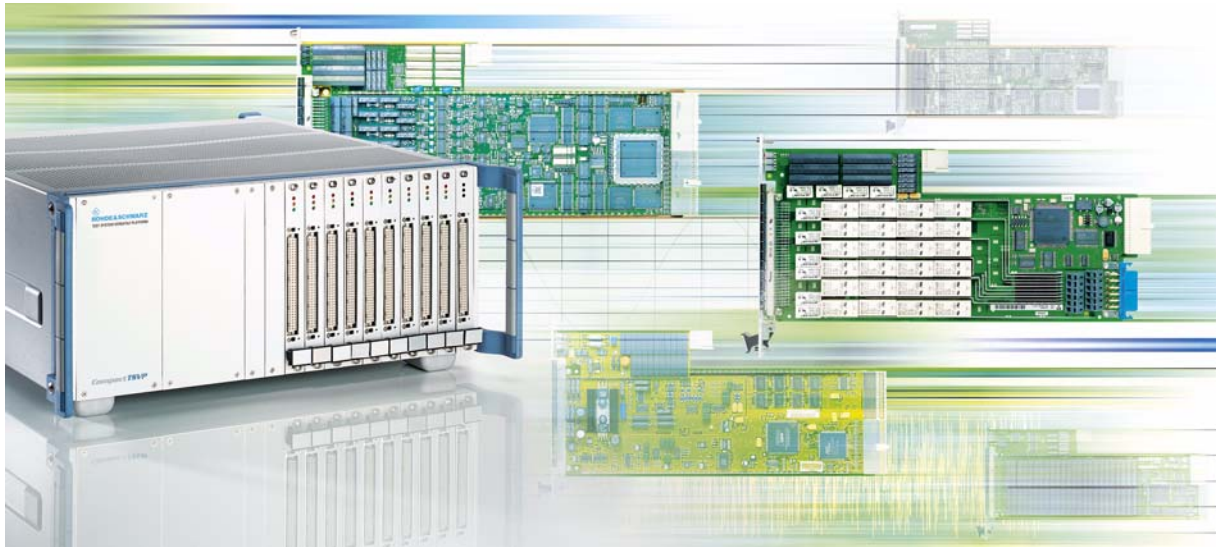




ROHDE & SCHWARZ

SOFTWARE DESCRIPTION



Enhanced Generic Test Software Library R&S®EGTSL

Software Description
for ROHDE & SCHWARZ
Enhanced Generic Test Software Library R&S EGTSL

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This Software Description is valid for the R&S EGTSL-Software version **2.90** and the R&S GTSL-Software version **2.90** (and higher versions).

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Basic Safety Instructions

Always read through and comply with the following safety instructions!

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

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

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

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





Symbols and safety labels

							
Notice, general danger location Observe product documentation	Caution when handling heavy equipment	Danger of electric shock	Warning! Hot surface	PE terminal	Ground	Ground terminal	Be careful when handling electrostatic sensitive devices

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

Tags and their meaning

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

	indicates a hazardous situation which, if not avoided, will result in death or serious injury.
	indicates a hazardous situation which, if not avoided, could result in death or serious injury.
	indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
	indicates the possibility of incorrect operation which can result in damage to the product. In the product documentation, the word ATTENTION is used synonymously.

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

Operating states and operating positions

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

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

Electrical safety

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

1. Prior to switching on the product, always ensure that the nominal voltage setting on the product matches the nominal voltage of the AC supply network. If a different voltage is to be set, the power fuse of the product may have to be changed accordingly.
2. In the case of products of safety class I with movable power cord and connector, operation is permitted only on sockets with an earthing contact and protective earth connection.
3. 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.
4. If the product does not have a power switch for disconnection from the AC supply network, the plug of the connecting cable is regarded as the disconnecting device. In such cases, always ensure that the power plug is easily reachable and accessible at all times (corresponding to the length of connecting cable, approx. 2 m). Functional or electronic switches are not suitable for providing disconnection from the AC supply network. If products without power switches are integrated into racks or systems, a disconnecting device must be provided at the system level.
5. Never use the product if the power cable is damaged. Check the power cable on a regular basis to ensure that it is in proper operating condition. By taking appropriate safety measures and carefully laying the power cable, you can ensure that the cable will not be damaged and that no one can be hurt by, for example, tripping over the cable or suffering an electric shock.
6. The product may be operated only from TN/TT supply networks fused with max. 16 A (higher fuse only after consulting with the Rohde & Schwarz group of companies).
7. Do not insert the plug into sockets that are dusty or dirty. Insert the plug firmly and all the way into the socket. Otherwise, sparks that result in fire and/or injuries may occur.
8. Do not overload any sockets, extension cords or connector strips; doing so can cause fire or electric shocks.
9. For measurements in circuits with voltages $V_{\text{rms}} > 30 \text{ V}$, suitable measures (e.g. appropriate measuring equipment, fusing, current limiting, electrical separation, insulation) should be taken to avoid any hazards.
10. Ensure that the connections with information technology equipment, e.g. PCs or other industrial computers, comply with the IEC60950-1/EN60950-1 or IEC61010-1/EN 61010-1 standards that apply in each case.
11. Unless expressly permitted, never remove the cover or any part of the housing while the product is in operation. Doing so will expose circuits and components and can lead to injuries, fire or damage to the product.
12. If a product is to be permanently installed, the connection between the 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 licensed electrician.
13. 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 anyone who has access to the product, as well as the product itself, is adequately protected from injury or damage.

Basic Safety Instructions

14. Use suitable overvoltage protection to ensure that no overvoltage (such as that caused by a bolt of lightning) can reach the product. Otherwise, the person operating the product will be exposed to the danger of an electric shock.
15. Any object that is not designed to be placed in the openings of the housing must not be used for this purpose. Doing so can cause short circuits inside the product and/or electric shocks, fire or injuries.
16. Unless specified otherwise, products are not liquid-proof (see also section "Operating states and operating positions", item 1. Therefore, the equipment must be protected against penetration by liquids. If the necessary precautions are not taken, the user may suffer electric shock or the product itself may be damaged, which can also lead to personal injury.
17. Never use the product under conditions in which condensation has formed or can form in or on the product, e.g. if the product has been moved from a cold to a warm environment. Penetration by water increases the risk of electric shock.
18. Prior to cleaning the product, disconnect it completely from the power supply (e.g. AC supply network or battery). Use a soft, non-linting cloth to clean the product. Never use chemical cleaning agents such as alcohol, acetone or diluents for cellulose lacquers.

Operation

1. Operating the products requires special training and intense concentration. Make sure that persons who use the products are physically, mentally and emotionally fit enough to do so; otherwise, injuries or material damage may occur. It is the responsibility of the employer/operator to select suitable personnel for operating the products.
2. Before you move or transport the product, read and observe the section titled "Transport".
3. As with all industrially manufactured goods, the use of substances that induce an allergic reaction (allergens) such as nickel cannot be generally excluded. If you develop an allergic reaction (such as a skin rash, frequent sneezing, red eyes or respiratory difficulties) when using a Rohde & Schwarz product, consult a physician immediately to determine the cause and to prevent health problems or stress.
4. Before you start processing the product mechanically and/or thermally, or before you take it apart, be sure to read and pay special attention to the section titled "Waste disposal", item 1.
5. Depending on the function, certain products such as RF radio equipment can produce an elevated level of electromagnetic radiation. Considering that unborn babies require increased protection, pregnant women must be protected by appropriate measures. Persons with pacemakers may also be exposed to risks from electromagnetic radiation. The employer/operator must evaluate workplaces where there is a special risk of exposure to radiation and, if necessary, take measures to avert the potential danger.
6. Should a fire occur, the product may release hazardous substances (gases, fluids, etc.) that can cause health problems. Therefore, suitable measures must be taken, e.g. protective masks and protective clothing must be worn.
7. If a laser product (e.g. a CD/DVD drive) is integrated into a Rohde & Schwarz product, absolutely no other settings or functions may be used as described in the product documentation. The objective is to prevent personal injury (e.g. due to laser beams).

Repair and service

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

Batteries and rechargeable batteries/cells

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

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

Transport

1. The product may be very heavy. Therefore, the product must be handled with care. In some cases, the user may require a suitable means of lifting or moving the product (e.g. with a lift-truck) to avoid back or other physical injuries.

2. Handles on the products are designed exclusively to enable personnel to transport the product. It is therefore not permissible to use handles to fasten the product to or on transport equipment such as cranes, fork lifts, wagons, etc. The user is responsible for securely fastening the products to or on the means of transport or lifting. Observe the safety regulations of the manufacturer of the means of transport or lifting. Noncompliance can result in personal injury or material damage.
3. If you use the product in a vehicle, it is the sole responsibility of the driver to drive the vehicle safely and properly. The manufacturer assumes no responsibility for accidents or collisions. Never use the product in a moving vehicle if doing so could distract the driver of the vehicle. Adequately secure the product in the vehicle to prevent injuries or other damage in the event of an accident.

Waste disposal

1. If products or their components are mechanically and/or thermally processed in a manner that goes beyond their intended use, hazardous substances (heavy-metal dust such as lead, beryllium, nickel) may be released. For this reason, the product may only be disassembled by specially trained personnel. Improper disassembly may be hazardous to your health. National waste disposal regulations must be observed.
2. If handling the product releases hazardous substances or fuels that must be disposed of in a special way, e.g. coolants or engine oils that must be replenished regularly, the safety instructions of the manufacturer of the hazardous substances or fuels and the applicable regional waste disposal regulations must be observed. Also observe the relevant safety instructions in the product documentation. The improper disposal of hazardous substances or fuels can cause health problems and lead to environmental damage.

Informaciones elementales de seguridad

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

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

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

Informaciones elementales de seguridad

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

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

Símbolos y definiciones de seguridad

							
Aviso: punto de peligro general Observar la documentación del producto	Atención en el manejo de dispositivos de peso elevado	Peligro de choque eléctrico	Advertencia: superficie caliente	Conexión a conductor de protección	Conexión a tierra	Conexión a masa	Aviso: Cuidado en el manejo de dispositivos sensibles a la electrostática (ESD)

					
Tensión de alimentación de PUESTA EN MARCHA / PARADA	Indicación de estado de espera (Standby)	Corriente continua (DC)	Corriente alterna (AC)	Corriente continua / Corriente alterna (DC/AC)	El aparato está protegido en su totalidad por un aislamiento doble (reforzado)

Palabras de señal y su significado

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



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



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



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



AVISO indica la posibilidad de utilizar mal el producto y, como consecuencia, dañarlo.

En la documentación del producto se emplea de forma sinónima el término CUIDADO.

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

Estados operativos y posiciones de funcionamiento

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

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

Seguridad eléctrica

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

1. Antes de la puesta en marcha del producto se deberá comprobar siempre que la tensión preseleccionada en el producto coincida con la de la red de alimentación eléctrica. Si es necesario modificar el ajuste de tensión, también se deberán cambiar en caso dado los fusibles correspondientes del producto.
2. Los productos de la clase de protección I con alimentación móvil y enchufe individual solamente podrán enchufarse a tomas de corriente con contacto de seguridad y con conductor de protección conectado.
3. Queda prohibida la interrupción intencionada del conductor de protección, tanto en la toma de corriente como en el mismo producto. La interrupción puede tener como consecuencia el riesgo de que el producto sea fuente de choques eléctricos. Si se utilizan cables alargadores o regletas de enchufe, deberá garantizarse la realización de un examen regular de los mismos en cuanto a su estado técnico de seguridad.
4. Si el producto no está equipado con un interruptor para desconectarlo de la red, se deberá considerar el enchufe del cable de conexión como interruptor. En estos casos se deberá asegurar que el enchufe siempre sea de fácil acceso (de acuerdo con la longitud del cable de conexión, aproximadamente 2 m). Los interruptores de función o electrónicos no son aptos para el corte de la red eléctrica. Si los productos sin interruptor están integrados en bastidores o instalaciones, se deberá colocar el interruptor en el nivel de la instalación.
5. No utilice nunca el producto si está dañado el cable de conexión a red. Compruebe regularmente el correcto estado de los cables de conexión a red. Asegúrese, mediante las medidas de protección y de instalación adecuadas, de que el cable de conexión a red no pueda ser dañado o de que nadie pueda ser dañado por él, p. ej. al tropezar o por un choque eléctrico.
6. Solamente está permitido el funcionamiento en redes de alimentación TN/TT aseguradas con fusibles de 16 A como máximo (utilización de fusibles de mayor amperaje solo previa consulta con el grupo de empresas Rohde & Schwarz).
7. Nunca conecte el enchufe en tomas de corriente sucias o llenas de polvo. Introduzca el enchufe por completo y fuertemente en la toma de corriente. La no observación de estas medidas puede provocar chispas, fuego y/o lesiones.
8. No sobrecargue las tomas de corriente, los cables alargadores o las regletas de enchufe ya que esto podría causar fuego o choques eléctricos.
9. En las mediciones en circuitos de corriente con una tensión $U_{\text{eff}} > 30 \text{ V}$ se deberán tomar las medidas apropiadas para impedir cualquier peligro (p. ej. medios de medición adecuados, seguros, limitación de tensión, corte protector, aislamiento etc.).
10. Para la conexión con dispositivos informáticos como un PC o un ordenador industrial, debe comprobarse que éstos cumplan los estándares IEC60950-1/EN60950-1 o IEC61010-1/EN 61010-1 válidos en cada caso.
11. A menos que esté permitido expresamente, no retire nunca la tapa ni componentes de la carcasa mientras el producto esté en servicio. Esto pone a descubierto los cables y componentes eléctricos y puede causar lesiones, fuego o daños en el producto.

12. Si un producto se instala en un lugar fijo, se deberá primero conectar el conductor de protección fijo con el conductor de protección del producto antes de hacer cualquier otra conexión. La instalación y la conexión deberán ser efectuadas por un electricista especializado.
13. En el caso de dispositivos fijos que no estén provistos de fusibles, interruptor automático ni otros mecanismos de seguridad similares, el circuito de alimentación debe estar protegido de modo que todas las personas que puedan acceder al producto, así como el producto mismo, estén a salvo de posibles daños.
14. Todo producto debe estar protegido contra sobretensión (debida p. ej. a una caída del rayo) mediante los correspondientes sistemas de protección. Si no, el personal que lo utilice quedará expuesto al peligro de choque eléctrico.
15. No debe introducirse en los orificios de la caja del aparato ningún objeto que no esté destinado a ello. Esto puede producir cortocircuitos en el producto y/o puede causar choques eléctricos, fuego o lesiones.
16. Salvo indicación contraria, los productos no están impermeabilizados (ver también el capítulo "Estados operativos y posiciones de funcionamiento", punto 1). Por eso es necesario tomar las medidas necesarias para evitar la entrada de líquidos. En caso contrario, existe peligro de choque eléctrico para el usuario o de daños en el producto, que también pueden redundar en peligro para las personas.
17. No utilice el producto en condiciones en las que pueda producirse o ya se hayan producido condensaciones sobre el producto o en el interior de éste, como p. ej. al desplazarlo de un lugar frío a otro caliente. La entrada de agua aumenta el riesgo de choque eléctrico.
18. Antes de la limpieza, desconecte por completo el producto de la alimentación de tensión (p. ej. red de alimentación o batería). Realice la limpieza de los aparatos con un paño suave, que no se deshilache. No utilice bajo ningún concepto productos de limpieza químicos como alcohol, acetona o diluyentes para lacas nitrocelulósicas.

Funcionamiento

1. El uso del producto requiere instrucciones especiales y una alta concentración durante el manejo. Debe asegurarse que las personas que manejen el producto estén a la altura de los requerimientos necesarios en cuanto a aptitudes físicas, psíquicas y emocionales, ya que de otra manera no se pueden excluir lesiones o daños de objetos. El empresario u operador es responsable de seleccionar el personal usuario apto para el manejo del producto.
2. Antes de desplazar o transportar el producto, lea y tenga en cuenta el capítulo "Transporte".
3. Como con todo producto de fabricación industrial no puede quedar excluida en general la posibilidad de que se produzcan alergias provocadas por algunos materiales empleados, los llamados alérgenos (p. ej. el níquel). Si durante el manejo de productos Rohde & Schwarz se producen reacciones alérgicas, como p. ej. irritaciones cutáneas, estornudos continuos, enrojecimiento de la conjuntiva o dificultades respiratorias, debe avisarse inmediatamente a un médico para investigar las causas y evitar cualquier molestia o daño a la salud.
4. Antes de la manipulación mecánica y/o térmica o el desmontaje del producto, debe tenerse en cuenta imprescindiblemente el capítulo "Eliminación", punto 1.

5. Ciertos productos, como p. ej. las instalaciones de radiocomunicación RF, pueden a causa de su función natural, emitir una radiación electromagnética aumentada. Deben tomarse todas las medidas necesarias para la protección de las mujeres embarazadas. También las personas con marcapasos pueden correr peligro a causa de la radiación electromagnética. El empresario/operador tiene la obligación de evaluar y señalar las áreas de trabajo en las que exista un riesgo elevado de exposición a radiaciones.
6. Tenga en cuenta que en caso de incendio pueden desprenderse del producto sustancias tóxicas (gases, líquidos etc.) que pueden generar daños a la salud. Por eso, en caso de incendio deben usarse medidas adecuadas, como p. ej. máscaras antigás e indumentaria de protección.
7. En caso de que un producto Rohde & Schwarz contenga un producto láser (p. ej. un lector de CD/DVD), no debe usarse ninguna otra configuración o función aparte de las descritas en la documentación del producto, a fin de evitar lesiones (p. ej. debidas a irradiación láser).

Reparación y mantenimiento

1. El producto solamente debe ser abierto por personal especializado con autorización para ello. Antes de manipular el producto o abrirlo, es obligatorio desconectarlo de la tensión de alimentación, para evitar toda posibilidad de choque eléctrico.
2. El ajuste, el cambio de partes, el mantenimiento y la reparación deberán ser efectuadas solamente por electricistas autorizados por Rohde & Schwarz. Si se reponen partes con importancia para los aspectos de seguridad (p. ej. el enchufe, los transformadores o los fusibles), solamente podrán ser sustituidos por partes originales. Después de cada cambio de partes relevantes para la seguridad deberá realizarse un control de seguridad (control a primera vista, control del conductor de protección, medición de resistencia de aislamiento, medición de la corriente de fuga, control de funcionamiento). Con esto queda garantizada la seguridad del producto.

Baterías y acumuladores o celdas

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

1. No deben desmontarse, abrirse ni triturarse las celdas.
2. Las celdas o baterías no deben someterse a calor ni fuego. Debe evitarse el almacenamiento a la luz directa del sol. Las celdas y baterías deben mantenerse limpias y secas. Limpiar las conexiones sucias con un paño seco y limpio.
3. Las celdas o baterías no deben cortocircuitarse. Es peligroso almacenar las celdas o baterías en estuches o cajones en cuyo interior puedan cortocircuitarse por contacto recíproco o por contacto con otros materiales conductores. No deben extraerse las celdas o baterías de sus embalajes originales hasta el momento en que vayan a utilizarse.
4. Mantener baterías y celdas fuera del alcance de los niños. En caso de ingestión de una celda o batería, avisar inmediatamente a un médico.
5. Las celdas o baterías no deben someterse a impactos mecánicos fuertes indebidos.

Informaciones elementales de seguridad

6. En caso de falta de estanqueidad de una celda, el líquido vertido no debe entrar en contacto con la piel ni los ojos. Si se produce contacto, lavar con agua abundante la zona afectada y avisar a un médico.
7. En caso de cambio o recarga inadecuados, las celdas o baterías que contienen electrolitos alcalinos (p. ej. las celdas de litio) pueden explotar. Para garantizar la seguridad del producto, las celdas o baterías solo deben ser sustituidas por el tipo Rohde & Schwarz correspondiente (ver lista de recambios).
8. Las baterías y celdas deben reciclarse y no deben tirarse a la basura doméstica. Las baterías o acumuladores que contienen plomo, mercurio o cadmio deben tratarse como residuos especiales. Respete en esta relación las normas nacionales de eliminación y reciclaje.

Transporte

1. El producto puede tener un peso elevado. Por eso es necesario desplazarlo o transportarlo con precaución y, si es necesario, usando un sistema de elevación adecuado (p. ej. una carretilla elevadora), a fin de evitar lesiones en la espalda u otros daños personales.
2. Las asas instaladas en los productos sirven solamente de ayuda para el transporte del producto por personas. Por eso no está permitido utilizar las asas para la sujeción en o sobre medios de transporte como p. ej. grúas, carretillas elevadoras de horquilla, carros etc. Es responsabilidad suya fijar los productos de manera segura a los medios de transporte o elevación. Para evitar daños personales o daños en el producto, siga las instrucciones de seguridad del fabricante del medio de transporte o elevación utilizado.
3. Si se utiliza el producto dentro de un vehículo, recae de manera exclusiva en el conductor la responsabilidad de conducir el vehículo de manera segura y adecuada. El fabricante no asumirá ninguna responsabilidad por accidentes o colisiones. No utilice nunca el producto dentro de un vehículo en movimiento si esto pudiera distraer al conductor. Asegure el producto dentro del vehículo debidamente para evitar, en caso de un accidente, lesiones u otra clase de daños.

Eliminación

1. Si se trabaja de manera mecánica y/o térmica cualquier producto o componente más allá del funcionamiento previsto, pueden liberarse sustancias peligrosas (polvos con contenido de metales pesados como p. ej. plomo, berilio o níquel). Por eso el producto solo debe ser desmontado por personal especializado con formación adecuada. Un desmontaje inadecuado puede ocasionar daños para la salud. Se deben tener en cuenta las directivas nacionales referentes a la eliminación de residuos.
2. En caso de que durante el trato del producto se formen sustancias peligrosas o combustibles que deban tratarse como residuos especiales (p. ej. refrigerantes o aceites de motor con intervalos de cambio definidos), deben tenerse en cuenta las indicaciones de seguridad del fabricante de dichas sustancias y las normas regionales de eliminación de residuos. Tenga en cuenta también en caso necesario las indicaciones de seguridad especiales contenidas en la documentación del producto. La eliminación incorrecta de sustancias peligrosas o combustibles puede causar daños a la salud o daños al medio ambiente.

Certified Quality System

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

DQS REG. NO 001954 QM UM

QUALITÄTSZERTIFIKAT

Sehr geehrter Kunde,
Sie haben sich für den Kauf eines Rohde & Schwarz-Produktes entschieden. Hiermit erhalten Sie ein nach modernsten Fertigungsmethoden hergestelltes Produkt. Es wurde nach den Regeln unseres Managementsystems entwickelt, gefertigt und geprüft. Das Rohde & Schwarz Managementsystem ist zertifiziert nach:

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

CERTIFICATE OF QUALITY

Dear Customer,
you have decided to buy a Rohde & Schwarz product. You are thus assured of receiving a product that is manufactured using the most modern methods available. This product was developed, manufactured and tested in compliance with our quality management system standards. The Rohde & Schwarz quality management system is certified according to:

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

CERTIFICAT DE QUALITÉ

Cher Client,
vous avez choisi d'acheter un produit Rohde & Schwarz. Vous disposez donc d'un produit fabriqué d'après les méthodes les plus avancées. Le développement, la fabrication et les tests respectent nos normes de gestion qualité. Le système de gestion qualité de Rohde & Schwarz a été homologué conformément aux normes:

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



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1 General

1.1 User information

This software description applies to the following ROHDE & SCHWARZ products:

R&S TS-LEGT	1143.4140.02	Enhanced R&S GTSL Software for ICT
R&S TS-LEG2	1166.3992.02	Enhanced R&S GTSL Software for Basic ICT on R&S TS-PSAM

1.2 Reference documents

The Enhanced Generic Test Software Library R&S EGTSL is part of the Generic Test Software Library R&S GTSL. For this reason, the following documentation is to be noted in addition to this software description:

- Software Description Generic Test Software Library R&S GTSL

The related test hardware is required for performing in-circuit tests. The test hardware is described in the following documentation:

- User Manual Test System Versatile Platform R&S CompactTSVP TS-PCA3
- User Manual Test System Versatile Platform R&S PowerTSVP TS-PWA3
- User Manual Analog Source and Measurement Module R&S TS-PSAM
- User Manual ICT Extension Module R&S TS-PICT
- User Manual Matrix Module B R&S TS-PMB
- Documentation of the test adapter

1.3 Explanation of Symbols

Certain text passages in this software description are specially highlighted. The passages marked in this way have the following significance:



CAUTION!

Failure to follow instructions can result in incorrect measurements.



NOTE:

Highlights important details to which special attention must be paid and that make your work easier.

2 Software installation

2.1 General

**NOTE:**

Enhanced Generic Test Software Library R&S EGTSL is installed using the installation routine for the Generic Test Software Library R&S GTSL.

To install the Generic Test Software Library R&S GTSL under **WINDOWS 2000/XP**, the user must be logged in as administrator or as a user with administrator rights.

For additional information on the deinstallation of previous versions of the **Generic Test Software Library R&S GTSL** or concerning installation, consult the `README.TXT` file on the installation CD.

Users of the **Enhanced Generic Test Software Library R&S EGTSL** are individually responsible for loading operating system updates (patches) and setting up and updating a virus scanner.

2.2 Installation

The **Generic Test Software Library R&S GTSL** is installed on the computer of the **Test System Versatile Platform R&S CompactTSVP** via an installation routine. Start the installation routine as follows:

1. Insert the CD containing the **Generic Test Software Library R&S GTSL**.
2. Start the installation routine by selecting **Start -> Run** and typing "X:\Setup".

X:\ is the drive letter of the CD-ROM drive.

3. Then follow the on-screen installation instructions.

A Welcome screen with installation wizard.

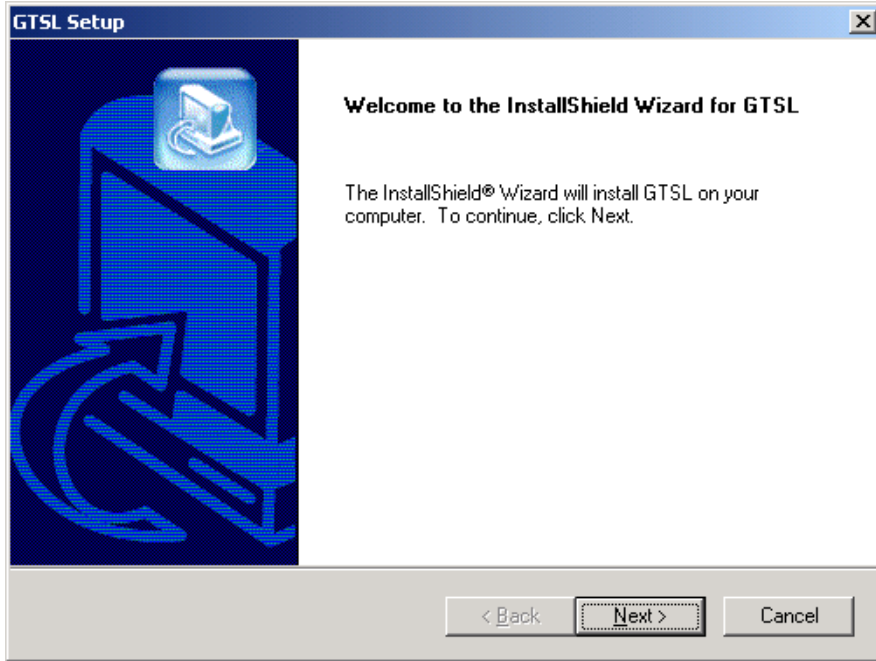


Figure 2-1 Setup Welcome Screen

B Accept the License Agreement.

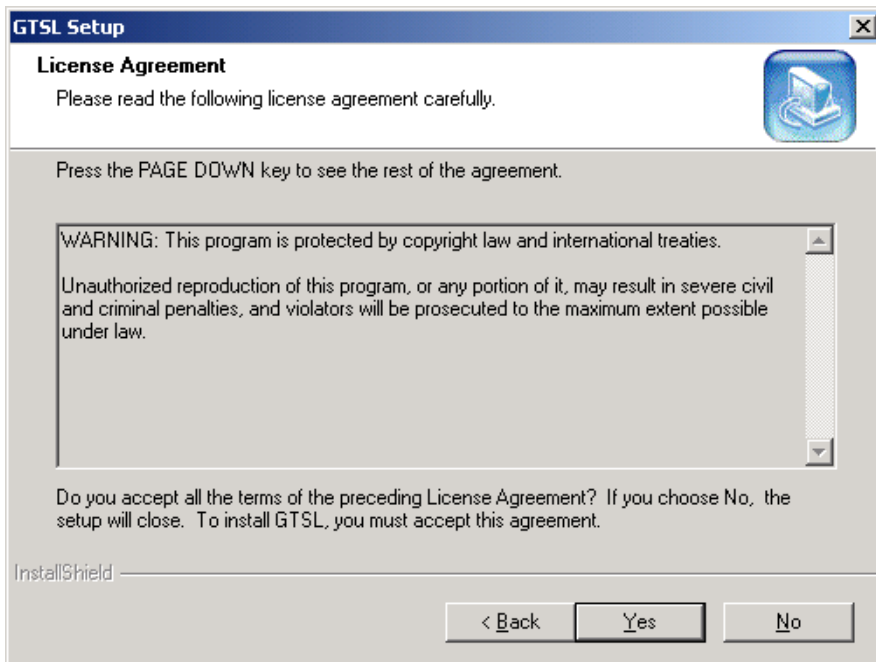


Figure 2-2 Setup License Agreement

C Enter a user name and company name.

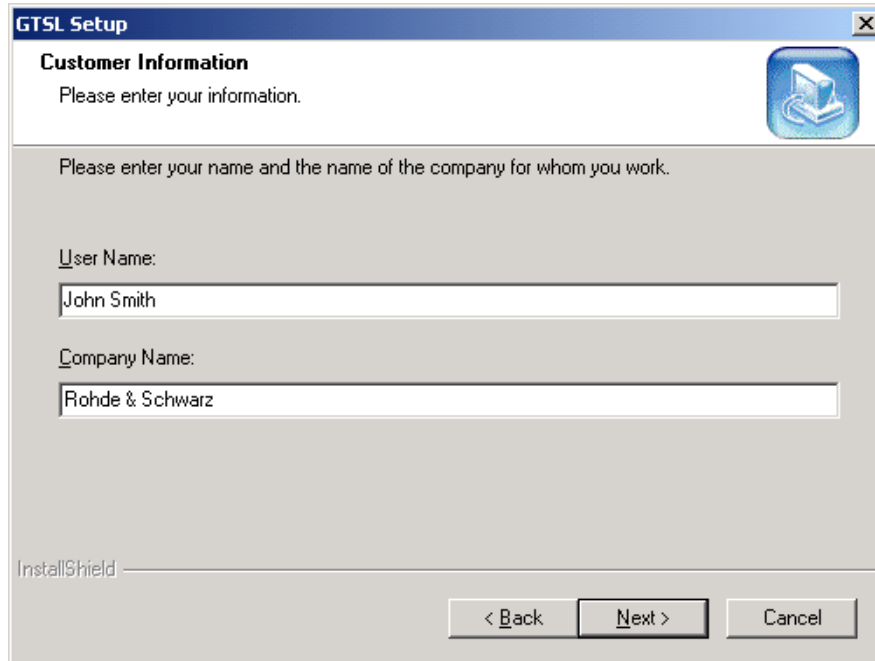


Figure 2-3 Setup User Information

D Select the directory where the R&S GTSL is to be installed.

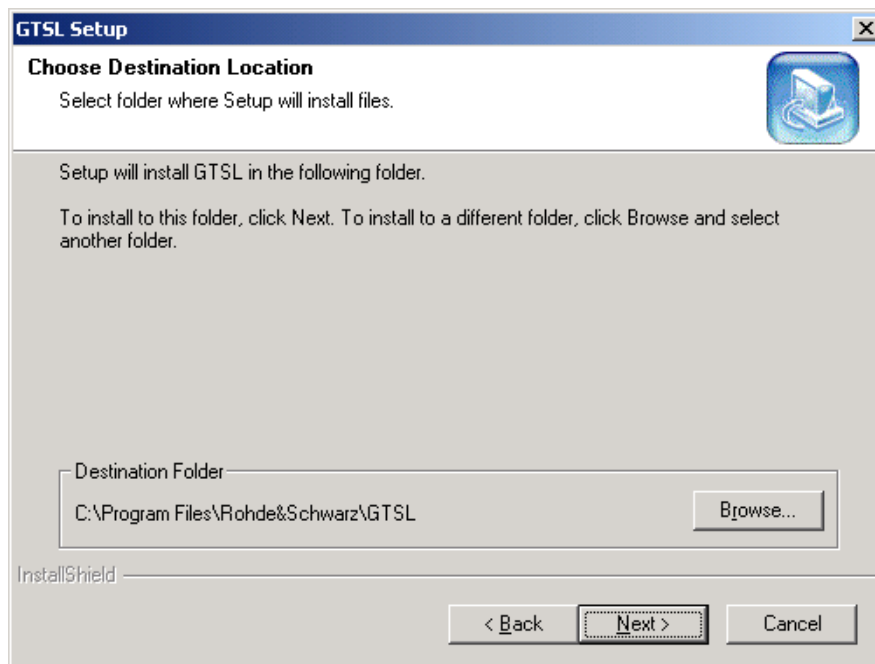


Figure 2-4 Setup Choose Destination Location

E Select the program components to be install.

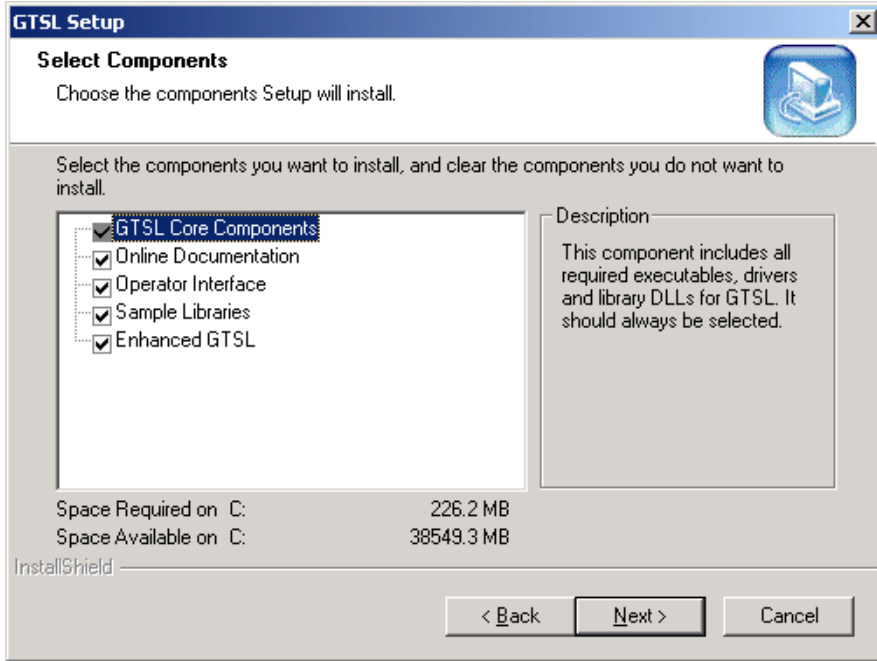


Figure 2-5 Setup Select Program Components

F Display of the current setup settings.

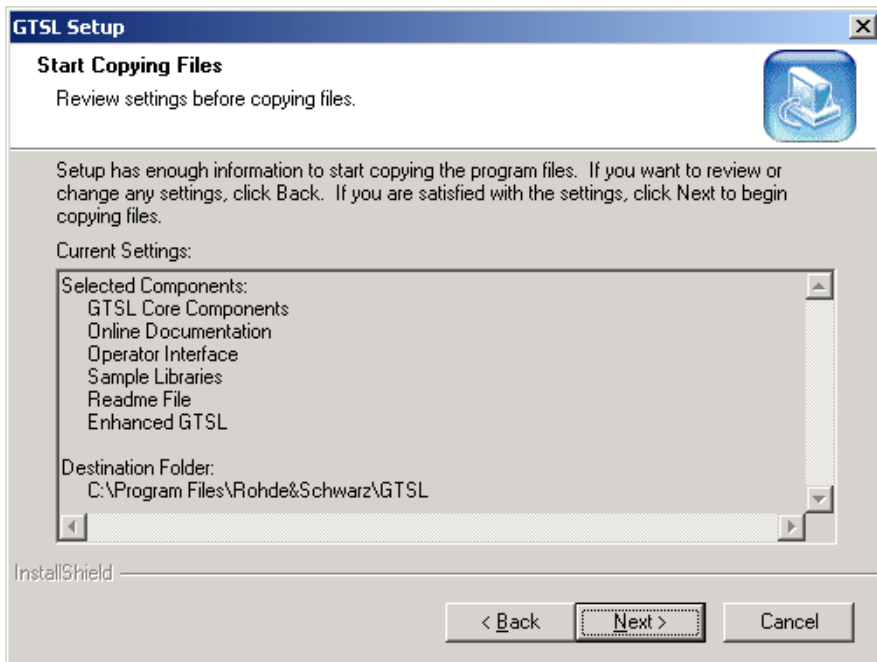


Figure 2-6 Setup Settings

G Display of the Setup Status

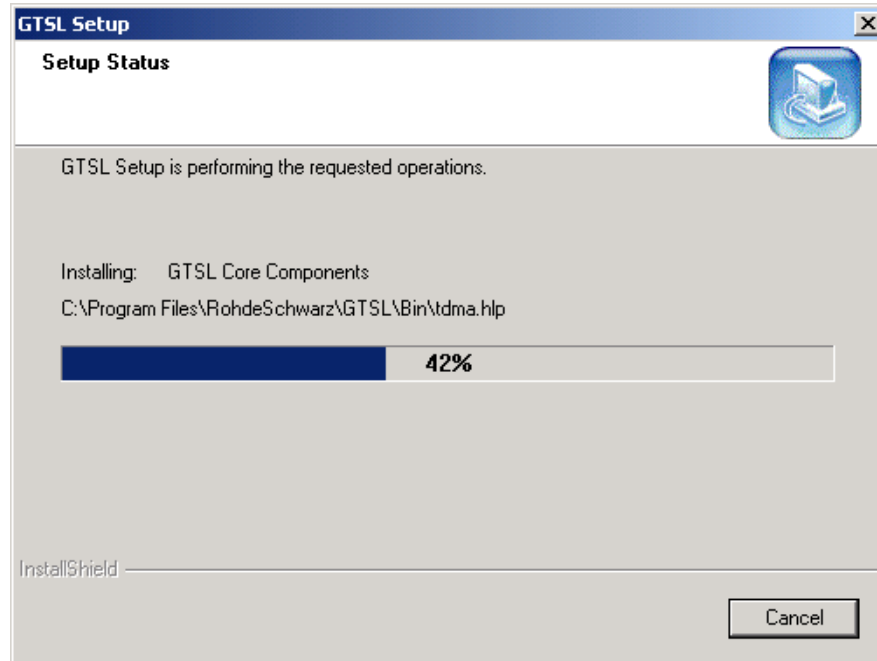


Figure 2-7 Setup Status

H Close the installation routine.

