Remote Control

The remote control functionality of the OFDM-VSA application is disabled after installing the software. It has to be enabled once by the following sequence:

- Start the OFDM-VSA application and press **[SETUP]**
- Enable the remote control functionality via the *<CONFIGURE SOFTWARE>* softkey.



### Description of commands

This section specifies all the remote control commands specific to the OFDM-VSA option. Only those commands provided for this option are specified. For details of remote control commands provided by the host analyzer please refer to the analyzer user manual.

### Notation

In the following sections, all commands implemented in the software are first listed in tables and then described in detail, arranged according to the command subsystems. The notation is adapted to the SCPI standard. The SCPI conformity information is included in the individual description of the commands.

#### Table of Command

Command:	In the command column, the table provides an overview of the commands and their hierarchical arrangement (see indentations).
Parameter:	The parameter column indicates the requested parameters together with their specified range.
Unit:	The unit column indicates the basic unit of the physical parameters.
Comment:	In the comment column an indication is made on: <ul style="list-style-type: none"> <li>– whether the command does not have a query form,</li> <li>– whether the command has only one query form</li> <li>– whether the command is implemented only with a certain option of the instrument</li> </ul>

#### Indentations

The different levels of the SCPI command hierarchy are represented in the table by means of indentations to the right. The lower the level, the

further the indentation to the right. Please note that the complete notation of the command always includes the higher levels as well.

Example: `SENSe:FREQuency:CENTer` is represented in the table as follows:

<code>SENSe</code>	first level
<code>:FREQuency</code>	second level
<code>:CENTer</code>	third level

**Individual description** The individual description contains the complete notation of the command. An example for each command, the \*RST value and the SCPI information are included as well.

**Upper/lower case notation** Upper/lower case letters are used to mark the long or short form of the key words of a command in the description. The instrument itself does not distinguish between upper and lower case letters.

**Special characters** | A selection of key words with an identical effect exists for several commands. These keywords are indicated in the same line; they are separated by a vertical stroke. Only one of these keywords needs to be included in the header of the command. The effect of the command is independent of which of the keywords is used.

Example: `SENSe:FREQuency:CW|:FIXed`

The two following commands with identical meaning can be created. They set the frequency of the fixed frequency signal to 1kHz:

`SENSe:FREQuency:CW 1E3 = SENSe:FREQuency:FIXed 1E3`

A vertical stroke in parameter indications marks alternative possibilities in the sense of "or". The effect of the command is different, depending on which parameter is used.

Example: Selection of the parameters for the command

`DISPlay:FORMat FULL | SPLit`

If parameter FULL is selected, full screen is displayed, in the case of SPLit, split screen is displayed.

[ ] Key words in square brackets can be omitted when composing the header (cf. Section 3.5.2, Optional Keywords). The full command length must be accepted by the instrument for reasons of compatibility with the SCPI standards. Parameters in square brackets can be incorporated optionally in the command or omitted as well.

{ } Parameters in braces can be incorporated optionally in the command, either not at all, once or several times.

**Description of parameters** Due to the standardisation, the parameter section of SCPI commands consists always of the same syntactical elements. SCPI has therefore specified a series of definitions, which are used in the tables of commands. In the tables, these established definitions are indicated in angled brackets (<...>) and will be briefly explained in the following.

<Boolean> This keyword refers to parameters which can adopt two states, "on" and "off". The "off" state may either be indicated by the keyword OFF or by the numeric value 0, the "on" state is indicated by ON or any numeric value other than zero. Parameter queries are always returned the numeric value 0 or 1.

<numeric value> These keywords mark parameters which may be entered as numeric values

## Common Commands

COMMAND	PARAMETERS	UNIT	COMMENT
*RST *IDN?			

### \*RST

RESET sets the OFDM-VSA software and the connected instrument to a defined default status. The command essentially corresponds to pressing the *PRESET* key. The default setting is indicated in the description of the commands.

**Example:**            "\*RST"   Resets the OFDM-VSA software and the connected instrument.

### \*IDN?

IDENTIFICATION QUERY queries the OFDM-VSA identification.

**Example:**            "\*IDN?"       Returns 'Rohde&Schwarz,K96,000000/000,Version x.x'

## CALCulate Subsystem

COMMAND	PARAMETERS	UNIT	COMMENT
CALCulate<1 2> :FEED	-	-	

### CALCulate<1|2>:FEED

This command can be used to set or get the measurement-data currently displayed on the selected screen A or B.

**Example:** "CALC2:FEED 'POW:CBUF'" Select Capture-Buffer to be displayed on screen B.

#### Parameters:

Parameter-String	Measurement-Data-Type
<i>POW:PVSC</i>	Power versus Symbol X Carrier
<i>POW:PVCA</i>	Power versus Carrier
<i>POW:PVSY</i>	Power versus Symbol
<i>POW:CBUF</i>	Capture Buffer
<i>POW:PSPE</i>	Power Spectrum
<i>EVM:EVSC</i>	EVM versus Symbol X Carrier
<i>EVM:EVCA</i>	EVM versus Carrier
<i>EVM:EVSY</i>	EVM versus Symbol
<i>EVM:FERR</i>	Frequency Error
<i>EVM:PERR</i>	Phase Error
<i>CHAN:FLAT</i>	Channel Flatness
<i>CHAN:GDEL</i>	Group Delay
<i>CHAN:IRES</i>	Channel Impulse Response
<i>CONS:CONS</i>	Constellation Diagram
<i>CONS:CVCA</i>	Constellation versus Carrier
<i>CONS:CVSY</i>	Constellation versus Symbol
<i>STAT:CCDF</i>	CCDF
<i>STAT:SFLO</i>	Signal Flow
<i>STAT:REPT</i>	Report

## CONFigure Subsystem

The CONFigure subsystem contains commands for configuring complex measurement tasks. The CONFigure subsystem is closely linked to the functions of the FETCH subsystem, where the measurement results of the measurements are queried.

