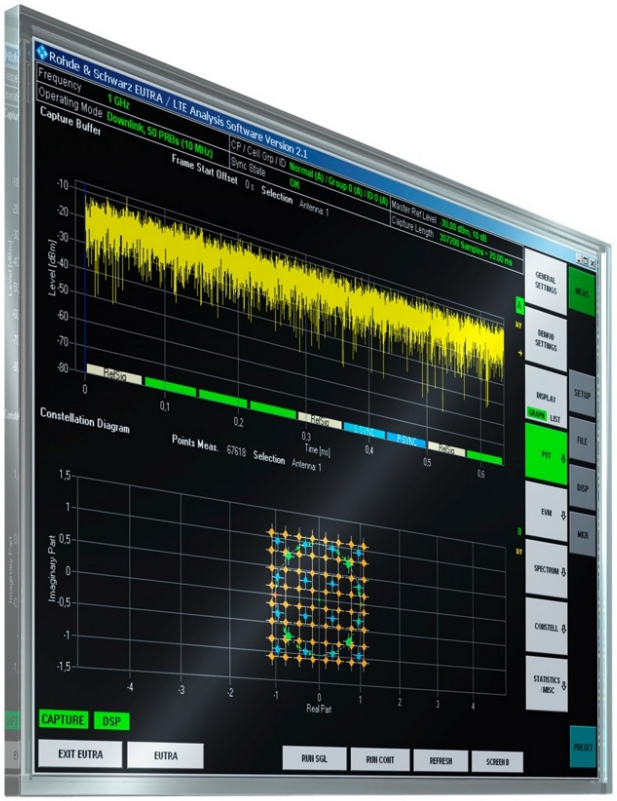
R&S®FS-K101/103/105PC
R&S®FSV-K101/103/105
R&S®FSQ-K101/103/105
EUTRA / LTE Uplink PC Software
User Manual



1308.9135.42 ─ 12

Test & Measurement

User Manual

ROHDE&SCHWARZ

This manual covers the following products.

- R&S®FSQ-K101 (1308.9058.02)
- R&S®FSQ-K103 (1309.9097.02)
- R&S®FSQ-K105 (1309.9516.02)
- R&S®FSV-K101 (1310.9100.02)
- R&S®FSV-K103 (1310.9200.02)
- R&S®FSV-K105 (1309.9780.02)
- R&S®FS-K101PC (1309.9922.02)
- R&S®FS-K103PC (1309.9945.02)
- R&S®FS-K105PC (1309.9968.02)

The R&S®FS-K10xPC versions are available for the following spectrum and signal analyzers

- R&S®FSG
- R&S®FSQ
- R&S®FSV
- R&S®FSVR
- R&S®FSW

The contents of the manual correspond to version 3.00 or higher.

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The following abbreviations are used throughout this manual: R&S®FS-K101-/K103/-K105 is abbreviated as R&S FS-K101/-K103/-K105.

Basic Safety Instructions

Always read through and comply with the following safety instructions!

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

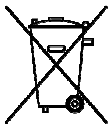
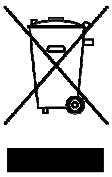
Furthermore, it is your responsibility to use the product in an appropriate manner. This product is designed for use solely in industrial and laboratory environments or, if expressly permitted, also in the field and must not be used in any way that may cause personal injury or property damage. You are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

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

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

Symbols and safety labels

Symbol	Meaning	Symbol	Meaning
	Notice, general danger location Observe product documentation		ON/OFF supply voltage
	Caution when handling heavy equipment		Standby indication
	Danger of electric shock		Direct current (DC)

Symbol	Meaning	Symbol	Meaning
	Warning! Hot surface		Alternating current (AC)
	Protective conductor terminal		Direct/alternating current (DC/AC)
	Ground		Device fully protected by double (reinforced) insulation
	Ground terminal		EU labeling for batteries and accumulators For additional information, see section "Waste disposal/Environmental protection", item 1.
	Be careful when handling electrostatic sensitive devices		EU labeling for separate collection of electrical and electronic devices For additonal information, see section "Waste disposal/Environmental protection", item 2.
	Warning! Laser radiation For additional information, see section "Operation", item 7.		

Signal words and their meaning

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

DANGER Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

WARNING Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE Indicates the possibility of incorrect operation which can result in damage to the product.
In the product documentation, the word ATTENTION is used synonymously.

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

Operating states and operating positions

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

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

Electrical safety

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

1. Prior to switching on the product, always ensure that the nominal voltage setting on the product matches the nominal voltage of the AC supply network. If a different voltage is to be set, the power fuse of the product may have to be changed accordingly.
2. In the case of products of safety class I with movable power cord and connector, operation is permitted only on sockets with a protective conductor contact and protective conductor.
3. Intentionally breaking the protective conductor either in the feed line or in the product itself is not permitted. Doing so can result in the danger of an electric shock from the product. If extension cords or connector strips are implemented, they must be checked on a regular basis to ensure that they are safe to use.
4. If there is no power switch for disconnecting the product from the AC supply network, or if the power switch is not suitable for this purpose, use the plug of the connecting cable to disconnect the product from the AC supply network. In such cases, always ensure that the power plug is easily reachable and accessible at all times. For example, if the power plug is the disconnecting device, the length of the connecting cable must not exceed 3 m. Functional or electronic switches are not suitable for providing disconnection from the AC supply network. If products without power switches are integrated into racks or systems, the disconnecting device must be provided at the system level.
5. Never use the product if the power cable is damaged. Check the power cables on a regular basis to ensure that they are in proper operating condition. By taking appropriate safety measures and carefully laying the power cable, ensure that the cable cannot be damaged and that no one can be hurt by, for example, tripping over the cable or suffering an electric shock.

6. The product may be operated only from TN/TT supply networks fuse-protected with max. 16 A (higher fuse only after consulting with the Rohde & Schwarz group of companies).
7. Do not insert the plug into sockets that are dusty or dirty. Insert the plug firmly and all the way into the socket provided for this purpose. Otherwise, sparks that result in fire and/or injuries may occur.
8. Do not overload any sockets, extension cords or connector strips; doing so can cause fire or electric shocks.
9. For measurements in circuits with voltages V_{rms} > 30 V, suitable measures (e.g. appropriate measuring equipment, fuse protection, current limiting, electrical separation, insulation) should be taken to avoid any hazards.
10. Ensure that the connections with information technology equipment, e.g. PCs or other industrial computers, comply with the IEC60950-1/EN60950-1 or IEC61010-1/EN 61010-1 standards that apply in each case.
11. Unless expressly permitted, never remove the cover or any part of the housing while the product is in operation. Doing so will expose circuits and components and can lead to injuries, fire or damage to the product.
12. If a product is to be permanently installed, the connection between the protective conductor terminal on site and the product's protective conductor must be made first before any other connection is made. The product may be installed and connected only by a licensed electrician.
13. For permanently installed equipment without built-in fuses, circuit breakers or similar protective devices, the supply circuit must be fuse-protected in such a way that anyone who has access to the product, as well as the product itself, is adequately protected from injury or damage.
14. Use suitable overvoltage protection to ensure that no overvoltage (such as that caused by a bolt of lightning) can reach the product. Otherwise, the person operating the product will be exposed to the danger of an electric shock.
15. Any object that is not designed to be placed in the openings of the housing must not be used for this purpose. Doing so can cause short circuits inside the product and/or electric shocks, fire or injuries.
16. Unless specified otherwise, products are not liquid-proof (see also section "Operating states and operating positions", item 1). Therefore, the equipment must be protected against penetration by liquids. If the necessary precautions are not taken, the user may suffer electric shock or the product itself may be damaged, which can also lead to personal injury.
17. Never use the product under conditions in which condensation has formed or can form in or on the product, e.g. if the product has been moved from a cold to a warm environment. Penetration by water increases the risk of electric shock.
18. Prior to cleaning the product, disconnect it completely from the power supply (e.g. AC supply network or battery). Use a soft, non-linting cloth to clean the product. Never use chemical cleaning agents such as alcohol, acetone or diluents for cellulose lacquers.

Operation

1. Operating the products requires special training and intense concentration. Make sure that persons who use the products are physically, mentally and emotionally fit enough to do so; otherwise, injuries or material damage may occur. It is the responsibility of the employer/operator to select suitable personnel for operating the products.

2. Before you move or transport the product, read and observe the section titled "Transport".
3. As with all industrially manufactured goods, the use of substances that induce an allergic reaction (allergens) such as nickel cannot be generally excluded. If you develop an allergic reaction (such as a skin rash, frequent sneezing, red eyes or respiratory difficulties) when using a Rohde & Schwarz product, consult a physician immediately to determine the cause and to prevent health problems or stress.
4. Before you start processing the product mechanically and/or thermally, or before you take it apart, be sure to read and pay special attention to the section titled "Waste disposal/Environmental protection", item 1.
5. Depending on the function, certain products such as RF radio equipment can produce an elevated level of electromagnetic radiation. Considering that unborn babies require increased protection, pregnant women must be protected by appropriate measures. Persons with pacemakers may also be exposed to risks from electromagnetic radiation. The employer/operator must evaluate workplaces where there is a special risk of exposure to radiation and, if necessary, take measures to avert the potential danger.
6. Should a fire occur, the product may release hazardous substances (gases, fluids, etc.) that can cause health problems. Therefore, suitable measures must be taken, e.g. protective masks and protective clothing must be worn.
7. Laser products are given warning labels that are standardized according to their laser class. Lasers can cause biological harm due to the properties of their radiation and due to their extremely concentrated electromagnetic power. If a laser product (e.g. a CD/DVD drive) is integrated into a Rohde & Schwarz product, absolutely no other settings or functions may be used as described in the product documentation. The objective is to prevent personal injury (e.g. due to laser beams).
8. EMC classes (in line with CISPR 11)
   Class A: Equipment suitable for use in all environments except residential environments and environments that are directly connected to a low-voltage supply network that supplies residential buildings.
   Class B: Equipment suitable for use in residential environments and environments that are directly connected to a low-voltage supply network that supplies residential buildings.

Repair and service

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

Batteries and rechargeable batteries/cells

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

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

Transport

1. The product may be very heavy. Therefore, the product must be handled with care. In some cases, the user may require a suitable means of lifting or moving the product (e.g. with a lift-truck) to avoid back or other physical injuries.
2. Handles on the products are designed exclusively to enable personnel to transport the product. It is therefore not permissible to use handles to fasten the product to or on transport equipment such as cranes, fork lifts, wagons, etc. The user is responsible for securely fastening the products to or on the means of transport or lifting. Observe the safety regulations of the manufacturer of the means of transport or lifting. Noncompliance can result in personal injury or material damage.
3. If you use the product in a vehicle, it is the sole responsibility of the driver to drive the vehicle safely and properly. The manufacturer assumes no responsibility for accidents or collisions. Never use the product in a moving vehicle if doing so could distract the driver of the vehicle. Adequately secure the product in the vehicle to prevent injuries or other damage in the event of an accident.

Waste disposal/Environmental protection

1. Specially marked equipment has a battery or accumulator that must not be disposed of with unsorted municipal waste, but must be collected separately. It may only be disposed of at a suitable collection point or via a Rohde & Schwarz customer service center.

2. Waste electrical and electronic equipment must not be disposed of with unsorted municipal waste, but must be collected separately.
   Rohde & Schwarz GmbH & Co. KG has developed a disposal concept and takes full responsibility for take-back obligations and disposal obligations for manufacturers within the EU. Contact your Rohde & Schwarz customer service center for environmentally responsible disposal of the product.
3. If products or their components are mechanically and/or thermally processed in a manner that goes beyond their intended use, hazardous substances (heavy-metal dust such as lead, beryllium, nickel) may be released. For this reason, the product may only be disassembled by specially trained personnel. Improper disassembly may be hazardous to your health. National waste disposal regulations must be observed.
4. If handling the product releases hazardous substances or fuels that must be disposed of in a special way, e.g. coolants or engine oils that must be replenished regularly, the safety instructions of the manufacturer of the hazardous substances or fuels and the applicable regional waste disposal regulations must be observed. Also observe the relevant safety instructions in the product documentation. The improper disposal of hazardous substances or fuels can cause health problems and lead to environmental damage.

For additional information about environmental protection, visit the Rohde & Schwarz website.

Instrucciones de seguridad elementales

¡Es imprescindible leer y cumplir las siguientes instrucciones e informaciones de seguridad!

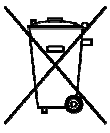
El principio del grupo de empresas Rohde & Schwarz consiste en tener nuestros productos siempre al día con los estándares de seguridad y de ofrecer a nuestros clientes el máximo grado de seguridad. Nuestros productos y todos los equipos adicionales son siempre fabricados y examinados según las normas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

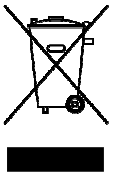
Además queda en la responsabilidad del usuario utilizar el producto en la forma debida. Este producto está destinado exclusivamente al uso en la industria y el laboratorio o, si ha sido expresamente autorizado, para aplicaciones de campo y de ninguna manera deberá ser utilizado de modo que alguna persona/cosa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

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

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

Símbolos y definiciones de seguridad

Símbolo	Significado	Símbolo	Significado
	Aviso: punto de peligro general Observar la documentación del producto		Tensión de alimentación de PUESTA EN MARCHA / PARADA
	Atención en el manejo de dispositivos de peso elevado		Indicación de estado de espera (standby)
	Peligro de choque eléctrico		Corriente continua (DC)
	Advertencia: superficie caliente		Corriente alterna (AC)
	Conexión a conductor de protección		Corriente continua / Corriente alterna (DC/AC)
	Conexión a tierra		El aparato está protegido en su totalidad por un aislamiento doble (reforzado)
	Conexión a masa		Distintivo de la UE para baterías y acumuladores Más información en la sección "Eliminación/protección del medio ambiente", punto 1.

Símbolo	Significado	Símbolo	Significado
	Aviso: Cuidado en el manejo de dispositivos sensibles a la electrostática (ESD)		Distintivo de la UE para la eliminación por separado de dispositivos eléctricos y electrónicos Más información en la sección "Eliminación/protección del medio ambiente", punto 2.
	Advertencia: rayo láser Más información en la sección "Funcionamiento", punto 7.		

Palabras de señal y su significado

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

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

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

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

AVISO indica la posibilidad de utilizar mal el producto y, como consecuencia, dañarlo.
En la documentación del producto se emplea de forma sinónima el término CUIDADO.

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

Estados operativos y posiciones de funcionamiento

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

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

Seguridad eléctrica

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

1. Antes de la puesta en marcha del producto se deberá comprobar siempre que la tensión preseleccionada en el producto coincida con la de la red de alimentación eléctrica. Si es necesario modificar el ajuste de tensión, también se deberán cambiar en caso dado los fusibles correspondientes del producto.
2. Los productos de la clase de protección I con alimentación móvil y enchufe individual solamente podrán enchufarse a tomas de corriente con contacto de seguridad y con conductor de protección conectado.
3. Queda prohibida la interrupción intencionada del conductor de protección, tanto en la toma de corriente como en el mismo producto. La interrupción puede tener como consecuencia el riesgo de que el producto sea fuente de choques eléctricos. Si se utilizan cables alargadores o regletas de enchufe, deberá garantizarse la realización de un examen regular de los mismos en cuanto a su estado técnico de seguridad.
4. Si el producto no está equipado con un interruptor para desconectarlo de la red, o bien si el interruptor existente no resulta apropiado para la desconexión de la red, el enchufe del cable de conexión se deberá considerar como un dispositivo de desconexión.
   El dispositivo de desconexión se debe poder alcanzar fácilmente y debe estar siempre bien accesible. Si, p. ej., el enchufe de conexión a la red es el dispositivo de desconexión, la longitud del cable de conexión no debe superar 3 m).
   Los interruptores selectores o electrónicos no son aptos para el corte de la red eléctrica. Si se integran productos sin interruptor en bastidores o instalaciones, se deberá colocar el interruptor en el nivel de la instalación.
5. No utilice nunca el producto si está dañado el cable de conexión a red. Compruebe regularmente el correcto estado de los cables de conexión a red. Asegúrese, mediante las medidas de protección y de instalación adecuadas, de que el cable de conexión a red no pueda ser dañado o de que nadie pueda ser dañado por él, p. ej. al tropezar o por un choque eléctrico.

6. Solamente está permitido el funcionamiento en redes de alimentación TN/TT aseguradas con fusibles de 16 A como máximo (utilización de fusibles de mayor amperaje solo previa consulta con el grupo de empresas Rohde & Schwarz).
7. Nunca conecte el enchufe en tomas de corriente sucias o llenas de polvo. Introduzca el enchufe por completo y fuertemente en la toma de corriente. La no observación de estas medidas puede provocar chispas, fuego y/o lesiones.
8. No sobrecargue las tomas de corriente, los cables alargadores o las regletas de enchufe ya que esto podría causar fuego o choques eléctricos.
9. En las mediciones en circuitos de corriente con una tensión U_{eff} > 30 V se deberán tomar las medidas apropiadas para impedir cualquier peligro (p. ej. medios de medición adecuados, seguros, limitación de tensión, corte protector, aislamiento etc.).
10. Para la conexión con dispositivos informáticos como un PC o un ordenador industrial, debe comprobarse que éstos cumplan los estándares IEC60950-1/EN60950-1 o IEC61010-1/EN 61010-1 válidos en cada caso.
11. A menos que esté permitido expresamente, no retire nunca la tapa ni componentes de la carcasa mientras el producto esté en servicio. Esto pone a descubierto los cables y componentes eléctricos y puede causar lesiones, fuego o daños en el producto.
12. Si un producto se instala en un lugar fijo, se deberá primero conectar el conductor de protección fijo con el conductor de protección del producto antes de hacer cualquier otra conexión. La instalación y la conexión deberán ser efectuadas por un electricista especializado.
13. En el caso de dispositivos fijos que no estén provistos de fusibles, interruptor automático ni otros mecanismos de seguridad similares, el circuito de alimentación debe estar protegido de modo que todas las personas que puedan acceder al producto, así como el producto mismo, estén a salvo de posibles daños.
14. Todo producto debe estar protegido contra sobretensión (debida p. ej. a una caída del rayo) mediante los correspondientes sistemas de protección. Si no, el personal que lo utilice quedará expuesto al peligro de choque eléctrico.
15. No debe introducirse en los orificios de la caja del aparato ningún objeto que no esté destinado a ello. Esto puede producir cortocircuitos en el producto y/o puede causar choques eléctricos, fuego o lesiones.
16. Salvo indicación contraria, los productos no están impermeabilizados (ver también el capítulo "Estados operativos y posiciones de funcionamiento", punto 1). Por eso es necesario tomar las medidas necesarias para evitar la entrada de líquidos. En caso contrario, existe peligro de choque eléctrico para el usuario o de daños en el producto, que también pueden redundar en peligro para las personas.
17. No utilice el producto en condiciones en las que pueda producirse o ya se hayan producido condensaciones sobre el producto o en el interior de éste, como p. ej. al desplazarlo de un lugar frío a otro caliente. La entrada de agua aumenta el riesgo de choque eléctrico.
18. Antes de la limpieza, desconecte por completo el producto de la alimentación de tensión (p. ej. red de alimentación o batería). Realice la limpieza de los aparatos con un paño suave, que no se deshilache. No utilice bajo ningún concepto productos de limpieza químicos como alcohol, acetona o diluyentes para lacas nitrocelulósicas.

Funcionamiento

1. El uso del producto requiere instrucciones especiales y una alta concentración durante el manejo. Debe asegurarse que las personas que manejen el producto estén a la altura de los requerimientos necesarios en cuanto a aptitudes físicas, psíquicas y emocionales, ya que de otra manera no se pueden excluir lesiones o daños de objetos. El empresario u operador es responsable de seleccionar el personal usuario apto para el manejo del producto.
2. Antes de desplazar o transportar el producto, lea y tenga en cuenta el capítulo "Transporte".
3. Como con todo producto de fabricación industrial no puede quedar excluida en general la posibilidad de que se produzcan alergias provocadas por algunos materiales empleados —los llamados alérgenos (p. ej. el níquel)—. Si durante el manejo de productos Rohde & Schwarz se producen reacciones alérgicas, como p. ej. irritaciones cutáneas, estornudos continuos, enrojecimiento de la conjuntiva o dificultades respiratorias, debe avisarse inmediatamente a un médico para investigar las causas y evitar cualquier molestia o daño a la salud.
4. Antes de la manipulación mecánica y/o térmica o el desmontaje del producto, debe tenerse en cuenta imprescindiblemente el capítulo "Eliminación/protección del medio ambiente", punto 1.
5. Ciertos productos, como p. ej. las instalaciones de radiocomunicación RF, pueden a causa de su función natural, emitir una radiación electromagnética aumentada. Deben tomarse todas las medidas necesarias para la protección de las mujeres embarazadas. También las personas con marcapasos pueden correr peligro a causa de la radiación electromagnética. El empresario/operador tiene la obligación de evaluar y señalizar las áreas de trabajo en las que exista un riesgo elevado de exposición a radiaciones.
6. Tenga en cuenta que en caso de incendio pueden desprenderse del producto sustancias tóxicas (gases, líquidos etc.) que pueden generar daños a la salud. Por eso, en caso de incendio deben usarse medidas adecuadas, como p. ej. máscaras antigás e indumentaria de protección.
7. Los productos con láser están provistos de indicaciones de advertencia normalizadas en función de la clase de láser del que se trate. Los rayos láser pueden provocar daños de tipo biológico a causa de las propiedades de su radiación y debido a su concentración extrema de potencia electromagnética. En caso de que un producto Rohde & Schwarz contenga un producto láser (p. ej. un lector de CD/DVD), no debe usarse ninguna otra configuración o función aparte de las descritas en la documentación del producto, a fin de evitar lesiones (p. ej. debidas a irradiación láser).
8. Clases CEM (según CISPR 11)
   Clase A: dispositivo apropiado para el uso en cualquier zona excepto en áreas residenciales y en aquellas zonas que se encuentran conectadas a una red de suministro de baja tensión que alimenta un edificio de viviendas.
   Clase B: dispositivo apropiado para el uso en áreas residenciales y en aquellas zonas que se encuentran conectadas a una red de suministro de baja tensión que alimenta un edificio de viviendas.

Reparación y mantenimiento

1. El producto solamente debe ser abierto por personal especializado con autorización para ello. Antes de manipular el producto o abrirlo, es obligatorio desconectarlo de la tensión de alimentación, para evitar toda posibilidad de choque eléctrico.

2. El ajuste, el cambio de partes, el mantenimiento y la reparación deberán ser efectuadas solamente por electricistas autorizados por Rohde & Schwarz. Si se reponen partes con importancia para los aspectos de seguridad (p. ej. el enchufe, los transformadores o los fusibles), solamente podrán ser sustituidos por partes originales. Después de cada cambio de partes relevantes para la seguridad deberá realizarse un control de seguridad (control a primera vista, control del conductor de protección, medición de resistencia de aislamiento, medición de la corriente de fuga, control de funcionamiento). Con esto queda garantizada la seguridad del producto.

Baterías y acumuladores o celdas

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

1. No deben desmontarse, abrirse ni triturarse las celdas.
2. Las celdas o baterías no deben someterse a calor ni fuego. Debe evitarse el almacenamiento a la luz directa del sol. Las celdas y baterías deben mantenerse limpias y secas. Limpiar las conexiones sucias con un paño seco y limpio.
3. Las celdas o baterías no deben cortocircuitarse. Es peligroso almacenar las celdas o baterías en estuches o cajones en cuyo interior puedan cortocircuitarse por contacto recíproco o por contacto con otros materiales conductores. No deben extraerse las celdas o baterías de sus embalajes originales hasta el momento en que vayan a utilizarse.
4. Las celdas o baterías no deben someterse a impactos mecánicos fuertes indebidos.
5. En caso de falta de estanqueidad de una celda, el líquido vertido no debe entrar en contacto con la piel ni los ojos. Si se produce contacto, lavar con agua abundante la zona afectada y avisar a un médico.
6. En caso de cambio o recarga inadecuados, las celdas o baterías que contienen electrolitos alcalinos (p. ej. las celdas de litio) pueden explotar. Para garantizar la seguridad del producto, las celdas o baterías solo deben ser sustituidas por el tipo Rohde & Schwarz correspondiente (ver lista de recambios).
7. Las baterías y celdas deben reciclarse y no deben tirarse a la basura doméstica. Las baterías o acumuladores que contienen plomo, mercurio o cadmio deben tratarse como residuos especiales. Respete en esta relación las normas nacionales de eliminación y reciclaje.

Transporte

1. El producto puede tener un peso elevado. Por eso es necesario desplazarlo o transportarlo con precaución y, si es necesario, usando un sistema de elevación adecuado (p. ej. una carretilla elevadora), a fin de evitar lesiones en la espalda u otros daños personales.
2. Las asas instaladas en los productos sirven solamente de ayuda para el transporte del producto por personas. Por eso no está permitido utilizar las asas para la sujeción en o sobre medios de transporte como p. ej. grúas, carretillas elevadoras de horquilla, carros etc. Es responsabilidad suya fijar los productos de manera segura a los medios de transporte o elevación. Para evitar daños personales o daños en el producto, siga las instrucciones de seguridad del fabricante del medio de transporte o elevación utilizado.

3. Si se utiliza el producto dentro de un vehículo, recae de manera exclusiva en el conductor la responsabilidad de conducir el vehículo de manera segura y adecuada. El fabricante no asumirá ninguna responsabilidad por accidentes o colisiones. No utilice nunca el producto dentro de un vehículo en movimiento si esto pudiera distraer al conductor. Asegure el producto dentro del vehículo debidamente para evitar, en caso de un accidente, lesiones u otra clase de daños.

Eliminación/protección del medio ambiente

1. Los dispositivos marcados contienen una batería o un acumulador que no se debe desechar con los residuos domésticos sin clasificar, sino que debe ser recogido por separado. La eliminación se debe efectuar exclusivamente a través de un punto de recogida apropiado o del servicio de atención al cliente de Rohde & Schwarz.
2. Los dispositivos eléctricos usados no se deben desechar con los residuos domésticos sin clasificar, sino que deben ser recogidos por separado.
   Rohde & Schwarz GmbH & Co.KG ha elaborado un concepto de eliminación de residuos y asume plenamente los deberes de recogida y eliminación para los fabricantes dentro de la UE. Para desechar el producto de manera respetuosa con el medio ambiente, diríjase a su servicio de atención al cliente de Rohde & Schwarz.
3. Si se trabaja de manera mecánica y/o térmica cualquier producto o componente más allá del funcionamiento previsto, pueden liberarse sustancias peligrosas (polvos con contenido de metales pesados como p. ej. plomo, berilio o níquel). Por eso el producto solo debe ser desmontado por personal especializado con formación adecuada. Un desmontaje inadecuado puede ocasionar daños para la salud. Se deben tener en cuenta las directivas nacionales referentes a la eliminación de residuos.
4. En caso de que durante el trato del producto se formen sustancias peligrosas o combustibles que deban tratarse como residuos especiales (p. ej. refrigerantes o aceites de motor con intervalos de cambio definidos), deben tenerse en cuenta las indicaciones de seguridad del fabricante de dichas sustancias y las normas regionales de eliminación de residuos. Tenga en cuenta también en caso necesario las indicaciones de seguridad especiales contenidas en la documentación del producto. La eliminación incorrecta de sustancias peligrosas o combustibles puede causar daños a la salud o daños al medio ambiente.

Se puede encontrar más información sobre la protección del medio ambiente en la página web de Rohde & Schwarz.

Customer Support

Technical support – where and when you need it

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

Up-to-date information and upgrades

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

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Contents

1 Introduction

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 WCDMAbased 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 (EUTRA) and evolved UMTS terrestrial radio access network (EUTRAN). LTE/EUTRA will then form part of 3GPP Release 8 core specifications.

This introduction focuses on LTE/EUTRA technology. In the following, the terms LTE or EUTRA 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).

1.1 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 EUTRAN 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. Costeffective 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 multivendor 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.

1.2 Long-Term Evolution Uplink Transmission Scheme

1.2.1 SC-FDMA

During the study item phase of LTE, alternatives for the optimum uplink transmission scheme were investigated. While OFDMA is seen optimum to fulfil the LTE requirements in downlink, OFDMA properties are less favourable for the uplink. This is mainly due to weaker peak-to-average power ratio (PAPR) properties of an OFDMA signal, resulting in worse uplink coverage.

Thus, the LTE uplink transmission scheme for FDD and TDD mode is based on SCFDMA with a cyclic prefix. SC-FDMA signals have better PAPR properties compared to an OFDMA signal. This was one of the main reasons for selecting SC-FDMA as LTE uplink access scheme. The PAPR characteristics are important for cost-effective design of UE power amplifiers. Still, SC-FDMA signal processing has some similarities with OFDMA signal processing, so parameterization of downlink and uplink can be harmonized.

There are different possibilities how to generate an SC-FDMA signal. DFT-spread- OFDM (DFT-s-OFDM) has been selected for EUTRA. The principle is illustrated in figure 1-1.

For DFT-s-OFDM, a size-M DFT is first applied to a block of M modulation symbols. QPSK, 16QAM and 64 QAM are used as uplink EUTRA modulation schemes, the latter being optional for the UE. The DFT transforms the modulation symbols into the frequency domain. The result is mapped onto the available sub-carriers. In EUTRA uplink, only localized transmission on consecutive sub-carriers is allowed. An N point IFFT where N>M is then performed as in OFDM, followed by addition of the cyclic prefix and parallel to serial conversion.

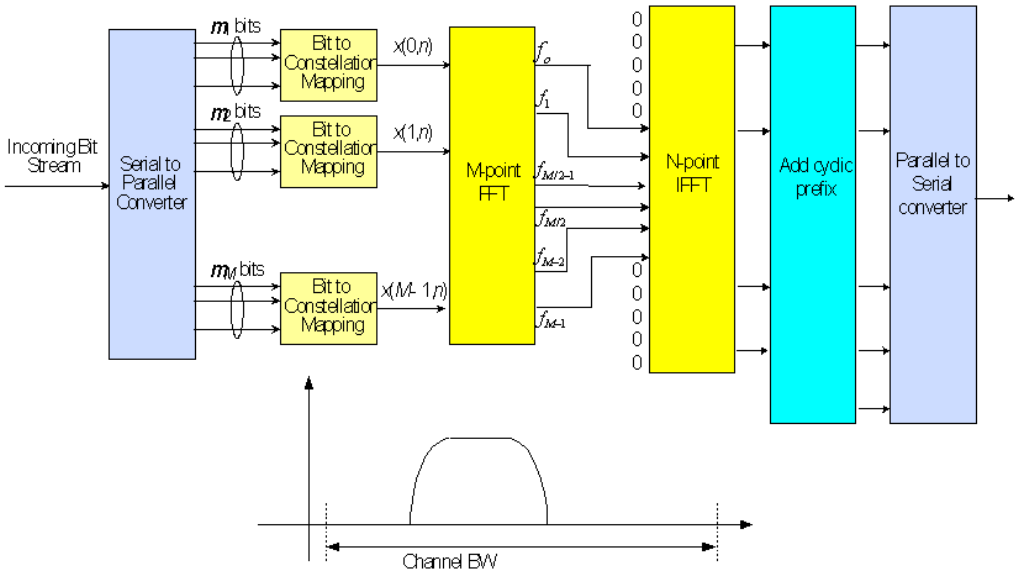


Fig. 1-1: Block Diagram of DFT-s-OFDM (Localized Transmission)

The DFT processing is therefore the fundamental difference between SC-FDMA and OFDMA signal generation. This is indicated by the term DFT-spread-OFDM. In an SCFDMA signal, each sub-carrier used for transmission contains information of all transmitted modulation symbols, since the input data stream has been spread by the DFT transform over the available sub-carriers. In contrast to this, each sub-carrier of an OFDMA signal only carries information related to specific modulation symbols.

1.2.2 SC-FDMA Parameterization

The EUTRA uplink structure is similar to the downlink. An uplink radio frame consists of 20 slots of 0.5 ms each, and 1 subframe consists of 2 slots. The slot structure is shown in figure 1-2.

Each slot carries N^{UL}_{symb} SC-FDMA symbols, where N^{UL}_{symb} = 7 for the normal cyclic prefix and N^{UL}_{symb} = 6 for the extended cyclic prefix. SC-FDMA symbol number 3 (i.e. the 4th symbol in a slot) carries the reference signal for channel demodulation.

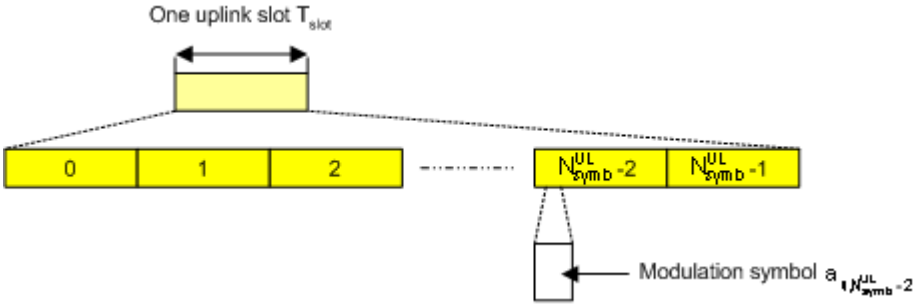


Fig. 1-2: Uplink Slot Structure

Also for the uplink, a bandwidth agnostic layer 1 specification has been selected. The table below shows the configuration parameters in an overview table.

Configuration	Number of symbols N^{UL}_{symb}	Cyclic prefix length in samples	Cyclic prefix length in µs
Normal cyclic prefix Δf=15kHz	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=15kHz	6	512	16.7 µs

1.2.3 Uplink Data Transmission

In uplink, data is allocated in multiples of one resource block. Uplink resource block size in the frequency domain is 12 sub-carriers, i.e. the same as in downlink. However, not all integer multiples are allowed in order to simplify the DFT design in uplink signal processing. Only factors 2, 3, and 5 are allowed.

The uplink transmission time interval (TTI) is 1 ms (same as downlink).

User data is carried on the Physical Uplink Shared Channel (**PUSCH**) that is determined by the transmission bandwidth NTx and the frequency hopping pattern k0.

The Physical Uplink Control Channel (**PUCCH**) carries uplink control information, e.g. CQI reports and ACK/NACK information related to data packets received in the downlink. The PUCCH is transmitted on a reserved frequency region in the uplink.

1.2.4 Uplink Reference Signal Structure

Uplink reference signals are used for two different purposes: on the one hand, they are used for channel estimation in the eNodeB receiver in order to demodulate control and data channels. On the other hand, the reference signals provide channel quality information as a basis for scheduling decisions in the base station. The latter purpose is also called channel sounding.

The uplink reference signals are based on CAZAC (Constant Amplitude Zero Auto- Correlation) sequences.

1.2.5 Uplink Physical Layer Procedures

For EUTRA, the following uplink physical layer procedures are especially important:

Non-synchronized random access

Random access may be used to request initial access, as part of handover, when transiting from idle to connected, or to re-establish uplink synchronization. The structure is shown in figure 1-3.

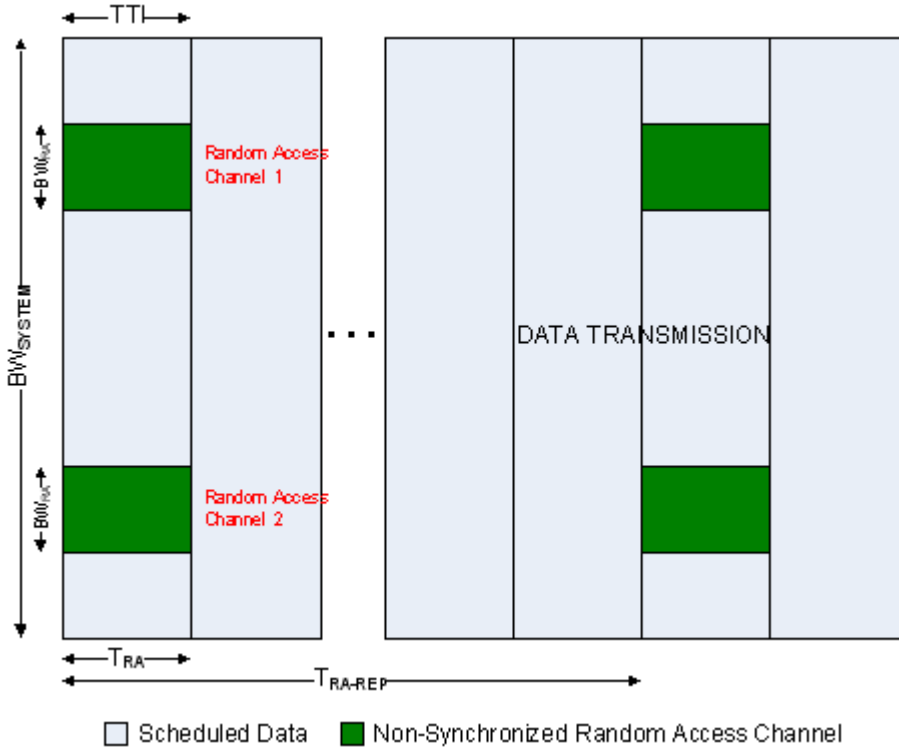


Fig. 1-3: Random Access Structure, principle

Multiple random access channels may be defined in the frequency domain within one access period T_{RA} in order to provide a sufficient number of random access opportunities.

