Software Manual

R&S® FSQ-K96

OFDM VSA
PC Software

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ROHDE&SCHWARZ
Test and Measurement

This Software Manual describes the following models:

R&S®FSQ

Dear Customer,

throughout this manual, R&S® FSQ-K96 are abbreviated as R&S FSQ-96.

Grouped Safety Messages

Make sure to read through and observe the following safety instructions!

All plants and locations of the Rohde & Schwarz group of companies make every effort to keep the safety standard of our products up to date and to offer our customers the highest possible degree of safety. Our products and the auxiliary equipment required for them are designed and tested in accordance with the relevant safety standards. Compliance with these standards is continuously monitored by our quality assurance system. The product described here has been designed and tested in accordance with the 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, 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 an 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.

Symbols and safety labels

							
Observe product documentation	Weight indication for units >18 kg	Danger of electric shock	Warning! Hot surface	PE terminal	Ground	Ground terminal	Attention! Electrostatic sensitive devices

					
Supply voltage ON/OFF	Standby indication	Direct current (DC)	Alternating current (AC)	Direct/alternating current (DC/AC)	Device fully protected by double/reinforced insulation

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 putting the product into operation. It is also absolutely essential to observe the additional safety instructions on personal safety 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.

Tags and their meaning

DANGER	DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.
WARNING	WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.
CAUTION	CAUTION indicates a hazardous situation which, if not avoided, may result in minor or moderate injury.
NOTICE	NOTICE indicates a property damage message. 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 thus contribute to personal injury or material damage.

Basic safety instructions

1. The product may be operated only under the operating conditions and in the positions specified by the manufacturer. Its ventilation must not be obstructed during operation. Unless otherwise specified, the following requirements apply to Rohde & Schwarz products:
   prescribed operating position is always with the housing floor facing down, IP protection 2X, pollution severity 2, overvoltage category 2, use only in enclosed spaces, max. operation altitude 2000 m above sea level, max. transport altitude 4500 m above sea level.
   A tolerance of ±10% shall apply to the nominal voltage and of ±5% to the nominal frequency.
2. Applicable local or national safety regulations and rules for the prevention of accidents must be observed in all work performed. The product may be opened only by authorized, specially trained personnel. Prior to performing any work on the product or opening the product, the product must be disconnected from the supply network. Any adjustments, replacements of parts, maintenance or repair must be carried out only by technical personnel 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).
3. As with all industrially manufactured goods, the use of substances that induce an allergic reaction (allergens, e.g. nickel) such as aluminum cannot be generally excluded. If you develop an allergic reaction (such as a skin rash, frequent sneezing, red eyes or respiratory difficulties), consult a physician immediately to determine the cause.
4. If products/components are mechanically and/or thermically 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, e.g. for disposal purposes, by specially trained personnel. Improper disassembly may be hazardous to your health. National waste disposal regulations must be observed.

5. If handling the product yields 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.
6. Depending on the function, certain products such as RF radio equipment can produce an elevated level of electromagnetic radiation. Considering that unborn life requires increased protection, pregnant women should be protected by appropriate measures. Persons with pacemakers may also be endangered by electromagnetic radiation. The employer/operator is required to assess workplaces where there is a special risk of exposure to radiation and, if necessary, take measures to avert the danger.
7. Operating the products requires special training and intense concentration. Make certain that persons who use the products are physically, mentally and emotionally fit enough to handle operating the products; otherwise injuries or material damage may occur. It is the responsibility of the employer to select suitable personnel for operating the products.
8. Prior to switching on the product, it must be ensured 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.
9. In the case of products of safety class I with movable power cord and connector, operation is permitted only on sockets with earthing contact and protective earth connection.
10. 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.
11. If the product has no power switch for disconnection from the AC supply, the plug of the connecting cable is regarded as the disconnecting device. In such cases, it must be ensured 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. If products without power switches are integrated in racks or systems, a disconnecting device must be provided at the system level.
12. 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, ensure that the cable cannot be damaged and that no one can be hurt by e.g. tripping over the cable or suffering an electric shock.
13. 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).
14. Do not insert the plug into sockets that are dusty or dirty. Insert the plug firmly and all the way into the socket. Otherwise, this can result in sparks, fire and/or injuries.
15. Do not overload any sockets, extension cords or connector strips; doing so can cause fire or electric shocks.
16. For measurements in circuits with voltages V_{rms} > 30 V, suitable measures (e.g. appropriate measuring equipment, fusing, current limiting, electrical separation, insulation) should be taken to avoid any hazards.
17. Ensure that the connections with information technology equipment comply with IEC 950/EN 60950.
18. 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.
19. 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 license electrician.

20. 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 suitable protection is provided for users and products.
21. Do not insert any objects into the openings in the housing that are not designed for this purpose. Never pour any liquids onto or into the housing. This can cause short circuits inside the product and/or electric shocks, fire or injuries.
22. Use suitable overvoltage protection to ensure that no overvoltage (such as that caused by a thunderstorm) can reach the product. Otherwise the operating personnel will be endangered by electric shocks.
23. Rohde & Schwarz products are not protected against penetration of liquids, unless otherwise specified (see also safety instruction 1.). If this is not taken into account, there exists the danger of electric shock for the user or damage to the product, which can also lead to personal injury.
24. Never use the product under conditions in which condensation has formed or can form in or on the product, e.g. if the product was moved from a cold to a warm environment.
25. Do not close any slots or openings on the product, since they are necessary for ventilation and prevent the product from overheating. Do not place the product on soft surfaces such as sofas or rugs or inside a closed housing, unless this is well ventilated.
26. Do not place the product on heat-generating devices such as radiators or fan heaters. The temperature of the environment must not exceed the maximum temperature specified in the data sheet.
27. Batteries and storage batteries must not be exposed to high temperatures or fire. Keep batteries and storage batteries away from children. Do not short-circuit batteries and storage batteries.
    If batteries or storage batteries are improperly replaced, this can cause an explosion (warning: lithium cells). Replace the battery or storage battery only with the matching Rohde & Schwarz type (see spare parts list). Batteries and storage batteries must be recycled and kept separate from residual waste. Batteries and storage batteries that contain lead, mercury or cadmium are hazardous waste. Observe the national regulations regarding waste disposal and recycling.
28. Please be aware that in the event of a fire, toxic substances (gases, liquids etc.) that may be hazardous to your health may escape from the product.
29. The product can be very heavy. Be careful when moving it to avoid back or other physical injuries.
30. 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).
31. Handles on the products are designed exclusively for personnel to hold or carry the product. It is therefore not permissible to use handles for fastening the product to or on means of transport such as cranes, fork lifts, wagons, etc. The user is responsible for securely fastening the products to or on the means of transport and for observing the safety regulations of the manufacturer of the means of transport. Noncompliance can result in personal injury or material damage.
32. If you use the product in a vehicle, it is the sole responsibility of the driver to drive the vehicle safely. Adequately secure the product in the vehicle to prevent injuries or other damage in the event of an accident. Never use the product in a moving vehicle if doing so could distract the driver of the vehicle. The driver is always responsible for the safety of the vehicle. The manufacturer assumes no responsibility for accidents or collisions.
33. If a laser product (e.g. a CD/DVD drive) is integrated in a Rohde & Schwarz product, do not use any other settings or functions than those described in the product documentation. Otherwise this may be hazardous to your health, since the laser beam can cause irreversible damage to your eyes. Never try to take such products apart, and never look into the laser beam.
34. Prior to cleaning, disconnect the product from the AC supply. Use a soft, non-linting cloth to clean the product. Never use chemical cleaning agents such as alcohol, acetone or diluent for cellulose lacquers.

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. Nuestra sección de gestión de la seguridad de calidad controla constantemente que sean cumplidas estas normas. El presente producto ha sido fabricado y examinado según el comprobante de conformidad adjunto según las normas de la CE 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 despreciando las informaciones de seguridad 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.

Se parte del uso correcto del producto para los fines definidos si el producto es utilizado dentro de las instrucciones de la correspondiente documentación de 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 profundos y conocimientos básicas del idioma inglés. Por eso se debe tener en cuenta que el producto sólo pueda ser operado por personal especializado o personas minuciosamente instruidas con las capacidades correspondientes. Si fuera necesaria indumentaria de seguridad para el uso de productos de R&S, encontrará 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 entréguela a usuarios posteriores.

Símbolos y definiciones de seguridad

							
Ver documen-tación de producto	Informaciones para maquinaria con un peso de > 18kg	Peligro de golpe de corriente	¡Advertencia! Superficie caliente	Conexión a conductor protector	Conexión a tierra	Conexión a masa conductora	¡Cuidado! Elementos de construcción con peligro de carga electroestática

					
Potencia EN MARCHA/PARADA	Indicación Stand-by	Corriente continua DC	Corriente alterna AC	Corriente continua/-alterna DC/AC	El aparato está protegido en su totalidad por un aislamiento de doble refuerzo

Tener en cuenta las informaciones de seguridad sirve para tratar de evitar daños y peligros de toda clase. Es necesario de que se lean las siguientes informaciones de seguridad concienzudamente y se tengan en cuenta debidamente antes de la puesta en funcionamiento del producto. También deberán ser tenidas en cuenta las informaciones para la protección de personas que encontrarán en el capítulo correspondiente de la documentación de producto y que también son obligatorias de seguir. En las informaciones de seguridad actuales hemos juntado todos los objetos vendidos por el grupo de empresas Rohde & Schwarz bajo la denominación de „producto“, entre ellos también aparatos, instalaciones así como toda clase de accesorios.

Palabras de señal y su significado

PELIGRO	Identifica un peligro directo con riesgo elevado de provocar muerte o lesiones de gravedad si no se toman las medidas oportunas.
ADVERTENCIA	Identifica un posible peligro con riesgo medio de provocar muerte o lesiones (de gravedad) si no se toman las medidas oportunas.
ATENCIÓN	Identifica un peligro con riesgo reducido de provocar lesiones de gravedad media o leve si no se toman las medidas oportunas.
AVISO	Indica la posibilidad de utilizar mal el producto y a 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 de 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 malinterpretaciones y tener por consecuencia daños en personas u objetos.

Informaciones de seguridad elementales

1. El producto solamente debe ser utilizado según lo indicado por el fabricante referente a la situación y posición de funcionamiento sin que se obstruya la ventilación. Si no se convino de otra manera, es para los productos R&S 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, utilizar solamente en estancias interiores, utilización hasta 2000 m sobre el nivel del mar, transporte hasta 4.500 m sobre el nivel del mar.
   Se aplicará una tolerancia de ±10% sobre el voltaje nominal y de ±5% sobre la frecuencia nominal.
2. En todos los trabajos deberán ser tenidas en cuenta las normas locales de seguridad de trabajo y de prevención de accidentes. El producto solamente debe de ser abierto por personal especializado autorizado. Antes de efectuar trabajos en el producto o abrirlo deberá este ser desconectado de la corriente. El ajuste, el cambio de partes, la manutención y la reparación deberán ser solamente efectuadas por electricistas autorizados por R&S. Si se reponen partes con importancia para los aspectos de seguridad (por ejemplo el enchufe, los transformadores o los fusibles), solamente podrán ser sustituidos por partes originales. Después de cada recambio de partes elementales para la seguridad deberá ser efectuado un control de seguridad (control a primera vista, control de conductor protector, medición de resistencia de aislamiento, medición de la corriente conductora, control de funcionamiento).

3. Como en todo producto de fabricación industrial no puede ser excluido en general de que se produzcan al usarlo elementos que puedan generar alergias, los llamados elementos alergénicos (por ejemplo el níquel). Si se producieran en el trato con productos R&S reacciones alérgicas, como por ejemplo urticaria, estornudos frecuentes, irritación de la conjuntiva o dificultades al respirar, se deberá consultar inmediatamente a un médico para averiguar los motivos de estas reacciones.
4. Si productos / elementos de construcción son tratados fuera del funcionamiento definido de forma mecánica o térmica, pueden generarse elementos peligrosos (polvos de sustancia de metales pesados como por ejemplo plomo, berilio, níquel). La partición elemental del producto, como por ejemplo sucede en el tratamiento de materias residuales, debe de ser efectuada solamente por personal especializado para estos tratamientos. La partición elemental efectuada inadecuadamente puede generar daños para la salud. Se deben tener en cuenta las directivas nacionales referentes al tratamiento de materias residuales.
5. En el caso de que se produjeran agentes de peligro o combustibles en la aplicación del producto que debieran de ser transferidos a un tratamiento de materias residuales, como por ejemplo agentes refrigerantes que deben ser repuestos en periodos definidos, o aceites para motores, deberán ser tenidas en cuenta las prescripciones de seguridad del fabricante de estos agentes de peligro o combustibles y las regulaciones regionales para el tratamiento de materias residuales. Cuiden también de tener en cuenta en caso dado las prescripciones de seguridad especiales en la descripción del producto.
6. Ciertos productos, como por ejemplo las instalaciones de radiocomunicación RF, pueden a causa de su función natural, emitir una radiación electromagnética aumentada. En vista a la protección de la vida en desarrollo deberían ser protegidas personas embarazadas debidamente. También las personas con un bypass pueden correr peligro a causa de la radiación electromagnética. El empresario/usuario está comprometido a valorar y señalar áreas de trabajo en las que se corra un riesgo aumentado de exposición a radiaciones para evitar riesgos.
7. La utilización de los productos requiere instrucciones especiales y una alta concentración en el manejo. Debe de ponerse por seguro de que las personas que manejen los productos estén a la altura de los requerimientos necesarios referente a sus aptitudes físicas, psíquicas y emocionales, ya que de otra manera no se pueden excluir lesiones o daños de objetos. El empresario lleva la responsabilidad de seleccionar el personal usuario apto para el manejo de los productos.
8. Antes de la puesta en marcha del producto se deberá tener por seguro de que la tensión preseleccionada en el producto equivalga a la del la red de distribución. Si es necesario cambiar la preselección de la tensión también se deberán en caso dabo cambiar los fusibles correspondientes del producto.
9. Productos de la clase de seguridad I con alimentación móvil y enchufe individual de producto solamente deberán ser conectados para el funcionamiento a tomas de corriente de contacto de seguridad y con conductor protector conectado.
10. Queda prohibida toda clase de interrupción intencionada del conductor protector, tanto en la toma de corriente como en el mismo producto. Puede tener como consecuencia el peligro de golpe de corriente por el producto. Si se utilizaran cables o enchufes de extensión se deberá poner al seguro que es controlado su estado técnico de seguridad.
11. Si el producto no está equipado con un interruptor para desconectarlo de la red, se deberá considerar el enchufe del cable de distribución como interruptor. En estos casos deberá asegurar de que el enchufe sea de fácil acceso y nabejo (según la medida del cable de distribución, 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 instalar el interruptor al nivel de la instalación.

12. No utilice nunca el producto si está dañado el cable eléctrico. Compruebe regularmente el correcto estado de los cables de conexión a red. Asegure a través de las medidas de protección y de instalación adecuadas de que el cable de eléctrico no pueda ser dañado o de que nadie pueda ser dañado por él, por ejemplo al tropezar o por un golpe de corriente.
13. Solamente está permitido el funcionamiento en redes de distribución TN/TT aseguradas con fusibles de como máximo 16 A (utilización de fusibles de mayor amperaje sólo previa consulta con el grupo de empresas Rohde & Schwarz).
14. 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. Si no tiene en consideración estas indicaciones se arriesga a que se originen chispas, fuego y/o heridas.
15. No sobrecargue las tomas de corriente, los cables de extensión o los enchufes de extensión ya que esto pudiera causar fuego o golpes de corriente.
16. En las mediciones en circuitos de corriente con una tensión de entrada de U_{eff} > 30 V se deberá tomar las precauciones debidas para impedir cualquier peligro (por ejemplo medios de medición adecuados, seguros, limitación de tensión, corte protector, aislamiento etc.).
17. En caso de conexión con aparatos de la técnica informática se deberá tener en cuenta que estos cumplan los requisitos del estándar IEC950/EN60950.
18. 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 heridas, fuego o daños en el producto.
19. Si un producto es instalado fijamente en un lugar, se deberá primero conectar el conductor protector fijo con el conductor protector del aparato antes de hacer cualquier otra conexión. La instalación y la conexión deberán ser efectuadas por un electricista especializado.
20. En caso de que los productos que son instalados fijamente en un lugar sean sin protector implementado, autointerruptor o similares objetos de protección, el circuito de suministro de corriente deberá estar protegido de manera que usuarios y productos estén suficientemente protegidos.
21. Por favor, no introduzca ningún objeto que no esté destinado a ello en los orificios de la caja del aparato. No vierta nunca ninguna clase de líquidos sobre o en la caja. Esto puede producir cortocircuitos en el producto y/o puede causar golpes de corriente, fuego o heridas.
22. Asegúrese con la protección adecuada de que no pueda originarse en el producto una sobrecarga por ejemplo a causa de una tormenta. Si no se verá el personal que lo utilice expuesto al peligro de un golpe de corriente.
23. Los productos R&S no están protegidos contra líquidos si no es que exista otra indicación, ver también punto 1. Si no se tiene en cuenta esto se arriesga el peligro de golpe de corriente para el usuario o de daños en el producto lo cual también puede llevar al peligro de personas.
24. No utilice el producto bajo condiciones en las que pueda producirse y se hayan producido líquidos de condensación en o dentro del producto como por ejemplo cuando se desplaza el producto de un lugar frío a un lugar caliente.
25. Por favor no cierre ninguna ranura u orificio del producto, ya que estas son necesarias para la ventilación e impiden que el producto se caliente demasiado. No pongan el producto encima de materiales blandos como por ejemplo sofás o alfombras o dentro de una caja cerrada, si esta no está suficientemente ventilada.
26. No ponga el producto sobre aparatos que produzcan calor, como por ejemplo radiadores o calentadores. La temperatura ambiental no debe superar la temperatura máxima especificada en la hoja de datos.