COMMAND	PARAMETERS	UNIT	COMMENT
CONFigure :ADDRESS :POWER :AUTO :SWEep :TIME :SYSTEM :MANual [:SYMBOL] :NFFT :NGuard :PREamble :BLENght :FOFFset	<string>  <Boolean>   ONCE  <numeric value>  <numeric value> <numeric value> <numeric value>	   s  Samples Samples  Samples Samples	

### CONFigure:ADDRESS <string>

This remote control command defines the network address of the signal analyzer. The string specifies a VISA resource descriptor.

Interface	Descriptor	Descriptor parameters
GPIB Instrument	GPIB[board]:: primary address [::INSTR]	GPIB board number (optional – typically skipped) Instrument primary GPIB address (0...31)
LAN VXI-11 protocol	TCPIP[board]:: host address [::LAN device name] [::INSTR]	TCP/IP board number (optional – typically skipped) Host address as TCP/IP address or computer name Device name (optional, default: inst0)
LAN RSIB protocol	RSIB:: host address [::INSTR]	RSIB protocol Host address as TCP/IP address or computer name

**Example:** "CONF:ADDR 'TCPIP::192.168.1.1::INSTR'"

**Characteristics:** \*RST value: -

### CONFigure:POWER:AUTO ON | OFF | ONCE

This remote control command is used to switch on or off automatic power level detection. When switched on, power level detection is performed at the start of each measurement sweep. If this command is issued with the ONCE parameter, the auto level routine is immediately performed one time regardless of the current state of this parameter (ON or OFF).

**Example:** "CONF:POW:AUTO 1" Automatic detection of the input power level.

**Characteristics:** \*RST value: ON

**CONFigure:POWer:AUTO:SWEep:TIME** <numeric value>

This remote control command is used to specify the sweep time for the automatic power level detection.

**Example:** "CONF:POW:AUTO:SWE:TIME 200MS" The auto power detect measurement will use a sweep time of 200 ms

**Characteristics:** \*RST value: 100 ms

**CONFigure:SYStem:MANual**

This command switches the OFDM system configuration to manual mode, if a configuration file was previously loaded.

**Example:** "CONF:SYS:MAN "

**Characteristics:** \*RST value: ON

**CONFigure[:SYMBOL]:NFFT** <numeric value>

This command specifies the FFT length of an OFDM symbol.

**Example:** "CONF:SYM:NFFT 1024" Specifies the FFT length to 1024 samples.

**Characteristics:** \*RST value: 64

**CONFigure[:SYMBOL]:NGuard** <numeric value>

This command specifies the guard length of an OFDM symbol. The guard interval contains the cyclic prefix.

**Example:** "CONF:SYM:NG 128" Specifies the guard length to 128 samples.

**Characteristics:** \*RST value: 16

**CONFigure:PREamble:BLENght** <numeric value>

This command specifies the length of one block within a repetitive preamble symbol.

**Example:** "CONF:PRE:BLEN 32" Specifies the block length to 32 samples.

**Characteristics:** \*RST value: 0

**CONFigure:PREamble:FOFFset** <numeric value>

This command defines the distance from the first preamble sample to the first sample of the frame.

**Example:** "CONF:PRE:FOFF 0" The frame starts with the first preamble sample.

**Characteristics:** \*RST value: 0



**DISPlay[:WINDow<1|2>]:TRACe<1...3>:Y[:SCALe]:RLEVel[:RF] <numeric value>**

This remote control command can be used to retrieve or set the current internal instrument reference level for RF input used when performing measurements. The numeric suffix at WINDow<1|2> and TRACe<1 to 3> are irrelevant.

**Example:** "DISP:TRAC:Y:RLEV?" returns the current RF reference level in use

"DISP:TRAC:Y:RLEV -20" sets the instrument reference level to -20 dBm

**Characteristics:** \*RST value: 0 dBm

**DISPlay[:WINDow<1|2>]:TRACe<1...3>:Y[:SCALe]:RLEVel:OFFSet <numeric value>**

This remote control command specifies the external attenuation/gain applied to measurements. The value corresponds to the reference level offset in the spectrum analyzer mode. The numeric suffix at WINDow<1|2> and TRACe<1 to 3> are irrelevant.

**Example:** "DISP:TRAC:Y:RLEV:OFFS 10" External attenuation (level offset) of the analyzer is 10 dB

"DISP:TRAC:Y:RLEV:OFFS -10" External attenuation of the analyzer is -10 dB. i.e. a gain of 10 dB

**Characteristics:** \*RST value: 0 dB

# FETCh Subsystem

COMMAND	PARAMETERS	UNIT	COMMENT
FETCh			
:SUMM			
:EVM			
[:ALL]			
[:AVERAge]		dB, %	
:MAXimum		dB, %	
:MINimum		dB, %	
:DATA			
[:AVERAge]		dB, %	
:MAXimum		dB, %	
:MINimum		dB, %	
:PILot			
[:AVERAge]		dB, %	
:MAXimum		dB, %	
:MINimum		dB, %	
:FERRor			
[:AVERAge]		Hz	
:MAXimum		Hz	
:MINimum		Hz	
:SERRor			
[:AVERAge]		ppm	
:MAXimum		ppm	
:MINimum		ppm	
:IQOFset			
[:AVERAge]		dB	
:MAXimum		dB	
:MINimum		dB	
:GIMBalance			
[:AVERAge]		dB	
:MAXimum		dB	
:MINimum		dB	
:QUADerror			
[:AVERAge]		deg	
:MAXimum		deg	
:MINimum		deg	
:POWer			
[:AVERAge]		dBm	
:MAXimum		dBm	
:MINimum		dBm	
:CRESt			
[:AVERAge]		dB	
:MAXimum		dB	
:MINimum		dB	

**FETCH:SUMMARY:EVM[:ALL][:AVERAGE]?****FETCH:SUMMARY:EVM[:ALL]:MINIMUM?****FETCH:SUMMARY:EVM[:ALL]:MAXIMUM?**

This command returns the “EVM All”-value from the result summary list. Depending on the EVM unit selected in the “General Settings”-Menu the value will be either in dB or in percent.

