Quick Start Guide

Vector Network Analyzer

R&S® ZVT8

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ROHDE&SCHWARZ
Test and Measurement Division

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This product includes software developed by the OpenSSL Project for use in the OpenSSL Toolkit (http://www.openssl.org).

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Glossary of Terms

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

Safety Instructions

Rohde & Schwarz makes every effort to keep the safety standard of its products up to date and to offer its customers the highest possible degree of safety. Our products and the auxiliary equipment required for them are designed and tested in accordance with the relevant safety standards. Compliance with these standards is continuously monitored by our quality assurance system. This product has been designed and tested in accordance with the EC Certificate of Conformity and has left the manufacturer's plant in a condition fully complying with safety standards. To maintain this condition and to ensure safe operation, observe all instructions and warnings provided in this manual. If you have any questions regarding these safety instructions, Rohde & Schwarz will be happy to answer them.

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

The product is used for its designated purpose if it is used in accordance with its operating manual and within its performance limits (see data sheet, documentation, the following safety instructions). Using the products requires technical skills and knowledge of English. It is therefore essential that the products be used exclusively by skilled and specialized staff or thoroughly trained personnel with the required skills. If personal safety gear is required for using Rohde & Schwarz products, this will be indicated at the appropriate place in the product documentation.

Symbols and safety labels

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

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

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

Tags and their meaning

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

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

Basic safety instructions

1. The product may be operated only under the operating conditions and in the positions specified by the manufacturer. Its ventilation must not be obstructed during operation. Unless otherwise specified, the following requirements apply to Rohde & Schwarz products: prescribed operating position is always with the housing floor facing down, IP protection 2X, pollution severity 2, overvoltage category 2, use only in enclosed spaces, max. operation altitude max. 2000 m. Unless specified otherwise in the data sheet, a tolerance of ±10% shall apply to the nominal voltage and of ±5% to the nominal frequency.
2. Applicable local or national safety regulations and rules for the prevention of accidents must be observed in all work performed. The product may be opened only by authorized, specially trained personnel. Prior to performing any work on the product or opening the product, the product must be disconnected from the supply network. Any adjustments, replacements of parts, maintenance or repair must be carried out only by technical personnel authorized by Rohde & Schwarz. Only original parts may be used for replacing parts relevant to safety (e.g. power switches, power transformers, fuses). A safety test must always be performed after parts relevant to safety have been replaced (visual inspection, PE conductor test, insulation resistance measurement, leakage current measurement, functional test).
3. As with all industrially manufactured goods, the use of substances that induce an allergic reaction (allergens, e.g. nickel) such as aluminum cannot be generally excluded. If you develop an allergic reaction (such as a skin rash, frequent sneezing, red eyes or respiratory difficulties), consult a physician immediately to determine the cause.

4. If products/components are mechanically and/or thermically processed in a manner that goes beyond their intended use, hazardous substances (heavy-metal dust such as lead, beryllium, nickel) may be released. For this reason, the product may only be disassembled, e.g. for disposal purposes, by specially trained personnel. Improper disassembly may be hazardous to your health. National waste disposal regulations must be observed.
5. If handling the product yields hazardous substances or fuels that must be disposed of in a special way, e.g. coolants or engine oils that must be replenished regularly, the safety instructions of the manufacturer of the hazardous substances or fuels and the applicable regional waste disposal regulations must be observed. Also observe the relevant safety instructions in the product documentation.
6. Depending on the function, certain products such as RF radio equipment can produce an elevated level of electromagnetic radiation. Considering that unborn life requires increased protection, pregnant women should be protected by appropriate measures. Persons with pacemakers may also be endangered by electromagnetic radiation. The employer is required to assess workplaces where there is a special risk of exposure to radiation and, if necessary, take measures to avert the danger.
7. Operating the products requires special training and intense concentration. Make certain that persons who use the products are physically, mentally and emotionally fit enough to handle operating the products; otherwise injuries or material damage may occur. It is the responsibility of the employer to select suitable personnel for operating the products.
8. Prior to switching on the product, it must be ensured that the nominal voltage setting on the product matches the nominal voltage of the AC supply network. If a different voltage is to be set, the power fuse of the product may have to be changed accordingly.
9. In the case of products of safety class I with movable power cord and connector, operation is permitted only on sockets with earthing contact and protective earth connection.
10. Intentionally breaking the protective earth connection either in the feed line or in the product itself is not permitted. Doing so can result in the danger of an electric shock from the product. If extension cords or connector strips are implemented, they must be checked on a regular basis to ensure that they are safe to use.
11. If the product has no power switch for disconnection from the AC supply, the plug of the connecting cable is regarded as the disconnecting device. In such cases, it must be ensured that the power plug is easily reachable and accessible at all times (length of connecting cable approx. 2 m). Functional or electronic switches are not suitable for providing disconnection from the AC supply. If products without power switches are integrated in racks or systems, a disconnecting device must be provided at the system level.
12. Never use the product if the power cable is damaged. By taking appropriate safety measures and carefully laying the power cable, ensure that the cable cannot be damaged and that no one can be hurt by e.g. tripping over the cable or suffering an electric shock.
13. The product may be operated only from TN/TT supply networks fused with max. 16 A.
14. Do not insert the plug into sockets that are dusty or dirty. Insert the plug firmly and all the way into the socket. Otherwise this can result in sparks, fire and/or injuries.
15. Do not overload any sockets, extension cords or connector strips; doing so can cause fire or electric shocks.
16. For measurements in circuits with voltages V_{rms} > 30 V, suitable measures (e.g. appropriate measuring equipment, fusing, current limiting, electrical separation, insulation) should be taken to avoid any hazards.
17. Ensure that the connections with information technology equipment comply with IEC 950/EN 60950.
18. Never remove the cover or part of the housing while you are operating the product. This will expose circuits and components and can lead to injuries, fire or damage to the product.

19. If a product is to be permanently installed, the connection between the PE terminal on site and the product's PE conductor must be made first before any other connection is made. The product may be installed and connected only by a skilled electrician.
20. For permanently installed equipment without built-in fuses, circuit breakers or similar protective devices, the supply circuit must be fused in such a way that suitable protection is provided for users and products.
21. Do not insert any objects into the openings in the housing that are not designed for this purpose. Never pour any liquids onto or into the housing. This can cause short circuits inside the product and/or electric shocks, fire or injuries.
22. Use suitable overvoltage protection to ensure that no overvoltage (such as that caused by a thunderstorm) can reach the product. Otherwise the operating personnel will be endangered by electric shocks.
23. Rohde & Schwarz products are not protected against penetration of water, unless otherwise specified (see also safety instruction 1.). If this is not taken into account, there exists the danger of electric shock or damage to the product, which can also lead to personal injury.
24. Never use the product under conditions in which condensation has formed or can form in or on the product, e.g. if the product was moved from a cold to a warm environment.
25. Do not close any slots or openings on the product, since they are necessary for ventilation and prevent the product from overheating. Do not place the product on soft surfaces such as sofas or rugs or inside a closed housing, unless this is well ventilated.
26. Do not place the product on heat-generating devices such as radiators or fan heaters. The temperature of the environment must not exceed the maximum temperature specified in the data sheet.
27. Batteries and storage batteries must not be exposed to high temperatures or fire. Keep batteries and storage batteries away from children. If batteries or storage batteries are improperly replaced, this can cause an explosion (warning: lithium cells). Replace the battery or storage battery only with the matching Rohde & Schwarz type (see spare parts list). Batteries and storage batteries are hazardous waste. Dispose of them only in specially marked containers. Observe local regulations regarding waste disposal. Do not short-circuit batteries or storage batteries.
28. Please be aware that in the event of a fire, toxic substances (gases, liquids etc.) that may be hazardous to your health may escape from the product.
29. Please be aware of the weight of the product. Be careful when moving it; otherwise you may injure your back or other parts of your body.
30. Do not place the product on surfaces, vehicles, cabinets or tables that for reasons of weight or stability are unsuitable for this purpose. Always follow the manufacturer's installation instructions when installing the product and fastening it to objects or structures (e.g. walls and shelves).
31. Handles on the products are designed exclusively for personnel to hold or carry the product. It is therefore not permissible to use handles for fastening the product to or on means of transport such as cranes, fork lifts, wagons, etc. The user is responsible for securely fastening the products to or on the means of transport and for observing the safety regulations of the manufacturer of the means of transport. Noncompliance can result in personal injury or material damage.
32. If you use the product in a vehicle, it is the sole responsibility of the driver to drive the vehicle safely. Adequately secure the product in the vehicle to prevent injuries or other damage in the event of an accident. Never use the product in a moving vehicle if doing so could distract the driver of the vehicle. The driver is always responsible for the safety of the vehicle; the manufacturer assumes no responsibility for accidents or collisions.
33. If a laser product (e.g. a CD/DVD drive) is integrated in a Rohde & Schwarz product, do not use any other settings or functions than those described in the documentation. Otherwise this may be hazardous to your health, since the laser beam can cause irreversible damage to your eyes. Never try to take such products apart, and never look into the laser beam.

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

Informaciones de seguridad

Es el principio de Rohde & Schwarz de tener a sus productos siempre al día con los estandards de seguridad y de ofrecer a sus clientes el máximo grado de seguridad. Nuestros productos y todos los equipos adicionales son siempre fabricados y examinados según las normas de seguridad vigentes. Nuestra sección de gestión de la seguridad de calidad controla constantemente que sean cumplidas estas normas. Este producto ha sido fabricado y examinado según el comprobante de conformidad adjunto según las normas de la CE y ha salido de nuestra planta en estado impecable según los estandards técnicos de seguridad. Para poder preservar este estado y garantizar un funcionamiento libre de peligros, deberá el usuario atenerse a todas las informaciones, informaciones de seguridad y notas de alerta. Rohde&Schwarz está siempre a su disposición en caso de que tengan preguntas referentes a estas informaciones de seguridad.

Además queda en la responsabilidad del usuario utilizar el producto en la forma debida. Este producto solamente fue elaborado para ser utilizado en la indústria y el laboratorio o para fines de campo y de ninguna manera deberá ser utilizado de modo que alguna persona/cosa pueda ser dañada. El uso del producto fuera de sus fines definidos o despreciando las informaciones de seguridad del fabricante queda en la responsabilidad del usuario. El fabricante no se hace en ninguna forma responsable de consecuencias a causa del maluso del producto.

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

Símbolos y definiciones de seguridad

	18 kg						
Ver manual de instrucciones del uso	Informaciones para maquinaria con uns peso de > 18kg	Peligro de golpe de corriente	¡Advertencia! Superficie caliente	Conexión a conductor protector	Conexión a tierra	Conexión a masa conductora	¡Cuidado! Elementos de construción con peligro de carga electroestática

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

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

Palabras de señal y su significado

PELIGRO	Indica un punto de peligro con gran potencial de riesgo para el ususario.Punto de peligro que puede llevar hasta la muerte o graves heridas.
ADVERTENCIA	Indica un punto de peligro con un protencial de riesgo mediano para el usuario. Punto de peligro que puede llevar hasta la muerte o graves heridas .
ATENCIÓN	Indica un punto de peligro con un protencial de riesgo pequeño para el usuario. Punto de peligro que puede llevar hasta heridas leves o pequeñas
CUIDADO	Indica la posibilidad de utilizar mal el producto y a consecuencia dañarlo.
INFORMACIÓN	Indica una situación en la que deberían seguirse las instrucciones en el uso del producto, pero que no consecuentemente deben de llevar a un daño del mismo.

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

Informaciones de seguridad elementales

1. El producto solamente debe ser utilizado según lo indicado por el fabricante referente a la situación y posición de funcionamiento sin que se obstruya la ventilación. Si no se convino de otra manera, es para los productos R&S válido lo que sigue:
   como posición de funcionamiento se define principialmente la posición con el suelo de la caja para abajo , modo de protección IP 2X, grado de suciedad 2, categoría de sobrecarga eléctrica 2, utilizar solamente en estancias interiores, utilización hasta 2000 m sobre el nivel del mar.
   A menos que se especifique otra cosa en la hoja de datos, se aplicará una tolerancia de ±10% sobre el voltaje nominal y de ±5% sobre la frecuencia nominal.
2. En todos los trabajos deberán ser tenidas en cuenta las normas locales de seguridad de trabajo y de prevención de accidentes. El producto solamente debe de ser abierto por personal périto autorizado. Antes de efectuar trabajos en el producto o abrirlo deberá este ser desconectado de la corriente. El ajuste, el cambio de partes, la manutención y la reparación deberán ser solamente efectuadas por electricistas autorizados por R&S. Si se reponen partes con importancia para los aspectos de seguridad (por ejemplo el enchufe, los transformadores o los fusibles), solamente podrán ser sustituidos por partes originales. Despues de cada recambio de partes elementales para la seguridad deberá ser efectuado un control de

seguridad (control a primera vista, control de conductor protector, medición de resistencia de aislamiento, medición de medición de la corriente conductora, control de funcionamiento).

3. Como en todo producto de fabricación industrial no puede ser excluido en general de que se produzcan al usarlo elementos que puedan generar alergias, los llamados elementos alergénicos (por ejemplo el níquel). Si se producieran en el trato con productos R&S reacciones alérgicas, como por ejemplo urticaria, estornudos frecuentes, irritación de la conjuntiva o dificultades al respirar, se deberá consultar inmediatamente a un médico para averigurar los motivos de estas reacciones.

4. Si productos / elementos de construcción son tratados fuera del funcionamiento definido de forma mecánica o térmica, pueden generarse elementos peligrosos (polvos de sustancia de metales pesados como por ejemplo plomo, berilio, níquel). La partición elemental del producto, como por ejemplo sucede en el tratamiento de materias residuales, debe de ser efectuada solamente por personal especializado para estos tratamientos. La partición elemental efectuada inadecuadamente puede generar daños para la salud. Se deben tener en cuenta las directivas nacionales referentes al tratamiento de materias residuales.

5. En el caso de que se produjeran agentes de peligro o combustibles en la aplicación del producto que debieran de ser transferidos a un tratamiento de materias residuales, como por ejemplo agentes refrigerantes que deben ser repuestos en periodos definidos, o aceites para motores, deberan ser tenidas en cuenta las prescripciones de seguridad del fabricante de estos agentes de peligro o combustibles y las regulaciones regionales para el tratamiento de materias residuales. Cuiden también de tener en cuenta en caso dado las prescripciones de seguridad especiales en la descripción del producto.

6. Ciertos productos, como por ejemplo las instalaciones de radiación HF, pueden a causa de su función natural, emitir una radiación electromagnética aumentada. En vista a la protección de la vida en desarrollo deberían ser protegidas personas embarazadas debidamente. También las personas con un bypass pueden correr peligro a causa de la radiación electromagnética. El empresario está comprometido a valorar y señalar areas de trabajo en las que se corra un riesgo de exposición a radiaciones aumentadas de riesgo aumentado para evitar riesgos.

7. La utilización de los productos requiere instrucciones especiales y una alta concentración en el manejo. Debe de ponerse por seguro de que las personas que manejen los productos estén a la altura de los requerimientos necesarios referente a sus aptitudes físicas, psíquicas y emocionales, ya que de otra manera no se pueden excluir lesiones o daños de objetos. El empresario lleva la responsabilidad de seleccionar el personal usuario apto para el manejo de los productos.

8. Antes de la puesta en marcha del producto se deberá tener por seguro de que la tensión preseleccionada en el producto equivalga a la del la red de distribución. Si es necesario cambiar la preselección de la tensión también se deberán en caso dabo cambiar los fusibles correspondientes del prodcuto.

9. Productos de la clase de seguridad I con alimentación móvil y enchufe individual de producto solamente deberán ser conectados para el funcionamiento a tomas de corriente de contacto de seguridad y con conductor protector conectado.

10. Queda prohibida toda clase de interrupción intencionada del conductor protector, tanto en la toma de corriente como en el mismo producto ya que puede tener como consecuencia el peligro de golpe de corriente por el producto. Si se utilizaran cables o enchufes de extensión se deberá poner al seguro, que es controlado su estado técnico de seguridad.

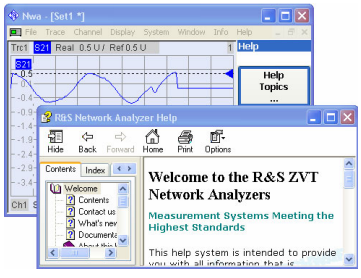
11. Si el producto no está equipado con un interruptor para desconectarlo de la red, se deberá considerar el enchufe del cable de distribución como interruptor. En estos casos deberá asegurar de que el enchufe sea de fácil acceso y nabejo (medida del cable de distribución aproximadamente 2 m). Los interruptores de función o electrónicos no son aptos para el corte de la red eléctrica. Si los productos sin interruptor están integrados en construciones o instalaciones, se deberá instalar el interruptor al nivel de la instalación.

12. No utilice nunca el producto si está dañado el cable eléctrico. Asegure a través de las medidas de protección y de instalación adecuadas de que el cable de eléctrico no pueda ser dañado o de que nadie pueda ser dañado por él, por ejemplo al tropezar o por un golpe de corriente.
13. Solamente está permitido el funcionamiento en redes de distribución TN/TT aseguradas con fusibles de como máximo 16 A.
14. Nunca conecte el enchufe en tomas de corriente sucias o llenas de polvo. Introduzca el enchufe por completo y fuertemente en la toma de corriente. Si no tiene en consideración estas indicaciones se arriesga a que se originen chispas, fuego y/o heridas.
15. No sobrecargue las tomas de corriente, los cables de extensión o los enchufes de extensión ya que esto pudiera causar fuego o golpes de corriente.
16. En las mediciones en circuitos de corriente con una tensión de entrada de Ueff > 30 V se deberá tomar las precauciones debidas para impedir cualquier peligro (por ejemplo medios de medición adecuados, seguros, limitación de tensión, corte protector, aislamiento etc.).
17. En caso de conexión con aparatos de la técnica informática se deberá tener en cuenta que estos cumplan los requisitos de la EC950/EN60950.
18. Nunca abra la tapa o parte de ella si el producto está en funcionamiento. Esto pone a descubierto los cables y componentes eléctricos y puede causar heridas, fuego o daños en el producto.
19. Si un producto es instalado fijamente en un lugar, se deberá primero conectar el conductor protector fijo con el conductor protector del aparato antes de hacer cualquier otra conexión. La instalación y la conexión deberán ser efecutadas por un electricista especializado.
20. En caso de que los productos que son instalados fijamente en un lugar sean sin protector implementado, autointerruptor o similares objetos de protección, deberá la toma de corriente estar protegida de manera que los productos o los usuarios estén suficientemente protegidos.
21. Por favor, no introduzca ningún objeto que no esté destinado a ello en los orificios de la caja del aparato. No vierta nunca ninguna clase de líquidos sobre o en la caja. Esto puede producir corto circuitos en el producto y/o puede causar golpes de corriente, fuego o heridas.
22. Asegúrese con la protección adecuada de que no pueda originarse en el producto una sobrecarga por ejemplo a causa de una tormenta. Si no se verá el personal que lo utilice expuesto al peligro de un golpe de corriente.
23. Los productos R&S no están protegidos contra el agua si no es que exista otra indicación, ver también punto 1. Si no se tiene en cuenta esto se arriesga el peligro de golpe de corriente o de daños en el producto lo cual también puede llevar al peligro de personas.
24. No utilice el producto bajo condiciones en las que pueda producirse y se hayan producido líquidos de condensación en o dentro del producto como por ejemplo cuando se desplaza el producto de un lugar frío a un lugar caliente.
25. Por favor no cierre ninguna ranura u orificio del producto, ya que estas son necesarias para la ventilación e impiden que el producto se caliente demasiado. No pongan el producto encima de materiales blandos como por ejemplo sofás o alfombras o dentro de una caja cerrada, si esta no está suficientemente ventilada.
26. No ponga el producto sobre aparatos que produzcan calor, como por ejemplo radiadores o calentadores. La temperatura ambiental no debe superar la temperatura máxima especificada en la hoja de datos.

27. Baterías y acumuladores no deben de ser expuestos a temperaturas altas o al fuego. Guardar baterías y acumuladores fuera del alcance de los niños. Si las baterías o los acumuladores no son cambiados con la debida atención existirá peligro de explosión (atención celulas de Litio). Cambiar las baterías o los acumuladores solamente por los del tipo R&S correspondiente (ver lista de piezas de recambio). Baterías y acumuladores son deshechos problemáticos. Por favor tirenlos en los recipientes especiales para este fín. Por favor tengan en cuenta las prescripciones nacionales de cada país referente al tratamiento de deshechos. Nunca sometan las baterías o acumuladores a un corto circuito.
28. Tengan en consideración de que en caso de un incendio pueden escaparse gases tóxicos del producto, que pueden causar daños a la salud.
29. Por favor tengan en cuenta que en caso de un incendio pueden desprenderse del producto agentes venenosos (gases, líquidos etc.) que pueden generar daños a la salud.
30. No sitúe el producto encima de superficies, vehículos, estantes o mesas, que por sus características de peso o de estabilidad no sean aptas para él. Siga siempre las instrucciones de instalación del fabricante cuando instale y asegure el producto en objetos o estructuras (por ejemplo paredes y estantes).
31. Las asas instaladas en los productos sirven solamente de ayuda para el manejo que solamente está previsto para personas. Por eso no está permitido utilizar las asas para la sujecion en o sobre medios de transporte como por ejemplo grúas, carretillas elevadoras de horquilla, carros etc. El usuario es responsable de que los productos sean sujetados de forma segura a los medios de transporte y de que las prescripciones de seguridad del fabricante de los medios de transporte sean tenidas en cuenta. En caso de que no se tengan en cuenta pueden causarse daños en personas y objetos.
32. Si llega a utilizar el producto dentro de un vehículo, queda en la responsabilidad absoluta del conductor que conducir el vehículo de manera segura. Asegure el producto dentro del vehículo debidamente para evitar en caso de un accidente las lesiones u otra clase de daños. No utilice nunca el producto dentro de un vehículo en movimiento si esto pudiera distraer al conductor. Siempre queda en la responsabilidad absoluta del conductor la seguridad del vehículo y el fabricante no asumirá ninguna clase de responsabilidad por accidentes o colisiones.
33. Dado el caso de que esté integrado un producto de laser en un producto R&S (por ejemplo CD/DVD-ROM) no utilice otras instalaciones o funciones que las descritas en la documentación. De otra manera pondrá en peligro su salud, ya que el rayo laser puede dañar irreversiblemente sus ojos. Nunca trate de descomponer estos productos. Nunca mire dentro del rayo laser.

R&S® ZVT Documentation Map

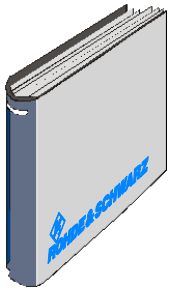
Help System



The help system is embedded in the instrument, offering quick, context-sensitive reference to the information needed for operation and programming. The help contains the complete user documentation for the network analyzer including the contents of the present quick start guide.

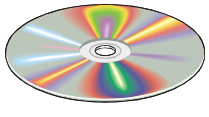
You can use the help if you control the analyzer from and external monitor. You can also transfer the help file RSZVT_help.chm to your PC and use it as a standalone help.

Quick Start Guide



The present quick start guide describes everything that is needed to put the instrument into operation and helps you to get familiar with the analyzer. The quick start guide gives an introduction to the instrument's functionality and provides procedures for typical measurement tasks.

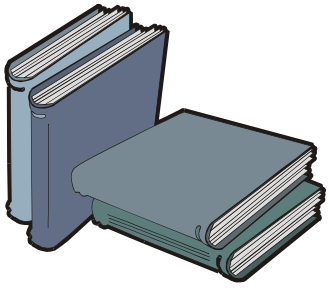
Documentation CD-ROM



The CD-ROM provides the complete user documentation for the network analyzer family:

- The online help system in two different HTML-based formats (*.chm for transfer to the hard disk and WebHelp for viewing from the CD).
- A printable (*.pdf) version of the online help.
- The quick start manual in printable form.
- The data sheet in printable form.
- Links to different useful sites in the R&S internet.

Optional Documentation



The printed version of the help system provides the contents of the quick start manual plus the complete reference information for operation and programming contained in the help. This manual can be ordered as an option (stock no. 1155.1084.12); see ordering information in the data sheet. Besides the CD-ROM contains a *.pdf version of the manual.