For random access, a preamble is defined as shown in figure 1-4. The preamble sequence occupies T_{PRE} = 0.8 ms and the cyclic prefix occupies T_{CP} = 0.1 ms within one subframe of 1 ms. During the guard time T_{GT}, nothing is transmitted. The preamble bandwidth is 1.08 MHz (72 sub-carriers). Higher layer signalling controls in which subframes the preamble transmission is allowed, and the location in the frequency domain. Per cell, there are 64 random access preambles. They are generated from Zadoff-Chu sequences.

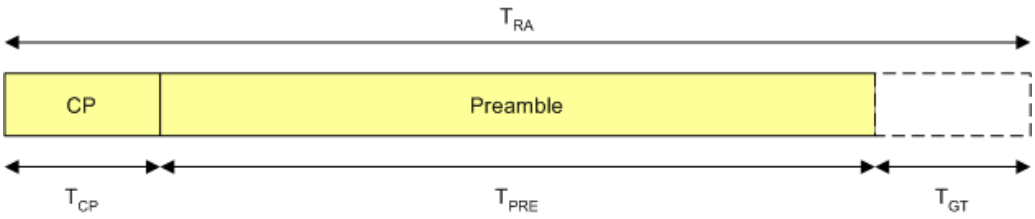


Fig. 1-4: Random Access Preamble

The random access procedure uses open loop power control with power ramping similar to WCDMA. After sending the preamble on a selected random access channel, the UE waits for the random access response message. If no response is detected then another random access channel is selected and a preamble is sent again.

Uplink scheduling

Scheduling of uplink resources is done by eNodeB. The eNodeB assigns certain time/frequency resources to the UEs and informs UEs about transmission formats to use. Scheduling decisions affecting the uplink are communicated to the UEs via the Physical Downlink Control Channel (PDCCH) in the downlink. The scheduling decisions may be based on QoS parameters, UE buffer status, uplink channel quality measurements, UE capabilities, UE measurement gaps, etc.

Uplink link adaptation

As uplink link adaptation methods, transmission power control, adaptive modulation and channel coding rate, as well as adaptive transmission bandwidth can be used.

Uplink timing control

Uplink timing control is needed to time align the transmissions from different UEs with the receiver window of the eNodeB. The eNodeB sends the appropriate timing-control commands to the UEs in the downlink, commanding them to adapt their respective transmit timing.

Hybrid automatic repeat request (ARQ)

The Uplink Hybrid ARQ protocol is already known from HSUPA. The eNodeB has the capability to request retransmissions of incorrectly received data packets.

1.3 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 v8.3.0: 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)

[7] 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.

[8] 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.

2 Welcome

The EUTRA/LTE software application makes use of the I/Q capture functionality of the following spectrum and signal analyzers to enable EUTRA/LTE TX measurements conforming to the EUTRA specification.

- R&S FSQ
- R&S FSG
- R&S FSV
- R&S FSVR
- R&S FSW

This manual contains all information necessary to configure, perform and analyze such measurements.

2.1 Licensing the Software

The EUTRA/LTE Software enables to

- capture and analyze I/Q data from an R&S®FSW, R&S®FSV, R&S®FSVR, R&S®FSQ or R&S®FSG
- read and analyze I/Q data from a file

You can purchase two different license types for the software.

- R&S®FS-K10xPC
  This license enables software operation with and without an R&S signal analyzer. It is e.g. possible to read data from file without a connection to an analyzer. A smartcard reader (dongle) is required for this license type.
- R&S®FSV/FSQ-K10x
  This license requires a connection to an R&S®FSV, R&S®FSVR, R&S®FSQ or R&S®FSG. The license must be installed on the analyzer.

Using the smartcard reader (dongle)

To enable the LTE software via smartcard (dongle), you have to load the LTE license(s) on an existing smartcard or order a new smartcard (FSPC).

You can use the smart card together with the USB smart card reader (for SIM format) supplied with the software or insert the smart card (Full format) in a reader already connected to your PC or built in your PC.

Note that support for problems with the smart card licensing can only be guaranteed if the supplied USB smart card reader (for SIM format) is used.

1. With the delivery of the FSPC you got a smart card and a smart card reader.

2. Remove the smart card.

3. Insert the smart card into the reader.
   If the OMNIKEY label faces upward, the smart card has to be inserted with the chip facedown and the angled corner facing away from the reader.

4. After pushing the smart card completely inside the USB smart card reader, you can use it together with the software.

When you insert the USB Smartcard reader into the PC, the drivers will be loaded. If your PC does not already have drivers installed for this reader, the hardware will not be detected and the software will not work.

In this case, install the required driver manually. On the CD, it is in the folder `\Install\USB SmartCard Reader Driver Files`, named according to the processor architecture (OMNIKEY3x21_x86... or OMNIKEY3x21_x64). Detailed information on the file content and the download location for updated drivers can be found in the `ReadMe.txt` file in the same folder.

You may have problems locking a computer while the card is inserted, because MS Windows tries to get log-in information from the card immediately after you have locked the computer.

Solve this issue by changing a registry entry.

Either execute the registry file DisableCAD.reg in the same folder the USM Smartcard reader installation files are located. Or manually change the entry.

- Open the Windows Start Menu and select the "Run" item.
- Enter "regedit" in the dialog to open the system reigistry.
- Navigate to `HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows\CurrentVersion\policies\system`.
- Set the value of DisableCAD to 0.

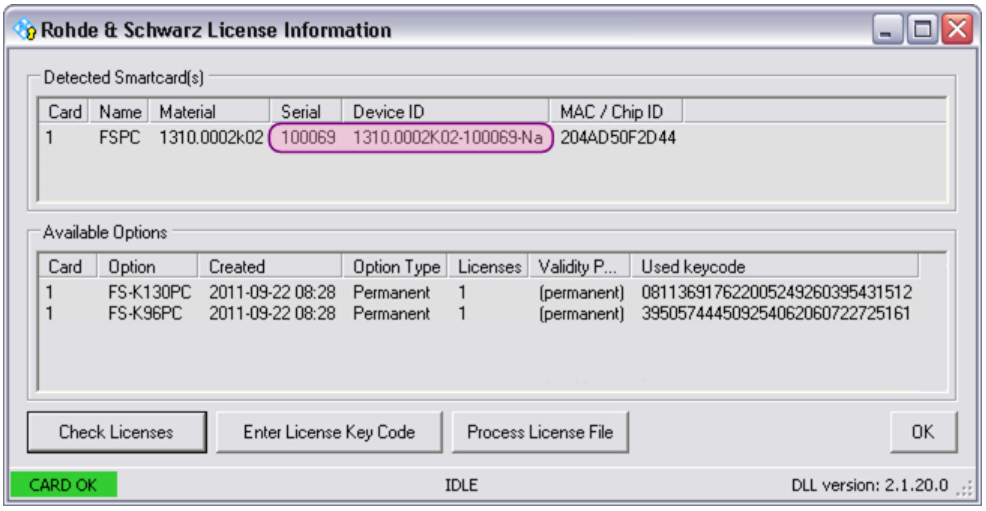
Note that security policies may prevent you from editing the value. Contact your IT administrator if you have problems with editing the value or installing the drivers.

Managing licenses

In case of registered licenses, the license key code is based on the serial number of the R&S FSPC smartcard. Thus, you need to know the serial number when you order a new license.

1. Start the software.
2. Press the SETUP key.
3. Press the "Dongle License Info" softkey.

   The software opens the "Rohde & Schwarz License Information" dialog box.



4. Connect the smartcard / dongle to the computer.
5. Press the "Check Licenses" button.

   The software shows all current licenses.

The serial number which is necessary to know if you need a license is shown in the "Serial" column.
The "Device ID" also contains the serial number.

6. To enter a new license code, press the "Enter License Key Code" button.

2.2 Installing the Software

For information on the installation procedure see the release notes of the software.

2.3 Connecting the Computer to an Analyzer

In order to be able to communicate with an analyzer (R&S FSQ, R&S FSG, R&S FSV, R&S FSVR or R&S FSW), you have to connect it to a computer. You can use the IEEE bus (GPIB) or a local area network (LAN).

Requirements

To be able to capture I/Q data, you need one of the signal analyzers mentioned above.

If you are using an R&S FSQ, you must

- use firmware 3.65 or higher to be able to establish a connection via TCP/IP
  or
- install the RSIB passport driver on the computer.
  The driver is available for download at http://www.rohde-schwarz.com/appnote/1EF47

To establish a connection, you also have to determine the network address of the analyzer and set it up in the LTE software.

For more information on including the analyzer configuration in the software see "MIMO Analyzer Configuration" on page 53.

2.3.1 Figuring Out the Address of an R&S FSQ or R&S FSG

Follow these steps to figure out GPIB or IP address of an R&S FSQ or R&S FSG.

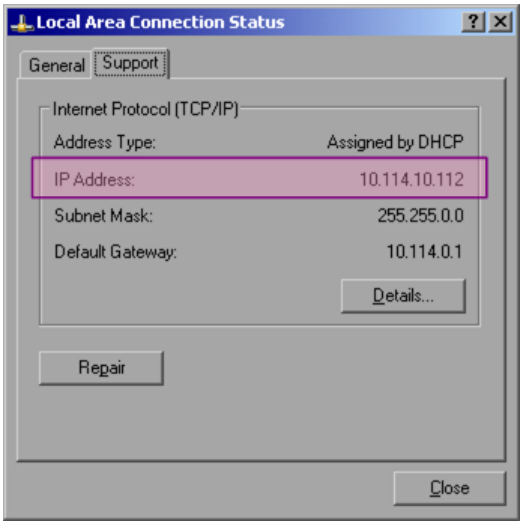
Figuring Out the GPIB address

1. Press the SETUP key.
2. Press the "General Setup" softkey.
3. Press the "GPIB" softkey.

   The R&S FSQ / FSG opens a dialog box that shows its current GPIB address.

Figuring Out the IP address

1. Press the SETUP key.
2. Press the "General Setup" softkey.
3. Press the "Configure Network" softkey.
4. Press the "Configure Network" softkey.
   The MS Windows "Network Connections" dialog box opens.
5. Select the "Local Area Connection" item.
   The "Local Area Connection Status" dialog box opens.
6. Select the "Support" tab.
   The "Support" tab shows the current TCP/IP information of the R&S FSQ.

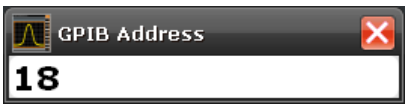


2.3.2 Figuring Out the Address of an R&S FSV or R&S FSVR

Follow these steps to figure out the GPIB or IP address of an R&S FSV or R&S FSVR.

Figuring Out the GPIB address

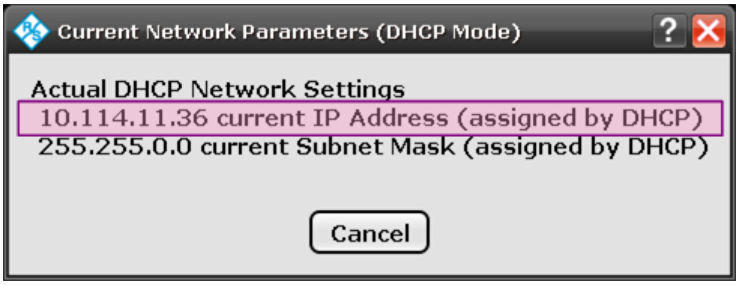
1. Press the SETUP key.
2. Press the "General Setup" softkey.
3. Press the "GPIB" softkey.
4. Press the "GPIB Address" softkey.
   The R&S FSV(R) opens a dialog box that shows its current GPIB address.



Figuring Out the IP address

1. Press the SETUP key.
2. Press the "General Setup" softkey.
3. Press the "Network Address" softkey.
4. Press the "IP Address" softkey.

   The R&S FSV(R) opens a dialog box that contains information about the LAN connection.



2.3.3 Figuring Out the Address of an R&S FSW

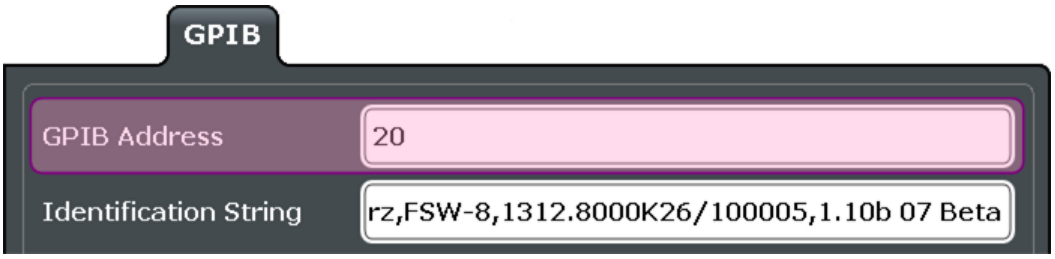
Follow these steps to figure out the GPIB or IP address of an R&S FSW.

Figuring Out the GPIB address

1. Press the SETUP key.
2. Press the "Network + Remote" softkey.

   The R&S FSW opens the "Network & Remote" dialog box.
3. Select the "GPIB" tab.

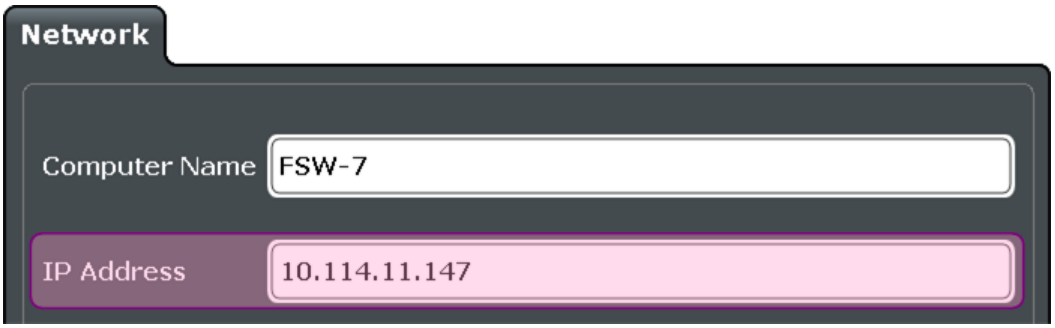
   The R&S FSW shows information about the GPIB connection, including the GPIB address.



Figuring Out the IP address

1. Press the SETUP key.
2. Press the "Network + Remote" softkey.

The R&S FSW opens the "Network & Remote" dialog box and shows its current IP address in the corresponding field.



2.4 Application Overview

Starting the application

To start the software, use either the shortcut on the computer desktop or the entry in the Microsoft Windows Start menu.

If you run the software on an analyzer, access the software via the "Mode" menu.

► Press the MODE key and select "EUTRA/LTE".

Presetting the software

When you first start the software, all settings are in their default state. After you have changed any parameter, you can restore the default state with the PRESET key.

Note that using the preset function also presets an analyzer if one is connected and you capture the data from the hardware.

`CONFigure:PRESet` on page 163

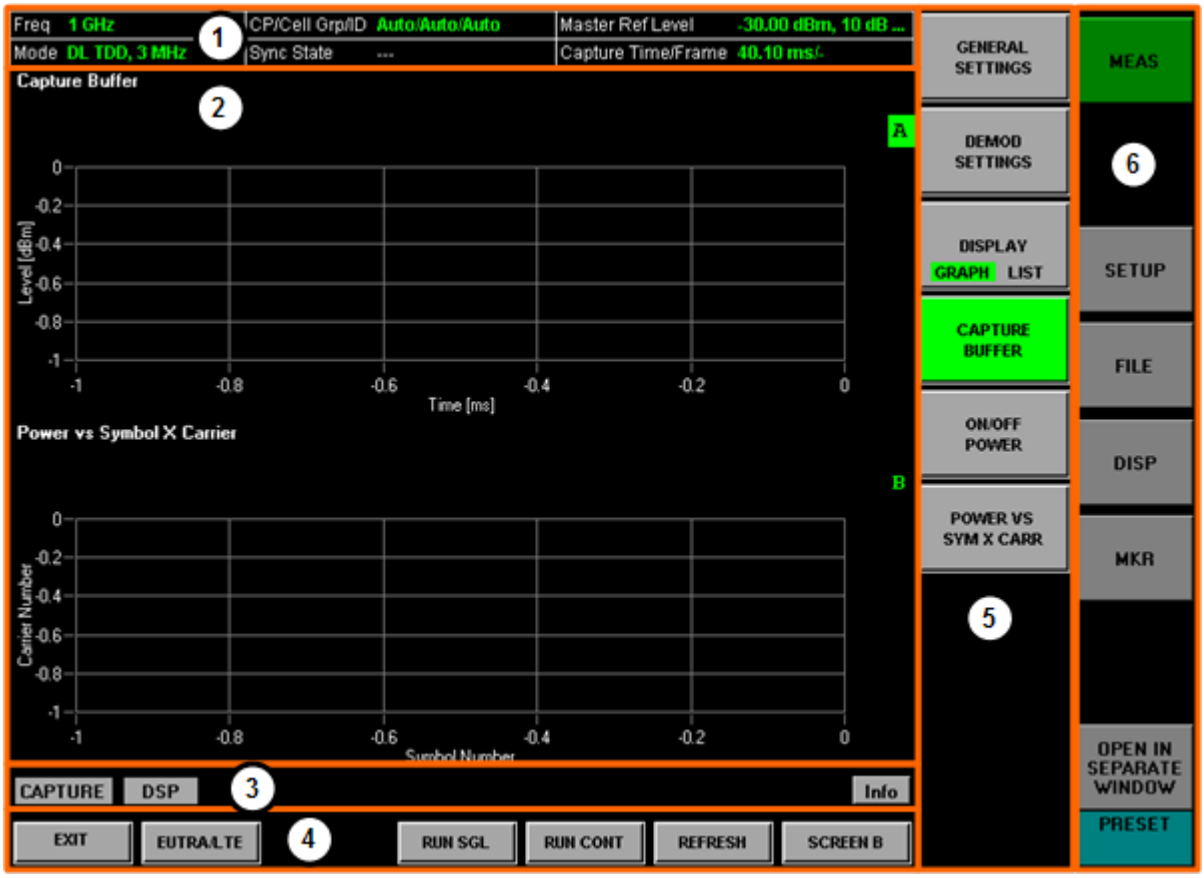
Using the preset if the software has been installed on an R&S FSQ, R&S FSG, R&S FSV, R&S FSVR or R&S FSW presets the software and the analyzer and exits the LTE software.

SCPI command:

```
*RST
```

Elements and layout of the user interface

The user interface of the LTE measurement application is made up of several elements.



1 = Header table. The header table shows basic information like measurement frequency or sync state.
2 = Diagram area. The diagram area contains the measurement results. You can display it in full screen or split screen mode. The result display is separated in a header that shows the title etc. and the diagram area that show the actual results.
3 = Status bar. The status bar contains information about the current status of the measurement and the software.
4 = Hotkeys. Hotkeys contain functionality to control the measurement process.
5 = Softkeys. Softkeys contain functionality to configure and select measurement functions.
6 = Hardkeys. Hardkeys open new softkey menus.

The status bar

The status bar is located at the bottom of the display. It shows the current measurement status and its progress in a running measurement. The status bar also shows warning and error messages. Error messages are generally highlighted.

Display of measurement settings

The header table above the result displays shows information on hardware and measurement settings.

Freq --- (File)	CP/Cell Grp/ID Auto/Auto/Auto	Master Ref Level (0 dB)
Mode DL TDD, 3 MHz	Sync State ---	Capture Time/Frame 40.10 ms/-

The header table includes the following information

- **Freq**

The analyzer RF frequency.

- **Mode**
  Link direction, duplexing, cyclic prefix and maximum number of physical resource blocks (PRBs) / signal bandwidth.
- **CP/Cell Grp/ID**
  Shows the cell identity information.
- **Sync State**
  The following synchronization states may occur:
  – **OK** The synchronization was successful.
  – **FAIL** The synchronization has failed.

  SCPI Command:
  `[SENSe]:SYNC[:STATe]?` on page 104
- **Master Ref Level**
  Shows the reference level of the master analyzer.
- **Capture Time/Frame**
  Shows the capture length in ms.
  In PRACH analysis mode, it also shows the preamble that is currently analyzed.

2.5 Configuring the Software

This chapter contains information about general software functionality.

2.5.1 Configuring the Display

The "Display" menu contains functionality to improve the display and documentation of results.

► Press the DISP key.

The application features four screens (or result displays). Each of the screens may contain a different result display. The number of visible screens depends on the screen layout.

Full screen mode

In full screen mode, the application shows the contents a single screen.

► Press the "Full Screen" softkey.

If you have configured more than one result displays, these are still working in the background.

Split screen mode

In split screen mode, the application shows the contents of two screens, either screen A and screen B or screen C and screen D.

► Press the "Split Screen" softkey.

If you have configured more than two result displays, these are still working in the background.

2x2 split screen mode

In 2x2 split screen mode, the application shows the contents of four screens.

► Press the "2x2 Split Screen" softkey.

Limitations

For the Spectrum Emission Mask, ACLR and On/Off Power measurements, a maximum of two screens is possible.

By default, the software shows the results in all four screens. The screens are labeled A to D to the right of the measurement diagrams. The label of the currently active screen is highlighted green (A). The currently active screen is the one settings are applied to.

Switch between the screens with the "Screen A", "Screen B", "Screen C" and "Screen D" hotkeys.

The background color of the software by default is black. Apply another color via the "Color Selection" softkey and the corresponding dialog box.

For documentation purposes the software provides a hardcopy function that lets you save the current results in one of the following formats.

- bmp
- gif
- jpeg
- png
- tiff

Use the "Hardcopy to Clipboard" function to take a screeshot.

`DISPlay[:WINDow<n>]:SELect` on page 163

2.5.2 Configuring the Software

The "Setup" menu contains various general software functions.

► Press the SETUP key to access the "Setup" menu.

Configure Analyzer Connection
Opens the "General Settings" dialog box.

For more information see "MIMO Analyzer Configuration" on page 53.

Data Source (Instr File)
Selects the general input source (an instrument or a file).

For more information see "Selecting the Input Source" on page 46.

Dongle License Info
Opens the "Rohde & Schwarz License Information" dialog box.

The dialog box contains functionality to add new (registered) licenses. For more information see chapter 2.1, "Licensing the Software", on page 14.

"Check Licenses"	Looks for all smartcards connected to the computer and returns their characteristics like the serial number of the smartcard or its device ID. Note that the smartcard has to be connected to figure out its properties.
"Enter License Key Code"	Opens an input field to manually enter a new license key code. A key code consists of 30 digits.
"Process License File"	Opens a dialog box to select a file (xml format) that contains a license. Opening that file automatically adds a new license.

Show Logging
Opens a dialog box that contains a log of all messages that the software has shown in the status bar.

Use the message log for debugging purposes in case any errors occur. You can refresh and clear the contents of the log or copy the contents of the system log to the clipboard.

"Refresh"	Updates the contents of the log.
"Clear All"	Deletes all entries in the log.
"Copy to Clipboard"	Copies the contents of the log to the clipboard.

System Info
Opens a dialog box that contains information about the system like driver versions or the utility software. You can use this information in case an analyzer does not work properly.

3 Measurements and Result Displays

The LTE measurement application features several measurements to examine and analyze different aspects of an LTE signal.

The source of the data that is processed is either a live signal or a previously recorded signal whose characteristics have been saved to a file. For more information see "Selecting the Input Source" on page 46.

In both cases, you can perform a continuous or a single measurement.

Continuous measurements capture and analyze the signal continuously and stop only after you turn it off manually.

► Press the "Run Cont" softkey to start and stop continuous measurements.

Single measurements capture and analyze the signal over a particular time span or number of frames. The measurement stops after the time has passed or the frames have been captured.

► Press the "Run Sgl" softkey to start a single measurement.

You can also repeat a measurement based on the data that has already been captured, e.g. if you want to apply different demodulation settings to the same signal.

► Press the "Refresh" softkey to measure the signal again.

This chapter provides information on all types of measurements that the LTE measurement application supports.

Note that all measurements are based on the I/Q data that is captured except the Spectrum Emission Mask and the Adjacent Channel Leakage Ratio. Those are based on a frequency sweep the analyzer performs for the measurement.

SCPI command:

`INITiate[:IMMediate]` on page 104

`INITiate:REFResh` on page 104

3.1 Numerical Results

Result Summary

The Result Summary shows all relevant measurement results in numerical form, combined in one table.

▸ Press the "Display (List Graph)" softkey so that the "List" element turns green to view the Result Summary.

SCPI command:

`DISPlay[:WINDow<n>]:TABLe` on page 103

Contents of the result summary

The contents of the result summary depend on the analysis mode you have selected. The first screenshot shows the results for PUSCH/PUCCH analysis mode, the second one those for PRACH analysis mode.

Result Summary **Symbols Meas.** 140

Frame Results 1/1	Min	Mean	Mean Limit	Max	Max Limit	Unit
EVM PUSCH QPSK		0,10	17,50			%
EVM PUSCH 16QAM			12,50			%
EVM DMRS PUSCH QPSK		0,10	17,50			%
EVM DMRS PUSCH 16QAM			12,50			%
EVM PUCCH			17,50			%
EVM DMRS PUCCH			17,50			%
Results for Selection	**Subframes ALL**		**Slots ALL**		**Frame 1/1**	
EVM All	0,00	0,00		0,00		%
EVM Phys. Channel	0,00	0,00		0,00		%
EVM Phys. Signal	0,00	0,00		0,00		%
Frequency Error	0,07	0,08		0,09		Hz
Sampling Error	0,00	0,00		0,00		ppm
IQ Offset	-141,97	-127,15		-121,23		dB
IQ Gain Imbalance						dB
IQ Quadrature Error						°
Power	-84,74	-84,53		-83,95		dBm
Crest Factor	5,60	6,19		6,19		dB

Result Summary

3GPP EVM Results	Min	Mean	Mean Limit	Max	Max Limit	Unit
EVM PRACH		5,77	17,50			%
Results for Selection	**Preamble**	**ALL**				
EVM All	5,77	5,77		5,77		%
Frequency Error	-0,40	-0,40		-0,40		Hz
Sampling Error						ppm
IQ Offset	-79,42	-79,42		-79,42		dB
IQ Gain Imbalance						dB
IQ Quadrature Error						°
Power	-20,39	-20,39		-20,39		dBm
Crest Factor	4,48	4,48		4,48		dB

The table is split in two parts. The first part shows results that refer to the complete frame. For each result, the minimum, mean and maximum values are displayed. It also indicates limit check results where available. The font of 'Pass' results is green and that of 'Fail' results is red.

By default, the software checks the limits defined by the standard. You can also import customized limits. In that case the software evaluates those limits instead of the predefined ones. For more information see chapter 7.4, "Importing and Exporting Limits", on page 88.

Note: In some cases, it is not possible to calculate the I/Q Gain Imbalance and the I/Q Quadrature Error.
The reason may be that the subframe selection is set to "All". In that case the software only displays the results if there is a result in all subframes. Try and search through individual subframes to find a subframe that provides those results.

- **EVM PUSCH QPSK**
  Shows the EVM for all QPSK-modulated resource elements of the PUSCH channel in the analyzed frame.
  `FETCh:SUMMary:EVM:USQP[:AVERage]?` on page 108
- **EVM PUSCH 16QAM**
  Shows the EVM for all 16QAM-modulated resource elements of the PUSCH channel in the analyzed frame.
  `FETCh:SUMMary:EVM:USST[:AVERage]?` on page 108
- **EVM DRMS PUSCH QPSK**
  Shows the EVM of all DMRS resource elements with QPSK modulation of the PUSCH in the analyzed frame.
  `FETCh:SUMMary:EVM:SDQP[:AVERage]?` on page 107
- **EVM DRMS PUSCH 16QAM**
  Shows the EVM of all DMRS resource elements with 16QAM modulation of the PUSCH in the analyzed frame.
  `FETCh:SUMMary:EVM:SDST[:AVERage]?` on page 107
- **EVM PUCCH**
  Shows the EVM of all resource elements of the PUCCH channel in the analyzed frame.
  `FETCh:SUMMary:EVM:UCCH[:AVERage]?` on page 108
- **EVM DMRS PUCCH**

Shows the EVM of all DMRS resource elements of the PUCCH channel in the analyzed frame.
FETCh:SUMMary:EVM:UCCD[:AVERage]? on page 107

- **EVM PRACH**
  Shows the EVM of all resource elements of the PRACH channel in the analyzed frame.
  FETCh:SUMMary:EVM:UPRA[:AVERage]? on page 108

By default, all EVM results are in %. To view the EVM results in dB, change the EVM Unit.

The second part of the table shows results that refer to a specifc selection of the frame.

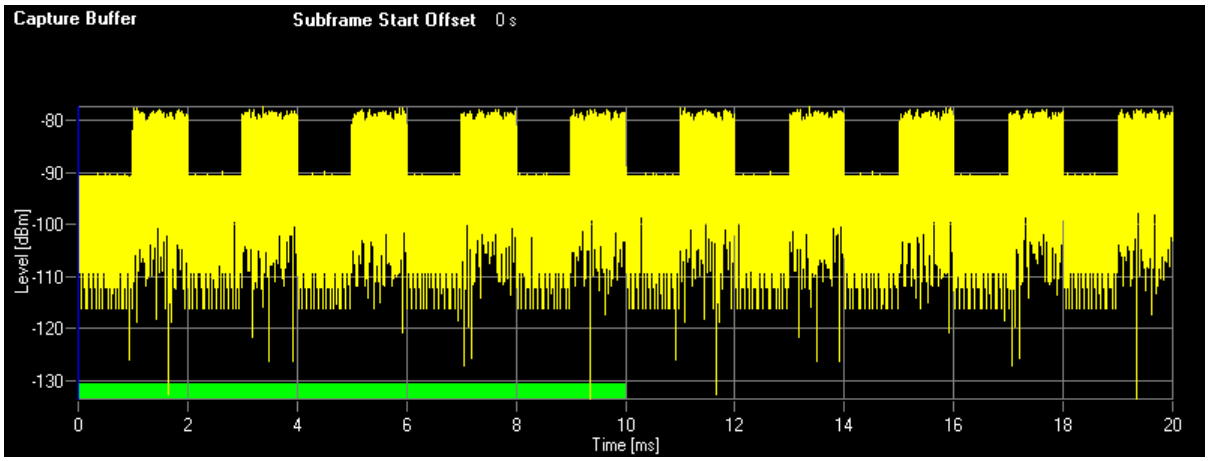
The header row of the table contains information about the selection you have made (like the subframe).

- **EVM All**
  Shows the EVM for all resource elements in the analyzed frame.
  FETCh:SUMMary:EVM[:ALL][:AVERage]? on page 106
- **EVM Phys Channel**
  Shows the EVM for all physical channel resource elements in the analyzed frame.
  FETCh:SUMMary:EVM:PCHannel[:AVERage]? on page 106
- **EVM Phys Signal**
  Shows the EVM for all physical signal resource elements in the analyzed frame.
  FETCh:SUMMary:EVM:PSIGnal[:AVERage]? on page 106
- **Frequency Error**
  Shows the difference in the measured center frequency and the reference center frequency.
  FETCh:SUMMary:FERRor[:AVERage]? on page 109
- **Sampling Error**
  Shows the difference in measured symbol clock and reference symbol clock relative to the system sampling rate.
  FETCh:SUMMary:SERRor[:AVERage]? on page 110
- **I/Q Offset**
  Shows the power at spectral line 0 normalized to the total transmitted power.
  FETCh:SUMMary:IQOFfset[:AVERage]? on page 109
- **I/Q Gain Imbalance**
  Shows the logarithm of the gain ratio of the Q-channel to the I-channel.
  FETCh:SUMMary:GIMBalance[:AVERage]? on page 109
- **I/Q Quadrature Error**
  Shows the measure of the phase angle between Q-channel and I-channel deviating from the ideal 90 degrees.
  FETCh:SUMMary:QUADerror[:AVERage]? on page 110
- **Power**
  Shows the average time domain power of the analyzed signal.
  FETCh:SUMMary:POWer[:AVERage]? on page 110
- **Crest Factor**
  Shows the peak-to-average power ratio of captured signal.
  FETCh:SUMMary:CRESt[:AVERage]? on page 105

3.2 Measuring the Power Over Time

This chapter contains information on all measurements that show the power of a signal over time.

Capture Buffer
The capture buffer result display shows the complete range of captured data for the last data capture. The x-axis represents the time scale. The maximum value of the x-axis is equal to the capture length that you can set in the General Settings dialog box. The y-axis represents the amplitude of the captured I/Q data in dBm (for RF input).



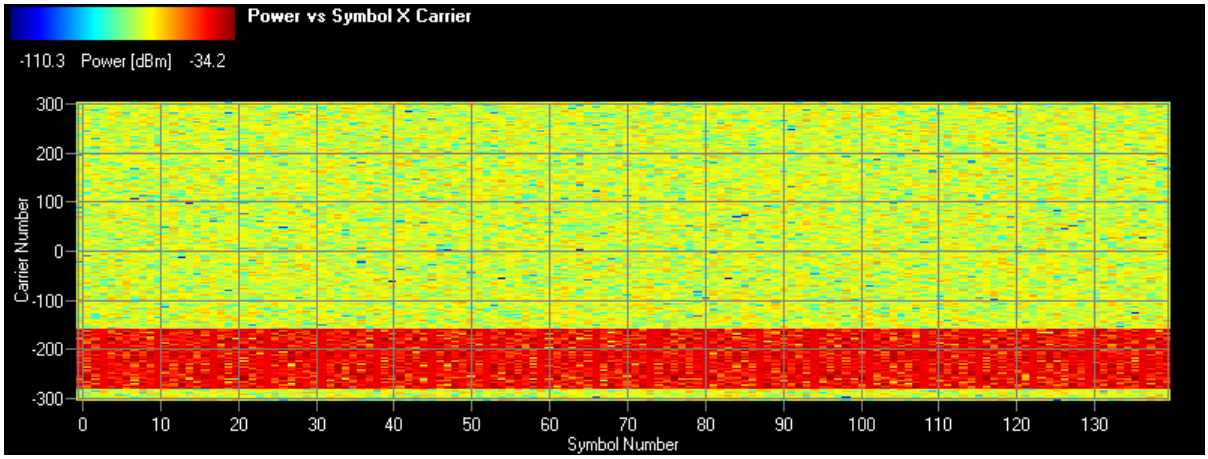
The bar at the bottom of the diagram represents the area that is currently analyzed.

A blue vertical line at the beginning of the green bar in the Capture Buffer display marks the subframe start. Additionally, the diagram includes the Subframe Start Offset value (blue text). This value is the time difference between the subframe start and capture buffer start.

SCPI command:
CALCulate<n>:FEED 'PVT:CBUF'
TRACe:DATA?

Power vs Symbol x Carrier
The Power vs Symbol x Carrier shows the power for each carrier in each symbol.

The horizontal axis represents the symbols. The vertical axis represents the carriers. Different colors in the diagram area represent the power. The color map for the power levels is provided above the diagram area.



SCPI command:
not yet supported

3.3 Measuring the Error Vector Magnitude (EVM)

This chapter contains information on all measurements that show the error vector magnitude (EVM) of a signal.

The EVM is one of the most important indicators for the quality of a signal. For more information on EVM calculation methods refer to chapter 8, "Measurement Basics", on page 89.

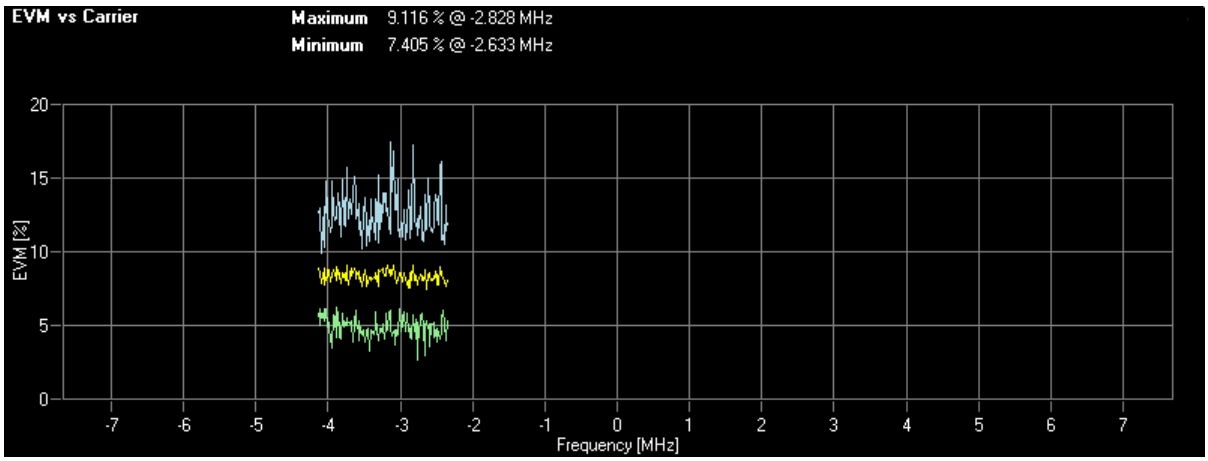
EVM vs Carrier
Starts the EVM vs Carrier result display.

This result display shows the Error Vector Magnitude (EVM) of the subcarriers. With the help of a marker, you can use it as a debugging technique to identify any subcarriers whose EVM is too high.

The displayed result is an average over all available OFDM symbols. By default, three traces are shown. One trace shows the average EVM. The second and the third trace show the minimum and maximum EVM values respectively. You can select to display the EVM for a specific subframe. In that case, the application shows the EVM of that subframe only.

