Software Manual

R&S® FSQ-K100/K102

EUTRA/LTE Downlink PC Software

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ROHDE&SCHWARZ
Test and Measurement

The following abbreviations are used throughout this manual
The R&S® FSQ-K100/K102 EUTRA / LTE downlink PC software is referred to as FSQ K100/K102.
The R&S® FSQ signal analyzer is referred to as FSQ.
The R&S® AFQ, AMU, SMATE, SMJ and SMU vector signal generators are referred to as R&S Signal Generator

Before putting the product into operation for the first time, make sure to read the following

Safety Instructions

Rohde & Schwarz makes every effort to keep the safety standard of its products up to date and to offer its 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. This product 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, Rohde & Schwarz 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 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 operating manual and within its performance limits (see data sheet, documentation, the following safety instructions). Using the products requires technical skills and knowledge of English. It is therefore essential that the products be used exclusively by skilled and specialized staff or thoroughly trained personnel with the required skills. If personal safety gear is required for using Rohde & Schwarz products, this will be indicated at the appropriate place in the product documentation.

Symbols and safety labels

							
Observe operating instructions	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 other parts of the documentation. In these safety instructions, the word "product" refers to all merchandise sold and distributed by Rohde & Schwarz, including instruments, systems and all accessories.

Tags and their meaning

DANGER	This tag indicates a safety hazard with a high potential of risk for the user that can result in death or serious injuries.
WARNING	This tag indicates a safety hazard with a medium potential of risk for the user that can result in death or serious injuries.
CAUTION	This tag indicates a safety hazard with a low potential of risk for the user that can result in slight or minor injuries.
ATTENTION	This tag indicates the possibility of incorrect use that can cause damage to the product.
NOTE	This tag indicates a situation where the user should pay special attention to operating the product but which does not lead to damage.

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. It is therefore essential to make sure that the tags described here are always used only in connection with the associated documentation and the associated product. The use of tags in connection with unassociated products or unassociated documentation can result in misinterpretations 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 max. 2000 m. Unless specified otherwise in the data sheet, 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 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 (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. 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.
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. Never remove the cover or part of the housing while you are operating the product. This 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 skilled 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 water, unless otherwise specified (see also safety instruction 1.). If this is not taken into account, there exists the danger of electric shock 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. 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 are hazardous waste. Dispose of them only in specially marked containers. Observe local regulations regarding waste disposal. Do not short-circuit batteries or storage batteries.
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. Please be aware of the weight of the product. Be careful when moving it; otherwise you may injure your back or other parts of your body.
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 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.

Por favor lea imprescindiblemente antes de la primera puesta en funcionamiento las siguientes informaciones de seguridad

Informaciones de seguridad

Es el principio de Rohde & Schwarz de tener a sus productos siempre al día con los estandards de seguridad y de ofrecer a sus 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. Este 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 estandards técnicos de seguridad. Para poder preservar este estado y garantizar un funcionamiento libre de peligros, deberá el usuario atenerse a todas las informaciones, informaciones de seguridad y notas de alerta. 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 solamente fue elaborado para ser utilizado en la indústria y el laboratorio o para fines de campo y de ninguna manera deberá ser utilizado de modo que alguna persona/cosa pueda ser dañada. 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 maluso del producto.

Se parte del uso correcto del producto para los fines definidos si el producto es utilizado dentro de las instrucciones del correspondiente manual del uso y dentro del margen de rendimiento definido (ver hoja de datos, documentación, informaciones de seguridad que siguen). El uso de los productos hace necesarios conocimientos profundos y el conocimiento del idioma inglés. Por eso se deberá tener en cuenta de exclusivamente autorizar para el uso de los productos a personas péritas o debidamente minuciosamente instruidas con los conocimientos citados. 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.

Símbolos y definiciones de seguridad

							
Ver manual de instrucciones del uso	Informaciones para maquinaria con uns 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 construción 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 otro capítulo de esta documentación y que también son obligatorias de seguir. En las informaciones de seguridad actuales hemos juntado todos los objetos vendidos por 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	Indica un punto de peligro con gran potencial de riesgo para el ususario.Punto de peligro que puede llevar hasta la muerte o graves heridas.
ADVERTENCIA	Indica un punto de peligro con un protencial de riesgo mediano para el usuario. Punto de peligro que puede llevar hasta la muerte o graves heridas .
ATENCIÓN	Indica un punto de peligro con un protencial de riesgo pequeño para el usuario. Punto de peligro que puede llevar hasta heridas leves o pequeñas
CUIDADO	Indica la posibilidad de utilizar mal el producto y a consecuencia dañarlo.
INFORMACIÓN	Indica una situación en la que deberían seguirse las instrucciones en el uso del producto, pero que no consecuentemente deben de llevar a un daño del mismo.

Las palabras de señal corresponden a la definición habitual para aplicaciones civiles en el ámbito de la comunidad económica europea. Pueden existir definiciones diferentes a esta definición. Por eso se debera tener en cuenta que las palabras de señal aquí descritas sean utilizadas siempre solamente en combinación con la correspondiente documentación 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 principialmente 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.
   A menos que se especifique otra cosa en la hoja de datos, 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 périto 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. Despues 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 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 averigurar 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, deberan 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 radiación HF, 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 está comprometido a valorar y señalar areas de trabajo en las que se corra un riesgo de exposición a radiaciones aumentadas de riesgo aumentado 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 prodcuto.
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 ya que 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 (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 construciones o instalaciones, se deberá instalar el interruptor al nivel de la instalación.

12. No utilice nunca el producto si está dañado el cable eléctrico. 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.
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 Ueff > 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 de la EC950/EN60950.
18. Nunca abra la tapa o parte de ella si el producto está en funcionamiento. 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 efecutadas 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, deberá la toma de corriente estar protegida de manera que los productos o los usuarios 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 corto circuitos 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 el agua 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 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. Si las baterías o los acumuladores no son cambiados con la debida atención existirá peligro de explosión (atención celulas de Litio). Cambiar las baterías o los acumuladores solamente por los del tipo R&S correspondiente (ver lista de piezas de recambio). Baterías y acumuladores son deshechos problemáticos. Por favor tirenlos en los recipientes especiales para este fín. Por favor tengan en cuenta las prescripciones nacionales de cada país referente al tratamiento de deshechos. Nunca sometan las baterías o acumuladores a un corto circuito.
28. Tengan en consideración de que en caso de un incendio pueden escaparse gases tóxicos del producto, que pueden causar daños a la salud.
29. 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.
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 sujecion 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 tenidas en cuenta. 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 y el fabricante no asumirá ninguna clase de responsabilidad por accidentes o colisiones.
33. Dado el caso de que esté integrado un producto de laser en un producto R&S (por ejemplo CD/DVD-ROM) no utilice otras instalaciones o funciones que las descritas en la documentación. De otra manera pondrá en peligro su salud, ya que el rayo laser puede dañar irreversiblemente sus ojos. Nunca trate de descomponer estos productos. Nunca mire dentro del rayo laser.

Contents

1 Introduction

The R&S FSQ-K100/K102 EUTRA/LTE downlink PC analysis software application uses the I/Q capture functionality of the R&S FSQ spectrum analyzer to enable EUTRA/LTE TX measurements in line with the EUTRA specification 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.

EUTRA/LTE

Currently, UMTS networks worldwide are being upgraded to high speed downlink packet access (HSDPA) in order to increase data rate and capacity for downlink packet data. In the next step, high speed uplink packet access (HSUPA) will boost uplink performance in UMTS networks. While HSDPA was introduced as a 3GPP Release 5 feature, HSUPA is an important feature of 3GPP Release 6. The combination of HSDPA and HSUPA is often referred to as HSPA.
However, even with the introduction of HSPA, the evolution of UMTS has not reached its end. HSPA+ will bring significant enhancements in 3GPP Release 7. The objective is to enhance the performance of HSPA-based radio networks in terms of spectrum efficiency, peak data rate and latency, and to exploit the full potential of WCDMA-based 5 MHz operation. Important features of HSPA+ are downlink multiple input multiple output (MIMO), higher order modulation for uplink and downlink, improvements of layer 2 protocols, and continuous packet connectivity.
In order to ensure the competitiveness of UMTS for the next 10 years and beyond, concepts for UMTS long term evolution (LTE) have been investigated. The objective is a high-data-rate, low-latency and packet-optimized radio access technology. Therefore, a study item was launched in 3GPP Release 7 on evolved UMTS terrestrial radio access (E-UTRA) and evolved UMTS terrestrial radio access network (E-UTRAN). LTE/E-UTRA will then form part of 3GPP Release 8 core specifications.
This introduction focuses on LTE/E-UTRA technology. In the following, the terms LTE or E-UTRA are used interchangeably.
In the context of the LTE study item, 3GPP work first focused on the definition of requirements, e.g. targets for data rate, capacity, spectrum efficiency, and latency. Also commercial aspects such as costs for installing and operating the network were considered. Based on these requirements, technical concepts for the air interface transmission schemes and protocols were studied. Notably, LTE uses new multiple access schemes on the air interface: orthogonal frequency division multiple access (OFDMA) in downlink and single carrier frequency division multiple access (SC-FDMA) in uplink. Furthermore, MIMO antenna schemes form an essential part of LTE. In an attempt to simplify protocol architecture, LTE brings some major changes to the existing UMTS protocol concepts. Impact on the overall network architecture including the core network is being investigated in the context of 3GPP system architecture evolution (SAE).

Requirements for UMTS Long-Term Evolution

LTE is focusing on optimum support of packet switched (PS) services. Main requirements for the design of an LTE system are documented in 3GPP TR 25.913 [1] and can be summarized as follows:

- **Data Rate:** Peak data rates target 100 Mbps (downlink) and 50 Mbps (uplink) for 20 MHz spectrum allocation, assuming two receive antennas and one transmit antenna are at the terminal.
- **Throughput:** The target for downlink average user throughput per MHz is three to four times better than Release 6. The target for uplink average user throughput per MHz is two to three times better than Release 6.
- **Spectrum efficiency**: The downlink target is three to four times better than Release 6. The uplink target is two to three times better than Release 6.
- **Latency**: The one-way transit time between a packet being available at the IP layer in either the UE or radio access network and the availability of this packet at IP layer in the radio access network/UE

shall be less than 5 ms. Also C-plane latency shall be reduced, e.g. to allow fast transition times of less than 100 ms from camped state to active state.

- **Bandwidth:** Scaleable bandwidths of 5 MHz, 10 MHz, 15 MHz, and 20 MHz shall be supported. Also bandwidths smaller than 5 MHz shall be supported for more flexibility.
- **Interworking**: Interworking with existing UTRAN/GERAN systems and non-3GPP systems shall be ensured. Multimode terminals shall support handover to and from UTRAN and GERAN as well as inter-RAT measurements. Interruption time for handover between E-UTRAN and UTRAN/GERAN shall be less than 300 ms for realtime services and less than 500 ms for non-realtime services.
- **Multimedia broadcast multicast services** (MBMS): MBMS shall be further enhanced and is then referred to as E-MBMS.
- **Costs:** Reduced CAPEX and OPEX including backhaul shall be achieved. Cost-effective migration from Release 6 UTRA radio interface and architecture shall be possible. Reasonable system and terminal complexity, cost, and power consumption shall be ensured. All the interfaces specified shall be open for multi-vendor equipment interoperability.
- **Mobility**: The system should be optimized for low mobile speed (0 to 15 km/h), but higher mobile speeds shall be supported as well, including high speed train environment as a special case.
- **Spectrum allocation**: Operation in paired (frequency division duplex / FDD mode) and unpaired spectrum (time division duplex / TDD mode) is possible.
- **Co-existence**: Co-existence in the same geographical area and co-location with GERAN/UTRAN shall be ensured. Also, co-existence between operators in adjacent bands as well as cross-border co-existence is a requirement.
- **Quality of Service**: End-to-end quality of service (QoS) shall be supported. VoIP should be supported with at least as good radio and backhaul efficiency and latency as voice traffic over the UMTS circuit switched networks.
- **Network synchronization**: Time synchronization of different network sites shall not be mandated.

Long-Term Evolution Downlink Transmission Scheme

OFDMA

The downlink transmission scheme for E-UTRA FDD and TDD modes is based on conventional OFDM. In an OFDM 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 [2]. In this figure, a signal with 5 MHz bandwidth is shown, but the principle is of course the same for the other E-UTRA bandwidths. Data symbols are independently modulated and transmitted over a high number of closely spaced orthogonal subcarriers. In E-UTRA, downlink modulation schemes QPSK, 16QAM, and 64QAM are available.
In the time domain, a guard interval may be added to each symbol to combat inter-OFDM-symbol-interference due to channel delay spread. In E-UTRA, the guard interval is a cyclic prefix which is inserted prior to each OFDM symbol.

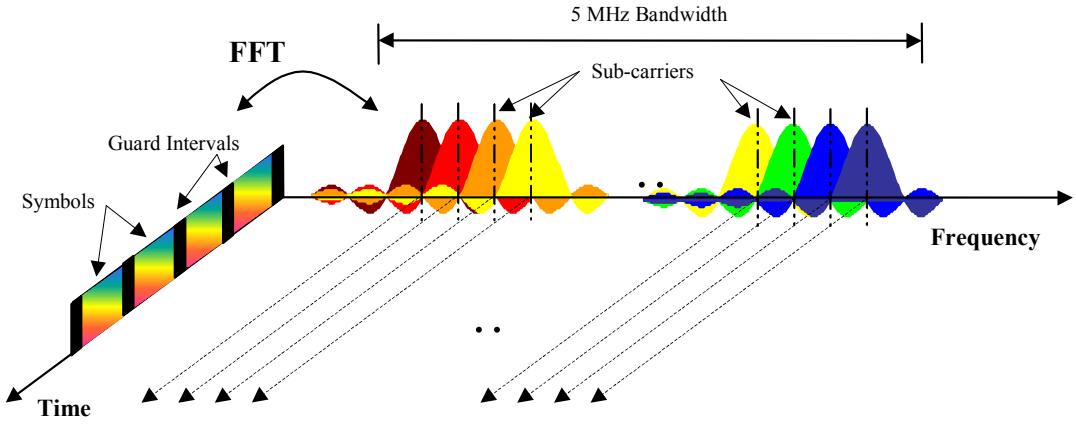


Fig. 1 Frequency-Time Representation of an OFDM Signal

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 $mT_u < t \leq (m+1)T_u$.

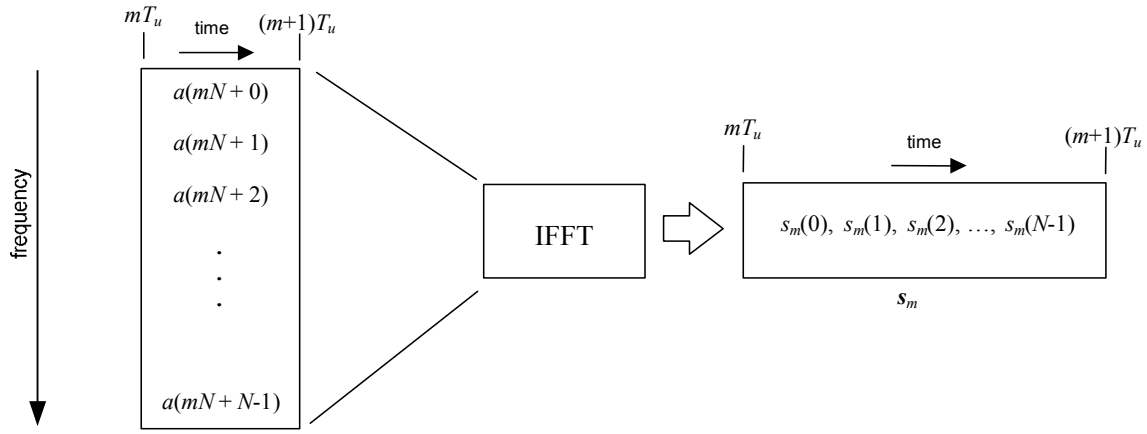


Fig. 2 OFDM Useful Symbol Generation Using an IFFT

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.

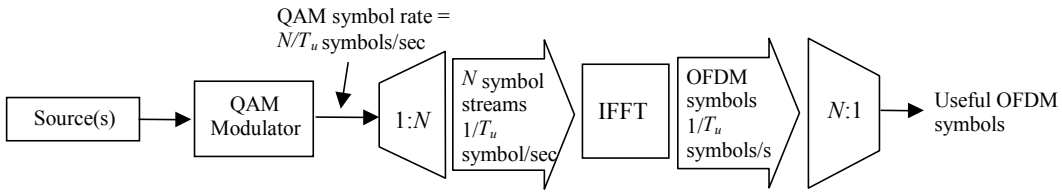


Fig. 3 OFDM Signal Generation Chain

In contrast to an OFDM transmission scheme, OFDMA allows the access of multiple users on the available bandwidth. Each user is assigned a specific time-frequency resource. As a fundamental principle of E-UTRA, the data channels are shared channels, i.e. for each transmission time interval of 1 ms, a new scheduling decision is taken regarding which users are assigned to which time/frequency resources during this transmission time interval.

OFDMA Parameterization

A generic frame structure is defined for both E-UTRA FDD and TDD modes. Additionally, an alternative frame structure is defined for the TDD mode only. The E-UTRA frame structures are defined in [3]. For the generic frame structure, the 10 ms radio frame is divided into 20 equally sized slots of 0.5 ms. A subframe consists of two consecutive slots, so one radio frame contains 10 subframes. This is illustrated in Fig. 4 (T_s expresses the basic time unit corresponding to 30.72 MHz).

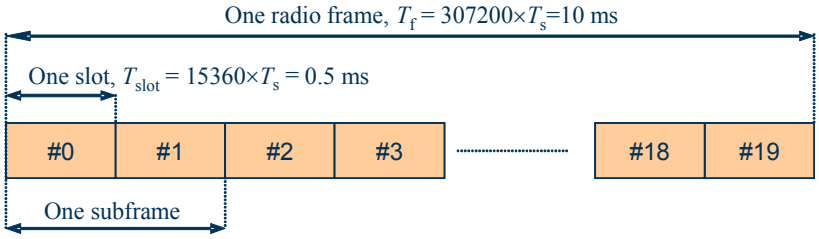


Fig. 4 Generic Frame Structure in E-UTRA Downlink

Fig. 5 shows the structure of the downlink resource grid for the duration of one downlink slot. The available downlink bandwidth consists of N_{BW}^{DL} subcarriers with a spacing of Δf = 15 kHz. In the case of multi-cell MBMS transmission (see chapter 7), a subcarrier spacing of Δf = 7.5 kHz is also possible. N_{BW}^{DL} can vary in order to allow for scalable bandwidth operation up to 20 MHz. Initially, the bandwidths for LTE were explicitly defined within layer 1 specifications. Later on a bandwidth agnostic layer 1 was introduced, with N_{BW}^{DL} for the different bandwidths to be specified by 3GPP RAN4 to meet performance requirements, e.g. for out-of-band emission requirements and regulatory emission limits.

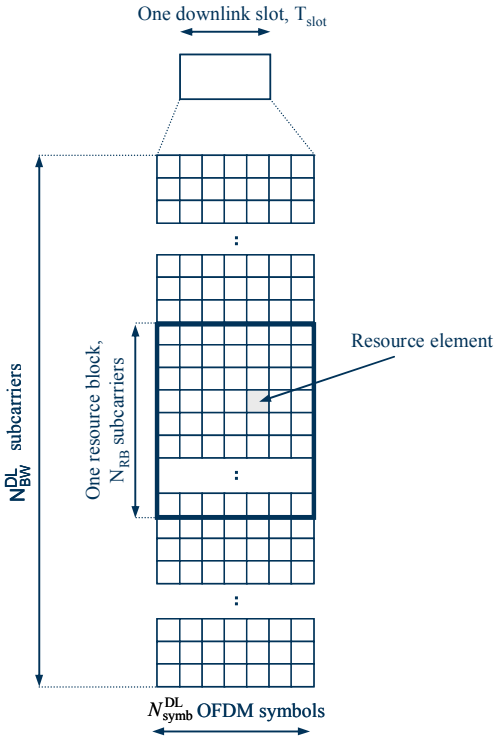


Fig. 5 Downlink Resource Grid

One downlink slot consists of N_{symb}^{DL} OFDM symbols. To each symbol, a cyclic prefix (CP) is appended as guard time, compare Fig. 1. N_{symb}^{DL} depends on the cyclic prefix length. The generic frame structure with normal cyclic prefix length contains N_{symb}^{DL} = 7 symbols. This translates into a cyclic prefix length of T_{CP} ≈5.2µs for the first symbol and T_{CP} ≈4.7µs for the remaining 6 symbols. Additionally, an extended cyclic prefix is defined in order to cover large cell scenarios with higher delay spread and MBMS transmission. The generic frame structure with extended cyclic prefix of T_{CP-E} ≈16.7µs contains N_{symb}^{DL} = 6 OFDM symbols (subcarrier spacing 15 kHz). The generic frame structure with extended cyclic prefix of T_{CP-E} ≈33.3µs contains N_{symb}^{DL} = 3 symbols (subcarrier spacing 7.5 kHz).
Table 1 gives an overview of the different parameters for the generic frame structure.