ROHDE&SCHWARZ

EC Certificate of Conformity

Certificate No.: 2005-13

This is to certify that:

Equipment type	Stock No.	Designation
ZVT8	1300.0008.08	Network Analyzer

complies with the provisions of the Directive of the Council of the European Union on the approximation of the laws of the Member States

- relating to electrical equipment for use within defined voltage limits (73/23/EEC revised by 93/68/EEC)
- relating to electromagnetic compatibility (89/336/EEC revised by 91/263/EEC, 92/31/EEC, 93/68/EEC)

Conformity is proven by compliance with the following standards:

EN61010-1 : 2001
EN55011 : 1998 + A1:1999 + A2:2002
EN61326 : 1997 + A1:1998 + A2:2001

For the assessment of electromagnetic compatibility, the limits of radio interference for Class B equipment as well as the immunity to interference for operation in industry have been used as a basis.

Affixing the EC conformity mark as from 2005

ROHDE & SCHWARZ GmbH & Co. KG
Mühldorfstr. 15, D-81671 München

Munich, 2005-03-17

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EC Certificate of Conformity

Certificate No.: 2005-11

This is to certify that:

Equipment type	Stock No.	Designation
ZV-Z51	1164.0515.30/.70	Calibration Unit
ZV-Z52	1164.0521.30/.72	Calibration Unit
ZV-Z58	1164.0638.78	Calibration Unit

complies with the provisions of the Directive of the Council of the European Union on the approximation of the laws of the Member States

- relating to electrical equipment for use within defined voltage limits (73/23/EEC revised by 93/68/EEC)
- relating to electromagnetic compatibility (89/336/EEC revised by 91/263/EEC, 92/31/EEC, 93/68/EEC)

Conformity is proven by compliance with the following standards:

EN61010-1 : 2001
EN55011 : 1998 + A1 : 1999 + A2 : 2002, Class B
EN61326 : 1997 + A1 : 1998 + A2 : 2001

For the assessment of electromagnetic compatibility, the limits of radio interference for Class B equipment as well as the immunity to interference for operation in industry have been used as a basis.

Affixing the EC conformity mark as from 2005

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Glossary

A

Active channel: Channel belonging to the active trace. The active channel is highlighted in the channel list below the diagram.

Active marker: Marker that can be changed using the settings of the Marker menu (Delta Mode, Ref. Mkr -> Mkr, Mkr Format). The active marker is also used for the Marker Functions. It appears in the diagram with an enlarged marker symbol and font size and with a dot placed in front of the marker line in the info field.

Active menu: The menu containing the last executed command. If the softkey bar is displayed (Display - Config./View - Softkey Labels on), then the active menu is indicated on top of the softkey bar.

Active trace (manual control): Trace that is selected to be modified using the settings in the Trace menu. The active trace is highlighted in the trace list of the active diagram area. It can be different from the active trace in remote control.

Active trace (remote control): Trace that has been selected implicitly (by means of a command for channel or trace settings) or explicitly (CALCulate[Ch]:PARameter:SELect <Trace Name>) as the active trace. Many commands (e.g. TRACE...) act on the active trace. It can be different from the active trace in manual control.

C

Cal pool: The cal pool is a collection of correction data sets (cal groups) that the analyzer stores in a common directory. Cal groups in the pool can beapplied to different channels and setups.

Calibration: The process of removing systematic errors from the measurement (system error correction). See also TOSM, TOM, TRM, TRL, TNA.

Calibration kit: Set of physical calibration standards for a particular connector family.

Calibration standard: Physical device that has a known or predictable magnitude and phase response within a given frequency range. Calibration standards are grouped into several types (open, through, match,...) corresponding to the different input quantities for the analyzer's error models.

Calibration unit: Integrated solution for automatic calibration of 1 to 4 ports (accessory ZV-Z41). The unit contains calibration standards that are electronically switched when a calibration is performed.

Channel: A channel contains hardware-related settings to specify how the network analyzer collects data. Each channel is stored in an independent data set. The channel settings complement the definitions of the Trace menu; they apply to all traces assigned to the channel.

Compression point: The x-dB compression point of an S-parameter or ratio is the stimulus signal level where the magnitude of the measured quantity has dropped by x dB compared to its value at small stimulus signal levels (small-signal value).

Confirmation dialog box: Standard dialog box that pops up to display an error message or a warning. The current action can be either continued (OK) or cancelled (Cancel) on closing the dialog box.

Crosstalk: The occurrence of a signal at the receive port of the analyzer which did not travel through the test setup and the DUT but leaks through other internal paths. Crosstalk causes an isolation error in the measurement which can be corrected by means of a calibration.

CW frequency: Continuous Wave frequency; fixed stimulus frequency used in Power, CW Time and CW Mode sweeps.

D

Data trace: Trace filled with measurement data and updated after each sweep (dynamic trace).

Diagram area: Rectangular portion of the screen used to display traces. Diagram areas are arranged in windows; they are independent of trace and channel settings.

Directivity error: Measurement error caused by a coupler or bridge in the analyzer's source port causing part of the generated signal to leak through the forward path into the receive path instead of being transmitted towards the DUT. The directivity error can be corrected by means of a full one port calibration or one of the two-port calibration methods (except normalization).

Discrete marker: The stimulus value of a discrete marker always coincides with a sweep point so that the marker does not show interpolated measurement values.

E

Excursion: Difference between the response values at a local maximum (minimum) of the trace and at the two closest local minima (maxima) to the left and to the right.

F

Forward: A measurement on a two-port DUT is said to be in forward direction if the source signal (stimulus) is applied to port 1 of the DUT.

I

Isolation error: Measurement error caused by a crosstalk between the source and receive port of the analyzer.

L

Limit check: Comparison of the measurement results with the limit lines and display of a pass/fail indication. An acoustic warning can be generated in addition if a limit is exceeded.

Limit line: A limit line is a set of data to specify the allowed range for some or all points of a trace. Typically, limit lines are used to check whether a DUT conforms to the rated specifications (conformance testing).

Load match error: Measurement error caused by a mismatch of the analyzer's receive (load) port causing part of the signal transmitted through the DUT to be reflected off the receive port so that it is not measured there. The load match error can be corrected by means of a two-port calibration (except normalization).

M

Marker: Tool for selecting points on the trace and for numerical readout of measured data. A marker is displayed with a symbol (a triangle, a crossbar or a line) on the trace; its coordinates are shown in the marker info field.

Mathematical trace: Trace that is calculated according to a mathematical expression, e.g. the one defined in the Define Math dialog. The expression is a mathematical relation between constants and the data or memory traces of the active setup.

Measurement point: Result of the measurement at a specified stimulus value (frequency/power/time).

Measurement result: Set of all measurement points acquired in a measurement (e.g. a sweep). The measurement result is displayed in a diagram area and forms a trace.

Memory trace: Trace that is associated to a data trace and stored in the memory. Data traces and the associated memory traces share the same channel and scale settings. Alternatively, memory traces can be imported from a file.

P

Partial measurement: Measurement at a specified stimulus value maintaining definite hardware settings. Depending on the measurement type, several partial measurements may be needed to obtain a measurement point. A full n-port S-parameter measurement requires n partial measurements with n different drive ports.

Peak: Local maximum or local minimum (dip) on the trace. In the Trace - Search menu, it is possible to define a minimum excursion that both types of peaks must have to be considered valid.

R

Reflection tracking error: Frequency-dependent variation of the ratio of the reflected wave to the reference wave at a test port when an ideal reflection coefficient (= 1) is measured. The reflection tracking error can be corrected by means of a reflection normalization or one of the more sophisticated calibration methods.

Reverse: A measurement on a two-port DUT is said to be in reverse direction if the source signal (stimulus) is applied to port 2 of the DUT.

S

Setup: A setup comprises a set of diagram areas with all displayed information that can be stored to a NWA setup file (*.zvx). Each setup is displayed in an independent window.

Source match error: Measurement error caused by a mismatch of the analyzer's source port causing part of the signal reflected off the DUT to be reflected again off the source port so that it is not measured there. The source match error can be corrected by means of a full one-port calibration or a two-port calibration (except normalization).

Stimulus value: Value of the sweep variable (frequency/power/time/point number) where a measurement is taken. Also termed sweep point.

Sweep: Series of consecutive measurements taken at a specified sequence of stimulus values = series of consecutive measurement points.

Sweep point: Value of the sweep variable (stimulus value: frequency/power/time) where a measurement is taken.

Sweep range: Continuous range of the sweep variable (frequency/power/time) containing the sweep points where the analyzer takes measurements. In a Segmented Frequency sweep the sweep range can be composed of several parameter ranges or single points.

Sweep segment: Continuous frequency range or single frequency point where the analyzer measures at specified instrument settings (generator power, IF bandwidth etc.). In the Segmented Frequency sweep type the entire sweep range can be composed of several sweep segments.

T

TNA: A calibration type using a through, a symmetric network and an attenuation standard. The properties of the network and the attenuation don't have to be known exactly. Like TRL and TRM, TNA is especially useful for DUTs in planar line technology.

TOM: A calibration type using three fully known standards (through, open, match), recommended for 2-port measurements on coaxial systems.

Topology: Assignment of the physical ports of the NWA to the logical ports used for the measurement of mixed mode S-parameters (balance-unbalance conversion).

TOSM: A calibration type using four known standards (through, open, short, match), also called SOLT or 12-term error correction model. TOSM calibration is available for 2, 3 and 4-port measurements.

Trace: A trace is a set of data points that can be displayed together on the screen. The trace settings specify the mathematical operations used to obtain traces from the collected data. They complement the definitions of the Channel menu. Each trace is assigned to a channel. The channel settings apply to all traces assigned to the channel.

Trace point: Point on the screen which is an element of the displayed trace. The trace points for ratios and wave quantities can be derived from the entire set of measurement points using different detector settings.

Transmission tracking error: Frequency-dependent variation of the ratio of the transmitted wave to the reference wave at a test port when an ideal transmission coefficient (= 1) is measured. The transmission tracking error can be corrected by means of a transmission normalization or one of the more sophisticated calibration methods.

TRL: A calibration type using a through and a line standard plus a possibly unknown reflect standard. The calibration range is limited. Like TNA and TRM, TRL is especially useful for DUTs in planar line technology.

TRM: A calibration type using a through and a match standard plus a possibly unknown reflect standard. Like TRL and TNA, TRM is especially useful for DUTs in planar line technology.

W

Window: Rectangular portion of the screen showing all diagram areas of a particular setup. Windows are limited by a blue frame with several icons. The analyzer uses standard windows provided by the operating system.

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1 Preparing for Use

This chapter gives an overview of the front panel controls and connectors of the network analyzer and gives all information that is necessary to put the instrument into operation and connect external devices. Notes on reinstallation of the analyzer software appear at the end of the chapter.

The ZVT is primarily intended to be remote-controlled via the GPIB interface or a LAN connection. Alternatively it is possible to control the instrument manually using an external monitor in combination with a mouse (see section *Connecting External Accessories* on p. 1.10) or a LAN connection (see section *Remote Control in a LAN* on p. 1.14).

Attention!

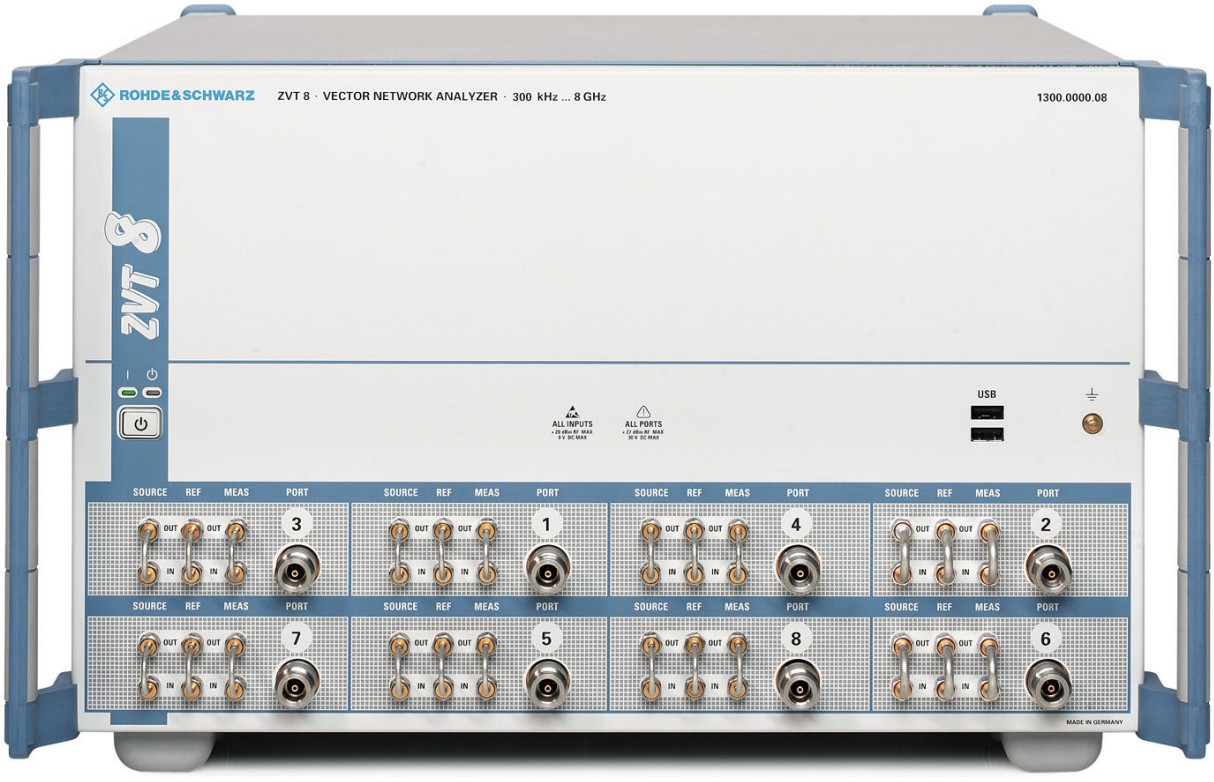
Please make sure to observe the instructions of the following sections so that you cannot cause damage to the instrument or endanger people. This is of particular importance when you use the instrument for the first time. Also observe the general safety instructions at the beginning of this manual.

Front Panel Tour

The front panel of the R&S ZVT network analyzer contains the following controls and connectors:

- The STANDBY toggle switch used to initiate the startup procedure or switch the analyzer to standby mode.
- A double USB connector to connect pointing or mass storage devices.
- The ground (GND) connector providing the ground of the analyzer's supply voltage.
- Tow RF test ports (PORT 1, PORT 2) serving as outputs for the RF stimulus signals and as inputs for the measured RF signals (response signals). Each test port is complemented by three pairs of front panel jumpers used to test high power devices and extend the dynamic range. Up to 6 additional test ports with jumpers can be purchased as options (order no. 1300.1506.03 to 1300.1506.08; see detailed ordering information in the data sheet).

Brief explanations on the controls and connectors and on the rear panel can be found on the next pages.



STANDBY Key

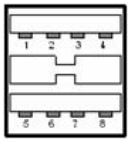
The *STANDBY* toggle switch is located near the left edge of the front panel.

The key serves two main purposes:

- Toggle between standby and ready state
- Shut down the instrument.

USB Connector

Double Universal Serial Bus connector of type A (master USB), used to connect e.g. a keyboard, mouse or other pointing devices, the Calibration Unit (accessory R&S ZV-Z51/-Z52 or R&S ZV-Z58), a printer or an external storage device (USB stick, CD-ROM drive etc.).



The length of passive connecting USB cables should not exceed 1 m. The maximum current per USB port is 500 mA.

Ground Connector

Connector providing the ground of the analyzer's supply voltage.

Attention!

Electrostatic discharge (ESD) may cause damage to the electronic components of the DUT and the analyzer. Use the wrist strap and cord supplied with the instrument to connect yourself to the GND *connector.*

Test Ports

N-connectors, numbered 1 and 2 for two-port instruments. The test ports serve as outputs for the RF stimulus signal and as inputs for the measured RF signals from the DUT (response signals). Up to 6 additional test ports can be purchased as options (order no. 1300.1506.03 to 1300.1506.08; see detailed ordering information in the data sheet).

- With a single test port, it is possible to generate a stimulus signal and measure the response signal in reflection.
- With 2 or more test ports, it is possible to perform full two-port or multiport measurements.
- Each test port is complemented by three pairs of front panel jumpers used to test high power devices and extend the dynamic range, see section *Front Panel Jumpers below*.

Attention!

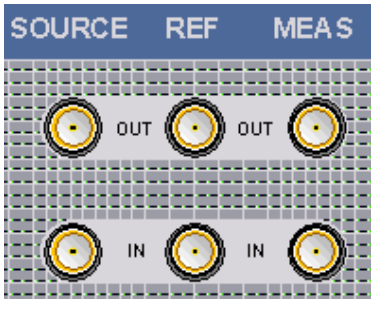
The maximum input levels at all test ports according to the front panel labeling or the data sheet must not be exceeded.

In addition, the maximum input voltages of the other input connectors at the front and rear panel must not be exceeded.

Front Panel Jumpers

3 pairs of SMA connectors for each test port. The front panel jumpers are available as option R&S ZVA<n>-B16, *Direct Generator/Receiver Access.* For detailed ordering information and application examples refer to the data sheet.

The jumpers give direct access to various RF input and output signals. They can be used to insert external components (e.g. external signal separating devices, power amplifiers, etc.) into the signal path in order to develop custom measurements, e.g. to test high power devices and extend the dynamic range. If no external components are connected, each pair of OUT/IN jumper connectors is through-connected internally.



- The SOURCE OUT signal comes from the internal RF signal source. The SOURCE IN signal goes to the test port. A power amplifier can be inserted between SOURCE OUT and SOURCE IN in order to boost the test port power.
- The REF OUT signal comes from the coupler and provides the reference signal. The REF IN signal goes to the receiver input for the reference signal.
- The MEAS OUT signal comes from the coupler and provides the received (measured) signal. The MEAS IN signal goes to the receiver input for the measured signal.

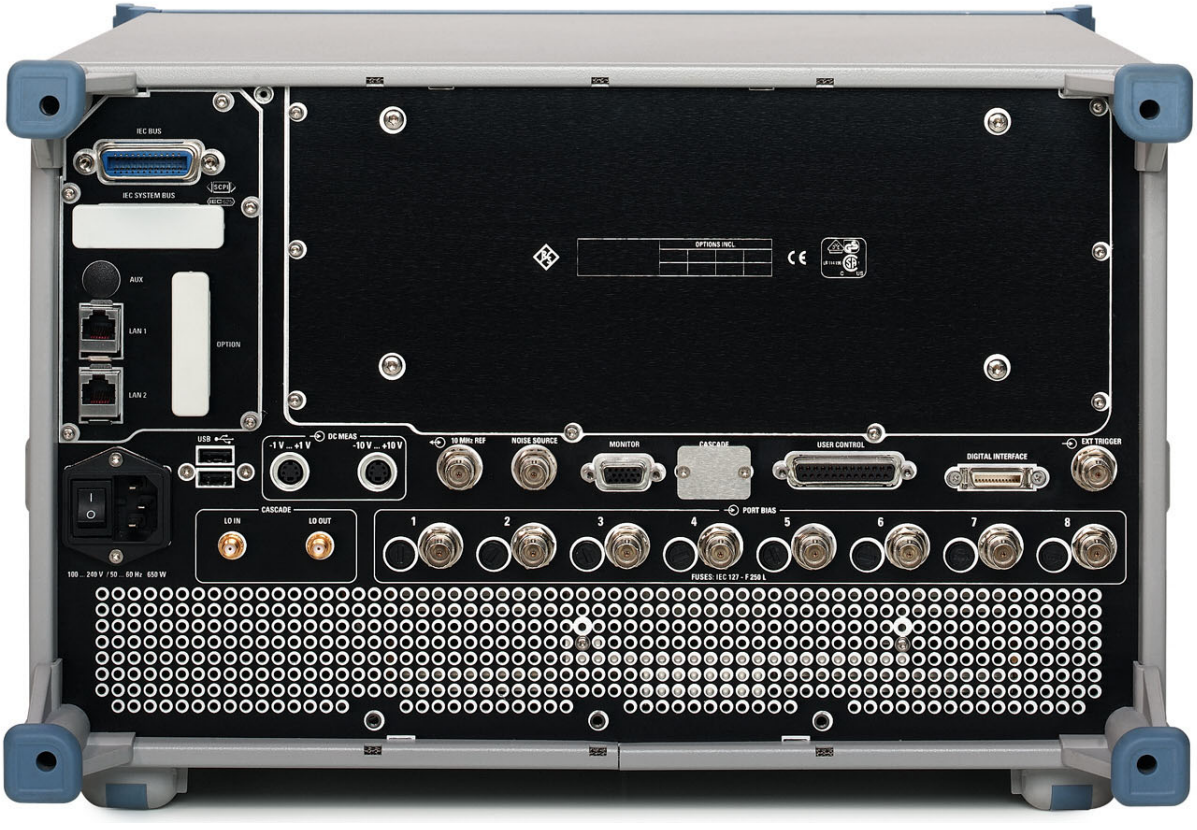
Attention!

The maximum RF input levels at all front panel jumpers inputs according to the front panel labeling or the data sheet must not be exceeded.

In addition, it is important that the signal fed in at the jumper input connectors contains no DC offset, as this may impair the measurements and even cause damage to the instrument.

Rear Panel Tour

This section gives an overview of the rear panel controls and connectors of the network analyzer.



The rear connectors are described in detail in the annex *Hardware Interfaces* in the online help system.

- The *PORT BIAS* panel contains inputs for an external DC voltage (bias) to be applied to the test ports. A separate input is provided for each test port. Each *PORT BIAS* input is protected by an exchangeable fuse.
- *IEC Bus* is the GPIB bus connector (according to standard IEEE 488 / IEC 625).
- *LAN 1* and *LAN 2* are two equivalent connectors to connect the analyzer to a Local Area Network.
- *USB* is a double Universal Serial Bus connector of type A (master USB), used to connect a keyboard, mouse or other pointing device.
- *DC MEAS* comprises two inputs for DC measurements, specified for different voltage ranges.
- *10 MHz REF* serves as an input or output for the 10 MHz reference clock signal.
- *MONITOR* is a sub-Min-D connector used to connect an external VGA monitor.
- *USER CONTROL* is a D-sub connector used as an input and output for low-voltage (3.3 V) TTL control signals.
- *EXT. TRIGGER* is an input for a low-voltage (3.3 V) TTL external trigger signal.
- The *Noise Source*, *Digital Interface*, and *Cascade* connectors are for future extensions.

The remaining connectors are intended for future extensions and not fitted on standard instruments.

Attention!

The maximum input levels and voltages of the input connectors at the front and rear panel must not be exceeded.

The *EXT TRIGGER* input connector and pin 2 of the *USER CONTROL* connector must never be used simultaneously as inputs for external trigger signals.

Putting the Instrument into Operation

This section describes the basic steps to be taken when setting up the analyzer for the first time.

Important Note:

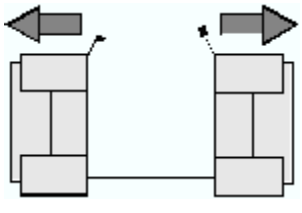
Before turning on the instrument, please make sure that the following conditions are fulfilled:

- Instrument covers are in place and all fasteners are tightened.
- Fan openings are free from obstructions.
- Signal levels at the input connectors are all within the specified maxima.
- Signal outputs are correctly connected and not overloaded.
- The instrument is dry and shows no condensation.

Non-observance may cause damage to the instrument!

Unpacking the Instrument and Checking the Shipment

1. Unpack the instrument and the other contents of the shipping container.
2. Check the shipment against the list of accessories to ensure that all items are included.
3. Remove the two protective caps from the front and rear and carefully inspect the analyzer to make sure that it was not damaged during shipment.



Should the instrument be damaged, immediately notify the forwarder who shipped the instrument to you and keep the container and packing material.

Equipment returned or sent in for repair must be packed in the original container or packing with electrostatic protection. It is recommended to keep at least the two protective caps for front and rear side in order to prevent damage to the controls and connectors.

Instrument Setup

The network analyzer is designed for use under laboratory conditions, either on a bench top or in a rack. The general ambient conditions required at the operating site are as follows:

- The ambient temperature must be in the ranges specified for operation and for compliance with specifications (see data sheet).
- All fan openings including the rear panel perforations must be unobstructed. The distance to the wall should be at least 10 cm.

Attention!

To avoid damage of electronic components of the DUT and the analyzer, the operating site must be protected against electrostatic discharge (ESD). ESD is most likely to occur when you connect or disconnect a DUT or test fixture to the analyzer's test ports.

To prevent ESD damage use the wrist strap and grounding cord supplied with the instrument and connect yourself to the GND connector at the front panel.