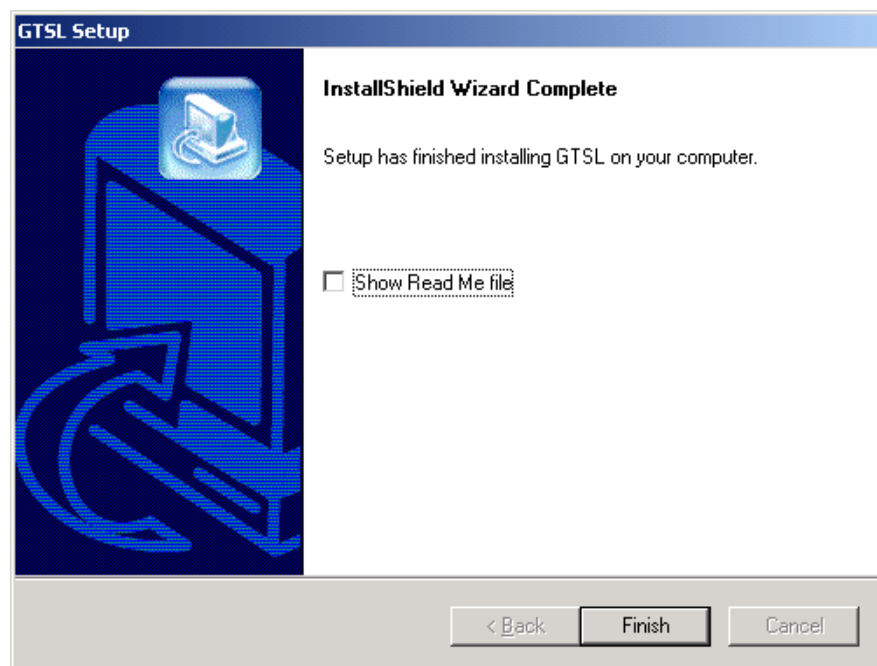


Figure 2-8 Setup Complete



During the installation process, the following programs are copied to the predefined file structure:

- Test libraries with help files
- Configuration files and calibration files
- Examples for the creation of test libraries
- Documentation
- Examples of test sequences
- Enhanced Generic Test Software Library R&S EGTSL
- Examples and templates of ICT programs

2.3 File structure

The test libraries, test sequences, examples, tools and documentation supplied by ROHDE & SCHWARZ are stored in fixed directories at the time of installation. The files from the corresponding directories are addressed from the TestStand Sequence Editor or other programs. ROHDE & SCHWARZ specify the following structure:

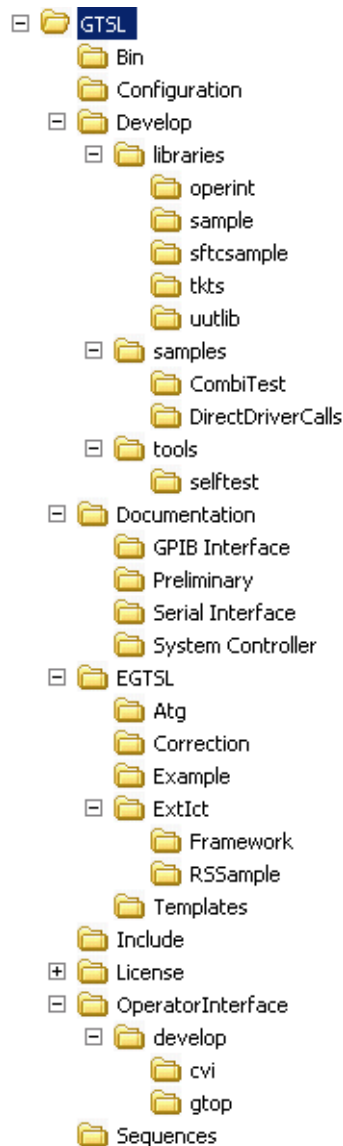


Figure 2-9 File structure

NOTE:

The file structure and the directory names below the GTSL directory must be maintained.



Directory	Contents
GTSL	<u>G</u> eneric <u>T</u> est <u>S</u> oftware <u>L</u> ibrary. The root directory for the R&S GTSL software can have any name.
Bin	Contains the test libraries (DLL, LIB) and the help files belonging to the test libraries (HLP). The program files for the utilities in R&S GTSL are also in this folder.
Configuration	Contains the Physical Layer Configuration File (Physical.INI) and the Application Layer Configuration Files (Application.INI) for various example applications. The files marked with the text "SFT" are needed for the self-test. This folder also contains the calibration data.
Develop Libraries operint sample sftcsample tkts uutlib	<p>The folder <code>... \operint</code> contains an example for the adaptation of the user interface.</p> <p>The directory <code>... \sample</code> contains a generally valid example for the creation of a test library.</p> <p>The folder <code>... \sftcsample</code> contains an example for the preparation of a custom self-test or the customer-specific adaptation of the self-test provided.</p> <p>The folder <code>... \tkts</code> contains an example for the adaptation of the Toolkit for Teststand.</p> <p>The directory <code>... \uutlib</code> contains an extended example for the creation of a test library for customer-specific communication with the mobile phone being tested.</p> <p>The directories contain the C source code of the example libraries.</p>
Develop samples CombiTest DirectDriverCalls	<p>The folder <code>... \CombiTest</code> contains an example for a combinational test (in-circuit and functional test).</p> <p>The folder <code>... \DirectDriverCalls</code> contains an example how to mix R&S GTSL library and device driver calls.</p>
Develop tools selftest	This folder contains the TSVP self-test including the executable and the C source code.
Documentation ...	Contains the various items of documentation in the form of PDF files.
EGTSL Atg	Contains the files for the execution of the Automatic Test Generator ATG.
EGTSL Correction	Contains the utility ICTCorrection with the correction data determined.

Table 2-1 File structure

Directory	Contents
EGTSL Examples	Contains the examples described in the software description R&S EGTSL.
EGTSL Extlct Framework RSSample	The folder ...\ <code>Framework</code> contains the framework code for the creation of a user-defined ICT extension library. The folder ...\ <code>RSSample</code> contains an example for the creation of a user-defined ICT extension library with source-code and binaries.
EGTSL templates	Contains a template for the preparation of a new ICT program on the R&S EGTSL user interface.
Include	Contains the h-files (include files) needed for the development of new test libraries.
License	Contains, for each installed iButton or R&S CompactTSVP / R&S PowerTSVP, a subdirectory with the corresponding serial number. The test library license key files belonging to the serial number are stored in the directory.
OperatorInterface develop	Contains the run time module for the operator interface of TestStand and the Generic Test Operator Interface GTOPI. A TestStand run time licence is required.
Sequences	Contains the test sequence examples created by ROHDE & SCHWARZ.

Table 2-1 File structure



3 Functional description

3.1 General

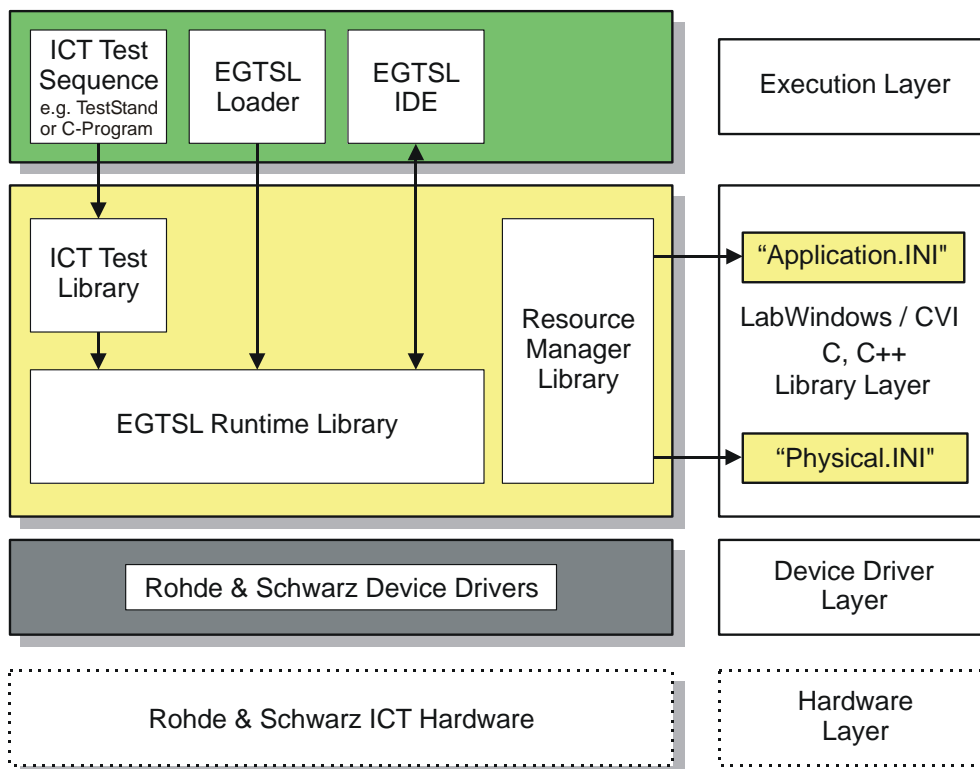


Figure 3-1 R&S EGTSL Layer Model

The Enhanced Generic Test Software Library R&S EGTSL is part of an extension to the Generic Test Software Library R&S GTSL. Using R&S EGTSL it is possible to prepare and perform in-circuit tests. The individual R&S EGTSL software components are arranged in individual layers exactly like R&S GTSL.

The bottom layer (device driver layer) of the R&S EGTSL contains the device drivers necessary for the test hardware used. The test hardware is accessed using these device drivers.

The middle layer (library layer) of the R&S EGTSL contains the ICT test library and the R&S EGTSL runtime library. The ICT test library provides the functions necessary for performing the in-circuit test. Using the R&S EGTSL runtime library (runtime engine) the internal R&S EGTSL program processes are run. In this layer further information is passed to the resource manager library via the two files PHYSICAL.INI and APPLICATION.INI. The various device drivers from the lowest lev-

el are called from this layer.

The top layer (execution layer) contains the test sequences for performing the in-circuit test. The test sequences call functions from the ICT test library in the middle layer. The function calls include, e.g.

- loading ICT programs,
- running ICT programs,
- debugging ICT programs and
- the generation of reports.

The calls for the individual functions from the ICT test library can, e.g., be made using a sequence editor (TestStand) or a dedicated C program.

The top layer (execution layer) also contains the R&S EGTSL Loader and the R&S EGTSL user interface (R&S EGTSL IDE). The R&S EGTSL user interface (R&S EGTSL IDE) is opened using the R&S EGTSL runtime library either by the R&S EGTSL Loader or a function call from the ICT test library.

Special test hardware is required for performing in-circuit tests. This hardware and thus the individual test functions are called using the R&S GTSL/R&S EGTSL-typical functions in the test libraries.



NOTE:

For further information on R&S GTSL see

“Software Description Generic Test Software Library R&S GTSL”

R&S EGTSL includes the following parts and programs:

- ICT runtime library
- ICT test library
- R&S EGTSL User interface (R&S EGTSL IDE)
- R&S EGTSL Loader
- Automatic Test Generator ATG (utility)
- ICT correction data (utility)

3.2 ICT test library

The following section provides a short overview of the test functions available in the ICT test library.



NOTE:

The individual test functions and their parameters are described in the online help for the ICT test library. The help files (.HLP) are in the folder . . . \GTSL\BIN.

3.2.1 General

Name of the dynamic link library (DLL):	ICT.DLL
Name of the help file (HLP):	ICT.HLP
License required	R&S TS-LBAS and R&S TS-LEGT or R&S TS-LEG2
Supported devices:	R&S TS-PICT ICT Extension Module R&S TS-PMB Matrix Module R&S TS-PSAM Source and Measurement Module R&S TS-PSU Power Supply / Load Module R&S TS-PSU12 Power Supply / Load Module 12V

The in-circuit test library offers functions for the in-circuit test using the R&S EGTSL software and the R&S TS-PSAM, R&S TS-PICT, R&S TS-PSU, R&S TS-PSU12 and R&S TS-PMB modules.

The functions allow to

- load, run and debug ICT programs
- load limit files
- generate a report

**3.2.2 Entries in PHYSICAL.INI****Section [device->...]**

Keyword	Value	Description
Type	String	<i>Mandatory entry</i> pict = R&S TS-PICT ICT Extension Module pmb = R&S TS-PMB Matrix Module psam = R&S TS-PSAM Source and Measurement Module psu = R&S TS-PSU Power Supply/Load Module psu12 = R&S TS-PSU12 Power Supply/Load Module 12V
ResourceDesc	String	<i>Mandatory entry</i> VISA resource descriptor in the form PXI[segment number]::[device number]::[function]::IN-STR CAN[board]::[controller]::[frame]::[slot]
DriverPrefix	String	<i>Mandatory entry</i> Prefix for the IVI driver functions, without underscore: R&S TS-PICT : rspict R&S TS-PMB : rspmb R&S TS-PSAM : rpsam R&S TS-PSU: rpsu R&S TS-PSU12: rpsu
DriverDLL	String	<i>Mandatory entry</i> File name of the driver DLL R&S TS-PICT : rspict.dll R&S TS-PMB : rspmb.dll R&S TS-PSAM : rpsam.dll R&S TS-PSU : rpsu.dll R&S TS-PSU12 : rpsu.dll
DriverOption	String	<i>Optional entry</i> Option string being passed to the device driver during the Driver_Init function. See the online help file for the appropriate device driver.

3.2.3 Entries in APPLICATION.INI

Section [bench->...]

Keyword	Value	Description
ICTDevice1	String	<i>Mandatory entry</i> Refers to the device section of the R&S TS-PSAM
ICTDevice2	String	<i>Optional entry</i> Refers to the device section of the R&S TS-PICT or R&S TS-PSU / R&S TS-PSU12
ICTDevice3	String	<i>Optional entry</i> Refers to the device section of the R&S TS-PICT or R&S TS-PSU / R&S TS-PSU12
ICTCorrResistor2W	REAL	<i>Optional entry</i> Unit: Ohm Bench correction value, that is taken into account for all 2-wire resistor test measurements (DC-measurements). The correction value is subtracted from the measurement. The result of the subtraction is compared with the limits.
ICTCorrImpedanceRes2W		
	REAL	<i>Optional entry</i> Unit: Ohm Bench correction value, that is taken into account for all 2-wire impedance test resistor measurements (AC-measurements). The correction value is subtracted from the measurement. The result of the subtraction is compared with the limits.
ICTCorrImpedanceCap2W		
	REAL	<i>Optional entry</i> Unit: Farad Bench correction value, that is taken into account for all 2-wire impedance test capacitance measurements. The correction value is subtracted from the measurement. The result of the subtraction is compared with the limits.



Keyword	Value	Description
ICTCorrImpedanceInd2W		
	REAL	<i>Optional entry</i> Unit: Henry Bench correction value, that is taken into account for all 2-wire impedance test inductance measurements. The correction value is subtracted from the measurement. The result of the subtraction is compared with the limits.
SwitchDevice<i>	String	<i>Mandatory entry</i> Refers to a section with switch devices in PHYSICAL.INI. <i> stands for a number from 1,2,3,...,n. The numbers must be assigned in ascending order without gaps. <i> may be omitted in the case it is 1.
AppChannelTable	String	<i>Mandatory entry</i> Refers to a section with defined channel names in APPLICATION.INI.
Simulation	0 / 1	<i>Optional entry</i> Blocks the simulation of the entered devices (value = 0). Enables simulation of the entered devices (value = 1). Default = 0
Trace	0 / 1	<i>Optional entry</i> Blocks the tracing function of the library (value = 0). Enables the tracing function of the library (value = 1). Default = 0
ChannelTableCase Sensitive		
	0 / 1	<i>Optional entry</i> The channel names in the channel table are treated case-sensitive (value = 1) or case-insensitive (value = 0).

Section [io_channel->...]

Contains a list of user-specific channel names (or ATG-defined channel names) which are assigned to the physical device names and to the physical device channel names. The defined names apply only to the relevant application. For details about channel name syntax, see "Software Description GTSL", chapter 8.3.4.

Keyword	Value	Description
<user-defined name>	String	Physical channel description in the combination <device name>!<device channel name>

3.2.4 Functions

Setup	ICT_Setup
Library Version	ICT_Lib_Version
EGTSL Runtime Version	ICT_Runtime_Version
Program Control	
Load Program	ICT_Load_Program
Run Program	ICT_Run_Program
Debug Program	ICT_Debug_Program
Unload Program	ICT_Unload_Program
Report Generation	
Write Report to File	ICT_Write_Report
Load Detailed Report	ICT_Load_Detailed_Report
Get Detailed Report Entry	ICT_Get_Detailed_Report_Entry
Get Detailed Report Entry (Extended)	ICT_Get_Detailed_Report_Entry_Ex
Get TestStand Report Entry	ICT_Get_TestStand_Report_Entry
Transfer Report to QUOTIS	ICT_Transfer_Quotis_Report
Limit Loader	
Load Limits	ICT_Load_Limits
Error Handling	
Get Error Log	ICT_Get_Error_Log
Cleanup	ICT_Cleanup



3.3 R&S EGTSL Loader

Using the **R&S EGTSL Loader** the R&S EGTSL user interface (*R&S EGTSL IDE*) can be opened directly. A function call from the ICT test library is not necessary.



NOTE:

The operation of the R&S EGTSL Loader is described in section 13.2.

3.4 R&S EGTSL user interface (R&S EGTSL IDE)

The R&S EGTSL user interface (*R&S EGTSL IDE*) for editing and debugging an ICT program is started either using a function from the ICT test library or using the R&S EGTSL Loader.

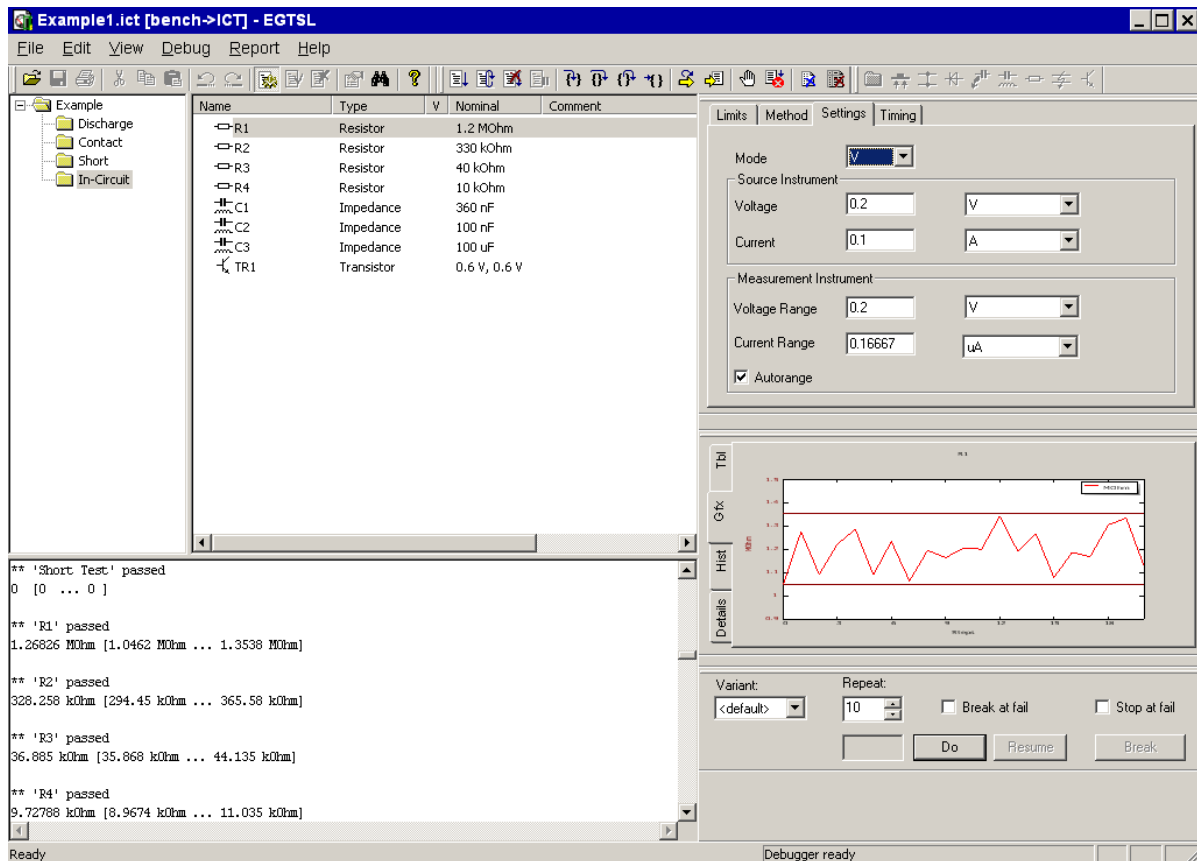


Figure 3-2 R&S EGTSL User interface (*R&S EGTSL IDE*)

The R&S EGTSL user interface (*R&S EGTSL IDE*) provides a wide range of functions for preparing, editing and debugging an ICT program.

- Loading ICT programs
- Editing general ICT program settings
- Importing and exporting values for limits for all test steps
- Printing the test report generated
- Inserting and deleting test steps
- Editing the test step settings
- Search functions
- Setting break points

- Debugging the ICT program
 - Complete execution of the ICT program
 - Execution in single steps
 - Execution until an error occurs
 - Execution of marked test steps
- Display of the test results (text and graphics)
- Preparation of a test report


NOTE:

The individual functions of the R&S EGTSL user interface (R&S EGTSL *IDE*) are described in section 5.

3.5 Automatic Test Generator ATG

Using the Automatic Test Generator ATG utility, a circuit description and the description of the test hardware available are used to generate an ICT program that will run in the Enhanced Generic Test Software Library R&S EGTSL. The ICT program generated can be opened in the R&S EGTSL user interface (*R&S EGTSL IDE*) and edited.


NOTE:

The individual functions of the Automatic Test Generator ATG are described in section 9.

3.6 ICT correction data

The test system is calibrated using the ICTCorrection utility. Resistances and capacitances in the system are determined and saved as correction data. Using this data, the values measured during the in-circuit test are corrected.


NOTE:

The individual functions of the ICTCorrection program are described in section 15.

3.7 Hardware for in-circuit test

To be able to perform an in-circuit test using R&S EGTSL the following test hardware must be available:

- Test System Versatile Platform R&S CompactTSVP TS-PCA3
- Test System Versatile Platform R&S PowerTSVP TS-PWA3 (alternative expansion)
- R&S TS-PSAM Source and Measurement Module
- R&S TS-PICT In-Circuit Test Module (alternative expansion for certain test methods)
- R&S TS-PSU Power Supply/Load Module / R&S TS-PSU12 Power Supply/Load Module 12V (expansion for zener diode and transistor test methods).
- R&S TS-PMB Matrix Module B
- Test adapters developed and built especially for the Unit Under Test (UUT) and the related test program



NOTE:

The precise composition and number of items of hardware is always dependent on the specific project and the test methods required.

The individual components of test hardware are described in the related user manuals.



4 Getting Started

4.1 General

This section describes the development process for an in-circuit test in a step-by-step manner based on a simple example. The individual steps can be followed using these instructions so that you can rapidly become familiar with the Enhanced Generic Test Software Library R&S EGTSL.



NOTE:

The example circuit, the related BDL file and the files generated by the Automatic Test Generator ATG are listed in appendix A. The related files are saved in . . . \GTSL\EGTSL\Example.

4.2 Development process for an in-circuit test

Based on the (existing) circuit documents for a unit under test (for the in-circuit test the unit is generally a circuit board) an ICT program is to be prepared that can test whether the circuit board is correctly populated. The mechanical-electrical adaptation of the unit under test to the test system, i.e. building a bed of nails adapter is also included.

The Enhanced Generic Test Software Library R&S EGTSL provides a series of utilities that enable these tasks to be tackled largely automatically. Based on an example circuit, the features provided by the software will be demonstrated.

To pass from the circuit documentation to the finished ICT program, the following steps are necessary:

- Preparation of the circuit documentation
- Entry of the circuit description
- Preparation of the test program by the Automatic Test Generator ATG
- Preparation of the adapter
- Commissioning and debugging the test program

4.3 Preparation of the circuit documentation

In the first step the test points, i.e. the pins on the bed of nails adapter, are entered on the circuit diagram. As during the in-circuit test, every component is measured separately, it is important that the test system can make contact to every pin on every component. For this purpose, a test nail must be provided at every node of the circuit.

The names of the test points, also called nodes, appear later in the test program. They must therefore be clear, i.e. either refer to the function in the circuit (like INPUT, OUTPUT) or to a component connected to the node (like TR1.B for the base of transistor TR1). Special rules apply for ground and supply voltage. The names of such test points must always start with GND or VCC respectively, so that the automatic test generator can detect them as ground and supply voltage and treat them appropriately.

4.3.1 Example circuit

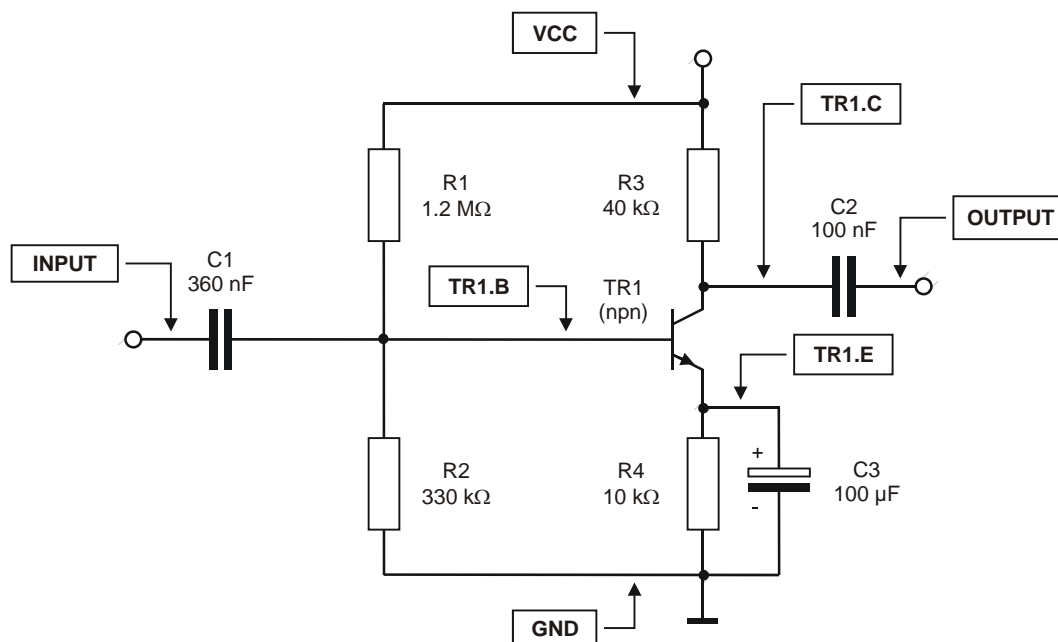


Figure 4-1 Circuit example 1

Figure 4-1 shows the circuit for a low frequency amplifier stage. The names of the test points are already entered.

4.3.2 Preparation of the circuit description

For further processing in R&S EGTSL the circuit description for the circuit to be tested must be available as a BDL file (see also section 8.2). There are now various ways you can prepare the necessary BDL file.

1. Prepare the BDL file (circuit description) manually in a text editor based on the circuit diagram.
2. Transfer the circuit description from a CAD system. Modern CAD systems for the preparation of electronic circuits provide a feature for exporting the circuit description. Using commercially available conversion software, the exported circuit description can be converted to the BDL format.

The manual preparation of the circuit description is of course tedious for larger circuits. Here it is best, if possible, to transfer the data from the CAD system. For the small example with only eight components, it is however easy to enter the BDL data by hand.



NOTE:

The BDL file is saved in `... \GTSL\EGTSL\Example\Example1.BDL`.

4.3.2.1 Entry of the resistors

BDL example for resistor R1

```
RESISTOR

NAME 'R1'
PART_ID '1234.5678.90'
VALUE 1.2 MOHM
TOL+ 10% TOL- 10%
I_LIM 100.0 MA
PIN_1 'VCC'
PIN_2 'TR1.B'
ERR_MSG 'Problem with R1'
```

The following information on a resistor must be entered in the text editor:

NAME	Component name
PART_ID	Optional component identifier for the component
VALUE	Nominal value and unit for the component
TOL+	Positive component tolerance in % (default value 10 %)



TOL-	Negative component tolerance in % (default value 10 %)
I_LIMIT	Maximum measuring current for determining the value with unit (default value 100 mA)
PIN_1	Test point 1 for the component
PIN_2	Test point 2 for the component
ERR_MSG	Optional error text The text entered here is displayed in the report if the component has been detected as faulty.

For the example circuit, all resistors must be entered in the same manner:

Name	Value	Pin 1	Pin 2
R1	1.2 MOHM	VCC	TR1.B
R2	330 KOHM	TR1.B	GND
R3	40 KOHM	VCC	TR1.C
R4	10 KOHM	TR1.E	GND

4.3.2.2 Entry of capacitors

BDL example for capacitor C1

CAPACITOR

```

NAME 'C1'
PART_ID '0987.6543.21'
VALUE 360 NF
TOL+ 10% TOL- 10%
PIN_1 'INPUT'
PIN_2 'TR1.B'
ERR_MSG 'Problem with C1'

```

The following information on a capacitor must be entered in the text editor:

NAME	Component name
PART_ID	Optional component identifier for the component
VALUE	Nominal value and unit for the component
TOL+	Positive component tolerance in % (default value 10 %)
TOL-	Negative component tolerance in % (default value 10 %)
PIN_1	Test point 1 for the component

PIN_2 Test point 2 for the component

ERR_MSG Optional error text
The text entered here is displayed in the report if the component has been detected as faulty.

For the example circuit, all capacitors must be entered in the same manner:

Name	Value	Pin 1	Pin 2
C1	360 NF	INPUT	TR1.B
C2	100 NF	TR1.C	OUTPUT

When entering electrolytic capacitors, attention must be paid to two special aspects: the unit microfarad is identified using a "U". The positive pole is termed pin A (= anode), the minus pole as pin C (=cathode).

BDL example for capacitor C3 (electrolytic)

POL_CAP

```

NAME 'C3'
PART_ID 'C300.4711'
VALUE 100 UF
TOL+ 10% TOL- 10%
PIN_A 'TR1.E'
PIN_C 'GND'
ERR_MSG 'Problem with C3'

```

Name	Value	Pin A	Pin C
C3	100 UF	TR1.E	GND



4.3.2.3 Entry of the transistor

BDL example for transistor T1

TRANSISTOR

```

NAME 'TR1'
PART_ID 'T1000'
NPN
UBE 0.6 V
TOL+ 30% TOL- 30%
I_LIM 100.0 MA
PIN_E 'TR1.E'
PIN_B 'TR1.B'
PIN_C 'TR1.C'
ERR_MSG 'Problem with T1'

```

The following information on a transistor must be edited in a text editor:

NAME	Component name
PART_ID	Optional component identifier for the component
NPN, PNP	Type of transistor
UBE	Base-emitter voltage of the transistor in the forward bias region
TOL+	Positive component tolerance in %
TOL-	Negative component tolerance in %
I_LIMIT	Maximum measuring current for determining the value with unit (default value 100 mA)
PIN_E	Test point for the transistor's emitter
PIN_B	Test point for the transistor's base
PIN_C	Test point for the transistor's collector
ERR_MSG	Optional error text The text entered here is displayed in the report if the component has been detected as faulty.

Name	Type	Pin E	Pin B	Pin C
TR1	N	TR1.E	TR1.B	TR1.C

4.4 Preparing the ICT program

Once the circuit description is available as a BDL file, an ICT program can be prepared with the aid of the Automatic Test Generator ATG.



NOTE:

The Automatic Test Generator ATG is described in section 9.2.



Automatic Test
Generator

Start the Automatic Test Generator ATG using **Start -> Programs -> GTSL -> Automatic Test Generator**.

The following files must be entered in the ATG:

- *Example1.BDL*
path and file name for the BDL file (circuit description)
- *Example_Physical.INI*
path and file name for the Physical Layer Configuration File (hardware description of the test system)

Following the automatic generation process, the ATG prepares the following files:

- *Example1_Report.TXT*
report with the data on the generation process

Any errors that have occurred during the generation process are indicated in the report using error messages and warning messages (see section 9.3.2.1). Only when there are no error messages or warning messages is the ICT program prepared. In addition, the alternative suggestions (proposals) made by the ATG are to be noted (see section 9.3.2.2).

- *Example1.ICT*
ICT program for execution in R&S EGTSL

The layout of the automatically generated ICT program is defined by a structure anchored in the ATG. In principle, the fully generated test program has the following layout:

1. Capacitor discharging (Discharge)
2. Contact test (Contact)
3. Continuity and short-circuit test (Short)
4. Group of analog tests (In-Circuit)

- *Example1_Application.INI*

Application Layer Configuration File for the execution of the ICT program generated in R&S EGTSL

In the Application Layer Configuration File, the specific information for the usage of the hardware is compiled by the ATG for the ICT program generated. On the execution of the ICT program, the name of the Application Layer Configuration File generated must be given.

4.5 Adapter manufacture

In the Application Layer Configuration File generated by the Automatic Test Generator ATG, an I/O channel on the R&S TS-PMB Matrix Module B is allocated to each test point (node) of the circuit.

Example:

```
[io_channel->ICT]
GND           = PMB1!P1
INPUT        = PMB1!P2
OUTPUT       = PMB1!P3
TR1.B        = PMB1!P4
TR1.C        = PMB1!P5
TR1.E        = PMB1!P6
VCC          = PMB1!P7
```

```
[io_wiring->ICT]
GND           = F1 S15 X10A1
INPUT        = F1 S15 X10A2
OUTPUT       = F1 S15 X10A3
TR1.B        = F1 S15 X10A4
TR1.C        = F1 S15 X10A5
TR1.E        = F1 S15 X10A6
VCC          = F1 S15 X10A7
```



NOTE:

This information can be used for the manufacture of the adapter.

4.6 Commissioning and debugging

The newly prepared ICT program is now, together with the finished adapter, ready to use. However, correct operation should first be checked on a few circuit boards. It may be necessary to slightly change test value limits or adjust settings.

The user interface for R&S EGTSL (*R&S EGTSL IDE*) for debugging (and executing) ICT programs can be started in two ways:

1. Start the user interface from a test sequence using a function call from the ICT test library (see section 13.1)
2. Start the user interface using the R&S EGTSL Loader (see section 13.2)

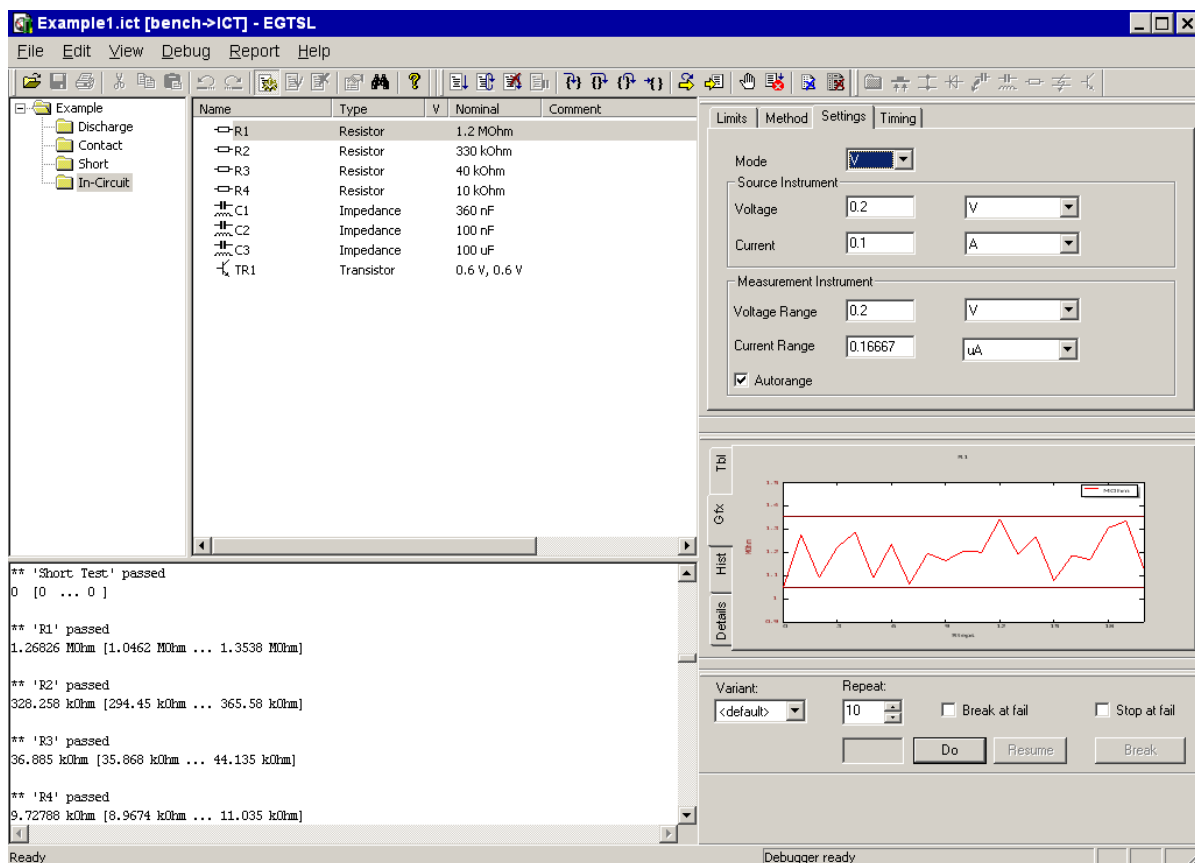


Figure 4-2 R&S EGTSL User interface (*R&S EGTSL IDE*)

When starting the *R&S EGTSL IDE* from a test sequence, the ICT program is automatically opened with the corresponding bench. When starting the *R&S EGTSL IDE* using the R&S EGTSL Loader, the ICT program must be opened manually using the menu command **File -> Open**. When opening the ICT file, the corresponding bench for execut-

ing the ICT program must be entered.

Modifications can be made to the ICT program in the various windows of the user interface. When the debugger is activated, various types of program execution are possible:

- Complete execution of the ICT program
- Execution in single steps
- Execution until an error occurs
- Execution of marked test steps



NOTE:

The various windows, menu commands and buttons on the R&S EGTSL user interface (R&S EGTSL IDE) are described in section 5. The detailed procedure for debugging ICT programs is described in section 15.

As the example circuit will probably not be built and an adapter has not been produced, the ICT program can only be tested and debugged in the simulation mode. For this purpose it is necessary to activate the simulation in the Application Layer Configuration File in the section [bench->...].

```
[bench->ICT]
Description      = ICT bench (Simulation)
Simulation      = 1
Trace           = 0
ICTDevice1      = device->psam
ICTDevice2      = device->pict
SwitchDevice1   = device->pmb1
AppChannelTable = io_channel->ICT
```

When the ICT program is opened with the corresponding bench, all functions in the ICT program and the R&S EGTSL user interface can be executed in the simulation mode.

5 User interface *(R&S EGTSL IDE)*

5.1 General

The Enhanced Generic Test Software Library R&S EGTSL runs under the WINDOWS 2000 and WINDOWS XP operating system.



NOTE:

To operate the Enhanced Generic Test Software Library R&S EGTSL basic skills in the usage of the WINDOWS 2000 or WINDOWS XP operating system are required.