For more information see "Subframe Selection" on page 51

The x-axis represents the center frequencies of the subcarriers. On the y-axis, the EVM is plotted either in % or in dB, depending on the EVM Unit.



SCPI command:
CALCulate<n>:FEED 'EVM:EVCA'
TRACe:DATA?

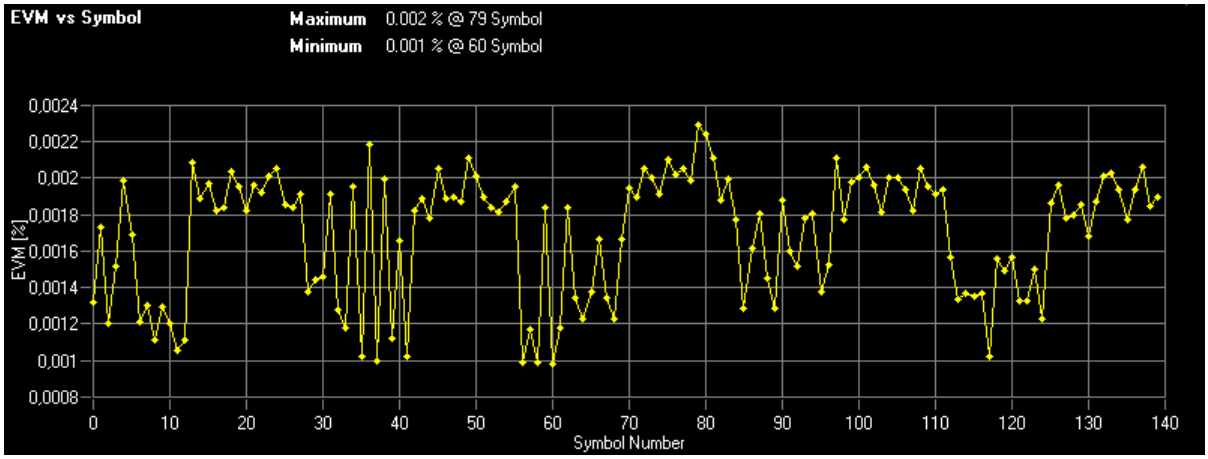
EVM vs Symbol
Starts the EVM vs Symbol result display.

This result display shows the Error Vector Magnitude (EVM) on symbol level for all OFDM symbols in all subframes. You can use it as a debugging technique to identify any symbols whose EVM is too high.

The result is an average over all subcarriers.

The x-axis represents the OFDM symbols, with each symbol represented by a dot on the line. The number of displayed symbols depends on the Subframe Selection and the length of the cyclic prefix. Any missing connections from one dot to another mean that the analyzer could not determine the EVM for that symbol. In case of TDD signals, the result display does not show OFDM symbols that are not part of the measured link direction.

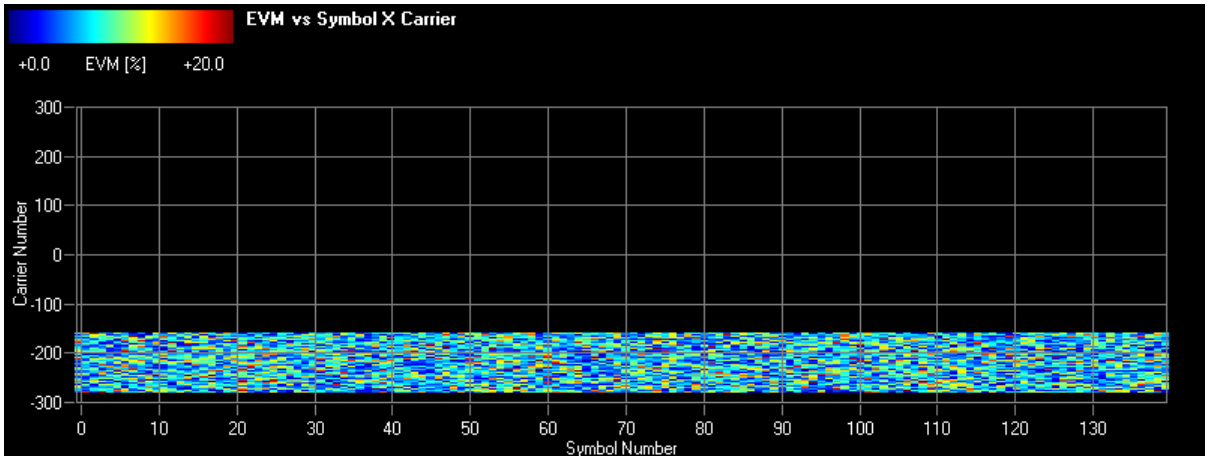
On the y-axis, the EVM is plotted either in % or in dB, depending on the EVM Unit



SCPI command:
CALCulate<n>:FEED 'EVM:EVSY'
TRACe:DATA?

EVM vs Sym x Carr
The EVM vs Symbol x Carrier shows the EVM for each carrier in each symbol.

The horizontal axis represents the symbols. The vertical axis represents the carriers. Different colors in the diagram area represent the EVM. The color map for the power levels is provided above the diagram area.



SCPI command:
not supported yet

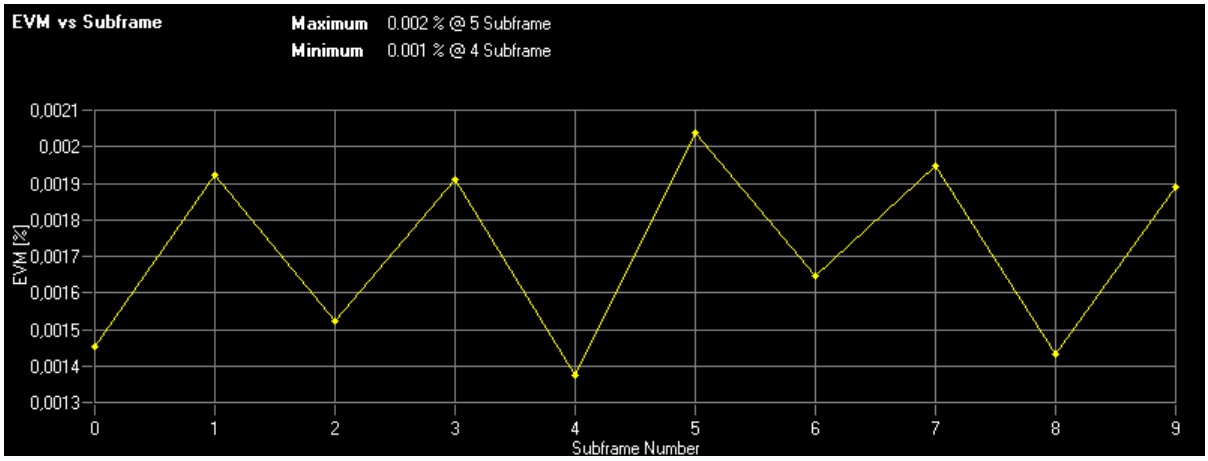
EVM vs Subframe
Starts the EVM vs Subframe result display.

This result display shows the Error Vector Magnitude (EVM) for each subframe. You can use it as a debugging technique to identify a subframe whose EVM is too high.

The result is an average over all subcarriers and symbols of a specific subframe.

The x-axis represents the subframes, with the number of displayed subframes being 10.

On the y-axis, the EVM is plotted either in % or in dB, depending on the EVM Unit.



SCPI command:
CALCulate<n>:FEED 'EVM:EVSU'
TRACe:DATA?

3.4 Measuring the Spectrum

This chapter contains information on all measurements that show the power of a signal in the frequency domain.

In addition to the I/Q measurements, spectrum measurements also include two frequency sweep measurements, the Spectrum Emission Mask and the Adjacent Channel Leakage Ratio.

3.4.1 Frequency Sweep Measurements

The Spectrum Emission Mask (SEM) and Adjacent Channel Leakage Ratio (ACLR) measurements are the only frequency sweep measurements available for the EUTRA/LTE measurement application. They do not use the I/Q data all other measurements use. Instead those measurements sweep the frequency spectrum every time you run a new measurement. Therefore it is not possible to to run an I/Q measurement and then view the results in the frequency sweep measurements and vice-versa. Also because each of the frequency sweep measurements uses different settings to obtain signal data it is not possible to run a frequency sweep measurement and view the results in another frequency sweep measurement.

Frequency sweep measurements are available if RF input is selected.

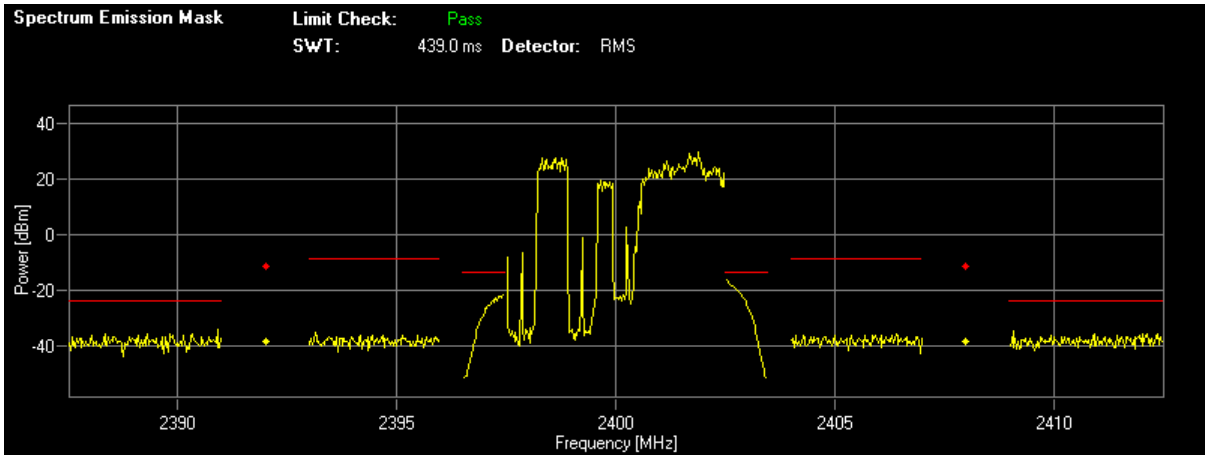
Spectrum Mask
Starts the Spectrum Emission Mask (SEM) result display.

The Spectrum Emission Mask measurement shows the quality of the measured signal by comparing the power values in the frequency range near the carrier against a spectral mask that is defined by the 3GPP specifications. In this way, you can test the performance of the DUT and identify the emissions and their distance to the limit.

In the diagram, the SEM is represented by a red line. If any measured power levels are above that limit line, the test fails. If all power levels are inside the specified limits, the test is passed. The analyzer puts a label to the limit line to indicate whether the limit check passed or failed.

The x-axis represents the frequency with a frequency span that relates to the specified EUTRA/LTE channel bandwidths. On the y-axis, the power is plotted in dBm.

The result display also contains some numerical results for the SEM measurement, for example the total signal power or the limit check result.



A table above the result display contains the numerical values for the limit check at each check point:

- **Start / Stop Freq Rel**
  Shows the start and stop frequency of each section of the Spectrum Mask relative to the center frequency.
- **RBW**
  Shows the resolution bandwidth of each section of the Spectrum Mask
- **Freq at Δ to Limit**
  Shows the absolute frequency whose power measurement being closest to the limit line for the corresponding frequency segment.
- **Power Abs**
  Shows the absolute measured power of the frequency whose power is closest to the limit. The application evaluates this value for each frequency segment.
- **Power Rel**
  Shows the distance from the measured power to the limit line at the frequency whose power is closest to the limit. The application evaluates this value for each frequency segment.
- **Δ to Limit**
  Shows the minimal distance of the tolerance limit to the SEM trace for the corresponding frequency segment. Negative distances indicate the trace is below the tolerance limit, positive distances indicate the trace is above the tolerance limit.

Spectrum Emission Mask List

Start Freq. Rel.	Stop Freq. Rel.	RBW	Freq. at Δ to Limit	Pwr Abs [dBm]	Pwr Rel [dB]	Δ to Limit [dB]
-17,50 MHz	-15,50 MHz	1,00 MHz	0,983173100 GHz	-38,26	-72,55	-25,26
-15,05 MHz	-10,05 MHz	0,10 MHz	0,986482400 GHz	-40,14	-74,44	-27,64
-10,05 MHz	-5,05 MHz	0,10 MHz	0,994727600 GHz	-10,81	-45,10	-5,00
5,05 MHz	10,05 MHz	0,10 MHz	1,005329000 GHz	-8,12	-42,41	-2,23
10,05 MHz	15,05 MHz	0,10 MHz	1,014135000 GHz	-40,14	-74,43	-27,64
15,50 MHz	17,50 MHz	1,00 MHz	1,016266000 GHz	-38,40	-72,70	-25,40

SCPI command:
CALCulate<n>:FEED 'SPEC:SEM'
TRACe:DATA?

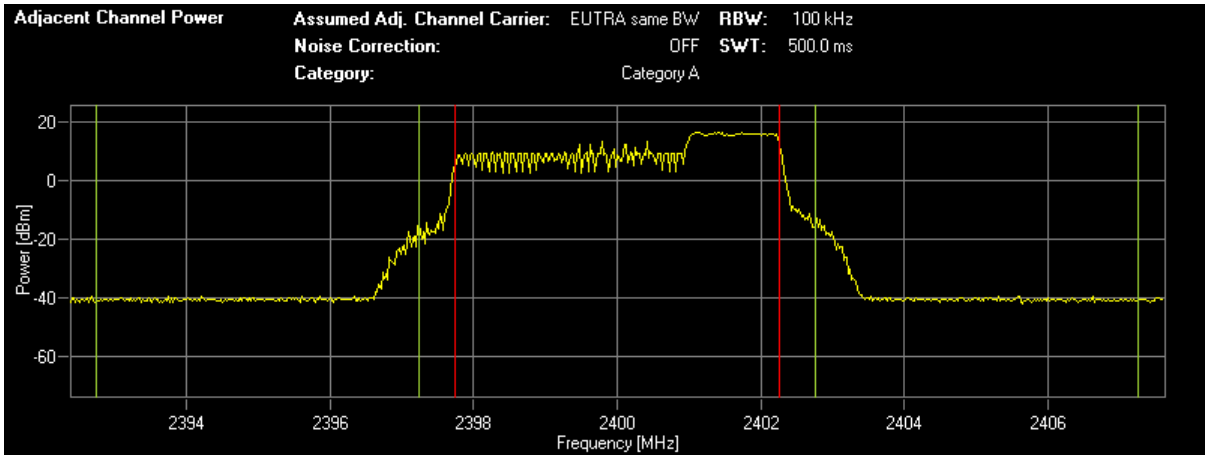
ACLR
Starts the Adjacent Channel Leakage Ratio (ACLR) measurement.

The Adjacent Channel Leakage Ratio measures the power of the TX channel and the power of adjacent and alternate channels to the left and right side of the TX channel. In this way, you can get information about the power of the channels adjacent to the transmission channel and the leakage into adjacent channels.

The results show the relative power measured in the two nearest channels either side of the transmission channel.

By default the ACLR settings are derived from the LTE Channel Bandwidth. You can change the assumed adjacent channel carrier type and the "Noise Correction" on page 57.

The x-axis represents the frequency with a frequency span that relates to the specified EUTRA/LTE channel and adjacent bandwidths. On the y-axis, the power is plotted in dBm.



A table above the result display contains information about the measurement in numerical form:

- **Channel**
  Shows the channel type (TX, Adjacent or Alternate Channel).
- **Bandwidth**
  Shows the bandwidth of the channel.
- **Spacing**
  Shows the channel spacing.
- **Channel Power**
  Shows the absolute power of the corresponding channel.


Adj. Chan. Leakage Power Ratio List Limit Adjacent: -30 dB

Channel	Bandwidth	Spacing (Offset)	Channel Power
TX	4,5 MHz		28,46 dBm
Lower Adj	4,5 MHz	-5 MHz	-42,96 dB
Upper Adj	4,5 MHz	5 MHz	-39,76 dB

SCPI command:
Selection:
CALCulate<n>:FEED 'SPEC:ACP'
Limit check:
`CALCulate<n>:LIMit<k>:ACPower:ACHannel:RESult?` on page 121
`CALCulate<n>:LIMit<k>:ACPower:ALTernate:RESult?` on page 121
`CALCulate<n>:LIMit<k>:FAIL?` on page 122
Reading results:
`CALCulate<n>:MARKer<m>:FUNCtion:POWer:RESult[:CURRent]?` on page 122
TRACe:DATA?

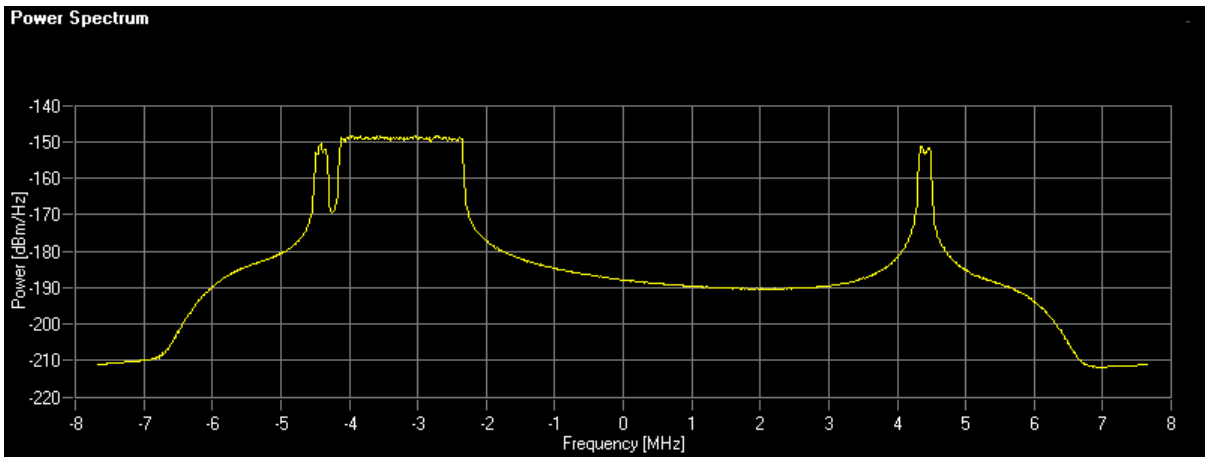
3.4.2 I/Q Measurements

Power Spectrum
Starts the Power Spectrum result display.

This result display shows the power density of the complete capture buffer in dBm/Hz. The displayed bandwidth depends on bandwidth or number of resource blocks you have set.

For more information see "Channel Bandwidth / Number of Resource Blocks" on page 66.

The x-axis represents the frequency. On the y-axis the power level is plotted.



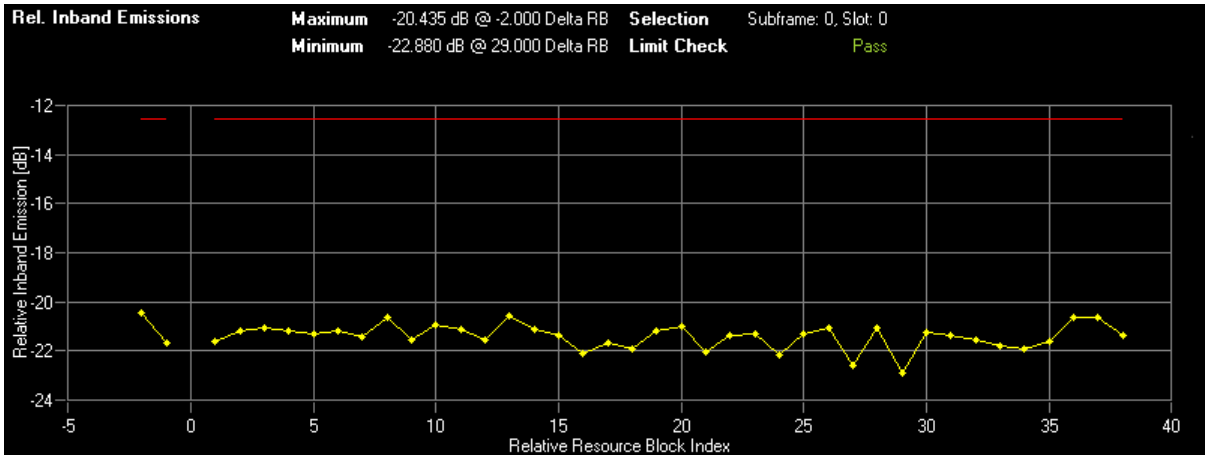
SCPI command:
CALCulate<screenid>:FEED 'SPEC:PSPE'
TRACe:DATA?

Inband Emission
Starts the Inband Emission result display.

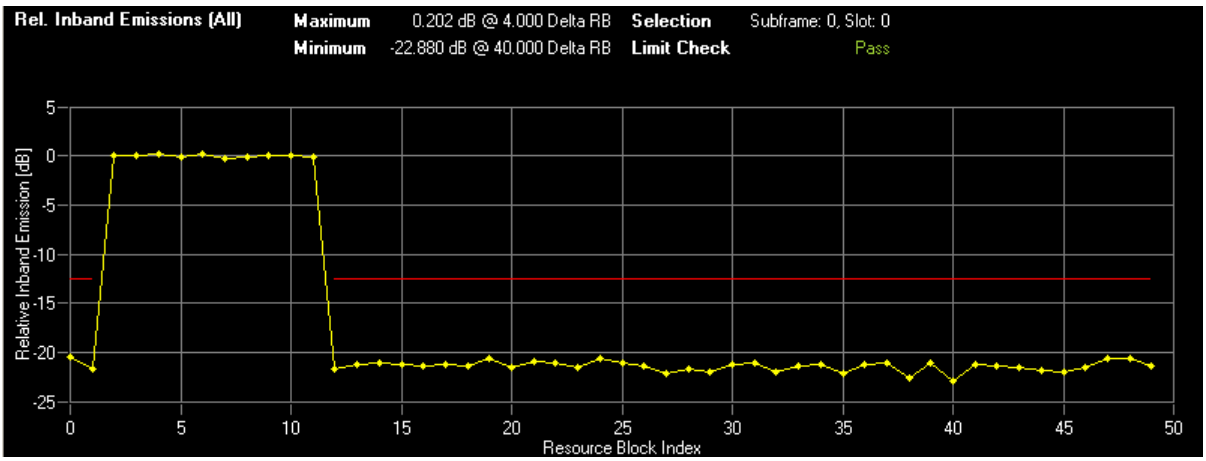
This result display shows the relative power of the unused resource blocks (yellow trace) and the inband emission limit lines (red trace) specified by the LTE standard document 3GPP TS36.10.

The measurement is evaluated over the currently selected slot in the currently selected subframe. The currently selected subframe depends on your selection.

Note that you have to select a specific subframe and slot to get valid measurement results.



Upon selecting Inband Emission All, the trace also shows the inband emissions for the allocated resource blocks in addition to the unused resource blocks.



SCPI command:
CALCulate<screenid>:FEED 'SPEC:IE'
CALCulate<screenid>:FEED 'SPEC:IEA'
TRACe:DATA?

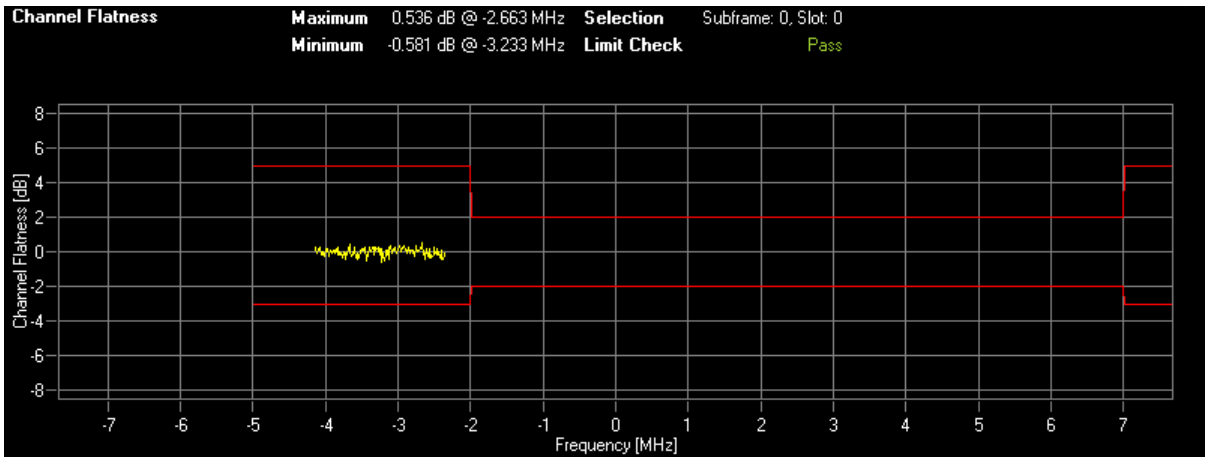
Channel Flatness
Starts the Channel Flatness result display.

This result display shows the relative power offset caused by the transmit channel.

The measurement is evaluated over the currently selected slot in the currently selected subframe.

The currently selected subframe depends on your selection.

The x-axis represents the frequency. On the y-axis, the channel flatness is plotted in dB.



SCPI command:
CALCulate<n>:FEED 'SPEC:FLAT'
TRACe:DATA?

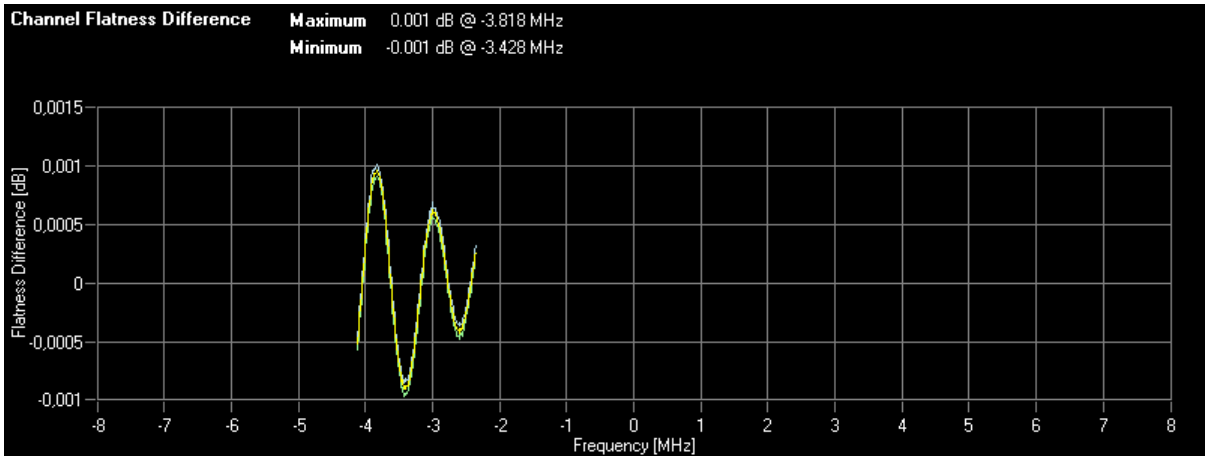
Channel Flatness Difference
Starts the Channel Flatness Difference result display.

This result display shows the level difference in the spectrum flatness result between two adjacent physical subcarriers.

The measurement is evaluated over the currently selected slot in the currently selected subframe.

The currently selected subframe depends on your selection.

The x-axis represents the frequency. On the y-axis, the power is plotted in dB.



SCPI command:
CALCulate<n>:FEED 'SPEC:FDIF'
TRACe:DATA?

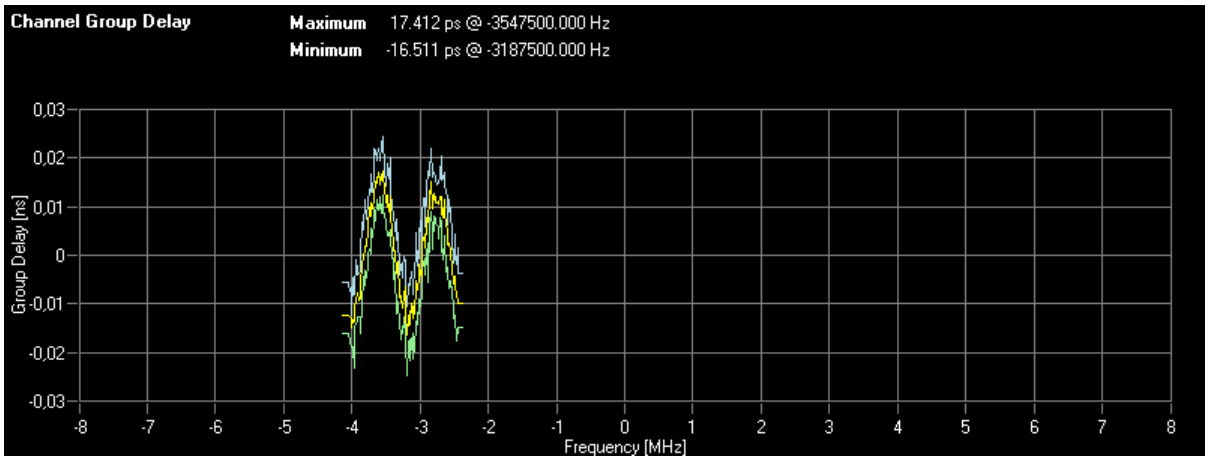
Channel Group Delay
Starts the Channel Group Delay result display.

This result display shows the group delay of each subcarrier.

The measurement is evaluated over the currently selected slot in the currently selected subframe.

The currently selected subframe depends on your selection.

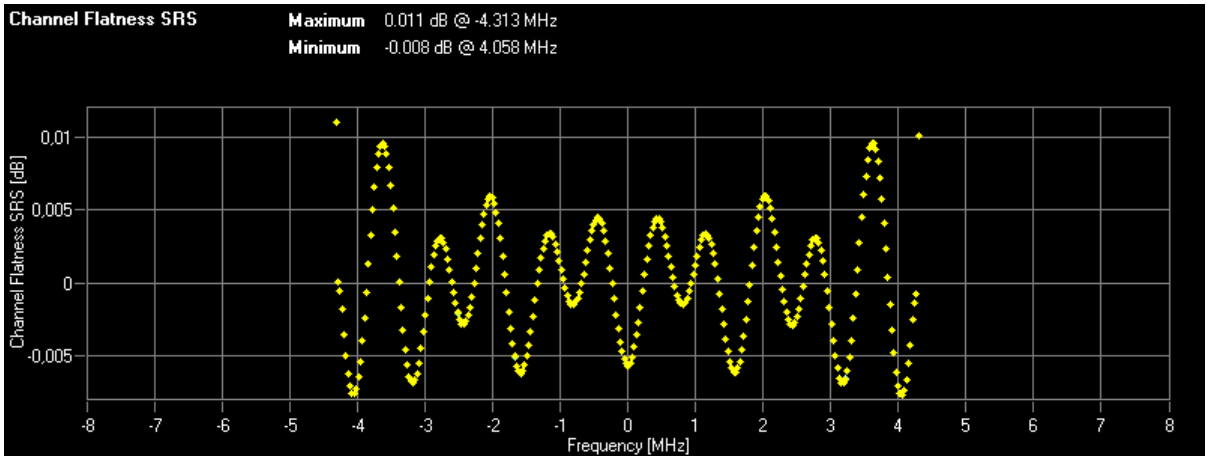
The x-axis represents the frequency. On the y-axis, the group delay is plotted in ns.



SCPI command:
CALCulate<n>:FEED 'SPEC:GDEL'
TRACe:DATA?

Channel Flatness SRS
The Channel Flatness SRS display shows the amplitude of the channel transfer function based on the sounding reference signal.

The measurement is evaluated over the currently selected slot in the currently selected subframe. The slot and subframe selection may be changed in the general settings.



SCPI command:
CALCulate<n>:FEED 'SPEC:FSRS'
TRACe:DATA

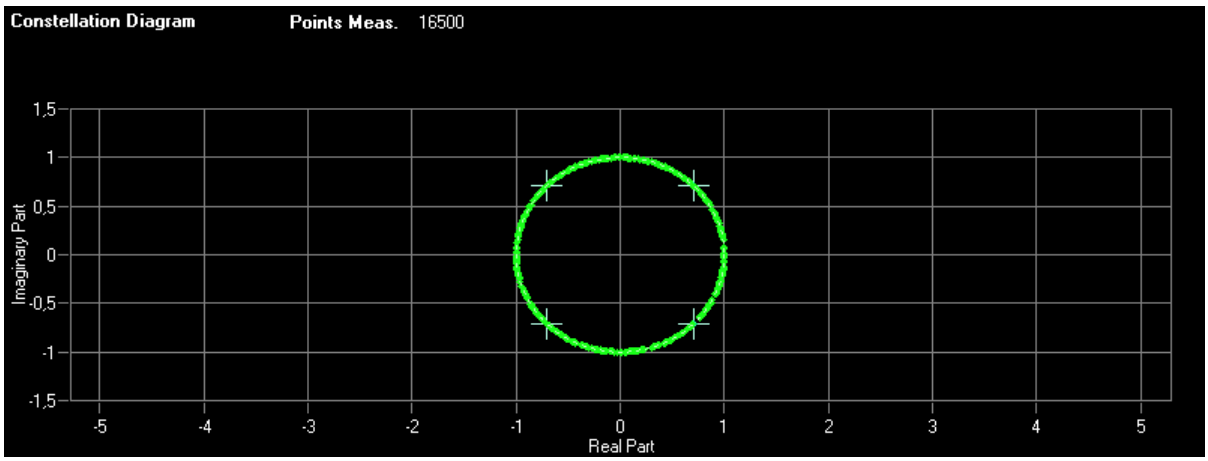
3.5 Measuring the Symbol Constellation

This chapter contains information on all measurements that show the constellation of a signal.

Constellation Diagram
Starts the Constellation Diagram result display.

This result display shows the inphase and quadrature phase results and is an indicator of the quality of the modulation of the signal. The result display evaluates the full range of the measured input data. You can filter the results in the Constellation Selection dialog box.

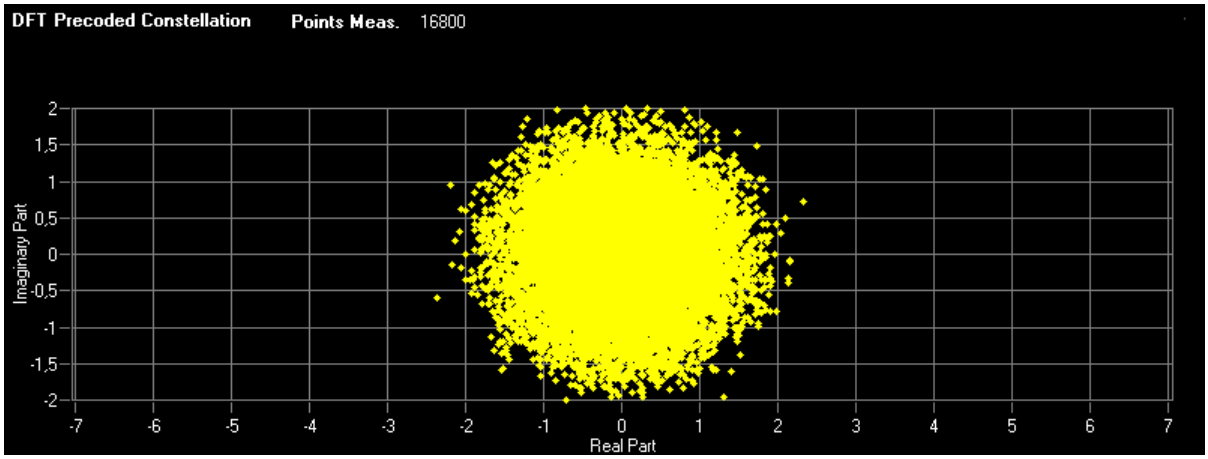
The ideal points for the selected modulation scheme are displayed for reference purposes.



SCPI command:
CALCulate<n>:FEED 'CONS:CONS'
TRACe:DATA?

DFT Precod Constellation
Starts the DFT Precod Constellation result display.

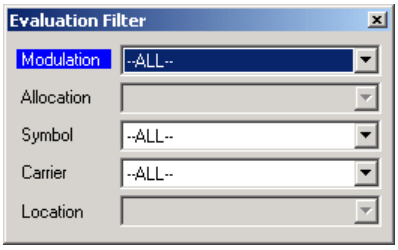
This result display shows the inphase and quadrature phase results. It shows the data without the DFT precoding. The result display evaluates the full range of the measured input data. You can filter the results in the Constellation Selection dialog box.



SCPI command:
CALCulate<screenid>:FEED 'CONS:DFTC'

Constellation Selection
Filters the displayed results. You can filter the results 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.

Note that the constellation selection is applied to all windows in split screen mode if the windows contain constellation diagrams.



You can filter the results by the following parameters:

- **Modulation**
  Filter by modulation scheme.
- **Symbol**
  Filter by OFDM symbol.
- **Carrier**
  Filter by subcarrier.