Bench Top Operation

If the analyzer is operated on a bench top, the surface should be flat. The instrument can be used in horizontal position, standing on its feet.

Mounting in a 19" Rack

Using the adapter ZZA-611 (order number 1096.3302.00) the instrument can be mounted in 19" racks according to the mounting instructions supplied with the rack adapter.

Attention!

- Allow for sufficient air supply in the rack.
- Make sure that there is sufficient space between the ventilation holes and the rack casing.

EMI Protective Measures

In order to avoid electromagnetic interference, the instrument may only be operated when it is closed and with all shielding covers fitted. Only appropriate shielded signal and control cables may be used.

Connecting the Instrument to the AC Supply

The network analyzer is automatically adapted to the AC supply voltage supplied. The supply voltage must be in the range 100 V to 240 V; 50 Hz to 60 Hz. The mains connector is located at the bottom left corner of the rear panel.

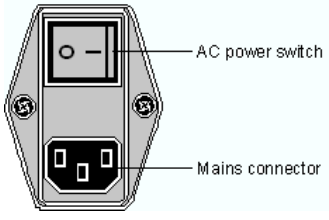
- Connect the network analyzer to the AC power source using the AC power cable delivered with the instrument.

The maximum power consumption of the analyzer is 650 W. The typical power consumption and the frequency range is listed in the data sheet.

The network analyzer is protected by two fuses as specified on the label on the power supply. The fuses are located on an AC Fuse Board (order no. 1145.3906.02) which must be replaced to change the fuses. Replacing the AC Fuse Board requires opening the instrument and is described in the service manual.

Power on and off

The mains connector is located at the bottom left corner of the rear panel.



- To turn the power on or off, press the AC power switch to position I (On) or 0 (Off).

After power-on, the analyzer is in standby or ready state, depending on the state of the *STANDBY* toggle switch at the front panel of the instrument when the instrument was switched off for the last time.

NOTE *The AC power switch can be permanently on. Switching off is required only if the instrument must be completely removed from the AC power supply.*

Standby and Ready State

The *STANDBY* toggle switch is located in the bottom left corner of the front panel.

- After switching on the AC power, press the *STANDBY* key briefly to switch the analyzer from the standby to ready state or vice versa.

- In standby state, the right, amber LED is on. The standby power only supplies the power switch circuits and the optional oven quartz (OCXO, 10 MHz reference oscillator, option ZVAB-B4, order no. 1164.1757.02). In this state it is safe to switch off the AC power and disconnect the instrument from the power supply.

- In ready state, the left, green LED is on. The analyzer is ready for operation. All modules are power-supplied and the analyzer initiates its startup procedure.

CAUTION!

The instrument is still power-supplied while it is in standby mode.

Replacing Fuses

The DC inputs PORT BIAS at the rear panel are protected by four fuses IEC 127 - F 250 L (250 mA flink).

- To replace the fuses open the fuse holder by slightly turning the lid counterclockwise.

Replacement fuses are provided with the instrument.

Starting the Analyzer, Shutdown

To start the analyzer, proceed as follows:

1. Make sure that the instrument is connected to the AC power supply and the power switch on the rear panel is in position I (On).
2. If necessary, press the STANDBY toggle switch on the front panel to switch the instrument to ready state (the green LED is on).

In ready state, the analyzer automatically performs a system check, boots the Windows XP operating system and then starts the network analyzer (NWA) application. If the last analyzer session was terminated regularly, the NWA application uses the last setup with all instrument settings.

To shut down the analyzer, proceed as follows:

1. Press the STANDBY key to save the current setup, close the NWA application, shut down Windows XP and set the instrument to standby state. Of course you can also perform this procedure step by step like in any Windows session.
2. If desired, set the AC power switch to position 0 (Off).

Attention!

It is strongly recommended to switch the analyzer to standby state before disconnecting it from the AC supply. If you set the power switch to 0 while the NWA application is still running, you will lose the current settings. Moreover, loss of program data can not be excluded if the application is terminated improperly.

Connecting External Accessories

The equivalent USB ports on the front and rear panel of the analyzer can be used to connect a variety of accessories:

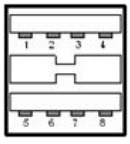
- A mouse simplifies operation of the instrument using the controls and dialogs of the Graphical User Interface (GUI); see *external monitor* below.
- A keyboard simplifies the entry of data.
- A printer generates hard copies of the Graphical User Interface (GUI, see *external monitor* below) and the measurement results.

In addition the analyzer provides interfaces for monitor connection and network integration:

- An external monitor shows the magnified Graphical User Interface (GUI) with all diagram areas and controls. With an additional mouse connected to the analyzer, it is possible to control the analyzer from the the GUI.
- A LAN connection can be established in order to access the hard disk or control the analyzer from an external PC.

Connecting a Mouse

A USB mouse can be connected to one of the Universal Serial Bus connectors on the front panel or on the rear panel (double USB connectors). It is recommended to use the mouse delivered with the instrument.

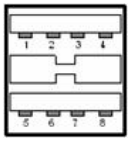


The mouse is detected automatically when it is connected. It is safe to connect or disconnect the mouse during the measurement.

Use the Start – Control Panel – Mouse menu of Windows XP to configure the mouse properties. To access Windows XP, press the Windows key on the external keyboard or on the hardkey bar of the GUI; see section Connecting a Monitor on p. 1.12.

Connecting a Keyboard

A keyboard can be connected to one of the Universal Serial Bus connectors on the front panel or on the rear panel (double USB connectors).

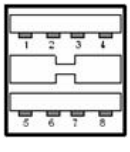


The keyboard is detected automatically when it is connected. The default input language is English – US. It is safe to connect or disconnect the external keyboard during the measurement.

Use the Start – Control Panel – Keyboard or Regional and Language Options menu of Windows XP to configure the keyboard properties. To access Windows XP, press the Windows key on the external keyboard or on the hardkey bar of the GUI; see section Connecting a Monitor on p. 1.12.

Connecting a Printer

A printer can be connected to one of the Universal Serial Bus connectors on the front panel or on the rear panel (double USB connectors).



It is safe to connect or disconnect the printer during the measurement. When printing a copy *(File – Print),* the analyzer checks whether a printer is connected and turned on and whether the appropriate

printer driver is installed. If required, printer driver installation is initiated using Windows XP's *Add Printer Wizard*. The wizard is self-explanatory. A printer driver needs to be installed only once, even though the printer may be temporarily removed from the analyzer.

Printer driver installation

A great variety of printer drivers is available on the analyzer. To obtain the complete list, access Windows XP (press the *Windows* key) and open the Add Printer Wizard in the *Start – Control Panel – Printer and Faxes* menu.

You can load updated and improved driver versions or new drivers from an installation disk, USB memory stick or another external storage medium. Alternatively, if the analyzer is integrated in a network, you can install driver data stored in a network directory. In either case, use the *Add Printer Wizard* to complete the installation.

Use the *Page Setup* dialog or the *Start – Control Panel – Printers and Faxes* menu of Windows XP to configure the printer properties. To access Windows XP, press the Windows key on the external keyboard or on the hardkey bar of the GUI; see section Connecting a Monitor on p. *1.12*.

Connecting a Monitor

A standard VGA monitor can be connected to the 15-pole Sub-Min-D MONITOR connector on the rear panel of the analyzer.

Attention!

The monitor must be connected while the instrument is switched off (in standby mode). Otherwise correct operation can not be guaranteed.

The monitor displays the magnified Graphical User Interface (GUI) with all diagram areas, measurement results and control elements. No extra configuration is required.

With an additional mouse or keyboard connected to the analyzer, you can control the measurement from the external monitor. The GUI contains the *Hardkey Bar* with key shortcuts for the most important menus and submenus.

Connecting a LAN Cable

A LAN cable can be connected to one of the LAN connectors on the rear panel of the analyzer. To establish a LAN connection proceed as follows:

1. Refer to section *Assigning an IP Address* and learn how to avoid connection errors.
2. Connect an appropriate LAN cable to one of the LAN ports. Use a commercial RJ-45 cable to establish a non-dedicated network connection, or a cross-over RJ-45 cable to establish a dedicated connection between the analyzer and a single PC.

Dedicated vs. non-dedicated network connections

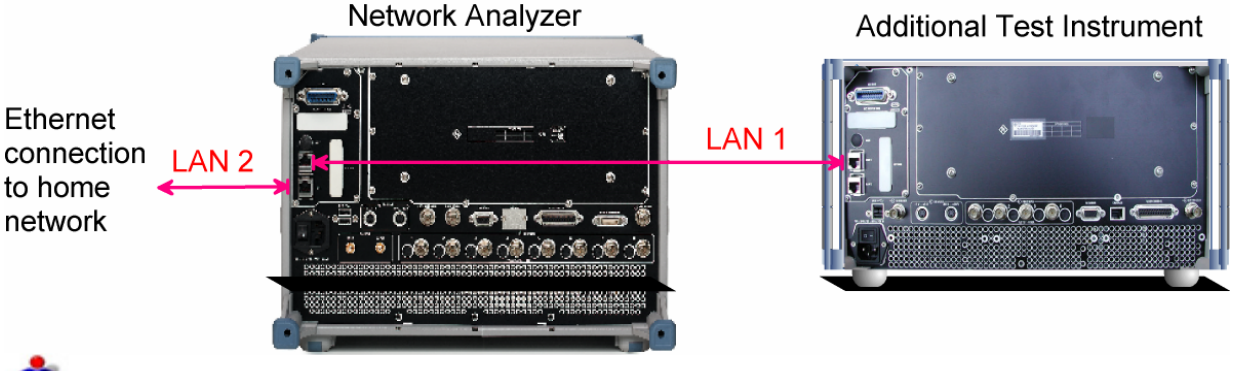
There are two methods to establish a LAN connection of the analyzer:

- A non-dedicated network (Ethernet) connection from the analyzer to an existing network made with an ordinary RJ-45 network cable. The analyzer is assigned an IP address and can coexist with a computer and with other hosts on the same network.
- A dedicated network connection between the analyzer and a single computer made with a cross-over RJ-45 network cable. The computer must be equipped with a network adapter and is directly connected to the analyzer. The use of hubs, switches, or gateways is not needed, however, data transfer is still made using the TCP/IP protocol.

The IP address information is displayed in the *Info – Setup Info* dialog.

Test Setups with Two LAN Connections

The two LAN connectors on the rear panel of the analyzer are equivalent. With one LAN connector used to establish a connection to a home/company network, the other one can be used to connect an additional instrument, e.g. an additional analyzer or signal generator:



Defining the network topology: Router vs. network client

With two LAN connections, it is possible to use the analyzer in two alternative ways:

- As a client participating in two independent networks, one comprising the home network including the analyzer, the second consisting of the additional test instrument plus the analyzer.

- As a data router between the additional test instrument and the home network. This configuration means that the analyzer and the additional test instrument are integrated into a single network.

The network topology is defined in Windows XP's *Control Panel – Network Connections – Local Area Connection Status – Local Area Connection Properties – Internet Protocol (TCP/IP) Properties – Advanced TCP/IP Settings* dialog. Both instruments must have independent IP addresses; see section *Assigning an IP Address* below. Contact your LAN administrator for details.

Attention!

Never use both LAN connectors to connect the analyzer in parallel to the same network as this will result in connection errors.

Remote Control in a LAN

A LAN connection is used to integrate the analyzer into a home/company network. This offers several applications:

- Transfer data between a controller and the analyzer, e.g. in order run a remote control program.
- Control the measurement from a remote computer using the *Remote Desktop* application.
- Use external network devices (e.g. printers).

Attention!

An efficient virus protection is a prerequisite for secure operation in the network. Never connect your analyzer to an unprotected network because this may cause damage to the instrument software.

To establish the connection proceed as follows:

1. Press the Windows button and open Windows XP's control panel.
2. Select System and open the Remote tab in the System Properties dialog. Enable Allow users to connect remotely to this computer.
3. Assign an IP address to the analyzer following the directions below and connect the analyzer to the network as described in *Connecting a LAN Cable*.
4. Create a *Remote Desktop Connection* using the analyzer's IP address.

NOTE

The analyzer uses a user name and password as credentials for remote access. In the factory configuration, instrument *is preset for both the user name and the password. To protect the analyzer from unauthorized access, it is recommended to change the factory setting.*

Assigning an IP Address

Depending on the network capacities, the TCP/IP address information for the analyzer can be obtained in different ways.

- If the network supports dynamic TCP/IP configuration using the Dynamic Host Configuration Protocol (DHCP), all address information can be assigned automatically.
- If the network does not support DHCP, or if the analyzer is set to use *alternate TCP/IP* configuration, the addresses must be set manually.

By default, the analyzer is configured to use dynamic TCP/IP configuration and obtain all address information automatically. This means that it is safe to establish a physical connection to the LAN without any previous analyzer configuration.

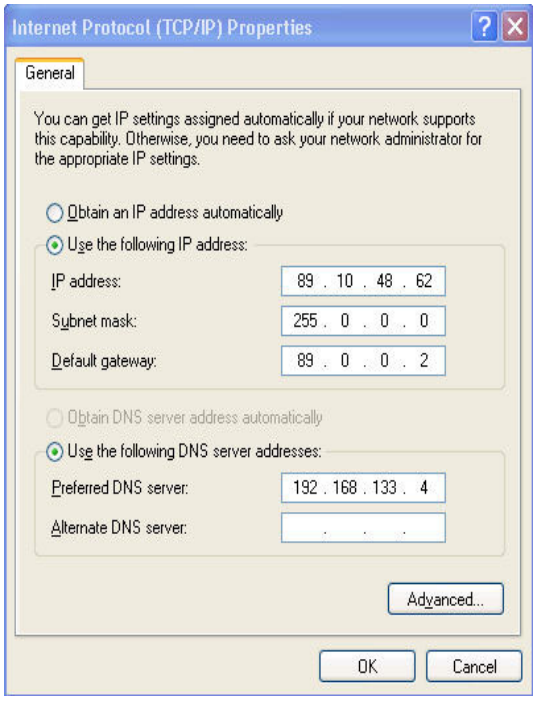
Attention!

If your network does not support DHCP, or if you choose to disable dynamic TCP/IP configuration, you must assign valid address information **before** connecting the analyzer to the LAN. Contact your network administrator to obtain a valid IP address, because connection errors can affect the entire network.

Manual TCP/IP configuration

To disable dynamic TCP/IP configuration and enter the TCP/IP address information manually proceed as follows:

1. Obtain the IP address and subnet mask for the analyzer and the IP address for the local default gateway from your network administrator. If needed, also obtain the name of your DNS domain and the IP addresses of the DNS and WINS servers on your network. If you use both LAN connectors, you need two different sets of address information.
2. Press the Windows key on the external keyboard or on the hardkey bar of the GUI to access Windows XP (see section *Connecting a Monitor* on p. *1.12)*.
3. Open the *Control Panel – Network Connections – Local Area Connection Status – Local Area Connection Properties – Internet Protocol (TCP/IP) Properties* dialog and enter the address information, e.g.:



For more information refer to the Windows XP Help.

Remote Desktop Connection

Remote Desktop is a Windows application which can be used to access and control the analyzer from a remote computer through a LAN connection. While the measurement is running, the analyzer screen contents are displayed on the remote computer, and *Remote Desktop* provides access to all of the applications, files, and network resources of the analyzer.

To set up a *Remote Desktop* connection

1. Connect the analyzer to a LAN and determine its IP address; see *Remote Control in a LAN.*
2. Set up your remote computer (integrated in the LAN) to use *Remote Desktop* and create the *Remote Desktop* connection to the analyzer.

For detailed information about *Remote Desktop* and the connection refer to the Windows XP Help.

Windows XP

The analyzer is equipped with a Windows XP operating system which has been configured according to the instrument's features and needs. Changes in the system configuration can be necessary in order to

- Establish a LAN connection
- Customize the properties of the external accessories connected to the analyzer
- Call up additional software tools

Attention!

The operating system is adapted to the network analyzer. To avoid impairment of instrument functions, only change the settings described in this manual. Existing software must be modified only with update software released by Rohde & Schwarz. Likewise, only programs authorized by Rohde & Schwarz for use on the instrument must be executed.

The *Start* menu of the operating system is accessed by pressing the Windows key on the external keyboard or on the hardkey bar of the GUI. All necessary settings can be accessed from the *Start* menu, in particular from the *Control Panel.*

Firmware Update

Upgrade versions of the analyzer firmware are supplied as single setup files *.msi. To perform a firmware update

1. Copy the setup file to any storage medium accessible from the analyzer. This may be the internal hard disk, an external storage medium (USB memory stick, CD-ROM with external drive) or a network connection (LAN, GPIB bus).
2. Start the installation using one of the following methods:
   - If you use an external monitor or PC to display the GUI, access the *Start* menu of the operating system by pressing the Windows key on the external keyboard or on the hardkey bar of the GUI and double-click the setup file.
   - Otherwise, use the remote control command SYSTem:FIRMware:UPDate '<setup_file_name>' to start the installation.
3. Follow the instructions of the setup wizard.

Setup files can be stored and installed again. The default drive name of the internal hard disk is C:. External storage devices are automatically mapped to the next free drive, i.e. D:, E: etc.

Attention!

The *Calibration Unit* (accessory R&S ZV-Z51/-Z52 or R&S ZV-Z58) must be disconnected during a firmware update.

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2 Getting Started

The following chapter presents a sample session with a R&S ZVT network analyzer using an external monitor and the Graphical User Interface (GUI) and explains how to solve basic tasks that you will frequently encounter when working with the instrument.

Note:

Before starting any measurement on your network analyzer, please note the instructions given in Chapter *Preparing for Use*.

In the *System Overview* you will find detailed information on customizing the instrument and the display according to your personal preferences. For a systematic explanation of all menus, functions and parameters and background information refer to the reference chapters in the online help system.

Use the *Measurement Wizard* in the *System* menu to perform a standard S-parameter measurement in a straightforward way. The wizard provides a series of dialogs where you can select the test setup, screen configuration and measurement parameters, configure the essential channel settings and perform a guided calibration.

Measurement stages in the wizard

The different dialogs of the measurement wizard correspond to the typical stages of any measurement:

1. Select the test setup
2. Select the measurement parameters and the diagram areas
3. Define the sweep range
4. Adjust the receiver and source settings (measurement bandwidth, source power)
5. Perform a calibration

In the following we assume that you are familiar with standard Windows dialogs and mouse operation. Refer to section Data Entry *to learn how to access instrument functions and control dialogs without a mouse and keyboard.*

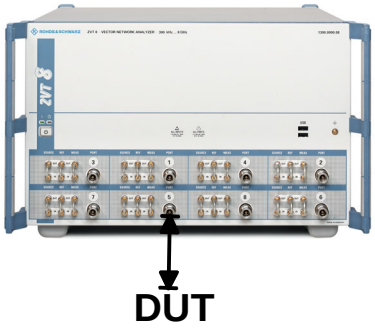
Reflection Measurements

In a reflection measurement, the analyzer transmits a stimulus signal to the input port of the device under test (DUT) and measures the reflected wave. A number of trace formats allow you to express and display the results. depending on what you want to learn from the data. Only one analyzer test port is required for reflection measurements.

In the following example, the analyzer is set up for a reflection measurement, a frequency sweep range and measurement parameter is selected, the instrument is calibrated and the result is evaluated using various formats.

Instrument Setup for Reflection Measurements

In order to prepare a reflection measurement, you have to connect your DUT (which is assumed to have a male N 50 Ω connector) to one of the (equivalent) analyzer test ports. Besides, it is recommended to preset the instrument in order to set it to a definite, known state.



1. Proceed as described in section *Starting the Analyzer and Shutting Down* in Chapter 1 to switch on the instrument and start the NWA application. The Graphical User Interface (GUI) on your external monitor shows the analyzer's main window including the hardkey and softkey bars.
2. Connect the input port of your DUT to test port 1 of the network analyzer.
3. Press the preset key in the SYSTEM keypad of the hardkey bar to perform a factory preset of the analyzer.

The analyzer is now set to its default state. The default measured quantity is the transmission S-parameter S_{21}. This quantity is zero in the current test setup, so the trace shows the noise level.

Press the TRACE SELECT key in the TRACE keypad of the hardkey bar and use the softkeys in the *Trace Select* menu if you wish to create a new trace or a new diagram area.

Parameter and Sweep Range Selection

After preset the display shows a diagram with a dB Mag scale. The sweep range (scale of the horizontal axis) is equal to the maximum frequency range of the analyzer, and the S-parameter S_{21} is selected as a measurement parameter.

To obtain information about the reflection characteristics of your DUT you have to select an appropriate measurement parameter and specify the sweep range.

1. In the CHANNEL keypad of the hardkey bar, press START CENTER and enter the lowest frequency you want to measure in the *Start Frequency* numeric entry bar (e.g. 5 GHz).

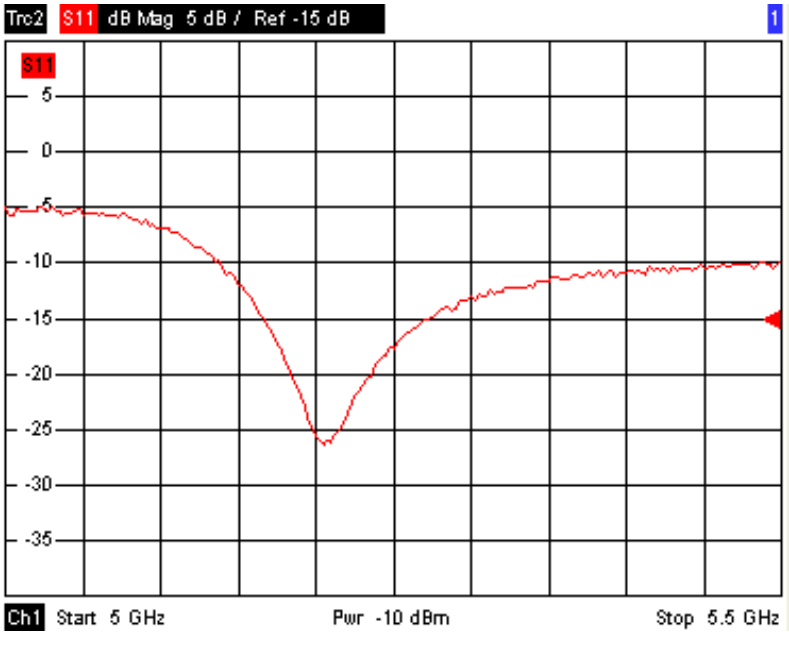
2. Press STOP SPAN and enter the highest frequency you want to measure in the *Stop Frequency* numeric entry bar (e.g. 5.5 GHz).

3. In the TRACE keypad of the hardkey bar, press MEAS and select the forward reflection coefficient S_{11} as a measurement parameter.

4. In the TRACE keypad, press SCALE and activate the *Autoscale* function.

The analyzer adjusts the scale of the diagram to fit in the entire S_{11} trace, leaving an appropriate display margin.

TIP Refer to section *Scaling Diagrams* to learn more about the different methods and tools for diagram scaling.



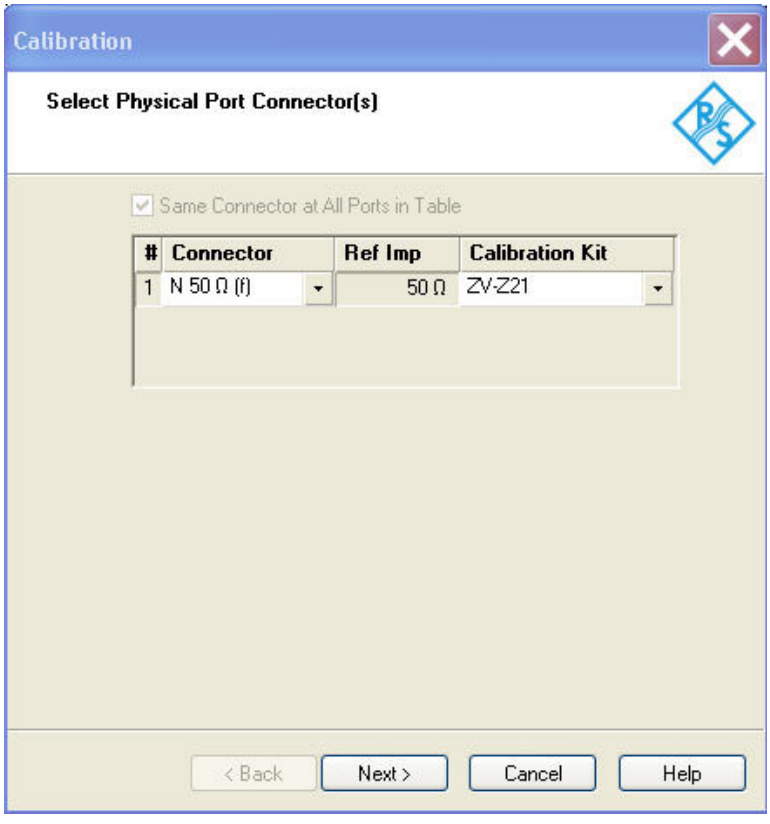
Instrument Calibration

The analyzer provides a wide range of sophisticated calibration methods for all types of measurements. Which calibration method is selected depends on the expected system errors, the accuracy requirements of the measurement, on the test setup and on the types of calibration standards available.