5.2 Menu structure

EGTSL					
File	Edit	View	Debug	Report	Help
Open	Undo	Main Toolbar	Go	Clear Report Window	About EGTSL
Save	Redo	Debug Toolbar	Restart	Report Enable	
Save Copy As	Cut	Toolbar for Insert	Terminate	Report Errors Only	
Select	Copy	User-defined Toolbar	Break	Clear Result	
Close	Paste	Status Bar	Repeat	Auto Clear	
Program Properties	Delete	Results	Resume		
Limits	Insert	Test Properties	Step Into		
Print	Select All	Debug	Step Over		
Print Setup	Apply		Step Out		
Exit	Revert		Run to Cursor		
	Auto apply		Set Next Step		
	Find		Show Next Step		
	Rename		Toggle Breakpoint		
	Step Properties		Stop At Fail		
	Breakpoints		Break At Fail		

Figure 5-1 Menu structure

5.3 Main screen

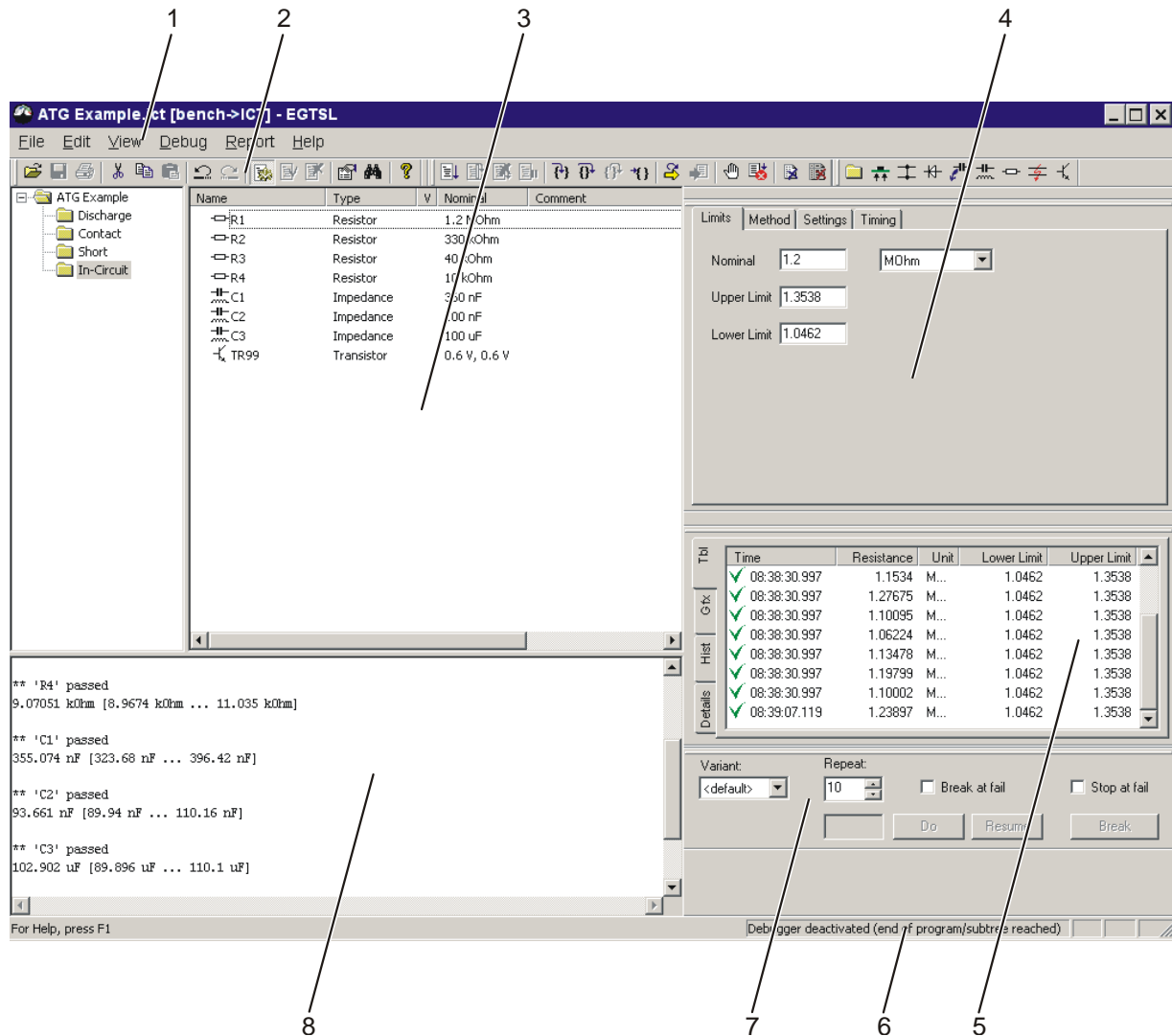


Figure 5-2 Main screen R&S EGTSL

- | | | |
|---|----------------------------|----------------------------|
| 1 | Menu bar | see section 5.6 |
| 2 | Toolbars | see section 5.7 |
| 3 | Program sub-window | see section 5.4.2 |
| 4 | Test Properties sub-window | see sections 5.4.4 and 5.5 |
| 5 | Results sub-window | see section 5.4.5 |
| 6 | Status bar | |
| 7 | Debug sub-window | see section 5.4.6 |
| 8 | Report sub-window | see section 5.4.3 |



5.4 Sub-window

5.4.1 Positioning of the sub-windows

See Figure 5-2.

The Program and Report sub-windows have a fixed position on the left of the R&S EGTSL screen. The vertical division between the two windows can be varied using the mouse.

The Test Properties, Result and Debug sub-windows are displayed on the right of the R&S EGTSL screen in a fixed position with a fixed size. The size of the Program and Report sub-windows is automatically adjusted when the Test Properties, Result and Debug sub-windows are displayed. The position of the Test Properties, Result and Debug sub-windows can be changed using the mouse. On the right of the R&S EGTSL screen the Test Properties, Result and Debug sub-windows dock in a fixed position when moved. When the **Ctrl** key is pressed, the Test Properties, Result and Debug sub-windows can be moved to any position using the mouse (no docking).

The size of the Result sub-window can be changed using the mouse (horizontal and vertical). By double-clicking the Result sub-window, you can change between the freely selectable position (and size) and the fixed position on the right of the R&S EGTSL screen.

5.4.2 Program sub-window

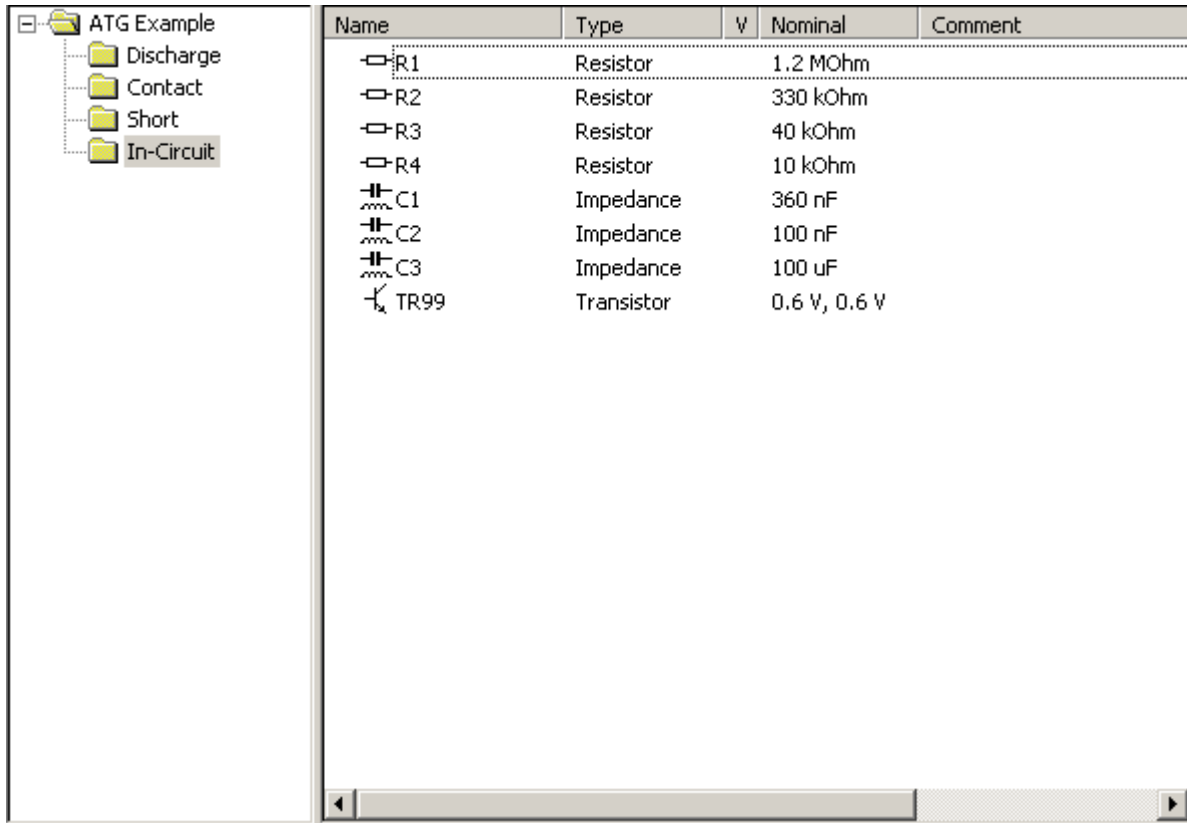


Figure 5-3 Program sub-window

The ICT program is displayed on the left of the Program sub-window together with its individual program groups in a tree structure. The individual test steps in the ICT program are displayed on the right of the Program sub-window.

The horizontal distribution between the two windows can be varied using the mouse.

The navigation within the two windows and the editing of test steps is performed using the familiar Windows mouse and key commands, e.g.:

Left mouse button pressed	Move and mark test steps and groups
Ctrl + left mouse button	Mark several test steps
Shift + left mouse button	Mark a range of test steps
Right mouse button	Open the context menu

5.4.2.1 Context menu

When you click the right mouse button in the Program window, a context menu is opened.

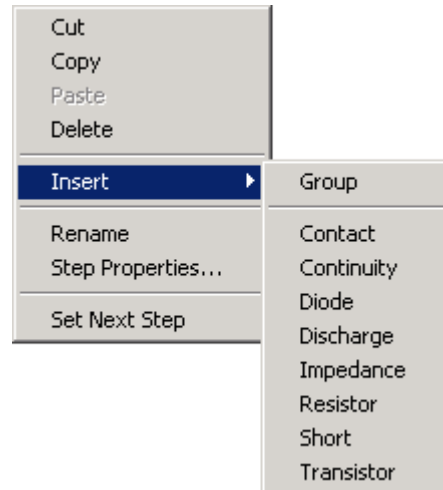


Figure 5-4 Program context menu

Cut	Deletes the marked test step or the marked program group and copies it to the Clipboard.
Copy	Copies the marked test step or the marked program group to the Clipboard.
Paste	Inserts the contents of the Clipboard (test step, program group, text content) at the current cursor position.
Delete	Deletes the marked test step or the marked program group.
Insert	Opens the list box for inserting test steps or program groups. On this topic, see also section 5.5: Test Steps.
Rename	Enables the marked test step name or program group name to be edited.
Step Properties	Opens the dialog box for the step properties for the selected test step or the selected program group. On this topic, see also section 5.6.2.3: Menu command <Step Properties>.
Set Next Step	Marks the cursor position as the test step that is to be executed next. A yellow arrow is displayed on the left beside the selected test step.

5.4.3 Report sub-window

```

** 'R1' passed
1.23897 MOhm [1.0462 MOhm ... 1.3538 MOhm]

** 'R2' passed
302.445 kOhm [294.45 kOhm ... 365.58 kOhm]

** 'R3' passed
41.191 kOhm [35.868 kOhm ... 44.135 kOhm]

** 'R4' passed
9.07051 kOhm [8.9674 kOhm ... 11.035 kOhm]

** 'C1' passed
355.074 nF [323.68 nF ... 396.42 nF]

** 'C2' passed
93.661 nF [89.94 nF ... 110.16 nF]

** 'C3' passed
102.902 uF [89.896 uF ... 110.1 uF]

```

Figure 5-5 Report sub-window

All messages from the ICT are displayed in the Report window. These messages include:

- Information on report preparation
- The test result for each test step with the measured values determined.
- Errors during the compilation of the test steps or the ICT program.

The vertical size of the Report window can be changed by dragging using the mouse.



NOTE:

Additional information on the report format is described in Chapter 14.

5.4.3.1 Context menu

When you click the Report window using the right mouse button, a context menu is opened.

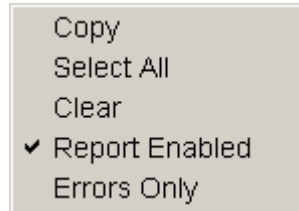


Figure 5-6 Report context menu

Copy

Copies all marked entries in the Report window to the Clipboard. Using the familiar Windows keyboard and mouse commands, you can mark the entries in the Report window.

Select All

Marks all entries in the Report window.

Clear

Deletes all entries in the Report window.

Report Enable

With this function activated a report is displayed in the Report window.

Errors Only

With this function activated, only erroneous measurements and error messages are displayed in the Report window.

5.4.4 Test Properties sub-window

In the Test Properties sub-window, the test step-specific settings are made. The various windows are displayed for every type of test step.



NOTE:

The functions in the individual windows are described in section 5.5 with the individual test steps.

5.4.5 Results sub-window

The measured results from the individual test steps of the ICT program are displayed in the Result windows in various ways.

5.4.5.1 Context menu

When you click the right mouse button in the Tbl, Gfx and Hist result windows, the following context menu is opened.

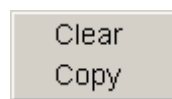


Figure 5-7 Results context menu

Clear

Deletes all entries in the Result windows (Tbl, Gfx, Hist) for all test steps.

Copy

Tbl

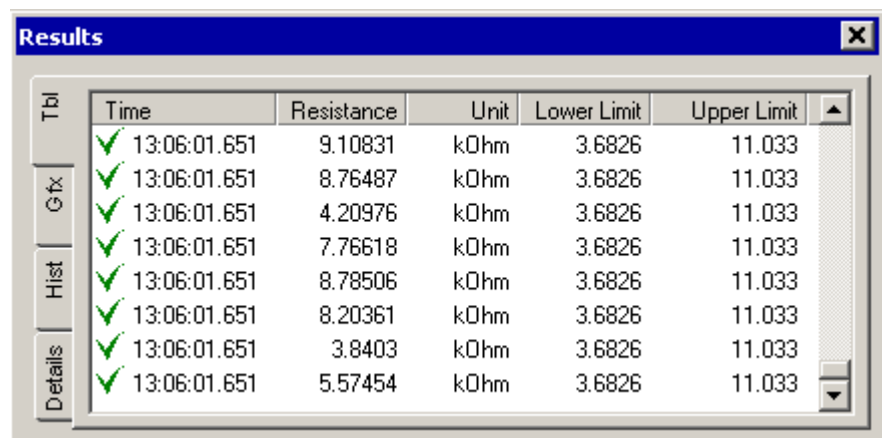
Copies all test entries for the test step marked to the Clipboard.

Gfx and Hist

Copies the graphic for the test step marked to the Clipboard.

Using the Clipboard, you can copy test and graphics to other programs. There you can, e.g., edit, save or print the information copied.

5.4.5.2 Results Tbl



	Time	Resistance	Unit	Lower Limit	Upper Limit
✓	13:06:01.651	9.10831	kOhm	3.6826	11.033
✓	13:06:01.651	8.76487	kOhm	3.6826	11.033
✓	13:06:01.651	4.20976	kOhm	3.6826	11.033
✓	13:06:01.651	7.76618	kOhm	3.6826	11.033
✓	13:06:01.651	8.78506	kOhm	3.6826	11.033
✓	13:06:01.651	8.20361	kOhm	3.6826	11.033
✓	13:06:01.651	3.8403	kOhm	3.6826	11.033
✓	13:06:01.651	5.57454	kOhm	3.6826	11.033

Figure 5-8 Results Table

In the **Results/Tbl** window, the test results for the test step marked are displayed in a table. The information displayed varies depending on the type of test step selected (measured values, values for limits, etc.).

5.4.5.3 Results Gfx

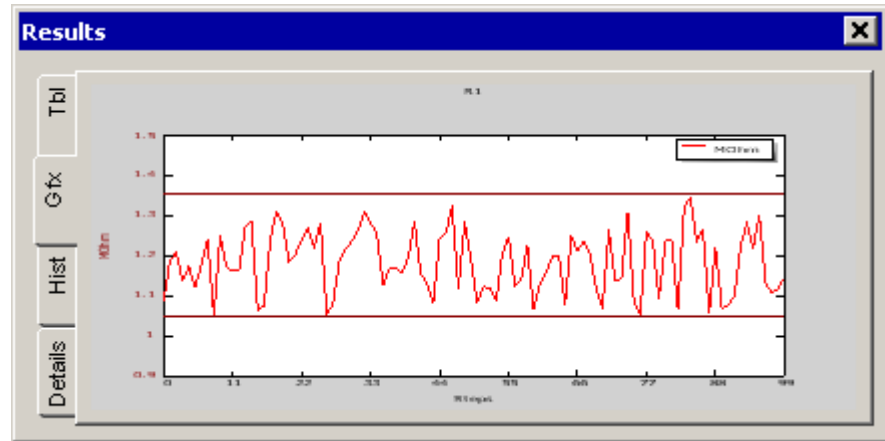


Figure 5-9 Results Graphic

In the **Results/Gfx** window the test results for the test step marked are displayed graphically. The information displayed varies depending on the type of test step selected. The measured results for the individual measurements and the stipulated values for the limits (horizontal line(s)) are displayed.

If a test step provides several test results (e.g. diode, transistor), the first test result is displayed in red. The second test result is displayed in blue.

5.4.5.4 Results Hist

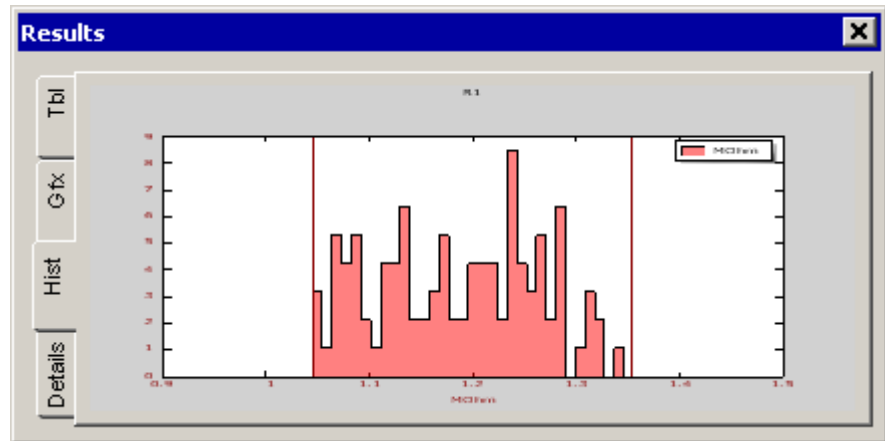


Figure 5-10 Results History

In the **Results/Hist** window the distribution of the measured results for the test step marked is displayed graphically. The information displayed varies depending on the type of test step selected. In addition, the stipulated values for the limits are displayed as vertical line(s).

If a test step provides several test results (e.g. diode, transistor), the first test result is displayed in red. The second test result is displayed in blue.

5.4.5.5 Results Details

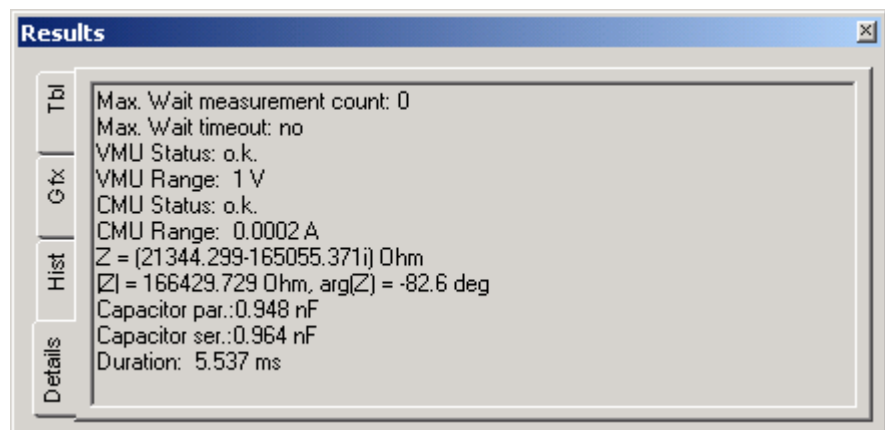


Figure 5-11 Results Details

In the **Results/Details** window, detailed information on the test step marked is displayed. The information displayed varies depending on

the type of test step selected.

When you click the right mouse button in the Result window, the following context menu is opened.

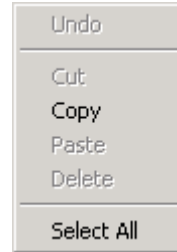


Figure 5-12 Results context menu

- Undo** This function is not available because the **Results/Details** window is “read only”.
- Cut** This function is not available because the **Results/Details** window is “read only”.
- Copy** Copies the text entry marked to the Clipboard.
- Paste** This function is not available because the **Results/Details** window is “read only”.
- Delete** This function is not available because the **Results/Details** window is “read only”.
- Select All** Marks all entries in the Results window.

5.4.6 Debug sub-window

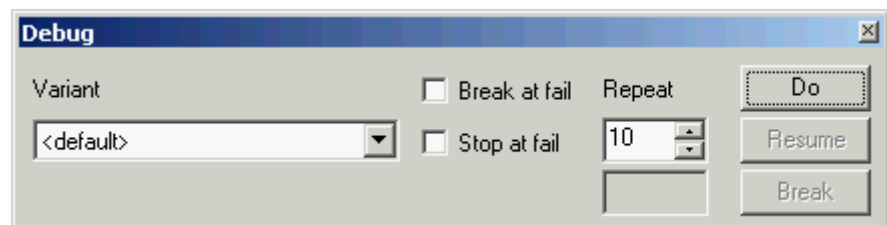


Figure 5-13 Debug

In the **Debug** sub-window, the settings for executing (individual) test steps are made. The marked test steps are executed. Only contiguous blocks of test steps can be executed. No test steps can be skipped.

To execute the test steps, the debugger must be started (a test step must be selected using the yellow arrow). The message **Debugger ready** is given in the status bar. The debug mode is activated with the following functions:

- Step Into [F11]
- Step Over [F10]
- Step Out [Shift+F11]
- Run to Cursor [Ctrl+F11]
- Set Next Step [Ctrl+Shift+F10]

Further information on debugging ICT programs is given in chapter 12.

Variant:

In the **Variant** list box, the test steps marked with a variant are enabled for execution. With the selection <default> test steps with a variant marker are not executed. Test steps without a variant marker are always executed.



NOTE:

The variants entered in the Variant list box apply not only to the execution of test steps using the Debug sub-window (see Figure 5-13) but also for all other debug functions (see section 5.6.4).

Break at fail

With this function activated, the execution of the ICT program (test steps marked) is interrupted when the test step result was "Fail". The program stops at the erroneous test step. The **Break at fail** function applies only to the **Repeat** function.

Stop at fail

With this function activated, the ICT program execution is stopped when the test step result was "Fail". The program stops at the erroneous test step. The **Stop at fail** function applies to all debug commands with the exception of the **Repeat** function.

Repeat:

In the **Repeat** field you can define how often the marked test steps are to be executed.

Do

Starts the execution of the test steps marked with the number of repetitions given

Resume

Continues the execution of the test steps marked on an interruption using the **Break** button.

Break

Interrupts the execution of the test steps marked.

5.5 Test Steps

5.5.1 Contact



NOTE:

The contact test is described in section 10.3.

5.5.1.1 General

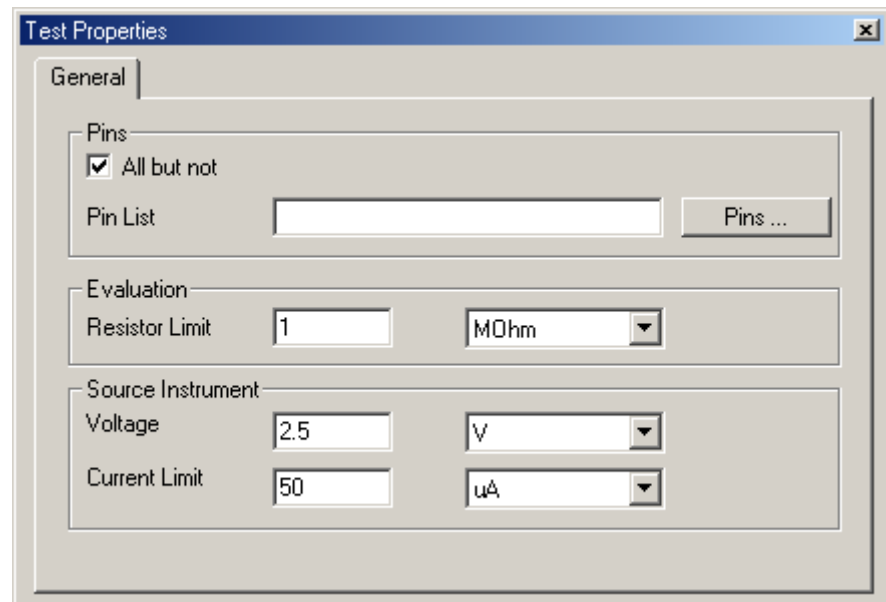


Figure 5-14 Test Step Contact, Test Properties General

Pins

All but not

With this check box selected, all available measuring pins are checked for contact. The list of available measuring pins is read from the “Available Pins” (see section 5.5.12.2). The measuring pins given in the **Pin List** are not checked for contact.

Pin List

Check box **All but not** cleared:

all the measuring pins entered in the **Pin List** are checked for contact.

Check box **All but not** selected:

all pins with the exception of the measuring pins entered in the Pin List are checked for contact.



Opens the **Pins** dialog box for inserting / removing pins on the Pin List.
For more information, see section 5.5.12.2.

Evaluation

Resistor Limit

The maximum resistance that is still evaluated as a contact is entered in this field.

Value range:

1 kΩ ... 1 MΩ

Default:

1 MΩ

Source Instrument

Voltage

The voltage of the voltage source is entered in this field.

Value range:

1.0 V ... 5.0 V

Default:

2.5 V

Current Limit

The current limit of the voltage source is entered in this field.

Value range:

1.0 μA ... 5.0 mA

Default:

50 μA

5.5.1.2 Results Details

For the Contact test step, the following information is displayed in the **Results/Details** window after the execution of test step:

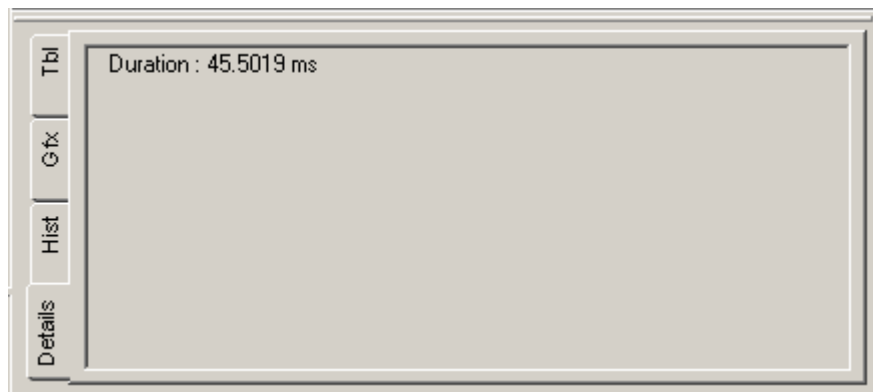


Figure 5-15 Test Step Contact, Results Details

Duration

Duration of the the last Contact test step executed.

5.5.2 Continuity



NOTE:

The continuity test is described in section 10.4.

5.5.2.1 General

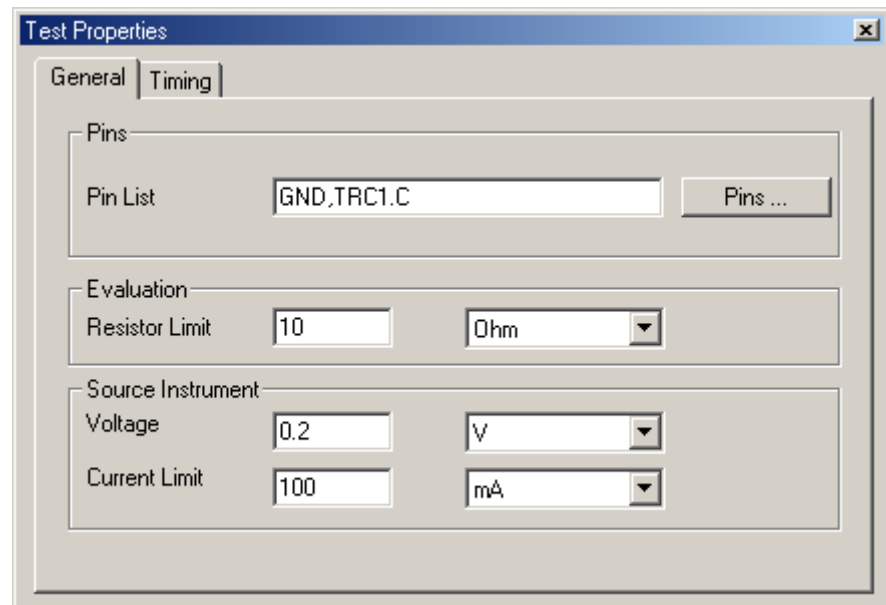


Figure 5-16 Test Step Continuity, Test Properties General

Pins

Pin List



All measuring pins entered in the **Pin List** are checked for continuity.

Opens the **Pins** dialog box for inserting / removing pins on the Pin List.

For more information, see section 5.5.12.2.

Evaluation

Resistor Limit

The maximum resistance that is still evaluated as continuity is entered in this field.

Value range:

1 Ω ... 1 kΩ

Default:

10 Ω

*Source Instrument***Voltage**

The voltage of the voltage source is entered in this field.

Value range:

0.1 V ... 0.5 V

Default:

0.2 V

Current Limit

The current limit of the voltage source is entered in this field.

Value range:

1 μ A ... 100 mA

Default:

100 mA

5.5.2.2 Timing

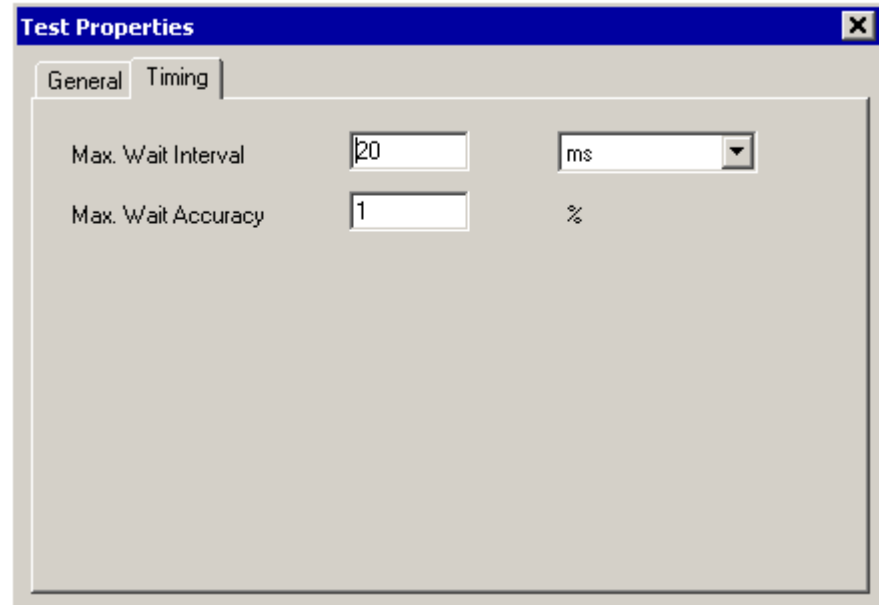


Figure 5-17 Test Step Continuity, Test Properties Timing



NOTE:

The individual options for the timing of the measurement operation are described in more detail in section 5.5.12.1.

Max. Wait Interval

The maximum duration of the test interval for each individual pin is entered in this field (maximum 20 samples).

Value range:

0 ms ... 10 s

Resolution:

1 ms (at a Max. Wait Interval of 1 ms a sample is taken every 50 μ s)

Default:

20 ms

Max. Wait Accuracy

In this field the maximum percentage difference between two measured values in succession (samples) is entered for test steps in which the measured value is applied (measurement with “Max. Wait Interval”).

Value range:

0.0 % ... 10.0 %

Default:

1.0 %

5.5.2.3 Results Details

For the Continuity test step, the following information is displayed in the **Results/Details** window after the execution of test step:

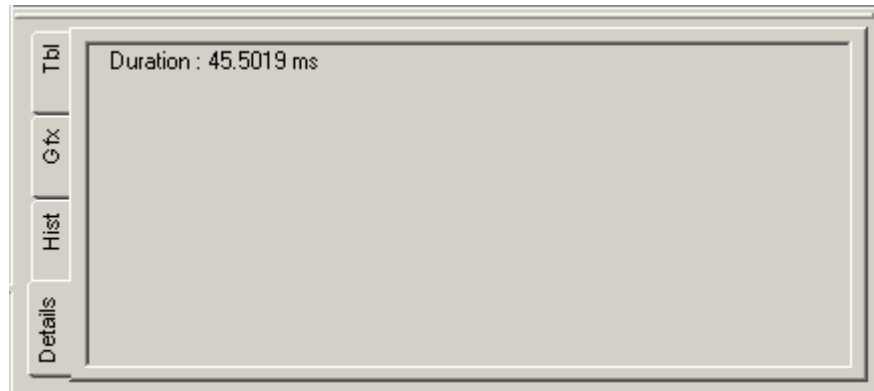


Figure 5-18 Test Step Continuity, Results Details

Duration

Duration of the last Continuity test step executed

5.5.3 Diode



NOTE:

The diode test is described in section 10.5.

5.5.3.1 Limits

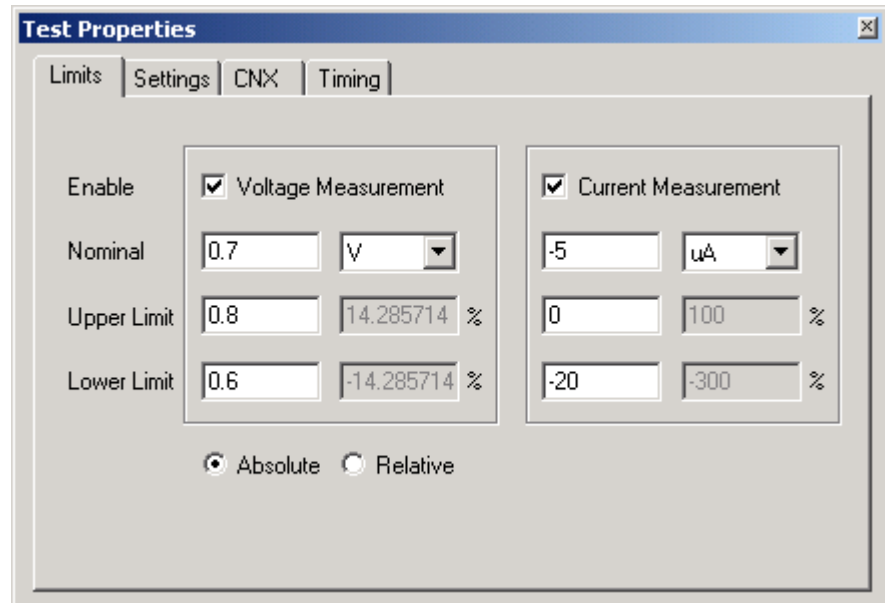


Figure 5-19 Test Step Diode, Test Properties Limits

Enable

During the diode test, two measurements are performed optionally:

- **Voltage Measurement**
Measurement of the forward bias voltage (knee voltage)
- **Current Measurement**
Measurement of the reverse bias current

The related measurement is performed when the check box is selected. At least one measurement must be activated.

Voltage Measurement

Nominal

The nominal value for the forward bias voltage (knee voltage) to be measured is entered in this field.

Upper Limit Lower Limit	<p>The upper and lower limits of the measured forward bias voltage (knee voltage) can be entered in these fields. The fields on the left contain the absolute value in the same unit as the nominal value. The fields on the right contain the deviation from the nominal value as a percentage.</p> <p>Inactive input fields (which appear in grey) are recalculated and displayed with the command "Edit...Apply".</p>
Absolute / Relative	<p>This setting determines whether limits will be entered as absolute values or relative values.</p>
<i>Current Measurement</i>	
Nominal	<p>The nominal value for the reverse bias current to be measured is entered in this field.</p>
Upper Limit Lower Limit	<p>The upper and lower limits of the measured reverse bias current can be entered in these fields. The fields on the left contain the absolute value in the same unit as the nominal value. The fields on the right contain the deviation from the nominal value as a percentage.</p> <p>Inactive input fields (which appear in grey) are recalculated and displayed with the command "Edit...Apply".</p>
Absolute / Relative	<p>This setting determines whether limits will be entered as absolute values or relative values.</p>

5.5.3.2 Settings

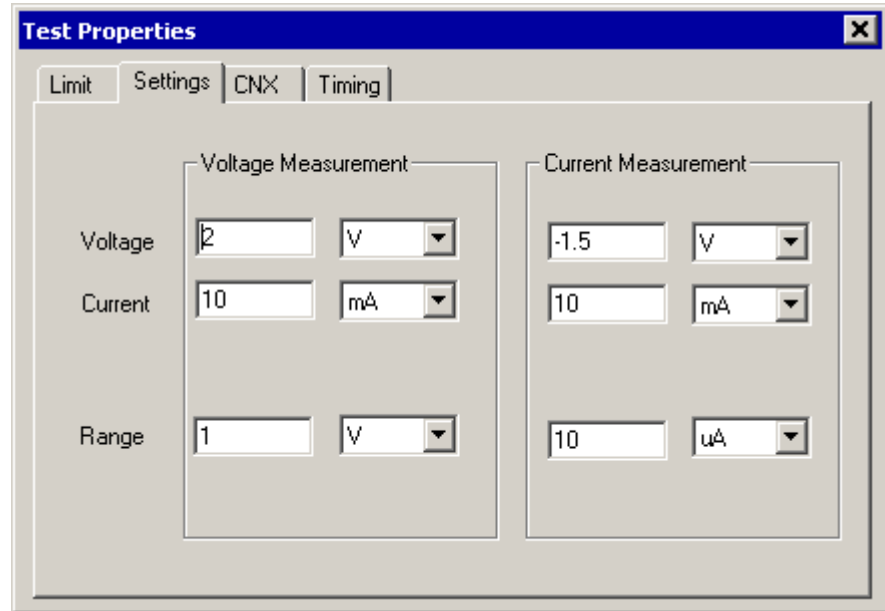


Figure 5-20 Test Step Diode, Test Properties Settings

Voltage Measurement

Voltage

The voltage of the voltage source is entered in this field.

Value range:

-5.0 V ... 5.0 V

Default:

2.0 V

Current

The current limit of the voltage source is entered in this field.

Value range:

1.0 μ A ... 100 mA

Default:

10 mA

Range

The measuring range of the voltmeter is entered in this field.

Value range:

10 mV ... 5.0 V

Default:

1.0 V

Current Measurement

- Voltage** The voltage of the voltage source is entered in this field.
Value range:
-5.0 V ... 5.0 V
Default:
-1.5 V
- Current** The current limit of the voltage source is entered in this field.
Value range:
1.0 μ A ... 100.0 mA
Default:
10 mA
- Range** The measuring range of the current meter is entered in this field.
Value range:
0.0 μ A ... 200 mA
Default:
10.0 μ A

5.5.3.3 CNX

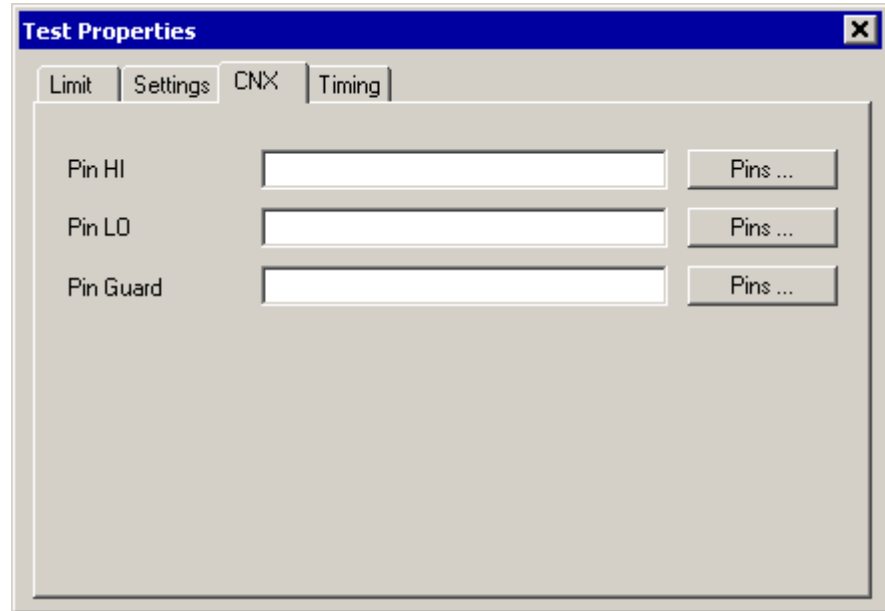


Figure 5-21 Test Step Diode, Test Properties CNX

Pin HI

The **Pin HI** (diode anode) is entered in this field. Only one measuring pin can be entered.

Pin LO

The **Pin LO** (diode cathode) is entered in this field. Only one measuring pin can be entered.

Pin Guard

The **Pin Guard** is entered in this field. Several measuring pins can be entered. The individual entries (measuring pins) are separated with commas.



Opens the **Pins** dialog box for inserting / removing pins on the Pin List. For more information, see section 5.5.12.2.