Table 1 Parameters for Downlink Generic Frame Structure

Configuration	Number of symbols N_{symb}^{DL}	Cyclic prefix length in samples	Cyclic prefix length in µs
Normal cyclic prefix Δf=15 kHz	7	160 for first symbol 144 for other symbols	5.2 µs for first symbol 4.7 µs for other symbols
Extended cyclic prefix Δf=15 kHz	6	512	16.7 µs
Extended cyclic prefix Δf=7.5 kHz	3	1024	33.3 µs

Downlink Data Transmission

Data is allocated to the UEs in terms of resource blocks. A physical resource block consists of 12 (24) consecutive subcarriers in the frequency domain for the Δf=15 kHz (Δf=7.5 kHz) case. In the time domain, a physical resource block consists of N_{symb}^{DL} consecutive OFDM symbols, see Fig. 5. N_{symb}^{DL} is equal to the number of OFDM symbols in a slot. The resource block size is the same for all bandwidths, therefore the number of available physical resource blocks depends on the bandwidth.
Depending on the required data rate, each UE can be assigned one or more resource blocks in each transmission time interval of 1 ms. The scheduling decision is done in the base station (eNodeB).
The user data is carried on the physical downlink shared channel (PDSCH). Downlink control signaling on the physical downlink control channel (PDCCH) is used to convey the scheduling decisions to individual UEs. The PDCCH is located in the first OFDM symbols of a slot.

Downlink Reference Signal Structure and Cell Search

The downlink reference signal structure is important for cell search, channel estimation and neighbor cell monitoring. Fig. 6 shows the principle of the downlink reference signal structure for one-antenna, two-antenna, and four-antenna transmission. Specific predefined resource elements in the time-frequency domain carry the reference signal sequence. Besides first reference symbols, there may be a need for second reference symbols. The different colors in Fig. 6 represent the sequences transmitted from up to four transmit antennas.

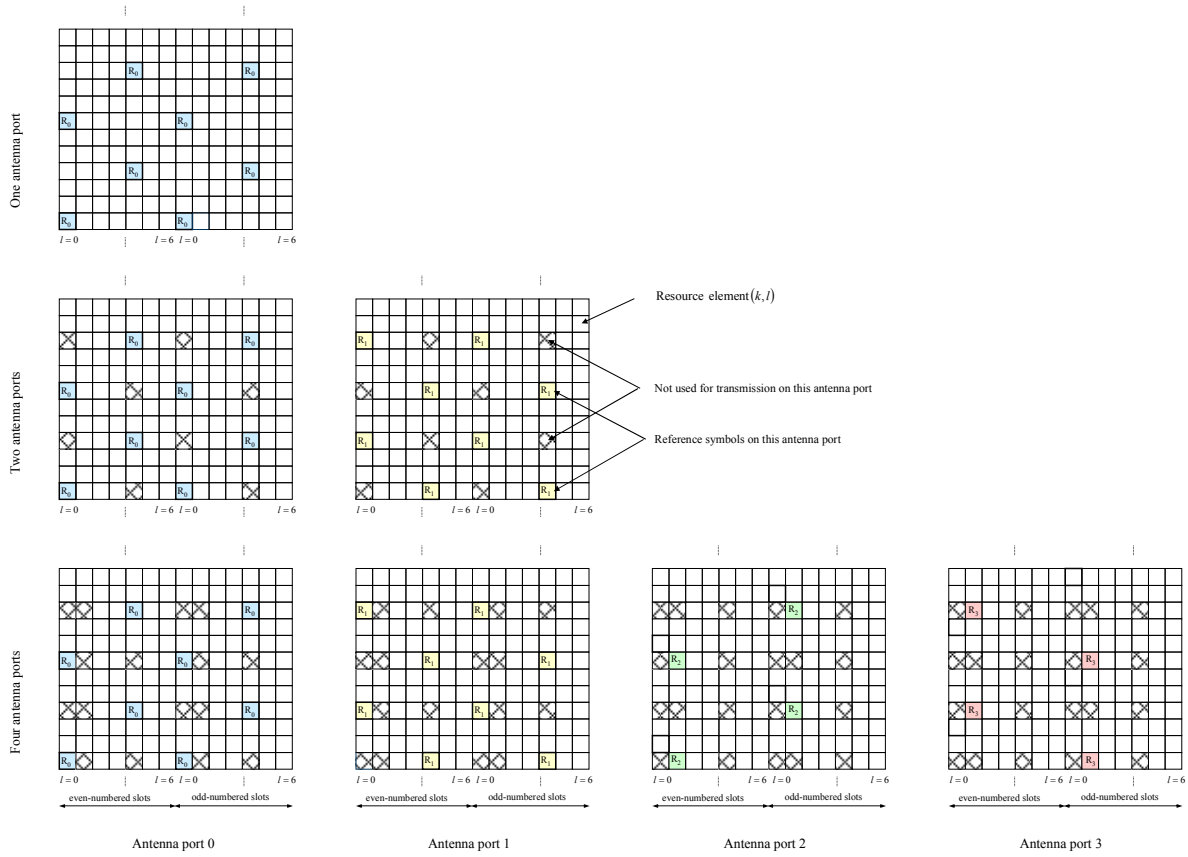


Fig. 6 Downlink Reference Signal Structure (Normal Cyclic Prefix)

The reference signal sequence carries the cell identity. Each reference signal sequence is generated as a symbol-by-symbol product of an orthogonal sequence r^{OS} (three of them existing) and a pseudo-random sequence r^{PRS} (170 of them existing). Each cell identity corresponds to a unique combination of one orthogonal sequence r^{OS} and one pseudo-random sequence r^{PRS}, allowing 510 different cell identities.
Frequency hopping can be applied to the downlink reference signals. The frequency hopping pattern has a period of one frame (10 ms).
During cell search, different types of information need to be identified by the handset: symbol and radio frame timing, frequency, cell identification, overall transmission bandwidth, antenna configuration, and cyclic prefix length.
Besides the reference symbols, synchronization signals are therefore needed during cell search. E-UTRA uses a hierarchical cell search scheme similar to WCDMA. This means that the synchronization acquisition and the cell group identifier are obtained from different synchronization signals. Thus, a primary synchronization signal (P-SYNC) and a secondary synchronization signal (S-SYNC) are assigned a predefined structure. They are transmitted on the 72 center subcarriers (around the DC subcarrier) within the same predefined slots (twice per 10 ms) on different resource elements, see Fig. 7.

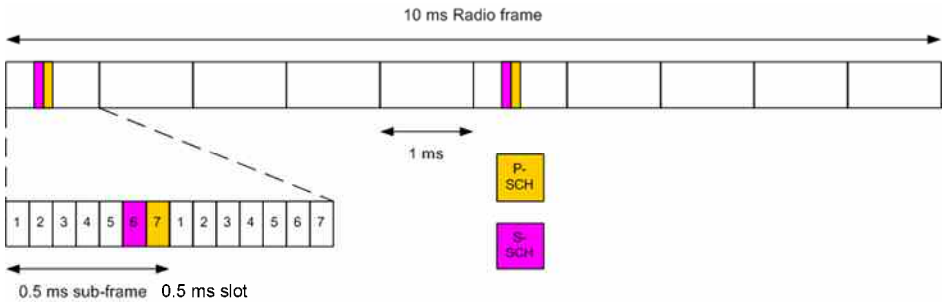


Fig. 7 P-SYNC and S-SYNC Stucture

As additional help during cell search, a common control physical channel (CCPCH) is available which carries BCH type of information, e.g. system bandwidth. It is transmitted at predefined time instants on the 72 subcarriers centered around the DC subcarrier.
In order to enable the UE to support this cell search concept, it was agreed to have a minimum UE bandwidth reception capability of 20 MHz.

Downlink Physical Layer Procedures

For E-UTRA, the following downlink physical layer procedures are especially important:

- **Cell search and synchronization:** See above.
- **Scheduling:** Scheduling is done in the base station (eNodeB). The downlink control channel PDCCH informs the users about their allocated time/frequency resources and the transmission formats to use. The scheduler evaluates different types of information, e.g. quality of service parameters, measurements from the UE, UE capabilities, and buffer status.
- **Link adaptation:** Link adaptation is already known from HSDPA as adaptive modulation and coding. Also in E-UTRA, modulation and coding for the shared data channel is not fixed, but rather is adapted according to radio link quality. For this purpose, the UE regularly reports channel quality indications (CQI) to the eNodeB.
- **Hybrid automatic repeat request (ARQ):** Downlink hybrid ARQ is also known from HSDPA. It is a retransmission protocol. The UE can request retransmissions of incorrectly received data packets.

EUTRA/LTE Test & Measurement Assumptions made by Rohde & Schwarz

This section describes working assumptions for EUTRA/LTE test & measurement solutions that cannot yet be derived from 3GPP specifications. These assumptions are valid for all current implementations on R&S signal generators and R&S signal analyzers.

OFDMA Parameterization

In order to configure the bandwidth of the signal to be generated and analyzed, the desired number of resource blocks can be specified in a range from 6 to 110 resource blocks with a granularity of 1. This results in bandwidths from 1.08 MHz…19.8 MHz.
The resulting FFT size is derived from the following formula:

$$N_{FFT} = 2^{nextpow2(\lceil 1.4 \cdot (12n+1) \rceil)},$$

- n is the selected number of resource blocks
- nextpow2(N) returns the first P such that 2^P >= abs(N)
- ⌈ ⌉ rounds up to the next highest integer

Regarding frame structure, focus is on the frame structure type 1 for FDD mode. Both normal and extended cyclic prefix can be selected for a subcarrier spacing of 15 kHz. Parameterization of cyclic prefixes is according to [3]. Resource block size is 12 subcarriers in the frequency domain and, depending on the cyclic prefix length, 7 or 6 consecutive OFDM symbols in the time-domain.
Subcarrier spacing of 7.5 kHz and resource block size of 24 subcarriers will be supported in a later version. TDD mode will be supported in a later version.

Reference Symbols

Fig. 6 of [3] shows an example for the possible distribution of downlink reference symbols for the normal cyclic prefix. The test instruments offer to select the antenna to simulate (1, 2, 3, or 4), and adjust the correct reference signal pattern accordingly. The reference signal pattern for the extended cyclic prefix is also done according to [3].
Availability of secondary reference symbols, the shift v of the reference signal sequence in the frequency domain, and the existence of empty resource elements also depend on the antenna selected.

Reference signal sequences are composed of an orthogonal sequence r^{OS} and a pseudo-random sequence r^{PRS}. According to [3], one of the 3 possible orthogonal sequences $\mathbf{r^{OS}}$ can be selected. Sequence r^{OS} contains 340 elements for the primary reference signal and an additional 340 elements for the secondary reference signal. The number 340 results from the fact that for a (maximum theoretical) bandwidth of 170 resource blocks, 2 reference symbols are needed per resource block of 12 subcarriers.

The pseudo-random sequence $\mathbf{r^{PRS}}$ of [3] has not been specified yet and can therefore be uploaded from a text or IQW file for signal generation and analysis. QPSK modulation can be selected for the pseudo-random sequence r^{PRS}, or alternatively, an I/Q file can be uploaded to determine r^{PRS}. The maximum length of r^{PRS} is the same as r^{OS} for each slot, but r^{PRS} may vary from slot to slot. Hence, the maximum composite length of all 20 sequences (20 slots per radio frame) r^{PRS} is given by 340 * 2 * 20 = 13600 symbols (i.e. 27200 Bits in case of QPSK text file). The data file is read out as follows:

- For QPSK, the first 680 bits are read out for the primary reference signal of the first slot. For I/Q file, the first 340 symbols are read out for the primary reference signal of the first slot.
- Then the next 680 bits (340 symbols for I/Q file) are read out for the secondary reference signal of the first slot.
- Then the next 680 bits (340 symbols for I/Q file) are read out for the primary reference signal of the second slot.
- …
- If secondary reference signals are not used, then the corresponding data in the text file is skipped.
- If the data file contains a shorter list, the information is read out cyclically. Thus, if the reference signal sequence should be the same for each slot, it would be sufficient to have a list with 27200 bits / 20 = 1360 bits.

Note that this approach also reflects the possibility to use a complex scrambling code as defined in [6] as sequence r^{PRS}.

The reference signal sequence $r_{m,n}$ is created and mapped onto the resource elements as described in [3].

Synchronization Signal (SYNC)

- Primary and secondary synchronization signals (P-SYNC and S-SYNC) are supported.
- They are transmitted as shown in Fig. 7 in slots 0 and 10, on the last 2 OFDM symbols of the slot.
- It is possible to determine P-SYNC and S-SYNC by an uploadable I/Q file so that any modulation scheme can be configured.
- P-SYNC and S-SYNC are transmitted within the center 72 subcarriers. Resource blocks containing P-SYNC/S-SYNC thus have fewer resource elements available for user data allocation.

- In addition to the definition in [3], different repetition periods for SYNC can be reflected: 1 subframe, 2 subframes, 5 subframes, 10 subframes (default is 5 subframes). P-SYNC and S-SYNC must always occur in the same subframe. The starting slot can also be defined.
- In case P-SYNC and S-SYNC symbols are uploaded by an I/Q definition file, each 10 ms radio frame, the P-SYNC and S-SYNC sequences are uploaded again from the file. If there are not enough symbols available in the file, it is started again from the beginning. As default settings it is assumed that P-SYNC contents are the same in each subframe, and S-SYNC contents are different from subframe to subframe. Precoding vector switching can be supported with this approach.
- The I/Q file for the SYNC bit sequence has therefore a maximum length of 72 [symbols] * 10 [subframes].

Physical Broadcast Channel (PBCH)

- PBCH is located in subframe 0. Position of PBCH within subframe 0 is according to [3] per default. However, the PBCH allocation may be changed in terms of PBCH symbol offset within subframe 0 (0…13 for normal CP) and length in symbols (1…14 for normal CP).
- PBCH is QPSK modulated.
- PBCH occupies the center 72 subcarriers around the DC subcarrier.

Data Allocations

- Physical Resource Block size is 12 subcarriers in the frequency domain.
- Localized transmission is assumed.
- For localized transmission, the numbering of resource blocks starts with the left-most (lower frequency) used subcarriers of the frequency band. The numbering starts with zero. With the FFT-shift the DC carrier is moved to the first position, which is required to be conform to the standard IFFT input. This is illustrated in Fig. 8.

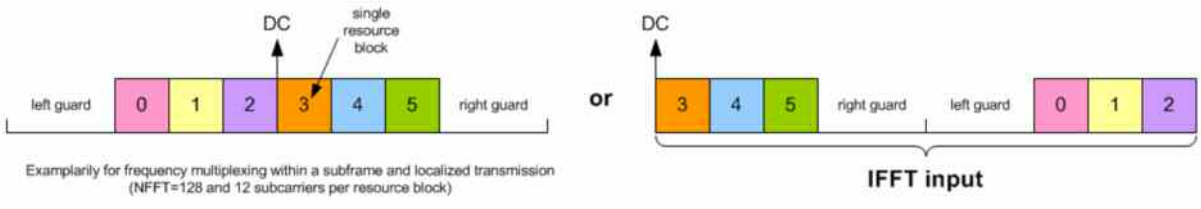


Fig. 8 Numbering of Resource Blocks

- The modulated data symbols are mapped onto the resource elements as described in [3].
- If predefined symbols (e.g. reference and synchronization signals) are transmitted in a subframe, the number of available data symbols for user data allocation is reduced in a resource block.
- Data allocation can be changed for each subframe.

Modulation Mapping

Modulation mapping is done according to [3]. All modulation schemes of [3] are supported.

References

[1] 3GPP TS 25.913: Requirements for E-UTRA and E-UTRAN (Release 7)
[2] 3GPP TR 25.892: Feasibility Study for Orthogonal Frequency Division Multiplexing (OFDM) for UTRAN enhancement (Release 6)
[3] 3GPP TS 36.211 v1.2.1: Physical Channels and Modulation (Release 8)
[4] 3GPP TS 36.300: E-UTRA and E-UTRAN; Overall Description; Stage 2 (Release 8)
[5] 3GPP TS 22.978: All-IP Network (AIPN) feasibility study (Release 7)
[6] 3GPP TS 25.213: Spreading and modulation (FDD)

2 Installation and Test Setup

Software Installation

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

Connection to the Instrument

In order to be able to communicate with the instruments, the PC must be connected to the F&S FSQ using either an IEEE bus or LAN connection.

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

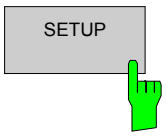
Configuration Settings

The R&S FSQ address (either GPIB or LAN address) has to be set in the R&S FSQ-K100/K102 EUTRA/LTE analysis software. Please refer to section "MIMO Analyzer Configuration" for details about this setting.

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

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

GPIB address



➢ Press the [**SETUP**] hardkey.

The *SETUP* menu will be opened.

➢ Press the <*GPIB*> softkey.

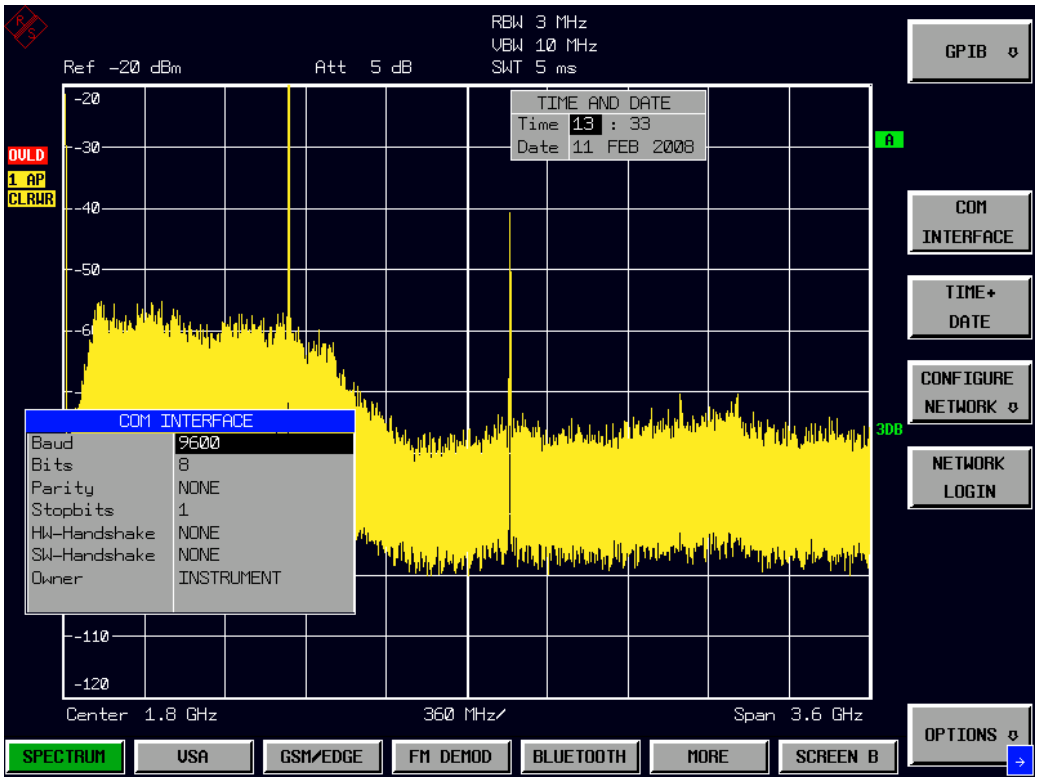
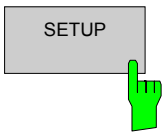


Fig. 9 Softkey: GPIB address

LAN address



➢ Press the [**SETUP**] hardkey.

The *SETUP* menu will be opened.

➢ Press the <*CONFIGURE NETWORK*> softkey.

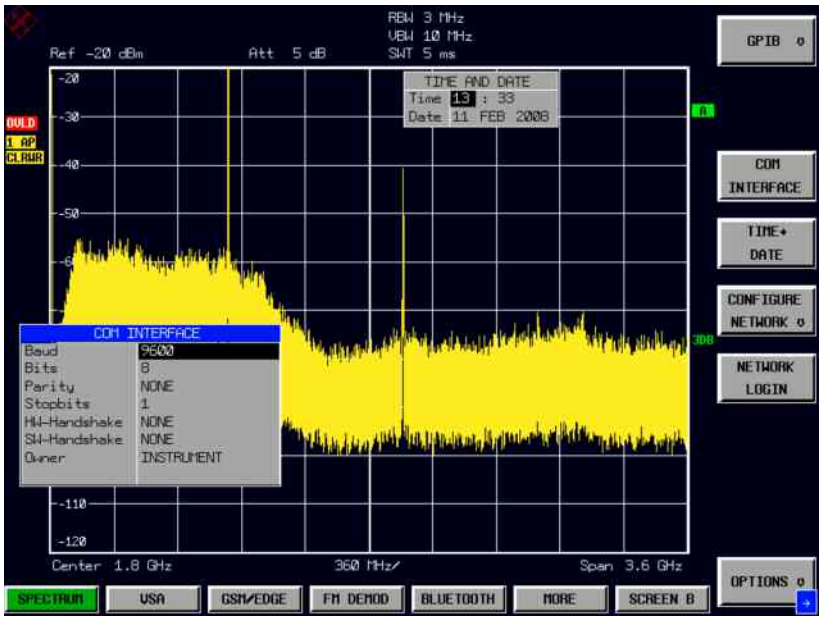


Fig. 10 Softkey: Configure Network

➢ Select *Local Area Connection* and press Enter.