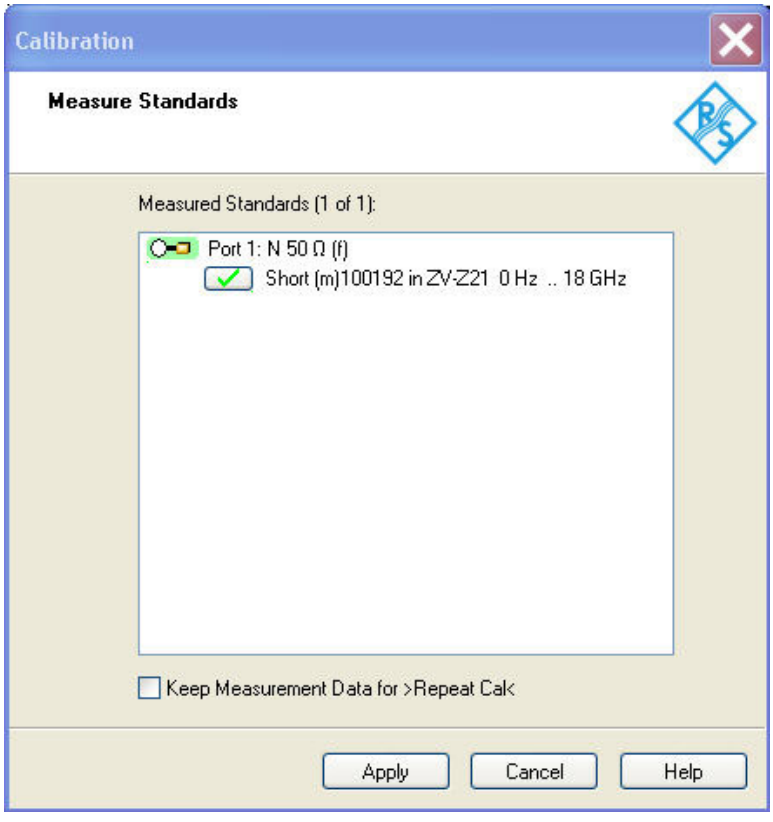
In the following we assume that the calibration kit ZV-Z21 contains an appropriate male short standard with known physical properties. With a single short standard, it is possible to perform a normalization, compensating for a frequency-dependent attenuation and phase shift in the signal path.

Due to the analyzer's calibration wizard, calibration is a straightforward, menu-guided process.

1. Unscrew the DUT and connect the male short standard from calibration kit ZV-Z21.
2. In the CHANNEL keypad, press CAL to open the calibration menu.
3. Activate *Start Cal – One Port P1 – Normalization (Short)* to open the calibration wizard for the selected calibration type.



4. In the first dialog of the wizard, select the calibration kit (here: ZV-Z21) and the test port connector (here: N 50 Ω (f), corresponding to a male calibration standard), and click *Next*.



The next dialog of the calibration wizard shows that only a single calibration standard needs to be measured.

5. Click the box *Short (m)...* to initiate the measurement of the connected short standard.

The analyzer performs a calibration sweep and displays a message box with a progress bar. After completing the sweep the analyzer generates a short sound and a green checkmark appears in the checkbox.

6. Click *Apply* to close the wizard, calculate and store the system error correction data and apply them to the current measurement.
7. Remove the short standard and connect the DUT again.

Evaluation of Data

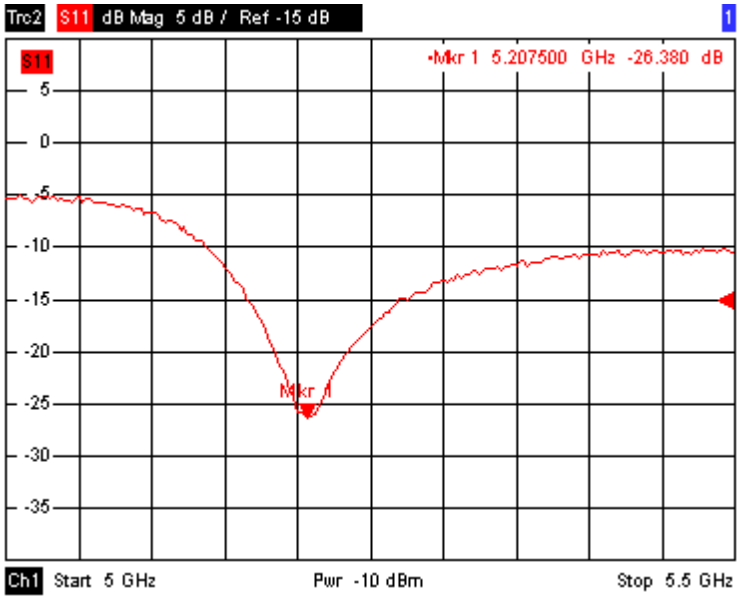
The analyzer provides various tools to optimize the display and analyze the measurement data. For instance, you can use markers determine the maximum of the reflection coefficient, and change the display format to obtain information about the phase shift of the reflected wave and the impedance of your DUT.

1. In the TRACE keypad of the hardkey bar, press MARKER. This places *Marker 1* to its default position (center of the sweep range).

A marker symbol (triangle) appears on the trace. The stimulus value (frequency) and response value (magnitude of the reflection coefficient converted to a dB value) at the marker position is displayed in the *marker info field* in the upper right corner of the diagram.

2. Press MARKER FUNCT and activate *Min Search*.

The marker jumps to the absolute minimum of the curve in the entire sweep range. The *marker info field* shows the coordinates of the new marker position.

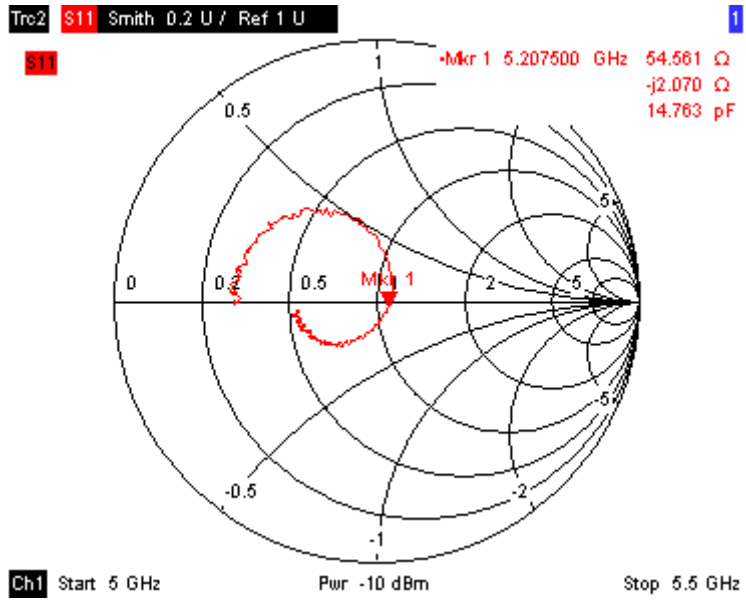


3. In the TRACE keypad, press FORMAT and select the *Phase* of the reflection coefficient to be displayed.

The phase is shown in a Cartesian diagram with a default vertical scale of –225 deg to +225 deg. The *marker info field* shows the frequency and phase at the marker position.

4. Still in the FORMAT menu, select *Smith*.

The Smith chart shows lines of constant real and imaginary part of the impedance in the reflection coefficient plane.



Refer to section *Display Formats and Diagram Types* in Chapter 3 to learn more about the diagram properties.

Saving and Printing Data

The analyzer provides standard functions for saving measurement settings and for printing the results. You can use these functions as if you were working on a standard PC. Moreover you can export your trace data to an ASCII file and reuse it in a later session or in an external application.

Data transfer is made easier if external accessories are connected to the analyzer or if the instrument is integrated into a LAN. Refer to sections *External Accessories* and *Remote Control in a LAN* in Chapter 1 to obtain information about the necessary steps.

TRACE FUNCT

1. Press TRACE FUNCT and activate *Import/Export Data – Export.*
2. In the *Export Data* dialog opened, select a file location, format and name and activate *Save.*

The active trace data are written to an ASCII file.

Refer to section *Trace File Formats* to learn more about trace files and their use.

PRINT

3. Press PRINT in the SYSTEM keypad of the hardkey bar and select *Print Now* to create a hardcopy of your diagram.
4. Select *Print to File...* or *Print to Clipboard* to copy the diagram to a file or an external application.

5. Press SAVE in the SYSTEM keypad.
6. In the *Save As* dialog opened, select a file location, format and name and activate *Save.*

The active setup is stored to a file and can be reused in a later session.

Proceed as described in section *Starting the Analyzer, Shutdown* to shut down your analyzer.

Basic Tasks

The following sections describe how to solve basic tasks that you will frequently encounter when working with the instrument. In particular you can learn how to access instrument functions and control dialogs without a mouse and keyboard.

Data Entry

The analyzer provides dialogs with various types of input fields where you can enter numeric values and character data. Data entry with a mouse and an external keyboard is a standard procedure known from other Windows applications. However, there are various alternative ways to enter data.

Using the Analyzer's On-Screen Keyboard

The on-screen keyboard allows you to enter characters, in particular letters, without an external keyboard. It is available for all character input fields which have a symbol.

Operation with a mouse

1. Click the symbol to open the on-screen keyboard.
2. Click a sequence of characters and *OK* to apply your selection and close the keyboard.

Using Windows XP's On-Screen Keyboard

Windows XP's on-screen keyboard allows you to enter characters, in particular letters, even if an input field can not call up the analyzer's own on-screen keyboard. Examples of such fields are the input fields in the *Index* and *Search* tabs of the Help system. A mouse is required for using the Windows XP's on-screen keyboard.

To call up the *On-Screen Keyboard,*

1. Press the Windows key in the SUPPORT keypad of the hardkey bar to open Windows XP's start menu.
2. Select All Programs – Accessories – Accessibility – On-Screen Keyboard.

The *System – External Tools* submenu contains a shortcut to Windows XP's on-screen keyboard. Simply click *Mouse Keyboard.lnk* to open the keyboard.

Scaling Diagrams

The analyzer provides several alternative tools for setting the sweep range and customizing the diagrams. Pick the method that is most convenient for you.

Setting the Sweep Range

The sweep range for all channels is displayed in the channel list across the bottom of the diagram area:

Ch1	Start 300 kHz	Pwr -10 dBm	Stop 8 GHz
Ch2	Start -25 dBm	Freq 1 GHz	Stop 0 dBm

To change the sweep range, use one of the following methods:

- Press the START CENTER or STOP SPAN keys in the CHANNEL keypad of the hardkey bar.
- Right-click the start or stop value in the channel list and select *Start, Stop, Center, Span* from the context menu.
- Select Start, Stop, Center, Span from the Channel – Stimulus menu.
- Use the marker functions (MARKER FUNCT key of the hardkey bar).

Reference Value and Position

The analyzer provides three parameters for changing the scale of the vertical (response) axis:

- Changing the *Reference Value* or *Reference Position* shifts the trace in vertical direction and adjusts the labels of the vertical axis. *Reference Value* also works for radial diagrams.
- Changing the *Scale/Div.* modifies the value of the vertical or radial diagram divisions and thus the entire range of response values displayed.
- The *Scale/Div.* and the *Reference Value* is indicated in the scale section of the trace list.

Trc2	S21	dB Mag 40 dB /	Ref -200 dB	Ch1	Invisible
Trc3	S21	Phase 45° /	Ref 0°	Ch2	
Trc7	S21	dB Mag 10 dB /	Ref 0 dB	Ch2	Math
Mem8[Trc7]	S21	dB Mag 10 dB /	Ref 0 dB	Ch2	

To change one of the parameters use one of the following methods:

- Press the SCALE key in the TRACE keypad of the hardkey bar.
- Right-click the scale section in the trace list and select the parameters from the context menu.
- Select the parameters from the *Trace – Scale* menu.
- Use the marker functions (MARKER FUNCT key).

Autoscale

The *Autoscale* function adjusts the scale divisions and the reference value so that the entire trace fits into the diagram area. To access *Autoscale*, use one of the following methods:

- Press the SCALE key in the TRACE keypad of the hardkey bar.
- Right-click the scale section in the trace list and select *Autoscale* from the context menu.
- Select *Autoscale* from the *Trace – Scale* menu.

Circular Diagrams

The radial scale of a circular *(Polar, Smith* or *Inverted Smith)* diagram can be changed with a single linear parameter, the *Reference Value*. The reference value defines the radius of the outer circumference.

Increasing the *Reference Value* scales down the polar diagram.

Decreasing the *Reference Value* magnifies the polar diagram.

The *Reference Value* is indicated in the scale section of the trace list.

Trc1	S21	Polar	0.26 U /	Ref 1.3 U
Trc3	S21	Smith	0.2 U /	Ref 1 U

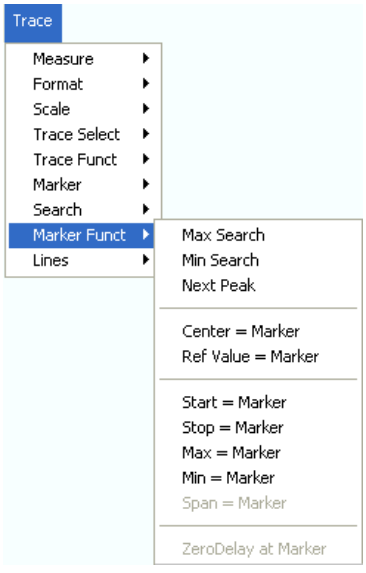
To change the *Reference Value* use one of the following methods:

- Press the SCALE key in the TRACE keypad of the hardkey bar.
- Right-click the scale section in the trace list and select the parameter from the context menu.
- Select the parameter from the *Trace – Scale* menu.
- Use the marker functions.

TIP The *Autoscale* function also works for polar diagrams.

Using Marker Functions

Marker functions are a convenient tool for scaling (in particular: magnifying) diagrams without entering explicit numeric values. You simply place a marker to a trace point and use the marker values to change the sweep range or move the trace relative to the vertical axis. A mouse makes it easier to activate (click) or move (drag and drop) markers.



To set the sweep range use one of the following methods:

Define Start and Stop values

1. Create two normal markers, e.g. the markers *Mkr 1* and *Mkr 2,* and place them to the desired start and stop values of the sweep range.
2. Activate Mkr 1 and click *Trace – Marker Funct. – Start = Marker*.
3. Activate Mkr 2 and click *Trace – Marker Funct. – Stop = Marker*.

Use a definite Span

1. Create a marker and set it to delta mode.

   The analyzer automatically creates a reference marker in addition to the delta marker.
2. Place the reference marker to the desired start value of the sweep range.
3. Set the value of the delta marker equal to the desired (positive or negative) span.
4. Activate the delta marker and click *Trace – Marker Funct. – Span = Marker*.

To move the trace relative to the vertical axis proceed as follows:

1. Create a normal marker, e.g. the marker *Mkr 1,* and place it to a particular trace point. E.g. you can use the marker *Search* functions to locate a maximum or minimum on the trace.
2. Click *Trace – Marker Funct. – Max = Marker* to move the trace towards the upper diagram edge, leaving the values of the vertical divisions *(Scale Div.)* and the overall vertical scale unchanged. Analogously, click *Min = Marker* to move the trace towards the lower diagram edge, or click *Ref Value = Marker* to move the trace towards the Reference Value.

Enlarging the Diagram Area

The analyzer provides different tools for customizing the contents and size of the diagram areas:

- *Maximize* allows you to enlarge the active diagram area to occupy the whole window. A double-click on any point in the diagram area is equivalent to the Maximize function.
- The *Title,* the *Softkey Labels,* the *Status Bar* and the *Front Panel Keys* are optional display elements which you can hide in order to gain space for the diagram.

Use the context menu of the diagram area, the keys in the DISPLAY keypad of the hardkey bar or the *Display* menu to access the scaling functions above.

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3 System Overview

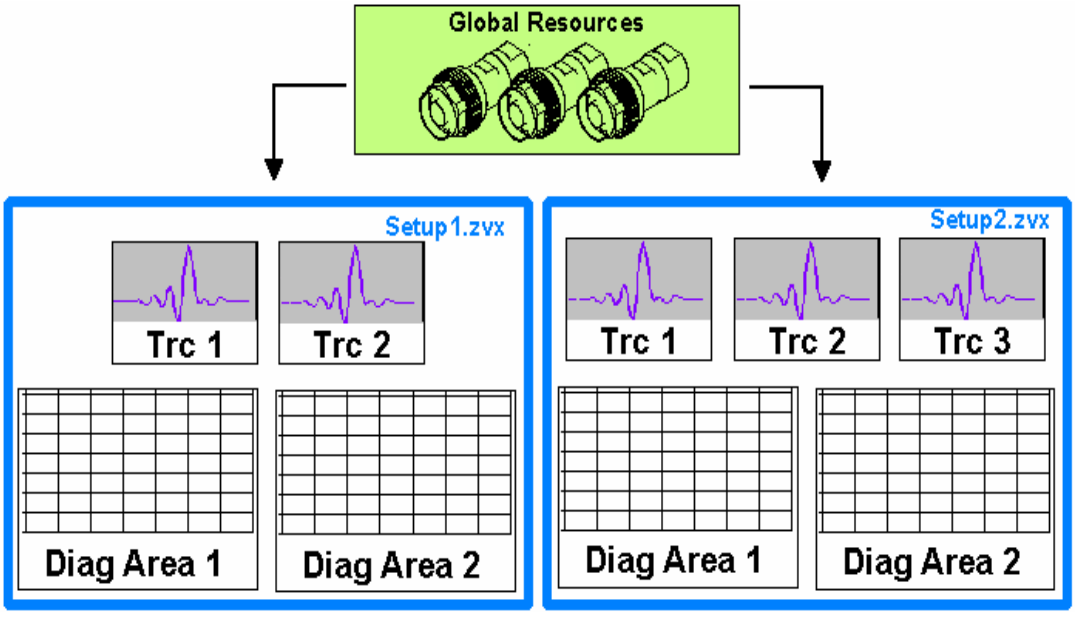
The following chapter provides an overview of the analyzer's capabilities and their use. This includes a description of the basic concepts that the analyzer uses to organize, process and display measurement data, of the screen contents, possible measured quantities, calibration methods and typical test setups.

For a systematic explanation of all menus, functions and parameters and background information refer to the reference description on the graphical user interface (*GUI Reference)* in the online help system.

Basic Concepts

The analyzer provides a variety of functions to perform a particular measurement and to customize and optimize the evaluation of results. To ensure that the instrument resources are easily accessible and that user-defined configurations can be conveniently implemented, stored and reused the instrument uses a hierarchy of structures:

- *Global resources* can be used for all measurements, irrespective of the current measurement session or setup.
- A *setup* comprises a set of *diagram areas* with all displayed information that can be stored to a setup file.
- The diagram areas show traces which are assigned to channels. See section *Traces, Channels and Diagram Areas*.



Global Resources

The analyzer provides global settings that are mostly hardware-related and can be used for all measurements, irrespective of the current measurement session or setup. The settings are stored in independent files and do not enter into any of the setup files. The following settings correspond to global resources:

- Calibration kits
- Adapter kits
- Connector types
- Cal pool
- Color schemes

The data related to global resources are not affected by a *Preset* of the analyzer. However, it is possible to delete or reset global resource data using the *Resets* tab in the *System Config* dialog.

Setups

A setup comprises a set of *diagram areas* with all displayed information that can be stored to a NWA setup file (*.zvx) and reused. Each setup is displayed in an independent window. The setup file contains the following information:

- General settings related to the setup
- The trace settings for all traces in the diagram areas
- The channel settings for all channels associated to the traces
- The display settings for each diagram area

The *File* menu is used to organize setups.

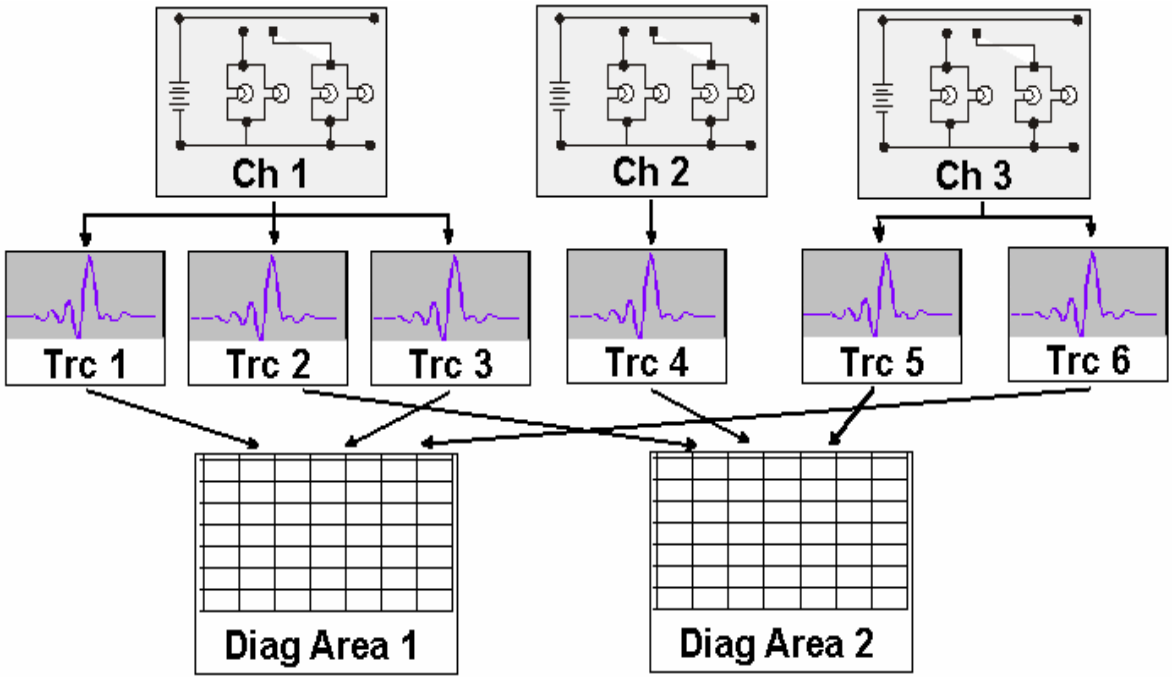
In the *System – External Tools* submenu, you can find demo setups *.vbs for various measurement scenarios. You can modify the demo setups and store them to a *.zvx file for later use. Moreover the *Measurement Wizard* provides predefined, optimized setup s for many measurements.

Traces, Channels and Diagram Areas

The analyzer arranges, displays or stores the measured data in *traces* which are assigned to *channels* and displayed in *diagram areas*. To understand the menu structure of the instrument and quickly find the appropriate settings, it is important to understand the exact meaning of the three terms.

- A trace is a set of data points that can be displayed together in a diagram area. The trace settings specify the mathematical operations used in order to obtain traces from the measured or stored data and to display them.
- A channel contains hardware-related settings to specify how the network analyzer collects data.
- A diagram area is a rectangular portion of the screen used to display traces. Diagram areas belonging to the same setup are arranged in a common window. The settings for diagram areas are described in section *Display Elements* in this chapter.

A diagram area can contain a practically unlimited number of traces, assigned to different channels. Diagram areas and channels are completely independent from each other.



Trace Settings

The trace settings specify the mathematical operations used in order to obtain traces from the measured or stored data. They can be divided into several main groups:

- Selection of the measured quantity (S-parameters, wave quantities, ratios, impedances,...)
- Conversion into the appropriate display format and selection of the diagram type
- Scaling of the diagram and selection of the traces associated to the same channel
- Readout and search of particular values on the trace by means of markers
- Limit check

The *Trace* menu provides all trace settings. They complement the definitions of the *Channel* menu. Each trace is assigned to a channel. The channel settings apply to all traces assigned to the channel.