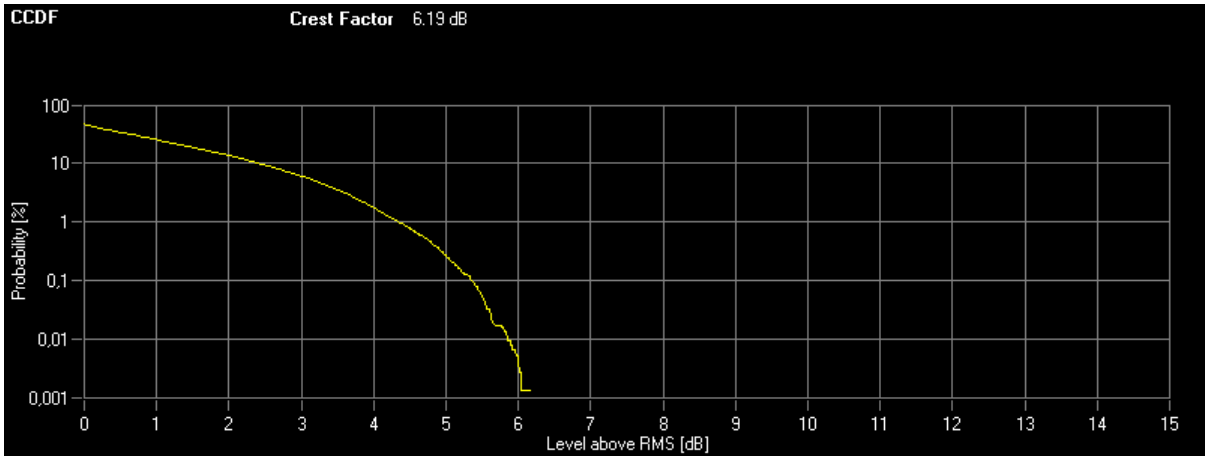
3.6 Measuring Statistics

This chapter contains information on all measurements that show the statistics of a signal.

CCDF
Starts the Complementary Cumulative Distribution Function (CCDF) result display.

This result display shows the probability of an amplitude exceeding the mean power. For the measurement, the complete capture buffer is used.

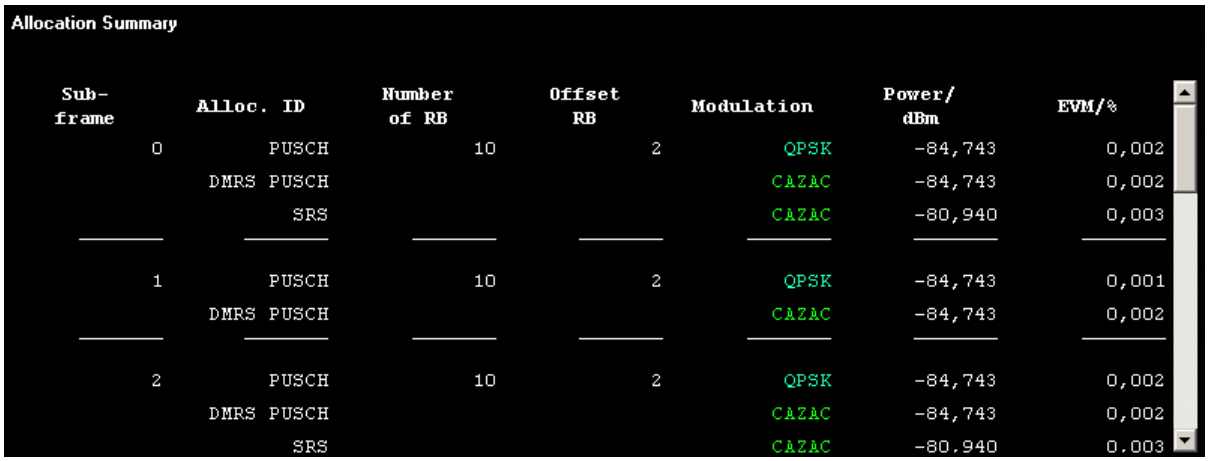
The x-axis represents the power relative to the measured mean power. On the y-axis, the probability is plotted in %.



SCPI command:
CALCulate<n>:FEED 'STAT:CCDF'
TRACe:DATA?

Allocation Summary
Starts the Allocation Summary result display.

This result display shows the results of the measured allocations in tabular form.


Allocation Summary

Sub-frame	Alloc. ID	Number of RB	Offset RB	Modulation	Power/ dBm	EVM/%
0	PUSCH	10	2	QPSK	-84,743	0,002
	DMRS PUSCH			CAZAC	-84,743	0,002
	SRS			CAZAC	-80,940	0,003
1	PUSCH	10	2	QPSK	-84,743	0,001
	DMRS PUSCH			CAZAC	-84,743	0,002
2	PUSCH	10	2	QPSK	-84,743	0,002
	DMRS PUSCH			CAZAC	-84,743	0,002
	SRS			CAZAC	-80,940	0,003

The rows in the table represent the allocations. A set of allocations form a subframe. The subframes are separated by a dashed line. The columns of the table contain the follwing information:

- **Subframe**
  Shows the subframe number.
- **Allocation ID**
  Shows the type / ID of the allocation.
- **Number of RB**
  Shows the number of resource blocks assigned to the current PDSCH allocation.
- **Offset RB**
  Shows the resource block offset of the allocation.
- **Modulation**
  Shows the modulation type.
- **Power**
  Shows the power of the allocation in dBm.
- **EVM**
  Shows the EVM of the allocation. The unit depends on your selection.

SCPI command:
CALCulate<n>:FEED 'STAT:ASUM'
TRACe:DATA?

Bit Stream
Starts the Bit Stream result display.

This result display shows the demodulated data stream for each data allocation. Depending on the Bit Stream Format, the numbers represent either bits (bit order) or symbols (symbol order).

Selecting symbol format shows the bit stream as symbols. In that case the bits belonging to one symbol are shown as hexadecimal numbers with two digits. In the case of bit format, each number represents one raw bit.

Symbols or bits that are not transmitted are represented by a "-".

If a symbol could not be decoded because the number of layers exceeds the number of receive antennas, the application shows a "#" sign.

Bit Stream

Sub-frame	Allocation ID	Code-word	Modulation	Symbol Index	Bit Stream
0	PUSCH	1/1	QPSK	0	03 01 02 03 03 00 00 00 01 02 02 01 02 01 00 00
0	PUSCH	1/1	QPSK	16	00 03 03 03 02 02 01 00 03 01 02 03 03 03 03 01
0	PUSCH	1/1	QPSK	32	03 03 00 00 03 01 02 00 01 00 02 00 02 00 00 03
0	PUSCH	1/1	QPSK	48	02 00 01 02 00 00 02 03 00 00 01 03 00 01 01 02
0	PUSCH	1/1	QPSK	64	01 02 00 03 00 03 01 02 00 00 00 02 03 03 00 03
0	PUSCH	1/1	QPSK	80	03 01 02 01 02 00 03 02 03 00 03 01 02 00 00 00
0	PUSCH	1/1	QPSK	96	00 01 02 03 03 01 02 01 03 03 03 01 02 00 00 03
0	PUSCH	1/1	QPSK	112	02 02 03 00 03 03 03 02 02 02 02 02 01 00 00 01
0	PUSCH	1/1	QPSK	128	02 02 02 00 02 01 00 02 00 00 00 03 00 01 03 00
0	PUSCH	1/1	QPSK	144	01 00 03 03 02 01 03 01 03 01 03 02 00 03 02 03

The table contains the following information:

- **Subframe**
  Number of the subframe the bits belong to.
- **Allocation ID**
  Channel the bits belong to.
- **Codeword**
  Code word of the allocation.
- **Modulation**
  Modulation type of the channels.
- **Bit Stream**
  The actual bit stream.

SCPI command:
CALCulate<n>:FEED 'STAT:BSTR'
TRACe:DATA?

4 General Settings

The following chapter contains all settings that are available in the "General Settings" dialog box.

4.1 Configuring the Measurement

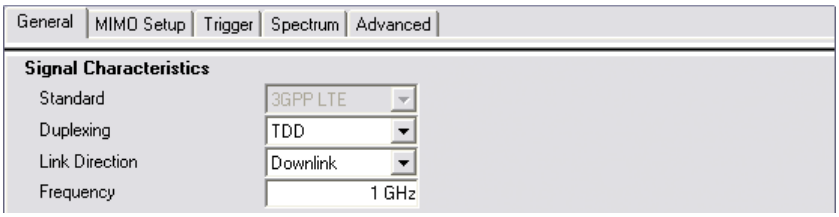
The general settings contain various settings that configure the general measurement setup.

You can find the signal characteristics in the "General Settings" dialog box.

4.1.1 Defining General Signal Characteristics

The general signal characteristics contain settings to describe the general physical attributes of the signal.

The signal characteristics are part of the "General Settings" tab of the "General Settings" dialog box.



Selecting the LTE Mode
The LTE mode is a combination of the "Standard" (always 3GPP LTE), the "Duplexing" mode and the "Link Direction".

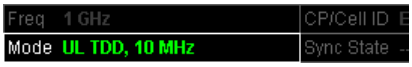
The choices you have depend on the configuration of the analyzer.

- option FSx-K100(PC) enables testing of 3GPP LTE FDD signals on the downlink
- option FSx-K101(PC) enables testing of 3GPP LTE FDD signals on the uplink
- option FSx-K102(PC) enables testing of 3GPP LTE MIMO signals on the downlink
- option FSx-K104(PC) enables testing of 3GPP LTE TDD signals on the downlink
- option FSx-K105(PC) enables testing of 3GPP LTE TDD signals on the uplink

FDD and TDD are **duplexing** methods.
- FDD mode uses different frequencies for the uplink and the downlink.
- TDD mode uses the same frequency for the uplink and the downlink.

Downlink (DL) and Uplink (UL) describe the **transmission path**.
- Downlink is the transmission path from the base station to the user equipment. The physical layer mode for the downlink is always OFDMA.
- Uplink is the transmission path from the user equipment to the base station. The physical layer mode for the uplink is always SC-FDMA.

The software shows the currently selected LTE mode (including the bandwidth) in the header table.



SCPI command:
CONFigure[:LTE]:LDIRection on page 130
CONFigure[:LTE]:DUPLexing on page 130

Defining the Signal Frequency
For measurements with an RF input source, you have to match the **center frequency** of the analyzer to the frequency of the signal.

The software shows the current center frequency in the header table.

The available frequency range depends on the hardware configuration of the analyzer you are using.

The frequency setting is available for the RF input source.

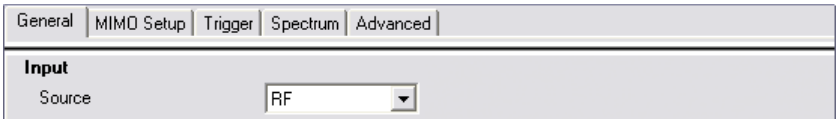
SCPI command:
Center frequency:
[SENSe]:FREQuency:CENTer on page 130

4.1.2 Configuring the Input

The input settings control the basic configuration of the input.

The input source selection is part of the "General Settings" tab of the "General Settings" dialog box.

For more information on advanced input configuration see chapter 4.5, "Advanced Settings", on page 58.



Selecting the Input Source
The input source selects the source of the data you'd like to analyze. You can either analyze a live signal or a signal that has been recorded previously and whose characteristics have been saved to a file.

You can select the input source from the "Source" dropdown menu.

- RF
  Captures and analyzes the data from the RF input of the spectrum analyzer in use.
- Baseband (BB)
  Captures and analyzes the data from the baseband input of the spectrum analyzer in use.
  Note that you have to use an analyzer that supports analog baseband input if you select that input source.
- Digital I/Q

Captures and analyzes the data from the digital baseband input of the spectrum analyzer in use.
Note that you have to use an analyzer that supports digital baseband input if you select that input source.

- File
  Analyzes data that has been recorded already and has been saved to a file.
  If selected, the software asks you to select a file from a dialog box after you have initiated a measurement. If the file contents are not valid or the file could not be found, the software shows an error message.
  A connection to an analyzer or a dongle is required to successfully load a file.
  For more information see chapter 7.1, "Importing and Exporting I/Q Data", on page 85.

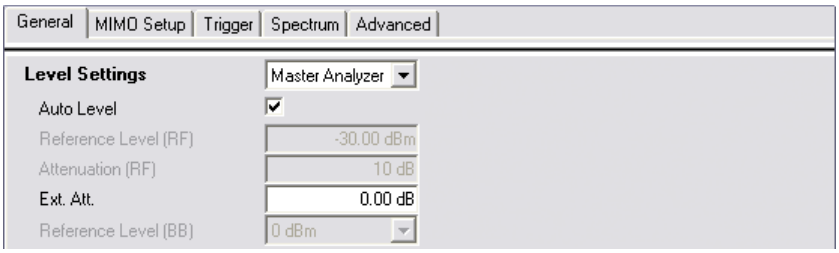
SCPI command:
`SENSe:INPut` on page 131

4.1.3 Configuring the Input Level

The level settings contain settings that control the input level of any analyzer in the measurement setup.

You can control the input level for any of the four possible analyzers in the measurement setup separately by selecting one of the analyzers from the dropdown menu next to the "Level Settings" label.

The level settings are part of the "General Settings" tab of the "General Settings" dialog box.



Defining a Reference Level
The reference level is the power level the analyzer expects at the RF input. Keep in mind that the power level at the RF input is the peak envelope power in case of signals with a high crest factor like LTE.

To get the best dynamic range, you have to set the reference level as low as possible. At the same time, make sure that the maximum signal level does not exceed the reference level. If it does, it will overload the A/D converter, regardless of the signal power. Measurement results may deteriorate (e.g. EVM). This applies especially for measurements with more than one active channel near the one you are trying to measure (± 6 MHz).

Note that the signal level at the A/D converter may be stronger than the level the application displays, depending on the current resolution bandwidth. This is because the resolution bandwidths are implemented digitally after the A/D converter.

You can either specify the **RF Reference Level** (in dBm) or **Baseband Reference Level** (in V), depending on the input source.

You can also use **automatic detection** of the reference level with the "Auto Level" function.

If active, the application measures and sets the reference level to its ideal value before each sweep. This process slightly increases the measurement time. You can define the measurement time of that measurement with the **Auto Level Track Time**.

Automatic level detection also optimizes RF attenuation.

Automatic level detection is available for an RF input source.

The software shows the current reference level of the master analyzer (including RF and external attenuation) in the header table.

SCPI command:
Manual (RF):
`CONFigure:POWer:EXPected:RF<analyzer>` on page 132
Manual (BB):
`CONFigure:POWer:EXPected:IQ<analyzer>` on page 132
Automatic:
`[SENSe]:POWer:AUTO<analyzer>[:STATe]` on page 131
Auto Level Track Time:
`[SENSe]:POWer:AUTO<analyzer>:TIME` on page 143

Attenuating the Signal
Attenuation of the signal may become necessary if you have to reduce the power of the signal that you have applied. Power reduction is necessary, for example, to prevent an overload of the input mixer.

You can attenuate the signal at the RF input of one of the analyzers in the measurement setup (mechanical or **RF attenuation**) or attenuate the signal externally (**external attenuation**).

If you attenuate or amplify the signal either way, the software adjusts the numeric and graphical results accordingly. In case of graphical power result displays, it moves the trace(s) vertically by the specified value.

Positive values correspond to an attenuation and negative values correspond to an amplification.

The range of the RF attenuation depends on the hardware you are using in the measurement setup. For details refer to its data sheet. If the attenuation you have set is not supported by the hardware, the software corrects the attenuation and shows a corresponding message.

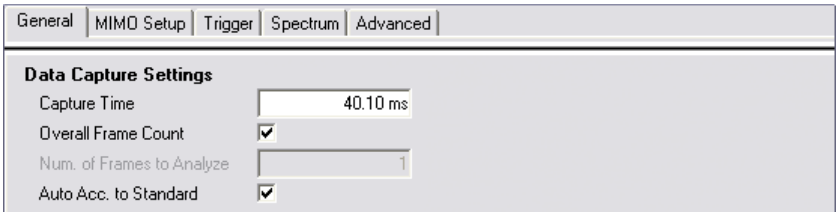
The software shows the RF and external attenuation level in the header table next to the reference level.

SCPI command:
RF attenuation:
INPut<n>:ATTenuation<analyzer> on page 132
External attenuation:
DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel:OFFSet on page 132

4.1.4 Configuring the Data Capture

The data capture settings contain settings that control the amount of data and the way that the application records the LTE signal.

The data capture settings are part of the "General Settings" tab of the "General Settings" dialog box.



Capture Time
Defines the capture time.

The capture time corresponds to the time of one sweep. Hence, it defines the amount of data the application captures during one sweep.

By default, the application captures 20.1 ms of data to make sure that at least one complete LTE frame is captured in one sweep.

The software shows the current capture time (including the frame number) in the header table.

SCPI command:
[SENSe]:SWEep:TIME on page 133

Overall Frame Count
Turns the manual selection of the number of frames to capture (and analyze) on and off.

If the overall frame count is active, you can define a particular number of frames to capture and analyze. The measurement runs until all required frames have been analyzed, even if it takes more than one sweep. The results are an average of the captured frames.

If the overall frame count is inactive, the analyzer analyzes all complete LTE frames currently in the capture buffer.

SCPI command:
[SENSe][:LTE]:FRAMe:COUNt:STATe on page 133

Number of Frames to Analyze
Sets the number of frames that you want to capture and analyze.

If the number of frames you have set last longer than a single sweep, the analyzer continues the measurement until all frames have been captured.

The parameter is read only if

- the overall frame count is inactive,
- the data is captured according to the standard.

SCPI command:
`[SENSe][:LTE]:FRAMe:COUNt` on page 133

Auto According to Standard
Turns automatic selection of the number of frames to capture and analyze on and off.

If active, the analyzer evaluates the number of frames as defined for EVM tests in the LTE standard.

If inactive, you can set the number of frames you want to analyze.

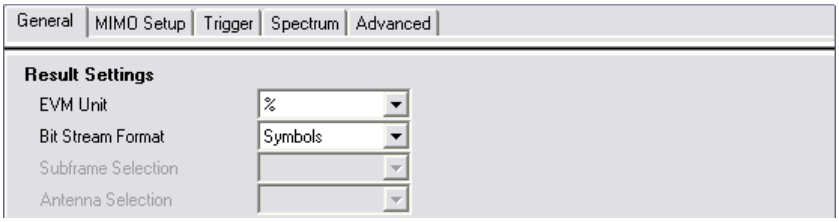
This parameter is not available if the overall frame count is inactive.

SCPI command:
`[SENSe][:LTE]:FRAMe:COUNt:AUTO` on page 133

4.1.5 Configuring Measurement Results

The measurement result settings contain settings that define certain aspects of the results that are displayed.

The result settings are part of the "General Settings" tab of the "General Settings" dialog box.



EVM Unit
Selects the unit for graphic and numerical EVM measurement results.

Possible units are dB and %.

SCPI command:
`UNIT:EVM` on page 134

Bit Stream Format
Selects the way the bit stream is displayed.

The bit stream is either a stream of raw bits or of symbols. In case of the symbol format, the bits that belong to a symbol are shown as hexadecimal numbers with two digits.

Examples:

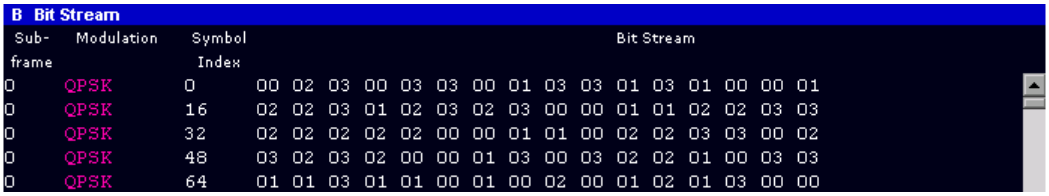


Fig. 4-1: Bit stream display in uplink application if the bit stream format is set to "symbols"

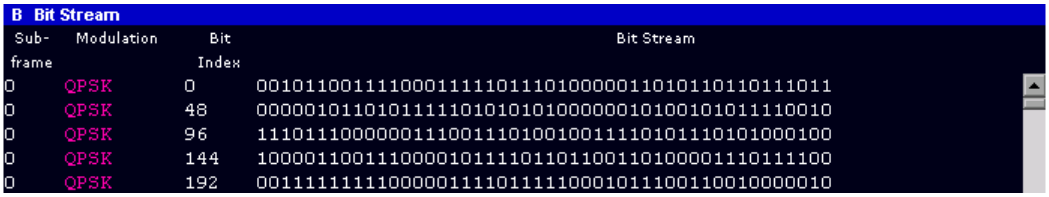


Fig. 4-2: Bit stream display in uplink application if the bit stream format is set to "bits"

SCPI command:
UNIT:BSTR on page 134

Subframe Selection
Selects a particular subframe whose results the software displays.

You can select a particular subframe for the following measurements.

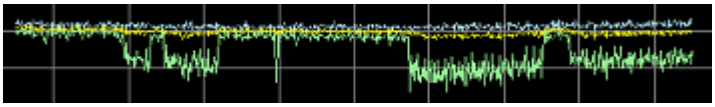
Result Summary, EVM vs. Carrier, EVM vs. Symbol, Inband Emission, Channel Flatness, Channel Flatness SRS, Channel Group Delay, Channel Flatness Difference, Constellation Diagram, DFT Precoded Constellation, Allocation Summary and Bit Stream. If ---All--- is selected, either the results from all subframes are displayed at once or a statistic is calculated over all analyzed subframes.

Selecting a subframe is not possible in PRACH analysis mode.

Selecting "All" either displays the results over all subframes or calculates a statistic over all subframes that have been analyzed.

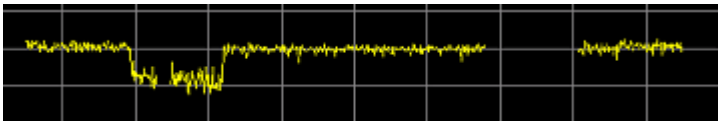
Example: Subframe selection

If you select all subframes ("All"), the application shows three traces. One trace shows the subframe with the minimum level characteristics, the second trace shows the subframe with the maximum level characteristics and the third subframe shows the averaged level characteristics of all subframes.



- PK: peak value
- AV: average value
- MI: minimum value

If you select a specific subframe, the application shows one trace. This trace contains the results for that subframe only.



SCPI command:
`[SENSe][:LTE]:SUBFrame:SELect` on page 135

Slot Selection
Selects a particular slot whose measurement results you want to see.

You can select a particular slot for the following measurements.

Result Summary, EVM vs Carrier, EVM vs Symbol, Inband Emission, Channel Flatness, Channel Flatness SRS, Channel Group Delay, Channel Flatness Difference, Constellation diagram and DFT Precoded Constellation diagram.

In PRACH analysis mode, you can not select a particular slot.

SCPI command:
`[SENSe][:LTE]:SLOT:SELect` on page 135

Preamble Selection
Selects a particular preamble for measurements that analyze individual preambles.

Selecting preambles is available in PRACH analysis mode.

SCPI command:
`[SENSe][:LTE]:PREamble:SELect` on page 135

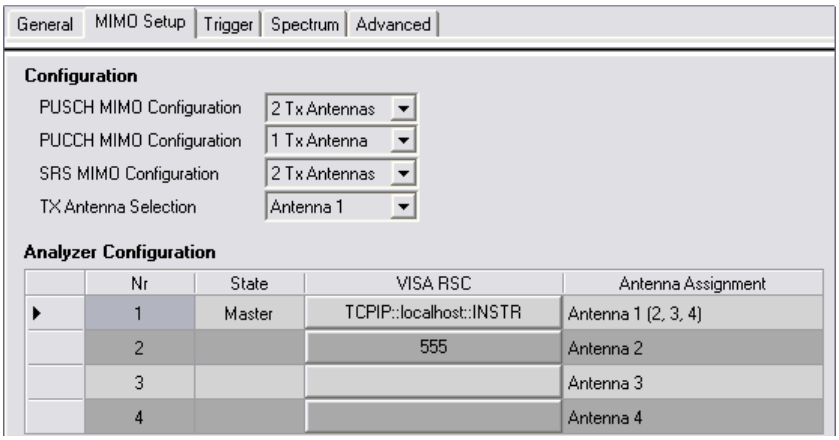
Antenna Selection
Selects the antenna you want to display the results for.

SCPI command:
`[SENSe][:LTE]:ANTenna:SELect` on page 134

4.2 Configuring MIMO Measurement Setups

The MIMO analyzer configuration contains settings that configure the analyzers in a MIMO measurement setup.

The MIMO analyzer configuration is part of the "General Settings" tab of the "General Settings" dialog box.



MIMO Configuration
Selects the antenna configuration and test conditions for a MIMO system.

The MIMO **configuration** selects the number of transmit antennas for selected channels in the system. MIMO configurations are supported for the PUSCH, the PUCCH and the Sounding Reference Signal (SRS). For each channel you can select from a 1- or 2-antenna configuration.

In setups with multiple antennas, the **antenna selection** defines the antenna you'd like to test. Note that as soon as you have selected a transmission on more than one antenna for one of the channels, antenna 2 becomes available for testing.

Antenna 1	Tests antenna 1 only.
Antenna 2	Tests antenna 2 only.
All	Tests all antennas in the test setup in consecutive order (1-2-3-4). A corresponding number of analyzers is required.

SCPI command:
`CONFigure[:LTE]:UL:MIMO:SRS:CONFig` on page 137
`CONFigure[:LTE]:UL:MIMO:PUCCh:CONFig` on page 137
`CONFigure[:LTE]:UL:MIMO:PUSCh:CONFig` on page 137
`CONFigure[:LTE]:UL:MIMO:ASELection` on page 136

MIMO Analyzer Configuration
In case you perform measurements on a MIMO measurement setup, you can configure the connection of each analyzer in that setup.

The analyzer configuration table is made up of four columns and four rows. Each row represents one analyzer. The columns show the tasks for the analyzers.

- Nr
  Shows the number of the analyzer.
- State
  Shows if the analyzer is master or slave. Analyzer number 1 is always the master analyzer.
- VISA RSC
  Button that opens a dialog box to configure the analyzer connection in the network (see below).
- Antenna Assignment
  Shows the antenna that the analyzer measures.

Instrument Connection Configuration

The "Instrument Connection Configuration" dialog box contains functionality that is necessary to successfully establish a connection in a network of analyzers. The dialog box contains several elements.

- Interface Type
  Selects the interface. You have to connect the analyzer via LAN interface or the IEEE bus (GPIB).
- Number
  Number of the interface if the PC has more than one interfaces (e.g. several LAN cards).
- Address
  Shows the instrument address. The type of content depends on the interface type.
  - GPIB Address
    Primary GPIB address of the analyzer. Possible values are in the range from 0 to 31.
    The default GPIB address for an R&S analyzer is 20.
    Available for IEEE bus systems using the IEEE 488 protocol. The interface type is GPIB.
  - IP Address or Computer Name
    Name or host address (TCP/IP) of the computer.
    Available for LAN bus systems using either the VXI-11 protocol or a Rohde&Schwarz specific protocol (RSIB). The interface type is either LAN (VXI-11) or LAN (RSIB).
    Contact your local IT support for information on free IP addresses.
    The RSIB protocol is supported by all firmware version of the R&S analyzers.
    The VXI-11 protocol is supported as of R&S FSQ firmware version 3.65 and by all firmware version of the R&S FSV(R) and R&S FSG.
  - Complete VISA Resource String
    Allows to enter the complete VISA string manually.
    Available for interface type "Free Entry".
- Subsystem
  Shows the subsystem in use. Typically you do not have to change the subsystem.

- VISA RSC
  Shows the complete VISA resource string.
- Test Connection
  Button that tests the connection. If the connection has been established successfully, the software returns a PASSED message. If not, it shows a FAILED message.

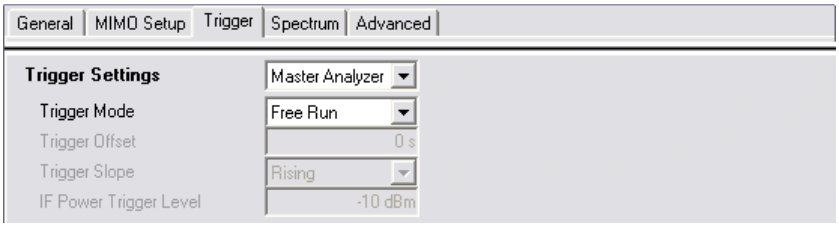
SCPI command:
`CONFigure:ADDRess<analyzer>` on page 136

4.3 Triggering Measurements

The trigger settings contain settings that control triggered measurements.

You can select a trigger for any of the four possible analyzers in the measurement setup separately by selecting one of the analyzers from the dropdown menu next to the "Trigger Settings" label.

The trigger settings are part of the "General Settings" tab of the "General Settings" dialog box.



Configuring the Trigger
A trigger allows you to capture those parts of the signal that you are really interested in.

While the analyzer runs freely and analyzes all signal data in its default state, no matter if the signal contains information or not, a trigger initiates a measurement only under certain circumstances (the trigger event).

The analyzer supports several **trigger modes** or sources.

- Free Run
  Starts the measurement immediately and measures continuously.
- External
  The trigger event is the level of an external trigger signal. The measurement starts when this signal meets or exceeds a specified trigger level at the "Ext Trigger/Gate" input.
- IF Power
  The trigger event is the IF power level. The measurement starts when the IF power meets or exceeds a specified power trigger level.
- Trigger Unit FS-Z11
  The R&S FS-Z11 is a trigger unit designed to control triggers in MIMO measurement setups.
  For more information see chapter 8.4.1.2, "Performing MIMO Measurements with a Trigger Unit", on page 97 and the documentation of the R&S FS-Z11.

You can define a **power level** for an external and an IF power trigger.

For most trigger sources you can select the **trigger slope**. The trigger slope defines whether triggering occurs when the signal rises to the trigger level or falls down to it.

The measurement starts as soon as the trigger event happens. It may become necessary to start the measurement some time after the trigger event. In that case, define a **trigger offset** (or trigger delay). The trigger offset is the time that should pass between the trigger event and the start of the measurement.

The trigger offset may be a negative time. The trigger offset is then called a **pretrigger**.

The trigger offset is available for all trigger modes, except free run.

SCPI command:
Trigger mode:
`TRIGger[:SEQuence]:MODE` on page 138
Trigger level:
`TRIGger[:SEQuence]:LEVel<analyzer>[:EXTernal]` on page 138
`TRIGger[:SEQuence]:LEVel<analyzer>:POWer` on page 138
Trigger slope:
`TRIGger[:SEQuence]:SLOPe` on page 139
Trigger offset:
`TRIGger[:SEQuence]:HOLDoff<analyzer>` on page 138

4.4 Spectrum Settings

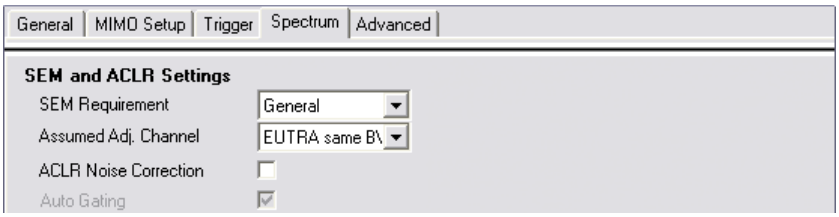
The spectrum settings contain settings to configure frequency sweep measurements (ACLR and SEM).

You can find the spectrum settings in the "General Settings" dialog box.

4.4.1 Configuring SEM and ACLR Measurements

The SEM (Spectrum Emission Mask) and ACLR (Adjacent Channel Leakage Ratio) settings contain settings that define aspects of those measurements.

The SEM and ACLR settings are part of the "General Settings" tab of the "General Settings" dialog box.



SEM Requirement
Selects the type of spectrum emission mask used for the Out of Band emission measurement.

The software supports general and specific (additional) spectrum emission masks. The specific spectrum emission masks contain additional SEM requirements. The additional requirements masks to use for the measurement depend on the network signalled value "NS_03", "NS_04", "NS_06" or "NS_07".

If "NS_06" or "NS_07" is indicated in the cell, use SEM requirement "NS_06_07".

SCPI command:

`[SENSe]:POWer:SEM:UL:REQuirement` on page 139

Assumed Adjacent Channel Carrier
Selects the assumed adjacent channel carrier for the ACLR measurement.

The supported types are EUTRA of same bandwidth, 1.28 Mcps UTRA, 3.84 Mcps UTRA and 7.68 Mcps UTRA.

Note that not all combinations of LTE Channel Bandwidth settings and Assumed Adj. Channel Carrier settings are defined in the 3GPP standard.

SCPI command:

`[SENSe]:POWer:ACHannel:AACHannel` on page 139

Noise Correction
Turns noise correction on and off.

For more information see the manual of the analyzer.

Note that the input attenuator makes a clicking noise after each sweep if you are using the noise correction in combination with the auto leveling process.

SCPI command:

`[SENSe]:POWer:NCORrection` on page 140

Auto Gating
Turns gating for SEM and ACLR measurements on and off.

If on, the software evaluates the on-periods of an LTE TDD signal only. The software determines the location and length of the on-period from the "TDD UL/DL Allocations" and the "Configuration of the Special Subframe".

Auto gating is available for TDD measurements in combination with an external or IF power trigger.

If you are using an external trigger, the DUT has to send an LTE frame trigger.

SCPI command:

`[SENSe]:SWEep:EGATe:AUTO` on page 140

4.4.2 Configuring Channel Flatness Measurements

The channel flatness settings contain settings that define certain aspects of those measurements.

The Channel Flatness measurement settings are part of the "General Settings" tab of the "General Settings" dialog box.

Operating Band Index
Selects one of the 40 operating bands for spectrum flatness measurements as defined in the standard.

The operating band defines the frequency band and the dedicated duplex mode.

SCPI command:
`[SENSe][:LTE]:SFLatness:OBANd` on page 141

Extreme Conditions
Turns extreme conditions on and off.

If you turn the extreme conditions on, the software will modify the limit lines for the limit check of the spectral flatness measurement.

SCPI command:
`[SENSe][:LTE]:SFLatness:ECONditions` on page 141

4.5 Advanced Settings

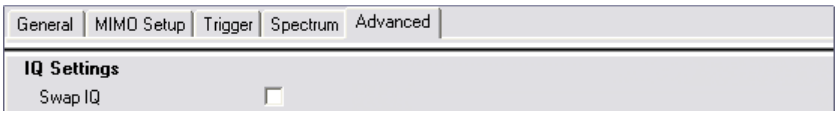
The advanced settings contain settings to configure the signal input and some global measurement analysis settings.

You can find the advanced settings in the "General Settings" dialog box.

4.5.1 Controlling I/Q Data

The I/Q settings contain settings that control the I/Q data flow.

The I/Q settings are part of the "Advanced Settings" tab of the "General Settings" dialog box.



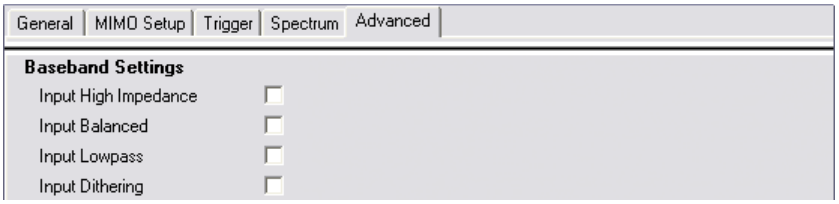
Swap I/Q
Swaps the real (I branch) and the imaginary (Q branch) parts of the signal.

SCPI command:
`[SENSe]:SWAPiq` on page 141

4.5.2 Configuring the Baseband Input

The baseband settings contain settings that configure the baseband input.

The baseband settings are part of the "Advanced Settings" tab of the "General Settings" dialog box.



High Impedance
Selects the impedance of the baseband input.

By default (high impedance is off), the impedance is 50 Ω.

If you turn the high impedance on, the impedance changes to 1 kΩ or 1 MΩ, depending on the configuration of the analyzer.

High impedance is available for a baseband input source.

SCPI command:
`INPut:IQ:IMPedance` on page 142

Balanced
Turns symmetric (or balanced) input on and off.

If active, a ground connection is not necessary. If you are using an assymetrical (unbalanced) setup, the ground connection runs through the shield of the coaxial cable that is used to connect the DUT

Balancing is available for a baseband input source.

SCPI command:
`INPut:IQ:BALanced[:STATe]` on page 142

Low Pass
Turns an anti-aliasing low pass filter on and off.

The filter has a cut-off frequency of 36 MHz and prevents frequencies above from being mixed into the usable frequency range. Note that if you turn the filter off, harmonics or spurious emissions of the DUT might be in the frequency range above 36 MHz and might be missed.

You can turn it off for measurement bandwidths greater than 30 MHz.

The low pass filter is available for a baseband input source.

SCPI command:
`[SENSe]:IQ:LPASs[:STATe]` on page 142

Dither
Adds a noise signal into the signal path of the baseband input.

Dithering improves the linearity of the A/D converter at low signal levels or low modulation. Improving the linearity also improves the accuracy of the displayed signal levels.

The signal has a bandwidth of 2 MHz with a center frequency of 38.93 MHz.

Dithering is available for a baseband input source.

SCPI command:
`[SENSe]:IQ:DITHer[:STATe]` on page 142

4.5.3 Using Advanced Input Settings

The advanced input settings contain settings that configure the RF input.

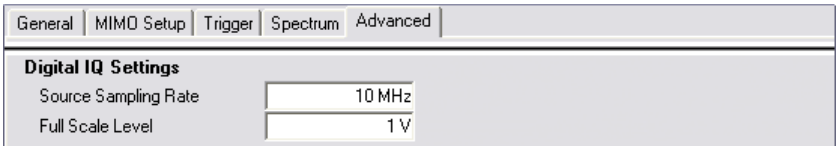
The advanced input settings are part of the "Advanced Settings" tab of the "General Settings" dialog box.

For more information see "Defining a Reference Level" on page 47.

4.5.4 Configuring the Digital I/Q Input

The digital I/Q settings contain settings that configure the digital I/Q input.