27. Baterías y acumuladores no deben de ser expuestos a temperaturas altas o al fuego. Guardar baterías y acumuladores fuera del alcance de los niños. No cortocircuitar baterías ni acumuladores. Si las baterías o los acumuladores no son cambiados con la debida atención existirá peligro de explosión (atención células de litio). Cambiar las baterías o los acumuladores solamente por los del tipo R&S correspondiente (ver lista de piezas de recambio). Las baterías y acumuladores deben reutilizarse y no deben acceder a los vertederos. Las baterías y acumuladores que contienen plomo, mercurio o cadmio deben tratarse como residuos especiales. Respete en esta relación las normas nacionales de evacuación y reciclaje.
28. Por favor tengan en cuenta que en caso de un incendio pueden desprenderse del producto agentes venenosos (gases, líquidos etc.) que pueden generar daños a la salud.
29. El producto puede poseer un peso elevado. Muévalo con cuidado para evitar lesiones en la espalda u otras partes corporales.
30. No sitúe el producto encima de superficies, vehículos, estantes o mesas, que por sus características de peso o de estabilidad no sean aptas para él. Siga siempre las instrucciones de instalación del fabricante cuando instale y asegure el producto en objetos o estructuras (por ejemplo paredes y estantes).
31. Las asas instaladas en los productos sirven solamente de ayuda para el manejo que solamente está previsto para personas. Por eso no está permitido utilizar las asas para la sujeción en o sobre medios de transporte como por ejemplo grúas, carretillas elevadoras de horquilla, carros etc. El usuario es responsable de que los productos sean sujetados de forma segura a los medios de transporte y de que las prescripciones de seguridad del fabricante de los medios de transporte sean observadas. En caso de que no se tengan en cuenta pueden causarse daños en personas y objetos.
32. Si llega a utilizar el producto dentro de un vehículo, queda en la responsabilidad absoluta del conductor que conducir el vehículo de manera segura. Asegure el producto dentro del vehículo debidamente para evitar en caso de un accidente las lesiones u otra clase de daños. No utilice nunca el producto dentro de un vehículo en movimiento si esto pudiera distraer al conductor. Siempre queda en la responsabilidad absoluta del conductor la seguridad del vehículo. El fabricante no asumirá ninguna clase de responsabilidad por accidentes o colisiones.
33. Dado el caso de que esté integrado un producto de láser en un producto R&S (por ejemplo CD/DVD-ROM) no utilice otras instalaciones o funciones que las descritas en la documentación de producto. De otra manera pondrá en peligro su salud, ya que el rayo láser puede dañar irreversiblemente sus ojos. Nunca trate de descomponer estos productos. Nunca mire dentro del rayo láser.
34. Antes de proceder a la limpieza, desconecte el producto de la red. Realice la limpieza con un paño suave, que no se deshilache. No utilice de ninguna manera agentes limpiadores químicos como, por ejemplo, alcohol, acetona o nitrodiluyente.

Certified Quality System

DIN EN ISO 9001 : 2000
DIN EN 9100 : 2003
DIN EN ISO 14001 : 2004

DQS REG. NO 001954 QM UM

QUALITÄTSZERTIFIKAT

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 Managementsystems entwickelt, gefertigt und geprüft.
Das Rohde&Schwarz Managementsystem ist zertifiziert nach:

DIN EN ISO 9001:2000
DIN EN 9100:2003
DIN EN ISO 14001:2004

CERTIFICATE OF QUALITY

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:

DIN EN ISO 9001:2000
DIN EN 9100:2003
DIN EN ISO 14001:2004

CERTIFICAT DE QUALITÉ

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 conformément aux normes:

DIN EN ISO 9001:2000
DIN EN 9100:2003
DIN EN ISO 14001:2004

ROHDE&SCHWARZ

1171.0200.11-02.00

Address List

Headquarters, Plants and Subsidiaries

Headquarters

ROHDE&SCHWARZ GmbH & Co. KG
Mühldorfstraße 15 · D-81671 München
P.O.Box 80 14 69 · D-81614 München

Phone +49 (89) 41 29-0
Fax +49 (89) 41 29-121 64
info.rs@rohde-schwarz.com

Plants

ROHDE&SCHWARZ Messgerätebau GmbH
Riedbachstraße 58 · D-87700 Memmingen
P.O.Box 16 52 · D-87686 Memmingen

Phone +49 (83 31) 1 08-0
+49 (83 31) 1 08-1124
info.rsmb@rohde-schwarz.com

ROHDE&SCHWARZ GmbH & Co. KG
Werk Teisnach
Kaikenrieder Straße 27 · D-94244 Teisnach
P.O.Box 11 49 · D-94240 Teisnach

Phone +49 (99 23) 8 50-0
Fax +49 (99 23) 8 50-174
info.rsdts@rohde-schwarz.com

ROHDE&SCHWARZ závod
Vimperk, s.r.o.
Location Spidrova 49
CZ-38501 Vimperk

Phone +420 (388) 45 21 09
Fax +420 (388) 45 21 13

ROHDE&SCHWARZ GmbH & Co. KG
Dienstleistungszentrum Köln
Graf-Zeppelin-Straße 18 · D-51147 Köln
P.O.Box 98 02 60 · D-51130 Köln

Phone +49 (22 03) 49-0
Fax +49 (22 03) 49 51-229
info.rsdc@rohde-schwarz.com
service.rsdc@rohde-schwarz.com

Subsidiaries

R&S BICK Mobilfunk GmbH
Fritz-Hahne-Str. 7 · D-31848 Bad Münder
P.O.Box 20 02 · D-31844 Bad Münder

Phone +49 (50 42) 9 98-0
Fax +49 (50 42) 9 98-105
info.bick@rohde-schwarz.com

ROHDE&SCHWARZ FTK GmbH
Wendenschloßstraße 168, Haus 28
D-12557 Berlin

Phone +49 (30) 658 91-122
Fax +49 (30) 655 50-221
info.ftk@rohde-schwarz.com

ROHDE&SCHWARZ SIT GmbH
Am Studio 3
D-12489 Berlin

Phone +49 (30) 658 84-0
Fax +49 (30) 658 84-183
info.sit@rohde-schwarz.com

R&S Systems GmbH
Graf-Zeppelin-Straße 18
D-51147 Köln

Phone +49 (22 03) 49-5 23 25
Fax +49 (22 03) 49-5 23 36
info.rssys@rohde-schwarz.com

GEDIS GmbH
Sophienblatt 100
D-24114 Kiel

Phone +49 (431) 600 51-0
Fax +49 (431) 600 51-11
sales@gedis-online.de

HAMEG Instruments GmbH
Industriestraße 6
D-63533 Mainhausen

Phone +49 (61 82) 800-0
Fax +49 (61 82) 800-100
info@hameg.de

Locations Worldwide

Please refer to our homepage: www.rohde-schwarz.com

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Contents

1 General Information

The R&S FSQ-K96 OFDM-VSA PC analysis software application uses the I/Q capture functionality of the R&S FSQ spectrum analyzer to enable generic OFDM measurements using 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.

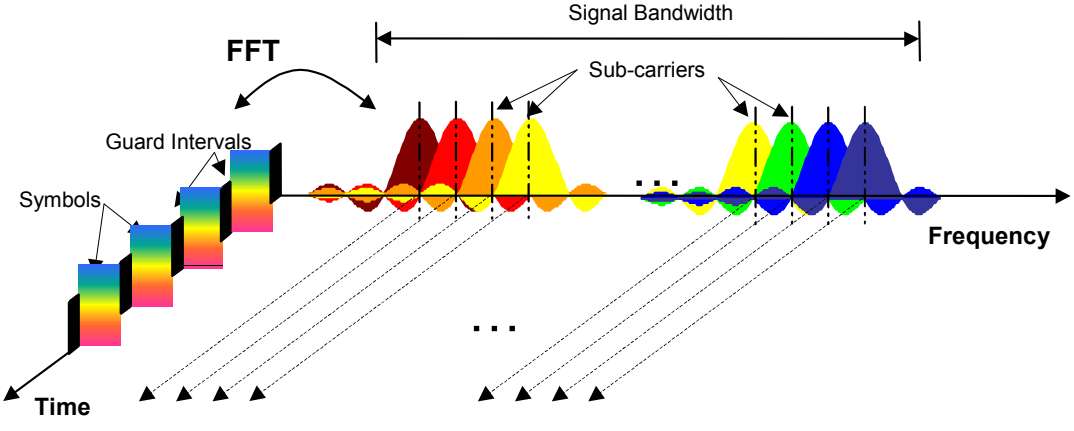


Fig. 1 Frequency-time representation of an OFDM signal

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^{th} subchannel modulated data symbol, during the time period $mT_u < t \leq (m+1)T_u$.

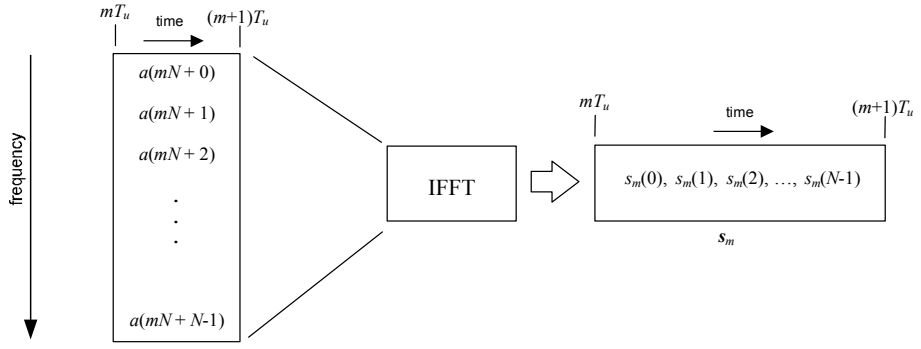


Fig. 2 OFDM useful symbol generation using an IFFT

The vector $\boldsymbol{s}_m$ 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.

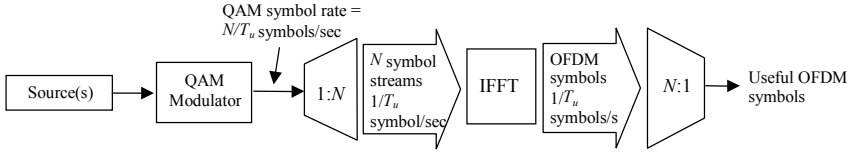


Fig. 3 OFDM signal generation chain

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

OFDM Parameterization

A generic OFDM analyzer requires definitions of 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}.

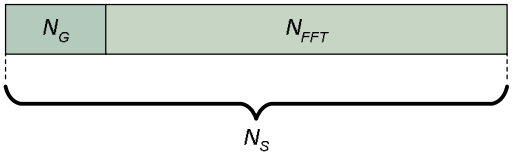


Fig. 4 OFDM symbol in time domain

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-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-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.

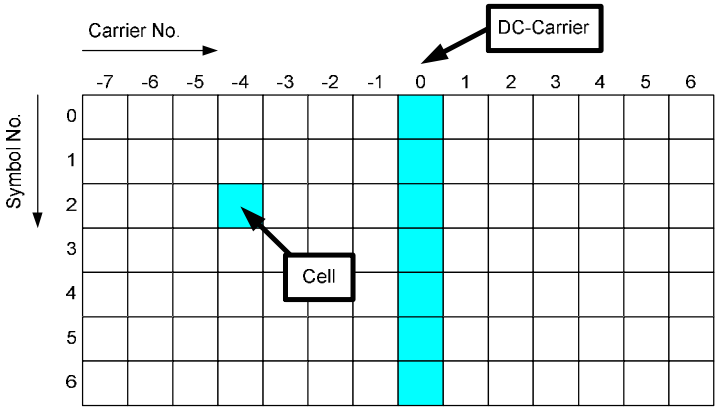


Fig. 5 Time-Frequency matrix

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.

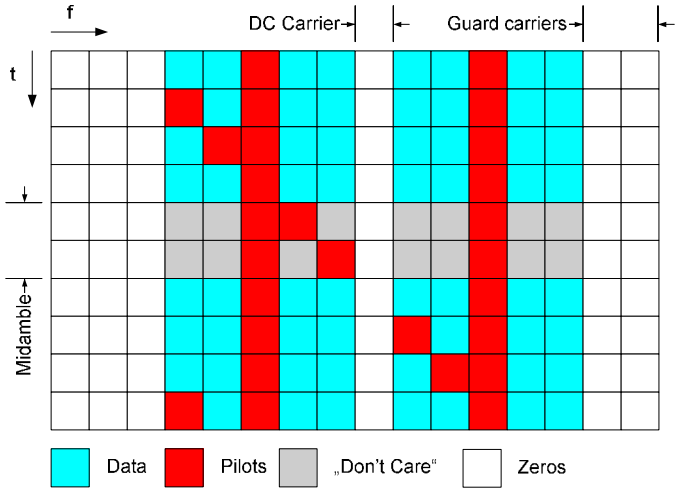


Fig. 6 Example of a structure matrix

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.

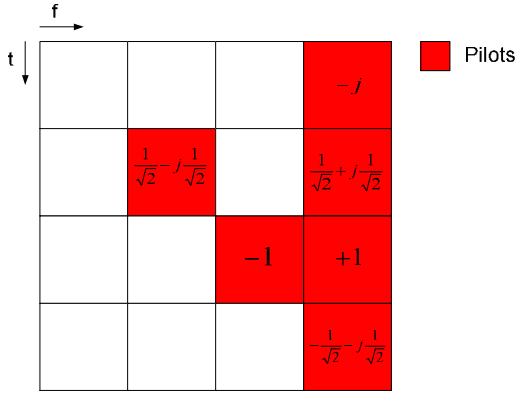


Fig. 7 Example of a pilot matrix

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).

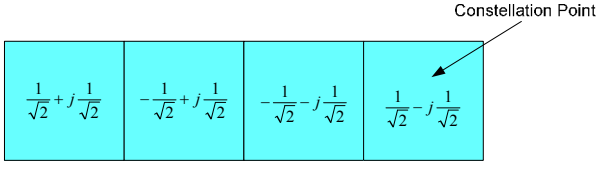


Fig. 8 QPSK constellation vector

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.

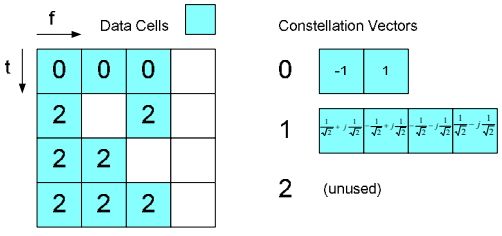


Fig. 9 Example of a modulation matrix

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.

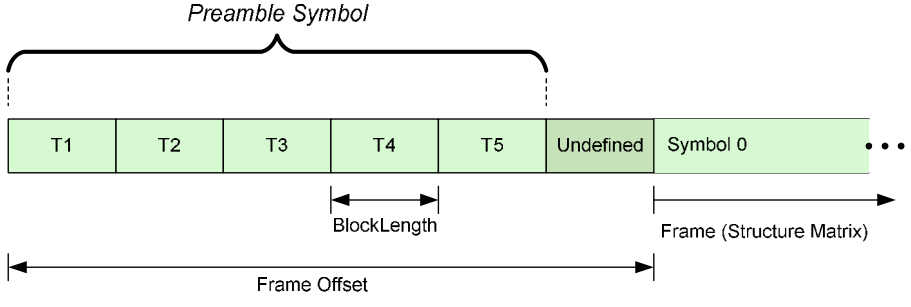


Fig. 10 Description of a repetitive preamble symbol

Installation

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

R&S FSQ requirements

To capture I/Q data, any R&S FSQ available can be used.
To connect the instrument using TCP/IP, you must either use firmware version 3.65 or higher or have the RSIB Passport driver installed on your PC. The driver can be downloaded from this website: http://www.rohde-schwarz.com/appnote/1EF47.

Operating the software

Starting the software

Use the desktop shortcut or the shortcut from the Start menu to start the R&S FSQ-K96 OFDM-VSA analysis software. The following window should appear:

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**].

Preparing for instrument connection

In order to be able to communicate with the instruments, the R&S FSQ must be connected with the PC 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.