Channel Settings

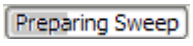
A channel contains hardware-related settings to specify how the network analyzer collects data. The channel settings can be divided into three main groups:

- Control of the measurement process *(Sweep, Trigger, Average)*
- Description of the test setup *(Power* of the internal source, IF filter *Bandwidth* and *Step Attenuators, Port Configuration)*
- Correction data (Calibration, Offset)

The *Channel* menu provides all channel settings.

NOTE

After changing the channel settings or selecting another measured quantity, the analyzer needs some time to initialize the new sweep. This preparation period increases with the number of points and the number of partial measurements involved. It is visualized by a Preparing Sweep symbol in the status bar:



All analyzer settings can still be changed during sweep initialization. If necessary, the analyzer terminates the current initialization and starts a new preparation period. During the first sweep after a change of the channel settings, an additional red asterisk symbol appears in the status bar:

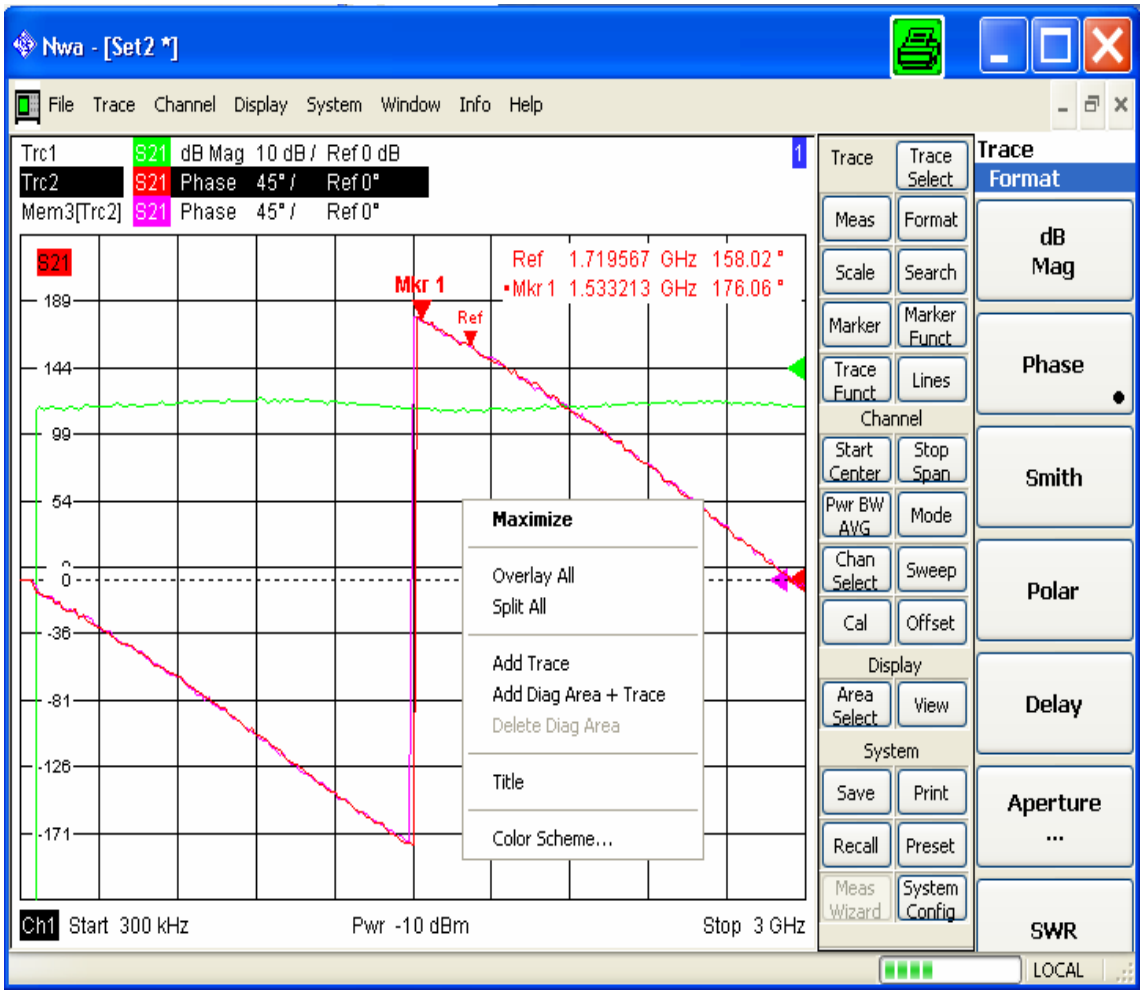
Screen Elements

This section describes the operating concept of the network analyzer, including the alternative navigation tools for mouse and hardkey operation, the trace settings, markers and diagram areas. For a description of the different quantities measured by the analyzer refer to the *Measured Quantities* section.

Navigation Tools of the Screen

The main window of the analyzer that you can display on an external monitor provides all control elements for the measurements and contains the diagram areas for the results. There are several alternative ways to access an instrument function:

- Using the menus and submenus of the menu bar (provides all settings)
- Using the softkeys of the softkey bar (alternative to the previous method)
- Using the hardkey bar (preselection of the most important menus)



Refer to section *Display Elements* to obtain information about the results in the diagram area.

Refer to section *Display Menu* in the reference chapter and learn how to customize the screen.

Menu Bar

All analyzer functions are arranged in drop-down menus. The menu bar is located across the top of the diagram area:

Menus can be controlled in different ways:

- With a mouse, like the menus in any Windows application. A left mouse click expands a menu or submenu. If a menu command has no submenu assigned, a left mouse click opens a dialog or directly activates the menu command.
- Using the hardkey bar (activated via *Display – Config./View)*.

The active menu is the menu containing the last executed command. If the softkey bar or hardkey bar is displayed *(Display – Config./View – Softkey Labels* on), then the active menu is indicated on top of the softkey/hardley bar.

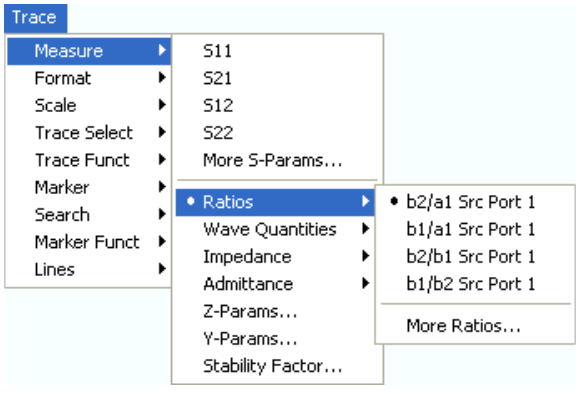
When you select a command in a new menu the softkey bar is updated to reflect the new active menu with all commands. You can continue operation using the softkeys.

Overview of menu functions

- The *Control* menu provide standard Windows functions to control windows.
- The *File* menu provides standard Windows functions to create, save, recall or print setups, to copy the current screen and to shut down the application.
- The *Trace* menu provides all trace settings and the functions to create, select, modify and store different traces. In addition the menu provides the marker, search and limit check functions.
- The *Channel* menu provides all channel settings and the functions to create, select, modify and store different channels.
- The *Display* menu provides all display settings and the functions to create, select, modify and arrange different diagram areas.
- The *System* menu provides functions to reverse operations, return to a defined instrument state, retrieve information on the instrument and access service functions. Besides, it configures the remote control operation, starts the *Measurement Wizard* and provides print options.
- The *Window* menu provides standard Windows™ functions to arrange different windows on the screen.
- The *Info* menu provides information and selftest options for service purposes and troubleshooting.
- The *Help* menu provides assistance with the network analyzer and its operation.

Menu Structure

All menus show an analogous structure.



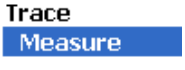
- A menu command with a right arrow ▶ expands a submenu with further related settings. **Example:** *Measure* ▶ expands a submenu to select the quantity to be measured and displayed.
- A menu command with three dots appended calls up a dialog providing several related settings.

  Example: *More S-Parameters...* opens a dialog to select S-parameters for multiport measurements or mixed mode S-parameters.
- A menu command with no arrow or dots directly initiates an action. **Example:** *S21* selects the forward transmission coefficient S_{21} as measured quantity.
- A dot preceding the menu command indicates the current selection in a list of alternative settings.
  Example: In the figure above, S_{21} is selected as measured quantity.

Softkey Bar

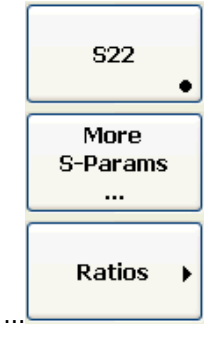
The softkey bar displays the commands of the active menu so that they can be activated by a mouse click. It consists of three elements:

Heading



The heading shows the two lowest level menu commands in the current branch of the menu tree. The lowest-level command appears on a shaded background.

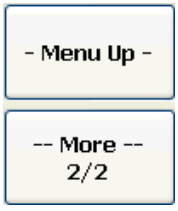
Function softkeys



Up to 8 softkeys, each corresponding to a command of the active menu. The function of the softkeys and their labels are strictly equivalent to the corresponding menu commands.

- A large dot in the lower right corner indicates the current selection in a list of alternative settings.
- Three dots indicate that the softkey calls up a dialog providing several related settings.
- A right arrow ▶ indicates a submenu with further related settings.
- A softkey with no arrow or dots directly initiates an action.

Navigation softkey (optional)



Softkey no. 8 or softkeys no. 7 and no. 8 are reserved for navigation:

- *More 1/2* and *More 2/2* toggle between two groups of softkeys which belong to the same menu. The softkeys are provided whenever the active menu contains more than 7 commands.
- *Menu Up* activates the higher-level menu and is provided in all menus except the top-level one listing the main menus in the menu bar.

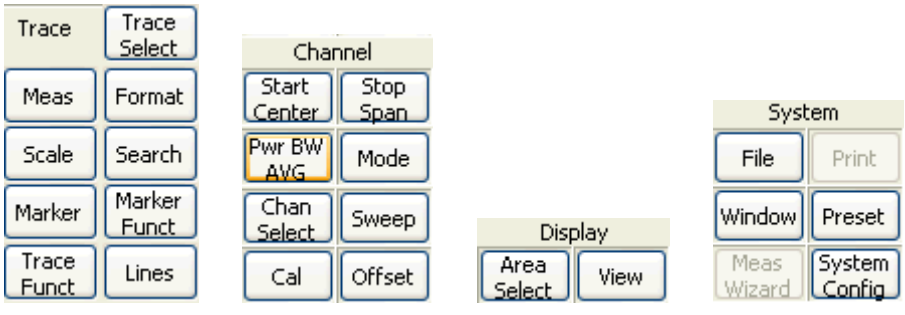
The softkey bar is automatically updated when the active menu is changed.

TIPS You can hide the softkey bar and gain screen space for the diagram areas if you use a mouse to control the analyzer (see *Diplay – Config./View*). All settings are accessible from the menus listed in the menu bar across the top of the screen.

Hardkey Bar

The hardkey bar (Display Config./View) provides shortcuts to the most commonly used submenus and menu commands. Clicking a hardkey symbol opens the corresponding submenu or executes a menu command.

The hardkey bar contains the TRACE, CHANNEL, DISPLAY and SYSTEM keypads:



TIPS The hardkey bar provides access to the basic groups of settings with a single mouse click. Alternatively the settings are accessible from the menus of the menu bar or from the softkey bar.

The hardkey bar is displayed by default but can be hidden *(Display Config./View)* to gain screen space for the diagram areas.

Status Bar

The status bar (*Diplay – Config./View)* describes the current channel (if the setup contains only one channel), the progress of the sweep and the control mode of the analyzer *(LOCAL* or *REMOTE)*.

During sweep initialization, the progress bar for the sweep is replaced by a Preparing Sweep symbol. During the first sweep after a change of the channel settings, an additional red asterisk symbol appears:

You can hide the status bar and gain screen space for the diagram areas.

Display Elements in the Diagram Area

The central part of the screen is occupied by one or several diagram areas.

Diagram Areas

A diagram area is a rectangular portion of the screen used to display traces. Diagram areas are arranged in windows; they are independent of trace and channel settings. A diagram area can contain a practically unlimited number of traces, assigned to different channels (overlay mode).

Diagram areas are controlled and configured by means of the functions in the *Display* menu and the following additional settings:

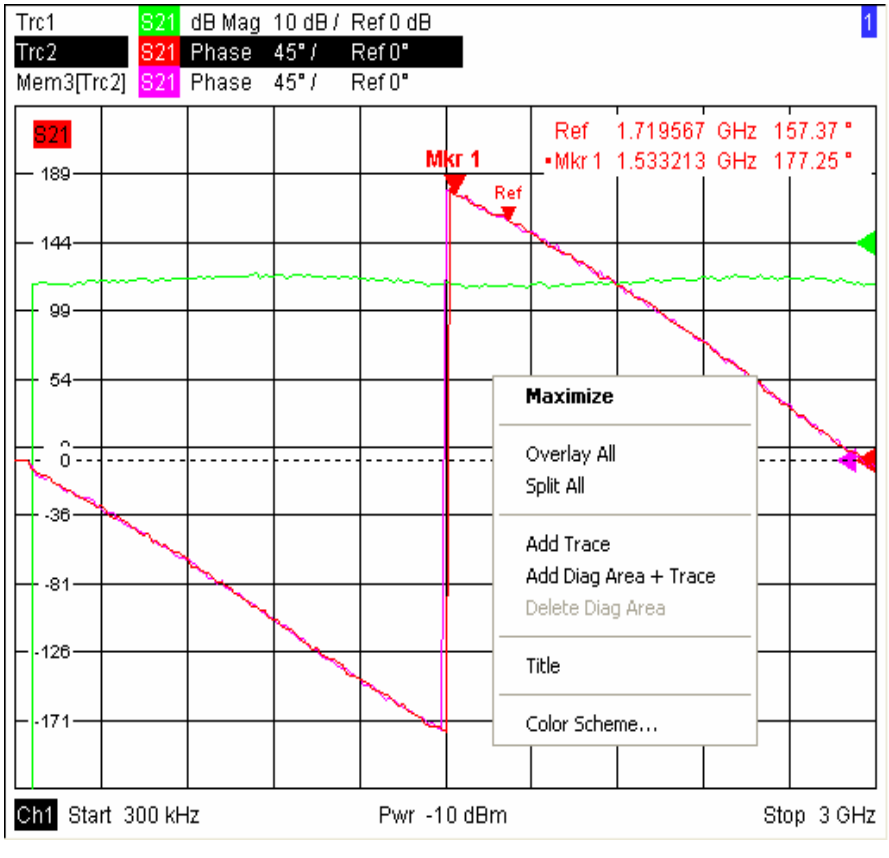
- The settings in the *Window* menu arrange several windows containing one or more diagram areas within the entire screen. Each window corresponds to a setup. Only one setup can be active at a time, and only the traces of the active setup are updated by the current measurements.
- Various settings to assign traces to diagram areas are provided in the *Trace – Traces* submenu.

Diagram areas may contain:

- Measurement results, in particular the traces and marker values
- An indication of the basic channel and trace settings
- Context menus providing settings related to the current screen

NOTE

The examples in this section have been taken from Cartesian diagrams. All other diagram types provide the same display elements.



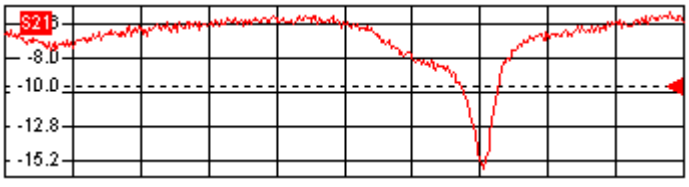
Title

Across the top of the diagram area, an optional title describes the contents of the area. Different areas within a setup are distinguished by area numbers in the upper right corner.

Use the context menu or the functions in the *Display* menu to display, hide or change the title and to add and customize diagram areas.

Traces

A trace is a set of data points displayed together in the diagram area. The individual data points are connected so that each trace forms a continuous line.



The trace can be complemented by the following display elements, plotted with the same color:

- ***Reference value*** (for all traces): The *Reference Value* is indicated with a triangle at the right edge of the diagram and a dashed, horizontal line. The value and position of the triangle can be changed in order to modify the diagram scale and shift the trace vertically.
- ***Measured quantity*** (for the active trace): The measured quantity is indicated in the left upper corner of the diagram.

A trace can be either a data trace, a memory trace, or a mathematical trace; see *Trace Types* below.

Context menu of the diagram area

A right mouse click on any point of the diagram area (except the marker info field and the measured quantity info) opens a context menu:

The settings correspond to the most common commands in the *Display – Area Select* and *Display – Config View* menus.

Trace Types

The analyzer uses traces to display the current measurement result in a diagram area but is also capable of storing traces to the memory, recalling stored traces, and defining mathematical relations between different traces. There are three basic trace types:

- **Data traces** show the current measurement data and are continuously updated as the measurement goes on. Data traces are dynamic traces.
- **Memory traces** are generated by storing the data trace to the memory. It represents the state of the data trace at the moment when it was stored. Memory traces are static traces which can be stored to a file and recalled.
- **Mathematical traces** are calculated according to a mathematical relation between constants and the data or memory traces of the active setup. A mathematical trace that is based on the active data trace is dynamic.

It is possible to generate an unlimited number of memory traces from a data trace and display them together, see *Data -> Mem*. Markers and marker functions are available for all trace types.

The trace type of each trace in a diagram area is indicated in the trace list. You can also make each trace *Invisible* without deleting it.

Trace List and Trace Settings

The main properties of all traces assigned to the diagram area are displayed in the trace list in the upper left corner.

Trc2	S21	dB Mag	40 dB /	Ref -200 dB	Ch1	Invisible
Trc3	S21	Phase	45° /	Ref 0°	Ch2	
Trc7	S21	dB Mag	10 dB /	Ref 0 dB	Ch2	Math
Mem8[Trc7]	S21	dB Mag	10 dB /	Ref 0 dB	Ch2	

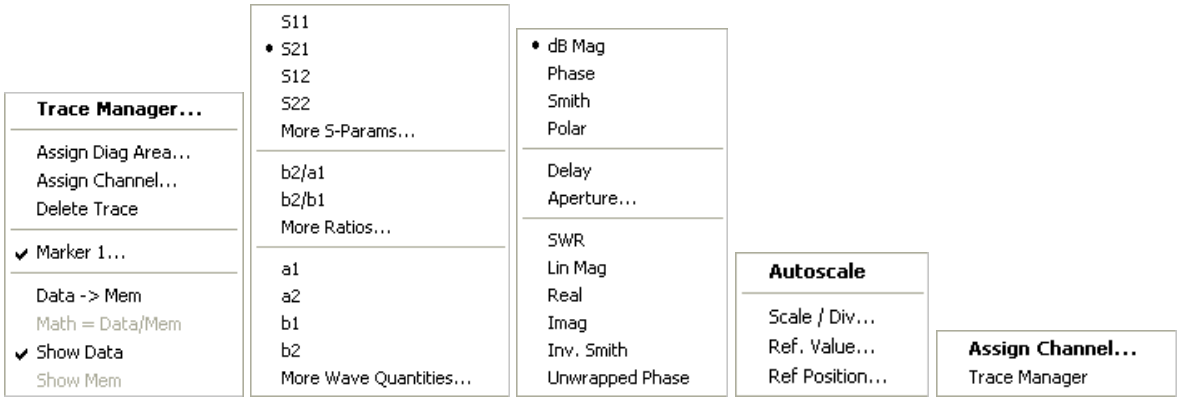
Each line in the trace list describes a single trace. The active trace is highlighted. The lines are divided into several sections with the following contents (from left to right):

- **Trace name** indicates the current trace name. The default names for new traces are Trc<n> where <n> is a current number. A *Mem...* preceding the trace name indicates a memory trace. Right-click the section and call the *Trace Manager* from the context menu to change the trace name.
- **Measured quantity** indicates the measured quantity, e.g. an S-parameter or a ratio. The measured quantity of the active trace is also displayed in the diagram area below the trace list.
- **Format** shows how the measured data is presented in the graphical display (trace format).
- **Scale** shows the value of the vertical or radial diagram divisions (Scale Div.) and the Reference Value.
- **Channel** shows the channel that each trace is assigned to. The channel section is omitted if the all traces in the diagram area are assigned to the same channel.
- **Type** shows *Invisible* if a trace is hidden and *Math* if the trace is a mathematical trace. Right-click the trace name and click *Show Data* or *Show Mem* from the context menu to display and hide data and memory traces. Use the *Trace Funct(ions)* to define mathematical traces.

Right-click any of the sections in the trace list (except *Type)* to open a context menu and access the most common tasks related to the section.

Context menus of the trace list

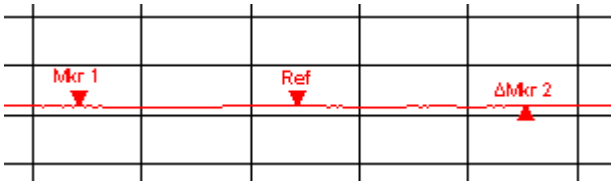
A right mouse click on the trace name, the measured quantity, and the format and scale section of the trace list opens the following context menus, respectively:



The settings correspond to the most common commands in the Trace – Trace Select, Trace – Trace Funct, Trace – Meas, Trace – Format and Trace – Scale menus.

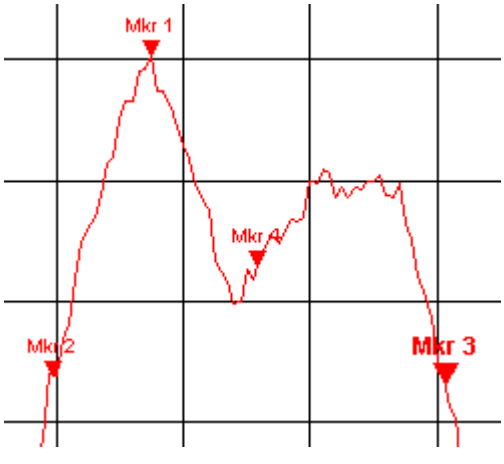
Markers

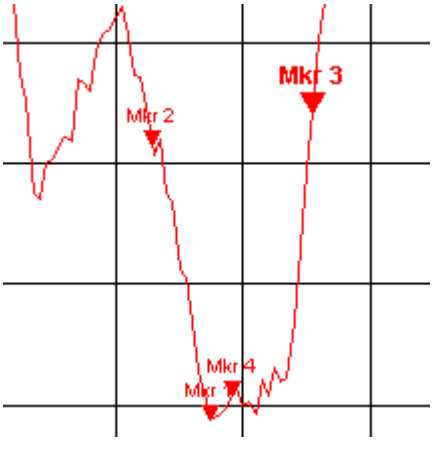
Markers are tools for selecting points on the trace and for numerical readout of measured data. The analyzer provides three different basic marker types.



- A (normal) marker *(Mkr 1, Mkr 2, ...)* determines the coordinates of a measurement point on the trace. Up to 10 different normal markers can be assigned to a trace.
- A reference marker *(Ref)* defines the reference value for all delta markers.
- A delta marker *(Δ)* indicates the coordinates relative to the reference marker.
- The stimulus value of a discrete marker always coincides with a sweep point so that the marker does not show interpolated measurement values.

The markers 1 to 4 are also used for bandfilter search mode. The examples below show a bandpass search and a bandstop search, respectively.

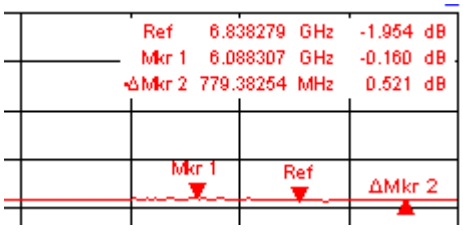




- *Mkr 1* indicates the maximum (minimum) of the peak.
- *Mkr 2* and *Mkr 3* indicate the lower and upper band edge where the trace value has decreased (increased) by a definite *Level* value.
- *Mkr 4* indicates the center of the peak, calculated as the arithmetic mean value of the *LBE* and *UBE* positions.

Marker Info Field

The coordinates of all markers defined in a diagram area are displayed in the info field, which by default is located in the upper right corner.