Fig. 11 Local Area Connection

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

Fig. 12 Local Area Connection: Support tab

MIMO Hardware Setup

In this section the hardware setup for MIMO measurements (capturing I/Q data from more than one instrument) is given.

One R&S FSQ is defined as the master FSQ (on this instrument the license key code for the R&S FSQ K100/K101/K102 has to be entered). The master R&S FSQ is the reference oscillator source for all slave R&S FSQs. The REF IN of all slave R&S FSQs must be connected to the REF OUT of the master R&S FSQ and all slave R&S FSQs must be set to external reference (in case two R&S SMUs are used, the second R&S SMU has to be set to external reference and the REF OUT of the first R&S SMU has to be connected to the REF IN of the second R&S SMU).

The EUTRA/LTE MIMO signal generator (device under test or R&S SMU signal generator) must provide a trigger signal. This trigger signal has to be connected to all R&S FSQs (in case two R&S SMUs are used, the second R&S SMU must be triggered by the first R&S SMU).

In Fig. 13 the MIMO hardware setup with 2 (or optional 4) R&S FSQs and 1 (or optional 2) 2-channel R&S SMUs is given.

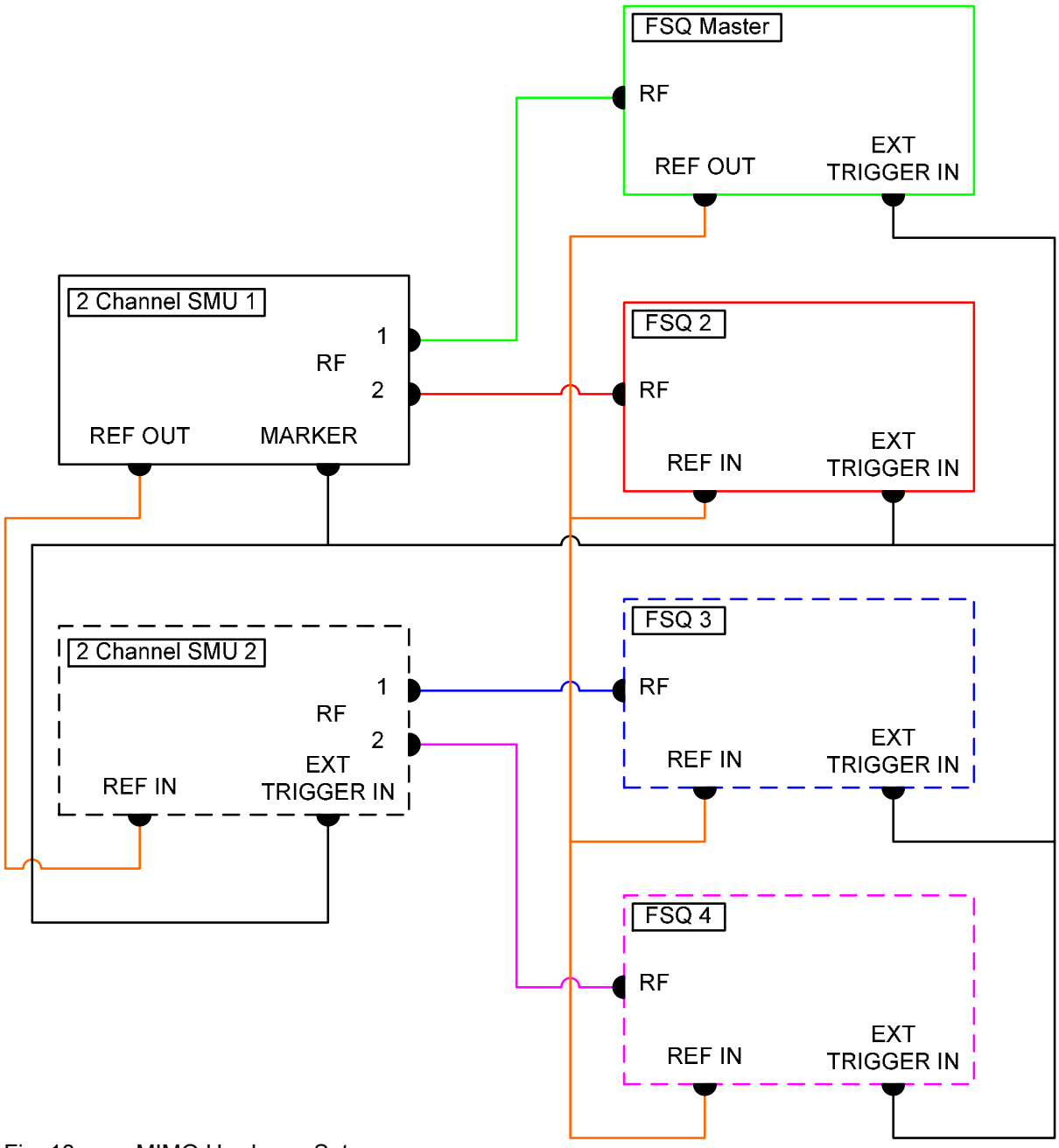


Fig. 13 MIMO Hardware Setup

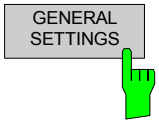
3 Quick Start Guide

This section will help you to quickly become familiar with R&S FSQ-K100/K102 (refer to section "Operating the Software" for detailed operating instructions).

Setting up the Measurement

➢ Start the R&S FSQ-K100/K102 application and press [**PRESET**].

General Setup (Frequency, Level, etc.)



Press <*GENERAL SETTINGS*> to open the General Settings dialog.

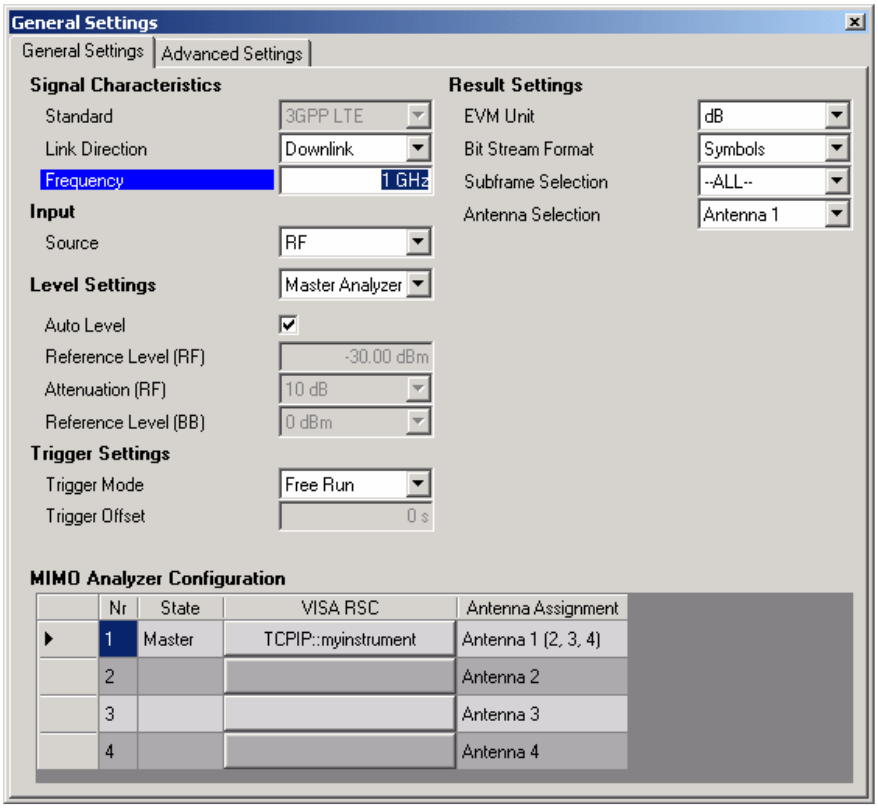


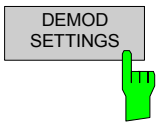
Fig. 14 General Setup Dialog

➢ Enter the desired frequency to measure in the *Frequency* field.

➢ Enter the VISA RSC of the FSQ in the table *MIMO Analyzer Configuration*.

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

Demodulation Setup (Tracking Modes, etc.)



Press <*DEMOD SETTINGS*> to open the Demodulation Settings dialog.

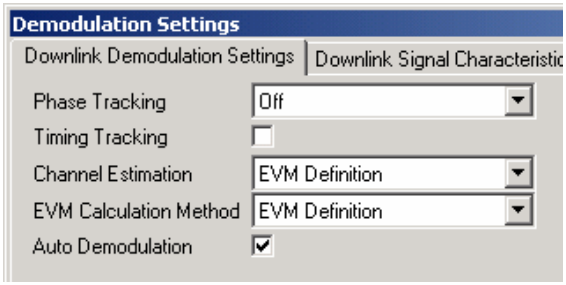


Fig. 15 Demodulation Settings Dialog, Downlink Demodulation Settings Tab

Make sure that the *Auto Demodulation* feature is enabled. All other settings in this dialog are sufficient for this example.

Performing the Main 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*>.

User-Defined Reference Symbols

Since the reference symbols are not yet defined in the standardization document, it is possible to load user-defined iq sequences. Please refer to section "Import and Export of Data" for details on how to set up custom data.

4 Operating the Software

Starting the Software

Use the desktop shortcut or the shortcut from the Start menu to start the R&S FSQ-K100/K102 EUTRA/LTE analysis software. The following window appears:

The software user interface consists of six main elements:

- **Header table** (1)
  Showing basic information such as measurement frequency or sync state.
- **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. [**MEAS**].

Loading a Frame Setup

Before starting the measurement, a frame setup, which describes the frame to be analyzed, can be loaded. Use [**FILE**] <*LOAD DEMOD SETUP*> to open a standard file dialog to select the demod setup to load.
A very simple 10 MHz bandwidth setup can be found in the FILE_IO subfolder of the application path.

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 Installation" for a detailed description.

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 "Import and Export of Data" for details on the file format.

Running the Measurement

Use the hotkeys of the EUTRA/LTE 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.

Frequency	1 GHz	CP / Cell Grp / ID	Normal (A) / Group 125 (A) / ID 0 (A)	Master Ref Level	-30.00 dBm, 10 dB
Operating Mode	Downlink, 50 PRBs (10 MHz)	Sync State	FAIL (C,P,S)	Capture Length	307200 Samples = 20.00 ms

Fig. 16 Overall measurement settings summary

The settings summary includes the following information:

- **Frequency** The analyzer RF frequency.
- **Operating Mode** Link direction and maximum number of PRBs / signal bandwidth.
- **CP Length** Cyclic prefix length (Normal or Extended). If *AUTO* is selected in the *Demodulation Settings, (Auto)* is shown, otherwise *(Manual).*
- **Sync State** The following synchronization states may occur:
  - **OK** The synchronization did not generate any errors.
  - **FAIL (C)** The cyclic prefix correlation failed.
  - **FAIL (P)** The P-SYNC correlation failed.
  - **FAIL (S)** The S-SYNC correlation failed.

  The combination of C, P and S may also occur.
- **Ref Level** *RF input:* RF reference level and RF attenuation settings.
  Baseband (BB) input: Reference level.
- **Capture Length** Capture length in samples and ms.

Evaluating the Results

Operating the Graph

Context Menu (Marker, 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.

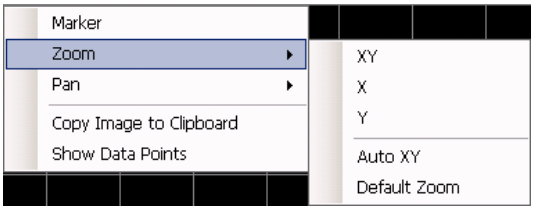


Fig. 17 Context Menu: Zoom

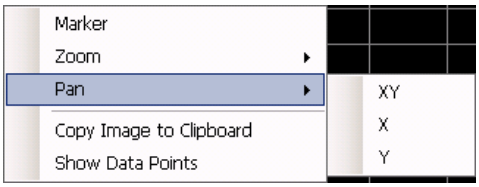


Fig. 18 Context Menu: Pan

Marker

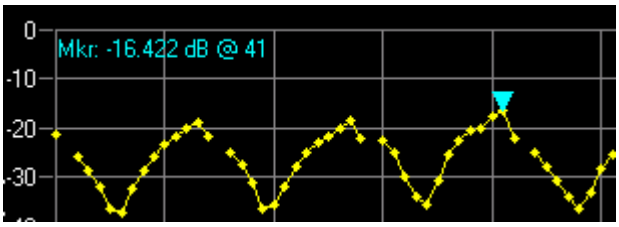
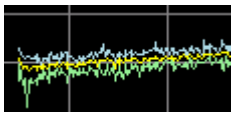


Fig. 19 Example: Marker

- The marker is activated via the context menu. If activated it is set on the absolute maximum of the trace menu.
  TIP: If you have shifted the marker and want to put is back on the absolute maximum, simply click "Marker" twice in the context menu (deactivates and activates the marker again).
- The text appearing in the upper left corner of the screen consists of:
  Mkr: [y value] [unit of y axis] @ [x value] [unit of x axis]

- **IMPORTANT**: the marker can only be activated if only ONE trace (yellow curve) exists. The marker cannot be set for Min/Mean/Max traces as in the following figure: 
- The marker is moved with the mouse, it jumps to the point closest to the cursor.
  TIP: move the mouse above the curve to hop between the local maxima, below the curve the marker moves between the local minima.
- **IMPORTANT**: Move the marker by pressing the left mouse button and keeping it pressed while moving the mouse. The marker is not moved by simply clicking the mouse.

Zoom

XY	Click and hold the left mouse button in the graph to select an X and Y area to zoom in on.
X	Click and hold the left mouse button in the graph to select a range on the X area to zoom in on.
Y	Click and hold the left mouse button in the graph to select a range on the Y area to zoom in on.
Auto XY	Scales the X and Y axes automatically to display the complete trace data. Alternatively double-click on the display area.
Default Zoom	Scales the X and Y axes to the default axis values.

Pan

XY	Click and hold the left mouse button in the graph to move the graph in the X and Y direction.
X	Click and hold the left mouse button in the graph to move the graph in the X direction.
Y	Click and hold the left mouse button in the graph to 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.

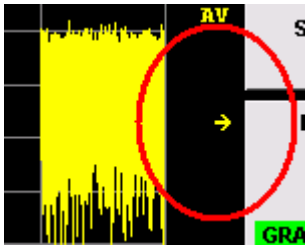


Fig. 20 "Data out of Display" Indication on Screen

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

5 Measurements

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

Numerical Results

EVM Measurements

- *EVM Physical Channel*
  EVM for all physical channel symbols for the analyzed frame.
- *EVM Physical Signal*
  EVM for all physical signal symbols for the analyzed frame.

I/Q Constellation Measurements

- *Center Frequency Error*
  Difference between measured and reference center frequency.
- *Symbol Clock Error*
  Difference between measured and reference symbol clock relative to the system sampling rate.
- *I/Q Offset*
  Power at spectral line 0 normalized to the total transmitted power.
- *Gain Imbalance*
  Logarithm of the 'Q-Channel to I-Channel gain ratio'.
- *Quadrature Error*
  Measure of the 'phase angle between Q-Channel and I-Channel' deviating from the ideal 90 degrees.

Power Measurement

- *Frame Power Physical Channel*
  Average time domain power of the analyzed physical channels.
- *Frame Power Physical Signal*
  Average time domain power of the analyzed physical signals.
- *Crest Factor*
  Peak-to-average power ratio of captured signal.

Graphical Results

Power vs Time Measurements

- *Capture Buffer*
  Power profile of the capture buffer data being analyzed.

EVM Measurements

- *EVM vs Carrier*
  EVM versus the physical carriers of the analyzed frame.
- *EVM vs Symbol*
  EVM versus the symbols of the analyzed frame.
- *Frequency Error vs Symbol*
  Difference between measured and reference center frequency versus the symbols of the analyzed frame.

- *EVM vs Subframe*
  EVM versus the subframes of the analyzed frame.

Spectrum Measurements

- *Power Spectrum*
  Power density spectrum of the complete capture buffer in dBm/Hz.
- *Channel Flatness*
  Amplitude of the channel transfer function.
- *Channel Group Delay*
  Group delay of each single carrier, averaged over all OFDM symbols.
- *Channel Flatness Difference*
  Absolute difference of adjacent carriers.

Constellation Measurements

- *Constellation Diagram*
  Complex constellation diagram of the modulation symbols. The different modulation formats are assigned unique colors. With the <CONSTELL SELECTION> softkey it is possible to suppress unwanted information.

Statistic Measurements

- *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.
- *Allocation Summary*
  Provides information about the allocations from the analyzed frame, i.e. PRB offset, PRB count and EVM of the allocation.
- *Bit Stream*
  Demodulated data stream for each data allocation.

Softkey Menu

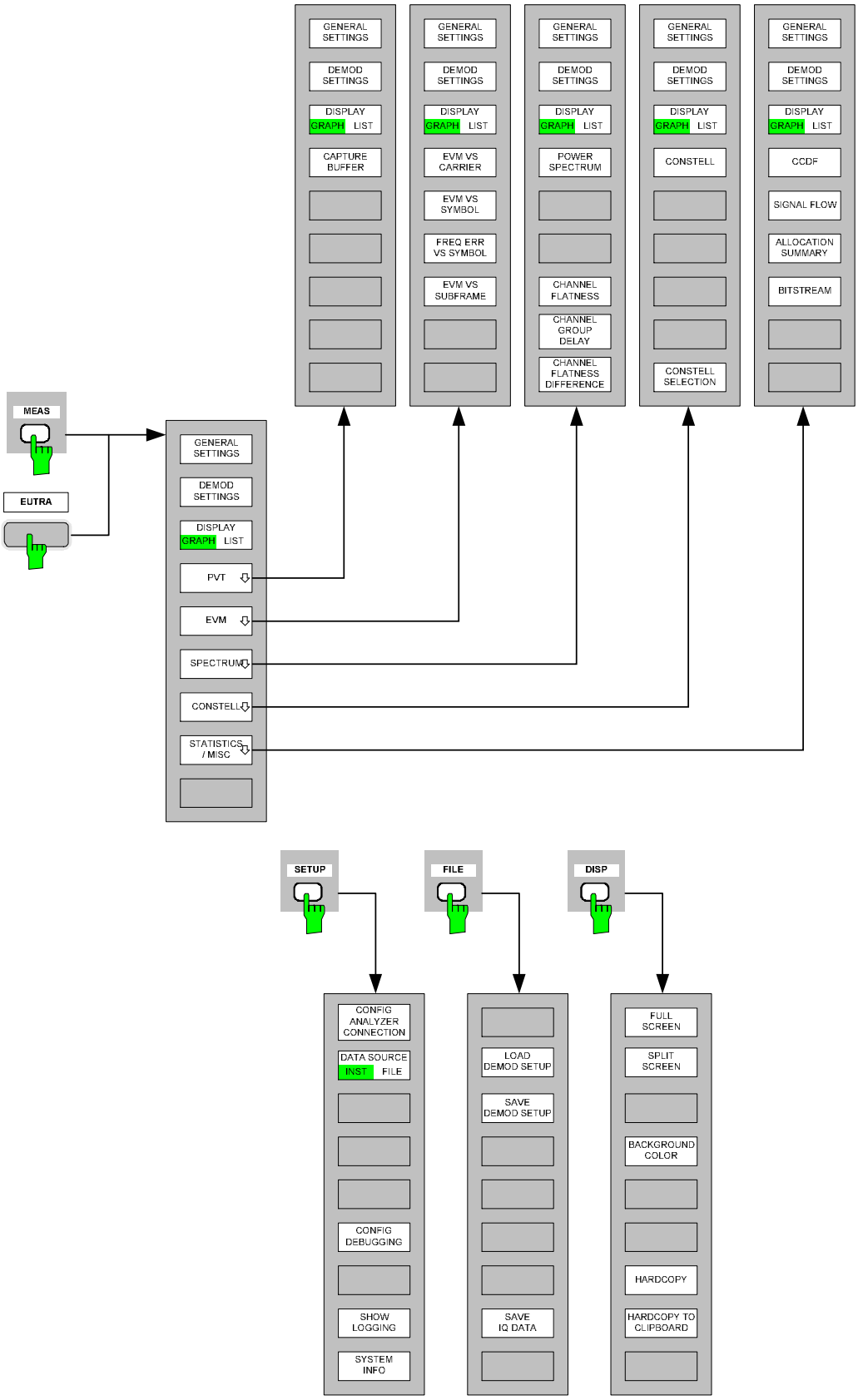
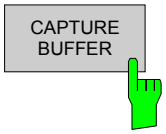


Fig. 21 EUTRA/LTE Downlink Menu

I/Q Measurements

This section contains a detailed description of the measurements.