Quick start guide

This section will help you to quickly become familiar with R&S FSQ-K96 (refer to section 2 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. 11 shows the exemplary settings of an R&S SMU Vector signal generator.

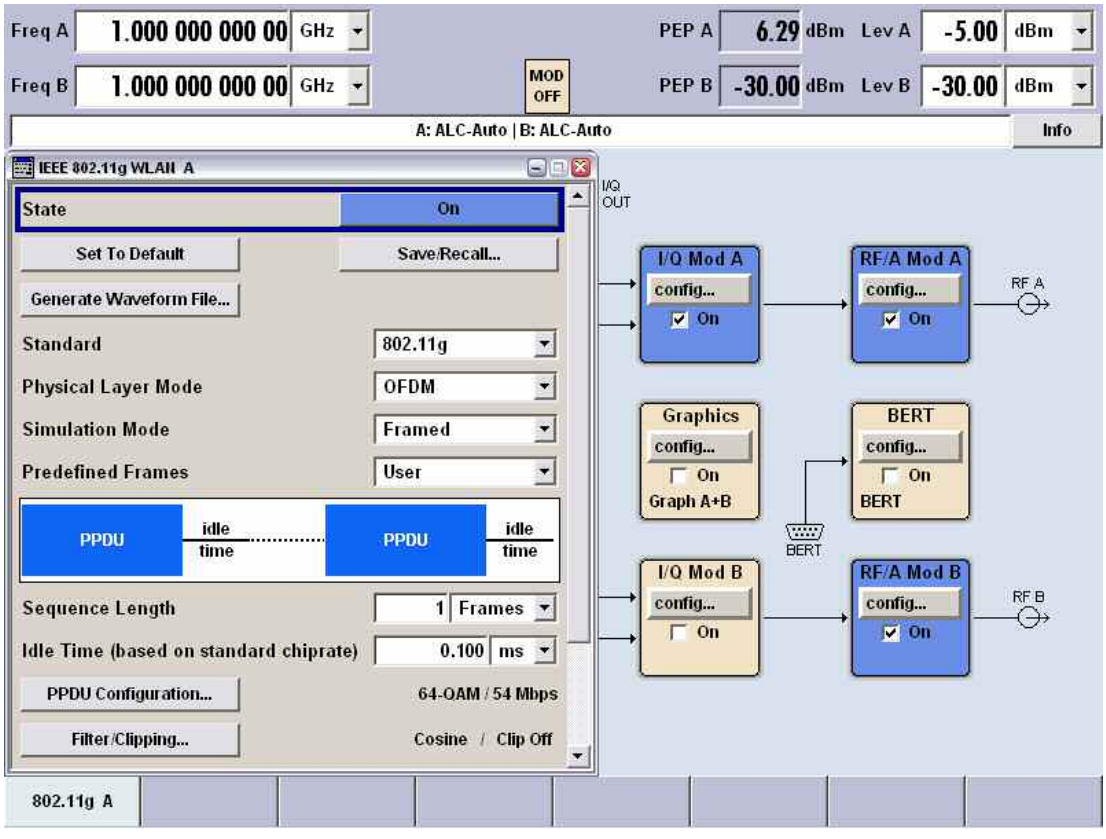
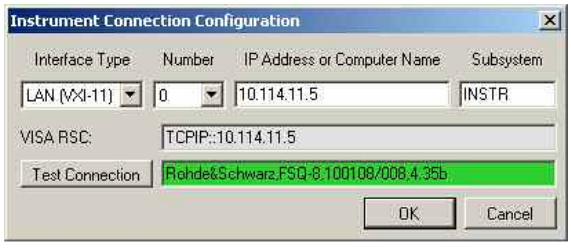


Fig. 11: WLAN settings menu of the R&S SMU Vector Signal Generator

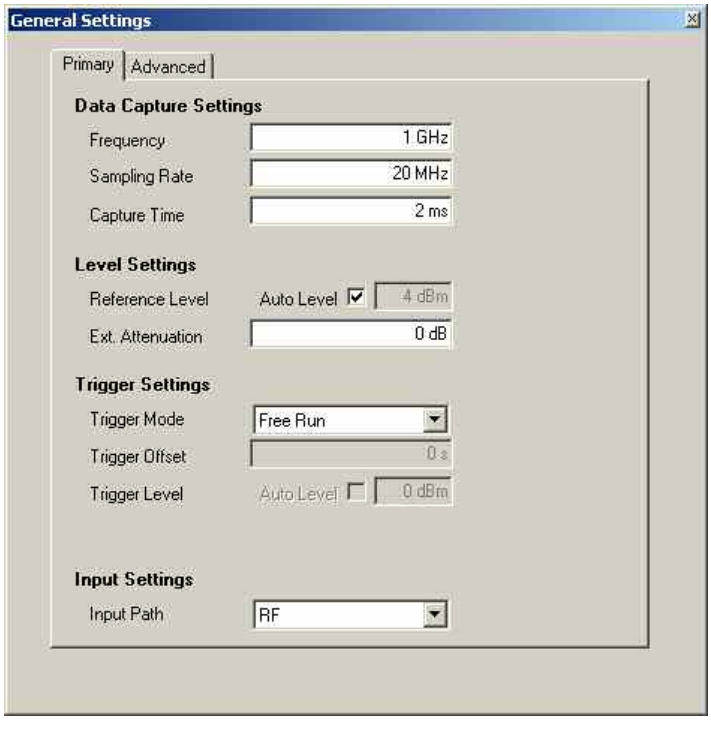
Setting up the measurement

- Start the R&S FSQ-K96 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.

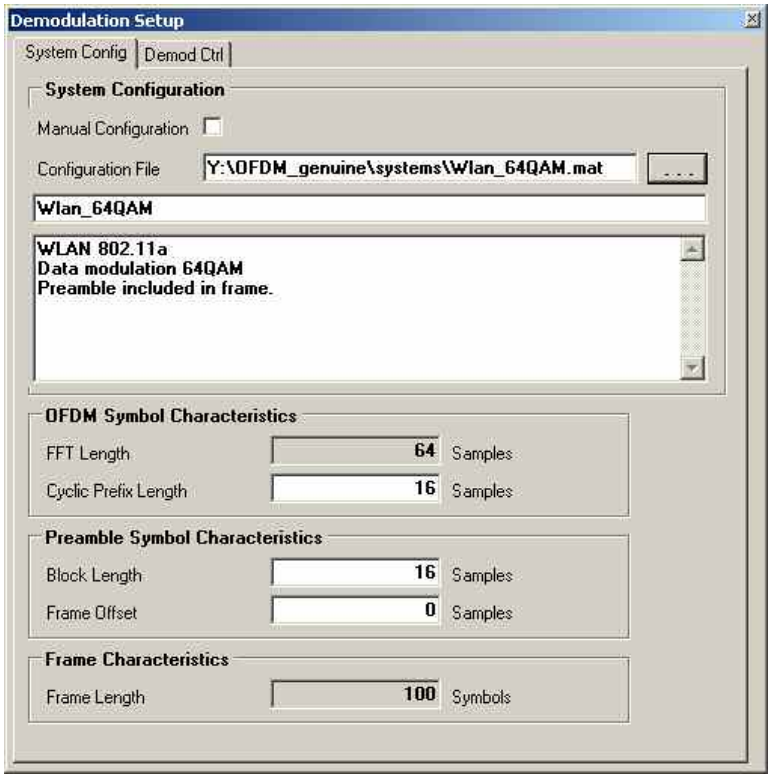


- Enter the desired frequency to measure in the *Frequency* field.
- Enter the 802.11a sample rate of 20 MHz in the *Sampling Rate* field.
- Enter a capture length of 5 ms in the *Capture Time* field.

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

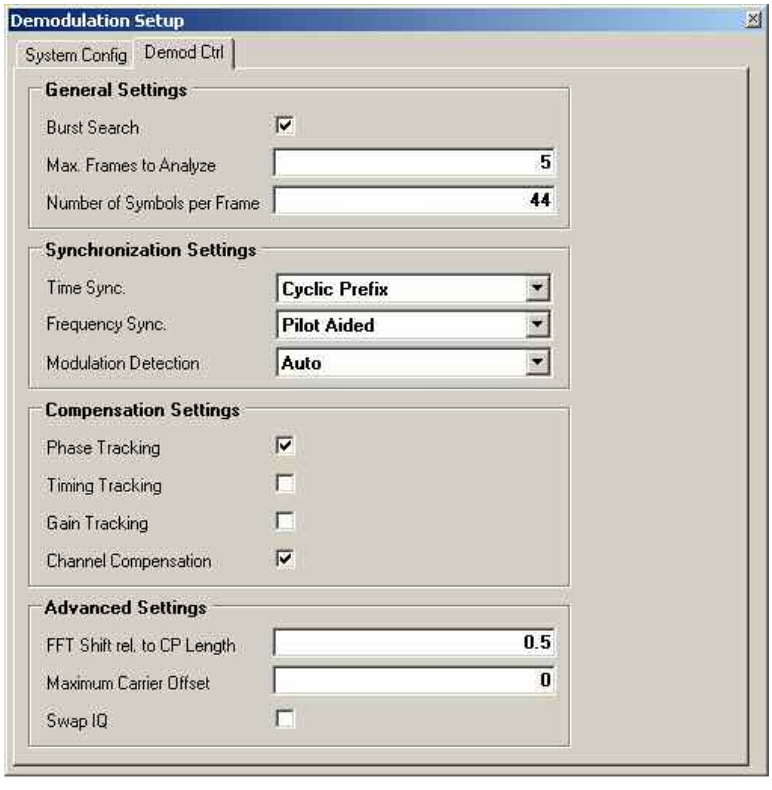
Demodulation setup (System configuration and demodulation control)

➢ Press <*DEMOD 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.

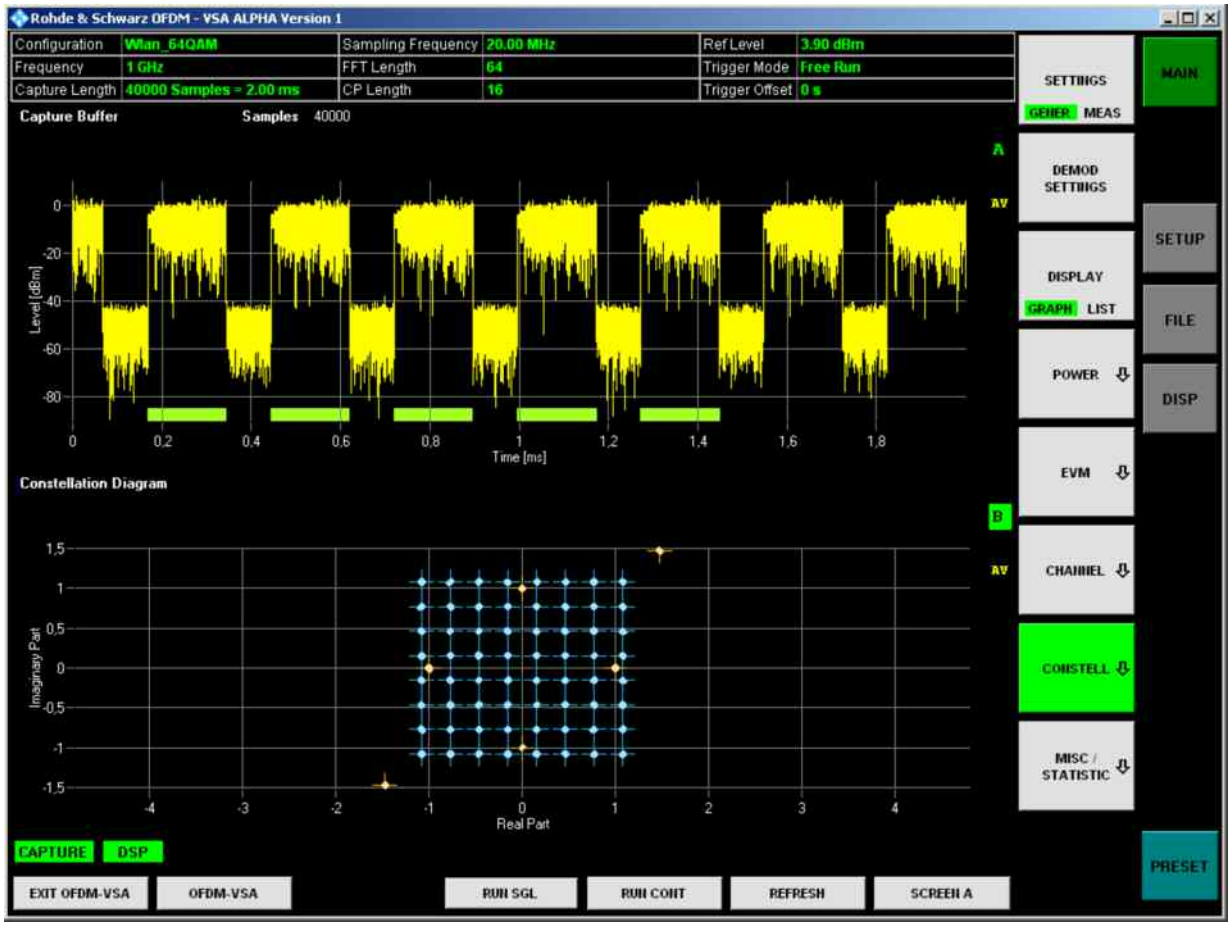


- Set the number of symbols per frame to the number of data symbols per OFDM burst plus 5 (4 preamble symbols + 1 signal field).

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*>.



2 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

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

Power measurement

- *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*
  Detailled list of the demodulation steps.

Softkey menu

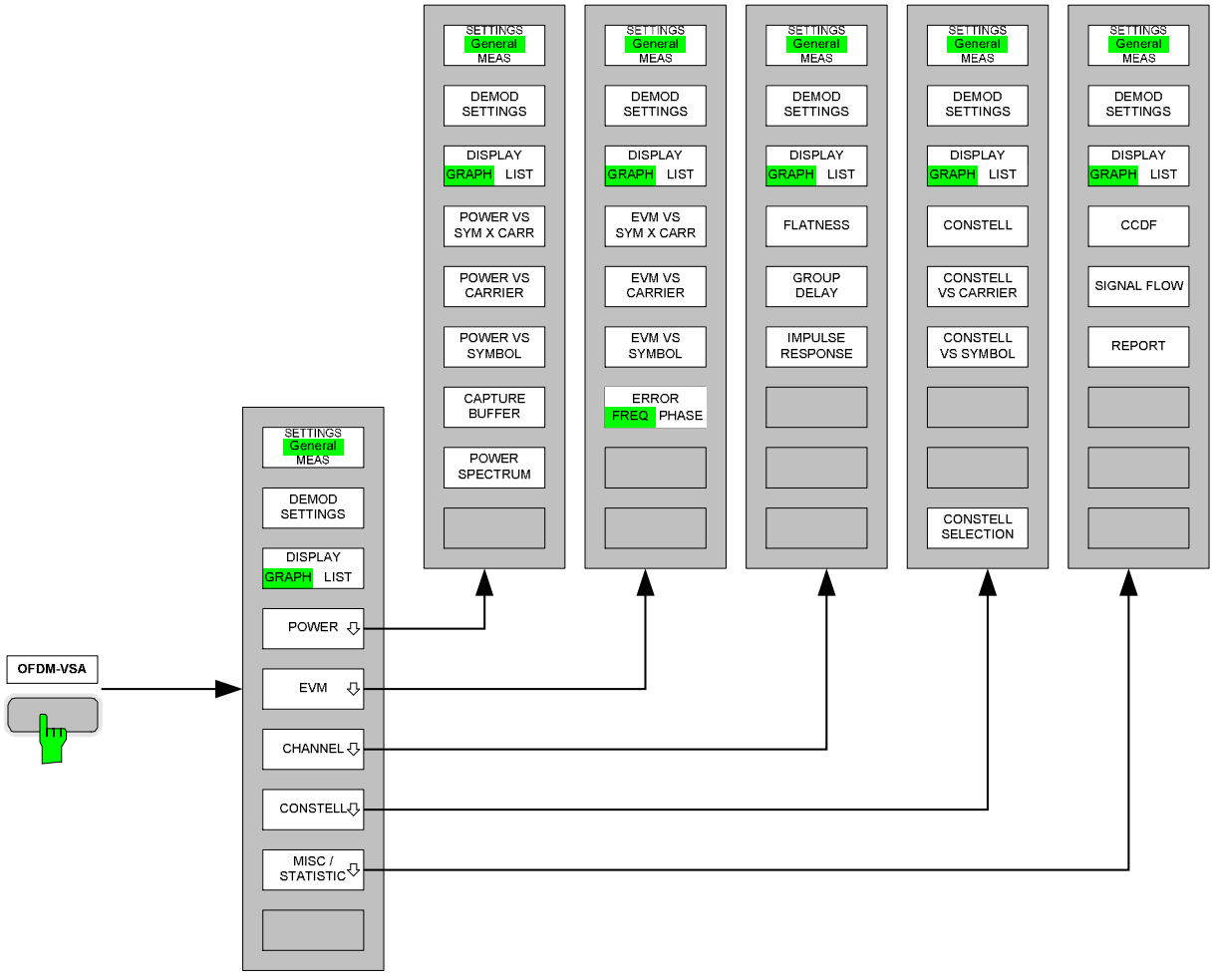


Fig. 12 OFDM-VSA menu structure

Performing measurements

You can either use the R&S FSQ 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 3 "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	Wlan_64QAM	Sampling Frequency	20.00 MHz	Ref Level	0.00 dBm
Frequency	1 GHz	FFT Length	64	Trigger Mode	Free Run
Capture Length	20000 Samples = 1.00 ms	CP Length	16	Trigger Offset	0 s

Fig. 13 Overall measurement settings summary

The settings summary includes the following information:

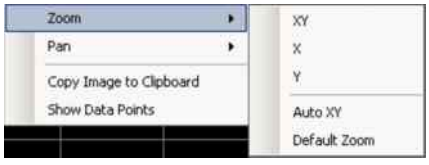
- **Configuration** Name of the loaded configuration or ‘Manual’.
- **Frequency** The analyzer RF frequency.
- **Capture Length** Capture length in number of samples and time.
- **Sampling Frequency** System sample rate.
- **FFT Length** Length of the FFT interval in number of samples.
- **CP Length** 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.