5.5.3.4 Timing

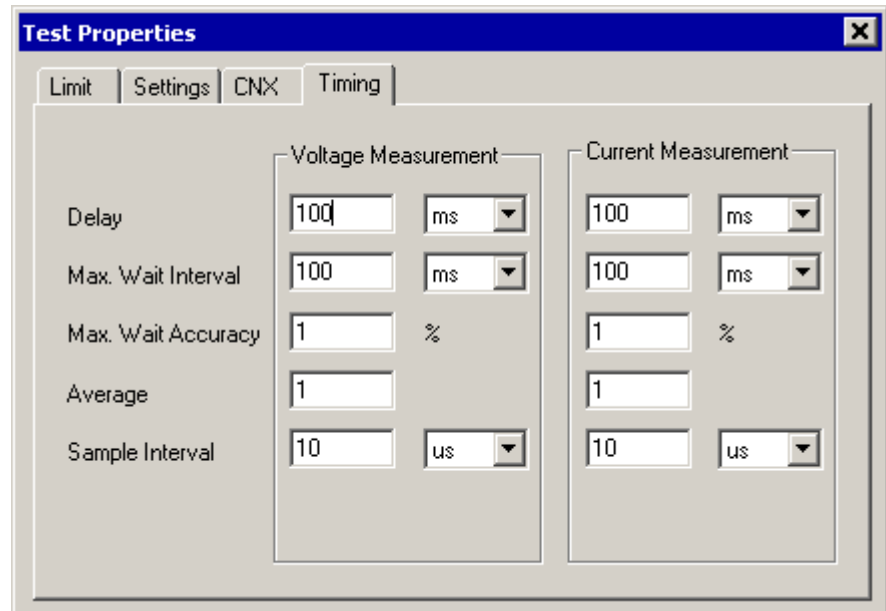


Figure 5-22 Test Step Diode, Test Properties Timing



NOTE:

The individual options for the timing of the measuring process are described in more detail in section 5.5.12.1.

The timing settings can be made separately for the *Voltage Measurement* and the *Current Measurement*.

Delay

The fixed delay to the start of the measurement is entered in this field.

Value range:

0 ms ... 1 s

Resolution:

1 ms

Default:

0 ms

Max. Wait Interval

The maximum duration of the test interval is entered in this field (maximum 20 samples).

Value range:

0 ms ... 10 s

Resolution:

1 ms (at a Max. Wait Interval of 1 ms a sample is taken every 50 μ s)

Default:

0 ms



Max. Wait Accuracy	<p>In this field the maximum percentage difference between two measured values in succession (samples) is entered for test steps in which the measured value is applied (measurement with “Max. Wait Interval”).</p> <p><u>Value range:</u> 0.0 % ... 10.0 %</p> <p><u>Default:</u> 1.0 %</p>
Average	<p>The number of measured values from which the mean for the measured result is to be determined is entered in this field.</p> <p><u>Value range:</u> 1 ... 1000</p> <p><u>Default:</u> 1</p>
Sample Interval	<p>The waiting time between the individual measurements for the formation of the mean is entered in this field (measurement with Average).</p> <p><u>Value range:</u> 5 μs ... 1 s</p> <p><u>Resolution:</u> 5 μs</p> <p><u>Default:</u> 5 μs (200 kHz)</p>

5.5.3.5 Results Details

For the Diode test step, the following information is displayed in the **Results/Details** window after the execution of test step:

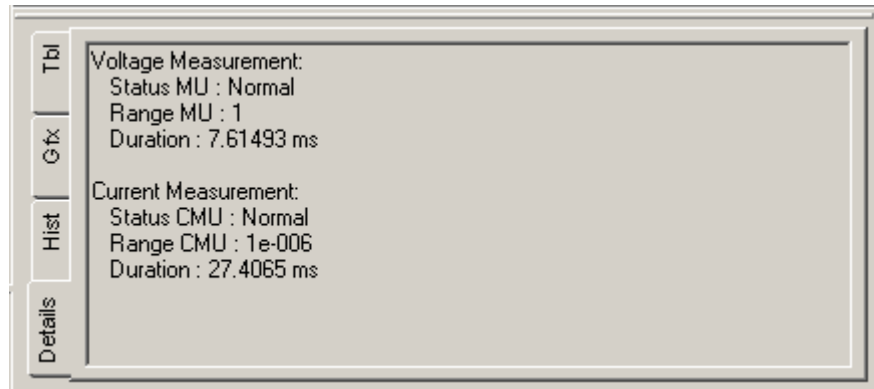


Figure 5-23 Test Step Diode, Results Details

MU = voltage measuring unit

CMU = current measuring unit

Status

Status of the measuring hardware:
Normal, Overrange, Underrange, Max Wait Timeout.

Range

Range of the measuring hardware in which the measurement was carried out.

Duration

Duration of the last measurement carried out.

5.5.4 Discharge



NOTE:

The discharging of capacitors is described in section 10.6.

5.5.4.1 General

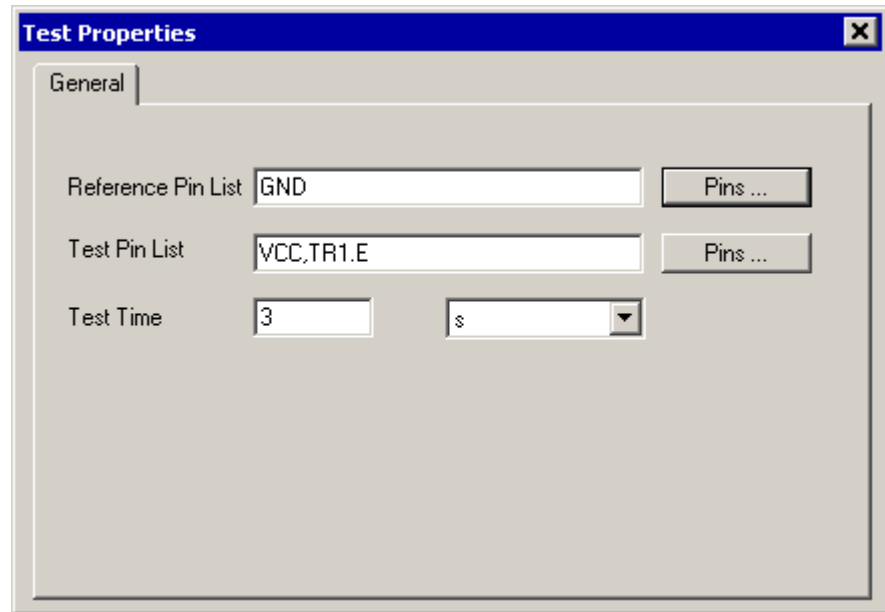


Figure 5-24 Test Step Discharge, Test Properties General

Reference Pin List

All measuring pins entered in the **Test Pin List** are connected one after the other to the measuring pins in the **Reference Pin List** via a discharge circuit.

Test Pin List

Test Time

The maximum duration of the connection between the measuring pins from the **Test Pin List** and the **Reference Pin List** via the discharge circuit is entered in this field. The maximum duration for the discharge of all measuring pins is given.

Value range:

1 ms ... 20 s

Default:

3 s



Opens the **Pins** dialog box for inserting / removing pins on the Pin List. For more information, see section 5.5.12.2.

5.5.4.2 Results Details

For the Discharge test step, the following information is displayed in the **Results/Details** window after the execution of test step:

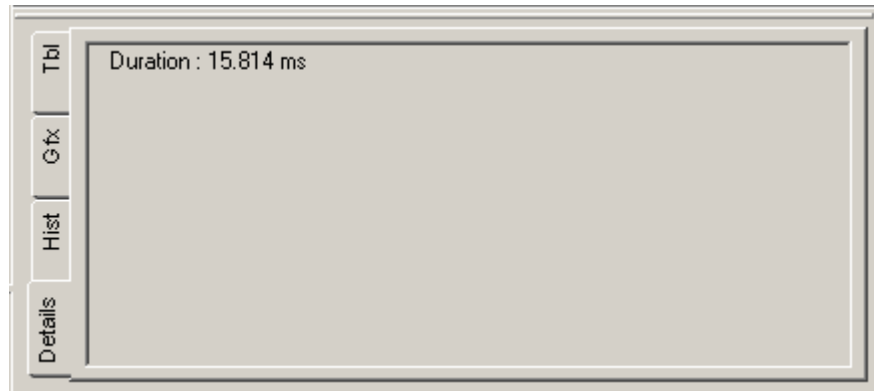


Figure 5-25 Test Step Discharge, Results Details

Duration

Duration of the last Discharge test step executed.

5.5.5 FET



NOTE:

The FET test is described in section 10.7.

5.5.5.1 Limits

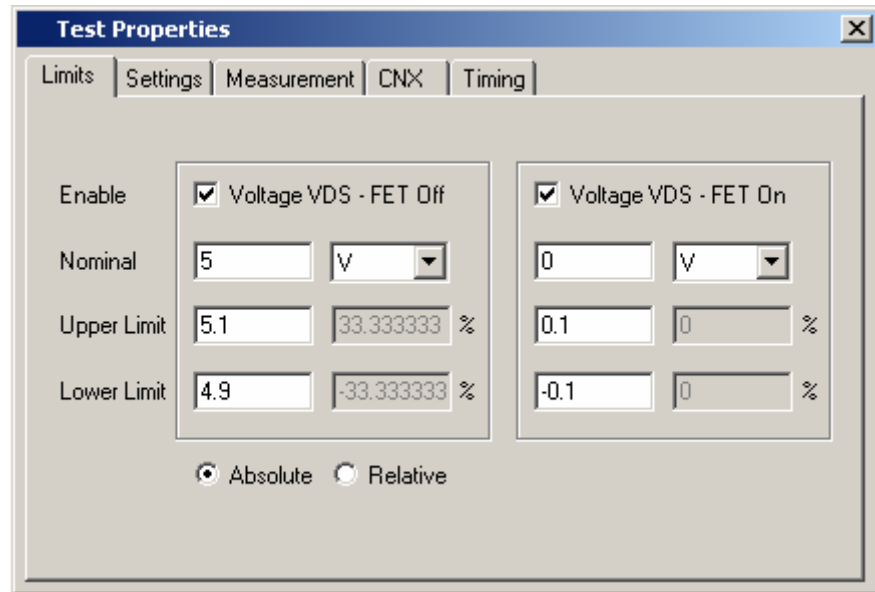


Figure 5-26 Test Step FET, Test Properties Limits

Enable

During the FET test, as an option two measurements are performed:

- **Voltage VDS - FET Off**
Measurement of the drain-source voltage of the FET while the FET is in switched off state.
- **Voltage VDS - FET On**
Measurement of the drain-source voltage of the FET while the FET is in switched on state.

The related measurement is performed when the check box is activated. At least one measurement must be activated.

Voltage VDS - FET Off

Nominal

The nominal value for the drain-source voltage of the switched off FET is entered in this field.

Upper Limit
Lower Limit

The upper and lower limits of the measured drain-source voltage can be entered in these fields. The fields on the left contain the absolute value in the same unit as the nominal value. The fields on the right contain the deviation from the nominal value as a percentage.

Inactive input fields (which appear in grey) are recalculated and displayed with the command "**Edit...Apply**".

Voltage VDS - FET On

Nominal

The nominal value for the drain-source voltage of the switched on FET is entered in this field.

Upper Limit
Lower Limit

The upper and lower limits of the measured drain-source voltage can be entered in these fields. The fields on the left contain the absolute value in the same unit as the nominal value. The fields on the right contain the deviation from the nominal value as a percentage.

Inactive input fields (which appear in grey) are recalculated and displayed with the command "**Edit...Apply**".

Absolute / Relative

This setting determines whether limits will be entered as absolute values or relative values.

5.5.5.2 Settings

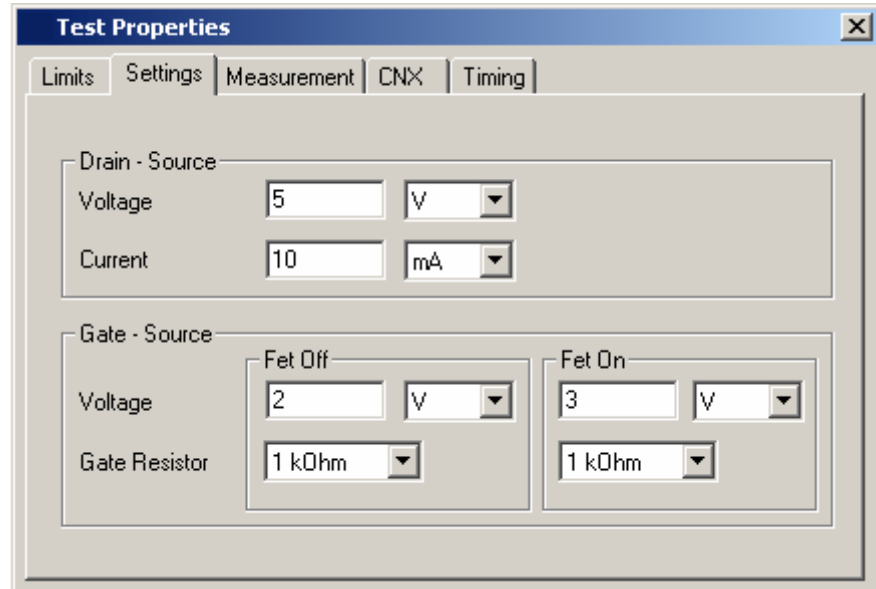


Figure 5-27 Test Step FET, Test Properties Settings

Drain - Source

Voltage

The value of the TS-PSAM DCS voltage source between drain and source of the FET is entered in this field.

Value range:

-5.0 V ... 5.0 V

Default:

5.0 V

Current

The current limit of the TS-PSAM DCS voltage source is entered in this field.

Value range:

3.0 μ A ... 100.0 mA

Default:

10.0 mA

*Gate - Source**(FET Off and FET On)***Voltage**

The value of the TS-PICT AOS voltage source between gate and source of the FET is entered in this field.

Value range:

-5.0 V ... 5.0 V

Default:

FET Off: 2.0 V

FET On: 3.0 V

Gate Resistor

The value of the TS-PICT AOS output resistance which is connected to the gate of the FET is entered in this field.

Value range:

0.0 Ohm ... 1.0 kOhm

Default:

1.0 kOhm

5.5.5.3 Measurement

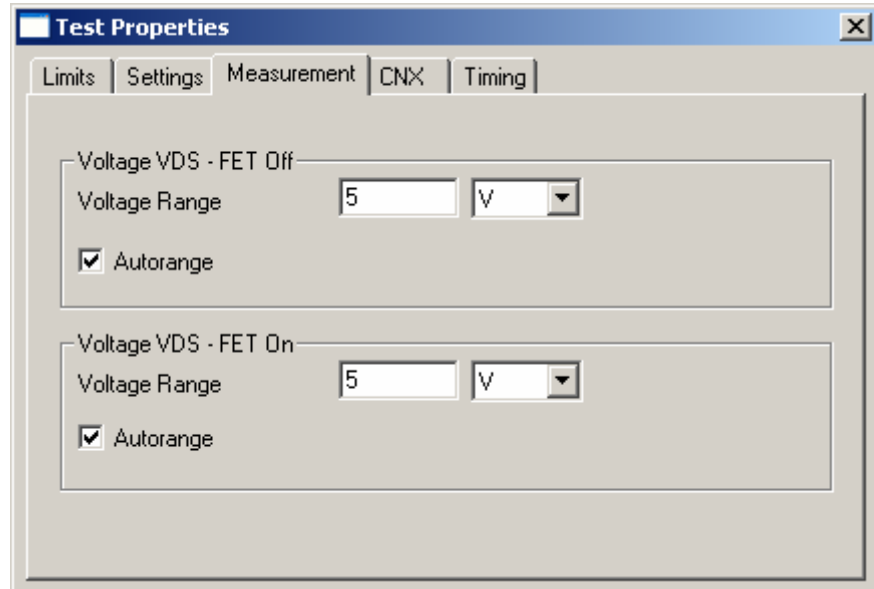


Figure 5-28 Test Step FET, Test Properties Measurement

Voltage VDS-FET Off
and
Voltage VDS-FET On

Voltage Range

The measuring range of the TS-PSAM voltmeter is entered in this field.

Value range:

10.0 mV ... 200.0 V

Default:

5.0 V

Aurorance

The measuring range for the voltmeter is set automatically when this check box is selected.

5.5.5.4 CNX

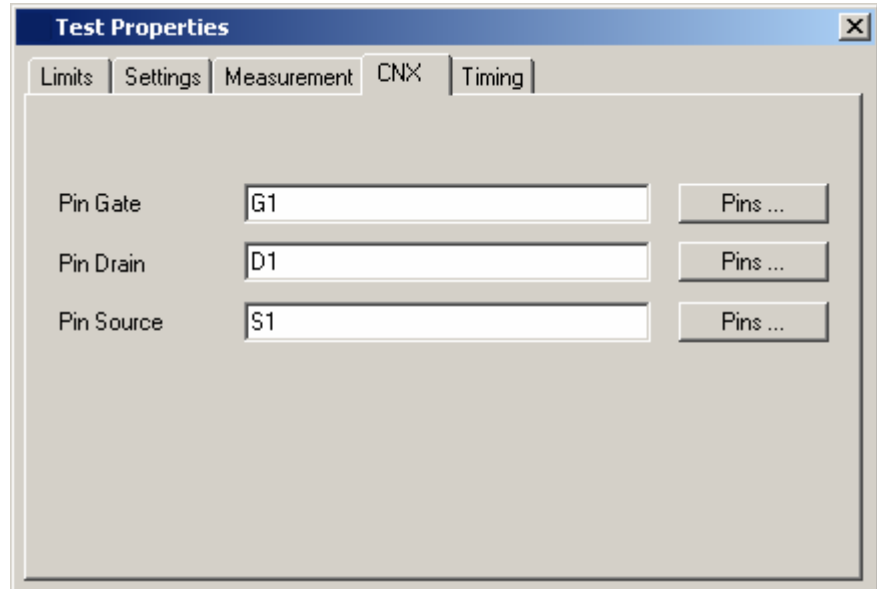


Figure 5-29 Test Step FET, Test Properties CNX

Pin Gate

The **gate pin** (gate of the FET) is entered in this field. Only one measuring pin can be entered.

Pin Drain

The **drain pin** (drain of the FET) is entered in this field. Only one measuring pin can be entered.

Pin Source

The **source pin** (source of the FET) is entered in this field. Only one measuring pin can be entered.

Pins ...

Opens the **Pins** dialog box for inserting / removing pins on the Pin List. For more information, see section 5.5.12.2.

5.5.5.5 Timing

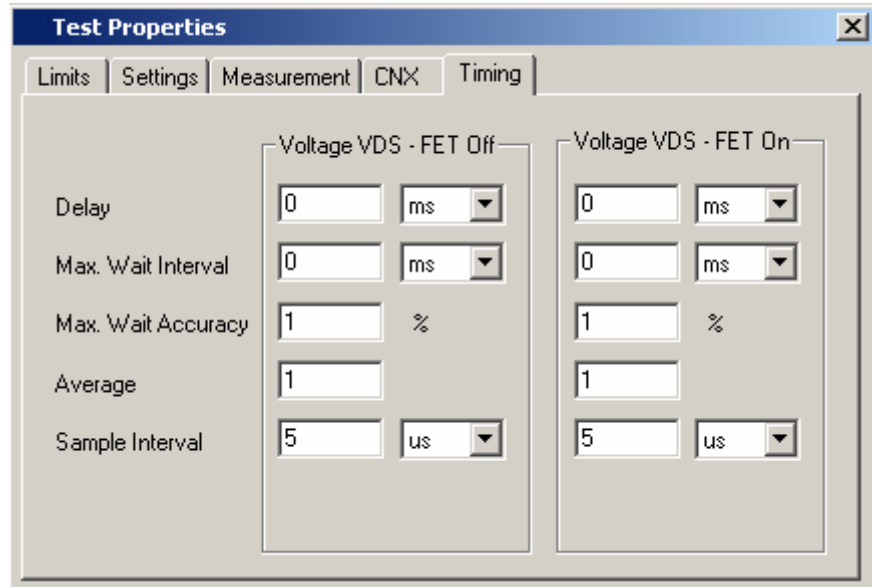


Figure 5-30 Test Step FET, Test Properties Timing



NOTE:

The individual options for the timing measurement operation are described in more detail in section 5.5.12.1.

Voltage VDS-FET Off
and
Voltage VDS-FET On

Delay

The fixed delay to the start of the measurement is entered in this field.

Value range:

0 ms ... 1 s

Resolution:

1 ms

Default: 0 ms

Max. Wait Interval

The maximum duration of the test interval is entered in this field (maximum 20 samples).

Value range:

0 ms ... 10 s

Resolution:

1 ms

Default:

0 ms

Max. Wait Accuracy	<p>In this field the maximum percentage difference between two measured values in succession (samples) is entered for test steps in which the measured value is applied (measurement with "Max. Wait Interval").</p> <p><u>Value range:</u> 0.0 % ... 10.0 %</p> <p><u>Default:</u> 1.0 %</p>
Average	<p>The number of measured values from which the mean for the measured result is to be determined is entered in this field.</p> <p><u>Value range:</u> 1 ... 1000</p> <p><u>Default:</u> 1</p>
Sample Interval	<p>The waiting time between the individual measurements for the formation of the mean is entered in this field (measurement with Average).</p> <p><u>Value range:</u> 5 μs ... 1 s</p> <p><u>Resolution:</u> 5 μs</p> <p><u>Default:</u> 5 μs (200 kHz)</p>

5.5.5.6 Results Details

For the FET test step, the following information is displayed in the Results/Details window after the execution of the test step:

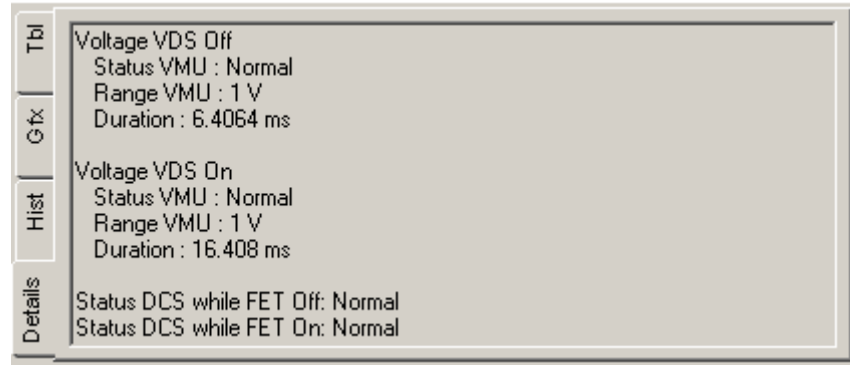


Figure 5-31 Test Step FET, Results Details

VMU = Voltage measuring unit (TS-PSAM)

DCS = DC Source (TS-PSAM)

Voltage VDS Off
and
Voltage VDS On

Status VMU

Status of the voltage measurement unit:
Normal, Overrange, Underrange, Max Wait Timeout

Range VMU

Range of the voltage measurement unit, in which the measurement was carried out.

Duration

Duration of the last measurement carried out.

Status DCS

Shows whether the TS-PSAM DCS voltage source is in the expected state. At the FET Off measurement the DCS must be in constant voltage state and at the FET On measurement the DCS must be in constant current state. If the DCS is in the expected state 'Normal' is displayed.

5.5.6 Impedance



NOTE:

The impedance test is described in section 10.8.

5.5.6.1 Limits

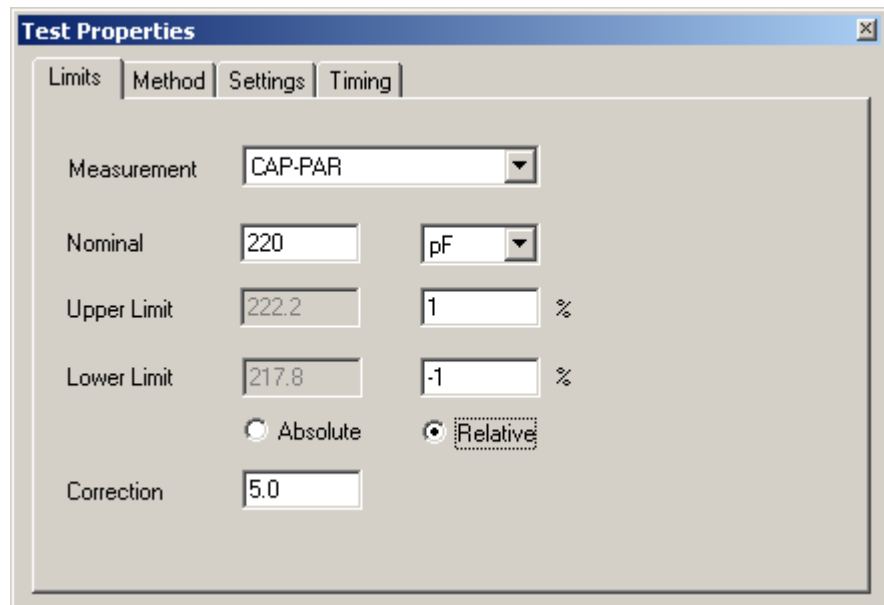


Figure 5-32 Test Step Impedance, Test Properties Limits

Measurement

The type of measured result and the related unit are selected in this drop-down list box. The internal calculation of the measured result is performed as a function of the measuring type selected (see also section 5.5.6.5).

Nominal

The nominal value for the impedance to be measured is entered in this field.

**Upper Limit
Lower Limit**

The upper and lower limits of the measured impedance can be entered in these fields. The fields on the left contain the absolute value in the same unit as the nominal value. The fields on the right contain the deviation from the nominal value as a percentage.

Inactive input fields (which appear in grey) are recalculated and displayed with the command **"Edit...Apply"**.

Absolute / Relative

This setting determines whether limits will be entered as absolute values or relative values.

Correction

A correction value can be entered in this field. The unit of the nominal value is assumed for that entry. The correction value is subtracted from the measurement. The result of the subtraction is compared with the limits.

The correction value is handled together with the limits. This makes it possible to load, import and export it with the limits. See section 5.6.1.7 how to do that.


NOTE:

The value ranges for Nominal, Upper Limit and Lower Limit are defined by the measuring and stimulation properties of the measuring hardware available. The related information is to be found in the user manuals and the data sheets on the measuring hardware.

For the 2-wire measurements it is possible to specify a common correction value for all DUTs of a bench in the Application Layer Configuration File. See section 3.2.3 for details.

5.5.6.2 Method

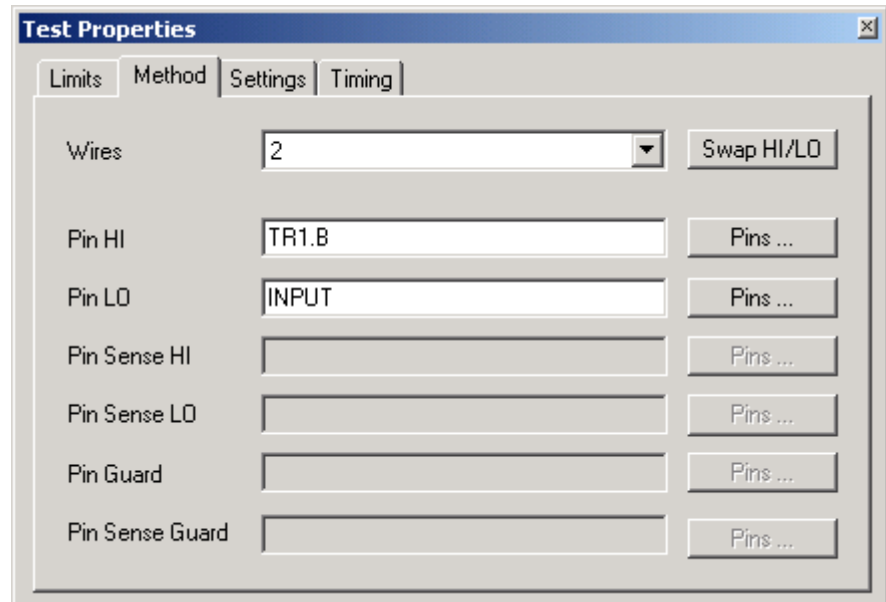


Figure 5-33 Test Step Impedance, Test Properties Method

- Wires** The impedance measuring method is selected in this drop-down list box. The measuring methods are described in section 10.9.
- Pin HI** The **Pin HI** for all measuring methods is entered in this field. Only one measuring pin can be entered.
- Pin LO** The **Pin LO** for all measuring methods is entered in this field. Only one measuring pin can be entered.
- Pin Sense HI** The **Pin Sense HI** is entered in this field for the following measuring methods:
- 4-wire measuring method
 - 6-wire guarded measuring method
- Only one measuring pin can be entered.
- Pin Sense LO** The **Pin Sense LO** is entered in this field for the following measuring methods:
- 4-wire measuring method
 - 6-wire guarded measuring method
- Only one measuring pin can be entered.

Pin Guard

The **Pin Guard** is entered in this field for the following measuring methods:

- 3-wire guarded measuring method
- 4-wire guarded measuring method
- 6-wire guarded measuring method

Several measuring pins can be entered.

Pin Sense Guard

The **Pin Sense Guard** is entered in this field for the following measuring methods:

- 4-wire guarded measuring method
- 6-wire guarded measuring method

Only one measuring pin can be entered.

Pins ...

Opens the **Pins** dialog box for inserting / removing pins on the Pin List. For more information, see section 5.5.12.2.

Swap HI/LO

Exchanges the contents of the Pin HI / Pin LO and Pin Sense HI / Pin Sense LO edit fields.

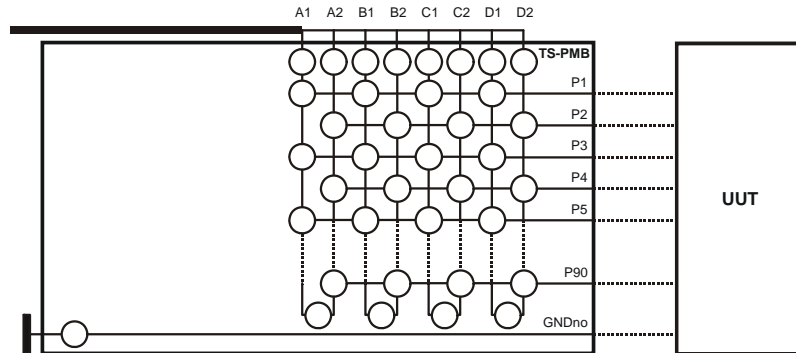


Figure 5-34 R&S TS-PMB wiring

As can be seen in Figure 5-34, only the following wiring between analog bus and UUT is possible for the R&S TS-PMB Matrix Module B:

Analog Bus	Pin
A1	P1, P3, P5, P7, P9, ... , P87, P89
A2	P2, P4, P6, P8, P10, ... , P88, P90
B1	P1, P3, P5, P7, P9, ... , P87, P89
B2	P2, P4, P6, P8, P10, ... , P88, P90
C1	P1, P3, P5, P7, P9, ... , P87, P89
C2	P2, P4, P6, P8, P10, ... , P88, P90
D1	P1, P3, P5, P7, P9, ... , P87, P89
D2	P2, P4, P6, P8, P10, ... , P88, P90

For guarded 6-wire impedance measurement, please note that the wiring is to be done in the following way:

- The Pins HI and Sense HI must be complementary, i.e. HI even and Sense HI odd or HI odd and Sense HI even.
- The Pins LO and Sense LO must also be complementary.
- For the Pin Guard and Sense Guard, there are no limitations. Guard is a pin list and can contain a combination of even and odd pins.

Example

Pin HI	even
Pin Sense HI	odd
Pin LO	odd
Pin Sense LO	even
Pin Guard	even, odd...
Pin Sense Gurard	odd

If this even/odd rule is not adhered to, the Enhanced Generic Test Software Library R&S EGTSL will report a compile error.

During generation of an ICT program by the Automatic Test Generator ATG this even/odd rule is followed.

5.5.6.3 Settings

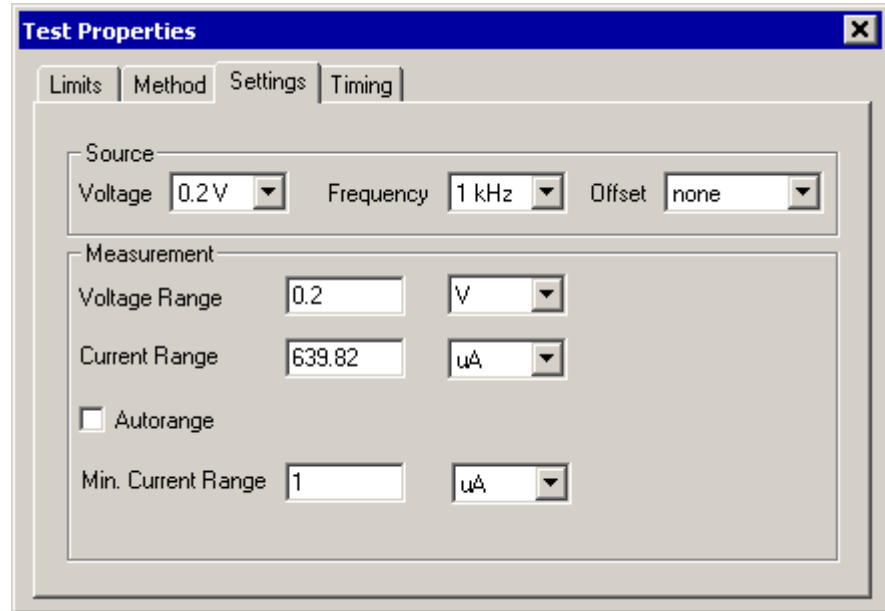


Figure 5-35 Test Step Impedance, Test Properties Settings

Source

Voltage

The voltage of the signal source is selected in this drop-down list box.

Value range:

0.1 V, 0.2 V, 1.0 V

Default:

0.2 V

Frequency

The frequency of the signal source is selected from this drop-down list box.

Value range:

100 Hz, 1 kHz, 10 kHz

Default:

10 kHz

Offset

The offset of the signal source is selected from this drop-down list box.

Value range:

none, positive, negative

Default:

none

Measurement

- Voltage Range** The measuring range of the voltmeter is entered in this field.
Value range:
 10 mV ... 5 V
Default:
 0.2 V
- Current Range** The measuring range of the current meter is entered in this field.
Value range:
 1 μ A ... 100 mA
Default:
 100 mA
- Autorange** The measuring ranges of the voltmeter and current meter are set automatically when this check box is selected.
- Min. Current Range** The smallest permissible measuring range for the current meter on the use of the **Autorange** function is entered in this field.
Value range:
 1 μ A ... 200 mA
Default:
 2 μ A


NOTE:

In some measuring conditions, the smallest measuring ranges are unstable. More reliable measured results are obtained in larger measuring ranges.

5.5.6.4 Timing

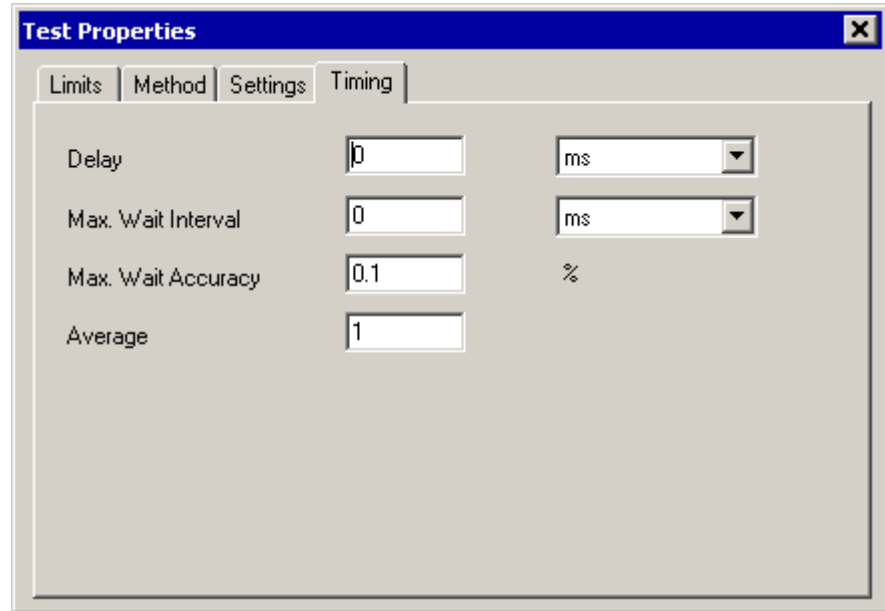


Figure 5-36 Test Step Impedance, Test Properties Timing



NOTE:

The individual options for the timing of the measurement operation are described in more detail in section 5.5.12.1.

Delay

The fixed delay to the start of the measurement is entered in this field.

Value range:

0 ms ... 1 s

Resolution:

1 ms

Default:

0 ms

Max. Wait Interval

The maximum duration of the test interval is entered in this field (maximum 20 samples).

Value range:

0 ms ... 10 s

Resolution:

1 ms

Default:

0 ms

Max. Wait Accuracy

In this field the maximum percentage difference between two measured values in succession (samples) is entered for test steps in which the measured value is applied (measurement with “Max. Wait Interval”).

Value range:
0.0 % ... 10.0 %
Default:
1.0 %

Average

The number of signal periods to be measured from which a mean is formed for the measured result is entered in this field.

Value range:
1 ... 1000
Default:
1

5.5.6.5 Determination of measured value

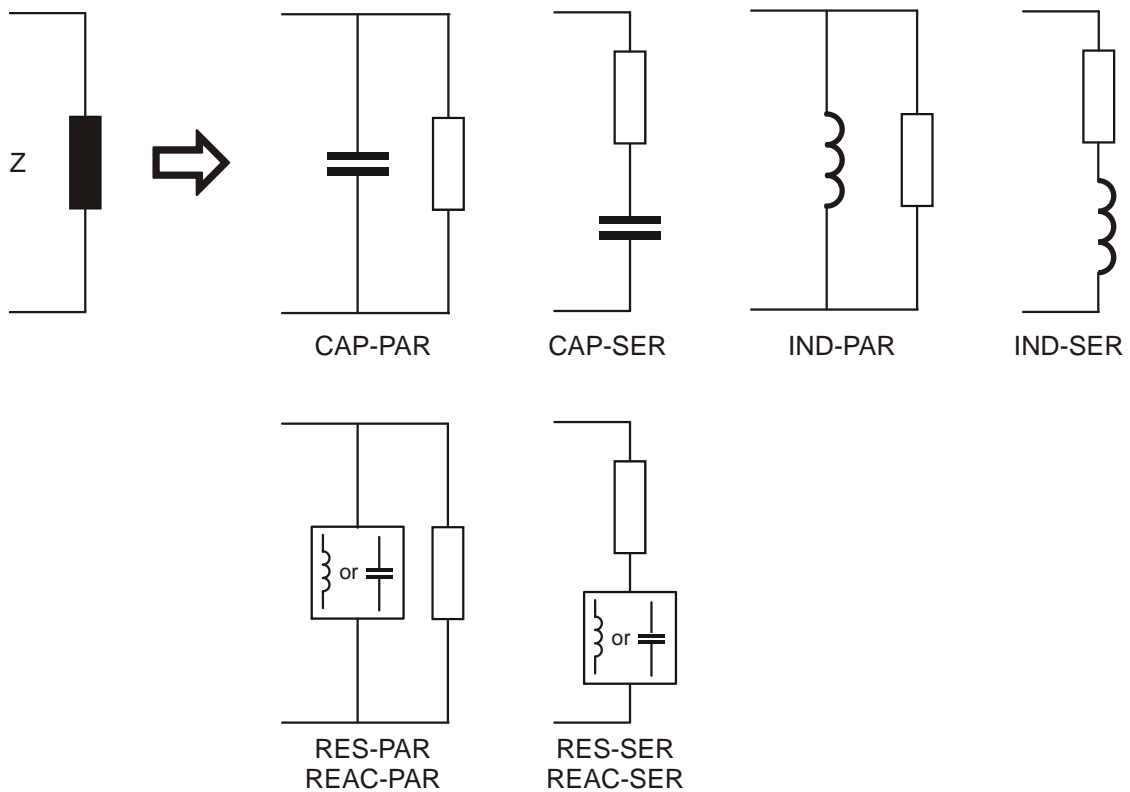


Figure 5-37 Equivalent circuit diagrams for determination of measured value

An equivalent circuit must be entered for the calculation of the required measured result for the capacitance measurement and the inductance

measurement (see Figure 5-37). The selection is made using the **Measurement** drop-down list box in Test Properties Limits.

Measurement	Measured result	Equivalent circuit	Unit
CAP-PAR	Capacitance	Capacitance measurement based on a parallel equivalent circuit	Farad (F)
CAP-SER	Capacitance	Capacitance measurement based on a serial equivalent circuit	Farad (F)
IND-PAR	Inductance	Inductance measurement based on a parallel equivalent circuit	Henry (H)
IND-SER	Inductance	Inductance measurement based on a serial equivalent circuit	Henry (H)

Table 5-1 Determination of measured value (1/2)

Two different representations of the impedance are available for the measurement of the impedance. On the one hand the representation in real and imaginary parts, on the other hand the representation in magnitude and phase. An equivalent circuit must be entered for the calculation of the required measured result for the representation in real and imaginary parts (see Figure 5-37).