**Example:**

“FETC : SUMM : EVM : MAX?”	Returns maximum value.
“FETC : SUMM : EVM : MIN?”	Returns minimum value.
“FETC : SUMM : EVM?”	Returns mean value.

**Characteristics:** \*RST value: -

**FETCH:SUMMARY:EVM:DATA[:AVERAGE]?****FETCH:SUMMARY:EVM:DATA:MINIMUM?****FETCH:SUMMARY:EVM:DATA:MAXIMUM?**

This command returns the “DATA EVM”-value from the result summary list. Depending on the EVM unit selected in the “General Settings”-Menu the value will be either in dB or in percent.

**Example:** “FETC : SUMM : EVM : DATA?” Returns mean data EVM value.

**Characteristics:** \*RST value: -

**FETCH:SUMMARY:EVM:PILOT[:AVERAGE]?****FETCH:SUMMARY:EVM:PILOT:MINIMUM?****FETCH:SUMMARY:EVM:PILOT:MAXIMUM?**

This command returns the “PILOT EVM”-value from the result summary list. Depending on the EVM unit selected in the “General Settings”-Menu the value will be either in dB or in percent.

**Example:** “FETC : SUMM : EVM : PIL?” Returns mean pilot EVM value.

**Characteristics:** \*RST value: -

**FETCH:SUMMARY:FERROR[:AVERAGE]?****FETCH:SUMMARY:FERROR:MINIMUM?****FETCH:SUMMARY:FERROR:MAXIMUM?**

This command returns the “Center Frequency Error”-value from the result summary list in Hz.

**Example:** “FETC : SUMM : FERR?” Returns average frequency error in Hz.

**Characteristics:** \*RST value: -

**FETCH:SUMMARY:SERROR[:AVERAGE]?****FETCH:SUMMARY:SERROR:MINIMUM?****FETCH:SUMMARY:SERROR:MAXIMUM?**

This command returns the “Sample Clock Error”-value from the result summary list in parts per million (ppm).

**Example:** “FETC : SUMM : SERR?” Returns average sample clock error in ppm.

**Characteristics:** \*RST value: -

**FETCh:SUMMary:IQOFfset[:AVERAge]?**  
**FETCh:SUMMary:IQOFfset:MINimum?**  
**FETCh:SUMMary:IQOFfset:MAXimum?**

This command returns the “IQ-Offset”-value from the result summary list in dB.

**Example:**           “FETC : SUMM : IQOF ? “           Returns average IQ Offset in dB.

**Characteristics:** \*RST value: -

**FETCh:SUMMary:GIMBalance[:AVERAge]?**  
**FETCh:SUMMary:GIMBalance:MINimum?**  
**FETCh:SUMMary:GIMBalance:MAXimum?**

This command returns the “IQ-Gain-Imbalance”-value from the result summary list in dB.

**Example:**           “FETC : SUMM : GIMB ? “           Returns average Gain Imbalance in dB.

**Characteristics:** \*RST value: -

**FETCh:SUMMary:QUADerror[:AVERAge]?**  
**FETCh:SUMMary:QUADerror:MINimum?**  
**FETCh:SUMMary:QUADerror:MAXimum?**

This command returns the “Quadrature Error”-value from the result summary list in degree.

**Example:**           “FETC : SUMM : QUAD ? “           Returns average Quadrature Error in degree.

**Characteristics:** \*RST value: -

**FETCh:SUMMary:POWer[:AVERAge]?**  
**FETCh:SUMMary:POWer:MINimum?**  
**FETCh:SUMMary:POWer:MAXimum?**

This command returns the “Frame Power”-value from the result summary list in dBm.

**Example:**           “FETC : SUMM : POW ? “           Returns average Frame Power in dBm.

**Characteristics:** \*RST value: -

**FETCh:SUMMary:CRESt[:AVERAge]?**  
**FETCh:SUMMary:CRESt:MINimum?**  
**FETCh:SUMMary:CRESt:MAXimum?**

This command returns the “Crest Factor”-value from the result summary list in dBm.

**Example:**           “FETC : SUMM : CRES ? “           Returns Crest Factor in dB.

**Characteristics:** \*RST value: -

## FORMat Subsystem

COMMAND	PARAMETERS	UNIT	COMMENT
FORMat [:DATA]	ASCii PACKED REAL	-	

### FORMat[:DATA]

This command specifies the data format for the data transmitted from the OFDM-VSA-Software to the control PC.

**Example:**           "FORM REAL"           The OFDM-VSA software will send binary data in Real32 data format.

**Parameters:**     ASCii | PACKED | REAL

**Characteristics:** \*RST value: ASCii

## HCOPY Subsystem

COMMAND	PARAMETERS	UNIT	COMMENT
HCOPY [:IMMEDIATE]			

### HCOPY[:IMMEDIATE]

This command starts a hardcopy output to the file specified by MMEMory:NAME. The graphic file format is determined by the file extension (\*.bmp, \*.gif, \*.jpg, \*.png or \*.tif).

**Example:**            "MMEM:NAME 'C:\TEMP\Screenshot.bmp' "  
                       "HCOPY"                A screenshot of the OFDM-VSA software is stored in the file  
   C:\TEMP\Screenshot.bmp.

**Characteristics:** -

## INITiate Subsystem

COMMAND	PARAMETERS	UNIT	COMMENT
INITiate [:IMMEDIATE]	<Boolean>		

### INITiate[:IMMEDIATE]

This remote control command requests the OFDM-VSA software to start a new measurement sequence. If a measurement sequence is already in progress, then the command will be ignored.

**Example:**           “INIT”                   The OFDM-VSA software will start a new measurement.

**Characteristics:** \*RST value: -

# INPut Subsystem

COMMAND	PARAMETERS	UNIT	COMMENT
INPut			
:ATTenuation	<numeric value>	dB	
:DIQ			
:RANGe			
[:UPPer]	<numeric value>	V	FSQ-B17 Option only
:SRATe	<numeric value>	Hz	FSQ-B17 Option only
:EATT	<numeric value>	dB	FSU-B25 Option only
:STATe	<Boolean>		FSU-B25 Option only
:FILTer			
:CHANnel			
:STATe]	<Boolean>		
:BANDwidth	<numeric value>	Hz	
:ORDer	<numeric value>		
:YIG			
[:STATe]	<Boolean>		
:SElect	RF   AIQ   DIQ   FILE		
:IQ			
:BALanced			FSQ-B71 Option only
[:STATe]	<Boolean>		FSQ-B71 Option only
:IMPedance	LOW   HIGH		FSQ-B71 Option only

## INPut:ATTenuation <numeric value>

This command specifies the current input mechanical attenuator. The step width is 10 dB without the electronic attenuator option, and the range is 0 dB to 70 dB.