The digital I/Q settings are part of the "Advanced Settings" tab of the "General Settings" dialog box.



Sampling Rate (Input Data Rate)
Defines the data sample rate at the digital baseband input.

The sample rate is available for a digital baseband input source.

SCPI command:
`INPut<n>:DIQ:SRATe` on page 143

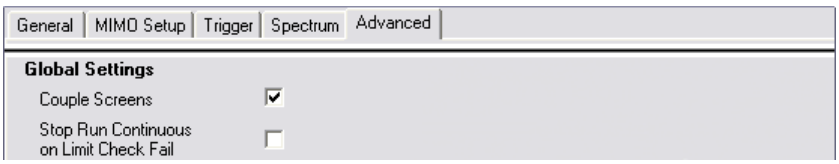
Full Scale Level
Defines the voltage corresponding to the maximum input value of the digital baseband input.

SCPI command:
`INPut<n>:DIQ:RANGe[:UPPer]` on page 143

4.5.5 Global Settings

The global settings contain settings that are independent of other settings.

The global settings are part of the "Advanced Settings" tab of the "General Settings" dialog box.



Couple Screens
Couples and decouples markers that have the same x-axis unit in the top and bottom result displays (e.g. both result displays have a frequency axis).

In case of the constellation diagram, the constellation selection is also coupled to the marker.

Stop Run Continuous On Limit Check Fail
Stops a continuous measurement if the signal fails any limit check in the currently active result display.

For example, the measurement would stop on an EVM PUSCH QPSK limit check fail if the result summary is active.

5 Demod Settings

The following chapter contains all settings that are available in the "Demodulation Settings" dialog box.

5.1 Configuring Uplink Signal Demodulation

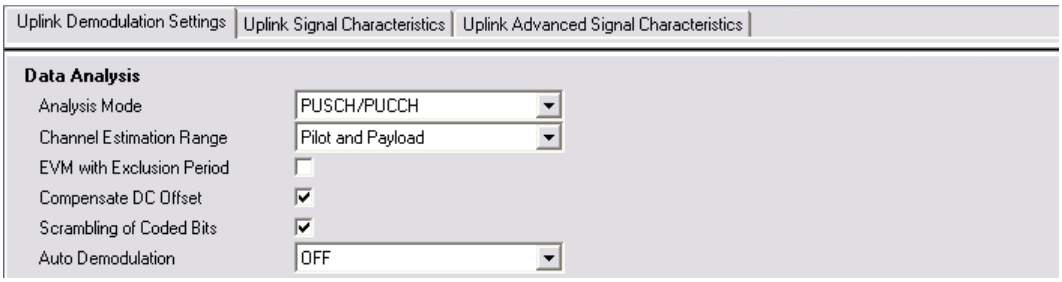
The uplink demodulation settings contain settings that describe the signal processing and the way the signal is measured.

You can find the demodulation settings in the "Demod Settings" dialog box.

5.1.1 Configuring the Data Analysis

The data analysis settings contain setting that control the data analysis.

The data analysis settings are part of the "Downlink Demodulation Settings" tab of the "Demodulation Settings" dialog box.



Analysis Mode
Selects the channel analysis mode.

You can select from "PUSCH/PUCCH" mode and "PRACH" mode.

PUSCH/PUCCH mode analyzes the PUSCH and PUCCH. This is the default.

PRACH mode analyzes the PRACH only.

SCPI command:
`[SENSe][:LTE]:UL:DEMod:MODE` on page 144

Channel Estimation Range
Selects the method for channel estimation.

Choose whether to use only the pilot symbols to perform channel estimation or both pilot and payload carriers.

SCPI command:
`[SENSe][:LTE]:UL:DEMod:CESTimation` on page 144

EVM with Exclusion Period
Turns exclusion periods for EVM measurements as defined in 3GPP TS 36.521 on and off.

The exclusion period affects the PUSCH data EVM of the first and last symbol.

The software automatically determines the length of the exclusion period according to 3GPP TS 36.521-1.

The exclusion period has no effect on the EVM vs Carrier and EVM vs Symbol x Carrier result displays.

SCPI command:
`[SENSe][:LTE]:UL:DEMod:EEPeriod` on page 145

Compensate DC Offset
Activates or deactivates DC offset compensation when calculating measurement results.

According to 3GPP TS 36.101 (Annex F.4), the analyzer removes the I/Q origin from the evaluated signal before it calculates the EVM and in-band emissions.

SCPI command:
`[SENSe][:LTE]:UL:DEMod:CDCoffset` on page 145

Scrambling of Coded Bits
Turns the scrambling of coded bits for the PUSCH on and off.

The scrambling of coded bits affects the bitstream results.

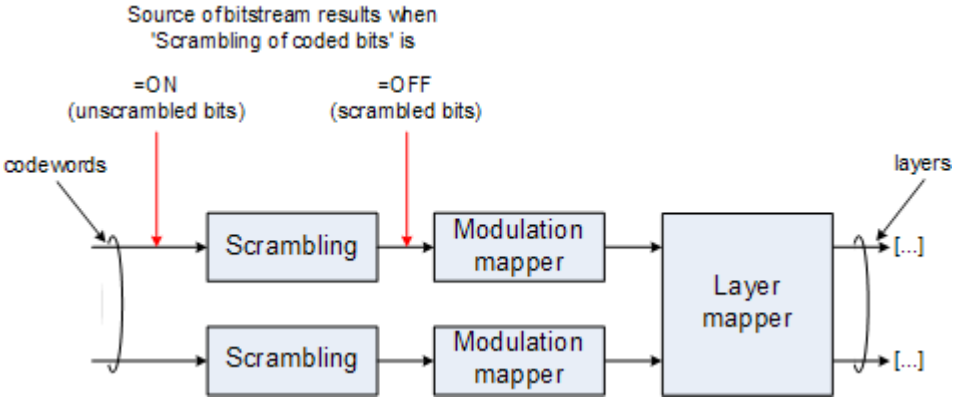


Fig. 5-1: Source for bitstream results if scrambling for coded bits is on and off

SCPI command:
`[SENSe][:LTE]:UL:DEMod:CBSCrambling` on page 145

Auto Demodulation
Turns automatic demodulation on and off.

If active, the analyzer automatically detects the resource allocation of the signal.

Two methods of detection are supported:

- Subframe Configuration
  This method automatically determines the values available in the subframe configuration table: Enable PUCCH / PUSCH, PUSCH Modulation, Number of RB, Offset RB, Resource Allocation Type 1.

The table is populated accordingly.

- Subframe Configuration & DMRS
  This method automatically detects the PUSCH and SRS (i.e. no PUCCH can be detected).
  To determine these characteristics, the software detects the CAZAC base parameters. Thus, the DMRS configuration parameters are not required for the synchronization and therefore are not available using this method.
  Note however that it is not possible to derive the DMRS configuration parameters from the CAZAC base parameters so that the disabled DMRS configuration parameters do not reflect the current parameters used for the synchronization. Also note that it can happen that the software successfully synchronizes on non-3GPP signals without a warning.

Automatic demodulation is not available if the suppressed interference synchronization is active.

SCPI command:
`[SENSe][:LTE]:UL:DEMod:ACON` on page 145

Subframe Configuration Detection
Turns the detection of the subframe configuration on and off.

Upon activation, the software compares the current demodulated LTE frame to the subframe configuration you have set. Only if the signal is consistent with the configuration, the software will further analyze the LTE frame.

If inactive, the software analyzes the signal even if it is not consistent with the current subframe configuration.

Subframe configuration detection is available if "Auto Demodulation" is inactive.

SCPI command:
`[SENSe][:LTE]:UL:FORMat:SCD` on page 145

Suppressed Interference Synchronization
Turns suppressed interference synchronization on and off.

If active, the synchronization on signals containing more than one user equipment (UE) is more robust. Additionally, the EVM is lower in case the UEs have different frequency offsets. Note that Auto Demodulation is not supported in this synchronization mode and the EVM may be higher in case only one UE is present in the signal.

SCPI command:
`[SENSe][:LTE]:UL:DEMod:SISYnc` on page 146

Multicarrier Filter
Turns the suppression of interference of neighboring carriers on and off.

SCPI command:
`[SENSe][:LTE]:UL:DEMod:MCFilter` on page 146

5.1.2 Compensating Signal Errors

The tracking settings contain settings that compensate for various common signal errors that may occur.

The tracking settings are part of the "Downlink Demodulation Settings" tab of the "Demodulation Settings" dialog box.

Phase
Specifies whether or not the measurement results should be compensated for common phase error. When phase compensation is used, the measurement results will be compensated for phase error on a per-symbol basis.

"Off"	Phase tracking is not applied.
"Pilot Only"	Only the reference signal is used for the estimation of the phase error.
"Pilot and Payload"	Both reference signal and payload resource elements are used for the estimation of the phase error.

SCPI command:
`[SENSe][:LTE]:UL:TRACking:PHASe` on page 146

Timing
Specifies whether or not the measurement results should be compensated for timing error. When timing compensation is used, the measurement results will be compensated for timing error on a per-symbol basis.

SCPI command:
`[SENSe][:LTE]:UL:TRACking:TIME` on page 147

5.2 Defining Uplink Signal Characteristics

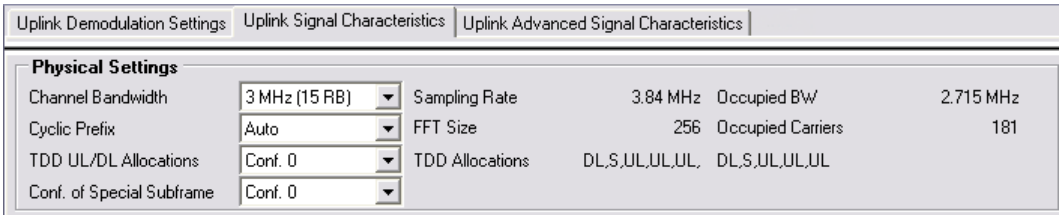
The uplink signal characteristics contain settings to describe the physical attributes and structure of an uplink LTE signal.

You can find the signal characteristics in the "Demod Settings" dialog box.

5.2.1 Defining the Physical Signal Characteristics

The physical signal characteristics contain settings to describe the physical attributes of an uplink LTE signal.

The physical settings are part of the "Uplink Signal Characteristics" tab of the "Demodulation Settings" dialog box.



Channel Bandwidth / Number of Resource Blocks
Specifies the channel bandwidth and the number of resource blocks (RB).

The channel bandwidth and number of resource blocks (RB) are interdependent. If you enter one, the analyzer automatically calculates and adjusts the other.

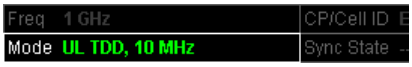
Currently, the LTE standard recommends six bandwidths (see table below).

If you enter a value different to those recommended by the standard, the analyzer labels the parameter as "User", but still does the calculations.

The analyzer also calculates the FFT size, sampling rate, occupied bandwidth and occupied carriers from the channel bandwidth. Those are read only.

Channel Bandwidth [MHz]	1.4	3	5	10	15	20
Number of Resource Blocks	6	15	25	50	75	100
Sample Rate [MHz]	1.92	3.84	7.68	15.36	23.04	30.72
FFT Size	128	256	512	1024	2048	2048

The software shows the currently selected LTE mode (including the bandwidth) in the header table.



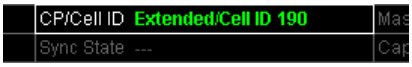
SCPI command:
`CONFigure[:LTE]:UL:BW` on page 147
`CONFigure[:LTE]:UL:NORB` on page 147

Cyclic Prefix
The cyclic prefix serves as a guard interval between OFDM symbols to avoid interferences. The standard specifies two cyclic prefix modes with a different length each.

The cyclic prefix mode defines the number of OFDM symbols in a slot.

- Normal
  A slot contains 7 OFDM symbols.
- Extended
  A slot contains 6 OFDM symbols.
  The extended cyclic prefix is able to cover larger cell sizes with higher delay spread of the radio channel.
- Auto
  The application automatically detects the cyclic prefix mode in use.

The software shows the currently selected cyclic prefix in the header table.



SCPI command:
`CONFigure[:LTE]:UL:CYCPrefix` on page 148

Configuring TDD Frames

TDD frames contain both uplink and downlink information separated in time with every subframe being responsible for either uplink or downlink transmission. The standard specifies several subframe configurations or resource allocations for TDD systems.

TDD UL/DL Allocations

Selects the configuration of the subframes in a radio frame in TDD systems.

The UL/DL configuration (or allocation) defines the way each subframe is used: for uplink, downlink or if it is a special subframe. The standard specifies seven different configurations.

Configuration	Subframe Number and Usage									
	0	1	2	3	4	5	6	7	8	9
0	D	S	U	U	U	D	S	U	U	U
1	D	S	U	U	D	D	S	U	U	D
2	D	S	U	D	D	D	S	U	D	D
3	D	S	U	U	U	D	D	D	D	D
4	D	S	U	U	D	D	D	D	D	D
5	D	S	U	D	D	D	D	D	D	D
6	D	S	U	U	U	D	S	U	U	D

U = uplink
D = downlink
S = special subframe

Conf. of Special Subframe

In combination with the cyclic prefix, the special subframes serve as guard periods for switches from uplink to downlink. They contain three parts or fields.

- DwPTS
  The DwPTS is the downlink part of the special subframe. It is used to transmit downlink data.
- GP
  The guard period makes sure that there are no overlaps of up- and downlink signals during a switch.
- UpPTS
  The UpPTS is the uplink part of the special subframe. It is used to transmit uplink data.

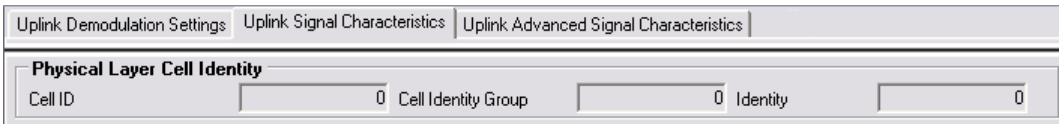
The length of the three fields is variable. This results in several possible configurations of the special subframe. The LTE standard defines 9 different configurations for the special subframe. However, configurations 7 and 8 only work for a normal cyclic prefix. If you select it using an extended cyclic prefix or automatic detection of the cyclic prefix, the application will show an error message.

SCPI command:
`CONFigure[:LTE]:UL:TDD:UDConf` on page 148
Special Subframe
`CONFigure[:LTE]:UL:TDD:SPSC` on page 148

5.2.2 Configuring the Physical Layer Cell Identity

The physical signal characteristics contain settings to describe the physical attributes of an uplink LTE signal.

The physical settings are part of the "Uplink Signal Characteristics" tab of the "Demodulation Settings" dialog box.



Configuring the Physical Layer Cell Identity
The cell ID, cell identity group and physical layer identity are interdependent parameters. In combination they are responsible for synchronization between network and user equipment.

The physical layer cell ID identifies a particular radio cell in the LTE network. The cell identities are divided into 168 unique cell identity groups. Each group consists of 3 physical layer identities. According to

$$N_{ID}^{cell} = 3 \cdot N_{ID}^{(1)} + N_{ID}^{(2)}$$

$N^{(1)}$ = cell identity group, {0...167}
$N^{(2)}$ = physical layer identity, {0...2}

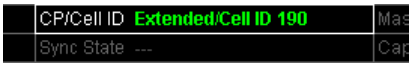
there is a total of 504 different cell IDs.

If you change one of these three parameters, the analyzer automatically updates the other two.

The Cell ID determines

- the reference signal grouping hopping pattern
- the reference signal sequence hopping
- the PUSCH demodulation reference signal pseudo-random sequence
- the cyclic shifts for PUCCH formats 1/1a/1b and sequences for PUCCH formats 2/2a/2b
- the pseudo-random sequence used for scrambling
- the pseudo-random sequence used for type 2 PUSCH frequency hopping

The software shows the currently selected cell ID in the header table.



SCPI command:
Cell ID:
CONFigure[:LTE]:UL:PLC:CID on page 148
Cell Identity Group:
CONFigure[:LTE]:UL:PLC:CIDGroup on page 149
Identity
CONFigure[:LTE]:UL:PLC:PLID on page 149

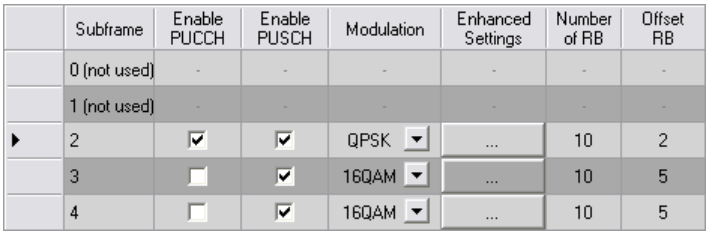
5.2.3 Configuring Subframes

The application allows you to configure individual subframes.

If you turn "Auto Demodulation" on, the appplication automatically determines the subframe configuration. In the default state, automatic configuration is on.

An LTE frame contains 10 subframes. The analyzer shows the contents for each subframe in the configuration table. In the configuration table, each row corresponds to one subframe, or, for clustered subframes, one cluster..

You can also define a frame number offset that the software uses to demodulate the captured frame.



Before you start to work on the contents of each subframe, you should define the number of subframes you want to customize with the "Configurable Subframes" parameter. The application supports the configuration of up to 10 subframes.

Configuring Subframes
According to the number of configurable subframes you have set, the analyzer adjusts the size of the subframe configuration table. Each row in the table corresponds to one allocation if the subframe is a cluster. Else, the row is a subframe.

The configuration table contains the settings to configure the subframes.

- Subframe

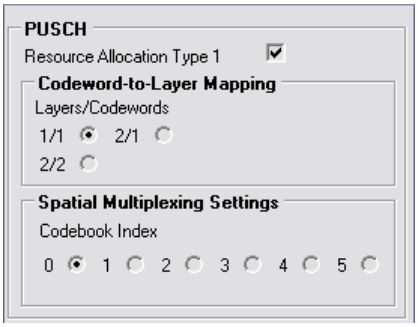
Shows the number of a subframe.
Note that, depending on the configuration, some subframes may not be available for editing. The analyzer labels those downlink subframes "(not used)". The corresponding cells in the table are greyed out.

- Enable PUCCH
  Turns the PUCCH in the corresponding subframe on and off.
- Enable PUSCH
  Turns the PUSCH in the corresponding subframe on and off.
  If you turn on a PUSCH, "Modulation", "Number of RBs" and "Offset RB" become available.
- Modulation
  Selects the modulation scheme for the corresponding PUSCH allocation.
  The modulation scheme is either QPSK, 16QAM or 64QAM.
- Enhanced Settings
  Opens a dialog box to configure enhanced functionality for selected channels in each subframe.
  For more information see "Enhanced Configuration" on page 70.
- Number of RB
  Sets the number of resource blocks the PUSCH allocation covers. The number of resource blocks defines the size or bandwidth of the PUSCH allocation.
- Offset RB
  Sets the resource block at which the PUSCH allocation begins.

SCPI command:
Configurable subframes:
`CONFigure[:LTE]:UL:CSUBframes` on page 150
Frame number offset:
`CONFigure[:LTE]:UL:SFNO` on page 150
Enable PUCCH and PUSCH:
`CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc:CONT` on page 150
Modulation:
`CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc:MODulation` on page 151
Number of RB:
`CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc[:CLUSter<cluster>]:RBCount` on page 150
Offset RB:
`CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc[:CLUSter<cluster>]:RBOFfset` on page 150

Enhanced Configuration
The "Enhanced Settings" contain functionality to define enhanced characteristics for selected channels.

Enhanced PUSCH configuration



Note that you have to select more than one antenna for the PUSCH transmission to access these parameters. For more information see "MIMO Configuration" on page 53.

- Resource Allocation Type 1
  Turns a clustered PUSCH allocation an and off. If on, a second row is added to the corresponding allocation. This second row represents the second cluster.
  You can define the number of resource block and the offset resource block for each cluster. All other parameters (power, modulation etc.) are the same for both clusters.
- Codeword-to-Layer Mapping
  If you are using a clustered PUSCH, you can also define the number of layers for any allocation and the codebook index.
  The number of layers of an allocation in combination with the number of code words determines the layer mapping. The available number of layers depends on the number of transmission antennas. Thus, the maximum number of layers you can select is two.
  The codebook index determines the precoding matrix. The available number of indices depends on the number of transmission antennas in use. The range is from 0 to 5.

Enhanced demodulation reference signal configuration

- n(2)_DMRS
  Defines the part of the demodulation reference signal index that is part of the uplink scheduling assignment. Thus, this part of the index is valid for corresponding UE and subframe only.
  The index applies when multiple shifts within a cell are used. It is used for the calculation of the DMRS sequence.
- Cyclic Shift Field
  If Activate-DMRS-With OCC is on, the "Cyclic Shift Field" becomes available to define the cyclic shift field.
  If the "Cyclic Shift Field" is off, the demodulation reference signal is configured by the n(2)_DMRS parameter.

Enhanced PUCCH configuration

- n_PUCCH

Defines the n_PUCCH parameter for each subframe. Available only if you have selected "Per Subframe" for the N_PUCCH.

SCPI command:
PUSCH settings:
CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc:RATO on page 152
CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc:PRECoding:CLMapping on page 151
CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc:PRECoding:CBINdex on page 151
Demodulation reference signal settings:
CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc:PUSCh:NDMRs on page 152
CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc:PUSCh:CSField on page 152
PUCCH settings:
CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc:PUCCh:NPAR on page 152

5.3 Defining Advanced Signal Characteristics

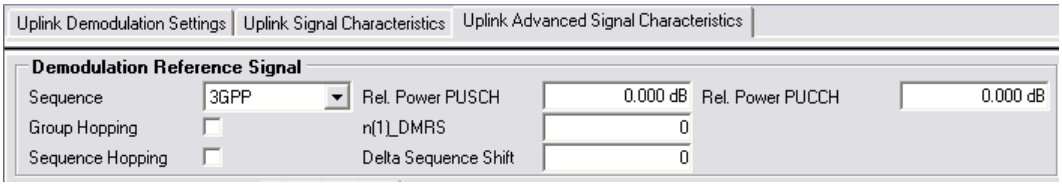
The uplink advanced signal characteristics contain settings that describe the detailed structure of an uplink LTE signal.

You can find the advanced signal characteristics in the "Demod Settings" dialog box.

5.3.1 Configuring the Demodulation Reference Signal

The demodulation reference signal settings contain settings that define the physical attributes and structure of the demodulation reference signal. This reference signal helps to demodulate the PUSCH.

The demodulation reference signal settings are part of the "Uplink Advanced Signal Characteristics" tab of the "Demodulation Settings" dialog box.



Sequence
Selects the definition the demodulation reference signal is based on.

"3GPP" The structure of the DRS is based on the 3GPP standard.
If you are using a DRS based on 3GPP, you have to set all parameters in the "Demodulation Reference Signal" settings group. They have to be the same as those of the signal generator.

"I/Q File" The structure of the DRS is customized.
Move the file that contains the signal definition into the default directory.
For more information see chapter 7.3, "Customizing Reference Symbols", on page 87.

SCPI command:
CONFigure[:LTE]:UL:DRS:SEQuence on page 154

Group Hopping
Indicates whether group hopping for the demodulation reference signal is activated or not.

17 different hopping patterns and 30 different sequence shift patterns are used for group hopping. PUSCH and PUCCH use the same group hopping pattern that is calculated if the group hopping is enabled. The group hopping pattern is generated by a pseudo-random sequence generator.

SCPI command:
CONFigure[:LTE]:UL:DRS:GRPHopping on page 153

Sequence Hopping
Turns sequence hopping for the uplink demodulation reference signal on and off.

Sequence hopping is generated by a pseudo-random sequence generator.

SCPI command:
CONFigure[:LTE]:UL:DRS:SEQHopping on page 154

Relative Power PUSCH
Sets the power offset of the Demodulation Reference Signal (DRS) relative to the power level of the PUSCH allocation of the corresponding subframe. The selected DRS power offset (PDRS_Offset) applies for all subframes. Depending on the allocation of the subframe, the effective power level of the DRS is calculated as following:

$P_{DRS}=P_{UE}+P_{PUSCH}+P_{DRS\_Offset}$

The PUSCH Power level (P_{PUSCH}) can vary per subframe.

SCPI command:
CONFigure[:LTE]:UL:DRS[:PUSCh]:POWer on page 154

Activate-DMRS-With OCC
Turns the configuration of the demodulation reference signal on a subframe basis via the "Cyclic Shift Field" on and off.

If on, the "Cyclic Shift Field" becomes available. Otherwise, the demodulation reference signal is configured by the n(2)_DMRS parameter.

Note that this parameter is automatically turned on if at least one of the physical channels uses more than one antenna.

For more information see "Enhanced Configuration" on page 70 and MIMO Configuration.

SCPI command:
CONFigure[:LTE]:UL:DRS:AOCC on page 153

n(1)_DMRS
Defines the part of the demodulation reference signal index that is broadcasted. It is valid for the whole cell.

The index applies when multiple shifts within a cell are used. It is used for the calculation of the DMRS sequence.

The n_DMRS parameter can be found in 3GPP TS36.211 V8.5.0, 5.5.2.1.1 Reference signal sequence.

SCPI command:
`CONFigure[:LTE]:UL:DRS:NDMRs` on page 154

Delta Sequence Shift
Delta Sequence Shift specifies the parameter Δ_{SS}

This parameter can be found in 3GPP TS 36.211 V8.5.0, 5.5.1.3 Group hopping. A sequence shift function f_ss is defined for the PUCCH. The corresponding function for the PUSCH is derived by applying this Delta Sequence Shift.

SCPI command:
`CONFigure[:LTE]:UL:DRS:DSSHift` on page 153

Relative Power PUCCH
Sets the power offset of the Demodulation Reference Signal (DRS) relative to the power level of the PUCCH allocation of the corresponding subframe. The selected DRS power offset (P_{DRS_Offset}) applies for all subframes. Depending on the allocation of the subframe, the effective power level of the DRS is calculated as following:

$P_{DRS}=P_{UE}+P_{PUCCH}+P_{DRS\_Offset}$ (for PUCCH allocation)

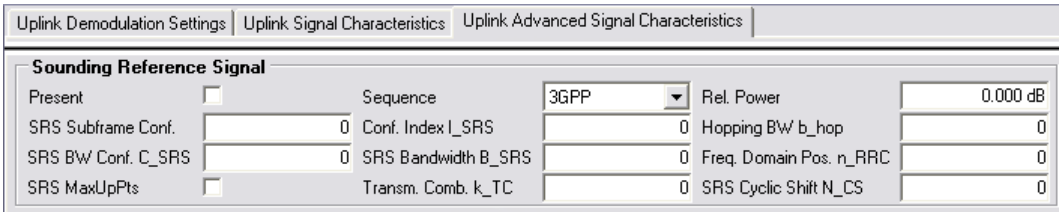
The PUCCH Power level (P_{PUCCH}) can vary per subframe.

SCPI command:
`CONFigure[:LTE]:UL:DRS:PUCCh:POWer` on page 154

5.3.2 Configuring the Sounding Reference Signal

The sounding reference signal settings contain settings that define the physical attributes and structure of the sounding reference signal.

The sounding reference signal settings are part of the "Uplink Advanced Signal Characteristics" tab of the "Demodulation Settings" dialog box.



Present
Indicates whether the sounding reference signal is present or not.

SCPI command:
CONFigure[:LTE]:UL:SRS:STAT on page 155

SRS Subframe Conf.
Sets the cell specific parameter SRS subframe configuration. The UEs will send shortened PUSCH/PUCCH in these cell-specific subframes, regardless whether the UEs are configured to send a SRS in the according subframe or not.

SCPI command:
CONFigure[:LTE]:UL:SRS:SUConfig on page 155

SRS BW Conf. C_SRS
Sets the cell specific parameter SRS Bandwidth Configuration (C_{SRS}).

The SRS Bandwidth Configuration C_{SRS}, the SRS Bandwidth B_{SRS} and the UL Channel Bandwidth determine the length of the sounding reference signal sequence, calculated according to 3GPP TS 36.211.

SCPI command:
CONFigure[:LTE]:UL:SRS:CSRS on page 156

SRS MaxUpPts
Turns the parameter srs_MaxUpPts on and off.

srs_MaxUpPts controls the SRS transmission in the UpPTS field in TDD systems. If on, the SRS is transmitted in a frequency range of the UpPTS field that does not overlap with resources reserved for PRACH preamble 4 transmissions.

To avoid an overlap, the number of SRS resource blocks otherwise determined by C_SRS and B_SRS are reconfigured.

SCPI command:
CONFigure[:LTE]:UL:SRS:MUPT on page 157

Conf. Index I_SRS
Sets the UE specific parameter SRS configuration index I_{SRS}. Depending on the selected Duplexing Mode, this parameter determines the parameters SRS Periodicity T_{SRS} and SRS Subframe Offset T_{offset} as defined in the 3GPP TS 36.213, Table 8.2-1 (FDD) and 8.2-2 (TDD) respectively.

SCPI command:
CONFigure[:LTE]:UL:SRS:ISRS on page 156

SRS Bandwidth B_SRS
Sets the UE specific parameter SRS Bandwidth B_{SRS}, as defined in the 3GPP TS 36.211, chapter 5.5.3.2.

The SRS either spans the entire frequency bandwidth or employs frequency hopping where several narrowband SRS cover the same total bandwidth.

There are up to four SRS bandwidths defined in the standard. The most narrow SRS bandwidth (B_{SRS} = 3) spans four resource blocks and is available for all channel bandwidths; the other three values of the parameter B_{SRS} define more wideband SRS bandwidths, available depending on the channel bandwidth.

The SRS transmission bandwidth is determined additionally by the SRS Bandwidth Configuration C_{SRS}.

SCPI command:
`CONFigure[:LTE]:UL:SRS:BSRS` on page 157

Transm. Comb. k_TC
Sets the UE specific parameter transmission comb k_{TC}, as defined in the 3GPP TS 36.211, chapter 5.5.3.2.

SCPI command:
`CONFigure[:LTE]:UL:SRS:TRComb` on page 157

SRS Rel Power
Defines the power offset of the sounding reference signal.

The power offset is relative to the power of the corresponding UE and applies to all subframes.

The effective power level of the SRS is thus

$P_{SRS} = P_{UE} + P_{SRS\_Offset}$

SCPI command:
`CONFigure[:LTE]:UL:SRS:POWer` on page 155

Hopping BW b_hop
Sets the UE specific parameter frequency hopping bandwidth b_{hop}, as defined in the 3GPP TS 36.211, chapter 5.5.3.2.

SRS frequency hopping is enabled, if $b_{HOP}<B_{SRS}$.

SCPI command:
`CONFigure[:LTE]:UL:SRS:BHOP` on page 156

Freq. Domain Pos. n_RRC
Sets the UE specific parameter Freq. Domain Position n_{RRC} , as defined in the 3GPP TS 36.211, chapter 5.5.3.2.

This parameter determines the starting physical resource block of the SRS transmission.

SCPI command:
`CONFigure[:LTE]:UL:SRS:NRRC` on page 157

SRS Cyclic Shift N_CS
Sets the cyclic shift n_CS used for the generation of the sounding reference signal CAZAC sequence.

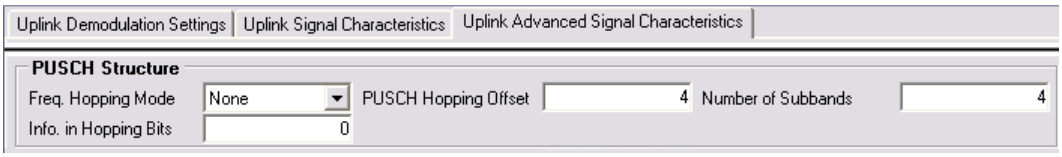
Since the different shifts of the same Zadoff-Chu sequence are orthogonal to each other, applying different SRS cyclic shifts can be used to schedule different users to transmit simultaneously their sounding reference signal.

SCPI command:
CONFigure[:LTE]:UL:SRS:CYCS on page 157

5.3.3 Defining the PUSCH Structure

The PUSCH structure settings contain settings that describe the physical attributes and structure of the PUSCH.

The PUSCH structure setup is part of the "Uplink Advanced Signal Characteristics" tab of the "Demodulation Settings" dialog box.



Frequency Hopping Mode
Frequency Hopping Mode specifies the hopping mode which is applied to the PUSCH. Available choices are NONE, Inter Subframe and Intra Subframe.

SCPI command:
CONFigure[:LTE]:UL:PUSCh:FHMode on page 158

Info. in Hopping Bits
Sets the information in hopping bits according to the PDCCH DCI format 0 hopping bit definition. This information determines whether type 1 or type 2 hopping is used in the subframe, and - in case of type 1 - additionally determines the exact hopping function to use.

Frequency hopping is applied according to 3GPP TS36.213.

SCPI command:
CONFigure[:LTE]:UL:PUSCh:FHOP:IIHB on page 158

PUSCH Hopping Offset
Sets the PUSCH Hopping Offset N_{RB}^{HO}.

The PUSCH Hopping Offset determines the first physical resource block and the maximum number of physical resource blocks available for PUSCH transmission if PUSCH frequency hopping is used.

SCPI command:
CONFigure[:LTE]:UL:PUSCh:FHOFfset on page 158

Number of Subbands
Number of Subbands specifies the number of subbands for PUSCH.

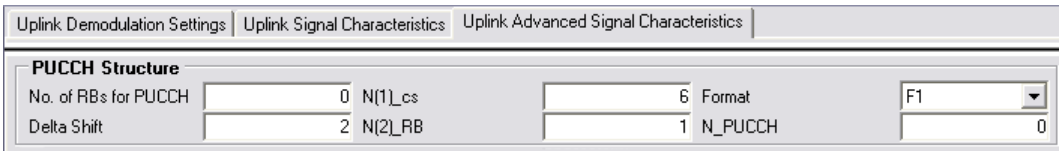
This parameter can be found in 3GPP TS36.211 V8.5.0, 5.5.3.2 Mapping to physical resources.

SCPI command:
CONFigure[:LTE]:UL:PUSCh:NOSM on page 159

5.3.4 Defining the PUCCH Structure

The PUCCH structure settings contain settings that describe the physical attributes and structure of the PUCCH.

The PUSCH structure setup is part of the "Uplink Advanced Signal Characteristics" tab of the "Demodulation Settings" dialog box.



No. of RBs for PUCCH
Number of RBs for PUCCH configures the number of resource blocks for PUCCH.

The resource blocks for PUCCH are always allocated at the edges of the LTE spectrum. If an even number of PUCCH resource blocks is specified, half of the available number of PUCCH resource blocks are allocated on the lower and upper edge of the LTE spectrum (outermost resource blocks). In case an odd number of PUCCH resource blocks is specified, the number of resource blocks on the lower edge is one resource block larger than the number of resource blocks on the upper edge of the LTE spectrum.

SCPI command:
CONFigure[:LTE]:UL:PUCCh:NORB on page 159

Delta Shift
Sets the delta shift parameter, i.e. the cyclic shift difference between two adjacent PUCCH resource indices with the same orthogonal cover sequence (OC).

The delta shift determinates the number of available sequences in a resource block that can be used for PUCCH formats 1/1a/1b.

This parameter can be found in 3GPP TS36.211 V8.5.0, 5.4 Physical uplink control channel.

SCPI command:
CONFigure[:LTE]:UL:PUCCh:DESHift on page 159

N(1)_cs
Sets the number of cyclic shifts used for PUCCH format 1/1a/1b in a resource block used for a combination of the formats 1/1a/1b and 2/2a/2b.

Only one resource block per slot can support a combination of the PUCCH formats 1/1a/1b and 2/2a/2b.

The number of cyclic shifts available for PUCCH format 2/2a/2b N(2)_cs in a block with combination of PUCCH formats is calculated as follow:

N(2)_cs = 12 - N(1)_cs -2

This parameter can be found in 3GPP TS36.211 V8.5.0, 5.4 Physical uplink control channel.

SCPI command:
`CONFigure[:LTE]:UL:PUCCh:N1CS` on page 159

N(2)_RB
Sets bandwidth in terms of resource blocks that are reserved for PUCCH formats 2/2a/2b transmission in each subframe.

Since there can be only one resource block per slot that supports a combination of the PUCCH formats 1/1a/1b and 2/2a/2b, the number of resource block(s) per slot available for PUCCH format 1/1a/1b is determined by N(2)_RB.

This parameter can be found in 3GPP TS36.211 V8.5.0, 5.4 Physical uplink control channel.

SCPI command:
`CONFigure[:LTE]:UL:PUCCh:N2RB` on page 160

Format
Configures the physical uplink control channel format. Formats 2a and 2b are only supported for normal cyclic prefix length.

This parameter can be found in 3GPP TS36.211 V8.5.0, Table 5.4-1 Supported PUCCH formats.

SCPI command:
`CONFigure[:LTE]:UL:PUCCh:FORMat` on page 160

N_PUCCH
Sets the resource index for PUCCH format 1/1a/1b respectively 2/2a/2b.

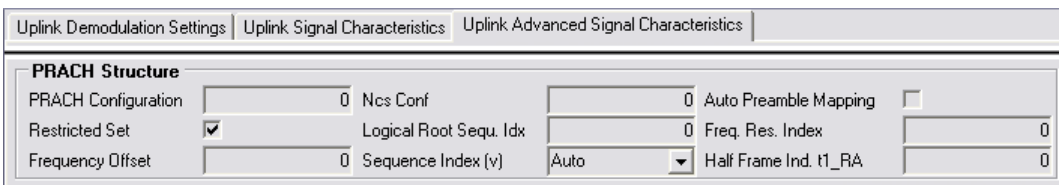
You can also select "Per Subframe" to set the N_PUCCH on a subframe level. For more information see chapter 5.2.3, "Configuring Subframes", on page 69.