Measurement	Measured result	Equivalent circuit	Unit
RES-SER	Real part of the measured impedance	Impedance measurement based on a serial equivalent circuit	Ohm (Ω)
RES-PAR	Real part of the measured impedance	Impedance measurement based on a parallel equivalent circuit	Ohm (Ω)
REAC-SER	Imaginary part of the measured impedance	Impedance measurement based on a serial equivalent circuit	Ohm (Ω)
REAC-PAR	Imaginary part of the measured impedance	Impedance measured	Ohm (Ω)

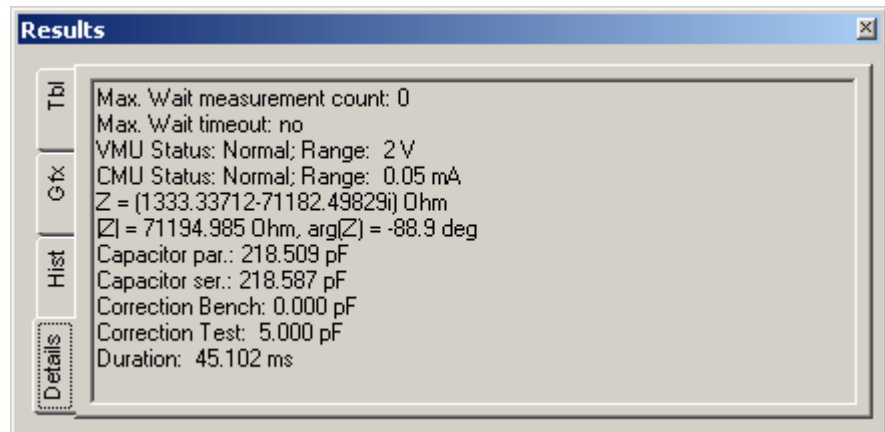
Table 5-2 Determination of measured value (2/2)

Measurement	Measured result	Equivalent circuit	Unit
IMP-MAG	Magnitude of the impedance measured		Ohm (Ω)
IMP-PHASE	Phase of the measured impedance		deg

Table 5-2 Determination of measured value (2/2)

5.5.6.6 Results Details

For the Impedance test step, the following information is displayed in the **Results/Details** window after the execution of test step:


Figure 5-38 Test Step Impedance, Results Details

Max. Wait measurement count	Number of the measurements which were carried out with Max.Wait until the measured value was stable.
Max. Wait timeout	“Yes”, if the measured value was not stable even after 20 Max. Wait measurements.
VMU Status	Status of the voltage measuring unit: Normal, Overrange, Underrange
VMU Range	Range of the voltage measuring unit in which the measurement was carried out.
CMU Status	Status of the current measuring unit: Normal, Overrange, Underrange
CMU Range	Range of the current measuring unit in which the measurement was carried out.
Z	Real part and imaginary part of the impedance
 Z , arg(Z)	Magnitude and Phase of the impedance

Capacitor par.	Measured value for the parallel equivalent circuit diagram
Capacitor ser.	Measured value for the serial equivalent circuit diagram
Correction Bench	Bench specific correction value taken into account for calculating the result. The indicated value is specified in the Application Layer Configuration File. See section 3.2.3 for details.
Correction Test	Test specific correction value taken into account for calculating the result. The indicated value is specified in the test properties limits.
Duration	Duration of the last Impedance test step carried out.

5.5.7 Resistor



NOTE:

The resistor test is described in section 10.9.

5.5.7.1 Limits

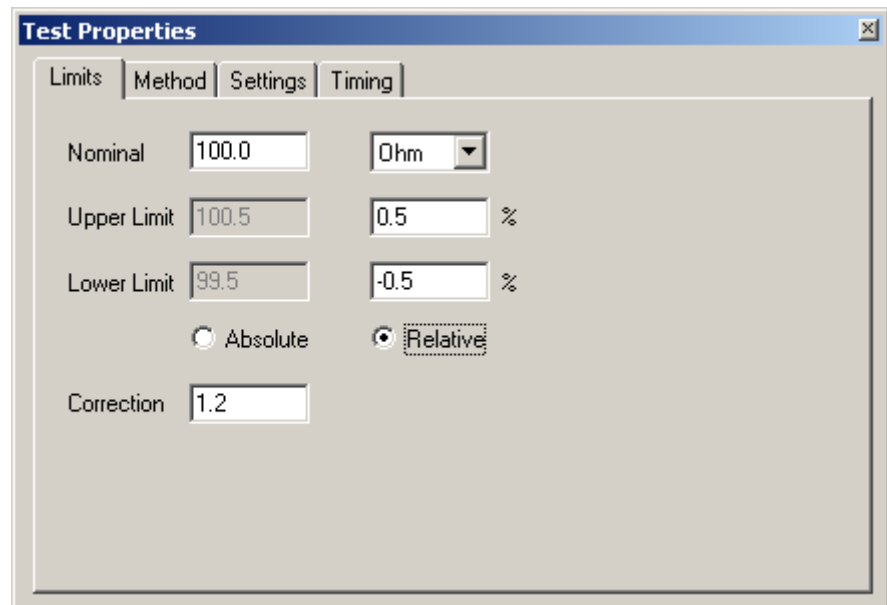


Figure 5-39 Test Step Resistor, Test Properties Limits

Nominal

The nominal value for the resistor to be measured is entered in this field.

Upper Limit
Lower Limit

The upper and lower limits of the measured resistor can be entered in these fields. The fields on the left contain the absolute value in the same unit as the nominal value. The fields on the right contain the deviation from the nominal value as a percentage.

Inactive input fields (which appear in grey) are recalculated and displayed with the command "**Edit...Apply**".

Absolute / Relative

This setting determines whether limits will be entered as absolute values or relative values.

Correction

A correction value can be entered in this field. The unit of the nominal value is assumed for that entry. The correction value is subtracted from the measurement. The result of the subtraction is compared with the limits.

The correction value is handled together with the limits. This makes it possible to load, import and export it with the limits. See section 5.6.1.7 how to do that.


NOTE:

The value ranges for Nominal, Upper Limit and Lower Limit are defined by the measuring and stimulation properties of the measuring hardware available. The related information is to be found in the user manuals and the data sheets on the measuring hardware.

For the 2-wire resistor measurements it is possible to specify a common correction value for all DUTs of a bench in the Application Layer Configuration File. See section 3.2.3 for details.

5.5.7.2 Method

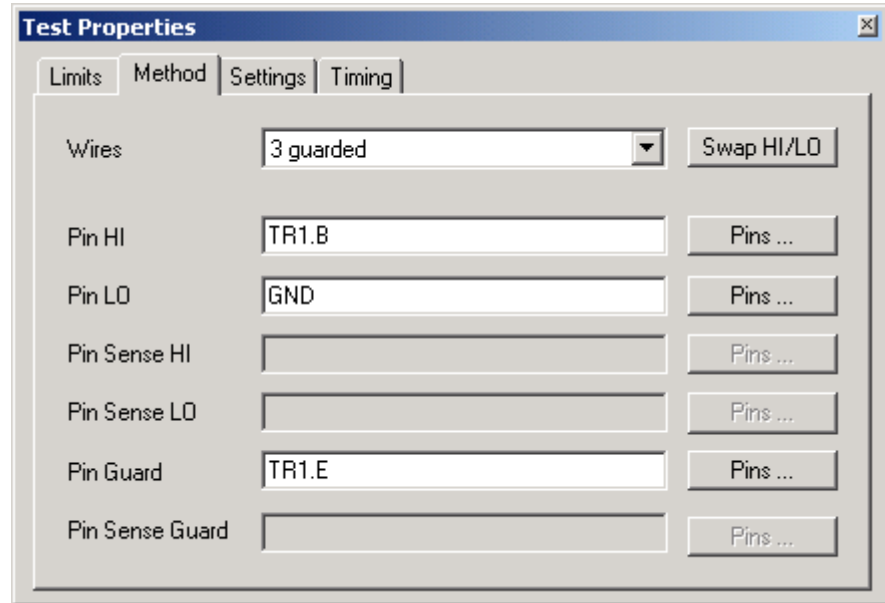


Figure 5-40 Test Step Resistor, Test Properties Method

- Wires** The resistance measuring method is selected in this drop-down list box. The measuring methods are described in section 10.9.
- Pin HI** The **Pin HI** for all measuring methods is entered in this field. Only one measuring pin can be entered.
- Pin LO** The **Pin LO** for all measuring methods is entered in this field. Only one measuring pin can be entered.
- Pin Sense HI** The **Pin Sense HI** is entered in this field for the following measuring methods:
- 4-wire measuring method
 - 6-wire guarded measuring method
- Only one measuring pin can be entered.
- Pin Sense LO** The **Pin Sense LO** is entered in this field for the following measuring methods:
- 4-wire measuring method
 - 6-wire guarded measuring method
- Only one measuring pin can be entered.

Pin Guard

The **Pin Guard** is entered in this field for the following measuring methods:

- 3-wire guarded measuring method
- 4-wire guarded measuring method
- 6-wire guarded measuring method

Several measuring pins can be entered.

Pin Sense Guard

The **Pin Sense Guard** is entered in this field for the following measuring methods:

- 4-wire guarded measuring method
- 6-wire guarded measuring method

Only one measuring pin can be entered.

Pins ...

Opens the **Pins** dialog box for inserting / removing pins on the Pin List. For more information, see section 5.5.12.2.

Swap HI/LO

Exchanges the contents of the Pin HI / Pin LO and Pin Sense HI / Pin Sense LO edit fields.

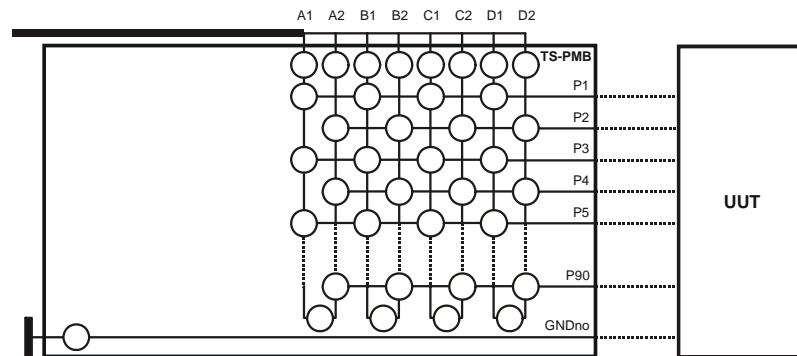


Figure 5-41 TS-PMB wiring

As can be seen in Figure 5-41, only the following wiring between analog bus and UUT is possible for the TS-PMB Matrix Module B:

Analog Bus	Pin
A1	P1, P3, P5, P7, P9, ... , P87, P89
A2	P2, P4, P6, P8, P10, ... , P88, P90
B1	P1, P3, P5, P7, P9, ... , P87, P89
B2	P2, P4, P6, P8, P10, ... , P88, P90
C1	P1, P3, P5, P7, P9, ... , P87, P89
C2	P2, P4, P6, P8, P10, ... , P88, P90
D1	P1, P3, P5, P7, P9, ... , P87, P89
D2	P2, P4, P6, P8, P10, ... , P88, P90



For guarded 6-wire resistance measurement, please note that the wiring is to be done in the following way:

- The Pins HI and Sense HI must be complementary, i.e. HI even and Sense HI odd or HI odd and Sense HI even.
- The Pins LO and Sense LO must also be complementary.
- For the Pin Guard and Sense Guard, there are no limitations. Guard is a pin list and can contain a combination of even and odd pins.

Example

Pin HI	even
Pin Sense HI	odd
Pin LO	odd
Pin Sense LO	even
Pin Guard	even, odd...
Pin Sense Gurard	odd

If this even/odd rule is not adhered to, the Enhanced Generic Test Software Library R&S EGTSL will report a compile error.

During generation of an ICT program by the Automatic Test Generator ATG this even/odd rule is followed.

5.5.7.3 Settings

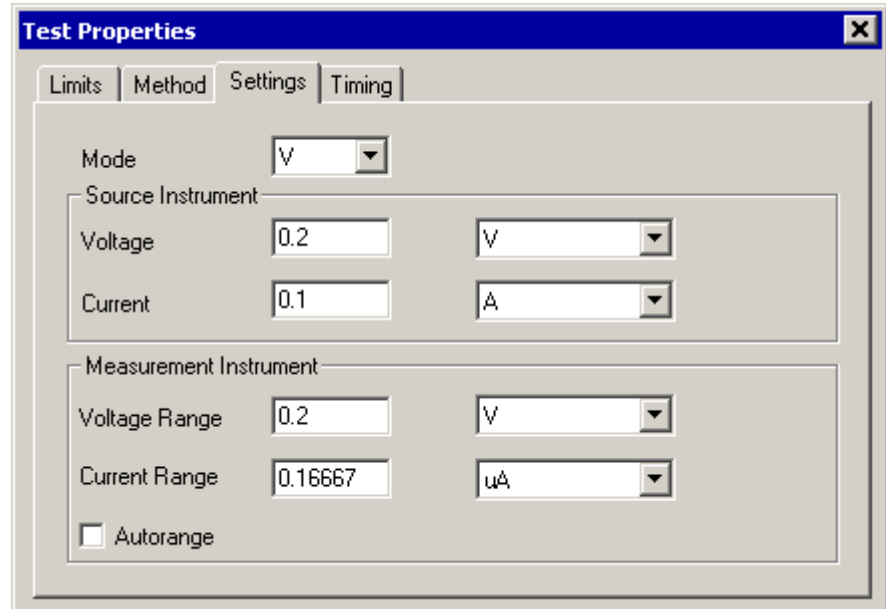


Figure 5-42 Test Step Resistor, Test Properties Settings

Mode

The type of resistor measurement is selected from this drop-down list box:

V: application of voltage with current measurement

C: application of current with voltage measurement

Source Instrument

Voltage

The voltage of the voltage source is entered in this field.

Value range:

1 mV ... 5 V

Default:

0.2 V

Current

The current limit of the voltage source is entered in this field.

Value range:

1 μ A ... 100 mA

Default:

100 mA



Measurement Instrument

Voltage Range The measuring range of the voltmeter is entered in this field.

Value range:

10 mV ... 5 V

Default:

0.2 V

Current Range The measuring range of the current meter is entered in this field.

Value range:

0 μ A ... 200 mA

Default:

100 mA

Autorange The measuring ranges for the voltmeter and current meter are set automatically when this check box is selected.

Only one measuring range is relevant depending on the type of resistor measurement:

Mode V: **Current Range** (application of voltage with current measurement)

Mode C: **Voltage Range** (application of current with voltage measurement)

When Autorange is selected, the search for the optimal measuring range starts with the values entered in the **Voltage Range** (voltage measurement) and **Current Range** (current measurement) fields.

5.5.7.4 Timing

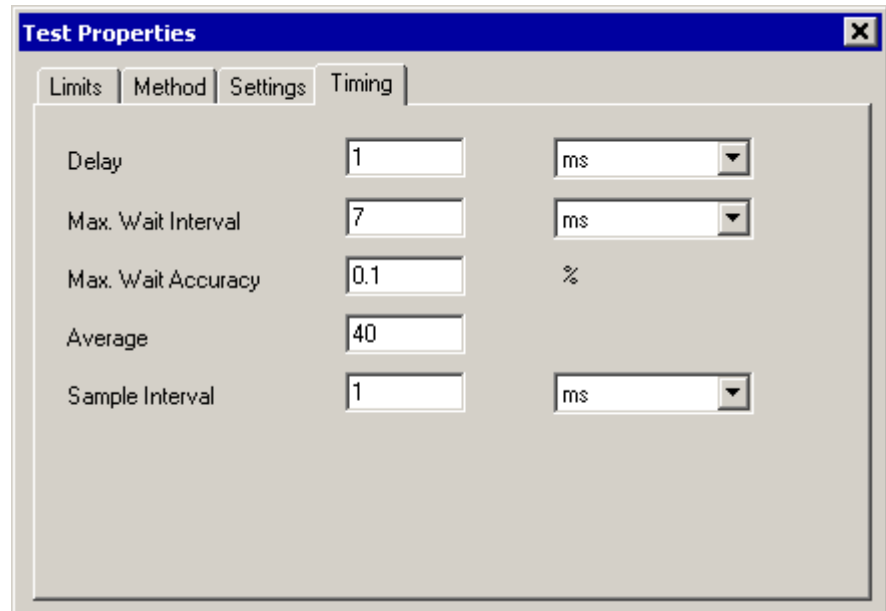


Figure 5-43 Test Step Resistor, Test Properties Timing



NOTE:

The individual options for the timing of the measurement operation are described in more detail in section 5.5.12.1.

Delay

The fixed delay to the start of the measurement is entered in this field.

Value range:

0 ms ... 1 s

Resolution:

1 ms

Default:

0 ms

Max. Wait Interval

The maximum duration of the test interval is entered in this field (maximum 20 samples).

Value range:

0 ms ... 10 s

Resolution:

1 ms (at a Max. Wait Interval of 1 ms a sample is taken every 50 μ s)

Default:

0 ms



Max. Wait Accuracy	<p>In this field the maximum percentage difference between two measured values in succession (samples) is entered for test steps in which the measured value is applied (measurement with “Max. Wait Interval”).</p> <p><u>Value range:</u> 0.0 % ... 10.0 %</p> <p><u>Default:</u> 1.0 %</p>
Average	<p>The number of measured values from which the mean for the measured result is to be determined is entered in this field.</p> <p><u>Value range:</u> 1 ... 1000</p> <p><u>Default:</u> 1</p>
Sample Interval	<p>The waiting time between the individual measurements for the formation of the mean is entered in this field (measurement with Average).</p> <p><u>Value range:</u> 5 μs ... 1 s</p> <p><u>Resolution:</u> 5 μs</p> <p><u>Default:</u> 5 μs (200 kHz)</p>

5.5.7.5 Results Details

For the Resistor test step, the following information is displayed in the **Results/Details** window after the execution of test step:

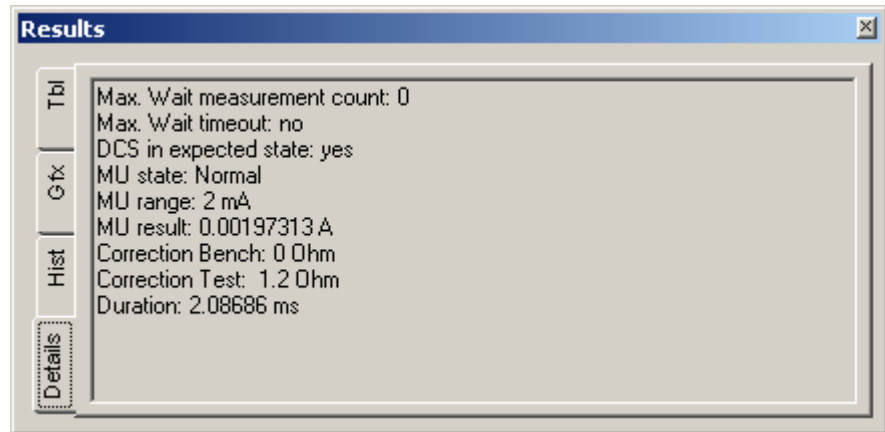


Figure 5-44 Test Step Resistor, Results Details

Max. Wait measurement count	Number of the measurements which were carried out with Max.Wait until the measured value was stable.
Max. Wait timeout	“Yes”, if the measured value was not stable even after 20 Max. Wait measurements.
DCS in expected state	Shows whether the voltage source is in the expected status. In Mode C it must be in the current limit, in Mode V it does not have to be in the current limit.
MU State	Status of the voltage measuring unit (Mode C) or of the current measuring unit (Mode V): Normal, Overrange, Underrange
MU Range	Voltage or current range, in which the measurement was carried out.
MU Result	Result of the the voltage measurement (Mode C) or current measurement (Mode V)
Correction Bench	Bench specific correction value taken into account for calculating the result. The indicated value is specified in the Application Layer Configuration File. See section 3.2.3 for details.
Correction Test	Test specific correction value taken into account for calculating the result. The indicated value is specified in the test properties limits.
Duration	Duration of the last Resistor test step carried out

5.5.8 Short



NOTE:

The short-circuit test is described in section 10.10.

5.5.8.1 General

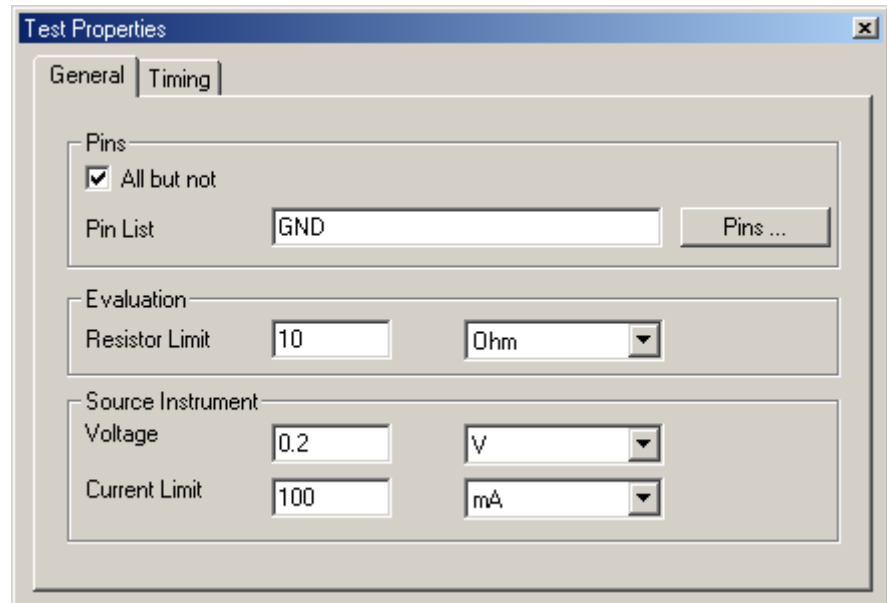


Figure 5-45 Test Step Short, Test Properties General

Pins

All but not

All available measuring pins are checked for short-circuit when the check box is selected. The list of available measuring pins is read from the “Available Pins” (see section 5.5.12.2). The measuring pins entered in the **Pin List** are not checked for short-circuit.

Pin List

All but not check box cleared:

All measuring pins entered in the **Pin List** are checked for short-circuit.

All but not check box selected:

all pins with the exception of the measuring pins entered in the Pin List are checked for short-circuit.

Opens the **Pins** dialog box for inserting / removing pins on the Pin List. For more information, see section 5.5.12.2.



Evaluation

Resistor Limit The maximum resistance that is still evaluated as a short-circuit is entered in this field.
Value range:
1 Ω ... 1 k Ω
Default:
10 Ω

Source Instrument

Voltage The voltage of the voltage source is entered in this field.
Value range:
0.1 V ... 0.5 V
Default:
0.2 V

Current Limit The current limit of the voltage source is entered in this field.
Value range:
1 μ A ... 100 mA
Default:
100 mA

When the **Voltage** value is appropriately selected, the threshold voltage can be designed such that diodes/transistors can be considered the same as missing components. Diode/transistors must not become forward biased.

5.5.8.2 Timing

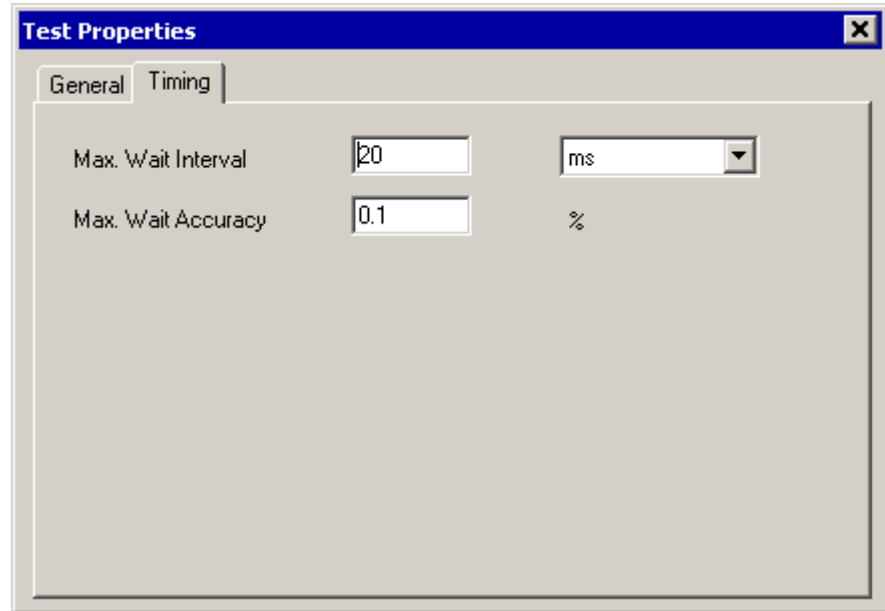


Figure 5-46 Test Step Short, Test Properties Timing



NOTE:

The individual options for the timing of the measurement operation are described in more detail in section 5.5.12.1.

Max. Wait Interval

The maximum duration of the test interval is entered in this field (maximum 20 samples).

Value range:

0 ms ... 10 s

Resolution:

1 ms (at a Max. Wait Interval of 1 ms a sample is taken every 50 µs)

Default:

20 ms

Max. Wait Accuracy

In this field the maximum percentage difference between two measured values in succession (samples) is entered for test steps in which the measured value is applied (measurement with “Max. Wait Interval”).

Value range:

0.0 % ... 10.0 %

Default:

1.0 %

5.5.8.3 Results Details

For the Short test step, the following information is displayed in the **Results/Details** window after the execution of test step:

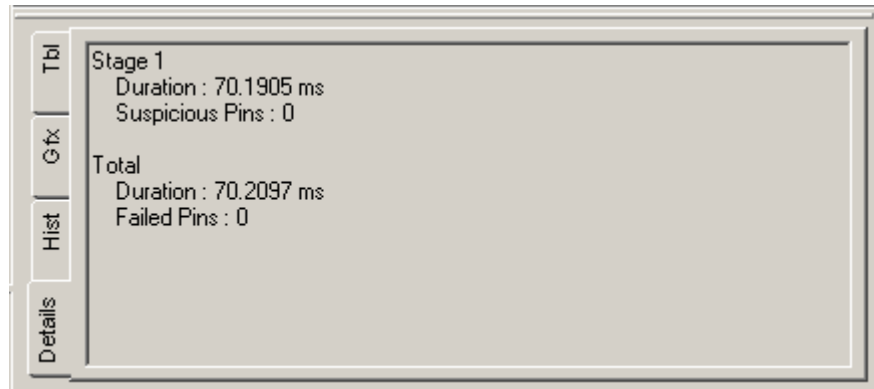


Figure 5-47 Test Step Short, Results Details

Stage 1:

Duration Duration of the 1st stage.

Suspicious Pins Number of “suspicious” pins found in the first stage.

Total:

Duration Total duration of the measurement.

Failed Pins Number of short-circuited pins.

5.5.9 Transistor



NOTE:

The transistor test is described in section 10.11.

5.5.9.1 Limits

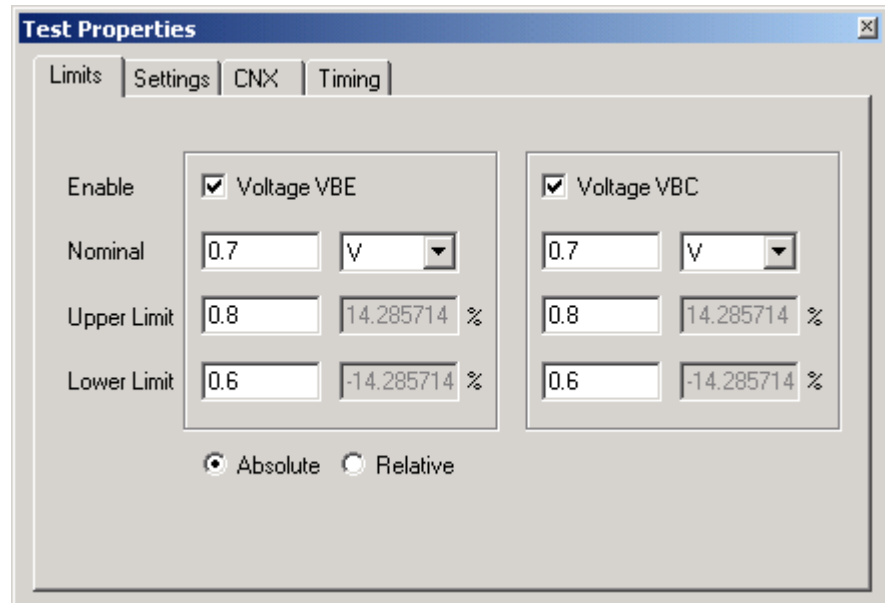


Figure 5-48 Test Step Transistor, Test Properties Limits

Enable

During the transistor test, as an option two measurements are performed:

- **Voltage VBE**
Measurement of the forward bias voltage (knee voltage) of the base-emitter diode
- **Voltage VBC**
Measurement of the forward bias voltage (knee voltage) of the base-collector diode

The related measurement is performed when the check box is activated. At least one measurement must be activated.

Nominal

The nominal value for the forward bias voltage (knee voltage) of the base-emitter diode or base-collector diode is entered in this field. The nominal value and limits are positive for NPN transistors and negative for PNP transistors.

Upper Limit
Lower Limit

The upper and lower limits of the measured forward bias voltage (knee voltage) of the base-emitter diode or base-collector diode can be entered in these fields. The fields on the left contain the absolute value in the same unit as the nominal value. The fields on the right contain the deviation from the nominal value as a percentage. Inactive input fields (which appear in grey) are recalculated and displayed with the command “**Edit...Apply**”.

Absolute / Relative

This setting determines whether limits will be entered as absolute values or relative values.

5.5.9.2 Settings

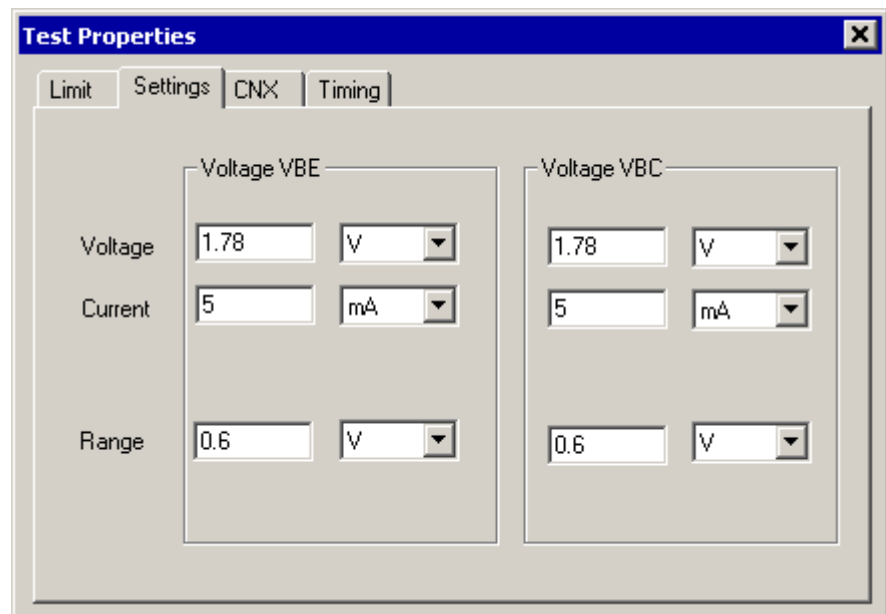


Figure 5-49 Test Step Transistor, Test Properties Settings

Voltage VBE + Voltage VBC

Voltage

The voltage of the voltage source is entered in this field. The voltage is positive for NPN transistors and negative for PNP transistors.

Value range:

-5.0 V ... 5.0 V

Default:

1.8 V

5.5.9.4 Timing

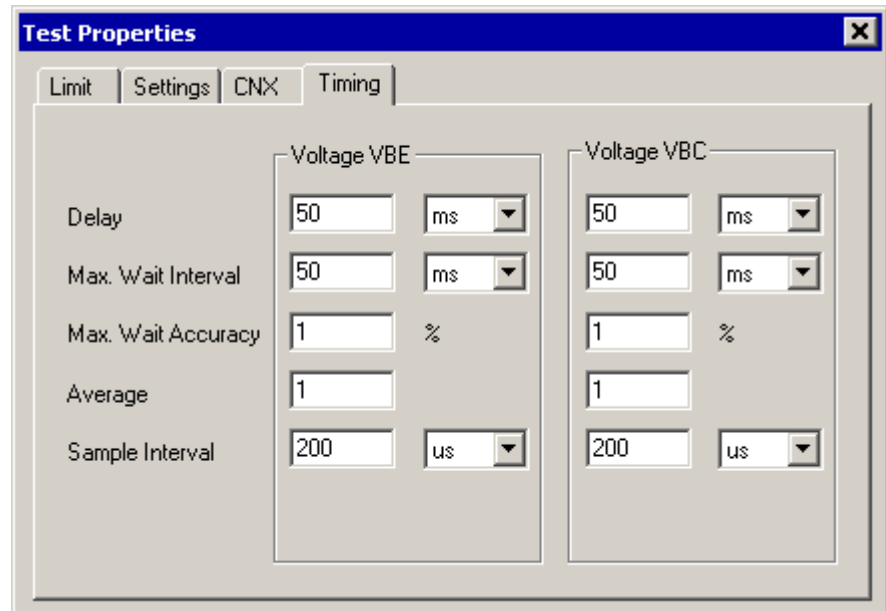


Figure 5-51 Test Step Transistor, Test Properties Timing



NOTE:

The individual options for the timing of the measurement operation are described in more detail in section 5.5.12.1.

Voltage VBE + Voltage VBC

Delay

The fixed delay to the start of the measurement is entered in this field.

Value range:

0 ms ... 1 s

Resolution:

1 ms

Default:

0 ms

Max. Wait Interval

The maximum duration of the test interval is entered in this field (maximum 20 samples).

Value range:

0 ms ... 10 s

Resolution:

1 ms

Default:

0 ms



Max. Wait Accuracy	<p>In this field the maximum percentage difference between two measured values in succession (samples) is entered for test steps in which the measured value is applied (measurement with “Max. Wait Interval”).</p> <p><u>Value range:</u> 0.0 % ... 10.0 %</p> <p><u>Default:</u> 1.0 %</p>
Average	<p>The number of measured values from which the mean for the measured result is to be determined is entered in this field.</p> <p><u>Value range:</u> 1 ... 1000</p> <p><u>Default:</u> 1</p>
Sample Interval	<p>The waiting time between the individual measurements for the formation of the mean is entered in this field (measurement with Average).</p> <p><u>Value range:</u> 5 μs ... 1 s</p> <p><u>Resolution:</u> 5 μs</p> <p><u>Default:</u> 5 μs (200 kHz)</p>

5.5.9.5 Results Details

For the Transistor test step, the following information is displayed in the **Results/Details** window after the execution of test step:

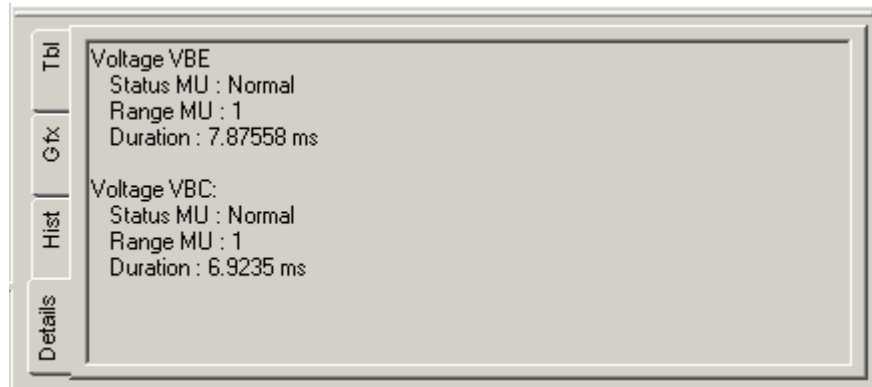


Figure 5-52 Test Step Transistor, Results Details

MU = Voltage measuring unit

Status

Status of the voltage measuring unit:
Normal, Overrange, Underrange, Max Wait Timeout.

Range

Range of the voltage measuring unit, in which the measurement was carried out.

Duration

Duration of the last measurement carried out.

5.5.10 Transistor Beta



NOTE:

The Transistor Beta test is described in section 10.12.

5.5.10.1 Limits

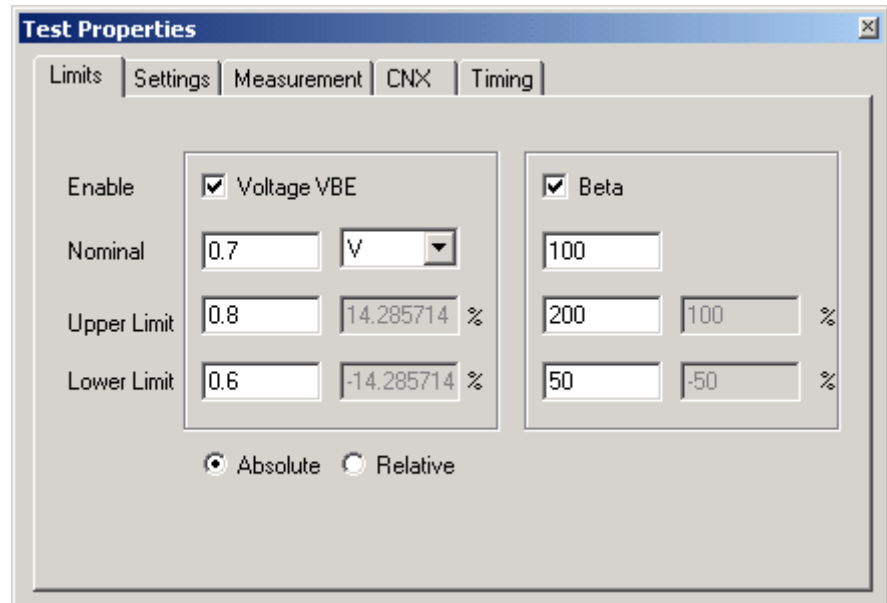


Figure 5-53 Test Step Transistor Beta, Test Properties Limits

Enable

During the transistor beta test, as an option two measurements are performed:

- **Voltage VBE**
Measurement of the forward bias voltage (knee voltage) of the base-emitter diode.
- **Beta**
Measurement of the dynamic current gain.

The related measurement is performed when the check box is activated. At least one measurement must be activated.

Voltage VBE

Nominal

The nominal value for the forward bias voltage (knee voltage) of the base-emitter diode is entered in this field.

Upper Limit
Lower Limit

The upper and lower limits of the measured forward bias voltage can be entered in these fields. The fields on the left contain the absolute value in the same unit as the nominal value. The fields on the right contain the deviation from the nominal value as a percentage. Inactive input fields (which appear in grey) are recalculated and displayed with the command “**Edit...Apply**”.

Beta

Nominal

The nominal value for the current gain (beta) is entered in this field.

Upper Limit
Lower Limit

The upper and lower limits of the measured current gain (beta) can be entered in these fields. The fields on the left contain the absolute value in the same unit as the nominal value. The fields on the right contain the deviation from the nominal value as a percentage. Inactive input fields (which appear in grey) are recalculated and displayed with the command “**Edit...Apply**”.

Absolute / Relative

This setting determines whether limits will be entered as absolute values or relative values.

5.5.10.2 Settings

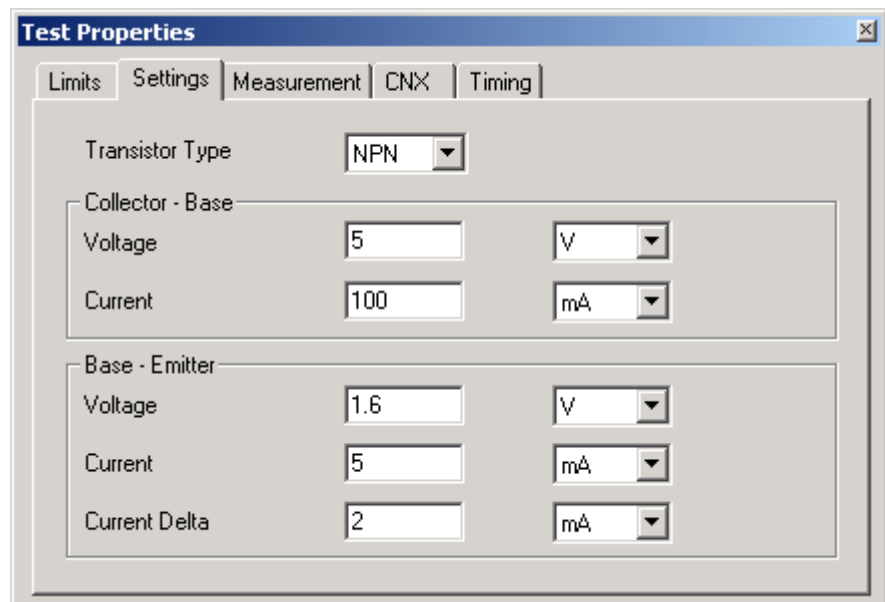


Figure 5-54 Test Step Transistor Beta, Test Properties Settings

Transistor Type

The type of the transistor (NPN or PNP). Note that the voltage values are always entered as positive numbers. The actual polarity is determined by the transistor type.



