

R&S®ViCom

Interface for R&S TSM Instruments

User Manual



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This manual describes the R&S®ViCom version 15.65.

The software contained in this product makes use of several valuable open source software packages. For information, see the "Open Source Acknowledgment" on the user documentation CD-ROM (included in delivery).

Rohde & Schwarz would like to thank the open source community for their valuable contribution to embedded computing.

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The following abbreviations are used throughout this manual: R&S®ViCom is abbreviated as R&S ViCom, R&S®TSMx is abbreviated as R&S TSMx, R&S®TSMW is abbreviated as R&S TSMW, R&S®TSME is abbreviated as R&S TSME, R&S®TSMA is abbreviated as R&S TSMA.

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 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.

Safety labels on products

The following safety labels are used on products to warn against risks and dangers.

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

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Symbol	Meaning	Symbol	Meaning
	Caution ! Hot surface		Alternating current (AC)
	Protective conductor terminal To identify any terminal which is intended for connection to an external conductor for protection against electric shock in case of a fault, or the terminal of a protective earth		Direct/alternating current (DC/AC)
	Earth (Ground)		Class II Equipment to identify equipment meeting the safety requirements specified for Class II equipment (device protected by double or reinforced insulation)
	Frame or chassis 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 additional 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.



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



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



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



Indicates information considered important, but not hazard-related, e.g. messages relating to property damage.

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.

Basic Safety Instructions

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 $\pm 10\%$ shall apply to the nominal voltage and $\pm 5\%$ to the nominal frequency, overvoltage category 2, pollution degree 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 mains-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 mains, or if the power switch is not suitable for this purpose, use the plug of the connecting cable to disconnect the product from the mains. 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.

Basic Safety Instructions

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 IEC 60950-1 / EN 60950-1 or IEC 61010-1 / 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.

Basic Safety Instructions

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 EN 55011/CISPR 11, and analogously with EN 55022/CISPR 22, EN 55032/CISPR 32)
 - Class A equipment:
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
Note: Class A equipment is intended for use in an industrial environment. This equipment may cause radio disturbances in residential environments, due to possible conducted as well as radiated disturbances. In this case, the operator may be required to take appropriate measures to eliminate these disturbances.
 - Class B equipment:
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.

Basic Safety Instructions

- 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.

- Cells must not be taken apart or crushed.
- 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.
- 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.
- Cells and batteries must not be exposed to any mechanical shocks that are stronger than permitted.
- 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.
- 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.
- 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

- 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.
- 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.
- 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.

Instrucciones de seguridad elementales

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 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.















Instrucciones de seguridad elementales

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.

Señalización de seguridad de los productos

Las siguientes señales de seguridad se utilizan en los productos para advertir sobre riesgos y peligros.

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.

Instrucciones de seguridad elementales

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.



Indica una situación de peligro que, si no se evita, causa lesiones graves o incluso la muerte.



Indica una situación de peligro que, si no se evita, puede causar lesiones graves o incluso la muerte.



Indica una situación de peligro que, si no se evita, puede causar lesiones leves o moderadas.



Indica información que se considera importante, pero no en relación con situaciones de peligro; p. ej., avisos sobre posibles daños materiales.

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.

Instrucciones de seguridad elementales

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 $\pm 10\%$ sobre el voltaje nominal y de $\pm 5\%$ 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.

Instrucciones de seguridad elementales

6. Solamente está permitido el funcionamiento en redes de alimentación TN/TT aseguradas con fusibles de 16 A como máximo (utilización de fusibles de mayor amperaje solo previa consulta con el grupo de empresas Rohde & Schwarz).
7. Nunca conecte el enchufe en tomas de corriente sucias o llenas de polvo. Introduzca el enchufe por completo y fuertemente en la toma de corriente. La no observación de estas medidas puede provocar chispas, fuego y/o lesiones.
8. No sobrecargue las tomas de corriente, los cables alargadores o las regletas de enchufe ya que esto podría causar fuego o choques eléctricos.
9. En las mediciones en circuitos de corriente con una tensión $U_{\text{eff}} > 30 \text{ V}$ se deberán tomar las medidas apropiadas para impedir cualquier peligro (p. ej. medios de medición adecuados, seguros, limitación de tensión, corte protector, aislamiento etc.).
10. Para la conexión con dispositivos informáticos como un PC o un ordenador industrial, debe comprobarse que éstos cumplan los estándares IEC60950-1/EN60950-1 o IEC61010-1/EN 61010-1 válidos en cada caso.
11. A menos que esté permitido expresamente, no retire nunca la tapa ni componentes de la carcasa mientras el producto esté en servicio. Esto pone a descubierto los cables y componentes eléctricos y puede causar lesiones, fuego o daños en el producto.
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.

Instrucciones de seguridad elementales

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 señalar 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 de compatibilidad electromagnética (conforme a EN 55011 / CISPR 11; y en analogía con EN 55022 / CISPR 22, EN 55032 / CISPR 32)
 - Aparato de clase A:
Aparato adecuado para su uso en todos los entornos excepto en los residenciales y en aquellos conectados directamente a una red de distribución de baja tensión que suministra corriente a edificios residenciales.
Nota: Los aparatos de clase A están destinados al uso en entornos industriales. Estos aparatos pueden causar perturbaciones radioeléctricas en entornos residenciales debido a posibles perturbaciones guiadas o radiadas. En este caso, se le podrá solicitar al operador que tome las medidas adecuadas para eliminar estas perturbaciones.
 - Aparato de clase B:
Aparato adecuado para su uso en entornos residenciales, así como en aquellos conectados directamente a una red de distribución de baja tensión que suministra corriente a edificios residenciales.

Instrucciones de seguridad elementales

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.

Instrucciones de seguridad elementales

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, dirijase 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.

Quality management and environmental management

Certified Quality System
ISO 9001

Certified Environmental System
ISO 14001

Sehr geehrter Kunde,

Sie haben sich für den Kauf eines Rohde&Schwarz Produktes entschieden. Sie erhalten damit ein nach modernsten Fertigungsmethoden hergestelltes Produkt. Es wurde nach den Regeln unserer Qualitäts- und Umweltmanagementsysteme entwickelt, gefertigt und geprüft. Rohde&Schwarz ist unter anderem nach den Managementsystemen ISO9001 und ISO 14001 zertifiziert.

Der Umwelt verpflichtet

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

Dear customer,

You have decided to buy a Rohde&Schwarz product. This product has been manufactured using the most advanced methods. It was developed, manufactured and tested in compliance with our quality management and environmental management systems. Rohde&Schwarz has been certified, for example, according to the ISO9001 and ISO 14001 management systems.

Environmental commitment

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

Cher client,

Vous avez choisi d'acheter un produit Rohde&Schwarz. Vous disposez donc d'un produit fabriqué d'après les méthodes les plus avancées. Le développement, la fabrication et les tests de ce produit ont été effectués selon nos systèmes de management de qualité et de management environnemental. La société Rohde&Schwarz a été homologuée, entre autres, conformément aux systèmes de management ISO 9001 et ISO 14001.

Engagement écologique

- Produits à efficience énergétique
- Amélioration continue de la durabilité environnementale
- Système de management environnemental certifié selon ISO 14001



Customer Support

Technical support – where and when you need it

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

Up-to-date information and upgrades

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

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1 Conventions Used in the Documentation

The following conventions are used throughout the R&S ViCom Interface Operating Manual:

Typographical conventions

Convention	Description
"Graphical user interface elements"	All names of graphical user interface elements both on the screen and on the front and rear panels, such as dialog boxes, soft keys, menus, options, buttons etc., are enclosed by quotation marks.
"KEYS"	Key names are written in capital letters and enclosed by quotation marks.
Input	Input to be entered by the user is displayed in italics.
File names, commands, program code	File names, commands, coding samples and screen output are distinguished by their font.
"Links"	Links that you can click are displayed in blue font.
"References"	References to other parts of the documentation are enclosed by quotation marks.

Other conventions

- **Remote commands:** Remote commands may include abbreviations to simplify input. In the description of such commands, all parts that have to be entered are written in capital letters. Additional text in lower-case characters is for information only.
- **Procedure descriptions:** When describing how to operate the device, several alternative methods may be available to perform the same task. In this case, the procedure using the touch screen is described, where available. Any elements that can be activated by touching can also be clicked using an additionally connected mouse. The alternative procedure using the keys on the device or the on-screen keyboard is only described if it deviates from the standard operating procedures as described in the Quick Start Guide under "Basic Operations".

The terms "**select**" and "**press**" may refer to any of the described methods, i.e. using a finger on the touch screen, a mouse pointer in the display, or a key on the device or on a keyboard.

2 Important Notes

In this document, the name R&S TSM Instruments stands for:

- R&S TSMx Family (R&S TSML models, R&S TSMM, R&S TSMQ, R&S TSMU)
- R&S TSMW
- R&S TSME

Differences in handling between the R&S TSMW and R&S TSME and the R&S TSMx Family on the another hand are mentioned in the chapters directly.

2.1 References

The R&S TSM Instruments manuals may be found on the CD-ROM accompanying the instrument.

1. R&S TSML Operating Manual
2. R&S TSMU/Q Operating Manual
3. R&S TSMW Operating Manual
4. R&S TSME User Manual
5. R&S TSMA User Manual
6. R&S ROMES Coverage Measurement Software (Online Help)
7. 3GPP TS 21.905 v5.x.x Technical Terms and Abbreviations
8. 3GPP TS 24.008 Mobile radio interface Layer 3 specification
9. 3GPP TS 25.101 v5.x.x User Equipment Radio Transmission and Reception (FDD)
10. 3GPP TS 25.105 Base Station (BS) radio transmission and reception (TDD)
11. 3GPP TS 25.215 v5.x.x Physical Layer Measurements (FDD)
12. 3GPP TS 25.331 v5.x.x Radio Resource Control Protocol Specification
13. 3GPP TS 36.331 E-UTRA Radio Resource Control (RRC)
14. IEEE Std 802.16™-2009 Air Interface for Broadband Wireless Access Systems

2.2 Key to Technical Terms

Abbreviation	Meaning
A-GPS	Assisted GPS
BCD	Binary Coded Decimal

Abbreviation	Meaning
BCH	Broadcast Channel. See Reference 4 on CD-ROM
BTS	Base Transceiver Station
CDMA	Code Division Multiple Access
CIR	Channel Impulse Response
C-PICH	See Reference 4 on CD-ROM.
DLL	Dynamic Linked Library
EVDO	Evolution Data Optimized
E-UTRA	Evolved Universal Terrestrial Radio Access
FDD	Frequency Division Duplex
Firewire	See IEEE1394.
FPGA	Field Programmable Gate Array
GSM	Global System for Mobile communications
GPS	Global Positioning System
IEEE1394	Used interchangeably with Firewire. Fast connection specified by IEEE 1394.
LTE	Long Term Evolution
OEM	Original Equipment Manufacturer
OHCI	Open Host Controller Interface
OTDOA	Observed Time Difference Of Arrival
PPS	Pulse Per Second
P-SYNC	Primary Synchronisation code transmitted on the UMTS Primary Synchronization Channel (PSCH)
PSCH	Primary Synchronisation Channel
RMS	Root Mean Square
R&S	Rohde & Schwarz GmbH & Co. KG
R&S TSME	Ultra Compact Drive Test Receiver R&S TSME
R&S TSML-CW	Radio Network Analyzer R&S TSML-CW (RF Continuous Wave measurements (CW))
R&S TSML-G	Radio Network Analyzer R&S TSML-G (GSM)
R&S TSML-C	Radio Network Analyzer R&S TSML-C (IS95/CDMA 2000)
R&S TSML-E	Radio Network Analyzer R&S TSML-E (CDMA2000 EV-DO)
R&S TSML-W	Radio Network Analyzer R&S TSML-W (WCDMA)
R&S TSMQ	Radio Network Analyzer R&S TSMQ (Multi Tech)
R&S TSMU	Radio Network Analyzer R&S TSMU (Single Tech)

Abbreviation	Meaning
R&S TSMW	High-End Radio Network Analyzer R&S TSMW (Multi Tech)
R&S TSMx Family	Signifies any of the R&S TSML-W, R&S TSML-C, R&S TSML-G, R&S TSML-CW, R&S TSML-E, R&S TSML-GW, R&S TSMU or R&S TSMQ.
SC	Scrambling Code
SIB	System Information Block
SSCH	Secondary Synchronisation Channel
TDD	Time Division Duplex
TD-SCDMA	Time Division Synchronous CDMA
UMTS	Universal Mobile Telecommunications System
UTRA	UMTS Terrestrial Radio Access
WCDMA	Wideband CDMA
WiMAX	Worldwide Interoperability for Microwave Access

3 General Description

This document describes the R&S ViCom software interface for R&S TSM Instruments. Using the R&S ViCom interface, developers can easily integrate the R&S TSM Instruments into their own Coverage Measurement Software applications as a kind of OEM receiver. The R&S TSM Instruments offer solutions for various kinds of mobile radio network technologies, e.g. GSM, WCDMA, TD-SCDMA, CDMA2000, EVDO, LTE, WiMAX and CW (RF Power Measurement). For more details about the R&S TSM Instruments, refer to manuals mentioned in [Chapter 2.1, "References"](#), on page 14.

The R&S ViCom interface allows you to:

- Set up an R&S TSM Instrument connection
- Set up measurement commands
- Start and stop measurements from the R&S TSM Instrument
- Retrieve measurement results
- Get error information
- Generate log files

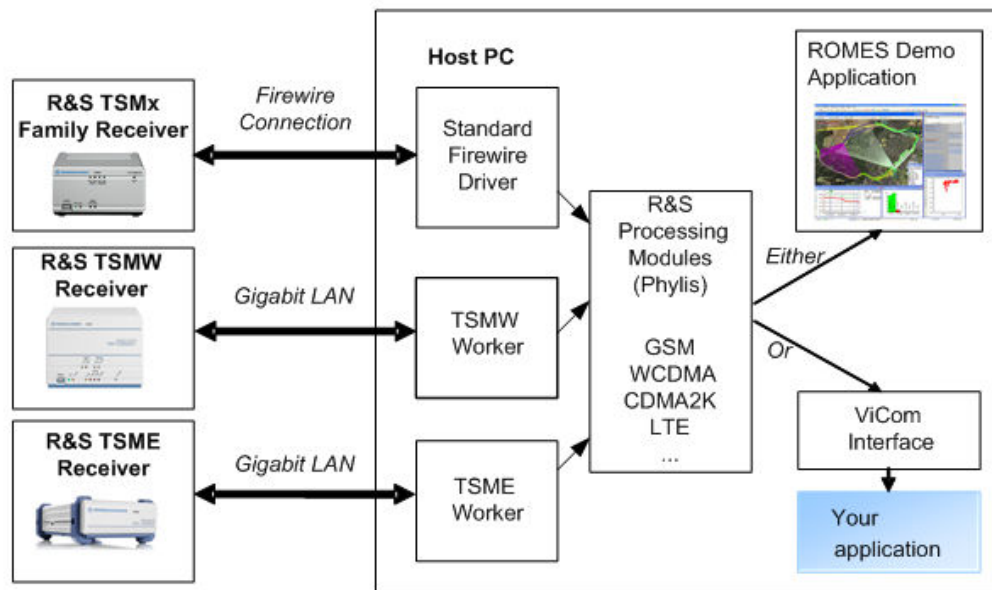


Figure 3-1: System overview of the software modules on the controlling computer

- [Configuration](#).....18
- [R&S TSM Instruments Product Family](#) 20

3.1 Configuration

3.1.1 Setup an R&S TSM Instrument Connection

The hardware configuration is quite straightforward.

The control computer is connected to an R&S TSMx Family Receiver with an IEEE1394 (FireWire) connection. A Windows device driver available from Rohde & Schwarz handles communication with the R&S TSMx Family receivers.

In case of the R&S TSMW and R&S TSME, the instruments are connected with a standard LAN cable. This must support Gigabit LAN and should therefore be at least a Cat5 cable.

The R&S TSMW / R&S TSME is connected to a PC or Laptop via an Ethernet (LAN) connection on the rear panel.

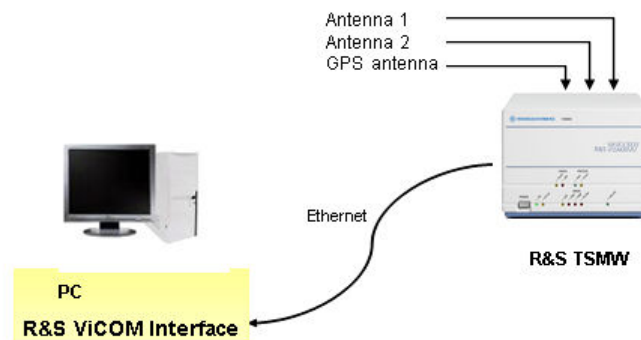


Figure 3-2: Hardware setup

The R&S TSMW has two frontends, each with a corresponding antenna connection on the rear panel (RF1 and RF2). The user can also make use of the built-in GPS receiver by connecting a GPS antenna to the R&S TSMW / R&S TSME using the connector on the rear panel.

These connections for R&S TSMW case are shown in the following figure.



Figure 3-3: R&S TSMW Rear Panel

The R&S TSME has one frontend with a corresponding antenna connection on the rear panel (RF1), see the following figure.



Figure 3-4: R&S TSME Rear Panel

The R&S TSMW has the default IP address 192.168.0.2.

The R&S TSME is identified similar to the R&S TSMx Family, i.e. by using the receiver index to get an IP address from the list of available IP addresses.

To connect to the R&S TSMW / R&S TSME, a network connection on the PC should be configured with a suitable host IP address (e.g. 192.168.0.1). However if several R&S Instruments are connected to the same host PC in a network, each instrument must have unique IP address.

After connecting the R&S TSMW / R&S TSME and configuring the host, the connection can be checked by opening a web browser and entering the IP address of the R&S TSMW / R&S TSME. A HTML page will be displayed showing details of the R&S TSMW / R&S TSME, the current firmware, etc.

3.1.2 R&S ViCom Interface Functions






The R&S ViCom interface includes C++ functions and data structures to control and manage the R&S TSM Instruments. The exact content of the R&S ViCom interface depends upon which model of the R&S TSM Instrument is going to be used by the application.






A group of basic R&S ViCom functions, that are common to all R&S TSM Instruments, is present in every R&S ViCom interface. Other R&S ViCom functions depend on the R&S TSM Instruments model, and may not be present in every R&S ViCom interface. R&S TSM Instruments control software includes libraries that are required by the R&S ViCom interface.

3.2 R&S TSM Instruments Product Family

The R&S TSM Instruments product family contains several different devices, each having some significant features making them suitable for different measurement situations. All instruments supported by the R&S ViCom API and the differences are listed in the table shown below.

Table 3-1: R&S TSM Instruments Capabilities Matrix

Device type	R&S TSMU 	R&S TSMQ 	R&S TSML-G TSML-C TSML-W	R&S TSML- CW 	R&S TSMW 	R&S TSME 
Connection	Firewire	Firewire	Firewire	Firewire	LAN	LAN
Min. Frequency	80 MHz	80 MHz	80 MHz	80 MHz	30 MHz	350 MHz
Max. Frequency	3 GHz	3 GHz	3 GHz	6 GHz	6 GHz	4,4 GHz
Resolution Bandwidth	10 kHz	10 kHz	10 kHz	10 kHz	140 Hz	140 Hz
RAKE Receivers	2500	2500	512 ^{1),2)}	-	Limited by SW only	Limited by SW only
High Speed Mode	-	✓	-	-	✓	✓
Parallel Measurements	-	✓	-	-	✓	✓
Max. Measurement Speed (Single Mode)		333 Hz (WCDMA)	40 Hz ¹⁾ 10 Hz ²⁾	625 Hz	-	-
Supported technologies:						
GSM	✓	✓	(✓) ¹⁾	-	✓	✓
WCDMA	✓	✓	(✓) ²⁾	-	✓	✓

Device type	R&S TSMU 	R&S TSMQ 	R&S TSML-G TSML-C TSML-W	R&S TSML- CW 	R&S TSMW 	R&S TSME 
CDMA / EVDO	✓	✓	(✓)	-	✓	✓
LTE	-	-	-	-	✓	✓
CW	✓	✓	-	✓	-	-
RF Power Scan	✓	✓	✓	✓	✓	✓
RS 232	✓	✓	✓	-	-	-
WIMAX	-	-	-	-	✓	✓
TD-SCDMA	-	-	-	-	✓	✓

1) only R&S TSML-G

2) only R&S TSML-W and R&S TSML-C

The type of R&S TSM Instruments can be assigned during the usage of the R&S ViCom API and once the initial setup has been performed. The `SConnectedReceiver` structure contains the type descriptor of the connected instrument. It can be requested using the `GetConnectedReceivers()` method of the basic R&S ViCom interface, after the `ViComLoader` has been used to load an interface successfully.

3.2.1 Technology Specific Features

Some of the functionality that is specified to a certain technology API differs in the same way as described above for different devices.

3.2.1.1 WCDMA

The WCDMA Technology R&S ViCom API changes several constants and thresholds depending on used instrument:

- Maximum number of channels that can be measured sequentially in an active measurement
- Maximum measurement rates, where different limits are set for high speed and high dynamic mode
- Certain minimum E_c/I_0 must be measured to start the demodulation process; this limit varies with the device used

R&S Instruments	R&S TSMU	R&S TSMQ	R&S TSML-W	R&S TSMW	R&S TSME
Max. Number of Channels	32	32	6	32	32
Max. Measurement Rate in High Dynamic Mode (with BCH Demodulation)	12 Hz	12 Hz	10 Hz	12 Hz	80 Hz
Max. Measurement Rate in High Speed Mode (with BCH Demodulation)	20 Hz	50 Hz	10 Hz	200 Hz	300 Hz
Min. Ec/Io threshold for demodulation	-20 dB	-25 dB	-10 dB	-25 dB	-20 dB

3.2.1.2 GSM

A maximum value for the measurement rate can be specified via the GSM Technology R&S ViCom API. The maximum value depends on the model of the instrument.

In the case of the R&S TSML models the values are reduced in all cases.

R&S Instruments	R&S TSMU	R&S TSMQ	R&S TSML-G	R&S TSMW	R&S TSME
Max. Measurement Rate	80 Hz	100 Hz	40 Hz	500 Hz	800 Hz

3.2.1.3 CDMA / EVDO

The part of the settings in the CDMA / EVDO Technology R&S ViCom API that depend on the instrument model are basically the same as the ones defined for WCDMA. The only difference is that there is no High Dynamic and High Speed Mode available. Therefore, only one maximum measurement rate is available; see the following table.

R&S Instruments	R&S TSMU	R&S TSMQ	R&S TSML-C	R&S TSMW	R&S TSME
Max. Number of Channels	32	32	6	32	32
Max. Measurement Rate for CDMA	12 Hz	12 Hz	12 Hz	80 Hz	70 Hz
Max. Measurement Rate for EVDO	12 Hz	12 Hz	12 Hz	30 Hz	20 Hz
Min. Ec/I0 threshold for demodulation	-20 dB	-25 dB	-10 dB	-13 dB	-13 dB

3.2.1.4 LTE

The LTE Technology R&S ViCom API does not offer support for the R&S TSMx Family.

There are three scanner algorithms

- Narrowband (NB)
- Wideband (WB)
- MIMO

Due to that there are three different measurement rates.

R&S Instruments	R&S TSMW	R&S TSME
Max. Number of Channels	32	32
Max. Measurement Rate NB (with BCH Demodulation)	200 Hz	330 Hz
Max. Measurement Rate WB	6 Hz	100 Hz
Max. Measurement Rate MIMO	6 Hz	-

R&S ViCom specifies the measurement rate as blocks/sec.

One block (100 ms) contains up to 20 sync signals.

Therefore, a setting of 16.5 means 330 sync signals per sec = 330 Hz.

3.2.1.5 WiMAX

The WiMAX Technology R&S ViCom API does not offer support for the R&S TSMx Family.

R&S Instruments	R&S TSMW	R&S TSME
Max. Number of Channels	32	323
Max. Measurement Rate	14,5 Hz	14,5 Hz

3.2.1.6 TD-SCDMA

The TD-SCDMA Technology R&S ViCom API does not offer support for the R&S TSMx Family.

R&S Instruments	R&S TSMW	R&S TSME
Max. Number of Channels	32	32
Max. Measurement Rate in High Dynamic Mode	8 Hz	20 Hz
Max. Measurement Rate in High Speed Mode	20 Hz	80 Hz

4 Getting Started

To get started R&S ViCom you need the Programming Demo application(s) along with the R&S ViCom Interface and R&S TSM Instruments control software. The Programming Demo application demonstrates the basic functionality of the R&S ViCom interface(s).

- [What you need](#)..... 24
- [Prerequisites](#)..... 29
- [Diagnostics Information](#)..... 30
- [Getting Started with R&S TSME](#)..... 32

4.1 What you need

4.1.1 Hardware Requirements

- Host PC or laptop requirements:
 - Running operating system: Microsoft Windows 7 (any edition, 32/64 bit)
 - Minimum recommended CPU: Core i5 (5th generation)
 - Connection: FireWire or Ethernet, depending on the used scanner model
- R&S TSM Instruments:
 - R&S TSMx Family receiver with OEM option(s) (R&S TSMU-K3x), with power cable for the R&S TSM Instruments (included in the R&S TSM Instruments shipment)
 - 12 V/1 ADC power supply (not included, for example R&S TSML-Z1, R&S TSMU-Z1)
 - FireWire cable (6-6 pin connector and 6-4 pin connectors are included)
 - Optional: For diagnostics an RS232 cable, with adapter if necessary, to connect to the control computer (null modem cable, not included)
 - Optional: Synchronizing the R&S TSM Instruments' internal clock from an external source via the 1PPS input connector. An appropriate connection cable/divider is needed that will output 1PPS (not included, e.g. R&S accessory TS-PNSYNC Ident. Nr. 1114.4817.02), see the following chapter
- R&S TSMW and R&S TSME with OEM option(s) requirements:
 - A Gigabit Ethernet (min. Cat5) cable to connect PC and R&S TSMW or R&S TSME
 - Power supply
 - Optionally a GPS antenna
- Antenna or standard RF connection

4.1.1.1 Synchronizing the R&S TSM Instruments Internal Clock from an External Source

The R&S TSM Instruments have an internal clock. However, the instruments will normally try to synchronize to an external source, to improve the accuracy of measurements.

If a GSM / WCDMA signal is available, the R&S TSM Instruments will normally synchronize to this via its antenna. However, if the scanner is being used with a signal generator, or if a high-precision GPS PPS reference is available, the R&S TSM Instruments may be synchronized via the PULSE IN connector on the back panel.

R&S TSM Instruments accept an incoming frequency reference of 1 pulse per second (PPS) via the PULSE IN connector. The reference frequency of the signal generator is typically 10 MHz. In such cases a divider is necessary to be connected between the reference output of the signal generator and the PULSE IN input connector of the R&S TSM Instrument.

A divider is available from Rohde & Schwarz, TS-PNSYNC Synchronization Unit for PN Scanner, part number 1114.4817.02.

4.1.2 Software Requirements

The complete R&S ViCom interface dataset can be download from the Rohde & Schwarz homepage.

Store the R&S ViCom interface package in a local directory `... \ViCom`.

The R&S ViCom folder contains a setup executable `setup-RS-ViCom-<version>.exe` (for the current version it is `setup-RS-ViCom-15.51.0.0.exe`) which installs the R&S ViCom interface development kit on a PC.

After running the `setup-RS-ViCom-<version>.exe` the following components have been installed on the PC in the default directory `C:\RuS\ViCom_<version>`:

- R&S ViCom interface header files ("inc" folder)
- R&S ViCom interface binary files ("bin" folder)
- R&S ViCom Sample Applications ("src" folder)
- R&S ViCom Manual and another referencing manual, and HTML API Reference ("doc" folder)
- R&S ViCom Tools ("tools" folder)

The "tools" folder contains the following subfolders:

- TSME (including ping `setup-RS-TsmeTools-1.3.3.6.exe` file)
- TSMW (Firmware utility)
- TSMx
 - R&S TSMx Firmwareinstaller utility
 - TSMx DriverInstall
 - R&S TSMx IEEE1394 (FireWire) device driver install utility
 - R&S TSMx OptionKeyInstaller utility

The R&S ViCom depends on the Microsoft Visual C++ runtime libraries for Visual Studio 2008 SP1 and Visual Studio 2013. The required redistributable files are located in `...\tools\vc_redist_x86_2013_0.exe`.

The "R&S ViCom Interface for R&S TSM Instruments" manual and other manuals can be accessed via a shortcut in the Windows start menu "Start > Programs > R&S ViCom > ViCom <version>".

With an internet browser, the internal configuration web page of the R&S TSMW can be viewed using the IP address (default is 192.168.0.2). See appendix for more details.

4.1.3 Installing the R&S ViCom Interface Dataset and Demo Applications

Double click the executable file `RS-ViCom-<version>.exe` file you find in the installation directory, e.g. `C:\ViCom\`.

The setup installs the R&S ViCom Interface dataset, available test application(s) and instrument utilities including the OptionKeyInstaller and IEEE1394 device driver installer. If the standard instructions are followed, a RuS directory will be created.

4.1.3.1 R&S ViCom Interface Files

C++ Namespaces are used for the R&S ViCom interface in general and for each technology interface in particular.

The ViCom interface is inside the **RohdeSchwarz::ViCom** namespace with nested namespaces for every specific interface.

All data structures contained in interface classes are part of the RohdeSchwarz::ViCom:Xxx namespace, e.g. RohdeSchwarz::ViCom::LTE for LTE.

Load handling has two variants, one with `CVicomError` return parameter and one without `CVicomError`, throwing an exception instead of returning a `CVicomError`.

The R&S ViCom API can only be used when a specific set of files is installed on the target machine. In this section, the list is given. For each technology, there are some specific DLLs that are required only for the technology besides a basic set of files

General Files

These files are necessary to run any of the supported technologies.

To run the R&S ViCom specific technology API and/or the BCCH demodulator, the list of the general (i.e. common) files is completed with the needed files for that technology. The common and technology specific files are listed in the following tables.

Table 4-1: Common Files

Dynamic Libraries	Supporting Files	Header Files
AppSpecificRuSLogFileInterface.dll	ELF (Firmware) Files:	ViComBasicErrors.h
CMS_IMD.dll	TSMx_Application.elf	ViComBasicInterface.h
CMSDecCDMA.dll	tsme_xxxxxxx.bin	ViComBasicInterfaceData.h
CMSDecGPRS.dll	TsmeBitFileInfo.txt	ViComError.h
FFTW.DLL	LteMimoScannerRsCinrEstimators.hex	ViComLoader.h
IMD_Base.dll	PEC Files:	ViComDataProcessor.h
k1394api.dll	TSMUFrames.pec	
libfftw3-3.dll	TSMWFrames.pec	
libfftw3f-3.dll	Microsoft Libraries:	
log4cxx.dll	Visual C++ Runtime Libraries	
ModulePool.dll	Configurariion Files:	
PhylisCrashReport.dll	PhylisKernalRuntimeRouting.txt	
PhylisEnvironmentInfoProvider.dll	ProcessIdent.txt	
PhylisFilterDesigner.dll		
PhylisKernelMessageModule.dll		
PhylisLowLevelErrorMessageHandler.dll		
PhylisTimer.dll		
RSToolbox.dll		
SampleForErrorHandler.dll		
ServiceExtension_TSME.dll		
SpectrumWorker.dll		
TsmeAdmin.dll		
TsmeParameters.dll		
TsmeResultProcessor.dll		
TsmeRfBoardInternals.dll		
TsmeTools.dll		
TsmeWorker.dll		
TsmuWorker.dll		
TsmwAdmin.dll		
TSMWSpectrum.dll		
TSMWWorker.dll		
UmtsL3DeclfcMod.dll		
ViComResourceManager.dll		
ViComLoaderManager.dll		

To run the R&S ViCom specific technology API and/or the BCCH demodulator, the list of common files is completed with the following entries.

Table 4-2: R&S ViCom WCDMA Technology related Interface Files

Dynamic Libraries	Header Files
UmmtsDemodulator.dll	ViComWcdmaErrors.h
UmstPnsOption2.dll	ViComWcdmaInterface.h
ViComWCDMA.dll	ViComWcdmaInterfaceData.h
ViComWCDMAe.dll	
ViComWCDMAw.dll	

Table 4-3: R&S ViCom GSM Technology related Interface Files

Dynamic Libraries	Header Files
GS3Worker.dll	ViComGSMErrors.h
GsmDemodulator.dll	ViComGSMInterface.h
ViComGSM.dll	ViComGSMInterfaceData.h
ViComGSM.e.dll	
ViComGSM.w.dll	

Table 4-4: R&S ViCom CDMA / EVDO Technology related Interface Files

Dynamic Libraries	Header Files
Cdma2000Pns.dll	ViComCdmaErrors.h
C2kDemodulator.dll	ViComCdmaInterface.h
EvdoPns.dll	ViComCdmaInterfaceData.h
EvdoDemodulator.dll	
ViComCdma.dll	
ViComCDMAe.dll	
ViComCDMAw.dll	

Table 4-5: R&S ViCom LTE Technology related Interface Files

Dynamic Libraries	Header Files
LteDemodulator.dll	ViComLteErrors.h
LteScanner.dll	ViComLteInterface.h
ViComLTEw.dll	ViComLteInterfaceData.h
ViComLTee.dll	
LteMimoScanner.dll	

Table 4-6: R&S ViCom WiMAX Technology related Interface Files

Dynamic Libraries	Header Files
WiMaxDemodulator.dll	ViComWiMaxErrors.h
ViComWIMAXe.dll	ViComWiMaxInterface.h
ViComWIMAXw.dll	ViComWiMaxInterfaceData.h
WiMaxScanner.dll	
WiMaxScannerSync.dll	

Table 4-7: R&S ViCom RF Power Scan Technology related Interface Files

Dynamic Libraries	Header Files
ViComRFPOWERSCANe.dll	ViComRFScanErrors.h
ViComRFPOWERSCANw.dll	ViComRFScanInterface.h
ViComRFScan.dll	ViComRFScanInterfaceData.h
	ViComRFPowerScanErrors.h
	ViComRFPowerScanInterface.h
	ViComRFPowerScanInterfaceData.h

Table 4-8: R&S ViCom TD-SCDMA Technology related Interface Files

Dynamic Libraries	Header Files
TDSCdmaDemodulator.dll	ViComTdScdmaErrors.h
TDSCdmaScanner.dll	ViComTdScdmaInterface.h
ViComTDSCDMAe.dll	ViComTdScdmaInterfaceData.h
ViComTDSCDMAw.dll	

Table 4-9: R&S ViCom CW Technology related Interface Files

Dynamic Libraries	Header Files
ViComCW.dll	ViComCWErrors.h
	ViComCWInterface.h
	ViComCWInterfaceData.h

Table 4-10: R&S ViCom GPS related Interface Files

Dynamic Libraries	Header Files
UbloxAdmin.dll	ViComGpsErrors.h
ViComGPSe.dll	ViComGpsInterface.h
ViComGPSw.dll	ViComGpsInterfaceData.h

Table 4-11: R&S ViCom RS232 related Interface Files

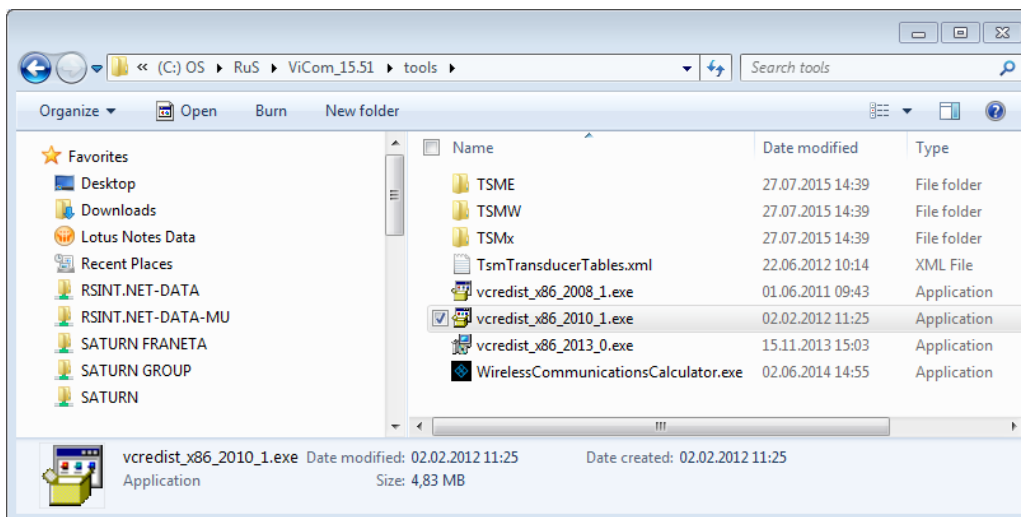
Dynamic Libraries	Header Files
ViComRS232.dll	ViComRS232Errors.h
	ViComRS232Interface.h
	ViComRS232InterfaceData.h

4.2 Prerequisites

If you want to access an R&S TSMx Family receiver, it will be necessary to install the Windows instrument driver for your R&S TSM Instrument manually, if such an instrument is used. The IEEE1394 install utility has been installed along with the R&S ViCom interface dataset. Refer to [R&S TSMx Family Option Handling](#) of this manual for details.

The R&S TSMW and R&S TSME do not need any special driver to be installed. However, the PC must have a LAN interface to connect the instruments, or the R&S TSMW / R&S TSME is connected using some kind of additional LAN hardware like a switch or a hub. It is important that the R&S TSMW / R&S TSME can be reached from the PC where R&S ViCom is actually installed.

For the proper operation you have to install all the Microsoft Visual Studio redistribution packages, which can be found in the "tools" directory, for example, `vc_redist_x86_2013_0.exe`, see [Chapter 4.1.2, "Software Requirements"](#), on page 25.



R&S TSMx-K14 – Option for TSMx/ROMES: WCDMA BCH Demodulator

4.3 Diagnostics Information

- [RS232 Output with the R&S TSMx Family Products](#)..... 30
- [Managing more than one R&S TSM Instrument](#) 31

4.3.1 RS232 Output with the R&S TSMx Family Products

Diagnostic information is available in a text file from the R&S TSMx receivers via the RS232 interface.

Connect the null modem cable into the back of the R&S TSMx Family instrument and connect the other end to the appropriate connector on the control computer. Settings for the connection are Baud rate 115200, 8 bit, no parity, 1 stop bit (8-N-1).

A stream of log information comes automatically when the R&S TSMx Family instrument is running. It can be read with a third party application like HyperTerminal, or saved in a log file by your application.

4.3.2 Managing more than one R&S TSM Instrument

4.3.2.1 R&S TSMx Family Receivers

Up to 3 R&S TSMx Family receivers may be connected in series, via the 2 IEEE 1394 connectors on the rear panel and used to take simultaneous measurements.

For example, one instance of the connected R&S Instruments could be used as a GSM network scanner, one as a PN scanner and one as a CW receiver. The position of an instance in the cascade is irrelevant for its use, just check whether the instance is equipped with the required options.

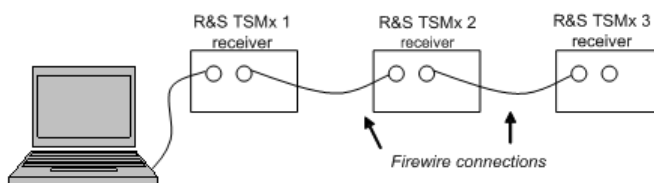


Figure 4-1: Three R&S TSMx Family receivers connected to one control PC

Short interruptions of the IEEE1394 connection are tolerated. However, if new R&S TSMx Family instruments are connected to the FireWire or an instance of the R&S TSMx Family instrument is switched off, the R&S ViCom interface must be re-loaded. While the interface is loading, the connected R&S TSMx Family instruments must not be switched off, disconnected or reordered.

The R&S ViCom Basic interface function `SelectReceiver` allows an application to select an R&S TSM Instruments' scanner to communicate with. For example,

```
bool success =
pViComIf->GetBasicInterface().SelectReceiver(m_ViComError, 2);
```

would select the third scanner from the computer, that is, the instance 3 of the R&S TSM Instruments connected R&S TSMx Family receivers in the previous figure.

4.3.2.2 R&S TSMW and R&S TSME Receivers

The following figure shows connection of more than one R&S TSMW or R&S TSME to the control computer. These instruments support Gigabit LAN connection.

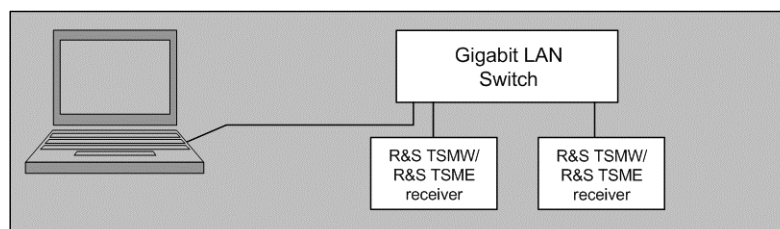


Figure 4-2: Two R&S TSMW or R&S TSME receivers connected to one control PC



All instruments included in such connection must have different IP addresses.

4.4 Getting Started with R&S TSME

The chapter describes the first steps to do with the R&S TSME and R&S ViCom version 15. For more detailed information on the various sections and the referenced tools, see the "R&S TSME User Manual".



R&S TSME receivers with Controller Board Product Change Index \geq 07.02 are not compatible with R&S ViCom prior to version 15.40.

4.4.1 Connectivity

The R&S TSME receiver and the host computer are connected via 802.3 Gigabit Ethernet network.

Make sure the following requirements on your network configuration are met.

Host Computer Connectivity

- Gigabit network interface card with 9k Jumbo Frame support
- Host computer operates in the 192.168.0.0 subnet having a different IP address than 192.168.0.2 (which is the default address of the R&S TSME)
- Using more than one R&S TSME in this application is currently not supported
- Disable the firewall
- If the receiver and host computer are connected via network switch or hub, these have to support 9k Jumbo Frames as well
- Enable flow control for Rx&Tx path

R&S TSME Connectivity

- Default IP address 192.168.0.2
Even if you change the R&S TSME IP address, the default address will still be active as a fallback option. You can change the R&S TSME IP address using the R&S TSME Device Manager tool which is a part of the R&S ViCom package. To install the tool, run the
`C:\RuS\ViCom_<version>\tools\TSME\setup-RS-TsmeTools-<version>.exe` file.
- In order to interact with the R&S ViCom interface, the corresponding scanner options must be installed on the device
Open the R&S TSME Device Manager to find out which scanner options are installed on the device, see [R&S TSME Device Manager window](#).
For more details: refer to "Installing and Managing Software License Keys" of the "R&S TSME User Manual".

You can find the manual in the R&S ViCom package in

`C:\RuS\ViCom_<version>\doc\TSME User Manual.pdf`

- If the R&S TSME does not answer to ICMP echo requests (PING), use the TsmeP-
ing tool contained in `C:\RuS\ViCom_<version>\tool\TSME` to check the con-
nectivity
- The R&S TSME does not provide a web interface like the R&S TSMW; instead,
use the R&S TSME Device Manager tool
If you encounter problems while connecting to the device with the R&S TSME
Device Manager tool, check the firewall settings; refer to troubleshooting section
"Guide to Solving instrument Connection Problems" of the "R&S TSME User Man-
ual".

4.4.2 R&S ViCom Known Issues

This section covers the known R&S ViCom 15 issues, workarounds and constraints.

- All R&S TSME tools / ViCom applications have to run in elevated mode, e.g. the
user needs administrator rights
- When upgrading to a new R&S ViCom 15 package, start the R&S TSME Device
Manager once, which will trigger the instrument firmware update process
- Do not open any R&S TSME tools in parallel, for example, the R&S TSME Device
Manager and the R&S ViCom applications
- ViCom requires installed the `vc redistrib_x86_2013_0.exe` Microsoft Visual C++
redistributable SW

4.4.3 R&S TSME Diagnosis and Updates

The R&S TSME Device Manager allows you to do a complete diagnosis of the R&S
TSME device and to perform updates, if necessary.

All new devices are preconfigured and specified technology and band options are
already installed. Only if you obtain additional software options later you have to
enable the options with the corresponding software license keys.

Software license keys are installed using the R&S TSME Device Manager, in the
"Options" tab. Other tabs provide information on device, network and band configura-
tion as well as the possibility to update the basic Field Programmable Gate Array
(FPGA) or correction data on your R&S TSME.

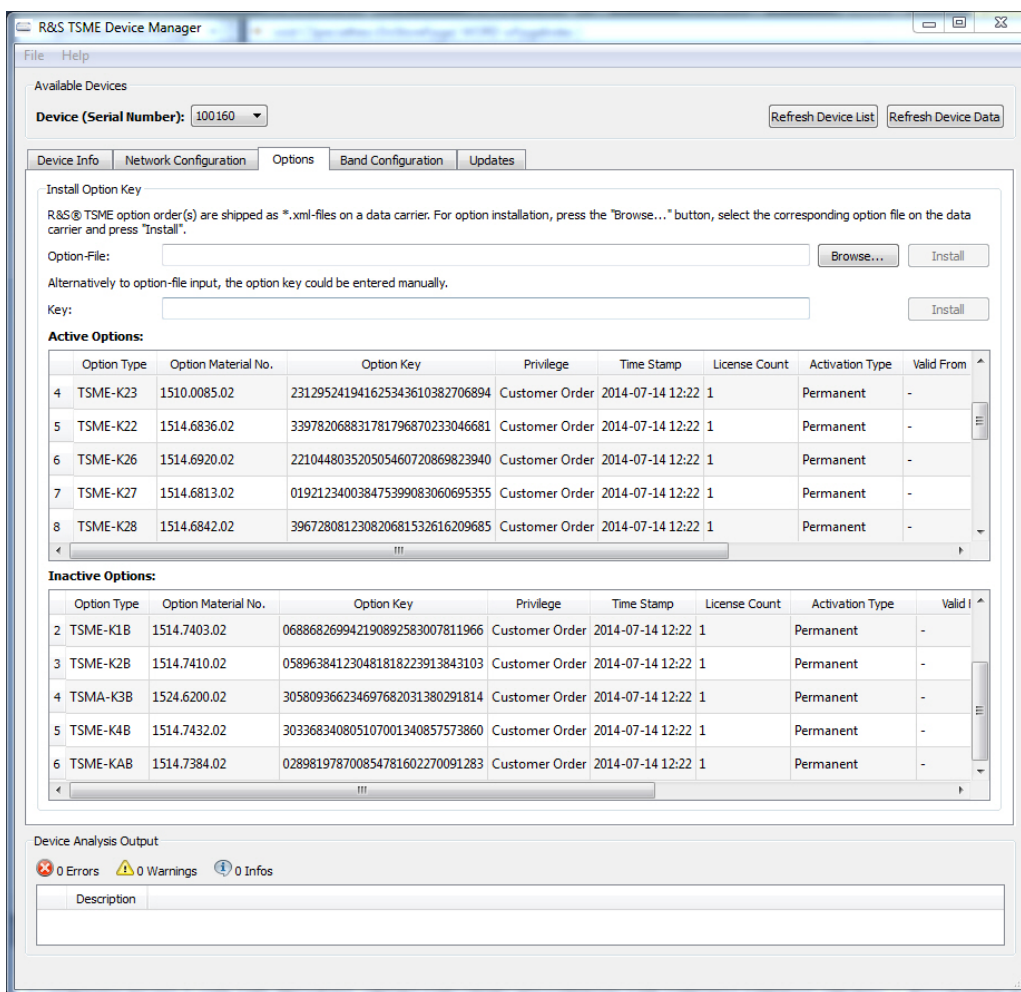


Figure 4-3: R&S TSME Device Manager window

The lower part of the R&S TSME Device Manager window shows the current errors, warnings and info.

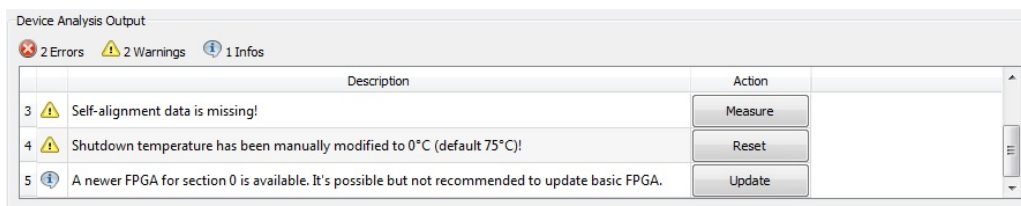


Figure 4-4: Device analysis output

For the complete information on the tool, see the "R&S TSME User Manual".

4.4.3.1 Obtaining Firmware and Correction Data Updates

The R&S TSME Device Manager is always provided with the most recent basic FPGA. If a newer one becomes available due to security or functional issues, a message is issued in the "Device Analysis Output", at the bottom of the R&S TSME Device Man-

ager window. In this case, and only in this case, it is recommended that you install this update on your R&S TSME.

The correction data on your R&S TSME should always be kept up-to-date. Available updates are also indicated in the "Device Analysis Output" and it is recommended that you install them.

NOTICE**Risk of inoperability of device due to FPGA update**

Before performing an update, make sure you have a stable power supply and the LAN connection will not be interrupted. Both updates take a few minutes.

If the LAN connection is interrupted during an FPGA update, the device may become inoperable. Thus, only install such an update if it is explicitly recommended by a message in the "Device Analysis Output" of the R&S TSME Device Manager or by the Rohde & Schwarz support center.

You can update the basic FPGA or the correction data on your R&S TSME directly from the R&S TSME Device Manager, in the "Update" tab. The currently installed versions and the newest supported version (of the FPGA) or the minimum recommended version (of the correction data) are indicated.

4.4.3.2 Automatic firmware updates

Each time R&S ViCom is started, the software automatically compares the firmware version of the connected R&S TSME with the version currently available on the host PC. If a newer version is available, it is copied to and installed on the R&S TSME. Up to two previously installed firmware versions are stored as backups and maintained on the R&S TSME. Thus, it is not necessary to perform firmware updates on the R&S TSME manually.

4.4.4 Getting Started with R&S TSME MIMO Measurements

The chapter describes the first steps to do with the R&S TSME Ultra Compact Drive Test Scanner MIMO 2x2 and 2x4 measurement mode using R&S ViCom. It is a summary of everything important to know to get the system running.

4.4.4.1 Connectivity

The R&S TSME receiver and the host computer are connected via 802.3 Gigabit Ethernet network. Make sure the following requirements on your network configuration are met.

Host Computer Connectivity

- Gigabit network interface card with 9k Jumbo Frame support

- Host computer operates in the 192.168.0.0 sub net having a different IP address than 192.168.0.2 (which is the default address of the R&S TSME)
- Using up to two R&S TSMEs in your application for LTE MIMO 2x2 operation is currently supported
- Disable the firewall
- In case of receiver and host computer are connected via network switch or hub these have to support 9k Jumbo Frames as well
- Enable flow control for Rx&Tx path

R&S TSME Connectivity

- Default IP address 192.168.0.2
Even if you change the R&S TSME IP address the default address will still be active as a fallback option. You can change the R&S TSME IP address using the R&S TSME Device Manager tool which is a part of the R&S ViCom package. To install the tool, run the
`C:\RuS\ViCom_<version>\tools\TSME\setup-RS-TsmeTools-<version>.exe` file.
- If the R&S TSME does not answer to ICMP echo requests (PING), use the TsmePing tool contained in `C:\RuS\ViCom_<version>\tools\TSME` to check the connectivity
- R&S TSME does not provide a web interface like the R&S TSMW; instead, use the R&S TSME Device Manager tool
If you encounter problems while connecting to the device with the R&S TSME Device Manager tool, check the firewall settings; refer to troubleshooting section "Guide to Solving instrument Connection Problems" of the "R&S TSME User Manual". You can find the manual in the R&S ViCom package in
`C:\RuS\ViCom_<version>\doc\TSME User Manual.pdf`.

4.4.4.2 R&S TSME Setup for MIMO Operation Mode

For MIMO 2x2 operation two R&S TSME units need to be connected to the host computer. The following constraints have to be met:

- Every R&S TSME is connected with its own network interface card to the host computer. Usage of a network switch is not yet supported!

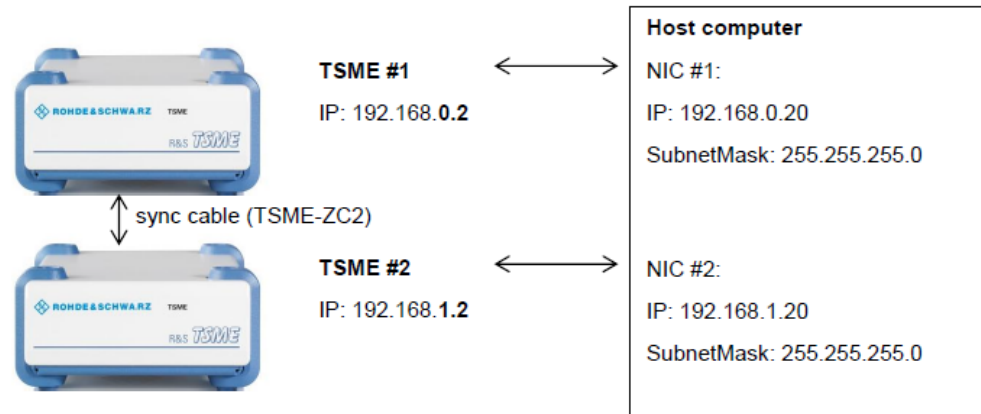


Figure 4-5: R&S TSME setup for MIMO

- Both receivers need to be connected via sync cable
- Currently the maximum number of supported R&S TSME units for MIMO operation is two
- While changing the IP address of the R&S TSME #2 the other R&S TSME unit should be switched off
- MIMO operation requires both the R&S TSME-K29 and R&S TSME-K30 option installed on at least one device; additionally both receivers need R&S TSME-Kxb band options (can be different number of bands)

4.4.4.3 R&S ViCom Setup for MIMO Operation Mode

R&S ViCom supports currently only LTE technology MIMO operation mode.

With several R&S TSME units connected to the host computer the list of connected receivers queried by the `CViComBasicInterface::GetConnectedReceivers()` command has multiple entries, one per receiver.

`CViComLteInterface` contains the definitions for further configurations.

The following code sequence shows how to evaluate the available frontend mask for MIMO operation:

```
const SConnectedReceiverTable* pReceiverTable = rInterface.GetBasicInterface().
GetConnectedReceivers();

if( pReceiverTable != NULL )
{
    DWORD dwAvailableFrontends = 0;

    for (DWORD i = 0; i < pReceiverTable->dwCountofReceivers; i++ )
        dwAvailableFrontends |= pReceiverTable->Receivers[i].dwAvailableFrontEndMask;
}
```

5 Programming with the R&S ViCom Interface

This chapter introduces to the R&S ViCom application-programming interface. In the later part of this chapter, the basic structure that is common to all different technologies is explained. Beforehand, the basic principle of how measurement tasks are handled on the R&S TSM Instruments is described to create a basic understanding for some technically enforced decisions.

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• Differences between the R&S TSMx Family and R&S TSMW / TSME	46
• Using the Demodulators	47
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5.1 Device Details

5.1.1 Measurement scheduling on the R&S TSM Instruments

The R&S TSM Instruments have one or two built-in receivers that can be used to perform different measurement tasks. The measurement tasks cover a variety of technologies and have different requirements on what shall be measured, so the access on the receiver unit has to be managed properly to use it efficiently.

In principle, there are three different groups of tasks the R&S TSM Instruments have to coordinate:

- Periodic measurements for the technology specific scanning, e.g. GSM or WCDMA technology scanning
- Demodulation measurements for the demodulators, e.g. WCDMA technology SIB demodulation
- Smaller management tasks, e.g. attenuation adaption

Since the R&S TSM Instruments can be used to perform several measurement tasks in parallel and all these tasks have different timing constraints, all these tasks have to be prioritized.

Periodic measurements have a configurable measurement rate that the scheduler tries to satisfy. Until no demodulation task has to be performed, the periodic measurements are done, until their measurement rates have been satisfied.

A demodulation request overrides a periodic measurement, if one is active. Most demodulations have to be done at a certain time, so it is necessary to perform the measurement then. If nothing is left to do, the receiver simply turns into idle mode until the next job is ready.

A sample configuration is shown in the following figure, where GSM measurements have to be done at 3 Hz, a WCDMA measurement at 1 Hz and 2 RF Power Scan mea-

measurements in a second. Additionally, a GSM demodulation is requested during the measurement phase.

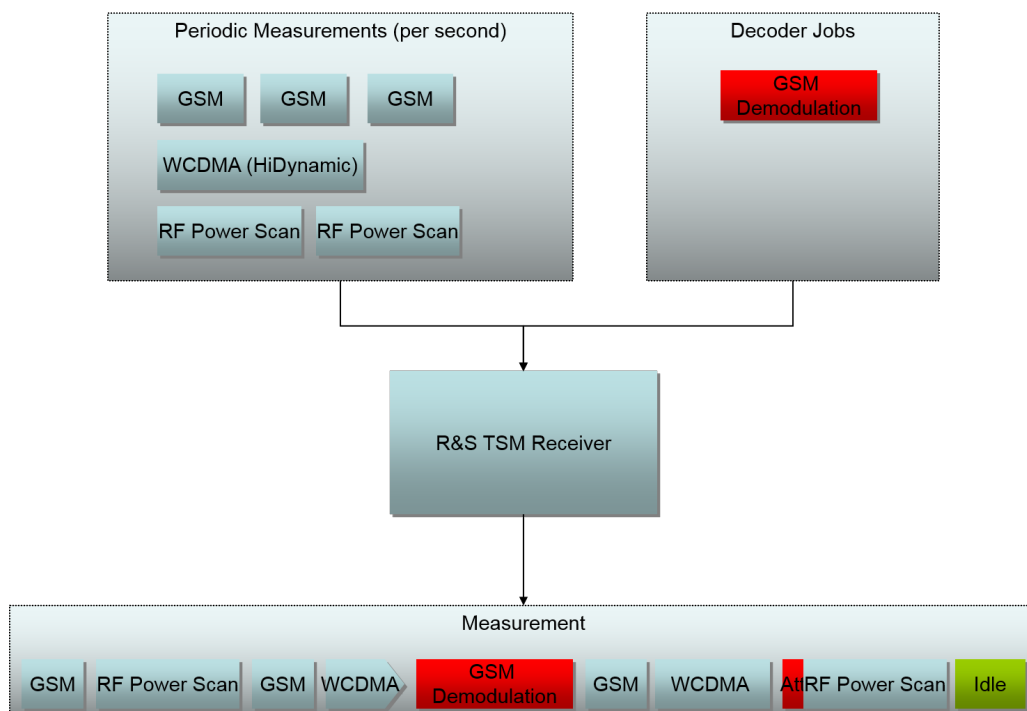


Figure 5-1: Scheduler Sample

The scheduler performs the tasks in a sequence similar to the one depicted in the previous figure. Since 3 GSM measurements have to be done, the first one is started. Next job is then to perform a RF Power Scan, before a second GSM measurement has its turn. The following WCDMA measurement is stopped since a GSM demodulation request has arrived and must be done immediately. The paused WCDMA measurement is then resumed once the demodulation request has been satisfied.

In the sample, the second RF Power Scan measurement started with an ADC overflow, which causes the attenuation to be modified and the measurement to be restarted. This adds some extra time overhead for the justification and therefore takes this time from the idle pool.



Note that the block sizes are not related to the actual execution times in the picture above. The R&S TSM Instruments are capable of doing more measurements than shown in this example, but for simplicity the sample has been chosen as described. In principle, more measurements are possible than the number depicted in the figure above.

5.1.1.1 Automatic Load Handling

If the requested measurement tasks exceed the receiver's capacity, all tasks are slowed down by the same percentage.

Prioritization of specific tasks has to be done by controlling the measurement rates, i.e. the user application has to compare the configured measurement rate with the measured measurement rate provided by the receiver and to adapt the settings, if necessary.

It is recommended to allow the user of the drive test SW to configure the measurement rate. The SW should report the achieved measurement rate by the scanner to the user.

All scanners are reporting the achieved measurement rate as part of the measurement results.

In case only a single measurement is started on the device, the device will perform measurements up to the maximum possible rate. In case several measurements are started on the device, it will try to perform measurements at the requested rates, but if these rates are not possible, the rates will be reduced, and resources will be shared equally between the scanning tasks. In such case, the user of the SW can see what is the specific achievable measurement rate for the desired configuration, and therefore can balance the rates between the tasks by tuning the configured measurement rate per task.



When programming with ViCom please check carefully the definition of the measurement rate; for some technologies, the measurement rate is the single channel measurement rate (i.e. how often one channel is measured), for some scanners the total measurement rate is configured.

5.1.2 Resource Allocation on the R&S TSMW

The R&S TSMW provides two separate receiver frontends, which can be used independently. This is especially useful for separation of scanning and demodulation measurement, because demodulation can then be done without interrupting the scanning.

For example, if you want the R&S TSMW to do WCDMA measurement and demodulation, it is possible to dedicate the first frontend to WCDMA scanning and the second frontend to demodulate the received WCDMA signals.

5.2 Start Programming

This section describes what a developer needs to do to control one R&S TSM Instrument, unless otherwise mentioned. All the functions and data structures mentioned in this section are also described in detail in the online reference manual that comes with the R&S ViCom delivery.

R&S ViCom interfaces include the following groups:

- Error functions, common to every R&S ViCom interface
- Loader functions, common to every R&S ViCom interface
- Basic functions, common to every R&S ViCom interface
- Specific functions that belong to a particular R&S ViCom interface, e.g. the functions of the class `RohdeSchwarz::ViCom::WCDMA::CViComWcdmaInterface`.

The Error and Loader interface functions are used to manage the interface. See the section [On Startup](#) for an explanation of how to use these functions.

The Basic and Specific interface functions carry out the tasks of setting parameters on the scanner and retrieving measurements. Note, that when a function returns a data structure, this data is valid as long as no other interface function is called, either to change settings or retrieve new information.

There are two mechanisms for programming:

- Retrieve Results via polling
- Retrieve Results via callback

Polling can be used in two ways. You can call `GetResults()` to retrieve results on the R&S ViCom interface. The measurements of the R&S TSM Instruments may be retrieved regularly from the R&S ViCom buffer. The requesting function is able to sleep for up to a specified timeout period, in case no results are available in the buffer. When measurements are being made and read regularly, this has the effect of synchronizing the measurement requests to the incoming data.

Another way of polling is to call `GetResultCounters()` and if results are available, to call `GetResult()` repeatedly for the number of results reported.

The calling thread will be blocked while R&S ViCom waits for the measurement function to return, but CPU resources will not be used up by repeated function calls.

To use callback, you have to use `RegisterResultDataListener()` to connect a callback function to the mechanism, which provides any kind of measurement results directly.

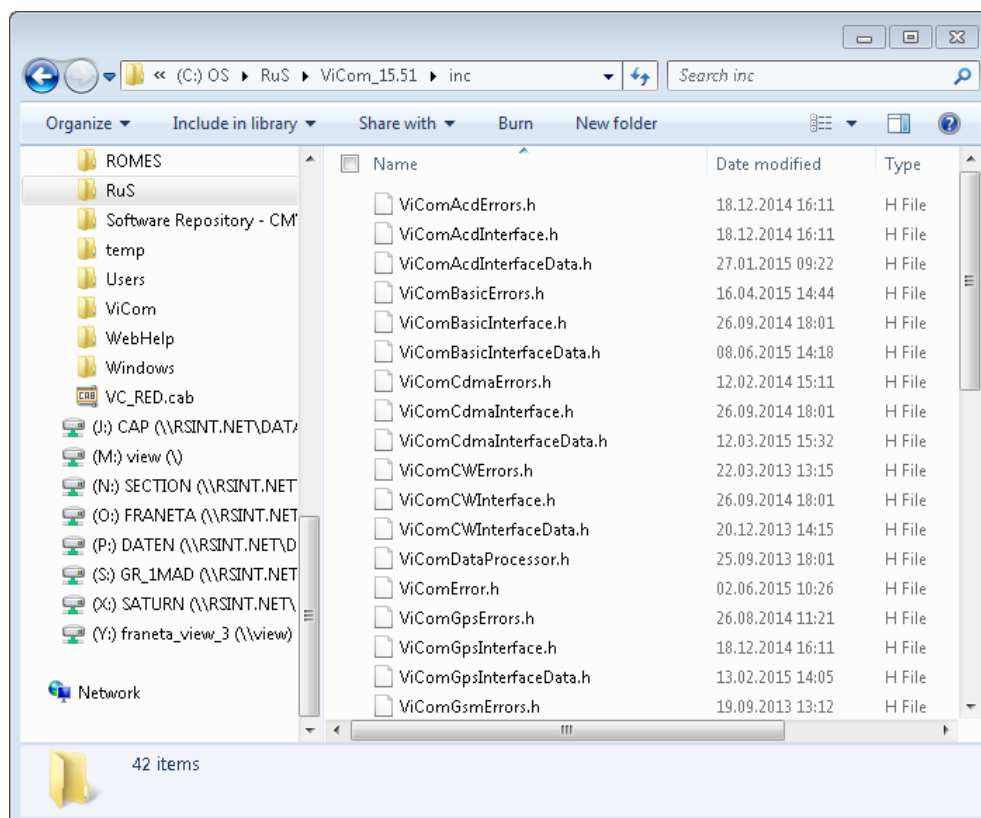


All functions are provided in two variants, with or without an explicit `CViComError` parameter. Functions without error parameter throw an exception, which provides the `CViComError`.

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5.2.1 Prerequisites

- Access to the receiver of an R&S TSM Instrument, that is, the FireWire connection for the R&S TSMx Family and LAN connection for the R&S TSMW and R&S TSME
- Visual Studio 2008 or newer
- Access to the header files; the R&S ViCom Interface header files that you will need to include in your project are found in the sub-directory "inc", see the following figure.



- Access to the runtime files (libraries, etc.); the interface libraries and other files are found in the sub-directory "bin"

5.2.2 On Startup

A typical series of steps is described below, that an application might follow in order to start using the R&S TSM Instrument.

Create a `CViComError` object, to be used as a parameter in R&S ViCom functions in order to get an error code if the function fails.

5.2.2.1 Connecting to the R&S TSMx Family

Connecting the R&S ViCom interface to the R&S TSMx Family is realized in two steps:

- **Create interface**
Create a `CViComLoader` object to get the R&S ViCom interface that you need. To do this, you must instantiate the `CViComLoader` template with the chosen interface class, for example:

```
CViComLoader<CViComWcdmaInterface> myViComLoader;
```
- **Connect interface**
After the application has finished initializing, call the `CViComLoader` function, `Connect()`, with the `CViComError` object as a parameter, for example:

```
bool bLoaded = myViComLoader.Connect(myViComError);
```

Loading the chosen interface takes 20-30 seconds, since the complete FireWire chain is searched for all connected devices.