SCPI command:
`CONFigure[:LTE]:UL:PUCCh:NPAR` on page 160

5.3.5 Defining the PRACH Structure

The PRACH structure settings contain settings that describe the physical attributes and structure of the PUCCH.

The PRACH structure setup is part of the "Uplink Advanced Signal Characteristics" tab of the "Demodulation Settings" dialog box.



PRACH Configuration
Sets the PRACH configuration index as defined in the 3GPP TS 36.211, i.e. defines the subframes in which random access preamble transmission is allowed.

The preamble format is automatically derived form the PRACH Configuration.

SCPI command:
`CONFigure[:LTE]:UL:PRACh:CONF` on page 161

Restricted Set
Selects whether a restricted preamble set (high speed mode) or the unrestricted preamble set (normal mode) will be used.

SCPI command:
`CONFigure[:LTE]:UL:PRACh:RSET` on page 161

Frequency Offset
For preamble formats 0-3, sets the PRACH Frequency Offset as defined in the 3GPP TS 36.211, i.e. determines the first physical resource block available for PRACH expressed as a physical resource block number.

SCPI command:
`CONFigure[:LTE]:UL:PRACh:FOFFset` on page 161

Ncs Conf
Selects the Ncs configuration, i.e. determines the Ncs value set according to TS 36.211, table 5.7.2.-2 and 5.7.2-3.

SCPI command:
`CONFigure[:LTE]:UL:PRACh:NCSC` on page 162

Logical Root Sequ. Idx
Selects the logical root sequence index.

The logical root sequence index is used to generate preamble sequences. It is provided by higher layers.

SCPI command:
`CONFigure[:LTE]:UL:PRACh:RSEQ` on page 162

Sequence Index (v)
Defines the sequence index (v).

The sequence index controls which of the 64 preambles available in a cell is used.

If you select the "Auto" menu item, the software automatically selects the required sequence index.

SCPI command:
`CONFigure[:LTE]:UL:PRACh:SINDex` on page 162

Freq. Res. Index / Half Frame Ind. t1_RA / Auto Preamble Mapping
The frequency resource index f_{RA} and the half frame indicator $t1_{RA}$ are neccessary to clearly specify the physical resource mapping of the PRACH in case a PRACH configuration index has more than one mapping alternative.

If you turn on the "Auto Preamble Mapping", the software automatically detects f_{RA} and $t1_{RA}$.

The values for both parameters are defined in table '5.7.1-4: Frame structure type 2 random access preamble mapping in time and frequency' (3GPP TS 36.211 v10.2.0).

The frequency resource index and half frame indicator are available in TDD mode.

SCPI command:

`CONFigure[:LTE]:UL:PRACh:APM` on page 161

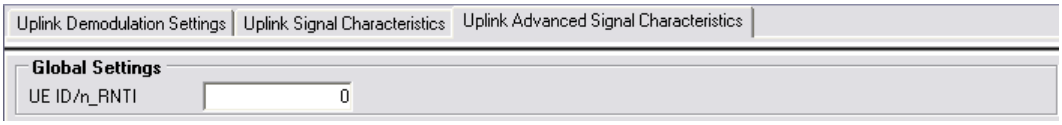
`CONFigure[:LTE]:UL:PRACh:FRINdex` on page 162

`CONFigure[:LTE]:UL:PRACh:HFINdicator` on page 162

5.3.6 Defining Global Signal Characteristics

The global settings contain settings that apply to the complete signal.

The global settings are part of the "Uplink Advanced Signal Characteristics" tab of the "Demodulation Settings" dialog box.



UE ID/n_RNTI
Sets the radio network temporary identifier (RNTI) of the UE.

SCPI command:

`CONFigure[:LTE]:UL:UEID` on page 163

6 Analyzing Measurement Results

The measurement application provides several tools to get more detailed information on the measurement results. The corresponding tools are part of the context menu.

► To access the context menu, click anywhere in the diagram grid with the right mouse button.

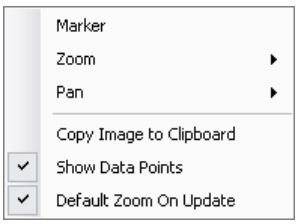


Fig. 6-1: Context menu

Using the marker

You can use a marker to get the coordinates of a single point in the diagram area.

► Open the context menu and select the "Marker" menu item.
When the marker is active, the software puts a check mark (✓) in front of the "Marker" menu item.

When you turn it on, the software positions the marker on the trace maximum. After that you can move it around freely to any point of the trace.

Marker positioning

If you try to put the marker on a coordinate not occupied by the trace, the software puts the marker to the nearest trace maximum (if you place it above the trace) or the nearest trace minimum (if you place it below the trace).

The marker coordinates are displayed in the upper left area of the diagram. The first number shows the vertical position, the second number the horizontal position of the marker including the units.

If you want to reposition the marker on the trace maximum after moving it around, you have to first deactivate the marker and then reactivate it.

To deactivate the marker, open the context menu and reselect the "Marker" menu item.

Note that the marker is not available for all measurements and result displays.

Zooming into the diagram area

If you'd like to see parts of the diagram area in more detail, you can use the zoom.

► Open the context menu and select the "Zoom" menu item.
The software opens a submenu with several zooming options.

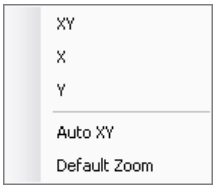


Fig. 6-2: Zooming options

- Zooming vertically and horizontally (XY)
  Click on any point in the diagram area and draw a rectangle with the mouse. The rectangle defines the part of the diagram area you are zooming into.
- Zooming horizontally (X)
  Click on any point in the diagram area and define the horizontal section of the diagram area you want to zoom into.
- Zooming vertically (Y)
  Click on any point in the diagram area and define the vertical section of the diagram area you want to zoom into.
- Zooming automatically (Auto XY)
  Automatically scales the diagram area so that the complete trace data is visible. Double-clicking on the diagram are has the same effect.
- Restoring the default zoom
  The "Default Zoom" entry restores the default zoom.

The software also provides functionality to restore the default zoom each time when the display is updated.

► Open the context menu and select the "Default Zoom on Update" menu item.

Panning the trace

If you'd like to see parts of the measurement results that are outside the diagram area, you can move the contents of the diagram area. To move the contents of the diagram area, click anywhere in the diagram area and drag the contents of the diagram area until the parts you'd like to see are visible.

If there are parts of the trace data that are outside the visible display area, the software shows arrows to the right of the diagram area.

The arrows point in the direction where the invisible trace data is. If parts of the trace data is outside the visible area, the arrows are yellow. If all data in a particular direction is outside the visible area, the arrows turn red.

To make sure that the whole trace is always visible, you can use the automatic zoom ("Auto XY") available in the "Zoom" menu.

► Open the context menu and select the "Pan" menu item.
The software opens a submenu with several panning options.

Fig. 6-3: Panning options

- Panning vertically and horizontally (XY)
  Panning is possible in all directions.
- Panning horizontally (X)
  Panning is possible to the left and right.
- Panning vertically (Y)
  Panning is possible upwards and downwards.

Copying an image to the clipboard

If you want to document measurement results, you can move a copy of them to the clipboard of the operating system.

► Open the context menu and select the "Copy to Clipboard" menu item.

7 Data Management

For easy handling of special measurement configurations, the software allows you to import or export various kinds of data.

7.1 Importing and Exporting I/Q Data

Instead of capturing data directly through hardware components, you can also analyze data that has been recorded previously and saved in a file. On the same lines, it is also possible to save the data that has been captured with an analyzer for further analysis at a later time or for documentation.

You can store and load I/Q data in binary or ASCII format. For a correct display of the power, the I/Q data has to be scaled linearily in Volt (e.g. for the Capture Buffer result display).

Loading I/Q data

Load the contents of an I/Q data file into the software fast and easy by dragging and dropping the file somwhere into the user interface.

The software updates the I/Q data to be measured automatically.

All functionality to import and export data is in the "File" menu (or file manager) that you can access via the FILE key.

ASCII format (.dat format)

In case of the ASCII (.dat) format, the data is expected as I and Q values in alternating rows.

<I value 1>

<Q value 1>

<I value 2>

<Q value 2>

(...)

To be able to analyze previously recorded data, you have to set the input source to "File". When you start a measurement, the software will ask you to select a file that contains the data.

To save data, enter the file manager and save the data with "Save IQ Data".

Binary format (.iqw format)

In case of the binary .iqw format, the data is expected in 32-bit floating point format. This format is also known as Little Endian, LSB Order or Intel format.

Example:

The hexadecimal value 0x1D86E7BB would be decoded to -7.0655481E-3.

For single antenna measurements, the order of the I/Q data is either IQIQIQ... or II...IQQ...Q.

For MIMO measurements, you also have to consider the antenna in the order of the data, with alternating I and Q data for every antenna.

[I/Q][antenna index]([symbol index])

Example:

For a two antenna system, the string of data would like:

I0(0),Q0(0),I1(0),Q1(0),I0(1),Q0(1),I1(1),Q1(1),I0(2),Q0(2),...

Binary format (.iq.tar format)

In case of the .iq.tar format, the I/Q data is stored in a compressed format with the file extension .iq.tar.

An .iq.tar file contains I/Q data in binary format together with meta information that describes the nature and the source of data, e.g. the sample rate. The objective of the .iq.tar file format is to separate I/Q data from the meta information while still having both inside one file. In addition, the file format allows you to preview the I/Q data in a web browser, and allows you to include customized data.

An .iq.tar file must contain the following files.

- I/Q parameter XML file
  Contains meta information about the I/Q data (e.g. sample rate). The filename can be defined freely, but there must be only one single I/Q parameter XML file inside an .iq.tar file.
- I/Q data binary file
  Contains the binary I/Q data of all channels. There must be only one single I/Q data binary file inside an .iq.tar file.

Optionally, an .iq.tar file can contain the following file.

- I/Q preview XSLT file
  Contains a stylesheet to display the I/Q parameter XML file and a preview of the I/Q data in a web browser.

7.2 Managing Frame Data

For fast access to the frame description (or structure of a signal), you can save it and again use it at a later time. To manage frame descriptions, enter the file manager and select "Save Demod Setup" to save the current setup or "Load Demod Setup" to restore a previously created setup.

The frame decription contains the complete modulation structure of the signal.

The frame structure is defined in the xml file format. The file contains all parameters that are part of the demodulation settings. If you want to define more than one allocation, you can do so by adding additional PRB entries (<PRB> element).

Note the following restrictions for the frame description.

- You have to define at least one PRB.
- You can allocate a maximum of one frames.

The example below shows a typical frame description.

```
<FrameDefinition LinkDirection="uplink" TDDULDLAllocationConfiguration="0"
RessourceBlocks="50" CP="auto" PhysLayCellIDGrp="Group 0" PhysLayID="ID 0"
N_RNTI="0" N_f="0" NOfSubbands="4" N_RB_HO="4" NOfRB_PUCCH="4" DeltaShift="2"
N1_cs="6" N2_RB="1" NPUCCH="0" DeltaOffset="0" PUCCHStructureFormat="F1 normal"
N_c_fastforward="1600" HoppingBitInformation="0" FrequencyHopping="None"
DemRefSeq="3GPP" DemPilBoostdBPUSCH="0" DemPilBoostdBPUCCH="0" GroupHop="0"
SequenceHop="0" EnableN_PRS="1" Delta_ss="0" N_DMRS1="0" N_DMRS2="0"
SoundRefSeq="3GPP" SoundRefBoostdB="0" SoundRefPresent="0" SoundRefSymOffs="13"
SoundRefCAZAC_u="2" SoundRefCAZAC_q="0" SoundRefCAZAC_alpha="0"
SoundRefCAZAC_mode="2" SoundRefB="0" SoundRefC="0" SRSSubframeConfiguration="0"
SoundRefN_CS="0" SoundRefK_TC="0" SoundRefN_RRC="0" SoundRefb_hop="0"
SoundRefI_SRS="0" SoundRefk0="24" SoundRefNumSubcarrier="132">
  <Frame>
    <Subframe>
      <PRBs>
        <PRB Start="2" Length="10" Modulation="QPSK" PUCCHOn="0" BoostingdB="0">
        </PRB>
      </PRBs>
    </Subframe>
  </Frame>
  <stControl PhaseTracking="1" TimingTracking="0" CompensateDCOffset="1"
  UseBitStreamScrambling="1" ChannelEstimationRange="2" AutoDemodulation="1">
  </stControl>
</FrameDefinition>
```

7.3 Customizing Reference Symbols

The software supports the use of customized iq sequences for the reference signal. The sequence of symbols for the reference signal is a string of I/Q data.

Customizing iq sequences

For more information on customizing I/Q symbol sequences see chapter 7.1, "Importing and Exporting I/Q Data", on page 85.

The length of the I/Q symbol sequence must be a multiple of 2. If not enough I/Q symbols are available for mapping, the I/Q symbols are repeated.

Importing iq sequences

The I/Q symbol 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 Reference Symbols definition file must be EutraUL_Pilots.iqw

7.4 Importing and Exporting Limits

In addition to the limits defined by the standard, you can create and use customized limits. After you have created the file, you have to name it Default.eutra_limits and copy it into the same folder as the software binary ("%Program folder%\Rohde-Schwarz\EUTRA LTE" by default). The limits are automatically loaded when you start the software.

The limits you can customize work for the Result Summary.

Limits are defined in the xml file format. Any xml elements you do not want to define can be left out, either by making no entry or by deleting the corresponding element.

```
<?xml version="1.0" encoding="utf-8"?>
<Limits>
 <UL>
  <EVM>
   <PUSCHQPSK Mean="0.175"/><!--Unit: linear (1 = 0 dB, 0.1 = -20 dB)-->
   <PUSCH16QAM Mean="0.125"/><!--Unit: linear (1 = 0 dB, 0.1 = -20 dB)-->
   <PUSCH64QAM/><!--Unit: linear (1 = 0 dB, 0.1 = -20 dB)-->
   <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)-->
   <DemodulationReference/><!--Unit: linear (1 = 0 dB, 0.1 = -20 dB)-->
   <SoundingReference/><!--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: [°]-->
  <PowerTotalPhysChan/><!--Unit: [W]-->
  <PowerTotalDemodRef/><!--Unit: [W]-->
  <PowerTotalSoundingRef/><!--Unit: [W]-->
  <PowerTotal/><!--Unit: [W]-->
  <CrestFactor/><!--Unit: linear (1 = 0 dB, 10 = 10 dB)-->
 </UL>
</Limits>
```

8 Measurement Basics

This chapter provides background information on the measurements and result displays available with the LTE Analysis Software.

8.1 Symbols and Variables

The following chapters use various symbols and variables in the equations that the measurements are based on. The table below explains these symbols for a better understanding of the measurement principles.

$a_{l,k}\hat{a}_{l,k}$	data symbol (actual, decided)
$A_{l,k}$	data symbol after DFT-precoding
Δf, $\Delta \hat{f}_{coarse}$	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
$\hat{i}_{coarse}$, $\hat{i}_{fine}$	timing estimate (coarse, fine)
k	subcarrier index
l	SC-FDMA symbol index
N_{DS}	number of SC-FDMA data symbols
N_{FFT}	length of FFT
N_g	number of samples in cyclic prefix (guard interval)
N_s	number of Nyquist samples
N_{TX}	number of allocated subcarriers
$N_{k,l}$	noise sample
n	index of modulated QAM symbol before DFT precoding
Φ_l	common phase error
r_i	received sample in the time domain

$R'_{k,l}$	uncompensated received sample in the frequency domain
$r_{n,l}$	equalized received symbols of measurement path after IDFT
T	duration of the useful part of an SC-FDMA symbol
T_g	duration of the guard interval
T_s	total duration of SC-FDMA symbol

8.2 Overview

The digital signal processing (DSP) involves several stages until the software can present results like the EVM.

The contents of this chapter are structered like the DSP.

8.3 The LTE Uplink Analysis Measurement Application

The block diagram in figure 8-1 shows the general structure of the LTE uplink measurement application from the capture buffer containing the I/Q data up to the actual analysis block.

After synchronization a fully compensated signal is produced in the reference path (purple) which is subsequently passed to the equalizer. An IDFT of the equalized symbols yields observations for the QAM transmit symbols $a_{n,l}$ from which the data estimates $\hat{a}_{n,l}$ are obtained via hard decision. Likewise a user defined compensation as well as equalization is carried out in the measurement path (cyan) and after an IDFT the observations of the QAM transmit symbols are provided. Accordingly, the measurement path might still contain impairments which are compensated in the reference path. The symbols of both signal processing paths form the basis for the analysis.

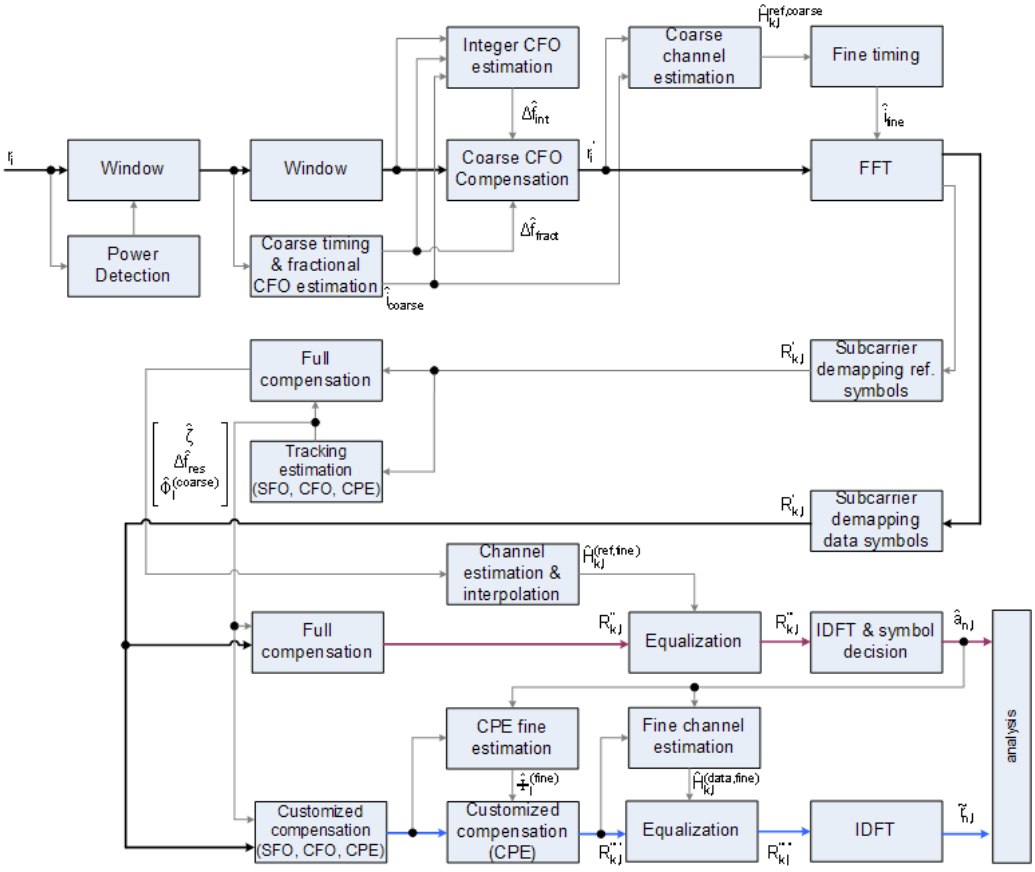


Fig. 8-1: Block diagram for the LTE UL measurement application

8.3.1 Synchronization

In a first step the areas of sufficient power are identified within the captured I/Q data stream which consists of the receive samples r_i. For each area of sufficient power, the analyzer synchronizes on subframes of the uplink generic frame structure [3]. After this coarse timing estimation, the fractional part as well as the integer part of the carrier frequency offset (CFO) are estimated and compensated. In order to obtain an OFDM demodulation via FFT of length N_{FFT} that is not corrupted by ISI, a fine timing is established which refines the coarse timing estimate.

A phase tracking based on the reference SC-FDMA symbols is performed in the frequency domain. The corresponding tracking estimation block provides estimates for

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

According to references [7] and [8], the uncompensated samples $R'_{k,l}$ in the DFT-precoded domain can be stated as

$$R'_{k,l} = A_{k,l} \cdot H_{k,l} \cdot \underbrace{e^{j\Phi_l}}_{CPE} \cdot \underbrace{e^{j2\pi \cdot N_S / N_{FFT} \cdot \zeta \cdot k \cdot l}}_{SFO} \cdot \underbrace{e^{j2\pi \cdot N_S / N_{FFT} \cdot \Delta f_{res} \cdot T \cdot l}}_{res.CFO} + N_{k,l}$$

(8 - 1)

with

- the DFT precoded data symbol $A_{k,l}$ on subcarrier k at SC-FDMA symbol l,
- the channel transfer function $H_{k,l}$,
- the number of Nyquist samples N_S within the total duration T_S,
- the duration of the useful part of the SC-FDMA symbol $T=T_S-T_g$
- the independent and Gaussian distributed noise sample $N_{k,l}$

Within one SC-FDMA 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 $R'_{k,l}$ completely in the reference path and according to the user settings in the measurement path. Thus the signal impairments that are of interest to the user are left uncompensated in the measurement path.

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

8.3.2 Analysis

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

EVM

The most important variable is the error vector magnitude which is defined as

$$EVM_{l,k} = \frac{\left|\tilde{r}_{n,l} - \hat{a}_{n,l}\right|}{\sqrt{E\left\{\left|a_{n,l}\right|^2\right\}}}$$

(8 - 2)

for QAM symbol n before precoding and SC-FDMA symbol l. Since the normalized average power of all possible constellations is 1, the equation can be simplified to

$$EVM_{n,l} = \left|\tilde{r}_{n,l} - \hat{a}_{n,l}\right|$$

(8 - 3)

The average EVM of all data subcarriers is then

$$EVM_{data} = \sqrt{\frac{1}{N_{DS} N_{TX}} \sum_{l=0}^{N_{LB}-1} \sum_{n=0}^{N_{TX}-1} EVM_{n,l}^2}$$

(8 - 4)

for N_{DS} SC-FDMA data symbols and the N_{TX} allocated subcarriers.

I/Q imbalance

The I/Q imbalance contained in the continuous received signal r(t) can be written as

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

(8 - 5)

where s(t) is the transmit signal and I and Q are the weighting factors describing the I/Q imbalance. We define that I:=1 and Q:=1+ΔQ.

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

$$\text{modulator gain balance} = |1 + \Delta Q|$$

(8 - 6)

and the

$$\text{quadrature mismatch} = \arg\{1 + \Delta Q\}$$

(8 - 7)

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

Basic in-band emissions measurement

The in-band emissions are a measure of the interference falling into the non-allocated resources blocks.

The relative in-band emissions are given by

$$Emissions_{relative}(\Delta_{RB}) = \frac{Emissions_{absolute}(\Delta_{RB})}{\frac{1}{|T_S| \cdot N_{RB}} \sum_{t \in T_S} \sum_{c}^{c+12 \cdot N_{RB}-1} |Y(t,f)|^2}$$

(8 - 8)

where T_S is a set $|T_S|$ of SC-FDMA symbols with the considered modulation scheme being active within the measurement period, Δ_{RB} is the starting frequency offset between the allocated RB and the measured non-allocated RB (e.g. Δ_{RB}=1 or Δ_{RB}=-1 for the first adjacent RB), c is the lower edge of the allocated BW, and Y(t,f) is the frequency domain signal evaluated for in-band emissions. N_{RB} is the number of allocated RBs .

The basic in-band emissions measurement interval is defined over one slot in the time domain.

Other measurement variables

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

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

8.4 MIMO Measurement Guide

Measurements on LTE MIMO signals become available with option R&S FS(x)-K103(PC). Performing measurements on MIMO signals requires two or four analyzers - depending on the number of antennas in the MIMO system.

True MIMO measurements are useful to verifiy MIMO precoding implementations for setups where it is not possible to decode the transmit data using only one antenna (e.g. applying spatial multiplexing MIMO precoding with more than 1 layer) and to measure the hardware performance of the MIMO transmitter hardware in a true MIMO measurement setup.

8.4.1 Setting Up MIMO Measurements

One analyzer is defined as the master analyzer. The master analyzer is the reference oscillator source for all slave analyzers. The REF IN of all slave analyzers must therefore be connected to the REF OUT of the master analyzer and all slave analyzers must be set to external reference (if 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).

To ensure all analyzers capture the data at the same point in time, a trigger signal has to be used. The device under test (DUT) or R&S SMU must therefore provide a trigger signal. This trigger signal has to be connected to all analyzers (if two R&S SMUs are used, the second R&S SMU must be triggered by the first R&S SMU, too).

The figure 8-2 shows a MIMO hardware setup with 2 (or optional 4) analyzers and 1 (or optional 2) 2-channel R&S SMUs.

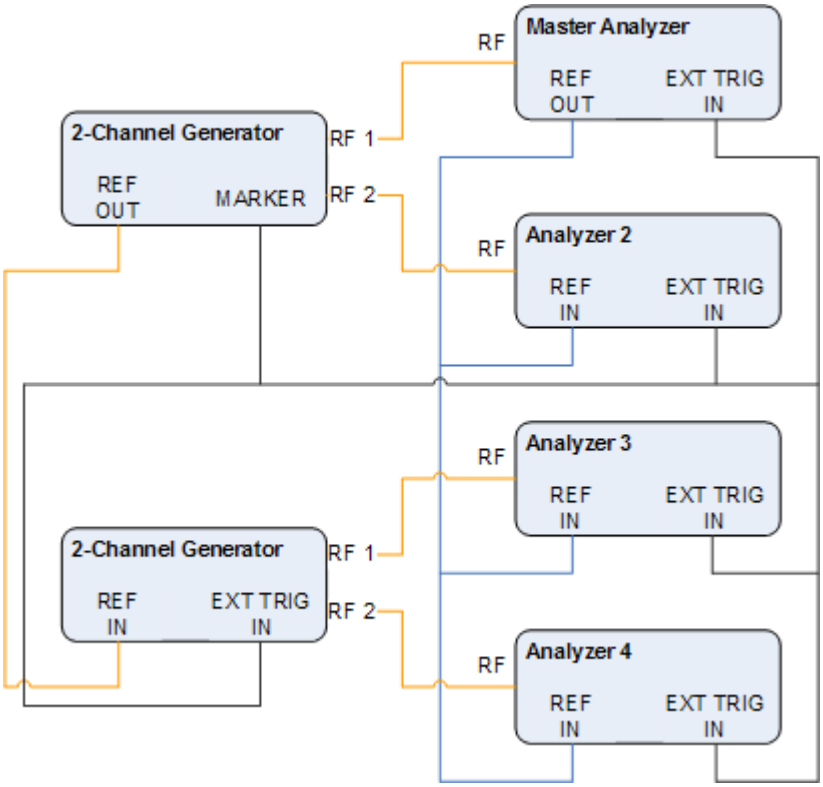


Fig. 8-2: MIMO Hardware Setup

8.4.1.1 Performing MIMO Measurements

The following measurement setups are possible without using special additional hardware.

Delayed trigger signal setup

Generally it is required to start the capturing of all antennas at the same point of time. The analyzers are connected to the application (R&S FSx-K10x) via GPIB or LAN connections which have a certain network delay. Since the network delay and tasks like auto-leveling require some time, a certain delay is introduced between the start of the measurement and the point in time when the trigger inputs of all analyzers are armed. To ensure that no trigger event occurs in this time frame, the user has to introduce a delay between starting the measurement (e.g. by pressing the „RUN SGL" button or initiating the measurement via remote control) and sending the trigger signal.

The expected time to arm the trigger of one analyzer depends on the GPIB/network conditions and the input settings. To estimate the delay, initiate a single run measurement using only one analyzer and measure the time until the „DSP" indicator flashes (note that this estimation also includes the time to transfer the I/Q samples from the instrument to the LTE software):

A typical delay to arm the trigger is 2 seconds per instrument.

The minimum delay of the trigger signal must now be greater than the measured time multiplied with the number of measured antennas (number of used analyzers) since the spectrum analyzers are initialized sequentially.

The usage of an LTE frame trigger is not possible for this measurement setup.

Frame trigger signal setup using identical LTE frames

In the special case that identical LTE frames are transmitted, i.e., all transmitted LTE frames use the same frame configuration and transmit exactly the same data, a special measurement setup is possible. In this case it is possible to use a frame trigger to start the measurement. The different analyzers capture data from different LTE frames but with equal content.

The problem with this measurement setup is that the phase variations of the reference oscillators of the different transmitted signals are not the same since the data are not captured at the same point in time.

As a result we get a phase error which degrades the EVM (see the figures below).

This measurement setup is therefore not recommended for measuring the hardware performance. One application to this measurement setup is, e.g., to check the MIMO precoding implementation.

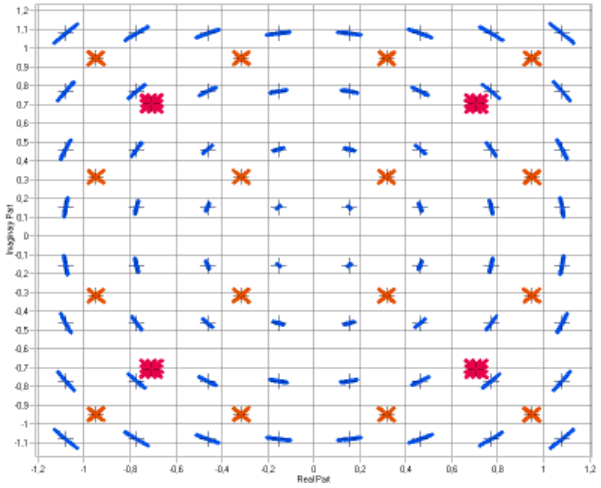


Fig. 8-3: Constellation diagram

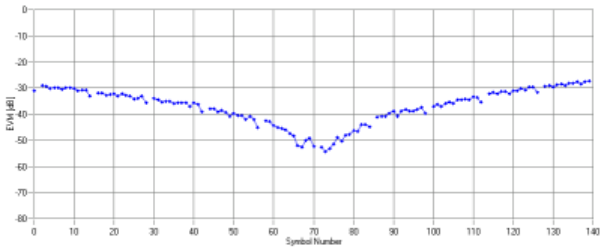


Fig. 8-4: EVM vs OFDM symbol number

8.4.1.2 Performing MIMO Measurements with a Trigger Unit

In MIMO test scenarios, you get the best results when all analyzers in the test setup simultaneously start to record the I/Q data. The trigger unit R&S FS-Z11 is a tool that makes sure that the measurement starts on all analyzers (master and slaves) at the same time.

Connecting the trigger unit to the analyzers

► Connect the NOISE SOURCE output of the master analyzer to the NOISE SOURCE CONTROL input of the trigger unit.

► Connect the EXT TRIG inputs of all analyzers (master **and** slaves) to the TRIG OUT 1 to 4 (or 1 and 2 in case of measurements on two antennas) of the trigger unit. The order is irrelevant, i.e. it would be no problem if you connect the master analyzer to the TRIG OUT 2 of the trigger unit.

WIth this setup, all analyzers (including the master analyzer) are triggered by the trigger unit.

The trigger unit also has a TRIG INPUT connector that you can connect an external trigger to. If you are using an external trigger, the external trigger supplies the trigger event. If not, the analyzer noise source control supplies the trigger event. Note that if you do not use an external trigger, the TRIG INPUT must remain open.

To use the R&S FS-Z11 as the trigger source, you have to select it as the trigger source in the "General Settings" dialog box of the LTE measurement application. For more information see "Configuring the Trigger" on page 55.

9 Remote Commands

When working via remote control, note that you have to establish a connection between your remote scripting tool and the software. Because the software runs directly on the PC and not an R&S instrument, you have to connect the remote scripting tool to your PC and not an instrument.

1. Start the software.
2. If you want to capture I/Q data from an analyzer, connect the software to that analyzer.
3. Start the remote scripting tool (e.g. Matlab) on the PC.
4. Connect the remote scripting tool to the local host (e.g. `TCPIC:LocalHost`)

9.1 Overview of Remote Command Suffixes

This chapter provides an overview of all suffixes used for remote commands in the LTE application.

Suffix	Description
<allocation>	Selects an allocation.
<analyzer>	Selects an analyzer for MIMO measurements.
<antenna>	Selects an antenna for MIMO measurements.
<cluster>	Selects a cluster (uplink only).
<cwnum>	Selects a codeword.
<k>	Selects a limit line. Irrelevant for the LTE application.
<m>	Selects a marker. Irrelevant for the LTE application.
<n>	Selects a measurement window.
<subframe>	Selects a subframe.
<t>	Selects a trace. Irrelevant for the LTE application.

9.2 Introduction

Commands are program messages that a controller (e.g. a PC) sends to the instrument or software. They operate its functions ('setting commands') and request information ('query commands'). Some commands only work either way (setting only, query only), others work both ways (setting and query).

The syntax of a SCPI command consists of a so-called header and, in most cases, one or more parameters. A query command must append a question mark after the last header element, even if it contains a parameter.

A header contains one or more keywords, separated by a colon. Header and parameters are separated by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank). If there is more than one parameter for a command, these are separated by a comma from one another.

This chapter summarizes the most important characteristics that you need to know when working with SCPI commands. For a more complete description, refer to the manual of one of the R&S analyzers.

Remote command examples

Note that some remote command examples mentioned in this introductory chapter may not be supported by this application.

9.2.1 Long and Short Form

The keywords have a long and a short form. You can use either the long or the short form, but no other abbreviations of the keywords.

The short form is emphasized in upper case letter. Note however, that this emphasis only serves the purpose to distinguish the short from the long form in the manual. For the instrument, the case does not matter.

Example:

`SENSe:FREQuency:CENTer` is the same as `SENS:FREQ:CENT`.

9.2.2 Numeric Suffixes

Some keywords have a numeric suffix if the command can be applied to multiple instances of an object. In that case, the suffix selects a particular instance (e.g. a measurement window).

Numeric suffixes are indicated by angular brackets (<n>) next to the keyword.

If you don't use a suffix for keywords that support one, it is treated as a 1.

Example:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe` enables the zoom in a particular measurement window, selected by the suffix at `WINDow`.

`DISPlay:WINDow4:ZOOM:STATe ON` refers to window 4.

9.2.3 Optional Keywords

Some keywords are optional and are only part of the syntax because of SCPI compliance. You can include them in the header or not.

Note that if an optional keyword has a numeric suffix and you need to use the suffix, you have to include the optional keyword. Otherwise, the suffix is recognized as a 1.

Optional keywords are emphasized with square brackets.

Example:

Without a numeric suffix in the optional keyword:

`[SENSe:]FREQuency:CENTer` is the same as `FREQuency:CENTer`

With a numeric suffix in the optional keyword:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe`

`DISPlay:ZOOM:STATe ON` enables the zoom in window 1 (no suffix).

`DISPlay:WINDow4:ZOOM:STATe ON` enables the zoom in window 4.

9.2.4 | (Vertical Stroke)

A vertical stroke indicates alternatives for a specific keyword. You can use both keywords to the same effect.

Example:

`[SENSe:]BANDwidth|BWIDth[:RESolution]`

In the short form without optional keywords, `BAND 1MHZ` would have the same effect as `BWID 1MHZ`.

9.2.5 SCPI Parameters

Many commands feature one or more parameters.

If a command supports more than one parameter, these are separated by a comma.

Example:

```
LAYout:ADD:WINDow Spectrum,LEFT,MTABle
```

Parameters may have different forms of values.

9.2.5.1 Numeric Values

Numeric values can be entered in any form, i.e. with sign, decimal point or exponent. In case of physical quantities, you can also add the unit. If the unit is missing, the command uses the basic unit.

Example:

with unit: `SENSe:FREQuency:CENTer 1GHZ`

without unit: `SENSe:FREQuency:CENTer 1E9` would also set a frequency of 1 GHz.

Values exceeding the resolution of the instrument are rounded up or down.

If the number you have entered is not supported (e.g. in case of discrete steps), the command returns an error.

Querying numeric values

When you query numeric values, the system returns a number. In case of physical quantities, it applies the basic unit (e.g. Hz in case of frequencies). The number of digits after the decimal point depends on the type of numeric value.

Example:

Setting: `SENSe:FREQuency:CENTer 1GHZ`

Query: `SENSe:FREQuency:CENTer?` would return `1E9`

In some cases, numeric values may be returned as text.

- INF/NINF
  Infinity or negative infinity. Represents the numeric values 9.9E37 or -9.9E37.
- NAN
  Not a number. Represents the numeric value 9.91E37. NAN is returned in case of errors.

9.2.5.2 Boolean

Boolean parameters represent two states. The "ON" state (logically true) is represented by "ON" or a numeric value 1. The "OFF" state (logically untrue) is represented by "OFF" or the numeric value 0.

Querying boolean parameters

When you query boolean parameters, the system returns either the value 1 ("ON") or the value 0 ("OFF").

Example:

Setting: `DISPlay:WINDow:ZOOM:STATe ON`

Query: `DISPlay:WINDow:ZOOM:STATe?` would return `1`

9.2.5.3 Text

Text parameters follow the syntactic rules of keywords. You can enter text using a short or a long form. For more information see chapter 9.2.1, "Long and Short Form", on page 99.

Querying text parameters

When you query text parameters, the system returns its short form.