Collector - Base

Voltage The voltage of the R&S TS-PSU / R&S TS-PSU12 voltage source between collector and base is entered in this field.

Value range:

0.0 V ... 10.0 V

Default:

5.0 V

Current The current limit of the R&S TS-PSU / R&S TS-PSU12 voltage source is entered in this field.

Value range:

1.0 μ A ... 100.0 mA

Default

100.0 mA

Base - Emitter

Voltage The voltage of the DCS voltage source between base and emitter is entered in this field.

Value range:

0.0 V ... 5.0 V

Default:

1.6 V

Current The current limit of the DCS voltage source is entered in this field.

Value range:

1.0 μ A ... 100.0 mA

Default

5.0 mA

Current Delta The increase of the current limit of the DCS voltage source between the first and second current measurement is entered in this field.

Value range:

-100.0 mA ... 100.0 mA

Default:

2.0 mA



NOTE:

The sum of Current and Current Delta must be in the range 0 mA ... 100 mA.

5.5.10.3 Measurement

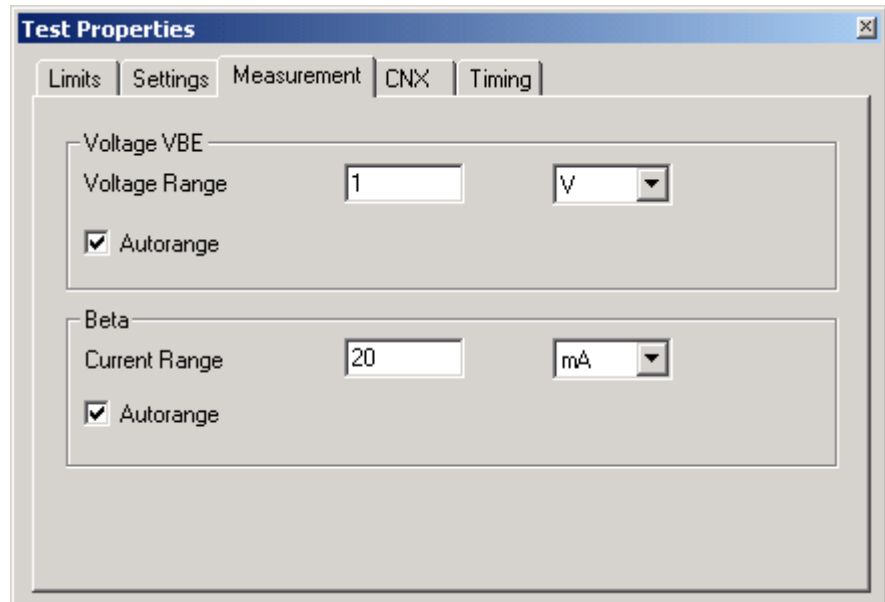


Figure 5-55 Test Step Transistor Beta, Test Properties Measurement

Voltage VBE

Voltage Range

The measuring range of the voltmeter is entered in this field.

Value range:

10.0 mV ... 100.0 V

Default:

1.0 V

Aurange

The measuring ranges for the voltmeter is set automatically when this check box is selected.

Beta

Current Range

The measuring range of the current meter is entered in this field.

Value range:

1.0 μ A ... 100.0 mA

Default:

20.0 mA

Aurange

The measuring ranges for the current meter is set automatically when this check box is selected.

5.5.10.4 CNX

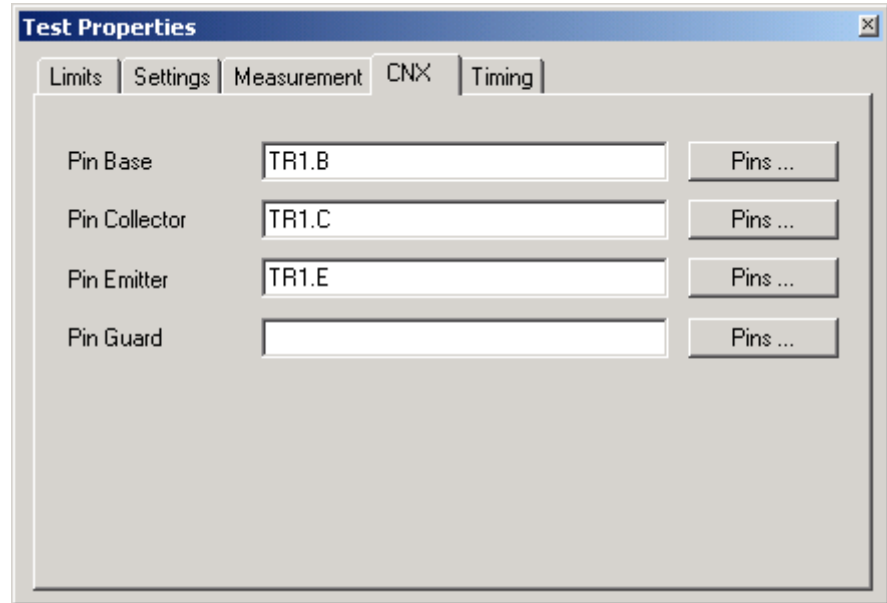


Figure 5-56 Test Step Transistor Beta, Test Properties CNX

Pin Base

The **base pin** (base of the transistor) is entered in this field. Only one measuring pin can be entered.

Pin Collector

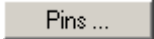
The **collector pin** (collector of the transistor) is entered in this field. Only one measuring pin can be entered.

Pin Emitter

The **emitter pin** (emitter of the transistor) is entered in this field. Only one measuring pin can be entered.

Pin Guard

The **guard pins** are entered in this field. Several measuring pins can be entered. The field remains empty for unguarded measurements.



Opens the **Pins** dialog box for inserting / removing pins on the Pin List. For more information, see section 5.5.12.2.

5.5.10.5 Timing

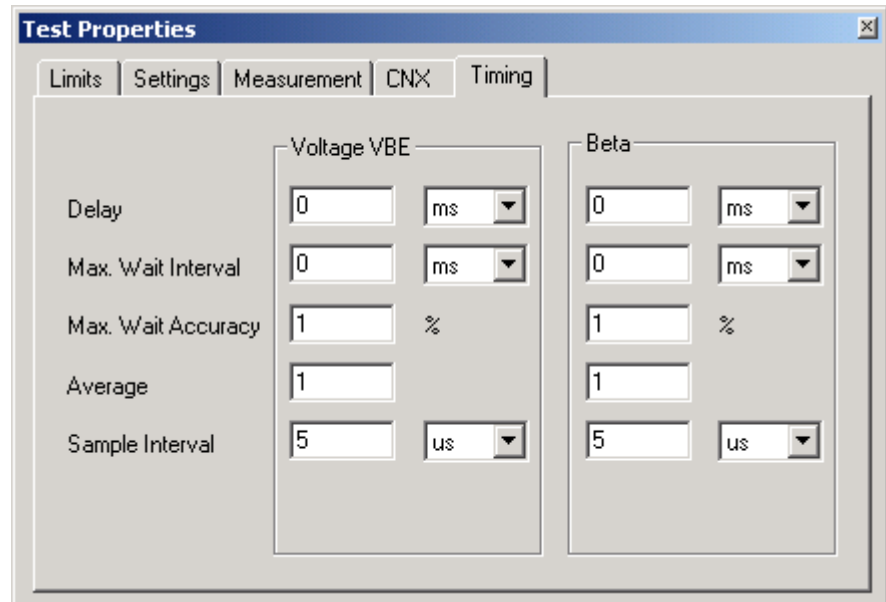


Figure 5-57 Test Step Transistor Beta, Test Properties Timing



NOTE:

The individual options for the timing of the measurement operation are described in more detail in section 5.5.12.1.

Voltage VBE + Beta

Delay

The fixed delay to the start of the measurement is entered in this field.

Value range:

0 ms ... 1 s

Resolution:

1 ms

Default:

0 ms

Max. Wait Interval

The maximum duration of the test interval is entered in this field (maximum 20 samples).

Value range:

0 ms ... 10 s

Resolution:

1 ms

Default:

0 ms



Max. Wait Accuracy	<p>In this field the maximum percentage difference between two measured values in succession (samples) is entered for test steps in which the measured value is applied (measurement with “Max. Wait Interval”).</p> <p><u>Value range:</u> 0.0 % ... 10.0 %</p> <p><u>Default:</u> 1.0 %</p>
Average	<p>The number of measured values from which the mean for the measured result is to be determined is entered in this field.</p> <p><u>Value range:</u> 1 ... 1000</p> <p><u>Default:</u> 1</p>
Sample Interval	<p>The waiting time between the individual measurements for the formation of the mean is entered in this field (measurement with Average).</p> <p><u>Value range:</u> 5 μs ... 1 s</p> <p><u>Resolution:</u> 5 μs</p> <p><u>Default:</u> 5 μs (200 kHz)</p>

5.5.10.6 Results Details

For the Transistor Beta test step, the following information is displayed in the Results/Details window after the execution of the test step:

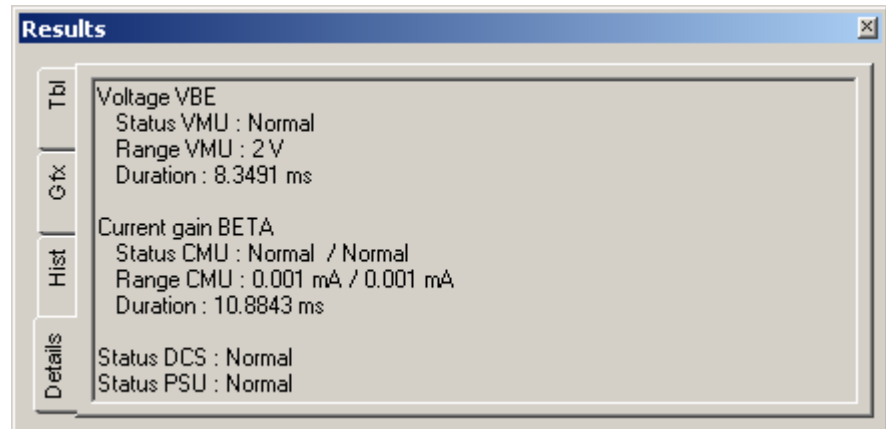


Figure 5-58 Test Step Transistor Beta, Results Details

VMU = Voltage measuring unit (R&S TS-PSAM)

CMU = Current measuring unit (R&S TS-PICT)

DCS = DC Source (R&S TS-PSAM)

PSU = DC Source (R&S TS-PSU / R&S TS-PSU12)

Voltage VBE

Status VMU

Status of the voltage measurement unit:
Normal, Overrange, Underrange, Max Wait Timeout

Range VMU

Range of the voltage measurement unit, in which the measurement was carried out.

Duration

Duration of the last measurement carried out.

Current gain BETA

Status CMU

Status of the current measurement unit for the first and second measurement:
Normal, Overrange, Underrange, Max Wait Timeout

Range CMU

Range of the current measurement unit, in which the measurement was carried out for the first and second measurement.

Duration

Duration of the last measurement carried out.



Status DCS

Status of the DC voltage source DCS:
Normal, Not in constant current state

Status PSU

Status of the DC voltage source TS-PSU / TS-PSU12:
Normal, Not in constant voltage state

5.5.11 Zener Diode



NOTE:

The Zener Diode test is described in section 10.13.

5.5.11.1 Limits

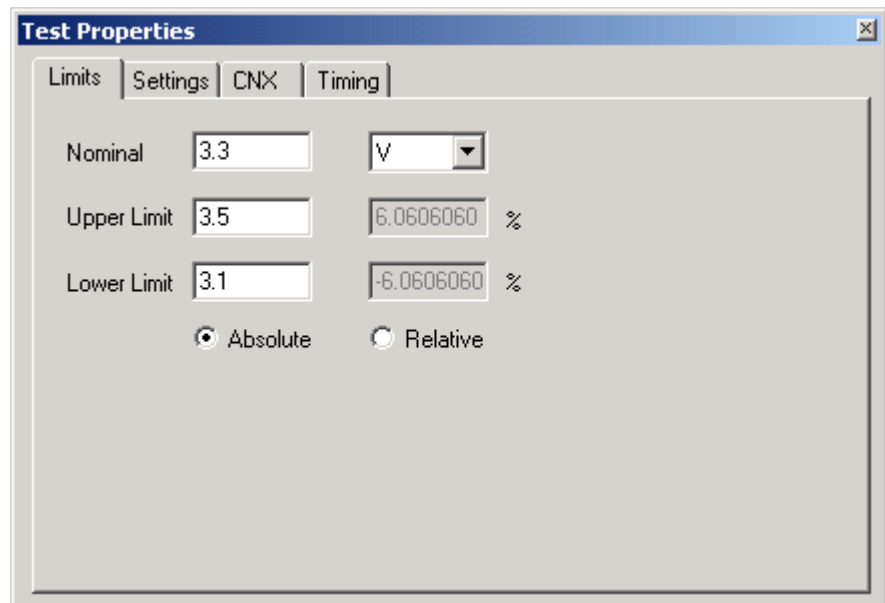


Figure 5-59 Test Step Zener Diode, Test Properties Limits

Nominal

The nominal value for the zener voltage (reverse working voltage) of the zener diode is entered in this field.

Upper Limit

Lower Limit

The upper and lower limits of the measured zener voltage (reverse working voltage) can be entered in these fields. The fields on the left contain the absolute value in the same unit as the nominal value. The fields on the right contain the deviation from the nominal value as a percentage.

Inactive input fields (which appear in grey) are recalculated and displayed with the command **"Edit...Apply"**.

Absolute / Relative

This setting determines whether limits will be entered as absolute values or relative values.

5.5.11.2 Settings

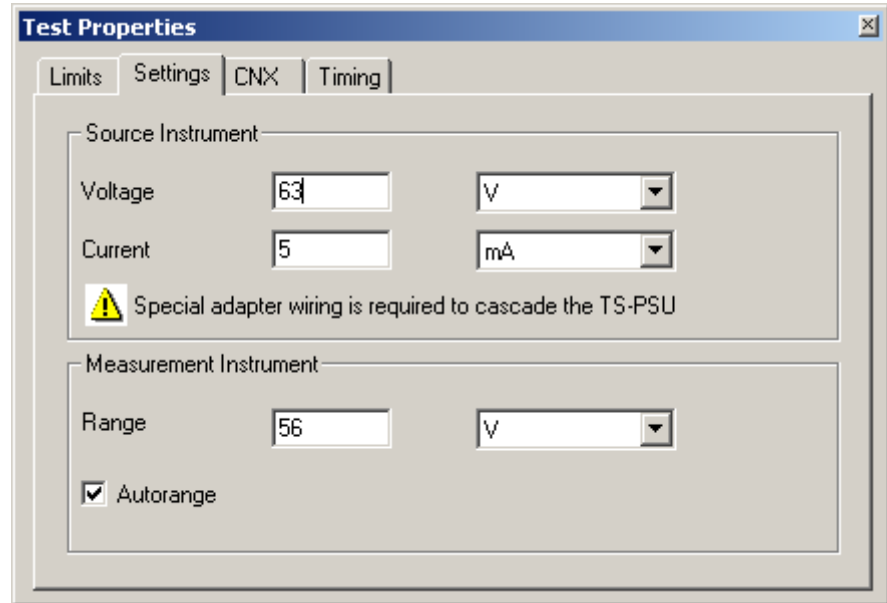


Figure 5-60 Test Step Zener Diode, Test Properties Settings

Voltage

The voltage of the voltage source is entered in this field.

Value range:

-100 V ... 100 V for TS-PSU

-24 V ... 24 V for TS-PSU12

Default:

3.3 V

Current

The current limit of the voltage source is entered in this field.

Value range:

1.0 μ A ... 100.0 mA

Default

5.0 mA



NOTE:

When Voltage exceeds 50 V for TS-PSU (12 V for TS-PSU12) , special test adapter wiring is necessary to cascade the two power supply output channels (see section 10.13).

- Range** The measuring range of the voltmeter is entered in this field.
Value range:
 10.0 mV ... 100.0 V
Default:
 5.0 V
- Autorange** The measuring range for the voltmeter is set automatically when this check box is selected.

5.5.11.3 CNX

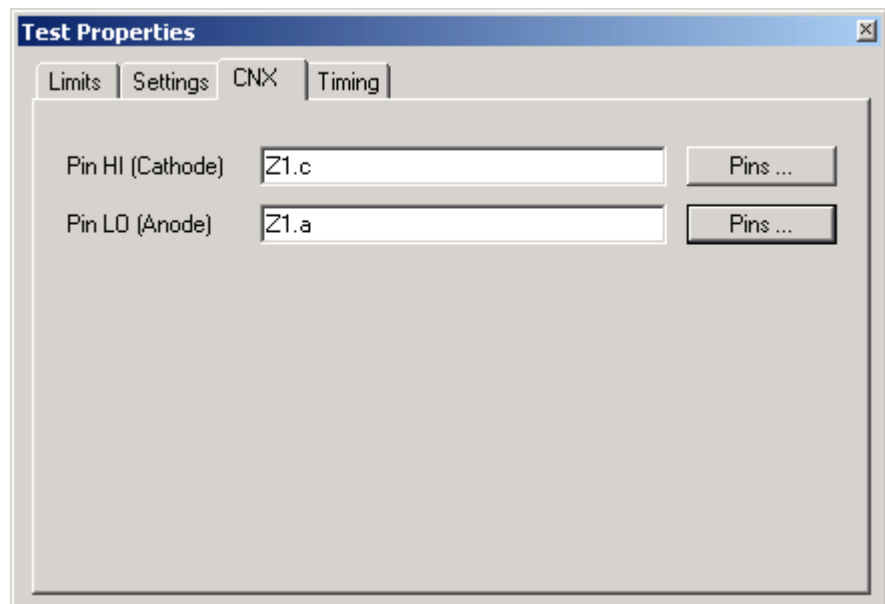


Figure 5-61 Test Step Zener Diode, Test Properties CNX

Pin HI (Cathode) The **Pin HI** (diode cathode) is entered in this field. Only one measuring pin can be entered.

Pin LO (Anode) The **Pin LO** (diode anode) is entered in this field. Only one measuring pin can be entered.



Opens the **Pins** dialog box for inserting / removing pins on the Pin List. For more information, see section 5.5.12.2.

5.5.11.4 Timing

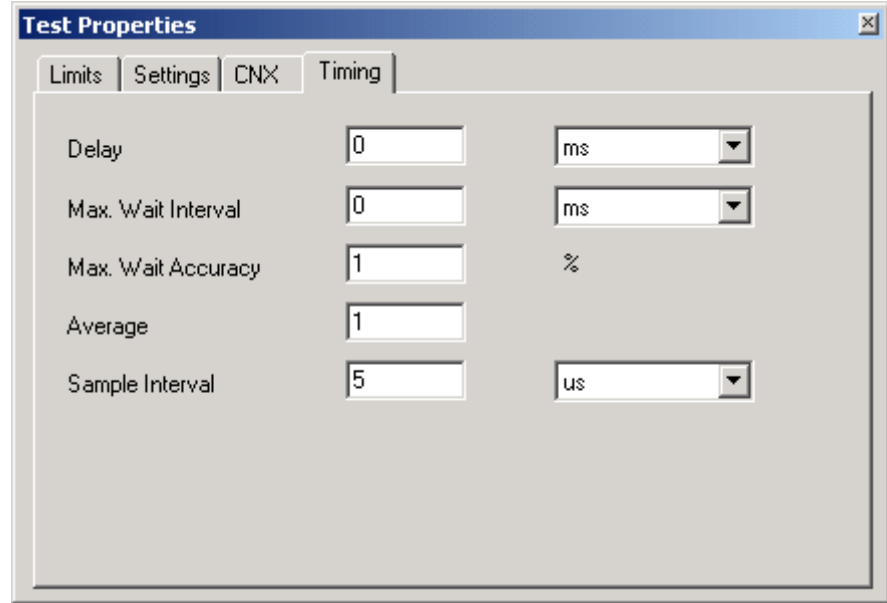


Figure 5-62 Test Step Zener Diode, Test Properties Timing



NOTE:

The individual options for the timing of the measurement operation are described in more detail in section 5.5.12.1.

Delay

The fixed delay to the start of the measurement is entered in this field.

Value range:

0 ms ... 1 s

Resolution:

1 ms

Default:

0 ms

Max. Wait Interval

The maximum duration of the test interval is entered in this field (maximum 20 samples).

Value range:

0 ms ... 10 s

Resolution:

1 ms

Default:

0 ms

- Max. Wait Accuracy** In this field the maximum percentage difference between two measured values in succession (samples) is entered for test steps in which the measured value is applied (measurement with “Max. Wait Interval”).
Value range:
0.0 % ... 10.0 %
Default:
1.0 %
- Average** The number of measured values from which the mean for the measured result is to be determined is entered in this field.
Value range:
1 ... 1000
Default:
1
- Sample Interval** The waiting time between the individual measurements for the formation of the mean is entered in this field (measurement with Average).
Value range:
5 μ s ... 1 s
Resolution:
5 μ s
Default:
5 μ s (200 kHz

5.5.11.5 Results Details

For the Zener Diode test step, the following information is displayed in the Results/Details window after the execution of the test step:

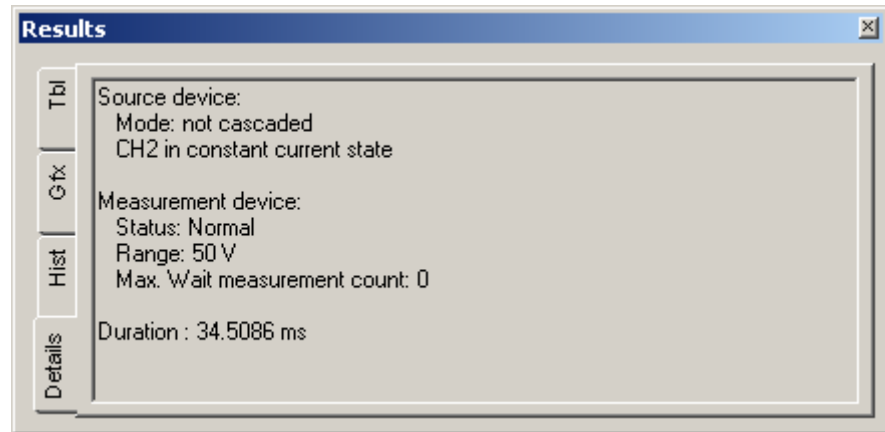


Figure 5-63 Test Step Zener Diode, Results Details

<i>Source device</i>	R&S TS-PSU / R&S TS-PSU12
Mode	Mode of the source output channels: <ul style="list-style-type: none"> • not cascaded (CH2 only) • cascaded (CH1 and CH2, requires special test adapter cabling)
State	Shows whether the R&S TS-PSU voltage source is in the expected state. The R&S TS-PSU must be in constant current state.
<i>Measurement device</i>	R&S TS-PSAM
Status	Status of the voltage measurement unit: Normal, Overrange, Underrange, Max Wait Timeout
Range	Range of the voltage measurement unit, in which the measurement was carried out.
Max. Wait measurement count	Number of the measurements which were carried out with Max. Wait until the measured value was stable.
Duration	Duration of the last measurement carried out.

5.5.12 Explanations

5.5.12.1 Timing

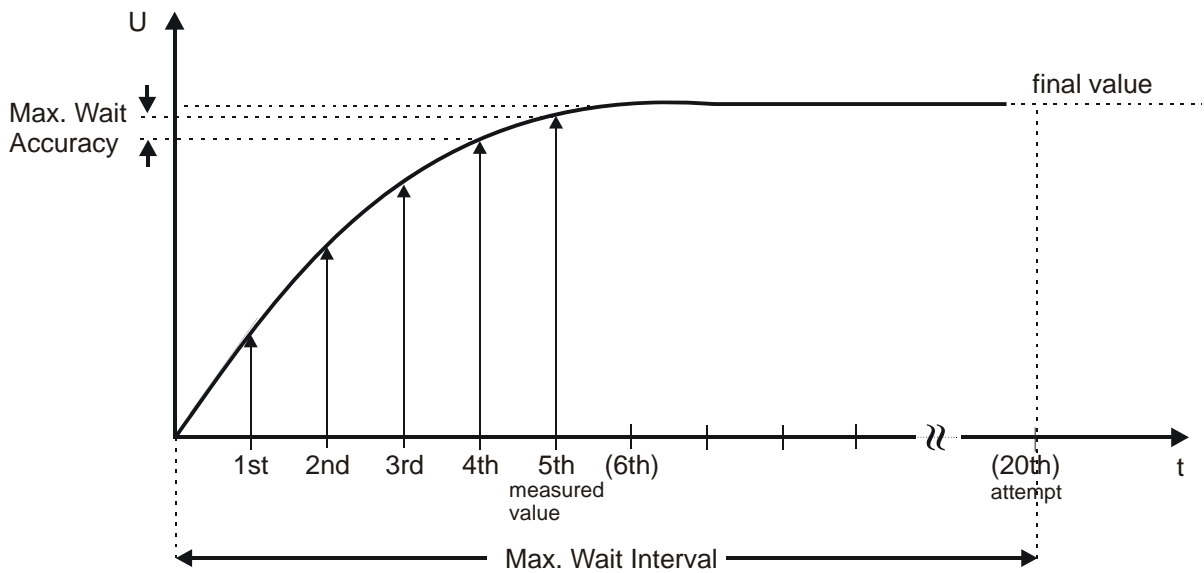


Figure 5-64 Timing example 1

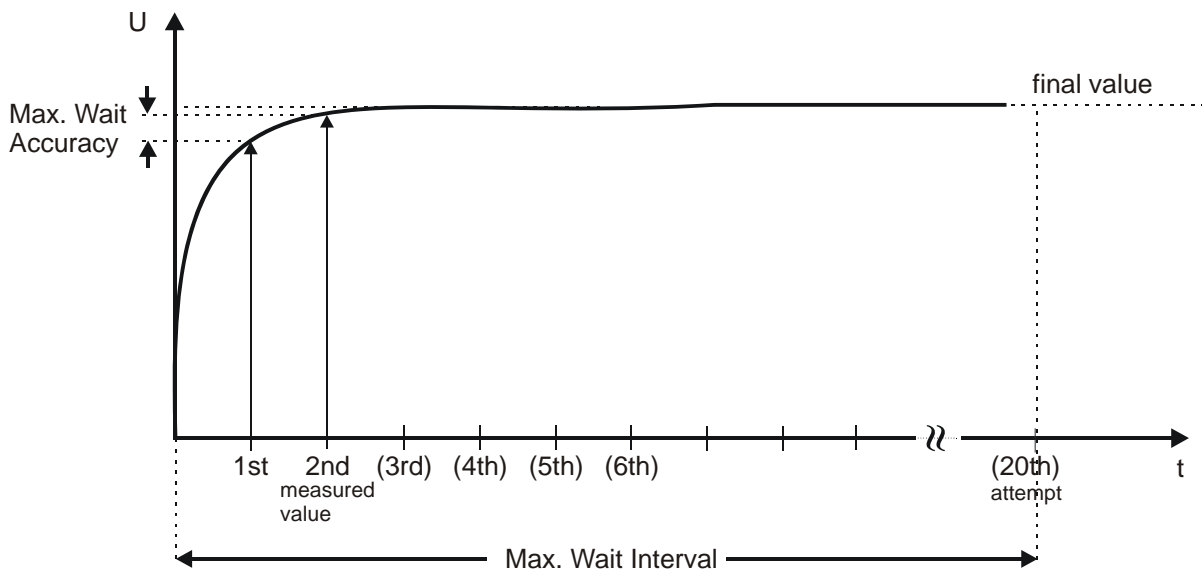


Figure 5-65 Timing example 2

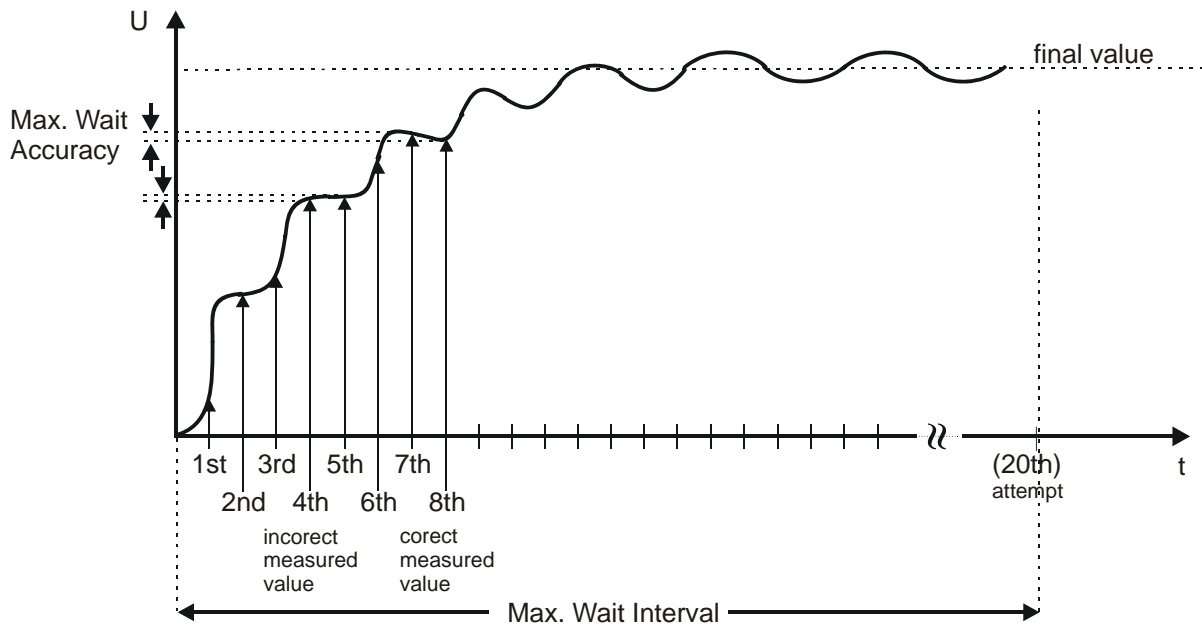


Figure 5-66 Timing example 3

The auto-delay technique (timing) is a technique that automatically adjusts the duration of analog measurements to the unit under test and thus optimizes the measurement duration (see Figure 5-65 to Figure 5-66). There is no additional effort for the programmer. The technique automatically determines the optimal time for the measurement from the transient response of the unit under test. In this way fixed waiting times that must be set unnecessarily long for the worst measuring case are avoided.

During the transient process in Figure 5-64 the relative difference between two individual measurements (**Max.Wait Accuracy**) after the 5th measurement is so low that the signal can be considered stable and thus the transient complete. The considerably faster transient signal from Figure 5-65 is already stable after the 2nd measurement so that here only half the measuring time is needed. A shorter **Max. Wait Interval** and thus shorter periods between two individual measurements would result in an even shorter measuring time here (e.g. a sampling rate as shown in Figure 5-66).

If the signal to be measured is very unstable, the technique is interrupted after a time that can be programmed by the user (**Max. Wait Interval**). During this time 20 measurements are performed and the measured value is checked for stability. A short **Max. Wait Interval** thus corresponds to short spacing between the individual measurements, a long time corresponds to a large spacing.

In the realistic case, the signal to be measured will have interference superimposed. The excessively small sampling interval selected in Figure 5-66 already reflects stable conditions after the 4th measurement, although relative stability of the measurement comparable with Figure 5-64 would only be achieved on the 8th measurement.

Half the sampling rate - this corresponds to the even numbered attempts in Figure 5-66 - would only achieve the value on the 8th measurement. As on real units under test, the response times are scattered by orders of magnitude, the sampling rate must not be constant, instead it must be possible to adapt it to the measuring problem. In this way the influence of interference is suppressed and high measuring accuracy achieved with optimized measuring time.



NOTE:

If the Max. Wait Interval is set to 0.0, the auto-delay technique (timing) is switched off.

A further possible method of measuring is to wait for the expected minimum response time using **Delay** and then to perform the measurement up to the maximum up to the maximum response time using the auto-delay technique (**Max. Wait Interval**) (see Figure 5-67).

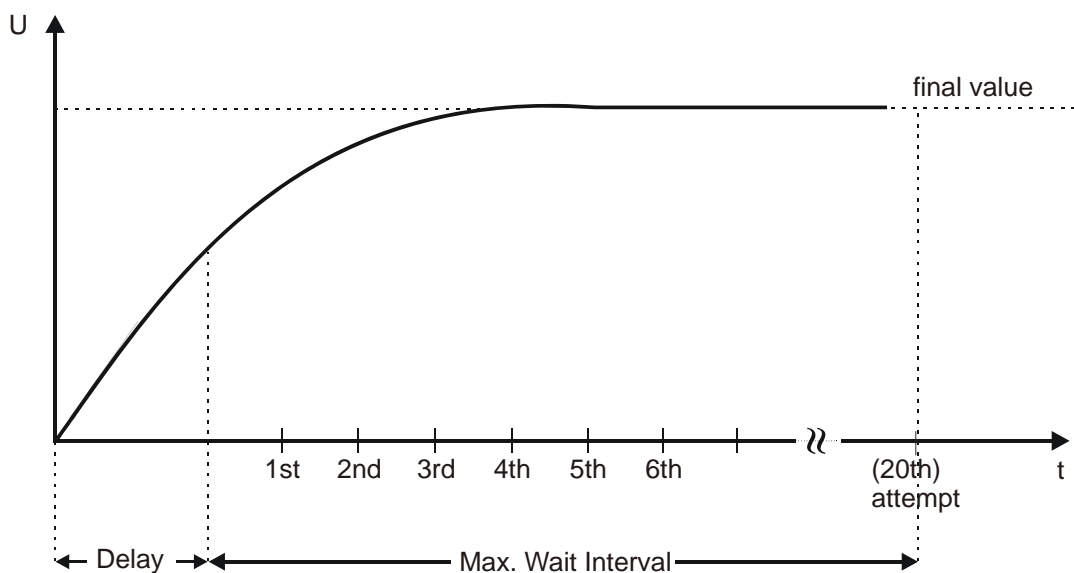


Figure 5-67 Timing example 4

Using **Sample Interval** and the formation of the mean (**Average**), hum interference can be suppressed. The time set using **Sample Interval** is

waited prior to each measurement. To suppress 50Hz hum interference, **Sample Interval** and **Average** must be selected such that the entire measuring time is a multiple of 20 ms. Recommended for the normal case:

Average = 20ms, Sample Interval = 1 ms

5.5.12.2 Editing pin lists

Using the **Pins** dialog box, the pin lists for the individual test steps are prepared and edited.

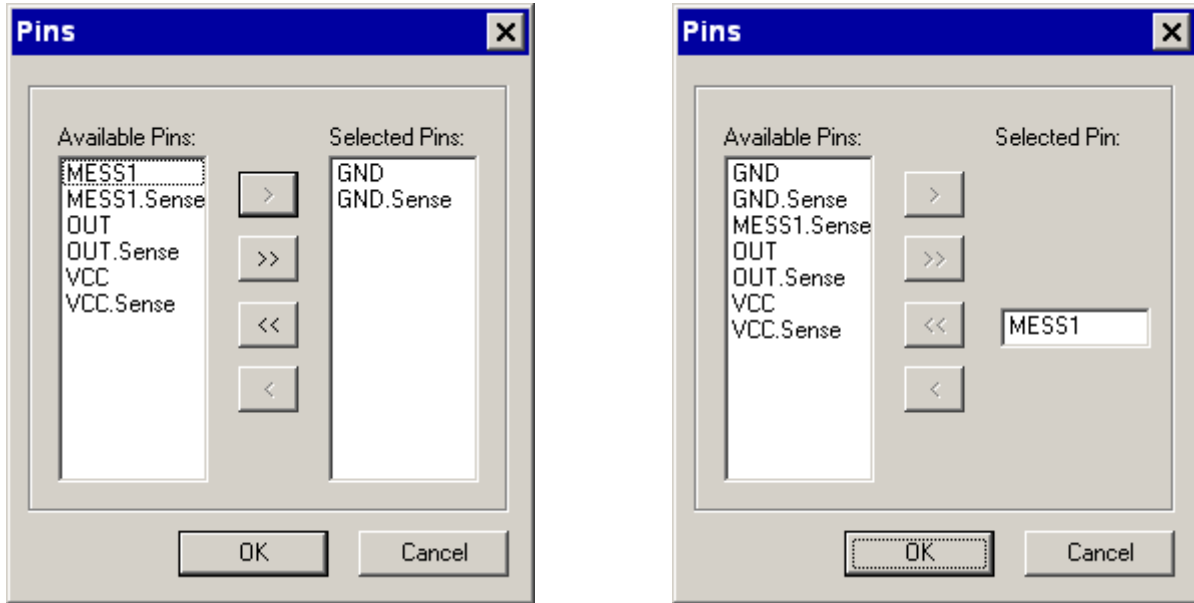


Figure 5-68 Pins dialog box

Pin Selector

Available Pins: All available measuring pins are listed in this field. The list of available measuring pins is read from the file "APPLICATION.INI" (on this topic, see also section 7.3).

Selected Pins: All measuring pins that are to be entered in the pin list for the related test step are entered in this field. Depending on the test step, it is possible to copy several pins (Figure 5-68, left) or only one pin (Figure 5-68 , right) to the pin list



All marked pins from the **Available Pins:** field are entered in the **Selected Pins:** field. Using **Ctrl + left mouse button** or **Shift + left mouse button** you can mark several pins.



All pins from the **Available Pins:** field are entered in the **Selected Pins:** field.



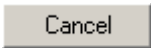
All pins from the **Selected Pins:** pins field are entered in the **Available Pins:** field.



All marked pins from the **Selected Pins:** field are entered in the **Available Pins:** field. Using **Ctrl + left mouse button** or **Shift + left mouse button** you can mark several pins.



All pins entered in the **Selected Pins:** field are copied to the pin list for the test step. The **Pins** dialog box is closed.



All entries made are discarded and the **Pins** dialog box is closed.

5.5.13.2 Settings

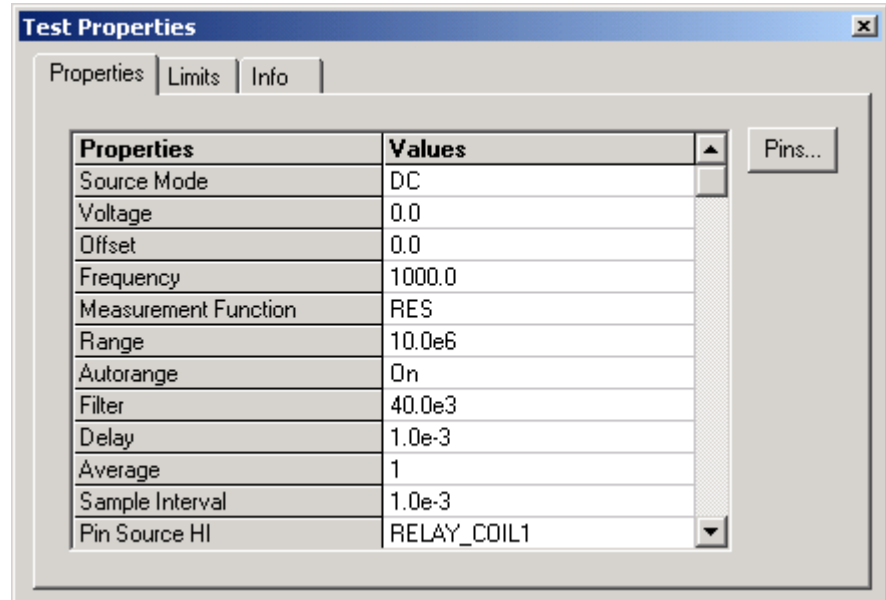


Figure 5-70 Test Step user-defined, Test Properties Settings

The settings for user-defined test methods are shown in the form of a table. The left column **Properties** shows the parameters that can be changed. The right column **Values** contains the corresponding values. The values in the right column can be edited.