5.2.2.2 Connecting to the R&S TSMW / R&S TSME

The handling is somewhat different when using the R&S TSMW / R&S TSME. The aforementioned loader object has to be created with an additional template parameter. This parameter is also used in the R&S TSMx Family sample, but there is an appropriate default to keep existing code working.

Writing a line as shown below will create a R&S ViCom loader object that can be used to connect interface with a specific R&S TSMW / R&S TSME.

```
CViComLoader<CViComLteInterface, CViComLoader_TSMW> myTsmwViComLoader,
```

To actually start communication between the PC and the R&S TSMW / R&S TSME, use the `Connect()` function made available in the new R&S ViCom loader object:

```
bool bLoaded = myTsmwViComLoader.Connect ("192.168.0.2");
```



The IP address parameter for R&S TSMW is deprecated and will not be necessary in a future ViCom versions.

5.2.2.3 Accessing the R&S ViCom Interface

If at least one device has been loaded successfully, then `GetInterface()` can be called, to get a pointer to the function interface, for example:

```
CViComWcdmaInterface *myIF =  
myViComLoader.GetInterface(myViComError);
```

The chosen R&S ViCom interface can now be used via its pointer. Interface functions that are specific to the instantiated interface are accessed directly, for example:

```
myViComIF->SetFrequencyTable(myViComError,  
mySettings->ChannelSettings)
```

Interface functions that are common to all R&S ViCom interfaces, and are part of the Basic Interface set, are accessed via the `GetBasicInterface()` function. For example (when working with the R&S TSMx Family):

```
bool success =  
myViComIF->GetBasicInterface().SelectReceiver(myViComError,  
mySettings->dwReceiverIndex)
```

The 'R&S ViCom Reference' manual lists the functions that belong to a single technology interface and those that belong to the BasicInterface.

5.2.3 R&S TSM Instruments Management Functions

`GetConnectedReceivers()` is a basic interface function, available in all R&S ViCom Interfaces, that returns details of all the R&S TSM Instruments connected to the control computer, in the structure `SConnectedReceiverTable`. For example:

```
SConnectedReceiverTable myReceivers =
myViComIF->GetBasicInterface().GetConnectedReceivers(myViComError);
```

where `myViComIF` is a pointer to a ViCom object. Note that `GetConnectedReceivers` is accessed via the `GetBasicInterface` function.

When a function that takes a `ViComError` reference as a parameter returns successfully, the `ViComError` code will be 0.

If an error is returned, the programmer can read the error code from `myViComError` using the function `GetErrorCode` as follows:

```
DWORD myErrorCode = myViComError.GetErrorCode();
```

A standard ViCom error message with more information can be read from `myViComError` by calling `GetErrorString`:

```
string myErrorString = myViComError.GetErrorString();
```

5.2.4 Reading and Changing Settings

The current settings of the selected R&S TSM Instruments can be read, before or during measuring, using the following function:

```
GetSettings()
```

The current settings of the selected R&S TSM Instruments can be changed using the following functions:

- `SetFrequencyTable()`
- `SetDemodulationSettings()`
- `SetResultBufferDepth()`
- `SetTimebaseSynchronisationMode()` (only for the R&S TSMx Family and R&S TSME)

More details of these functions can be found in the 'R&S ViCom Reference' manual.

5.2.5 Getting Measurements

Note that `SetFrequencyTable()` should be called before measurement is started! An application must specify which frequencies an R&S TSM Instrument should scan before starting to measure. The R&S Instrument has no default frequency values. Start taking measurements by calling the `StartMeasurement()` method on the basic interface, for example:

```
myViComIF->GetBasicInterface().StartMeasurement(myViComError);
```



As the `StartMeasurement()` is a member of the Basic part of the R&S ViCom interface, it must be called via the `GetBasicInterface()` function.

It is useful to get information from the R&S TSM Instrument while it is preparing to take measurements. Do this by calling the function `GetTSMxMessagesDuringStartMeasurement()` soon after calling `StartMeasurement()`. The `GetMessagesDuringStartMeasurement()` returns a list of messages, which may be Information, warnings or errors.

```
SViComList<CViComBasicInterface::SMessage> *myMessageList =
pViComIf->GetBasicInterface().GetMessagesDuringStartMeasurement(myViComError);
```

After `StartTakingMeasurements` has returned successfully, measurements can be retrieved from R&S ViCom's result buffer. It may be useful to know, how many messages are in the buffer, whether it has overflowed and if so, how many measurements have been lost. Do this by calling the `GetResultCounters()` R&S ViCom Basic interface function.

```
CViComBasicInterface::SResultCounters *myResultCounters =
myViComIF->GetBasicInterface().GetResultCounters(myViComError);
```

The measurements can be retrieved from the result buffer by repeatedly calling the R&S ViCom Interface function `GetResult()`, which returns a single measurement result in the `SMeasResult` structure. For example, to read a hundred measurements:

```
for (DWORD i = 0; i < 100; i++)
{
    CViComWcdmaInterface::SMeasResult *myResult =
        myViComIF->GetResult(myViComError, myTimeOutInMs);

    //
    // Do something with the results here..
    //
}
```

`myTimeOutInMs` is the time in milliseconds that the function should wait if no results are available.

To stop taking measurements, call the R&S ViCom Basic interface function,

```
StopMeasurement().
myViComIF->GetBasicInterface().StopMeasurement(myViComError);
```

To check that the R&S TSM Instrument has stopped measuring, call the R&S ViCom Basic interface function `HasMeasurementStopped()`. In the following example, `HasMeasurementStopped()` is called with a timeout of 5 seconds. The application thus checks to see if measurement stops within 5 seconds.

```
bool *pbStopped =
myViComIF->GetBasicInterface().HasMeasurementStopped(myViComError, 5000);
```

5.2.6 Connect / Disconnect Scanner

The R&S ViCom loader function `Disconnect` releases all resources used by R&S ViCom, and resets the R&S TSM Instrument.

```
myViComLoader.Disconnect(myViComError);
```

5.3 Differences between the R&S TSMx Family and R&S TSMW / TSME

The main interface functions can be used for all R&S TSM Instruments supported by the R&S ViCom. However, there are a few but subtle differences that are revealed here.

5.3.1 Selecting Device

The **R&S TSMx Family** models are identified by their position in the FireWire chain. The `SetReceiverIndex()` function can be used to load the R&S TSMx Family model. When working with the R&S TSMW, this function should not be used. It will return an error code (129) if called in this case, indicating that calling that function does not change anything. This also applies to the `SetConnectedReceivers()` method, which only makes sense in the context of the R&S TSMx Family.

The **R&S TSMW / TSME** on the other hand is not connected via FireWire, but uses a Gigabit LAN connection to the host PC.

The R&S TSMW is loaded using its unique IP address (unique at least in the local network). Therefore, there is no receiver index in that case, but a single IP address that the device has, see [Chapter 18.2, "R&S TSMW Configuration"](#), on page 250.

This IP address must be specified when creating the

`CViComLoader<ViComInterfaceName, CViComLoader_TSMW>` instance used to create the actual technology specific R&S ViCom Interface.

The **R&S TSME** is identified similar to the R&S TSMx Family, i.e. by using the receiver index to get an IP address from the list of available IP addresses.

5.3.2 Frontend Allocation

The R&S TSMW enhances some of the interface functions to be able to select the frontend used for the configured measurement, since the device itself has two frontends built into it.

This mechanism is also reflected in the different sample applications that come with the R&S ViCom interfaces. Each sample application that can load the R&S TSM Instrument offers a receiver selection as shown in the following figure. When selecting the R&S TSMW, the IP address has to be entered in the "Address" field and the measurement and demodulator frontend usage can be set. This field is not active when select-

ing the R&S TSME receiver because the receiver index is used to get an IP address from the list of available IP addresses.

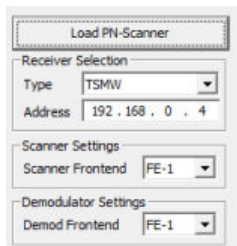


Figure 5-2: R&S TSMW Settings

5.4 Using the Demodulators

Many of the technologies supported by the scanners can additionally demodulate information sent on specific channels of the underlying RAT. It is even possible to receive a textual representation of the information in most cases (as long as the internal decoder supports the appropriate standard).

In each chapter, special constraints of the specific implementations are described besides the usage of the sample application and a coding example. Refer to the appropriate chapter to learn more about the implementation.

- [General Concept](#).....47

5.4.1 General Concept

The API provides two ways to configure the demodulation process, depending on the current state of an R&S TSM Instrument. When there is no measurement active at the moment, the initial configuration is made. In that phase many parameters of the demodulation process can be specified. During the measurement different commands can be used to change the demodulation. For example, internal results can be reset to enforce another demodulation of a message already decoded.

The demodulator is configured by specifying a set of data records. Each data record is used to define how a specific message type (PDU, System Type Information etc.) is demodulated on a specific channel. Several modes are available to do the actual demodulation, some performing their job automatically, some requiring additional user input. Some of the so-called demodulation modes require a timeout value as additional parameter.

In summary there are up to five arguments that have to be specified:

- Channel Index / Frequency Index
- Message Type (PDU ID, System Information Block Type, etc.)
- Demodulation Mode (see below)
- Timeout (only required for special modes)
- BTS reference (only required for special modes during measurement)



R&S ViCom uses the GSM term BTS in general to indicate a mobile base station, although there are different terms for different technologies, e.g. NodeB for WCDMA or eNodeB for LTE.

5.4.1.1 Demodulation Modes

The demodulator API allows you to specify in detail when and how often a message type shall be decoded. The available options depend on whether the decoding is defined at start of the measurement, or if a single demodulation request is issued during the measurement.

Demodulation Modes at the Start of Measurement

When a measurement is started, for each channel and message type the following demodulation modes can be set:

- **Demodulate ONCE (0)**
Each message type is only decoded one time for each base station. After a decoding result is available, the message type is never updated again. This is the fastest solution, but can lead into troubles (in rare cases) when using on long drive tests and the same base station indices are assigned to different base stations.
- **Demodulate ON_CMD (1)**
The message is not decoded automatically. A special decoding command has to be sent during the measurement to start decoding, which must then specify for which BTS the demodulation shall be done.
- **REPETITION (2)**
Decode a message as fast as possible, and then again after N ms. The delay specifies the time the demodulator waits after a complete demodulation of the SIB has been finished before a new one is started. As a consequence, the new result will be available after the delay plus the time needed to perform a new demodulation. For an example, refer to the figure below. A repetitive demodulation of SIB 7 (in the case of WCDMA) is demonstrated. After the SIB7 has been demodulated completely, the R&S TSM Instrument does not attempt to do another demodulation until the delay time has elapsed. Afterwards the next demodulation attempt is started. The same applies to other technologies as well.

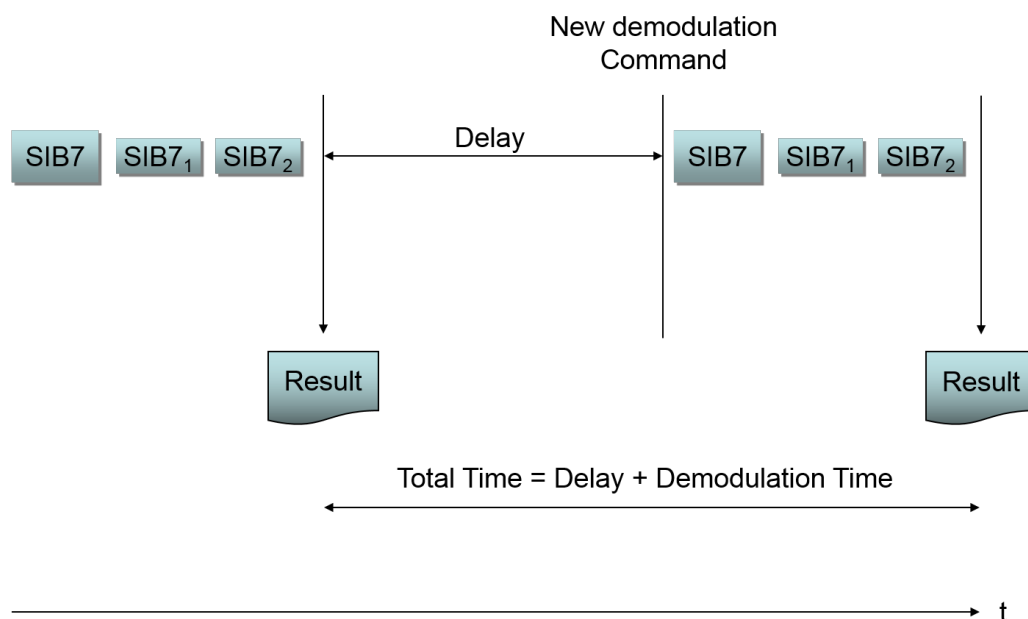


Figure 5-3: Automatic Repetitive Demodulation

For each channel and message type combination that has to be decoded at some time during the measurement one of those three settings has to be specified before the measurement is started. For messages that don't need to be decoded all the time but only in special cases, the "Demodulate ON_CMD" setting should be chosen.

All those settings apply to all base stations found on one channel. BTS specific decoding is only possible during measurement, see the following section.



The numbers in braces after the demodulation type refer to the number that is assigned to the mode in the API. Since they are part of an enumeration, names similar to the appropriate meaning are also available, so you normally want to deal with those identifiers.

Demodulation Modes during the Measurement

In some cases it might be desired to save resources and decode messages only for special base stations or under certain circumstances. As mentioned above, for such messages the "Decode on Command" setting has to be specified before a measurement is started. At any point when a measurement is active, it is then possible to issue one of the decoding commands below:

- Demodulate BTS (3)
For a special base station on one channel, this command tries to decode a defined message. To avoid too much resource allocation, a time-out can be specified when using this command. If the specified time is consumed and no decoding could be done, no result is returned and the resources are freed for other tasks. The timeout can be 0 as well, in which case the demodulation is performed until it succeeds.
- Demodulate BTS_FORCE (4)

It is similar to the mode described previously, but utilizes more receiver resources, since no probability calculation is done to reduce resource allocation like above. The demodulator then does all it can do to demodulate the result in the given time constraint (if specified).

As in the “Demodulate BTS” mode, a time-out can be set for this operation in which it must complete. Otherwise, the request is stopped. The time-out can again be 0, which tells the demodulator to try demodulation until it succeeds.

It is also possible to clear the contents of the internal message containers associated with a channel and the BTS. Two commands are designed for that purpose:

- Demodulate BTS_RESET (5)
Clears only the frame container content within one base station of a channel. This can be used to explicitly restart demodulation for a specific cell.
- Demodulate CHANNEL_RESET (6)
This clears all demodulation results associated with a certain channel. After this command, the demodulation for that channel will restart according to the configuration made before the measurement was started.
The "Demodulate BTS" and "Demodulate BTS_FORCE" commands have a second variation. These modes are:
 - Demodulate BTS_OLD (7)
 - Demodulate BTS_OLD_FORCE (8)
The difference is in both cases that old results might be returned, if available. The old content can be deleted with the Reset command described above.

All commands can be issued only during the measurement. Compared to the commands mentioned in the previous section, these will have an effect immediately since they don't depend on the availability of a signaling. There is no “Undo” function for this, so use the commands carefully if you work on a highly efficient R&S TSM Instruments project.

5.5 Setting up a Custom Project

This section describes how to set up your own project that enables you to work with the R&S ViCom API and that helps you to create a distributable application. Perform the tasks described below step-by-step and you should end up with a ready to start application frame.



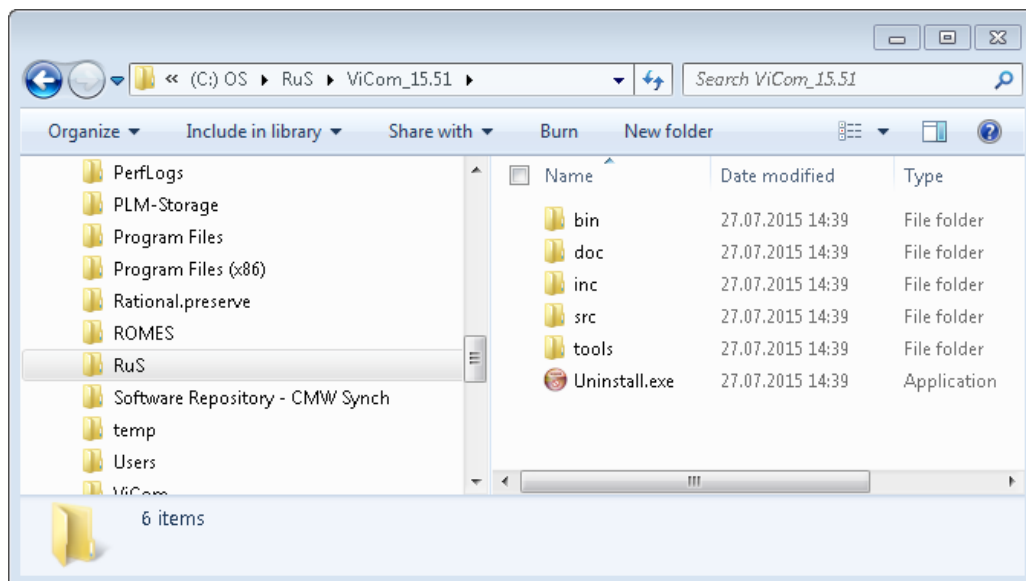
In the subsequent chapters (small) demo applications are shown as code pieces. These can simply be put into the main C++ file.

- [Project Structure](#)..... 51
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- [Project Settings](#)..... 51
- [Working with the Code](#)..... 53
- [Installation Issues](#)..... 54
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5.5.1 Project Structure

We recommend a standard project structure for your own developments that consists of three folders. One folder holds the source data (it is called “src”), one the header file provided by the API in the “inc” folder and the last folder holds the application runtime environment (“bin”). The content of the latter folder can be used as a base for your own program installer, once you finished the development of your application.

The folders are shown in the following figure.



The content of the folder can be moved and copied to any location on your computer and should still work. It is not necessary to keep it where it has been created.

5.5.2 Create the Project Environment

To compile your demo project you need the R&S ViCom header files, to run the application you need a set of DLLs (and other files). In the “Project” folder of the R&S ViCom installation directory you can find a script called “createProject.cmd”. Run this script, providing it with a command line argument that holds the name of the project folder to create. For example, run the following command line to get the same result as shown in the screenshot above:

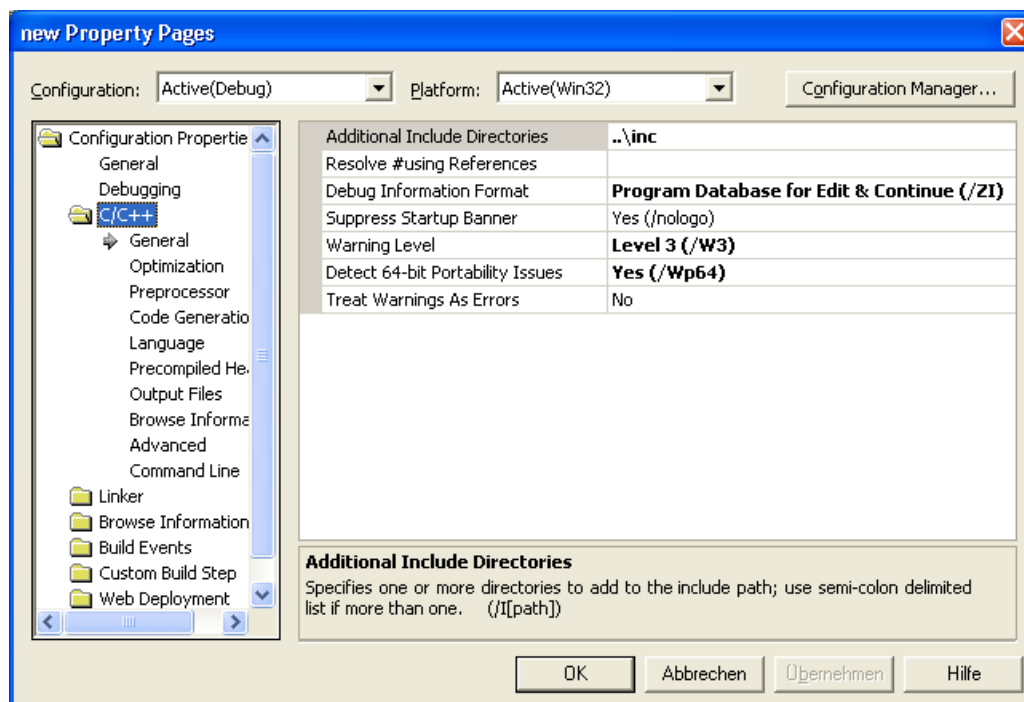
```
C:\RuS\ViCom\Project>createProject new
```

5.5.3 Project Settings

In the source folder you will find a Visual Studio.NET 2003 ® project that is set up to work in the created folder structure. The project is a Windows console project, so if you need some other type of project (like one for a MFC application), you should carefully read through the following paragraphs. There you can find the important settings that

make the project run. When the console project is sufficient for your needs, you can skip the rest of the section.

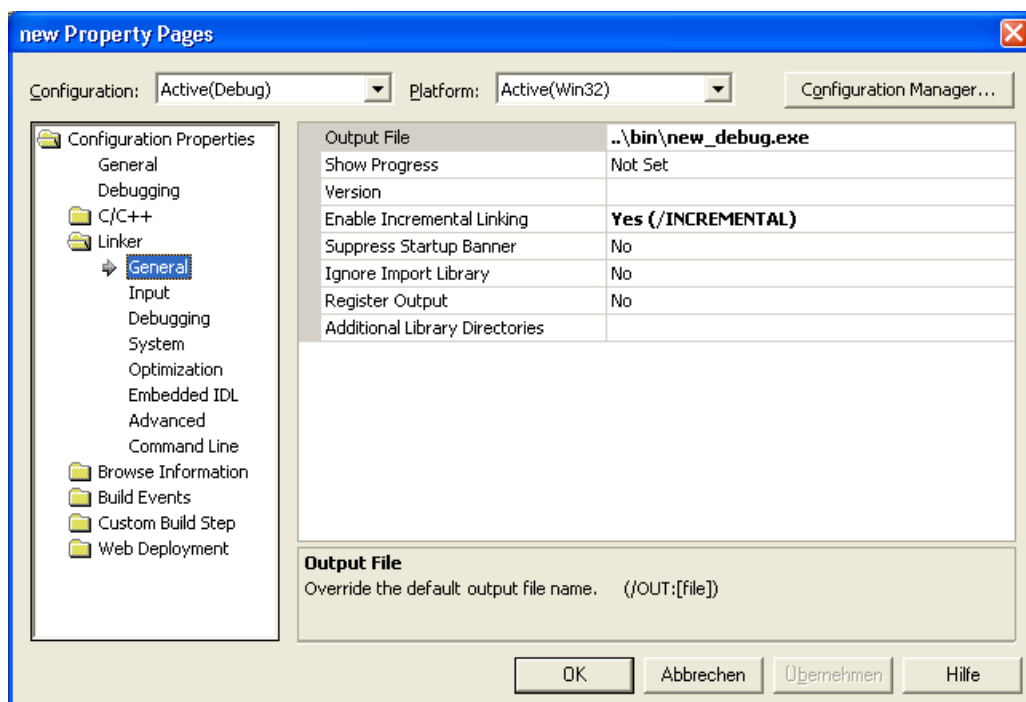
The first important part of the project configuration is the default inclusion of the R&S ViCom headers. The header files were copied while running the script to the “inc” folder, which therefore must be set in the “C\C++\General” settings.



The second important change in the default project settings is the output file. The application executable is required to run a specific environment to use the R&S ViCom functionality. The phylis kernel and its configuration as the central element in the R&S ViCom libraries must be found in the same directory resp. in the directory “PhylisKernelRouting” folder.

Therefore, the output file is set in the sample project to be placed into the “bin” folder. In the property pages, this can be specified in the section “Linker\General” as shown in the screenshots below.

One important thing to know is that the R&S ViCom API does not require any additional linkage specifications. The complete API is made of dynamically loaded DLLs and the interface header files, so no settings have to be changed in the “Linker\Input” tab.



5.5.4 Working with the Code

The first steps when setting up a R&S ViCom application is to select which technology you want to use (depending on your scanner, only some parts of the ViCom functionality can be used), and include the related header files. In the automatically generated `main.cpp` file, you find a minimal R&S ViCom sample program that you can use as starting point for a simple console application. The code is shown here.

```
#include "stdafx.h"

#include <windows.h>

#include "ViComRS232Interface.h"

/*****

int _tmain(int argc, _TCHAR* argv[])
{
    CViComError cError;

    CViComLoader<CViComRS232Interface> cLoader;
    cLoader.Connect( cError );

    CViComRS232Interface* pInterface = cLoader.GetInterface( cError );

    // TODO: specify measurement settings
```

```
// TODO: start measurement

// TODO: stop measurement

cLoader.Disconnect( cError );

return 0;
}
```

Important things to notice are the header files that are included at the very beginning of the file. The `<windows.h>` file is required for the definition of the `DWORD` datatype. The very basic code structure in the main procedure is similar for all R&S ViCom application as well. In any case, you need a `CViComError` object that you can pass in any call to a R&S ViCom method as first input parameter. The next step normally is to load the R&S TSM Instrument and get a pointer to the interface object which is used to control the device. Further information can be found in the chapters that cover the special technologies and in the [Start Programming](#).

5.5.5 Installation Issues

Once you finished your application and you want to deploy it to your customers, the application result must be packaged into some installation format. The R&S ViCom does not require any special operating system settings to be made, the content of the “bin” directory can directly be used for deployment.



Make sure that you don't forget to remove the debug version of your program from the bin folder before shipping the content of the bin folder.

Nevertheless, some additional steps must be made to properly setup a customer's computer to run R&S ViCom applications on it:

- The FireWire driver must be installed on the target machine to connect to a R&S TSMx Family. It must be performed before the R&S ViCom application is used.
- The ViCom redistributable package `ViComRedistSetup.exe` shall be used to copy the R&S ViCom libraries (dlls) in your customer application directory (where your .exe program is placed).
- The redistributable installer packages for Microsoft Libraries (vcredist...), which can also be found in the directory `"%VICOM_HOME%\tools"`, must be installed.

5.5.6 Updating the Projects

Once a project has been created with the procedure described above, the files are different than the ones in the main R&S ViCom directory. To keep them up-to-date when new releases are installed, a new sample script is added to the R&S ViCom delivery. It is used similar to the `createProject` script and takes the project name as the only input argument. So, the command

```
C:\RuS\ViCom\Project>updateProject new
```

would copy the most-recent files from the top-level installation directory into the project path. This includes the interface headers, binaries and the other stuffs.

5.6 Debugging and Error Handling

5.6.1 Debugging Techniques

When debugging an application that utilizes the R&S ViCom API to access one or more devices from an R&S TSM Instrument, some registry keys control the way the underlying framework behaves in terms of logging, error handling etc. These registry settings can be controlled by some registry files that are stored in the `ViCom\LogFiles` folder of your R&S ViCom installation. This section describes those registry settings in detail.

The `LogFiles` directory is also used to store the output files of the sample applications. In that directory, the following registry setting files are also available:

- `PhylisKernelTraceSettings.reg`: Used to enable the internal message tracing facility of the dispatching mechanism, the so-called Phylis Kernel. Normally you don't want to use this, but when a technically complicated problem occurs, you might be requested by the Rohde & Schwarz support to enable the tracing and transfer the output to our technical experts.
- `TsmuWorkerDebugSettings.reg`: When the content of this file is inserted into the registry, the debugging capabilities of the R&S ViCom applications are improved. Normally, the R&S TSM Instrument loses connection to the driver very quickly when no processing can be done on the PC side. That is the case when you try to debug your application that utilizes the R&S ViCom API and stop at a specific location with a breakpoint. To leverage the problems that occur in that situation, load this file into the registry and you won't get bothered with the "Connection lost" message any longer.
- `SetPhylisLogPath.reg`: Used to adjust the location of the `LogFiles` folder of the R&S ViCom installation. Per default this registry file changes the location to `C:\Temp\ViCom Phylis Logs`. In order to manually specify another path one has to open the `SetPhylisLogPath.reg` file in a text editor (e.g. notepad) and change the `RuSPhylModDir=C:\\Temp\\ViCom Phylis Logs\\` entry appropriately.
- `RemoveAllViComRegistrySettings.reg`: Used to clear the registry from all previously made settings.

5.6.2 Message Handler

Underneath the surface, the R&S ViCom API utilizes a Rohde & Schwarz internal mechanism, the so-called PhylisKernel. This message dispatching mechanism is mostly used in graphical environments, which makes it use the possibility to get feedback from the user in some way, especially when it comes to error handling.

This may not be the desired behavior when the R&S ViCom API is used. Usage scenarios may contain environments where no user feedback is possible or where software components have to run in an unattended way.

For such cases, the PhylisKernel supports a mechanism to overwrite the default behavior of asking the user for confirmation in several ways:

5.6.2.1 Error Handling Mechanism

The error handling mechanism in the Phylis Kernel is designed to be extensible by providing a new DLL with a specific API. R&S ViCom itself ships with a default Error Handler that supports the configuration of the error handling as described below.

In case that a message box shall be shown, the kernel checks if it can load a user defined DLL (see below). If such a DLL is found and it exports a function named `DumpLowLevelErrorMessage` with the signature shown below, then it calls that function to take care about the error message. The DLL can handle the error message in any way it wants to.

```
extern "C" _declspec( dllexport ) int DumpLowLevelErrorMessage(LPCSTR lpszText,
LPCSTR lpszCaption, UINT nType)
```

To extend the default behavior, you have to put a DLL named `UserLowLevelErrorMessageHandler.dll` (resp. `UserLowLevelErrorMessageHandlerd.dll` in Debug Mode, if there is any difference required in these two modes; otherwise one of the two is enough) into the Application folder of the R&S ViCom installation directory.

R&S ViCom is shipped with a default handler DLL that supports disabling the message logging using the registry, see [Registry](#).

You can use the `SampleForErrorHandler` sample project as a base for your own DLL. This project contains a configuration which shows the above mentioned message box in case of a Phylis Kernel error. The R&S ViCom setup package supplies this sample only as source code. Therefore you have to build the project, if you want to use the `UserLowLevelErrorMessageHandler.dll`.

```
#include "stdafx.h"
#include <afxwin.h>

extern "C" _declspec( dllexport ) int DumpLowLevelErrorMessage(LPCSTR lpszText,
LPCSTR lpszCaption, UINT nType)
{
    //
    // TODO:
    // Integrate your personal error handling routines here.
    //
    CString csMsg;
    csMsg.Format(_T("Module: %s\nMessage: %s\n"), (CString)lpszCaption,
(CString)lpszText);
    AfxMessageBox( csMsg, MB_OK | MB_ICONINFORMATION );
}
```



```
    return 0;  
}
```

5.6.2.2 Registry

The default error handler DLL that is shipped with the R&S ViCom delivery is called `PhylisLowLevelErrorMessageHandler.dll` (or `PhylisLowLevelErrorMessageHandlerd.dll` in debug mode) and can be used to control the behavior using the registry.

In the key “HKCU\SOFTWARE\Rohde&Schwarz\PhylisModules”, the two values `DisableLowLevelMessages` and `DisableLowLevelMessageLogFile` can be used to control if the message shall be written to a file and if the message boxes shall be displayed.

If the first value is set to a value not equal to 0, the message will not be written to a file named `LowLevelPhylisMessage XXX.txt`, where XXX is replaced by a time-stamp. If the second value is specified and set to a value not equal to 0, no message boxes are shown.

6 R&S ViCom WCDMA Technology

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6.1 Measuring of WCDMA Signals

The R&S TSM Instruments can measure the basic RF parameters of any Node B which is transmitting within a range.

For the Primary and Secondary Synchronisation Channels (P-SCH and S-SCH) this includes:

- Correlation result of all P-SCHs found at the requested frequency
- Relative power of detected peaks in dB
- Time delay of detected peaks in us

For each Primary Common Pilot Channel (P-CPICH) found at the requested frequency, this includes:

- Scrambling Code
- Total Power of the CPICH

For each Scrambling Code:

- CPICH Channel Impulse Response (CIR) measurements
- Received Signal Code Power (RSCP) and Interference Signal Code Power (ISCP)
- Time drift of C-PICH CIR measurements, giving an indication of Node B timing drift.
- Root Mean Square (RMS) of delay spread related to Chip
- Optionally, frequency (Doppler) drift of the Node B signal

For each peak within the CIR measurement of one Scrambling Code:

- Power of the identified peak
- Relative time of arrival

To support the above measurements, (and when this option is present) the R&S TSM Instruments use the synchronisation channels to synchronise to the Broadcast Channel (BCH) of the same network, and decode System Information Broadcasts (SIBs). SIB information is available across the R&S ViCom Interface, in the measurement result structure. A complete list of information available in each SIB is given in [Table 18-3](#).

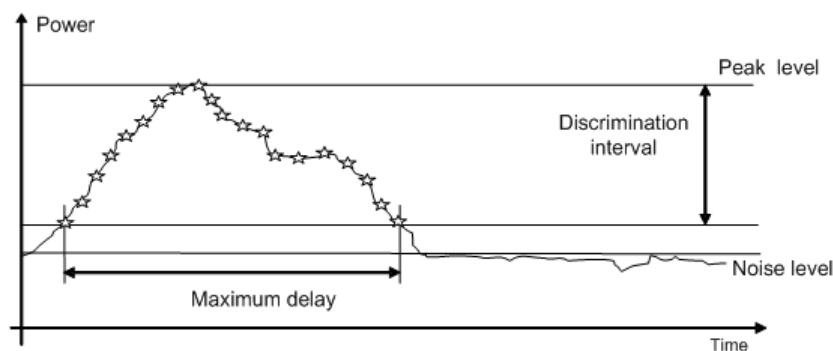
• CPICH Channel Impulse Response (CIR) Measurements	59
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6.1.1 CPICH Channel Impulse Response (CIR) Measurements

The R&S TSM Instruments return a CIR measurement for each Common Pilot Channel (CPICH) that was found during the measurement time, on the requested frequency. This will include the C-PICHs transmitted by different NodeBs belonging to the same network, in the reception area. Each NodeB broadcasts the CPICH with a different scrambling code, as well as with a different delay to the code broadcasts, because the Node Bs are not synchronised.

A channel impulse response is a measurement of the effect on an impulse or sequence of impulses, of transmitting it along a particular channel. The R&S TSM Instruments measure the effect on a sequence of impulses, when a Node B transmits them along the CPICH transmitted by a NodeB at the requested frequency.

From each impulse, the R&S TSM Instruments measure a power delay profile, by sampling the power at regular time intervals along the pulse (see the figure).



The R&S TSM Instruments estimate a lower level for the code power that is high enough above the noise floor to be sure that noise measurements are not included in the CIR measurement. Then they get an array of code power measurements sampled from the signal over the discrimination interval (see below).

The maximum delay is the interval between the first code measurement of the CIR and the last one.

The signal is likely to have reached the receiver via several different reflected paths (multipath). The resulting peaks may overlap, leading to a broader peak, possibly with several sub-peaks. Alternatively, there may be adjacent peaks close together, from the same NodeB CPICH transmission.

The signal quality can be estimated by measuring the width of the peak (maximum delay), and the delay to the impulse peak, as well as the code power to inband power ratio E_c / I_0 .

The RMS delay spread (S) measures the standard deviation of the delay spread. Delay spread is an indication of the average drift of signals. Delay spread is a common problem, and is very important for optimisation. High delay spreads mean that more fingers are needed in a rake receiver to make a connection between a mobile and a NodeB.

For each CPICH signal found, the R&S TSM Instruments also return the Received Signal Code Power (RSCP), and the Interference Signal Code Power (ISCP). The RSCP is the average power of the received signal after despreading and combining. The ISCP

is the interference on the received signal in the given timeslot that cannot be eliminated by the receiver.

Together with the spreading factor (SF), these two values can be used to calculate the Signal to Interference Ratio (SIR).

$$\text{SIR} = (\text{RSCP} / \text{ISCP}) * \text{SF}$$

The ratio E_c / I_o , the average chip energy divided by the total inband energy per chip duration, may be calculated by subtracting the inband power from the absolute code power, both reported in the measurement result structure.

The R&S TSM Instruments return a time drift for each CPICH measurement. They also return a standard deviation for an approximated Gaussian distribution of time drifts of the PDPs. The accuracy of the time drift can be estimated by considering the standard deviation, i.e. if the deviation is low, then the calculated time drift is likely to be accurate.

6.1.2 Peak Information

If the signal of one CPICH has reached the scanner via several different paths, there may be several peaks, either overlapping or single peaks. The R&S TSM Instruments separate these peaks and returns a list of structures containing peak information.

The information returned includes the time delay of the peak, relative to the start of the measurement, and a measurement of the peak power.

Each time that the R&S TSM Instruments synchronise to a CPICH by using the Primary and Secondary Synchronisation Channels, it also returns the inband power and the code power measurements for the PSCH and SSCH. If the R&S TSM Instruments are reporting a measurement of a CPICH to which it synchronised previously, then these values will not be reported.

In the peak information structure, the R&S TSM Instruments will also report an estimate of the frequency drift of the CPICH signal. This frequency drift could be caused by movement of the receiver (if it is mounted in a moving vehicle, for example). However, if the receiver is stationary, then the frequency drift of a Node B can be measured.

6.2 Sample Application

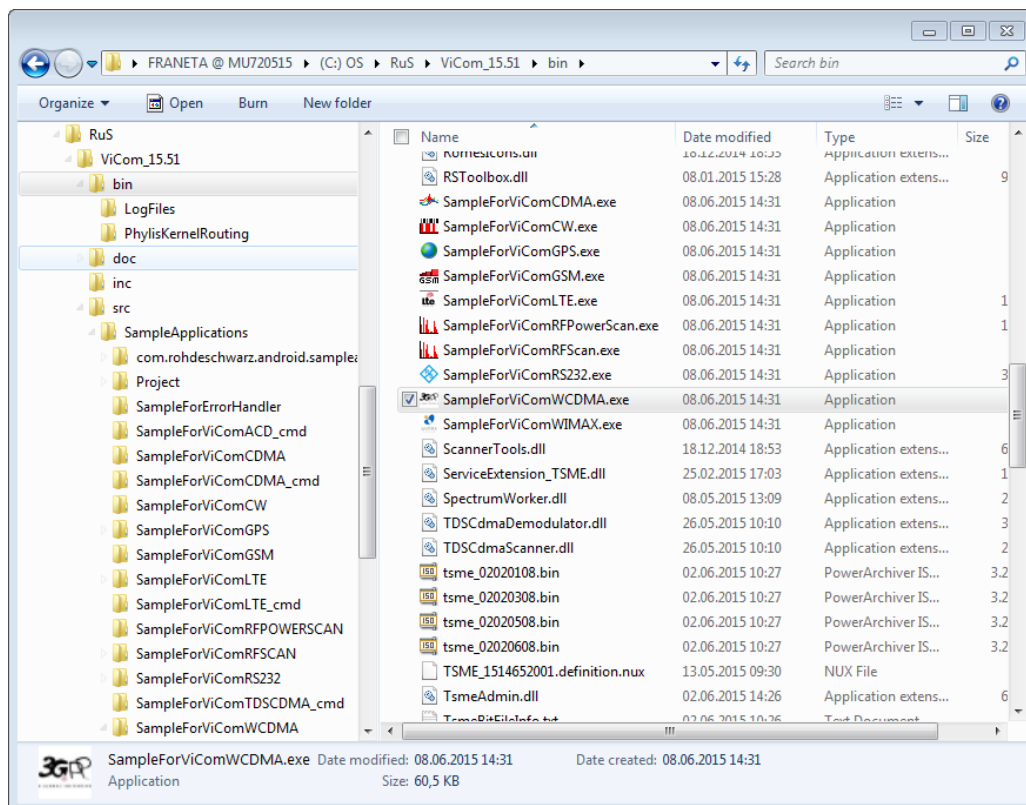
The sample application is a simple implementation of the R&S ViCom Interface, to control the R&S TSM Instruments' PN scanner. It may be used to:

- test the R&S TSM Instrument's PN scanner
- understand the R&S ViCom programming interface

The sample application is supplied in both Release and Debug versions. In this document, it is assumed that the Release version is being used. The code for the sample application is found in the directory named "SampleForViComXXX", where XXX describes a particular R&S ViCom Interface.

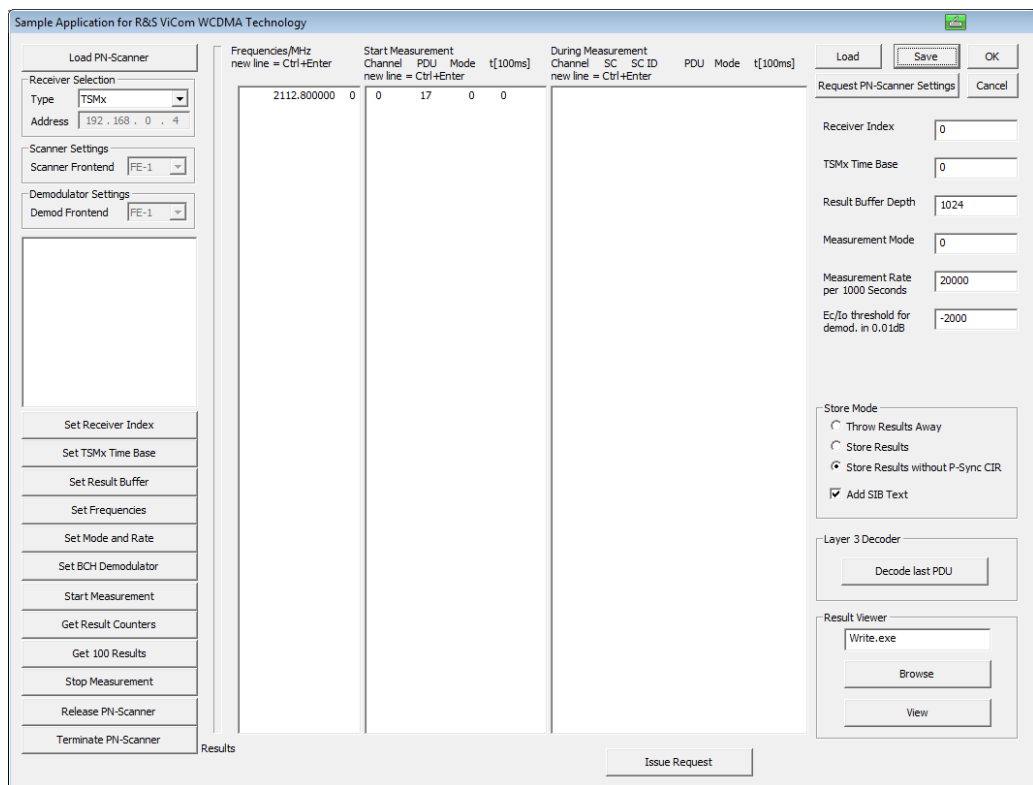
The application and its user interface is rather designed to test the R&S ViCom interface functions than to give an example for a measurement application. Therefore, it is possible to call the interface functions at any time from the GUI, and it is possible to set values out of range to check the responses and the behaviour of the measurement in different situations.

The test applications for different RAN technologies are located in the `C:\RuS\ViCom_<version>\bin` folder. In the following figure selected is the `SampleForViComWcdma.exe` file which opens the demo application for WCDMA.



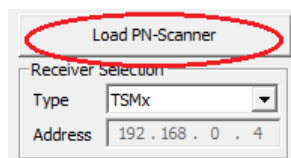
Double click the executable file `SampleForViComWcdma.exe` to get the WCDMA demo application page.

There is only one screen in the test application, as shown here.



6.2.1 Setup Connection

The first action after starting the sample application, should be to click the "Load PN Scanner" button, highlighted in the figure. Before that, the receiver that shall be used should be chosen, i.e. if it is one out of the R&S TSM Instruments.



If the PN Scanner is connected to an instrument and this is switched on as described above, then clicking "Load PN Scanner" will cause the sample application to load a ViComWCDMA Technology interface. See [Chapter 5, "Programming with the R&S ViCom Interface"](#), on page 38 for more explanation about loading the interface. If the scanner is loaded successfully, information similar to that shown in the previous figure will appear in the text box below the "Load PN Scanner" button.

6.2.2 Setup Measurement Command

The interface functions can now be accessed, by clicking the buttons highlighted in the ring below.

Load PN-Scanner

Receiver Selection
 Type: TSMx
 Address: 192.168.0.4

Scanner Settings
 Scanner Frontend: FE-1

Demodulator Settings
 Demod Frontend: FE-1

Set Receiver Index
 Set TSMx Time Base
 Set Result Buffer
 Set Frequencies
 Set Mode and Rate
 Set BCH Demodulator
 Start Measurement
 Get Result Counters
 Get 100 Results
 Stop Measurement
 Release PN-Scanner
 Terminate PN-Scanner

The "Set" buttons correspond to interface functions that set parameters in the scanner. An initial set of default values will appear in the settings fields (circled in ring 3, and the two long fields in the centre of the window). These can be edited in the fields, and sent to the scanner by clicking the corresponding button.

Note that the PN scanner has its own set of default values for all parameters except the frequencies. The PN scanner will use its own default values, unless they have been overridden by interface function calls using the dialogue buttons. Because there is no default value for the frequency in the PN scanner, at least one frequency must be set using the "Set Frequencies" dialogue button, before any measurements can be taken.

The PN Scanner settings remain in the scanner until new interface functions are called, and the only exception to this is the settings for the BCH demodulator. These settings are channel specific and set to default values (PDU 17 (SIB 3) for each channel), if the frequency settings are changed.

Another buttons in the previous figure correspond to the interface functions that deal with measurements, and with unloading the scanner. "Start Measurement" starts the scanner measuring. "Get Result Counters" causes displaying the current number of measurement results in the ViCom interface buffer, as well as the number of measurements that have been deleted if the buffer has overflowed.

"Get 100 Results" causes the application to get the next 100 measurement results from the interface buffer. Results are either stored or thrown away, according to the radio buttons in the Store Mode box. If stored, the results will be written to the file `ViComMeasurements`, in the sub-directory `\Application\LogFiles`.

The following figure shows the two central text boxes in the GUI. The frequency or frequencies which the PN scanner should search, together with a number that is the local channel (frequency) identifier for the measurements, can be entered in the left column. Note, that although a default value appears in the GUI, this is not entered in the scanner until the "Set Frequencies" button has been checked.

CDMA Technology - ViCom 15.0 (BasicInterface 18, ApplicationInterface 14) Build 0

Frequencies/MHz new line = Ctrl+Enter	Start Measurement Channel PDU Mode t[100ms] new line = Ctrl+Enter				During Measurement Channel SC SC ID PDU Mode t[100ms] new line = Ctrl+Enter				
2112.800000	0	0	17	0	0				

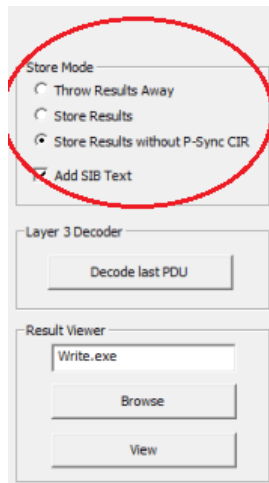
In the right column of the GUI you can enter the PDU values corresponding to the SIBs that the R&S TSM Instruments should demodulate, if this option is present. Each PDU value must have a corresponding channel identifier, which must refer to one of the frequencies entered in the left column. For UMTS SIBs and the corresponding PDU values refer to [UMTS SIB numbers and corresponding PDUs](#). Also refer to [Chapter 6.3, "WCDMA BCH Demodulation"](#), on page 66.

6.2.3 Save and Load

Stored results can be browsed and viewed using the dialogue in the "Result Viewer" box.

1. Type the name of your preferred text editor, for example `notepad.exe` in the text field. The "Browse" button can be used to find the program, if needed.
2. Click the "View" button.

The sample application will open the result file using the preferred text editor.



A sample of an R&S TSM Instruments' measurement file is shown in the following figure. For an explanation of the shown fields, see the R&S ViCom data fields, and the SMeasResult structure.

```

ViComMeasurements.txt - WordPad
File Edit View Insert Format Help
Log File of ViCom WCDMA 3GPP PN-Scanner

MeasResult:
pTimeBaseSynchronisation: eMode = 1, -676ns/s, 10278061ms, 37.34°C
dwChannelIndex = 0
dwPcTimeStamp = 10278060ms
TSMxTimeIn40ns = 9791795786
sAverageInbandPowerInDbm100 = -8888
PSyncCirc excluded.
MeasResult.ListOfCPichCirc.dwCount = 1
CPichCirc for SC 0x1AD0(429):0,
TimeDelayInCircSamples = 47104, CountOfCodePowerValues = 1 C-PICH CIR in 0.01dBm:
-9452
sInbandPower in 0.01dBm = -8888
sRSCP in 0.01dBm = -9461
sISCP in 0.01dBm = -9023
wRmsDelaySpreadInChip100 = 0
lDriftInNsPerSec = 0
lStdDevOfDriftInNsPerSec = 101
CPichCirc.ListOfPeaks.dwCount = 1
TimeDelayInCircSamples = 47104, PeakPower in 0.01dBm = -9470
SCHPowerValues in 0.01dBm: sInbandPower = -8831, PSCHPower = -9851, SSCHPower = -
10044,

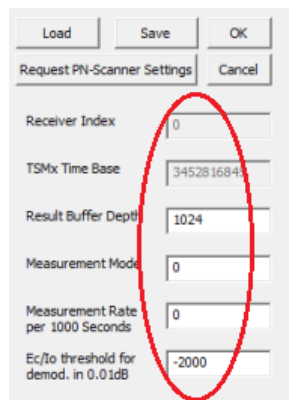
MeasResult:
pTimeBaseSynchronisation: eMode = 1, -676ns/s, 10278061ms, 37.34°C
dwChannelIndex = 1
dwPcTimeStamp = 10278200ms
TSMxTimeIn40ns = 9795297210
sAverageInbandPowerInDbm100 = -9035
PSyncCirc excluded.
MeasResult.ListOfCPichCirc.dwCount = 1
For Help, press F1
NUM

```

6.2.4 Update GUI with Current Scanner Settings

The "Request PN-Scanner Settings" button highlighted in the following figure displays all PN Scanner settings which apply at that moment to the scanner. This button can be clicked after starting a measurement, and will display the settings in the appropriate dialogue fields. The settings can also be stored in an R&S TSM Instruments settings file (*.t.sm), and later reloaded, using the "Save" and "Load" buttons respectively.

There is also a function to force a reset of the PN Scanner interface which has to be used, if the R&S TSM Instruments are not responding due to longer disconnection or due to reset or power off during PN Scanner operation.



6.2.5 Miscellaneous

"Cancel" and "OK" buttons terminate the application.

"OK" will store the settings in the `WCDMA3GPP_PnScannerSettings.bin` file of the application directory. If available, this file is used to initialise the application, (not the scanner!), after reloading.

The interface must be reloaded, if a new R&S TSM Family instance is connected to the FireWire or an R&S TSM Family instance is switched off. Note that although short interruptions of the IEEE1394 connection are tolerated, the R&S TSM Family instance must not be switched off, disconnected or re-ordered while the interface is loading or loaded.

To see the code of the test application in MS Visual Studio, open the project file, `SampleForViComWcdma.vcxproj`, in the folder `...\SampleForViComWcdma`.

6.3 WCDMA BCH Demodulation

One central feature of the R&S TSM Instruments is the possibility to decode the messages sent on the BCCH-BCH for each cell that is encountered during the scan process. These messages contain information about the cell and various radio parameters available, besides information on specific capabilities a cell offers to the UE. How this demodulation process is controlled is the subject of this chapter.

This section refers to the general description of the demodulation process in chapter “Using the Demodulators”. Please be sure to read that chapter first before starting with this section.

In the following you can find a description of the way how the messages are obtained. It is a technically detailed description of the demodulation process. The second part shows how to use the ViCom API to get BCCH-BCH messages. Therefore, the sample application delivered with the API is shown and as the code of demo program is analyzed and explained. Common pitfalls are shown in the last section to help you to avoid those.

- [Measurement Details](#)..... 67
- [Sample Application](#)..... 71
- [Frequently Asked Question](#).....75

6.3.1 Measurement Details

The BCH demodulator is part of the WCDMA PN Scanner interface in the R&S ViCom. It has to be configured before a scan measurement is started. The configuration defines which information shall be demodulated and how the decoding process is controlled.

In the measurement configuration, for each channel a list of PDUs can be defined that shall be decoded. When the measurement is started, the scanner analyses the signals that are found and extracts information about the Node Bs on air. The demodulator then first tries to synchronize on the master information block sent. After the MIB has been decoded, the remaining frames are analyzed.

The frames contain parts of or complete System Information Blocks. For each Node B that is found, the frame data is accumulated until all required frames have been found to start the demodulation of that SIB, if enabled.

To separate frames from different cells, the Scrambling Code is demodulated from the incoming signal and used as a key to store the PDUs in different frame containers. Since the SC is not a unique identifier, the system uses an additional indicator if the Scanner is not sure if a SC belongs to an already measured cell or not. This indicator increases each time such an uncertainty makes it necessary to split the data.



This uncertainty can be resolved by decoding the SIB 3 and investigating the Cell ID.

In the figure below, an example of that process is shown. Let's assume that it was requested to decode SIB 1, 3, 11 and 13. The upper stream is sent by a Node B that has the SC 312, the lower on uses a SC of 13.

The BCH demodulator then extracts and saves the PDUs that were configured, each in the appropriate container of the Scrambling Code. Both scrambling codes 312 and 13 are found for the first time, so the aforementioned indicator is set to 0 for each (see the number after the scrambling code in the figure).

Once all required information is available, a decoding result is generated and made available to the caller. In the example, after the first 8 frames have been dispatched, SIB 13, 1 and 3 are ready to be demodulated for the Node B with SC 312. To completely decode the SIB 11, some elements are still missing (these are marked as red element).



Note that the Master Information Block is always decoded, since it is necessary to get information from the MIB to decode other SIBs. In some networks, the Scheduling Information Blocks also contain data that is required to decode the SIBs correctly. They are implicitly decoded as well, if required.

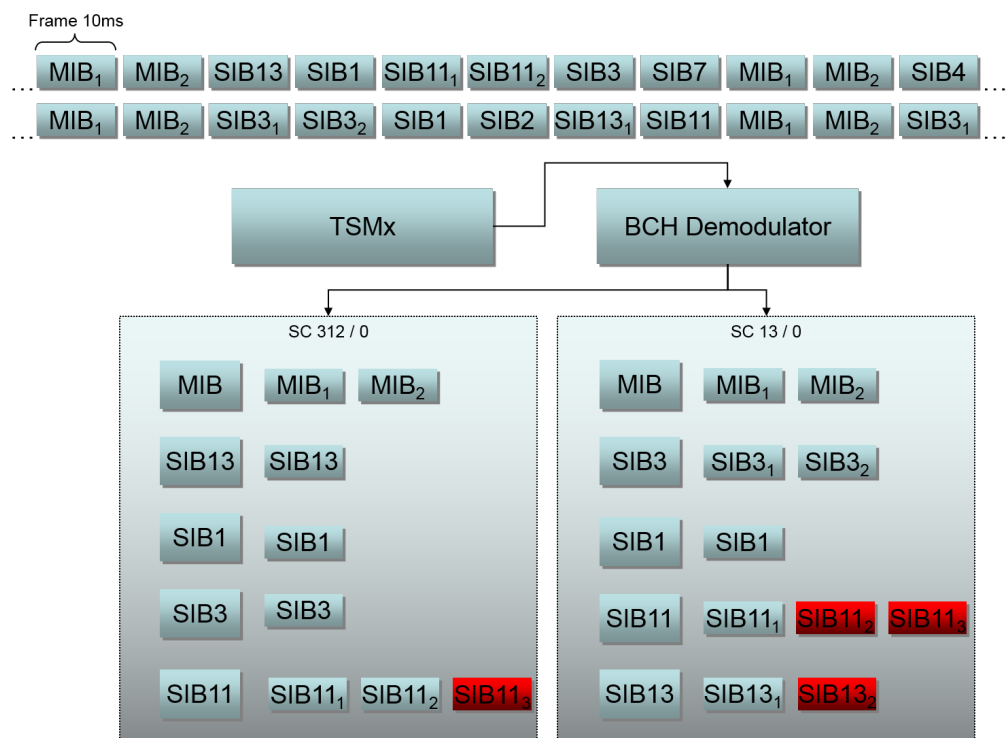


Figure 6-1: BCH Demodulator Measurements

6.3.1.1 Demodulation Modes

The demodulation settings described in the general chapter apply to the WCDMA demodulation as well, but there are some special constraints when it comes to demodulation of the WCDMA messages. These are described below.

The MIB handling differs from the default handling two ways:

- The MIB cannot be requested explicitly, even if it was defined with demodulation mode ON_CMD.
- If the MIB was configured to be reported on request only, it will be reported as soon as another SIB is reported or requested.

Since this handling is sometimes difficult to understand, we recommend not to change the default settings unless you definitely know what the modifications mean.



Due to internal architectural reasons, it is required to request the SIB 3 for a channel before other results might be returned. So make sure that for every configured channel, at least the SIB 3 is in mode ONCE or REPETITION. If the mode is set to ON_CMD, other results will be returned after the first demodulation request for that SIB 3 has been performed successfully.

This also applies to the MIB.

6.3.1.2 Performance Measurements

The measurement rate at which decoding takes place is a crucial aspect in the BCH demodulation module. It was designed to be highly efficient and producing best results under various conditions. The actual demodulation probabilities are shown in this section.

Laboratory Measurements

One important aspect of the decoder quality is its block error rate. This block error rate tells one how many packets could not be decoded compared to how many packets were received in total.

To do a real-world performance measurement, the following test scenario was used: A R&S TSMU received two signals, one from a R&S CMU that acted as the data sender and a R&S SMIQ device used to simulate some noise. Both were connected using a multiplexer to connect to the R&S TSMU.

The E_c/I_0 threshold (P-CCPCH) was required to be at most -18 dB. With these constraints, 17915 PDUs were decoded correctly compared to 18045 received packets. That results in a block error rate of 0,72%, which is a reasonable value.

Additionally, measurements for lower E_c/I_0 were made. The R&S CMU signal was decreased by 2 resp. 3 dBm to produce the results summarized in the table below:

Table 6-1: Laboratory BLER Results for R&S CMU/SMIQ Test Environment

E_c/I_0 (P-CCPCH)	BLER
-18dB	0.72 %
-20 dB	40%
-21 dB	75%

Field Measurements

To get results under drift, additional measurements were done in a real network environment. The results are shown in following Table 3.

The results were produced in an urban area with a maximum delay of 2 seconds between the E_c/I_0 measurement and the demodulation attempt. It can be observed that with E_c/I_0 falling below -11 dB, the demodulation probability decreases below 80%. With an E_c/I_0 value of -13 to -14 2/3 of the demodulation attempts still succeed, which should result in a fairly stable demodulation.

Table 6-2: Field Measurement Results

Ec/I0 [dB]	# Attempts	# Successful Attempts	Success Rate
-1..-2	4	4	100 %
-2..-3	66	66	100 %
-3..-4	338	336	99.4 %
-4..-5	766	758	99.0 %
-5..-6	832	812	97.6 %
-6..-7	815	779	95.6 %
-7..-8	780	727	93.2 %
-8..-9	727	652	89.7 %
-9..-10	750	654	87.2 %
-10..-11	704	582	82.7 %
-11..-12	834	658	78.9 %
-12..-13	748	545	72.9 %
-13..-14	907	607	66.9 %
-14..-15	1050	579	55.1 %
-15..-16	914	476	52.1 %
-16..-17	876	312	35.6 %
-17..-18	966	271	28.1 %
-18..-19	1029	220	21.4 %
-19..-20	1180	256	21.7 %
-20..-21	1070	96	9.0 %
-21..-22	958	70	7.3 %
-22..-23	767	61	8.0 %
-23..-24	617	25	4.1 %
-24..-25	496	27	5.4 %
-25..-26	305	15	4.9 %
-26..-27	150	7	4.7 %
-27..-28	76	6	7.9 %
-28..-29	44	1	2.3 %

6.3.2 Sample Application

In the `SampleForViComWcdma.exe` application it is possible to experiment with the usage of the WCDMA R&S ViCom API to demodulate the BCCH-BCH channel and decode the demodulated PDUs. A screenshot is shown below.

In this section, a complete walk-through is shown to help you getting a first demodulation result. So if you follow the steps shown below, you should get the BCH demodulation up and running very fast and also gain an impression of how to use the API.

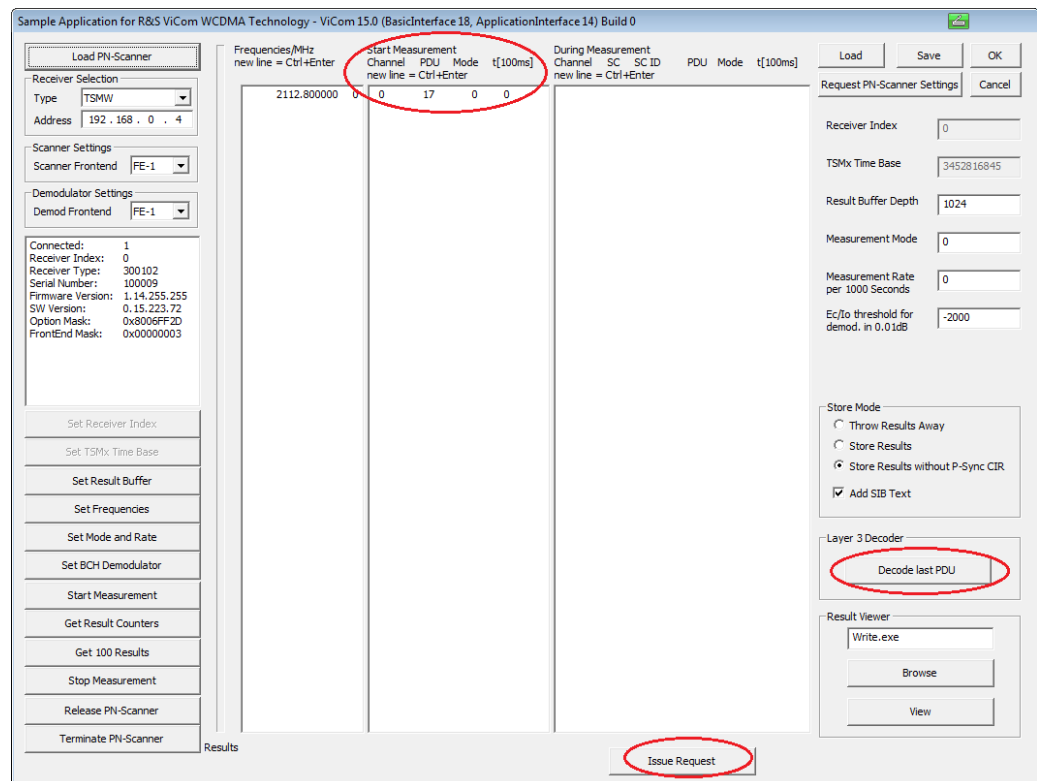


Figure 6-2: R&S ViCom WCDMA technology demo application

The important parts of the demo application concerning the BCH demodulator are the center and right-handed columns and the "Add SIB Text" checkbox. For the case that dynamic requests shall be issued during the measurement, the "Issue Request" button can be used.

Once the application has been started, the following operation sequence should be performed to do a first sample measurement:

- Load a PN scanner. This can be done by clicking on "Load PN-Scanner" button. If this command was successful, the list box is filled with some details of the device.
- Click the buttons "Set Receiver Index", "Set TSMx Time Base" and "Set Result Buffer" to do a proper setup of the standard settings in the R&S TSM Instruments. These set the values in the text fields next to "Receiver Index", "TSMx Time Base" and "Result Buffer Depth" in the R&S TSM Instruments.
- Define the frequency table and set the table using the "Set Frequencies" button. In the table, space-delimited pairs of a frequency and a channel index can be defined.

For a simpler editing, it is also possible to add the frequencies only, one per line (a new line is started with Ctrl+Enter). The channel indices will be added automatically when "Set Frequencies" is pressed.

For example, the mid-frequencies 2167.2, 2112.8, 2132.6 and 2157.2 MHz can be entered. These are the downlink frequencies of the UMTS channels in Germany, if you perform tests in another county, enter the according values.

Frequencies/MHz new line = Ctrl+Enter	Start Chan new li	
2167.200000	0	0
2112.800000	1	1
2132.600000	2	2
2157.200000	3	3

Figure 6-3: Sample Frequency Settings for Germany

Figure 12 Sample Frequency Settings for Germany

- As next step press "Set Mode and Rate" button. This applies the values stored in "Measurement Rate" and "Measurement Mode" text fields (shown on the right side) to the internal data model.
- Mark the "Add SIB Text" checkbox and make sure that the "Store Mode" is set to one of the "Store Results" radio buttons. Otherwise, no demodulation result will be stored in the output file.

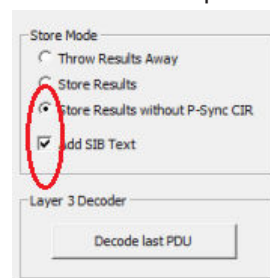


Figure 6-4: Layer 3 Decoder Options in Sample Application

- Specify the demodulation settings. Each line in the central list box contains demodulation settings for one channel/PDU pair. The numbers in the columns have the meanings defined below:
 - The first number is the channel number that can be seen in the frequency list box. It is used a short-cut to avoid handling with frequencies all the time, which is much more error-prone.
 - The second number is the internal PDU name. Refer to the `viCom::WCDMA::Pdu` enumeration in the reference to find the mapping from SIB to PDU.
 - The third number is the demodulation mode. A description of the different modes can be found in [Chapter 6.3.1.1, "Demodulation Modes"](#), on page 68.
 - The fourth and the final column contains a timeout, if the demodulation mode is set to 2 (which means repetition mode). The value here is entered in 100 milliseconds. For example, a value of 10 defines $10 * 100 \text{ ms} = 1 \text{ second}$ as timeout.

To decode all SIB 3 for all four channels, enter the values shown in the screenshot below. Note that the SIB 1 of the third channel (channel index 2, PDU 15) will not

be decoded from the start, but only after a request; see description in [Chapter 6.3.2.1, "Issuing a Request during Measurement"](#), on page 74.



All channels have configured SIB 3 decoding at least one time. This is necessary to get any result.