The input attenuation can be set in 5 dB steps between 0 dB and 75 dB with the electronic attenuator option.

**Example:** "INP:ATT?" Returns the current mechanical attenuator setting in use

Characteristics: \*RST value: 10 dB

## INPut:DIQ:RANGe[:UPPer] <numeric value>

This remote control command specifies the full scale level of the digital base band input. Note that this command requires option FSQ-B17.

**Example:** "INP:DIQ:RANG?" Returns the full scale level of the digital baseband input

Characteristics: \*RST value: 1 V

## INPut:DIQ:SRATe <numeric value>

This remote control command specifies the sampling rate for the digital base band input. Note that this command requires option FSQ-B17.

**Example:** "INP:DIQ:SRAT"

**Characteristics:** \*RST value: 81.6 MHz

**INPut:EATT** <numeric value>

This command specifies the attenuation of the current input electronic input attenuator. The attenuation setting can only be varied in 5 dB steps from 0 to 30 dB. Other entries are rounded to the next lower integer value. The electronic attenuator is switched off in the default state.

**Example:** "INP:EATT?" Returns the current electronic attenuator setting in use.

**Characteristics:** \*RST value: 0 dB

The command is only available with the electronic attenuator option (FSU-B25).

**INPut:EATT:STATe** <Boolean>

This command switches the electronic input attenuation into the signal path (state ON) or removes it from the signal path (state OFF).

**Example:** "INP:EATT:STAT ON" Switches the electronic attenuator into the signal path.

**Characteristics:** \*RST value: OFF

The command is only available with the electronic attenuator option (FSU-B25).

**INPut:FILTer:CHANnel[:STATe]** <Boolean>

This command switches an adjustable channel filter into the signal path (condition ON) or removes it from the signal path (condition OFF).

**Example:** "INP:FILT:CHAN ON" Selects the adjustable channel filter.

**Characteristics:** \*RST value: OFF

**INPut:FILTer:CHANnel:BANDwidth** <numeric value>

The 6 dB bandwidth of the channel filter is specified by this command.

**Example:** "INP:FILT:CHAN:BAND 14MHZ" Sets the filter bandwidth to 14 MHz.

**Characteristics:** \*RST value: 20 MHz

**INPut:FILTer:CHANnel:ORDer** <numeric value>

This command sets the filter order of the lowpass channel filter. Odd orders are rounded to the next higher even number. The number of filter taps is the filter order plus 1.

**Example:** "INP:FILT:CHAN:ORD 256" Selects a filter order of 256.

**Characteristics:** \*RST value: 96

**INPut:FILTer:YIG[:STATe]** <Boolean>

This command switches the YIG filter for image frequency suppression into the signal path (condition ON) or removes it from the signal path (condition OFF).

**Example:** "INP:FILT:YIG OFF" Switches the YIG filter off.

**Characteristics:** \*RST value: OFF

**INPut:SELEct** AIQ | RF | DIQ | FILE

This remote control command specifies whether the Analog baseband Inputs, Digital Baseband input, RF input or File input is the currently selected signal input. Note that Analog baseband input requires option B71. Digital Baseband Input requires option B17.

**Example:** "INP:SEL AIQ" Select analog baseband input.

**Characteristics:** \*RST value: FILE

**INPut:IQ:BALanced[:STATE]** <Boolean>

This remote control command specifies whether the IQ inputs are symmetrical (balanced) or asymmetrical (unbalanced). Note that this command requires option FSQ-B71.

**Example:** "INP:IQ:BAL ON" Specifies symmetrical (balanced) IQ inputs.

**Characteristics:** \*RST value: OFF

**INPut:IQ:IMPedance** LOW | HIGH

This remote control command specifies the input impedance for the IQ inputs. Note that this command requires option FSQ-B71.

**Example:** "INP:IQ:IMP LOW" Specifies low input impedance for IQ inputs.

**Characteristics:** \*RST value: LOW

## MMEMemory Subsystem

COMMAND	PARAMETERS	UNIT	COMMENT
MMEMemory :LOAD :STATe :CFGFile :STORE :STATe :IQ :STATe :NAME	  <file_name> <file_name>  <file_name>  <file_name> <file_name>		

### MMEMemory:LOAD:STATe <file\_name>

This command restores previously saved settings. The file must be of type "\*.ovsa".

**Example:** "MMEM:LOAD:STAT 'C:\TEMP\K96Test.ovsa'"

**Characteristics:** \*RST value: –

### MMEMemory:LOAD:CFGFile <file\_name>

This command loads a configuration file which describes the OFDM system. The file must be of type "\*.mat".

**Example:** "MMEM:LOAD:CFGF 'C:\TEMP\K96Test.mat'"

**Characteristics:** \*RST value: –

### MMEMemory:STORE:STATe <file\_name>

This command stores the current settings to a file. The resulting filetype is "\*.ovsa". Existing files will be overwritten.

**Example:** "MMEM:STOR:STAT 'C:\TEMP\K96Test.ovsa'"

**Characteristics:** \*RST value: –

### MMEMemory:STORE:IQ:STATe <file\_name>

This command stores the current IQ data to a file with the extension ".iqw". The data format is 32 bit floating point and the data order is II..IQQ..Q. Existing files will be overwritten.

**Example:** "MMEM:STOR:IQ:STAT 'C:\TEMP\MyCapture.iqw'"

**Characteristics:** \*RST value: –

### MMEMemory:NAME <file\_name>

This command defines a destination file for the printout started with the command HCOPY:IMMEDIATE. The graphic file format is determined by the file extension (\*.bmp, \*.gif, \*.jpg, \*.png or \*.tif).