Capture Buffer



To display the Capture Buffer PVT (power versus time) results select <*PVT*> <*CAPTURE BUFFER*> .

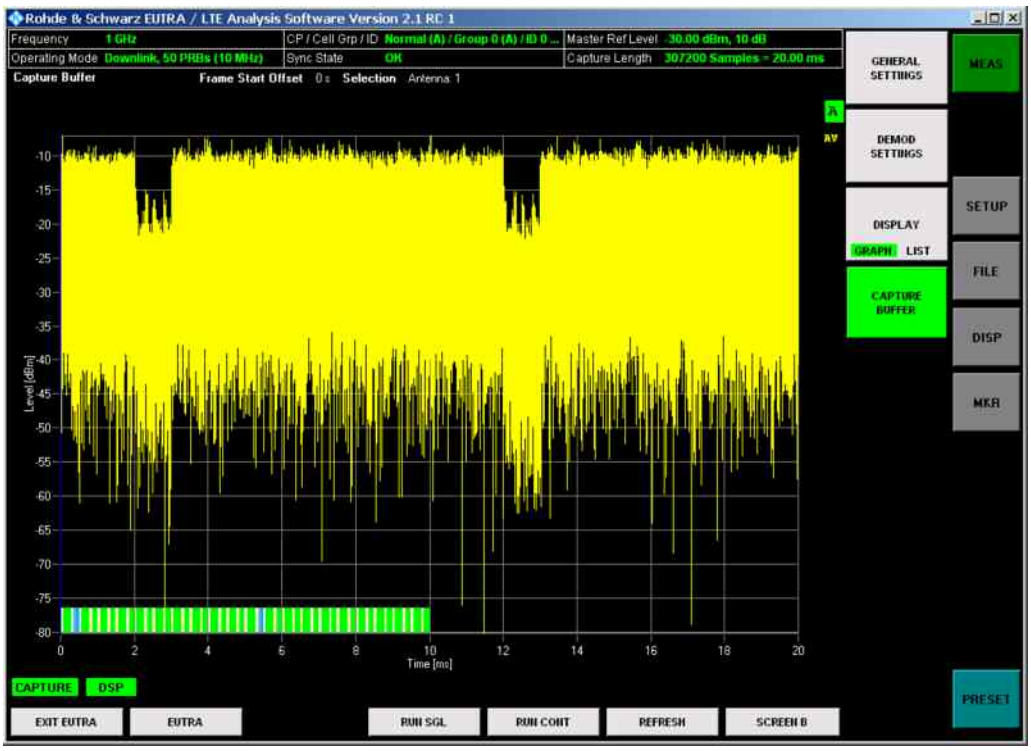


Fig. 22 Capture Buffer Display

The capture buffer shows the complete range of captured data for the last sweep. The Capture Buffer display shows the amplitude of the captured I/Q data in dBm.

The analyzed frame is identified with a bar at the bottom of the Capture Buffer display. The useful part of each analyzed OFDM symbol is marked by its own bar; the different colors indicate the OFDM symbol type. The following OFDM symbol types are used:

Data
Pilot reference and data
P-SYNC and data
S-SYNC and data

A blue vertical line at the beginning of the bar at the bottom of the Capture Buffer display marks the frame start. Additionally, the display header includes the *Frame Start Offset* value. This value is the time difference between the frame start and capture buffer start (also known as *Trigger To Frame* measurement).

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.
The following figure shows a zoomed version of the above graph:

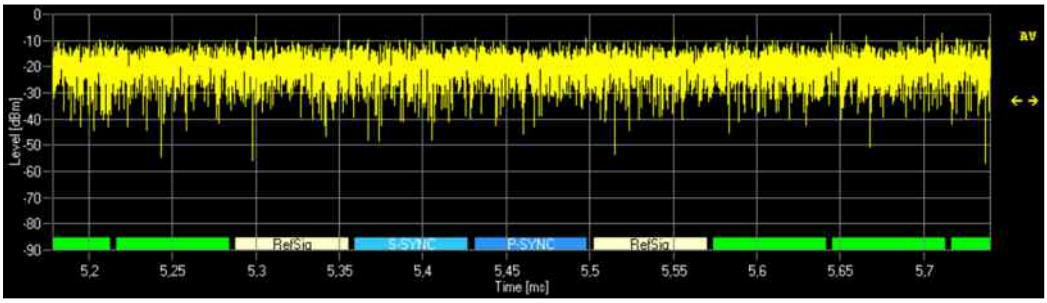


Fig. 23 Capture Buffer Display (Zoom in)

EVM vs Carrier

EVM VS CARRIER

To display the EVM vs Carrier measurement results select <*EVM*> <*EVM vs CARRIER*>.

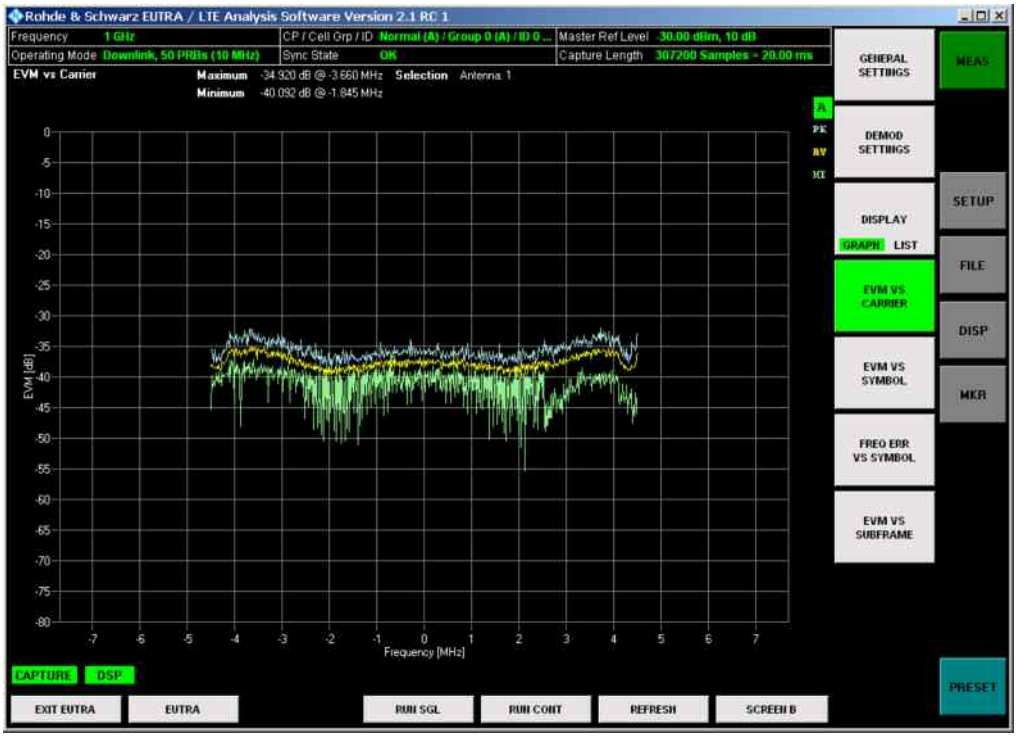


Fig. 24 EVM vs Carrier Display

The EVM vs Carrier display shows the EVM of each carrier, averaged over all OFDM data symbols.

EVM vs Symbol

EVM VS SYMBOL

To display the EVM vs Symbol measurement results select *<EVM> <EVM VS SYMBOL>*.

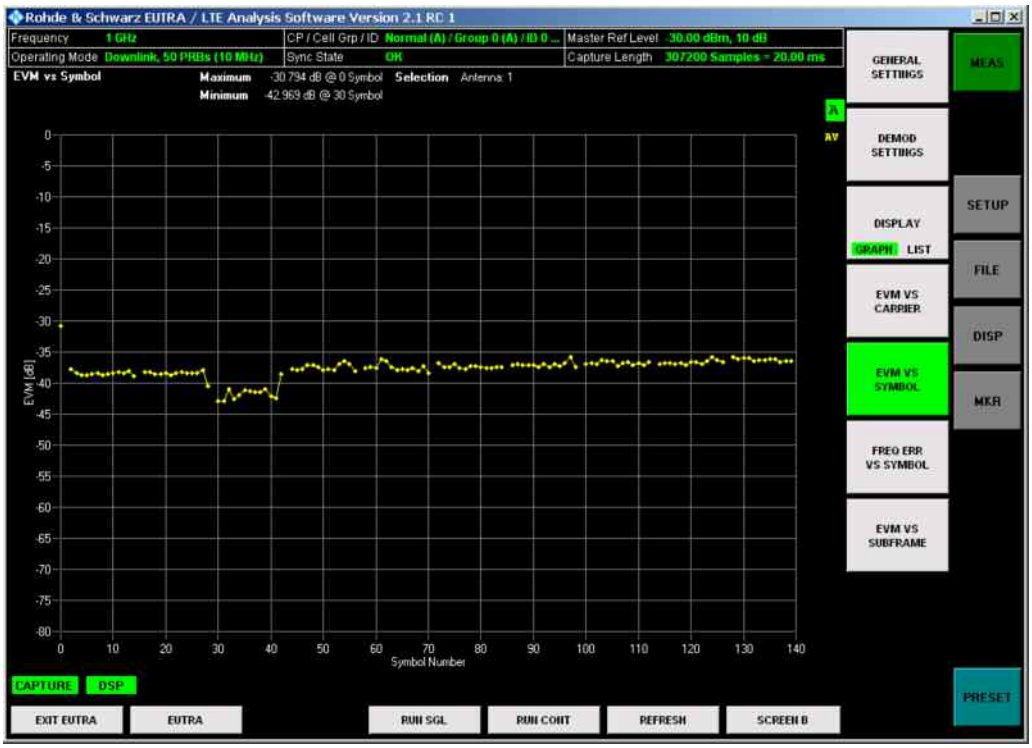


Fig. 25 EVM vs Symbol Display

The EVM vs Symbol results display shows the EVM of each symbol, averaged over all OFDM data carriers. The results are displayed on a per-symbol basis.

Frequency Error vs Symbol

FREQ ERR VS SYMBOL

To display the Frequency Error vs Symbol measurement results select <*EVM*> <*FREQ ERR VS SYMBOL*>.

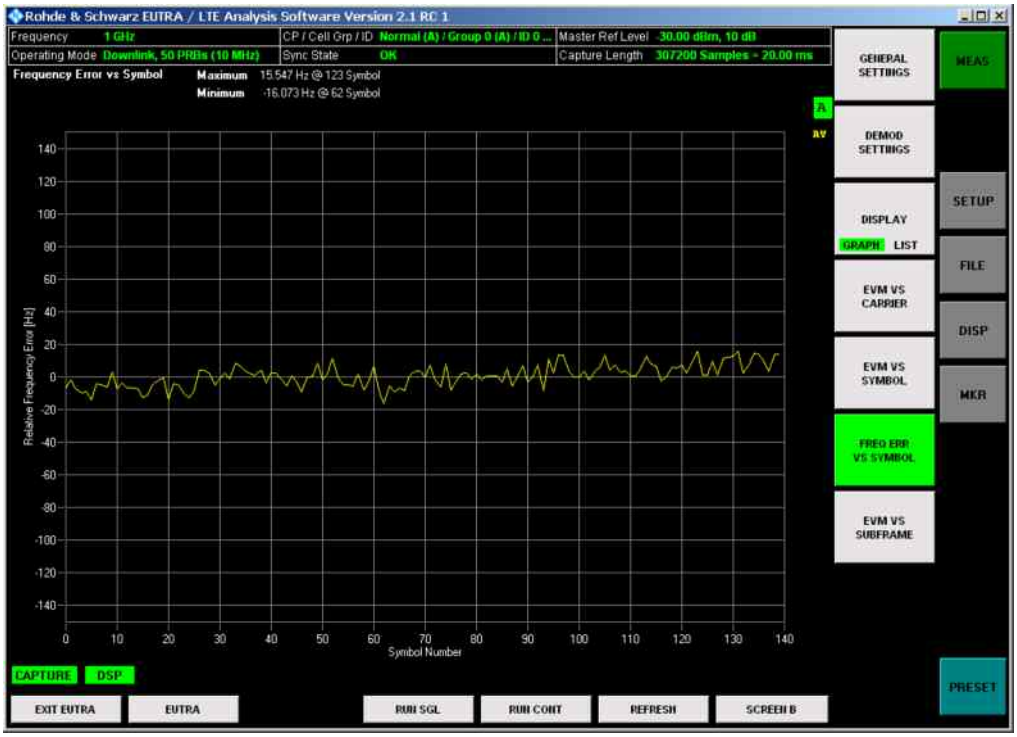


Fig. 26 Frequency Error vs Symbol Display

The Frequency Error vs Symbol results display shows the frequency error values recorded versus the analyzed OFDM symbols.

EVM vs Subframe

EVM VS SUBFRAME

To display the EVM vs Subframe measurement results select <*EVM*> <*EVM VS SUBFRAME*>.

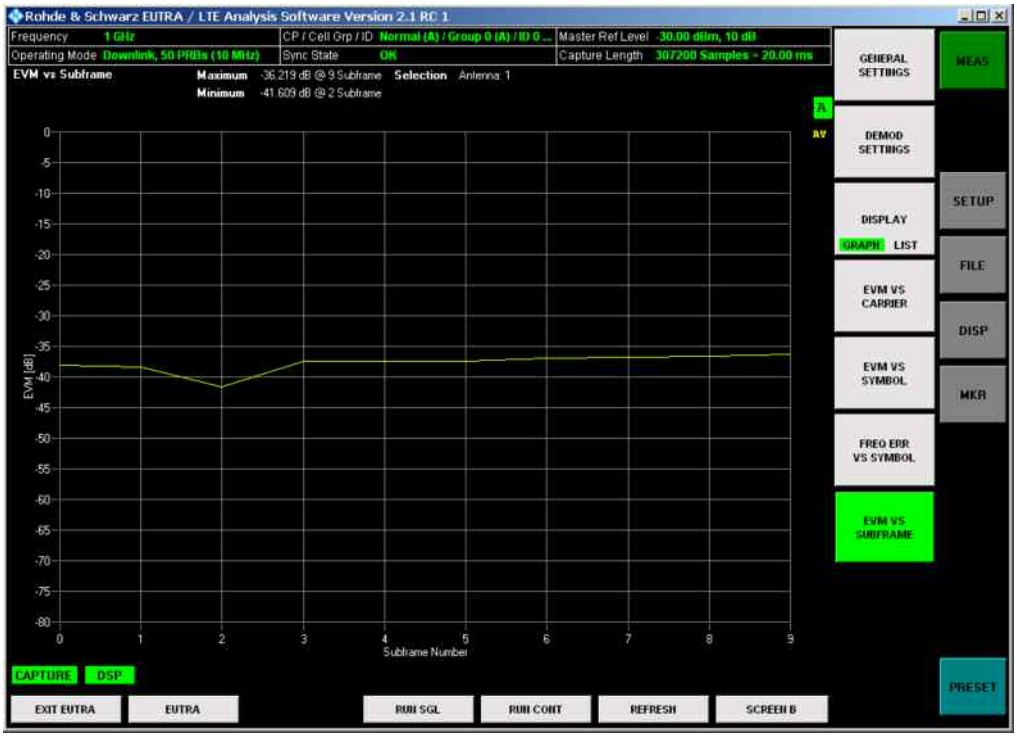


Fig. 27 EVM vs Subframe Display

The EVM vs Subframe results display shows the EVM of each subframe. The results are displayed on a per-subframe basis.

Power Spectrum

POWER SPECTRUM

To display the Power Spectrum measurement results select <*SPECTRUM*> <*POWER SPECTRUM*>.

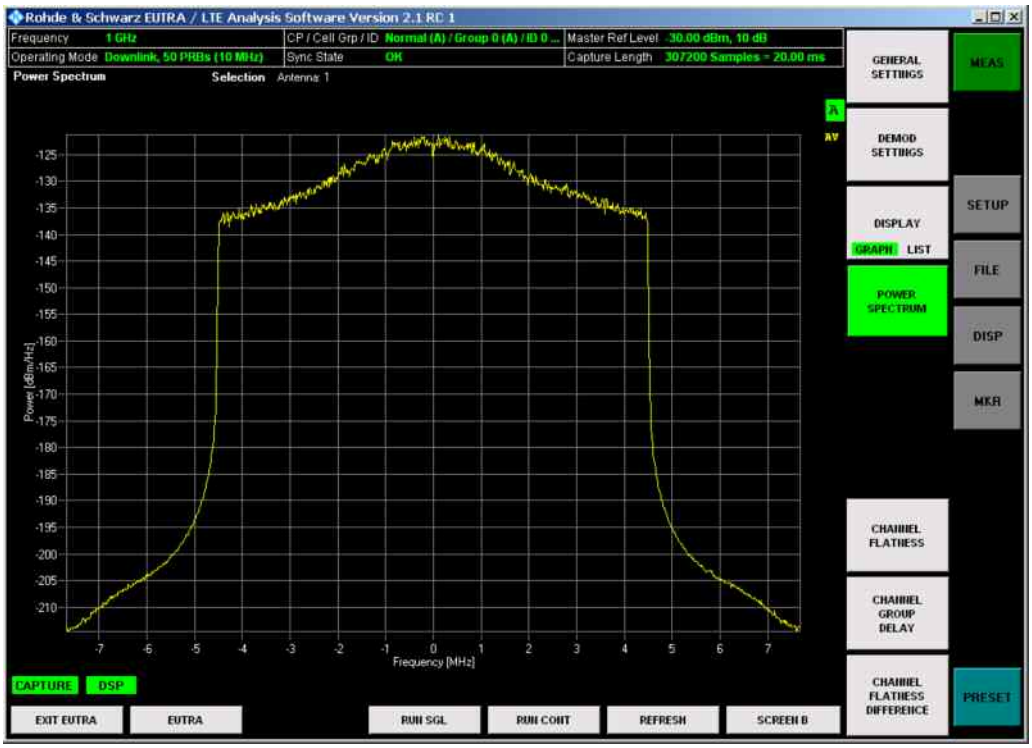


Fig. 28 Spectrum Flatness Display

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

Channel Flatness

CHANNEL FLATNESS

To display the Channel Flatness measurement results select <*SPECTRUM*> <*CHANNEL FLATNESS*>.

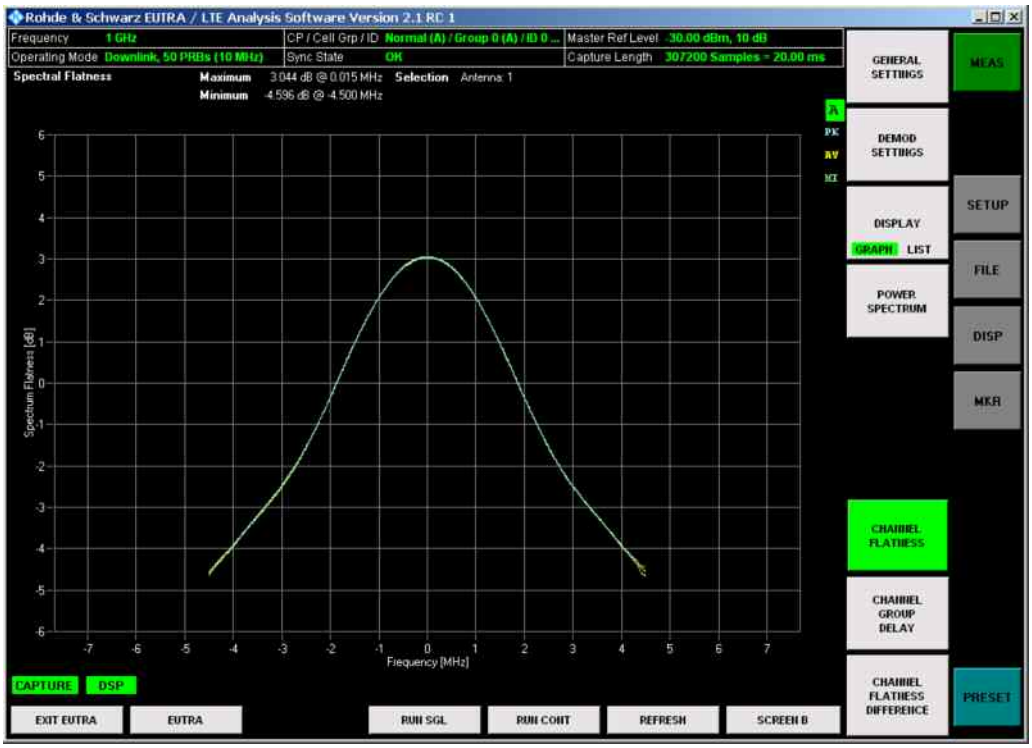


Fig. 29 Channel Flatness Display

The Channel Flatness display shows the amplitude of the channel transfer function.

Channel Group Delay

CHANNEL GROUP DELAY

To display the Channel Group Delay measurement results select <*SPECTRUM*> <*CHANNEL GROUP DELAY*>.