Start Measurement			
Channel	PDU	Mode	t[100ms]
new line = Ctrl+Enter			
0	17	0	0
1	17	0	0
2	17	0	0
2	15	1	0
3	17	2	10

Figure 6-5: Channel / PDU demodulation settings

- Start the measurement with the equally named button. If you now click the "Get Result Counters" button regularly, you will find that new data is collected after the measurement has started.
- Fetch the results with "Get 100 Results", so that if one of the store options was selected and the "Add SIB Text" checkbox was marked. Display the output file (using the "View" button). The file is stored in the ViCom root dir as `C:\RuS\ViCom_<version>\bin\LogFiles\ViComMeasurements.txt`. In the opened text file, there should be some decoded SIB 3 message that was defined above, if the demodulation could be done within the 100 results. You can search for L3 in the file to find demodulation results faster.

```

TimeDelayInCirSamples = 2980, PeakPower in 0.01dBm = -8429
SCHPowerValues in 0.01dBm: sInbandPower = -7622, PSCHPower = -8909, SSCHPower = -9043,
TimeDelayInCirSamples = 2984, PeakPower in 0.01dBm = -9495

MeasResult:
dwChannelIndex = 3
dwPcTimeStamp = 87955043ms
PduResult: SC 0x1030(259):0 PDU14 with 133 bits
00001000000110010000000110100111010000000010000001000100001110000001000000100100010
011000000111101100101000001101011000010001100011
MeasResult.ListOfCPichCirs.dwCount = 0

L3DecoderResult: value MasterInformationBlock ::= { mib-ValueTag 2, plmn-Type
gsm-MAP : { plmn-Identity { mcc { 2, 6,
2 }, mnc { 0, 7 } }, sibSb-
ReferenceList { sibSb-Type sysInfoType1 : 66, scheduling
{ scheduling { sib-Pos rep16 : 1 } },
{ sibSb-Type sysInfoType2 : 4, scheduling { scheduling
{ sib-Pos rep8 : 0 } }, { sibSb-Type
sysInfoType3 : 2, scheduling { scheduling {
sib-Pos rep32 : 2 } }, { sibSb-Type sysInfoType7 :
NULL, scheduling { scheduling { sib-Pos rep8
: 0 } }, { sibSb-Type sysInfoType18 : 3,
scheduling { scheduling { sib-Pos rep16 : 1
} }, { sibSb-Type sysInfoTypeSB1 : 4, scheduling
{ scheduling { sib-Pos rep64 : 31 } }
} )
} )

MeasResult:
dwChannelIndex = 3

```

Figure 6-6: Sample Result of BCH Demodulation

6.3.2.1 Issuing a Request during Measurement

In the example described above, the SIB 1 of the third channel is not included in the result file. To demodulate that PDU, it is now necessary to request that data explicitly. Follow those steps to accomplish this task.

It is assumed that the configuration is used for the example above. If you used different settings, please adapt these accordingly.

- Open the result viewer and search for the MIB of channel 2. If there is no MIB in the result file, try to get another 100 results into the file, until there is one in the file. Using the Scrambling code of that cell, the data for a specific demodulation request can be put together.
- Enter the request details in the right-most list box. Six columns have to be specified, which have the following meanings:
 - The first column defines the channel
 - The second and third columns define the scrambling code of the Node B that shall be demodulated. The first value is the scrambling code (0 to 511), the second the iteration counter.

- The fourth column holds the PDU to decode, which must be the same as one of the PDUs defined in the centered list box with demodulation type 1 (ON_CMD)
- The demodulation mode is entered in the fifth column. A good value is 3 for a NodeB specific demodulation, although any of the commands defined in the section Measurement Details can be put here.
- If a time-out shall be specified, this can be done in the last column. In the example below, the time-out is 2 seconds (20 * 100 ms = 2000 ms = 2 s).

During Measurement					
Channel	SC	SC ID	PDU	Mode	t[100ms]
new line = Ctrl+Enter					
2	429	3	17	3	20

Figure 6-7: Specific Demodulation Request Configuration

- Click the "Issue Request" button to send the request to the demodulator.
- Click on "Get 100 Results" and check the result file as described above for the demodulated string that has been requested. Be sure to close a previously started instance of your file viewer (default: `write.exe`) if the editor does not support automatic file updates (`write.exe` does NOT support that feature).

When you finished working with the demo application, don't forget to stop the measurement and release the resources of the R&S TSM Instruments.



If you run another application that also accesses the same physical R&S TSM Instruments as PN Scanner, trying to initialize the R&S ViCom in the second application, it will fail. So be sure no other program uses the WCDMA R&S ViCom Interface in parallel.

6.3.3 Frequently Asked Question

This section explains some of the most common questions that arise when using the ViCom BCH demodulator. They don't have any particular order, so skip through them when you encounter a problem – maybe it's one of the problems other people already had.

- ? Are there any other representation layouts other than the string format? Which ones are ASN.1 compliant?
- ! The ViCom API returns a string formatted version of the data according to the formatting rules defined in ASN.1 specification. Additionally, some prefixes are used to distinguish different versions of the UMTS RRC message standard (r3 for Release 99, r5 or r6), when necessary. There is no other meaningful form of the data returned from the ViCom library, except the raw byte-stream.
- ? Is the LAC parameter in the `SBchCellIdentification` structure filled at any time?
- ! It is only provided, if SIB 1 has been demodulated, which contains the LAC.
- ? I don't get any results although I configured some PDUs to be demodulated. Even the MIB is not reported. What's wrong?

- ! Please check that your configuration allows the reporting of SIB 3 for that channel. You can verify this by checking if a PDU 17 is set either to mode 0 or 2 in the demo application. If not, configure the SIB 3 to be decoded in your start measurement setting.
- ? SIB10 and 16 are not enumerated in the ViCom etPDU. How can we select them (their corresponding PDUs) for decoding in ViCom, particularly SIB16?
- ! SIB 10 is not demodulated because it is only used in FDD and has been omitted completely as of UMTS TS25.331 Rel. 5. Currently SIBs which carry information in multiple occurrences are not demodulated in general. This is the reason, why SIBs 15.2, 15.3 and 16 have no related PDUs in the interface..
- ? BCH Ec/I0 threshold (IEcToloThresholdInDB100) is the Ec/I0 threshold for which physical channel (P-CCPCH or CPICH)?
- ! It is the Ec/I0 of the P-CPICH. The data needed for demodulation are requested when the Ec/I0 of the P-CPICH is exceeding the given threshold. The CPICH is used as the scanner monitors all Node Bs by means of C-PICH Ec/I0 measurements and there is no extra measurement of the P-CCPCH Ec/I0 during the monitoring phase. But both values should be in a fix ratio per node B anyway. And actually both the P-CPICH and the P-CCPCH signals will be used for demodulation, as the channel estimation as a part of demodulation is done by the P-CPICH.
- ? What is the minimum configuration of decoded PDUs that have to be set to make the decoder work?
- ! You must request at least SIB3. No SIB PDU result will be provided until SIB3 has been decoded, because the BCH Demodulator provides each SIB PDU together with CI (Cell Identity from SIB 3). E.g. if you request SIB 3 (= PDU 17) you will receive MIB, SIB3 and, if applicable, SB1 and SB2, after SIB 3 has been decoded by the BCH Demodulator.
- ? Once a SIB has been decoded for a Node B, is it ever decoded again at a later point in time?
- ! As long as the system is sure that the same signal is received, the first decoding result is considered valid and returned. If there is an uncertainty about the signal source (for the same SC on the same channel, different frame timing or a longer pause between the measurement points occurred), the decoding process is repeated. To notify about this event, the scrambling code indicator is incremented. To be sure to have the same Node B in the case that two results have been found with two different indicator values, the CellID must be decoded. This behaviour can be changed when configuring the measurement. For each Node B, it is possible to define another strategy how often the PDUs shall be decoded. It is also possible to reset the stored results cache.
- ? Is there any effect in changing load for BCH demodulation in R&S ROMES with the R&S TSM Instruments in HiSpeed or HiDynamic mode?
- ! No, the load is fixed to 10%. This was a quite reasonable value that was found out with the R&S ROMES. With the NRE for the BCH demodulator the demodulations with much higher priority may be requested. The scheduling is influenced in a way that the R&S TSMx gets a maximum penalty in measurement rates on 10% between SIB decoding and not decoding.
- ? Is there a way to adjust R&S TSM Instruments Sync. Rate in ViCom as it is possible in R&S ROMES? If yes, how does this affect scheduling?
- ! If the R&S TSM Instruments are used with the R&S ViCom, new Node Bs are searched on each measurement. As this procedure (WCDMA synchronisation) is done with the same RF signal section as all the other measurements (RSCP, CIR etc.) the synchronisation does not affect the load of the R&S TSM Instruments or causes additional receiver usage. It affects only the processor load at the connected PC. The difference in processing one RF section with and without synchronisation was up to 30% in the phase. At present, with more CPU cache, this difference is less than 10%. So we decided to synchronise on each RF sample with R&S ViCom and simplify R&S ViCom usage by elimination of another parameter. By the way, we are able to synchronise to a Node B in the high speed mode when it is visible for at least 1 ms.

7 R&S ViCom GSM Technology

The R&S ViCom GSM technology measurements offer a whole bunch of measurement methods to monitor and analyze GSM networks. Therefore, high sophisticated algorithms have been integrated in the R&S TSM Instruments software. Nevertheless, the API was designed to be as simple as possible. A basic understanding of the things happening behind the scene is still necessary to make full use of the power the device offers to you.

This chapter explains that functionality. In order to make you familiar with the different measurement modes the network scanner provides, the basic principles of how the network scanner actually finds the data are explained in the first section. The next section explains the usage of the sample application provided with the API. A step-by-step example helps you to do the first measurements.

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7.1 Measuring of GSM Signals

The API of the R&S ViCom GSM technology (called GSM measurements in the rest of the chapter) provides a very flexible way to specify what kind of measurements shall be done and in what way. To use this flexibility efficiently and to understand what the different tasks are really doing, this section gives some detailed insights into the algorithms of the network scanner.



It is important to know that the API of the R&S ViCom for GSM technology is capable of modifying the measurement tasks while the measurement is active. This allows to adapt the measurement specification to new environmental settings etc. For most of the other R&S ViCom APIs this is not the case. The single exception for this capability is that the list of channels that shall be scanned must be known upfront and cannot be changed during the measurement.

7.1.1 Measurement Specials

Before the measurement tasks are described, the following sections set the scene for the usage and explain some common elements of the R&S ViCom API for GSM technology. Most of them deal with configuration and result interpretation.

7.1.1.1 Time Synchronisation

GSM network scanners permit the following time synchronisation modes:

- Internal
- GSM network

- PPS (GPS)
- GSM network | PPs

7.1.1.2 Measurement Scans

When the R&S TSM Instrument has measured all channels and gathered the results this is called a scan. One scan always covers the complete band specified by the frequencies configured before. These channels are measured and processed in groups of at most ten by the R&S TSM Instrument due to internal reasons.

Since most of the R&S TSM Instrument can perform multiple different measurements in parallel, it might occur that one scan cannot be performed completely in one row. In such a case, another measurement task is processed before the scan is continued. A scan interrupted in that way is finished as fast as possible, but it might be the case that the API reports some results before the complete task is finished. It is even possible that some results of a not finished scan have to be thrown away and another scan is started. The missing parts are then measured as soon as there is time to do so.

The channel groups that are measured can contain up to 10 channels, where all channels must be within 2 MHz. This is done to use the capabilities of the R&S TSM Instruments' hardware as efficiently as possible. If there is only a subset of channels to be measured, the group can contain less than 10 channels.

The better the groups are filled, the higher measurement rates are possible. The R&S TSMQ can measure up to 100 channels per second when most of the groups are filled. For the R&S TSML, the maximum reduces to about 20 channels per second.

7.1.1.3 Result Details

Some data in the result structure is not directly related to one single measurement task, but common to more than one or all. These are explained in the subsequent paragraphs.

Split Scans

One measurement result that is requested can contain many different types of results, depending on which measurement tasks are currently activated. Besides this, one measurement result must not necessarily contain all the data made in one scan (as explained above). It is possible that the data of one scan is not completely put into one result structure. Therefore, the result contains a scan index and a flag whether it is the last structure holding data for that scan index.

In the result structure, the `pdwScanCount` member is a pointer where number of the current scan is found. This is an increasing value, for each scan this will be incremented by one. With this attribute, the split results can be grouped again to form a complete scan result.

Frequency Index

The channels are referenced in the result structures as index that can be used to refer to the frequency settings table configured before the measurement is started. The index is called `wFrequencyIndex` inside the structures.

List of Executed Measurements

In some cases, there is no frequency index given directly. For these results, there is a way to match the result data onto the frequencies specified in the `ListExecutedMeasSpec` structure of the result. This list provides the frequency indices of all measured data in the result. Note that the order is important here when it comes to match the indices to the result data. Details are explained in the related sections.

7.1.2 Measurement Tasks

Different types of measurement tasks that the GSM technology can handle are described in this section. The short code fragments are shown to demonstrate the usage of the API in more details.

7.1.2.1 Power Measurement

This measurement is the one which is enabled per default for every frequency that is being measured. It cannot be disabled and will deliver results in every scan. One scan contains a complete set of power values for all configured channels.

The GSM technology measurement is capable of measuring different types of power. Which type is actually used for a power value is specified as part of the result and explained below.

Total Channel Inband Power

This is the default way of measuring power of a channel. After a channel has been measured for about 50 ms, the R&S TSM Instrument searches for the part of the signal that covers highest power and lasts as long as a timeslot.

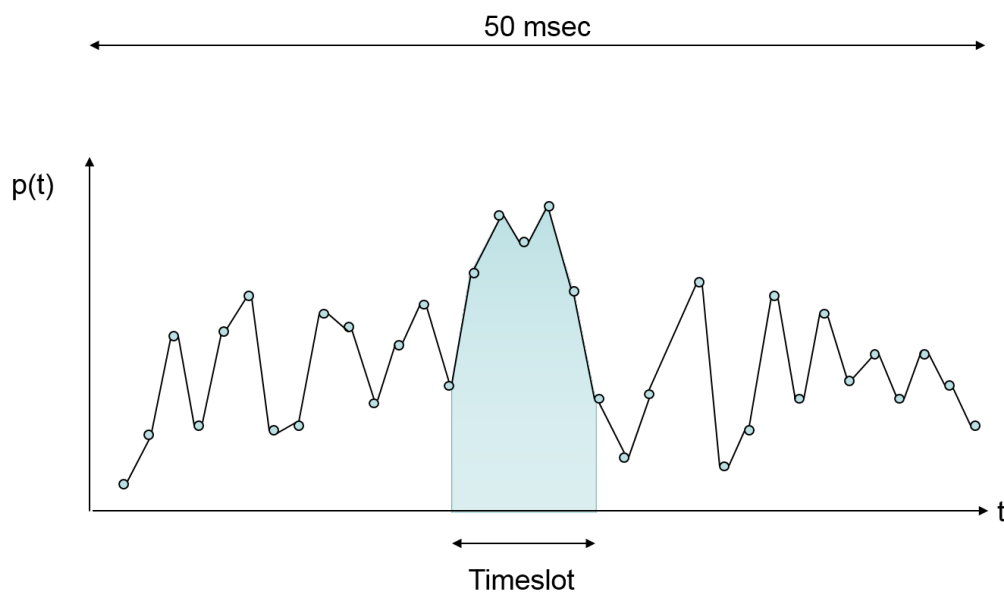


Figure 7-1: Total Channel Inband Power Calculation

Power of the SCH

When the scanner is synchronised on a channel, it can measure the SCH power (time-slot 0). There are several modes for SCH power measuring, which are also returned in the result.

- ETS only: The extended training sequence burst has been found and the power of burst is returned.
- SCH Demodulation: An SCH demodulation attempt was successful and the power value is derived from that burst. Once such a demodulation was successful, the BTS found is managed in so-called Active Set containers. When a later SCH demodulation fail, it is then possible to relate the signal to a formerly demodulated BTS using cross correlation algorithm. The SCH of a BTS is demodulated successfully if the ratio of the SCH power to the total inband power is greater than -6 dBm. There are two Active Set containers that are used in different ways.
 - Active Set 1: The SCH signal has been demodulated in the last 5 minutes. The drift of the incoming signal is within $-16\mu\text{s}$ and $+35\mu\text{s}$ to be able to process reflected and faded signals as well. The incoming signal must then have $P_{\text{SCH}}/P_{\text{tot}}$ of at least -11 dBm.
 - Active Set 2: The SCH signal has been demodulated in the last 30 seconds. The drift of the incoming signal is within a range of $\pm 6\mu\text{s}$. The power ratio must not be less than -9 dBm in that case to perform a correlation to the original BTS.

The code below is an example how the maximum power value in a scan result can be found. The result normally contains a whole bunch of that power values.

```
double dMaxPower = -9999.0;
long nFrequency = 0;
SViComList<SMeasResult::SPowerResult>::SLinkedObject*
pcPowerResult = pcMeasResult->ListPowerResults.pFirst;

while ( pcPowerResult )
{
    if ( dMaxPower < 0.01 * pcPowerResult->sPowerInDBm100 )
    {
        dMaxPower = 0.01 * pcPowerResult->sPowerInDBm100;
        nFrequencyIndex = pcPowerResult->wFrequencyIndex;
    }
    pcPowerResult = pcPowerResult->pNext;
}
cout << "Max pow: " << dMaxPower;
cout << " Frequency: " << ptFrequencySettings[nFrequencyIndex]
.dCenterFrequencyInHz
cout << endl;
```

7.1.2.2 SCH Measurement Report Data

Once a SCH has been demodulated, the GSM technology measurement can report the content of the data sent in the SCH burst. This data consists of the BSIC of the BTS and the frame number, in which that specific SCH was sent. The information is espe-

cially important to start a specific demodulation request of System Information Type messages. Such command can be answered only after the scanner (an R&S TSM Instrument) is successfully synchronized to a BTS. The data can be found in the `viCom::GSM::SMeasResult::SSCHInfoResult` structure and can directly be used to fill the request structure for a decoding request.

7.1.2.3 Counting SCH Measurement Failures

Not every SCH demodulation attempt will be a successful one. For some applications, it might be useful to know how many failures occurred when SCH demodulation was requested. Therefore, the GSM technology measurement gives also the number of failures when the SCH measurement mode is active.

The power values derived from those attempts can be used as an estimation of the upper limit of the measured signal. Since the scanning already extracted all channel information it could from the incoming signal, the remaining signal power is at most the one from one or more remaining cells (+/- some noise).

The result values are returned in the same way as the default power measurements described above.

7.1.2.4 Demodulation of BCCH and System Information Type

Another measurement task allows the demodulation of the System Information (SI) Type messages sent on the BCCH. Before that can be done, the scanner must be synchronized on a BTS signal, i.e. there must be at least one successful attempt to demodulate the SCH burst.

There are two different ways of requesting the decoding from the scanner:

- Either during the initial configuration procedure. In the frequency table, a flag can be set that the decoding process shall be done automatically until the attempt was successful.
- Or during the measurement. Some more setup details have to be fixed in that case, time-out values for example.

Since the first option is relatively self-explanatory to use, we concentrate on the second option here. The configuration for a request is done using the structure `SDemodulationSettings`.

Besides the information retrieved from the `SSCHInfoResult`, these settings must be defined for each message types 1 to 4:

- Shall a new request be started, an existing request be cancelled or shall the current settings be kept as it is.
- How long shall the network scanner try to satisfy the demodulation (if mode is set to `DEMOMREQUEST_START_REQUEST`).
- An optional user-defined request id can be given to identify the request later in the result. This value is not used by the R&S ViCom API and can therefore be used freely by you.

```

ViCom::GSM::SDemodulationSettings cDemodSettings;
cDemodSettings.wFrequencyIndex = pcSCHInfoResult->wFrequencyIndex;
cDemodSettings.wBSIC = pcSCHInfoResult->wBSIC;
cDemodSettings.dwIndicatorOfSCHInfo = pcSCHInfoResult->dwIndicatorOfSCHInfo;

cDemodSettings.DemodulationRequestST1.eRequestType =
cDemodSettings.DemodulationRequestST2.eRequestType = cDemodSettings.
DemodulationRequestST4.eRequestType = CViComGSMNWSInterfaceData::
SDemodulationSettings::SDemodRequest::DEMODREQUEST_DO_NOTHING;
cDemodSettings.DemodulationRequestST3.eRequestType = CViComGSMNWSInterfaceData::
SDemodulationSettings::SDemodRequest::DEMODREQUEST_START_REQUEST;
cDemodSettings.DemodulationRequestST3.dwDemodulationTimeoutInMs = 10000;
cDemodSettings.DemodulationRequestST3.dwRequestIdent = 1;

pcGsmScanner->RequestDemodulationOfST1To4( cError, cDemodSettings );

```

The sample shown above demonstrates how to specifically request a System Information Type 3 message for a channel with a timeout of 10 seconds. When a requested message cannot be decoded, attempts are stopped after that time.

If a result can be demodulated, a structure is filled with the desired information. The most important information is stored in the hex dump field in the structure. It can be used to analyse it with a GSM Layer 3 compatible parser.

As a special case, some content of the System Information Type 3 message is decoded by the scanner itself to gain the current network infrastructure IDs, namely:

- CI
- LAC
- MCC
- MNC

These will be reported in the structure

```
SCellIdentResult
```

Refer to [GSM BCH Demodulation](#) to learn more about the new demodulation capabilities. The automatic demodulation described here is complex and less flexible than the new method.

7.1.2.5 Spectrum Measurement

The GSM technology measurements also provide a way to create a spectrum of the GSM channels defined for the measurement. The spectrum is calculated from a set of raw measurements, which are the results of the FFTs applied to the digitized signal.

The data from the FFTs is reduced to a configurable number of spectrum power values for a GSM channel. Therefore, the channel bandwidth of 200 KHz is divided in N equally sized intervals. For each interval, the highest power value is used as characteristic value.

From that spectrum data one sub-spectrum result is derived. This time aggregation can either be done in the same way as described above, or the root-mean-square is calcu-

lated for the set of sub-channel peaks. To illustrate that calculation, the figure [Spectrum Calculation](#) shows the combination of 3 FFTs to one single sub-spectrum.

Each sub-spectrum is based on a number of FFTs. The number of FFTs is chosen to best-fit into the collection time constraint specified in the spectrum setting.

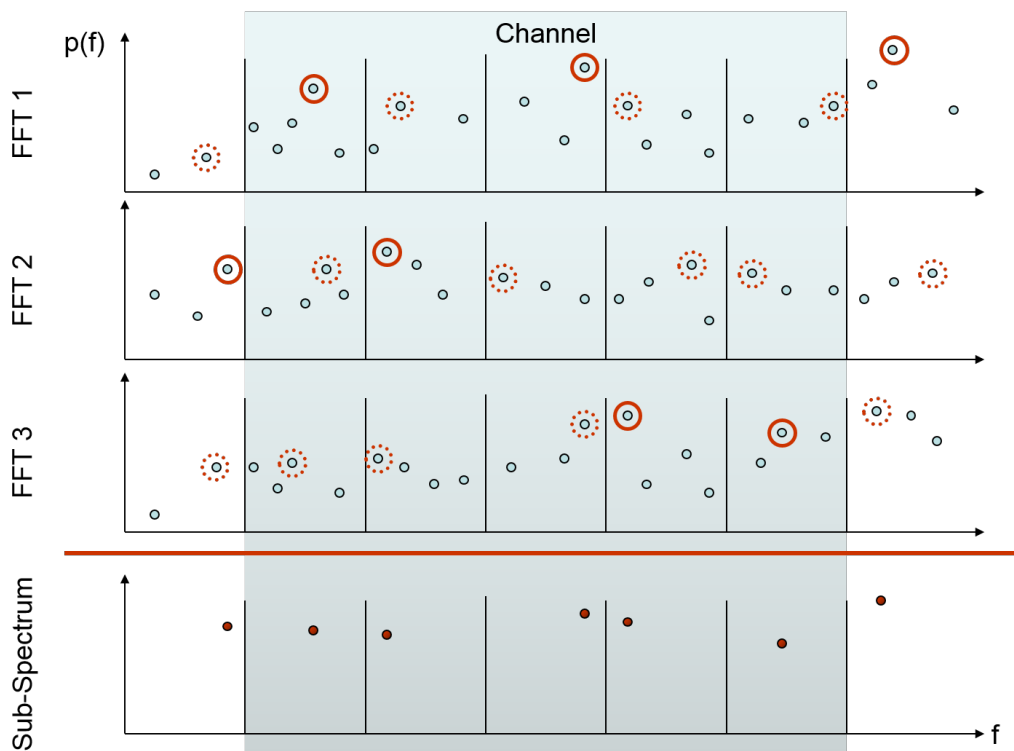


Figure 7-2: Spectrum Calculation

There are five sub-channels and three FFTs shown in the example. From the in this sample highly reduced amount of raw data, the sub-channel data per scan is found by using the peaks.

For time aggregation, also the peak power value is used: The first and the third sub-channel have their time peak in the first FFT. The second sub-channel is taken from the second one, and the last two values are derived from the third FFT.

The settings can be defined in the

`CViComGSMNWSInterfaceData::SSpectrumSpec` structure when enabling the spectrum creation in the measurement details structure. The code fragment below shows how to enable the spectrum creation during an active measurement.

```
ViCom::GSM::SMeasurementDetails cDetailSettings;
cDetailSettings.dwCount = 1;
cDetailSettings.pTableOfChannelMeasSpec = new
    CViComGSMNWSInterfaceData::SChannelMeasSpec[1];
cDetailSettings.pTableOfChannelMeasSpec[0].wFrequencyIndex = 0;
cDetailSettings.pTableOfChannelMeasSpec[0].bMEAS_SPECTRUM = TRUE;
cDetailSettings.SpectrumSpec.wCountOfPowerValuesPerChannel = 5;
cDetailSettings.SpectrumSpec.wCollectionTimeIn100us = 300; // == 30 msec
```

```

cDetailSettings.SpectrumSpec.eFreqDetector =
    CViComGSMNWSInterfaceData::SSpectrumSpec::FREQ_DETECTOR_PEAK;
cDetailSettings.SpectrumSpec.eTimeDetector =
    CViComGSMNWSInterfaceData::SSpectrumSpec::TIME_DETECTOR_PEAK;

EXEC_VICOM( "Requesting detailed measurements",
    pcGsmScanner->RedefineMeasurementDetails( cError, cDetailSettings ) );

delete [] cDetailSettings.pTableOfChannelMeasSpec;

```



The spectrum configuration can be changed during the measurement. Each time the spectrum configuration is changed, the new configuration is used for all spectrum measurements from then on. It is not possible to create different kinds of spectrum measurements for different frequencies in the same measurement at one time.

The results of such a request will be returned as part of the GSM technology measurement result in the `ViCom::GSM::SSpectrumResult` structure. The result contains a set of sub-spectrums. Such a sub-spectrum is the result of the combined FFTs of all measured channels, as described above.

Within the byte buffer, the data is organized primarily in sub-spectrums. In each sub-spectrum, the power values from each measured frequency are given in an ascending order. Data from one frequency is given in one block. This is depicted in the figure below. The term Δf refers to the fraction of one channel that is determined by the number of power values per channel.

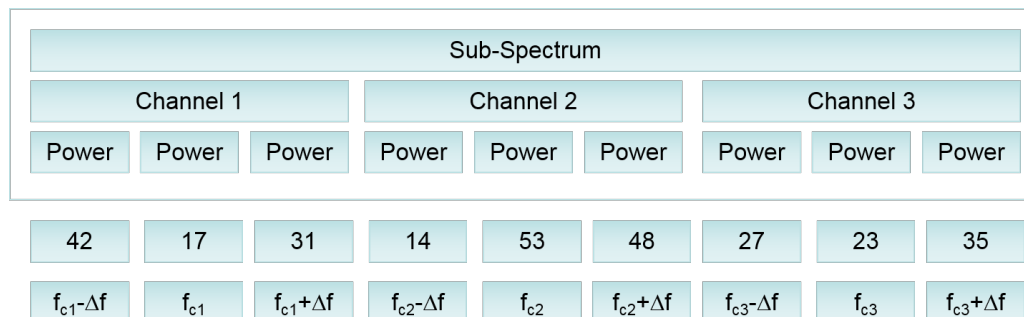


Figure 7-3: Structure of Result Buffer

A sample shown in the following figure describes that structure and the power value conversion. In that picture, the buffer is shown in the upper part of the figure. Three sub spectrums were created in the sample for three frequencies (this implies there is only one power value per frequency).

In the byte buffer of the result structure, the list of spectrum power values is stored. Every power value result is specified in a 0.5 dB unit relative to on a minimum value, which is given in the field `SSpectrumResult::sMinPowerInDBm100`. To get the real power values from the bytes in the buffer, the raw data has to be converted according to this formula:

$$dPower[i] = 100.0 * pcMeasResult->pSpectrumResult->sMinPowerValueInDBm100 + 0.5 * pcMeasResult->pSpectrumResult->pbBuffer[i];$$

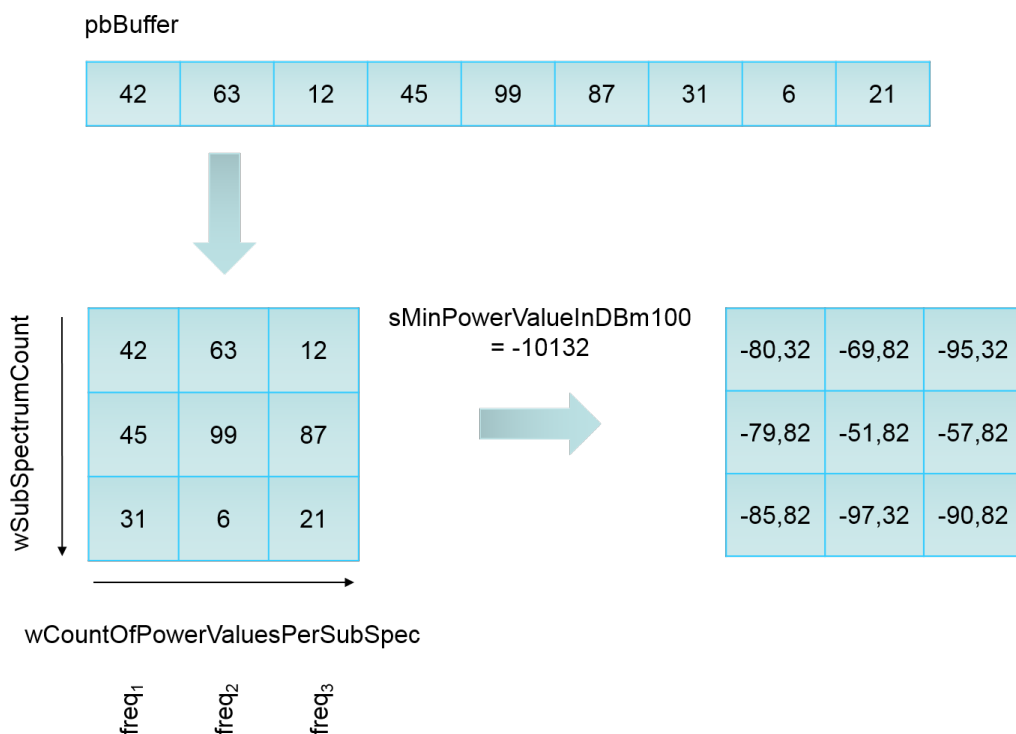


Figure 7-4: Spectrum Result Interpretation

The sub-spectrums contain the measured channels in the same order as they are given in the structure `ListExecutedMeasSpec`. That means, the first `wCountOfPowerValuesPerSubSpec` values in the buffer belong to the first entry in `ListExecutedMeasSpec`, the second set to the second entry and so on.

7.1.2.6 Channel Power Measurement

The power measurement mode that is enabled per default calculates one characteristic power value per every 50 msec (circa). Another mode to measure much more such power values is the channel power measurement mode. In this mode it is possible to get a very high resolution and therefore a big amount of data from the scanner.

A main concept in the channel power measurement mode is the reduction of the available signal bandwidth. Instead of using all power values from the 200 kHz bandwidth of a GSM channel, the GSM network scanner only uses the data from the 156 kHz interval around the center frequency.

This approach removes the influence of adjacent channels on the channel that is investigated. Since some of the signal power is therefore lost, the power is divided by 85%, because it has been shown that about 85% of the signal power of a GSM channel is within a 156 kHz bandwidth.

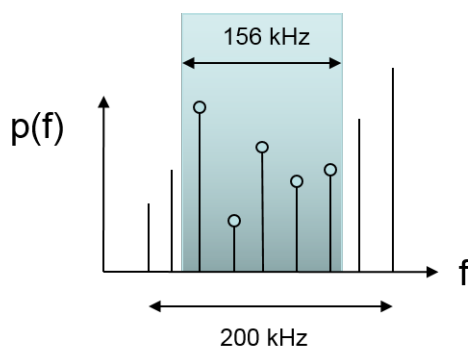


Figure 7-5: Reduction of used Signal Bandwidth

From the remaining input data, the FFT results are grouped to form one power value. One group consists of FFTs falling in a time-interval which is a multiple of 40 nsec. The set of power values calculated from the FFTs is then averaged by a root-mean-square algorithm to get the single power value of a sub-group.



GSM network scanners (the R&S TSM Instruments) do not synchronise on the time-slot to find the real timeslot borders in the channel power measurement mode. The term time-slot is used in this description and the interface documentation to clarify the calculation algorithm and the concept of dividing a time period of that length into sub-groups.

Since the calculation of results is a continuous process and can be compared to a sliding window calculation, time-slot synchronisation is not necessary.

For the requested number of result values per timeslot this calculation is repeated. The algorithm is illustrated in the following figure.

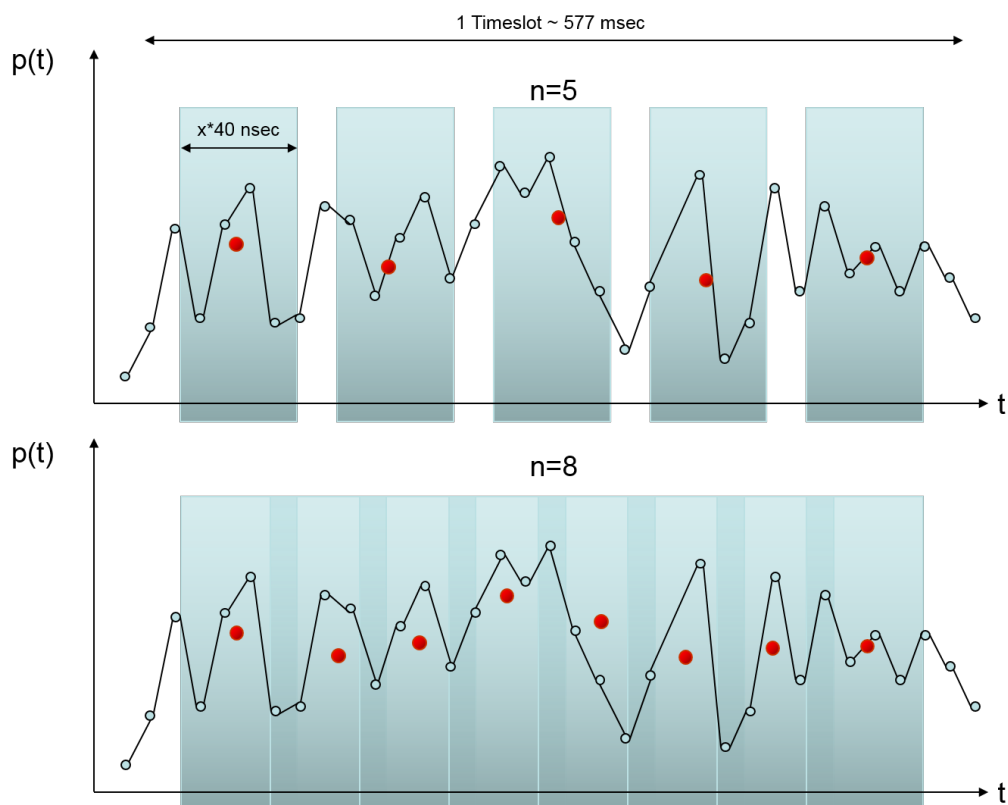


Figure 7-6: Channel Power Calculation Scheme

The upper part of the figure shows a power sample of one time-slot divided into 5 sub-groups. One interesting aspect shown is that it is not necessary always to use the same amount of data in the average process. This can be seen in the first two groups, where four resp. five values contribute to the overall result.



Data shown in the sample is nowhere near the amount of data used in real-world measurements. This is just another simplification.

It is also possible to create overlapping sub-groups. For example, if you use 500 times 40 nsec blocks for a subgroup and you divide the time-slot in 30 sub-groups, there will be an intersection of about 760 nsec between the groups. An example for this is shown in the lower part of the figure.

```
ViCom::GSM::SMeasurementDetails cDetailSettings;
cDetailSettings.ChannelPowerSpec.wCountOfResultsPerGSMTimeslot = 30;
cDetailSettings.ChannelPowerSpec.wRMSLengthIn40ns = 500;
//...
```

The channel power measurement mode can be configured easily. There are only two attributes that must be specified:

- Amount of time in which FFTs contribute to a power value; this must be specified in multiples of 40 nsec

- Number of sub-groups within a time-slot

In this way you can directly control the number of results, since for each measured channel exactly this number of results will be created.

In the API, the `SChannelPowerSpec` structure is used for that purpose and it is a part of the `SMeasurementDetails` structure. When the channel power measurement mode is enabled in the details structure, the `ChannelPowerSpec` field must be configured properly.

The result of the channel power measurements are similar to the ones created by the Spectrum mode. There is again an array of power values that follow some defined order. The actual power values in the buffer are specified in steps of 0.5 dB and have to be added to some given minimum power value. Inside the buffer, the values are structured similar in two dimensions: First they are grouped by channels, then by sub-group within one time-slot.

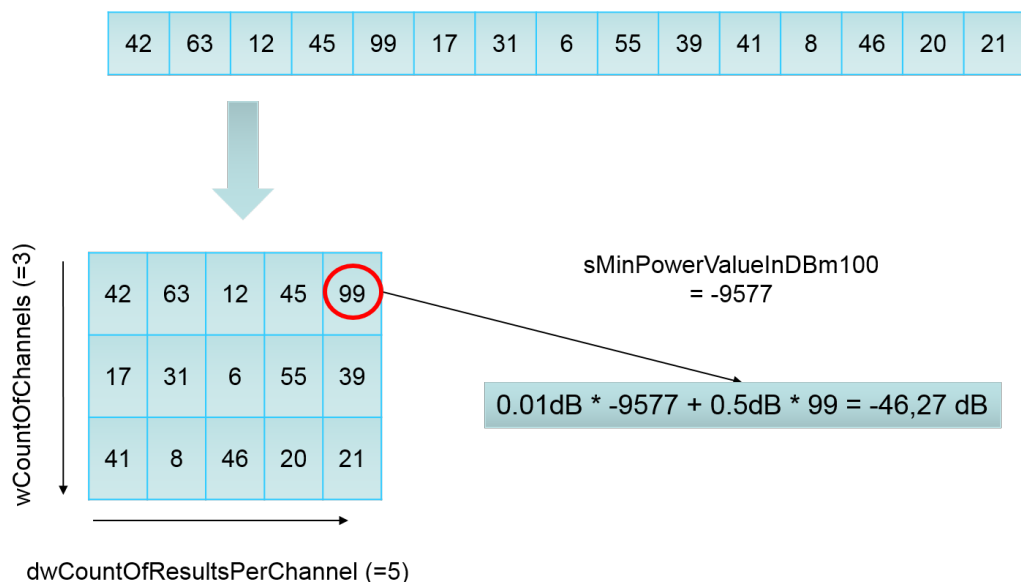


Figure 7-7: Result of Channel Power Measurement

The figure shows the conversion from the linear result buffer into the aforementioned two dimensions and the calculation of the power values based on a specific sample. The calculation is done in exactly the same way as shown in the spectrum measurement mode.

That means: The i^{th} power value of the k^{th} channel can be calculated as follows:

$$Pk(i) = 0.01 * sMinPowerValueInDBm100 + 0.5 * pbBuffer[k * wCountOfResultsPerChannel + i];$$

7.1.2.7 Time-Slot Measurement

Multiple BTS can send their information on a same GSM channel. In urban areas it might happen many times that, for example, ten different BTS transfer data on a same physical channel. The signal from one such BTS can be separated from the others

using the time-slot detection task. Therefore, the R&S TSM Instruments software tries to detect many different information streams on the signal and synchronize on the time-slots.

If the synchronisation process is successful, the software is able to identify the Training Sequence Code. This TSC and the timing information are used to build a so-called cluster. In such a cluster data from one BTS is gathered (with a high certainty). To get to this point, several time slot measurements are combined. This is also necessary to reduce the presence of ghost codes.

The Time-Slot Measurement does not support any specialized configuration. You can simply enable or disable it in the measurement details structure and will receive results accordingly.

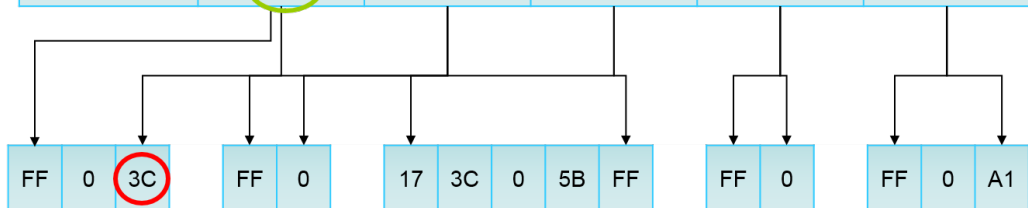
Results made in this mode are returned in two different lists. The first list contains the different clusters measured. Each cluster is made up of a back reference to the frequency index, and the following attributes:

- Minimum power value `sMinPowerInDBm100` for a cluster and the total power range `wPowerRangeInDBm100`. In combination, both values specify the value range interval `[sMinPowerInDBm100; sMinPowerInDBm100 + wPowerRangeInDBm100]` in which the power values in the associated list are.
- Slot alignment of the timeslots (refer to the subsection Slot Alignment below for more information on that subject).
- Training Sequence Code and the type of the time-slot. A time-slot may contain data from a normal or a dummy burst. Dummy bursts can be removed from the measurements by setting the `bMEAS_DB_REMOVAL` in the channel measurement specification.

The power values in the value list have to be set in relation to the interval specified in the cluster result. The calculation is shown in the following figure and explained afterwards.

STimeSlotPowerClusterResult

dwFreqIndex	0	1	2	3	4
sMinPower	-9732	-10198	-8301	-8512	-7767
wPowerRange	1245	873	2013	1749	1944



ListTimeSlotPowerValuesResult

$$0.01\text{dB} * -9732 + 0.01 * 1245 * 60 / 255 = -94.39 \text{ dB}$$

Figure 7-8: Result Structures of Time Slot Measurement Mode

From the `STimeSlotPowerClusterResult`, we know the minimum power value and the range. The time-slot power values are given in the value list as a fraction of the power range. This fraction is based on the maximum value of a byte, 255. So the complete calculation is as shown above:

- Multiply the power value `bPower` with the power range `wPowerRangeInDBm100` and divide the result by 255.
- When this intermediate result is multiplied with 0.01, the difference to the minimum value is available in dBm
- Now the minimum value `sMinPowerInDBm100` is transformed into dBm units (multiply with 0.01) and the difference calculated before is added.

The total time-slot power can be calculated in a similar way. To the result calculated above, the value from `bOffsetToTotalPowerInDBm10` can be added (after multiplying it by 0.1). The offset power specifies the total power of the signal (not only of the time-slot which is assigned to a BTS) as offset to the already available minimum value.

Slot Alignment

According to the GSM standard, one TDMA frame consists of eight timeslots. Each timeslot can contain at most 156.25 bits of information. Of course, the decimal part is not really a carrier of information, it is just a tribute to the timing constraints.

As an alternative to send the burst in that odd time delta, a GSM cell is allowed to insert a full filling bit after each 4th burst. The overall time of the TDMA frame is therefore not changed, but the timing properties of the burst have. With the knowledge whether the first or second option is used, additional information about the cell can be gained.

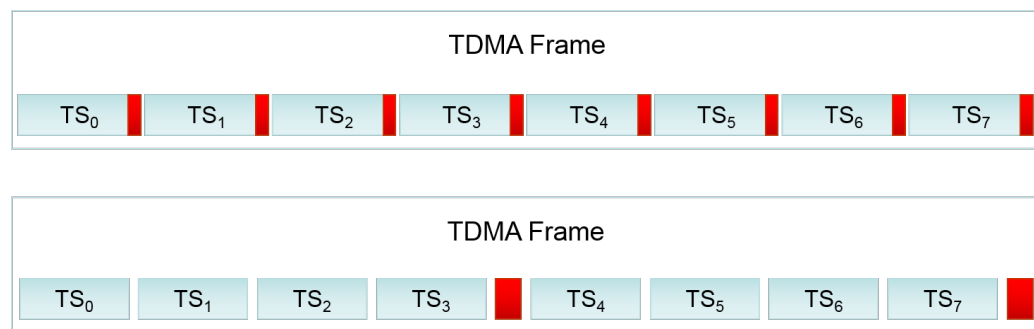


Figure 7-9: TDMA Slot Alignment Schemes in GSM

These aforementioned timing effects are used by the GSM NWS API to make an as-good-as-possible guess what slot alignment is used by a cell. The internal calculation of the slot alignment uses a probabilistic algorithm to finally find some probabilities for each of five possible positions (Time-Slots are equidistant, as shown in the figure above, upper half, or the fill bit is placed before every 0th, 1st, 2nd or 3rd timeslot.

The maximum probability is then referred to as 100%. Then the scanner software reports two results in form of a bitmask: One mask holds all that alignments that have a relative probability to the maximum of at least 95%. The second mask holds all that possibilities that have a probability that is at least 50% of the maximum peak. That behavior is shown in the following figure.

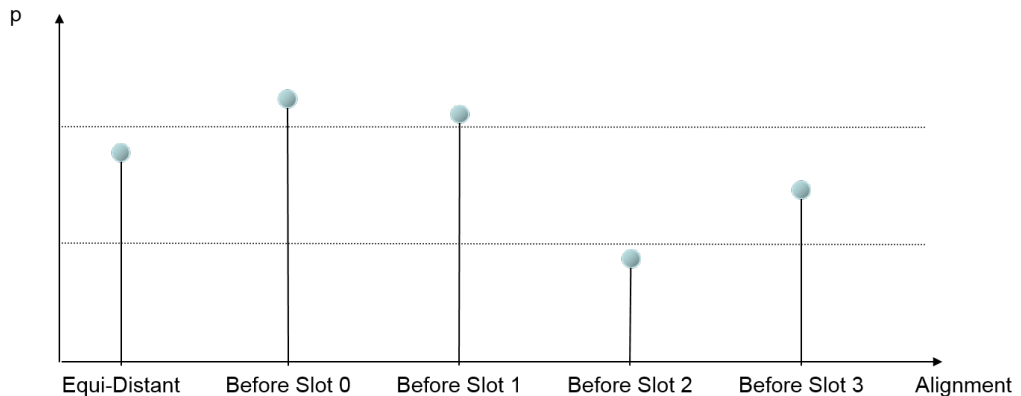


Figure 7-10: Slot Alignment Probabilities

The picture shows the situation, that it is most likely a fill-bit is used and it is placed directly before the first scan.



The more different time-slots measured and the more these time-slots have different positions to each other, the better the results will be and the more exactly can the measurement report the probabilities.

7.1.2.8 Removing Dummy Burst Measurements

Dummy Bursts can have a significant influence on the results of other measurement types. It is possible to remove those dummy bursts after demodulation and before other measurement task perform their calculation, which is especially useful for the channel power and the time slot measurements.

However, the algorithm applied to remove those dummy bursts is a very time consuming task and consumes some of the PCs computing time. It might therefore be necessary to selectively enable and disable that removal for specific channels during the measurement. To achieve this, it is only necessary to set the flag `bMEAS_DB_REMOVAL` in the structure `SChannelMeasSpec` accordingly.

7.2 GSM Measurements Demo Application

Like with all other R&S ViCom APIs, a demo application is packaged with the GSM measurements. The interface is similar to the other demo applications. To start the application double click the

`C:\RuS\ViCom_<version>\bin\SampleForViComGSM.exe` file in the `bin` folder. Refer to [Sample Application](#).

The application window is a dialog that is organized in columns.

The left-most column is similar to the one from other demo applications. It contains the control center in which buttons are provided that relate to the methods in the

CViComGsmInterface class (and their base interface). The order of the buttons implies the logical order in which they should be executed.

The middle column provides fields for setting the measurement and technology specific properties. In the frequency list, the channels that shall be measured must be specified. This is the only setting that must be done before starting the measurement. For each frequency, the automatic demodulation of SI messages can be specified upfront, as well as the frequency index (which must be ascending, starting by 0 and unique).

The right column contains a mixture of functions, like settings management, basic settings and result evaluation (i.e. showing the results which are written into a text-file in an editor).

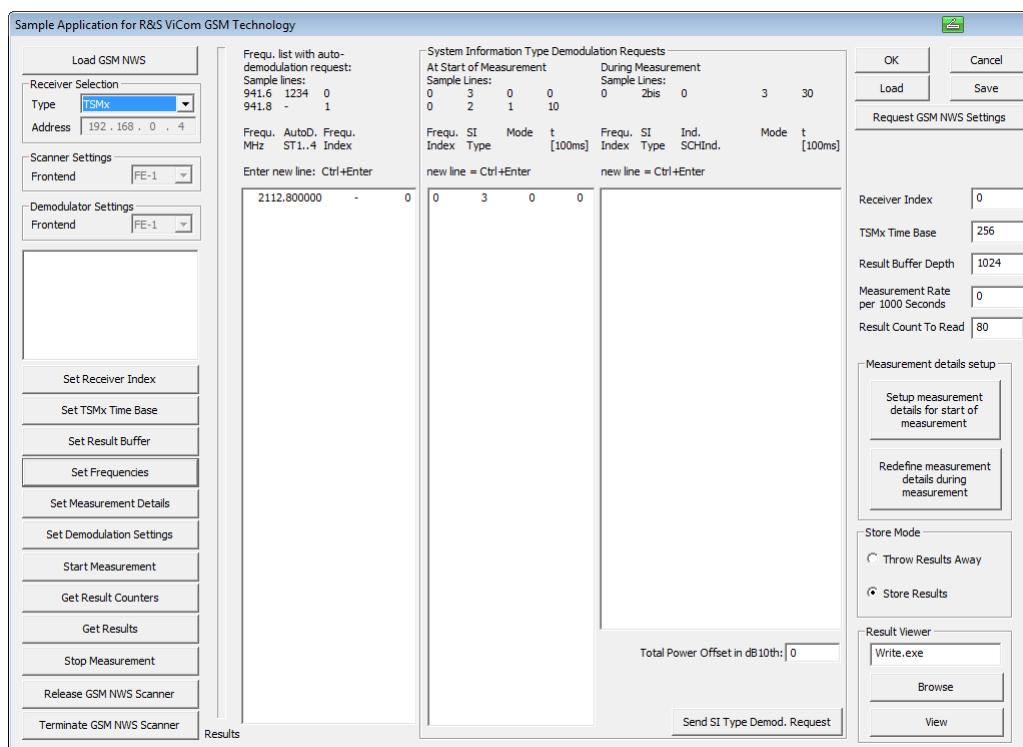


Figure 7-11: R&S ViCom GSM technology demo application

- Basic Channel Configuration.....92
- Specifying Measurement Details.....93
- Requesting System Information Type.....95

7.2.1 Basic Channel Configuration

The first step when using the application is to define the list of frequencies that shall be scanned. Therefore, the following steps must be done:

- Load the R&S TSM Instrument (by pressing "Load GSM NWS") and set the initial values for Time Base, Result Buffer and Measurement Rate by pressing the related buttons. This is not really necessary when the application is started for the first time or the value has not been changed, but once a setting has been modified it is required to update the parameters in the R&S TSM instrument.

- Put the list of frequencies into the list in the middle column. You don't have to enter the auto-demodulation settings and frequency index; they are added automatically with default values. A line in the edit control contains up to three elements, each separated by a white space:
 - Channel center frequency in MHz (decimals follow a period)
 - Auto-Demodulation settings for System Information messages. You must specify which shall be enabled by entering the numbers in one block. For example, if the SI Type 1 and 4 shall be decoded, enter 14.
 - Frequency index to be used later in the result. This is not mandatory and will be filled automatically when you enter the frequencies.



You can enter new lines by pressing Ctrl+Enter when the focus is in the list control.

- Press the "Set Frequencies" button to transfer the settings to the R&S TSM Instrument.
- Optionally, a more detailed setup of the measurement can be made. Therefore, press the "Setup measurement details for start of measurement" button below the frequency list. See the section below for a more detailed discussion. By default, only SCH measurements are enabled.
- By pressing "Start Measurement" the measurement starts
- To fetch some results, check the number of result available and transfer some of them to the PC (using the "Get Result Counter" and "Get Results" buttons).

7.2.2 Specifying Measurement Details

Most of the settings necessary to define the different measurement tasks which have been explained in the previous chapter must be setup in a special dialog that is shown in [Measurement details dialog](#). The same dialog is used to initialize the measurement details before a measurement is started and when the measurement configuration is changing while the R&S TSM Instruments are active. Slight differences concerning the buttons at the bottom of the dialog can be seen when comparing the dialogs, but the major part of the dialog is consistent.

To show the dialog, press "Setup measurement details for start of measurement" before you press the "Start Measurement" button. Once the measurement is active, the button "Redefine measurement details during measurement" can be used.

The configuration should be straightforward after the previous chapter has been read. The input fields reflect the fields in the C-structures for many parts of the `SMeasurementDetails`. Besides the settings for the spectrum and channel power measurement modes, the dialog also provides a way to enable and disable the measurement tasks.

One important aspect is that the configuration can be applied to a different scope of channels. It's possible to modify the details for a single channel, for all channels or to modify the spectrum and channel power measurement modes without changing other

settings. The behaviour can be defined in the lower part using the different radio buttons.

Figure 7-12: Measurement details dialog

Even a subset of the measurement frequencies can be configured. Click the "Press button for individual setup" button that appears, if the radio button "Individual setup for a list of frequencies" is active. In the upcoming dialog, the active measurement tasks can easily be defined per each configured frequency.



The spectrum and channel power measurement settings cannot be defined on a per-channel basis, as the dialog illustrates. Both configurations are valid for all channels that perform that measurement tasks. Each modification always concerns all active measurements.

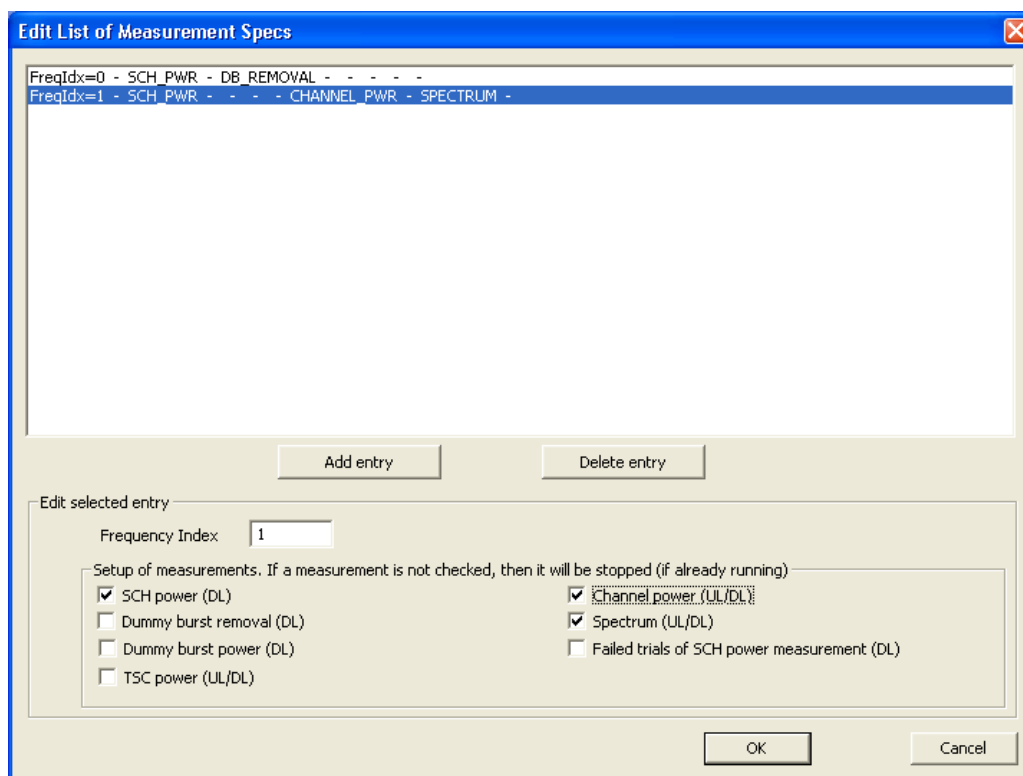


Figure 7-13: Measurement mode specification

7.2.3 Requesting System Information Type

Once a measurement has been started, you can request the System Information type 1 to 4 for a specific BTS. Therefore, the lower part of the main dialog offers the appropriate controls.

Before such a request is sent, it is required that the SCH has been demodulated successfully. This is due to the fact that the SCH contains information required to synchronise and demodulate the BCCH (namely the BSIC).

For each message type, a user-managed request id can be specified. This helps identifying to which request a result belongs. The dialog also allows setting a timeout, after which the demodulation request is stopped. A currently active demodulation request can also be cancelled again. The related checkbox has to be selected when the request is sent.

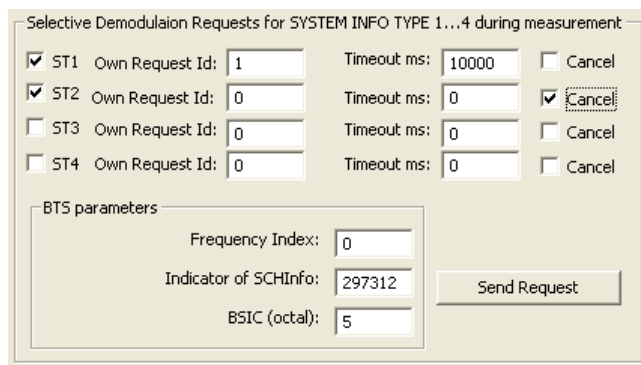


Figure 7-14: System Info type demodulation request

For all requests the channel (identified by its center frequency index), the indicator of the SCH Info (taken from the SCH demodulation result) and the BTSs BSIC have to be given to the network scanner.

7.3 GSM BCH Demodulation

The GSM network scanner has also the capabilities to demodulate System Information Type sent on BCH. Therefore, the R&S ViCom provides an API to the demodulation functionality as described in the general section. To show the usage of the API, the demo application has been enhanced, as shown in the [Enhanced Sample Application GSM demodulator](#).

Following the description how to use the API, a code listing completes the introduction into the usage of the GSM NWS API, as it is the case in the other chapters.



The measurement results from the GSM technology demodulation process are derived using data from different time slots. This is reflected in the start and stop time arguments of the demodulation result structure.

- [Sample Application](#)..... 96

7.3.1 Sample Application

In the middle column, the two new lists can be used to enter the data requests for demodulation. These lists are in "System Information Type Demodulation Requests" box in the following screenshot.

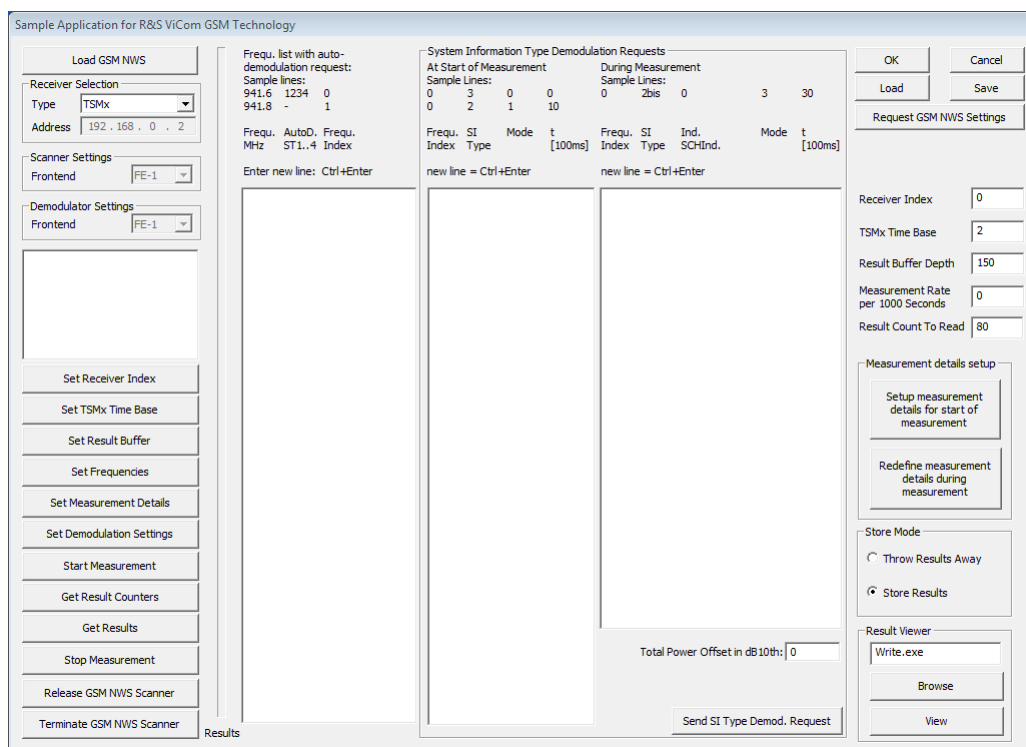


Figure 7-15: Enhanced Sample Application GSM demodulator

In the left list, the configuration is entered to setup an initial configuration of the demodulation process that is used when the measurement is started. Four values have to be entered in one line, and each line is one configuration record. These values have the following meaning:

- Channel Index – The index of the frequency for which the configuration records shall be applied entered in the list on the left side
- System Information Type – The type id of the message that shall be demodulated. This is not necessarily a number, valid values are also 2bis, 2ter etc. besides the numbered messages.
- Demodulation Type – Can be either 0, 1 or 2. 0 means that the demodulation for the system information shall be done until it has been performed successfully for one time. 1 should be used when the demodulation shall be requested dynamically (using the right list). 2 means that the demodulation shall be performed in regular intervals. This value corresponds to the values defined in `etSIType_DEMOD_MODE`.
- The last value is only used when the third value was set to 2. This value defines the delay that the demodulator delays the next demodulation attempt once the message has been decoded successfully.

There can be any number of such rows in the list. When pressing the "Set SI Type Demodulation Setting" button, these values are used to configure the scanner. Besides the configuration defined in the list, the two values entered in the text fields below are transferred to the scanner.



You can NOT use the SI Type Demodulation together with the automatic demodulation of System Information Type 1 to 4.

The new demodulation algorithm can fully replace the formerly used configuration and provides better performance and more configuration options. Make sure fully to migrate existing software when using the new modes.

The list on the right side is used to define the demodulation tasks during the measurement. The content can be defined upfront, but pressing the "Send SI Type Demod Request" button is only supported when a measurement is active.

The main differences to the left list are listed below:

- The records are defined related to a specific basestation. The third column in the list should be an entry formerly measured with the scanner and can be taken from the standard measurement results (the internal basestation id that is assigned by the scanner must be used here).
- The demodulation types are now restricted to values 3 to 8, which correlate to the remaining definitions from the `etSIType_DEMOD_MODE` enumeration.

Additionally, the request identifier can be specified to distinguish different requests when the results are processed, since they may occur in any order.

8 R&S ViCom CDMA / EVDO Technology

The R&S ViCom API CDMA / EVDO technology measurements support measuring different parameters of a CDMA 2000 / EVDO network. Such parameters are listed below.

- For the F-PICH:
 - The Channel Impulse Response
 - Absolute Inband Power of the Channel and the Pilot to calculate E_c/I_0 values
 - Automatic peak detection for the CIR measurements
- For the F-SYNC:
 - Configurable demodulation of information sent on the F-SYNC
- General measurement results:
 - Time Estimation of PN arrival time delays
 - Basestation identification

The chapter is organized in three major sections. First, the different measurement modes and how they are configured are described. The sample application is discussed in a separate section, where a descriptive walk-through example is given. Last but not least the chapter closes with a small demo application, showing how to use the API and how to set up a small measurement environment.

- [Measuring of CDMA 2000 Signals](#)..... 99
- [Sample Application for CDMA 2000/EVDO](#)..... 106
- [Measuring of EVDO Signals](#)..... 110
- [EVDO BCH Demodulation](#)..... 111
- [Measurement Rates](#)..... 111

8.1 Measuring of CDMA 2000 Signals

In the following a description of what kind of CDMA 2000 measurements is performed with the R&S TSM Instruments is given. What consequences arise from the implementation of these measurements are described too. In comparison to other R&S ViCom APIs, the different measurement modes are not enabled or disabled directly. The results are provided once they are available.

8.1.1 Measurement Types

8.1.1.1 Basestation Identification

For each measurement result, an attempt is started to identify the transmitting unit as uniquely as possible. Since it is not possible in all cases to do this automatically in an unambiguous way, the R&S TSM Instruments provide some sort of best effort estimation (see below for a description).

In the result a basestation is identified by the channel index (i.e. the frequency measured) and a so-called indicator. The indicator is simply a counter that is incremented when a (possibly) new basestation is found on a channel.

If this indicator in combination with the channel index is equal between two measurements, the same BTS has been detected with a high certainty. Under rare circumstances, it might be the case that two different basestations are assigned the same indicator. If the channel is the same, but the indicator is different, it could be the same station, but it can also be another one.

The PN Offset returned besides the channel index and the indicator must not necessarily be the same for two results that belong to the same BTS. It might be the case that in a first step a wrong PN offset was derived from the time estimation, and the correct PN offset has been demodulated later.

The table below summarizes the description above using some example values. There are two columns, one for a possible first and one for the second result. The third column contains the conclusion what can be said about the two results.

First Result			Second Result			Result
Channel	Indicator	PNOffset	Channel	Indicator	PNOffset	
0	0	65535	0	0	64	For the first result, no PN Offset estimation or demodulation has been available, so the offset value is set to invalid. The second attempt seems to provide a better result, either from demodulation or time estimation.
1	154	32	2	154	32	Different BTS, since they were measured on different channels
1	14	31	1	18	98	No certain conclusion can be made, but the cells are very likely to be different.

1	98	87	1	98	89	Probably identical BTS, since channel and indicator are equal, second PN Offset is presumably correct.
1	98	87	1	98	87	Identical BTS when PN offset was demodulated, all values are the same.

8.1.1.2 PN Offset Detection

The identification of a PN offset is done as shown in the figure below. At first, the signal is handled as pseudo-noise if all attempts fail to match the identifying sequence in the signal. The only value reported now is the inband power of the channel.

After some signal power can be separated from the noise and other information in a channel, the CIRs of the F-PICH is measured and reported. The PN offset is still unknown at that point of time if no prior demodulation has been done. In that case, the PN offset is set to an invalid value (65535). If there has been a successful demodulation on that frequency before, the new incoming signal is set into relation to the previous demodulation result. Based on the arrival time, the scanner makes an assumption what PN offset is assigned to the newly found basestation.