Example:

Setting: `SENSe:BANDwidth:RESolution:TYPE NORMal`

Query: `SENSe:BANDwidth:RESolution:TYPE?` would return `NORM`

9.2.5.4 Character Strings

Strings are either text or number. They have to be in straight quotation marks. You can use a single quotation mark - ' - or a double quotation mark - ".

Example:

```
INSTRument:DELete 'Spectrum'
```

9.2.5.5 Block Data

Block data is a format which is suitable for the transmission of large amounts of data.

The ASCII character # introduces the data block. The next number indicates how many of the following digits describe the length of the data block. In the example the 4 following digits indicate the length to be 5168 bytes. The data bytes follow. During the transmission of these data bytes all end or other control signs are ignored until all bytes are transmitted. #0 specifies a data block of indefinite length. The use of the indefinite format requires a NL^END message to terminate the data block. This format is useful when the length of the transmission is not known or if speed or other considerations prevent segmentation of the data into blocks of definite length.

9.3 Remote Commands to Select a Result Display

CALCulate<n>:FEED <DispType>

This command selects the measurement and result display.

Parameters:

<DispType> String containing the short form of the result display.

'EVM:EVCA' (EVM vs carrier result display)

'EVM:EVSY' (EVM vs symbol result display)

'EVM:FEVS' (frequency error vs symbol result display)

'EVM:EVSU' (EVM vs subframe result display)

'PVT:CBUF' (capture buffer result display)

'SPEC:SEM' (spectrum emission mask)

'SPEC:ACP' (ACLR)

'SPEC:PSPE' (power spectrum result display)

'SPEC:FLAT' (spectrum flatness result display)

'SPEC:GDEL' (group delay result display)

'SPEC:FDIF' (flatness difference result display)

SPEC:IE (inband emission result display: uplink only)

'CONS:CONS' (constellation diagram)

CONS:DFTC (DFT precoded constellation diagram: uplink only)

'STAT:BSTR' (bitstream)

'STAT:ASUM' (allocation summary)

'STAT:CCDF' (CCDF)

Example:

```
CALC2:FEED 'PVT:CBUF'
```

Select Capture Buffer to be displayed on screen B.

DISPlay[:WINDow<n>]:TABLe <State>

This command turns the result summary on and off.

Parameters:

<State>

ON

Turns the result summary on and removes all graphical results from the screen.

OFF

Turns the result summary off and restores the graphical results that were previously set.

Example:

```
DISP:TABL OFF
```

Turns the result summary off.

9.4 Remote Commands to Perform Measurements

INITiate[:IMMediate]

This command initiates a new measurement sequence.

With a frame count > 0, this means a restart of the corresponding number of measurements.

In single sweep mode, you can synchronize to the end of the measurement with `*OPC`. In continuous sweep mode, synchronization to the end of the sweep is not possible.

Example: `INIT`
Initiates a new measurement.

Usage: Event

INITiate:REFResh

This command updates the current I/Q measurement results to reflect the current measurement settings.

No new I/Q data is captured. Thus, measurement settings apply to the I/Q data currently in the capture buffer.

The command applies exclusively to I/Q measurements. It requires I/Q data.

Example: `INIT:REFR`
The application updates the IQ results

Usage: Event

[SENSe]:SYNC[:STATe]?

This command queries the current synchronization state.

Return values:
<State> The string contains the following information.
A zero represents a failure and a one represents a successful synchronization.

Example: `SYNC:STAT?`
Would return, e.g. '1' for successful synchronization.

Usage: Query only

9.5 Remote Commands to Read Numeric Results

FETCh:SUMMary:CRESt[:AVERage]?

This command queries the average crest factor as shown in the result summary.

Return values:

<CrestFactor> <numeric value>
Crest Factor in dB.

Example: `FETC:SUMM:CRES?`
Returns the current crest factor in dB.

Usage: Query only

FETCh:CYCPrefix?

This command queries the cyclic prefix type that has been detected.

Return values:

<PrefixType> The command returns -1 if no valid result has been detected yet.

NORM
Normal cyclic prefix length detected

EXT
Extended cyclic prefix length detected

Example: `FETC:CYCP?`
Returns the current cyclic prefix length type.

Usage: Query only

FETCh:SUMMary:EVM[:ALL]:MAXimum?
FETCh:SUMMary:EVM[:ALL]:MINimum?
FETCh:SUMMary:EVM[:ALL][:AVERage]?

This command queries the EVM of all resource elements.

Return values:

<EVM> <numeric value>

Minimum, maximum or average EVM, depending on the last command syntax element.
The unit is % or dB, depending on your selection.

Example: `FETC:SUMM:EVM?`
Returns the mean value.

Usage: Query only

FETCh:SUMMary:EVM:PCHannel:MAXimum?
FETCh:SUMMary:EVM:PCHannel:MINimum?
FETCh:SUMMary:EVM:PCHannel[:AVERage]?

This command queries the EVM of all physical channel resource elements.

Return values:

<EVM> <numeric value>

Minimum, maximum or average EVM, depending on the last command syntax element.
The unit is % or dB, depending on your selection.

Example: `FETC:SUMM:EVM:PCH?`
Returns the mean value.

Usage: Query only

FETCh:SUMMary:EVM:PSIGnal:MAXimum?
FETCh:SUMMary:EVM:PSIGnal:MINimum?
FETCh:SUMMary:EVM:PSIGnal[:AVERage]?

This command queries the EVM of all physical signal resource elements.

Return values:

<EVM> <numeric value>

Minimum, maximum or average EVM, depending on the last command syntax element.
The unit is % or dB, depending on your selection.

Example: `FETC:SUMM:EVM:PSIG?`
Returns the mean value.

Usage: Query only

FETCh:SUMMary:EVM:SDQP[:AVERage]?

This command queries the EVM of all DMRS resource elements with QPSK modulation of the PUSCH.

Return values:

<EVM> <numeric value>

EVM in % or dB, depending on the unit you have set.

Example: `FETC:SUMM:EVM:SDQP?`
Returns the EVM of all DMRS resource elements with QPSK modulation.

Usage: Query only

FETCh:SUMMary:EVM:SDST[:AVERage]?

This command queries the EVM of all DMRS resource elements with 16QAM modulation of the PUSCH.

Return values:

<EVM> <numeric value>

EVM in % or dB, depending on the unit you have set.

Example: `FETC:SUMM:EVM:SDST?`
Returns the EVM of all DMRS resource elements with 16QAM modulation.

Usage: Query only

FETCh:SUMMary:EVM:UCCD[:AVERage]?

This command queries the EVM of all DMRS resource elements of the PUCCH as shown in the result summary.

Return values:

<EVM> EVM in % or dB, depending on the unit you have set.

Example: `FETC:SUMM:EVM:UCCD?`
Returns the average EVM of all DMRS resource elements.

Usage: Query only

FETCh:SUMMary:EVM:UCCH[:AVERage]?

This command queries the EVM of all resource elements of the PUCCH as shown in the result summary.

Return values:

<EVM> EVM in % or dB, depending on the unit you have set.

Example: `FETC:SUMM:EVM:UCCH?`
Returns the average EVM of all resource elements.

Usage: Query only

FETCh:SUMMary:EVM:UPRA[:AVERage]?

This command queries the EVM of all resource elements of the PRACH as shown in the result summary.

Return values:

<EVM> EVM in % or dB, depending on the unit you have set.

Example: `FETC:SUMM:EVM:UPRA?`
Returns the average EVM of all resource elements.

Usage: Query only

FETCh:SUMMary:EVM:USQP[:AVERage]?

This query returns the EVM for all QPSK-modulated resource elements of the PUSCH.

Return values:

<EVM> <numeric value>
EVM in % or dB, depending on the unit you have set.

Example: `FETC:SUMM:EVM:USQP?`
Queries the PUSCH QPSK EVM.

Usage: Query only

FETCh:SUMMary:EVM:USST[:AVERage]?

This query returns the the EVM for all 16QAM-modulated resource elements of the PUSCH.

Return values:

<EVM> EVM in % or dB, depending on the unit you have set.

Example: `FETC:SUMM:EVM:USST?`
Queries the PUSCH 16QAM EVM.

Usage: Query only

FETCh:SUMMary:FERRor:MAXimum?
FETCh:SUMMary:FERRor:MINimum?
FETCh:SUMMary:FERRor[:AVERage]?

This command queries the frequency error.

Return values:

<FreqError> <numeric value>

Minimum, maximum or average frequency error, depending on the last command syntax element.

Default unit: Hz

Example: `FETC:SUMM:FERR?`
Returns the average frequency error in Hz.

Usage: Query only

FETCh:SUMMary:GIMBalance:MAXimum?
FETCh:SUMMary:GIMBalance:MINimum?
FETCh:SUMMary:GIMBalance[:AVERage]?

This command queries the I/Q gain imbalance.

Return values:

<GainImbalance> <numeric value>

Minimum, maximum or average I/Q imbalance, depending on the last command syntax element.

Default unit: dB

Example: `FETC:SUMM:GIMB?`
Returns the current gain imbalance in dB.

Usage: Query only

FETCh:SUMMary:IQOFfset:MAXimum?
FETCh:SUMMary:IQOFfset:MINimum?
FETCh:SUMMary:IQOFfset[:AVERage]?

This command queries the I/Q offset.

Return values:

<IQOffset> <numeric value>

Minimum, maximum or average I/Q offset, depending on the last command syntax element.

Default unit: dB

Example: `FETC:SUMM:IQOF?`
Returns the current IQ-offset in dB

Usage: Query only

FETCh:SUMMary:POWer:MAXimum?
FETCh:SUMMary:POWer:MINimum?
FETCh:SUMMary:POWer[:AVERage]?

This command queries the total power.

Return values:

<Power> <numeric value>

Minimum, maximum or average power, depending on the last command syntax element.

Default unit: dBm

Example: `FETC:SUMM:POW?`
Returns the total power in dBm

Usage: Query only

FETCh:SUMMary:QUADerror:MAXimum?
FETCh:SUMMary:QUADerror:MINimum?
FETCh:SUMMary:QUADerror[:AVERage]?

This command queries the quadrature error.

Return values:

<QuadError> <numeric value>

Minimum, maximum or average quadrature error, depending on the last command syntax element.

Default unit: deg

Example: `FETC:SUMM:QUAD?`
Returns the current mean quadrature error in degrees.

Usage: Query only

FETCh:SUMMary:SERRor:MAXimum?
FETCh:SUMMary:SERRor:MINimum?
FETCh:SUMMary:SERRor[:AVERage]?

This command queries the sampling error.

Return values:

<SamplingError> <numeric value>

Minimum, maximum or average sampling error, depending on the last command syntax element.

Default unit: ppm

Example: `FETC:SUMM:SERR?`
Returns the current mean sampling error in ppm.

Usage: Query only

FETCh:SUMMary:TFRame?

This command queries the trigger to frame result for downlink signals and the trigger to subframe result for uplink signals.

Return values:

<TrigToFrame> <numeric value>
Default unit: s

Example: `FETC:SUMM:TFR?`
Returns the trigger to frame value.

Usage: Query only

9.6 Remote Commands to Read Trace Data

9.6.1 Using the TRACe[:DATA] Command

This chapter contains information on the TRACe:DATA command and a detailed description of the characteristics of that command.

The TRACe:DATA command queries the trace data or results of the currently active measurement or result display. The type, number and structure of the return values are specific for each result display. In case of results that have any kind of unit, the command returns the results in the unit you have currently set for that result display.

Note also that return values for results that are available for both downlink and uplink may be different.

For several result displays, the command also supports various SCPI parameters in combination with the query. If available, each SCPI parameter returns a different aspect of the results. If SCPI parameters are supported, you have to quote one in the query.

Example:

```
TRAC:DATA? TRACE1
```

The format of the return values is either in ASCII or binary characters and depends on the format you have set with `FORMat[:DATA]`.

Following this detailed description, you will find a short summary of the most important functions of the command (`TRACe[:DATA]?`).

9.6.1.1 Adjacent Channel Leakage Ratio

For the ACLR result display, the number and type of returns values depend on the parameter.

- TRACE1
  Returns one value for each trace point.
- LIST
  Returns the contents of the ACLR table.

9.6.1.2 Allocation Summary

For the Allocation Summary, the command returns seven values for each line of the table.

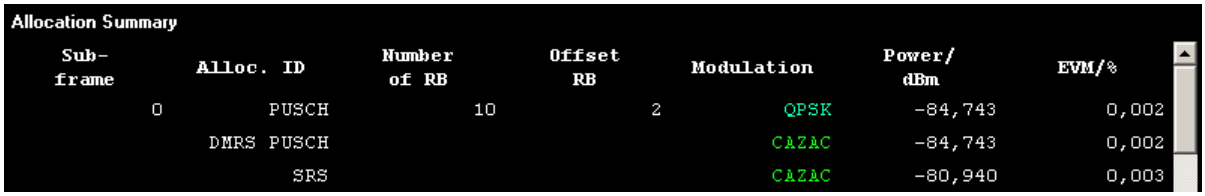
```
<subframe>, <allocation ID>, <number of RB>, <offset RB>,
<modulation>, <absolute power>, <EVM>, ...
```

The unit for `<absolute power>` is always dBm. The unit for `<EVM>` depends on `UNIT:EVM`. All other values have no unit.

The `<allocation ID>` and `<modulation>` are encoded. For the code assignment see chapter 9.6.1.19, "Return Value Codes", on page 119.

Note that the data format of the return values is always ASCII.

Example:


Allocation Summary

Sub-frame	Alloc. ID	Number of RB	Offset RB	Modulation	Power/ dBm	EVM/%
0	PUSCH	10	2	QPSK	-84,743	0,002
	DMRS PUSCH			CAZAC	-84,743	0,002
	SRS			CAZAC	-80,940	0,003

`TRAC:DATA? TRACE1` would return:

```
0, -40, 10, 2, 2, -84.7431947342849, 2.68723483754626E-06,
0, -41, 0, 0, 6, -84.7431432845264, 2.37549449584568E-06,
0, -42, 0, 0, 6, -80.9404231343884, 3.97834623871343E-06,
...
```

9.6.1.3 Bit Stream

For the Bit Stream result display, the command returns five values and the bitstream for each line of the table.

`<subframe>, <allocation ID>, <codeword>, <modulation>, <# of symbols/bits>, <hexadecimal/binary numbers>,...`

All values have no unit. The format of the bitstream depends on Bit Stream Format.

The `<allocation ID>`, `<codeword>` and `<modulation>` are encoded. For the code assignment see chapter 9.6.1.19, "Return Value Codes", on page 119.

For symbols or bits that are not transmitted, the command returns

- "FF" if the bit stream format is "Symbols"
- "9" if the bit stream format is "Bits".

For symbols or bits that could not be decoded because the number of layer exceeds the number of receive antennas, the command returns

- "FE" if the bit stream format is "Symbols"
- "8" if the bit stream format is "Bits".

Note that the data format of the return values is always ASCII.

Example:

Bit Stream

Sub-frame	Allocation ID	Code-word	Modulation	Symbol Index	Bit Stream
0	PUSCH	1/1	QPSK	0	03 01 02 03 03 00 00 00 01 02 02 01 02 01 00 00
0	PUSCH	1/1	QPSK	16	00 03 03 03 02 02 01 00 03 01 02 03 03 03 03 01
0	PUSCH	1/1	QPSK	32	03 03 00 00 03 01 02 00 01 00 02 00 02 00 00 03

`TRAC:DATA? TRACE1` would return:

```
0, -40, 0, 2, 0, 03, 01, 02, 03, 03, 00, 00, 00, 01, 02, 02, ...
<continues like this until the next data block starts or the end of data is reached>
0, -40, 0, 2, 32, 03, 03, 00, 00, 03, 01, 02, 00, 01, 00, ...
```

9.6.1.4 Capture Buffer

For the Capture Buffer result display, the command returns one value for each I/Q sample in the capture buffer.

```
<absolute power>, ...
```

The unit is always dBm.

The following parameters are supported.

- TRACE1

9.6.1.5 CCDF

For the CCDF result display, the type of return values depends on the parameter.

- TRACE1
  Returns the probability values (y-axis).
  `<# of values>, <probability>, ...`
  The unit is always %.
  The first value that is returned is the number of the following values.
- TRACE2
  Returns the corresponding power levels (x-axis).
  `<# of values>, <relative power>, ...`
  The unit is always dB.
  The first value that is returned is the number of the following values.

9.6.1.6 Channel Flatness

For the Channel Flatness result display, the command returns one value for each trace point.

```
<relative power>, ...
```

The unit is always dB.

The following parameters are supported.

- TRACE1
  Returns the average power over all subframes.
- TRACE2
  Returns the minimum power found over all subframes. If you are analyzing a particular subframe, it returns nothing.
- TRACE3
  Returns the maximum power found over all subframes. If you are analyzing a particular subframe, it returns nothing.

9.6.1.7 Channel Flatness Difference

For the Channel Flatness Difference result display, the command returns one value for each trace point.

```
<relative power>, ...
```

The unit is always dB. The number of values depends on the selected LTE bandwidth.

The following parameters are supported.

- TRACE1
  Returns the average power over all subframes.
- TRACE2
  Returns the minimum power found over all subframes. If you are analyzing a particular subframe, it returns nothing.
- TRACE3
  Returns the maximum power found over all subframes. If you are analyzing a particular subframe, it returns nothing.

9.6.1.8 Channel Flatness SRS

For the Channel Flatness SRS result display, the command returns one value for each trace point.

```
<relative power>, ...
```

The unit is always dB.

The following parameters are supported.

- TRACE1
  Returns the average power over all subframes.
- TRACE2
  Returns the minimum power found over all subframes. If you are analyzing a particular subframe, it returns nothing.
- TRACE3
  Returns the maximum power found over all subframes. If you are analyzing a particular subframe, it returns nothing.

9.6.1.9 Channel Group Delay

For the Channel Group Delay result display, the command returns one value for each trace point.

```
<group delay>, ...
```

The unit is always ns. The number of values depends on the selected LTE bandwidth.

The following parameters are supported.

- TRACE1
  Returns the average group delay over all subframes.
- TRACE2
  Returns the minimum group delay found over all subframes. If you are analyzing a particular subframe, it returns nothing.
- TRACE3
  Returns the maximum group delay found over all subframes. If you are analyzing a particular subframe, it returns nothing.

9.6.1.10 Constellation Diagram

For the Constellation Diagram, the command returns two values for each constellation point.

<I[SF0][Symb0][Carrier1]>, <Q[SF0][Symb0][Carrier1]>, ..., <I[SF0][Symb0][Carrier(n)]>, <Q[SF0][Symb0][Carrier(n)]>,

<I[SF0][Symb1][Carrier1]>, <Q[SF0][Symb1][Carrier1]>, ..., <I[SF0][Symb1][Carrier(n)]>, <Q[SF0][Symb1][Carrier(n)]>,

<I[SF0][Symb(n)][Carrier1]>, <Q[SF0][Symb(n)][Carrier1]>, ..., <I[SF0][Symb(n)][Carrier(n)]>, <Q[SF0][Symb(n)][Carrier(n)]>,

<I[SF1][Symb0][Carrier1]>, <Q[SF1][Symb0][Carrier1]>, ..., <I[SF1][Symb0][Carrier(n)]>, <Q[SF1][Symb0][Carrier(n)]>,

<I[SF1][Symb1][Carrier1]>, <Q[SF1][Symb1][Carrier1]>, ..., <I[SF1][Symb1][Carrier(n)]>, <Q[SF1][Symb1][Carrier(n)]>,

<I[SF(n)][Symb(n)][Carrier1]>, <Q[SF(n)][Symb(n)][Carrier1]>, ..., <I[SF(n)][Symb(n)][Carrier(n)]>, <Q[SF(n)][Symb(n)][Carrier(n)]>

With SF = subframe and Symb = symbol of that subframe.

The I and Q values have no unit.

The number of return values depends on the constellation selection. By default, it returns all resource elements including the DC carrier.

The following parameters are supported.

- TRACE1
  Returns all constellation points included in the selection.
- TRACE2
  Returns the constellation points of the reference symbols included in the selection.
- TRACE3
  Returns the constellation points of the SRS included in the selection.

9.6.1.11 EVM vs Carrier

For the EVM vs Carrier result display, the command returns one value for each subcarrier that has been analyzed.

```
<EVM>, ...
```

The unit depends on `UNIT:EVM`.

The following parameters are supported.

- TRACE1
  Returns the average EVM over all subframes
- TRACE2
  Returns the minimum EVM found over all subframes. If you are analyzing a particular subframe, it returns nothing.
- TRACE3
  Returns the maximum EVM found over all subframes. If you are analyzing a particular subframe, it returns nothing.

9.6.1.12 EVM vs RB

For the EVM vs RB result display, the command returns one value for each resource block that has been analyzed.

```
<EVM>, ...
```

The unit depends on `UNIT:EVM`.

The following parameters are supported.

- TRACE1
  Returns the average power for each resource block over all subframes.
- TRACE2
  Returns the minimum power found over all subframes. If you are analyzing a particular subframe, it returns nothing.
- TRACE3
  Returns the maximum power found over all subframes. If you are analyzing a particular subframe, it returns nothing.

9.6.1.13 EVM vs Symbol

For the EVM vs Symbol result display, the command returns one value for each OFDM symbol that has been analyzed.

```
<EVM>, ...
```

For measurements on a single subframe, the command returns the symbols of that subframe only.

The unit depends on `UNIT:EVM`.

The following parameters are supported.

- TRACE1

9.6.1.14 EVM vs Subframe

For the EVM vs Subframe result display, the command returns one value for each subframe that has been analyzed.

```
<EVM>, ...
```

The unit depends on `UNIT:EVM`.

The following parameters are supported.

- TRACE1

9.6.1.15 Frequency Error vs Symbol

For the Frequency Error vs Symbol result display, the command returns one value for each OFDM symbol that has been analyzed.

```
<frequency error>,...
```

The unit is always Hz.

The following parameters are supported.

- TRACE1

9.6.1.16 Inband Emission

For the Inband Emission result display, the number and type of returns values depend on the parameter.

- TRACE1
  Returns the relative resource block indices (x-axis values).
  `<RB index>, ...`
  The resource block index has no unit.
- TRACE2
  Returns one value for each resource block index.
  `<relative power>, ...`
  The unit of the relative inband emission is dB.
- TRACE3
  Returns the data points of the upper limit line.
  `<limit>, ...`
  The unit is always dB.

Note that you have to select a particular subframe to get results.

9.6.1.17 Power Spectrum

For the Power Spectrum result display, the command returns one value for each trace point.

<power>,...

The unit is always dBm/Hz.

The following parameters are supported.

- TRACE1

9.6.1.18 Spectrum Emission Mask

For the SEM measurement, the number and type of returns values depend on the parameter.

- TRACE1
  Returns one value for each trace point.
  <absolute power>, ...
  The unit is always dBm.
- LIST
  Returns the contents of the SEM table. For every frequency in the spectrum emission mask, it returns nine values.
  <index>, <start frequency in Hz>, <stop frequency in Hz>, <RBW in Hz>, <limit fail frequency in Hz>, <absolute power in dBm>, <relative power in dBc>, <limit distance in dB>, <limit check result>, ...
  The <limit check result> is either a 0 (for PASS) or a 1 (for FAIL).

9.6.1.19 Return Value Codes

This chapter contains a list for encoded return values.

<allocation ID>

Represents the allocation ID. The value is a number in the range {1...-70}.

- **1** = Reference symbol
- **0** = Data symbol
- **-1** = Invalid
- **-40** = PUSCH
- **-41** = DMRS PUSCH
- **-42** = SRS PUSCH
- **-50** = PUCCH
- **-51** = DMRS PUCCH
- **-70** = PRACH

<codeword>

Represents the codeword of an allocation. The range is {0...2}.

- **0** = 1/1
- **1** = 1/2

- **2** = 2/2

<modulation>

Represents the modulation scheme. The range is {0...8}.

- **0** = unrecognized
- **1** = RBPSK
- **2** = QPSK
- **3** = 16QAM
- **4** = 64QAM
- **5** = 8PSK
- **6** = PSK
- **7** = mixed modulation
- **8** = BPSK

<number of symbols or bits>

In hexadecimal mode, this represents the number of symbols to be transmitted. In binary mode, it represents the number of bits to be transmitted.

TRACe[:DATA]? <Result>

This command returns the trace data for the current measurement or result display.

For more information see chapter 9.6.1, "Using the TRACe[:DATA] Command", on page 111.

Query parameters:

<TraceNumber> **TRACE1 | TRACE2 | TRACE3**

LIST

Usage: Query only

9.6.2 Reading Out Limit Check Results

9.6.2.1 Checking Limits for Graphical Result Displays

CALCulate<n>:LIMit<k>:ACPower:ACHannel:RESult? <Result>

This command queries the limit check results for the adjacent channels during ACLR measurements.

Query parameters:

<Result>

ALL
Queries the overall limit check results.

REL
Queries the channel power limit check results.

ABS
Queries the distance to the limit line.

Return values:

<LimitCheck>

Returns two values, one for the upper and one for the lower adjacent channel.

1
Limit check has passed.

0
Limit check has failed.

Example:

```
CALC:LIM:ACP:ACH:RES? ALL
```

Queries the results of the adjacent channel limit check.

Usage: Query only

CALCulate<n>:LIMit<k>:ACPower:ALTernate:RESult? <Result>

This command queries the limit check results for the alternate channels during ACLR measurements.

Query parameters:

<Result>

ALL
Queries the overall limit check results.

REL
Queries the channel power limit check results.

ABS
Queries the distance to the limit line.

Return values:

<LimitCheck>

Returns two values, one for the upper and one for the lower alternate channel.

1
Limit check has passed.

0
Limit check has failed.

Example:

```
CALC:LIM:ACP:ALT:RES? ALL
```

Queries the results of the alternate channel limit check.

Usage: Query only

CALCulate<n>:LIMit<k>:FAIL?

This command queries the limit check results for all measurements that feature a limit check.

Return values:

<LimitCheck> Returns two values, one for the upper and one for the lower adjacent or alternate channel.

0
Limit check has passed.

1
Limit check has failed.

Example: `CALC:LIM:FAIL?`
Queries the limit check of the active result display.

Usage: Query only

CALCulate<n>:MARKer<m>:FUNCtion:POWer:RESult[:CURRent]?

This command queries the current results of the ACLR measurement or the total signal power level of the SEM measurement.

To get a valid result, you have to perform a complete measurement with synchronization to the end of the measurement before reading out the result. This is only possible for single sweeps.

Suffix:

<m> 1

Query parameters:

CPOW This parameter queries the signal power of the SEM measurement.

Return values:

<Result>

SEMResults
Power level in dBm.

ACLRResults
Relative power levels of the ACLR channels. The number of return values depends on the number of transmission and adjacent channels. The order of return values is:
• <TXChannelPower> is the power of the transmission channel in dBm
• <LowerAdjChannelPower> is the relative power of the lower adjacent channel in dB
• <UpperAdjChannelPower> is the relative power of the upper adjacent channel in dB
• <1stLowerAltChannelPower> is the relative power of the first lower alternate channel in dB
• <1stUpperAltChannelPower> is the relative power of the first lower alternate channel in dB
(...)
• <nthLowerAltChannelPower> is the relative power of a subsequent lower alternate channel in dB
• <nthUpperAltChannelPower> is the relative power of a subsequent lower alternate channel in dB

Example: `CALC1:MARK:FUNC:POW:RES?`
Returns the current ACLR measurement results.

Usage: Query only

9.6.2.2 Checking Limits for Numerical Result Display

CALCulate<n>:LIMit<k>:SUMMary:EVM[:ALL]:MAXimum:RESult
CALCulate<n>:LIMit<k>:SUMMary:EVM[:ALL][:AVERage]:RESult?

This command queries the results of the EVM limit check of all resource elements.

Return values:

<LimitCheck> The type of limit (average or maximum) that is queried depends on the last syntax element.

FAILED
Limit check has failed.

PASSED
Limit check has passed.

NOTEVALUATED
Limits have not been evaluated.

Example: `CALC:LIM:SUMM:EVM:RES?`
Queries the limit check.

Usage: Query only

CALCulate<n>:LIMit<k>:SUMMary:EVM:PCHannel:MAXimum:RESult
CALCulate<n>:LIMit<k>:SUMMary:EVM:PCHannel[:AVERage]:RESult?

This command queries the results of the EVM limit check of all physical channel resource elements.

Return values:

<LimitCheck> The type of limit (average or maximum) that is queried depends on the last syntax element.

FAILED
Limit check has failed.

PASSED
Limit check has passed.

NOTEVALUATED
Limits have not been evaluated.

Example: `CALC:LIM:SUMM:EVM:PCH:RES?`
Queries the limit check.

Usage: Query only

CALCulate<n>:LIMit<k>:SUMMary:EVM:PSIGnal:MAXimum:RESult
CALCulate<n>:LIMit<k>:SUMMary:EVM:PSIGnal[:AVERage]:RESult?

This command queries the results of the EVM limit check of all physical signal resource elements.

Return values:

<LimitCheck> The type of limit (average or maximum) that is queried depends on the last syntax element.

FAILED
Limit check has failed.

PASSED
Limit check has passed.

NOTEVALUATED
Limits have not been evaluated.

Example: `CALC:LIM:SUMM:EVM:PSIG:RES?`
Queries the limit check.

Usage: Query only

CALCulate<n>:LIMit<k>:SUMMary:EVM:SDQP[:AVERage]:RESult?

This command queries the results of the EVM limit check of all PUSCH DMRS resource elements with a QPSK modulation.

Return values:

<LimitCheck>

FAILED
Limit check has failed.

PASSED
Limit check has passed.

NOTEVALUATED
Limits have not been evaluated.

Example: `CALC:LIM:SUMM:SDQP:RES?`
Queries the limit check.

Usage: Query only

CALCulate<n>:LIMit<k>:SUMMary:EVM:SDST[:AVERage]:RESult?

This command queries the results of the EVM limit check of all PUSCH DMRS resource elements with a 16QAM modulation.

Return values:

<LimitCheck>

FAILED
Limit check has failed.

PASSED
Limit check has passed.

NOTEVALUATED
Limits have not been evaluated.

Example: `CALC:LIM:SUMM:EVM:SDST:RES?`
Queries the limit check.

Usage: Query only

CALCulate<n>:LIMit<k>:SUMMary:EVM:UCCD[:AVERage]:RESult?

This command queries the results of the EVM limit check of all PUCCH DMRS resource elements.

Return values:

<LimitCheck>

FAILED
Limit check has failed.

PASSED
Limit check has passed.

NOTEVALUATED
Limits have not been evaluated.

Example: `CALC:LIM:SUMM:EVM:UCCD:RES?`
Queries the limit check.

Usage: Query only

CALCulate<n>:LIMit<k>:SUMMary:EVM:UCCH[:AVERage]:RESult?

This command queries the results of the EVM limit check of all PUCCH resource elements.

Return values:

<LimitCheck>

FAILED
Limit check has failed.

PASSED
Limit check has passed.

NOTEVALUATED
Limits have not been evaluated.

Example: `CALC:LIM:SUMM:EVM:UCCH:RES?`
Queries the limit check.

Usage: Query only

CALCulate<n>:LIMit<k>:SUMMary:EVM:UPRA[:AVERage]:RESult?

This command queries the results of the EVM limit check of all PRACH resource elements.

Return values:

<LimitCheck>

FAILED
Limit check has failed.

PASSED
Limit check has passed.

NOTEVALUATED
Limits have not been evaluated.

Example: `CALC:LIM:SUMM:EVM:UPRA:RES?`
Queries the limit check.

Usage: Query only

CALCulate<n>:LIMit<k>:SUMMary:EVM:USQP[:AVERage]:RESult?

This command queries the results of the EVM limit check of all PUSCH resource elements with a QPSK modulation

Return values:

<LimitCheck> **FAILED**
Limit check has failed.

PASSED
Limit check has passed.

NOTEVALUATED
Limits have not been evaluated.

Example: `CALC:LIM:SUMM:EVM:USQP:RES?`
Queries the limit check.

Usage: Query only

CALCulate<n>:LIMit<k>:SUMMary:EVM:USST[:AVERage]:RESult?

This command queries the results of the EVM limit check of all PUSCH resource elements with a 16QAM modulation.

Return values:

<LimitCheck> **FAILED**
Limit check has failed.

PASSED
Limit check has passed.

NOTEVALUATED
Limits have not been evaluated.

Example: `CALC:LIM:SUMM:EVM:USST:RES?`
Queries the limit check.

Usage: Query only

CALCulate<n>:LIMit<k>:SUMMary:FERRor:MAXimum:RESult
CALCulate<n>:LIMit<k>:SUMMary:FERRor[:AVERage]:RESult?

This command queries the result of the frequency error limit check.

Return values:

<LimitCheck> The type of limit (average or maximum) that is queried depends on the last syntax element.

FAILED
Limit check has failed.

PASSED
Limit check has passed.

NOTEVALUATED
Limits have not been evaluated.

Example: `CALC:LIM:SUMM:SERR:RES?`
Queries the limit check.

Usage: Query only

CALCulate<n>:LIMit<k>:SUMMary:GIMBalance:MAXimum:RESult
CALCulate<n>:LIMit<k>:SUMMary:GIMBalance[:AVERage]:RESult?

This command queries the result of the gain imbalance limit check.

Return values:

<LimitCheck> The type of limit (average or maximum) that is queried depends on the last syntax element.

FAILED
Limit check has failed.

PASSED
Limit check has passed.

NOTEVALUATED
Limits have not been evaluated.

Example: `CALC:LIM:SUMM:GIMB:RES?`
Queries the limit check.

Usage: Query only

CALCulate<n>:LIMit<k>:SUMMary:IQOFfset:MAXimum:RESult
CALCulate<n>:LIMit<k>:SUMMary:IQOFfset[:AVERage]:RESult?

This command queries the result of the I/Q offset limit check.

Return values:

<LimitCheck> The type of limit (average or maximum) that is queried depends on the last syntax element.

FAILED
Limit check has failed.

PASSED
Limit check has passed.

NOTEVALUATED
Limits have not been evaluated.

Example: CALC:LIM:SUMM:IQOF:MAX:RES?
Queries the limit check.

Usage: Query only

CALCulate<n>:LIMit<k>:SUMMary:QUADerror:MAXimum:RESult
CALCulate<n>:LIMit<k>:SUMMary:QUADerror[:AVERage]:RESult?

This command queries the result of the quadrature error limit check.

Return values:

<LimitCheck> The type of limit (average or maximum) that is queried depends on the last syntax element.

FAILED
Limit check has failed.

PASSED
Limit check has passed.

NOTEVALUATED
Limits have not been evaluated.

Example: CALC:LIM:SUMM:QUAD:RES?
Queries the limit check.

Usage: Query only

CALCulate<n>:LIMit<k>:SUMMary:SERRor:MAXimum:RESult
CALCulate<n>:LIMit<k>:SUMMary:SERRor[:AVERage]:RESult?

This command queries the results of the sampling error limit check.

Return values:

<LimitCheck> The type of limit (average or maximum) that is queried depends on the last syntax element.

FAILED
Limit check has failed.

PASSED
Limit check has passed.

NOTEVALUATED
Limits have not been evaluated.

Example: CALC:LIM:SUMM:SERR:RES?
Queries the limit check.

Usage: Query only

9.7 Remote Commands to Configure General Settings

9.7.1 Remote Commands for General Settings

This chapter contains remote control commands necessary to control the general measurement settings.

For more information see chapter 4.1, "Configuring the Measurement", on page 45.

9.7.1.1 Defining General Signal Characteristics

CONFigure[:LTE]:DUPLexing <Duplexing>

This command selects the duplexing mode.

Parameters:

<Duplexing>

TDD
Time division duplex

FDD
Frequency division duplex

*RST: FDD

Example: `CONF:DUPL TDD`
Activates time division duplex.

CONFigure[:LTE]:LDIRection <Direction>

This command selects the link direction

Parameters:

<Direction>

DL
Downlink

UL
Uplink

Example: `CONF:LDIR DL`
EUTRA/LTE option is configured to analyze downlink signals.

[SENSe]:FREQuency:CENTer <Frequency>

This command sets the center frequency for RF measurements.

Parameters:

<Frequency> <numeric value>

Range: fmin to fmax
*RST: 1 GHz
Default unit: Hz

Example: `FREQ:CENT 2GHZ`
Set the center frequency to 2 GHz.

9.7.1.2 Selecting the Input Source

SENSe:INPut <Source>

This command selects the signal source.

Parameters:

<Source>

RF
Select radio frequency input as signal source.

AIQ
Select analog I/Q input (baseband) as signal source.

DIQ
Select digital I/Q input as signal source.

Example: `INP DIQ`
Select digital I/Q as signal source.

9.7.1.3 Configuring the Input Level

[SENSe]:POWer:AUTO<analyzer>[:STATe] <State>

This command initiates a measurement that determines the ideal reference level.

Parameters:

<State>

OFF
Performs no automatic reference level detection.

ON
Performs an automatic reference level detection before each measurement.

ONCE
Performs an automatic reference level once.

*RST: ON

Example: `POW:AUTO2 ON`
Activate auto level for analyzer number 2.

CONFigure:POWer:EXPected:RF<analyzer> <RefLevel>

This command defines the reference level when the input source is RF.

Parameters:
<RefLevel> *RST: -30 dBm
Default unit: DBM

Example: `CONF:POW:EXP:RF3 -20`
Sets the radio frequency reference level used by analyzer 3 to -20 dBm.

CONFigure:POWer:EXPected:IQ<analyzer> <RefLevel>

This command defines the reference level when the input source is baseband.