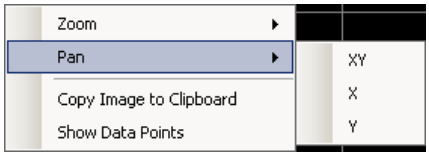
Evaluating the results

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

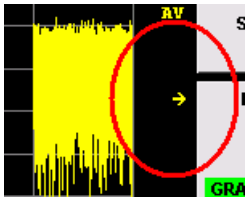
XY	Clicking the graph with the left mouse button and holding it down will select an X and Y area to zoom in on.
X	Clicking the graph with the left mouse button and holding it down will open a range which can be used to select an X area to zoom in on.
Y	Clicking the graph with the left mouse button and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

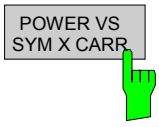


This yellow arrow indicates that parts of the data are outside to the right of the visible area (arrow points to the right).

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.

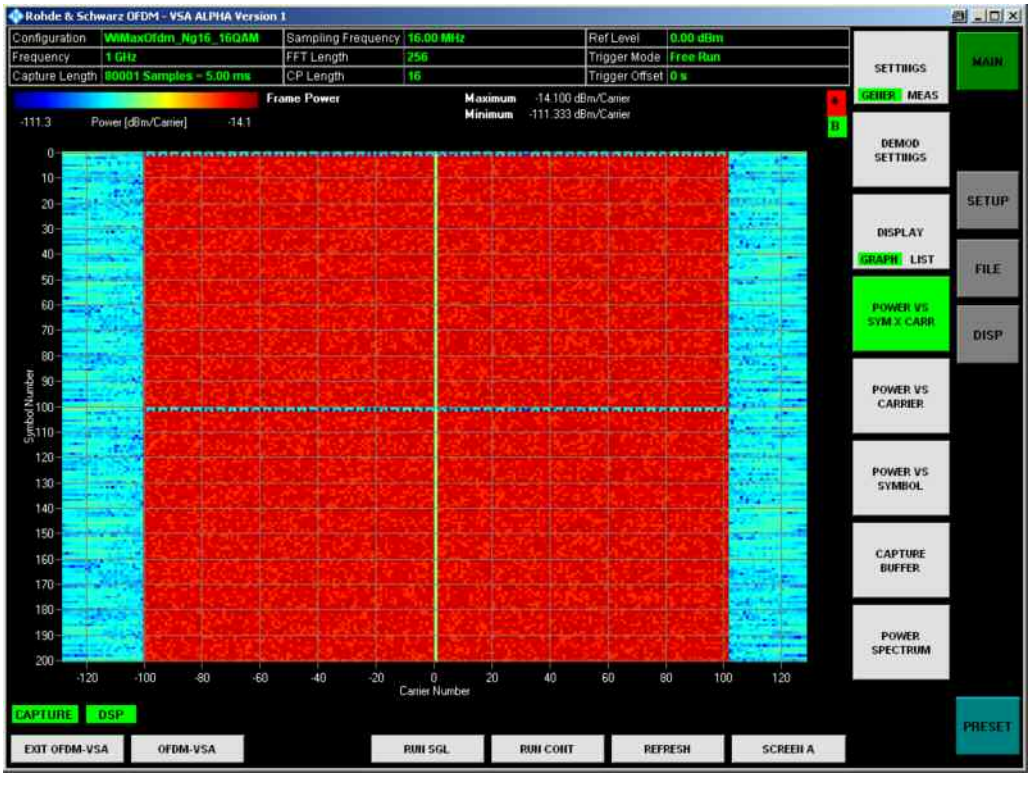
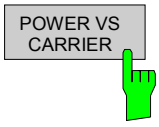


Fig. 14 Power vs. Sym. X Carr. display

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



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.

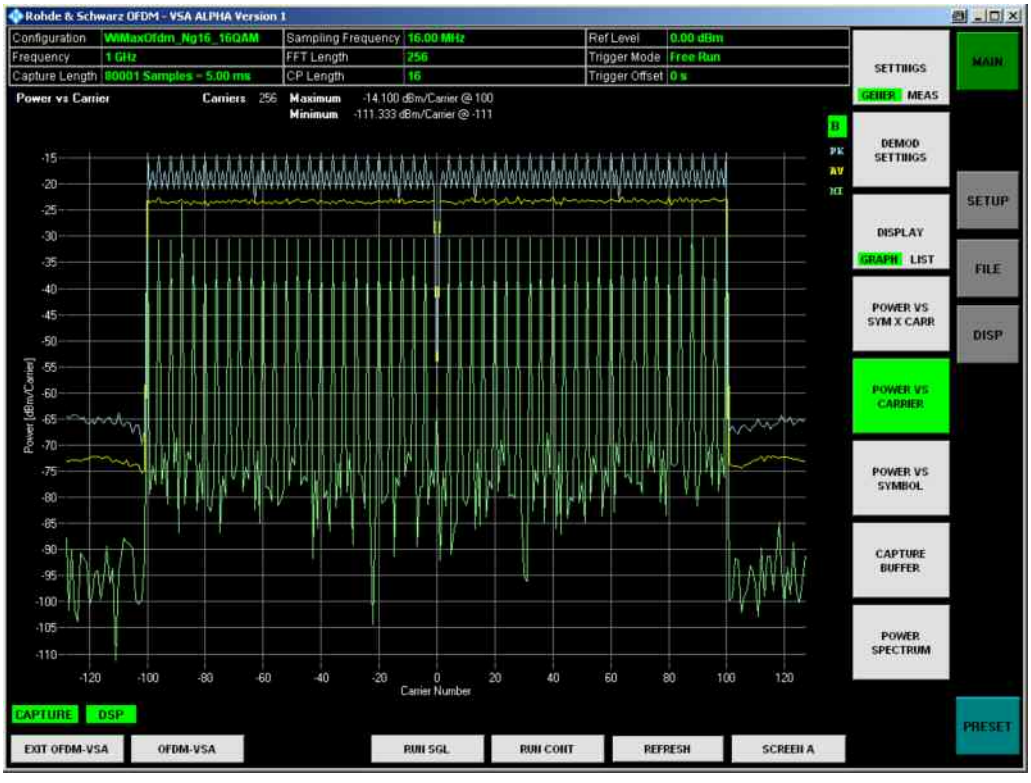
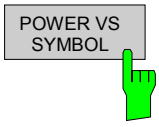


Fig. 15 Power vs. Carrier display

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.

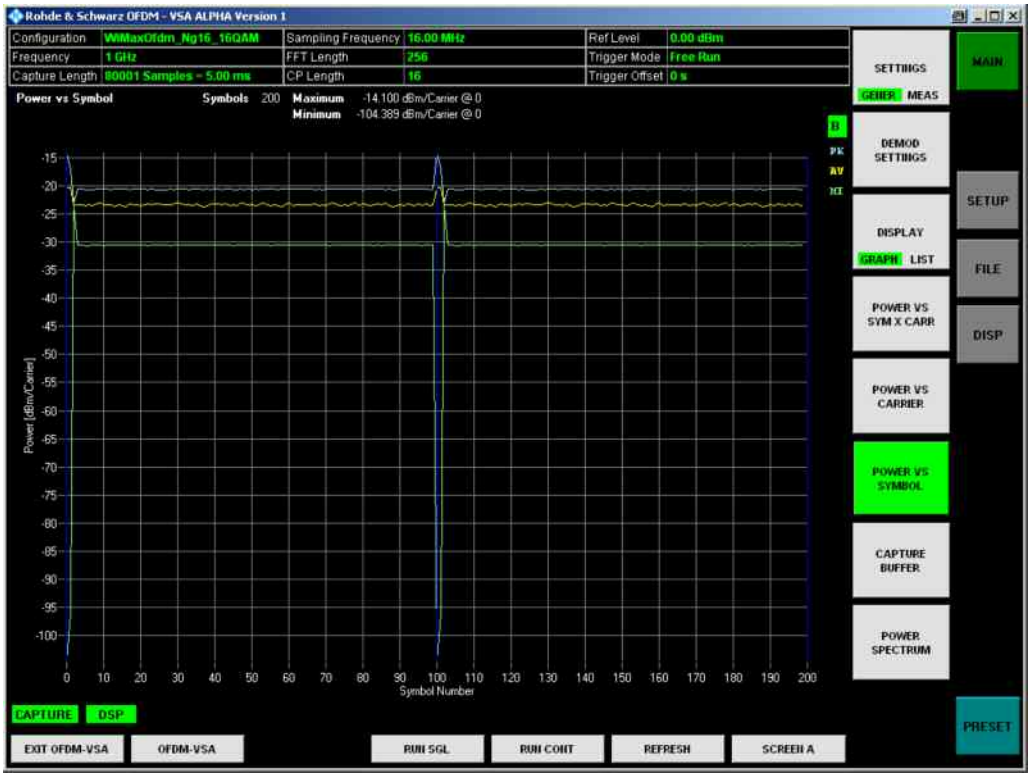
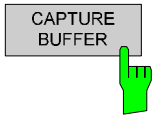


Fig. 16 Power vs. Symbol display

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.

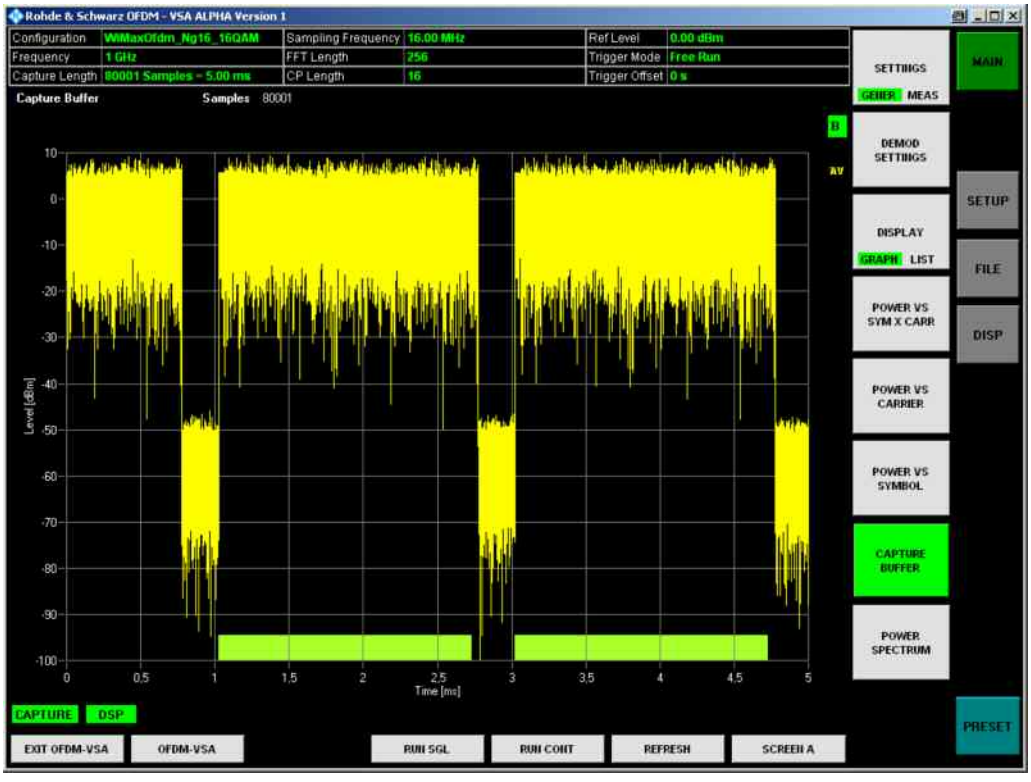
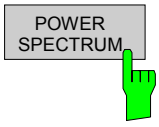


Fig. 17 Capture Buffer display

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.

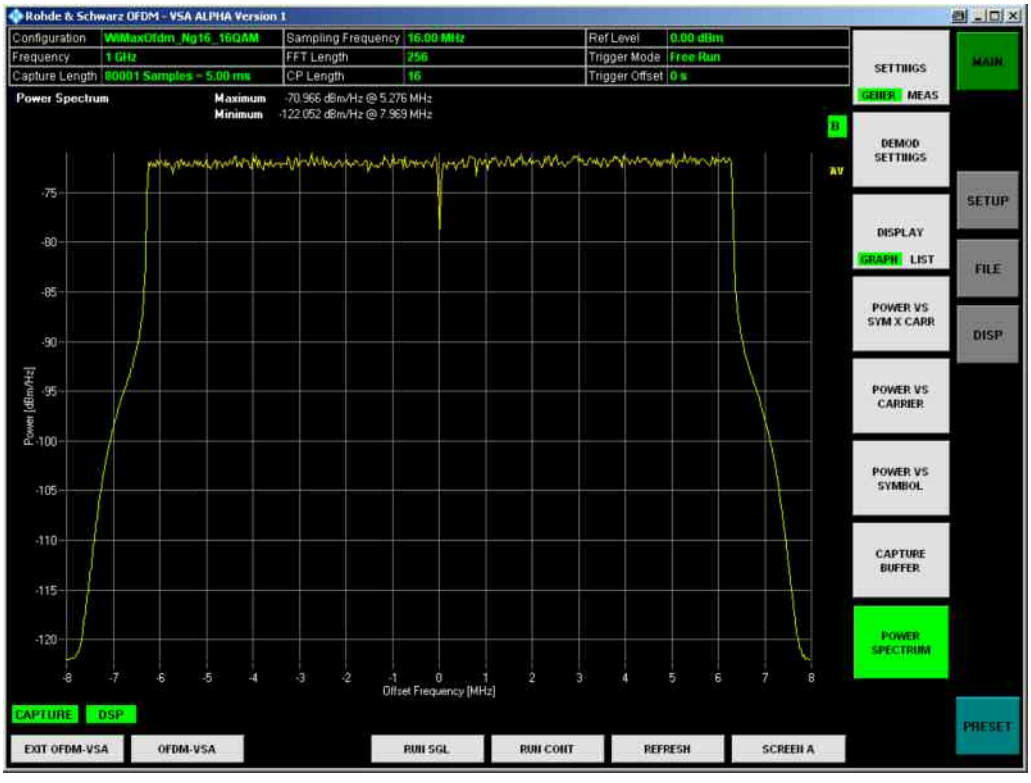
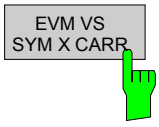


Fig. 18 Power Spectrum display

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.

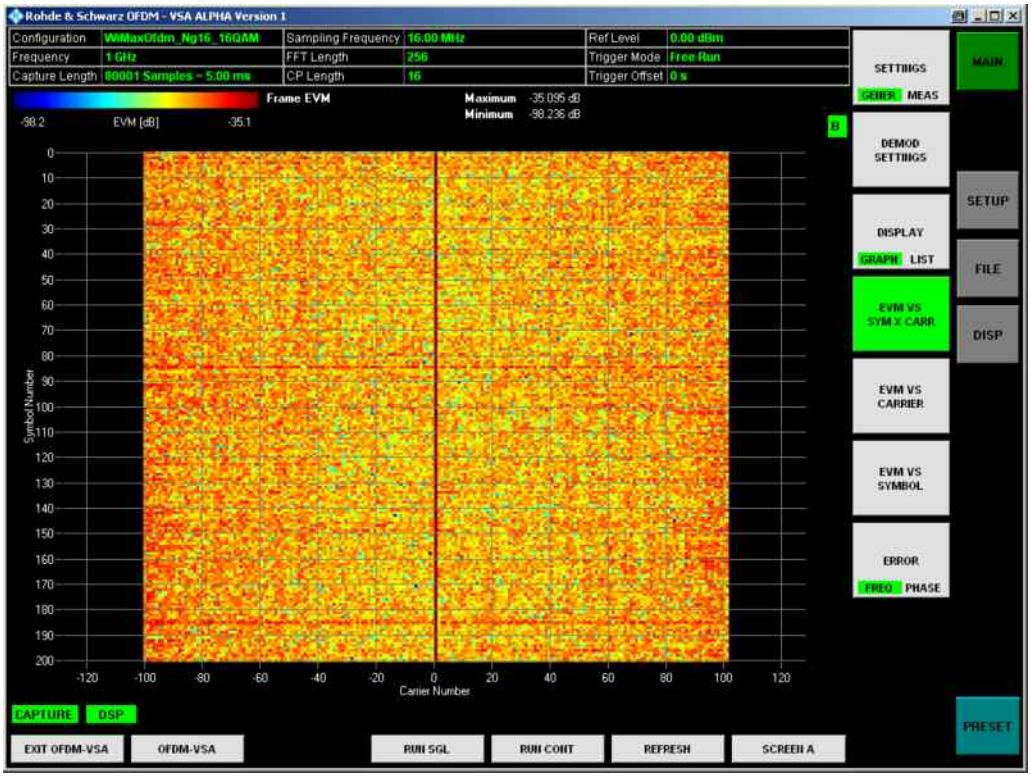
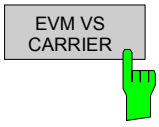


Fig. 19 EVM vs. Sym. X Carr. display

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.