In that phase, the scanner reports Inband power, CIR values and a total power for the signal (RSCP). From these values, the E_c/I_0 can be calculated for the basestation reported.

Once the content of the F-SYNC gets demodulated, the PN offset must not be guessed any more but can be confirmed. The demodulation for a signal can be done in several different ways; see the section below on F-SYNC demodulation settings for more details. The demodulation also is not necessarily performed for all new pilots, so it might be the case that this state is never reached. As an additional result, the content of the F-SYNC is returned by the R&S ViCom API.

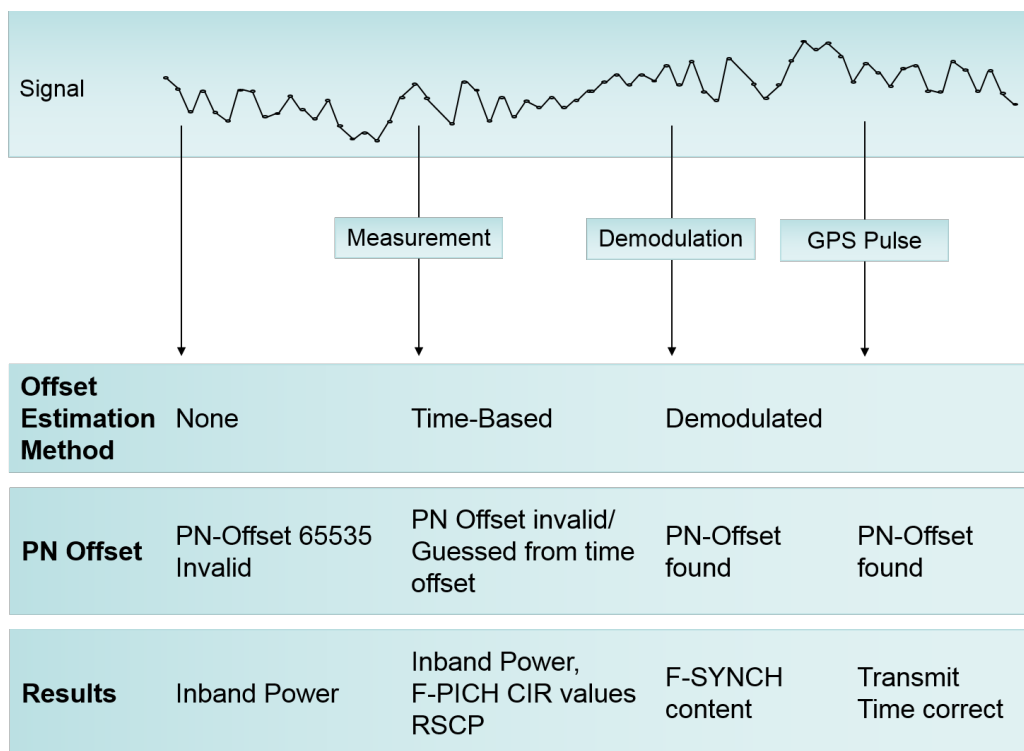


Figure 8-1: N offset estimation method

8.1.1.3 Channel Impulse Response

One operating mode in the CDMA 2000 scanner is to perform CIR measurements on the F-PICH. In that measurement mode, the R&S TSM Instruments attempt to demodulate a signal and detect the F-PICH content sent by a basestation on the CDMA channel. When the demodulation and correlation is successful, the R&S TSM Instruments measure at a constant sampling rate power values from the F-PICH and performs a peak analysis on the result.

Such a measurement result is depicted in the figure shown below. For one channel and basestation, the first thing to know is that the samples are all measured at constant intervals. This sampling rate is chosen to be very small, about 0.152 ns.

Since the time plays an important role in a CDMA2000 network, the exact arrival time of the first signal is also contained in the result. The time is specified as offset to the R&S TSM Instruments measurement result time in the number of samples. For example, in the picture below, the delay in number of CIR samples would be 2 (since the second sample after the arrival time is the first valid one).

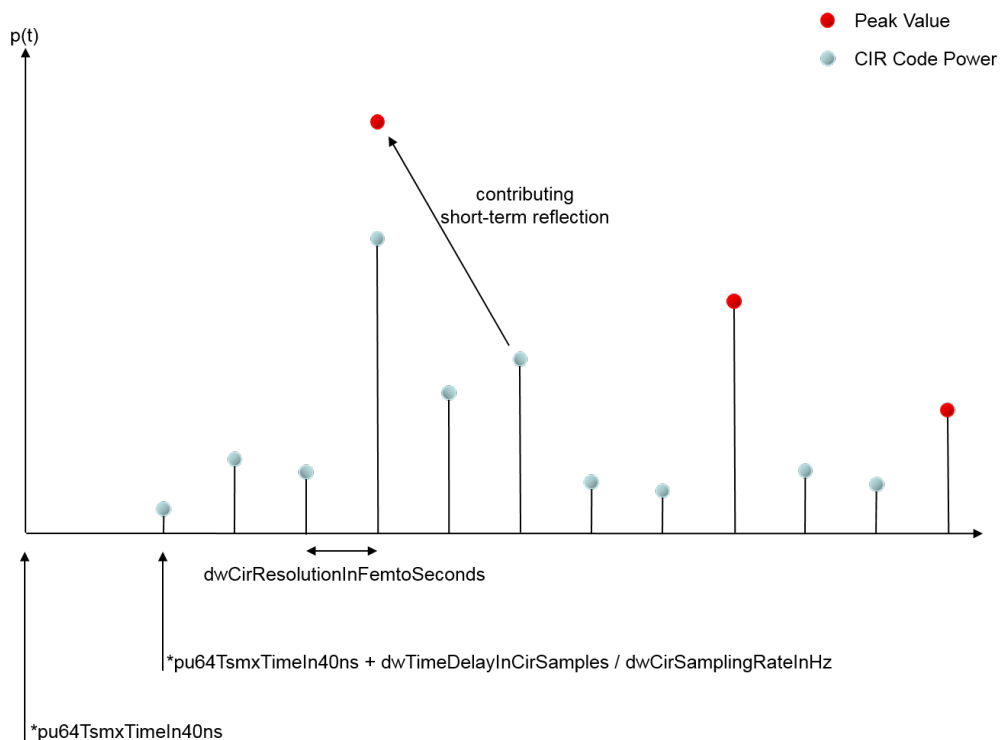


Figure 8-2: CIR samples and peaks

After that point in time, the code power values are measured every $dwCirResolutionInFemtoSeconds$ femto seconds. The data recorded in that way can be used to search for peaks that signalize impulse data sent on the F-PICH. This raw data is drawn in light blue circles.

The R&S TSM Instruments' software also performs peak detection and automatically includes minor reflection peaks into one that is identified as real impulse that has been sent. In the figure shown above, the first peak found also includes a minor reflection (two steps after the peak occurred). The calculated peak is therefore higher than the original one (it is drawn as red circle, like the two peaks found later).

As another part of the result for the code power measurements the RSCP and inband power values are measured for a detected F-PICH. From both values it is also possible to derive the E_c/I_0 of the pilot. You can do so by subtracting the RSCP from the inband power.



If no CIR measurement can be performed, the R&S TSM Instruments report the average inband power that has been measured on the channel. It can be found in the `psAverageInbandPowerInDBm100` parameter, if that parameter is not set to NULL.

8.1.1.4 F-SYNC Demodulation

Once the R&S TSM Instruments have detected a pilot on the F-PICH, they try to synchronize on the F-SYNC and to demodulate the information on that channel. If this is

performed successfully, the result is returned in the `sSyncChannelDemodulationResult` structure.

The number of demodulation attempts can be controlled using the `etSyncChannelDemodulationMode` input parameter. For this value, three possible values can be set, each specifying a different kind of demodulation strategy resulting in a different amount of result data.

- ONCE (1): For each channel (frequency), the F-SYNC is only demodulated once. The other PN offsets are therefore calculated by putting the arrival time into relation to the first identified pilot. This can be done since all cells in a CDMA 2000 network are time synchronized and send their information with different offsets.
- ALL (3): When the R&S TSM Instruments detect a new pilot (or assume to have found a new one), a new demodulation attempt of the F-SYNC is started again. This is a time-consuming task, since the scanner must spend some time to perform the demodulation on a specific pilot signal.
- FAST (4): If a new pilot is found, the demodulation is not performed completely, but in a high-speed fashion. This yields very similar results to the type ALL, but does not consume so much time since only a smaller part of the signal must be analyzed.

More details on the content of the demodulation result can be found in the 3GPP2 specification TIA-200.5-D, C.S0005-D. When this document was written, a copy could be found at http://www.3gpp2.org/Public_html/specs/C.S0005-D_v2.0_051006.pdf, section 3.7.2.3.2.26.

The demodulation result parameter stored in the `pSyncChannelDemodulationResult` contains, for example, the following information:

- Network identification
- The system time and other time information
- The PN offset of the pilot measured
- Channel configuration details

8.1.1.5 Time Estimation

Besides the other results, the R&S TSM Instruments deliver a correction for the time line used for the current measurements. This time estimation is used to correct the time base that is used in a CDMA 2000 system and is specified by single value that defines the currently measured difference between signal and pulse.

The time estimation is based on two different sources: One is the pulse signal from an attached GPS device, the other the demodulation results. Depending what kind of source is currently used to derive the delay value, one of the following three states is active:

- No source available: The transmission time is estimated by setting the received pilots into relation and trying to find a best-match. The delay value cannot be specified.

- Only Demodulation: In this case, the delay is estimated by the received pilots, where the transmission time is still estimated from the different offsets measured. The delay is calculated.
- Demodulation and PPS: Both offsets and transmission time can now be determined, so both values are correct.

8.1.2 Configuration

Before measurements can be done concerning the CDMA 2000 technology, the instrument has to be configured in order to prepare the measurement process for the desired task. Most of the configuration issues discussed below take influence on all measurement modes, until otherwise noted.

8.1.2.1 Channels and PN Offsets

Before any other type of measurement can be started, it must be defined what channel and what PN Offsets in that channel shall be measured. A CDMA 2000 channel is defined by its center frequency in the R&S ViCom API. The set of PN offsets which shall be measured can be defined by enabled or disabling one of 512 boolean attributes in the configuration structure.



The PN offsets that are disabled are not used in the time estimation algorithm as potential candidates for a valid PN. These settings do not influence the demodulation process, so if a PN offset is not set to true in the array, it might nevertheless be demodulated and reported later.

8.1.2.2 Velocity

The R&S TSM instruments use a fading correction algorithm that tries to minimize the effect of fading in a moving vehicle. In order to make the algorithm does its job in the best way it can, they need the maximum speed at which the instruments will operate. The better this value will match the reality, the better the algorithm will minimize the fading effects.

The maximum speed at which the R&S TSM Instruments are able to operate is 300 km/h (or about 186.4 mph). Using the `SMaxVelocity` structure, the estimated maximum velocity can be set.

8.1.2.3 Calibration

The R&S ViCom API supports the initial calibration of the PPS Pulse Delay with R&S TSM Instruments to improve detection speed and accuracy. Therefore, the value `lMeasuredPPSDelayInNs` parameter in the result structure can be used to specify the measured delay in the `dDelayOfPPSFallingEdgeInSec` configuration parameter. Such a calibration is recommended if you want to measure signals from different networks.

To perform the calibration, it is important to know the PN offset and the distance to a specific basestation. Such a basestation signal is measured with the R&S TSM Instruments, and based on the timing found during that initial measurement the PPS delay can be calculated.

From the distance d_{PN} [m] and the PN offset $offset_{PN}$, the expected time delay T_{exp} can be calculated as follows:

$$T_{exp} = offset_{PN} * 64 / 1228800 \text{ sec} + d_{PN} / (300 \text{ m/sec})$$

This expected time offset can then be compared with the measured time offset T_{meas} . The difference of both values is the time delay that must be subtracted from measurements and the GPS pulse signal. To let the R&S TSM automatically adjust the GPS pulse, you have to set the time delay in the `iDelayOfPPSFallingEdgeInSec` configuration setting.

8.2 Sample Application for CDMA 2000/EVDO

As in the previous chapters, the CDMA 2000 functionality and handling of the R&S ViCom Interface can be tested in the distributed sample application. The goal of the user interface design of the sample application is not to have maximum comfort or to make it available to end-users, but to provide all possible configurations and operations to a developer who wants to find out how the API is used.

A configuration dialog shown in the following figure is displayed when double-click the `C:\RuS\ViCom_<version>\bin\SampleForViCom CDMA.exe` file. The left side of the dialog shows a set of buttons used to perform the various operations on the R&S TSM Instruments. Many of them transfer a specific configuration setting that has been modified in the dialog to the device, others control the current state (i.e. measurement mode active or not).

On the right side, some common settings and result viewing controls can be found. Settings can be stored on the harddisk as well, using the Load and Save mechanisms in that part of the dialog.

The biggest part of the dialog is occupied by controls that specify measurement settings of the CDMA 2000 technology. Besides the left-most list of frequencies that shall be scanned, a control that can be used to enable and disable the scanning of a specific PN Offset is the most obvious element.

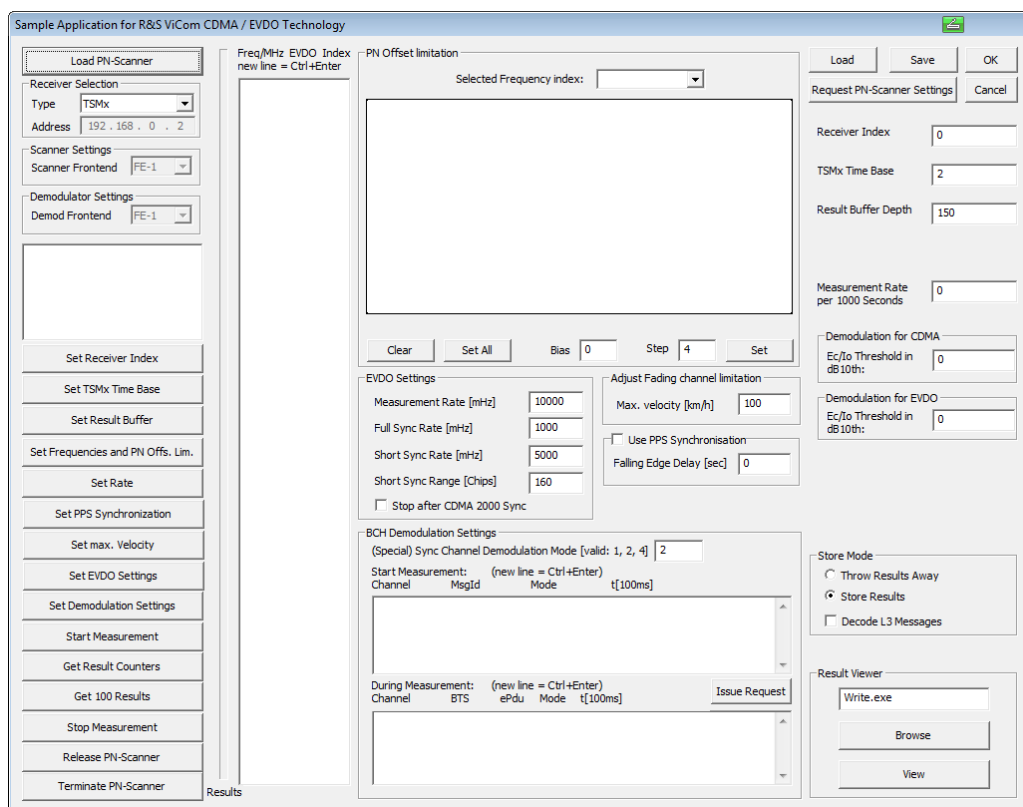


Figure 8-3: R&S ViCom CDMA / EVDO technology demo application

Below that element, some CDMA 2000 specific settings can also be specified. These measurement settings are described in the following sections.

- [Setting the PN Offsets for Time Estimation](#).....107
- [Sync Channel Demodulation Mode](#).....108
- [Performing Measurements](#).....108
- [Sample Application](#) 109

8.2.1 Setting the PN Offsets for Time Estimation

To specify which PN Offsets shall be used for time estimation during scans, a big switch matrix is used in the sample application. Each rectangle in the matrix that is shown in the upper center of the dialog stands for one PN Offset. Green signalizes an enabled scan, where a light gray filling stands for disabled reporting.

The upper left box is used to control estimation of PN offset 0, the other offsets are first set from left to right (offsets 0-31 in the first line), then from top to bottom.

You can simply enable/disable single points by clicking on them. To modify all entries at once, use the two buttons below the matrix on the left set. On the right side, there is a function to enable a certain pattern of PN offsets. The value stored in "Bias" is the starting offset, and "Setup" is the distance between two different offsets that shall be enabled. For example, if you choose "Bias" to be 13 and "Step" to be 7, the PN offsets 13, 20, 27, 34 and so on, will be enabled after you click "Setup".



Pressing the "Set" button before the "Bias"/"Setup", erases the whole content of the manipulations made previously.

8.2.2 Sync Channel Demodulation Mode

In this field, you can specify how often an attempt is started to demodulate a probably new incoming signal. The values that can be put in there can either be 1, 2 or 4. The meaning of the numeric value is the same as described above in the F-SYNC Demodulation section. The value 4 allows fast and highly sensitive detection of pilots and might therefore be a good default setting.

8.2.3 Performing Measurements

To perform measurements with the demo application, some steps must be performed in a specific sequence. If you follow the list of actions described below, this should help you to circumvent pitfalls, when programming your own applications with the API.

1. Load the R&S TSM instrument by clicking the "Load PN-Scanner" button. Assure that the driver is loaded successfully and information from the loaded instrument is shown in the box below.
2. Click the buttons "Set Receiver Index", "Set TSMx Time Base", "Set Result Buffer" and "Set Rate" to apply the related settings shown on the right-hand side of the dialog. Change them before clicking the buttons if you want different values than the defaults to be applied.
3. Enter the frequencies that shall be measured in the appropriate list. You can add multiple frequencies by pressing <Ctrl>+<Enter> to add a new line to the list. The channel indices are optional, you can omit them to let the sample application create them automatically. In the same step you have to define which PN offsets shall be detected using the time estimation result. This does not influence demodulation, so if you choose that all pilots shall be demodulated (setting 4 in the related field), then each PN offset should at some point be the result of a successful demodulation, even if the field was disabled in the matrix. Click the "Set Frequencies" to finish that step.
4. Apply the CDMA 2000 measurement specific settings using the buttons "Set PPS Synchronisation", "Set max.Velocity" and "Set Sync Channel Demod. Mode". Do your modifications to these settings before, for example, perform a measurement calibration to put a meaningful value into the "Delay of PPS falling edge" field.
5. Start the measurement using "Start Measurement" button.
6. Choose whether you want to store the results in a text file and what kind of information shall be saved. Then you can click "Get Results" to write 100 measurement results into the file. When this is done, the application is blocked until 100 results have been measured (unless older results are still in the buffer).

- Once you have all your data, click the "Stop Measurement" button to stop the measurement again. You can then either change the settings (steps 2, 3 and 4) or you can unload the R&S TSM instrument ("Release PN-Scanner") and quit the application.

8.2.4 Sample Application

The sample application as shown in the previous section has been extended to also support the demodulation request configuration before and during the measurement. Structure and usage is very similar to the demodulator extensions described in [Chapter 6, "R&S ViCom WCDMA Technology"](#), on page 58 and the related GSM equivalent.

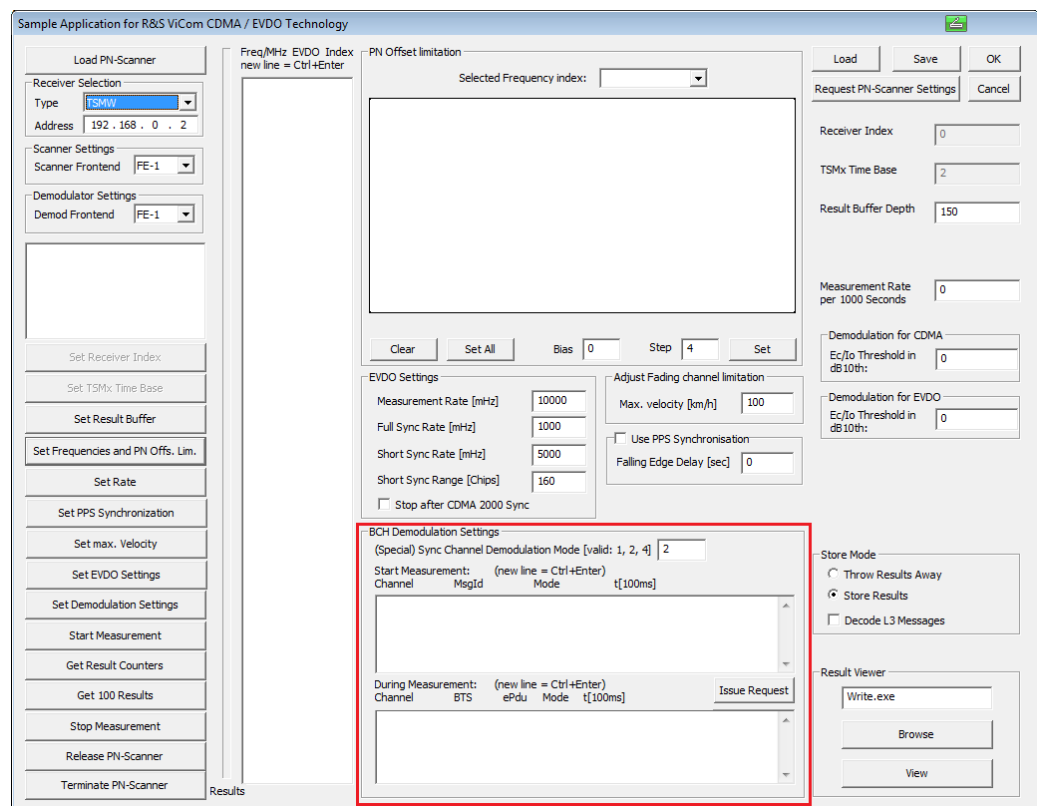


Figure 8-4: Sample Application CDMA 2000 Demodulator

The CDMA 2000 sample application GUI makes it possible to define the demodulation settings in two ways:

- Configure initial demodulation settings before a measurement is started using the upper list in the "BCH DemodulationSettings" panel
- Define demodulation commands during measurement in the lower list

How to use that controls: see [Chapter 6.2, "Sample Application"](#), on page 60 and [Chapter 7.3, "GSM BCH Demodulation"](#), on page 96

Read these sections to find out the demodulator configuration.

8.3 Measuring of EVDO Signals

The EVDO measurement capabilities are embedded within the R&S ViCom API CDMA 2000 / EVDO technology measurements.

Only a few additional control settings are required in order to do a proper setup of an EVDO measurement. The basic initialization has to be done as shown in the CDMA 2000 example.

However, there are two major differences:

- Frequencies that shall be interpreted as EVDO for measurement have to be marked as such. Therefore, the `bIsEvdoFrequency` attribute has to be set to TRUE.
- Due to the fact that the measurement is done in a different way compared to the CDMA 2000 measurement, the EVDO settings that control the measurement algorithms slightly differ. A special settings structure is available to control all EVDO related parameters. Users should specify the content of the `SEvdoControlSettings` structure.

8.3.1 The SEvdoControlSettings Structure

The correct timing for EVDO measurement can be found by synchronizing to a CDMA channel. If at least one CDMA channel is specified in addition to the EVDO channels, this method is used. In this way, the time relationship between the different PN offsets is resolved. If no additional CDMA 2000 measurements have to be performed, the CDMA 2000 measurement can be disabled after the first successful demodulation. This is done by setting the `bStopCdma2000AfterSync` attribute to true.

If no CDMA channel is specified, another method is used to find the correct timing for EVDO measurement. In this case, the `bStopCdma2000AfterSync` attribute must not be used.

Time offset estimation is done in a quite different way compared to the CDMA 2000 measurements, and three of the five attributes of the structure are dealing with that subject. Once the signals of a basestation has been detected, the scanner knows in principle when the arrival of the next information can be expected, and only processes that subrange of the incoming data to find new information. In regular intervals, the subrange has to be extended to either find signals from new basestations or to compensate shifts due to fading or movement of the measurement device.

In these cases, the processing overhead is increased. To save processing time, two different types of subrange extensions are done: A short sync and a full sync. The short sync also only uses a subset of chips that are part of a PN offset timeslot. The size of the subrange is specified by the `dwShortSyncRangeInChips` parameter, and the frequency of the short sync `dwShortSyncRateInmHz` in milliHertz. The full sync is (normally) done less frequently, and uses all the available data for signal recognition. The frequency of that task is specified in the `dwFullSyncRateInmHz` attribute.

Finally the measurement rate of the overall EVDO measurement scan can be set, using the `dwMeasRateInmHz`. Note that this parameter specifies the frequency for a

full scan of all the EVDO channels specified upfront. The more channels are specified, the less often they will be measured when the same measurement rate is used.

Once the settings have been done, the structure can be set in the ViCOM API using the `SetEvdoSettings()` method of the `CViComCdma2000Interface`.

In the following a short example is shown that can be inserted into the CDMA 2000 sample at line 98. In that case, at least one frequency should be set to be measured as EVDO frequency.

```
SEvdoControlSettings cEvdoSettings;
    cEvdoSettings.dwMeasRateInmHz = 10000;
    cEvdoSettings.dwFullSyncRateInmHz = 1000;
    cEvdoSettings.dwShortSyncRateInmHz = 5000;
    cEvdoSettings.dwShortSyncRangeInChips = 160;

    EXEC_VICOM( "Configuring EvDO scanner",
        pcC2kScanner->SetEvdoSettings ( cError, cEvdoSettings ) );
```

8.4 EVDO BCH Demodulation

The BCH Demodulation part allows requests for CDMA and EVDO BCH Demodulation. The message IDs are unique, therefore it is clear if CDMA or EVDO BCH demodulation is requested. Of course, only if CDMA and EVDO channels are configured for measurement, the corresponding BCH demodulation is available.

There are some general parameters for BCH demodulation, the CPU Load and the E_c/I_o Threshold. These parameters must be specified for CDMA and for EVDO, as appropriate.

The CPU Load for CDMA and EVDO BCH demodulation together shall not exceed 50% of the full CPU load utilized by ViCom. Therefore one ViCom instance can allocate from 10% up to 50% for CDMA or for EVDO BCH demodulation only. If CDMA and EVDO BCH demodulation are requested, only 10% up to 40% can be assigned to CDMA or EVDO and the other one is limited to the difference to 50%. See [Chapter 5.4, "Using the Demodulators"](#), on page 47.

8.5 Measurement Rates

The maximum measurement rates are different for CDMA and EVDO and they depend highly on the PC performance.

Up to 80 Hz are possible for CDMA only measurements and up to 30 Hz are possible for EVDO only measurements. For combined measurements (one or more CDMA channels and at least one EVDO channel measured in parallel), up to 30 Hz are possible.

9 R&S ViCom LTE Technology

The 3rd generation network technologies like WCDMA and EVDO are the first step into solely IP based data exchange. The first real network technology that is completely based on the transmission of IP packets is LTE.

The R&S TSMW or R&S TSME can be used to perform LTE related measurements.



There is no support of LTE for the R&S TSMx Family; this technology is only supported by the R&S TSMW and R&S TSME.

The programming API for the R&S TSMW / R&S TSME and the LTE specific measurement details are described in the following sections.

A short introduction to which and how the LTE measurements are made in the R&S ViCom is given. After that, the LTE sample application included in the R&S ViCom delivery is explained. The LTE sample application is a command line application similar to the small sample programs shown in the other R&S ViCom APIs.

- [Measuring of LTE Signals](#)..... 112
- [LTE BCH Demodulation](#)..... 132
- [GUI Sample Application](#)..... 132
- [Building a LTE TopN View](#)..... 140

9.1 Measuring of LTE Signals

Compared to GSM and WCDMA, LTE is a fairly new technology. Experience in the field of measurement modes and data analysis is currently gained, and the ViCom LTE module supports building such knowledge by providing different power, quality and channel impulse response measurements.

The LTE module itself offers a simple and straightforward interface to achieve that.

The configuration of an LTE measurement mainly consists of a list of frequencies that shall be monitored. This frequency is the center frequency of the LTE channel.

The LTE module consists of three scanner algorithms that build on top of each other.

- The Narrowband scanner takes measurements from the inner 72 LTE subcarriers on SYNC and Reference signals. It runs very fast (200Hz SYNC signal measurements), and allows to find all LTE cells, check if the UE can synchronize to the cell, and decide if a cell is a possible server or a possible interferer. Based on the results from the narrowband scanner, additionally scanner modules (wideband and MIMO) can be performed, to further analyze the network.
- The Wideband scanner takes Reference Signal measurements and power measurements over the complete LTE system bandwidth (up to 20 MHz). The actual system bandwidth can be configured in the SW or detected by the scanner from the MIB. The wideband scanner can provide detailed sub-band measurements to check the quality of a cell in more detail.

- The MIMO scanner takes Reference Signal measurements over the complete system bandwidth and provides the MIMO results.

In contrast to other interfaces, the configuration mainly concerns the way how the receiver synchronizes to the LTE signal and helps providing a fast synchronization when the apriority knowledge about the signal is available.



The R&S ViCom is preparing for eMBMS measurements, see the note in [Reference Signal Measurements](#).

9.1.1 Narrowband Measurements Configuration

For each frequency, additional information can be provided to improve the synchronization performance during the measurement.

One of that additional information concerns the number of OFDM symbols per slot used on that frequency. If that information is not available, the LTE scanner is able to automatically detect the number of symbols.

9.1.1.1 Receiver Frontend

The R&S TSMW contains two frontends that can be used to perform measurements on different channels in parallel. These frontends are simply identified by their index, which is either 1 or 2. Each frequency can be measured on a specific frontend, which has to be specified during measurement setup; see [Frontend Allocation](#).

9.1.1.2 S-Sync to P-Sync Ratio

Furthermore, the power ratio between P-SYNC and S-SYNC can be specified, either as range or as a set of up to six single ratios. This information is used to provide fast synchronization, i.e. while the LTE module is searching for signals it first uses the information provided in the power ratios to detect valid LTE data in the air. Even more important, a correct information places here increases the measurement accuracy significantly and reduced the probability of ghost code detection. So it is recommended that once the power ratios are known for the set of configured frequencies that these values are in the measurement configuration.

In the case that a range is specified, the LTE module has of course more possibilities to correlate to the detected signal, and must therefore spend more time in the signal processing algorithms. Providing up to six single ratios can boost the measurement performance and accuracy as described. Valid values for these ratios are returned as part of the measurement result and may be reused in further measurements.

The actual power ratios between the S-SYNC and P-SYNC are specified in dB.

If, for example, the emitted power of the S-SYNC is 4 times higher than that one used for the P-SYNC, the value 6 must be set in the

`RatioList::afSSyncToPSyncRatioInDB`, respectively

RatioRange::fLowerRatioInDB/RatioRange:: fUpperRatioInDB of the ViCom::LTE::SFrequencySetting::SSyncToPSyncRatioSettings structure.

A range from 0 to -6 dB is allowed.

To calculate the value, the following formula can be used:

$$r[dB] = 10 \log \left(\frac{P_{S-Sync} [W]}{P_{P-Sync} [W]} \right)$$

The figure below visualizes shows some calculation examples for simple relations between S-SYNC and P-SYNC power.

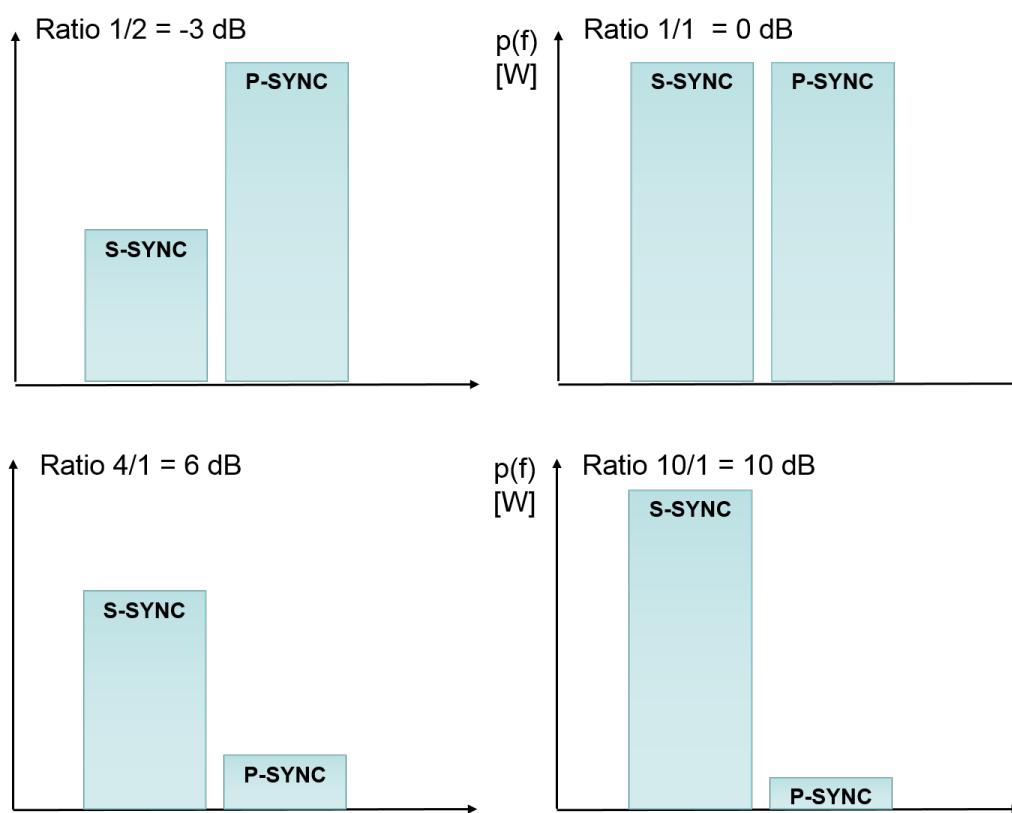


Figure 9-1: S-Sync to P-Sync ratios

Some standard values are listed in the table below. The S-Sync and P-Sync weighting refers to the power values in Watt. If the power values of S-Sync and P-Sync are given in dBm, the ratio is simply the difference between those values.

S-Sync	P-Sync	Value [dB]
10	1	10
5	1	6.99
4	1	6.02

S-Sync	P-Sync	Value [dB]
2	1	3.01
1	1	0
1	2	-3.01
1	4	-6.02
1	5	-6.99
1	10	-10

9.1.1.3 Reference Signal Measurements

RSRP, RSRQ and RS-CINR sub band values can be measured with the LTE module as well. It measures those values on the six innermost resource blocks the scanner finds in a 100ms LTE measurement sample. According to the 3GPP spec. TS 36.214 it utilizes only antenna 0 and 1 for the RSRP and RSRQ measurements. The six innermost resource blocks will be located in the 1MHz bandwidth around the center frequency.

RSRQ value is calculated based on the measured RSRP value. This is done by putting the aforementioned RSRP in relation to the total in-band power of all the PBCH resource blocks within the 100 ms signal sample.

To get those results, it is required to turn the RSRP measurement mode on in the measurement configuration. This is achieved by setting

```
ViCom::LTE::SFrequencySetting::wNarrowbandRefSignalMeasMode
```

The measurement can provide only one RS-CINR value for the bandwidth of the PBCH, but also sub-band values (2,3 or 6, depending on `wNarrowbandRefSignalMeasMode`) to identify frequency selective interference.



The R&S ViCom is capable of doing the NB RS-CINR measurements in eMBMS enabled areas.

On top of the narrowband measurement a wideband measurement using the full channel bandwidth is available. This measurement allows extended reference signal measurements and supports RSRP, RSRQ, RS-CINR, RSSI as well as spectrum values.

There are two types of wideband (WB) measurements available, that can be used separately or combined:

1. sub-band measurements

In this case, one measurement is provided per sub-band. The granularity of the sub-band can be configured, the finest granularity is one RB.

The following chart shows the concept of sub-band measurements in a 3 MHz system.

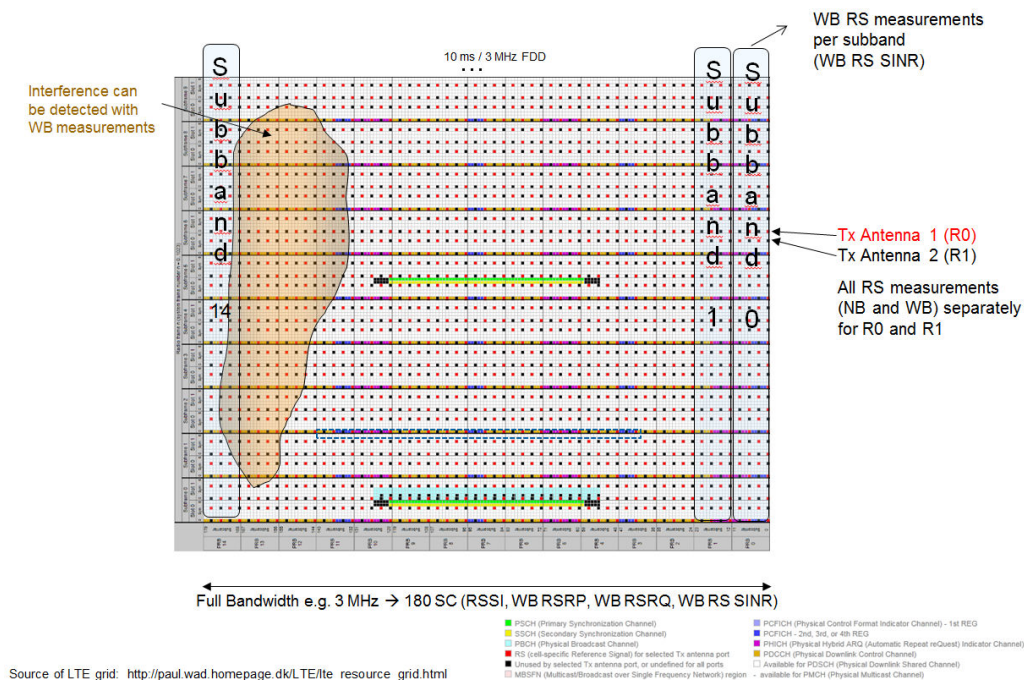


Figure 9-2: sub-band WB measurements

The wideband sub-band measurements allow to detect frequency selective interference in a potential serving cell.

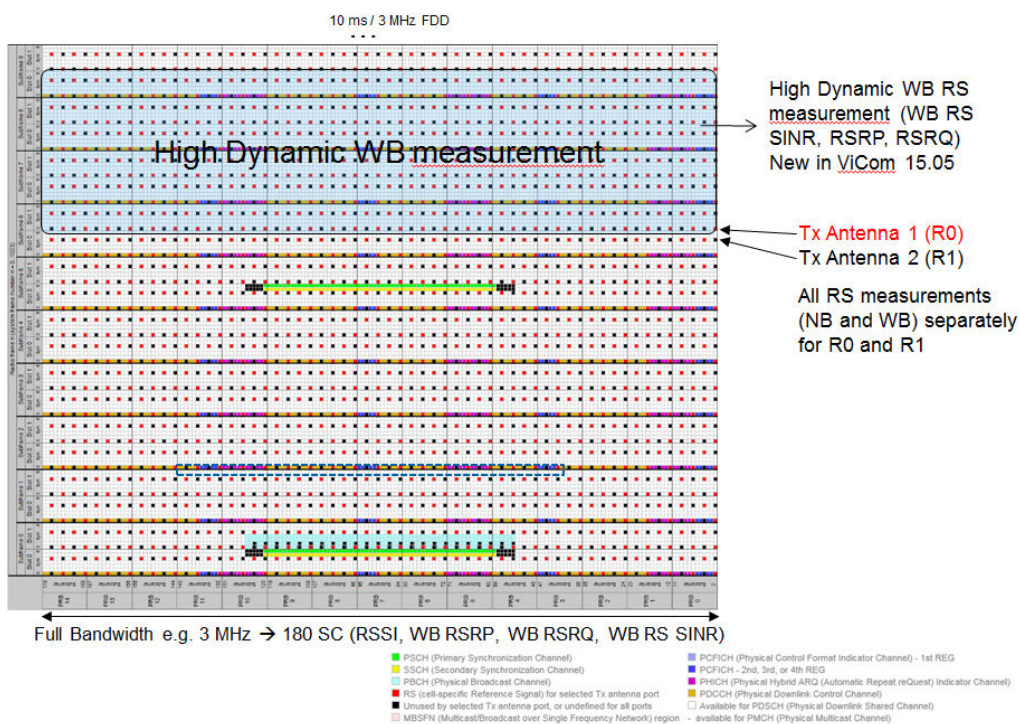
Since these measurements are done with a fine granularity (e.g. 100 values per measurement cycles in a 20MHz system) they consume more receiver and processing resource, and are therefore intended to be slower and done only on the stronger cells detected by the fast narrowband measurements. Therefore some conditions can be specified to limit the measurement to stronger cells only. These include:

- Maximum number of cells to measure on the specified channel.
- Minimum RSRP in dBm as reported by the narrowband scanner.
- Minimum RS-CINR in dB reported by the narrowband scanner.
- Maximum RSRP difference in dB to the strongest cell.

2. High Dynamic wideband measurements

These measurements have been introduced with ViCom 15.05. They require less receiver time, and can therefore be provide at very fast speed. The fastest results are achieved, when the narrowband scanner runs on TSMW frontend 1, and the WB scanner runs on TSMW frontend 2 only, while sub-band measurements are not active.

The following chart shows the concept of high dynamic WB measurements:



Source of LTE grid: http://paul.wad.homepage.dk/LTE/lte_resource_grid.html

Figure 9-3: High Dynamic WB measurements

One RS measurement is provided over the complete system bandwidth. This measurement can be provided for all cells (dynamic range to -20 dB), while the dynamic range of the sub-band measurements is limited.

For both modes the system will automatically calculate the required amount of signal. With the functionality introduced in ViCom 15.05 the manual setting of several parameters is no longer required.

As all wideband measurement relies results from the narrowband mode the narrowband mode has to be activated using the above mentioned settings.

9.1.2 Wideband Measurements Configuration

The WB measurements offer the possibility to activate independently several measurements: RSSI, Reference Signals and MIMO.

The WB measurements work on „blocks“ of automatically configured length (see before) of received signal that is processed by the scanner module for RSSI, Reference Signals and MIMO.

To adjust the speed of the measurement, the number of blocks per 1000 seconds can be configured: `dAvgBlockCountPer1000Sec`. The maximum rate is limited to 100000, corresponding to 100 measurements per second. Note that the rate configured here is the target rate, the achievable speed strongly depends on the settings.

The following use cases can be implemented in a drive test SW, for example as measurement modes or templates selectable by the user, depending on the measurements that the user wants to achieve.

Usecase	Meaning
NB only	No wideband measurements, focus on cell detection only, narrowband RS measurement sufficient
MIMO	Activate all possible measurements on both frontends (MIMO, sub-band in finest resolution, high dynamic) Provides the most detailed insight to the network, but is slowest
WB sub-band	Activates all possible measurements, but no MIMO (sub-band in finest resolution, high dynamic) Useful for single RX scanner, like single R&S TSME or R&S TSMW with R&S TSMW-K71 single receiver option
WB Highspeed 2 Frontends	Activates the WB high dynamic measurements on frontend 2 only. In this configuration narrowband measurements are performed on frontend 1 and wideband measurements on frontend 2, so the highest measurement rates can be achieved
WB Highspeed 1 Frontend	Activates only the WB high dynamic measurements on frontend 1. For scanners with a single Frontend only: single R&S TSME or R&S TSMW with R&S TSMW-K71 single frontend option

The usage of the time block depends on the scanner module; so the number of output values per block depends on the module - RSSI, Reference Signals or MIMO.

9.1.2.1 Wideband Reference Signal Measurements

Run on one frontend or both frontends (measurements on two frontends can only be made with the R&S TSMW-K30 MIMO option).

The RS CINR module provides one set of measurement values per block. The set can include sub-band measurements and high dynamic wideband measurements.

Enable sub-band measurements with

```
wWidebandRsCinrMeasMode =  
wWIDEBAND_RS_CINR|wsub-band_MEASUREMENTS = 1.
```

Enable high dynamic measurements with

```
wWidebandRsCinrMeasMode = wWIDEBAND_RS_CINR
```

The scanner module can measure the reference signal R0, R1, R2, and R3 with either or both RF frontends of the scanner.

Which reference signals shall be measured can be configured with `bTransmitAntennaSelectionMask`.

This is a bitmask, where each bit represents an eNodeB's antenna port:

Bit 0: R0

Bit 1: R1

Bit 2: R2

Bit 3: R3

For example, to measure R0 and R1, bit 0 and bit 1 needs to be set, so decimal $3 = bTransmitAntennaSelectionMask$.

Which scanner frontend shall be used for measurements can be configured with `dwFrontEndSelectionMask`.

Bit 0: frontend 0

Bit 1: frontend 1

E.g. to measure on both frontends, bit 0 and bit 1 need to be set, so decimal $3 = dwFrontEndSelectionMask$.

The scanner can provide sub-band measurements, if activated. When configuring the scanner the granularity can be defined by setting

`wNumberOfRBsInsub-band`.

With `wNumberOfRBsInsub-band = 1` one sub-band value is provided per resource block. It is possible to use a coarser granularity and aggregate up to 5 RB in one sub-band measurement (`wNumberOfRBsInsub-band=5`).

Typically, sub-band measurements are performed for possible server cells only, not for interferers. The following thresholds can be set depending on the results of the narrow-band scanner:

`bMaxCountOfeNodeBs`

Maximum number of eNodeB's per channel index for which sub-band measurements shall be done.

Typical range: 3 to 5

`sMinCenterRsrpInDBm100`

The minimum required sub-band RSRP value in 0.01 dB (obtained from the narrow-band LTE technology measurement) for the eNodeB to enable the sub-band measurements.

Typical range: -110 dBm to -130 dBm

`wMaxRsrpDiffToBestCellInDB100`

The maximum difference (distance) allowed in sub-band RSRP in 0.01 dB (obtained from the narrowband LTE scanner) from the best received eNodeB to enable the sub-band measurements.

Typical: 10dB

`sMinRsCinrInDB100`

The minimum required RS CINR value in 0.01 dB (obtained from the narrowband LTE scanner) for the eNodeB to enable the sub-band measurements.

Typical range: 1dB or lower

9.1.2.2 Wideband RSSI Module

Runs on one frontend or both frontends (measurements on two frontends can only be made with R&S TSMW-K30 MIMO option).

The RSSI module provides one measurement value per block (2 in TDD mode: UL+DL). It is configurable if less amount of signal shall be used. In addition, the module provides a complete spectrum measurement of the LTE bandwidth.

Output: RSSI, Spectrum measurement for the LTE system bandwidth

Enable this module with `wRssiMeasMode` to activate RSSI measurements for FDD, TDD DL, TDD UL or any combination.

Which scanner frontend shall be used for measurements can be configured with `dwFrontEndSelectionMask` (see the previous section for details).



WB RSSI and MIMO measurements require WB RS measurements.

If WB RSSI or MIMO is switched on, the WB RS measurements are automatically switched on as well.

9.1.2.3 MIMO Scanner Configuration Measurements

Using the R&S TSMW-K30 MIMO option both R&S TSMW receive antenna ports can be utilized for Multiple-Input Multiple-Output (MIMO) LTE measurements. All of the MIMO-specific measurements are based on the full bandwidth and can be applied to 4x2 and 2x2 MIMO systems. The output is based on the channel H-matrix with complex values, mean amplitude and phase. From the channel matrix, singular-value decomposition is calculated. The result, the singular value, is used to obtain the condition number, which qualifies whether the channel is “ill-conditioned” (no MIMO applicable) or “well-conditioned” (MIMO usable).

As a requirement for MIMO, one needs to activate the narrow- and wideband- RS-CINR measurements. Intentionally the MIMO measurements are only to be done for strong cells, which means, there are switches to restrict the calculations.

`bMaxCountOfeNodeBs`

Maximum number of eNodeBs per channel index for which wideband RS-CINR, RSRP/RSRQ measurements shall be performed.

Typical range: 3 to 5

`sMinCenterRsrpInDBm100`

The minimum required sub-band RSRP value in 0.01 dB (obtained from the narrow-band LTE scanner) for the eNodeB to enable the measurements.

Typical range: -110 dBm to -130 dBm

`wMaxRsrpDiffToBestCellInDB100`

The maximum difference (distance) allowed in sub-band RSRP in 0.01 dB (obtained from the narrowband LTE scanner) from the best received eNodeB to enable the measurements.

Typical: 10dB

`sMinRsCinrInDB100`

The minimum required RS CINR value in 0.01 dB (obtained from the narrowband LTE scanner) for the eNodeB to enable the measurements.

Typical range: 1dB or lower

In the same way it is done for wideband RS-CINR.

The basic step to activate MIMO is to set the

`ViComLteInterfaceData::SFrequencySetting::SMimoSettings::wMimoMeasMode` parameter to either `wMIMO_MODE_2x2` for 2x2 MIMO configurations or to `wMIMO_MODE_2x4` for 2x4 MIMO respectively.

The measurements rely on the H-channel matrix, which is calculated per cell and per resource block. This enables further drill-down to determine factors such as interference, multipath fading, antenna correlation and noise in relation to their spectral position.

The scanner can provide the following measurements: H-channel matrix, condition number (CN) and rank, or any combination of them.

With `dwMimoResultMaskFor2x2` it is defined what information the MIMO scanner will provide:

`dwMimoResultMaskFor2x2 = 1`: H matrix (binary 0000 0001)

`dwMimoResultMaskFor2x2 = 2`: CN (binary 0000 0010)

`dwMimoResultMaskFor2x2 = 4`: rank (binary 0000 0100)

Also bit combinations are possible. The default is 7 (1+2+4 = 7), in this case the scanner measures H matrix, CN and rank.

The MIMO module can provide several results per block. The

`wTimeResolutionInMs` defines the time interval between MIMO measurements which are calculated per resource block at a given time position within the captured IQ data.

For example, `wTimeResolutionInMs` of 1 ms, 5ms and 50ms of captured IQ data leads to up to 10 results. For TDD the time resolution has to be a multiple of the 10 ms LTE frame duration.

Furthermore, `wTimeResolutionInMs` must be less or equal to `dwSignalAquisitionInMs`. Set to 0 for only one result per IQ acquisition.

9.1.3 Narrowband Measurement Result

Once the measurement has been set up, the measured power values are returned when requested using `GetResult()`, as shown in the other R&S ViCom applications.

There are up to two different result structures returned in the measurement mode: The channel impulse responses and the power values combined with the related CINR values of the S-SYNC channel.

- [General](#)..... 122
- [Channel Impulse Responses](#)..... 123
- [SYNC Signal Power & CINR Values](#)..... 124
- [Reference Signal Measurement](#)..... 125

9.1.3.1 General

The narrowband scanner finds the individual PCIs in the measured signal, and provides the following general measurements:

Table 9-1: General measurements

Measurement	Description	ViCom Name	Part of ViCom structure
PCI	The physical Cell ID, which can take one from the values defined by [0;503]	wPhysicalCellId	ViCom::LTE::SMeasResult::SSignals ViCom::LTE::SMeasResult::SWidebandRsCinrResult ViCom::LTE::SMeasResult::SMimoResult
Cyclic Prefix	7 means normal, 6 means extended	bNumberOfSymbolsPerSlot	ViCom::LTE::SMeasResult::SSignals
Frame structure	FDD or TDD	enFrameStructureType	ViCom::LTE::SMeasResult::SSignals
TD LTE UL/DL configuration	Optional Up- / Downlink configuration used for the TD-LTE RSRP measurement. Configuration 0 to 6 are supported for TDD.	pbUpDownLinkConfig	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
TD LTE Special sub-frame configuration	The configuration of the special subframe in TD LTE is provided for sub-frame 1.	pwSpecialSub-frame1Config	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
TD LTE Special sub-frame configuration	The configuration of the special subframe in TD LTE is provided for sub-frame 6.	pwSpecialSub-frame6Config	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
Frame time-of-arrival offset to PPS	Time difference between PPS and the start of a LTE frame received by the scanner	pfFrameToaOffsetToPpsInSec	ViCom::LTE::SMeasResult::SSignals
Antenna Port detection	Detected transmit antenna ports of the eNodeB	bDetectedTransmitAntennaPorts	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal

9.1.3.2 Channel Impulse Responses

The channel impulse responses are always calculated for a 100ms block. The signal processing performed on that timeframe may deliver any combination of the following two results, if the signal is good enough:

CIR Peaks

From a 100ms S-Sync signal the processing algorithms in the LTE scanner module extract the CIR peaks. The CIR Peaks also come with Doppler frequency estimates, which are a result from the way the values are calculated internally.

Power Delay Profiles

Based on that CIR Peaks, which are not necessarily equally distributed on a time axis, the power delay profile is derived. The power delay profile consists of a list of power values which are actually sampled from the CIR Peak value resp. some interpolated data between those peaks. The sampling rate

`SCir::SPowerDelayProfile::fSamplingTimeInSec` is constant for all the values, but it can happen that invalid power values are a part of the result when there is no meaningful interpolation result available (when peaks are missing, for example).

One result may be a so-called Power-Delay-Profile. Power values are measured at a constant sampling rate, which is returned in. The single power value results measured at that rate are specified in the

`SCir::SPowerDelayProfile::SPowerDelayProfileValues::psValuesInDBm100` array.

The original peaks are distributed in a much higher resolution than the power delay profile values. In the figure below the connection between the CIR Peaks and the sampled power delay profile values is depicted. Please note however that this is a schematic figure, which shall clarify the idea behind the two different result types.

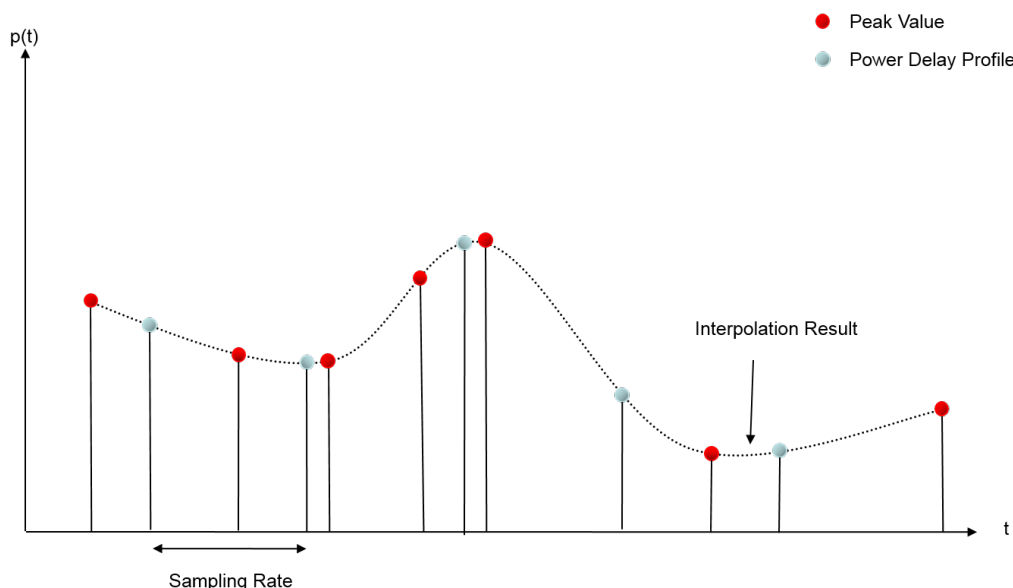


Figure 9-4: CIR Peak and Power Delay Profile

9.1.3.3 SYNC Signal Power & CINR Values

Another result lists the power measured for the S- Sync channels in the 100ms signal in `ViCom::LTE::SMeasResult::SSignals::SPowerValue`.

The SYNC signal can be measured in two ways.

Servercase

If the cell is strong, it will measure every instance of the SYNC signal, which is repeated every 5 ms. So, it delivers up to 20 SYNC signal measurements per 100ms signal block, or up to 200 values per second (200 Hz). The time delay between the start of the block and the symbol that has been used to derive the measurement value is listed in the result as `pdwTimeFromStartOfBlockInNs`.

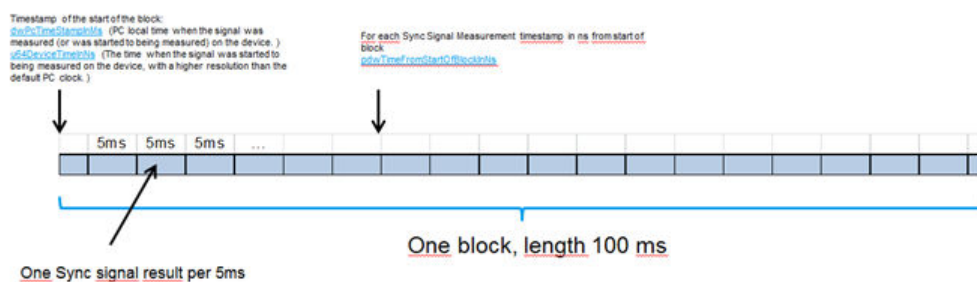


Figure 9-5: Power Measurement for S-Sync Channel

Interferercase

In this case the observed signal is weak, and in order to increase the dynamic range the scanner is now using the full 100 ms of the signal to calculate one SYNC signal measurement value. This operating mode of the scanner can be seen from the results as the `pdwTimeFromStartOfBlockInNs` is not set (Nullpointer).

The following results are provided:

- `fPowerInDBm`: S-Sync power [dB] (both servercase and interferercase)

The related power values of the P-Sync channel can be derived using the reported S-Sync to P-Sync ratio (`pfSSyncToPSyncRatioInDB`) by simply adding that value to the S-Sync power.

- `pfCinrPSyncInDB`: P-Sync CINR [dB] in servercase only
- `pfCinrSSyncInDB`: S-Sync CINR [dB] in servercase only
- `fCinrInDB`:
 - servercase: average of P-Sync CINR and S-Sync CINR [dB]
 - o interferercase: S-Sync CINR [dB]
- `pfSSyncRssiInDBm`: Comprises the linear average of the total received power observed only in OFDM symbols containing Secondary Synchronization Signals over the center 62 resource elements, including co-channel serving and non-serving cells, adjacent channel interference, thermal noise etc. Valid in server and interferercase

- `pFSSyncQualityInDB`: Calculated as the ratio of SSYNC Power and SSYNC RSSI

Additionally, an amplitude CINR is calculated for each of the two channels, where the phase CINR component is removed from the overall CINR. If the difference between the CINR and the amplitude CINR is high, this indicates a phase-noise problem in the basestation itself, i.e. there is no a real interferer that causes the situation.

9.1.3.4 Reference Signal Measurement

From each 100ms block of signal the narrowband scanner provides one Reference Signal measurement.

The following measurements are available:

RSRP

`sCenterRSRPinDBm100`: Gives the RSRP value based on the reference signal power measurement of the 6 innermost resource blocks (1MHz BW around center frequency). If both R0 and R1 can be received, the average of both is taken to compute RSRP. `bAntennaMaskUsedForRSRP` indicated if only R0, or the combination of R0 and R1 has been used.

`pNarrowbandRSRPinDBm100`: RSRP from narrowband scanner per eNB's antenna port:

- RSRP R0
- RSRP R1
- RSRP R2
- RSRP R3

RSRQ

`sPBCHbasedRSRQinDB10`: RSRQ value based on `sCenterRSRPinDBm100` and the total inband power in those symbols used to transmit the PBCH.

RS-CINR

The NB RS-CINR measurement in `pNarrowbandRsCinrValues` delivers one value for the complete measurement bandwidth (72 SC) or individual values per configurable number of sub-bands (1,2,3 or 6), depending how the setting is done; see [Narrowband Measurements Configuration](#). Measurements are provided for:

- NB RS-CINR (TX0) [dB]
- NB RS-CINR (TX1) [dB]
- NB RS-CINR (TX2) [dB]
- NB RS-CINR (TX3) [dB]

9.1.4 Wideband Measurement Results

If any of the wideband scanner modules are active, the returned measurement results include also wideband results.

- [Wideband Reference Signal Measurement Results](#)..... 126
- [Wideband RSSI Measurement Results](#)..... 128

9.1.4.1 Wideband Reference Signal Measurement Results

The results are available in

`ViCom::LTE::SMeasResult::SWidebandRsCinrResult`.

The scanner provides measurement results according to the tasked settings regarding:

- Which reference signals to measure: R0, R1, R2, R3
- On which frontends to measure: FE0 or FE1

From the values of `bTransmitAntennaPort` and `dwFrontEndSelectionMask` it is known, which path has been measured.

`dwFrontEndSelectionMask = 0` means frontend 0 was used.

`dwFrontEndSelectionMask = 1` means frontend 1 was used.

`bTransmitAntennaPort` is a bitmask, where each bit represents an eNodeB antenna port:

Bit 0: R0

Bit 1: R1

Bit 2: R2

Bit 3: R3

RSRP/RSRQ

The scanner provides combined RSRP/RSRQ values according to 3GPP 36.214, where “If the UE can reliably detect that R1 is available it may use R1 in addition to R0 to determine RSRP”.

To indicate this case, both bit 0 and bit 1 in `bTransmitAntennaPort` are set. R2 and R3 are never used for a combined RSRP/RSRQ.

The scanner also provides RSRP/RSRQ for each path. In this case only one bit in `bTransmitAntennaPort` is set.

Bit 3	Bit 2	Bit 1	Bit 0	Decimal	Meaning
			1	1	Single path: Only R0 was used for the measurement
		1		2	Single path: Only R1 was used for the measurement
		1	1	3	Combination of R0 and R1 was used for the measurement

RSRP and RSRQ values are provided as one value over the complete system bandwidth in `sRSRPinDBm100` and `sRSRQinDB100`.

If the high dynamic WB measurement have been activated, these values come from the high dynamic measurement. If only sub-band measurement have been activated, these values come from the sub-band measurements, and are therefore not available for weak cells.

- WB RSRP (TX0/RX0) [dBm]
- WB RSRQ (TX0/RX0) [dB]
- WB RSRP (TX1/RX0) [dBm]
- WB RSRQ (TX1/RX0) [dB]
- WB RSRP (TX0/RX1) [dBm]
- WB RSRQ (TX0/RX1) [dB]
- WB RSRP (TX1/RX1) [dBm]
- WB RSRQ (TX1/RX1) [dB]
- WB RSRP (TX2/RX0) [dBm]
- WB RSRQ (TX2/RX0) [dB]
- WB RSRP (TX3/RX0) [dBm]
- WB RSRQ (TX3/RX0) [dB]
- WB RSRP (TX2/RX1) [dBm]
- WB RSRQ (TX2/RX1) [dB]
- WB RSRP (TX3/RX1) [dBm]
- WB RSRQ (TX3/RX1) [dB]

If sub-band measurement have been activated, in addition RSRP is available as sub-band values (e.g. one value per resource block) in `pWidebandsub-bandRSRPinDBm100`.

- WB RSRP (TX0/RX0) [dBm] (e.g. per resource block)
- WB RSRP (TX1/RX0) [dBm] (e.g. per resource block)
- WB RSRP (TX0/RX1) [dBm] (e.g. per resource block)
- WB RSRP (TX1/RX1) [dBm] (e.g. per resource block)

- WB RSRP (TX2/RX0) [dBm] (e.g. per resource block)
- WB RSRP (TX3/RX0) [dBm] (e.g. per resource block)
- WB RSRP (TX2/RX1) [dBm] (e.g. per resource block)
- WB RSRP (TX3/RX1) [dBm] (e.g. per resource block)

In combination with the available RS-CINR measurements per resource block and the spectrum measurement that is delivered by the LTE WB RSSI scanner module, this allows most detailed interference hunting.

RS-CINR

RS-CINR values are provided as one value over the complete system bandwidth in `sAverageRsCinrInDB100`.

If High dynamic WB measurement have been activated, these values come from the high dynamic measurement. If only sub-band measurement have been activated, these values come from the sub-band measurements, and are therefore not available for weak cells:

- RS-CINR (TX0/RX0) [dB]
- RS-CINR (TX1/RX0) [dB]
- RS-CINR (TX2/RX0) [dB]
- RS-CINR (TX3/RX0) [dB]
- RS-CINR (TX0/RX1) [dB]
- RS-CINR (TX1/RX1) [dB]
- RS-CINR (TX2/RX1) [dB]
- RS-CINR (TX3/RX1) [dB]

If sub-band measurement have been activated, in addition RS-CINR is available as sub-band values (e.g. one value per resource block) in `pWidebandRsCinrValues`:

- sub-band RS-CINR (TX0/RX0) [dB]
- sub-band RS-CINR (TX1/RX0) [dB]
- sub-band RS-CINR (TX2/RX0) [dB]
- sub-band RS-CINR (TX3/RX0) [dB]
- sub-band RS-CINR (TX0/RX1) [dB]
- sub-band RS-CINR (TX1/RX1) [dB]
- sub-band RS-CINR (TX2/RX1) [dB]
- sub-band RS-CINR (TX3/RX1) [dB]

9.1.4.2 Wideband RSSI Measurement Results

The results are available in

`ViCom::LTE::SMeasResult::SRssiAndSpectrumResult`.

RSSI Measurement

Two different RSSI measurements over the complete system bandwidth are provided.

- `sRsRssiInDBm100` is a power measurement according to the definition in 3GPP 36.214: Received signal strength indicator (RSSI) using only OFDM symbols that contain reference signals. This RSSI value is different per PCI.
- `psRssiInDBm100` is a total power measurement over the complete bandwidth, not synchronized. The value is the same for each PCI.

Spectrum measurement

The measurement provides a spectrum in `psRmsSpectralPowerValueInDBm100`.

This measurement is particularly useful for TDD-LTE networks. RSSI measurements are synchronized with the TDD frame structure and allow easy interference hunting; UL RSSI = interference, if there is no UE close to the scanner. The spectrum view allows to see at which frequency the interference takes place.

9.1.5 MIMO Measurement Results

The MIMO measurement provides condition number, rank and H-Matrix per resource block in

```
ViCom::LTE::SMeasResult::SMimoResult::SChannelMatrix
```

Depending how the scanner has been configured, several MIMO results can be included in one measurement result. See section MIMO Scanner Configuration Measurements above.

The total measurement count (i.e. the number of available MIMO channel matrices) is

```
wRBNumberOfBts * wNumberOfMeasTimes
```

For example,

```
wRBNumberOfBts=50
```

and

```
wNumberOfMeasTimes=4
```

means that BTS has a system bandwidth of 50 RBs and there are 4 channel matrices for every resource block, so in total 200 matrices.

The matrix ordering is first measured matrix first and lower RB number (meaning lower frequency) first, e.g. [H_RB0_T0 H_RB1_T0 ... H_RBn_T0 H_RB0_T1 H_RB1_T1 H_RBn_T1 ...] where RBX is a RB index and TY is a time index.