**Example:** "MMEM:NAME 'C:\TEMP\Screenshot.bmp'"

**Characteristics:** \*RST value: –



**[SENSe:]IQ:LPASs[:STATe]** <Boolean>

This instruction switches a 36 MHz filter into the I and Q branch of the baseband inputs. Note that this command requires option FSQ-B71.

**Example:** "SENS:IQ:LPAS 1" Switches on the lowpass filter for the IQ inputs.

**Characteristics:** \*RST value: ON

**[SENSe:]VOLTage:IQ:RANGe** <numeric value>

This command defines the measurement range of the analog baseband input. The value range depends on the input impedance. The measurement range defines the measurable peak voltage (positive and negative). Note that this command requires option FSQ-B71.

Input Impedance	Range of values / Volt (5 dB steps)
Low (50 $\Omega$ )	0.0316; 0.0562; 0.1; 0.178 ; 0.316; 0.562; 1; 1.78; 3.16; 5.62
High (1 k $\Omega$ )	0.0316; 0.0562; 0.1; 0.178 ; 0.316; 0.562; 1; 1.78

**Example:** "SENS:VOLT:IQ:RANGE 0.1" Sets the IQ input range to 0.1 V.

**Characteristics:** \*RST value: 1 V

**[SENSe:]SWEep:TIME** <numeric value>

The remote control command is used to specify the sweep acquisition period (capture time) for which the input signal is to be measured.

**Example:** "SENS:SWEep:TIME 20ms" A capture time of 20 ms is specified.

**Characteristics:** \*RST value: 20 ms

**[SENSe:]DEMod:FORMat:BURSt** <Boolean>

The burst search is controlled by this command. It should be switched on for bursted OFDM signals.

**Example:** "SENS:DEMod:FORM:BURS ON" Switches on burst search.

**Characteristics:** \*RST value: ON

**[SENSe:]DEMod:FORMat:MAXFrames** <numeric value>

This command sets the maximum number of frames to be demodulated.

**Example:** "SENS:DEMod:FORM:MAXF 10" At most 10 frames are analyzed.

**Characteristics:** \*RST value: 1

**[SENSe:]DEMod:FORMat:NOFSymbols** <numeric value>

This command sets the number of symbols per frame to be analyzed. Frames with less symbols are discarded.

**Example:** "SENS:DEM:FORM:NOFS 44" 44 symbols per frame are analyzed.

**Characteristics:** \*RST value: 10

**[SENSe:]DEMod:TSYNc** PREAM | CP

The time synchronization can be performed by correlating the repetitive preamble structure or the cyclic prefix.

**Example:** "SENS:DEM:TSYN CP" Cyclic prefix time synchronization is selected

**Characteristics:** \*RST value: CP

**[SENSe:]DEMod:FSYNc** NONE | PIL | DAT

This command selects the frequency synchronization and parameter estimation mode of the OFDM demodulator. The synchronization either uses pilot cells only (PIL) or includes a second stage, where also the decided data cells are accounted for (DAT). If 'NONE' is selected, the demodulator stops after the rough time synchronization.

**Example:** "SENS:DEM:FSYN PIL" The frequency sync. is done on pilots

**Characteristics:** \*RST value: PIL

**[SENSe:]DEMod:MDETect** CFG | SYM | CARR

This command configures the auto demodulation functionality. If 'CFG' is selected, the modulation matrix within the configuration file is evaluated. 'SYM' assigns the data cells of each symbol to one constellation, 'CARR' assumes one constellation for all data cells in each carrier.

**Example:** "SENS:DEM:MDET SYM" The modulation type is detected symbolwise

**Characteristics:** \*RST value: CFG

**[SENSe:]DEMod:FFTShift** <numeric value>

This command shifts the FFT start sample within the guard interval. The value is normalized to the guard interval length.

**Example:** "SENS:DEM:FFTS 0.6"

**Characteristics:** \*RST value: 0.5

**[SENSe:]DEMod:COFFset** <numeric value>

This command defines the maximum carrier offset allowed for frame synchronization.

**Example:** "SENS:DEM:COFF 2" Freq. Offset of max. two subcarriers is allowed

**Characteristics:** \*RST value: 0

**[SENSe:]TRACking:PHASe** <Boolean>

This command activates or deactivates the phase tracking within the demodulator.

**Note:** [SENSe] is not optional for this command when using the short form "TRAC" as it conflicts with the "TRACe" command.

**Example:** "SENS:TRAC:PHASe ON"      Activate phase tracking

**Characteristics:** \*RST value: ON

**[SENSe:]TRACking:TIME** <Boolean>

This command activates or deactivates the sample clock deviation tracking within the demodulator.

**Note:** [SENSe] is not optional for this command when using the short form "TRAC" as it conflicts with the "TRACe" command.

**Example:** "SENS:TRAC:TIME ON"      Activate tracking of sample clock deviations

**Characteristics:** \*RST value: OFF

**[SENSe:]TRACking:LEVeL** <Boolean>

This command activates or deactivates the power level tracking within the demodulator.

**Note:** [SENSe] is not optional for this command when using the short form "TRAC" as it conflicts with the "TRACe" command.

**Example:** "SENS:TRAC:LEV ON"      Activate power level tracking

**Characteristics:** \*RST value: OFF

**[SENSe:]COMPensate:CHANnel** <Boolean>

This command defines whether the estimated channel transfer function shall be compensated before EVM measurements.

**Example:** "SENS:COMP:CHAN ON"      Activate channel compensation

**Characteristics:** \*RST value: ON

**[SENSe:]SWAPiq** <Boolean>

This remote control command can be used to specify if the IQ data shall be swapped.

**Example:** "SENS:SWAP ON"      SWAP IQ data

**Characteristics:** \*RST value: OFF

## TRACe Subsystem

The TRACe subsystem controls access to the software's internal trace memory.