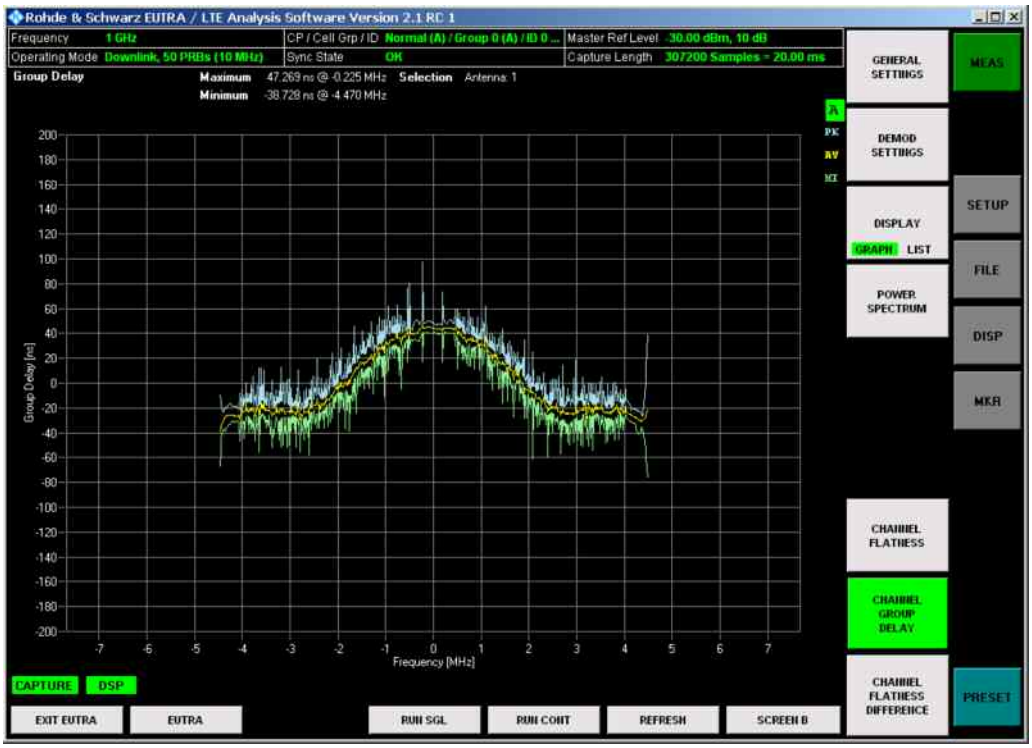


Fig. 30 Channel Group Delay Display

The Channel Group Delay display shows the group delay of each single subcarrier.

Channel Flatness Difference

CHANNEL FLATNESS DIFFERENCE

To display the Channel Flatness Difference results select <*SPECTRUM*> <*CHANNEL FLATNESS DIFFERENCE*>.

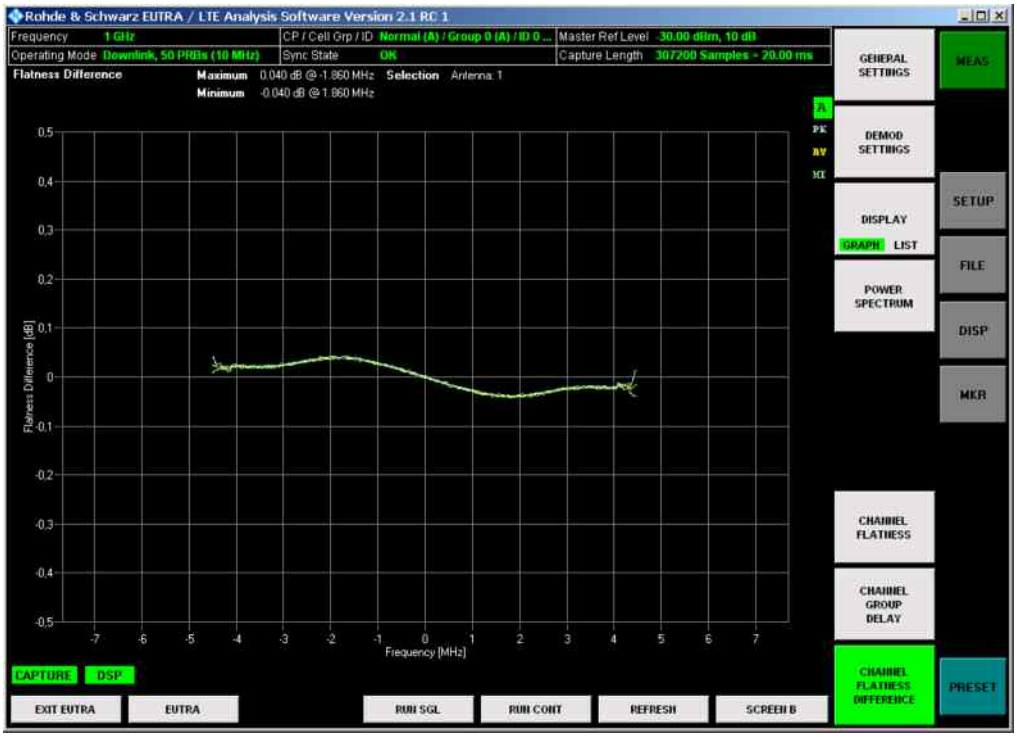


Fig. 31 Channel Flatness Difference Results

The Channel Flatness Difference display shows the level difference in the spectrum flatness result between two adjacent physical subcarriers.

Constellation Diagram

CONSTELL

To display the Constellation Diagram select <*CONSTELL*> <*CONSTELL*>.

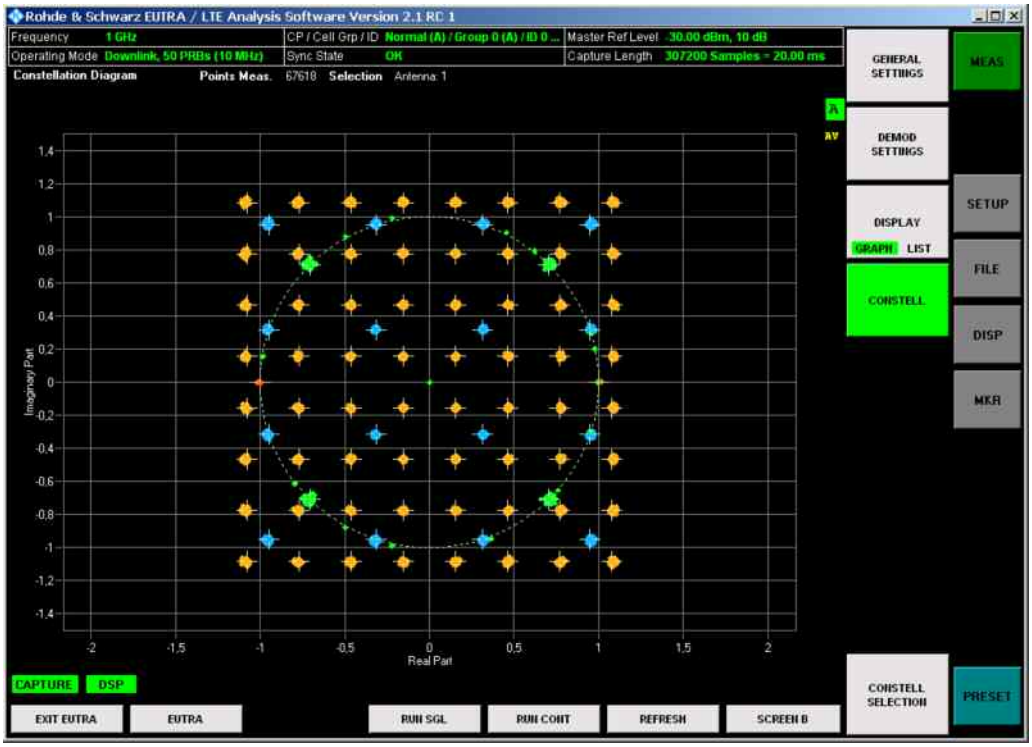


Fig. 32 Constellation Diagram Display

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 modulation scheme are displayed for reference purposes.

Constellation Selection

CONSTELL 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 modulation, allocation ID, symbol, carrier or location. 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.)

Location: Choose the location where the constellation diagram is generated, if before or after the MIMO encoder.
If you use Spatial Multiplexing, in the MIMO encoder symbols of different encoding schemes are merged. Thus you get a mix of different modulation alphabets. Filter these symbols in the field "Modulation" with the value "MIXTURE". You get the mixed symbols only if "Location" is set to "Before MIMO encoder".
Dependencies:

- If "Location is set to "After MIMO decoder", the filters "Symbol" and "Carrier" are not available.
- "Allocation" is only accessible, if in the General Settings dialog "Subframe Selection" is set to "0".

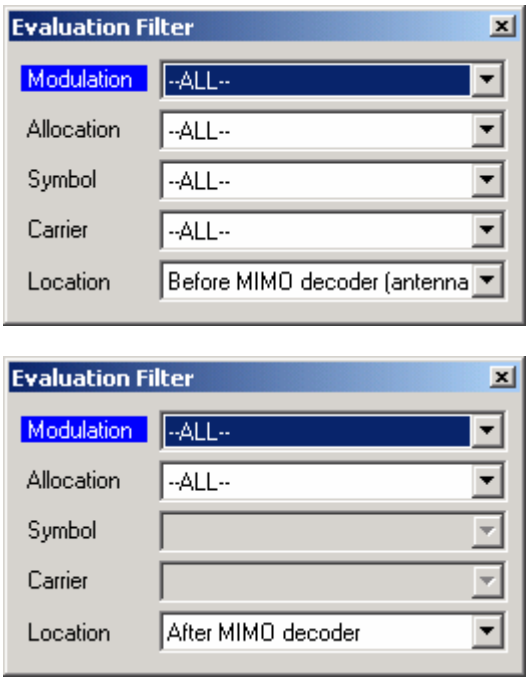
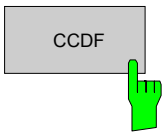


Fig. 33 Constellation Evaluation Filter Panel

CCDF (Complementary Cumulative Distribution Function)



To display the CCDF measurement results select <*STATISTICS / MISC*> <*CCDF*>.

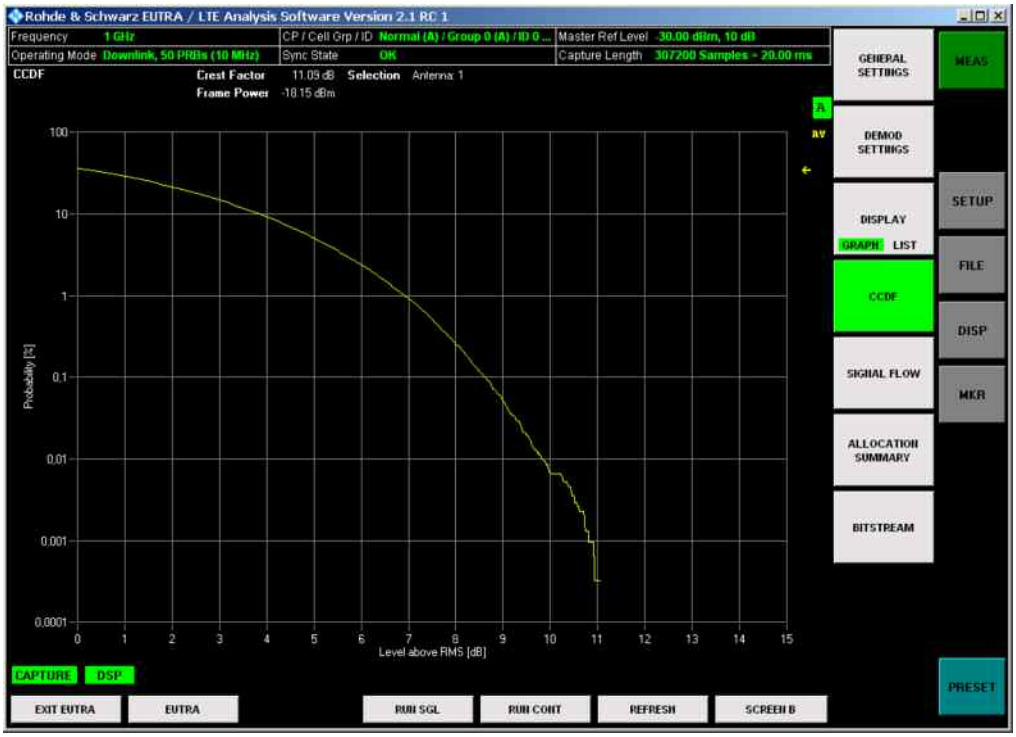


Fig. 34 CCDF Display

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

Signal Flow

SIGNAL FLOW

To display the Signal Flow display select <*STATISTICS*> <*SIGNAL FLOW*>.

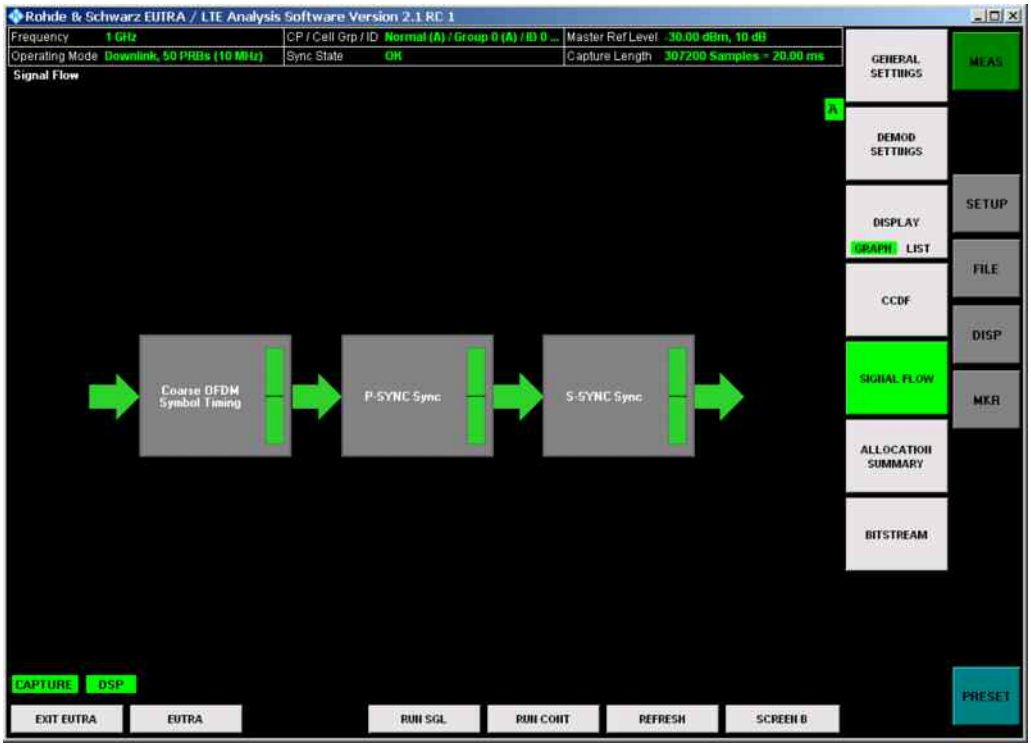


Fig. 35 Signal Flow Display

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

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

For detailed information about the complete synchronization process, please refer to section "Measurements in Detail".

Allocation Summary

ALLOCATION SUMMARY

To display the Allocation Summary measurement results select <*STATISTICS / MISC*> <*ALLOCATION SUMMARY*>.

Fig. 36 Allocation Summary Display

The Allocation Summary list displays detailed results on the measured allocations. The EVM unit can be switched in the General Settings panel.

Bit Stream

BITSTREAM

To display the Bit Stream measurement results select <*STATISTICS / MISC*> <*BITSTREAM*>.

Fig. 37 Bit Stream Display

The bit stream results display shows the demodulated data stream for each data allocation.

Result Summary

RESULT SUMMARY

To display the Result Summary results select <*DISPLAY*>.

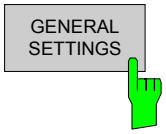
Fig. 38 Result Summary Display

The Result Summary table is displayed for I/Q measurements when the display mode is set to LIST. This table shows the overall measurement results and optionally provides limit checking for the result value in accordance with the selected standard.

As the EUTRA/LTE standard currently does not contain any limit values, the limits can be loaded via an XML file. If no limits are specified, "---" is displayed in the result list. Please refer to section "Import and Export of Data" for details on the import format.
The results are evaluated in the table, and pass or fail verdicts are displayed in green and red, respectively.

6 Settings

This section describes the General Settings dialog, where all settings related to the overall measurement (i.e. Signal Characteristics, Data Capture, Result Evaluation, Trigger and Input settings) can be modified.



The <*GENERAL SETTINGS*> softkey opens the General Settings dialog with two tabs: General Settings and Advanced Settings. To see the content of the tabs as shown below click on one of the tabs.

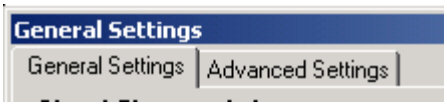


Fig. 39 Tabs in General Settings Dialog

For a detailed description of the General and Advanced Settings see below.

General Settings

The General Settings dialog opens displaying the General Settings tab.

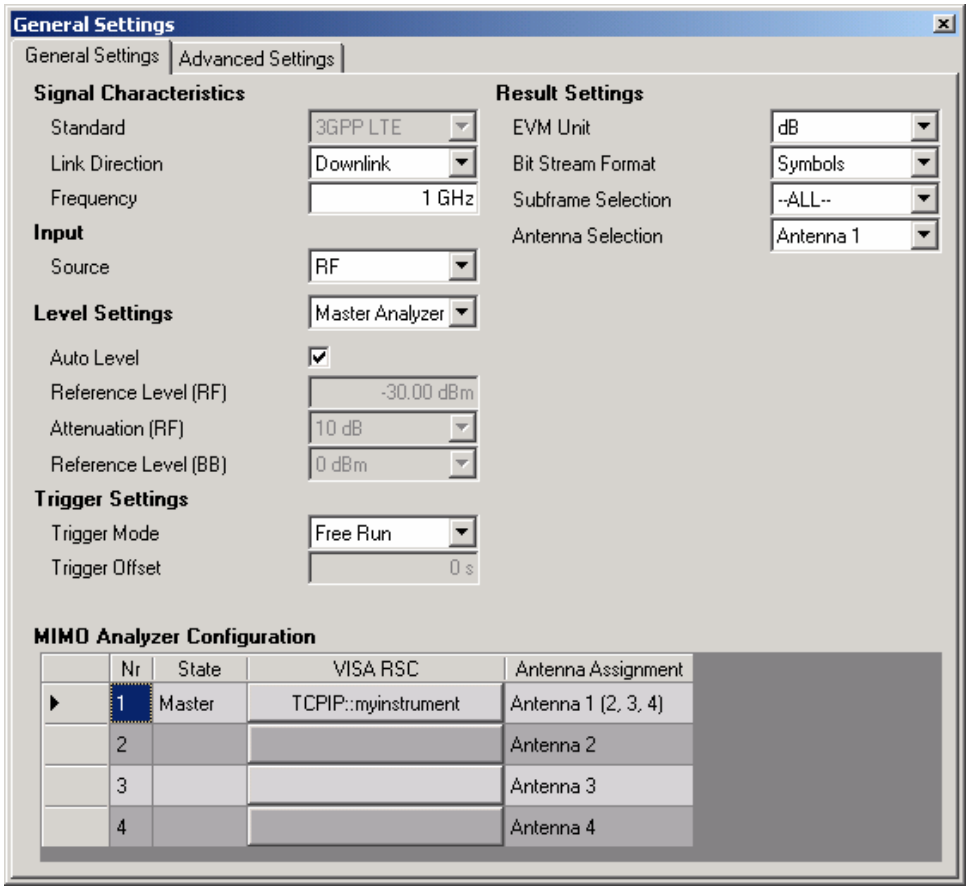


Fig. 40 General Settings Dialog

Signal Characteristics

The Signal Characteristics settings are the general settings concerning the physical attributes of the signals to be measured.

Standard

Set the standard version to use for this measurement. At the moment, only the preliminary EUTRA/LTE standard version is supported. Therefore, this configuration is disabled.

Link direction

Set the link direction to use for this measurement.

Frequency

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

Input

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

Source

Selects whether the RF input, Baseband (BB) input, Digital I/Q or File is used.

The "Source" drop-down combo box is used to specify the I/Q data source. Data can either be captured from the R&S FSQ instrument (select *RF*, *Baseband (BB)* or *Digital IQ*) or read from file (select *FILE*). 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.

Level Settings

The Input settings group contains settings related to the input source.

Chooses to which instrument the Level/Attenuation settings are applied. This concerns the settings

- Auto Level
- Reference Level (RF)
- Attenuation (RF)
- Reference Level (BB)

Auto level

Selects whether the reference level for measurements is measured automatically (ON) or entered manually by the user (OFF).
When Auto Level is set to ON, the R&S FSQ-K100/K102 EUTRA/LTE 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.