The rank is available in `pbRankFor2x2Mimo` respectively `pbRankFor2x4Mimo`.

The condition number is available in `pwConditionNumber2x2MimoInDB100` respectively `pwConditionNumber2x4MimoInDB100`.

The complex coefficients of the channel matrix are available in `pComplexCoefficient`.

9.1.6 Throughput Estimation Results

9.1.6.1 CQI Measurement Results

The Channel Quality Indicator (CQI) references a table of 16 (0-15) Modulation and Coding Schemes (MCS) that the UE can suggest the eNodeB to use, based on the measured channel conditions. The CQI index increases as the channel conditions improve, where a CQI of 1 represents poor channel conditions and a CQI of 15 represents excellent channel conditions. A CQI of zero is out of range, and as a result has no associated MCS.

In SISO transmission mode, the CQI can be determined by a mapping of SINR to CQI. Multiple antenna transmission schemes (SFBC, MIMO) need to take into account the dependency between the transmission paths when computing the CQI.

SISO, SIMO, and SFBC transmission schemes provide a single CQI result for the channel.

MIMO transmission schemes provide a number of CQI results equal to the number of spatial layers. A CQI of 0 reported for a spatial layer indicates that the rank of the channel has been reduced, resulting in 0 throughput on one of the spatial layers. Currently 2x2 MIMO is supported, with one CQI for each spatial layer, i.e. a total of 2 CQI values.

CQI results are wideband and sub-band. The wideband CQI represents the CQI for the entire bandwidth, and the sub-band CQI results are computed individually for each sub-band. The sub-bands are identical to the sub-bands used for the MIMO results.

CQI results give a basic indicator of the quality of the channel.

9.1.6.2 Throughput Measurement Results

The throughput results are estimates of the channel capacity in bits per second for each transmission scheme.

MIMO has a throughput estimate for each spatial layer. As with CQI, there are wideband and sub-band throughput results.

The CQI results divide the channel quality into fifteen discrete values. The code rate obtained from the CQI is then used to scale the output of a Shannon Capacity equation that approximates the bit rate for the particular modulation type for a given SINR. The throughput estimates will vary not only when the CQI changes, but as the channel conditions vary within a single CQI value. Throughput results give a more thorough indicator of the quality of the channel, for situations where a finer granularity is needed than what the CQI provides. The UE category is not considered during the computation of the throughput estimate.

The maximum throughput values expected for each bandwidth and transmission scheme are shown in the following table.

Maximum Throughput in Mbps			
Bandwidth in Resource Blocks	SISO/SIMO (1Tx)	SFBC	MIMO
6	4.285997	4.092694	8.185388
15	12.184763	11.691506	23.383013
25	20.516794	19.690256	39.380513
50	41.346872	39.687131	79.374263
75	62.176950	59.684006	119.368013
100	83.007028	79.680881	159.361763

The actual bandwidth obtained by a UE will be limited based on the UE category.

Comparison with R&S ROMES4 Legacy Throughput Estimation Algorithm

The R&S ROMES legacy throughput estimation algorithm uses a SINR to bit rate lookup table of seven values representing a subset of the total number of modulation scheme and code rate combinations.

The lookup table of the algorithm has the following number of modulation scheme and code rate combinations:

- Three QPSK bit rates
- Two 16QAM bit rates
- Two 64QAM bit rates

The throughput value is doubled for MIMO throughput estimates.

The new throughput estimation algorithm added to R&S ViCom attempts to use an algorithm similar to that a UE might use to determine an appropriate modulation and coding scheme. It works in a similar manner as the legacy algorithm to determine the modulation and coding scheme in the SISO case, but with a table of 15 lookup values instead of 7.

This algorithm uses a capacity equation, which allows for a continuous throughput value from 0 bps to the theoretical maximum for the channel configuration, rather than seven discrete results for the same channel configuration using the legacy algorithm.

The amount of unavailable resource elements is also estimated and removed from the estimated bit rate (assuming the minimum PDCCH size and reference signals for only 1 Tx on SISO/SIMO). The new algorithm factors in the dependence between the two spatial layers in MIMO and Transmit Diversity. MIMO has a result for each spatial layer, while Transmit Diversity has one result which effectively has a gain in SINR relative to a SISO channel.

For example, if the two spatial layers are highly dependent (high condition number), the MIMO throughput estimate will be similar to an equivalent SISO channel for one spatial layer and will be 0 bps on the second spatial layer. The Transmit Diversity result for two highly dependent spatial layers will not benefit from any SINR gain from the spatial layers, resulting again in an estimate similar to an equivalent SISO channel.

9.1.7 Error Handling

The LTE R&S ViCom interface is the first that supports C++ exceptions natively. For every method in the interface (and also in the basic interface) taking a `CViComError` reference to be filled with potential error messages, there is a counterpart method that will throw a `CViComError` object in case that a problem arises. All the remaining behavior is consistent between both methods, so you can choose which version fits your needs best.

9.2 LTE BCH Demodulation

In the same way as offered by the other R&S ViCom interfaces, it is possible to perform BCH demodulation in the LTE R&S ViCom interface as well. The main difference here is that it is possible to define different demodulation load on a frontend for different channels, whereas the other interfaces only offer the possibility to define a global demodulation load.

This minimum load limit that is spent on demodulation is combined with the general load indicator. A detailed description how to use the BCH demodulation capabilities is given in [Chapter 5.4, "Using the Demodulators"](#), on page 47.

9.3 GUI Sample Application

The R&S ViCom installer comes with a GUI sample application to demonstrate how to make LTE measurements through the R&S ViCom Interface. The complete source code of the sample application is in the `C:\RuS\ViCom_<version>\src\SampleApplications\SampleForViComLTE` of the ViCom installation directory.

It is possible to build both the debug and release sample applications by opening the `SampleForViComLte.vcproj` file with Visual C++ 2008 and then performing a batch build. The binaries will be generated inside the "bin" directory with the name `SampleForViComLTE.exe` for the release build and `SampleForViComLTEDebug.exe` for the debug one.

The release binary also comes directly with the ViCom installation and is used as the reference of discussion in this document

9.3.1 Using the Sample Application

The interface of the sample application looks like in following figure:

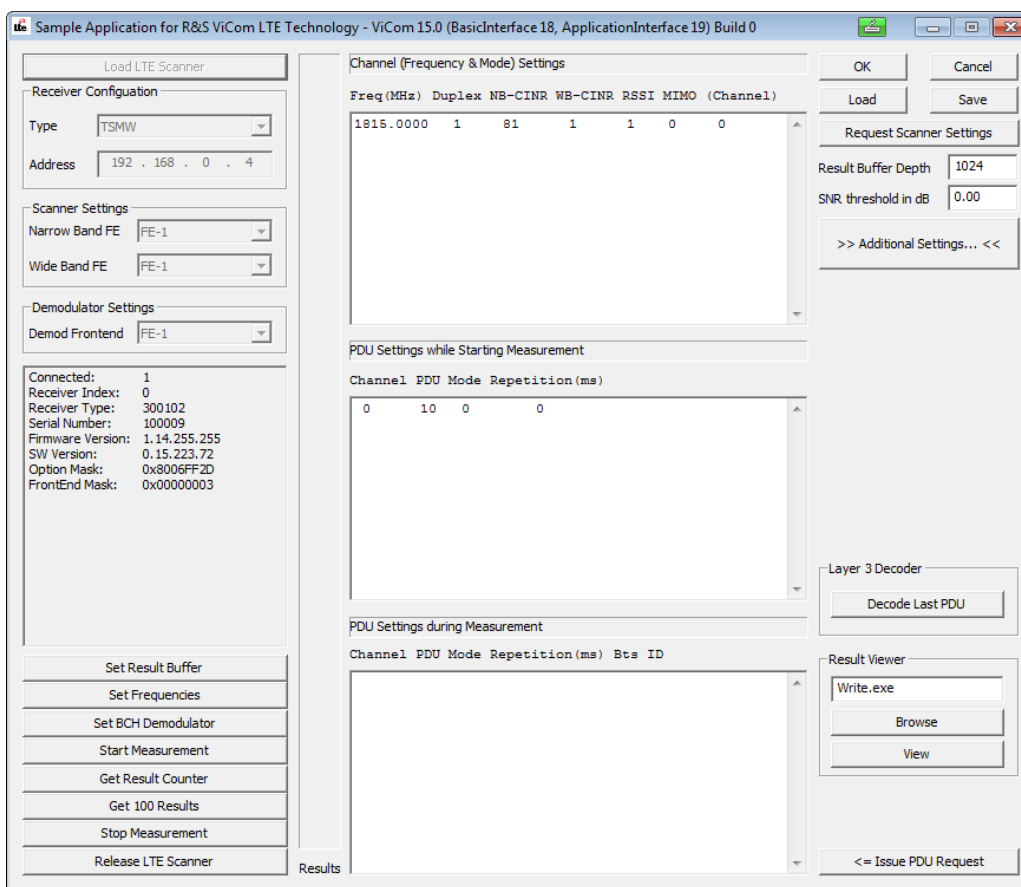
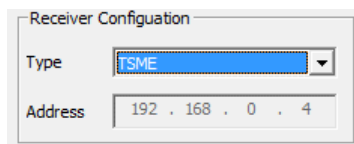


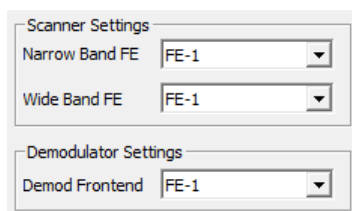
Figure 9-6: R&S ViCom LTE technology sample application

9.3.1.1 Connecting to R&S TSMW / R&S TSME

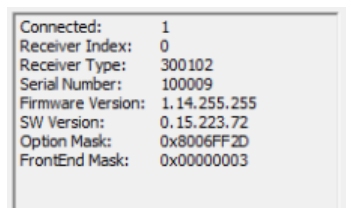
1. Select the receiver type.
2. Define the receiver IP address in the "Address" box if the selected instrument is the R&S TSMW. When selecting the R&S TSME, the box is disabled because the receiver is associated an IP address from the list of available IP addresses.



3. Select the frontends for narrowband and wideband measurements and for demodulation.

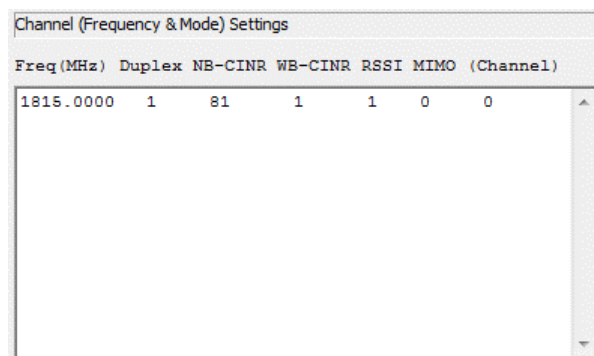


4. Press the "Load LTE Scanner" button at the upper left corner of the sample application. The application will try to connect to the R&S TSMW / R&S TSME at the specified IP address and assign the front ends load accordingly. If the connection is successfully established, some information about the R&S TSMW / R&S TSME will be displayed in the read-only text box at the middle left of the dialog box.



9.3.1.2 Configure the R&S ViCom Interface

Frequency / Channel Settings



This text box specifies the frequency / channel settings. Each line configures one channel and consists of seven numbers. The meanings of these parameters are shown in the following table. Press "Enter" to create a new line in the text box and configure another channel (the channel number).

Seq.	Label	Meaning
1	Freq (MHz)	Channel Frequency in MHz.
2	Duplex	Duplex Mode. (1 – FDD; 2 - TDD)

Seq.	Label	Meaning
3	NB-CINR	Narrow-Band RS-CINR Mode. This is a bit flag, please refer to SFrequencySetting::wNarrowbandRefSignalMeasMode inside "ViComLteInterfaceData.h" for more information. The default value is 67.
4	WB-CINR	Wide-Band RS-CINR Mode. Set to '1' to enable wide-band RS-CINR measurement, set to '0' to disable it.
5	RSSI	Reference Signal Measurement modes. The default is '1' for RSSI Normal Mode.
6	MIMO	MIMO mode. (0 – No MIMO measurement; 1 – 2 x 2 MIMO measurement; 2 – 4 x 4 MIMO measurement)
7	#	Channel Number. This number is automatically generated from the program, and it is the same as the zero-based line number of the edit box. This value is for the user's reference only, changing it at the edit box won't affect ViCom's frequency settings.

Demodulation mode

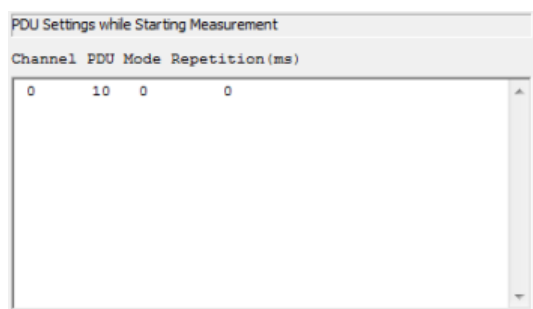
There are different modes to perform LTE demodulations at measurement startup and during measurement. The meaning of each demodulation mode and its usage is explained in the following table.

Table 9-2: LTE Demodulation Modes

Mode (Integer value)	Meaning	Usage ¹
ONCE (0)	Demodulate the PDU for each BTS at the specified channel only once.	S
ON_CMD (1)	The PDU is only demodulated if an extra command for demodulation requests the demodulation.	S
REPETITION (2)	After each successful demodulation a new one will be started automatically after the repetition time specified in wRepetitionDelayIn100ms.	S

Mode (Integer value)	Meaning	Usage ¹
CHANNEL_RESET (6)	Delete all demodulation results for all BTS at the specified channel. Restart demodulation for this channel as specified in the command.	D
BTS (3)	For a special basestation on one channel, this command tries to decode a defined message.	D

Start Measurement



- This text box specifies demodulation configurations for each channel when starting measurement. Each line configures the parameters for one PDU/demodulation mode and consists of four numbers. The first one specifies the channel to configure the demodulation parameters on, it must be one of the channel number specified in the Frequency/Channel Settings (the first multi-line) text box; The second one specifies which PDU to demodulate (for example: 10 for MIB, 13 for SIB 3 and so on); The third one specifies the demodulation mode as described in Table 7 LTE Demodulation Modes; The last one specifies the time if the demodulation mode is REPETITION (It should be zero for all other cases). Press “Ctrl + Enter” to create a new line in the text box and configure another demodulation request.

During Measurement



This text box specifies the demodulation requests to be sent during the measurement. Each line specifies one request and consists of five numbers. The first four parameters are the same as described in the previous paragraph “Start Measurement”. The fifth one specifies the BTS. It shall be set to zero by default. Press “Ctrl + Enter” to create a new line in the text box and configure another demodulation request.

If all the demodulation requests are properly configured, press the "Issue Request" button to issue these demodulation requests while measurement is running, i.e. after the "Start Measurement" button is pressed.

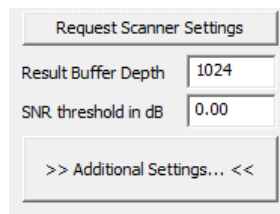
Saving/Loading

The buttons at the upper right corner are for setting saving/loading (serialization). Press "OK" to save the configuration to the default configuration file `LteScannerSettings.bin` (which will be examined and loaded on program start up) and dismiss the dialog box; press "Cancel" to dismiss the dialog without saving the configurations. The "Load"/"Save" buttons are to load /save the configurations from/to a file whose path is chosen at the user's preference.

Request Scanner Settings

Press the "Request Scanner Settings" button to refresh the text boxes with the current settings of the R&S ViCom instance.

At the right side of the dialog box, there are text boxes to configure some parameters of the scanning.



Result Buffer Depth

This setting configures the maximum number of LTE measurement results The R&S ViCom will buffer. The results are buffered after the measurement is started, and if they are not retrieved by any `GetResult()` function calls, and when the number of buffered results reach the number specified in this text box, the earliest results will be discarded. The default value is 1024. Press the "Set Result Buffer" button will set this value for the R&S ViCom.

SNR threshold in dB

This setting specifies the SNR threshold for the demodulator. Only when the calculated SNR of the signal is higher than the value specified here, the demodulator will demodulate the signal. The default value is 0 (dB). Press the "Set BCH Demodulator" button to set this value for the R&S ViCom.

Additional Channel Settings

Press the "Additional Settings" button to open the "Additional Channel Settings" dialog box. This dialog box offers many additional settings for the channels.

The dialog box can be used to configure one single channel or all channels.

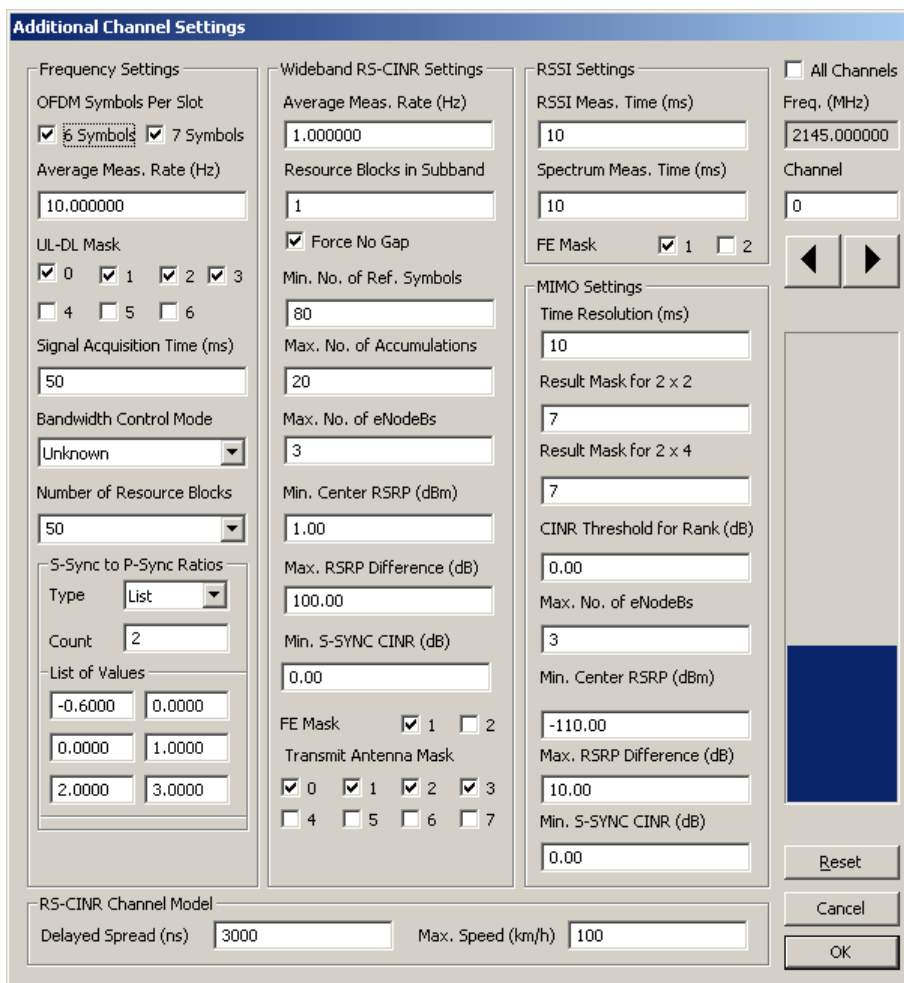


Figure 9-7: Additional channel settings for single channel

Leave the "All Channels" checkbox at the right upper corner of the dialog box unchecked to configure a single channel. In this single channel configuration mode, you can switch among the channels by clicking the big horizontal spin control at the right side of the dialog box, or you can directly input the channel number into the "Channel" box, just above the spin control. The large vertical horizontal progress bar is an obvious indicator of the channel you are configuring; it changes its progress position when the channel is changed. If you made some changes in the dialog box, you will be prompted to save the changes to that channel before switching to another channel.

Figure 9-8: Additional channel settings for all channels

Select "All Channels" to configure all channels. In this mode, if a specific setting is different among the channels, the value will be displayed as blank (for text boxes or combo boxes) or intermediate-checked (for checkboxes), and if you leave these blanks or intermediate-checks unchanged, the dialog will not modify these settings, if you click "OK" to save the changes.

9.3.1.3 Start Measurement

After all the parameters are properly configured, you can press the "Start Measurement" button to start measurement and the R&S ViCom will retrieve and buffer measurement /demodulation results from the R&S TSMW / R&S TSME. To get these results, press the "Get 100 Results" button. It will gather 100 measurement results and write them to the log file `LogFiles\ViComLteMeasurements.txt` every time it is pressed.

9.3.1.4 Stop Measurement

To end measurement, press the "Stop Measurement" button to stop the measurement and the "Release LTE Scanner" button to destroy the R&S ViCom interface.

9.4 Building a LTE TopN View

A TopN view is a sorted list of measurements of all LTE cells that the user wants to scan. The R&S TSMW R&S TSME ViCom interface provides all information to build such a TopN view.

In this section we describe which measurements need to be configured to create a typical TopN view for drive testing.

The following measurements are provided by the LTE scanner. The measurements typically shown in a TopN view in a 2x2 MIMO system are marked **bold**. Some of the values could also be combined before showing them in the TopN, for example it could be useful to display RS-CINR = MAX[RS CINR (TX1/RX0) [dB], RS CINR (TX0/RX1) [dB], RS CINR (TX0/RX0) [dB], RS CINR (TX1/RX1) [dB]] instead of the individual values. This is up to the measurement philosophy of the user.

Measurement	Description	ViCom Name	Part of ViCom structure
EARFCN or frequency	Center frequency of the measured channel (input parameter to configure the scanner)	dCenterFrequencyInHz	ViCom::LTE::SFrequencySetting
PCI	The physical Cell ID, which can take one from the values defined by [0;503]	wPhysicalCellId	ViCom::LTE::SMeasResult::SSignals ViCom::LTE::SMeasResult::SWidebandRsCinrResult ViCom::LTE::SMeasResult::SMimoResult
Values provided by the Narrowband Scanner:			
Cyclic Prefix	7 means normal, 6 means extended	bNumberOfSymbolsPerSlot	ViCom::LTE::SMeasResult::SSignals
Frame structure	FDD or TDD	enFrameStructureType	ViCom::LTE::SMeasResult::SSignals
TD LTE UL/DL configuration	Optional Up- / Downlink configuration used for the TD-LTE RSRP measurement. Configuration 0 to 6 are supported for TDD.	pbUpDownLinkConfig	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
TD LTE Special sub-frame configuration	The configuration of the special subframe in TD LTE is provided for sub-frame 1.	pwSpecialSubframe1Config	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal

Measurement	Description	ViCom Name	Part of ViCom structure
TD LTE Special sub-frame configuration	The configuration of the special subframe in TD LTE is provided for sub-frame 6.	pwSpecialSub-frame6Config	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
Narrowband RSRP	Gives the RSRP value based on the reference signal power measurement of the 6 innermost resource blocks (1 MHz BW around center frequency, where PBCH is broadcast)	sCenterRSRPinDBm100	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
Narrowband RSRP (TX0)	Gives the RSRP based only on R0 based on the reference signal power measurement of the 6 innermost resource blocks (1MHz BW around center frequency, where PBCH is broadcast). The scanner can be configured to provide up to 6 RSRP sub-band values.	pNarrowbandRSRPinDBm100 bRsCinrMeasResultConfig	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
Narrowband RSRP (TX1)	Gives the RSRP based only on R1 based on the reference signal power measurement of the 6 innermost resource blocks (1 MHz BW around center frequency, where PBCH is broadcast). The scanner can be configured to provide up to 6 RSRP sub-band values.	pNarrowbandRSRPinDBm100 bRsCinrMeasResultConfig	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
Narrowband RSRP (TX2)	Gives the RSRP based only on R2 based on the reference signal power measurement of the 6 innermost resource blocks (1MHz BW around center frequency, where PBCH is broadcast). The scanner can be configured to provide up to 6 RSRP sub-band values.	pNarrowbandRSRPinDBm100 bRsCinrMeasResultConfig	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal

Measurement	Description	ViCom Name	Part of ViCom structure
Narrowband RSRP (TX3)	Gives the RSRP based only on R3 based on the reference signal power measurement of the 6 innermost resource blocks (1MHz BW around center frequency, where PBCH is broadcast). The scanner can be configured to provide up to 6 RSRP sub-band values.	pNarrowbandRSR-PinDBm100 bRsCinrMeasResultConfig	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
Narrowband RSRQ	RSRQ value based on sCenterRSRPinDBm100 and the total inband power of the 6 innermost resource blocks (1MHz BW around center frequency, where PBCH is broadcast)	sPBCHbasedRSR-QinDB100	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
NB RS-CINR (TX0) [dB]	Narrowband RS-CINR measurements taken for antenna port 0 (1MHz BW around center frequency, where PBCH is broadcast). The scanner can be configured to provide up to 6 sub-band RS-CINR values.	pNarrowbandRsCinrValues bRsCinrMeasResultConfig	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
NB RS-CINR (TX1) [dB]	Narrowband RS-CINR measurements taken for antenna port 1 (1MHz BW around center frequency, where PBCH is broadcast). The scanner can be configured to provide up to 6 sub-band RS-CINR values.	pNarrowbandRsCinrValues bRsCinrMeasResultConfig	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
NB RS-CINR (TX2) [dB]	Narrowband RS-CINR measurements taken for antenna port 2 (1MHz BW around center frequency, where PBCH is broadcast). The scanner can be configured to provide up to 6 sub-band RS-CINR values.	pNarrowbandRsCinrValues bRsCinrMeasResultConfig	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
NB RS-CINR (TX3) [dB]	Narrowband RS-CINR measurements taken for antenna port 3 (1MHz BW around center frequency, where PBCH is broadcast). The scanner can be configured to provide up to 6 sub-band RS-CINR values.	pNarrowbandRsCinrValues bRsCinrMeasResultConfig	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal

Measurement	Description	ViCom Name	Part of ViCom structure
NB sub-band RS-CINR (TX0) [dB] (2, 3 or 6 values are provided)	Narrowband sub-band RS-CINR measurements taken for antenna port 0 (in 2, 3 or 6 sub-bands of the 1MHz BW around center frequency, where PBCH is broadcast)	pNarrowbandRsCinrValues bRsCinrMeasResultConfig	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
NB sub-band RS-CINR (TX1) [dB] (2, 3 or 6 values are provided)	Narrowband sub-band RS-CINR measurements taken for antenna port 1 (in 2, 3 or 6 sub-bands of the 1MHz BW around center frequency, where PBCH is broadcast)	pNarrowbandRsCinrValues bRsCinrMeasResultConfig	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
NB sub-band RS-CINR (TX2) [dB] (2, 3 or 6 values are provided)	Narrowband sub-band RS-CINR measurements taken for antenna port 2 (in 2, 3 or 6 sub-bands of the 1MHz BW around center frequency, where PBCH is broadcast)	pNarrowbandRsCinrValues bRsCinrMeasResultConfig	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
NB sub-band RS-CINR (TX3) [dB] (2, 3 or 6 values are provided)	Narrowband sub-band RS-CINR measurements taken for antenna port 3 (in 2, 3 or 6 sub-bands of the 1MHz BW around center frequency, where PBCH is broadcast)	pNarrowbandRsCinrValues bRsCinrMeasResultConfig	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
Number of eNodeB antenna ports	Detect the number of reference signals transmitted by the eNodeB (up to 2 reference signals)	bAntennaMaskUsedForRSRP	ViCom::LTE::SMeasResult::SSignals::SReferenceSignal
SSYNC CINR high speed for servers	CINR of the S-SYNC signal for possible serving cells (CINR > 0dB) up to 200 measurements per seconds	pfCinrSSyncInDB timestamp: dwPcTimeStampInMs + pdwTimeFromStartOfBlockInNs	ViCom::LTE::SMeasResult::SSignals::SPowerValue
PSYNC CINR high speed for servers	CINR of the P-SYNC signal for possible serving cells (CINR > 0dB) up to 200 measurements per seconds	pfCinrPSyncInDB timestamp: dwPcTimeStampInMs + pdwTimeFromStartOfBlockInNs	ViCom::LTE::SMeasResult::SSignals::SPowerValue
SSYNC CINR normal speed for interferers	CINR of the S-SYNC signal for possible interfering cells (CINR < 0dB)	fCinrInDB if pdwTimeFromStartOfBlockInNs == NULL	ViCom::LTE::SMeasResult::SSignals::SPowerValue
SSYNC Power high speed for servers	Power of S-SYNC signal up to 200 measurements per seconds	fPowerInDBm timestamp: dwPcTimeStampInMs + pdwTimeFromStartOfBlockInNs	ViCom::LTE::SMeasResult::SSignals::SPowerValue

Measurement	Description	ViCom Name	Part of ViCom structure
SSYNC CINR for servers and interferers	CINR of the S-SYNC signal	take fCinrInDB if pdwTimeFromStartOfBlockInNs == NULL take pfCinrSSyncInDB if pdwTimeFromStartOfBlockInNs != NULL	ViCom::LTE::SMeasResult::SSignals::SPowerValue
PSYNC Power high speed for servers	Power of P-SYNC signal up to 200 measurements per seconds	fPowerInDBm - *pfSSyncToPSyncRatioInDB timestamp: dwPcTimeStampInMs + pdwTimeFromStartOfBlockInNs	ViCom::LTE::SMeasResult::SSignals::SPowerValue ViCom::LTE::SMeasResult::SSignals
CINR of the S-SYNC based on amplitude noise	CINR of the SSS in dB based on amplitude noise. The measurement performed for this result value reduces noise contributions produced by transmitter or receiver phase noise. If either receiver or transmitter phase noise contributions are not neglectable then the amplitude based CINR is higher than the CINR based on the regular CINR measurement. The TSMW is a receiver with low phase noise contribution. Therefore a high transmitter phase noise is indicated if the amplitude based CINR value is permanently significantly higher (> 3dB) than the regular CINR value and both values are lower than 40 dB.	pfAmpBasedCinrSSyncInDB pdwTimeFromStartOfBlockInNs	ViCom::LTE::SMeasResult::SSignals::SPowerValue

Measurement	Description	ViCom Name	Part of ViCom structure
CINR of the P-SYNC based on amplitude noise	<p>CINR of the PSS in dB based on amplitude noise. The measurement performed for this result value reduces noise contributions produced by transmitter or receiver phase noise. If either receiver or transmitter phase noise contributions are not neglectable then the amplitude based CINR is higher than the CINR based on the regular CINR measurement.</p> <p>The TSMW is a receiver with low phase noise contribution. Therefore a high transmitter phase noise is indicated if the amplitude based CINR value is permanently significantly higher (> 3dB) than the regular CINR value and both values are lower than 40dB.</p>	<p>pfAmpBasedCinrPsyncInDB pdwTimeFromStartOfBlockInNs</p>	ViCom::LTE::SMeasResult::SSignals::SPowerValue
SSYNC RSSI	Comprises the linear average of the total received power observed only in OFDM symbols containing Secondary Synchronization Signals over the center 62 resource elements, including co-channel serving and non-serving cells, adjacent channel interference, thermal noise etc.	<p>pfSSyncRssiInDBm timestamp: dwPcTimeStampInMs + pdwTimeFromStartOfBlockInNs</p>	ViCom::LTE::SMeasResult::SSignals::SPowerValue
SSYNC signal quality	Calculated as the ratio of SSYNC Power and SSYNC RSSI	<p>pfSSyncQualityInDB timestamp: dwPcTimeStampInMs + pdwTimeFromStartOfBlockInNs</p>	ViCom::LTE::SMeasResult::SSignals::SPowerValue
Channel Impulse Response	Channel impulse response calculated from the SSYNC signals. This contains a list of all peaks including peak power, peak delay, peak Doppler, and SSYNC total inband power (SSYNC RSSI)	<p>fInbandPowerInDBm fPeakPowerInDBm sDopplerInHz fDelayInSec</p>	ViCom::LTE::SMeasResult::SSignals::SCir::Speak

Measurement	Description	ViCom Name	Part of ViCom structure
Delay Spread	Maximum time difference between the first and the last peak of the channel impulse response	MAX of fDelayInSec of the peak included in the CIR	ViCom::LTE::SMeasResult::SSignals::SCir::Speak
Frame time-of-arrival offset to PPS	Time difference between PPS and the start of a LTE frame received by the scanner	pfFrameToaOffsetToPpsInSec	ViCom::LTE::SMeasResult::Signals
Antenna Port detection	Detected transmit antenna ports of the eNodeB	bDetectedTransmitAntennaPorts	ViCom::LTE::SMeasResult::Signals::SReferenceSignal
Values provided by the wideband Scanner:			
LTE system bandwidth	Number of resource block transmitted by the eNode (or MHz)	wRBNumberOfBts The number of resource blocks transmitted from the eNodeB, i.e. LTE system bandwidth in MHz when multiplied with 200	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
WB RSRP [dBm]	Wideband RSRP, combined from R0 and R1, over the complete system bandwidth	sRSRPinDBm100 dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
WB RSRP (TX0/RX0) [dBm]	Wideband RSRP, measured from R0 on Frontend RF1, over the complete system bandwidth	sRSRPinDBm100 dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
WB RSRP (TX1/RX0) [dBm]	Wideband RSRP, measured from R1 on Frontend RF1, over the complete system bandwidth	sRSRPinDBm100 dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
WB RSRP (TX0/RX1) [dBm]	Wideband RSRP, measured from R0 on Frontend RF2, over the complete system bandwidth	sRSRPinDBm100 dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
WB RSRP (TX1/RX1) [dBm]	Wideband RSRP, measured from R1 on Frontend RF2, over the complete system bandwidth	sRSRPinDBm100 dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
WB RSRP (TX2/RX0) [dBm]	Wideband RSRP, measured from R2 on Frontend RF1, over the complete system bandwidth	sRSRPinDBm100 dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult

Measurement	Description	ViCom Name	Part of ViCom structure
WB RSRP (TX3/RX0) [dBm]	Wideband RSRP, measured from R3 on Frontend RF1, over the complete system bandwidth	sRSRPinDBm100 dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
WB RSRP (TX2/RX1) [dBm]	Wideband RSRP, measured from R2 on Frontend RF2, over the complete system bandwidth	sRSRPinDBm100 dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
WB RSRP (TX4/RX1) [dBm]	Wideband RSRP, measured from R3 on the Frontend RF2. The measurement is performed over the complete system bandwidth	sRSRPinDBm100 dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
WB RSRP noise clipped [dBm]	Noise clipped RSRP value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRP result regarding noise and interference. Combined from R0 and R1, over the complete system bandwidth	sNoiseClippedRSRPinDBm100 dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
WB RSRP noise clipped (TX0/RX0) [dBm]	Noise clipped RSRP value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRP result regarding noise and interference. Measured from R0 on Frontend RF1, over the complete system bandwidth	sNoiseClippedRSRPinDBm100 dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
WB RSRP noise clipped (TX1/RX0) [dBm]	Noise clipped RSRP value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRP result regarding noise and interference. Measured from R1 on Frontend RF1, over the complete system bandwidth.	sNoiseClippedRSRPinDBm100 dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult

Measurement	Description	ViCom Name	Part of ViCom structure
WB RSRP noise clipped (TX0/RX1) [dBm]	Noise clipped RSRP value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRP result regarding noise and interference. Measured from R0 on Frontend RF2, over the complete system bandwidth.	sNoiseClippedRSR-PinDBm100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB RSRP noise clipped (TX1/RX1) [dBm]	Noise clipped RSRP value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRP result regarding noise and interference. Measured from R1 on Frontend RF2, over the complete system bandwidth	sNoiseClippedRSR-PinDBm100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB RSRP noise clipped (TX2/RX0) [dBm]	Noise clipped RSRP value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRP result regarding noise and interference. Measured from R2 on Frontend RF1, over the complete system bandwidth	sNoiseClippedRSR-PinDBm100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB RSRP noise clipped (TX3/RX0) [dBm]	Noise clipped RSRP value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRP result regarding noise and interference. Measured from R3 on Frontend RF1, over the complete system bandwidth.	sNoiseClippedRSR-PinDBm100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result

Measurement	Description	ViCom Name	Part of ViCom structure
WB RSRP noise clipped (TX2/RX1) [dBm]	Noise clipped RSRP value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRP result regarding noise and interference. Measured from R2 on Frontend RF2, over the complete system bandwidth.	sNoiseClippedRSR-PinDBm100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB RSRP noise clipped (TX3/RX1) [dBm]	Noise clipped RSRP value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRP result regarding noise and interference. Measured from R3 on Frontend RF2, over the complete system bandwidth	sNoiseClippedRSR-PinDBm100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB RSRQ [dB]	Wideband RSRQ, combined from R0 and R1, over the complete system bandwidth	sRSRQinDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB RSRQ (TX0/RX0) [dB]	Wideband RSRQ, measured from R0 on Frontend RF1, over the complete system bandwidth	sRSRQinDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB RSRQ (TX1/RX0) [dB]	Wideband RSRQ, measured from R1 on Frontend RF1, over the complete system bandwidth	sRSRQinDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB RSRQ (TX0/RX1) [dB]	Wideband RSRQ, measured from R0 on Frontend RF2, over the complete system bandwidth	sRSRQinDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB RSRQ (TX1/RX1) [dB]	Wideband RSRQ, measured from R1 on Frontend RF2, over the complete system bandwidth	sRSRQinDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result

Measurement	Description	ViCom Name	Part of ViCom structure
WB RSRQ (TX2/RX0) [dB]	Wideband RSRQ, measured from R2 on Frontend RF1, over the complete system bandwidth	sRSRQinDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB RSRQ (TX3/RX0) [dB]	Wideband RSRQ, measured from R3 on Frontend RF1, over the complete system bandwidth	sRSRQinDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB RSRQ (TX2/RX1) [dB]	Wideband RSRQ, measured from R2 on Frontend RF2, over the complete system bandwidth	sRSRQinDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB RSRQ (TX3/RX1) [dB]	Wideband RSRQ, measured from R3 on Frontend RF2, over the complete system bandwidth	sRSRQinDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB RSRQ noise clipped [dBm]	Noise clipped RSRP value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRP result regarding noise and interference. Combined from R0 and R1, over the complete system bandwidth	sNoiseClippedRSRQinDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB RSRQ noise clipped (TX0/RX0) [dBm]	Noise clipped RSRQ value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRQ result regarding noise and interference. Measured from R0 on Frontend RF1, over the complete system bandwidth	sNoiseClippedRSRQinDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result

Measurement	Description	ViCom Name	Part of ViCom structure
WB RSRQ noise clipped (TX1/RX0) [dBm]	Noise clipped RSRQ value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRQ result regarding noise and interference. Measured from R1 on Frontend RF1, over the complete system bandwidth.	sNoiseClippedRSR-QinDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB RSRQ noise clipped (TX0/RX1) [dBm]	Noise clipped RSRQ value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRQ result regarding noise and interference. Measured from R0 on Frontend RF2, over the complete system bandwidth.	sNoiseClippedRSR-QinDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB RSRQ noise clipped (TX1/RX1) [dBm]	Noise clipped RSRQ value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRQ result regarding noise and interference. Measured from R1 on Frontend RF2, over the complete system bandwidth.	sNoiseClippedRSR-QinDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB RSRQ noise clipped (TX2/RX0) [dBm]	Noise clipped RSRQ value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRQ result regarding noise and interference. Measured from R2 on Frontend RF1, over the complete system bandwidth.	sNoiseClippedRSR-QinDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result

Measurement	Description	ViCom Name	Part of ViCom structure
WB RSRQ noise clipped (TX3/RX0) [dBm]	Noise clipped RSRQ value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRQ result regarding noise and interference. Measured from R1 on Frontend RF3, over the complete system bandwidth.	sNoiseClippedRSRQinDB100 dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
WB RSRQ noise clipped (TX2/RX1) [dBm]	Noise clipped RSRQ value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRQ result regarding noise and interference. Measured from R2 on Frontend RF2, over the complete system bandwidth.	sNoiseClippedRSRQinDB100 dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
WB RSRQ noise clipped (TX3/RX1) [dBm]	Noise clipped RSRQ value based on the wideband reference signal power measurement in 0.01 dB. For this value the measured RS-CINR was taken into account to correct the RSRQ result regarding noise and interference. Measured from R3 on Frontend RF2, over the complete system bandwidth.	sNoiseClippedRSRQinDB100 dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
WB sub-band RSRP (TX0/RX0) [dBm]	RSRP per RB, measured from R0 on Frontend RF1, over the complete system bandwidth	pWidebandsubbandRSRPinDBm100 dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
WB sub-band RSRP (TX1/RX0) [dBm]	RSRP per RB, measured from R1 on Frontend RF1, over the complete system bandwidth	pWidebandsubbandRSRPinDBm100 dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult

Measurement	Description	ViCom Name	Part of ViCom structure
WB sub-band RSRP (TX0/RX1) [dBm]	RSRP per RB, measured from R0 on Frontend RF2, over the complete system bandwidth	pWidebandsub-bandRSRPinDBm100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB sub-band RSRP (TX1/RX1) [dBm]	RSRP per RB, measured from R1 on Frontend RF2, over the complete system bandwidth	pWidebandsub-bandRSRPinDBm100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB sub-band RSRP (TX2/RX0) [dBm]	RSRP per RB, measured from R2 on Frontend RF1, over the complete system bandwidth	pWidebandsub-bandRSRPinDBm100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB sub-band RSRP (TX3/RX0) [dBm]	RSRP per RB, measured from R3 on Frontend RF1, over the complete system bandwidth	pWidebandsub-bandRSRPinDBm100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB sub-band RSRP (TX2/RX1) [dBm]	RSRP per RB, measured from R2 on Frontend RF2, over the complete system bandwidth	pWidebandsub-bandRSRPinDBm100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
WB sub-band RSRP (TX4/RX1) [dBm]	RSRP per RB, measured from R3 on Frontend RF2, over the complete system bandwidth	pWidebandsub-bandRSRPinDBm100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
RS CINR (TX0/RX0) [dB]	RS CINR over the complete system bandwidth, measured from reference signal R0 on frontend RF1	sAverageRsCin-rInDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
RS CINR (TX1/RX0) [dB]	RS CINR over the complete system bandwidth, measured from reference signal R1 on frontend RF1	sAverageRsCin-rInDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
RS CINR (TX2/RX0) [dB]	RS CINR over the complete system bandwidth, measured from reference signal R2 on frontend RF1	sAverageRsCin-rInDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result

Measurement	Description	ViCom Name	Part of ViCom structure
RS CINR (TX3/RX0) [dB]	RS CINR over the complete system bandwidth, measured from reference signal R3 on front-end RF1	sAverageRsCin-rInDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
RS CINR (TX0/RX1) [dB]	RS CINR over the complete system bandwidth, measured from reference signal R0 on front-end RF2	sAverageRsCin-rInDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
RS CINR (TX1/RX1) [dB]	RS CINR over the complete system bandwidth, measured from reference signal R1 on front-end RF2	sAverageRsCin-rInDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
RS CINR (TX2/RX1) [dB]	RS CINR over the complete system bandwidth, measured from reference signal R2 on front-end RF2	sAverageRsCin-rInDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
RS CINR (TX3/RX1) [dB]	RS CINR over the complete system bandwidth, measured from reference signal R3 on front-end RF2	sAverageRsCin-rInDB100 dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
RS sub-band CINR (TX0/RX0) [dB] (one value per RB)	RS sub-band CINR, measured from reference signal R0 on front-end RF1, one value is provided per resource block	pWidebandRsCinrValues dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
RS sub-band CINR (TX1/RX0) [dB] (one value per RB)	RS sub-band CINR, measured from reference signal R1 on front-end RF1, one value is provided per resource block	pWidebandRsCinrValues dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
RS sub-band CINR (TX2/RX0) [dB] (one value per RB)	RS sub-band CINR, measured from reference signal R2 on front-end RF1, one value is provided per resource block	pWidebandRsCinrValues dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result
RS sub-band CINR (TX3/RX0) [dB] (one value per RB)	RS sub-band CINR, measured from reference signal R3 on front-end RF1, one value is provided per resource block	pWidebandRsCinrValues dwFrontEndSelection-Mask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinr-Result

Measurement	Description	ViCom Name	Part of ViCom structure
RS sub-band CINR (TX0/RX1) [dB] (one value per RB)	RS sub-band CINR, measured from reference signal R0 on front-end RF2, one value is provided per resource block	pWidebandRsCinrValues dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
RS sub-band CINR (TX1/RX1) [dB] (one value per RB)	RS sub-band CINR, measured from reference signal R1 on front-end RF2, one value is provided per resource block	pWidebandRsCinrValues dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
RS sub-band CINR (TX2/RX1) [dB] (one value per RB)	RS sub-band CINR, measured from reference signal R2 on front-end RF2, one value is provided per resource block	pWidebandRsCinrValues dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
RS sub-band CINR (TX3/RX1) [dB] (one value per RB)	RS sub-band CINR, measured from reference signal R3 on front-end RF2, one value is provided per resource block	pWidebandRsCinrValues dwFrontEndSelectionMask bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
Number of eNodeB antenna ports	Detect the number of reference signals transmitted by the eNodeB (up to 4 reference signals)	bTransmitAntennaPort	ViCom::LTE::SMeasResult::SWidebandRsCinrResult
WB RSSI (Rx0) [dBm]	RSSI measured over the complete system bandwidth measured on front-end RF1, not synchronized to TDD frame structure	psRssiInDBm100 dwFrontEndSelectionMask wRssiMeasMode	ViCom::LTE::SMeasResult::SRssiAndSpectrumResult
WB RSSI (Rx1) [dBm]	RSSI measured over the complete system bandwidth measured on front-end RF2, not synchronized to TDD frame structure	psRssiInDBm100 dwFrontEndSelectionMask wRssiMeasMode	ViCom::LTE::SMeasResult::SRssiAndSpectrumResult
WB RSSI TDD UL (Rx0) [dBm]	RSSI measured over the complete system bandwidth measured on front-end RF1, only in TDD UL frames	psRssiInDBm100 dwFrontEndSelectionMask wRssiMeasMode	ViCom::LTE::SMeasResult::SRssiAndSpectrumResult
WB RSSI TDD UL (Rx1) [dBm]	RSSI measured over the complete system bandwidth measured on front-end RF2, only in TDD UL frames	psRssiInDBm100 dwFrontEndSelectionMask wRssiMeasMode	ViCom::LTE::SMeasResult::SRssiAndSpectrumResult

Measurement	Description	ViCom Name	Part of ViCom structure
WB RSSI TDD DL (Rx0) [dBm]	RSSI measured over the complete system bandwidth measured on frontend RF1, only in TDD DL frames	psRssiInDBm100 dwFrontEndSelection-Mask wRssiMeasMode	ViCom::LTE::SMeasResult::SRssiAndSpectrum-Result
WB RSSI TDD DL (Rx1) [dBm]	RSSI measured over the complete system bandwidth measured on frontend RF2, only in TDD DL frames	psRssiInDBm100 dwFrontEndSelection-Mask wRssiMeasMode	ViCom::LTE::SMeasResult::SRssiAndSpectrum-Result
WB spectrum scan FDD	Spectrum measurement over the LTE system bandwidth	SSpectrumResult wRssiMeasMode	ViCom::LTE::SMeasResult::SRssiAndSpectrum-Result
WB spectrum scan TDD DL	Spectrum measurement over the LTE system bandwidth synchronized to the TDD DL	SSpectrumResult wRssiMeasMode	ViCom::LTE::SMeasResult::SRssiAndSpectrum-Result
WB spectrum scan TDD UL	Spectrum measurement over the LTE system bandwidth synchronized to the TDD UL	SSpectrumResult wRssiMeasMode	ViCom::LTE::SMeasResult::SRssiAndSpectrum-Result
WB RS RSSI (Rx0) [dBm]	RSSI measurement taken according to 3GPP specification over the complete system bandwidth only from OFDM symbols that contain reference symbols for R0 measured on frontend RF1	sRsRssiInDBm100 dwFrontEndSelection-Mask	ViCom::LTE::SMeasResult::SRssiAndSpectrum-Result
WB RS RSSI (Rx1) [dBm]	RSSI measurement taken according to 3GPP specification over the complete system bandwidth only from OFDM symbols that contain reference symbols for R0 measured on frontend RF2	sRsRssiInDBm100 dwFrontEndSelection-Mask	ViCom::LTE::SMeasResult::SRssiAndSpectrum-Result
Values provided by the MIMO scanner:			
Number of MIMO RX ports	Number of receive antenna ports used for the MIMO measurement	bNumberOfReceiveAntennas	ViCom::LTE::SMeasResult::SMimoResult
Number of MIMO TX ports	Number of eNodeB transmit antenna ports used for the MIMO measurement	bNumberOfTransmitAntennas	ViCom::LTE::SMeasResult::SMimoResult

Measurement	Description	ViCom Name	Part of ViCom structure
LTE system bandwidth	Number of resource block transmitted by the eNode (or MHz)	wRBNumberOfBts The number of resource blocks transmitted from the eNodeB, i.e. LTE system bandwidth in MHz when multiplied with 200	ViCom::LTE::SMeasResult::SMimoResult
MIMO rank 2x2 (one value per RB)	rank of the channel matrix (H matrix) for MIMO 2x2	pbRankFor2x2Mimo	ViCom::LTE::SMeasResult::SMimoResult::SChannelMatrix
MIMO rank 2x4 (one value per RB)	rank of the channel matrix (H matrix) for MIMO 2x2	pbRankFor2x4Mimo	ViCom::LTE::SMeasResult::SMimoResult::SChannelMatrix
Complex H matrix values: h11, h12, h21, h22 (one value per RB)	Complex coefficient of the H matrix in sqrt(mW)	pComplexCoefficient dwCountOfComplexCoefficients	ViCom::LTE::SMeasResult::SMimoResult::SChannelMatrix
Channel Matrix RS CINR (one value per RB)	RS sub-band CINR, measured combination of reference signals R0, R1, R2 and R3 (where available) on frontend RF1 and RF2, one value is provided per resource block	psChannelMatrixCinrInDB100	ViCom::LTE::SMeasResult::SMimoResult::SChannelMatrix
Condition Number MIMO 2x2 (one value per RB)	condition number for the channel matrix (H matrix) for MIMO 2x2	pwConditionNumber2x2MimoInDB100	ViCom::LTE::SMeasResult::SMimoResult::SChannelMatrix
Condition Number MIMO 2x4 (one value per RB)	condition number for the channel matrix (H matrix) for MIMO 2x4	pwConditionNumber2x4MimoInDB100	ViCom::LTE::SMeasResult::SMimoResult::SChannelMatrix

To get these values from the scanner the sample application from the previous section can be used for an FDD 2x2 MIMO network, using both R&S TSMW frontends and the R&S TSMW-K30 MIMO option. The following changes can be used to simplify the results:

Narrowband measurement

To get only one RS CINR result for the complete bandwidth, and no sub-band results use the following settings:

```
s.wNarrowbandRefSignalMeasMode =
SFrequencySetting::wNARROWBAND_RSRP_RSRQ |
SFrequencySetting::wCENTER_RSCINR_1x1080KHZ |
SFrequencySetting::w1MHZ_FILTER_NOISE_FOR_15RB;
```

MIMO measurement

The sample application provides the complex channel matrix, which is not needed in a TopN view. Therefore, the MIMO measurement should be configured in this way:

```
s.MimoSettings.dwMimoResultMaskFor2x2 =  
ViCom::LTE::SFrequencySetting::SMimoSettings::dwMIMO_RES_COND_NUMBER  
ViCom::LTE::SFrequencySetting::SMimoSettings::dwMIMO_RES_RANK;
```

The application provides several MIMO results per block. In the TopN only one is needed, use the following settings.

```
s.MimoSettings.wTimeResolutionInMs= 0;
```

10 R&S ViCom WiMAX Technology

WiMAX stands for Worldwide Interoperability for Microwave Access. Based on the IEEE 802.16 standard, WiMAX provides ubiquitous broadband communication enabling cost-effective access to multiple kinds of networks regardless of whether they are fixed or mobile and allowing high throughput rates by robust implementation.

The downlink and uplink frame structures of WiMAX are shown below:

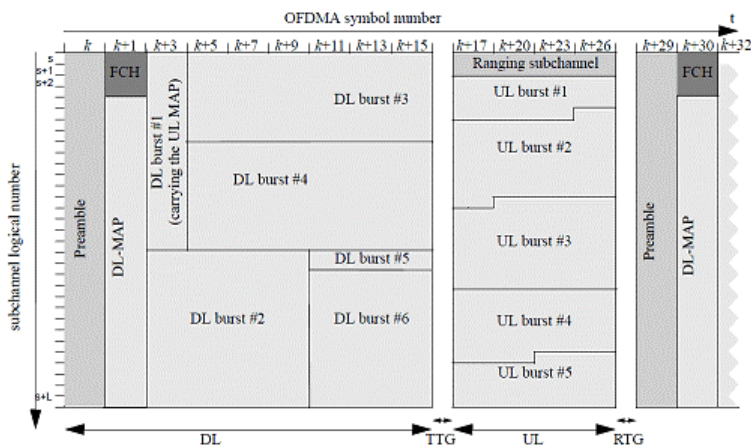


Figure 10-1: WiMAX downlink & uplink frame structures

This R&S ViCom Interface utilizes R&S TSMW / R&S TSME to measure downlink WiMAX signals modulated using OFDMA (Orthogonal Frequency Division Multiple Access) in TDD (Time Division Duplex) mode.

In the following sections, the programming API (Application Program Interface) for R&S TSMW / R&S TSME and the WiMAX specific measurement details are described. Firstly, a short introduction into which and how WiMAX measurements are made in the R&S ViCom is given. After that the sample console application coming with the R&S ViCom delivery for WiMAX is explained.

- [Measuring of WiMAX Signals](#)..... 159
- [GUI Sample Application](#)..... 164

10.1 Measuring of WiMAX Signals

The WiMAX R&S ViCom module offers a simple and straightforward interface to provide a fast synchronization, if a priori knowledge about the signal is available. Each result of WiMAX signals measurement is stored in some easy-to-understand structures for the client application to access.

10.1.1 Configuration

The first step to do WiMAX measurements via the WiMAX R&S ViCom module is to config its settings. Once the WiMAX R&S ViCom module is properly configured, the client application can then make subsequent API calls to retrieve the measurement results from the R&S TSMW / R&S TSME scanner. These configurations are stored in the `SSettings` structure, which contains the following:

- Result Buffer Depth
- Channel Settings
- Demodulation Settings

10.1.1.1 Result Buffer Depth

After the `StartMeasurement()` function is called, whenever there is some result sent from R&S TSMW / R&S TSME, the WiMAX ViCom module stores it into some internal FIFO (First In, First Out) buffer. Then only when the `GetResult()` function is called, the “front” (earliest) result is pop out from this buffer. The size of this buffer (which must be between 1 to 1024 results) is configurable in the `SResultBufferDepth` structure within `SSettings`.

10.1.1.2 Channel Settings

The Channel Settings (`SChannelSettings`) mainly consists of a list of (up to 32) center frequencies and the corresponding bandwidths to be scanned. Another information it holds is the R&S TSMW frontends. The R&S TSMW contains two frontends that can be used to perform measurements on different channels in parallel. The measurement can be run on either one. The `resourceHandleForScanner` and `resourceHandleForDemodulator` variable hold the handles to the front-end used for scan and demodulation correspondingly. You can refer to the Frontend allocation section for more info.

10.1.1.3 Demodulation Settings

The Demodulation Settings (`SBchDemodulationSettings`) specifies CINR threshold, the load percentage on R&S TSMW / R&S TSME to be used for demodulation (maximum value is 50) and the PDU Request Settings to start the measurement.

PDU Request Settings

The PDU Request Settings (`SDemodRequests`) specifies the following:

- On which channel to request PDU decode result (`dwChannelIndex`),
- The type of PDU to be decoded (`ePDU`).
- PDU demodulation mode (`eDemodulationMode`) and its related parameters.

10.1.2 Measurement Result

Once the measurement has been set up, the measurement results are returned when requested using `GetResult()`. The WiMAX measurement results (`SMeasResult`) can be classified into two:

- WiMAX Scan Results
- WiMAX Demodulation Results
- [WiMAX Scan Results](#)..... 161
- [WiMAX Demodulation Results](#)..... 164

10.1.2.1 WiMAX Scan Results

WiMAX Scan Results contain information about the Channel Quality (RSSI and CINR) and Serving Cell (Preamble Index, Segment and ID Cell).

Channel Quality

- RSSI
The received signal strength indicator is the received wide band power in dBm, including thermal noise and noise generated in the receiver.
- CINR
The ratio of carrier/interference plus noise in dB.

RSSI and CINR are calculated from the power parameters of the Power Delay Profile inside the Channel Impulse Responses. For more details on CIR, please refer to the Channel Impulse Responses section in the LTE chapter.

Serving Cell

- Preamble Index
Downlink Preamble Index of the Base Station. It varies from 0 to 113 according to standard IEEE 802.16.
- Segment
A cell site can be divided up into three different segments. Thus segment number can be 0, 1 or 2.

ID Cell

ID of the cell; ranges from 0 to 31.

Downlink Frame Prefix

The downlink (DL) frame in WiMAX starts with preamble as its first symbol. In the DL symbols followed by preamble, the initial four subchannels are allocated for the Frame Control Header (FCH). The Downlink Frame Prefix (DLFP) is a data structure that contains information regarding the current frame and is mapped to the FCH. More specifically the DLFP contains the following information:

The downlink (DL) frame in WiMAX starts with preamble as its first symbol. In the DL symbols followed by preamble, the initial four subchannels are allocated for the Frame Control Header (FCH). The Downlink Frame Prefix (DLFP) is a data structure that con-

tains information regarding the current frame and is mapped to the FCH. More specifically the DLFP contains the following information:

- Bitmap of Used Subchannels
- Length of Downlink Map (DL-MAP) that immediately follows the DLFP
- DL-MAP Repetition Coding (0, 2, 4 or 6)
- DL-MAP Encoding (such as CC, BTC, CTC, ZT CC, CC with interleaver and LDPC)

The FCH is always coded with the QPSK rate 1/2 mode with four repetitions to ensure maximum robustness and reliable performance, even at the cell edge.

Downlink Map

The Downlink Map (DL-MAP) message (Management Message Type = 2) defines the access to the DL information. It contains the following information:

- DCD Count
- No. OFDMA Symbols

DL-MAP also contains some IEs, of which we are interested in the Downlink Burst Profile (whose DIUC is between 0 and 12, both inclusive). It contains the following information:

- OFDMA Symbol Offset
- Subchannel Offset
- Boosting
- No. OFDMA Symbols
- No. Subchannels
- Repetition Coding

Uplink Map

The Uplink Map (UL-MAP) message (Management Message Type = 3) allocates access to the UL channel. It contains the following information:

- UCD Count
- Allocation Start Time
- No. OFDMA Symbols

UL-MAP also contains some IEs, of which we are interested in the CDMA BR, CDMA ranging (whose UIUC is 12). It contains the following information:

- OFDMA Symbol Offset
- Subchannel Offset
- No. OFDMA Symbols
- No. Subchannels
- Ranging Method
- Dedicated Ranging Indicator

Compressed Map

In addition to the standard DL-MAP and UL-MAP formats described above, there are also Compressed Maps. The presence of the Compressed DL-MAP format is indicated

by the contents of the most significant three bits of the first data byte. When this combination of three bits is set to 110 (an invalid combination for a standard header in the downlink), the compressed DL-MAP format is present. A compressed UL-MAP shall only appear after a compressed DL-MAP. The presence of the compressed UL-MAP is indicated by a bit in the compressed DLMAP data structure.

Compressed DL-Map

The Compressed DL-MAP presents the same information as the standard format with one exception. In place of the DL-MAP's 48-bit Base Station ID parameter, the compressed format provides a subset of the full value, i.e. Operator ID and Sector ID. The Operator ID holds the 8 LSBs of the 24 MSBs of the 48-bit Base Station ID parameter, and the sector ID holds the 8 LSBs of the 48-bit Base Station ID parameter. When the compressed format is used, the full 48-bit Base Station ID parameter shall be published in the DCD.

Compressed UL-Map

The Compressed Uplink Map (UL-MAP) format may only appear after a compressed DL-MAP message to which it shall be appended. The message presents the same information as the standard format with the exception that the generic MAC header is omitted.

DL Channel Descriptor & UL Channel Descriptor

A DL Channel Descriptor (DCD) is transmitted by the BS at a periodic interval to define the characteristics of a DL physical channel. A UL Channel Descriptor (UCD) is transmitted by the BS at a periodic interval to define the characteristics of a UL physical channel. They contain information described below.

DCD

- Configuration Change Count

UCD

- Configuration Change Count
- Ranging Backoff Start
- Ranging Backoff End
- Request Backoff Start
- Request Backoff End

Both DCD and UCD may contain optional TLV fields, some of them are described as follows

DCD

- Transmit/Receive Transition Gap (TTG)
- Receive/Rransmit Transition Gap (RTG)
- BS EIRP in dBm
- EIRxPIR,max
- Base Station ID in case of compressed DLMAP.
- MAC Version

10.1.2.2 WiMAX Demodulation Results

The WiMAX demodulation results are the decoded contents of the PDU of MAC Management message. To get demodulation results, the client application first needs to check to make sure that `pPduResult` field of `SMeasResult` is no NULL (i.e. it contains valid PDU data). And then it uses this PDU data to fill the `SL3DecoderRequestData` structure and uses that structure to call the `RetrieveTextForPDU` function to retrieve the demodulation results. The results (`SL3DecoderResultData`) will be filled in with variables containing decoded contents and a descriptive string of all these contents (`pcStringPDU`) for the PDU requested, which can be DL-MAP, UL-MAP, DCD, UCD and so on.

10.1.3 Error Handling

The WiMAX ViCom interface supports C++ exceptions natively. For every method in the interface (and also in the basic interface) taking a `CViComError` reference to be filled with potential error messages, there is a counterpart method that will throw a `CViComError` object in case that a problem arises. All the remaining behavior is consistent between both methods, so you can choose which version fits your needs best.

10.2 GUI Sample Application

The sample application is a simple implementation of the R&S ViCom Interface, to control one WiMAX scanner (R&S TSMW or R&S TSME). It may be used

- to test the R&S TSMW / R&S TSME
- to understand the R&S ViCom programming interface

The application and its user interface was principally designed for testing the R&S ViCom interface functions so it is possible to call interface functions at any time from the GUI, and it is possible to set values out of range to check the responses and the behaviour of the PN-Scanner in different situations. This means the code is quite straightforward and provides a good example of how to program a measurement application.

Double click the `SampleForViComWiMax.exe` file in the R&S ViCom installation directory "bin".

There is only one screen in the test application shown in the [Figure 10-4](#).

- [Setup Connection](#)..... 165
- [Measurement Controls](#) 166
- [View Results](#)..... 167
- [Update GUI with Current Scanner Settings](#)..... 168
- [Miscellaneous](#)..... 169
- [Demodulation](#)..... 169

10.2.1 Setup Connection

The first action after starting the sample application, should be to enter the receiver type and the IP address of the R&S Instrument and click the "Load WiMAX Scanner" button, highlighted below.

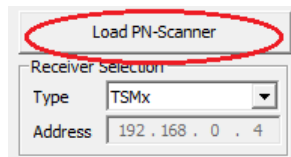


Figure 10-2: Dialog to load the scanner

If the WiMAX scanner is connected and configured with an IP address, clicking the "Load WiMAX Scanner" will cause the sample application to load the WiMAX R&S ViCom Interface. See [Programming with the R&S ViCom Interface](#) for more explanation about loading the interface. If the scanner is loaded successfully, information similar to that shown in the following figure, will appear in the text box below the Demodulator settings. Note that the button is now greyed out to indicate that a device is now loaded.

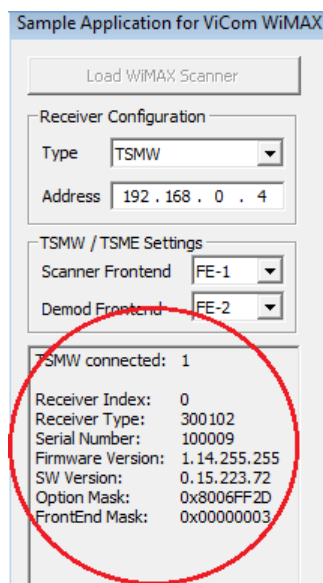


Figure 10-3: Scanner information

The information box in the figure are two groups of settings:

- Frontend selection for measurement settings
- Frontend selection for demodulator settings

The first settings defines the frontend number on which measurements will be performed.. The R&S TSMW has 2 frontends and each can be configured using the pull-down list.

The demodulator settings defines the frontend number for BCH.

10.2.2 Measurement Controls

The interface functions can now be accessed by clicking on the buttons shown below. The parameters to be used by the scanner (e.g. frequency and bandwidth) can be entered and edited in the columns in the center of the GUI.

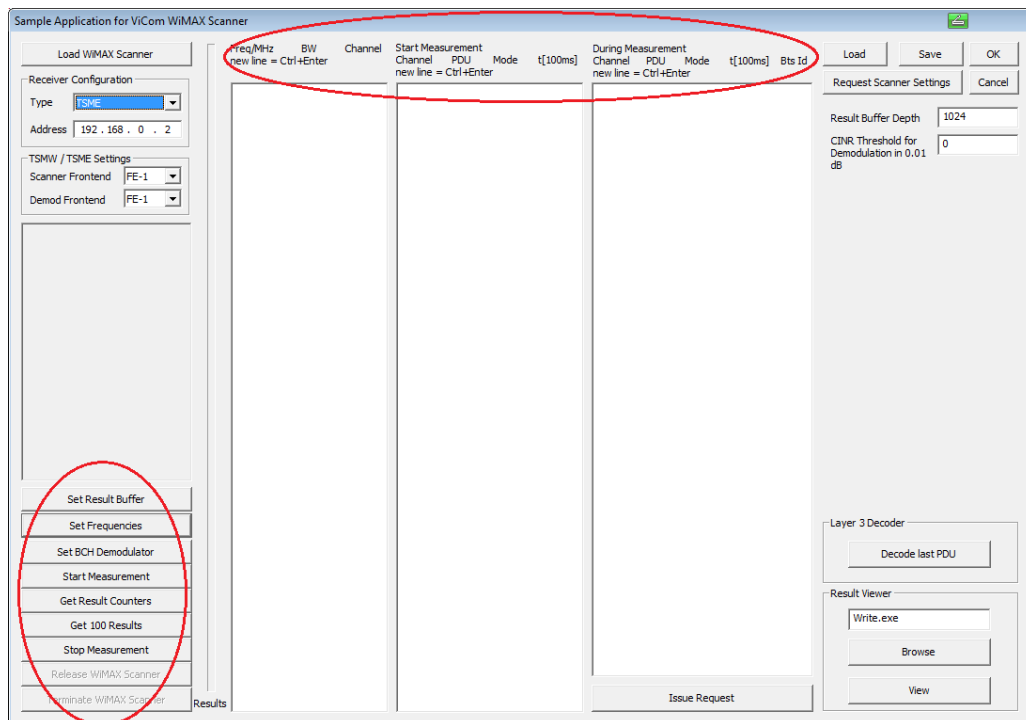


Figure 10-4: Control buttons and parameter fields

The "Set" buttons correspond to interface functions that set parameters in the scanner. An initial set of default values appear in the settings fields (the white columns in the figure above). These can be edited in the fields, and sent to the scanner by clicking the corresponding "Set" button.