Parameters:
<RefLevel> <numeric value>
Range: 31.6 mV to 5.62 V
*RST: 1 V
Default unit: V

Example: `CONF:POW:EXP:IQ2 3.61`
Sets the baseband-reference level used by analyzer 2 to 3.61 V.

INPut<n>:ATTenuation<analyzer> <Attenuation>

This command sets the RF attenuation level.

Parameters:
<Attenuation> <numeric value>
*RST: 5 dB
Default unit: dB

Example: `INP:ATT 10`
Defines an RF attenuation of 10 dB.

DISPlay[:WINDow<n>]:TRACe<t>:Y[:SCALe]:RLEVel:OFFSet <Attenuation>

This command selects the external attenuation or gain applied to the RF signal.

Parameters:
<Attenuation> <numeric value>
*RST: 0
Default unit: dB

Example: `DISP:TRAC:Y:RLEV:OFFS 10`
Sets an external attenuation of 10 dB.

9.7.1.4 Configuring the Data Capture

[SENSe]:SWEep:TIME <CaptLength>

This command sets the capture time.

Parameters:

<CaptLength> Numeric value in seconds.
Default unit: s

Example: `SWE:TIME 40`
Defines a capture time of 40 seconds.

[SENSe][:LTE]:FRAMe:COUNt:STATe <State>

This command turns manual selection of the number of frames you want to analyze on and off.

Parameters:

<State> **ON**
You can set the number of frames to analyze.
OFF
The analyzer analyzes a single sweep.
*RST: ON

Example: `FRAM:COUN:STAT ON`
Turns manual setting of number of frames to analyze on.

[SENSe][:LTE]:FRAMe:COUNt <Subframes>

This command sets the number of frames you want to analyze.

Parameters:

<Subframes> <numeric value>
*RST: 1

Example: `FRAM:COUN:STAT ON`
Activates manual input of frames to be analyzed.
`FRAM:COUN 20`
Analyzes 20 frames.

[SENSe][:LTE]:FRAMe:COUNt:AUTO <State>

This command turns automatic selection of the number of frames to analyze on and off.

Parameters:

<State> **ON**
Selects the number of frames to analyze according to the LTE standard.

OFF
Turns manual selection of the frame number on.

Example: `FRAM:COUN:AUTO ON`
Turns automatic selection of the analyzed frames on.

9.7.1.5 Configuring Measurement Results

UNIT:EVM <Unit>

This command selects the EVM unit.

Parameters:

<Unit> **DB**
EVM results returned in dB

PCT
EVM results returned in %

*RST: PCT

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

UNIT:BSTR <Unit>

This command selects the way the bit stream is displayed.

Parameters:

<Unit> **SYMbols**
Displays the bit stream using symbols

BITs
Displays the bit stream using bits

*RST: SYMbols

Example: `UNIT:BSTR BIT`
Bit stream gets displayed using Bits.

[SENSe][:LTE]:ANTenna:SELect <Antenna>

Configures which antenna shall be used for analysis.

Parameters:

<Antenna> <numeric value>

*RST: 1

Example: `SENS:ANT:SEL 2`
Select antenna 2 for analysis.

[SENSe][:LTE]:SLOT:SELect <Slot>

This command selects the slot to analyze.

Parameters:

<Slot> **S0**
Slot 0

S1
Slot 1

ALL
Both slots

*RST: ALL

Example: `SLOT:SEL S1`
Selects slot 1 for analysis.

[SENSe][:LTE]:PREamble:SELect <Subframe>

This command selects a particular preamble for measurements that analyze individual preambles.

The command is available in PRACH analysis mode.

Parameters:

<Subframe> **ALL**
Analyzes all preambles.

<numeric value>
Selects the premable to analyze.

*RST: ALL

Example: `PRE:SEL ALL`
Analyzes all preambles.

[SENSe][:LTE]:SUBFrame:SELect <Subframe>

This command selects the subframe to be analyzed.

Parameters:

<Subframe> ALL | <numeric value>

ALL
Select all subframes

0...39
Select a single subframe

*RST: ALL

Example: `SUBF:SEL ALL`
Select all subframes for analysis.

9.7.2 Configuring MIMO Measurement Setups

CONFigure:ADDRess<analyzer> <Address>

This command defines the network address of an analyzer in a MIMO measurement setup.

Parameters:

<Address> String containing the address of the analyzer.
Connections are possible via TCP/IP or GPIB. Depending on the type of connection, the string has the following syntax.
`'GPIB[board]::<PrimaryAddress>[::<SecondaryAddress>][::INSTR]'`
`'TCPIP[board]::<HostAddress>[::<LANDeviceName>][::INSTR]'`
Elements in square brackets are optional.

Example: `CONF:ADDR 'TCPIP::192.168.0.1'`
Defines a TCP/IP connection for the first analyzer in the test setup.
`CONF:ADDR 'GPIB::28'`
Defines a GPIB connection for the first analyzer in the test setup.

CONFigure[:LTE]:UL:MIMO:ASELection <Antenna>

This command selects the antenna for measurements with MIMO setups.

Parameters:

<Antenna> **ANT1 | ANT2**
Select a single antenna to be analyzed

ALL
Select all antennas to be analyzed

Example: `CONF:DL:MIMO:ASEL ANT2`
Selects antenna 2 to be analyzed.

CONFigure[:LTE]:UL:MIMO:PUCCh:CONFig <NofAntennas>

This command selects the number of antennas for the PUCCH in a MIMO setup.

Parameters:
<NofAntennas> **TX1**
Use 1 antenna.
TX2
Use 2 antennas.

Example: `CONF:UL:MIMO:PUCC:CONF TX1`
The PUCCH is transmitted on one antenna.

CONFigure[:LTE]:UL:MIMO:PUSCh:CONFig <NofAntennas>

This command selects the number of antennas for the PUSCH in a MIMO setup.

Parameters:
<NofAntennas> **TX1**
Use 1 antenna.
TX2
Use 2 antennas.

Example: `CONF:UL:MIMO:PUSC:CONF TX1`
The PUSCH is transmitted on one antenna.

CONFigure[:LTE]:UL:MIMO:SRS:CONFig <NofAntennas>

This command selects the number of antennas for the sounding reference signal in a MIMO setup.

Parameters:
<NofAntennas> **TX1**
Use 1 antenna.
TX2
Use 2 antennas.

Example: `CONF:UL:MIMO:SRS:CONF TX1`
The sounding reference signal is transmitted on one antenna.

9.7.3 Using a Trigger

TRIGger[:SEQuence]:MODE <Source>

This command selects the trigger source.

Parameters:

<Source>

EXTernal
Selects external trigger source.

IMMediate
Selects free run trigger source.

POWer
Selects IF power trigger source.

*RST: IMMediate

Example:
```
TRIG:MODE EXT
```
Selects an external trigger source.

TRIGger[:SEQuence]:HOLDoff<analyzer> <Offset>

This command defines the trigger offset.

Parameters:

<Offset>

<numeric value>

*RST: 0 s
Default unit: s

Example:
```
TRIG:HOLD 5MS
```
Sets the trigger offset to 5 ms.

TRIGger[:SEQuence]:LEVel<analyzer>[:EXTernal] <Level>

This command defines the level for an external trigger.

Parameters:

<Level>

Range: 0.5 V to 3.5 V
*RST: 1.4 V
Default unit: V

Example:
```
TRIG:LEV 2V
```
Defines a trigger level of 2 V.

TRIGger[:SEQuence]:LEVel<analyzer>:POWer <Level>

This command defines the trigger level for an IF power trigger.

Parameters:

<Level>

Default unit: DBM

Example:
```
TRIG:LEV:POW 10
```
Defines a trigger level of 10 dBm.

TRIGger[:SEQuence]:SLOPe <Slope>

This command selects the trigger slope.

Parameters:

<Slope>

POSitive
Triggers a measurement when the signal rises to the trigger level.

NEGative
Triggers a measurement when the signal falls to the trigger level.

Example: `TRIG:SLOP POS`
Selects a positive trigger slope.

9.7.4 Configuring Spectrum Measurements

9.7.4.1 Configuring SEM and ACLR Measurements

[SENSe]:POWer:SEM:UL:REQuirement <Requirement>

This command selects the requirements for a spectrum emission mask.

Parameters:

<Requirement>

GEN | NS3 | NS4 | NS67

GEN
General spectrum emission mask.

NS3 | NS4 | NS67
Spectrum emission masks with additional requirements.

Example: `POW:SEM:UL:REQ NS3`
Selects a spectrum emission mask with requirement for network signalled value NS3.

[SENSe]:POWer:ACHannel:AACHannel <Channel>

This command selects the assumed adjacent channel carrier for ACLR measurements.

Parameters:

<Channel>

EUTRA
Selects an EUTRA signal of the same bandwidth like the TX channel as assumed adjacent channel carrier.

UTRA128
Selects an UTRA signal with a bandwidth of 1.28MHz as assumed adjacent channel carrier.

UTRA384
Selects an UTRA signal with a bandwidth of 3.84MHz as assumed adjacent channel carrier.

UTRA768
Selects an UTRA signal with a bandwidth of 7.68MHz as assumed adjacent channel carrier.

*RST: EUTRA

Example: `POW:ACH:AACH UTRA384`
Selects an UTRA signal with a bandwidth of 3.84MHz as assumed adjacent channel carrier.

[SENSe]:POWer:NCORrection <State>

This command turns noise correction for ACLR measurements on and off.

Parameters:

<State> ON | OFF

*RST: OFF

Example: `POW:NCOR ON`
Activates noise correction.

[SENSe]:SWEep:EGATe:AUTO <State>

This command turns auto gating for SEM and ACLR measurements on and off.

This command is available for TDD measurements in combination with an external or IF power trigger.

Parameters:

<State>

ON
Evaluates the on-period of the LTE signal only.

OFF
Evaluates the complete signal.

Example: `SWE:EGAT:AUTO ON`
Turns auto gating on.

9.7.4.2 Configuring Spectrum Flatness Measurements

[SENSe][:LTE]:SFLatness:ECONditions <State>

This command turns extreme conditions for spectrum flatness measurements on and off.

Parameters:

<State> ON | OFF

*RST: OFF

Example: `SFL:ECON ON`

Turns extreme conditions on.

[SENSe][:LTE]:SFLatness:OBANd <NofSubbands>

This command selects the operating band for spectrum flatness Measurements.

Parameters:

<NofSubbands> <numeric value>

Range: 1 to 40

*RST: 1

Example: `SFL:OBAN 10`

Selects operating band 10.

9.7.5 Remote Commands for Advanced Settings

This chapter contains all remote control commands to control the advanced settings.

For more information on advanced settings see chapter 4.5, "Advanced Settings", on page 58.

9.7.5.1 Controlling I/Q Data

[SENSe]:SWAPiq <State>

This command turns a swap of the I and Q branches on and off.

Parameters:

<State> ON | OFF

*RST: OFF

Example: `SWAP ON`

Turns a swap of the I and Q branches on.

9.7.5.2 Configuring the Baseband Input

INPut:IQ:IMPedance <Impedance>

This command selects the input impedance for I/Q inputs.

Parameters:
<Impedance> LOW | HIGH
*RST: LOW

Example: `INP:IQ:IMP LOW`
Selects low input impedance for I/Q input.

INPut:IQ:BALanced[:STATe] <State>

This command selects if the I/Q inputs are symmetrical (balanced) or asymmetrical (unbalanced)

Parameters:
<State> ON | OFF
*RST: ON

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

[SENSe]:IQ:LPASs[:STATe] <State>

This command turns a baseband input lowpass filter on and off.

Parameters:
<State> ON | OFF
*RST: ON

Example: `IQ:LPAS ON`
Activate the input lowpass.

[SENSe]:IQ:DITHer[:STATe] <State>

This command adds or removes a noise signal into the signal path (dithering).

Parameters:
<State> ON | OFF
*RST: OFF

Example: `IQ:DITH ON`
Activate input dithering.

9.7.5.3 Using Advanced Input Settings

[SENSe]:POWer:AUTO<analyzer>:TIME <Time>

This command defines the track time for the auto level process.

Parameters:

<Time> <numeric value>

*RST: 100 ms
Default unit: s

Example: `POW:AUTO:TIME 200ms`
An auto level track time of 200 ms gets set.

9.7.5.4 Configuring the Digital I/Q Input

The digital I/Q input is available with option R&S FSQ-B17 or R&S FSV-B17.

INPut<n>:DIQ:RANGe[:UPPer] <ScaleLevel>

This command defines the full scale level for a digital I/Q signal source.

Parameters:

<ScaleLevel> *RST: 1 V
Default unit: V

Example: `INP:DIQ:RANG 0.7`
Sets the full scale level to 0.7 V.

INPut<n>:DIQ:SRATe <SampleRate>

This command defines the sampling rate for a digital I/Q signal source.

Parameters:

<SampleRate> *RST: 10 MHz
Default unit: Hz

Example: `INP:DIQ:SRAT 10MHZ`
Defines a sampling rate of 10 MHz.

9.8 Remote Commands to Configure the Demodulation

9.8.1 Remote Commands for UL Demodulation Settings

This chapter contains remote commands necessary to define PDSCH demodulation.

For more information see chapter 5.1, "Configuring Uplink Signal Demodulation", on page 62.

9.8.1.1 Configuring the Data Analysis

[SENSe][:LTE]:UL:DEMod:MODE <Reference>

This command selects the uplink analysis mode.

Parameters:

<Reference>

PUSCh
Analyzes the PUSCH and PUCCH.

PRACh
Analyzes the PRACH.

*RST: PUSCh

Example: `UL:DEM:MODE PRAC`
Selects PRACH analysis mode.

[SENSe][:LTE]:UL:DEMod:CESTimation <Type>

This command selects the channel estimation type for uplink signals.

Parameters:

<Type>

PIL | PILPAY

PIL
Pilot only

PILP
Pilot and payload

*RST: PILP

Example: `UL:DEM:CEST PIL`
Uses only the pilot signal for channel estimation.

[SENSe][:LTE]:UL:DEMod:EEPeriod <State>

This command includes or excludes the exclusion period from EVM results.

Parameters:
<State> ON | OFF

Example: `UL:DEM:EEP ON`
Turns the exclusion periods for EVM calculation on.

[SENSe][:LTE]:UL:DEMod:CDCoffset <State>

This command turns DC offset compensation for uplink signals on and off.

Parameters:
<State> ON | OFF
*RST: ON

Example: `UL:DEM:CDC OFF`
Deactivates DC offset compensation.

[SENSe][:LTE]:UL:DEMod:CBSCrambling <State>

This command turns scrambling of coded bits for uplink signals on and off.

Parameters:
<State> ON | OFF
*RST: ON

Example: `UL:DEM:CBSC OFF`
Deactivates the scrambling.

[SENSe][:LTE]:UL:DEMod:ACON <Type>

This command selects the method of automatic demodulation for uplink signals.

Parameters:
<Type>
ALL
Automatically detects and demodulates the PUSCH and SRS.
OFF
Automatic demodulation is off.
SCON
Automatically detects and demodulates the values available in the subframe configuration table.

Example: `UL:DEM:ACON OFF`
Turns automatic demodulation off.

[SENSe][:LTE]:UL:FORMat:SCD <State>

This command turns detection of the subframe configuration on and off.

The command is available if "Auto Demodulation" is turned off.

Parameters:

<State> ON | OFF

*RST: OFF

Example: `UL:FORM:SCD ON`

Turns detection of the subframe configuration on.

[SENSe][:LTE]:UL:DEMod:SISYnc <State>

This command turns suppressed interference synchronization on and off.

Parameters:

<State> ON | OFF

*RST: OFF

Example: `UL:DEM:SISY ON`

Turns suppressed interference synchronization on.

[SENSe][:LTE]:UL:DEMod:MCFilter <State>

This command turns suppression of interfering neighboring carriers on and off (e.g. LTE, WCDMA, GSM etc).

Parameters:

<State> ON | OFF

*RST: OFF

Example: `UL:DEM:MCF ON`

Turns suppression on of neighboring carriers on.

9.8.1.2 Compensating Measurement Errors

[SENSe][:LTE]:UL:TRACking:PHASe <Type>

This command selects the phase tracking type for uplink signals.

Parameters:

<Type> **OFF**
Deactivate phase tracking

PIL
Pilot only

PILP
Pilot and payload

*RST: OFF

Example: `SENS:UL:TRAC:PHAS PILP`
Use pilots and payload for channel estimation.

[SENSe][:LTE]:UL:TRACking:TIME <State>

This command turns timing tracking for uplink signals on and off.

Parameters:
<State> ON | OFF
*RST: OFF

Example: `UL:TRAC:TIME ON`
Activates timing tracking.

9.8.2 Remote Commands for UL Signal Characteristics

This chapter contains remote commands necessary to define uplink signal characteristics.

For more information see chapter 5.2, "Defining Uplink Signal Characteristics", on page 65.

9.8.2.1 Defining the Physical Signal Characteristics

CONFigure[:LTE]:UL:BW <Bandwidth>

This command selects the uplink bandwidth.

Parameters:
<Bandwidth> BW1_40 | BW3_00 | BW5_00 | BW10_00 | BW15_00 | BW20_00

Example: `CONF:UL:BW BW1_40`
Sets a signal bandwidth of 1.4 MHz in uplink.

CONFigure[:LTE]:UL:NORB <ResourceBlocks>

This command selects the number of resource blocks for uplink signals.

Parameters:
<ResourceBlocks> <numeric value>
*RST: 50

Example: `CONF:UL:NORB 25`
Sets the number of resource blocks to 25.

CONFigure[:LTE]:UL:CYCPrefix <PrefixLength>

This command selects the cyclic prefix for uplink signals.

Parameters:
<PrefixLength>
NORM
Normal cyclic prefix length
EXT
Extended cyclic prefix length
AUTO
Automatic cyclic prefix length detection
*RST: AUTO

Example: `CONF:UL:CYCP EXT`
Sets cyclic prefix type to extended.

CONFigure[:LTE]:UL:TDD:UDConf <Configuration>

This command selects the UL/DL TDD subframe configuration for uplink signals.

Parameters:
<Configuration>
Range: 0 to 6
*RST: 0

Example: `CONF:UL:TDD:UDC 4`
Selects allocation configuration number 4.

CONFigure[:LTE]:UL:TDD:SPSC <Configuration>

This command selects the special subframe configuration for LTE uplink signals.

Parameters:
<Configuration>
<numeric value>

Example: `CONF:UL:TDD:SPSC 2`
Selects special subframe configuration 2.

9.8.2.2 Configuring the Physical Layer Cell Identity

CONFigure[:LTE]:UL:PLC:CID <CellId>

This command defines the cell ID.

Parameters:

<CellId>

AUTO
Automatically defines the cell ID.

<numeric value>
Number of the cell ID.

Range: 0 to 503

CONFigure[:LTE]:UL:PLC:CIDGroup <GroupNumber>

This command selects the cell identity group for uplink signals.

Parameters:

<GroupNumber>

Range: 1 to 167
*RST: 0

Example:

```
CONF:UL:PLCI:CIDG 12
```

Selects cell identity group 12.

CONFigure[:LTE]:UL:PLC:PLID <Identity>

This command selects the physical layer identity for uplink signals.

Parameters:

<Identity>

AUTO
Automatic selection

0...2
Manual selection

*RST: AUTO

Example:

```
CONF:DL:PLC:PLID 2
```

Sets the physical layer identity to 2.

```
CONF:DL:PLC:PLID AUTO
```

Physical layer ID is selected automatically.

9.8.2.3 Configuring Subframes

CONFigure[:LTE]:UL:SFNO <Offset>

This command defines the system frame number offset.

The application uses the offset to demodulate the frame.

Parameters:

<Offset> <numeric value>

*RST: 0

Example: `CONF:UL:SFNO 2`

Selects frame number offset 2.

CONFigure[:LTE]:UL:CSUBframes <NofSubframes>

This command selects the number of configurable subframes in the uplink signal.

Parameters:

<NofSubframes> Range: 0 to 9

*RST: 1

Example: `CONF:UL:CSUB 5`

Sets the number of configurable subframes to 5.

CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc[:CLUSter<cluster>]:RBCount <ResourceBlocks>

This command selects the number of resource blocks in an uplink subframe.

Parameters:

<NofRBs> <numeric value>

*RST: 11

Example: `CONF:UL:SUBF8:ALL:RBC 8`

Subframe 8 consists of 8 resource blocks.

CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc[:CLUSter<cluster>]:RBOFfset <Offset>

This command defines the resource block offset in an uplink subframe.

Parameters:

<RBOffset> <numeric value>

*RST: 2

Example: `CONF:UL:SUBF8:ALL:CLUS2:RBOF 5`

Cluster 2 of subframe 8 has a resource block offset of 5.

CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc:CONT <Content>

This command allocates a PUCCH or PUSCH to an uplink allocation.

Parameters:

<Content>

NONE
Turns off the PUSCH and the PUCCH.

PUCCh
Turns on the PUCCH.

PUSCh
Turns on the PUSCH.

PSCC
Turns on the PUCCH as well as the PUSCH.

*RST: PUSC

Example: `CONF:UL:SUBF8:ALL:CONT PUCC`
Subframe 8 contains a PUCCH.

CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc:MODulation <Modulation>

This command selects the modulation of an uplink allocation.

Parameters:

<Modulation> QPSK | QAM16 | QAM64

*RST: QPSK

Example: `CONF:UL:SUBF8:ALL:MOD QPSK`
The modulation of the allocation in subframe 8 is QPSK.

CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc:PRECoding:CBINdex <CBIndex>

This command selects the codebook index for a PUSCH allocation.

Parameters:

<CBIndex> Range: 0 to 5
*RST: 0

Example: `CONF:UL:SUBF:ALL:PREC:CBIN 1`
Selects codebook index 1 for the PUSCH allocation.

CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc:PRECoding:CLMapping <Mapping>

This command selects the codeword to layer mapping for a PUSCH allocation.

Parameters:

<Mapping> LC11 | LC21 | LC22

Example: `CONF:UL:SUBF2:ALL:PREC:CLM LC11`
Assigns codeword-to-layer mapping 1/1 to subframe 2.

CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc:PUCCh:NPAR <Parameter>

This command defines N_PUCCH on a subframe basis.

The command is available if `CONFigure[:LTE]:UL:PUCCh:NPAR` on page 160 is turned on.

Parameters:

<Parameter> <numeric value>

Example: `CONF:UL:SUBF:ALL:PUCC:NPAR 2`
Sets N_PUCCH to 2.

CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc:PUSCh:CSField <CyclicShiftField>

This command defines the cyclic shift field of the demodulation reference signal.

Available if `CONFigure[:LTE]:UL:DRS:AOCC` has been turned on.

Parameters:

<CyclicShiftField> Range: 0 to 7
*RST: 0

Example: `CONF:UL:SUBF:ALL:PUSC:CSF 4`
Defines cyclic shift field 4.

CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc:PUSCh:NDMRs <PuschNDMRS>

This command defines the part of the DMRS index that is used for the uplink scheduling assignment.

Parameters:

<PuschNDMRS> <numeric value>
Range: 0 to 11
*RST: 0

Example: `CONF:UL:SUBF:ALL:PUSC:NDMR 2`
Defines index 2.

CONFigure[:LTE]:UL:SUBFrame<subframe>:ALLoc:RATO <State>

This command turns the resource allocation type 1 on and off.

Parameters:

<State> ON | OFF
*RST: OFF

Example: `CONF:UL:SUBF:ALL:RATO ON`
Turns resource allocation type 1 on.

9.8.3 Remote Commands for UL Advanced Signal Characteristics

This chapter contains remote commands necessary to define advanced uplink signal characteristics.

For more information see chapter 5.3, "Defining Advanced Signal Characteristics", on page 72.

9.8.3.1 Configuring the Demodulation Reference Signal

CONFigure[:LTE]:UL:DRS:AOCC <State>

This command turns the configuration of the demodulation reference signal on a sub-frame basis via the "Cyclic Field Shift" on and off.

Parameters:
<State> ON | OFF

Example: `CONF:UL:DRS:AOCC ON`
Turns Activate-DMRS-with OCC on.

CONFigure[:LTE]:UL:DRS:DSSHift <Shift>

This command selects the delta sequence shift of the uplink signal.

Parameters:
<Shift> <numeric value>
*RST: 0

Example: `CONF:UL:DRS:DSSH 3`
Sets the delta sequence shift to 3.

CONFigure[:LTE]:UL:DRS:GRPHopping <State>

This command turns group hopping for uplink signals on and off.

Parameters:
<State> ON | OFF
*RST: OFF

Example: `CONF:UL:DRS:GRPHopping ON`
Activates group hopping.

CONFigure[:LTE]:UL:DRS:NDMRs <nDMRS>

This command defines the n_{DMRS}.

Parameters:

<nDMRS> <numeric value>

Example: `CONF:UL:DRS:NDMR 0`
Selects n_{DMRS} 0.

CONFigure[:LTE]:UL:DRS:PUCCh:POWer <Power>

This command sets the relative power of the PUCCH.

Parameters:

<Power> *RST: 0
Default unit: DB

Example: `CONF:UL:DRS:PUCC:POW 2`
Sets the power of the PUCCH to 2 dB.

CONFigure[:LTE]:UL:DRS[:PUSCh]:POWer <Power>

This command sets the relative power of the PUSCH.

Parameters:

<Power> *RST: 0
Default unit: DB

Example: `CONF:UL:DRS:POW 2`
Sets the relative power of the PUSCH to 2 dB.

CONFigure[:LTE]:UL:DRS:SEQuence <Sequence>

This command selects the modulation for the reference signal.

Parameters:

<Sequence> **IQF**
For use of a customized reference signal. The data has to come from a file.

TGPP
For use of a reference signal according to 3GPP.

Example: `CONF:UL:DRS:SEQ IQF`
Activates the IQF type of sequence.

CONFigure[:LTE]:UL:DRS:SEQHopping <State>

This command turns sequence hopping for uplink signals on and off.

Parameters:
<State> ON | OFF
*RST: OFF

Example: `CONF:UL:DRS:SEQH ON`
Activates sequence hopping.

9.8.3.2 Configuring the Sounding Reference Signal

CONFigure[:LTE]:UL:SRS:STAT <State>

Activates or deactivates the sounding reference signal.

Parameters:
<State> ON | OFF
*RST: OFF

Example: `CONF:UL:SRS:STAT ON`
Activates the sounding reference signal.

CONFigure[:LTE]:UL:SRS:SUConfig <Configuration>

This command defines the SRS subframe configuration.

Parameters:
<Configuration> <numeric value>
*RST: 0

Example: `CONF:UL:SRS:SUC 4`
Sets SRS subframe configuration to 4.

CONFigure[:LTE]:UL:SRS:POWer <Power>

Defines the relative power of the sounding reference signal.

Parameters:

<Power> <numeric value>

*RST: 0
Default unit: DB

Example: `CONF:UL:SRS:POW -1.2`
Sets the power to -1.2 dB.

CONFigure[:LTE]:UL:SRS:SUConfig <Configuration>

This command defines the SRS subframe configuration.

Parameters:

<Configuration> <numeric value>

*RST: 0

Example: `CONF:UL:SRS:SUC 4`
Sets SRS subframe configuration to 4.

CONFigure[:LTE]:UL:SRS:BHOP <Bandwidth>

This command defines the frequency hopping bandwidth b_{hop}.

Parameters:

<Bandwidth> <numeric value>

*RST: 0

Example: `CONF:UL:SRS:BHOP 1`
Sets the frequency hopping bandwidth to 1.

CONFigure[:LTE]:UL:SRS:ISRS <ConfIndex>

This command defines the SRS configuration index (I_{SRS}).

Parameters:

<ConfIndex> <numeric value>

*RST: 0

Example: `CONF:UL:SRS:ISRS 1`
Sets the configuration index to 1.

CONFigure[:LTE]:UL:SRS:CSRS <Configuration>

This command defines the SRS bandwidth configuration (C_{SRS}).

Parameters:

<Configuration> <numeric value>

*RST: 0

Example: `CONF:UL:SRS:CSRS 2`
Sets the SRS bandwidth configuration to 2.

CONFigure[:LTE]:UL:SRS:BSRS <Bandwidth>

This command defines the bandwidth of the SRS (B_{SRS}).

Parameters:
<Bandwidth> <numeric value>
*RST: 0

Example: `CONF:UL:SRS:BSRS 1`
Sets the SRS bandwidth to 1.

CONFigure[:LTE]:UL:SRS:NRRC <FreqDomPos>

Sets the UE specific parameter Freq. Domain Position n_{RRC}.

Parameters:
<FreqDomPos> <numeric value>
*RST: 0

Example: `CONF:UL:SRS:NRRC 1`
Sets n_{RRC} to 1.

CONFigure[:LTE]:UL:SRS:MUPT <State>

This command turns SRS MaxUpPts on and off.

Parameters:
<State> ON | OFF
*RST: OFF

CONFigure[:LTE]:UL:SRS:TRComb <TransComb>

This command defines the transmission comb (k_{TC}).

Parameters:
<TransComb> <numeric value>
*RST: 0

Example: `CONF:UL:SRS:TRC 1`
Sets transmission comb to 1.

CONFigure[:LTE]:UL:SRS:CYCS <CyclicShift>

Sets the cyclic shift n_CS used for the generation of the sounding reference signal CAZAC sequence.

Parameters:
<CyclicShift> <numeric value>
*RST: 0

Example: `CONF:UL:SRS:CYCS 2`
Sets the cyclic shift to 2.

9.8.3.3 Defining the PUSCH Structure

CONFigure[:LTE]:UL:PUSCh:FHMode <HoppingMode>

This command selects the frequency hopping mode in the PUSCH structure.

Parameters:
<HoppingMode>
NONE
No hopping
INTer
Inter subframe hopping
INTRa
Intra subframe hopping
*RST: NONE

Example: `CONF:UL:PUSC:FHM NONE`
Deactivates frequency hopping for the PUSCH.

CONFigure[:LTE]:UL:PUSCh:FHOP:IIHB <HBInfo>

This command defines the information in hopping bits of the PUSCH.

Parameters:
<HBInfo>
<numeric value>
Range: 0 to 3
*RST: 0

Example: `CONF:UL:PUSC:FHOP:IIHB 1`
Defines type 1 as the information in hopping bits.

CONFigure[:LTE]:UL:PUSCh:FHOFfset <Offset>

This command defines the frequency hopping offset for the PUSCH.

Parameters:
<Offset>
<numeric value>
*RST: 4

Example: `CONF:UL:PUSC:FHOF 5`
Sets the hopping offset to 5.

CONFigure[:LTE]:UL:PUSCh:NOSM <NofSubbands>

This command defines the number of subbands/M of the PUSCH.

Parameters:

<NofSubbands> <numeric value>

*RST: 4

Example: `CONF:UL:PUSC:NOSM 2`

Sets the number of subbands to 2.

9.8.3.4 Defining the PUCCH Structure

CONFigure[:LTE]:UL:PUCCh:NORB <ResourceBlocks>

This command selects the number of resource blocks for the PUCCH.

Parameters:

<ResourceBlocks> <numeric value>

*RST: 0

Example: `CONF:UL:PUCC:NORB 6`

Sets the number of resource blocks to 6.

CONFigure[:LTE]:UL:PUCCh:DESHift <Shift>

This command defines the delta shift of the PUCCH.

Parameters:

<Shift> <numeric value>

Range: 1 to 3

*RST: 2

Example: `CONF:UL:PUCC:DESH 3`

Sets the delta shift of the PUCCH to 3.

CONFigure[:LTE]:UL:PUCCh:N1CS <N1cs>

This command defines the N(1)_cs of the PUCCH.

Parameters:

<N1cs> <numeric value>

*RST: 6

Example: `CONF:UL:PUCC:N1CS 4`
Sets N(1)_cs to 4.

CONFigure[:LTE]:UL:PUCCh:N2RB <N2RB>

This command defines the N(2)_RB of the PUCCH.

Parameters:
<N2RB> <numeric value>
*RST: 1

Example: `CONF:UL:PUCC:N2RB 2`
Sets N2_RB to 2.

CONFigure[:LTE]:UL:PUCCh:FORMat <Format>

This command selects the PUCCH format.

Note that formats 2a and 2b are available for normal cyclic prefix length only.

Parameters:
<Format> **F1N (F1 normal)**
F1S (F1 shortened)
F1AN (F1a normal)
F1AS (F1a shortened)
F1BN (F1b normal)
F1BS (F1b shortened)
F2 (F2)
F2A (F2a)
F2B (F2b)
F3 (F3)
*RST: F1N

Example: `CONF:UL:PUCC:FORM F1N`
Sets the PUCCH format to F1 normal.

CONFigure[:LTE]:UL:PUCCh:NPAR <NPUCCH>

This command defines the N_PUCCH parameter in the PUCCH structure settings.

Parameters:
<NPUCCH> <numeric value>
<numeric value>
SUBF
Selects the definition of N_PUCCH on subframe level.
*RST: 0

Example: `CONF:UL:PUCC:NPAR 2`
Sets N_PUCCH to 2.

9.8.3.5 Defining the PRACH Structure

CONFigure[:LTE]:UL:PRACh:APM <State>

This command turns automatic preamble mapping for the PRACH on and off.

Parameters:
<State> ON | OFF

Example: `CONF:UL:PRAC:APM ON`
Turns automatic preamble mapping on.

CONFigure[:LTE]:UL:PRACh:CONF <Configuration>

This command selects the PRACH preamble format.

Parameters:
<Configuration> <numeric value>

Example: `CONF:UL:PRAC:CONF 2`
Selects PRACH configuration 2.

CONFigure[:LTE]:UL:PRACh:RSET <State>

This command turns the restricted preamble set for PRACH on and off.

Parameters:
<State> ON | OFF
*RST: OFF

Example: `CONF:UL:PRAC:RSET ON`
Turns the restricted set on.

CONFigure[:LTE]:UL:PRACh:FOFFset <Offset>

This command defines the PRACH frequency offset.

The command is available for preamble formats 0 to 3.

Parameters:
<Offset> Resource block offset.

Example: `CONF:UL:PRAC:FOFF 5`
Defines a frequency offset of 5 resource blocks.

CONFigure[:LTE]:UL:PRACh:NCSC <Configuration>

This command defines the Ncs configuration for the PRACH.

Parameters:
<Configuration> <numeric value>

Example: `CONF:UL:PRAC:NCSC 1`
Selects Ncs configuration 1.

CONFigure[:LTE]:UL:PRACh:RSEQ <RootSeqIdx>

This command defines the PRACH logical root sequence index.

Parameters:
<RootSeqIdx> <numeric value>

Example: `CONF:UL:PRAC:RSEQ 2`
Selects logical root sequence index 2.

CONFigure[:LTE]:UL:PRACh:SINDex <Index>

This command selects the PRACH sequence index.

Parameters:
<Index> **<IndexValue>**
Number that defines the index manually.
AUTO
Automatcailly determines the index.

Example: `CONF:UL:PRAC:SIND 2`
Selects sequence index 2.

CONFigure[:LTE]:UL:PRACh:FRINdex <FRINdex>

This command selects the PRACH frequency index.

Parameters:
<FRINdex> <numeric value>

Example: `CONF:UL:PRAC:FRIN 10`
Selects the frequency index 10.

CONFigure[:LTE]:UL:PRACh:HFINdicator <HFINdicator>

This command defines the PRACH half frame indicator.

Parameters:
<HFINdicator> <numeric value>

Example: `CONF:UL:PRAC:HFIN 5`
Selects half frame indicator 5.

9.8.3.6 Defining Global Signal Characteristics

CONFigure[:LTE]:UL:UEID <ID>

Sets the radio network temporary identifier (RNTI) of the UE.

Parameters:
<ID> <numeric value>
*RST: 0

Example: `CONF:UL:UEID 2`
Sets the UE ID to 2.

9.9 Configuring the Software

CONFigure:PRESet

Initiates a preset to the default state of the software, and, if connected to an analyzer, also presets the analyzer.

Example: `CONF:PRES`
Presets the software.

Usage: Event

DISPlay[:WINDow<n>]:SELect

This command selects the measurement window.

Example: `DISP:WIND2:SEL`
Selects screen B.

Usage: Event

9.10 Managing Files

FORMat[:DATA] [<Format>]

This command specifies the data format for the data transmission between the LTE measurement application and the remote client. Supported formats are ASCII or REAL32.

Parameters:

<Format> ASCii | REAL

*RST: ASCii

Example: `FORM REAL`

The software will send binary data in Real32 data format.

MMEMory:LOAD:DEModsetting <Path>

This command restores previously saved demodulation settings.

The file must be of type "*.allocation" and depends on the link direction that was currently selected when the file was saved. You can load only files with correct link directions.

Setting parameters:

<Path> String containing the path and name of the file.

Example: `MMEM:LOAD:DEM 'D:\USER\Settingsfile.allocation'`

Usage: Setting only

MMEMory:LOAD:IQ:STATe <Path>

This command restores I/Q data from a file.

Parameters:

1

Setting parameters:

<Path> String containing the path and name of the source file.

Example:
```
MMEM:LOAD:IQ:STAT 1,'C:
\R_S\Instr\user\data.iq.tar'
```
Loads IQ data from the specified file.

Usage: Setting only

MMEMory:STORe:DEModsetting <Path>

Stores the current demodulation settings to a file. The resulting file type is "*.allocation". Existing files will be overwritten.

Setting parameters:
<Path>

Example: `MMEM:STOR:DEM 'D:\USER\Settingsfile.allocation'`

Usage: Setting only

List of Commands

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