Reference level (RF)

Specifies the *RF 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.

Attenuation (RF)

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.

Reference level (BB)

Specifies the *Baseband Reference Level* to use when running measurements.
Available values:
-20 dBm to 25 dBm in steps of 5 dBm.

The *Reference Level* parameter is editable only when Baseband input is selected.

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.

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.

Result Settings

The Result Settings set parameters for post-processing of the acquired data.

EVM unit

The EVM Unit setting allows you to display EVM results in the graphs and the numerical results in [dB] or [%].

Bit stream format

The *Bit Stream Format* setting allows you to display the bit stream as symbols (the bits belonging to one symbol are shown as hexadecimal numbers, always with two digits) or raw bits.

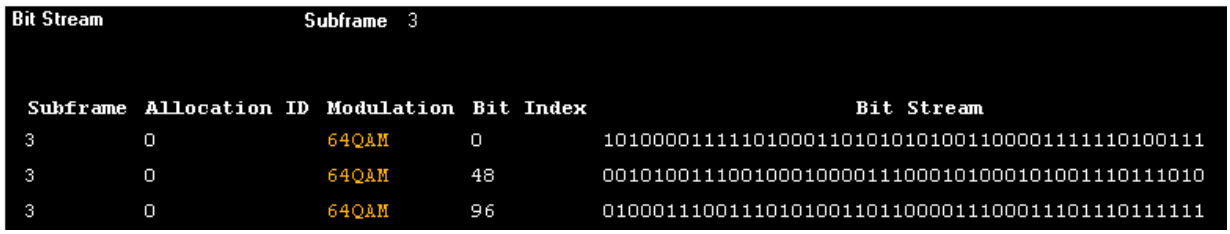
Example:

Bit stream output if *Bit Stream Format* is set to *Symbols*:

Bit Stream Subframe 3

Subframe	Allocation ID	Modulation	Symbol Index	Bit Stream
3	0	64QAM	0	28 1F 11 2A 29 21 3E 27 0A 1C 22 07 05 05 0E 3A
3	0	64QAM	16	11 33 2A 1B 03 23 2E 3F 1C 3D 1D 3A 25 25 16 17
3	0	64QAM	32	1E 17 30 09 11 04 0B 09 26 1A 31 14 1A 0B 00 06

Bit stream output if *Bit Stream Format* is set to *Bits*:

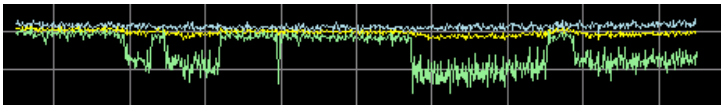


Subframe selection

With the *Subframe Selection*, subframe-specific measurement results can be selected. This setting applies to the following measurements: *Result Summary, EVM vs Carrier, EVM vs Symbol, Frequency Error vs Symbol, Channel Flatness, Channel Group Delay, Channel Flatness Difference, Constellation diagram, Allocation Summary list* and *Bit Stream*. If *---All---* is selected, either the results from all subframes are displayed at once or a statistic is calculated over all analyzed subframes.

Example:

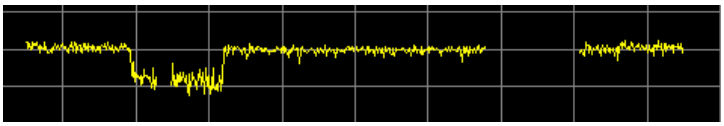
Min/mean/max statistic is shown if *---All---* is selected:



where

PK are the peak values,
AV is the average and
MI are the minimum values.

If a specific subframe is selected, only the current results of the selected subframe are shown:



Antenna selection

Selects a specific antenna to display the results for.

MIMO Analyzer Configuration

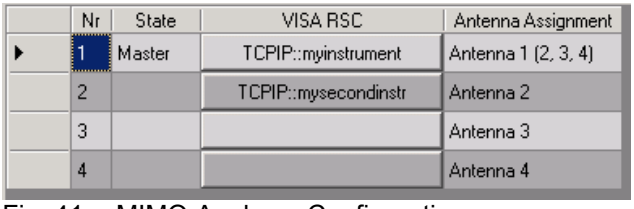


Fig. 41 MIMO Analyzer Configuration

- Clicking on one of the buttons in the VISA RSC column opens the "Instrument Connection Configuration" dialog. (**TIP**: pressing Return does not work in this dialog.

Configure analyzer 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. For information how to obtain the GPIB or LAN address, see section "How to Obtain the GPIB or LAN Address in the R&S FSQ Instrument".

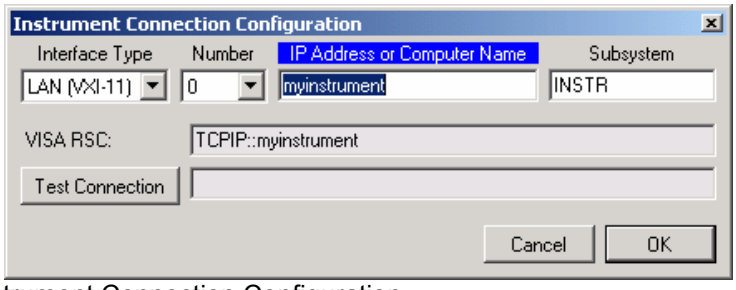


Fig. 42 Instrument Connection Configuration

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.

Advanced Settings

In the General Settings dialog click on the Advanced Settings tab to display the settings.

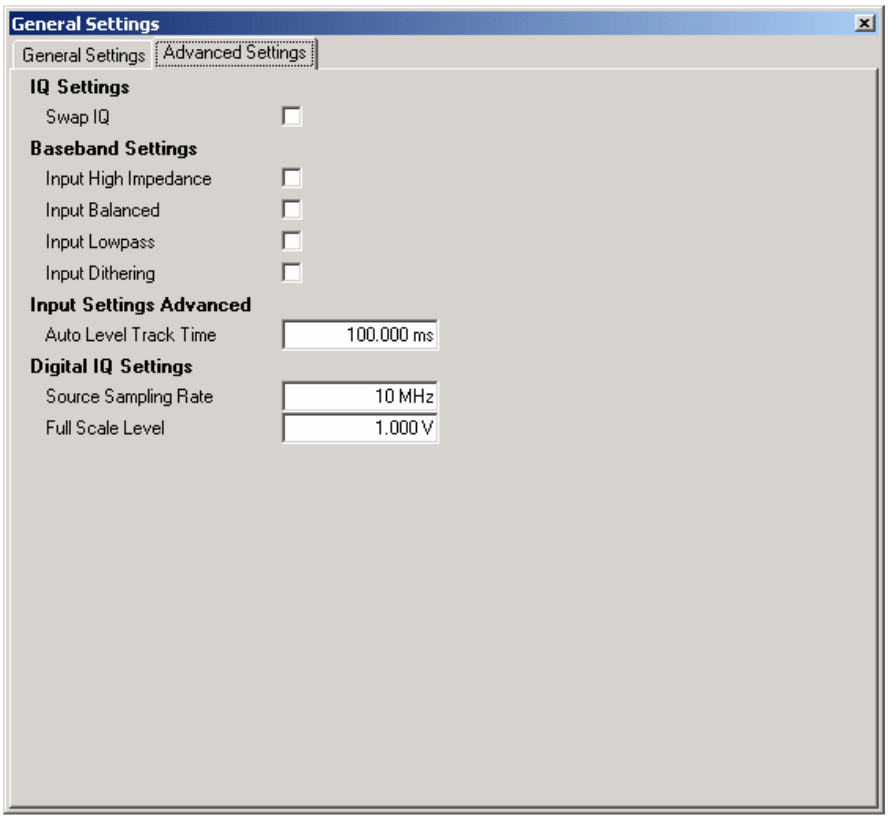


Fig. 43 Advanced Settings Dialog

IQ Settings

The Data Capture settings are the general settings concerning the signal to be measured.

Swap IQ

Swap IQ applies to both hardware I/Q data and file I/Q data.

Baseband Settings

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

Input high impedance

Input High Impedance allows the selection of the impedance of the Baseband inputs. If this parameter is not enabled, the impedance is 50 Ω; otherwise the impedance is 1 kΩ or 1 MΩ (depending on the instrument configuration).

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

Input balanced

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

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

Input lowpass

When enabled, the *Lowpass* parameter specifies that a filter is applied from 36 MHz for the I/Q inputs.

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

Input dithering

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.

Input Settings Advanced

The Input Settings Advanced group contains settings related to the RF input source.

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.

Digital IQ Settings

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

Source sampling rate

Specifies the *Source Sampling Rate* of the digital IQ input signal.

The *Source Sampling Rate* parameter is editable only if Digital IQ input is selected.

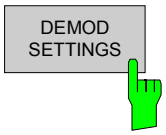
Full scale level

Specifies the *Full Scale Level* of the digital IQ input signal.

The *Full Scale Level* parameter is editable only if Digital IQ input is selected.

Demodulation Settings

This section describes the demodulation settings of the software for running a correct measurement by means of logical channel mapping and demodulation configuration.



The <*DEMOD SETTINGS*> softkey opens the Demodulation Settings dialog with three tabs: Downlink Demodulation Settings, Downlink Signal Characteristics and Downlink Advanced Signal Characteristics. To see the content of the tabs as shown below click on one of the tabs.

Fig. 44 Tabs in the Demodulation Settings Dialog

For a detailed description of the Demodulation, Signal Characteristics and Advanced Signal Characteristics Settings see below.

Downlink Demodulation Settings

The Demodulation Settings dialog opens displaying the Downlink Signal Characteristics tab. Click on the Downlink Demodulation Settings tab to display the settings.

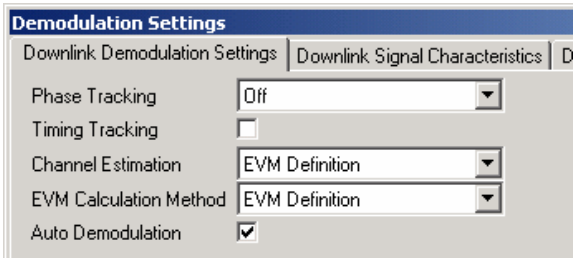


Fig. 45 Tabs in the Demodulation Settings Dialog

The Downlink Demodulation Settings tab sets the signal processing configuration with respect to how the signal is to be measured. It does not contain any description of the signal structure.

Phase Tracking

Specifies whether or not the measurement results should be compensated for common phase error.

Off	Common phase tracking is not applied.
Pilot only	Only the pilot carriers are used.
Pilot and Payload	Both pilot and payload carriers are used.

Timing Tracking

Specifies whether or not the measurement results should be compensated for timing error.

Channel Estimation

Channel Estimation EVM Definition

Specifies how channel estimation is performed for the signal.

EVM Definition	Channel estimation method as proposed in R4-071930, section 6.8.1.1.8 (averaging in frequency direction and linear interpolation). Only the reference signal carriers are used.
Optimal, Pilot only	Optimal channel estimation method, only the reference signal carriers are used.
Optimal, Pilot and Payload	Optimal channel estimation method, both reference signal and payload carriers are used.

EVM Calculation Method

EVM Calculation Method EVM Definition

Specifies the EVM calculation method.

EVM Definition	EVM calculation method as proposed in R4-071930, section 6.8.1.1.9. The EVM is evaluated at two trial timing positions and the maximum EVM of these two trials is used.
At Optimal Timing Position	The EVM is calculated using the optimal timing position

Auto Demodulation

Auto Demodulation ☑

Specifies whether or not the auto demodulation feature shall be used. If auto demodulation is enabled, the resource allocation is automatically detected by analyzing the received signal.

Downlink Signal Characteristics

The Downlink Signal Characteristics tab describes the structure of the signal to be analyzed.

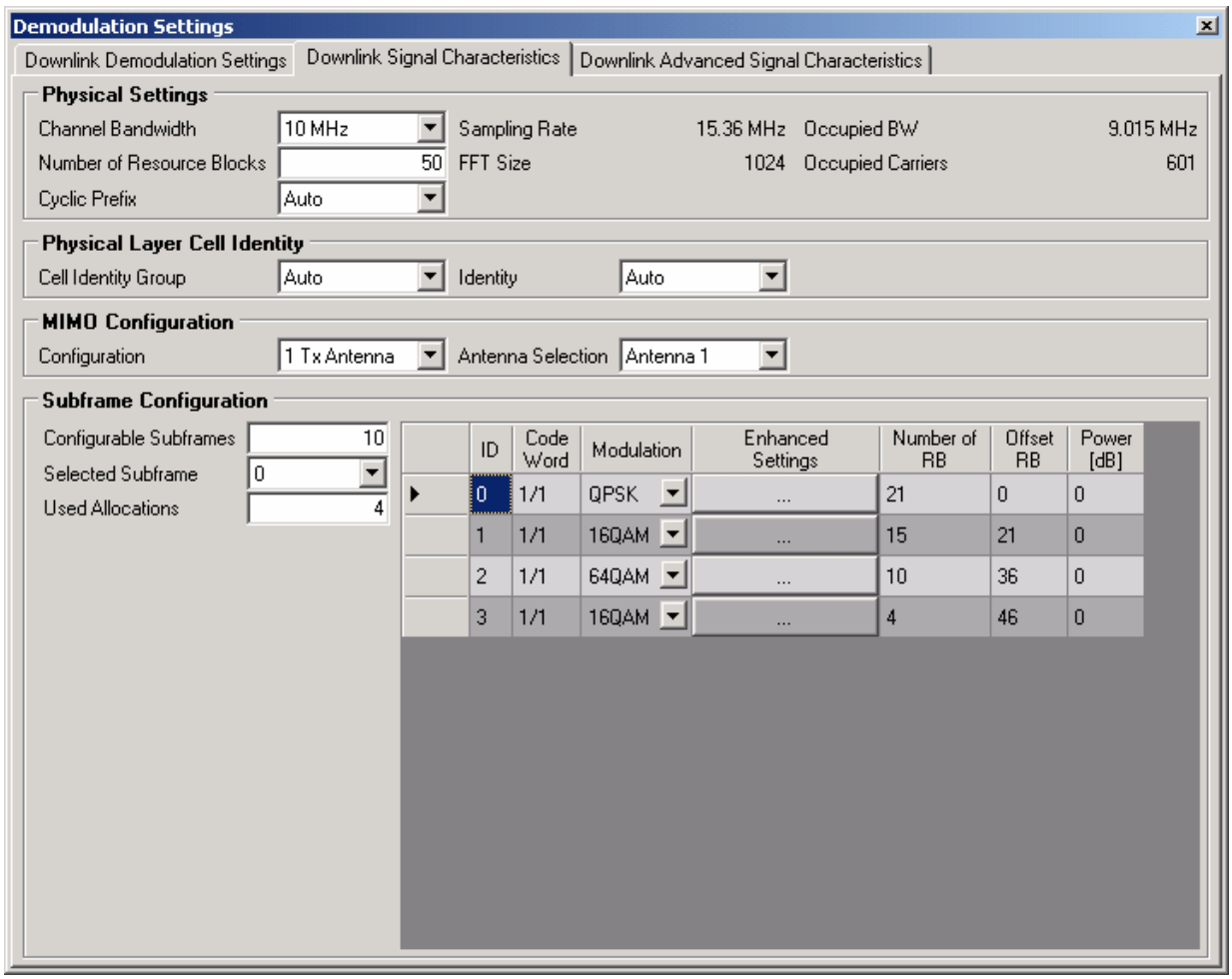


Fig. 46 Demodulation Settings Dialog

Physical Settings

The physical settings are the general settings concerning the physical attributes of the signal to be measured.

Channel bandwidth

Channel Bandwidth or alternatively the *Number of Resource Blocks* specify the bandwidth of the channel to be measured. If a channel bandwidth is selected, the number of resource blocks is automatically set according to the definitions in the standard.

The *Sampling Rate, FFT Size, Occupied BW* and *Occupied Carriers* are read-only parameters which depend on the *Channel Bandwidth* / *Number of Resource Blocks* setting.

Cyclic prefix

Cyclic Prefix specifies the cyclic prefix type. The types *Normal* and *Extended* are supported. If *Auto* is selected, the cyclic prefix type is detected automatically.

Physical Layer Cell Identity

There are 504 unique physical-layer cell identities. The physical-layer cell identities are grouped into 168 unique physical-layer cell-identity groups, each group containing three unique identities. A physical-layer cell identity $N_{\mathrm{ID}}^{\mathrm{cell}} = 3N_{\mathrm{ID}}^{(1)} + N_{\mathrm{ID}}^{(2)}$ is uniquely defined by a number $N_{\mathrm{ID}}^{(1)}$ in the range of 0 to 167, representing the physical-layer cell-identity group, and a number $N_{\mathrm{ID}}^{(2)}$ in the range of 0 to 2, representing the physical-layer identity within the physical-layer cell-identity group.

Cell identity group

Cell Identity Group specifies the physical-layer cell-identity group. If set to *Auto*, the physical-layer cell-identity group is detected automatically.

Identity

Identity specifies the physical-layer identity. If set to *Auto*, the physical-layer identity is detected automatically.

MIMO Configuration

The MIMO configuration sets essential antenna configuration parameters.

Configuration

Configuration specifies the number of transmit antennas. One-, two- and four-antenna configuration is supported.

Antenna selection

Antenna Selection selects the antenna to be analyzed.

If the MIMO configuration is set to two or four antennas, the *Antenna Selection* can be set to *All*. In this case the signals from all antennas are captured by more than one FSQ. Please refer to section “MIMO Hardware Setup” for setting up the hardware for this type of measurement.

Subframe Configuration

The Resource Allocation settings allow you to configure the OFDMA resource allocations. If *Auto Demodulation* is enabled, these settings are automatically detected from the received signal.

Configurable subframes

Configurable Subframes specifies the number of subframes which can be configured in the subframe configuration frame.

Selected subframe

Selected Subframe specifies the subframe to be displayed in the allocation settings table.

Used allocations

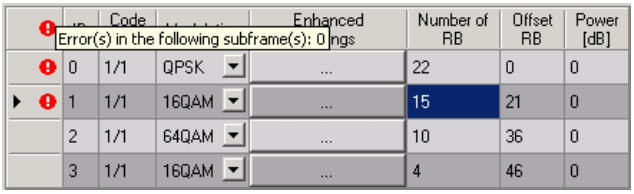
The *Used Allocations* setting specifies the number of allocations used in this subframe. This setting defines the number of rows in the allocation settings table.

Allocation settings table

	ID	Code Word	Modulation	Enhanced Settings	Number of RB	Offset RB	Power [dB]
▶	0	1/1	QPSK	...	21	0	0
	1	1/1	16QAM	...	15	21	0
	2	1/1	64QAM	...	10	36	0
	3	1/1	16QAM	...	4	46	0

	ID	Code Word	Modulation	Enhanced Settings	Number of RB	Offset RB	Power [dB]
	0	1/1	QPSK	...	22	0	0
▶	1	1/1	16QAM	...	15	21	0
	2	1/1	64QAM	...	10	36	0
	3	1/1	16QAM	...	4	46	0

Collision with allocation 0



	Code	Enhanced	Number of RB	Offset RB	Power [dB]
	0	1/1	QPSK	...	22	0	0
▶	1	1/1	16QAM	...	15	21	0
	2	1/1	64QAM	...	10	36	0
	3	1/1	16QAM	...	4	46	0

Error(s) in the following subframe(s): 0

The *Allocation Settings Table* specifies the properties of each allocation used. Each allocation is assigned an ID which counts from 0 to the number of allocations minus one. For each allocation, the following settings are provided:

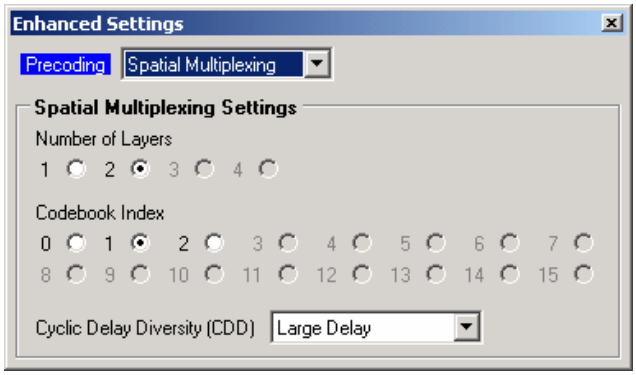
- *Code Word*: See description below
- *Modulation:* Modulation type
- *Enhanced Settings*: Accesses precoding and spatial multiplexing settings
- *Number of RB:* Sets the size of the selected allocation in resource blocks
- *Offset RB:* Sets the start resource block of the selected allocation
- *Power [dB]:* Sets the power in dB

Code Word: if 2 or 4 TX antennas are used and in the *Enhanced Settings* dialog *Spatial Multiplexing* is selected as Precoding value, then the number of layers can be changed. If 2 or more layers are selected (in the Enhanced Settings dialog), then two code words are assigned and hence two rows for the same allocation are visible in the Allocation Settings table. For the second code word the columns *Number of RB*, *Offset RB* and *Power* are not accessible, the settings are the same as for the first code word. In the Code Word column 1/2 and 2/2 is shown do distinguish the two code words.