Note that the scanner has its own set of default values for all parameters except the frequencies. The scanner will use its own default values, unless they have been overridden by interface function calls using the dialogue buttons. Because there is no default value for the frequency in the scanner, at least one frequency must be set using the "Set Frequencies" dialogue, before any measurements can be made.

The scanner settings remain in the scanner until new interface functions are called. The only exception is the settings for the BCH demodulator. These settings are channel specific and reset to default values when the frequency settings are changed.

The other buttons in the figure above correspond to interface functions that deal with measurements, and with unloading the scanner. "Start Measurement" tells the system to start measuring. "Get Result Counters" causes the current number of measurement results in the R&S ViCom interface buffer to be displayed, as well as the number of measurements that have been deleted if the buffer has overflowed.

"Get next 100" causes the application to get the next 100 measurement results from the interface buffer. The results will be written to the file `ViComMeasurements`, in the `C:\RuS\ViCom_<version>\bin\LogFiles` directory.

After making a measurement, the R&S TSMW / R&S TSME can be unloaded using the "Release WiMAX Scanner" button.

If problems are encountered during the release procedure, the "Terminate WiMAX Scanner" button should be used. The R&S ViCom API then forces a deletion of the `ViComWiMAXInterface` object.

The figure below shows the columns in the central area of the GUI. The frequency to be scanned can be entered in the left column along with the local channel identifier.



Default frequency

Although a default value appears in the GUI, this is not entered in the scanner until the "Set Frequencies" button has been pressed.

Frequencies/MHz new line = Ctrl+Enter		Start Measurement Channel PDU Mode t[100ms] new line = Ctrl+Enter				During Measurement Channel SC SC ID PDU Mode t[100ms] new line = Ctrl+Enter			
2112.800000	0	0	17	0	0				

Figure 10-5: Columns in the GUI

The center column lists the PDU's which correspond to the management messages which the scanner should demodulate. Each PDU value must have a corresponding channel identifier which refers to one of the frequencies entered in the left hand box.

10.2.3 View Results

Stored results can be browsed and viewed using the dialogue in the "Result Viewer" box. Enter the file name of your preferred text editor in the text field - for example "notepad.exe" (the "Browse" button can be used to find the program if need be). Click the "View" button. The sample application opens the result file using the preferred text editor.

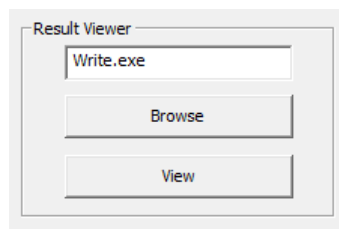


Figure 10-6: Result viewer

A sample of a measurement file is shown in the following figure. For an explanation of the fields listed, see section 5, ViComdata fields, and the SMeasResult structure.

```

ViComWiMax_GUI_Measurements.txt - Notepad
File Edit Format View Help
Log File of ViCom WiMAX Scanner
===== Measurement Result 1 =====
Channel Index      = 0
Center Frequency   = 2.657e+009 Hz
Nominal Bandwidth  = 10000000 Hz
FFT Size           = 1024
CP Ratio           = 8
Frame Rate         = 200 Hz
[Segment Measurement 0]
  Preamble Index   = 60
  Segment          = 1
  ID Cell          = 28
[CIR 0]
  RSSI             = -31.93 dBm
  CINR             = 26.4 dB
===== Measurement Result 2 =====
Channel Index      = 0
Center Frequency   = 2.657e+009 Hz
Nominal Bandwidth  = 10000000 Hz
FFT Size           = 1024
CP Ratio           = 8
Frame Rate         = 200 Hz
[Segment Measurement 0]
  Preamble Index   = 60
  Segment          = 1
  ID Cell          = 28
[CIR 0]
  RSSI             = -32.02 dBm
  CINR             = 26.4 dB
===== Measurement Result 3 =====
+++++ DLFP Result +++++
Channel Index      = 0
Subchannel Groups  = 0x3f
Repetition Coding  = 1
DLMAP Coding       = 2
DLMAP Length       = 10
----- PDU Result -----
Channel Index      = 0
Time stamp        = 18945521
BTS ID            = 0
Preamble Index    = 60
Segment           = 1
Base Station ID   = 0xffffffff
Sector ID         = 192
Operator ID       = 2
PDU Type          = 2
PDU Bit Count     = 240
PDU Bit Stream:
0XD01A04A87FBAEC02C01D01FF3033030070000058781253EAAAE4FFFFFFF
----- PDU Decoded Contents -----
Downlink Access Definition
WIMAX Compressed Map with Header
MESSAGE-HEADER
  No of IE
  0
  Extension 0
  SubDL_UL_Map Length 65536
WIMAX Compressed Map
Compressed MAP Indicator
MAC Header

```

Figure 10-7: Example of a measurement file

10.2.4 Update GUI with Current Scanner Settings

The "Request Scanner Settings" button is shown below and when clicked displays the values of all settings which are in use in the scanner at that moment. This button can be clicked after starting a measurement, and will display the settings in the appropriate

dialogue fields. The settings can also be stored in an R&S TSMW / R&S TSME settings file (*.t_{sm}), and later reloaded, using the "Save"/"Load" buttons respectively.

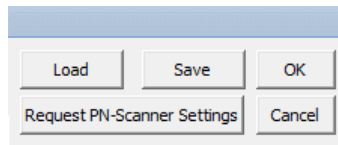


Figure 10-8: Scanner settings

10.2.5 Miscellaneous

Both the "Cancel" and "OK" buttons terminate the application. "OK" stores the settings in a "bin" directory before terminating. If available, this file is used to initialise the application (not the scanner!), after reloading.

10.2.6 Demodulation

In the sample application it is possible to experiment with the usage of the WiMAX R&S ViCom API to demodulate the BCH channel and decode the demodulated PDUs.

In this section, a complete walk-through is shown to help you getting a first demodulation result. So if you follow the steps shown below, you should get the BCH demodulation up and running very fast and also gain an impression of how to use the API.

The important parts of the demo application concerning the BCH demodulator are the center and right-handed columns. If dynamic requests are to be issued during measurement, the "Issue Request" button can be used.

Once the application has been started, the following operation sequence should be performed to do a first sample measurement:

- Load the R&S TSMW / R&S TSME. This can be done by clicking on "Load Scanner" button. If this command was successful, the list box is filled with some details of the device.
- Click the buttons "Set Result Buffer" to set the "Result Buffer Depth" in the R&S TSMW / R&S TSME.
- Define the frequency table and set the table using the "Set Frequencies" button. The space-delimited pairs of a frequency and a channel index can be defined in the table. For a simpler editing, it is also possible to add the frequencies only, one per line (a new line is started with Ctrl+Enter). The channel indices will be added automatically when "Set Frequencies" is pressed.
- Specify the demodulation settings. Each line in the central list box contains demodulation settings for one channel / PDU pair. The numbers in the columns have the following meanings:
 - The first number is the channel number that can be seen in the frequency list box. It is simply used as a label to represent a particular frequency – this avoids having to work with the actual frequency numbers (which is inefficient and error prone).

- The second number is the internal PDU name.
- The third number is the demodulation mode.
- The fourth and final number is a timeout, if the demodulation mode is set to 2 (which means repetition mode). The value here is entered in 100 milliseconds. For example, a value of 10 defines $10 * 100 \text{ ms} = 1 \text{ second}$ as time-out.
- Start the measurement. If you now click on "Get Result Counters" button regularly, you will find that new data is collected after the measurement has started.
- Fetch the results with "Get 100 Results". Display the output file (using the "View" button). The file is stored in the ViCom root dir in the file `C:\RuS\ViCom_<version>\bin\LogFiles\ViComMeasurements.txt`. If the demodulation could be done within the 100 results there should be some decoded Layer 3 messages in the text file.

You can search for "L3" in the file to find demodulation results faster.

10.2.6.1 Issuing a Request during Measurement

It is possible to explicitly request a demodulation of a certain cell during measurement.

To do this you need to:

- In the "During Measurement" column, enter the same four parameters described in the previous section, along with the Cell Id.
- Click the "Issue Request" button to send the request to the demodulator.
- Click "Get 100 Results" and check the result file as described above for the demodulated string that has been requested. Be sure to close any previously started instances of your file viewer (default: `write.exe`) if the editor does not support automatic file updates (`write.exe` does NOT support this feature).

When you finished working with the demo application, don't forget to stop the measurement and release the resources of the R&S TSMW / R&S TSME.

11 R&S ViCom RF Scan and RF Power Scan Technology

This chapter describes how the RF Scan technology scan API is used to control one or more R&S TSMx Family instrument to measure the spectrum of multiple frequency ranges in a high-speed fashion.

The first section gives insight into how the RF Scan Technology library and its firmware perform measurements with an R&S TSM Instrument. It is crucial for understanding the remaining sections to know how the results are created from the raw measurement data that the R&S TSMx Family instrument provides.

In the second section a rough overview of how the power frequency measurement API is designed and how the scan values are calculated is given. This explains the configuration details and the logic behind the post-processing units used to prepare a frequency spectrum.

Section Sample Application demonstrates the usage of the packaged sample application. The design of the demo application is tightly coupled to the API, so once one can use this demo application, programming the API becomes easy.

The chapter concludes with a small FAQ section in that some common pitfalls are discussed.



The R&S ViCom RF Scan technology only supports the R&S TSMx Family instruments. It is not available for R&S TSMW and R&S TSME.

The R&S ViCom RF Power Scan technology only supports R&S TSMW and R&S TSME. It is not available for R&S TSMx Family instruments.

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11.1 Measuring with the RF Scan

The R&S TSM instruments are not directly designed to be a radio-frequency spectrum analyzer. Such a functionality is implemented in the R&S TSM Instruments in software and firmware. Several software modules are available to perform typical tasks of a radio-frequency spectrum analyzer.

Most of the time, measurements within the R&S TSM Instruments will be done asynchronously to user requests, which has certain impacts on the design of the API. One

such measurement from a lower frequency to higher one is called sweep. The R&S TSM Instruments perform sweeps at a constant rate.

To generate a frequency spectrum from raw R&S TSM Instrument measurements, at least one sweep must be performed. With one or more sweeps, one user request for a frequency spectrum can be satisfied. In the simplest case, measurement data would directly translate to the result. However, this case may only occur rarely.

Most of the time, the result will be created from a set of sweeps. Since there is no unique algorithm to perform such a transformation, the R&S ViCom RF Scan Technology interface provides many configuration options.

Data for a frequency spectrum may be requested when one of the conditions below is valid:

- No sweep data is available at the R&S TSM Instruments. In that case, the response has to be postponed until data is available. When another result is requested while the first one is waiting, the second request will not be answered separately. So one important consequence of this is that there might be fewer results that requests.
- One sweep is available. This simple case can be translated easily into a result. Nevertheless, it's not that simple, the frequency spectrum might be converted into a channel spectrum.
- At least two sweeps are available in the R&S TSM Instrument cache. In such a case, all the raw measurements have to be combined into one spectrum. There are several possible ways to do this, so the user can choose how this actually done. For example, data for a single frequency can be the maximum of the set of power values.

All these scenarios are shown in the figure below. On the left side, four user requests are depicted in their order of occurrence. An internal timer is started to issue all these requests in regular intervals. On the right side, sweep data is coming from the R&S TSMx and stored in the data cache. The measurement data is processed to derive a result for a request then.

Both requests and sweep measurement data have a timestamp assigned to them in the figure. Timestamps are marked as t_x , where a measurement at t_{x+1} occurred at a later time than one done at t_x .

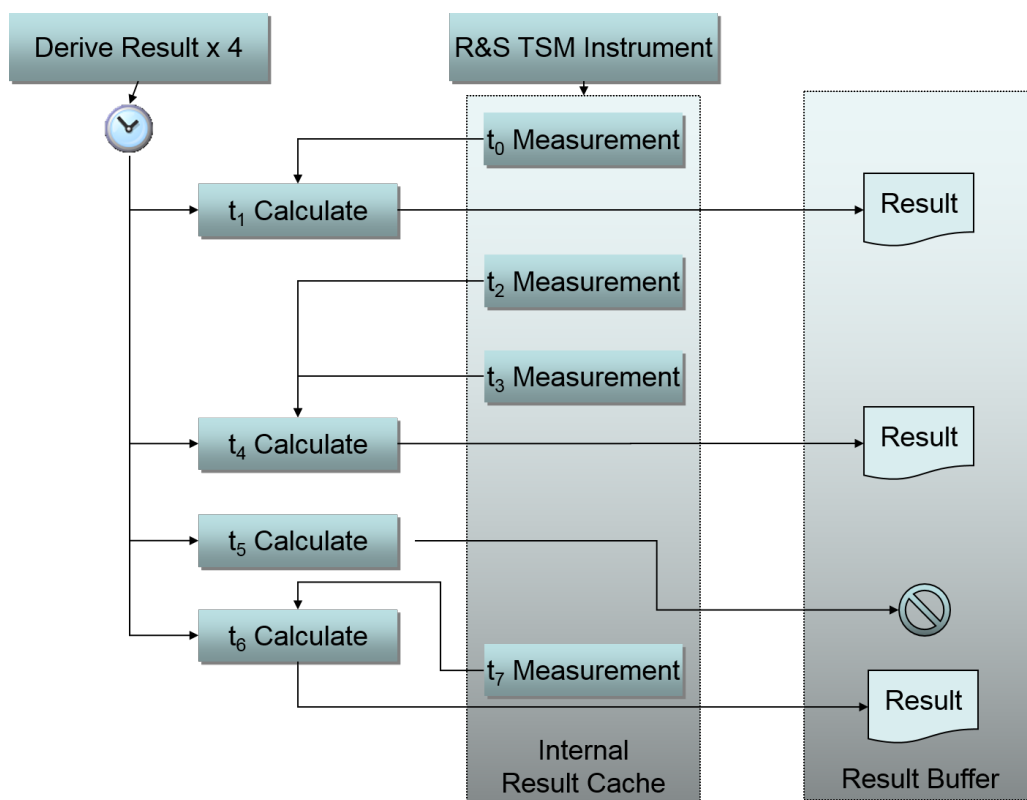


Figure 11-1: Request processing scheme over time

The situation depicted in the previous figure is handled like explained in following:

When the processing of the first request is started, a single sweep is available in the R&S TSM Instrument cache. The measurement data is used directly as result. This is always the case for the first request: If there is any data in the cache, all the data is used to satisfy the need of the first request. If there is no such data, the processing of the request is delayed until data arrives or a new request is issued.

The second request is issued after two sweeps have been stored in the result cache. These two measurements are combined into a result, which is made available to the caller.

For some reason, no measurement data arrives after the third request has been issued, and no data can be found in the cache. Since no data arrives in the internal result cache until the fourth request is activated by the timer, no result is created for the third request.

The measurement at t₇ is used as an input for the final request. If a request cannot be satisfied with data from the data cache, the processing is delayed until one sweep has been done and data is available again. If there is a new request put into the queue, the old request is cancelled and no result will be generated.

11.2 Architecture and Functionality of the RF Scan Technology

This section describes the architecture of the R&S ViCom RF Power Technology Interface, along with the details of how the different post processing units work.

The main goal during the design phase was to have a simple and efficient way to make the R&S TSM Instruments perform multiple different measurement tasks in parallel. Another requirement was to provide the developer with a highly configurable system that can be used to get exactly those results one would expect without doing complex calculation manually.

All the abstraction layers described below were introduced to meet these goals. The next section describes the system components and abstraction layers. This is followed by a detailed analysis of what kind of post-processing capabilities are offered.

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11.2.1 System Layers

As mentioned above, one design goal was to make parallel measurements easy and manageable. So there had to be some kind of middle tier between the physical R&S TSM Instrument and the object that can be used to retrieve measurements.

For each physical R&S TSM Instrument, multiple logical devices in the software can exist. These logical devices are called RF Power Scan Technology. They all run in their own designated thread, in which they process the incoming results from the R&S TSM Instrument. RF Power Scan Technology has some basic configuration attributes, among them the frequency range that is scanned and the derived result buffer.

Once a RF Scan Technology object has started communication with the R&S TSM Instrument, it is able to process the incoming measurement results. To prepare the raw measurement data for analysis, developer must use a so-called derived result to request data.

Such a derived result monitors the data in the RF Scan Technology over some defined time interval. It extracts and processes those measurement data that is required to fulfil the request constraints. Once a raw measurement data (called sweep) has been processed, the result is stored in the RF Power Scan Technology result buffer. From there you can get them via the R&S ViCom API asynchronously.

Since there might be different measurement task at one time, one RF Power Scan Technology object can handle up to ten derived result requests in parallel.

The figure below shows this system architecture and the interaction. Note that you can also have more than one RF Power Scan Technology object running in the so-called Sweep Worker thread to communicate with a single R&S TSM Instrument.

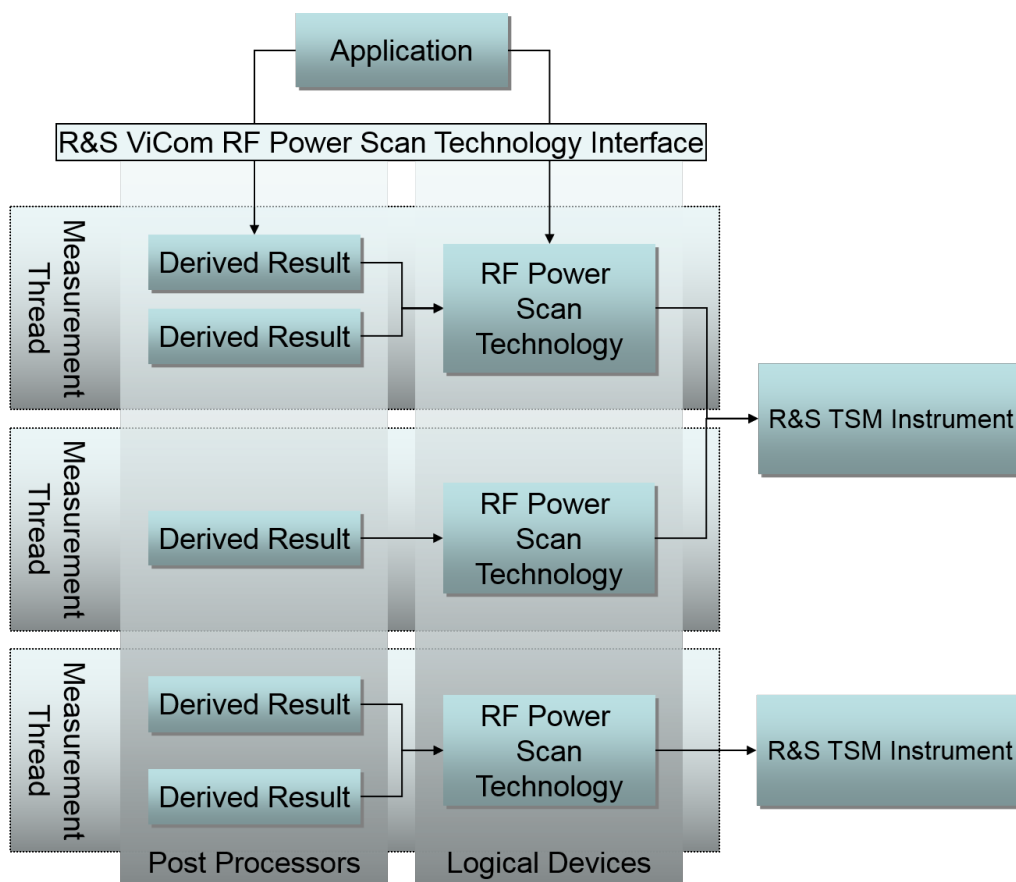


Figure 11-2: RF Power Scan Technology Architecture

11.2.2 The Post Processor Chain

In the previous section, the calculation of the derived results was described as a way to convert the raw measurement data from the R&S TSM Instrument to a more convenient presentation form. The details how to configure that post process are explained in this section.

One important part of data preparation is reduction. Since it is not useful in most cases to use each of the incoming values for analysis, it is crucial to reduce the amount of data to a manageable size. For example, most GUI applications are not able to display all measured power values in the frequency range from 100 MHz to 1 GHz, using the native resolution of the R&S TSM Instrument of 12.8 KHz. This would result in approx. 70000 values, which is difficult to show using about 1000 pixels width of modern screens.

The post-processing step is designed in a modular way so that processing is split up in small units. The processing units work in a pipeline: Each element takes the input of the previous element, applies its own filter and calculation mechanisms, and provides the result to the next element.

This design was chosen because post-processing can be configured in many ways. For example, one use case is to aggregate data into channels. Based on that result, one might wish to know what the strongest transmitter is in such a channel list. In another step, all the raw values shall be analyzed to also find adjacent interferers. The channel calculation is the same in both cases, so it is convenient to have that configuration shared among both use cases.

To perform these things with one single device the approach described above was designed. Refer to the following figure to get a feeling for how the post-process calculation takes place.

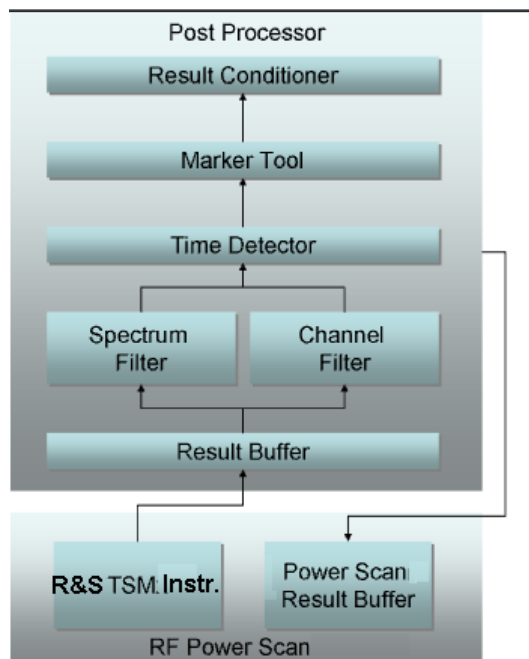


Figure 11-3: Post Processor Chain

There are seven different processing modules available. The one that starts processing is the sweep result buffer, the final result is returned from the result conditioner. These results are stored in the RF Power Scan Technology result buffer. To simplify handling, the API supports multiple equally configured post processes to be performed in one row.

One important detail to notice is that the spectrum filter and channel filter unit are mutually exclusive. Exactly one of both can be active. If both are enabled using the API, only the spectrum filter will perform its work, the channel filter will not be used.

The units and the calculations they perform are now described in the order of processing sequence.

11.2.2.1 Sweep Result Buffer

The result buffer, as the name implies, is used to save the incoming R&S TSM Instrument's results. The data structure where these results are stored in provides the sub-

sequent filters to find appropriate values faster than searching in a complete list of values.



This result buffer stores the raw measurement data gathered from the R&S TSM Instruments. It is other then result buffer that stores the post processing results of the RF Power Scan.

The results are only stored for some amount of time. After a measurement sample reached its lifetime, it is purged when the next sample arrives.

11.2.2.2 Spectrum Filter

The task of this module is to select only frequencies from the result buffer that fit into a given sub-range and adapting the samples to a given number of result values. The sub-range must be contained within the RF Power Scan Technology sweep range interval.

The number of input values available in the raw sweep is:

$$\frac{f_{\max} - f_{\min}}{0.0128}$$

where the frequencies are given in MHz. For a sweep scan range of 100 MHz, there will be approx 7812 values in the result buffer.

In many cases the output of the frequency selection does not directly map to the number of results you might need. The spectrum filter unit helps you to get the number of samples you need in your application.

If the number of measurements selected from the raw data does not fit to the number of results required, there are two possible approaches: Either there are less measurements then results, in which case the data has to be interpolated. Or the reduction in the previous modules on the data set was not restrictive enough, so the data has to be compressed once more.

In the API, the number of result samples is called `dwCountOfDisplayLines` and is set in the `SSpecificParameter` structure.

Data Interpolation

If more display lines are requested than available, the data has to be interpolated. To calculate power values for frequencies that don't directly match the native resolution, the power value is the result of a linear interpolation.

If the nearest lower frequency is f_{\min} and the nearest higher frequency is f_{\max} , the power for the requested frequency f is calculated like:

$$p(f) = p(f_i) + (p(f_{\max}) - p(f_{\min})) \frac{f - f_i}{f_{\max} - f_{\min}}$$



The power values are converted to Watt internally before the interpolation can be performed, since the input values must be linearized. This might result in small numerical errors when transforming the power values from one representation into another and back.

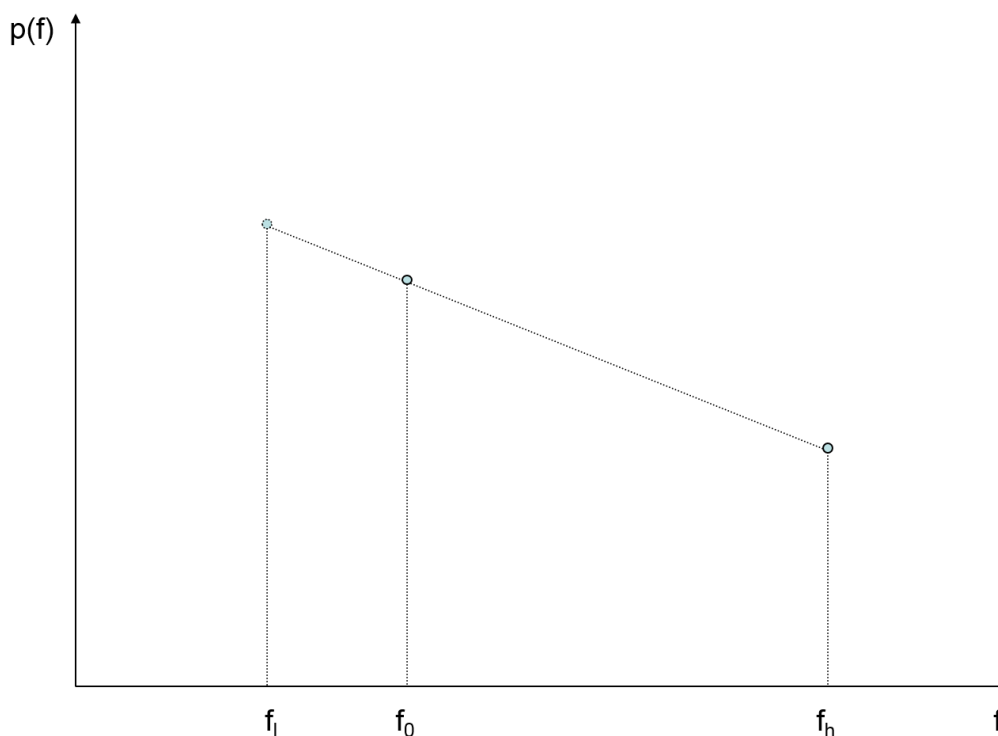


Figure 11-4: Linear Interpolation

Data Compression

This is used to reduce the amount of data from the previous units. Most of time, this will be necessary. The input data set is divided in the number of classes configured with the `dwCountOfDisplayLines` member. For each class, one result value will be calculated.

In order to perform a meaningful compression, you have the choice between three types of how to find the representing value for one data class:

- Max Peak: This uses the maximum value in the class.
- Auto Peak: Returns both the minimum and maximum value of a class, so you get twice the number of results requested
- RMS: The Root-Mean-Square of all values. To calculate this value, the power values stored in dBm are converted to Watt temporarily (see comment above).

The figure below shows that mechanism: The small dots represent a single power value for one of the native frequencies. The twelve native measurements from the sweep data have to be compressed to three frequencies (classes). The Max Peak selector would then choose the native measurement marked in red, whereas the Auto Peak would additionally add the measurement samples marked in a light yellow. The

RMS would calculate the average of the native measurements, which are shown as bigger circles in the figure.

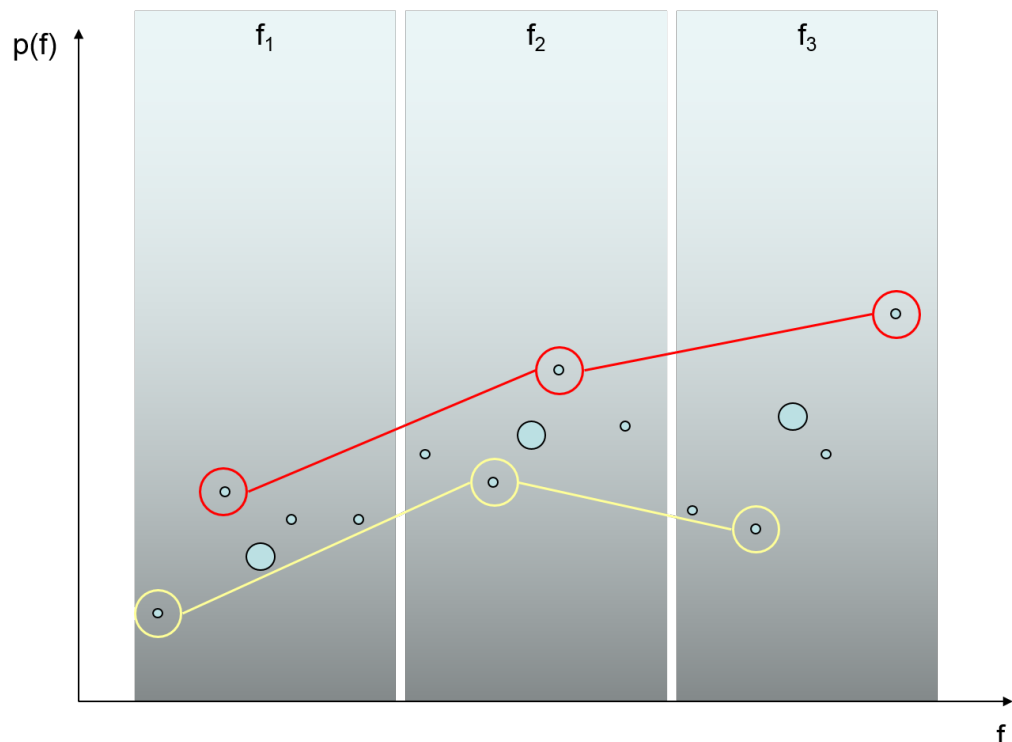


Figure 11-5: Power value compression

The spectrum filter itself decides which algorithm to apply. The only thing to configure is the number of result lines which are desired and the frequency interval borders.

11.2.2.3 Channel Filter

The channel filter can be used to calculate power values for a set of frequency channels. That means that the sample values that fall into the bandwidth are used to calculate the power value of the channel, although it is not required that only values of the bandwidth are used. Under some circumstances, it might be useful to also consider the adjacent power values for the bandwidth calculation.

The channels can be defined in an arbitrary way, even as a mixture of evenly spaced sub-sequences and freely defined ones. Each channel is specified by its centre frequency and its span. Optionally, multiple equidistant channels can be defined by specifying a repetition count.

For the rest of the section it is important to know that the R&S TSM Instrument has a native frequency resolution of 12.8 KHz. These sample values cannot be used directly for the calculation of a channels power value (except for very specific configurations).

The central element of the algorithm to calculate the overall channel power is a power scale function for the measurement samples. It is used to control how different raw measurements contribute to the overall channel bandwidth.

The power scale function is always symmetrical and is defined in equidistant steps from the center frequency to some lower/upper limit. The limit is implicitly defined by the number of equidistant points and the spacing between those points. The calculation of the channel bandwidth power p is done as follows:

$$p = c \sum_{i=0}^N p(f_c + \Delta f) s(i)$$

where

- f_c is the center frequency of the channel
- f is the frequency span
- $s(i)$ is the i -th element in the power scale function. All the values of the power scale function must be within $[0; 2]$
- c is a correction factor to equalize the impact of the weights on the measurement samples
- N is the number of points that define the power scale function

This power scale function is the base for a channel filter. In the figure below, the basic principle is depicted. All the values explained above are shown there again. It is noteworthy that the channel bandwidth for a channel is defined by the scaling function. It can be calculated as $2 * N * \Delta f$

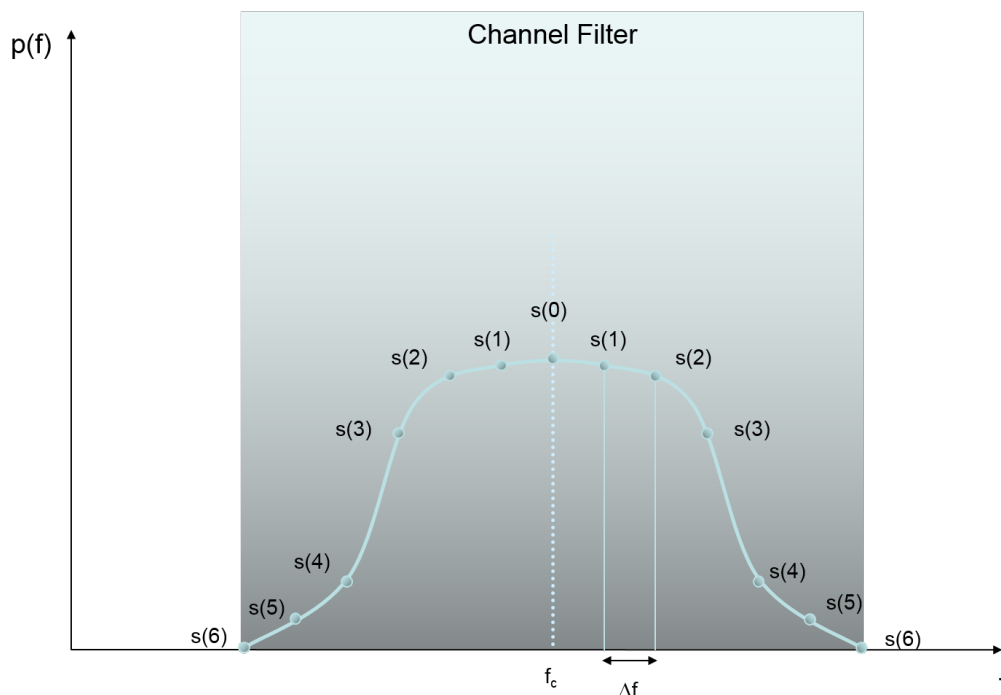


Figure 11-6: Channel filter definition

For example, if the center frequency is 935.2 MHz and there are 4 points, spaced by 200 KHz, the power scale function is applied to the incoming spectrum at frequencies

934.6 MHz, 934.8 MHz, 935.0 MHz, 935.2 MHz, 935.4 MHz, 935.6 MHz and 935.8 MHz.

This approach can be used to make the center frequency dominant, for example, by setting the weight function to 2 at the center and to low values for the rest. Another use case is that channels might overlap and consider parts of the neighbour channels as well.

Usually, the pairs that define the power scale function (frequency and weight) don't map directly to the native measurement values. In such a case, the required values will be interpolated using the two nearest neighbours and a linear interpolation.

The sum of all the weighted values is then multiplied by a correction factor to reduce the power to a meaningful value. This algorithm is visualized in the figure below. In the figure, raw measurement samples are shown as small dots. Marked with a background is the channel for which the bandwidth power shall be calculated. The power scale function is shown in light blue.

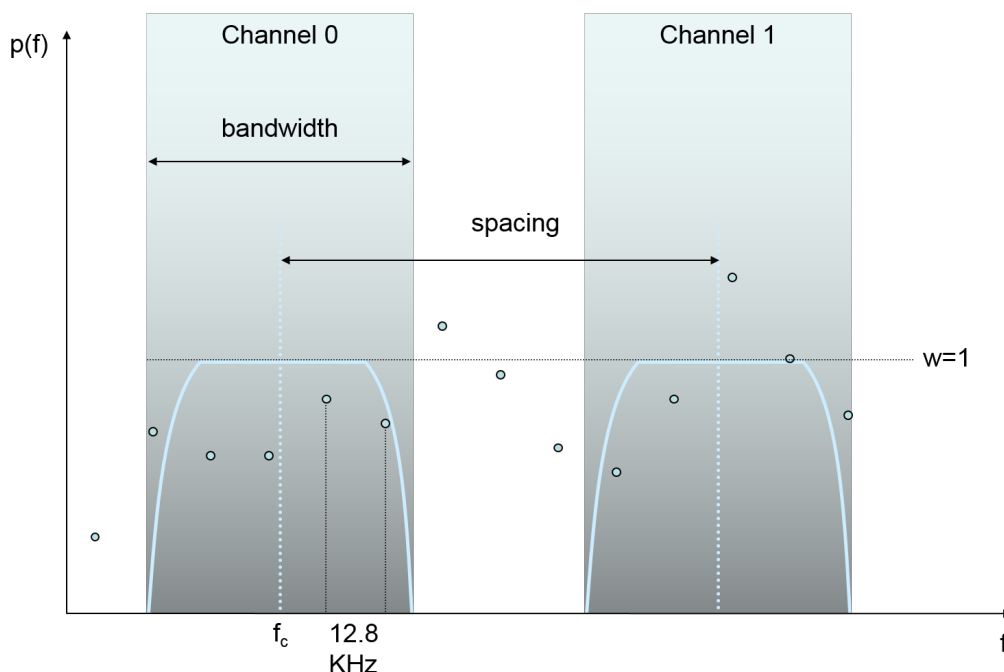


Figure 11-7: Calculation of channel power for a channel sequence

The channel filter is applied to every defined channel to calculate its power. The resulting number of values is therefore the number of channels requested. Channels can be defined in so-called sub-sequences. One sub-sequence is defined by a center frequency, the number and the spacing between the remaining center-frequencies.

11.2.2.4 Time Detector

Since there might be multiple sweeps that have to be combined into one result, the kind of aggregation in terms of time has to be specified as well. The choice made here also influences the number and layout of the result.

As for the spectrum filter, the central problem is how to find a representing value from a set of values for a frequency gathered over time. Compared to the frequency detector, the different values from which one must be chosen have the same frequency.

The following algorithms are available (in brackets numerical values are given to use them in the sample application):

- Max Peak (0): The maximum value from all power values inside the data set for the frequency/channel.
- Auto Peak (2): Maximum and minimum value are used. So the result of the request will be twice the number of values from the spectrum/channel filter.
- Min Peak (3): The minimum value is used analogue to the Max Peak.
- RMS (1): The root-mean-square value is calculated of all input values to retrieve one output value.



The original power values have to be converted into Watt internally to do this calculation. This conversion might result in small numerical errors.

- All (5): All values are used and returned as a list of measurement values in one chunk. So if data is available from more than one sweep, the result consists of a series of single results. For example, the output of a frequency detector post-process might be doubled etc. when two sweeps were made and all raw data shall be used.
- Histogram (4): The RF Power Scan Technology interface provides the possibility to return a histogram, where for each (frequency; power value) or (channel; power value) the number of occurrences in a set of measurements is returned. The result has to be interpreted as a two dimensional array, where the columns reflect the frequencies or channels, and the rows specify the power value (in integer values). Each row covers a certain range of power values. The range for a column is defined as follows:
 - For row index 0, all power values smaller than `fMinPowerValueInDBm` are counted.
 - For row index $i = 1$ to `wMaxPowerInteger - 1`, the power value is in the range `[fMinPowerValueInDBm + i * fPowerResolutionInDB; fMinPowerValueInDBm + (i + 1) * fPowerResolutionInDB [`
 - For the row index `wMaxPowerInteger`, all power values that are greater than or equal to `fMinPowerValueInDBm + wMaxPowerInteger * fPowerResolutionInDB` are considered.

The example below shows a potential result of this function. As input four channels were defined, the minimum level set to -120 dBm and resolution to 5 dB. The maximum power integer was set to 4.

Table 11-1: Sample Histogram

Power dBm	935.2 MHz	935.4 MHz	935.6 MHz	935.8 MHz
0: $p < -115$	8	6	0	3
1: $-115 (p < -110$	2	6	1	3
2: $-110 (p < -105$	1	0	4	2

Power dBm	935.2 MHz	935.4 MHz	935.6 MHz	935.8 MHz
3: -105 (p < -100	1	0	7	4
4: p (-100	0	0	1	0

Twelve sweeps per each frequency were used to generate the resulting histogram. In these twelve sweeps, a value between -115 dBm and -110 dBm was measured 6 times for frequency 935.4 MHz. Similar, the frequency 935.6 MHz was 4 times in the range -110 dBm and -105 dBm. The maximum power integer was set to 4. So all values greater than -100 dBm will be put into the row containing the maximum power integer. For frequency 935.8 MHz, the histogram shows that there was a power value less than -115 dBm measured three times.

11.2.2.5 Marker Tool

The marker tool helps when it comes to select the frequency that provided the maximum power value in a set of frequencies. With this it is an easy task to report the strongest power value and frequency.

If the marker tool is enabled, it reports the result of the marker evaluation as part of result.



The measurement values are also changed so that they can't be interpreted as mentioned above. After the marker has been applied, they reflect the values of the marker frequency in each different raw sweep, after the frequency detector or the channel filter processing has been done.

For example, if there were three sweeps made by the R&S TSM Instrument, the input data might look similar to:

1. Sweep	-61.9	-77.1	-65.4	-71.4	-64.2	-62.2
2. Sweep	-62.3	-79.1	-69.3	-71.3	-61.9	-62.1
3. Sweep	-63.8	-78.8	-69.2	-71.9	-62.4	-61.5
RMS	-62.6	-78.3	-67.9	-71.5	-62.8	-61.9

The maximum is calculated based on the result of the previous processing steps. In this case, we assume that the Time Detector is configured to calculate the root mean square of all input samples. The highest frequency would result in the maximum power here. As marker result, this maximum of -61.9 dBm would be returned then as special marker result. The standard result structure would contain -62.2 dBm, -62.1 dBm and -61.5 dBm.

11.2.2.6 Result Conditioner

The result conditioner is a utility to convert the resulting power values into a specific layout. Therefore it provides several options:

Minimum Power Level and Resolution

The final results are returned in a WORD-Array. The unsigned integer numbers stored there have to be set in relation to a minimum threshold and have been shifted to make the minimum resolution that shall be available an integer.

For example, a resolution of 0.1 and a base level of -120, the value 234 means $-120 + 234 * 0.1 = -96.6$ dBm

Histogram Axis Definition

The maximum value of the power dimension when a histogram is calculated can be set in this structure. That means, that the size of the histogram is number of frequencies/channel * (maximum power value + 1).



This value is specified as an integer. The calculation of the dBm value is the same as mentioned previously, so you can calculate that value by using the inverse function:

$$wMaxPowerInteger = (p[dBm] - fMinPowerValueInDBm) / fPowerResolutionInDB.$$

Overflow Representation

If an overflow occurs while the measurement is done in the R&S TSM Instrument, this can be signaled in the result. The least significant bit in the result can be used as a flag indicating whether the value has been the result of some overflow (if set to true) or if not.

An overflow might arise in the A/D converter, for example. The R&S TSM Instrument can be configured to react in different ways in such a situation. Refer to the reference for more details on overflow handling.

11.3 Sample Application

The R&S ViCom API delivery provides for RF Scan Technology a dialog-based sample application. This helps to get a first feeling of how to use the R&S ViCom Interface for RF Power Scan Technology, since the applications user interface directly reflects the entities available in the API. See the figure below for a sample.

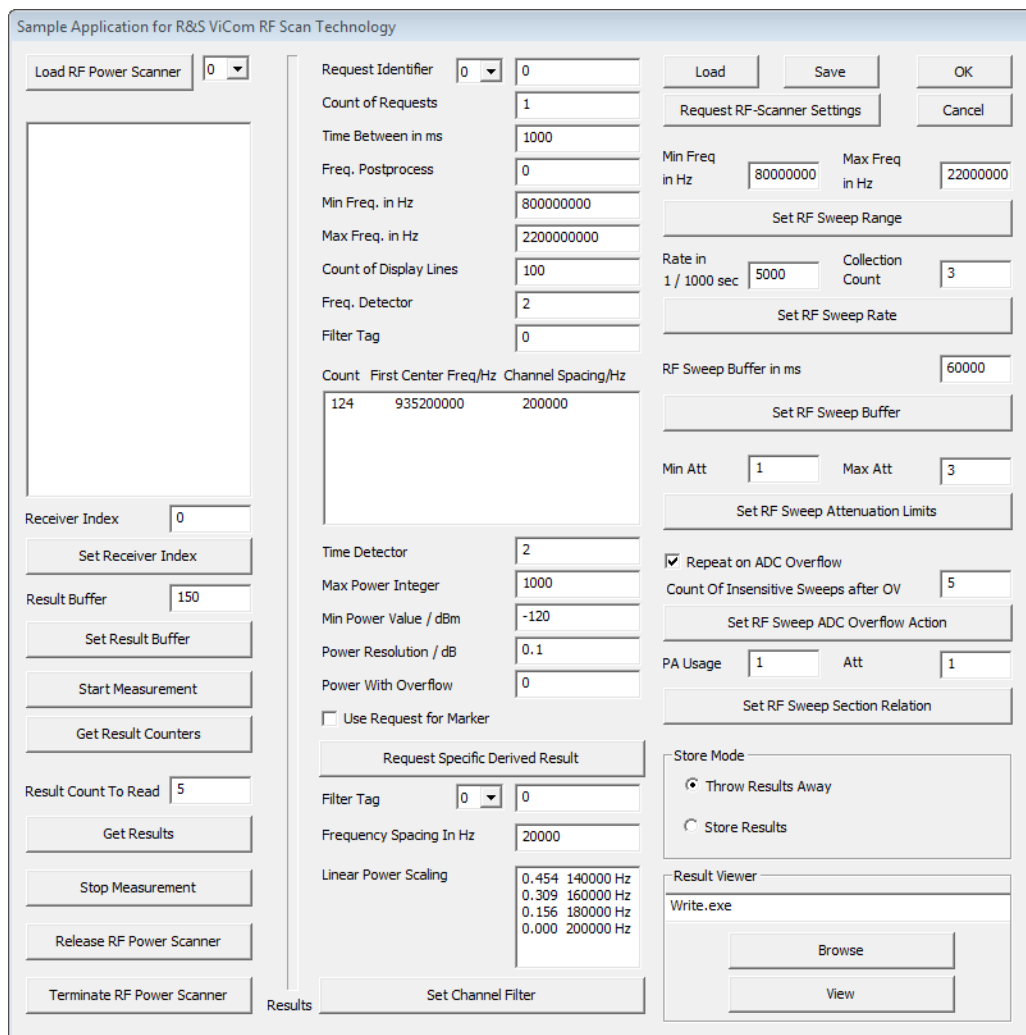


Figure 11-8: ViCom RF Scan technology sample application

As the figure shows, the dialog is divided in three major columns.

The left-most column manages the different logical receivers. Each receiver stands for one of the connected R&S TSM Instruments. Multiple logical receivers can be connected to one physical R&S TSM Instrument. You can configure up to 32 logical receivers.

The column in the middle contains controls for managing the actual result configuration. Here you can specify how a concrete measurement shall be made. For one receiver, there can be up to 32 different request configurations. The settings here have to fulfill the constraints made in the right column.

The right-most column controls general settings of the receiver and the application. Once you have set up a configuration, you can save and restore it here.

11.3.1 A Walk-Through Example

The general workflow when using the application is as follows:

- Load receiver(s)
- Read device settings
- Change them to your needs and update them in the device
- Start the measurement
- Define specific requests
- Fetch results
- Stop measurement
- Unload receivers(s)

Steps 3 to 7 can be repeated various times and with different settings.

11.3.1.1 Step 1: Load Receiver(s)

In this walk-through, we assume that one R&S TSM Instrument is connected to the computer. We want to have two logical receivers, one scanning below 1GHz, the other in the UMTS frequencies.

Therefore, we load two receivers using the "Load RF Power Scanner" button. Click the button and select a receiver from the list of the available receivers in the "SampleforViComRFScan". Then change the number in the combo box to 1 and click the button for a second time.

Each time the button is clicked you should see the text field below the button getting filled with information on the available scanners after some time (approx. 20-30 seconds).

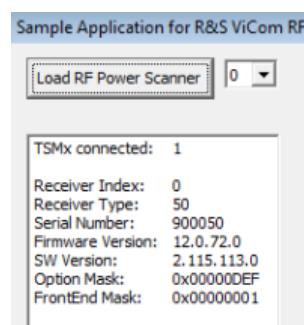
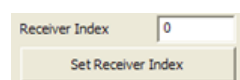


Figure 11-9: Load RF power scanner

The previous figure shows only one R&S TSM Instrument connected to the PC.

If you have more than one such device, you can configure the application to use the second device. Each of the loaded logical receivers can be mapped to the according value of the available physical units by changing the receiver index in "Receiver Index" and then pressing "Set Receiver Index".



The combo box right to the "Load RF Power Scanner" button controls to which logical receiver all the changes made in the rest of the GUI apply to. If you change the value in here, the control values also update accordingly, except for the settings in the right-most column.

11.3.1.2 Step 2: Reading the Device Settings

Before you change the general configuration of a logical receiver, you should first retrieve the current settings from the R&S ViCom interface. This can be done by clicking the button "Request RF-Scanner Settings". By the successful completion of the operation, the controls in the right column of the dialog should reflect the values from the logical device.

The screenshot shows a dialog box titled "Sweep settings section" with the following controls:

- Buttons: Load, Save, OK, Request RF-Scanner Settings, Cancel.
- Min Freq in MHz: 80000000
- Max Freq in MHz: 22000000
- Button: Set RF Sweep Range
- Rate in 1 / 1000 sec: 5000
- Collection Count: 3
- Button: Set RF Sweep Rate
- RF Sweep Buffer in ms: 60000
- Button: Set RF Sweep Buffer
- Min Att: 1
- Max Att: 3
- Button: Set RF Sweep Attenuation Limits
- Repeat on ADC Overflow
- Count Of Insensitive Sweeps after OV: 5
- Button: Set RF Sweep ADC Overflow Action
- PA Usage: 1
- Att: 1
- Button: Set RF Sweep Section Relation

Figure 11-10: Sweep settings section

In the sweep settings section, the following settings can be changed:

- The sweep range, i.e. the interval for which derived results can be requested. That influences the measurement speed, so this has to be set carefully when speed is a critical factor.
- The sweep rate, which can be set to a slower value than the theoretical maximum if different measurements shall be made in parallel.
- The time how long sweep data is kept in the sweep result buffer before samples get invalid
- Attenuation settings
- Error handling strategy in case that the A/D converter detects an overflow

Note that these settings exactly match the values from the structures

- SRfSweepRange
- SRfSweepRate
- SRfSweepBuffer
- SRfSweepAttenuationLimits
- SRfSweepAdcOverflowAction
- SRfSweepSectionRelation

stored in the `ViCom::RFPOWERSCAN::SSettings` structure.

11.3.1.3 Step 3: Set parameters

Before a changed value is set in the logical device, the related "Set" button below the input fields must be pressed to transfer the value into the related R&S ViCom object. For our example, we set the Sweep Range of our first device from 100 to 1000, and for the second to 1800 to 2200. The minimum value for a frequency is 80 and the maximum 3000 (If you have a R&S TSML-CW device, the upper limit is 6000).

11.3.1.4 Step 4: Start Measurement

Once the common settings are set as desired, you can put the logical power scanner object into measurement state. Note that you have to do this for every instance. Once you did this, you cannot change common settings until you stop the measurement.



After you started a measurement, the mapped R&S TSM Instrument already scans all frequencies repeatedly. Nevertheless, you won't see any measurement results, unless you do specific measurement value requests.

11.3.1.5 Step 5: Define Specific Values

For each logical receiver, you can define up to ten different derived results from the scanning process. Each of these derived results can be requested in parallel. Such a result is called derived because the raw measurement values from the R&S TSM Instrument can be post processed to filter, reduce and prepare the measurement results in a more convenient form, refer to [Measurement Controls](#) .

Request Identifier	0 ▾	0
Count of Requests		1
Time Between in ms		1000
Freq. Postprocess		0
Min Freq. in MHz		800000000
Max Freq. in MHz		2200000000
Count of Display Lines		100
Freq. Detector		2
Filter Tag		0

Figure 11-11: General derived result settings

The figure above shows some of the settings you can specify for a derived request. Each different post-process is identified by the number shown in the combobox.

For our example, we create two request identifiers for the first logical device. Make sure that both the Power Scanner Identifier and the Request Identifier are set to zero. Enter the values 2, 1000, 0, 100, 500, 5 into the fields "Count of Requests", "Time Between in ms", "Freq. Postprocess", "Min/Max Freq. in MHz" and "Count of Display Lines". Press the "Request Specific Derived Result" button to tell the scanner to record measurements and prepare them.

Switch the request identifier to 1 and enter 10, 100, 0, 600, 700, 20 in the fields mentioned above. Again, press the "Request Specific Derived Result" button.

11.3.1.6 Step 6: Fetch and View Measurement Results

Once you send a request to the R&S TSM Instrument using the "Request Specific Derived Result" button, an internal timer is configured to issue the number of requests in the specified time interval. This is done until the number of results has been processed or the measurement is stopped.



You have enough space left in the result buffer to store all results from the requests you start at one time. To check how much space is already occupied, use the "Get Result Counter" button. The upcoming message box shows you how many results have been stored and how many have been thrown away already, if any.

You can change the size of the result buffer only if the logical device is in idle state (i.e. has not been started yet or stopped again).

As described in the architecture section before, the results from the post-processes are stored in a result buffer inside the memory. The sample application provides a way to retrieve values from that buffer (in FIFO order) and store them in a file. The output file `ViComMeasurements.txt` is stored in the `C:\RuS\ViCom_<version>\bin\LogFiles` directory.

Make sure to mark the radio button "Store Results". Then put 10 in the text field next to "Result Count To Read" and press "Get Results". The system then fetches ten results from the result buffer and writes them into the file mentioned above.

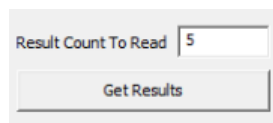


Figure 11-12: How to fetch results

If there are not enough results in the buffer to satisfy the request, the demo application waits for five seconds if other records arrive. If not, a message box is shown.

Any result that is available and requested will be written into the file. Each single record looks similar to the one shown below:

```
MeasResult:
dwPcTimeStampInMs = 12192898
    SpecificParameters:
        wRequestIdentifier = 0
        dwCountOfRequests = 2
        dwTimeBetweenRequestsInMs = 1000
        eFreqPostProcess = 0
            dMinFrequencyInMHz = 100.000000
            dMaxFrequencyInMHz = 500.000000
            dwCountOfDisplayLines = 5
            eFreqDetector = 2
        etTimeDetector = 2
        SPowerValueFormatSpec:
            wMaxPowerInteger = 1000
            fMinPowerValueInDBm = -120.000000
            fPowerResolutionInDB = 0.100000
            ePowerWithOverflowFormat = 0
            bUseRequestForMarker = 0

dwCountOfPowerWithOverflowValues = 10
pwPowerResultValues:
    581    0  312    0  250    0  268    0  249    0
bOverflowIndicator = 0
```

The result contains from top to bottom the following information:

- When did the response arrive (in milliseconds after the start of the R&S TSM Instrument).
- The configuration details that were used to create that result
- The number of result values (`dwCountOfPowerWithOverflowValues`)
- The result values. In this case, we have five maximum/minimum pairs. The first pair (581, 0) is the one associated for `dMinFrequencyInMHz`, the last one for `dMaxFrequencyInMHz`. In between this interval, frequency values are placed in equidistant steps. The maximum power can be calculated from the value 581 by multiplying the value with `fPowerResolutionInDB` and adding the result to the value of `fMinPowerValueInDBm`. In this sample, the power of the first value would therefore be $581 * 0.1 - 120 = -61.9$ dBm.

- The overflow indicator tells whether an overflow occurred during calculation of this result or not. If so, the values might not be the real measurement values, according to what was specified in the common settings of the power scanner before.

11.3.1.7 Step 7: Stop Measurement

To stop the logical device from recording raw measurement data, press the "Stop Measurement" button. After the receiver has been stopped, it is possible to change the common settings again.

You can now configure the logical devices again to perform some different measurements, or you can exit the application. Before the application is quit, the receivers should be unloaded to properly clean up acquired resources.

11.3.1.8 Step 8: Unload Receivers

Make sure to unload all logical receivers that were used using the "Release RF Power Scanner" button. If you encounter a problem during the release procedure, try to use the "Terminate RF Power Scanner" button. The R&S ViCom API then forces a deletion of the `ViComRFPowerScanInterface` object.

11.4 RF Power Scan Technology

This chapter describes the special features of R&S RF Power Scan technology. There are similarities with the RF Scan on R&S TSMx Family, therefore the understanding of the measurement concept and the post processing chain of the previous chapter is required.

The first section describes the principal conceptual differences when using RF Power Scan compared to the RF Scan. The second section contains a description of the interface structure for the RF Power Scan.

This section is important for the successful integration of the interface functionalities into a control application.

The sample application in the third section demonstrates the features of the interface and provides a reference for own developments.

- [Measurement and Post-Processing Concept](#)..... 191
- [Interface Concept](#)..... 192
- [Sample Application](#)..... 193

11.4.1 Measurement and Post-Processing Concept

Similar to the R&S RF Scan, the basic measurement result of a RF Power Scan is a sweep over a defined frequency range. With the RF Power Scan the sweep is done by acquiring data in time domain and calculating the spectrum using an FFT. Therefore additional parameters like the FFT size (frequency resolution) or window type (selectiv-

ity) are available to define the measurement. If the desired sweep range exceeds the maximum real time bandwidth of the R&S TSMW or the R&S TSME, the frequency band is segmented. Normally the width of the segment is selected for maximum measurement speed, but the user has the possibility to overrule the automatic settings and define her own segment width.

After gathering the information in spectral domain the postprocessing follows the same concept as the RF Scan:

- Frequency detector to limit the number of spectral lines
- Time detector for averaging or peak detection in time domain
- Channel filter to perform sweeps over several subbands with fixed frequency raster and defined filter characteristics.

Only one out of the three analysis modes in frequency domain – frequency detector, channel filter or raw data analysis – can be selected. With raw data analysis the measurement data is delivered right after the FFT without any further postprocessing. When the marker is enabled, no spectrum information but the frequency with the maximum power is returned. Depending on the settings of the time detector one or more power values are available. The marker is active for all three analysis modes.

11.4.2 Interface Concept

The R&S ViCom interface for RF Power Scan technology controls all parameters of a single sweep. Multiple instances of interfaces can run independently in a single application. Therefore it is possible to perform spectrum analysis over different frequency bands within a single control program; the same task can be done by using a channel filter in a single instance of the interface.

The interface is created and used with the following steps, for example for the R&S TSMW:

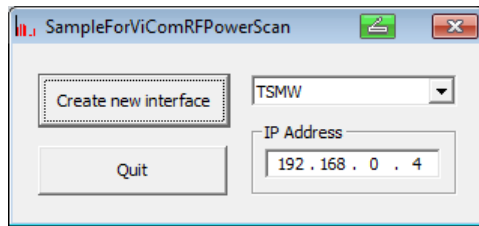
- Create a pointer to an instance of the interface by using the `CViComLoader_TSMW` function `connect()` and identifying the R&S TSMW by his IP address
- Prepare the sweep settings by filling the structure `SSettings`
- Transfer the settings to the power scan module with the interface function `SetSettings`
- Start the measurement with the interface function `StartMeasurement`
- Check the availability of measurement results with the interface function `GetResultCounters`
- Retrieve the measurement results with the interface function `GetResult`. The structure `SResult` holds all measured data
- Stop the measurement with the interface function `StopMeasurement`
- Release the interface using the `CViComLoader_TSMW` function `Disconnect`

There are additional interface functions like `GetSettings` to retrieve the current sweep settings from the interface or `SetResultBufferDepth` to define the number of results stored in the interface.

11.4.3 Sample Application

The sample application is a simple program to demonstrate the capabilities of the RF Power Scan and to give examples for the interface integration.

The sample application itself is only a launcher of interface instances. By clicking "Create new interface" a new instance of the interface is created which is controlled by an individual window. The user should select between the R&S TSMW and R&S TSME and has to define the IP address for the R&S TSMW in the "IP Address" box. For the R&S TSME the IP address is taken from the list of available IP addresses based on the instrument's index.



The control window provides access to all interface functions, settings and results.

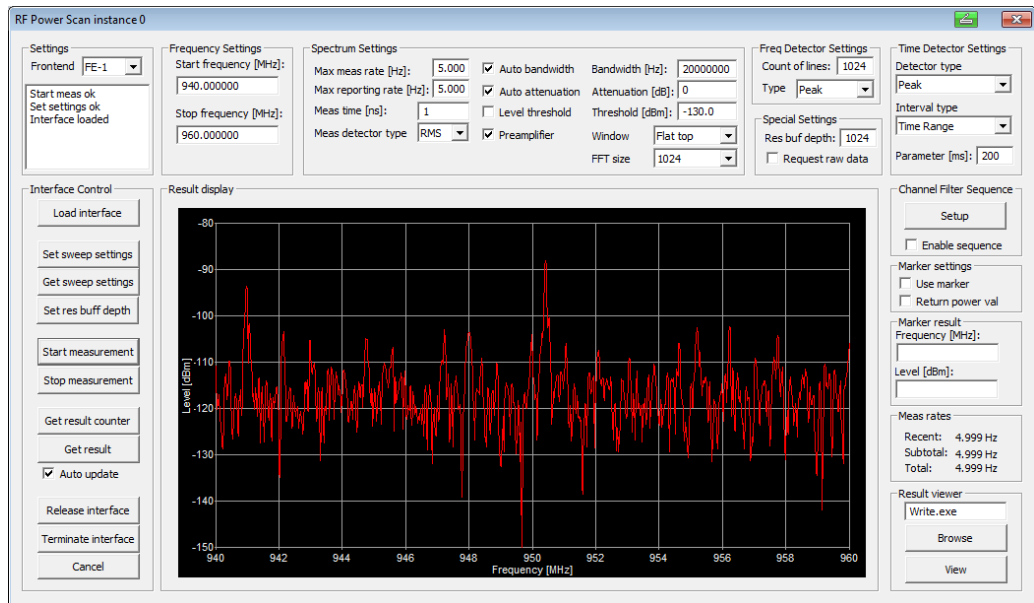
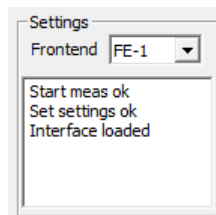
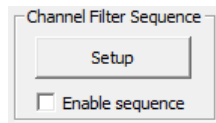


Figure 11-13: RF Power Scanner instance 0

In the field "Settings" the front end of the selected instrument for the measurement is defined. The display field shows samples status messages.

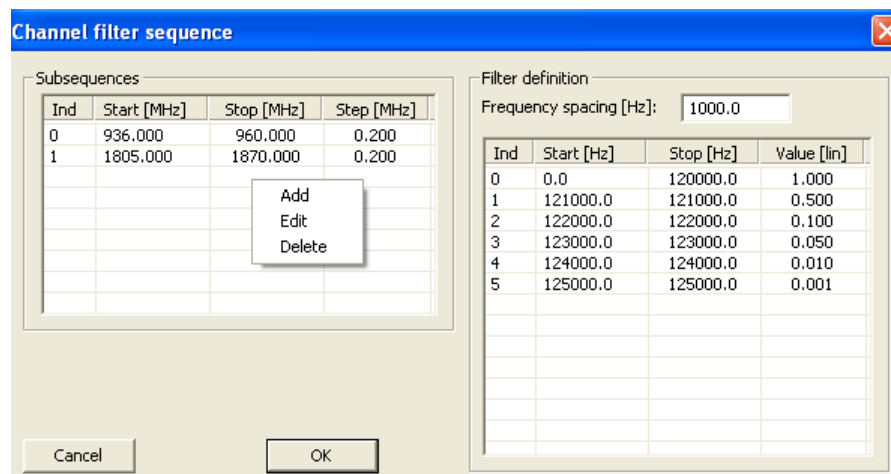


The channel filter mode is activated by checking the "Enable sequence" box.



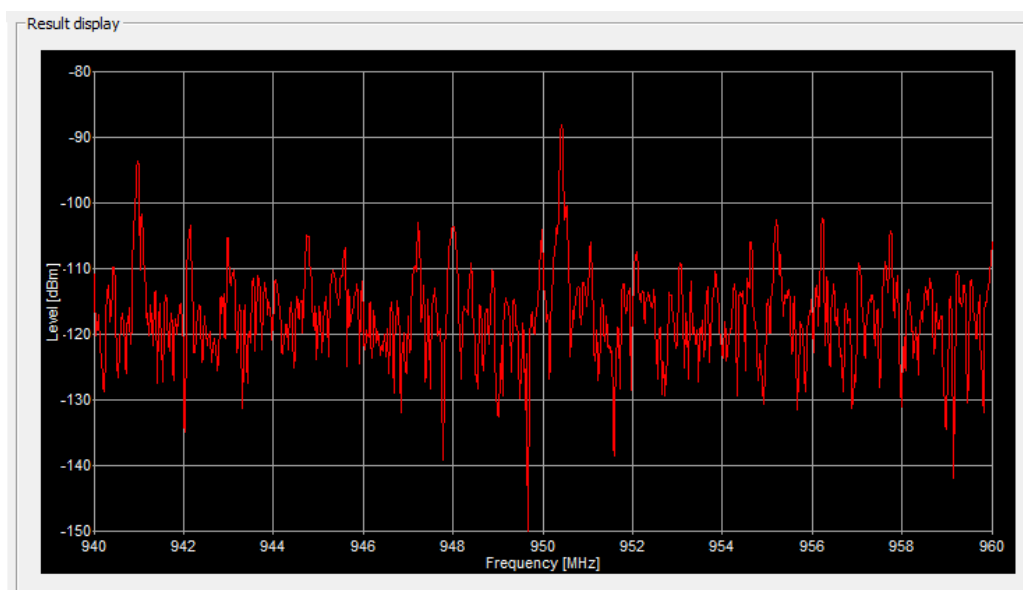
There is a special dialog window for the filter setup. The channel filter setup consists of two parts:

- The list of subsequences defines the frequency ranges that will be analyzed.
- The passband shape of the filter is defined for individual points or ranges beginning at 0 (center frequency). The filter is symmetrical to the center. All frequency entries have to match the common frequency spacing.



A right mouse button click on a list opens a menu to edit or delete existing entries or to add a new line.

The measured spectrum is displayed in a simple graph with auto-scaling. There is no listing of individual spectral levels. If the "Auto update" box is checked, the results will be collected and displayed automatically, else a new result will be shown when the "Get Result" button is clicked.



If the marker is enabled, there is no spectrum data to display. Instead the frequency and the maximum power level of the marker is shown. In this case the individual results are collected in the log file which can be viewed by clicking the "View" button.