For the meaning of properties, their data types and permissible value ranges, please refer to the documentation for the test method.



Opens the Pins dialog box to insert / delete pin names.

5.5.13.3 Info

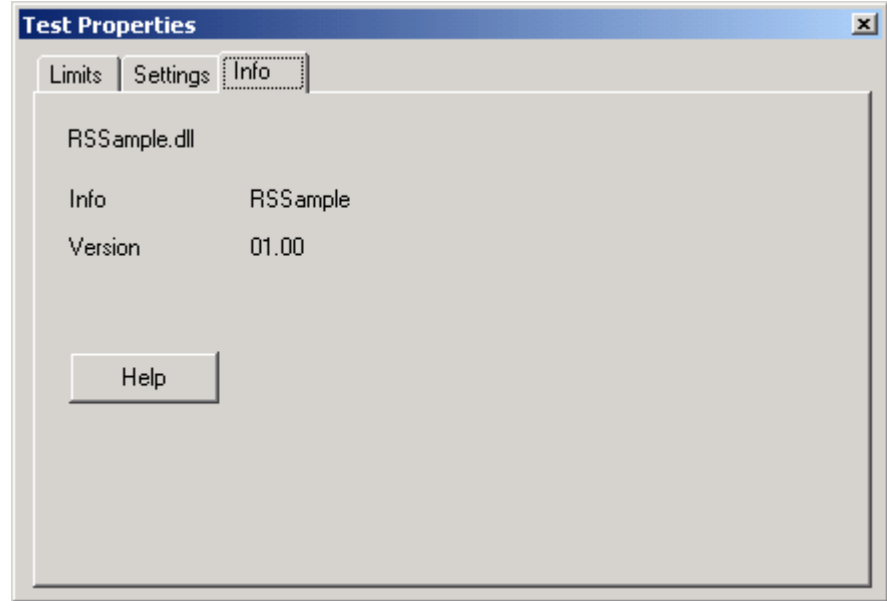
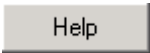


Figure 5-71 Test Step user-defined, Test Properties Info

This property sheet shows the name of the ICT Extension DLL, the name of the user-specific test method and its version number.



Opens the documentation for the user-specific test method.

5.5.13.4 Results Details

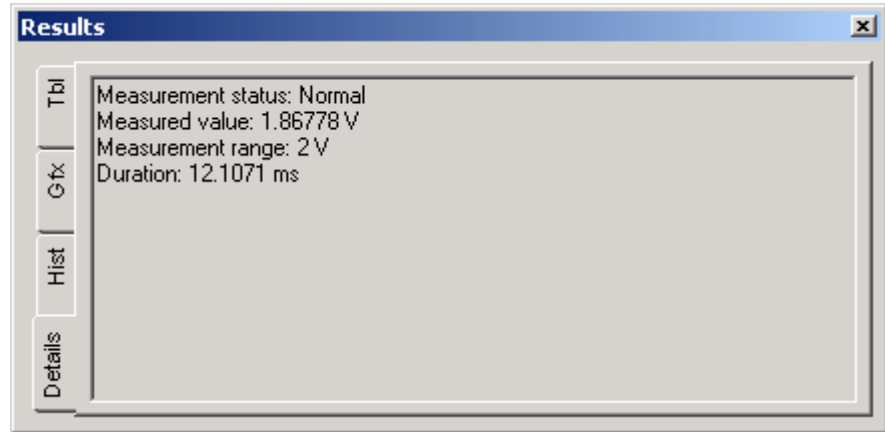


Figure 5-72 Test Step user-defined, Results Details

The data shown here refers to the last test step executed. The meaning of the output is explained in the documentation for the test method.

5.6 Menu bar functions

5.6.1 Main menu command <File>

5.6.1.1 Menu command <Open>

[Ctrl+O]



Opens the window for opening an ICT program.

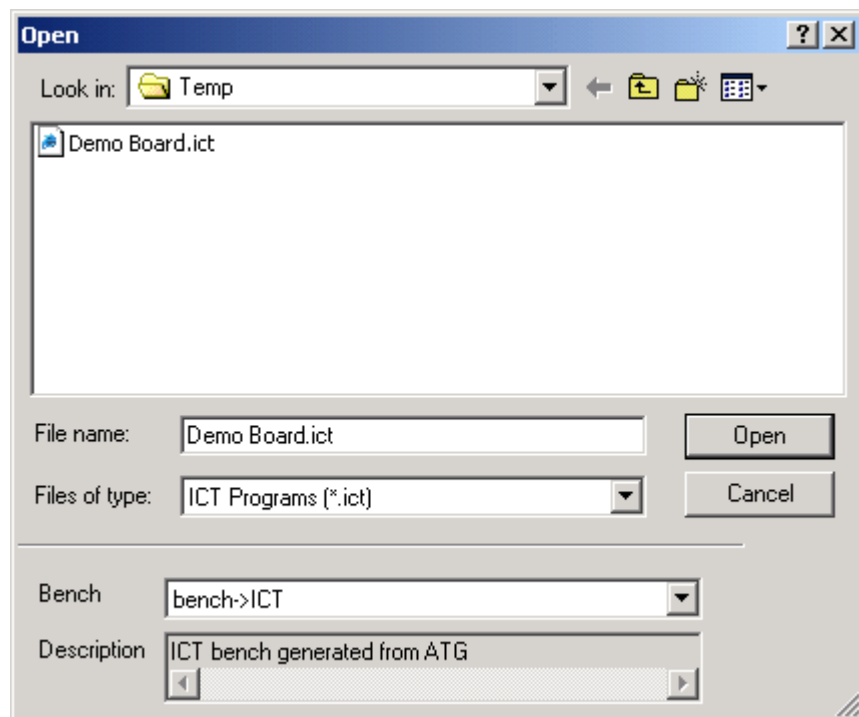


Figure 5-73 Open

The standard Windows dialog box for opening files is displayed. As in every other Windows program, using this dialog box the location, the file name and the file type for the ICT program to be opened can be selected.

Bench

In addition, you can enter the bench section for the ICT program using a list box. The bench sections given in the `Application.INI` are listed in the list box.

Description

The entry in the selected bench section that is entered under the keyword **Description** is displayed in this field.

When an ICT program is opened, it is “compiled”. During compilation, all checks are made. Then a metacode of the ICT program is prepared. When the ICT program is started, only the compiled metacode is executed. As no further check is performed, the execution speed of the ICT program is increased.

5.6.1.2 Menu command <Save>

[Ctrl+S]



Saves the ICT program displayed using the current name.

5.6.1.3 Menu command <Save Copy As>

Opens the standard Windows dialog box for saving the ICT program displayed. The ICT program displayed is saved as a copy using a new name. The original ICT program remains open with the old file name.

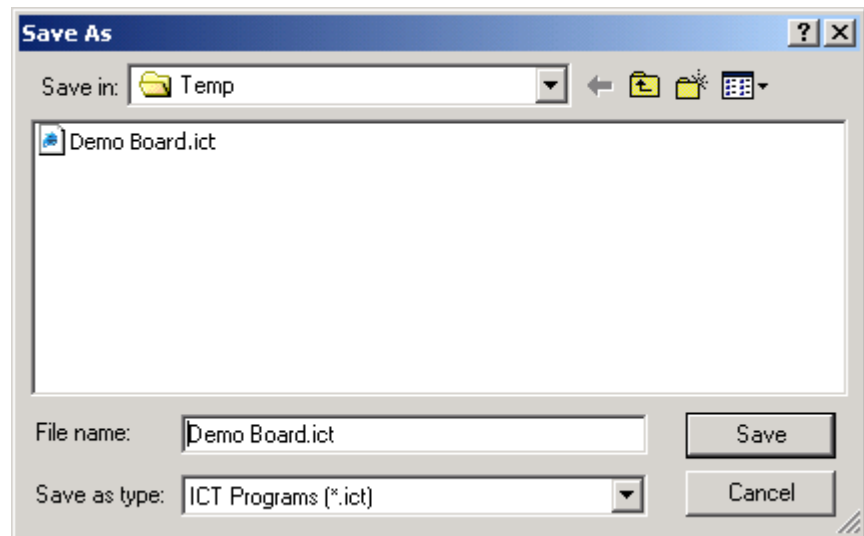


Figure 5-74 Save Copy As



NOTE:

Using the Enhanced Generic Test Software Library R&S EGTSL it is not possible to create a new ICT program. A new ICT program is always a copy of an existing ICT program. During the installation of R&S EGTSL an ICT program is supplied as a template for copying.

...GTSL\EGTSL\Templates\Template.ict

5.6.1.4 Menu command <Sel ect>

In the R&S EGTSL display environment, you can open several ICT programs. However, only one ICT program can be displayed and edited. Using the <Sel ect> menu command, you can select the program to be edited from the ICT programs open.

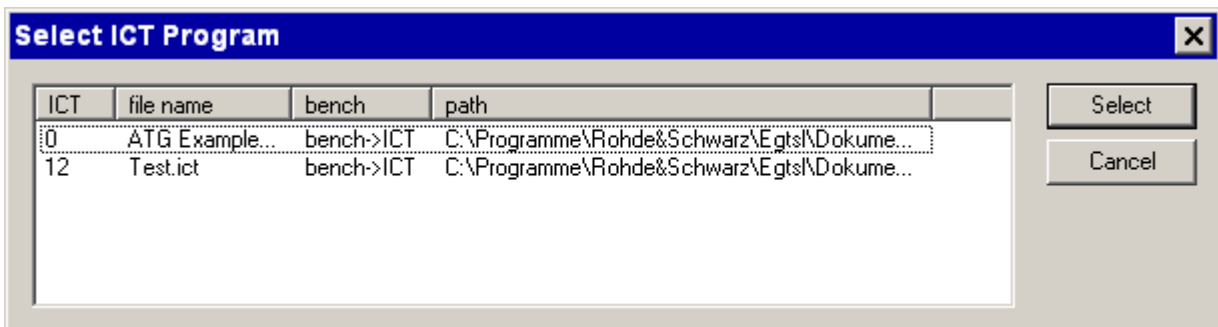
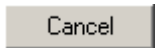


Figure 5-75 Select ICT Program



The ICT program marked is displayed and can be edited.



The new selection for the ICT program is discarded and the window closed.

5.6.1.5 Menu command <Cl ose>

The ICT program displayed is closed. If changes have been made to the ICT program and not yet saved, a warning message is displayed.

5.6.1.6 Menu command <Program Properties>

Opens a window where you can make general settings for the ICT program. The following buttons have the same function in all sub-windows of the Program Properties.



All changes made are applied and saved. The window is closed.



All changes made are discarded. The window is closed.

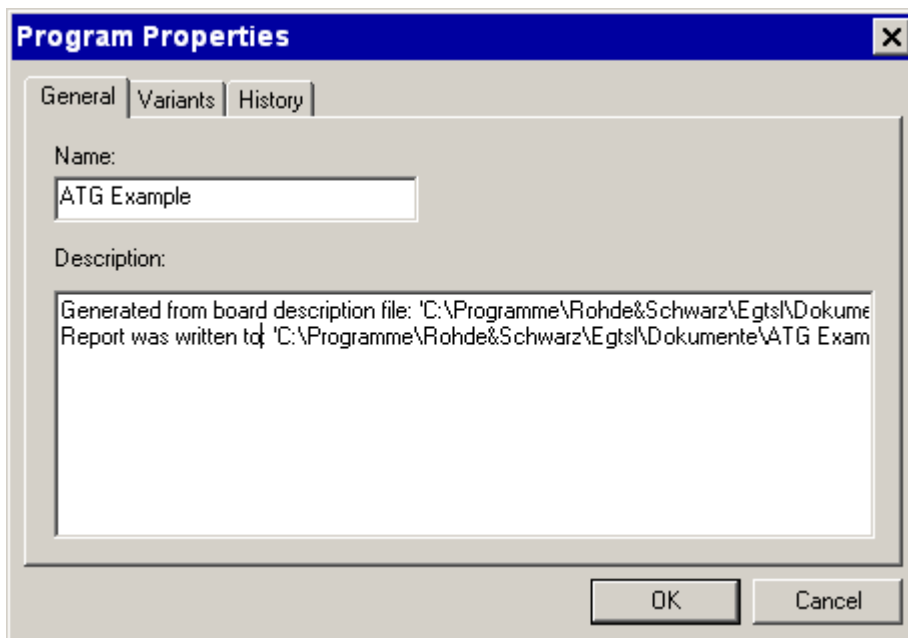


Figure 5-76 ICT Program Properties, General

In the *Program Properties, General* window, general information on the ICT program is given.

Name: The name of the ICT program is entered in this field. The name appears as the root folder name in the tree structure in the Program window (see section 5.4.2).

Description: Arbitrary text describing the ICT program can be entered in this window. Text can be copied to the window using the Clipboard.

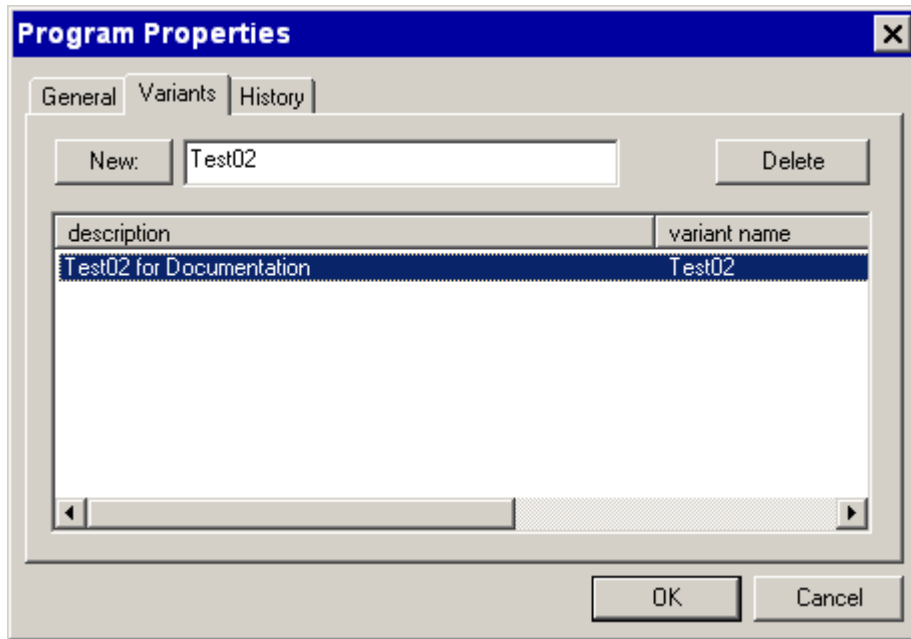


Figure 5-77 ICT Program Properties, Variants

In the *Program Properties, Variants* window you can define the variants that are to apply for the ICT program.



NOTE:

For more information on variants, see section 11.2.



The variant name entered in the field is copied to the list using the **New** button.



Deletes the marked variant entry from the list. Once a variant is allocated to a test step or a program group, this variant cannot be deleted. The **Delete** button is hidden.

description

The description of the variant is entered in this column. The text can be edited by clicking the entry marked.

variant name

The variant name entered is copied to this column. The variant name cannot be changed subsequently.

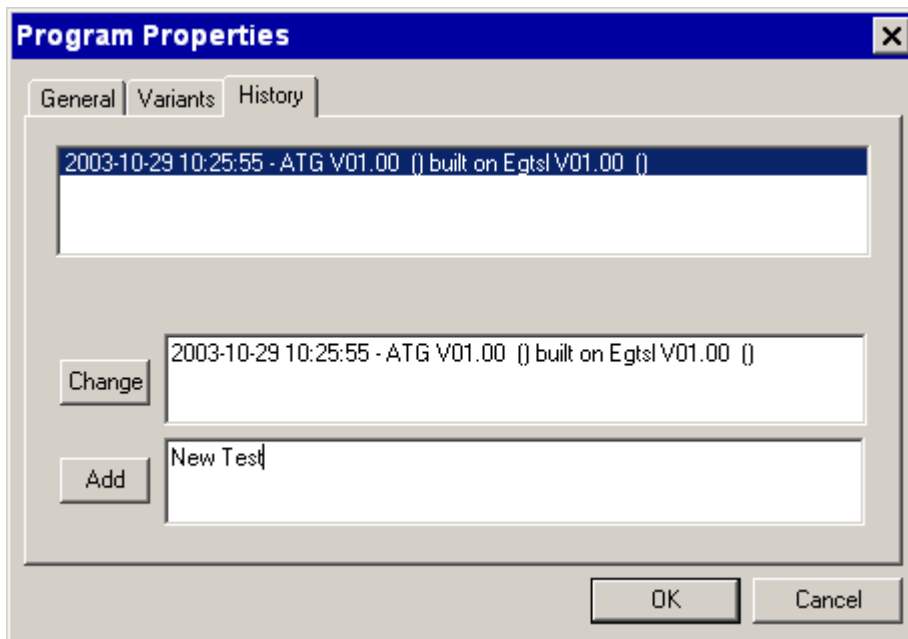


Figure 5-78 ICT Program Properties, History

In the *Program Properties, History* window the history of the ICT program is logged. The information must be entered manually.

A list of all entries is displayed in the window at the top.



The entry marked in the window is changed. Using the **Change** button the change is copied to the list.



A new entry is made in the window. Using the **Add** button the new entry is entered at the top of the list.

5.6.1.7 Menu command <Limits>

Opens the editing window for loading, importing and exporting the values for the limits for the individual test steps.

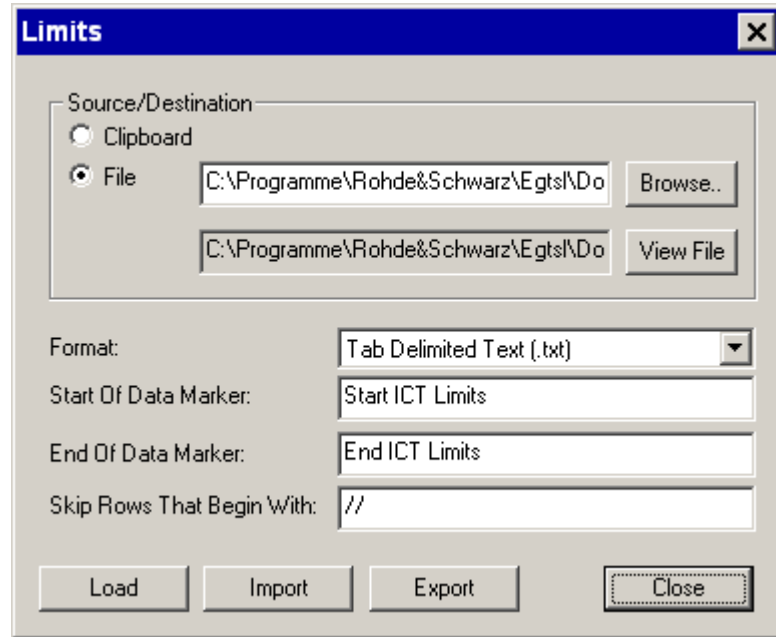


Figure 5-79 Limits

Source/Destination

Clipboard

With this function activated, the data for loading, importing and exporting values for limits are written to the Clipboard or read from the Clipboard.

File



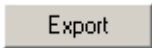

With this function activated, the data for loading, importing and exporting values for limits are written to a `txt` file or read from a `txt` file.

Browse..

Opens the standard Windows window for selecting an existing file with values for limits. In the standard Windows window it is also possible to create a new file for exporting the values for the limits. The folder and the file name for the selected export/import file are displayed next to the **Browse...** button and next to the **View File** button.

View File

Opens the selected export/import file in the Windows text editor. Changes can be made and saved in the editor.

Format:	<p>There is a choice of two data formats for exporting or importing:</p> <ul style="list-style-type: none"> • Tab Delimited Text (file extension <code>*.txt</code>) The individual entries on a line are separated by tabs (see example 1) • Comma Delimited Text (file extension <code>*.csv</code>) The individual entries on a line are separated by commas (see example 2) <p>The data formats apply for</p> <ul style="list-style-type: none"> – Importing (loading) from the Clipboard. – Exporting to the Clipboard. – Importing (loading) from a file. – Exporting to a file.
Start Of Data Marker:	The start of the data area in the import/export file is marked with the text given here (format setting).
End Of Data Marker:	The end of the data area in the import/export file is marked with the text given here (format setting).
Skip Rows That Begin With:	Lines in the import/export file that are to be skipped during loading/importing are marked with the characters (text) given here (format setting).
	<p>Loads the values for the limits from the Clipboard or the import file given. The values for the limits are temporarily changed and displayed. The values loaded cannot be saved. When the ICT program is opened next time, the original values for the limits will be displayed again. The data format given and the format settings must match the information in the file to be loaded.</p>
	<p>Imports the values for the limits from the Clipboard or the import file given. The old values for the limits are overwritten and saved with the ICT program.</p> <p>The data format given and the format settings must match the information in the file to be imported.</p>
	Exports the values for the limits for all test steps (when present) to the Clipboard or the export file given. The data format from the format settings is applied during the export
	The editing window for loading, importing and exporting the values for the limits is closed.



Examples for an export/import file with values for limits:

Example 1:

```

Start ICT Limits
<Step Name>          Limits.High  Limits.Low  [Limits.High Limits.Low]
// example of a comment line
Discharge Test      0           0
Contact Test        0           0
Short Test          0           0
R1                   1.3538      1.0462
R2                   365.58      294.45
R3                   44.135      35.868
R4                   11.035      8.9674
C1                   396.42      323.68
C2                   110.16      89.94
C3                   110.1       89.896
TR1                  0.78        0.42        0.78        0.42
End ICT Limits

```

Example 2:

```

START SECTION LIMITS
<Step Name> ,Limits.High ,Limits.Low , [Limits.High ,Limits.Low]
// example of a comment line
Discharge Test ,0 ,0
Contact Test ,0 ,0
Short Test ,0 ,0
R1 ,1.3538 ,1.0462
R2 ,365.58 ,294.45
R3 ,44.135 ,35.868
R4 ,11.035 ,8.9674
C1 ,396.42 ,323.68
C2 ,110.16 ,89.94
C3 ,110.1 ,89.896
TR1 ,0.78 ,0.42 ,0.78 ,0.42
END SECTION LIMITS

```

The following points are to be observed when editing the export/import file with values for the limits:

- The numerical values have the English number format i.e.. the decimal point and not the decimal comma must be used.
- The names of the individual tests are given in the first column. If there are test steps with the same test step name (e.g. the resistor test Rx twice), the test step names are expanded by the test step ID

Example:

Rx[27]

Rx[28]

- Resistor and impedance tests have no second limit. The column “Limits.High” for the second limit is used to store the optional correction value.

5.6.1.8 Menu command <Print>

[Ctrl+P]



Opens the standard Windows print dialog box for printing the report.



NOTE:

It is not possible to print an ICT program. It is only possible to print the contents of the Report window

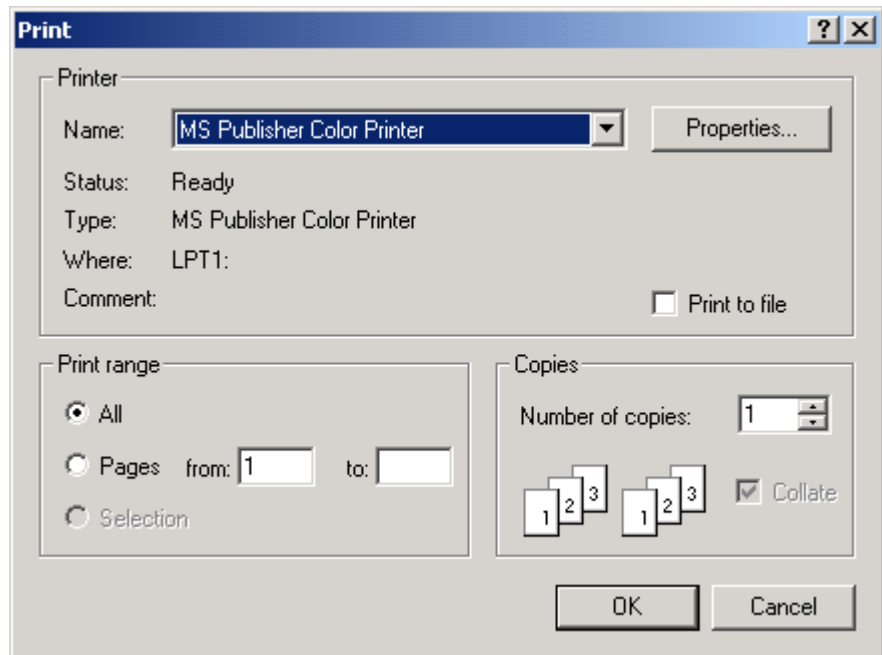


Figure 5-80 Print



NOTE:

The standard Windows functions are used.

All marked areas of the Report window are printed. The entire report can be marked using the context menu (see section 5.4.3.1).

5.6.1.9 Menu command <Print Setup>

Opens the standard Windows printer dialog box with the settings for the printer connected.

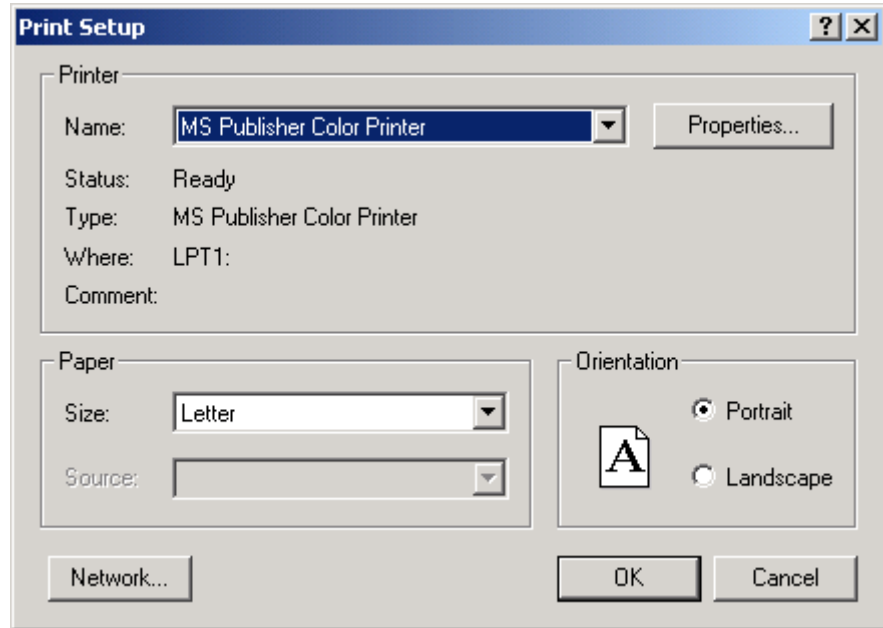


Figure 5-81 Print Setup



NOTE:

The standard Windows functions are used.

5.6.1.10 Menu command <Exit>

Quits the program Enhanced Generic Test Software Library R&S EGTSL. If changes have been made to the ICT program opened and these have not yet been saved, a warning message is displayed (see Figure 5-82).

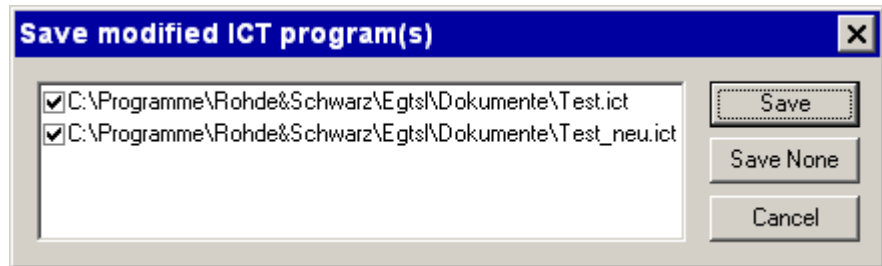
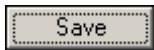


Figure 5-82 Exit Warning

The ICT programs that have not yet been saved are listed.



The ICT programs marked with a check mark are saved. The changes to ICT programs that are not marked are discarded. The Enhanced Generic Test Software Library R&S EGTSL program is quit.



None of the ICT programs displayed are saved. All changes made are discarded. The Enhanced Generic Test Software Library R&S EGTSL program is quit.



The quitting of the Enhanced Generic Test Software Library R&S EGTSL program is cancelled. The ICT program last edited is displayed.

5.6.2 Main menu command <Edit>



NOTE:

The descriptions of the menu commands that only execute functions and for which a dedicated window is not opened are summarized in section 5.6.2.1.

5.6.2.1 Functions

Undo [Ctrl+Z]		Undoes the last action. Up to 256 actions can be undone.
Redo [Ctrl+Y]		Reverses the action of the <Undo> command.
Cut [Ctrl+X]		Removes the item currently marked (test step, program group, text content) and places it in the Clipboard.
Copy [Ctrl+C]		Copies the item currently marked (test step, program group, text content) to the Clipboard.
Paste [Ctrl+V]		Inserts the contents of the Clipboard (test step, program group, text content) at the current cursor position.
Delete [Ctrl+Del]		Deletes a marked test step or the marked program group.
Insert		Opens a list box for inserting test steps. On this topic, see also section 5.5: Test Steps.
Select All [Ctrl+A]		Marks all test steps or all entries in the Report window. The function is dependent on the cursor position.
Apply [Ctrl+Enter]		The changes made in the test properties for the test step marked are applied. The entries are checked for plausibility and compliance with the value ranges. The metacode for the ICT program is updated.
Revert [Ctrl+Back]		The changes made in the test properties for the test step marked are discarded. The values that applied when the test step was marked are displayed again.

Auto apply



When this button is activated, the changes made in the test properties for the test step marked are automatically applied when you change to a different test step. The entries are checked for plausibility and compliance with the value ranges. The metacode for the ICT program is updated.

Rename
[F2]

Enables the name of the marked test step to be edited.

5.6.2.2 Menu command <Find>

[Ctrl+F]



Opens the dialog box for the selection of the search criteria for individual test step names or program group names (see Figure 5-83) or for text in the Report window (see Figure 5-84). The function is dependent on the cursor position.

Search for text step name or program group name:

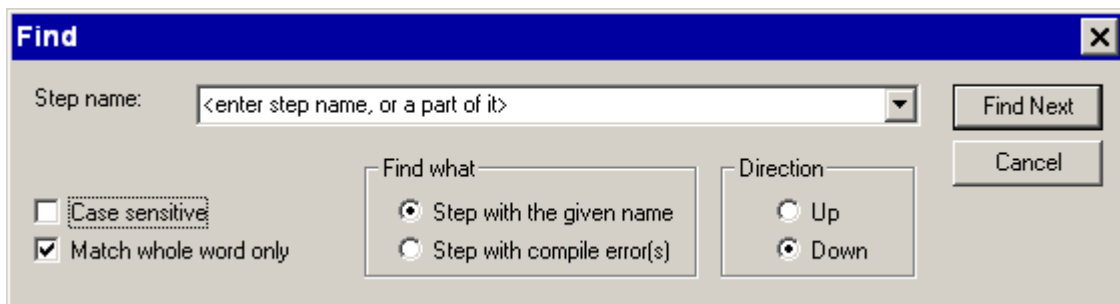


Figure 5-83 Find (Program)

Step name:

The search text for the test step name or program group name is entered in this field. The most recent search texts are saved and can be selected again using the list box. When R&S EGTSL is quit, the saved search texts are deleted.

Case sensitive

When this function is activated, the search is only performed for test step names or program group names with the same upper and lower case as in the **Step name:** field.

Match whole word only

With this function activated, the search is only performed for test step names or program group names that exactly match the information in the **Step name:** field.

Find what

Step with the given name

With this function activated, the search is performed for test step names or program group names that match the information in the **Step name:** field.

Step with compile error(s)

With this function activated, the search is only performed for test step names that have a compile error. The information in the **Step name:** field are ignored.

Direction
Up

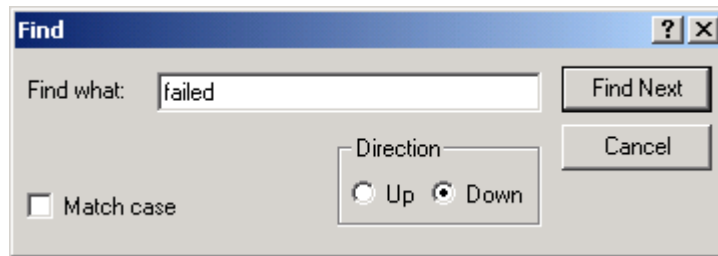
Defines the direction starting from the cursor position in which the ICT program is to be searched. With the **Up** function activated, the search is performed from the cursor position upwards. With the **Down** function activated, the search is performed from the cursor position downwards.

Down


The search is continued to the next entry (test step name, program group name) that matches the entry made. The test step or the program group found is marked.



The search in the Program window is stopped.

Searching for text in the report:

Figure 5-84 Find (Report)

Find what:

The search text is entered in this field.

Match case

With this function activated, the search is only performed for text with the same upper and lower case as in the **Find what:** field.

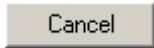
Direction
Up

Defines the direction starting from the cursor position in which the report is to be searched. With the **Up** function activated, the search is performed from the cursor position upwards. With the **Down** function activated, the search is performed from the cursor position downwards.

Down



The search is continued for the next entry that matches the information given. The test entry found is marked.



The test search in the Report window is stopped.

5.6.2.3 Menu command <Step Properties>

[Alt+Enter]



Opens the dialog button for the step properties for the test step or program group marked.



NOTE:

The dialog box for the step properties can also be opened using the program context menu (see section 5.4.2.1).

The *Step Properties, Common* (see Figure 5-85) are displayed when opened from a marked test step or program group.

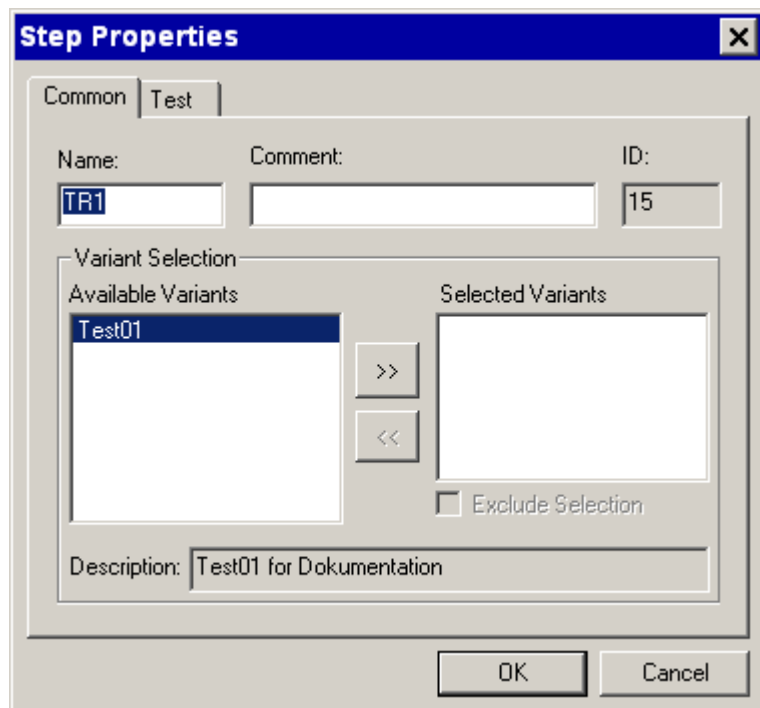


Figure 5-85 Step Properties, Common

- Name:** The name of the test step or program group is edited in this field.
- Comment:** The comment for the test step or for the program group is entered in this field. The text entered is displayed in the Program window in the **Comment** column.
- ID** To be able to uniquely identify each test step and each program group in the program, each entry is automatically allocated an ID number when it is created. This **ID** is displayed in this window.

Variant Selection

- Available Variants** All variants for the ICT program are listed in this list. Variants are added in the program properties (see section 5.6.1.6).
- Selected Variants** All variants allocated to the test step or the program group are given in this list. Several variants can be allocated to a test step or a program group. The test step or the program group is only executed when the corresponding variant has been selected in the Debug sub-window (see section 5.4.6).

- Exclude Selection** With this function activated, the test step or the program group is executed for all variants and the <default> setting. The test step or the program group is not executed with the variants that are listed in the **Selected Variants** list.

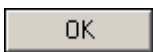


Moves the marked variant entry from the **Available Variants** list to the **Selected Variants** list.

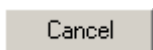


Moves the marked variant entry from the **Selected Variants** list to the **Available Variants** list.

- Description** A short description of the variants is displayed in this field (see section 5.6.1.6).



All changes made are applied and saved. The dialog box is closed.



All changes made are discarded. The dialog box is closed.



NOTE:

For more information on variants, see section 11.2.

The *Step Properties, Test* (see Figure 5-86) are only displayed when opened from a marked test step.

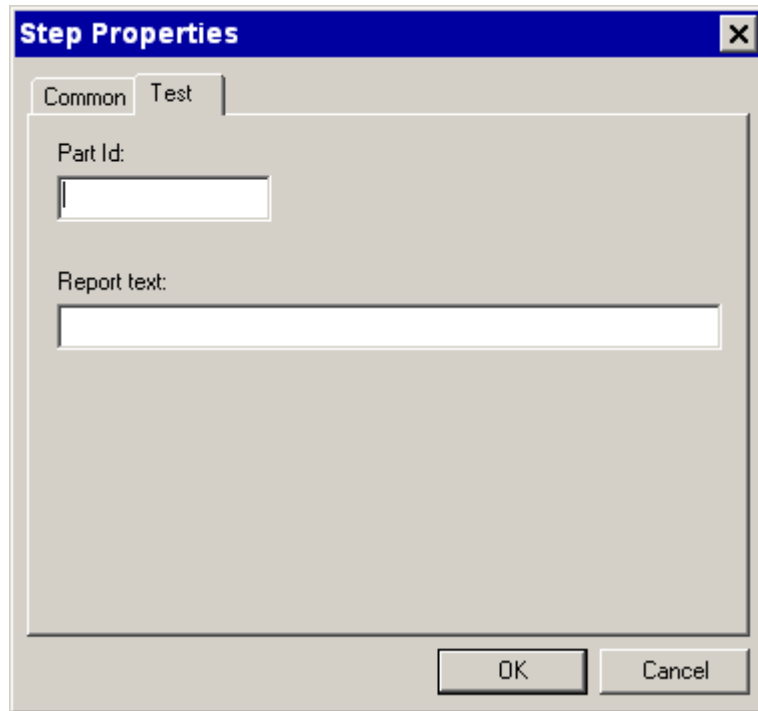


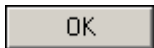
Figure 5-86 Step Properties, Test

Part Id:

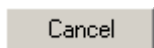
The type identifier or the ident number of the component to be tested is entered in this field. The entry is displayed in the Report window.

Report text:

Error instructions or repair instructions for the component to be tested are entered in this field. The entry is only displayed in the Report window in case of an error.



All changes made are applied and saved. The dialog box is closed.



All changes made are discarded. The dialog box is closed.

The *Step Properties, Group* (see Figure 5-87) are only displayed when opened from a marked program group.

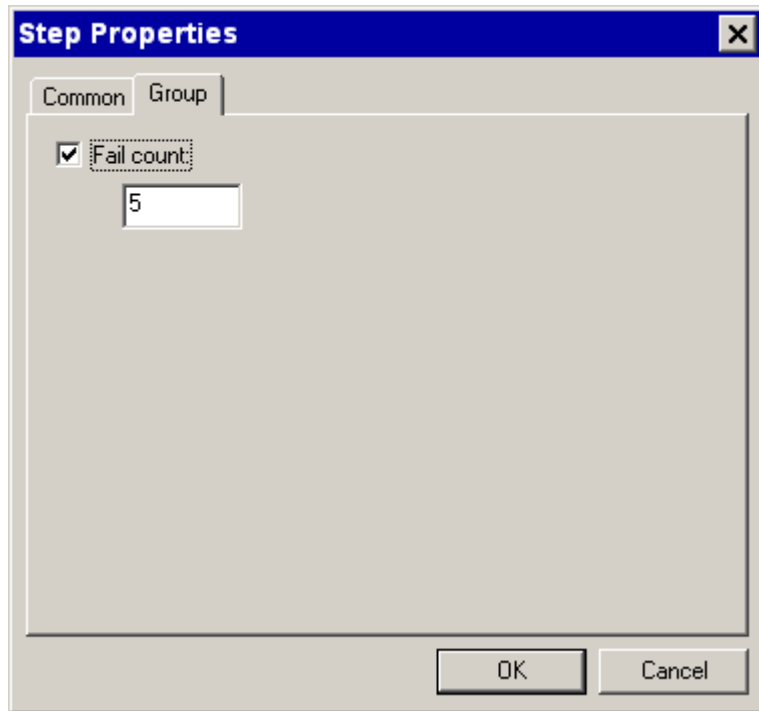
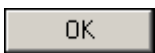


Figure 5-87 Step Properties, Group

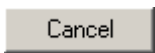
Fail count:

With this function activated, the erroneous test steps in a program group are counted. If the number of erroneous test steps given is reached, none of test steps that follow in the program group are executed.