COMMAND	PARAMETERS	UNIT	COMMENT
TRACe [:DATA] :IQ :SRATe	TRACE1   TRACE2   TRACE3  <numeric value>	   Hz	

### TRACe[:DATA] TRACE1 | TRACE2 | TRACE3

This command returns all the measured data that relates to the currently selected measurement type. The data format returned is particular to the currently selected measurement type and is specified below.

#### Return values:

The returned values are scaled in the current measurement unit. For some measurements the unit may change depending on the unit-settings specified in the General Setup menu (or set by the UNIT:EVM-command).

#### ASCII format (FORMat ASCII):

In ASCII format, a list of values separated by commas is returned (Comma Separated Values = CSV). Empty fields will return *NaN*.

#### Binary format (FORMat REAL,32):

If the transmission takes place using the binary format (REAL,32), the data are transferred in block format (Definite Length Block Data according to IEEE 488.2). They are arranged in lists of 32 Bit IEEE 754 floating point numbers.

#### Power vs Symbol X Carrier

Returns the power values of all evaluated OFDM cells. The result matrix is written symbol-wise, i.e. all subcarriers of one symbol are written before the next symbol begins. All detected frames are transferred.

*Trace1:* Power values [dBm/Carrier]

#### Power vs Carrier

Returns the power values as list over all carriers. The statistic is performed in symbol direction.

*Trace1:* Mean values (averaged over all symbols) [dBm/Carrier]

*Trace2:* Minimum values [dBm/Carrier]

*Trace3:* Maximum values [dBm/Carrier]

#### Power vs Symbol

Returns the power values as list over all symbols. The statistic is performed in carrier direction.

*Trace1:* Mean values (averaged over all carriers) [dBm/Carrier]

*Trace2:* Minimum values[dBm/Carrier]  
*Trace3:* Maximum values [dBm/Carrier]

### **Capture Buffer**

Returns the power values of all IQ samples within the capture buffer.

*Trace1:* Power values [dBm]

### **Power Spectrum**

Returns the power density spectrum of the capture buffer. The result values span the frequency range of  $-\text{SampleRate} / 2$  to  $+\text{SampleRate} / 2 - \text{SampleRate}/\text{NOfResultValues}$ .

*Trace1:* Power density values [dBm/Hz]

### **EVM vs Symbol X Carrier**

Returns the EVM values of all evaluated OFDM cells. The result matrix is written symbol-wise, i.e. all subcarriers of one symbol are written before the next symbol begins. All detected frames are transferred.

*Trace1:* Power values [dB | Percent]

### **EVM vs Carrier**

Returns the EVM values as list over all carriers. The statistic is performed in symbol direction.

*Trace1:* Mean values (averaged over all symbols) [dB | Percent]

*Trace2:* Minimum values[dB | Percent]

*Trace3:* Maximum values [dB | Percent]

### **EVM vs Symbol**

Returns the EVM values as list over all symbols. The statistic is performed in carrier direction.

*Trace1:* Mean values (averaged over all carriers) [dB | Percent]

*Trace2:* Minimum values[dB | Percent]

*Trace3:* Maximum values [dB | Percent]

### **Frequency Error**

Returns the frequency error versus time. The length of the time axis is specified as number of settling symbols in the EVM measurement setup menu.

*Trace1:* Frequency error vs time [Hz]

### **Phase Error**

Returns the phase error versus time. The length of the time axis is specified as number of settling symbols in the EVM measurement setup menu.

*Trace1:* Phase error vs time [deg]

### **Channel Flatness**

Returns the spectrum flatness in dB as list over all subcarriers.

*Trace1:* Mean values (averaged over all frames) [dB]  
*Trace2:* Minimum values [dB]  
*Trace3:* Maximum values [dB]

### Channel Group Delay

Returns the channel group delay in ns as list over all subcarriers.

*Trace1:* Mean values (averaged over all frames) [ns]  
*Trace2:* Minimum values [ns]  
*Trace3:* Maximum values [ns]

### Channel Impulse Response

Returns the channel impulse response versus time. This is the inverse FFT of the estimated channel transfer function. The time axis spans one FFT interval.

*Trace1:* Normalized channel impulse response (averaged over all frames)  
*Trace2:* Minimum values  
*Trace3:* Maximum values

### Constellation

Returns the constellation points of all evaluated OFDM cells. The result matrix is written symbol-wise, i.e. all subcarriers of one symbol are written before the next symbol begins. All detected frames are transferred. The IQ data is interleaved, i.e. each constellation point comprises of an I value followed immediately by the associated Q value.

*Trace1:* Received Constellation points  
*Trace2:* Ideal Constellation points

### CCDF

Returns the complementary cumulative distribution function of the analyzed frames. The power values are normalized to the mean power.

*Trace1:* Normalized power values [dB]  
*Trace2:* Probability values associated with the power values of trace 1

### TRACe:IQ:SRATe <numeric value>

This command sets the sample rate for IQ measurements.

**Example:** "TRAC:IQ:SRAT 16MHz" Specifies a sample rate of 16 MHz.

**Characteristics:** \*RST value: -

## TRIGger Subsystem

The trigger subsystem is used to synchronize device action(s) with events.

COMMAND	PARAMETERS	UNIT	COMMENT
TRIGger [:SEquence] :MODE :LEVel [:EXTernal] :POWer :AUTO :HOLDoff	IMMediate   EXTernal   POWer  <numeric_value> <numeric_value> <Boolean> <numeric_value>	  V DBM   V  S	

### TRIGger[:SEquence]:MODE IMMEDIATE | EXTERNAL | POWER

This command configures how triggering is to be performed.

**Parameter:**

- IMMediate Automatically triggers the next measurement at the end of the previous measurement. This corresponds to the FREE RUN setting.
- EXTernal The next measurement is triggered by the signal at the external trigger input, e.g. a gated trigger
- POWer The next measurement is triggered by the detection of a signal with sufficient power.

**Example:** "TRIG:MODE IMM" The measurement will be done in free run mode

**Characteristics:** \*RST value: IMMEDIATE

### TRIGger[:SEquence]:LEVel[:EXTernal] <numeric value>

This command accepts the level of the external trigger input for which triggering will occur.