For the table, a conflict detection is integrated. If two or more resource allocations overlap with others, a red circle containing an exclamation mark is shown in the upper left corner to indicate a conflict. The same icon is displayed in the row of the allocation causing the conflict. The tool tip (shown by moving the mouse pointer over the red circle) provides additional information about the conflict. If only the exclamation mark in the upper left corner is visible, you have to change the number of the selected subframe to find the location of the conflict.
Conflicts must be resolved before a measurement can be started.

Pressing a button in the Enhanced Settings column opens the Enhanced Settings dialog, see below.

Enhanced settings



With the Enhanced Settings dialog the precoding for a physical channel is defined.

The precoding types *None, Transmit Diversity and Spatial Multiplexing* can be selected with the *Precoding* setting.

In case *Spatial Multiplexing* is used, the *Number of Layers* and the *Codebook Index* can be selected. Additionally, one of the three possible *Cyclic Delay Diversity (CDD)* modes can be selected: *None, Small Delay, Large Delay*

Downlink Advanced Signal Characteristics

The Downlink Signal Characteristics tab describes the structure of the signal to be analyzed.

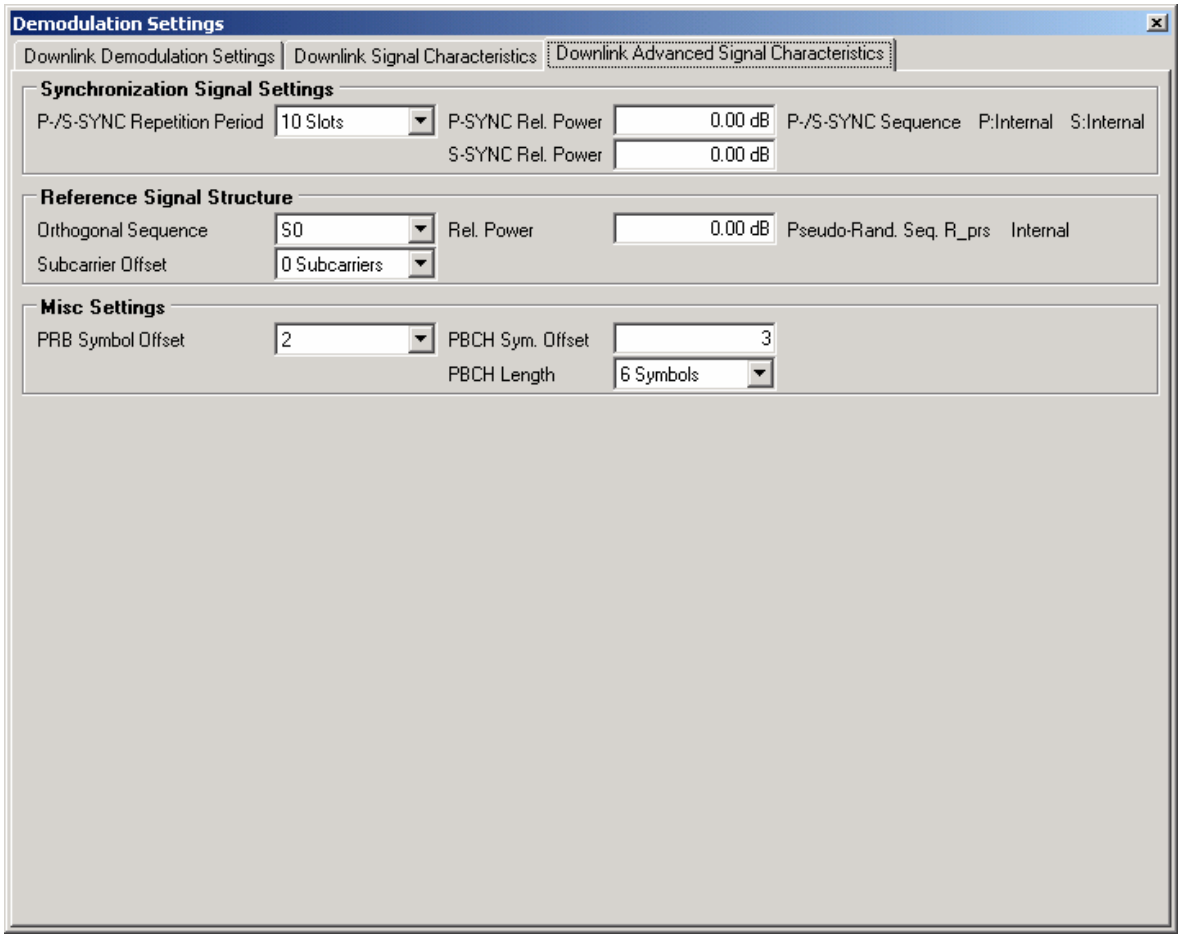


Fig. 47 Demodulation Settings Panel

Synchronization Signal Settings

The P-SYNC and S-SYNC settings are the general settings concerning the physical attributes of the synchronization signals and the physical broadcast channel (PBCH).

P-/S-SYNC repetition period

Repetition period of P-/S-SYNC symbols in slots.

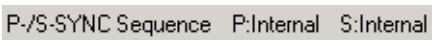
P-SYNC relative power

Relative power of the P-SYNC signals.

S-SYNC relative power

Relative power of the S-SYNC signals.

P-/S-SYNC Sequence



P-/S-SYNC Sequences indicates whether the internal P-SYNC/S-SYNC symbol sequence or a user-defined P-SYNC/S-SYNC symbol sequence is used. This information is given for the primary (P:) and secondary (S:) synchronization signal separately.
If an external symbol definition file is used, the font color changes to red and the type of input file (txt or iqw format) is indicated.

Reference Signal Structure

The Reference Signal Structure settings are the general settings concerning the physical attributes of the reference signal.

Orthogonal sequence

Orthogonal Sequence specifies which S-matrix shall be used to generate the orthogonal sequence $r_{m,n}^{OS}$.

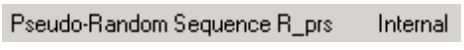
Subcarrier offset

Subcarrier Offset specifies the subcarrier offset of the reference symbols in the frequency (subcarrier) direction. The offset specifies the distance of the first references relative to the lowest subcarrier (subcarrier on the left edge of the OFDM spectrum).

Relative power

Relative power of the reference signal structure.

Pseudo-random sequence R_prs



Indicates whether the internal pilot symbol sequence or a user-defined pilot symbol sequence is used.

If an external symbol definition file is used, the font color changes to red and the type of input file (txt or iqw format) is indicated.

Misc Settings

The Miscellaneous Settings are the general settings concerning the PRB and PBCH symbols.

PRB symbol offset

PRB Symbol Offset specifies the symbol offset of the data allocations relative to the subframe start. This setting applies to all subframes in the frame.

PBCH offset

PBCH Symbol Offset specifies the symbol offset of the physical broadcast channel relative to the subframe.

PBCH length

PBCH Length specifies the length of the physical broadcast channel in symbols.

Display Settings

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

The [**DISP**] hardkey opens the display softkey menu.

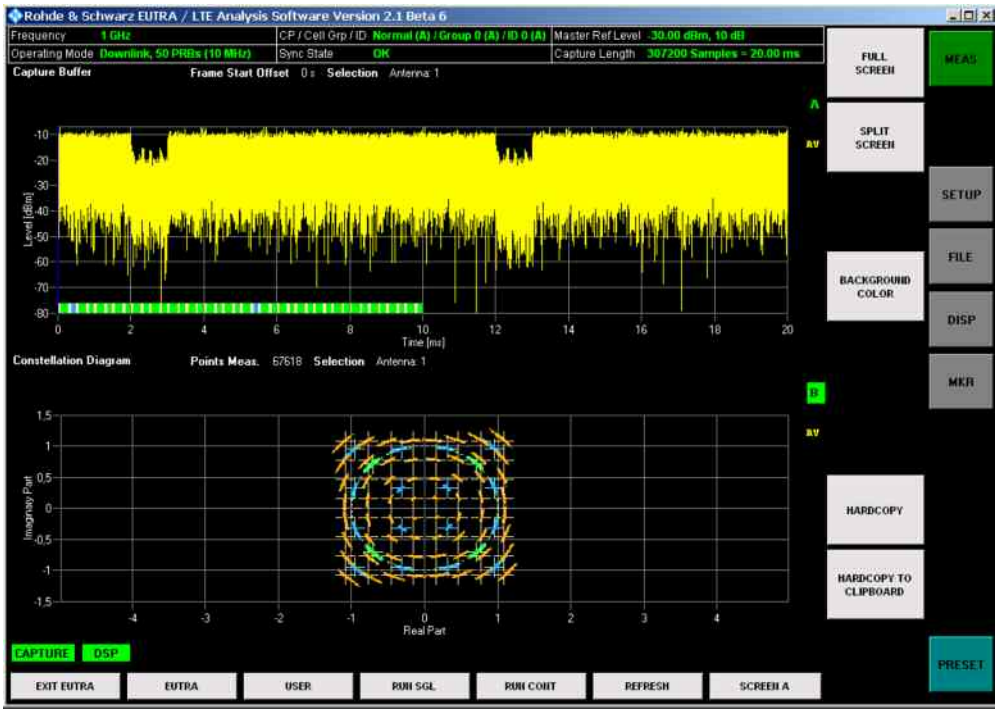


Fig. 48 Display Menu

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.

FILE

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

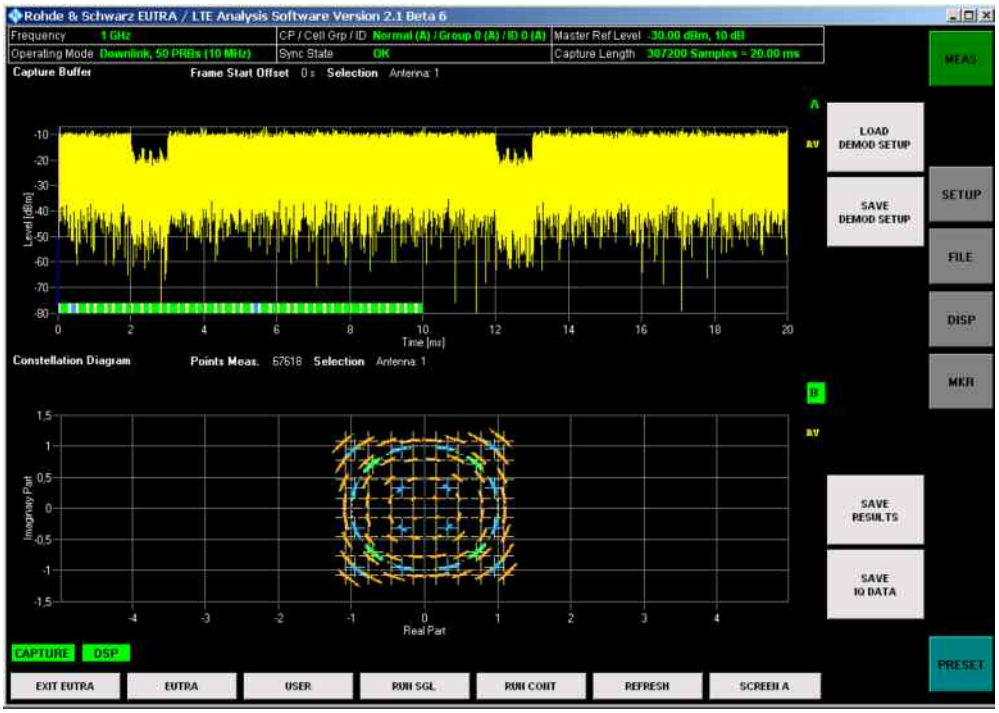


Fig. 49 File Management Menu

Use <*LOAD DEMOD SETUP*> to open a standard file dialog to select a demodulation setup to load.
Use <*SAVE DEMOD SETUP*> to open a standard file dialog to save the current demodulation setup to a file.
Use <*SAVE IQ DATA*> to open a standard file dialog to save the current I/Q data in the capture buffer.

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

Software Setup

This section describes the software setup of demodulation settings, global settings and I/Q data.

SETUP

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

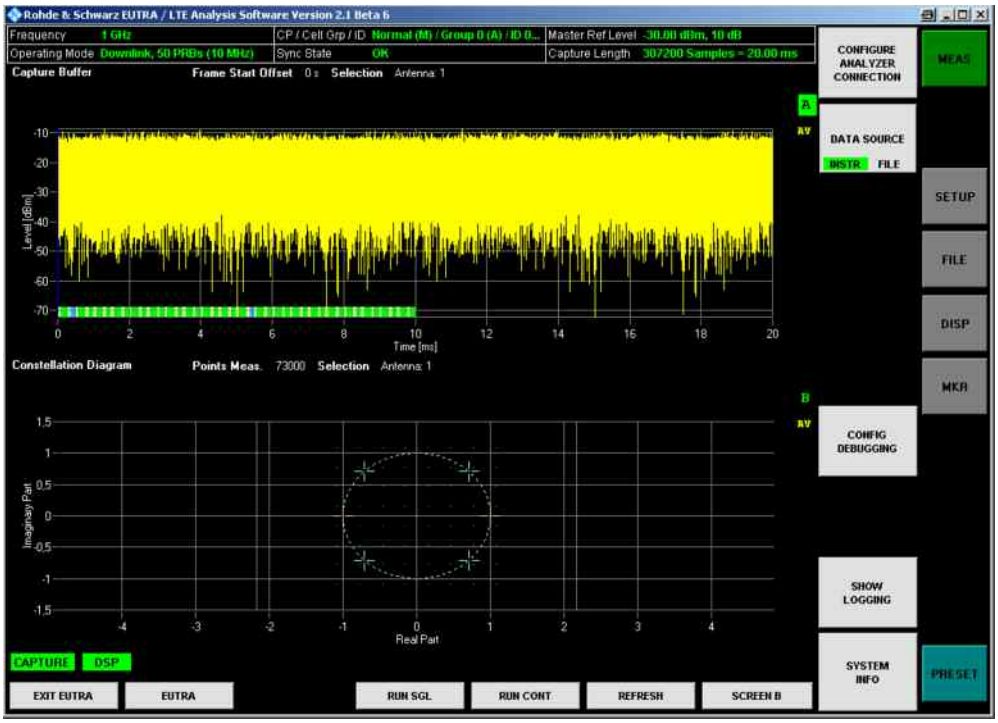
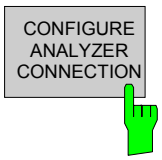


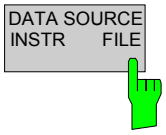
Fig. 50 Software Setup Menu

Configure Analyzer Connection



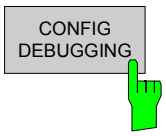
This button opens the General Settings Dialog. For more information how to change the analyzer connection see "MIMO Analyzer Configuration".

Data Source (Instrument or File)



This button changes the data source from instrument to file. It is advisable to change this setting only in the combo box "Source" under Input in the General Settings dialog.

Config Debugging



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

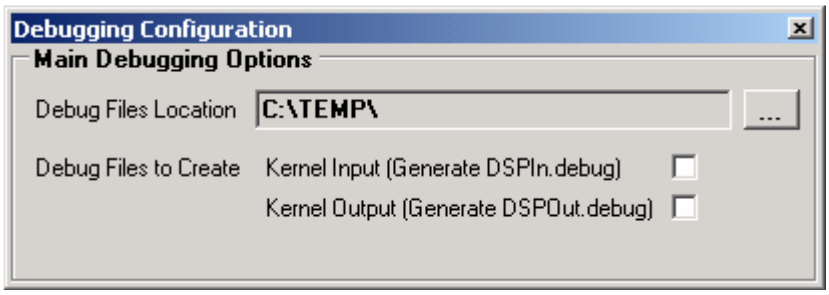
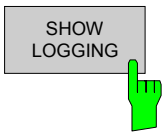


Fig. 51 Debugging Configuration Dialog

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.

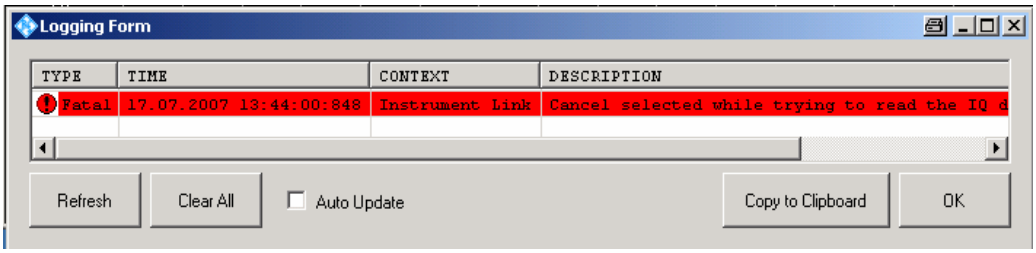


Fig. 52 Debugging Form Dialog

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

System Info

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.

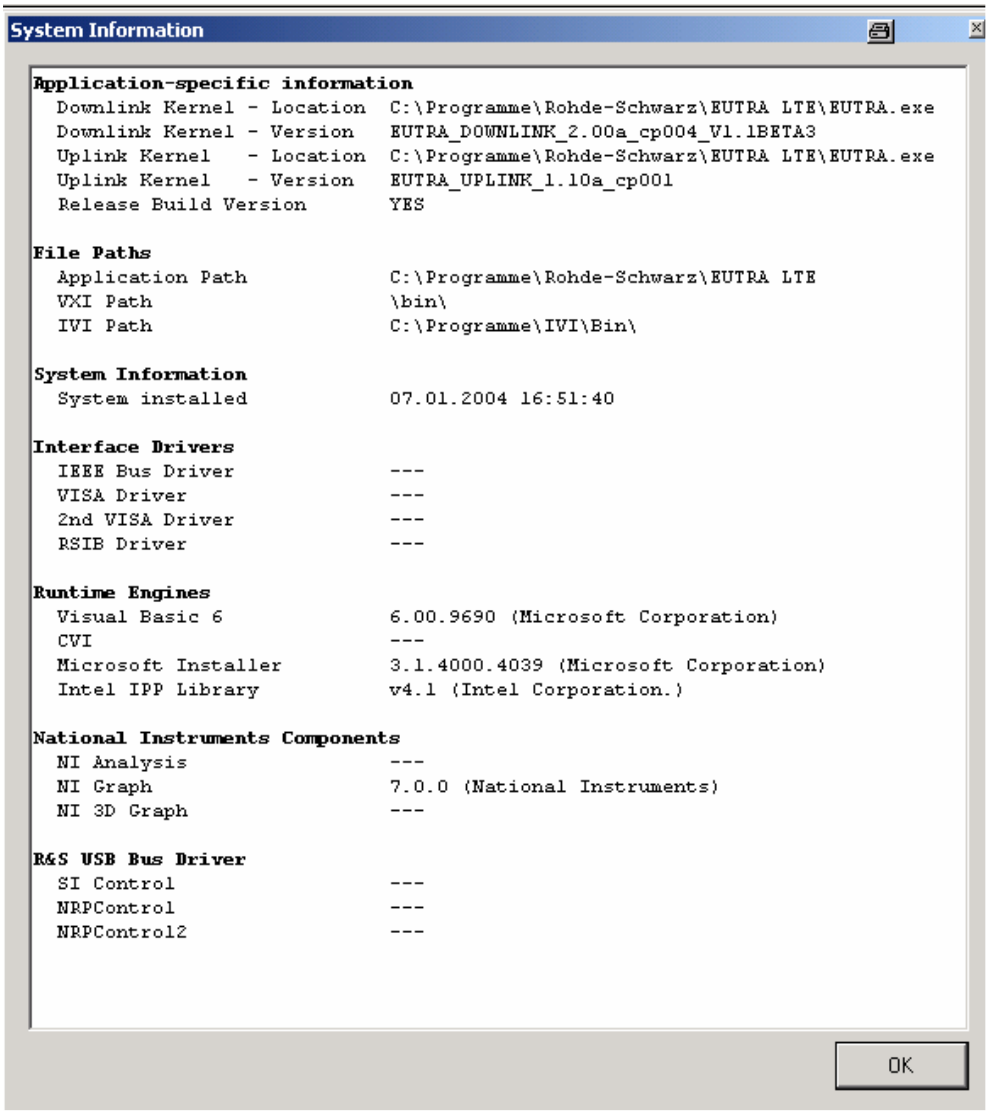


Fig. 53 System Information

Marker

MKR

The [**MARKER**] hardkey has the same functionality as the "Marker" entry in the context menu. For an explanation how to use the [**MARKER**] hardkey, see section "Operating the Graph".
IMPORTANT: The [**MARKER**] hardkey acts on the actual selected graph. If the graph contains more than one trace, nothing happens, see section "Operating the Graph".

Appendix A Import and Export of Data

This section describes how to import and export data from and to the EUTRA/LTE software.

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

- I/Q data
- Frame description
- User-defined P-SYNC, S-SYNC and reference symbols
- Screenshots
- Limit line definitions

I/Q Data

Purpose
The EUTRA/LTE 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 input source *File* in the General Settings dialog. 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*>.