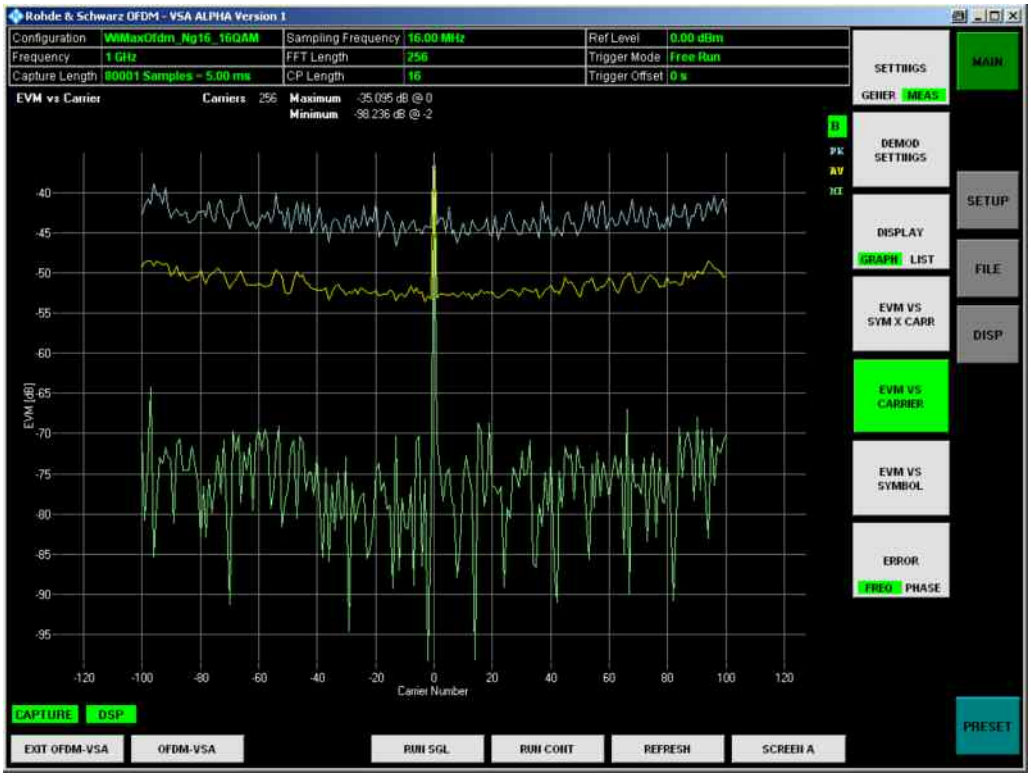
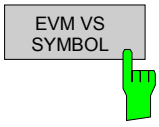


Fig. 20 EVM vs. Carrier display

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.

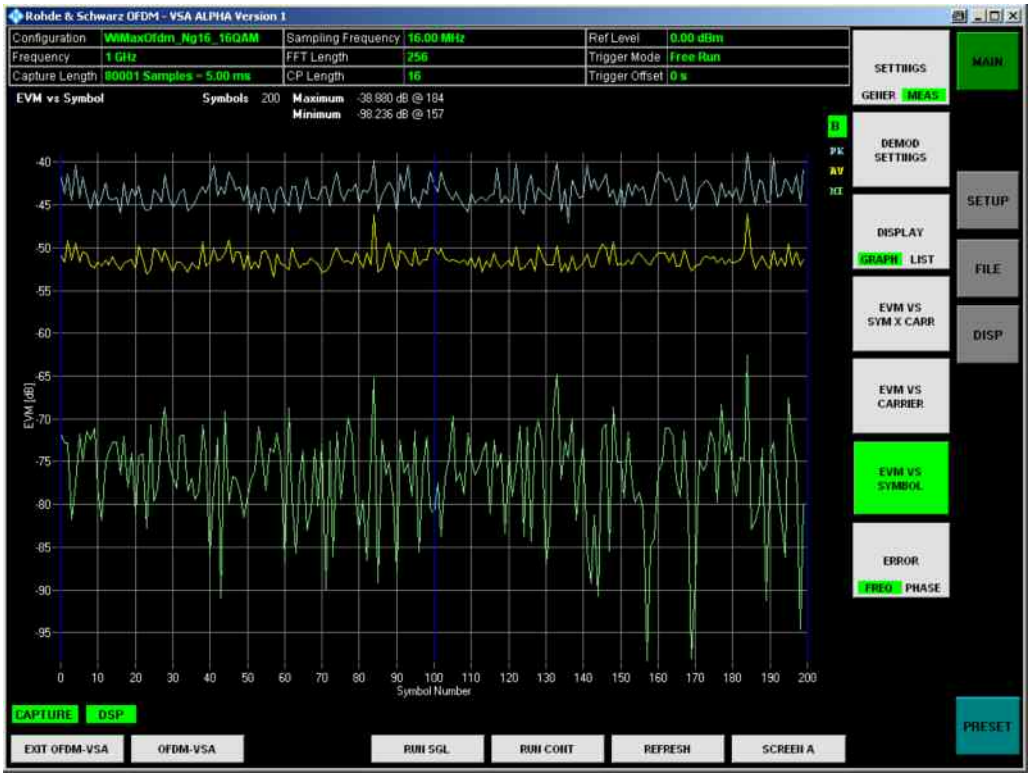
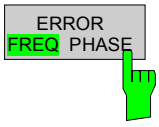


Fig. 21 EVM vs. Symbol display

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.

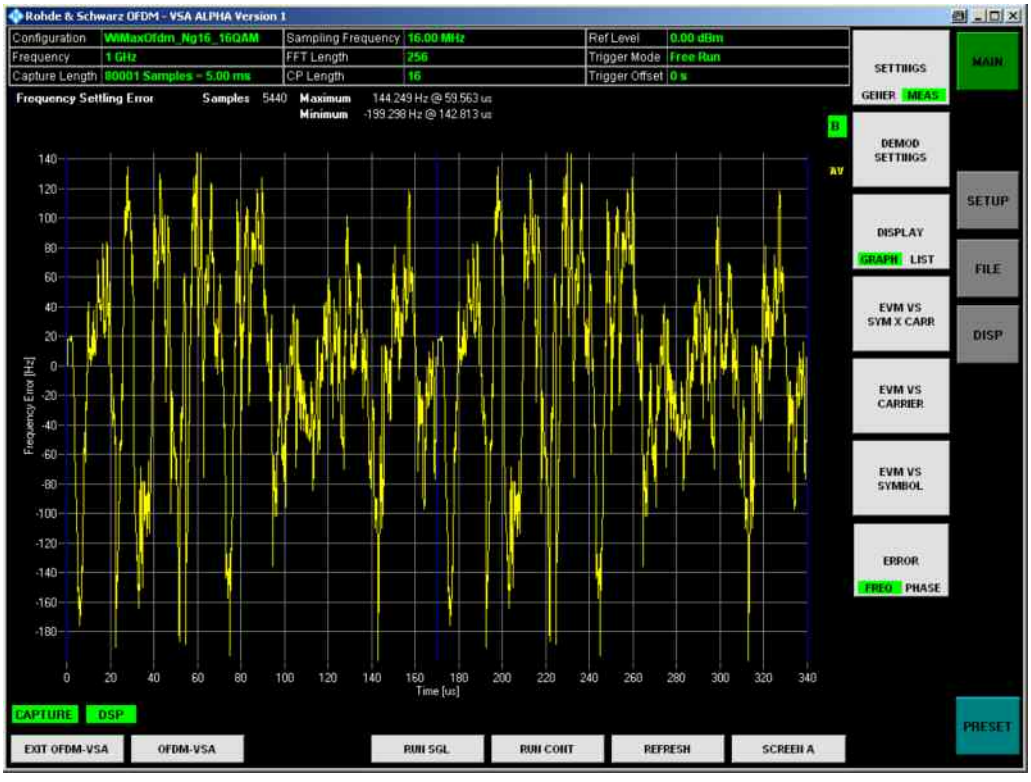
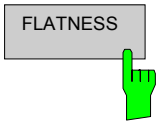


Fig. 22 Frequency Error display

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

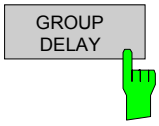


The Channel Flatness measurement results are selected by pressing the <*CHANNEL*> softkey in the main measurement softkey menu followed by the <*FLATNESS*> softkey.

Fig. 23 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.

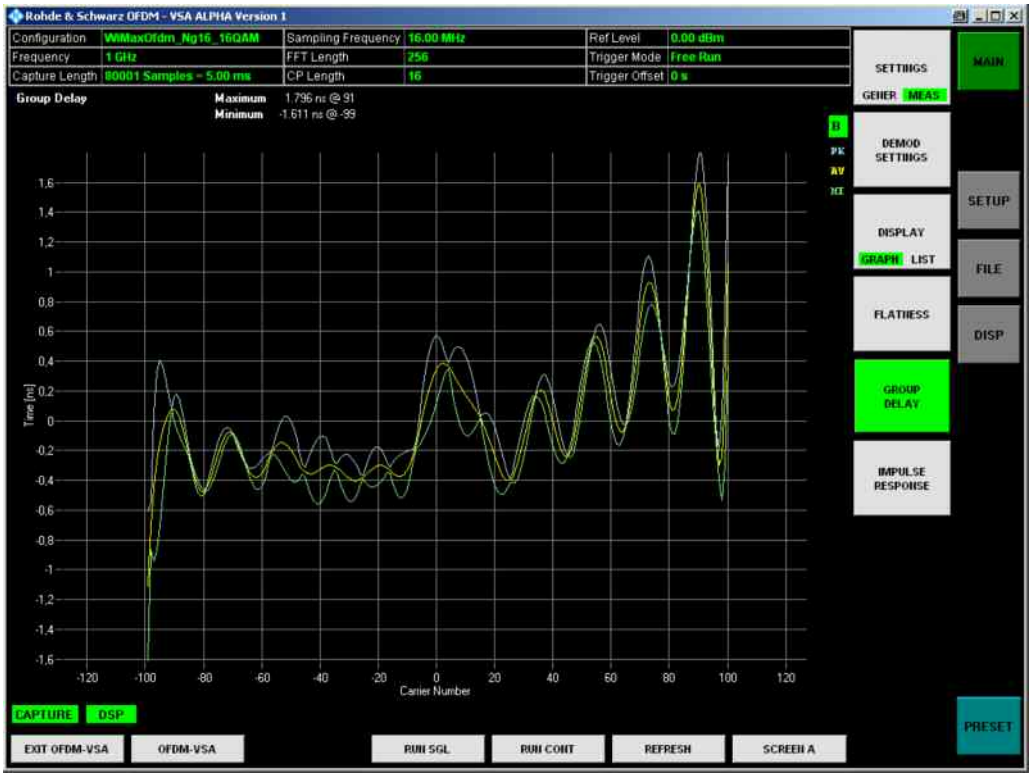
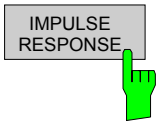


Fig. 24 Group Delay display

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.

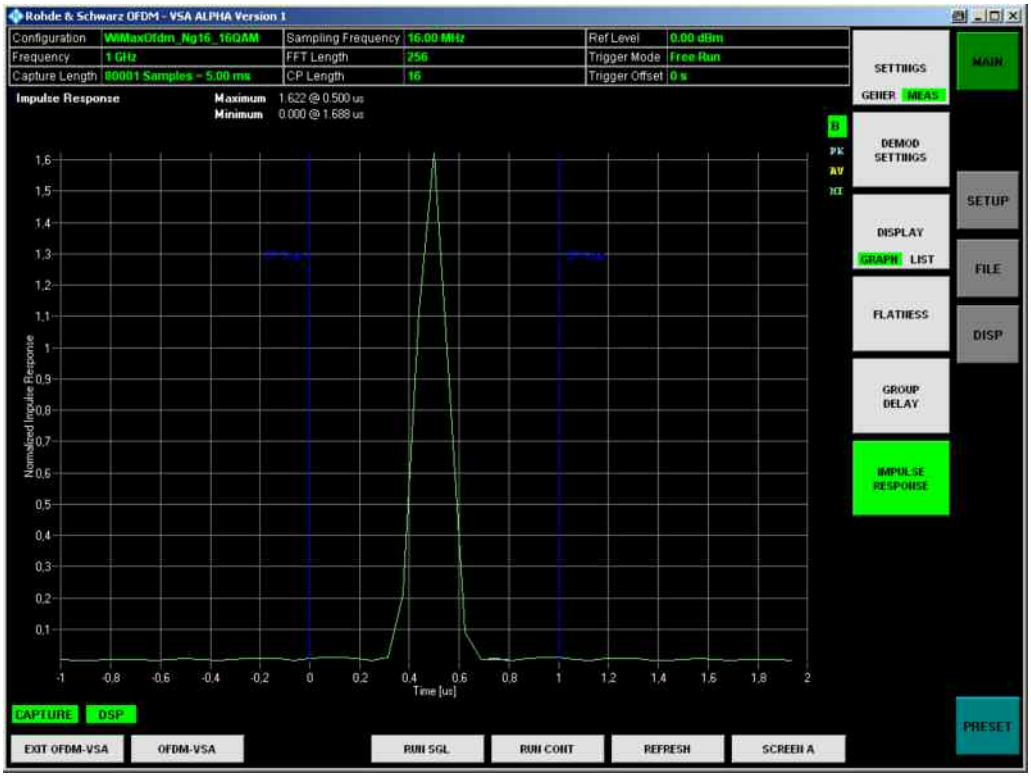
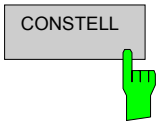


Fig. 25 Channel Impulse Response display

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.

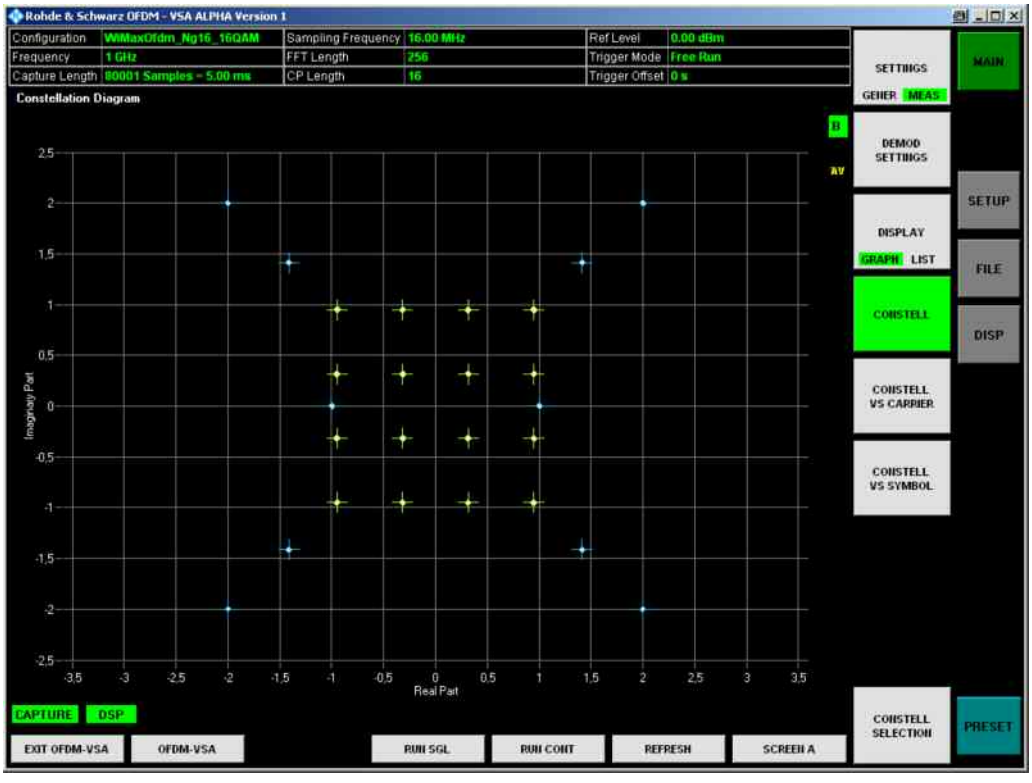
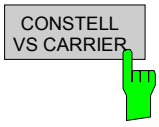


Fig. 26 Constellation Diagram display

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.