**Example:** "TRIG:LEV 1 V" Sets the external trigger level to 1 V.

**Characteristics:** \*RST value: 1.4 V

### TRIGger[:SEquence]:LEVel:POWer <numeric value>

This command accepts the level of the input signal for which triggering will occur. The value is specified in dBm for RF input and V for baseband inputs.

**Example:** "TRIG:LEV:POW 10" Set to 10 dBm for RF measurement.  
"TRIG:LEV:POW 1" Set to 1 V for baseband measurement.

**Characteristics:** \*RST value: 0 dBm

### TRIGger[:SEquence]:LEVel:POWer:AUTO <Boolean>

This command specifies whether or not an automatic power trigger level calculation is performed before each main measurement. The setting of this command is ignored if the setting for TRIGger[:SEquence]:MODE is not POWER.

**Example:** "TRIG:LEV:POW:AUTO 1" Specifies that an automatic power trigger level calculation should be performed before the start of each main measurement.

**Characteristics:** \*RST value: OFF

**TRIGger[:SEQuence]:HOLDoff** <numeric value>

This command defines the length of the trigger delay. A negative delay time (pretrigger) can be set.

**Example:**           "TRIG:HOLD 500us"           A trigger offset of 500  $\mu$ s is set.

**Characteristics:** \*RST value:   0  $\mu$ s

## UNIT Subsystem

The unit subsystem specifies the units for specific result types.

COMMAND	PARAMETERS	UNIT	COMMENT
UNIT :EVM :SAXes :CAXes :TAXes :FAXes	DB   PCT SYM   S CARR   HZ S   SAM   SYM HZ   SRAT   CSP		

### UNIT:EVM DB | PCT

This command specifies the units for EVM results.

**Parameter:** DB EVM results returned in dB  
PCT EVM results returned in %

**Example:** "UNIT:EVM PCT" EVM results to be returned in %.

**Characteristics:** \*RST value: dB

### UNIT:SAXes SYM | S

This command specifies the units for symbol axes, e.g. EVM vs symbol.

**Parameter:** SYM Symbol numbers  
S Seconds

**Example:** "UNIT:SAX SYM" Symbol numbers as axis unit.

**Characteristics:** \*RST value: SYM

### UNIT:CAXes CARR | HZ

This command specifies the units for carrier axes, e.g. EVM vs. carrier.

**Parameter:** CARR Subcarrier numbers  
HZ Hertz

**Example:** "UNIT:CAX CARR" Subcarrier numbers as axis unit.

**Characteristics:** \*RST value: CARR

### UNIT:TAXes S | SAM | SYM

This command specifies the units for time axes, e.g. channel impulse response.

**Parameter:** S Seconds  
SAM Sample numbers  
SYM Symbol numbers

**Example:** "UNIT:TAX S" Seconds as axis unit.

**Characteristics:** \*RST value: s

**UNIT:FAXes** HZ | SRAT | CSP

This command specifies the units for frequency axes, e.g. power spectrum.

**Parameter:**       HZ       Seconds  
                  SRAT     Sample rate  
                  CSP     Subcarrier spacing

**Example:**         "UNIT:FAX HZ"         Hertz as axis unit.

**Characteristics:** \*RST value: Hz

## Softkeys with assignment of IEC/IEEE bus commands

### Hardkey MAIN

SETTINGS
GENER MEAS

#### **Primary**

```
[SENSe]:FREQuency:CENTer
TRACe:IQ:SRATe
[SENSe]:SWEep:TIME

DISPlay:TRACe:Y:RLEVel:RF
SENSe:VOLTAge:IQ:RANGe
CONFIgure:POWer:AUTO
DISPlay:TRACe:Y:RLEVel:OFFSet

TRIGger[:SEQuence]:MODE
TRIGger[:SEQuence]:HOLDoff
TRIGger[:SEQuence]:LEVel:POWer
TRIGger[:SEQuence]:LEVel:POWer:AUTO

INPut:SElect
INPut:FILTer:CHANnel:STATe
INPut:FILTer:CHANnel:BANDwidth
INPut:FILTer:CHANnel:ORDER
```

#### **Advanced**

```
INPut:IQ:IMPedance
INPut:IQ:BALanced[:STATe]
[SENSe]:IQ:LPASs[:STATe]
[SENSe]:IQ:DITHer[:STATe]

INPut:DIQ:SRATe
INPut:DIQ:RANGe[:UPPer]

CONFIgure:POWer:AUTO:SWEep:TIME
INPut:ATTenuation
INPut:EATT
INPut:EATT:AUTO
INPut:EATT:STATe
INPut:FILTer:YIG[:STATe]
```

SETTINGS
GENER MEAS

#### **Units**

```
UNIT:EVM
UNIT:SAXes
UNIT:CAXes
UNIT:TAXes
UNIT:FAXes
```

#### **EVM**

DEMOD  
SETTINGS

**System Config**

CONFigure:SYStem:MANual  
MMEMory:LOAD:CFGFile  
CONFigure:SYStem[:SYMBOL]:NFFT  
CONFigure:SYStem[:SYMBOL]:NGuard  
CONFigure:SYStem:PREamble:BLENght  
CONFigure:SYStem:PREamble:FOFFset

**Demod Control**

[SENSe]:DEMod:FORMat:BURSt  
[SENSe]:DEMod:FORMat:MAXFrames  
[SENSe]:DEMod:FORMat:NOFSymbols  
  
[SENSe]:DEMod:TSYnc  
[SENSe]:DEMod:FSYnc  
[SENSe]:DEMod:MDETect  
  
[SENSe]:TRACking:PHASE  
[SENSe]:TRACking:TIME  
[SENSe]:TRACking:LEVel  
[SENSe]:COMPeNsate:CHANnel  
  
[SENSe]:DEMod:FFTShift  
[SENSe]:DEMod:COFFset  
[SENSe]:SWAPiq

DISPLAY  
GRAPH LIST

DISP:TABLE

POWER

CALCulate<1|2>:FEED `POW:PVSC`  
CALCulate<1|2>:FEED `POW:PVCA`  
CALCulate<1|2>:FEED `POW:PVSy`  
CALCulate<1|2>:FEED `POW:CBuf`  
CALCulate<1|2>:FEED `POW:PSPE`