Marker result	
Frequency [MHz]:	<input type="text"/>
Level [dBm]:	<input type="text"/>
Meas rates	
Recent:	4,999 Hz
Subtotal:	4,999 Hz
Total:	4,999 Hz
Result viewer	
<input type="text" value="Write.exe"/>	
<input type="button" value="Browse"/>	
<input type="button" value="View"/>	

11.5 RF Power Scan Technology Specific Trouble Shooting

This section lists some of the most common pitfalls when using the RF Power Scan Technology.

- ? I try to get results from RF Power Scan, but no matter how many lines I request, I only get a small set of results. What is wrong?
- ! Maybe you have not set the `bUseRequestForMarker` variable explicitly of the interface class. In some situations, this may be set to true and therefore you won't get the number of results configured in `dwCountOfLinesRequested` or the number of channels.

- ? I enabled the marker tool on my channel filtered data. The marked frequency is always in the first group of channels that I configured. What's wrong here?
- ! This is a bug in current version and will be fixed in one of the next releases. If there are several sub-groups configured in the channel filter that are not equidistant, the marker tool will only work on the first group.
- ? I configured the frequency detector to return 124 lines, but I get sometimes multiples like 248 lines. How can I calculate which value belongs to which frequency, then?
- ! This case might occur if the time detector is configured to return all samples with `ViCom::RFPOWERSCAN::SSpecificParameters::eTimeDetector == TD_ALL`. In that situation, there might be data from more than one sweep returned, since no time aggregation is done. The result therefore consists of sequences of the output of the frequency detector. So, the frequency of the *n*th entry in the result is $\text{freq}(n) = \text{dMinFrequencyInMHz} + [n \% \text{dwCountOfDisplayLines}] * (\text{dMaxFrequencyInMHz} - \text{dMinFrequencyInMHz})$

11.6 Using R&S TSMW RF Power Scan in a Typical Drive Test Use Case

This section describes the typical R&S ViCom settings and their background for a typical drive test application.

- [Frequency Resolution](#)..... 196
- [Measurement Settings](#)..... 196
- [Measurement Rate](#)..... 197
- [Data Aggregation](#)..... 199

11.6.1 Frequency Resolution

Recommended mode is to enable autobandwidth (set to 1). The scanner will split the frequency span automatically in blocks of 20 MHz to make most efficient use of the R&S TSMW RF frontend.

```
ViCom::RFPOWERSCAN::SSpectrumSettings
```

`bAutoBandwidth = 1`: this means auto bandwidth is enabled

Then the frequency resolution is $\Delta F = (20\text{MHz} * 1.15) / \text{FFT size}$

Recommended FFT size is 1024:

```
ViCom::RFPOWERSCAN::SSpectrumSettings
```

`etFFTSize`; set this to `RFPOWERSCANTSMW_FFTSIZE_1024 = 1024`,

With FFT size of 1024 the frequency resolution is $\Delta F = 22.46 \text{ kHz}$ with is fully sufficient to measure power and interference in cellular networks.

11.6.2 Measurement Settings

Following settings are recommended for drive test use case.

ViCom::RFPOWERSCAN::SSpectrumSettings:

bAutoAttenuation: set this to 1 to enable automatic attenuation management in the instrument. Other setting is expert mode.

eWindowType: set this to RFPOWERSCAN_WINDOWTYPE_FLATTOP = 4. This is the same window as used by a spectrum analyzer. Other settings are expert modes.

bLevelThreshold: set this to 0. Other settings are expert modes.

ViCom::RFPOWERSCAN::SSettings

dStartFrequencyInHz and dStopFrequencyInHz: this is input by the user of the drive test SW application.

ViCom::RFPOWERSCAN::SSettings

dwMeasTimeInNs: set this to 1. Other settings are expert mode.

11.6.3 Measurement Rate

R&S TSMW provides one measurement value for a signal of length FFT size / (1.15*20 MHz).

For the recommended FFT size of 1024 this is 44 μ s for a sweep of 20 MHz.

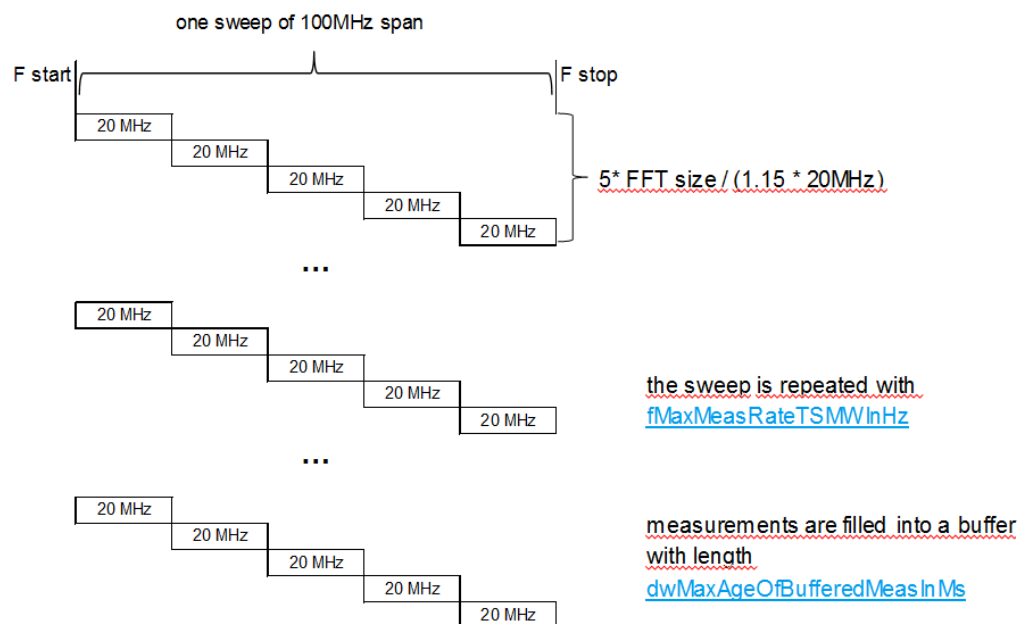


Figure 11-14: Sweep composed of several 20 MHz blocks

The measurements are filled into a buffer.

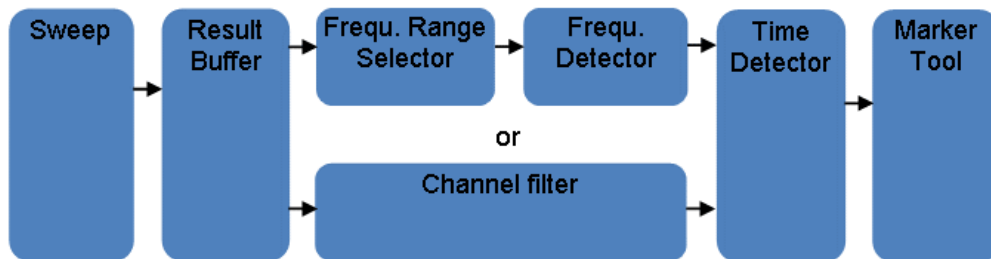


Figure 11-15: Processing steps of measurements data

Further processing after the buffer allows aggregating several sweeps into a single measurement value. This has the advantage to provide a more readable visualization update rate to the user, while still looking at a larger amount of signal.

The rate that is made available to the user for reporting can be set with

```
ViCom::RFPOWERSCAN::SSpectrumSettings
```

fMaxReportingRateInHz: This is the maximum result reporting rate.

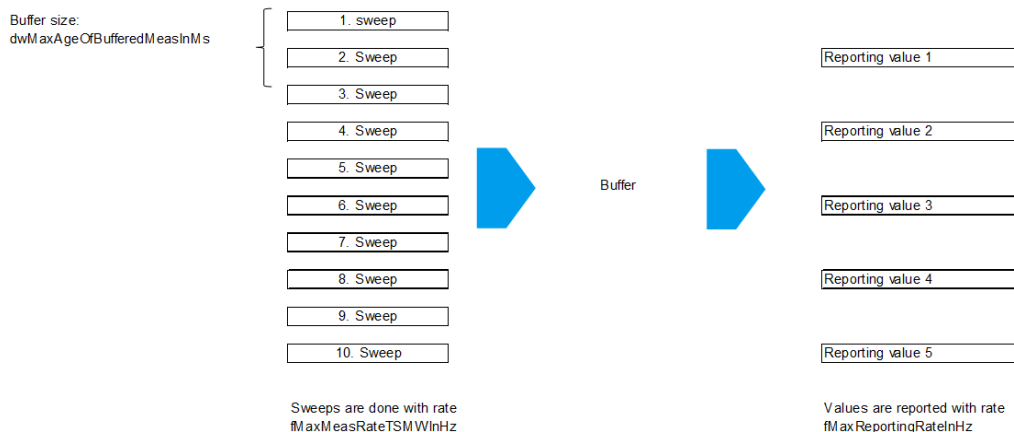


Figure 11-16: Aggregated measured data

Measurement data is aggregated from measured to reported data.

The buffer needs to keep as many sweeps as are needed for the aggregation to reduce the rate from fMaxMeasRateInHz to fMaxReportingRateInHz.

Therefore the minimum buffer length to be configured as dwMaxAgeOfBufferedMeasInMs is

$$(1 / fMaxMeasRateInHz) * (fMaxMeasRateInHz / fMaxReportingRateInHz) = 1 / fMaxReportingRateInHz$$

Therefore:

dwMaxAgeOfBufferedMeasInMs: set this to 1 / fMaxReportingRateInHz

For a normal drive test application the following settings are recommended:

```
ViCom::RFPOWERSCAN::SSpectrumSettings
fMaxMeasRateInHz = 10
fMaxReportingRateInHz = 5
dwMaxAgeOfBufferedMeasInMs = 200
```



These rates are the requested measurement rates to the R&S TSMW. The R&S TSMW will aim to fulfill these rates, but depending on other measurement tasks running on the scanner (e.g. GSM, WCDMA, CDMA/EV-DO, LTE) it may not be possible to fulfill the rates. This needs to be taken into account by the developer of the drive test SW or the user of that SW.

11.6.4 Data Aggregation

For effective visualization to the user, the raw spectrum measurement results are processed, to aggregate measurement values both in time and in frequency.

11.6.4.1 Aggregation in time

In time: as explained above the reporting rate can be set lower than the measurement rate. Several methods are available to aggregate several measured values into one reported value. Those are described in the R&S ViCom documentation.

The calculation is done by the Time Detector.

Following settings are recommended for drive test:

```
ViCom::RFPOWERSCAN::STimeDetector
```

`etTimeDetectorType = RFPOWERSCANTSMW_TIMEDET_TYPE_RMS = 1`: the setting means that the reported value will be calculated by taking the quadratic mean (root mean square) over the measured values.

```
etTimeDetectorIntervalType =
```

`RFPOWERSCANTSMW_TIMEDET_INTERVAL_TIMERANGE = 1`: the setting means that all measurements values within the timesrange given in `dwTimeParameterInMs` will be used to calculate the reported value from the measured values,

`dwTimeParameterInMs = dwMaxAgeOfBufferedMeasInMs = 200`: the setting means use all measured values from the buffer. As we have already calculated the buffer size above, we can use the same value.

11.6.4.2 Aggregation in Frequency

With our recommended settings, the measurements are performed with a frequency resolution of $\Delta F = 22.46$ kHz. Even a rather narrow sweep of 20 MHz only will therefore lead to 890 measurement values, which are difficult to display on a monitor given the pixel count available.

Therefore the Frequency Detector is able to aggregate several measurement values into one value on the frequency axis.

Using a user configurable frequency resolution for the display of the results, the SW can automatically scale the amount of values reported in the frequency axis.

The following settings are recommended for drive test:

```
ViCom::RFPOWERSCAN::STimeDetector
```

`eDetectorType = RFPOWERSCANTSMW_FREQDET_TYPE_RMS = 1`: the setting means that the reported value will be the quadratic mean (root mean square) of the measured values.

`dwCountOfLines` = resolution of the spectrum window in the drive test SW. This could also depend on a zoom-factor in the visualization window or input by the user. To avoid interpolation this value should not exceed $(dStopFrequencyInHz - dStartFrequencyInHz) / [20MHz * 1.15 / FFT \text{ size}]$. With our recommended settings this is $(dStopFrequencyInHz - dStartFrequencyInHz) / 22460 \text{ Hz}$.

11.6.4.3 Other Settings

```
ViCom::RFPOWERSCAN::SMarker
```

`bUseMarker`: set this to 0. Other settings are expert mode.

11.7 Spectrum Clearance Use Case with RF Power Scan

The aim of spectrum clearance is to find any power in the measured bandwidth. Therefore the data aggregation methods should be set to use the peak value, instead of the mean value.

These settings should be used:

```
ViCom::RFPOWERSCAN::STimeDetector
```

`eTimeDetectorType = RFPOWERSCAN_TIMEDET_TYPE_PEAK = 0`: the setting means that the reported value will be calculated by taking the peak over the measured values.

```
ViCom::RFPOWERSCAN::SFrequencyDetector
```

`eDetectorType = RFPOWERSCAN_FREQDET_TYPE_PEAK = 0`: the setting means that the reported value will be on the peak of the measured values.

```
ViCom::RFPOWERSCAN::SSpectrumSettings:
```

`eWindowType`: set this to `RFPOWERSCAN_WINDOWTYPE_HANNING = 1`. This is the recommended setting for spectrum clearance.

12 R&S ViCom TD-SCDMA Technology

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- [Measurement Configuration](#)..... 202
- [Measurement Results](#)..... 202

12.1 General

TD-SCDMA is one of the third generation technologies used for mobile communication. It is based on time division multiple access with downlink and uplink on the same frequency and asymmetric (configurable) bandwidth distribution.

The chip rate is 1.28 MChip/sec and the signal bandwidth approximately 1.6 MHz.

12.1.1 Frame Structure

The TDMA frame in the TD-SCDMA-System has duration of 10 ms and is divided in 2 subframes of 5 ms. Frame structure for each subframe is the same:

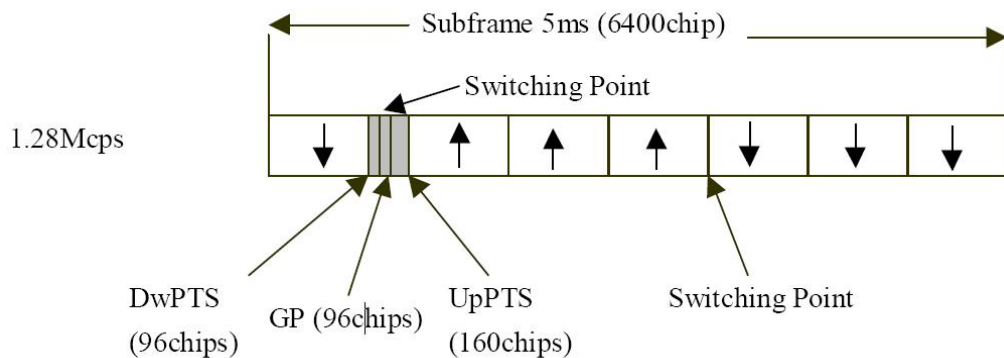


Figure 12-1: Subframe structure according to ETSI TS 125.221

The subframe consists of 7 slots, denoted TS0 to TS6, and a synchronization part. TS0 has fixed allocation to downlink and TS1 to uplink. The allocation of the other timeslots depends on the traffic load on downlink and uplink. In the shown example 3 timeslots are used for uplink and 4 for downlink.

The synchronization part consists of the downlink pilot timeslot DwPTS and the uplink pilot timeslot UpPTS separated by a guard period.

On downlink the DwPTS is one of 32 different sync codes. The DwPTS is used for rough frame synchronization and coarse BTS identification.

12.1.2 Slot Structure

The standard timeslot is structured into two data fields and a midamble section. At the end of the slot is an empty guard period:

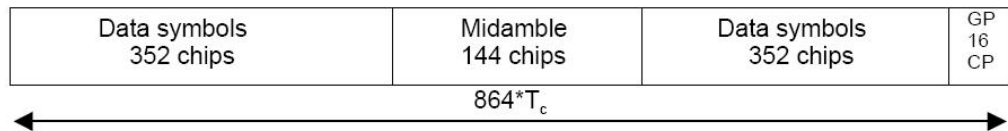


Figure 12-2: Timeslot structure according to ETSI TS 125.221

The data fields carry scrambled information symbols. The scrambling has a fixed length of 16 chips. Different channels are separated by orthogonal spreading.

The midamble part is a combination of several periodically continued sequences of a basic midamble code with length 128 chips. The offset from the basic code identifies the transport channel. Scrambling code and basic midamble code are connected and BTS-specific. There are 128 different code sets.

12.2 Measurement Configuration

The TD-SCDMA scanner allows parallel measurements in different networks. The network is identified by the exact frequency.

Two types of measurements can be defined for every channel.

In standard mode the measurement is performed over several subframes thus gaining sensitivity and accuracy at the cost of measurement speed. In fast mode the calculations are performed over a single subframe for maximized measurement speed.

In addition to the standard network analysis three further measurement results can be obtained. With BCH decoding the signaling information of every detected BTS is decoded. The spectrum measurement provides a narrowband view of the spectrum including the neighbor channels. The power profile shows the distribution of the received signal strength over time.

12.3 Measurement Results

The measurement results can be divided in BTS related data and general RF channel information.

For every detected BTS the delivered parameters are shown in the following table:

Parameter	Description	Comment
Sync code	Sync code of the BTS	One of 32 codes
Scrambling code	Scrambling and midamble code of the BTS	One of 128 codes. Sync and scrambling code are connected.

Parameter	Description	Comment
Time offset	Time offset of the subframe with respect to the beginning of the acquisition.	An absolute time is obtained in combination with the acquisition time from the R&S TSMW
RSSI TS 0	Received signal strength averaged over TS0	The RSSI values for different BTS's differ only in the time interval for averaging. Perfectly Synchronized BTS's will have the same RSSI results. The RSSI measurement does not isolate the signal part from a single BTS.
RSSI DwPTS	Received signal strength averaged over the downlink sync interval	
RSSI UpPTS	Received signal strength averaged over the uplink sync interval	
RSSI TS1	Receiver signal strengths averaged over the corresponding timeslots	
RSSI TS2		
RSSI TS3		
RSSI TS4		
RSSI TS5		
RSSI TS5		
RSSI TS6		
RSCP PCCPCH	Received code power for the PCCPCH	
RSSI PCCPCH	Received signal strength for the PCCPCH	
ISCP PCCPCH	Cumulated interference power for the PCCPCH	
C/I PCCPCH	Signal-to-Interference ratio for the PCCPCH	
Ec/Io PCCPCH	Ratio between the received signal strength averaged over the PCCPCH and PCCPCH code power	
RSSI Midamble	Received signal strength averaged over the midamble of Slot 0	Please note that for midambles there is no spreading gain.
RSCP Midamble	Code power in the midamble of slot 0	
ISCP Midamble	Cumulated interference power in the midamble of slot 0	
C/I Midamble	Signal-to-Interference ratio in the midamble of slot 0	
Ec/Io Midamble	Ratio between RSSI midamble and RSCP midamble	
CIR	A list of discrete peaks of the channel impulse response of the BTS based on the midamble correlation.	For each peak the absolute power level and the arrival time with respect to the beginning of the acquisition is provided.

The general RF characteristics of the radio channel are the spectrum and the power profile.

The spectrum is measured over a 320 μ sec interval in the acquisition providing a resolution of 3.125 kHz and a bandwidth of 4.1 MHz. Assuming a channel spacing of 1.6 MHz parts of the spectral components of neighbor channels are included. Due to the bursty nature of the TD-SCDMA-signal, the spectrum measurement may be misleading. If at least one single BTS has been acquired the spectrum measurement is centered over slot 0 of the strongest BTS. If no BTS has been detected the spectrum measurement is centered over the strongest power in time domain which may come from a nearby mobile station.

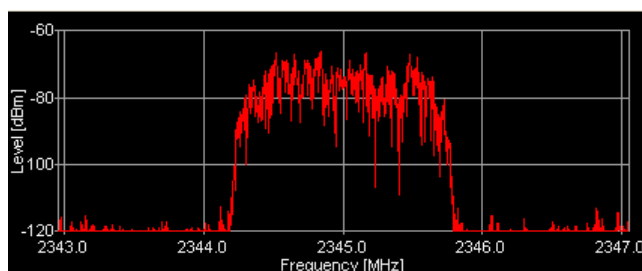


Figure 12-3: Spectrum example for a single TD-SCDMA-carrier (lab environment)

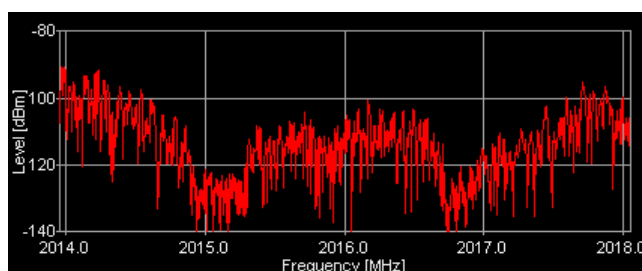


Figure 12-4: Spectrum example from a live measurement with active neighbor channels

Power profile shows the received signal power as a function of time. The channel filter is applied to the input data and the power is averaged over slices of 12.5 μ sec (16 chips). The power profile shows the different power levels for the slots and synchronization sequences and provides an indication of downlink-uplink distribution. It can be used for first verification of BTS synchronization and interference analysis.

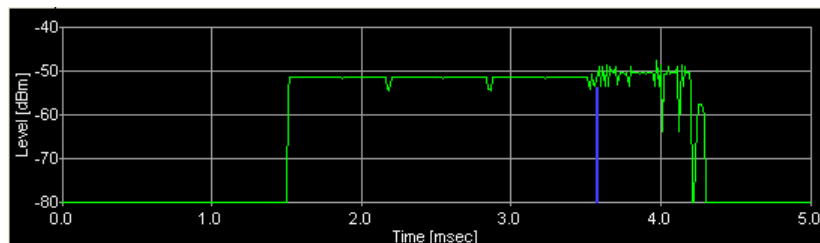


Figure 12-5: Power profile for a single base station in lab environment

The blue line indicates the beginning of slot 0. The DwPTS burst level is approx. 6 dB lower than the downlink slots. The uplink slots are not used.

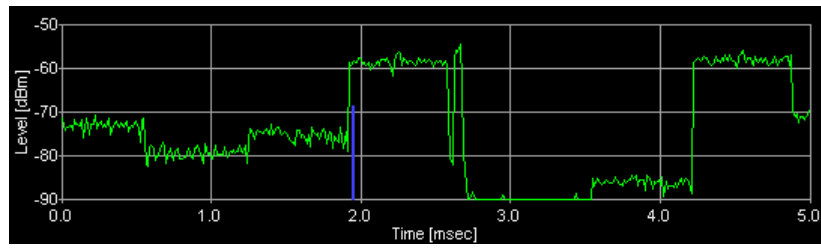


Figure 12-6: Power profile from a live measurement with different levels for the slots

13 R&S ViCom CW Technology

In this chapter, the Receiver Channel Power measurement module is described. Channel power measurement is similar to the inband power measurement available in the GSM network scanner, but it can be configured in a more flexible way using the CW measurements API.

Like in the previous chapters, this one begins with the description of the basic processing and calculation issues that arise in the different measurement modes. It is important to understand these basics to make the best use of the capabilities of the device.

The two subsequent chapters cover the sample application deployed with the R&S ViCom shipment.

The R&S TSML model capable of performing channel power measurements is the R&S TSML-CW. In the subsequent sections, this CW module and the Receiver Channel Power Measurements API are used to describe the technology and programming interface.



You can use the CW interface of the R&S ViCom on one instance only. No other R&S ViCom interfaces must be loaded on that receiver. The system will behave in unexpected ways (measurements will fail, for example), if this is done.

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13.1 Channel Power Measurements

Up to a certain degree, all the measurements provided by the R&S TSM Instruments are performed in the same way. The measured frequency is set in the receiver unit together with the bandwidth and the measurement is started after some pause time. Incoming data is converted to digital signals, demodulated and finally reduced to a downsampled set of IQ data.

Depending on the measurement mode, 512 IQ data pairs (so called raw measurement data) are written into an internal memory buffer and an interrupt is raised after some time elapsed. Additionally, an externally connected trigger device generates pulses that are also recorded and counted. The interrupt handling routine then transfers some of the raw data chunks to an internal ring buffer. Depending on the trigger mode, all chunks or only a subset of them are stored in that ring buffer.

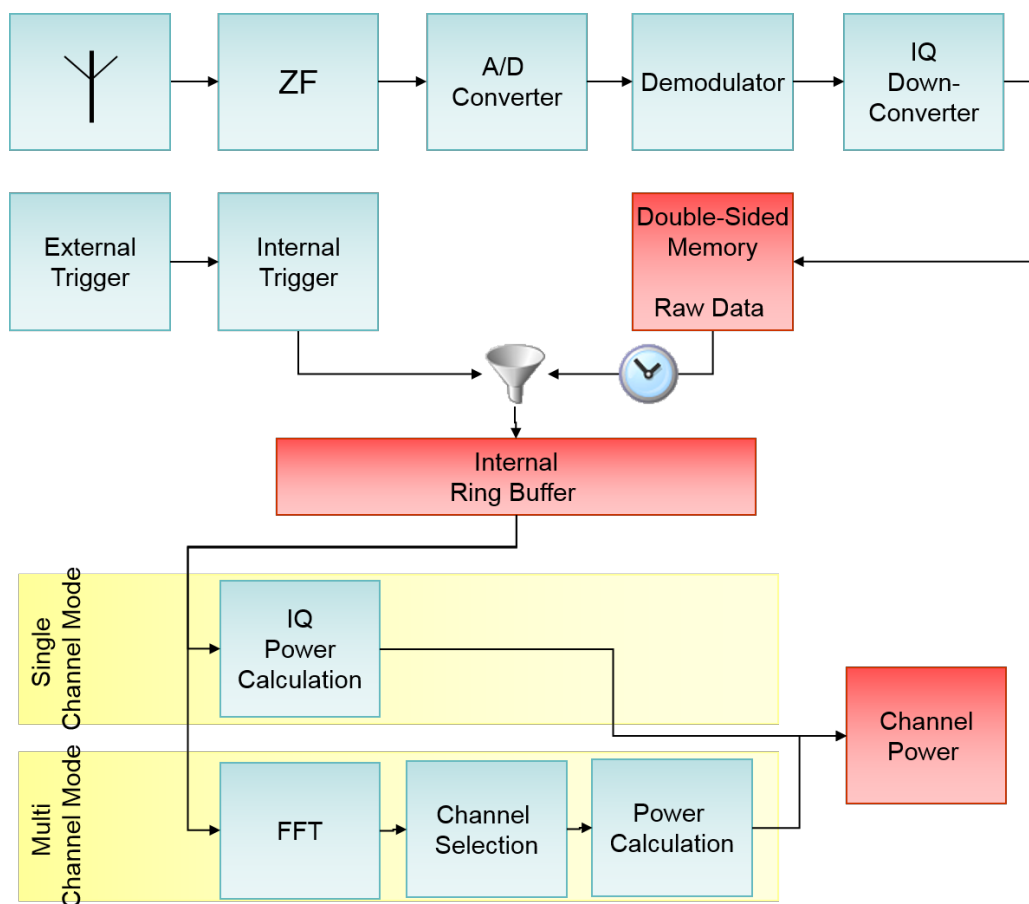


Figure 13-1: Channel power measurement

From the external triggers, the number of times they have been recorded and the time intervals between those triggers, internal triggers are generated. These internal triggers are the basic element to decide which raw measurement blocks are moved to the internal ring buffer, which in turn is used as input for different calculation routines. For more details on the triggering, refer to the section about triggering below.

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13.1.1 Measurement Modes

These two different calculation routines in the R&S TSM Instruments are called Single Channel and Multi Channel measurement modes. Both differ in the accuracy, sensitivity to noise and measurement speed they provide, where the single channel measurement is used to focus the measurement on one specific channel, being as accurate as possible and reducing the influence from strong senders in the neighbourhood. A faster way to do the measuring is provided by the multi channel measurement mode, which in turn leads to stronger noise levels.

As input both modes require a list of channels to be defined. Each channel consists of a center frequency, a bandwidth and a measurement time specification. The measurement mode can be specified for each single channel, the R&S TSM Instruments software will then combine related channels and measurement modes appropriately to make the best use of the available processing time.

13.1.1.1 Single Channel Measurement

The concept of the single channel measurement mode is very simple. The internal hardware of the R&S TSM Instruments is set to a specific frequency and a specific bandwidth, which must not exceed 4 MHz. Then the hardware measurement is performed for a specific amount of time. The results of this data lead to a whole bunch of IQ-samples, which in turn are then used to calculate the channel power. The overall result is the sum of the squares of the real and imaginary part of the IQ samples.

This direct approach leads to very accurate results, since the attenuator is set to best-fit the measured channel and the IQ samples can be used directly and completely to calculate the power value. All this has to be paid off by blocking the measurement unit for the measurement time where only one channel is measured, even if the bandwidth is significantly smaller than the maximum. In that way, all channels have to be measured sequentially, so that one sweep will last at least the sum of the measurement times (there are additional costs, because the equipment must be synchronized internally).

All this is depicted in the figure shown below. Each of the three channels configured is measured on its own. The read bar in the mid of the channels is the center frequency and the blue background shall indicate the bandwidth.

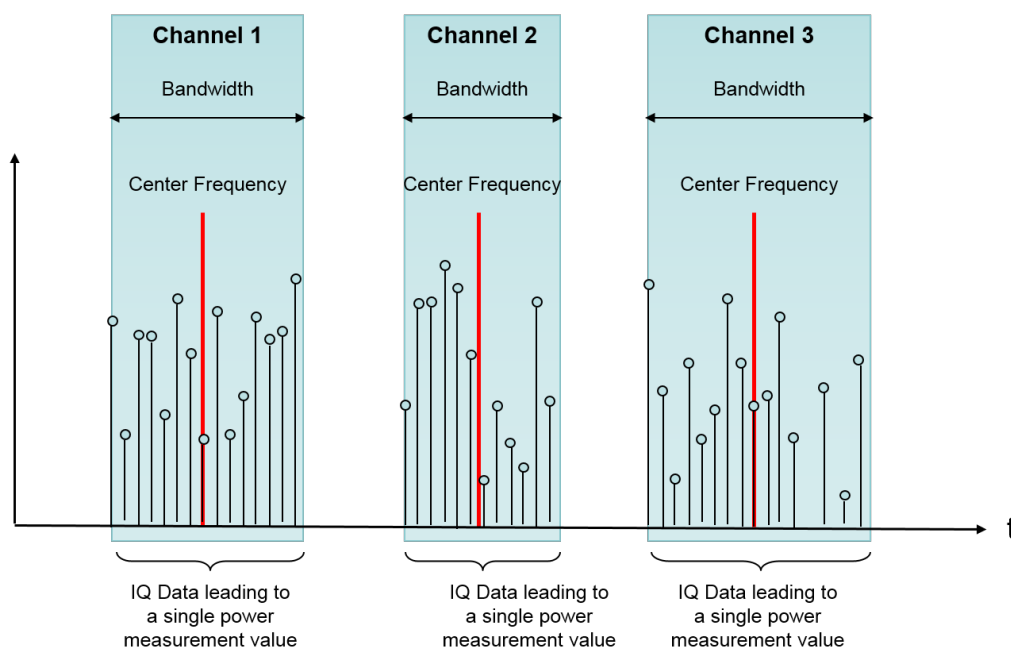


Figure 13-2: Single channel measurement

13.1.1.2 Multi Channel Measurement

To gain high measurement performance the channels specified to be measured are grouped together to cover a bandwidth of at most 4 MHz in each group. One such group is then measured together, which leads to higher measurement rates since the frequency has to be set only once in the hardware.

There are several drawbacks of this measurement method. One problem that might arise is that the attenuator is set for the set of frequencies, which may lead to higher noise levels in the case of some strong channels and the others being relatively weak.

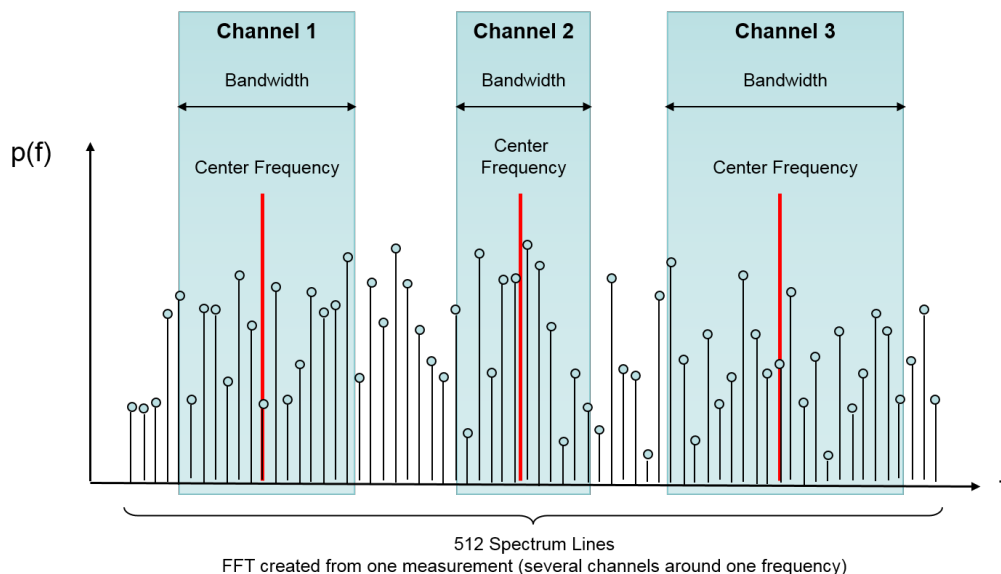


Figure 13-3: Multi channel measurement

Grouping Algorithm

The grouping mechanism is a sophisticated algorithm to also assure that at least 10 spectrum lines in the resulting spectrum of the FFT contribute to the overall power value for one channel.

For example, if two channels shall be measured with a bandwidth of 50 kHz at frequencies 400.1 and 400.15 MHz, and one with 3.1 MHz at 401.7 MHz. This would mean that the total bandwidth is 3.2 MHz, and since this bandwidth would be split into 512 spectrum lines, the distance between each line is 6.25 kHz. In this case two groups would be created from these three channels, because the 6.25 resolution would not lead to 10 power values for the channels with 50 kHz bandwidth.

13.1.2 Measurement Scheduling

One major difference to the other APIs in the R&S ViCom library is that the measurement results are not necessarily delivered when the internal processing is finished or some time has elapsed. One of the available operation modes works in that way, but there is also the possibility to make the result creation depending on an external trigger device.

13.1.2.1 Free Run

The Free Run Mode works without external triggering and processes the raw data as soon as enough chunks are available to serve the required measurement time. In single channel mode, that means that one channel is measured until the total time required to measure the raw chunks exceeds the required measurement time. Based on these chunks, the overall power is calculated as described in the following chapter about power value aggregation.

In multi channel mode, the raw measurement chunks are processed by a FFT, and the spectrum lines belonging to one channel of the channel group are used to calculate the single power values.



Different measurement times in a frequency cannot be used in this mode. The maximum measurement time is used in this case to record the raw measurement data, and for all channels the data of all resulting FFTs is used.

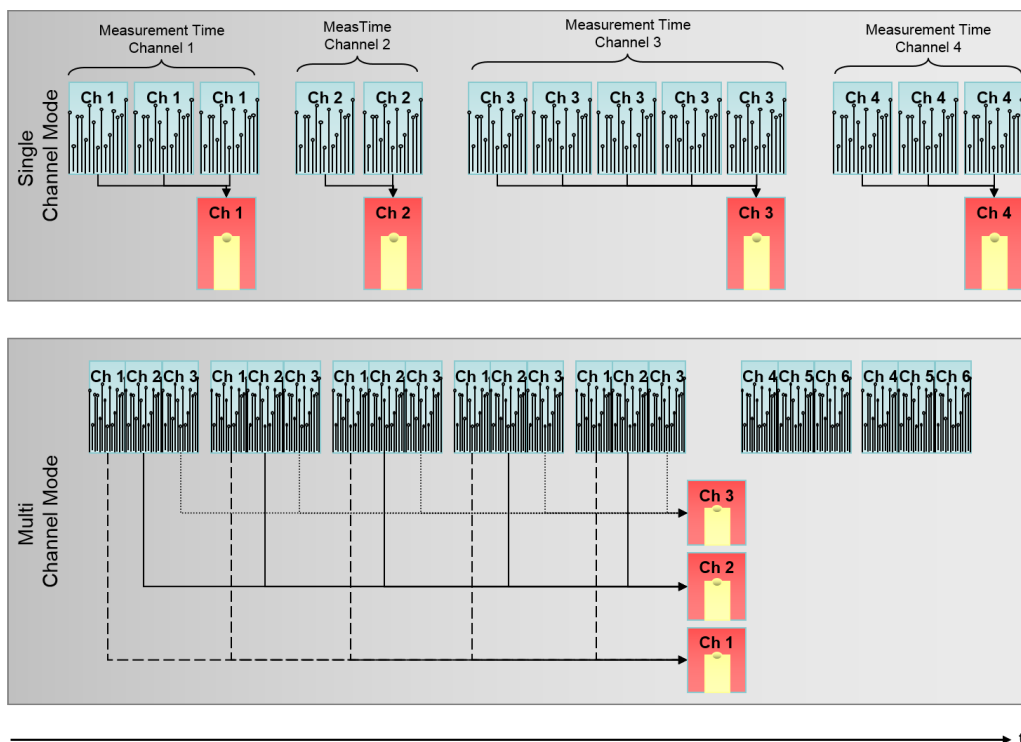


Figure 13-4: Free run mode

13.1.2.2 Time and Distance Triggering

To reduce the amount of data used to calculate channel power results, external trigger devices can be connected to the R&S TSM Instrument. Each time a trigger is fired, the event is logged with its timestamp. As soon as a raw measurement chunk is available, the R&S TSM Instruments' software checks if the chunk belongs to a certain trigger,

and if so, the chunk (and possible the following ones as well) will be used to calculate the channel power.

When triggering is active, the trigger signal from the external device can be filtered to generate internal triggers that result in the creation of a measurement result. For example, if it is useful to use only every 10th trigger, this can be configured. It is even possible to specify non integers as trigger filter, as long as the rational does not get less than 1. As a consequence, it is not possible to create more internal trigger signals by software than actually fired by hardware. In the subsequent sections, the trigger events from the trigger device are called external triggers, and the calculated ones are called internal triggers.

As soon as the trigger factor is set to a value that is not equal to 1 (i.e. every external trigger is exactly the same as an internal trigger for the result creation), the CW module must extrapolate the timestamp when the output trigger has to be generated based on the history of the last input triggers.



This extrapolation step is of course not a 100% exact replacement and the triggers raised in that way might differ from the ones really measured, especially when integer multiples are used. For example, if the factor is set to 2 it is not necessarily true that each second input trigger leads to an output trigger, since the calculation based on the time intervals of the trigger history might be different (see figure below).

In the figure below, several examples are shown how the internal triggers are derived from the external triggers. In the simplest case, the external triggers exactly match the internal ones, which is the case when 1:1 triggering is active.

If a 3:2 triggering is active, the first two external triggers are used to extrapolate the timestamp of the internal trigger. This step is repeated when the next external triggers arrive. In the sample, the distance between the first and second internal trigger is increased because the third external trigger also is raised after a longer pause. The fourth external trigger is fired faster and therefore the internal trigger also is fired nearly immediately.

In the last case, a 2:1 triggering is shown. The time delta between two subsequent external triggers is therefore doubled to calculate the internal trigger timestamp (although the real algorithm is somewhat more complicated). An interesting detail is that the fourth external trigger is ignored, since the internal trigger calculated from external trigger two and three is after the one calculated from the third and fourth.

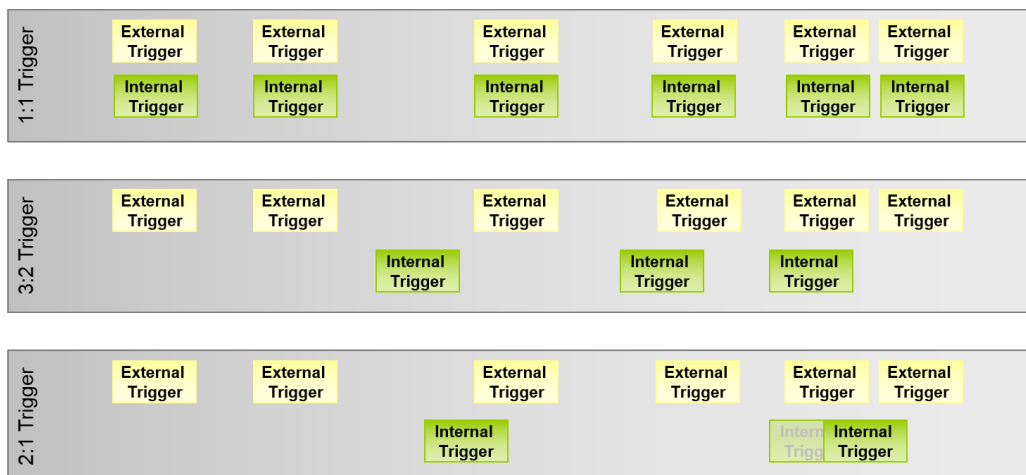


Figure 13-5: Internal trigger calculation

Until the first internal trigger for a sweep is raised, the raw measurement data is ignored and not stored for later power value calculation. The chunk that is associated with the time interval that contains the extrapolated timestamp for the internal trigger, is the first used to calculate the power value for the channel. Depending on the measurement time specified for one channel, the additional chunks have to be taken into account to calculate that value.

In single channel measurement mode this means that also parts of a chunk can be used to calculate the power value. As depicted the figure below, the internal trigger timestamp is located in the mid of the time interval associated with the third raw measurement chunk. Therefore, the second half of that chunk and the first of the next are used to calculate a raw power value. In total, three raw power values are calculated from four chunks. From these three raw power values, the overall channel power is calculated.

Once all chunks required to fulfill the measurement time constraint for the channel are available, the measurement unit is tuned to the next frequency and the raw measurements are processed immediately in the same way as before.



Additional trigger is not required, since once the internal trigger is located in a chunk, all configured channels are measured.

As a consequence, the internal trigger intervals must not be smaller to the total sweep time required to setup, measure and process all channels.

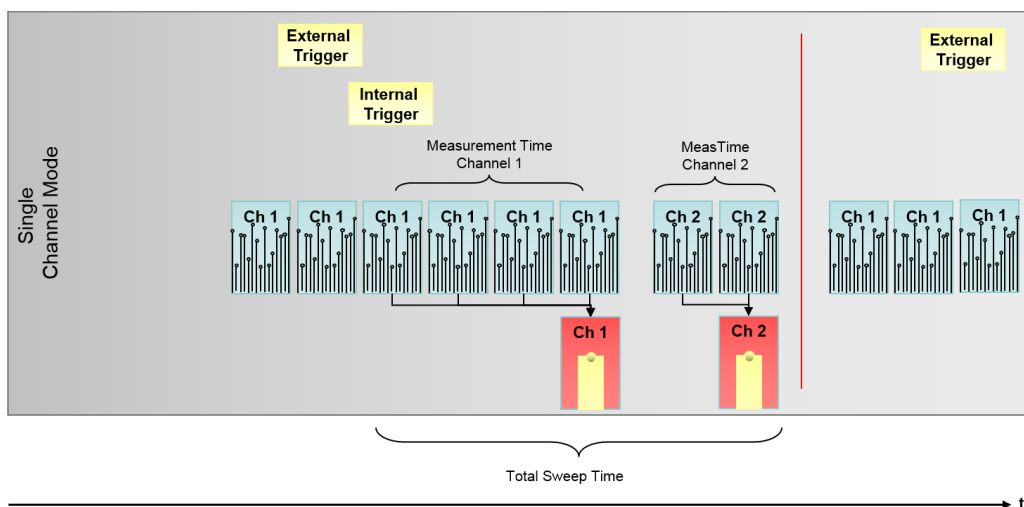


Figure 13-6: Triggering in single channel mode

The Multi Channel mode basically works in the same way. The raw measurement data is only processed with the FFT and the spectrum is analysed after the internal trigger is raised. In comparison to the single channel mode, the raw data is not split to only use parts of a chunk or to combine to chunks for a FFT. Chunks are always used completely or ignored in this mode.

In the sample shown below, the tuning to the channel group containing the channel 4, 5 and 6 occurs after all channels in the first group have been measured once.

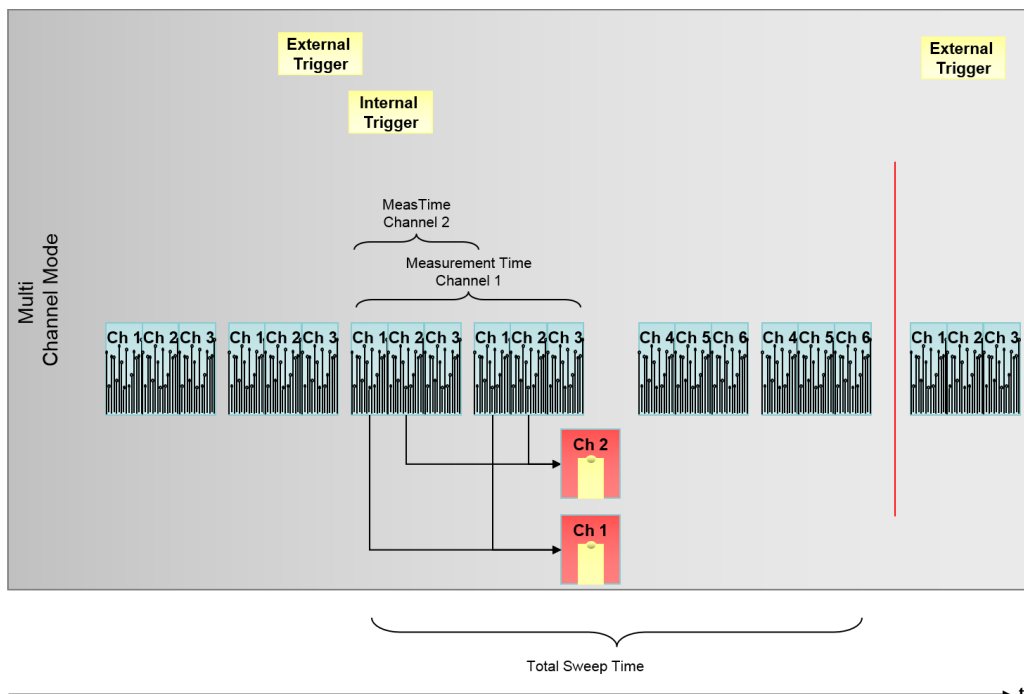


Figure 13-7: Triggering in multi channel mode

One important difference between the Single and Multi Channel Measurement mode is illustrated in the figure above as well. In case of the Multi Channel Mode, the measurement time of one set of frequency that is measured in a row is chosen to best-fit the maximum measurement time of the included channels. For example, if the measurement times for channels 1, 2 and 3 are 300, 200 and 500 μs , then the data used to calculate the channel powers for those channels is taken from raw measurements received within about 500 μs .

13.1.3 Channel Power Aggregation

In case that multiple channel power values have to be merged to create one final result (because more than one raw measurement chunk shall be used to calculate the overall power for a channel/channel group), a strategy must be chosen how this can be done. From the raw measurement data, i.e. either the subset of spectrum lines from the FFT in case that the Multi Channel measurement mode was active, or the IQ samples from the IQ down-converter in case of the Single Channel measurement mode, power values are calculated for each raw power value group.

If more than one group of 512 power values is within the measurement time for a channel (in the figure depicted below, there are four such chunks from which four power values are created), then from the set of these values one result has to be calculated for the channel for which the measurement was configured.

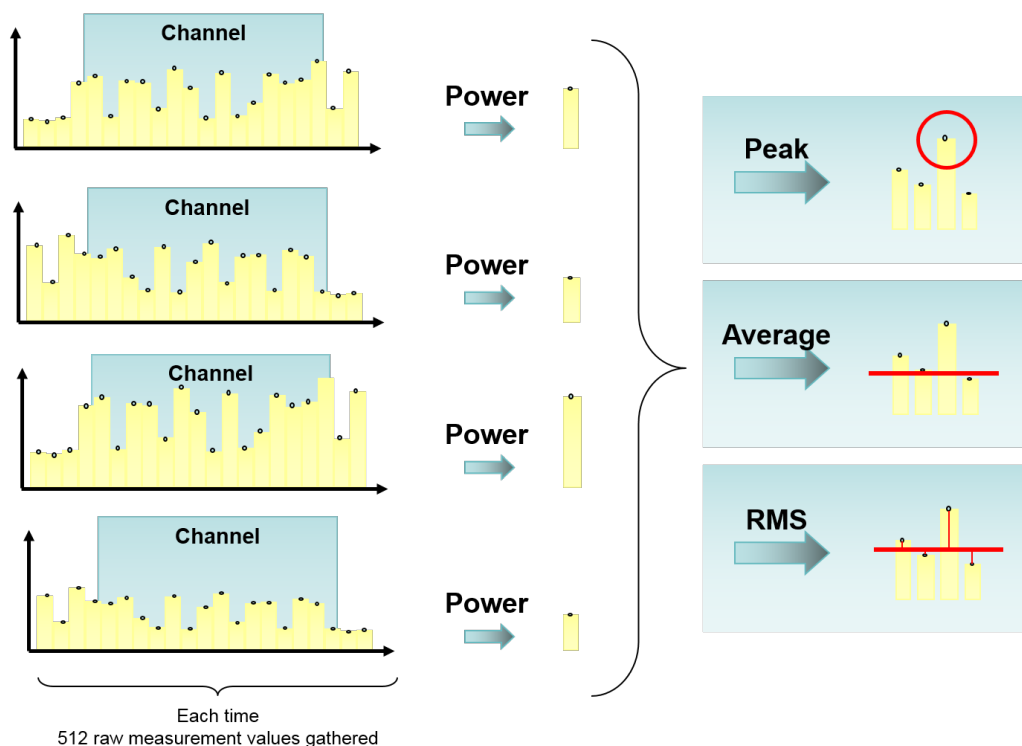


Figure 13-8: Power aggregation modes

The aggregation mode can be chosen from one of the following three options:

- PEAK: Select the maximum power value from the single measurement results.

- **AVERAGE:** Calculate the linearized average of all the power values calculated for the different raw measurements, where p is the power value of the raw measurement i , and N is the number of measurements contributing to the overall result.

$$P_{avg} = \frac{1}{N} \sum_{i=1}^N P_{f_i}$$

- **ROOT-MEAN-SQUARE:** The root mean square of all intermediate results is calculated based on the equation shown below. As for the average, the power values are converted to Watt to have a linear scale for calculating the final result.

$$P_{rms} = \sqrt{\sum_{i=1}^N P_{f_i}^2}$$



The last two modes do not use the calculated power values directly, but first linearize the power values. Otherwise the aggregation would lead to incorrect results.

13.2 Sample Application

In the same way as shown in the other R&S ViCom APIs, a sample application is packaged with the RF Channel Power measurements module (R&S ViCom CW). It has a similar look and feel as the other sample applications and shares the same purpose: The usage of the API shall be shown as a GUI in the same way as it looks in the code, to reduce the time to get familiar with the API and to make trial and error possible without coding.

Basically, the user interface looks familiar if you have used one of the other sample applications deployed with the other modules of the R&S ViCom library. The application shows one big dialog that contains three columns of functionality: The left column holds the buttons that correspond to the functions the interface provides. The structures given to these functions are filled with the content of the controls shown in the central column (and partially with some of the right one).

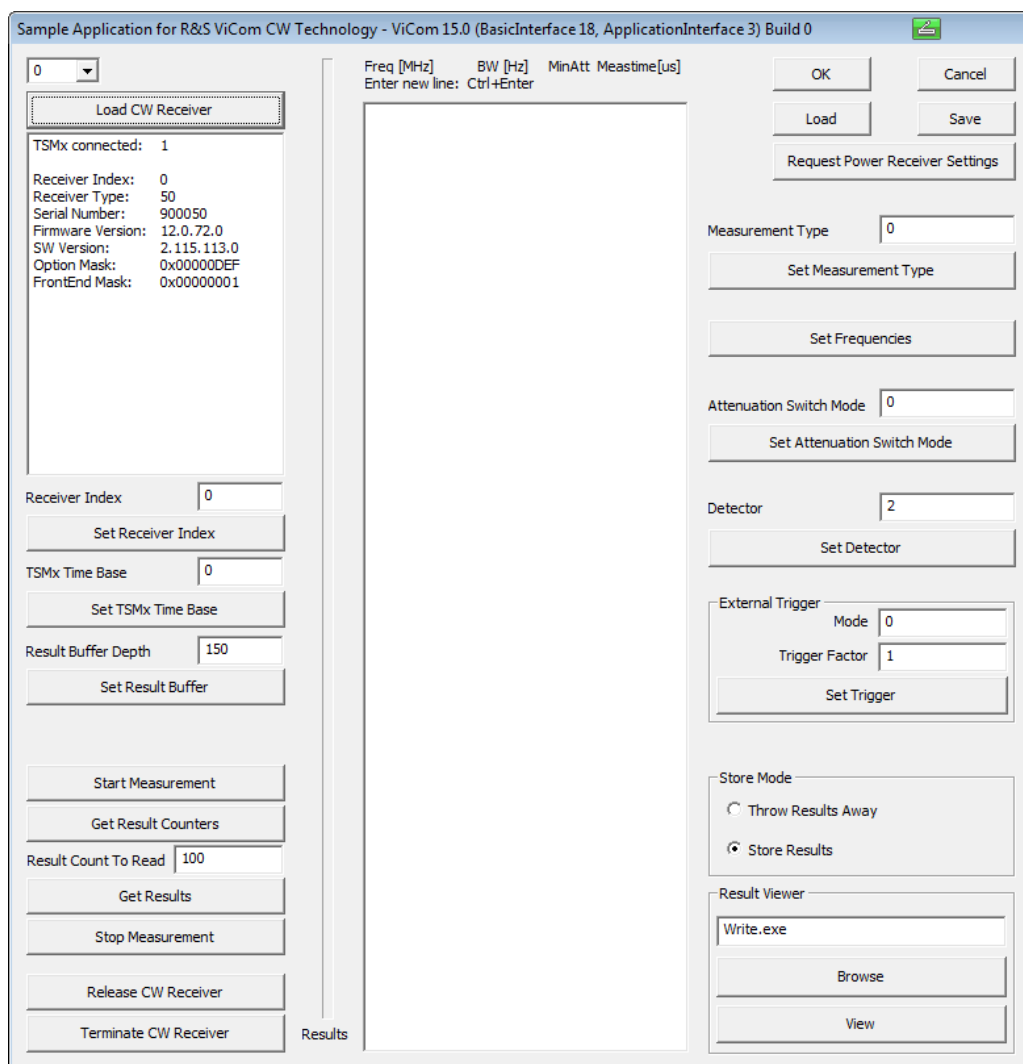


Figure 13-9: R&S ViCom CW technology sample application

In this demo application, the usage is straightforward. The most important settings are made in the central column, that is, the measured channels' configuration. Important settings are also made in the right column, in the text boxes "Measurement Type" and "Detector".

In this central column, the list of frequencies that shall be measured can be specified. Each line in the edit field must contain one channel specification, consisting of the measured frequency in MHz, the bandwidth in Hz, the attenuation mode and the measurement time in microseconds.



It is important to specify all of these settings. If there are less than four columns entered (separated by at least one space character), the line is rejected when clicking the "Set Frequencies" button.

New lines can be entered by pressing Ctrl+Enter. Once the frequencies are specified, a click on "Set Frequencies" transfers these settings to the R&S TSM Instrument, if all validation routines have been passed successfully.

The measurement type can be one of the values listed below, and is set using the "Set Measurement Mode" button.

- 0 – Single Channel Mode, each channel is measured until one power value can be calculated (based on the measurement time specified)
- 1 – Multi Channel Mode, Channels are grouped and measured together if possible

As detector, the following values are valid, which can be set by pressing "Set Detector".

- 0 – Peak detection (highest power value is chosen when multiple raw measurements are available)
- 1 – The raw data is averaged (i.e. the linearized power values are averaged)
- 2 – Root-Mean-Square: The single (linearized) values from the raw measurements are squared, and the square-root of the sum of the power values makes the final power value.

Once configuration is finished, the measurement can be started by clicking on "Start Measurement". After checking the buffer state with "Get Result Counters", the number of results specified in "Result Count To Read" can be removed from the buffer by pressing "Get Results".

If the "Store Results" radio button is active when fetching the results, they are written into the `ViComMeasurements.txt` file stored in the `C:\RuS\ViCom_<version>\bin\LogFiles` directory. The content of the file looks similar to the one shown in the following figure.

```

ViComMeasurements.txt - WordPad
File Edit View Insert Format Help
wFrequencyIndex = 11 u64TSMxTimeIn40ns = 26291972608 sPowerInDbm100 = -12032 eAttMode = 0
wFrequencyIndex = 12 u64TSMxTimeIn40ns = 26291972608 sPowerInDbm100 = -11840 eAttMode = 0
wFrequencyIndex = 13 u64TSMxTimeIn40ns = 26291972608 sPowerInDbm100 = -11936 eAttMode = 0
wFrequencyIndex = 14 u64TSMxTimeIn40ns = 26291972608 sPowerInDbm100 = -11680 eAttMode = 0
wFrequencyIndex = 15 u64TSMxTimeIn40ns = 26291972608 sPowerInDbm100 = -11616 eAttMode = 0
wFrequencyIndex = 16 u64TSMxTimeIn40ns = 26291972608 sPowerInDbm100 = -11728 eAttMode = 0
wFrequencyIndex = 17 u64TSMxTimeIn40ns = 26291972608 sPowerInDbm100 = -11712 eAttMode = 0
wFrequencyIndex = 18 u64TSMxTimeIn40ns = 26291972608 sPowerInDbm100 = -12080 eAttMode = 0
wFrequencyIndex = 19 u64TSMxTimeIn40ns = 26291972608 sPowerInDbm100 = -11552 eAttMode = 0

MeasResult:
dwPcTimeStamp = 378617765ms
u64TSMxTimeIn40ns = 26292207616
MeasResult.ListOfCPichCirs.dwCount = 280
wFrequencyIndex = 20 u64TSMxTimeIn40ns = 26292207616 sPowerInDbm100 = -11712 eAttMode = 0
wFrequencyIndex = 21 u64TSMxTimeIn40ns = 26292207616 sPowerInDbm100 = -11776 eAttMode = 0
wFrequencyIndex = 22 u64TSMxTimeIn40ns = 26292207616 sPowerInDbm100 = -11792 eAttMode = 0
wFrequencyIndex = 23 u64TSMxTimeIn40ns = 26292207616 sPowerInDbm100 = -11648 eAttMode = 0
wFrequencyIndex = 24 u64TSMxTimeIn40ns = 26292207616 sPowerInDbm100 = -11680 eAttMode = 0
wFrequencyIndex = 25 u64TSMxTimeIn40ns = 26292207616 sPowerInDbm100 = -11728 eAttMode = 0
wFrequencyIndex = 26 u64TSMxTimeIn40ns = 26292207616 sPowerInDbm100 = -11744 eAttMode = 0
wFrequencyIndex = 27 u64TSMxTimeIn40ns = 26292207616 sPowerInDbm100 = -11696 eAttMode = 0
wFrequencyIndex = 28 u64TSMxTimeIn40ns = 26292207616 sPowerInDbm100 = -11776 eAttMode = 0
wFrequencyIndex = 29 u64TSMxTimeIn40ns = 26292207616 sPowerInDbm100 = -11664 eAttMode = 0
wFrequencyIndex = 0 u64TSMxTimeIn40ns = 26292544512 sPowerInDbm100 = -11728 eAttMode = 0
wFrequencyIndex = 1 u64TSMxTimeIn40ns = 26292544512 sPowerInDbm100 = -12064 eAttMode = 0
wFrequencyIndex = 2 u64TSMxTimeIn40ns = 26292544512 sPowerInDbm100 = -11808 eAttMode = 0
wFrequencyIndex = 3 u64TSMxTimeIn40ns = 26292544512 sPowerInDbm100 = -11744 eAttMode = 0
wFrequencyIndex = 4 u64TSMxTimeIn40ns = 26292544512 sPowerInDbm100 = -11552 eAttMode = 0
wFrequencyIndex = 5 u64TSMxTimeIn40ns = 26292544512 sPowerInDbm100 = -11680 eAttMode = 0
wFrequencyIndex = 6 u64TSMxTimeIn40ns = 26292544512 sPowerInDbm100 = -11696 eAttMode = 0
wFrequencyIndex = 7 u64TSMxTimeIn40ns = 26292544512 sPowerInDbm100 = -11536 eAttMode = 0
wFrequencyIndex = 8 u64TSMxTimeIn40ns = 26292544512 sPowerInDbm100 = -11696 eAttMode = 0
wFrequencyIndex = 9 u64TSMxTimeIn40ns = 26292544512 sPowerInDbm100 = -11904 eAttMode = 0
wFrequencyIndex = 10 u64TSMxTimeIn40ns = 26292544512 sPowerInDbm100 = -11552 eAttMode = 0
wFrequencyIndex = 11 u64TSMxTimeIn40ns = 26292544512 sPowerInDbm100 = -11856 eAttMode = 0

For Help, press F1

```

Figure 13-10: Screenshot of measurement result

Each result contains a number of sweeps, where the frequencies are given in ascending order.



The sweeps are not necessarily delivered completely; parts of sweeps maybe delivered with the next result, as shown in the previous figure.

14 R&S ViCom Automatic Channel Detection

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14.1 General Operation

The R&S ViCom Automatic Channel Detection (R&S ViCom ACD) allows to detect and locate all channels in use on specified frequency bands for several scanner technologies. The frequency bands are typically known from the spectrum allocation plan provided by the local regulator.

The main use case for the Automatic Channel Detection (further in the text ACD) is to enable the user to start measuring anywhere without any knowledge of the currently used channels within the known bands. Typically, the user will initiate a measurement with the ACD and for the best measurement rates will use detected channels as a starting point for scanner measurements.

Two different modes of operation are implemented:

- Simple ACD
- Smart ACD



This R&S ViCom version does not support the R&S TSMx.

R&S ViCom ACD currently supports LTE, UMTS, CDMA and EVDO technologies.

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14.1.1 Programming

The R&S ViCom ACD interface can be programmed according to the R&S ViCom programming principles. The installer provides a sample application (`SampleForViComACD_cmd`) demonstrating the use of the ACD.

14.1.2 Simple ACD

This mode simply tries scanner measurement on every possible channel of the selected frequency bands. After the evaluation of all channels, the ACD stops scanning and provides the results via the R&S ViCom interface.

This mode is useful to detect channels at one location, and for starting a drive from that location assuming that the channel allocation will not change during the drive route.

If the primary goal of the measurement is the detection of cells and the speed of the measurement on already detected cells is of secondary interest, running the ACD in simple mode is the best solution.

14.1.3 Smart ACD

This mode uses the RF Power Scan. The corresponding options for the R&S TSMW / R&S TSME and R&S ROMES have to be available. The RF Power Scanner is running on Frontend 1 of the R&S TSMW to do the spectrum measurements. Based on the measured spectrum the ACD optimizes the search for channels via the technology specific scanner.

Detected channels are automatically added to the result list of scanned channels. The Smart ACD never stops by itself and continues evaluating the defined spectra and adding detected channels, until the measurement is stopped by the user. The mode is useful, if ACD is used while driving in an inhomogeneous network, where the channel allocation changes during the driven route. This may be the case where spectrum is shared between technologies.

If the detection of transmitters along a drive is the goal of the measurement, running the ACD in smart mode is the best solution.



If Smart ACD is selected, the RF Power Scan will be loaded automatically, if not already loaded.

14.1.4 Performance Requirements

The performance of the R&S ViCom ACD depends mainly on the amount of different technologies and the size of the observed frequency ranges. It is highly recommended to keep both parameters as small as possible in order to achieve the maximum benefit of this feature.

14.1.5 Device Options

To use the R&S ViCom ACD, the appropriate options for the R&S TSMW or R&S TSME have to be available on the device.

The options are:

- K40 (ACD) for general ACD operation
- K27 (RF Power Scan) for Smart ACD operation
- K21 (GSM/WCDMA) for UMTS scanning
- K22 (CDMA/EVDO) for CDMA or EVDO scanning
- K29 (LTE) for LTE scanning

Example:

- If you want to use Smart ACD for LTE channel detection with the R&S TSME you need the R&S options K40, K27 and K29.
- If you want to use Simple ACD for CDMA channel detection with the R&S TSMW you need the R&S options K40 and K22.

14.2 Configuration

14.2.1 General Settings

Usually frequency ranges are defined via frequency band numbers. These numbers are standardized for each mobile radio technology (e.g. LTE, UMTS, CDMA and EVDO) per geographic region.

Therefore, a list of technology settings (`STechnolgySettings`) containing an identifier for the mobile radio technology and a set of related frequency bands (`u64BandIdMask`) is used to set which frequency range shall be scanned for which technology up.

It is strongly recommend to specify only those bands, which are defined for the measurement region.

This list is implemented as an array of `STechnolgySettings` with `dwCount` elements as a part of the ACD settings structure `SACdSettings`.

Further parameters of this structure are:

- `enMeasuremetnMode` to select simple or smart ACD operation
- `enSensitivity` (only used for smart mode): Three different levels of sensitivity are available. Depending on the requirements of the measurement, the user may select a faster or more sensitive ACD
- `dwNumberOfTrialsPerChannel` to specify the maximum number of attempts to evaluate one channel
Increasing this number helps to find weaker cells and increases the detection probability, but reduces the detection speed.
- `dwMinimumDetectedBwInMhz` to specify the minimum of blocked bandwidth
Whenever a channel has been detected, it is assumed that it will block at least this bandwidth. The gaps in the spectrum must have at least this bandwidth for evaluating.
- `dwFrontEndSelectionMask` to specify which radio front end shall be used by the ACD

14.2.2 LTE Constraints

The Smart ACD for LTE will search for bandwidths starting with the minimum bandwidth as specified in the ACD's configuration. It supports bandwidths of 1.4MHz, 3MHz, 5MHz, 10MHz, 15MHz and 20MHz.

To improve the detection rate, it is highly recommended to set the minimum bandwidth correctly (if known), especially in bands which are used for several technologies.

The given minimal bandwidth only takes effect, if the specified minimal LTE bandwidth for the band processed is less than this bandwidth value. The specified minimal LTE bandwidth for the band processed will be used, if it is larger than the setup value.

14.3 Measurements

14.3.1 Measurement Results

R&S ViCom ACD provides a list of `SChannel` and `SMeasResult` structures as measurement result.