The list contains the following information:

- *Mkr 1, Mkr2,* ... denote the marker numbers.
- Markers are displayed with the same color as the associated trace.
- The marker coordinates are expressed in one of the marker formats selected via *Marker Format.* The formats of the markers assigned to a trace are independent of each other and of the trace format settings.
- The active marker has a dot placed in front of the marker line.
- A Δ sign placed in front of the marker line indicates that the marker is in *Delta Mode.*

Customizing the marker info field

To change the position, appearance or contents of the marker info field use one of the following methods:

- Double-click the info field to open the *Mkr Properties* dialog with extended settings for all markers of the active trace.
- Right-click the info field to open a context menu providing frequently used marker settings.
- To change the position of the marker info field, select *Movable Marker Info* from the context menu. Drag-and-drop the info field to any position in the active diagram area.
- To change the format of the active marker, select *Mkr Format.*
- To express the coordinates of the active marker relative to the reference marker, activate the *Delta Mode.*

For more information: Show Info Table

In addition to the marker info field, the analyzer provides an info table with extended marker information.

Marker	Trace	Stimulus	Response	Delta	Discr	Fixed	Tracking	Search Range
Ref	Trc1	3.440171000 GHz	-6.426 dB	☐	☑	☑	Off	Full Range
Mkr 1	Trc1	4.000150000 GHz	-5.364 dB	☐	☐	☐	Off	Full Range

The table is hidden by default. To display the table double-click the marker info field to open the *Marker Properties* dialog.

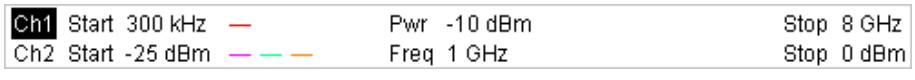
Context menu of the marker info field

A right mouse click on the marker info field opens a context menu:

Movable Marker Info allows the marker info field to be placed to any position in the diagram area. The remaining settings correspond to the most common commands in the *Trace – Marker* and *Trace – Search* menus.

Channel Settings

The main properties of all channels assigned to the traces in the diagram area are displayed in the channel list below the diagram.



Each line in the channel list describes a single channel. The channel of the active trace is highlighted. The lines are divided into several sections with the following contents (from left to right):

- **Channel name** indicates the current channel name. The default names for new channels are Ch<n> where <n> is a current number. Right-click the section and call the *Channel Manager* from the context menu to change the channel name.
- **Start value of the sweep** indicates the lowest value of the sweep variable (e.g. the lowest frequency measured), corresponding to the left edge of the Cartesian diagram.
- **Color legend** shows the display color of all traces assigned to the channel. The colors are different, so the number of colors is equal to the numbers of traces assigned to the channel.
- **Additional stimulus parameter** shows either the power of the internal signal source (for frequency sweeps and time sweeps) or the CW frequency (for power sweeps).
- **Stop value of the sweep** indicates the highest value of the sweep variable (e.g. the highest frequency measured), corresponding to the right edge of the Cartesian diagram.

Right-click any of the sections in the trace list (except *Color legend)* to open a context menu and access the most common tasks related to the section.

Context menus of the channel list

A right mouse click on the channel name, the sweep range, and the additional parameter section of the channel list opens the following context menus, respectively:

The settings correspond to the most common commands in the *Channel – Channel Select, Channel – Stimulus* and *Channel – Power Bandwidth Average* menus.

Context Menus

To provide access to the most common tasks and speed up the operation, the analyzer offers context menus (right-click menus) for the following display elements:

- Diagram area
- Marker info field
- Trace list (separate context menus for trace name section, measured quantity section, format section, scale section, and channel section)
- Channel list (separate context menus for channel name section, sweep range section, additional parameter section)

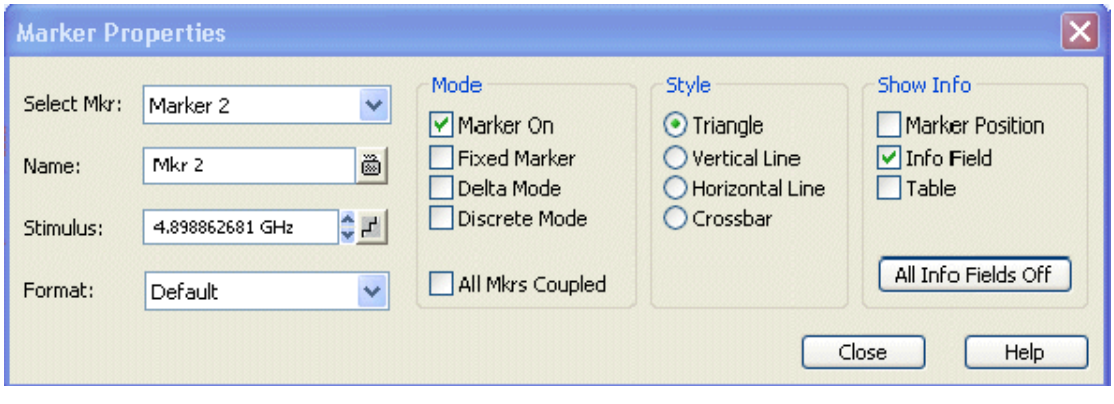
Working with context menus requires a mouse. Click inside the display element that you want to work with using the **right** mouse button.

Except from some particular screen configurations, anything you can do from a context menu you can also do from the menu bar or hardkey and softkey bar. Use whatever method is most convenient for you.

Dialogs

Dialogs provide groups of related settings and allow to make selections and enter data in an organized way. All softkeys with three dots behind their labeling (as in *Marker Properties...*) call up a dialog. The dialogs of the analyzer have an analogous structure and a number of common control elements.

The *Dialog Transparency* function in the *System Config* menu varies the transparency of all dialogs. With an appropriate setting, you can control the dialogs and at the same time view the underlying traces and display elements.



Immediate vs. Confirmed Settings

In some dialogs, the settings take effect immediately so that the effect on the measurement is observable while the dialog is still open. This is especially convenient when a numeric value is incremented or decremented, e.g. via the rotary knob.

In most dialogs, however, it is possible to cancel an erroneous input before it takes effect. The settings in such dialogs must be confirmed explicitly.

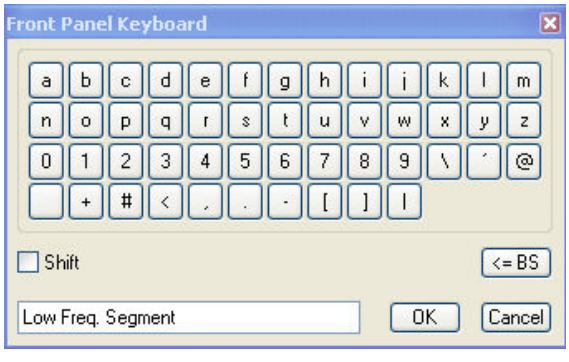
The two types of dialogs are easy to distinguish:

- Dialogs with immediate settings provide a *Close* button but no *OK* button. Example: *Step Size* dialog.
- Dialogs with confirmed settings provide both an OK button and a *Cancel* button. Example: On-screen keyboard.

You can also cancel an immediate setting using *System – Undo!*.

On-Screen Keyboard

A keyboard symbol next to a character input field opens the analyzer's on-screen keyboard.



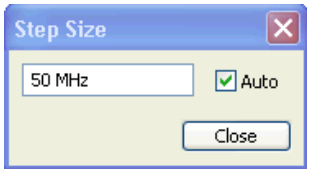
The on-screen keyboard contains two sets of characters plus the following additional controls:

- *Shift* changes between the two character sets containing lower case letters/numbers and upper case letters/special characters, respectively.
- *<= BS* deletes the current string in the alphanumeric input field.
- *OK* applies the current selection and closes the keyboard. The current string is written into the input field of the calling dialog. See also *Immediate vs. Confirmed Settings*.
- *Cancel* discards the current selection and closes the keyboard. The input field of the calling dialog is left unchanged.

The on-screen keyboard allows you to enter characters, in particular letters, without an external keyboard; see *Data Entry.* To enter numbers and units, you can also use the DATA ENTRY keys on the front panel of the instrument.

Step Size

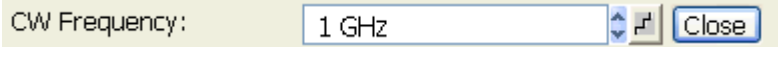
A step symbol next to a numeric input field opens the *Step Size* dialog to define an increment for data variation using the *Cursor Up/Down* buttons in the dialogs or the rotary knob.



- The input value for the step size takes effect immediately; see *Immediate vs. Confirmed Settings.*
- *Auto* activates the default step size for the current input parameter.
- *Close* closes the *Step Size* dialog.

Numeric Entry Bar

Single numeric values can be entered using the input field of the numeric entry bar. The numeric entry bar appears just below the menu bar as soon as a function implying a single numeric entry is activated. In contrast to dialogs, it does not hide any of the display elements in the diagram area.



The numeric entry bar contains the name of the calling function, a numeric input field including the Cursor Up/Down buttons for data variation and a step symbol, and a *Close* button. Besides it is closed automatically as soon as an active display element in the diagram area is clicked or a new menu command is activated.

Display Formats and Diagram Types

A display format defines how the set of (complex) measurement points is converted and displayed in a diagram. The display formats in the *Trace – Format* menu use the following basic diagram types:

- Cartesian (rectangular) diagrams are used for all display formats involving a conversion of the measurement data into a real (scalar) quantity, i.e. for *dB Mag, Phase, Delay, SWR, Lin Mag, Real, Imag* and *Unwrapped Phase.*
- Polar diagrams are used for the display format *Polar* and show a complex quantity as a vector in a single trace.
- Smith charts are used for the display format *Smith* and show a vector like polar diagrams but with grid lines of constant real and imaginary part of the impedance.
- Inverted Smith charts are used for the display format *Inverted Smith* and show a vector like polar diagrams but with grid lines of constant real and imaginary part of the admittance.

NOTE

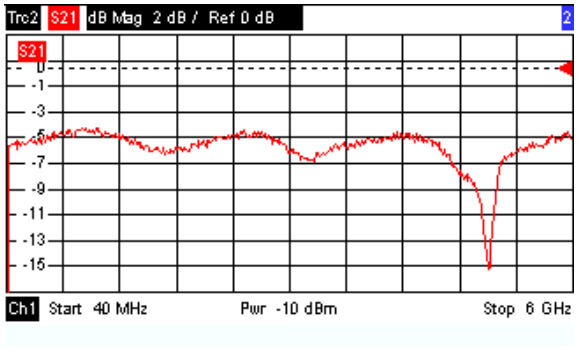
The analyzer allows arbitrary combinations of display formats and measured quantities (Trace – Measure). Nevertheless, in order to extract useful information from the data, it is important to select a display format which is appropriate to the analysis of a particular measured quantity; see Measured Quantities and Display Formats.

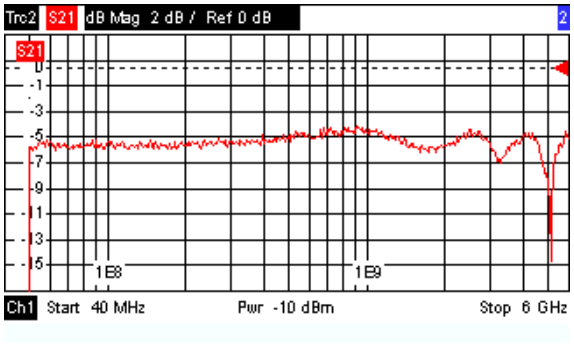
Cartesian Diagrams

Cartesian diagrams are rectangular diagrams used to display a scalar quantity as a function of the stimulus variable (frequency / power / time).

- The stimulus variable appears on the horizontal axis (x-axis), scaled linearly (sweep types *Lin Frequency, Power, Time, CW Mode)* or logarithmically (sweep type *Log Frequency)*.
- The measured data (response values) appears on the vertical axis (y-axis). The scale of the y-axis is linear with equidistant grid lines although the y-axis values may be obtained from the measured data by non-linear conversions.

The following examples show the same trace in Cartesian diagrams with linear and logarithmic x-axis scaling.





Conversion of Complex into Real Quantities

The results to be selected in the *Trace – Measure* menu can be divided into two groups:

- S-Parameters, Ratios, Wave Quantities, Impedances, Admittances, Z-Parameters and Y-Parameters are complex.
- *Stability Factors* and *DC Input* values (voltages, PAE) are real.

The following table shows how the response values in the different Cartesian diagrams are calculated from the complex measurement values z = x + jy (where x, y, z are functions of the sweep variable). The formulas also hold for real results, which are treated as complex values with zero imaginary part (y = 0).

Trace Format	Description	Formula
dB Mag	Magnitude of z in dB	$\lvert z\rvert = \mathrm{sqrt}\,(x^2 + y^2)$ dB Mag(z) = 20 * log|z| dB
Lin Mag	Magnitude of z, unconverted	$\lvert z\rvert = \mathrm{sqrt}\,(x^2 + y^2)$
Phase	Phase of z	$\phi(z) = \arctan(y/x)$
Real	Real part of z	Re(z) = x
Imag	Imaginary part of z	Im(z) = y
SWR	(Voltage) Standing Wave Ratio	SWR = (1 + |z|) / (1 – |z|)
Delay	Group delay, neg. derivative of the phase response	$-d\phi(z)/d\omega$ $(\omega = 2\pi * f)$

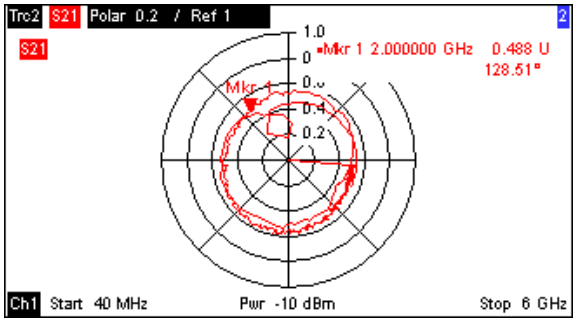
TIP An extended range of formats and conversion formulas is available for markers. To convert any point on a trace, create a marker and select the appropriate marker format. Marker and trace formats can be selected independently.

Polar Diagrams

Polar diagrams show the measured data (response values) in the complex plane with a horizontal real axis and a vertical imaginary axis. The grid lines correspond to points of equal magnitude and phase.

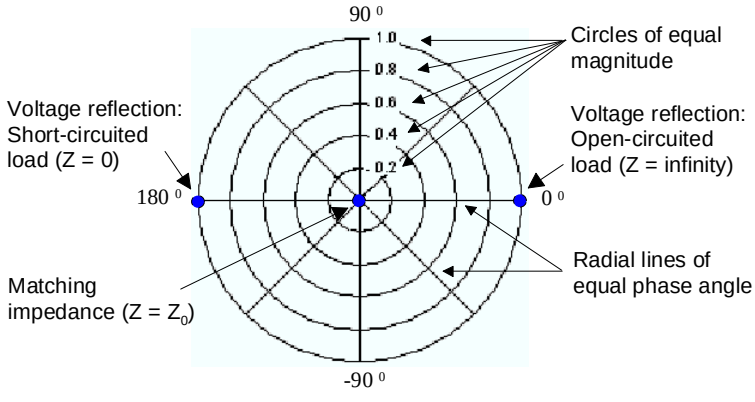
- The magnitude of the response values corresponds to their distance from the center. Values with the same magnitude are located on circles.
- The phase of the response values is given by the angle from the positive horizontal axis. Values with the same phase on straight lines originating at the center.

The following example shows a polar diagram with a marker used to display a pair of stimulus and response values.



Example: Reflection coefficients in polar diagrams

If the measured quantity is a complex reflection coefficient (S_{11}, S_{22} etc.), then the center of the polar diagram corresponds to a perfect load Z_0 at the input test port of the DUT (no reflection, matched input), whereas the outer circumference ($|S_{ii}| = 1$) represents a totally reflected signal.



Examples for definite magnitudes and phase angles:

- The magnitude of the reflection coefficient of an open circuit (Z = infinity, I = 0) is one, its phase is zero.
- The magnitude of the reflection coefficient of a short circuit (Z = 0, U = 0) is one, its phase is -180^0.

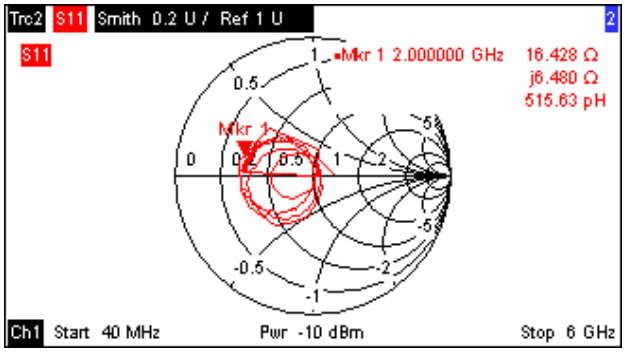
Smith Chart

The Smith chart is a circular diagram that maps the complex reflection coefficients S_{ii} to normalized impedance values. In contrast to the polar diagram, the scaling of the diagram is not linear. The grid lines correspond to points of constant resistance and reactance.

- Points with the same resistance are located on circles.

- Points with the same reactance produce arcs.

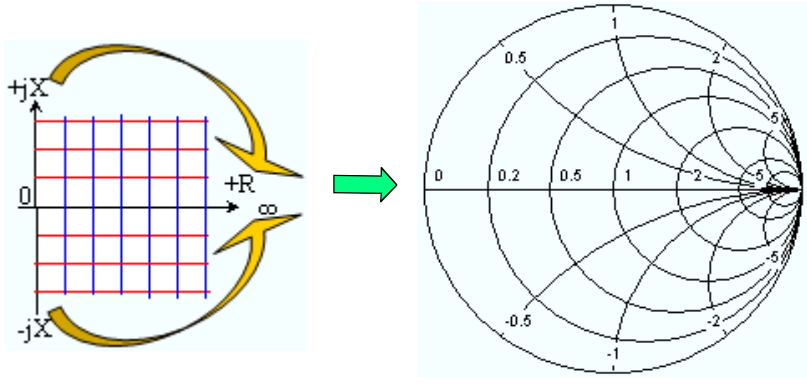
The following example shows a Smith chart with a marker used to display the stimulus value, the complex impedance Z = R + j X and the equivalent inductance L (see marker format description in the help system).



A comparison of the Smith chart, the inverted Smith chart and the polar diagram reveals many similarities between the two representations. In fact the shape of a trace does not change at all if the display format is switched from *Polar* to *Smith* or *Inverted Smith* – the analyzer simply replaces the underlying grid and the default marker format.

Smith chart construction

In a Smith chart, the impedance plane is reshaped so that the area with positive resistance is mapped into a unit circle.



The basic properties of the Smith chart follow from this construction:

- The central horizontal axis corresponds to zero reactance (real impedance). The center of the diagram represents $Z/Z_0 = 1$ which is the reference impedance of the system (zero reflection). At the left and right intersection points between the horizontal axis and the outer circle, the impedance is zero (short) and infinity (open).
- The outer circle corresponds to zero resistance (purely imaginary impedance). Points outside the outer circle indicate an active component.
- The upper and lower half of the diagram correspond to positive (inductive) and negative (capacitive) reactive components of the impedance, respectively.

Example: Reflection coefficients in the Smith chart

If the measured quantity is a complex reflection coefficient Γ (e.g. S_{11}, S_{22}), then the unit Smith chart can be used to read the normalized impedance of the DUT. The coordinates in the normalized impedance plane and in the reflection coefficient plane are related as follows (see also: definition of

matched-circuit (converted) impedances):

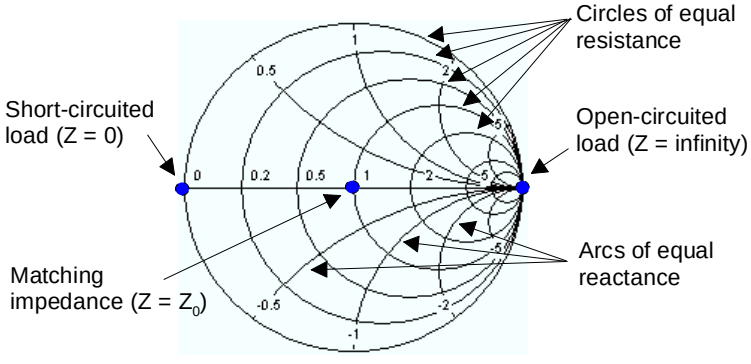
$Z / Z_0 = (1 + \Gamma) / (1 - \Gamma)$

From this equation it is easy to relate the real and imaginary components of the complex resistance to the real and imaginary parts of Γ

$$R = \mathrm{Re}(Z / Z_0) = \frac{1 - \mathrm{Re}(\Gamma)^2 - \mathrm{Im}(\Gamma)^2}{[1 - \mathrm{Re}(\Gamma)]^2 + \mathrm{Im}(\Gamma)^2}, \quad X = \mathrm{Im}(Z / Z_0) = \frac{2 \cdot \mathrm{Im}(\Gamma)}{[1 - \mathrm{Re}(\Gamma)]^2 + \mathrm{Im}(\Gamma)^2} \ ,$$

in order to deduce the following properties of the graphical representation in a Smith chart:

- Real reflection coefficients are mapped to real impedances (resistances).
- The center of the Γ plane ($\Gamma = 0$) is mapped to the reference impedance Z_0, whereas the circle with $|\Gamma| = 1$ is mapped to the imaginary axis of the Z plane.
- The circles for the points of equal resistance are centered on the real axis and intersect at Z = infinity. The arcs for the points of equal reactance also belong to circles intersecting at Z = infinity (open circuit point (1,0)), centered on a straight vertical line.



Examples for special points in the Smith chart:

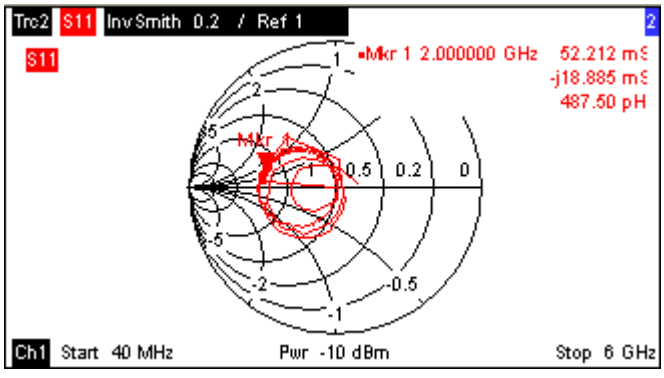
- The magnitude of the reflection coefficient of an open circuit (Z = infinity, I = 0) is one, its phase is zero.
- The magnitude of the reflection coefficient of a short circuit (Z = 0, U = 0) is one, its phase is -180^0.

Inverted Smith Chart

The inverted Smith chart is a circular diagram that maps the complex reflection coefficients S_{ii} to normalized admittance values. In contrast to the polar diagram, the scaling of the diagram is not linear. The grid lines correspond to points of constant conductance and susceptance.

- Points with the same conductance are located on circles.
- Points with the same susceptance produce arcs.

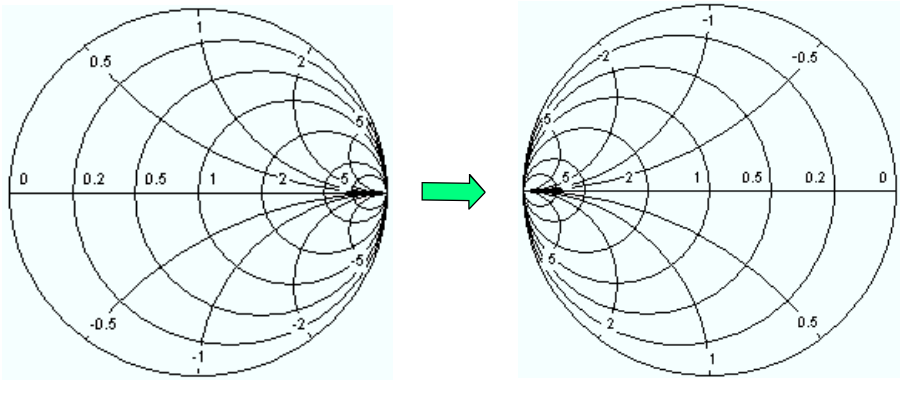
The following example shows an inverted Smith chart with a marker used to display the stimulus value, the complex admittance Y = G + j B and the equivalent inductance L (see marker format description in the help system).



A comparison of the inverted Smith chart with the Smith chart and the polar diagram reveals many similarities between the different representations. In fact the shape of a trace does not change at all if the display format is switched from *Polar* to *Inverted Smith* or *Smith* – the analyzer simply replaces the underlying grid and the default marker format.

Inverted Smith chart construction

The inverted Smith chart is point-symmetric to the Smith chart:



The basic properties of the inverted Smith chart follow from this construction:

- The central horizontal axis corresponds to zero susceptance (real admittance). The center of the diagram represents $Y/Y_0 = 1$, where Y_0 is the reference admittance of the system (zero reflection). At the left and right intersection points between the horizontal axis and the outer circle, the admittance is infinity (short) and zero (open).
- The outer circle corresponds to zero conductance (purely imaginary admittance). Points outside the outer circle indicate an active component.
- The upper and lower half of the diagram correspond to negative (inductive) and positive (capacitive) susceptive components of the admittance, respectively.