EVM

CALCulate<1|2>:FEED `EVM:EVSC`  
CALCulate<1|2>:FEED `EVM:EVCA`  
CALCulate<1|2>:FEED `EVM:EVSY`  
CALCulate<1|2>:FEED `EVM:FERR`  
CALCulate<1|2>:FEED `EVM:PERR`

CHANNEL

CALCulate<1|2>:FEED `CHAN:FLAT`  
CALCulate<1|2>:FEED `CHAN:GDEL`  
CALCulate<1|2>:FEED `CHAN:IRES`

CONSTELL

CALCulate<1|2>:FEED `CONS:CONS`  
CALCulate<1|2>:FEED `CONS:CVCA`  
CALCulate<1|2>:FEED `CONS:CVSY`

MISC /  
STATISTIC

CALCulate<1|2>:FEED `STAT:CCDF`  
CALCulate<1|2>:FEED `STAT:SFLO`  
CALCulate<1|2>:FEED `STAT:REPT`

**Hardkey SETUP**

CONFIGURE  
ANALYZER  
CONNECTION

CONF:ADDR

**Hardkey FILE**

SAVE

MMEMory:STORe:STATe

RECALL

MMEMoRY:LOAD:STATe

SAVE  
IQ DATA

MMEMoRY:STORe:IQ:STATe

## Hardkey DISPLAY

SINGLE  
SCREEN

DISPlay:FORMat SING

SPLIT  
SCREEN

DISPlay:FORMat SPL

HARDCOPY

MMEM:NAME  
HCOP

## Hardkey PRESET

\*RST

## 8 Glossary

<b>Application path</b>	The path where the setup software installed the R&S FSQ-K96 OFDM-VSA analysis software (“%Program folder%\Rohde-Schwarz\OFDM-VSA” by default)
<b>Cell</b>	Basic unit of an OFDM time frequency matrix. A cell is identified by a symbol number and a subcarrier number.
<b>Cyclic Prefix</b>	Guard interval at the begin of the OFDM symbol to prevent intersymbol interference. It contains a copy of the OFDM symbol's end.
<b>FFT</b>	Fast Fourier Transform
<b>OFDM</b>	Orthogonal Frequency Division Multiplexing
<b>Subcarrier</b>	Basic unit in frequency domain. Each subcarrier can be modulated independently.
<b>Symbol</b>	Block in time domain consisting of the cyclic prefix and FFT interval
<b>Frame</b>	Total area of a time frequency matrix which is evaluated by the OFDMA analysis software
<b>System root</b>	The path where Microsoft Windows is installed; by default, this is C:\WINNT

## 9 Troubleshooting

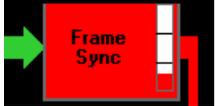
This section shows the most common problems that occur when using the OFDM-VSA analysis software.

### General errors

Error	Remedy
The software does not start up – only an error message occurs.	The graphical display component may not be installed correctly. Check if the file cwui.ocx is present in the System Root folder. If yes, re-register the component by opening a command prompt in the System Root folder and typing in "regsvr32 cwui.ocx".
The software shows the start-up screen but crashes during that state.	Delete the folder "OFDM_VSA_mcr" from the Application Path and re-start the software.
When trying to run a measurement with the analyzer, the error message "Instrument not found @ ..." occurs.	The software cannot connect to the measurement instrument. Check the connection setup ([ <b>SETUP</b> ] <CONFIGURE ANALYZER CONNECTION>). Make sure the instrument is connected to the specified bus and has the stated address assigned. If you are using a firewall, make sure that the firewall does not block the connection to the instrument.
When trying to run a measurement with the analyzer, the error message "Auto level FAILED: NO SIGNAL" occurs.	The measured signal level during the auto-level process is too low. Increase the signal level at the analyzer input.

## Using the signal flow diagram

The signal flow diagram can be a powerful tool to find and remedy demodulation problems. The following table lists some hints how to interpret failures at the different blocks.

Block	Hints
 <p>The diagram shows a red rectangular block labeled 'Burst Detection'. A green arrow points into the block from the left, and a red arrow points out of the block to the right.</p>	<ul style="list-style-type: none"> <li>• Burst Search ON but signal is not bursted</li> <li>• Bursts are shorter than required by the setting 'Number of Symbol per Frame' in 'Demod Ctrl'</li> </ul>
 <p>The diagram shows a red rectangular block labeled 'Time Sync'. A green arrow points into the block from the left, and a red arrow points out of the block to the right. To the right of the block is a vertical bar with a white scale and a red indicator.</p>	<ul style="list-style-type: none"> <li>• The time domain structure of the signal doesn't match the settings. Check the following parameters:                             <ul style="list-style-type: none"> <li>○ Sampling Rate</li> <li>○ FFT Length</li> <li>○ Cyclic Prefix Length (If 'Time Sync' = 'Cyclic Prefix')</li> <li>○ Preamble Block Length (If 'Time Sync' = 'Preamble')</li> </ul> </li> </ul>
 <p>The diagram shows a red rectangular block labeled 'Frame Sync'. A green arrow points into the block from the left, and a red arrow points out of the block to the right. To the right of the block is a vertical bar with a white scale and a red indicator.</p>	<ul style="list-style-type: none"> <li>• Frames are shorter than required by the setting 'Number of Symbol per Frame' in 'Demod Ctrl'</li> <li>• The pilot cells of the signal doesn't match the configuration                             <ul style="list-style-type: none"> <li>○ Check the pilot matrix in the configuration file</li> <li>○ Increase 'Maximum bin offset' in 'Demod Ctrl' if a frequency offset of more than one subcarrier spacing could occur</li> <li>○ Try 'Swap IQ' to interchange I and Q parts of the signal</li> </ul> </li> <li>• The channel transfer function varies over the frame                             <ul style="list-style-type: none"> <li>○ Decrease 'Number of Symbols per Frame' in 'Demod Ctrl'</li> </ul> </li> </ul>

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