The `SChannel` structure describes a detected channel and the state of location via the following fields:

- `u64FrequencyInHz`: Channel frequency in Hz
- `enState`: State of the channel location (PENDING, SCANNING, DETECTED, LOST)
- `penTechnology`: Technology type of the channel (LTE, UMTS, CDMA, EVDO)
- `pwBandId`: Frequency band id of the channel
- `pdwBandwidthInHz`: Bandwidth of the channel, in Hz
- `pfRssiInDBm`: Last measured RSSI on this channel; the value is updated each time a channel is found. Only available in smart mode
- `pdwPcTimeStampInMs`: PC local time when this channel was measured the last time
- `bBandwidthConfirmed`: Status of detected bandwidth

15 R&S ViCom GPS

As mentioned in previous chapters, the R&S TSMW / R&S TSME have a built-in GPS module. This chapter describes how to use this GPS receiver with the R&S ViCom.

R&S ViCom GPS implements functionality which:

- can retrieve data from the GPS device
- send commands to the GPS device

The messages from the GPS device can be interpreted to provide information such as:

- GPS time
- Longitude
- Latitude
- Altitude
- Satellite information

Examples of the GPS functionality implemented in the R&S ViCom are provided in this chapter.

The R&S TSMW / R&S TSME should be connected and configured as described in the Appendix (Appendix A – "R&S TSMW Configuration"). No extra configuration for the GPS is required.

The GPS data is provided over the same IP connection as the scanner data.

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15.1 Sample Application

Below is a figure showing the R&S ViCom GPS sample application. As with other sample applications, the layout consists of several parts. On the left side are the general user controls used to control the application. The panel at the top allows the user to send commands to the GPS module and the middle panel shows the results.

The following section describes how to make measurements using the sample application and explains which R&S ViCom functions are being used.

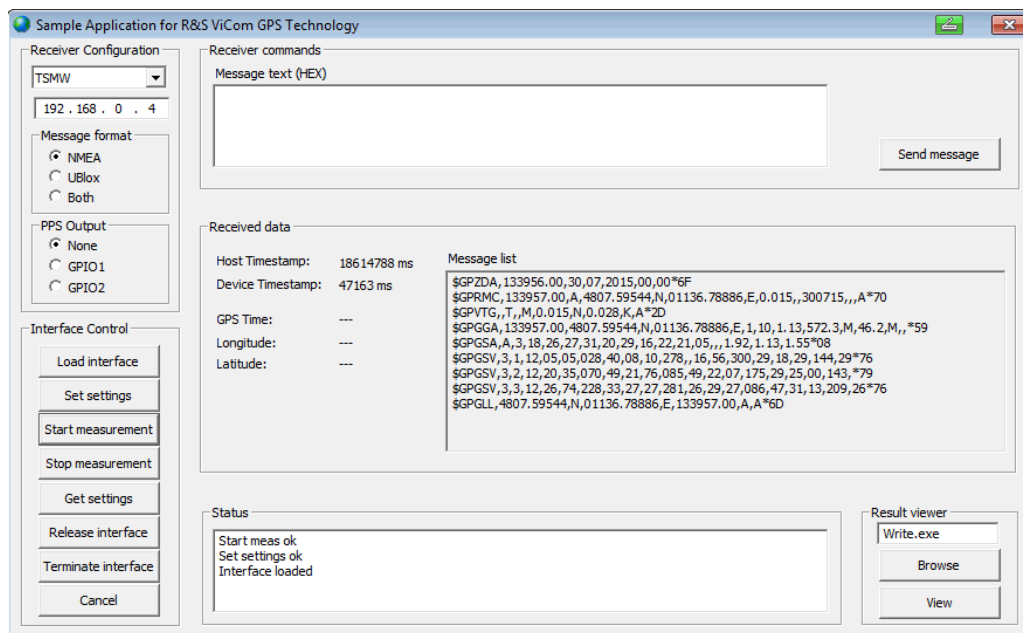


Figure 15-1: R&S ViCom GPS sample application

15.2 Measurements

Perform the following steps to make a GPS measurement.

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15.2.1 R&S TSMW / R&S TSME Address

Enter the IP address of the R&S TSMW in the given box (top left).

This generally has the form 192.168.0.x – where “x” is usually set to “2”.

After entering the address, press the "Load Interface" button to establish a connection with the R&S TSMW.

To establish a connection with the R&S TSME, if selected, just press the "Load Interface" button, as the IP address is already assigned from the list of IP addresses.

15.2.2 Message Format

Messages can have the NMEA format, Ublox format or both.

Select the format in the "Message format" box.

The dialog box "Send message" allows you to send command messages to the GPS module. Obviously, messages should be sent in the given format.

Messages resulting from commands or from measurements, will appear in the message window. The messages begin with the command and are followed by the response; see [Commands](#), for examples.

15.2.3 Measurement

Pressing "Start measurement" starts the measurement process but does not generate any results.

The application takes the messages in the buffer of the GPS module automatically. The result is displayed in "Message list", in the "Received data" area.

Pressing "Stop measurement" ends the measurement process but does not release the interface.

15.2.4 Commands

Commands can be entered as ASCII characters or hex codes depending on the message format. The interface does not check the validity of the commands you enter. Error messages resulting from incorrect or unsupported commands will be displayed in the message window.

In [R&S ViCom GPS sample application](#) the message window contains several commands and their results. Many such commands are available and some examples are explained in the following tables.

\$GPZDA	Date & Time	
	Format	\$GPZDA,hhmmss.ss,dd,mm,yyyy,xx,yy*CC \$GPZDA, 201530.00,04,07,2002,00,00*60
	hhmmss	HrMinSec(UTC)
	dd,mm,yyy	Day,Month,Year
	xx	local zone hours -13..13
	yy	local zone minutes 0..59
	*CC	the checksum data, always begins with *

\$GPGSV	Satellites in View	
	Format	\$GPGSV, 2,1,08,01,40,083,46,02,17,308,41 ,12,07,344,39,14,22,228,45*7
	2	Number of sentences for full data
	1	sentence 1 of 2
	08	Number of satellites in view
	01	Satellite PRN number
	40	Elevation, degrees
	083	Azimuth, degrees
	46	SNR - higher is better
	As above	For upto 4 satellites per sequence
	*75	the checksum data, always begins with *

\$GPGLL	Geographic position, Latitude and Longitude	
	Format	\$GPGLL,4916.45,N,12311.12,W, 225444,A,*1D
	4916.46,N	Latitude 49 deg. 16.45 min. North
	12311.12,W	Longitude 123 deg. 11.12 min. West
	225444	Fix taken at 22:54:44 UTC
	A	Data Active or V (void)
	*iD	the checksum data, always begins with *

A complete list can be obtained from many sources on the internet.

15.2.5 Ending the Session

After making your measurements you can unload the GPS receiver using the "Release interface" button.

If you encounter a problem during the release procedure, try using the "Terminate interface" button. The R&S ViCom API then forces a deletion of the `ViComGPSInterface` object.

15.2.6 Viewing the Results

To view the results, use the controls in the lower right corner.

Clicking "Browse" lets you find the result file you want to open, and "View" opens the file in the viewer.

16 R&S ViCom RS232 Tunneling

The R&S TSMx Family has different connection ports at the back: Two FireWire connections, several antenna connectors, a power connector and one RS232 interface. The latter can be used to connect an additional device to the R&S TSMx Family model, making it controllable by the PC that the R&S TSMx Family model is connected too.

RS232 communication supports two-way communication, as long as it is not done parallel. For example, some older mobiles can be connected by a serial connector to the pc. In general, any device that supports a serial communication interface (RS232) can be connected and controlled using the R&S ViCom API.



Figure 16-1: RS232 system configuration

In this chapter, the API of the R&S ViCom package is described that covers the area of communicating with the connected device. Since there are no special measurement modes in general that can be described, this chapter only contains two sections:

The next section contains a brief walk-through example of the sample application which is part of the delivery.



Make sure that the firmware version 12.xx or higher is installed on the R&S TSMx Family model. You can do this in the sample application after the device has been loaded. Check the Firmware version property shown in the list below the "Load Device" button.

Firmware versions less than 12.xx do not support the RS232 API. In the sample application, you encounter a "Selected R&S TSMx does not support the desired measurement" message when clicking on the "Start Measurement" button. Refer to [R&S TSMx Family Firmware Upgrade](#) for a description how to update the R&S TSMx Family firmware.

16.1 Sample Application

Below you can a screenshot of the RS232 sample application. Its layout structure is taken from the other sample applications. The left side contains the general control

buttons that are used to set the R&S TSMx Family model in a desired state or to apply settings.

As in the other applications, the center of the dialog is consumed by the technology specific elements. In this case, this is only a text field in which data can be entered. Using the button “Send Data” below the text field, the data can be transmitted via the R&S TSMx Family model to the connected device.

The right side contains the configuration elements. In this case, two settings can be modified:

- The baud rate: This determines the through-put of the connection. Normally, one value of the following list fits for most devices: 4800, 9600, 14400, 19200, 38400, 57600 or 115200.
- Silent mode (marked in the screenshot with a green ellipsis): This specifies whether the silent mode is switched on (4) or off (2). A value of 0 means that the current configuration is not changed. Refer to the section below for more details.

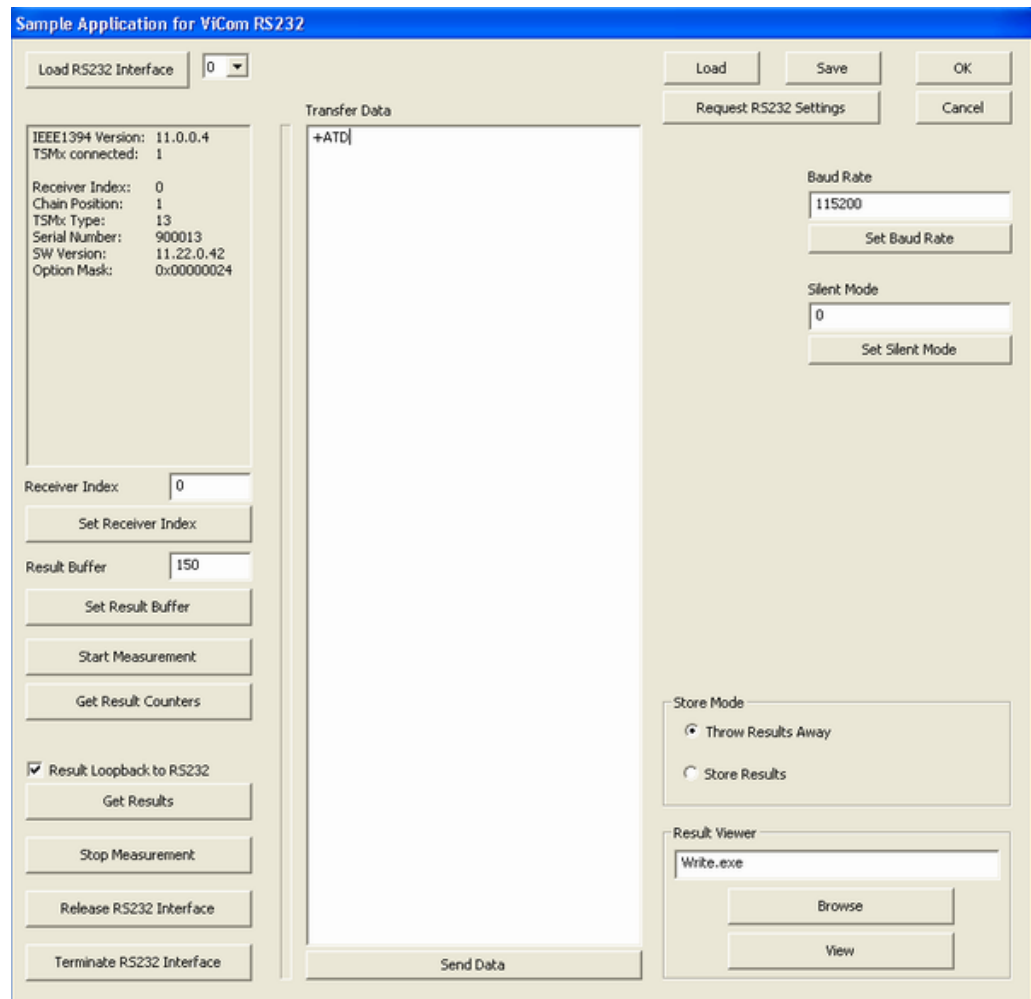


Figure 16-2: R&S ViCom RS232 sample application

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16.1.1 Walk-Through Example

The general procedure to set up a measurement with the RS232 API is as follows:

1. Press button "Load RS232 Interface"
2. Check if an appropriate firmware version is loaded (Firmware Version \geq 12.x)
3. Press the "Set Receiver Index" button to specify which device shall be controlled in the FireWire chain.
4. Set the result buffer size with the according button.
5. Set "Baud Rate" and "Silent Mode" if desired with the buttons on the right side of the dialog.
6. Press the "Start Measurement" button
7. Perform you work (see sections below for details).
8. Press the "Stop Measurement" button. You can now change some settings and restart the measurement (see step 6).
9. Press the "Release Measurement" button. You can now close the application or load another device (see step 1).

16.1.1.1 Sending Data

Now the communication with the serial port can be started. Data can be sent by entering text into the central text field and send it to the connected device by pressing "Send Data".

16.1.1.2 Getting Data

Data can be fetched by clicking on "Get Results". The sample reads data until no further data can be found in the result buffer.

To fill the result buffer, the R&S ViCom implementation of the RS232 tunneling API starts a thread to repeatedly watch the data sent on the FireWire connection. If it finds data from the serial port of an R&S TSMx Family model, it stores the data in the result buffer. If there is no such data found in one second, an empty result is stored.



Therefore, the result counters constantly increases, even if there is no communication at all. Be aware when using the API that after a call to `GetResult()` succeeded, the returned result might not necessarily contain valid information.

If there is data in the result buffer, its content is written to the output file `ViComMeasurements.txt` when the "Get Results" button is pressed and the "Store Results" mode is set. Additionally, the received raw data is written into another text file called `ViComMeasurements_RS232Received.txt` of the `LogFiles` directory.

16.1.2 Result Loopback to RS232

The sample application supports a special test mode, in which incoming data is immediately sent back to the transmitter. For example, this is useful when a terminal is connected to the COM port of the R&S TSMx Family model (like the HyperTerminal application shipped with Microsoft Windows). Data sent by the terminal is then bounced back to have some kind of debug facility.

To enable that special mode, just check the "Result Loopback to RS232" check box in the application.



This only works in the measurement mode. So, be sure to check that box before you click on the `GetResults()` button. During the receiving of the results, this will force them back.

16.1.3 Silent Mode

Normally, the R&S TSMx Family model uses the integrated COM-Port to show trace messages that can be used to check about the current state of the device. In the RS232 measurement mode, this is automatically switched off. If you also want to turn that messages off when no RS232 API is active, set this value in the R&S TSMx Family model persistently (enter mode, press the "Set Silent Mode" button and "Start Measurement"; only if the measurement has been started once after the mode was changed, the change will take effect).



The silent mode will be stored as setting in the R&S TSMx Family model itself. Even after releasing the R&S ViCom interface or after switching the device off and on, this setting is restored in the next session. Therefore the value of 0 can be specified as well, indicating that the current setting shall not be changed.

When the silent mode is activated, the R&S TSMx Family model indicates that mode by letting the Process/State LED blink constantly (when the interface is loaded and no measurement is active).

17 R&S Remote ViCom Interface

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- Example of R&S Remote ViCom Application with R&S TSMA..... 233
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17.1 Overview of R&S Remote ViCom Architecture

The R&S Remote ViCom allows the creation of applications running on measurement devices with different operating systems and programming languages. Currently, the R&S Remote ViCom is only available together with a R&S TSMA scanner.

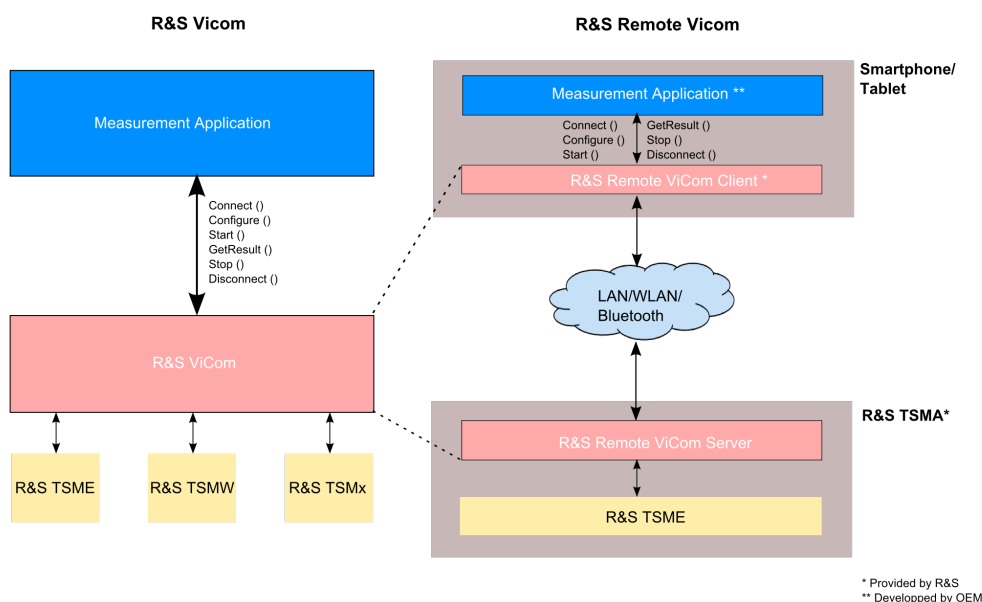


Figure 17-1: R&S Remote ViCom Architecture

In contrast to the standard R&S ViCom application interface (API), the R&S Remote ViCom API is based on a client-server architecture, as shown in previous figure.

The Remote ViCom client is running together with the measurement application on a smartphone or tablet PC. Via LAN, WLAN or Bluetooth, the client is communicating with the Remote ViCom server, which is running on the R&S TSMA.

For details about the R&S TSMA, see the “R&S TSMA Autonomous Mobile Network Scanner - User Manual” (R&S No. 1177.5610.02).

17.2 Usage of R&S Remote ViCom Interface

The delivery of the R&S Remote ViCom package contains a sample application, compiled as an *.apk and the related structured source code. It can be downloaded also from the R&S website:

<http://www.rohde-schwarz.com/en/software/tsma/>

The following measurement tasks are supported by the sample application:

- Scanning of GSM, UMTS and LTE
- RF Power Scan
- Wireless interface throughput tests

More details concerning the usage of the measurement tasks of the sample application can be found in chapter Example of R&S Remote ViCom Application with R&S TSMA.

It is recommended to use the Google Android Studio IDE for developing and modifying source code. (The structured source code of the sample app can be imported to this IDE). It can be downloaded from following URL:

<http://www.rohde-schwarz.com/en/software/tsma/>

The current version of Google Android Studio IDE is 1.1. The supported programming language on the Remote ViCom client is Java.

The supported operating systems for the Remote ViCom client are the following:

- Android, Version \geq 4.4.2 (API level 19)
- Windows

The source code of the sample application can be divided in an Android specific part and an R&S Remote ViCom specific part. In order to develop own applications, it is recommended to check the R&S Remote ViCom specific parts and adapt this code according to your own needs.

17.3 Example of R&S Remote ViCom Application with R&S TSMA

17.3.1 Requirements

The following requirements must be fulfilled in order to use this app successfully:

- An Android device with at least Android 4.4.2 (Android 4.4.4 is recommended)
- Possibility to establish connections via WLAN and/or Bluetooth
- R&S TSMA or a R&S TSME connected to a PC with a running version of the Remote Vicom Server

Before starting a scan or test it is necessary to make sure that a connection can be established.

17.3.1.1 Requirement for Bluetooth Connection

In order to use a Bluetooth connection, turn on the Bluetooth adapter and establish the connection with the device the server is running on.

17.3.1.2 Requirement for WLAN Connection

In order to use a WLAN connection, establish the connection to the WLAN network with the device the server is running on.

17.3.2 Connection Establishment

17.3.2.1 Connection Type Selection

In order to connect to R&S TSMA, it is either possible to use a WLAN connection or a Bluetooth connection.

The selection of the connection type depends on the measurement task.



The WLAN connection allows a throughput, which is about 10 times higher compared to Bluetooth. On the other hand, the Bluetooth connection is less influenced by interference.

- For normal LTE, UMTS or GSM measurements, the connection via Bluetooth is sufficient
- In case of higher data traffic due to more detailed measurements, a connection via WLAN is recommended.

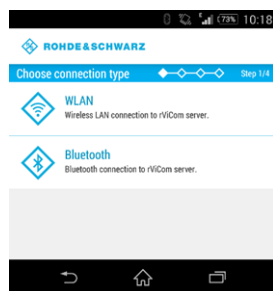


Figure 17-2: Connection Type Selection

17.3.2.2 Server Discovery

In order to connect with an existing server, the following steps must be performed.

1. Choose a connection type, as described in chapter Connection Type Selection.
2. The server discovery starts and the following dialog appears.

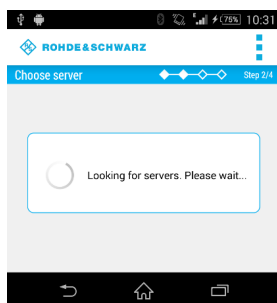


Figure 17-3: Active Server Discovery

3. If a server is found, the server will be connected and the name of the server is displayed.

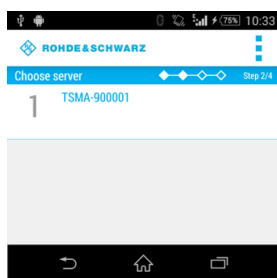


Figure 17-4: Successful Server Discovery



In order to stop the server discovery the application has to be closed.

If no server was found, it is possible to start a new scan by selecting "Rescan" in the menu inflater in the top right corner.

17.4 Task Configuration

After choosing the server by tapping on it five example tasks will appear. There are four scan tasks and one throughput task available. For further introductions on every task see the following chapters.



GSM RSSI scan: provides a GSM scan by selecting a band and radio channels



WCDMA scan: provides an UMTS scan by selecting a frequency band and the UARFCN



LTE scan: provides an LTE scan by selecting the frequency band and the EARFCN



Throughput test: provides a throughput test for the connection using configurable buffer size



RF Power Scan: provides a spectrum analysis by selecting the frequency range

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17.4.1 GSM RSSI Scan

In order to start a GSM RSSI scan, the following steps must be performed:

1. Choose a frequency band The channels will be set automatically to the maximum range available for the selected band.

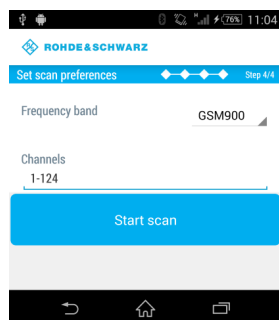


Figure 17-5: Setting the GSM Preferences

2. If necessary, change the channels manually according to your needs. The input in the "Channels" field can be done like following:
 - a) Add a single number for one specific channel, for example 7
 - b) Add a range of channels, for example 1-124
 - c) Add more than one single number separated by semicolon, for example 2,4,7,76
3. Click "Start scan" to start the scan
4. In order to stop the scan, use "Stop scan" in the menu inflator in the top right corner

The GSM scan result graph displays one column for each channel selected. The height of a column represents the RSSI value (in dBm).

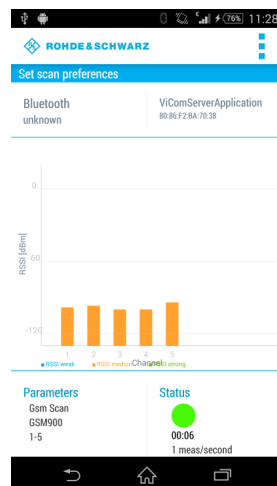


Figure 17-6: GSM Scan Result View

Following additional information is displayed:

Parameters

Displays the configured preferences for the GSM RSSI scan.

Status

Displays the measurement duration and the measurement rate. The status button displays the following colored statuses.

- Green
The measurement is running and measurement data will be received
- Yellow
The measurement is running, but no measurement data will be received
- Red
The measurement was stopped

17.4.2 WCDMA Scan

In order to start a WCDMA scan, the following steps must be performed.

1. Choose a frequency band
The minimum UARFCN of this band will be set automatically.
2. If necessary, change the UARFCN according to your needs.

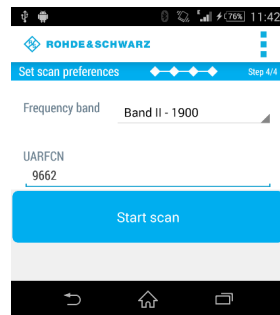


Figure 17-7: Setting the WCDMA Preferences

3. Click "Start scan" to start the scan.
4. In order to stop the scan, use "Stop scan" in the menu inflator in the top right corner.



Due to processing issues, it is not possible to select more than one UARFCN



NOTE: In the menu inflator on top of the right corner, templates for existing preferences (Munich and surrounding areas) can be selected.

The WCDMA scan result graph displays one column for each SC found by the measurement. The height of a column represents the RSCP value (in dBm).

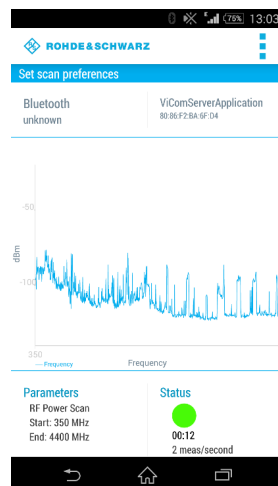


Figure 17-8: WCDMA Scan Result View

Following additional information is displayed:

Parameters

Displays the configured preferences for the WCDMA scan.

Status

Displays the measurement duration and the measurement rate. The status button displays the colored statuses previously mentioned, see [Chapter 17.4.1, "GSM RSSI Scan"](#), on page 236.

17.4.3 LTE Scan

In order to start a LTE scan, the following steps must be performed.

1. Choose a frequency band.
The minimum EARFCN of this band will be set automatically.
2. If necessary, change the EARFCN according to your needs.

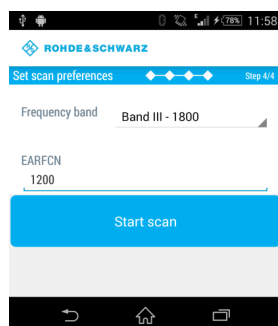


Figure 17-9: Setting the LTE Preferences

3. Click "Start scan" to start the scan.
4. In order to stop the scan, use "Stop scan" in the menu inflator in the top right corner.



Due to processing issues, it is not possible to select more than one EARFCN.



In the menu inflator on top of the right corner, templates for existing preferences (e.g. Munich and surrounding areas) can be selected.

The LTE scan result graph displays one column for each PCI found by the measurement. The height of a column represents the PBCH RSRP value (in dBm).

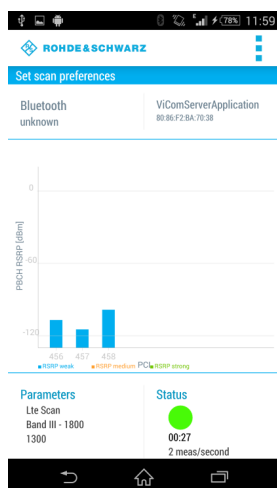


Figure 17-10: LTE Scan Result View

Following additional information is displayed.

Parameters

Displays the configured parameters for the LTE scan.

Status

Displays the measurement duration and the measurement rate. The status button displays the colored statuses previously mentioned, see [Chapter 17.4.1, "GSM RSSI Scan"](#), on page 236.

17.4.4 Throughput Test

The throughput test case is useful to find out the throughput speed of your connection. This allows to decide, which connection type (WLAN or Bluetooth) should be used.

In order to start the throughput test, the following steps must be performed.

1. Specify the parameter "Buffer size (in Byte)". The default buffer size is 20480 byte.

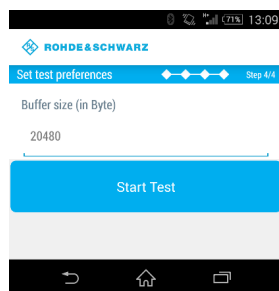


Figure 17-11: Throughput Preferences

2. Click "Start Test" to start the throughput test.

- In order to stop the scan, use "Stop scan" in the menu inflator in the top right corner.



For WLAN, the optimal buffer size varies between 950.000 byte and 1.000.000 byte.
For Bluetooth, the optimal buffer size varies between 81.000 byte and 165.000 byte.

The result of the throughput test case is a line chart with the following axes:

- x-axis The x-axis displays the number of measurements
- y-axis The y-axis displays the corresponding throughput value (kbit/s)

The blue line shows the measured values. The orange line represents the visualized average of all values.

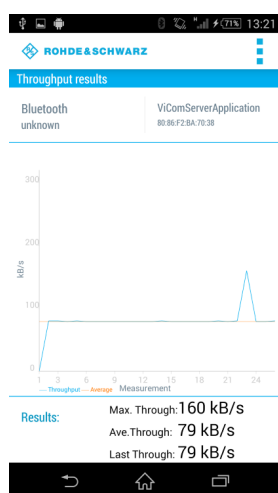


Figure 17-12: Throughput Result View

Following additional information is displayed. Results:

- Max. Through Displays the maximum throughput
- Ave. Through Displays the average throughput
- Last Through Displays the current throughput

17.4.5 RF Power Scan

In order to start an RF power scan, the following steps must be performed.

- Specify the parameters "Start Frequency (in Mhz)" and "End Frequency (in Mhz)" to define the frequency range of the RF power scan.

The maximum range is from 350 MHz to 4.400 MHz.

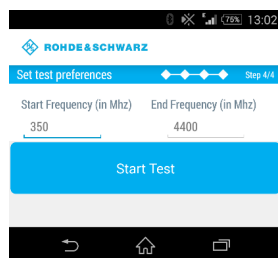


Figure 17-13: RF Power Scan Preferences

- Click "Start Test" to start the scan.

The result of the RF power scan is a spectrum of the frequency range set before with the following axes:

- x-axis
The x-axis displays the frequency
- y-axis
The y-axis displays the power level for each frequency (dBm)

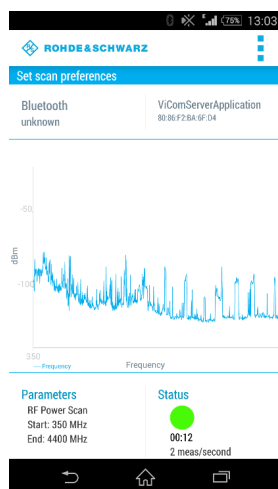


Figure 17-14: RF Power Scan Results

Following additional information is displayed:

Parameters

- Start
Displays the start frequency
- End
Displays the end frequency

Status

Displays the measurement duration and the measurement rate. The status button displays the colored statuses previously mentioned, see [Chapter 17.4.1, "GSM RSSI Scan"](#), on page 236.

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18.1 R&S TSMx Family Option Handling

With the TsmxOptionKeyInstaller utility, it is possible to check the IEEE1394 connection and check the instrument data set. Additionally, the program displays all the enabled options for a certain instrument and can be used to install new options. The instrument specific Device Identification file can be read out.

This tool can be started from the Windows "Start" menu:

"R&SViCom > ViCom <version> > Tools > TsmxOptionKeyInstaller"

If the log messages of the OptionKeyInstaller show that a connected R&S TSMx Family instrument has been found, this means that the IEEE1394 connection is working, and that the R&S ROMES demo or the test application can be run. The OptionKeyInstaller utility can also be used to recall instrument data, to verify the installed options and to install new options if required.

When you are satisfied that the IEEE1394 connection is working, disconnect the OptionKeyInstaller from the R&S TSMx Family model and close the utility.

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18.1.1 Prerequisites

- PC and an R&S TSMx Family instrument connected via IEEE1394
- PC and an R&S TSMx Family instrument connected via a serial null-modem cable
- R&S proprietary IEEE1394 driver installed on the PC
- Terminal program started
- No other instrument interfacing the R&S TSMx Family instrument.

18.1.2 Program Start

To use this program, reset the R&S TSMx Family instrument and wait for the terminal output "Waiting for elf file from IEEE1394".

Start the TsmxOptionKeyInstaller utility by executing the TsmxOptionKeyInstaller.exe in the program's directory C:\RuS\ViCom_<version>\tools\TSMx\OptionKeyInstaller. After establishing the connection, a dialog similar to the one shown in the following figure comes up.

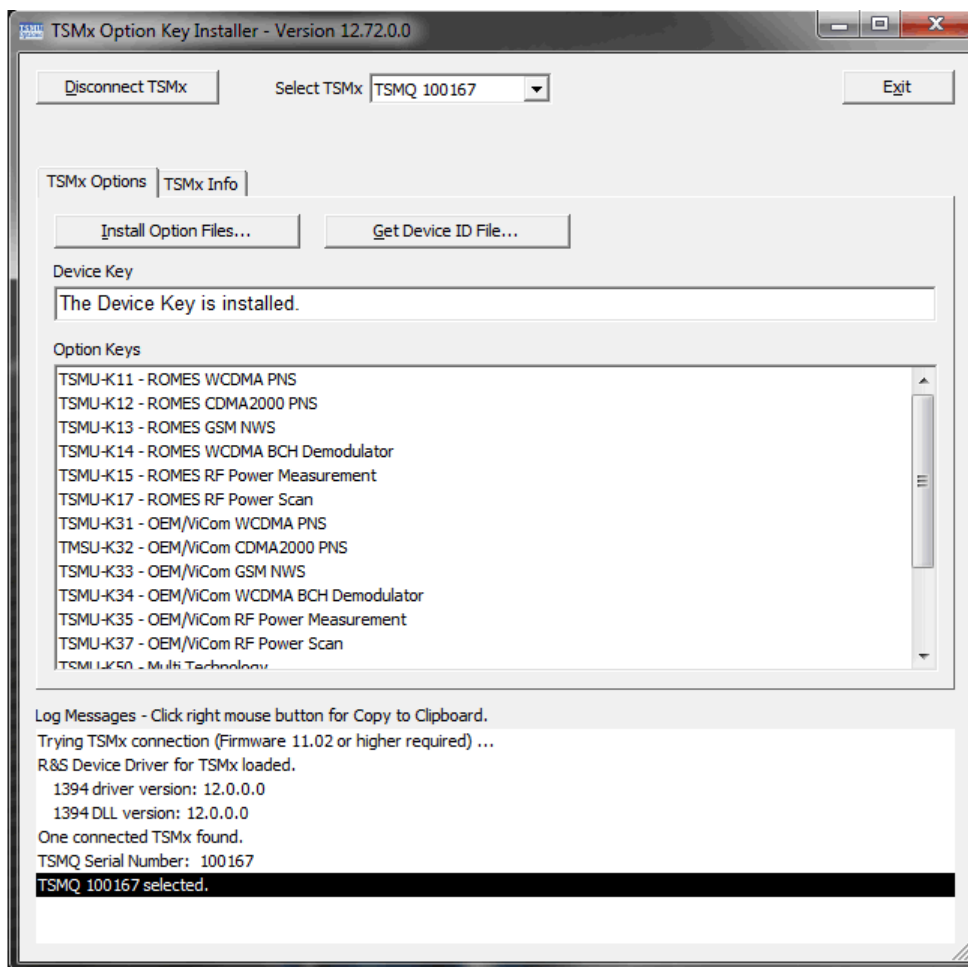


Figure 18-1: TSMx Option Key Installer Dialog

18.1.3 Display Contents of the R&S TSMx Family Info Tab

The following information can be read out from the "TSMx Info" tab:

Hardware

- Instrument type
 - R&S TSMU, VAR 02
 - R&S TSMU-H, VAR 03
 - R&S TSML-x, x has to be identical with the label at the rear panel!

- Input Power type of input stage
Normal: standard input power (R&S TSMU, R&S TSML-x)
High: extended input power (R&S TSMU-H)
- JTAG Devices
ACE V2Pro: 1st Controller Board version
ACE V2Pro Counter: 2nd Controller Board version (with CPLD)
- IEEE1394 Chip Rev.: Revision of the OHCI1394 chip version has to be $\geq 0x61$

Serial Numbers

Programmed serial numbers in the EEPROM and in the flash card.

The following two serial numbers should be identical:

- TSMx (Flash): R&S TSMU serial number that is stored on the flash card
- TSMx (EPROM): R&S TSMU serial number that is programmed in the EEPROM

The following two serial numbers should be identical (but not necessarily the same as the R&S TSMU serial number above!):

- Receiver (Flash): Front-End serial number that is stored on the flash card
- Receiver (EPROM): Front-End serial number programmed in the Front-End EEPROM

Firmware

- Virtex2Pro version of the FPGA configuration data and boot code e.g. H01V10B0
H01: 2nd Hardware version Controller Board
(H00: 1st Hardware Version Controller Board
V10: Firmware version 10
B0: Beta state 0)
- Application version and file data of the TxmsOptionKeyInstaller utility application file *.elf
- Firewire Loader: version and file length of the Firewire Loader program
- Flash Loader: version and file length of the Flash Loader program file

Calibration

- Level: Level calibration file over the full input frequency range of the R&S TSMx
- IF-Filter: IF-Filter calibration file over the full input frequency range of the R&S TSMx
- WCDMA 3GPP: Derived calibration data set of the IF-Filter (only for WCDMA 3GPP measurements)

Level- and IF-Filter files are created during calibration process. The WCDMA 3GPP IF-Filter correction file is stored when the UMTS PN Scanner Application is started for the first time after calibration.

18.1.4 Display Contents of the R&S TSMx Family Options Tab

The "Available Options" list box in the "R&S TSMx Options" tab gives an overview of all the enabled options for a particular instrument.

The "Installed Option Keys" list box displays all the installed OptionKeys and the expiry date of time limited keys.

If that list is empty and the program indicates "No device key has been found" (circled in red in following figure) all the available options are enabled with application file coding.



Instruments without installed device key require the installation of option keys!

Installed option files for measuring in different technologies, using different R&S TSMx Family instruments, should be as follows:

Phylis modules	R&S TSML-W	R&S TSMU
W-CDMA 3GPP measuring without BCH Demodulator:		
ViComWCDMA.dll	11	31 (locked)
W-CDMA 3GPP measuring with BCH Demodulator:		
ViComWCDMA.dll UmtsDemodulator.dll	11, 14	31, 34 (locked)
CDMA2000 measuring:		
ViComCdma.dll	12	32 (locked)
GSM Network Scanner measuring:		
ViComGsm.dll	13	33 (locked)

Program Exit

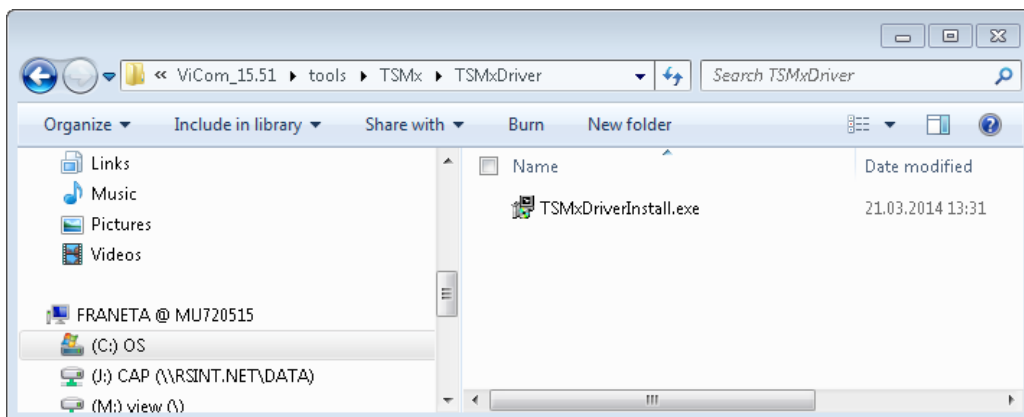
The "Disconnect TSMx" button of the TsmxOptionKeyInstaller utility can be used to stop the connection with the connected instrument(s). This will initialize every connected R&S TSMx Family instrument to reboot.

Afterwards, press "Exit" to quit the program or "Connect TSMx" to connect the instruments again.

18.1.5 Installing the R&S TSMx Family Windows Driver Manually

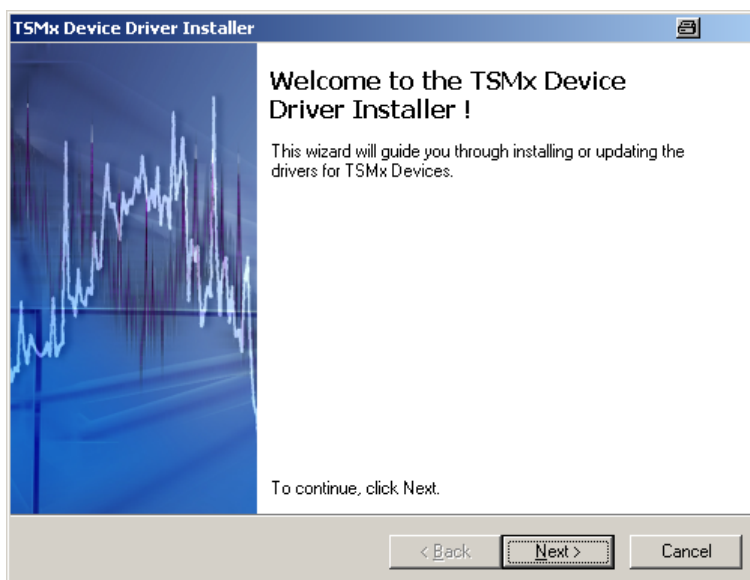
You need to install the Windows driver manually, before a connection to an R&S TSMx Family instrument can be made.

If the ViCom exe installer file was run onto your C:\ drive, the executable TSMXDriverInstall.exe will be found in the following location:



Double-click the executable `TSMxDriverInstall.exe` file.

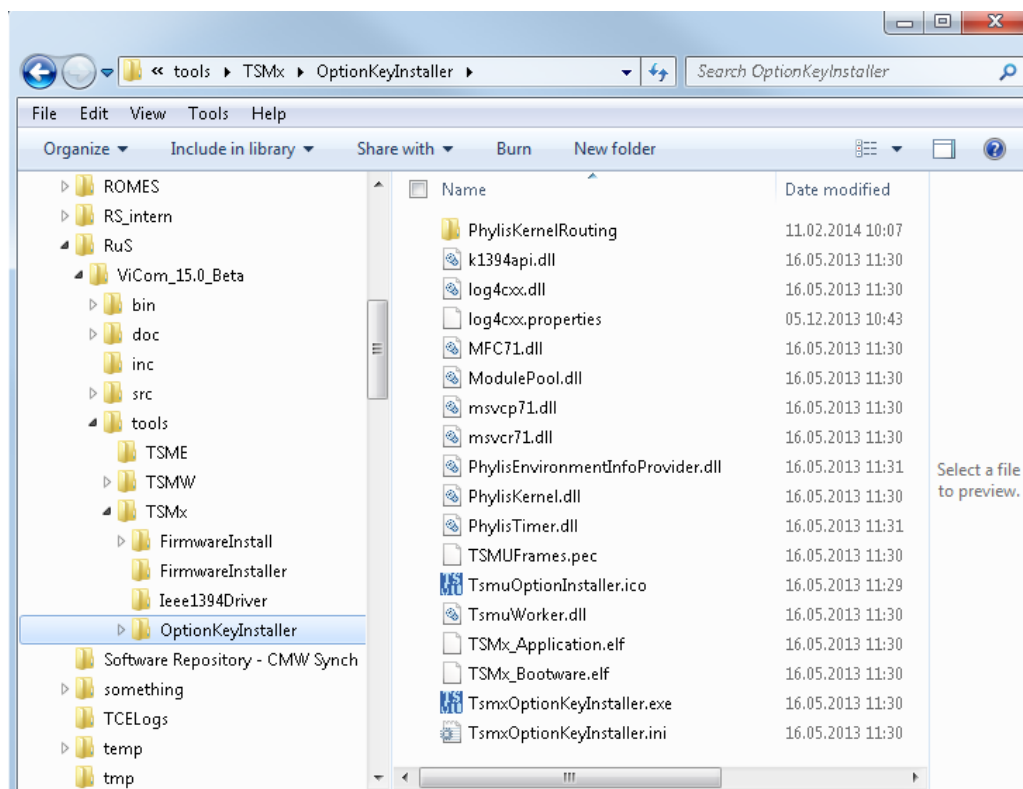
After a short pause, the following splash screen appears.



Follow the instructions in the dialogue box; make sure that no application is using an R&S TSMx Family instrument and that the Device Manager is not displaying R&S TSMx Family instrument's property pages.

Click "Next" to start installing the device driver, and follow the instructions in the install wizard.

When the driver is installed, the FireWire connection to the R&S TSMx Family instrument may be checked with the OptionKeyInstaller utility supplied by the exe installer. The OptionKeyInstaller may be found in the following location
`C:\RuS\ViCom_<version>\tools\TSMx.`



Instructions for using TsmxOptionKeyInstaller are given in [R&S TSMx Family Option Handling](#). If the log messages of the OptionKeyInstaller show that a connected R&S TSMx Family instrument has been found, this means that the IEEE1394 connection is working, and that the test application can be run. The OptionKeyInstaller utility can also be used to recall instrument data, to verify the installed options and to install new options if required.

When you are satisfied that the IEEE1394 connection is working, disconnect the OptionKeyInstaller from the R&S TSMx Family instrument and close the utility.

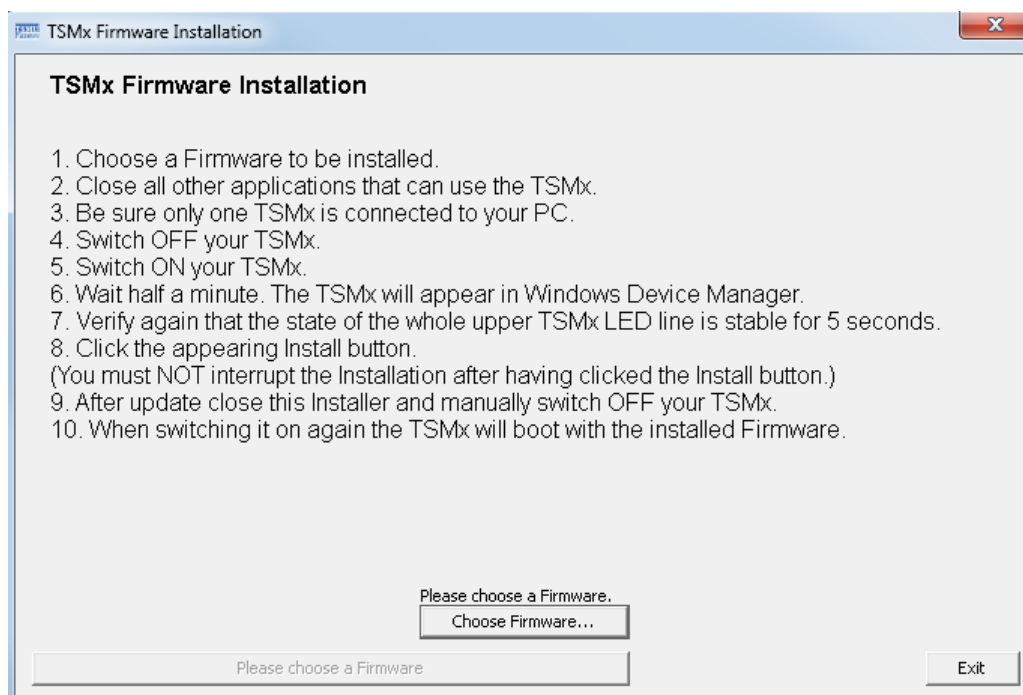
18.1.6 R&S TSMx Family Firmware Upgrade

For some special functions, a new firmware must be installed on the R&S TSMx Family instrument. A special tool called `TsmxFirmwareInstall.exe` can be used, location `C:\RuS\ViCom_<version>\tools\TSMx\FirmwareInstaller`.



If you do a firmware installation, make sure to follow ALL listed steps in this manual CAREFULLY. If you miss any single detail, this might cause the firmware installation to fail and leave an unusable device up to you.

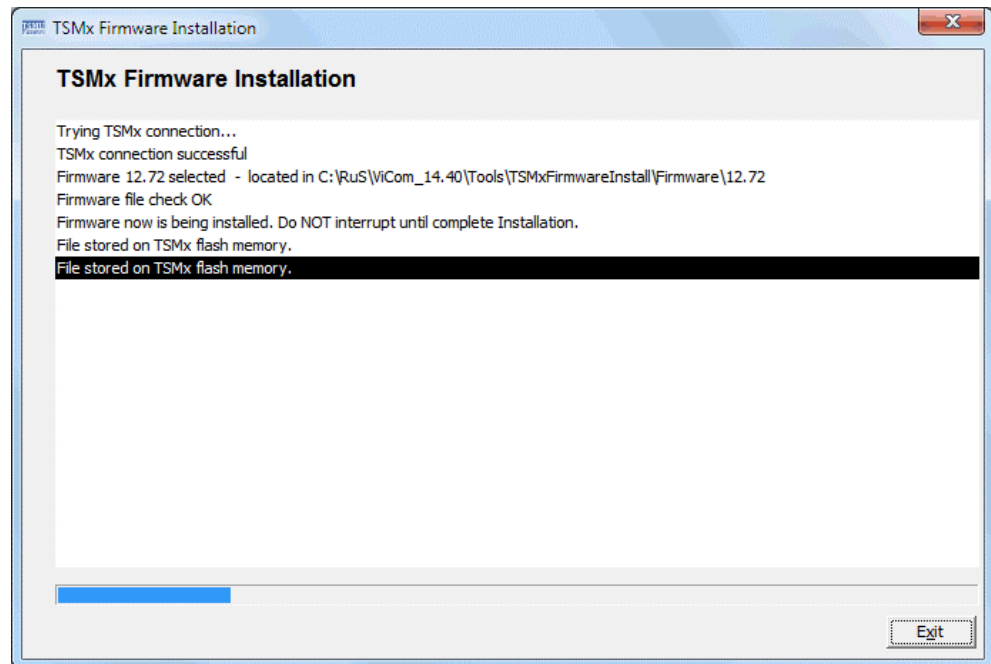
After you started the tool, a window appears as shown in the following figure:



To perform the installation:

1. Click the button "Choose Firmware" to choose the firmware that shall be installed.
A drop-down menu opens and lists all the available firmware versions. These are extracted from the Firmware subfolder that can be found in the application path.
2. Select the appropriate version marked with a pale blue rectangular.
The dimmed "Please choose a Firmware" button turns into the active button showing the selected firmware version.
3. Close all other applications that might use R&S TSMx Family instrument. These are the sample applications, the option installer tool and your own R&S TSMx Family-related applications.
4. Check if only one R&S TSMx Family instrument is connected to the PC. The tool does not check how many instances of R&S TSMx Family instrument are connected with each other and the PC. Since the data is transferred on the FireWire connection without a specific destination, the behavior is undefined, if multiple devices are connected to the PC during installation.
5. Switch R&S TSMx Family instrument off and on.
6. Wait about 30 seconds until the R&S TSMx Family instrument's LEDs stopped blinking. After that time, the LEDs should not blink at all or show a constant behavior for at least 5 seconds. If the Process/State LED keeps blinking, the silent mode of the RS232 API might still be turned on. In that case, a firmware update can be started.

- Press the installation button showing the selected firmware version. A progress view window is shown.



- When the installation is finished, reboot your R&S TSMx Family instrument manually to really apply the update to all parts of the software.



It is essential to reboot the R&S TSMx Family instrument after the firmware upgrade. Otherwise some new functionality might not work correctly.

18.2 R&S TSMW Configuration

The R&S TSMW does not come with a desktop utility to install software options on the device or to perform firmware updates. It offers a configuration web page similar to the configuration tools of DSL routers, for example. That page can be found when entering the IP address of the device into the address bar of a web browser (192.168.0.2 is the default address).

In the following sections, a short overview of the functionality and information offered within that web page is described. This must be seen as a quick reference on these topics. For a more decent description of these issues, the "R&S TSMW User Manual" must be consulted (see References [3]).

- [System Information](#)..... 251
- [Option Handling](#)..... 251
- [Firmware Update](#).....253

18.2.1 System Information

If the web page can be opened, it should look similar to the one depicted below. There are several basic information, like the software version numbers and the current IP configuration, shown on the first page.



Within that page, the IP address can be changed. Please be aware that changing the IP address might require additional changes on the host PC resp. might also disable the possibility to connect to the R&S TSMW at all (if the IP address is always in use, for example).

The screenshot shows a web browser window displaying the R&S TSMW configuration page. The page title is "R&S® TSMW 1503.3001K02/100009". The main content area is divided into several sections:

- R&S® TSMW 1503.3001K02**
Serialnumber: 100009
- System Configuration**
 - MAC Address: 9E:8F:19:B8:90:00
 - Calibration Version: 01.01
 - Calibration Read Code: 0102
 - Calibration Date: 2009-08-18
- Firmware Configuration**
 - Firmware Version: 01.07 Beta 13
 - Software Version: 01.03.06.00
 - FPGA Version: 00.00.00.00
 - PCB Version: 03
- Hardware Configuration**
 - Hardware Code: 000
 - Change Index: 01.05
 - Production Date: 2008-08-01
- Network Configuration**
 - IP Address: 192.168.0.2
 - IP Netmask: 255.255.255.0 (currently active)
 - Input fields: 192.168.0.2 and 255.255.255.0
 - Button: Change IP Setting

Below the network configuration, there is a warning: "Please carefully verify IP address und netmask settings in the corresponding input fields before pressing "Change IP Setting"!!! IP address and netmask settings of the host PC LAN adapter potentially need to be adapted in order to reconnect with the R&S® TSMW successfully."

18.2.2 Option Handling

The options currently installed on the R&S TSMW are listed in the "Active Optionkeys" section of the page. An additional section lists the options that were once active but have been disabled in the meantime.

Active Optionkeys

Option Index	Option Type	Material Number	Optionkey	Format Privilege	Timestamp	License Count	Activation Type	Valid From	Valid To	Time To Expiration
1	TSMW- K1	1503.3960.02	136969178412034997631573236926	0	Customer Order 2008-07-03 06:30	1	Permanent	-	-	-
21	TSMW- K21	1503.4514.02	356866547527413676630206567647	0	Customer Order 2009-07-29 06:18	1	Permanent	-	-	-
22	TSMW- K22	1503.4520.02	205947346541342637510377498559	0	Customer Order 2009-07-29 06:18	1	Permanent	-	-	-
26	TSMW- K26	1510.8792.02	016053306928060559851401349648	0	Customer Order 2009-07-29 06:18	1	Permanent	-	-	-
27	TSMW- K27	1503.4537.02	22682678911988685561107045374	0	Customer Order 2009-10-20 09:26	1	Permanent	-	-	-
28	TSMW- K28	1503.4543.02	258331664939731883060795245924	0	Customer Order 2008-07-17 07:52	1	Permanent	-	-	-
29	TSMW- K29	1503.4550.02	015430682406919203092337151146	0	Customer Order 2009-03-18 06:42	1	Permanent	-	-	-
121	TSMW- K121	1503.4589.02	311757375413324347150953894928	0	Customer Order 2009-07-29 06:18	1	Permanent	-	-	-
122	TSMW- K122	1503.4595.02	245543933616086293802786216943	0	Customer Order 2009-07-29 06:18	1	Permanent	-	-	-
126	TSMW- K126	1503.4789.02	159963900903968861720640471947	0	Customer Order 2009-07-29 06:18	1	Permanent	-	-	-
127	TSMW- K127	1503.4614.02	254181590639533920572822368360	0	Customer Order 2009-10-20 09:26	1	Permanent	-	-	-
128	TSMW- K128	1503.4566.02	295036083233863879230626211017	0	Customer Order 2008-07-17 07:52	1	Permanent	-	-	-
129	TSMW- K129	1503.4572.02	397169887811946762342241135434	0	Customer Order 2009-03-18 06:42	1	Permanent	-	-	-
221	TSMW- K221	1503.4795.02	084823431638520694222366864086	0	Customer Order 2009-07-29 06:18	1	Permanent	-	-	-
222	TSMW- K222	1503.4808.02	053019402304397846903845663196	0	Customer Order 2009-07-29 06:18	1	Permanent	-	-	-

Inactive Optionkeys

Option Index	Option Type	Material Number	Optionkey	Format Privilege	Timestamp	License Count	Activation Type	Valid From	Valid To	Invalidity Reason
0	TSMW- K0	1514.4327.02	380469971912113853701473899089	0	Demo 2010-02-24 14:12	1	Temporary Date	2010-02-24	2011-02-24	not yet in activation phase

New options can be installed when either an option file or an option key is available. This can be done in the "Install Option Key" section shown in the following figure.

Install Option Key

xml-file

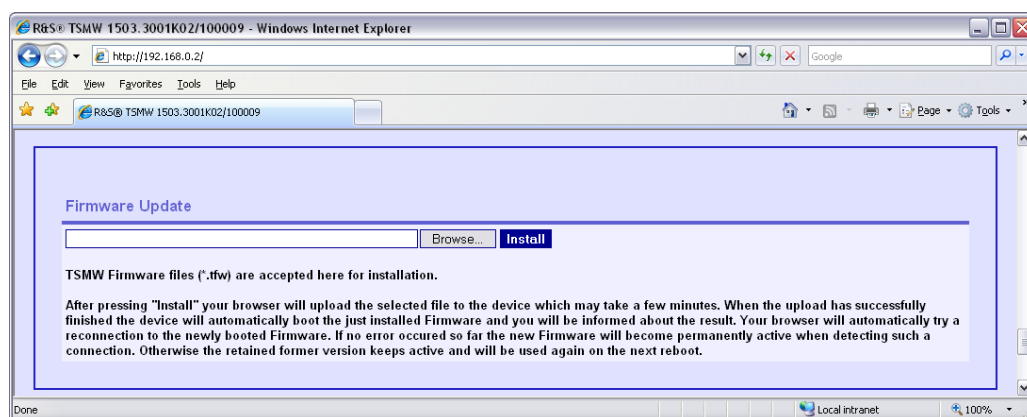
enter manually

R&S® TSMW option order(s) are shipped as *.xml files on a CD-ROM. For option installation, insert the CD-ROM into the computer drive, press the "Browse" button, select the corresponding option file on the CD-ROM and press "Install". Alternatively to xml-file input, the option key could be entered manually.

After finishing installation this page is being updated automatically and the added option should be listed in the instrument options section.

18.2.3 Firmware Update

The R&S TSMW firmware can be updated using the same HTML page where the options can be queried. The "Browse" button in the section "Firmware Update" can be used to search for the firmware file containing the new firmware code. Once the path to the file is visible in the text field, the "Install" button can be used to start the update of the R&S TSMW firmware.



Always install the latest available firmware version; use the <https://www.rohde-schwarz.com/en/software/tsmw/> link.

18.3 R&S TSME Configuration

After installing the R&S ViCom on a PC, the C:\RuS\ViCom_<version>\doc directory contains the TSME user manual (TSME User Manual.pdf). The manual describes how to obtain information (e.g. version number) about the device, how to install options and how to configure measurement bands.



Always install the latest available installer version; use the <https://www.rohde-schwarz.com/en/software/tsma/> link.

18.4 Frequently Asked Questions

- ? Does the ViCom system take advantage of multi-core PC architecture?
- ! Yes, ViCom is designed internally to use multiple threads for different measurement tasks, so more CPUs result in a "more parallel" execution of the measurement processing algorithms.
- ? When I run the sample application, it asks for dlls that are not listed in Section 2 of this document, and are not present on the CD-ROM
- ! Check that all dlls in the Application sub-directory are writeable as well as readable (Read Only box of the Properties is not checked).

- ? When I click “Load PNS Scanner” in the sample program, I get an error message “The interface version of the ViCom library and the interface header file does not match.”
- ! The interface version corresponds to the last part of the file version string of the ViCom interface dll, named ViComXXXX.dll, where XXXX specifies the interface type. For example, if the file version of the interface dll, ViComWCDMA3GppPns.dll is 10.70.0.18 then the interface version of the DLL is 18. The interface version of the DLL has to match the interface version that is defined in the corresponding ViCom header files. If the version does not match then the interface loader will fail and will produce a ViCom Error. In this case, please contact Rohde & Schwarz Technical Support.
- You can view the version of the interface dll by right clicking on the dll in Windows Explorer, choosing Properties, and the Version tab.
- ? When I click “Start Measurement” in the RS232 application, I get the message " Hardware: Selected R&S TSMx does not support desired measurement." What is wrong here?
- ! The firmware version does not support the RS232 application. Please make sure to have a firmware version of 12.x.x.x or higher installed on the R&S TSMx device. Refer to the firmware installation section to update your device.
- ? Why do I always get a message “Connection lost” when I try to debug the ViCom sample application or my own ViCom using programs?
- ! The communication between the device and the internal processing modules assumes to have very little timeouts. When the processing of an application is paused (for example, because a breakpoint is hit in the debugger), chances are high that the timeout is reached before execution is continued. Use the “TsmuWorkerDebugSettings.reg” file in the LogFiles to increase the timeout and leverage that effect in your debug environment.
- Please be aware that this also changes the behavior in released versions, so be sure to disable that setting again when doing tests in the release version. Refer to chapter Debugging Techniques.

18.5 Technical Notes

18.5.1 UMTS Technical Notes

Channels

The relationship between UMTS UARFCNs (UTRA Absolute Radio Frequency Channel Numbers) N and carrier frequencies F is defined in Reference 6, Section 5.

From Reference 6, UARFCN is calculated according to the following formula:

$$N = 5 * (F - F_{\text{Offset}}),$$

The frequency offset F_{Offset} is defined in Reference 6 for each UMTS band, as well as for the extra frequencies assigned in Band II.

The downlink and uplink channels assigned in the operating Bands I, II and III are listed in the tables below. Note in operating band II, the 12 additional centre frequencies that are specified, shifted by 100 kHz relative to the normal raster. The uplink and downlink channels assigned in the operating Bands I, II and III are listed in the following tables. Note that in operating Band II, 12 additional center frequencies are specified. These additional channels are shifted by 100 kHz relative to the normal raster and not calculated according to the previously given formula.

Table 18-1: UTRA operating bands and channel numbers: Uplink

Operating Band	UL Frequency Band	Frequency offset FOffset	Assigned Channels	Assigned Center Frequencies
I	1920 MHz to 1980 MHz	0	9612 to 9888	1922.4 MHz to 1977.6 MHz in steps of 0.2 MHz
II	1850 MHz to 1910 MHz	0	9262 to 9538	1852.4 MHz to 1907.6 MHz in steps of 0.2 MHz
Extra uplink channels of Band II	as for Band II.	1850.1	12, 37, 62, 87, 112, 137, 162, 187, 212, 237, 262, 287	1852.5, 1857.5, 1862.5, 1867.5, 1872.5, 1877.5, 1882.5, 1887.5, 1892.5, 1897.5, 1902.5, 1907.5
III	1710 MHz to 1785 MHz	1525	937 to 1288	1712.4 MHz to 1782.6 MHz, in steps of 0.2 MHz.

Table 18-2: UTRA operating bands and channel numbers: Downlink

Operating Band	DL Frequency Band	Frequency offset FOffset	Assigned Channels	Assigned Center Frequencies
I	2110 MHz to 2170 MHz	0	10562 to 10838	2112.4 MHz to 2167.6 MHz in steps of 0.2 MHz
II	1930 MHz to 1990 MHz	0	9662 to 9938	1932.4 MHz to 1987.6 MHz, in steps of 0.2 MHz
Extra downlink channels of Band II	as for Band II	1850.1	412, 437, 462, 487, 512, 537, 562, 587, 612, 637, 662, 687	1932.5, 1937.5, 1942.5, 1947.5, 1952.5, 1957.5, 1962.5, 1967.5, 1972.5, 1977.5, 1982.5, 1987.5
III	1805 MHz to 1880 MHz	1575	1162 to 1513	1807.4 MHz to 1877.6 MHz in steps of 0.2 MHz

UMTS System Information Blocks

UMTS System Information Blocks (SIBs) are emitted on the Broadcast Channel (BCH). They contain information that is likely to be relevant to any phone in the cell. SIBs and their contents are defined in References [6], the 3GPP RRC protocol specification. The table below shows a summary.

The corresponding PDU column refers to the ViCom interface parameter used to specify which SIB(s) are to be demodulated by the BCH demodulator of the R&S TSML-W. See also Section 6 “SChannelPDUPair” above.

Table 18-3: UMTS SIB numbers and corresponding PDUs

SIB Number	Contents	Reference in 3GPP TS 25.133v5.x.x	Corresponding PDU
3	NAS system information. UE timers and counters.	10.2.48.8.4	15
3	URA Identity	10.2.48.8.5	16
3	Parameters needed for cell selection and reselection, including the identity of the current cell.	10.2.48.8.6	17
4	Parameters needed for cell selection and reselection when in connected mode.	10.2.48.8.7	18
5	Parameters for the configuration of the common physical channels in the cell.	10.2.48.8.8	19
6	Parameters for the configuration of the common and shared physical channels to be used in connected mode.	10.2.48.8.9	20
7	Two fast changing parameters; UL interference and Dynamic persistence level.	10.2.48.8.10	21
8	not defined		22
9	not defined		23
10	not defined		24
11	Measurement control information for the cell that is broadcasting the SIB.	10.2.48.8.14	25
12	Measurement control information to be used in connected mode.	10.2.48.8.15	26
13	ANSI-41 system information	10.2.48.8.16	27
13.1	ANSI-41 RAND information.	10.2.48.8.16.1	28
13.2	ANSI-41 User Zone Identification information.	10.2.48.8.16.2	29
13.3	ANSI-41 Private Neighbour List information.	10.2.48.8.16.3	30
13.4	ANSI-41 Global Service Redirection information.	10.2.48.8.16.4	31

SIB Number	Contents	Reference in 3GPP TS 25.133v5.x.x	Corresponding PDU
14	Parameters for common and dedicated physical channel uplink outer loop power control information to be used in both idle and connected mode.	10.2.48.8.17	32
SIB Number	Contents	Reference in 3GPP TS 25.133v5.x.x	Corresponding PDU
15	Assistance information for UE-based or UE-assisted positioning methods	10.2.48.8.18	33
15.1	Assistance data for Differential GPS measurements.	10.2.48.8.18.1	34
15.2	Assistance data for A-GPS measurements	10.2.48.8.18.2	35
15.3	Assistance data for A-GPS measurements.	10.2.48.8.18.3	36
15.4	Ciphering information and assistance data for OTDOA positioning.	10.2.48.8.18.4	37
15.5	Assistance data for OTDOA positioning.	10.2.48.8.18.5	38
16	Radio bearer, transport channel and physical channel parameters to be stored by UE in idle and connected mode for use during inter-system handovers.	10.2.48.8.19	39
17	fast changing parameters for the configuration of the shared physical channels to be used in connected mode (UMTS TDD systems only).	10.2.48.8.20	40
18	PLMN identities of neighbouring cells, used in idle mode as well as in connected mode.	10.2.48.8.21	41

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