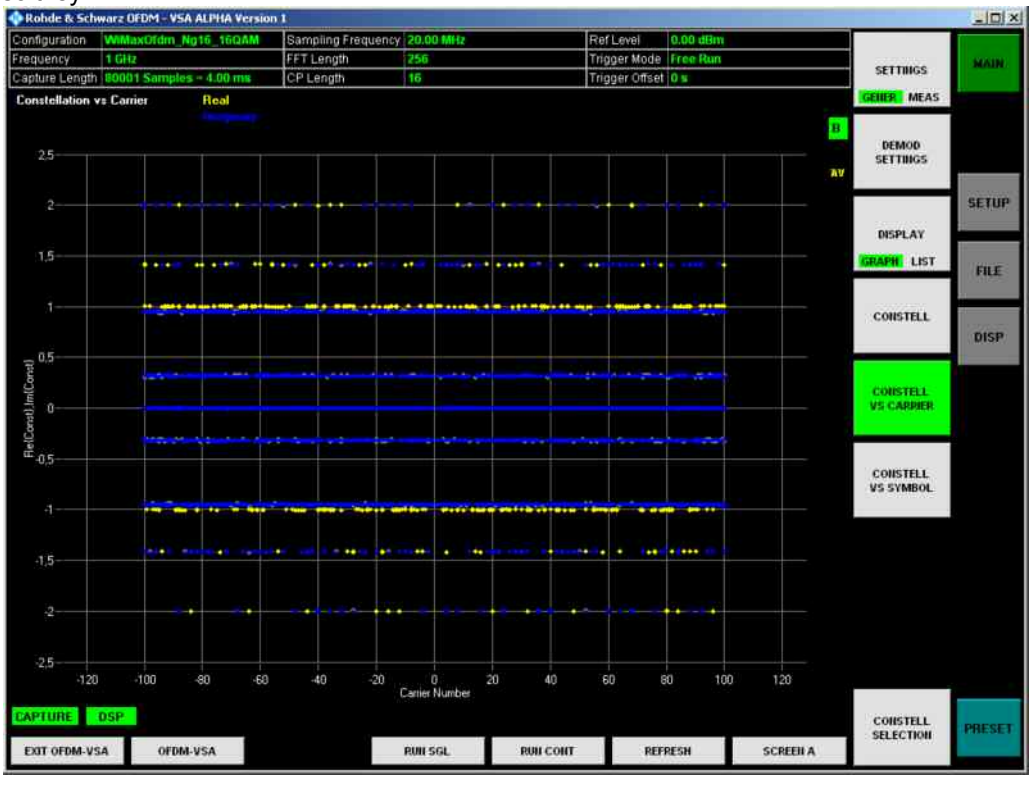
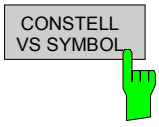


Fig. 27 Constellation vs. Carrier display

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.

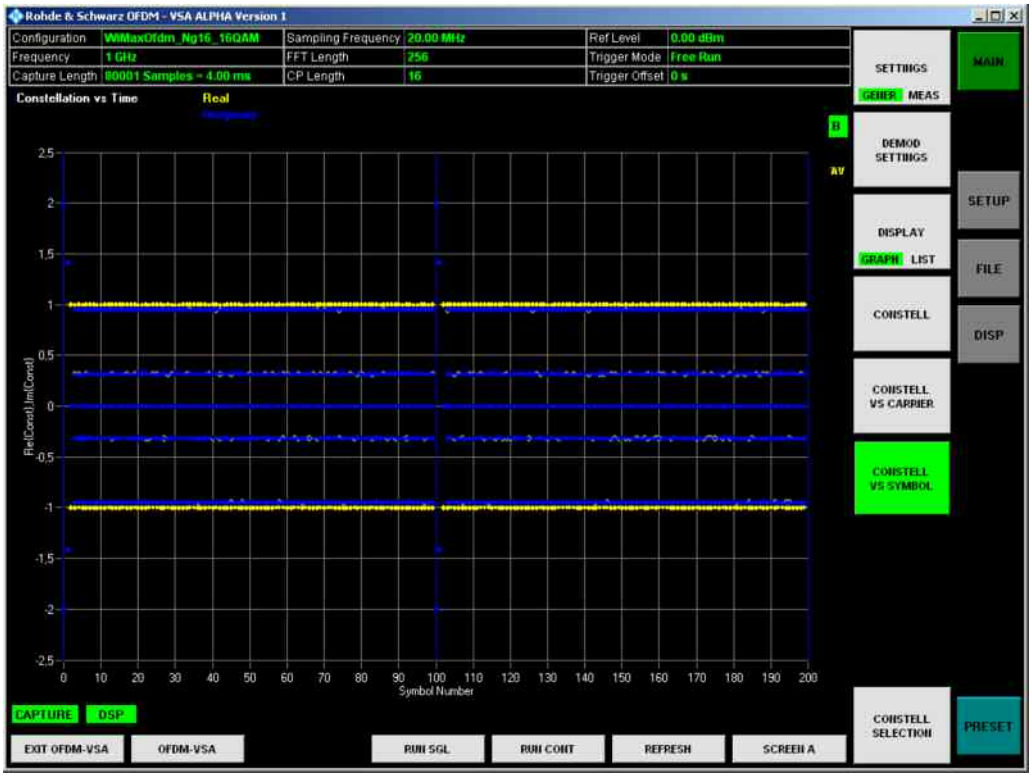
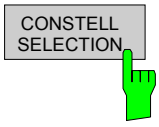


Fig. 28 Constellation vs. Symbol display

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.)

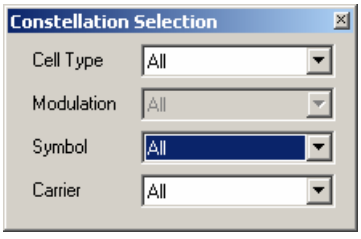
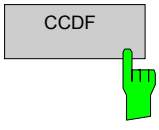


Fig. 29 Constellation Evaluation Filter panel

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.

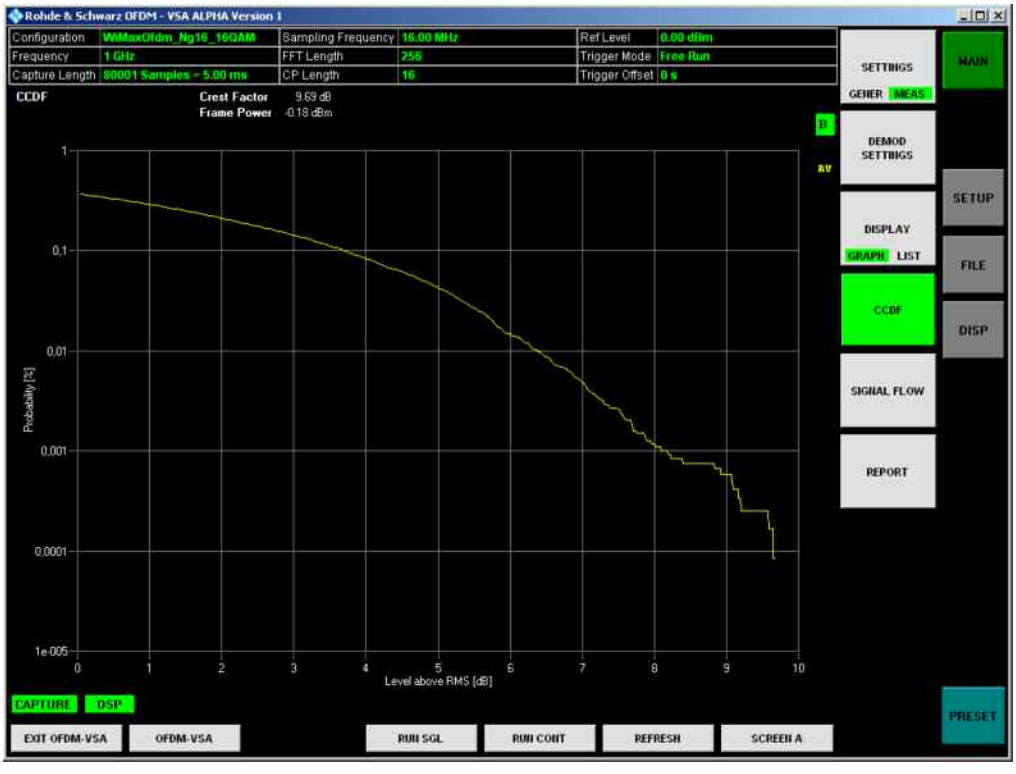
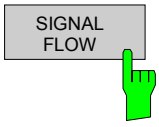


Fig. 30 CCDF display

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.

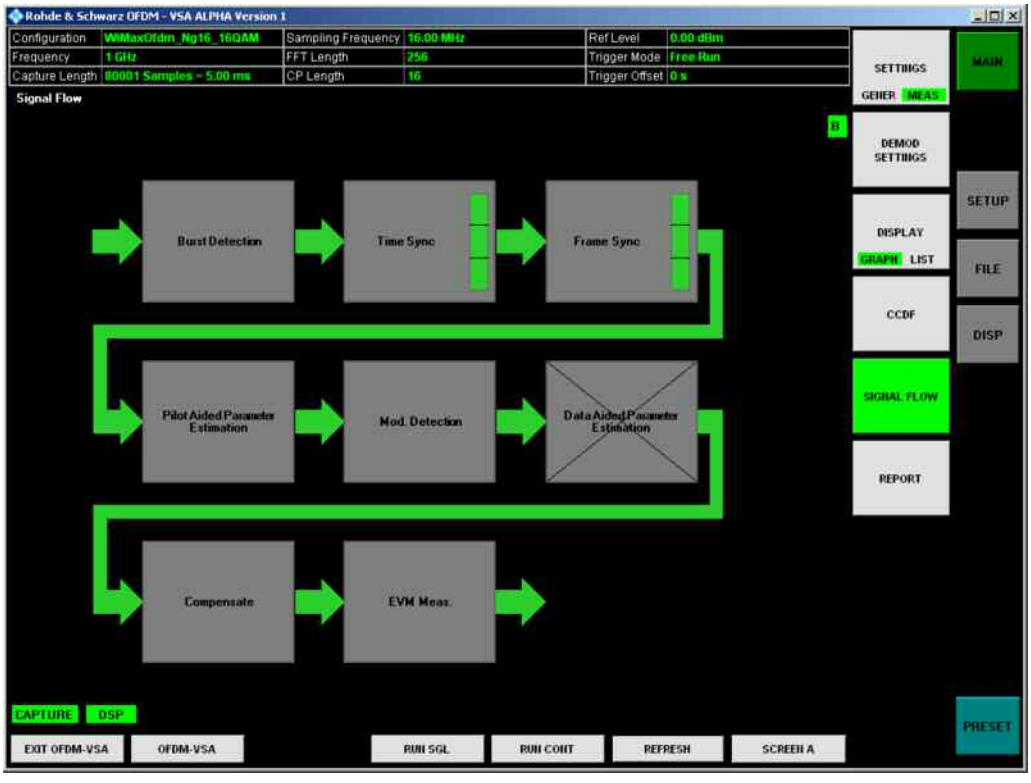


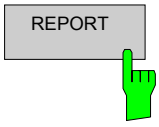
Fig. 31 Signal Flow display

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 4.

Demodulation Report



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

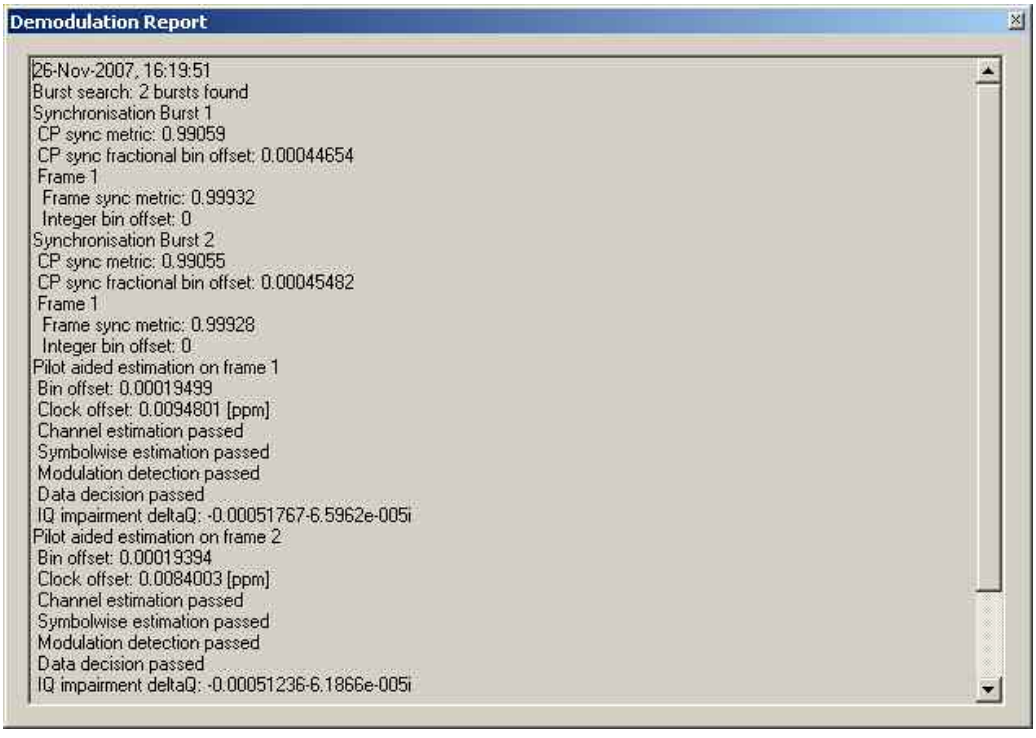


Fig. 32 Demodulation Report

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. 33 Result Summary display

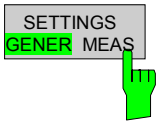
The Result Summary display is selected by pressing the <*DISPLAY – LIST*> softkey, which is available in all main measurement menus and submenus.

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 main 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.

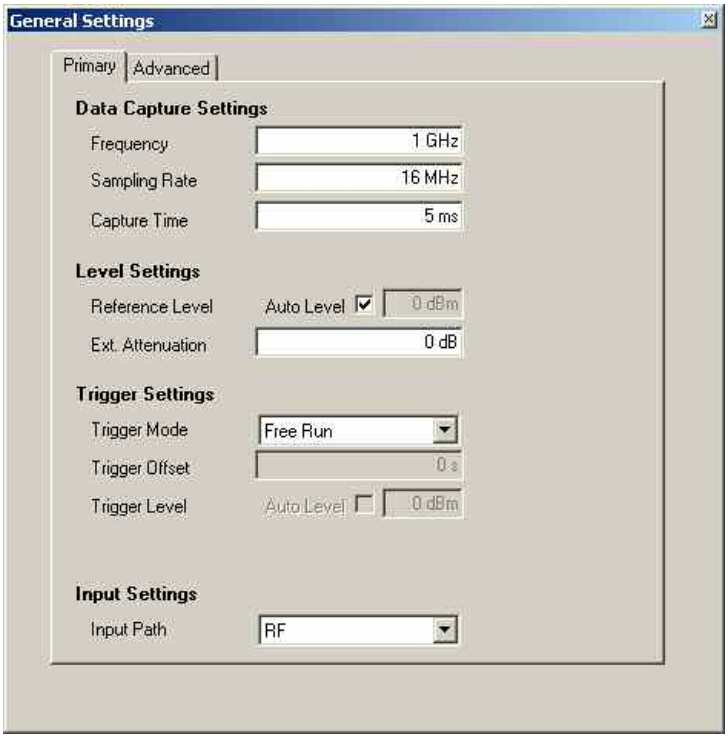


Fig. 34 Primary Tab of the General Settings Menu

Data Capture Settings

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

Frequency

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

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

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

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

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 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 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 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.