Example: Reflection coefficients in the inverted Smith chart

If the measured quantity is a complex reflection coefficient Γ (e.g. S_{11}, S_{22}), then the unit inverted Smith chart can be used to read the normalized admittance of the DUT. The coordinates in the normalized admittance plane and in the reflection coefficient plane are related as follows (see also: definition of matched-circuit (converted) admittances):

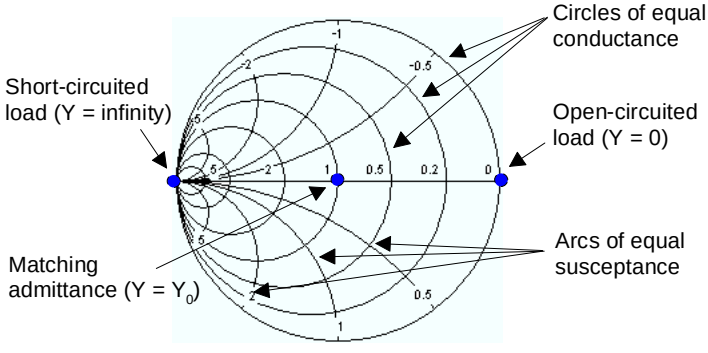
$$Y / Y_0 = (1 - \Gamma) / (1 + \Gamma)$$

From this equation it is easy to relate the real and imaginary components of the complex admittance to the real and imaginary parts of Γ

$$G = \mathrm{Re}(Y/Y_0) = \frac{1-\mathrm{Re}(\Gamma)^2 - \mathrm{Im}(\Gamma)^2}{[1+\mathrm{Re}(\Gamma)]^2 + \mathrm{Im}(\Gamma)^2}, \quad B = \mathrm{Im}(Y/Y_0) = \frac{-2\cdot\mathrm{Im}(\Gamma)}{[1+\mathrm{Re}(\Gamma)]^2 + \mathrm{Im}(\Gamma)^2} \ ,$$

in order to deduce the following properties of the graphical representation in an inverted Smith chart:

- Real reflection coefficients are mapped to real admittances (conductances).
- The center of the Γ plane (Γ = 0) is mapped to the reference admittance Y_0, whereas the circle with |Γ| = 1 is mapped to the imaginary axis of the Y plane.
- The circles for the points of equal conductance are centered on the real axis and intersect at Y = infinity. The arcs for the points of equal susceptance also belong to circles intersecting at Y = infinity (short circuit point (–1,0)), centered on a straight vertical line.



Examples for special points in the inverted Smith chart:

- The magnitude of the reflection coefficient of a short circuit (Y = infinity, U = 0) is one, its phase is -180^0.
- The magnitude of the reflection coefficient of an open circuit (Y = 0, I = 0) is one, its phase is zero.

Measured Quantities and Display Formats

The analyzer allows any combination of a display format and a measured quantity. The following rules can help to avoid inappropriate formats and find the format that is ideally suited to the measurement task.

- All formats are suitable for the analysis of reflection coefficients S_{ii}. The formats *SWR, Smith* and *Inverted Smith* lose their original meaning (standing wave ratio, normalized impedance or admittance) if they are used for transmission *S-parameters*, *Ratios* and other quantities.
- The complex *Impedances, Admittances, Z-parameters,* and *Y-parameters* are generally displayed in one of the Cartesian diagrams with linear vertical axis scale or in a polar diagram.
- The real *Stability Factors, DC Inputs,* and the *PAE* is generally displayed in a linear Cartesian diagram *(Lin Mag* or *Real).* In complex formats, real numbers represent complex numbers with zero imaginary part.

The following table gives an overview of recommended display formats.

	Complex dimensionless quantities: S-parameters and ratios	**Complex quantities with dimensions: Wave quantities, Z-parameters, Y-pParameters, impedances, admittances**	**Real quantities: Stability factors, DC input 1/2, PAE**
Lin Mag	☑	☑ (default for Z-parameters, Y-parameters, impedances, admittances)	☑ (default)
dB Mag	☑ (default)	☑ (default for wave quantities)	–
Phase	☑	☑	–
Real	☑	☑	☑
Imag	☑	☑	–
Unwrapped Phase	☑	☑	–
Smith	☑ (reflection coefficients S_{ii})	–	–
Polar	☑	–	–
Inverted Smith	☑ (reflection coefficients S_{ii})	–	–
SWR	☑ (reflection coefficients S_{ii})	–	–
Delay	☑ (transmission coefficients S_{ij})	–	–

The default formats are activated automatically when the measured quantity is changed.

Measured Quantities

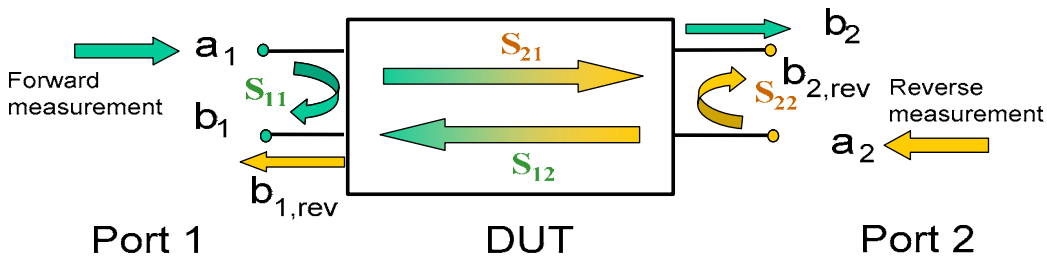
This section gives an overview of the measurement results of the network analyzer and the meaning of the different measured quantities. All quantities can be selected in the *Trace – Meas.* submenu.

NOTE

The definitions in this and the following sections apply to general n-port DUTs. An analyzer with a smaller number of test ports provides a subset of the n-port quantities.

S-Parameters

S-parameters are the basic measured quantities of a network analyzer. They describe how the DUT modifies a signal that is transmitted or reflected in forward or reverse direction. For a 2-port measurement the signal flow is as follows:



Extensions to the signal flow

The figure above is sufficient for the definition of S-parameters but does not necessarily show the complete signal flow. In fact, if the source and load ports are not ideally matched, part of the transmitted waves are reflected off the receiver ports so that an additional a_2 contribution occurs in forward measurements, an a_1 contribution occurs in reverse measurements. The 7-term calibration types Txx take these additional contributions into account.

The scattering matrix links the incident waves a_1, a_2 to the outgoing waves b_1, b_2 according to the following linear equation:

$$\begin{bmatrix} \mathbf{b_1} \\ \mathbf{b_2} \end{bmatrix} = \begin{bmatrix} \mathbf{S_{11}} & \mathbf{S_{12}} \\ \mathbf{S_{21}} & \mathbf{S_{22}} \end{bmatrix} * \begin{bmatrix} \mathbf{a_1} \\ \mathbf{a_2} \end{bmatrix}$$

The equation shows that the S-parameters are expressed as $S_{<out><in>}$, where <out> and <in> denote the output and input port numbers of the DUT.

Meaning of 2-port S-parameters

The four 2-port S-parameters can be interpreted as follows:

- S_{11} isthe input reflection coefficient, defined as the ratio of the wave quantities b_1/a_1, measured at PORT 1 (forward measurement with matched output and $a_2 = 0$).
- S_{21} is the forward transmission coefficient, defined as the ratio of the wave quantities b_2/a_1 (forward measurement with matched output and $a_2 = 0$).
- S_{12} is the reverse transmission coefficient, defined as the ratio of the wave quantities b_1 (reverse measurement with matched input, $b_{1,rev}$ in the figure above and $a_1 = 0$) to a_2.
- S_{22} is the output reflection coefficient, defined as the ratio of the wave quantities b_2 (reverse

measurement with matched input, $b_{2,rev}$ in the figure above and $a_1 = 0$) to a_2, measured at PORT 2.

Meaning of squared amplitudes

The squared amplitudes of the incident and outgoing waves and of the matrix elements have a simple meaning:

$\|a1\|^2$	Available incident power at the input of a two-port (= the power provided by a generator with a source impedance equal to the reference impedance Z_0)
$\|a2\|^2$	Available incident power at the output
$\|b1\|^2$	Reflected power at the input of a two-port
$\|b2\|^2$	Reflected power at the output
$10*\log\|S_{11}\|^2$ (= $20*\log\|S_{11}\|$)	Reflection loss at the input
$10*\log\|S_{22}\|^2$	Reflection loss at the output
$10*\log\|S_{21}\|^2$	Insertion loss at the input
$10*\log\|S_{12}\|^2$	Insertion loss at the output

Multiport Parameters

The multiport S-parameters extend the standard 2-port S-parameters to a larger number of incoming and outgoing waves. For a 4-port DUT,

$$\begin{bmatrix} \mathbf{b}_1 \\ \mathbf{b}_2 \\ \mathbf{b}_3 \\ \mathbf{b}_4 \end{bmatrix} = \begin{bmatrix} \mathbf{S}_{11} & \mathbf{S}_{12} & \mathbf{S}_{13} & \mathbf{S}_{14} \\ \mathbf{S}_{21} & \mathbf{S}_{22} & \mathbf{S}_{23} & \mathbf{S}_{24} \\ \mathbf{S}_{31} & \mathbf{S}_{32} & \mathbf{S}_{33} & \mathbf{S}_{34} \\ \mathbf{S}_{41} & \mathbf{S}_{42} & \mathbf{S}_{43} & \mathbf{S}_{44} \end{bmatrix} * \begin{bmatrix} \mathbf{a}_1 \\ \mathbf{a}_2 \\ \mathbf{a}_3 \\ \mathbf{a}_4 \end{bmatrix},$$

where again a_i (i = 1 to 4) denote the incident, b_i (i = 1 to 4) denote the outgoing waves, and the S-parameters are expressed as $S_{<out><in>}$.

The indices of the S-parameters described so far number the output and input ports of a DUT; the parameters are referred to as single-ended S-parameters. The S-parameter description can also be used to differentiate between different propagation modes of the waves at the output and input ports. This results in the so-called mixed mode S-parameters. The analyzer measures either single-ended or mixed mode S-parameters.

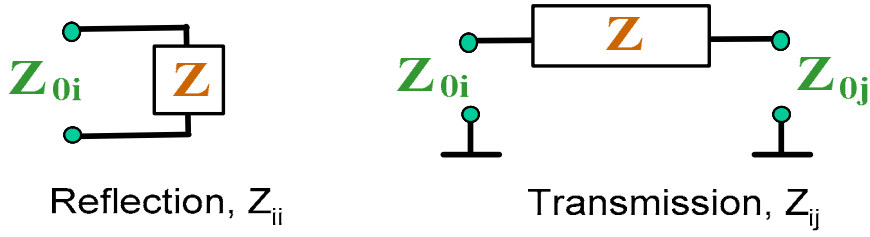
Impedance Parameters

An impedance is the complex ratio between a voltage and a current. The analyzer provides two independent sets of impedance parameters, essentially based on different n-port circuit models:

- Matched-circuit impedances, converted from reflection S-parameters
- Open-circuit Z-parameters

Converted Impedances

The converted, matched-circuit impedances describe the impedances of a DUT that is terminated at its outputs with the reference impedance Z_{0i} displayed in the *Port Configuration* dialog. i numbers the analyzer/DUT port.



The analyzer converts the measured S-parameters to determine the matched-circuit impedances.

Relation with S-parameters

It is possible to express the matched-circuit impedances Z_{ii} in terms of the reflection S-parameters S_{ii} and vice versa. The reflection parameters are calculated according to:

$$Z_{ii} = Z_{0i} \frac{1+S_{ii}}{1-S_{ii}} ,$$

where i numbers the analyzer/DUT port. The transmission parameters are calculated according to:

$$Z_{ij} = 2 \cdot \frac{\sqrt{Z_{0i} \cdot Z_{0j}}}{S_{ij}} - \left(Z_{0i} + Z_{0j}\right), \quad i \neq j ,$$

The two sets of reflection S-parameters and input/output impedances provide equivalent descriptions of the reflection in a linear n-port network. Another set of equivalent parameters is given by the matched-circuit admittances, defined as the inverse of the impedances.

Examples:

- Z_{11} is the input impedance of a 2-port DUT that is terminated at its output with the reference impedance Z_0 (matched -circuit impedance measured in a forward reflection measurement).
- The extension of the impedances to more ports and mixed mode measurements is analogous to S-parameters. Z_{dd44} is the differential mode input impedance at port 4 of a DUT that is terminated at its other ports with the reference impedance Z_0. See *More Impedances* for detailed information.

TIP You can also read the converted impedances in a reflection coefficient measurement from the Smith chart.

Z-Parameters

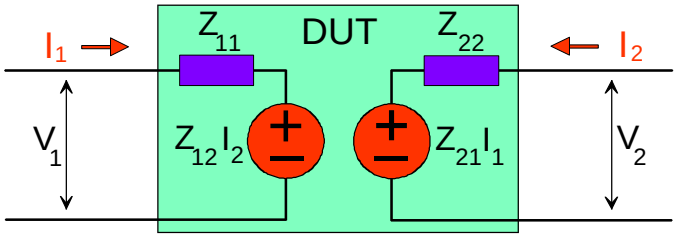
The Z-parameters describe the impedances of a DUT with open output ports (I = 0). The analyzer provides the full set of open-circuit impedances including the transfer impedances (i.e. the complete nxn Z-matrix for an n port DUT).

This means that Z-parameters can be used as an alternative to S-parameters (or Y-parameters) in order to completely characterize a linear n-port network.

2-Port Open-Circuit Z-Parameters

In analogy to S-parameters, Z-parameters are expressed as $Z_{<out><in>}$, where <out> and <in> denote the output and input port numbers of the DUT.

The open-circuit Z-parameters for a two-port are based on a circuit model that can be expressed with two linear equations:



$$V_1 = Z_{11} I_1 + Z_{12} I_2$$
$$V_2 = Z_{21} I_1 + Z_{22} I_2$$

Meaning of Z-parameters

The four 2-port open-circuit Z-parameters can be interpreted as follows:

- Z_{11} is the input impedance, defined as the ratio of the voltage V_1 to the current I_1, measured at port 1 (forward measurement with open output, $I_2 = 0$).
- Z_{21} is the forward transfer impedance, defined as the ratio of the voltage V_2 to the current I_1 (forward measurement with open output, $I_2 = 0$).
- Z_{12} is the reverse transfer impedance, defined as the ratio of the voltage V_1 to the current I_2 (reverse measurement with open input, $I_1 = 0$).
- Z_{22} is the output impedance, defined as the ratio of the voltage V_2 to the current I_2, measured at port 2 (reverse measurement with open input, $I_1 = 0$).

Z-parameters can be easily extended to describe circuits with more than two ports or several modes of propagation.

Admittance Parameters

An admittance is the complex ratio between a current and a voltage. The analyzer provides two independent sets of admittance parameters, essentially based on different n-port circuit models:

- Matched-circuit admittances, converted from S-parameters
- Short-circuit Y-parameters

Converted Admittances

The converted (matched-circuit) admittances describe the admittances of a DUT that is terminated at its outputs with the reference impedance values Z_{0i} displayed in the *Port Configuration* dialog. i numbers the analyzer/DUT port. The analyzer converts the measured S-parameters to determine the matched-circuit admittances. The converted admittances are the inverse of the converted impedances. The reflection parameters are calculated according to:

$$Y_{ii} = \frac{1}{Z_{0i}} \frac{1 - S_{ii}}{1 + S_{ii}} = 1 / Z_{ii} \ ,$$

where i numbers the analyzer/DUT port. The transmission parameters are calculated according to:

$$Y_{ij} = \frac{S_{ij}}{2 \cdot \sqrt{Z_{0i} \cdot Z_{0j}} - S_{ij} \cdot \left(Z_{0i} + Z_{0j}\right)} = 1 / Z_{ij}, \quad i \neq j, \quad i, j = 1, \ldots, 99$$

Examples:

- Y_{11} is the input admittance of a 2-port DUT that is terminated at its output with the reference impedance Z_0 (matched -circuit admittance measured in a forward reflection measurement).
- The extension of the admittances to more ports and mixed mode measurements is analogous to S-parameters. Y_{dd44} is the differential mode input admittance at port 4 of a DUT that is terminated at its other ports with the reference impedance Z_0. See *More Admittances* for detailed information.

You can also read the converted admittances in a reflection coefficient measurement from the inverted Smith chart.

Y-Parameters

The Y-parameters describe the admittances of a DUT with output ports terminated in a short circuit (V = 0). The analyzer provides the full set of short-circuit admittances including the transfer admittances (i.e. the complete n x n Y-matrix for an n port DUT).

This means that Y-parameters can be used as an alternative to S-parameters (or Z-parameters) in order to completely characterize a linear n-port network.

2-Port Short-Circuit Y-Parameters

In analogy to S-parameters, Y-parameters are expressed as $Y_{<out><in>}$, where <out> and <in> denote the output and input port numbers of the DUT.

In analogy to open-circuit Z-parameters, the short-circuit Y-parameters for a two-port are based on a circuit model that can be expressed with two linear equations:

$$I_1 = Y_{11}V_1 + Y_{12}V_2$$
$$I_2 = Y_{21}V_1 + Y_{22}V_2$$

Meaning of Y-parameters

The four 2-port Y-parameters can be interpreted as follows:

- Y_{11} is the input admittance, defined as the ratio of the current I_1 to the voltage V_1, measured at port 1 (forward measurement with output terminated in a short circuit, $V_2 = 0$).
- Y_{21} is the forward transfer admittance, defined as the ratio of the current I_2 to the voltage V_1 (forward measurement with output terminated in a short circuit, $V_2 = 0$).
- Y_{12} is the reverse transfer admittance, defined as the ratio of the current I_1 to the voltage V_2 (reverse measurement with input terminated in a short circuit, $V_1 = 0$).
- Y_{22} is the output admittance, defined as the ratio of the current I_2 to the voltage V_2, measured at port 2 (reverse measurement with input terminated in a short circuit, $V_1 = 0$).

Y-parameters can be easily extended to describe circuits with more than two ports or several modes of propagation.

Wave Quantities and Ratios

The elements of the S-, Z- and Y-matrices represent fixed ratios of complex wave amplitudes. As long as the assumption of linearity holds, the S-, Z- and Y-parameters are independent of the source power.

The network analyzer provides two additional sets of measurement parameters which have a unambiguous meaning even if the DUT is measured outside its linear range:

- *Wave Quantities* provide the power of any of the transmitted or received waves.
- *Ratios* provide the complex ratio of any combination of transmitted or received wave amplitudes.

NOTE

In contrast to S-, Z- and Y-parameters, wave quantities and ratios are not system-error corrected.

Wave Quantities

A wave quantity measurement provides the power of any of the transmitted or received waves. The power can be displayed in voltage (e.g. V or dBmV) or equivalent power units (e.g. W or dBm).

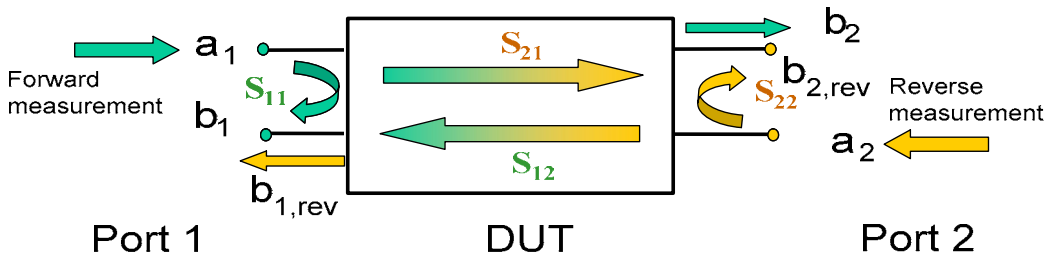
TIP

Examples for using wave quantities

The wave quantities provide the power at the different receive ports of the analyzer. This is different from an S-parameter measurement, where the absolute power of a linear device is cancelled. Wave quantities are therefore suitable for the following measurement tasks:

- Analysis of non-linearities of the DUT.
- Use of the analyzer as a selective power meter.

The notation for wave quantities includes the direction and the test port number. Additionally, the source port must be specified. The letter a indicates a transmitted wave, b a received wave.



Examples:

- *a1 Src Port 1* is the outgoing wave at test port 1. In a standard S-parameter measurement, this wave is fed to the input port (port 1) of the DUT (forward measurement).
- *b1 Src Port 1* is the incoming wave at test port 1. In a standard S-parameter measurement, this is the reflected wave at port 1 of the DUT (forward measurement).
-

Ratios

A ratio measurement provides the complex ratio of any combination of transmitted or received wave amplitudes. Ratios complement the S-parameter measurements, where only ratios of the form b_i/a_j (ratio of the incoming wave to the outgoing wave at the test ports i and j of the DUT) are considered.

Examples for using ratios

A measurement of ratios is particularly suitable for the following test scenarios:

- The test setup or some of its components (e.g. active components or non-reciprocal devices) do not allow a system error correction so that a complete S-parameter measurement is not possible.
- The test setup contains frequency-converting components so that the transmitted and the received waves are at different frequencies.
- A ratio of two arbitrary waves that is not an element of the S-matrix (e.g. a ratio of the form a_i/a_j) is needed.

The notation for ratios includes the two waves with their directions and test port numbers. Additionally, the source port must be specified. In analogy to wave quantities, the letter a indicates an outgoing wave, b an incoming wave.

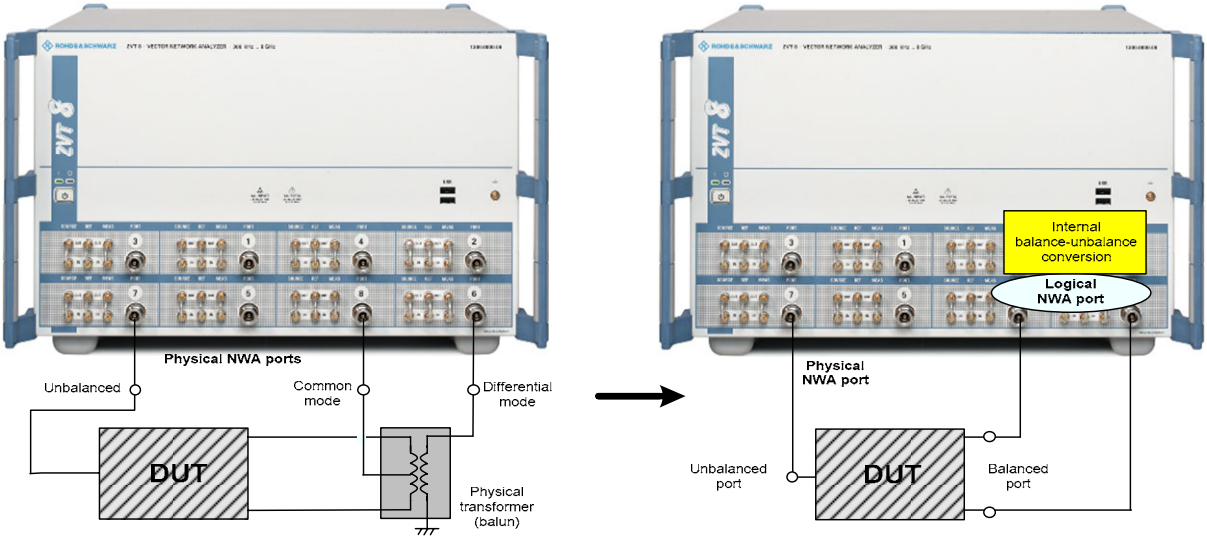
Examples:

- *b2/a1 Src Port 1* is the ratio of the incoming wave at port 2 and the outgoing wave at port 1 b_2 and a_1 and corresponds to the S-parameter S_{21} (forward transmission coefficient).
- *b1/a1 Src Port 1* is the ratio of the wave quantities b_1 and a_1, measured at PORT 1, and corresponds to the S-parameter S_{11} (input reflection coefficient).

Balance - Unbalance Conversion

Balance-unbalance conversion is the simulation of one or more balance-unbalance transformers (baluns) integrated in the measurement circuit in order to convert the DUT ports from an unbalanced state into a balanced state and virtually separate the differential and common mode signals. The analyzer measures the unbalanced state but converts the results and calculates mixed mode parameters, e.g. mixed mode S-parameters. No physical transformer is needed.