Frame Description

Purpose
The frame description is used to describe the complete modulation structure of the signal, such as bandwidth, modulation, etc.

Format
The frame setup is stored as an XML file. XML files are very commonly used to describe hierarchical structures in an easy-to-read format for both humans and PC. A typical frame setup file is shown below:

```
<?xml version="1.0" encoding="utf-8"?>
<FrameDefinition LinkDirection="downlink" RessourceBlocks="50" CP="auto"
RefSigSubcarrierOffset="0" PSYNCBoostingdB="0" SSYNCBoostingdB="0"
ReferenceSignalBoostingdB="0" PBCHSymbolOffset="3" PBCHLength="6" PDCCHNumberOfModSymbols="0"
PSSYNCRepetitionPeriod="10" DataSymbolOffsetSubFrame="2" MIMOConfiguration="1 Tx Antenna"
MIMOAntennaSelection="Antenna 1" PhysLayCellIDGrp="Auto" PhysLayID="Auto"
PilotOrthogonalSequence="1">
  <Frame>
    <Subframe>
      <PRBs>
        <PRB Start="0" Length="6" Boosting="0" Modulation="QPSK" Precoding="None" Layers="1"
Codebook="0" CDD="None"/>
      </PRBs>
    </Subframe>
  </Frame>
</FrameDefinition>
```

All settings which can be entered via <*DEMOD SETTINGS*> can also be found in the frame setup file. Additional allocations can be entered by adding additional PRB entries in the PRBs list.

The following restrictions apply to the frame setup content:

- At least one PRB must exist.
- Only one frame can be allocated in this software version.

Usage – IMPORT
To load a stored frame setup, select [**FILE**] <*LOAD DEMOD SETUP*>.

Usage – EXPORT
To save a frame setup, select [**FILE**] <*SAVE DEMOD SETUP*>.

User-Defined P-SYNC, S-SYNC and Reference Symbols

Purpose
Since the reference symbols are not yet defined in the standardization document and to offer maximum flexibility, it is possible to load user-defined **bit** or **iq sequences** for the P-SYNC, S-SYNCH and reference signal. The modulation of the bit sequences is QPSK.

Format
To create user-defined **bit sequences**, create a text file (ACSII format) with the numbers 0 and 1, with one number per line. A "0" corresponds to a 0 bit and a "1" corresponds to a 1 bit:

<QPSK symbol 1, I bit >
<QPSK symbol 1, Q bit >
<QPSK symbol 2, I bit >
<QPSK symbol 2, Q bit >
<QPSK symbol 3, I bit >
…

The length of the P-SYNC bit definition vector must be 144 (bits per symbol * carriers = 2 * 72). For S-SYNC and reference symbols, if not enough bits are available for the mapping, the bits are repeated. The length of the reference symbols bit definition vectors must be a multiple of 2.

To create user-defined **iq sequences**, create a binary file containing the complex valued iq symbols. 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 is IQIQIQ.

To generate iqw-files of the correct format, the following Matlab code can be used, assuming that *x* is the complex valued I/Q-symbol column vector and the file name is stored in *sExportFileName* as string:

```
% open file
fid = fopen(sExportFileName, 'w');

% make complex data real according to I Q I Q I Q ...
x = [real(x) imag(x)].';
fwrite(fid, x(:), 'float32');
fclose(fid);
```

The length of the P-SYNC iq symbol definition vector must be 144 (inphase/quadrature component * carriers = 2 * 72). For S-SYNC and reference symbols, if not enough iqw symbols are available for the mapping, the iqw symbols are repeated.

Usage – IMPORT
The bit/iq definition file must be placed in the same folder as the EUTRA/LTE application binary ((“%Program folder%\Rohde-Schwarz\EUTRA LTE” by default).

- The name of the **P-SYNC bit** definition file must be *PSCHBitsQPSKUser.txt*.
- The name of the **P-SYNC iq** definition file must be *PSCHSymbolsUser.iqw*.
- The name of the **S-SYNC bit** definition file must be *SSCHBitsQPSKUser.txt*.
- The name of the **S-SYNC iq** definition file must be *SSCHSymbolsUser.iqw*.
- The name of the **Reference Pilots bit** definition file must be *PilotBitsQPSKUser.txt*.
- The name of the **Reference Pilots iq** definition file must be *PilotSymbolsUser.iqw*.

Limits

Purpose
The limit definition is used to specify user-defined limits, as the EUTRA/LTE standard does not describe explicit limits at the moment.
Currently, limits are only used in the Result Table ([**MAIN**] <*DISPLAY LIST*>).
Format
The limit definition can be provided as XML. An example, including comments on how to use the definition, can be found in the following paragraph:

```
<?xml version="1.0" encoding="utf-8"?>
<Limits>
  <DL>
    <EVM>
      <PhysicalChannel/><!--Unit: linear (1 = 0 dB, 0.1 = -20 dB)-->
      <PhysicalSignal/><!--Unit: linear (1 = 0 dB, 0.1 = -20 dB)-->
      <All/><!--Unit: linear (1 = 0 dB, 0.1 = -20 dB)-->
    </EVM>
    <FrequencyError/><!--Unit: [Hz]-->
    <SamplingClockError/><!--Unit [ppm]-->
    <IQOffset/><!--Unit: linear (1 = 0 dB, 0.1 = -20 dB)-->
    <IQGainImbalance/><!--Unit: linear (1 = 0 dB, 0.1 = -20 dB)-->
    <IQQuadraturError/><!--Unit: [°]-->
    <PowerTotal/><!--Unit: [W]-->
    <CrestFactor/><!--Unit: linear (1 = 0 dB, 10 = 10 dB)-->
  </DL>
</Limits>
```

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

Usage – IMPORT
The bit definition file must be placed in the same folder as the EUTRA/LTE application binary (“%Program folder%\Rohde-Schwarz\EUTRA LTE” by default). The file name must be Default.eutra_limits. The file is read once during the start-up process of the software.

Appendix B Measurements in Detail

This section provides a detailed explanation of the measurements provided by R&S FSQ-K100/K102 and provides help for using R&S FSQ-K100/K102 to measure the characteristics of specific types of DUT.

Signal Processing of the EUTRA / LTE Downlink Measurement Application

Symbols

$a_{l,k}, \hat{a}_{l,k}$	data symbol (actual, decided)
$b_{l,k}$	boosting factor
$\Delta f, \Delta\hat{f}_{\text{coarse}}$	carrier frequency offset between transmitter and receiver (actual, coarse estimate)
Δf_{res}	residual carrier frequency offset
ζ	relative sampling frequency offset
$H_{l,k}, \hat{H}_{l,k}$	channel transfer function (actual, estimate)
i	time index
$\hat{i}_{\text{coarse}}, \hat{i}_{\text{fine}}$	timing estimate (coarse, fine)
k	subcarrier index
l	OFDM symbol index
N_{FFT}	length of FFT
N_{g}	number of samples in cyclic prefix (guard interval)
N_{s}	number of Nyquist samples
N_{sc}	number of subcarriers
n	subchannel index, subframe index
$n_{l,k}$	noise sample
Φ_l	common phase error
$r(i)$	received sample in the time domain
$r_{l,k}, r'_{l,k}, r''_{l,k}$	received sample (uncompensated, partially compensated, equalized) in the frequency domain
T	useful symbol time
T_{g}	guard time
T_{s}	symbol time

Introduction

The following description provides a brief overview of the digital signal processing used in the R&S FSQ EUTRA/LTE downlink measurement application.
From the received IF signal as the point of origin to the actual analysis results such as EVM, the digital signal processing can be divided into four major groups:

- Data capturing
- Synchronization
- Channel estimation / equalization } EUTRA/LTE downlink measurement application
- Analysis

The remainder of this description is structured accordingly.

Signal Processing

Data Capturing

The block diagram in Fig. 54 shows the R&S FSQ hardware from the IF section to the processor running the EUTRA/LTE 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.

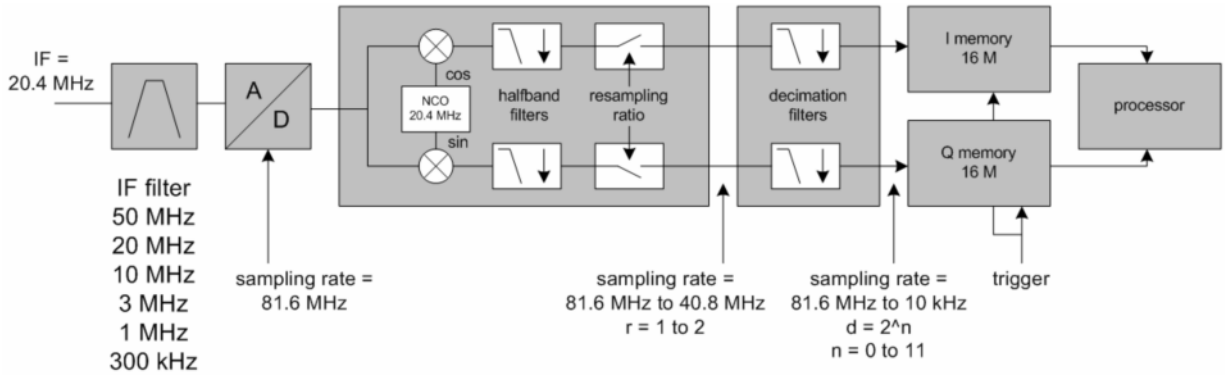


Fig. 54 Data Capturing Mechanism of the R&S FSQ

The maximum allowable bandwidth of the measurement signal depends on the target sampling rate according to Table 2.

Table 2 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.

EUTRA/LTE Downlink Measurement Application

The block diagram in Fig. 55 shows the EUTRA/LTE downlink measurement application from the capture buffer containing the I/Q data to the actual analysis block. The outcome of the fully compensated reference path (green) are the estimates $\hat{a}_{l,k}$ of the transmitted data symbols $a_{l,k}$. Depending on the user-defined compensation, the received samples $r''_{l,k}$ of the measurement path (yellow) still contain the transmitted signal impairments of interest. The analysis block reveals these impairments by comparing the reference and the measurement path. Prior to the analysis, diverse synchronization and channel estimation tasks have to be accomplished.

Synchronization

The first of the synchronization tasks is to estimate the OFDM symbol timing, which coarsely estimates both timing and carrier frequency offset. The frame synchronization block determines the position of the SCH symbol in time and frequency by using the coarse fractional frequency offset compensated capture buffer and the timing estimate $\hat{i}_{\text{coarse}}$ to position the window of the FFT. The fine timing block prior to the FFT allows a timing improvement using a level-based search for the beginning and end of the estimated channel impulse response. A coarse estimate of the CIR can be directly obtained from the SCH.

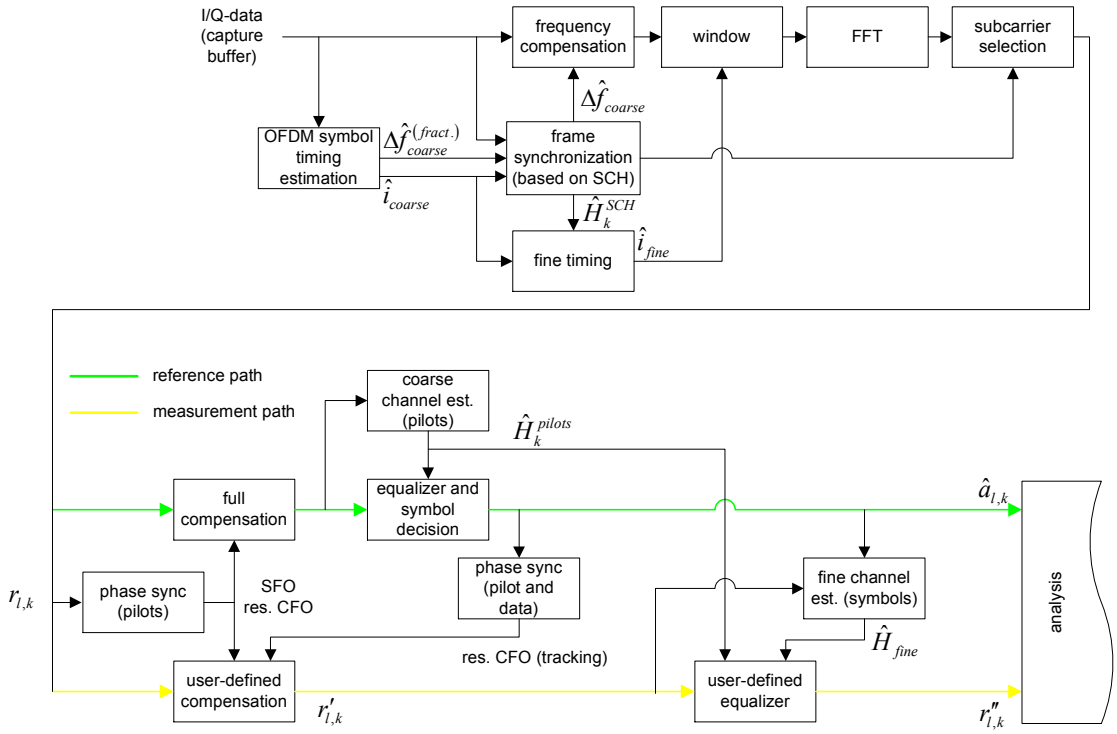


Fig. 55 EUTRA/LTE Downlink Measurement Application

After the time to frequency transformation by an FFT of length N_{FFT}, the tracking estimation block is used to estimate the following:

- the relative sampling frequency offset ζ
- the residual carrier frequency offset Δf_{res}
- the common phase error Φ_l

According to references [1] and [2], the uncompensated samples $r_{l,k}$ can be expressed as

$$r_{l,k} = a_{l,k} \cdot H_{l,k} \cdot \underbrace{\mathrm{e}^{\mathrm{j}\,\Phi_l}}_{\text{CPE}} \cdot \underbrace{\mathrm{e}^{\mathrm{j}\,2\pi \cdot N_\mathrm{s}/N_\mathrm{FFT} \cdot \zeta \cdot k \cdot l}}_{\text{SFO}} \cdot \underbrace{\mathrm{e}^{\mathrm{j}\,2\pi \cdot N_\mathrm{s}/N_\mathrm{FFT} \cdot \Delta f_\mathrm{res} \cdot T \cdot l}}_{\text{res. CFO}} + n_{l,k} \qquad (6.1)$$

where

- the data symbol is $a_{l,k}$ on subcarrier k at OFDM symbol l,
- the channel transfer function is $H_{l,k}$,
- the number of Nyquist samples is N_s within the symbol time T_s,
- the useful symbol time $T = T_\mathrm{s} - T_\mathrm{g}$,
- the independent and Gaussian distributed noise sample is $n_{l,k}$.

Within one OFDM symbol, both the CPE and the residual CFO cause the same phase rotation for each subcarrier, while the rotation due to the SFO depends linearly on the subcarrier index. A linear phase increase in symbol direction can be observed for the residual CFO as well as for the SFO.

The results of the tracking estimation block are used to compensate the samples $r_{l,k}$. Whereas a full compensation is performed in the reference path, the signal impairments that are of interest to the user are left uncompensated in the measurement path.

After having decided the data symbols in the reference path, an additional phase tracking can be utilized to refine the common phase error estimation.

Channel Estimation/Equalization

As shown in Fig. 55, there is one coarse and one fine channel estimation block. The pilot-based coarse estimation is tapped behind the full compensation block of the reference path. The coarse estimation block uses available training symbols to determine initial estimates $\hat{H}_{l,k}$ of the channel transfer function at fixed positions in the subcarrier-symbol plane. Based on these nodes, the missing CTF values are obtained by interpolation in both time and frequency direction. The coarse estimation results are used to equalize the samples $r'_{l,k}$ of the reference path prior to symbol decision. Based on the decided data symbols, a fine channel estimation is optimally performed and then used to equalize the partially compensated samples of the measurement path.

Analysis

The analysis block of the EUTRA/LTE downlink measurement application allows you to compute a variety of measurement variables.

EVM

The most important variable is the error vector magnitude

$$EVM_{l,k} = \frac{\left| r''_{l,k} - \hat{a}_{l,k} \right|}{b_{l,k} \sqrt{\mathrm{E}\left\{ \left| \frac{a_{l,k}}{b_{l,k}} \right|^2 \right\}}} \qquad (6.2)$$

on subcarrier k at OFDM symbol l, where $b_{l,k}$ is the boosting factor. Since the average power of all possible constellations is 1 when no boosting is applied, (6.2) can be rewritten as

$$EVM_{l,k} = \frac{\left| r''_{l,k} - \hat{a}_{l,k} \right|}{b_{l,k}}. \quad (6.3)$$

The average EVM of all data subcarriers is then

$$EVM_{\text{data}} = \sqrt{\frac{1}{N_{\text{sc}}} \sum_{l} \sum_{k_{\text{d}}} EVM_{l,k_{\text{d}}}^2}. \quad (6.4)$$

The number of subcarriers taken into account is denoted by N_{sc}.

I/Q imbalance

The I/Q imbalance can be written as

$$r(t) = I \ \Re\{s(t)\} + jQ \ \Im\{s(t)\}, \quad (6.5)$$

where $s(t)$ is the transmit signal, $r(t)$ is the received signal, and I and Q are the weighting factors. We define that $I := 1$ and $Q := 1 + \Delta Q$.

The I/Q imbalance estimation makes it possible to evaluate the

$$modulator\ gain\ balance = |1 + \Delta Q| \quad (6.6)$$

and the

$$quadrature\ mismatch = \arg\{1 + \Delta Q\} \quad (6.7)$$

based on the complex-valued estimate $\Delta\hat{Q}$.

Other measurement variables

Without going into detail, the EUTRA/LTE downlink measurement application additionally provides the following results:

- Total power
- Constellation diagram
- Group delay
- I/Q offset
- Crest factor
- Spectral flatness

References

[1] Speth, M., Fechtel, S., Fock, G., and Meyr, H.: Optimum Receiver Design for Wireless Broad-Band Systems Using OFDM – Part I. IEEE Trans. on Commun. Vol. 47 (1999) No. 11, pp. 1668-1677.

[2] Speth, M., Fechtel, S., Fock, G., and Meyr, H.: Optimum Receiver Design for OFDM-Based Broadband Transmission – Part II: A Case Study. IEEE Trans. on Commun. Vol. 49 (2001) No. 4, pp. 571-578.

Appendix C Glossary

3GPP	3rd Generation Partnership Project
Application path	The path where the setup software installed the R&S FSQ-K100/K102 EUTRA/LTE analysis software ("%Program folder%\Rohde-Schwarz\EUTRA LTE" by default)
ARQ	Automatic Repeat Request
BB	Baseband
BCH	Broadcast channel
BW	Bandwidth
CAPEX	Capital Expenditure
CCDF	Complementary Cumulative Distribution Function
CCPCH	Common Control Physical Channel
CFO	Carrier Frequency Offset
CIR	Channel Impulse Response
CP	Cyclic Prefix (Guard Interval)
CPE	Common Phase Error
CQI	Channel Quality Indicator
CTF	Channel Transfer Function
DL	Downlink
DUT	Device under Test
DVB	Digital Video Broadcast
EUTRA	Evolved Universal Terrestrial Radio Access
EUTRAN	Evolved Universal Terrestrial Radio Access Network
EVM	Error Vector Magnitude
FDD	Frequency Division Duplex
FFT	Fast Fourier Transform
GERAN	GSM EDGE Radio Access Network
HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
IF	IntermediateFrequency
IFFT	Inverse Fast Fourier Transformation
LAN	Local Area Network
LTE	Long Term Evolution
MBMS	Multimedia Broadcast Multicast Services

MIMO	Multiple Input Multiple Output
OFDM	Orthogonal Frequency Division Mulitplexing
OFDMA	Orthogonal Frequency Division Multiple Access
OPEX	Operational Expenditures
PBCH	Physical Broadcast Channel
PDCCH	Physical Downlink Control Channel
PDSCH	Physical Downlink Shared Channel
PRB	Physical Resource Block
Program folder	The path where programs are installed; by default, this is C:\Program Files
PS	Packet switched
PSCH	Primary Synchronization Channel (no longer used, now replaced by P-SYNC)
P-SYNC	Primary Synchronization Signal
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
RAT	Radio Access Technology
RB	Resource Block
RF	Radio Frequency
R&S FSQ	Rohde & Schwarz Signal Analyzer
SAE	System Architecture Evolution
SC-FDMA	Single Carrier Frequency Division Multiple Access
SFO	Sampling Frequency Offset
SSCH	Secondary Synchronization Channel (no longer used, now replaced by S-SYNC)
S-SYNC	Secondary Synchronization Signal
System root	The path where Microsoft Windows is installed; by default, this is C:\WINNT
TDD	Time Division Duplex
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunications System
UTRA	UMTS Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network
WCDMA	Wideband Code Division Multiple Access
WLAN	Wireless Local Area Network
WiMAX	Worldwide Interoperability for Microwave Access

Appendix D Common Errors and Remedies

This section shows the most common problems that occur when using the R&S FSQ-K100/K102 EUTRA/LTE analysis software.

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 "EUTRA_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.

7 Index

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