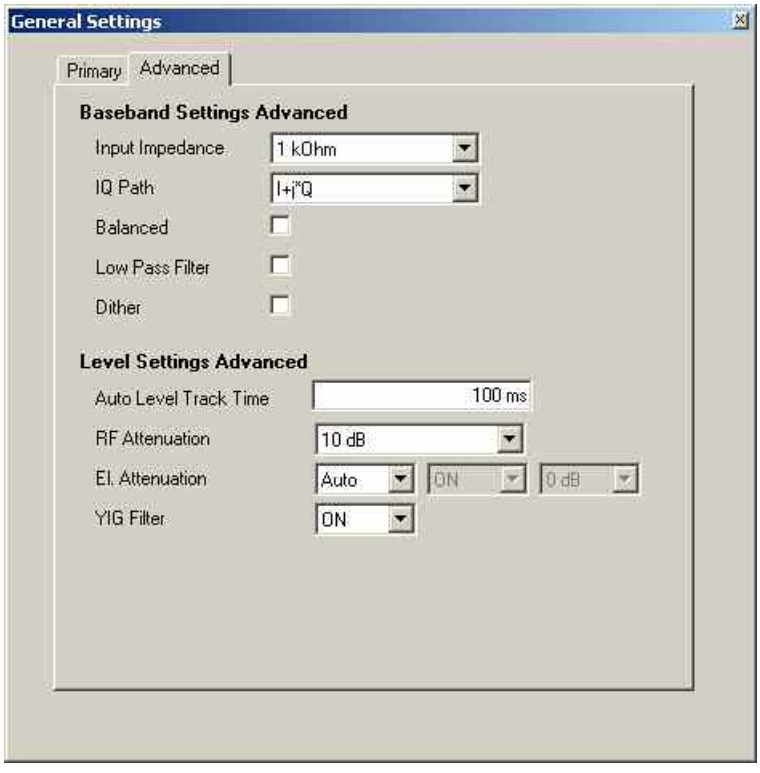


Fig. 35 Advanced Tab of the General Settings Menu

Baseband Settings Advanced

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

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

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

Lowpass

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

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.

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 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 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.

El. 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.

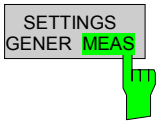
The *EL Attenuation* parameter can manually switched off or determined automatically.

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 specifiy units of the result axes. The following tabs offer specific settings for the different measurements.



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

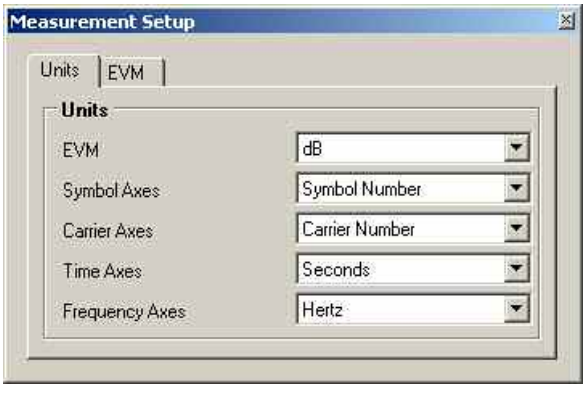


Fig. 36 Units Tab of the Measurement Settings Menu

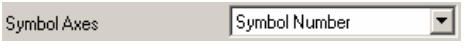
Units

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

EVM

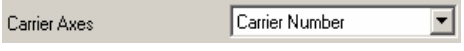
EVM specifies the unit of EVM results.
Available values: *dB* or *%*

Symbol Axes



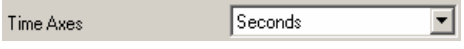
Symbol Axes specifies the unit of time axes representing symbol numbers.
Available values: *Symbol Number* or *Seconds*

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 specifies the unit of general frequency axes
Available values:
Hertz, Sample Rate or Subcarrier Spacing

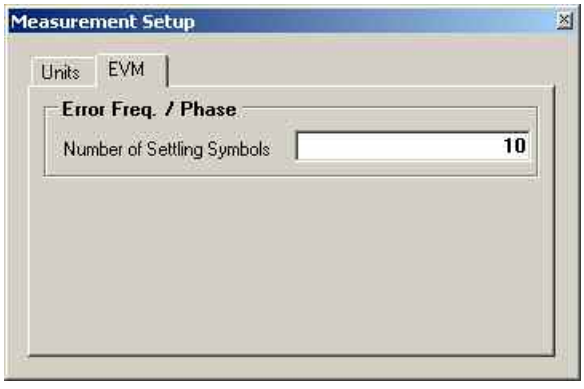


Fig. 37 EVM Tab of the Measurement Settings Menu

Error Freq. / Phase

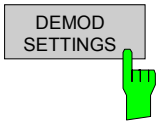
The Error Freq. / Phase group contains settings regarding the Error Freq. / Phase measurement within the EVM measurement group.

Number of Settling Symbols

Number of Settling Symbols 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 <*DEMOD SETTINGS*> softkey opens the Demodulation Settings panel.

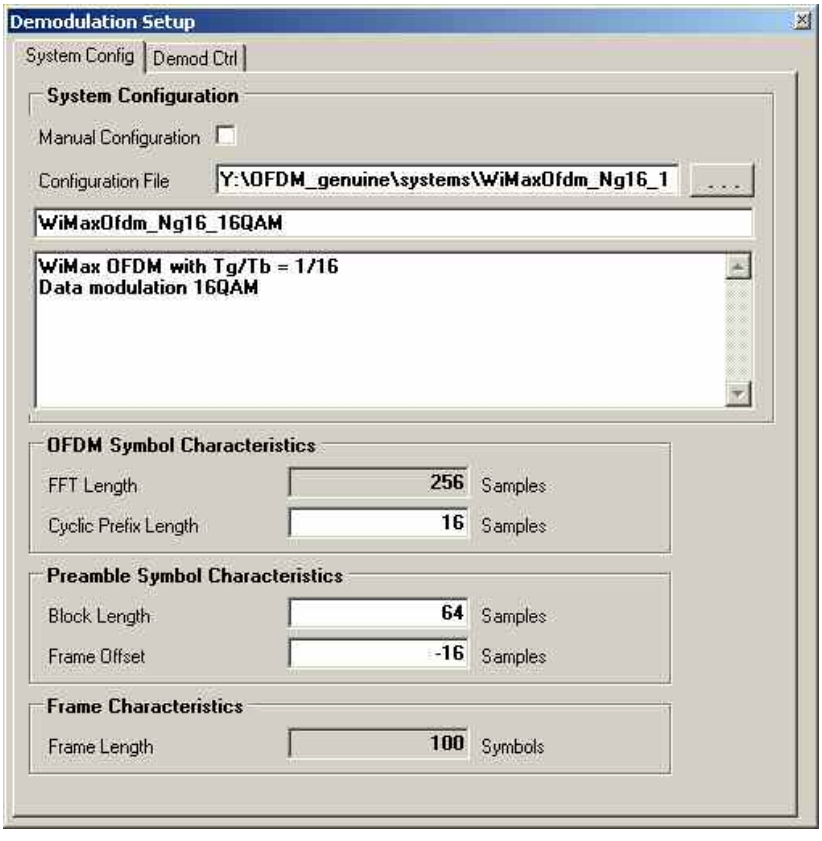


Fig. 38 System configuration tab of the Demodulation Setup menu

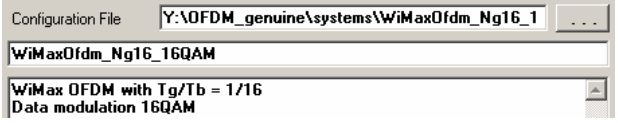
System Configuration

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

Frame Offset

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 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.

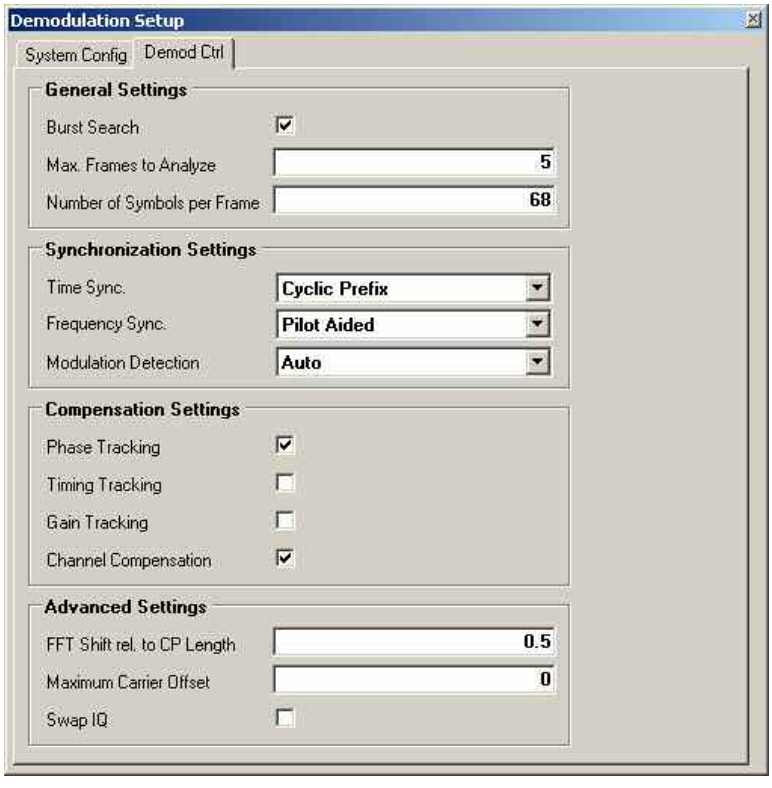


Fig. 39 Demodulation Control Tab of the Demodulation Setup Menu

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 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 specifies the maximum number of frames which are analyzed within one capture buffer.

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 Sytem Config menu.

Synchronization Settings

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

Time Synchronization

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. 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 specifies the operation mode of the automatic modulation detection for the data cells. If *Auto* 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.

Gain Tracking

Gain Tracking ☐

Gain Tracking specifies whether or not the measurement results should be compensated for gain 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.

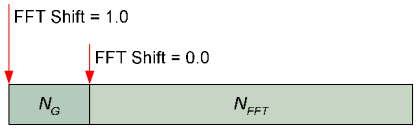
Advanced Settings

The Advanced Settings group contains settings which control certain signal processing steps within the R&S FSQ-K96 OFDM-VSA PC analysis software application.

FFT Shift relative to Cyclic Prefix Length

FFT Shift rel. to CP Length 0.5

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 0

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.

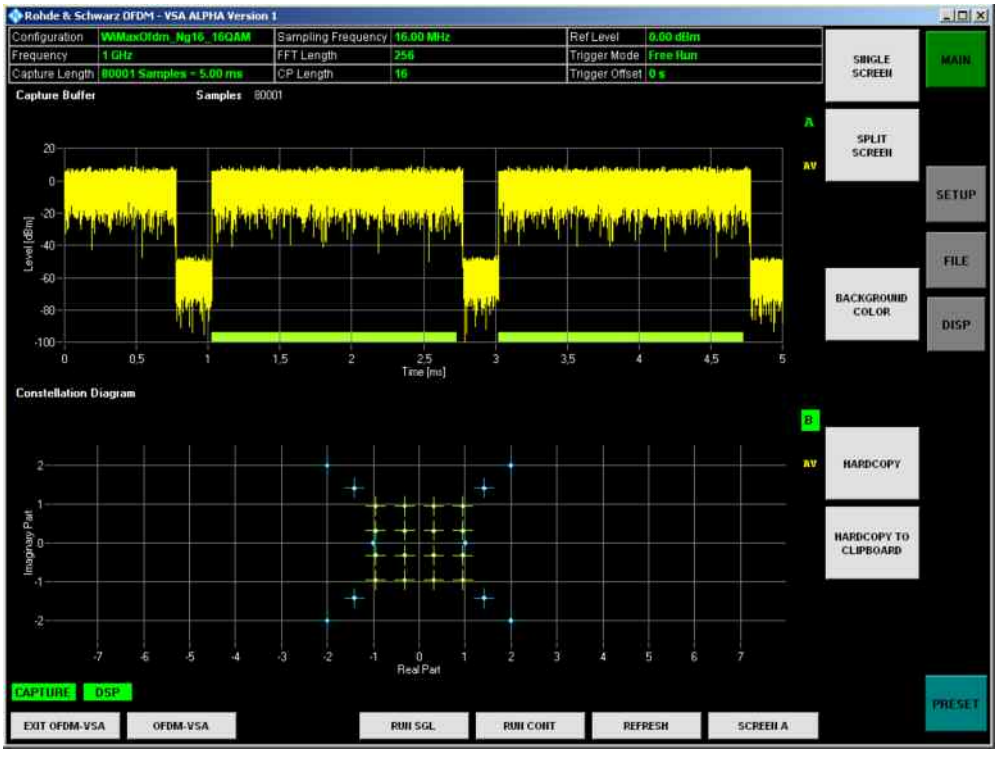


Fig. 40 Display menu

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.

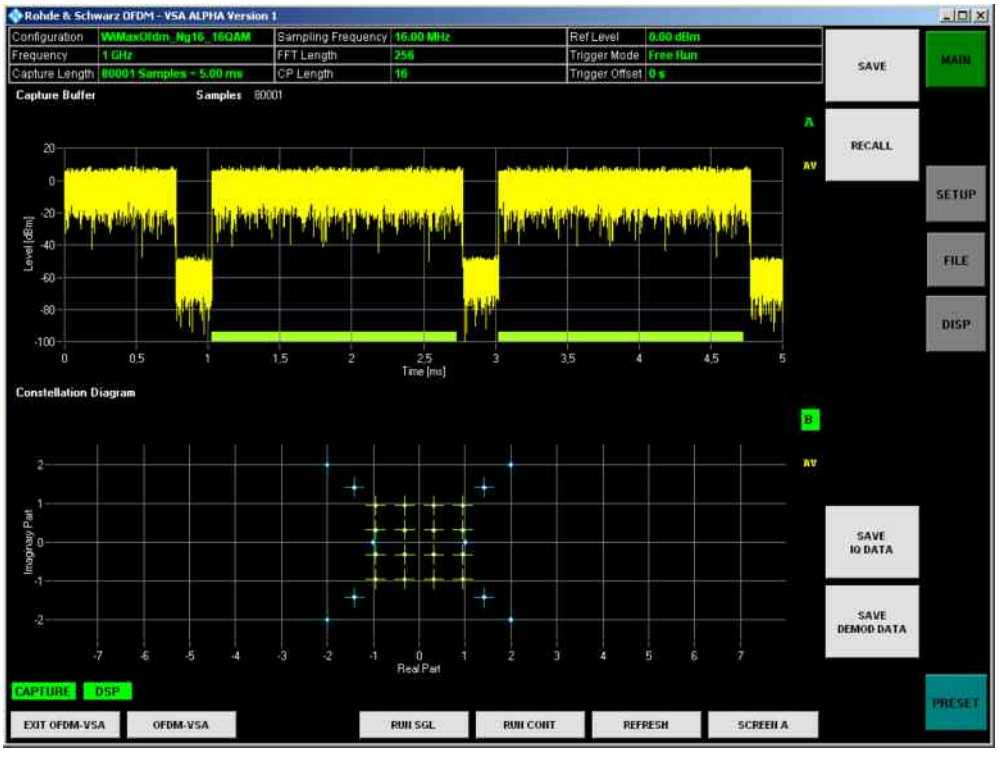


Fig. 41 File management menu

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 3 "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.

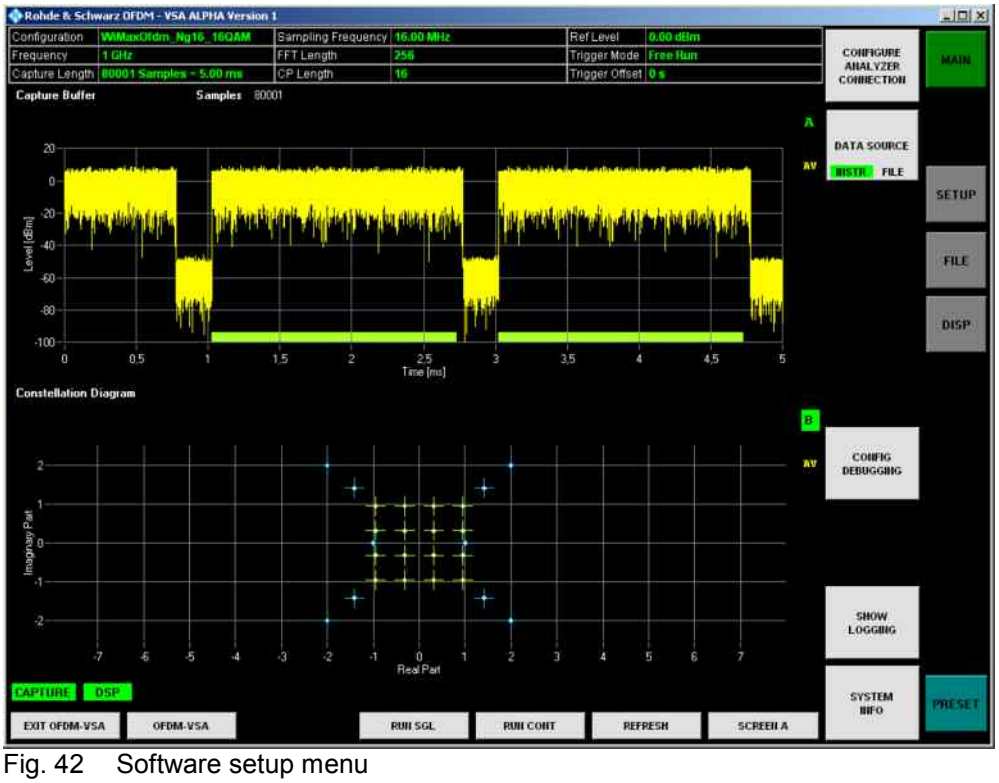
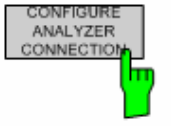
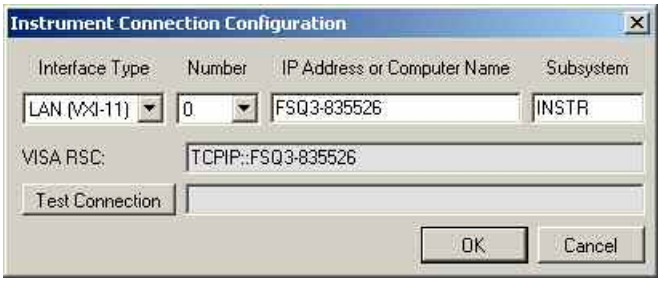


Fig. 42 Software setup menu

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:

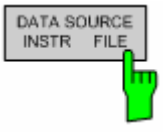


If more than one interface is available on the PC (e.g. because two LAN cards are installed), please select the appropriate interface *Number*. The *Subsystem* does not need to be changed.