To perform balanced measurements, a pair of physical analyzer ports is combined to form a *logical port.* The balanced port of the DUT is directly connected to the analyzer ports



Balance-unbalance conversion avoids the disadvantages of real transformers:

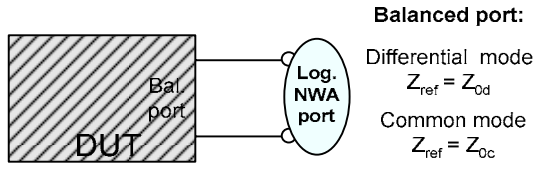
- There is no need to fabricate test fixtures with integrated baluns for each type of DUT.
- The measurement is not impaired by the non-ideal characteristics of the balun (e.g. error tolerances, limited frequency range).

- Calibration can be performed at the DUT's ports. If necessary (e.g. to compensate for the effect of a test fixture), it is possible to shift the calibration plane using length offset parameters.
- Differential and common mode parameters can be evaluated with a single test setup.

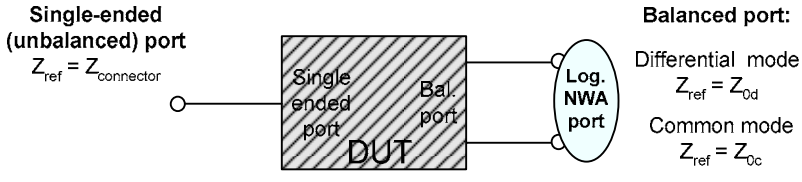
Balanced Port Configurations

Defining a logical ports requires two physical analyzer ports. The ports of an analyzer are equivalent and can be freely combined. Moreover, it is possible to assign arbitrary, independent reference impedance values to each unbalanced port and to the differential and common mode of each logical port. The following types of balanced devices can be measured with 2-port, 3-port and 4-port analyzers:

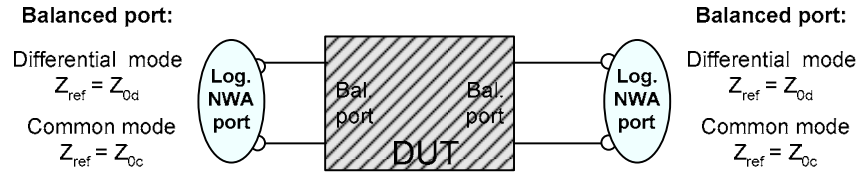
2-port analyzers: Reflection measurements on 1 balanced port

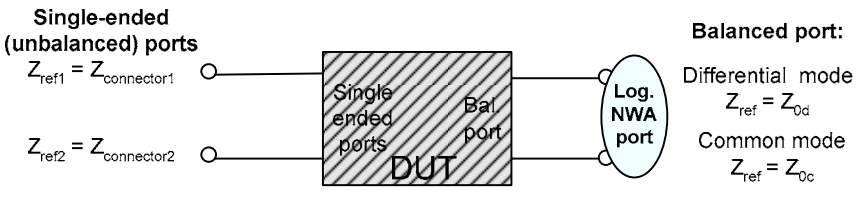


- **3-port analyzers:** Reflection and transmission measurements on 1 balanced port



- **4-port analyzers:** Reflection and transmission measurements on 1 or 2 balanced ports





A balanced port configuration is defined by simply selecting the pairs of physical ports that are combined to form balanced ports and defining the two reference impedances for the differential and common mode at each balanced port. All this is done in a single dialog; refer to the help system for details and measurement examples. The most commonly used balanced port configurations and impedances are predefined and can be selected in the *Measurement Wizard.*

Depending on the test setup, the analyzer provides different types of mixed mode parameters; refer to the following sections for details.

Mixed Mode Parameters

Mixed mode parameters are an extension of normal mode parameters (e.g. S-parameters, impedances and admittances) for balanced measurements. The analyzer can measure mixed mode parameters as soon as a balanced port configuration is selected.

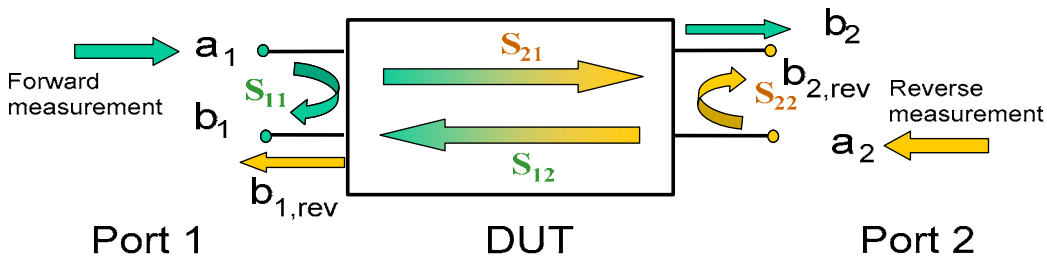
Mixed mode parameters are used to distinguish the following three port modes:

- s: Singe-ended (for unbalanced ports)
- d: Differential mode (for balanced ports)
- c: Common mode (for balanced ports)

The notation of a general S-parameter is $S_{<mout><min><out><in>}$, where <mout> and <min> denote the output and input port modes, <out> and <in> denote the output and input port numbers.

Meaning of 2-port mixed mode S-parameters

The mixed mode 2-port S-parameters can be interpreted as follows:



- $S_{<mout><min>11}$ is the mixed mode input reflection coefficient, defined as the ratio of the wave quantities b_1 (mode mout) to a_1 (mode min), measured at PORT 1 (forward measurement with matched output and $a_2 = 0$).
- $S_{<mout><min>21}$ is the mixed mode forward transmission coefficient, defined as the ratio of the wave quantities b_2 (mode mout) to a_1 (mode min) (forward measurement with matched output and $a_2 = 0$).
- $S_{<mout><min>12}$ is the mixed mode reverse transmission coefficient, defined as the ratio of the wave quantities b_1 (mode mout) (reverse measurement with matched input, b_1' in the figure above and $a_1 = 0$) to a_2 (mode min).
- $S_{<mout><min>22}$ is the mixed mode output reflection coefficient, defined as the ratio of the wave quantities b_2 (mode mout) (reverse measurement with matched input, b_2' in the figure above and $a_1 = 0$) to a_2 (mode min), measured at PORT 2.

If <mout> is different from <min>, the S-parameters are called mode conversion factors.

Mixed Mode Parameters for Different Test Setups

The mixed mode parameter types available depend on the measured device and the port configuration of the analyzer. The following examples of mixed more parameters can all be obtained with a 4-port analyzer.

1. DUT with only single-ended ports: No balanced port definition necessary, the analyzer provides single-ended multiport parameters.
2. DUT with one balanced port: Only reflection and mode conversion measurements with differential and common mode parameters.

$$\begin{array}{lc} & \begin{array}{cc} \text{Diff. mode stimulus} & \text{Comm. mode stimulus} \\ \downarrow & \downarrow \end{array} \\ \begin{array}{l} \text{Differential mode response} \rightarrow \\ \text{Common mode response} \rightarrow \end{array} & \begin{bmatrix} S_{dd11} & S_{dc11} \\ S_{cd11} & S_{cc11} \end{bmatrix} \end{array}$$

3. DUT with one balanced and one single-ended port.

$$\begin{array}{lc} & \begin{array}{ccc} \text{Single ended stimulus} & \text{Diff. mode stimulus} & \text{Comm. mode stimulus} \\ \downarrow & \downarrow & \downarrow \end{array} \\ \begin{array}{l} \text{Single-ended response} \rightarrow \\ \text{Differential mode response} \rightarrow \\ \text{Common mode response} \rightarrow \end{array} & \begin{bmatrix} S_{ss22} & S_{sd12} & S_{sc12} \\ S_{ds21} & S_{dd11} & S_{dc11} \\ S_{cs21} & S_{cd11} & S_{cc11} \end{bmatrix} \end{array}$$

4. DUT with two balanced ports or one balanced and two single-ended ports. Both device types are fully characterized by 4x4 mixed mode S-matrices.

Calibration Overview

Calibration is the process of eliminating systematic, reproducible errors from the measurement results (system error correction). The process involves the following stages:

1. A set of calibration standards is selected and measured over the required sweep range. For many calibration types the magnitude and phase response of each calibration standard (i.e. its S-parameters if no system errors occur) must be known within the entire sweep range. In some calibration procedures (TRL, TNA, TRM), part of the characteristics of the standards can be auto-determined due to implicit redundancy (self-calibration).
2. The analyzer compares the measurement data of the standards with their known, ideal response. The difference is used to calculate the system errors using a particular error model (calibration type) and derive a set of system error correction data.
3. The system error correction data is used to correct the measurement results of a DUT that is measured instead of the standards.

Calibration is always channel-specific because it depends on the hardware settings, in particular on the sweep range. The means that a system error correction data set is stored with the calibrated channel.

The analyzer provides a wide range of sophisticated calibration methods for all types of measurements. Which calibration method is selected depends on the expected system errors, the accuracy requirements of the measurement, on the test setup and on the types of calibration standards available.

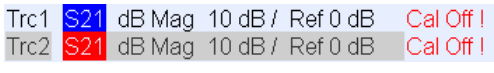
Due to the analyzer's calibration wizard, calibration is a straightforward, menu-guided process. Moreover, it is possible to perform the entire calibration process automatically using the *Calibration Unit* (accessory ZV-Z58).

TIPS

The system error correction data determined in a calibration procedure are stored on the analyzer. You can read these correction data using the remote control command `[SENSe<Ch>:]CORRection:CDATa`. You can also replace the correction data of the analyzer by your own correction data sets.

NOTE

A red label Cal Off ! appears behind the trace list if the system error correction no longer applies to one or more traces:



This may happen for the one of the following reasons:
– The sweep range is outside the calibrated frequency range.
– The channel calibration is not sufficient for the measured quantity (e.g. a one-port calibration has been performed, but the measured quantity is a transmission parameter).
– The system error correction has been switched off deliberately (Correction Off).

In addition to the system error correction described in this section the analyzer supports source and receiver power calibrations using external power meters and generators. Refer to the help system for a comprehensive overview and comparison of the calibration types, including their use, properties and advantages.

Calibration Standards and Calibration Kits

A calibration kit is a set of physical calibration standards for a particular connector type. The magnitude and phase response of the calibration standards (i.e. their S-parameters) must be known or predictable within a given frequency range.

The standards are grouped into several types (open, through, match,...) corresponding to the different input quantities for the analyzer's error models. The standard type also determines the equivalent circuit model used to describe its properties. The circuit model depends on several parameters that are stored in the cal kit file associated with the calibration kit.

As an alternative to using circuit models, it is possible to describe the standards by means of S-parameter tables stored in a file.

The analyzer provides a large number of predefined cal kits but can also import cal kit files and create new kits:

- A selection of predefined kits is available for all connector types. The parameters of these kits are displayed in the *Add/Modify Standards* dialog, however, it is not possible to change or delete the kits.
- Imported and user-defined kits can be changed in the *Calibration Kits* dialog and its various sub-dialogs.

Calibration kits and connector types are global resources; the parameters are stored independently and are available irrespective of the current setup.

Calibration Types

The analyzer provides a wide range of calibration types for one, two or more ports. The calibration types differ in the number and types of standards used, the error terms, i.e. the type of systematic errors corrected and the general accuracy. For a detailed description of the calibration types refer to the help system of your analyzer. The following table gives an overview.

Calibration Type	Standards	Parameters	Error Terms	General Accuracy	Application
Reflection Normalization	Open or Short	S_{11} (or S_{22}, ...)	Reflection tracking	Low to medium	Reflection measurements on any port.
Transmission Normalization	Through	S_{12}, S_{21} (or S_{13},...)	Transmission tracking	Medium	Transmission measurements in any direction and between any combination of ports.
Full One-Port	Open, Short, Match[1)]	S_{11} (or S_{22}, ...)	Reflection tracking, Source match Directivity,	High	Reflection measurements on any port.
One-Path Two-Port	Open, Short, Match[1)] (at source port), Through[2)]	S_{11}, S_{21} (or S_{22},...)	Reflection tracking, Source match, Directivity, Transmission tracking	Medium to high	Unidirectional transmission measurements in any direction and between any combination of ports.
TOSM (2-port, 3-port or 4-port) or UOSM	Open, Short, Match[1)] (at each port), Through[2)] (between all combinations of 2 ports)	All	Reflection tracking, Source match, Directivity, Load match, Transmission tracking,	High	Reflection and transmission measurements on DUTs with 2, 3, or 4 ports; classical 12-term error correction model.

Calibration Type	Standards	Parameters	Error Terms	General Accuracy	Application
TOM (2-port, 3-port or 4-port)	Open, Match (at both ports), Through	All	Reflection tracking, Source match, Directivity, Load match, Transmission tracking	High, implicit verification	Reflection and transmission measurements on DUTs with 2, 3, or 4 ports.
TRM (2-port, 3-port or 4-port)	Reflect (equal at both ports), Match, Through	All	Reflection tracking, Source match, Directivity, Load match, Transmission tracking	High	Reflection and transmission measurements on DUTs with 2, 3, or 4 ports, especially in test fixtures.
TRL (2-port, 3-port or 4-port)	Reflect (at both ports), Through, Line1, Line2 (optional), combination with TRM (optional)	All	Reflection tracking, Source match, Directivity, Load match, Transmission tracking	High, high directivity	Reflection and transmission measurements on DUTs with 2, 3, or 4 ports, especially for planar circuits. Limited bandwidth.
TNA (2-port, 3-port or 4-port)	Through, Attenuation, Symmetric network	All	Reflection tracking, Source match, Directivity, Load match, Transmission tracking	High, lowest requirements on standards	Reflection and transmission measurements on DUTs with 2, 3, or 4 ports, especially for planar circuits.

1) Or any other 3 known one-port standards. To be used in a guided calibration, the known standards must be declared to be open, short, and match irrespective of their properties.

2) Or any other known two-port standard. See remark above.

TIP The calibration type must be selected in accordance with the test setup. Select the calibration type for which you can obtain or design the most accurate standards and for which you can measure the required parameters with best accuracy.

Automatic Calibration

A *Calibration Unit* is an integrated solution for automatic system error calibration of vector network analyzers of the R&S ZVAB family. Rohde & Schwarz provides different types of calibration units:

calibration units:

- The 4-port calibration units R&S ZV-Z51 (order numbers 1164.0515.30 or 1164.0515.70 for models equipped with 3.5 mm or type N sockets, respectively) are especially suited for R&S ZVB and R&S ZVA vector network analyzers in the frequency range up to 8 GHz.

- The calibration units R&S ZV-Z52 (order numbers 1164.0521.30 and 1164.0521.72 for models equipped with 3.5 mm or type N sockets) are especially suited for R&S ZVB and R&S ZVA vector network analyzers in the frequency range up to 18 GHz (model 72, 2 ports) or up to 24 GHz (model 30, 4 ports).
- The 8-port calibration unit (accessory R&S ZV-Z58, order number 1164.0638.78) are especially suited for R&S ZVT vector network analyzers.

The units contain calibration standards that are electronically switched when a calibration is performed. The calibration kit data for the internal standards are also stored in the calibration unit, so that the analyzer can calculate the error terms and apply the calibration without any further input.

Advantages of automatic calibration

Automatic calibration is generally faster and more secure than manual calibration, because:

- There is no need to connect several standards manually. The number of standards to be connected quickly increases with the number of ports; see *TOSM Calibration.*
- Invalid calibrations due to operator errors (e.g. wrong standards or improper connections) are almost excluded.
- No need to handle calibration kit data.
- The internal standards don't wear out because they are switched electronically.

Attention!

Please observe the safety instructions on the technical information provided with the calibration unit to avoid any damage to the unit and the network analyzer. For all aspects regarding the connection and operation refer to the help system of your analyzer.

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4 Remote Control

This chapter provides instructions on how to set up the analyzer for remote control and toggle between remote control and manual operation using an external monitor and the Graphical User Interface (GUI). For a general introduction to remote control of programmable instruments and a description of the analyzer's remote control concept, refer to the Help system. The Help system also provides reference information about all remote control commands implemented by the instrument, complemented by comprehensive program examples.

General Considerations

The instrument is equipped with different interfaces for remote control:

- A GPIB bus interface according to standard IEC 625.1/IEEE 488.1. The GPIB bus connector for direct connection to a controller is located on the rear panel of the instrument.
- Instruments connected to a Local Area Network can be controlled via the RSIB or VX 11 interface. Two connectors for LAN connection are located on the rear panel.

TIP

The *GPIB Explorer* is a easy-to-use program tool that allows you to obtain an overview of all implemented remote control programs, test programs, compile and run test scripts.

This section assumes basic knowledge of GPIB bus programming and operation of the controller. A description of the interface commands can be found in sections *GPIB Bus Interface* and *RSIB Interface Functions* in the Help system, respectively.

SCPI compatibility

The analyzers are compatible to the final SCPI version 1999.0. Not all of the commands supported by the instrument are taken from the SCPI standard (Standard Commands for Programmable Instruments), however, their syntax follows SCPI rules. The SCPI standard is based on standard IEEE 488.2 and aims at the standardization of device-specific commands, error handling and the status registers.

The requirements that the SCPI standard places on command syntax, error handling and configuration of the status registers are explained in detail in the following sections. Tables provide a fast overview of the bit assignment in the status registers. The tables are supplemented by a comprehensive description of the status registers.

NOTE

Reset values

In contrast to instruments with manual control, which are designed for maximum possible operating convenience, the priority of remote control is the "predictability" of the device status. This means that when incompatible settings are attempted, the command is ignored and the device status remains unchanged, i.e. other settings are not automatically adapted. Therefore, GPIB bus control programs should always define an initial device status (e.g. with the command *RST) and then implement the required settings.

GPIB Explorer

The *GPIB Explorer* is a easy-to-use program tool that allows you to obtain an overview of all implemented remote control programs, test programs, compile and run test scripts. The program can be opened from Windows XP's start menu: *Programs – R&S Network Analyzer – GPIB Explorer* or by starting the executable file `iecwin32.exe` in the program directory of the network analyzer (e.g. `C:\Program Files\Rohde&Schwarz\Network Analyzer\Bin`).

After the *GPIB Explorer* is started, the interface for the connection to the instrument can be selected in a dialog:

The following options are provided:

- NT named pipe (not supported at present)
- GPIB address (for connection to controllers equipped with a National Instrument GPIB interface using the GPIB bus connector)
- RSIB address (for LAN connection, requires an appropriate IP or local host address; see *LAN Connection* sections in Chapter 1)
- Socket interface (not supported at present)
- Named pipe A/B (only for local connection on the analyzer, recommended for remote test on the instrument)

Select *Info – Setup Info* to look up the IP address information of your analyzer.

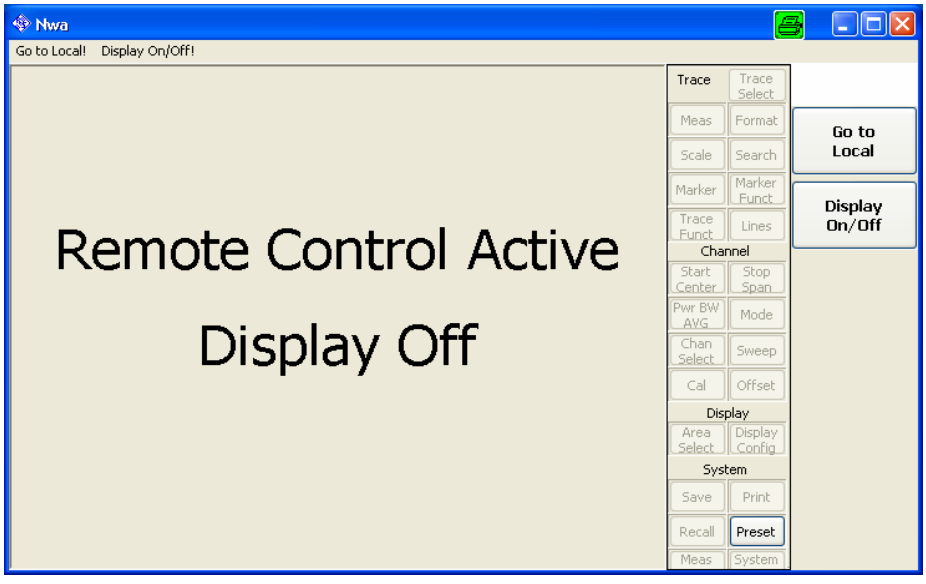
- After the connection is established, the GPIB explorer displays a tree view of all commands included in the current firmware version of the network analyzer. The programs can be selected for execution by a single mouse click.

Refer to the GPIB explorer's help system for more information.

Switchover to Remote Control

On power-up, the instrument is always in the manual operating state and can be operated via the Graphical User Interface (GUI) displayed on an external monitor. The instrument is switched to remote control as soon as it receives a command from the controller. If the instrument is controlled via RSIB or VX 11 interface, the alternative commands *@REM* and *@LOC* can be used to switch from manual to remote control and back.

While remote control is active, operation via the front panel is disabled with the exception of two softkeys. The instrument settings are optimized for maximum measurement speed; the display is switched off:

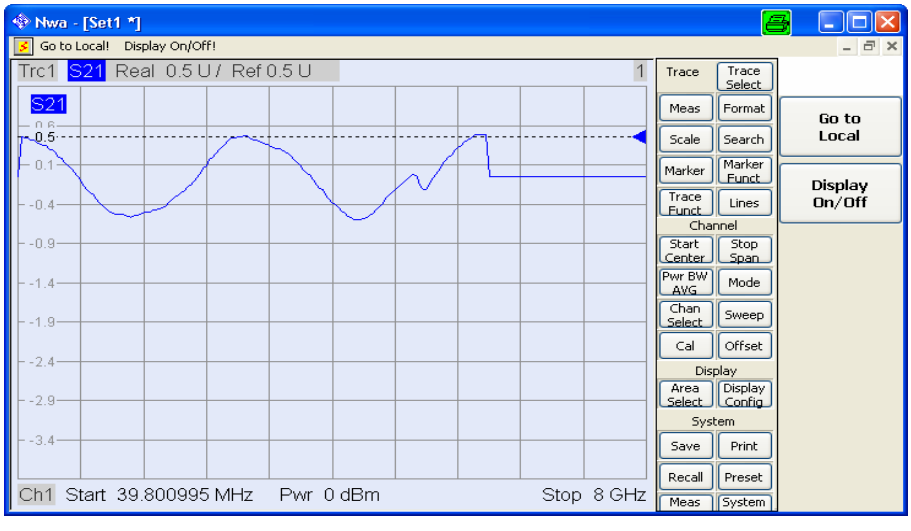


The two softkeys in the remote screen are used to modify or quit the remote state:

- *Go to Local* switches the instrument to local state.
- *Display On/Off* switches the display on or off.

Display On/Off states

Switching on the display means that the analyzer shows the measurement screen with the current setups, diagram areas and traces without leaving the remote state. In this operating mode, it is possible to observe the screen while a remote control script is executed and the control elements on the front panel are still disabled:



Switching on the display is ideal for program test purposes but tends to slow down the measurement. Therefore it is recommended to switch off the display in real measurement applications where a tested program script is to be executed repeatedly.

The analyzer provides a third display option where the measurement screen is only updated when this is triggered by a remote control command; see `SYSTem:DISPlay:UPDate ONCE`.

The instrument remains in the remote state until it is reset to the manual state via the front panel or via GPIB bus (see section *Return to Manual Operation)*.

Remote control: *@REM*
`SYSTem:DISPlay:UPDate`

Setting the Device Address

The GPIB address (primary address) of the instrument is factory-set to 20. It can be changed manually in the *System* menu or via GPIB bus. For remote control, addresses 0 through 30 are permissible. The GPIB address is maintained after a reset of the instrument settings.

Remote control: `SYSTem:COMMunicate:GPIB[:SELF]:ADDRess`

Return to Manual Operation

Return to manual operation can be initiated via the front panel or via remote control.

- Manually: Press the *Local* softkey in the remote screen.
- Via GPIB bus: CALL IBLOC(device%)
- Via RSIB or VX 11 interface: *@LOC* and *@REM* can be used to switch from remote to manual control and back.

Local lockout

Before returning to manual control, command processing must be completed. If this is not the case, the analyzer switches back to remote control immediately.

Returning to manual control by pressing the *Local* softkey can be disabled by the GPIB Local Lockout Message (LLO; see *GPIB Bus Interface, Universal Commands)* which is also included in the NI commands SetRWLS (Set Remote With Lockout State) or SendLLO. This prevents unintentional switch-over, i.e. return to manual control is possible via the GPIB bus only.

Returning to manual control via the front panel keys can be enabled again by deactivating the REN control line of the GPIB bus .

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