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 *VXI-11 protocol*	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 *RSIB protocol*	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.

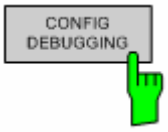
Data Source (Instrument or File)



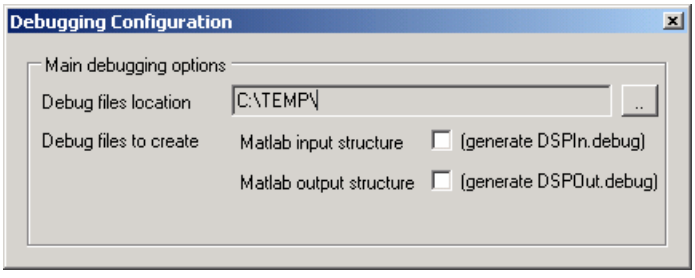
The <*DATA SOURCE*> softkey is used to specify the I/Q data source. Data can either be captured from the R&S analyzer (*INSTR* is selected) or read from file (*FILE* is selected). If *FILE* is selected, each time the user presses the <***RUN SGL***> or <***RUN CONT***> hotkey, a dialog is shown where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

Config Debugging



Pressing the <*CONFIG DEBUGGING*> softkey opens the following pop-up dialog:

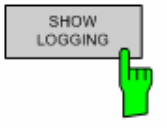


In this dialog you can choose whether to store debug information each time data is analyzed. The path where the debug information is stored can be selected as well as whether the input, the output, or both debug files shall be stored.

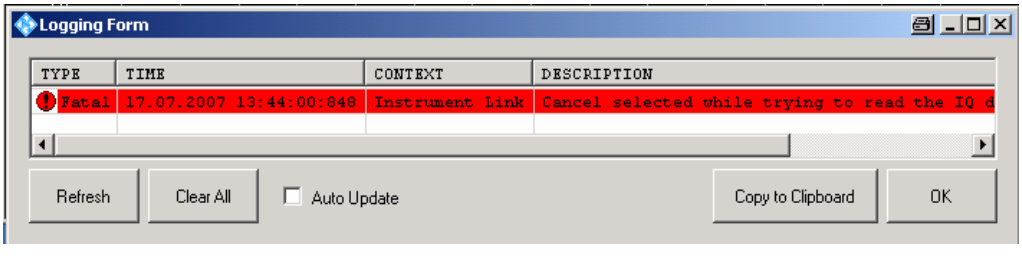
Note: *The creation of the debug files takes some time and will slow down the measurement, so this feature should not be activated unless it is necessary.*

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.

Show Logging

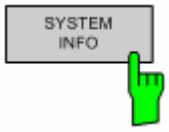


The <*SHOW LOGGING*> softkey is used to display an error messages history.

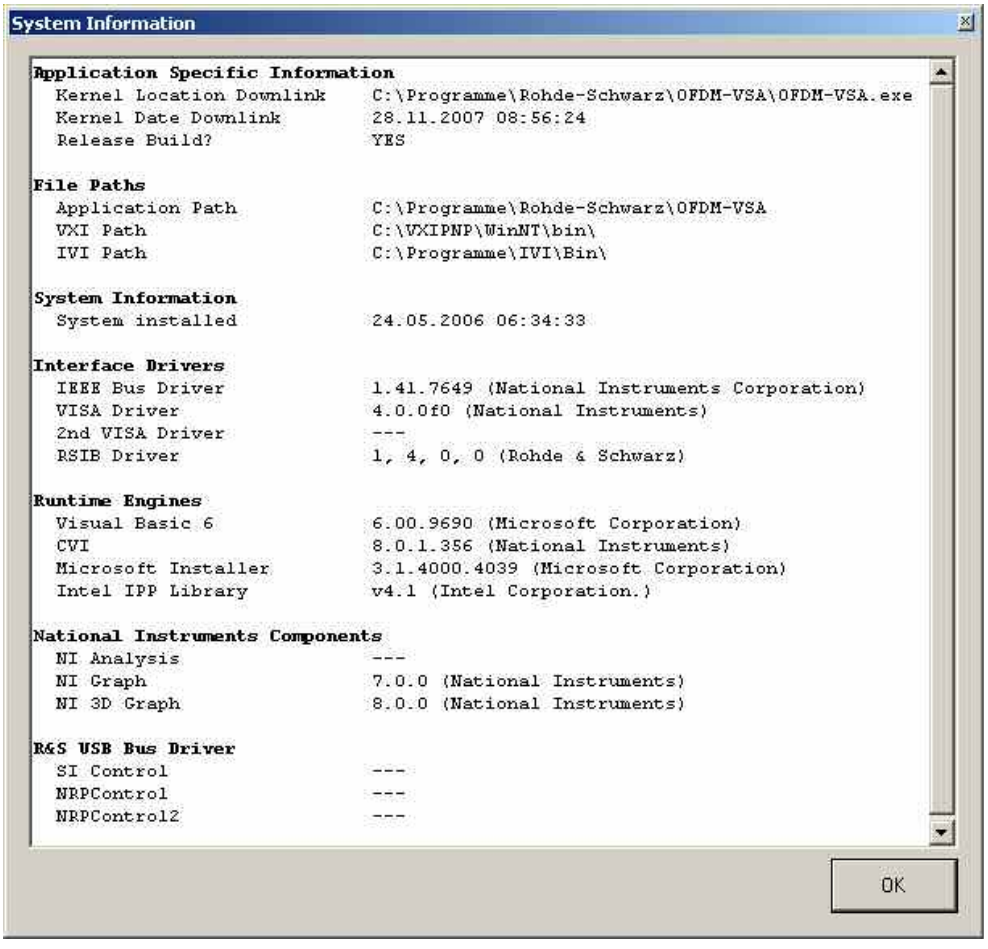


The message history can be refreshed and cleared, and the contents can be copied to the operating system clipboard.

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.



3 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

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*>.

4 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
iNOfSymbols	int32	Number of symbols described by this system definition. This is also the maximum result range.	100
meStructure	[iNOfSymbols 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	[0,0,1,1,1,1,1,1,1,1,0,0; 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

5 Measurements in Detail

This section provides a detailed explanation of the measurements provided by R&S FSQ-K96 OFDM-VSA and provides help to measure the characteristics of specific types of DUT.

Signal processing

Data capturing

The block diagram in Fig. 34 shows the R&S FSQ hardware from the IF section to the processor running the OFDM-VSA downlink measurement application. The selectable IF filter bandwidth ranges from 300 kHz to 50 MHz. The A/D converter samples the IF signal at a rate of 81.6 MHz. The digital signal is converted down to the complex baseband, is lowpass-filtered, and is resampled to the nearest multiple of the target sampling rate. The decimation filters suppress the aliasing frequencies arising from the subsequent downsampling to the target rate. Up to 16 M samples[1] of the now available I/Q data can be stored in the capture buffer.

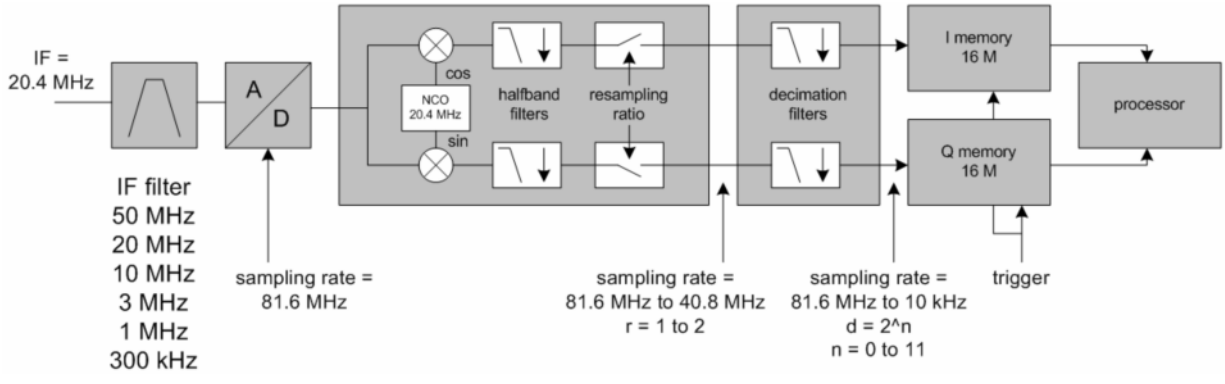


Fig. 43 Data capturing mechanism of the R&S FSQ

The maximum allowable bandwidth of the measurement signal depends on the target sampling rate according to Table 1.

Table 1 Maximum bandwidth depending on the target sampling rate

sampling rate	**max. bandwidth**
10 kHz to 20.4 MHz	0.8 x sampling rate
20.4 MHz to 40.8 MHz	0.68 x sampling rate
40.8 MHz to 81.6 MHz	30 MHz

[1] More capture buffer is available with additional R&S FSQ-B100/-B102 options.

OFDM-VSA measurement application

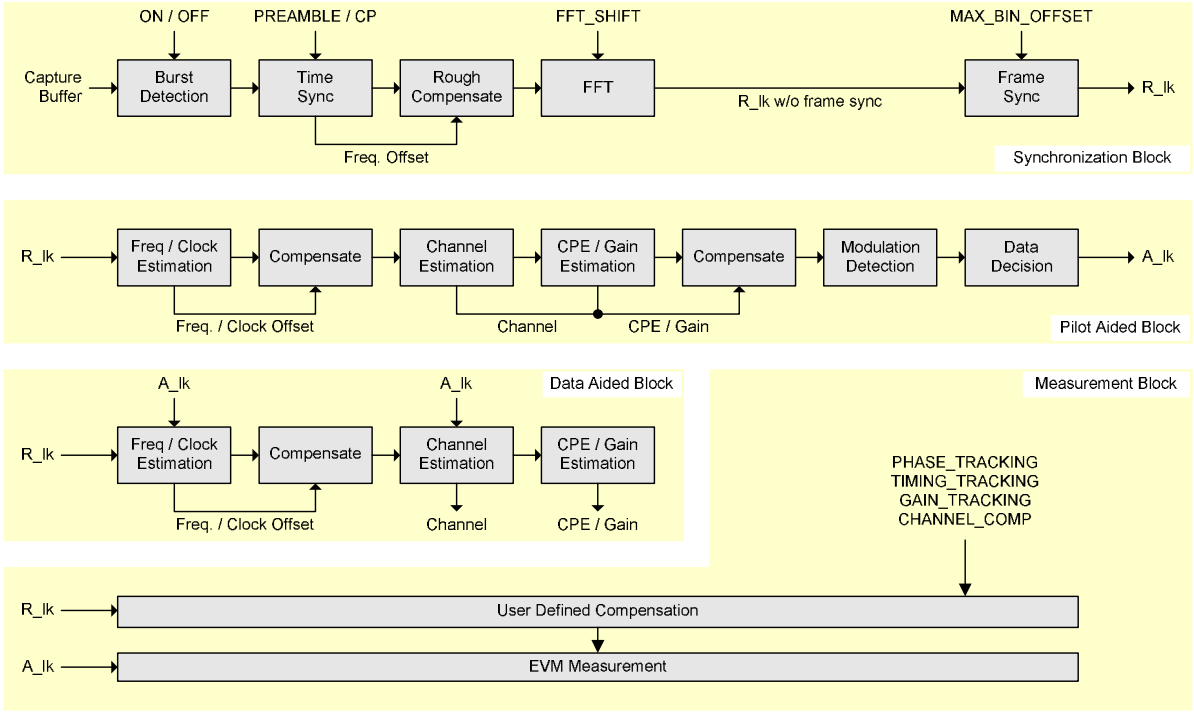


Fig. 44 Block diagram of the OFDM-VSA measurement application

The block diagram in Fig. 44 shows the OFDM-VSA measurement application from the capture buffer containing the I/Q data to the actual analysis block. The signal processing process can be divided in four major blocks:

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

Synchronization Block

The synchronization block starts with an optional detection of power bursts. If burst detection is selected, only bursts with sufficient power are transferred to the subsequent blocks.
The time synchronization module estimates the OFDM symbol timing and coarsely the frequency offset, which is compensated afterwards. The time synchronization can work either by cyclic prefix correlation or by evaluating repetitive preamble structures.
The FFT performs the transform from time domain into frequency domain. Its output is the time-frequency matrix ‘R_lk’ which contains the uncompensated OFDM cells. In manual configuration mode or if no frequency synchronization is selected, the demodulation stops at this point.
The frame synchronization matches the preknown pilot pattern to the actual received signal and returns the frame start symbol within ‘R_lk’.

Pilot Aided Block

The pilot aided measurement block uses the pilot cells as reference data to estimate the frequency error, clock error and channel transfer function. The channel transfer function is assumed to be stationary in time direction. A Wiener interpolation in frequency direction is used to calculate the channel at non-pilot positions.
Additionally the common phase error (CPE), clock deviations and gain deviations are tracked symbol by symbol. These parameters are fully compensated to get the best possible signal for the subsequent modulation detection and data decision. The block returns the deceided data matrix 'A_lk'.

Data Aided Block

The data aided measurement block can optionally switched on to refine the parameter estimations with the help of the decided data used as reference signal. In good signal to noise environments this block increases the accuracy of the estimates. However, if data decision errors lead to wrong decided data cells, the data aided estimation can corrupt the estimation results.

Measurement Block

The measurement block takes the received OFDM symbols 'R_lk' and the previously determined reference OFDM symbols 'A_lk' to calculate the error vector magnitude. The received OFDM symbols can optionally be compensated by means of phase, timing and gain deviations as well as the channel transfer function. The compensation can be controlled in detail by the Demod Control settings.

Measurement result definitions

Error vector magnitude (EVM)

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

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

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)

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

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

6 Glossary

Application path The path where the setup software installed the R&S FSQ-K96 OFDM-VSA analysis software (“%Program folder%\Rohde-Schwarz\OFDM-VSA” by default)

Cell Basic unit of an OFDM time frequency matrix. A cell is identified by a symbol number and a subcarrier number.

Cyclic Prefix Guard interval at the begin of the OFDM symbol to prevent intersymbol interference

FFT Fast Fourier Transform

OFDM Orthogonal Frequency Division Multiplexing

Subcarrier Basic unit in frequency domain. Each subcarrier can be modulated independently.

Symbol Block in time domain consisting of the cyclic prefix and FFT interval

System root The path where Microsoft Windows is installed;
by default, this is C:\WINNT

7 Troubleshooting

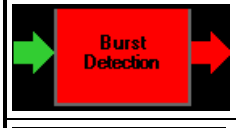
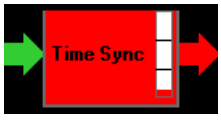
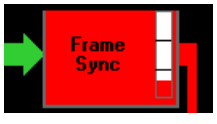
This section shows the most common problems that occur when using the R&S FSQ-K96 OFDM-VSA analysis software.

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 R&S FSQ, the error message "Instrument not found @ …" occurs.	The software cannot connect to the measurement instrument. Check the connection setup ([**SETUP**] <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 R&S FSQ, 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 R&S FSQ 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
	• Burst Search ON but signal is not bursted • Bursts are shorter than required by the setting ‘Number of Symbol per Frame’ in ‘Demod Ctrl’
	• The time domain structure of the signal doesn’t match the settings. Check the following parameters: ○ Sampling Rate ○ FFT Length ○ Cyclic Prefix Length (If ‘Time Sync’ = ‘Cyclic Prefix’) ○ Preamble Block Length (If ‘Time Sync’ = ‘Preamble’)
	• Frames are shorter than required by the setting ‘Number of Symbol per Frame’ in ‘Demod Ctrl’ • The pilot cells of the signal doesn’t match the configuration ○ Check the pilot matrix in the configuration file ○ Increase ‘Maximum bin offset’ in ‘Demod Ctrl’ if a frequency offset of more than one subcarrier spacing could occur ○ Try ‘Swap IQ’ to interchange I and Q parts of the signal

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