All changes made are applied and saved. The dialog box is closed.



All changes made are discarded. The dialog box is closed.



5.6.2.4 Menu point <Breakpoints>

[Alt+F9]

Opens the dialog box for editing breakpoints.

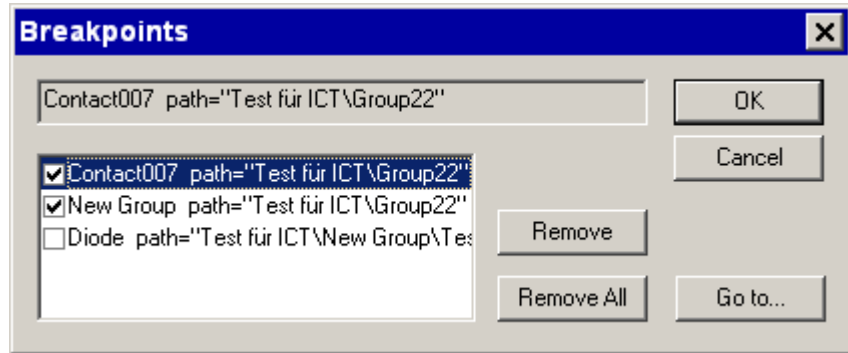
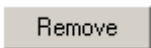


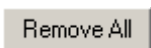
Figure 5-88 Breakpoints

A list with all the breakpoints added to the ICT program is displayed. The test step name or the program group name and the “folder” for the breakpoint added are displayed. Breakpoints marked with a check mark are active. Breakpoints that are not marked with a check mark are deactivated. The entry for the marked breakpoint is displayed in the top line.

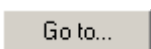
The marked breakpoint is deleted from the list and the ICT program.



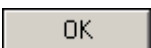
All breakpoints are deleted from the list and the ICT program.



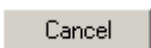
A jump is made to the marked breakpoint in the ICT program. The dialog box is closed. The corresponding test step or the corresponding program group is marked.



All changes made are applied and saved. The dialog box is closed.



All changes made are discarded. The dialog box is closed.
















5.6.3 Main menu command <View>

Main Toolbar	This command hides and displays the Main toolbar.
Debug Toolbar	This command hides and displays the Debug toolbar.
Toolbar for Insert	This command hides and displays the Insert toolbar.
User-defined Toolbar	This command hides and displays the toolbar for user-defined test steps.
Status Bar	This command hides and displays the Status bar at the bottom of the screen.
Results [Alt+0]	This command hides and displays the Result window.
Test Properties [Alt+1]	This command hides and displays the Test Properties window.
Debug [Alt+2]	This command hides and displays the Debug window.

5.6.4 Main menu command <Debug>

	Text in status bar
Debugger activated	Debugger ready
Debugger deactivated	Debugger deactivated

- Go**
[F5]  Executes the ICT program once from the test step marked with the yellow arrow (current debugger execution point) to the end. If the debugger is deactivated, the ICT program is executed from start to finish.
- Restart**
[Ctrl+Shift+F5]  With the debugger activated, executes the ICT program from the start to the finish.
- Terminate**
[Shift+F5]  Stops the execution of the ICT program. The marking with the yellow arrow (current debugger execution point) is removed. The debugger is deactivated.
- Break**
Interrupts the execution of the ICT program. The test step at which the interruption takes place is marked with the yellow arrow (current debugger execution point) and displayed. Using the **Go** command the execution of the ICT program can be continued.
- Repeat**
[F4] With the debugger activated, starts the execution of the test steps marked (test steps with a color background) with the number of repetitions given.
- Resume**
[Shift+F4] Continues the execution of the marked test steps (test steps with a color background) following an interruption using the **Break** button.
- Step Into**
[F11]  Executes the ICT program from the test step marked with the yellow arrow (current execution point of the debugger) in single steps. If the test step is a group, automatically each test step of the group will be executed in single steps.
- Step Over**
[F10]  Executes the ICT program from the test step marked with the yellow arrow (current execution point of the debugger) in single steps. If the test step is a group, all test steps in the group are performed automatically.
- Step Out**
[Shift+F11]  If the test step marked with the yellow arrow (current execution point of the debugger) is in a group, the group is left with this button. The test steps that follow in the group are performed automatically. If the test step marked with the yellow arrow (current execution point of the debugger) is at the top program level, all following test steps including groups are executed.

- | | | |
|---|--|--|
| Run to Cursor
[Ctrl+F10] |  | <p>Executes the ICT program from the test step marked with the yellow arrow (current execution point of the debugger) to the test step marked with the cursor. The test step marked by the position of the cursor is marked as the next test step that can be executed using the yellow arrow.</p> |
| Set Next Step
[Ctrl+Shift+F10] |  | <p>Marks the position of the cursor as the test step that is to be executed next. A yellow arrow is displayed on the left beside the test step marked. The debugger is activated.</p> |
| Show Next Step
[Alt+F10] |  | <p>Jumps to the current debugger execution position (test step marked with the yellow arrow). The test step is the next that is executed.</p> |
| Toggle Breakpoint
[F9] |  | <p>Sets a breakpoint at the cursor position. The breakpoint is deactivated when you click the button again. The third time you click the button, the breakpoint is deleted (see also section 5.6.2.4).</p> |
| Stop At Fail |  | <p>With this function activated, the ICT program execution is stopped when the test step result was "Fail". The program stops at the erroneous test step. The Stop at fail function applies to all debug commands with the exception of the Repeat function.</p> |
| Break At Fail | | <p>With this function activated, the execution of the ICT program (test steps marked) is interrupted when the test step result was "Fail". The program stops at the erroneous test step. The Break at fail function applies only to the Repeat function.</p> |

5.6.5 Main menu command <Report>

Clear Report Window

Deletes all entries in the Report window.

Report Enable

With this function activated a report is displayed in the Report window.

Report Errors Only

With this function activated, only erroneous measurements and error messages are displayed in the Report window.

Clear Results

Deletes all entries in the Result windows (Tbl, Gfx, Hist, Details) for all test steps.

Auto Clear

With this function activated, all entries in the Result window (Tbl, Gfx, Hist, Details) will be deleted for all test steps on any test step command (e.g. Run, Step, Repeat).

5.6.6 Main menu command <Hel p>

5.6.6.1 Menu command <About EGTSL>



Opens the window on the Enhanced Generic Test Software Library R&S EGTSL with information on the software.

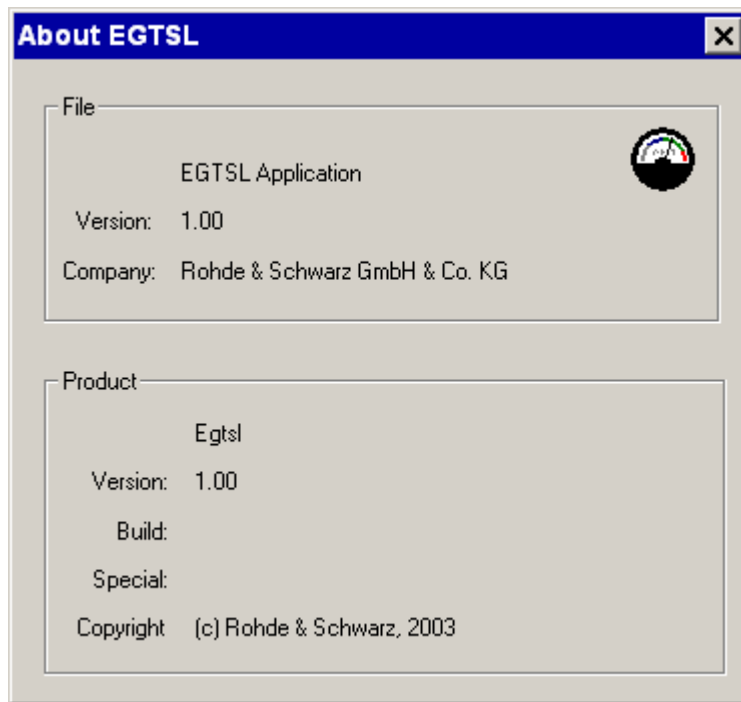


Figure 5-89 About EGTSL



NOTE:

For further inquiries and technical support about the Enhanced Generic Test Software Library R&S EGTSL the information from this window are required.

5.7 Toolbar functions

5.7.1 Main Toolbar



Open

Opens the window for opening an ICT program.
See <Open> menu command in section 5.6.1.1.



Save

Saves the ICT program using the current name.
See <Save> menu command in section 5.6.1.2.



Print

Opens the standard printer dialog box for printing the report.
See <Print> menu command in section 5.6.1.8.



Cut

Removes the item currently marked (test step, text content, program group) and places it in the Clipboard.



Copy

Copies the item currently marked (test step, text content, program group) to the Clipboard.



Paste

Inserts the contents of the Clipboard (test step, text content, program group) at the current position of the cursor.



Undo

Undoes the last action.



Redo

Reverses the action of the <Undo> command.



Auto Apply

When this button is activated, the changes made in the test properties for the test step marked are applied automatically when you change test step. The entries are checked for plausibility and compliance with the value ranges. The metacode for the ICT program is updated.



Apply

The changes made in the test properties for the test step marked are applied. The entries are checked for plausibility and compliance with the value ranges. The metacode for the ICT program is updated.


Revert

The changes made in the test properties for the test step marked are discarded. The values that applied when the test step was marked are displayed again.


Step Properties

Opens the dialog box for the entry of the general step properties. See <Step Properties> menu command in section 5.6.2.3.


Find

Opens the dialog box for selecting the search criteria for individual test steps or for text content in the Report window. The function is dependent on the position of the cursor.

See <Find> menu command in section 5.6.2.2.


About

Open the window with information on the Enhanced Generic Test Software Library R&S EGTSL.

See <About EGTSL> menu command in section 5.6.6.1.

5.7.2 Debug Toolbar

Go

Executes the ICT program once from the test step marked with the yellow arrow (current debugger execution point) to the end. If the debugger is deactivated, the ICT program is executed from start to finish.


Restart

With the debugger activated executes the ICT program from the start to the finish.


Terminate

Stops the execution of the ICT program. The marking with the yellow arrow (current debugger execution point) is removed. The debugger is deactivated.


Break

Interrupts the execution of the ICT program. The test step at which the interruption takes place is marked with the yellow arrow (current debugger execution point) and displayed. Using the **Go** command the execution of the ICT program can be continued.



Step Into

Executes the ICT program from the test step marked with the yellow arrow (current execution point of the debugger) in single steps. If the test step is a group, automatically each test step of the group will be executed in single steps.



Step Over

Executes the ICT program from the test step marked with the yellow arrow (current execution point of the debugger) in single steps. If the test step is a group, all test steps in the group are performed automatically.



Step Out

If the test step marked with the yellow arrow (current execution point of the debugger) is in a group, the group is left with this button. The test steps that follow in the group are performed automatically. If the test step marked with the yellow arrow (current execution point of the debugger) is at the top program level, all following test steps including groups are executed.



Run to Cursor

Executes the ICT program from the test step marked with the yellow arrow (current execution point of the debugger) to the test step marked with the cursor. The test step marked by the position of the cursor is marked as the next test step that can be executed using the yellow arrow.



Set Next Step

Marks the position of the cursor as the test step that is to be executed next. A yellow arrow is displayed on the left beside the test step marked. The debugger is activated.



Show Next Step

Jumps to the current debugger execution position (test step marked with the yellow arrow). The test step is the next that is executed.



Toggle Breakpoint

Sets a breakpoint at the cursor position. The breakpoint is deactivated when you click the button again. The third time you click the button, the breakpoint is deleted (see also section 5.6.2.4).



Stop At Fail

With this function activated, the ICT program execution is stopped when the test step result was "Fail". The program stops at the erroneous test step. The **Stop at fail** function applies to all debug commands with the exception of the **Repeat** function.


Clear report window

Deletes all entries in the Report window.


Clear Results

Deletes all entries in the Result windows (Tbl, Gfx, Hist, Details) for all test steps.

5.7.3 Toolbar for Insert

On this topic, see also 5.5: Test Steps.


Insert Group

Inserts a new group above the cursor position.


Insert Contact

Inserts a contact test step above the cursor position.


Insert Continuity

Inserts a continuity test step above the cursor position.


Insert Diode

Inserts a diode test step above the cursor.


Insert Discharge

Inserts a discharge test step above the cursor.


Insert FET

Inserts a FET test step above the cursor.


Insert Impedance

Inserts an impedance test step above the cursor position.


Insert Resistor

Inserts a resistor test step above the cursor position.


Insert Short

Inserts a short-circuit test step above the cursor position.


Insert Transistor

Inserts a transistor test step above the cursor position.


Insert Transistor Beta

Inserts a transistor beta test step above the cursor position.


Insert Zener Diode

Inserts a zener diode test step above the cursor.

5.7.4 Toolbar for user-defined tests

On this topic, see also 5.5.13: User-defined Test Methods.



Insert <user-defined test>

Inserts a user-defined test step above the cursor position.

(The icon displayed is specific to the user-defined test extension library.)



5.8 Shortcuts

SHORTCUT	Command
<i>Ctrl+O</i>	Open
<i>Ctrl+S</i>	Save
<i>Ctrl+P</i>	Print
<i>Ctrl+Z</i>	Undo
<i>Ctrl+Y</i>	Redo
<i>Ctrl+X</i>	Cut
<i>Ctrl+C</i>	Copy
<i>Ctrl+V</i>	Paste
<i>Ctrl+Del</i>	Delete
<i>Ctrl+A</i>	Select All
<i>Ctrl+Enter</i>	Apply
<i>Ctrl+Back</i>	Revert
<i>Ctrl+F</i>	Find
<i>Alt+Enter</i>	Step Properties
<i>Alt+0</i>	Hides and displays the Results sub-window.
<i>Alt+1</i>	Hides and displays the Test Properties sub-window.
<i>Alt+2</i>	Hides and displays the Debug sub-window.
<i>Alt+F10</i>	Show Next Step



FUNCTION KEY	Command
<i>F2</i>	Rename
<i>F3</i>	Find next
<i>F4</i>	Repeat
<i>Shift+F4</i>	Resume
<i>F5</i>	Go
<i>Shift+F5</i>	Terminate
<i>Ctrl+Shift+F5</i>	Restart
<i>F6</i>	Next sub-window
<i>Shift+F6</i>	Previous sub-window
<i>F9</i>	Toggle Breakpoint
<i>Alt+F9</i>	Breakpoints
<i>F10</i>	Step Over
<i>Ctrl+F10</i>	Run to Cursor
<i>Shift+F10</i>	Context menu
<i>Ctrl+Shift+F10</i>	Set Next Step
<i>F11</i>	Step Into
<i>Shift+F11</i>	Step Out



6 License management

The Enhanced Generic Test Software Library R&S EGTSL is part of the Generic Test Software Library R&S GTSL.

During the installation of the Generic Test Software Library R&S GTSL, all available test libraries and R&S EGTSL are copied to the system. You need a License Key File in order to access the functions from the test libraries and R&S EGTSL. Refer to chapter 7 of the “Software Description Generic Test Software Library R&S GTSL” for the license key required for each test library and R&S EGTSL.

Without a valid License Key File, the functions of R&S EGTSL will only work in “demo mode”. Access to the hardware is only simulated.

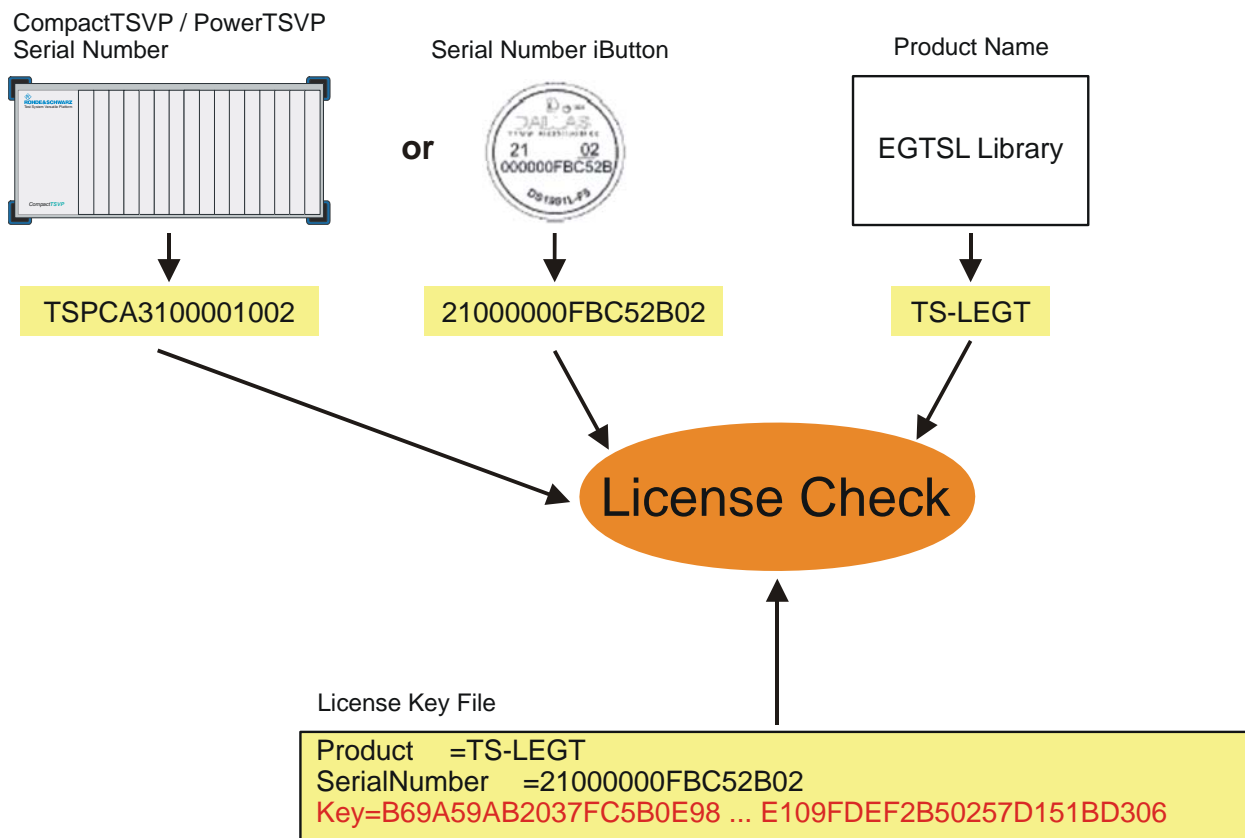


Figure 6-1 License checking

Each license is bound to a system serial number. The enabled R&S EGTSL can only be run on the system with this serial number. The hardware system used is identified via the system module PSYS (R&S CompactTSVP, R&S PowerTSVP) or via an iButton (TSVP, desktop PC, notebook). The iButton is located on a Hardlock-Adapter, which is



plugged into the serial interface (usually COM1) of the system controller of the Test System Versatile Platform TSVP or of the connected control computer. The system module or iButton has a unique serial number whereby the hardware system can be unambiguously identified.

During license checking, the serial number and the name of the called test library (R&S EGTSL) are compared with the License Key from the License Key File. The test library (R&S EGTSL) in question will only be enabled if these coincide. The serial number and the name of the test library (R&S EGTSL) are encoded in the License Key.

Example of a License Key File:

```
[Header]
FileVer=1.0
[Project]
Info=EGTSL
[Modul]
Product=TS-LEGT
SerialNumber=850000008E4BD202
Key=C146648E1DEF9AD78663728A5D8E8D25885F457367D7F7C359F2C63BDB926 ...
```

The serial number is queried and a new License Key File is installed via the R&S GTSL License Viewer. To open the R&S GTSL License Viewer, select

Start -> Programs -> GTSL -> License Viewer



NOTE:

The R&S GTSL License Viewer is described in section 4 of the “Software Description Generic Test Software Library R&S GTSL”.

7 Configuration Files

The required configuration files are stored by default in the `..\GTSL\Configuration` directory.

7.1 Syntax

The syntax of the Physical Layer Configuration File (PHYSICAL.INI) and of the Application Layer Configuration File (APPLICATION.INI) is identical. The only difference between the two files is in terms of how they are used (see sections 7.2 and 7.3).

Both files use the standard INI file format.

Example of standard INI file format:

```
[section]

key = value
...
```

A section begins with the section name written inside closed brackets ([]). The following lines contain pairs of keywords and values. The keywords and the assigned values are separated by an equals sign (“=”).

In the section names and keywords, no distinction is made between upper and lower case characters. However, the values after the equals sign are transferred exactly as they are written in the file. Leading and trailing spaces are truncated.

7.1.1 Naming conventions

In the Physical Layer Configuration File and in the Application Layer Configuration File, several groups of keywords and sections are allowed. These refer to other sections and reflect the relationships and interconnections. The section names follow the naming conventions indicated below.

The section name begins with the section type followed by an arrow (“->”, a minus sign followed by a greater than sign). A unique name appears after the arrow. No spaces are permitted between the name and the arrow.

In the section names, no distinction is made between upper and lower

case characters.

The following characters are permitted for the logical names, the device names and the bench names.

"A" ... "Z"	Upper case characters
"a" ... "z"	Lower case characters
"0" ... "9"	Numbers
"_"	Underscore
"."	Decimal point

Table 7-1 Character set for names

The following maximum character lengths are permitted for section names, keywords and values:

section	80 characters
key	80 characters
value	260 characters

Table 7-2 Maximum character lengths

- [LogicalNames] This section contains a list of names of devices and benches. Any name can be used to identify a device or bench (Application Layer Configuration File).
- [Device->...] A device section contains different keywords to identify the devices. These include the GPIB address, the device type etc. (Physical Layer Configuration File and Application Layer Configuration File).
- [Bench->...] This section contains a group of device entries which together form a bench. A High Level Library requires the name of a bench in its set-up routine (Application Layer Configuration File).
- [ResourceManager] This section contains information for the configuration of the Resource Manager.

7.1.2 [LogicalNames] section

The [LogicalNames] section is used to assign a short, meaningful name to a device or bench. Any name can be chosen. This section contains a list of unique name allocations. The values on the right side of the expressions must be valid names of a bench or of a device section.

The [LogicalNames] section is an optional entry and is used only in the

Application Layer Configuration File.

Example:

```
[LogicalNames]
ICT = bench->ICT
SIMU = bench->ICT_Simulation
```

7.1.3 [Device] section

The [Device] section contains a list of keywords and assigned values. These keywords and values precisely describe the relevant device. The name of the [Device] section begins with “Device->” followed by a unique name. Any name can be chosen.

There must be a [Device] section for each device in the Physical Layer Configuration File.

A [Device] section with the same name can be defined in the Application Layer Configuration File. Additional device information can be given at this point by means of further keywords and values, or device information from the Physical Layer Configuration File can be overwritten. However, it is not possible to define a [Device] section in the Application Layer Configuration File which is not present in the Physical Layer Configuration File.

The keywords in a [Device] section and their meaning depend on the libraries used by the devices.

Keyword	Description
Description	<i>Optional entry</i> Device description, remarks
Type	<i>Mandatory entry</i> Device type (e.g. PSAM, PICT, PMB etc.)
ResourceDesc	<i>Mandatory entry</i> VISA device properties and device description in the form: GPIB[card number]::[primary address]::[secondary address] PXI[segment number]::[device number]::[function]::INSTR CAN[board]::[controller]::[frame]::[slot] Example: “CAN0::0::1::15”
DriverSetup	<i>Optional entry</i> Special setup string for IVI driver, e.g. for simulation of devices

Table 7-3 Standard keywords of [Device] section

The “Type” and “ResourceDesc” entries are required for the test libraries (e.g. ICT.DLL). Both entries must be present in the Physical Layer Configuration File.

The information from the “Type” entry allows the test libraries to distinguish between different supported devices (such as PMB or PSM1). This information is also needed for the system self-test. The information from the “ResourceDesc” entry is needed to set up the device driver and create the physical connection with the indicated device.

Example:

```
[device->pmb1]
Description = "TS-PMB, Matrix Module, Slot 15"
Type        = PMB
ResourceDesc = CAN0::0::1::15
```

7.1.4 [Bench] section

The [Bench] section contains a list of keywords and assigned values which describes a group of devices and their use. The name of the [Bench] section begins with “Bench->” followed by a unique name. Any name can be chosen. A [Bench] section can only be defined in the Application Layer Configuration File.

The keywords in a [Bench] section depend on the test library used by the bench. A keyword always provides at least one reference to a device entry. Other keywords may be necessary to describe the bench. The following keywords are predefined and should be present in each [Bench] section.

Keyword	Description
Description	<i>Optional entry</i> Bench description, remarks
Simulation	<i>Optional entry</i> If set to “1”, the complete bench is simulated by the test library.
Trace	<i>Optional entry</i> If set to “1”, the tracing function is enabled for the test library

Table 7-4 Standard keywords of [Bench] section

The [Bench] section can contain further useful keywords and values which are used by a test library. For the test library GSM.LIB, entries for the calibration, the calibration files, the network etc. may be useful.

Example:

```
[bench->ICT]
Description      = ICT bench (Simulation)
Simulation      = 1
Trace           = 0
ICTDevice1     = device->psam
ICTDevice2     = device->pict
SwitchDevice1  = device->pmb1
AppChannelTable = io_channel->ICT
```

7.1.5 [ResourceManager] section

The [ResourceManager] section contains keywords and assigned values to control the behaviour of the Resource Manager library. The following keywords are supported:

Key name	Remarks
Trace	Blocks the tracing function (value = 0), enables the tracing function (value = 1). The function impacts on all libraries.
TraceFile	Defines the path and the name of the trace file.
TraceToScreen	The tracing information is displayed on the standard screen (value = 1).
TraceTimeStamp	Writes the time of day at the start of each tracing line (value = 1).
TraceThreadID	Writes the ID of the current thread at the start of each tracing line (value = 1).

Table 7-5 Keywords of [ResourceManager] section

7.1.6 [Extlct] Section

The [Extlct] section contains keywords and assigned values for the ICT extension libraries. The following keywords are supported:

Key name	Remarks
UserDefinedDll	Defines the path and name of the ICT extension DLL.

Table 7-6 Keywords of [Extlct] section

7.2 PHYSICAL.INI

In the file PHYSICAL.INI (Physical Layer Configuration File), all hardware assemblies available in the Enhanced Generic Test Software Library are described along with the corresponding definitions and settings (see example PHYSICAL.INI file). This file also contains definitions which are applicable to all test applications to be executed on the system (e.g. type definition). The information entered in this file is used by all test libraries and thus by each test step.

The PHYSICAL.INI file normally exists only once in the system as it reflects the exact physical structure. The file must only be modified in the event of a hardware change.

The Resource Manager calls and administers the information from the PHYSICAL.INI file.



NOTE:

The file **PHYSICAL.INI** is saved in the folder `... \GTSL \Configuration \physical.ini`

7.2.1 Example file for PHYSICAL.INI (Example_Physical.ini)

	Description
[device->psam]	1
Description = "TS-PSAM, Source and Measurement Module, Slot 8"	2
Type = PSAM	3
ResourceDesc = PXI1::10::0::INSTR	4
DriverDll = rspsam.dll	5
DriverPrefix = rspsam	6
DriverOption = "Simulate=0,RangeCheck=1"	7
 [device->pict]	 1
Description = "TS-PICT, ICT Extension Module, Slot 9"	2
Type = PICT	3
ResourceDesc = PXI2::15::0::INSTR	4
DriverDll = rspict.dll	5
DriverPrefix = rspict	6
DriverOption = "Simulate=0,RangeCheck=1"	7
SFTDll = sftmpict.dll	8
SFTPprefix = SFTMPICT	9

	Description
[device->pmb1]	1
Description = "TS-PMB, Matrix Module, Slot 15"	2
Type = PMB	3
ResourceDesc = CAN0::0::1::15	4
DriverDll = rspmb.dll	5
DriverPrefix = rspmb	6
DriverOption = "Simulate=0,RangeCheck=1"	7
SFTDll = sftmpmb.dll	8
SFTPprefix = SFTMPMB	9
; Analog Bus	10
[device->ABUS]	1
Description = "Analog Bus"	2
Type = AB	3

7.2.2 Description of example file PHYSICAL.INI

The description is based on the example file in section 7.2.1. The indicated numbers refer to the corresponding positions in the example file. The place-holder "XY" in the following listing stands for the corresponding entries.

1	[device->XY]	Defines the name under which the device is called in the test libraries. A separate entry must be made for each device. The entry in square brackets [] defines a new section within which new definitions are made.
2	Description = "XY"	Gives a detailed description of the defined device. The entry is optional.
3	Type = XY	Gives the exact designation of the defined device. This designation is needed to call the corresponding device driver. The entry is mandatory.

Table 7-7 Description of PHYSICAL.INI



4	ResourceDesc = XY	<p>Gives the necessary hardware information required for the defined device.</p> <p>The entry is mandatory.</p> <p>Details provided at this point include, for example:</p> <p>GPIB address: GPIB1::20::1 (example)</p> <p>GPIB[card number]::[primary address]::[secondary address]</p> <p>Serial interface: COMX</p> <p>PXI address: PXI1::10::0::INSTR (example)</p> <p>PXI[segment number]::[device number]::[function]::INSTR</p> <p>CAN-address: CAN0::0::1::5 (example)</p> <p>CAN[board]::[controller]::[frame]::[slot]</p>
5	DriverDll = XY	Gives the path and the file name of the device driver.
6	DriverPrefix = XY	Gives a prefix for the device driver.
7	Driver Option = XY	Gives certain options applicable to the device driver.
8	SFTDll = XY	Gives the path and the file name of the selftest device driver.
9	SFTPprefix = XY	Gives a prefix for the selftest device driver.
10		Text appearing after a semicolon (;) is interpreted as a comment.

Table 7-7 Description of PHYSICAL.INI

7.3 APPLICATION.INI

In the APPLICATION.INI file (Application Layer Configuration File) is a description of how the individual test libraries and the test functions use the hardware components (see example file APPLICATION.INI). Different hardware components can be combined into groups (bench). This bench can then be used within the test function. Furthermore, definitions are made in this file which apply to certain test applications to be executed on the system (e.g. definition of designations in the case of multi-channel operation).

The Resource Manager calls and administers the information from the APPLICATION.INI file.



NOTE:

A special Application Layer Configuration File is produced by the Automatic Test Generator ATG for each ICT program generated. The name of the Application Layer Configuration File is given in the ATG.

During the execution of the ICT program, the corresponding Application Layer Configuration File must be given.

7.3.1 Example file for APPLICATION.INI (Example1_Application.ini)

	Description
[ResourceManager]	1
; general trace settings (normally off)	2
Trace = 0	3
TraceFile = %GTSLROOT%\resmgr_trace.txt	4
;	2
[ExtIct]	5
UserDefinedDll = %GTSLROOT%\EGTSL\ExtIct\RSSample\RSSample.dll	6
UserDefinedDll = C:\UserDefinedDlls\MyOpAmp.dll	6
UserDefinedDll = C:\UserDefinedDlls\MyRelay.dll	6
;	2
[LogicalNames]	7
ICT = bench->ICT	8
;	2



	Description
[bench->ICT]	9
Description = ICT bench (Simulation)	10
Simulation = 1	11
Trace = 0	12
ICTDevice1 = device->PSAM	13
ICTDevice2 = device->PICT	14
SwitchDevice1 = device->PMB1	15
AppChannelTable = io_channel->ICT	16
AppWiringTable = io_wiring->ICT	17
 [io_channel->ICT]	 18
GND = PMB1!P1	19
INPUT = PMB1!P2	19
OUTPUT = PMB1!P3	19
TR1.B = PMB1!P4	19
TR1.C = PMB1!P5	19
TR1.E = PMB1!P6	19
VCC = PMB1!P7	19
 ;-----	 2
 [io_wiring->ICT]	 20
GND = F1 S15 X10A1	21
INPUT = F1 S15 X10A2	21
OUTPUT = F1 S15 X10A3	21
TR1.B = F1 S15 X10A4	21
TR1.C = F1 S15 X10A5	21
TR1.E = F1 S15 X10A6	21
VCC = F1 S15 X10A7	21
 ;-----	

7.3.2 Description of example file APPLICATION.INI

The description is based on the example file in section 7.3.1. The indicated numbers refer to the corresponding positions in the example file. The place-holder “XY” in the following listing stands for the corresponding entries.

1	[ResourceManager]	Defines a new section (identified by the square brackets []) with information evaluated directly by the Resource Manager.
2		Text appearing after a semicolon (;) is interpreted as a comment.
3	Trace = 0 Trace = 1	Tracing of information is not carried out (Trace = 0) or is carried out (Trace = 1).

Table 7-8 Description of APPLICATION.INI

4	TraceFile = XY	Gives the path and file name for storing trace information.
5 + 6	[ExtIct] UserDefinedDll = XY	Defines a section in which the user-defined ICT extension DLLs are listed.
7 to 8	[LogicalNames]	Defines a new section in which logical short names are defined. The short names can be used to call the libraries.
9	[bench->XY]	Defines a new bench with its name. The name, which is defined at this point, is called in the SETUP routine of the corresponding test library.
10	Description = "XY"	Provides a detailed description of the bench defined. The entry is optional.
11	Simulation = 0 Simulation = 1	Defines whether the execution is only to be simulated (Simulation = 1) or specific measurements are to be performed (Simulation = 0).
12	Trace = 0 Trace = 1	Tracing of information is not carried out (Trace = 0) or is carried out (Trace = 1).
13*	ICTDevice1 = XY	Refers to the entry for the R&S TS-PSAM. The addressed devices must be defined in the PHYSICAL.INI file with their details.
14	ICTDevice2 = XY	Refers (optional) to the entry for the R&S TS-PICT. Without the R&S TS-PICT some test methods cannot be used, e.g. impedance test. The addressed devices must be defined in the PHYSICAL.INI file with their details.
15*	SwitchDevice1 = XY	Refers to the entry for the R&S TS-PMB. As an option, it is possible to refer to further R&S TS-PMB modules using the entries SwitchDevice2 ... n. The addressed devices must be defined in the PHYSICAL.INI file with their details.
16*	AppChannelTable = XY	Refers to the section with the definitions of the I/O channels that are to apply for this bench.
17	AppWiringTable = XY	Refers to the section with the definitions of the wiring table that is to apply for this bench.
18* + 19*	[io_channel->XY]	The definitions of I/O channels that follow apply for the applications that are to be run with the bench given. The test points (nodes) that have been determined from the circuit description (BDL file) by the Automatic Test Generator ATG are on the left. The I/O channels on the R&S TS-PMB Matrix Card allocated by the ATG are on the right.

Table 7-8 Description of APPLICATION.INI



20 + 21	[io_wiring->XY]	<p>The physical wiring from the UUT pins to the front connectors of the R&S TS-PMB Matrix Cards. The test points (nodes) are on the left. The front connector locations are on the right in the form:</p> <p>F<frame number> S<slot number> X10<column><row></p> <p>F1 S15 X10A1 means:</p> <ul style="list-style-type: none">- TSVP frame 1- Slot 15- Front connector X10, column A, row 1.
---------------	-----------------	--

Table 7-8 Description of APPLICATION.INI

For an in-circuit tests always the items marked with an asterisk (*) must exist in the APPLICATION.INI file.

8 Circuit description

8.1 Definition of metalanguage

In the following a metalanguage is explained that is used for the description of the syntax for the external representation of data. This metalanguage is a derivative of the Backus-Naur form.

8.1.1 Terminology, symbols

The text that contains the formal description of the syntax comprises a sequence of so-called "tokens". A token is either an identifier, a literal or an operator.

Identifier

An identifier is a string of lower case letters, numbers and special character. Each identifier must start with a lower case letter that can then be followed by any number of lower case letters, numbers or special characters.

Examples:

ict-compilation
program-header-stmt
execution
dd

Literals

Literals comprise a chain of alphanumeric characters that are enclosed in quotation marks "". If there are also quotation marks in the literal, each quotation mark must be given twice.

Examples:

"voltage"
"Literal with quotation mark "" in the text"
"SYSTEM"

Operators

The operators are used to be able to better represent the structure of a metaprogram. The following operators are used:

:	=	Separator between rule name and rule body
%	=	The preceding token occurs 1 to n-times
*	=	The preceding token occurs 0 to n-times
n	=	The preceding token occurs exactly n-times
n-m	=	The preceding token occurs at least n-times, however m-times at the most
	=	Alternative
{	=	Start of the use of parenthesis for several tokens for a unit
}	=	End of the use of parenthesis for several tokens for a unit
[=	Start of the optional use of parenthesis for one or more tokens
]	=	End of the optional use of parenthesis for one or more tokens
;	=	Conclusion of a production rule
!	=	Character for comment

Layout

For separation of the individual tokens as many spaces as required can be used.

Comments

Using the operator '!' a comment is started that is intended to make it easier to read the metaprogram. The comment starts after the operator and concludes at the end of the line.

8.1.2 Structure of a metaprogram

The formal description of a language syntax is called a 'metaprogram'. A metaprogram comprises a sequence of production rules.

A production rule comprises the following elements:

- The rule name that is used for referencing the production rule in other production rules
- The operator ':' for separating rule names and rule body
- The rule body that defines the syntax or part of the syntax and
- a semicolon that concludes the production rule.

A metaprogram is complete when

- Each rule name only occurs once and describes exactly one production rule

- There is exactly one and only one rule name that is not in a rule body. This rule forms the start of the syntax.

8.1.3 Structure of rule bodies

Every rule body contains a sequence of identifiers or literals that are separated or linked by operators.

Daisy chaining

If a rule is to comprise several tokens one after the other, then these tokens are simply written one after the other, separated by at least 1 space.

Example:

```
while : "WHILE" condition "DO" ;
```

Information on alternatives

If two or more tokens are to be allowed alternately in a rule, then this is represented by the '|' operator.

Example:

If the rule a is to be able to comprise the rule body b, as well as alternatively the rule body c, the alternative operator is used:

```
a: b | c ;
```

Optional information

If a token is only to be present in a rule as an option, i.e. it can be present, but can also be missing, then this token must be placed in parenthesis using the "[" and "]" operators.

Example:

```
a: b; or a: bc;
```

Can be represented by

```
a: b[c];
```

Multiple repetition

If a token is to be repeated several times in a rule, one of the following repetition operators can be given after the token:

"%" Means that the preceding token must occur at least once, but can also occur as any number of times.

Example:

The following rules are equivalent:

a: b[n]; and a: b%;

"*" Means that the preceding token does not need to occur at all, and that it can also occur any number of times.

Example:

The following rules are equivalent:

a: [b[n]]; and a: b*;

"n" Means that the preceding token must occur exactly n-times.

Example:

The following rules are equivalent:

a: b[cccc]; and a: b{c4};

as well as

a: bcdcdcd ; and a: b{cd}3;

"n-m" Means that the preceding token must occur at least n-times, but is allowed to occur a maximum of m-times.

Example:

The following rules are equivalent:

a: bcc[c][c][c]; and a: bc2-5;

Use of parentheses

If several tokens are to be combined logically to form a single, complex token, this can be achieved by placing the tokens in parenthesis using the "{" and "}" operators.

Example:

With the aid of the rule a: bcd{efg}*; the following information is allowed syntactically:

bcd

bcdefg

bcdefgefg

bcdefgefgefg

Binding of the operators

The individual operators in the above defined metalanguage have the following priorities:

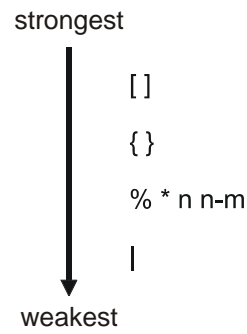


Figure 8-1 Priorities of the operators

8.2 External file format (BDL)

8.2.1 Syntax

The syntax of the external circuit description is described in a metalanguage that is defined in section 8.1: Definition of metalanguage.

board_description:

```
{ resistor_list
  | var_res_list
  | poti_list
  | res_array_list
  | cap_list
  | pol_cap_list
  | inductor_list
  | diode_list
  | led_list
  | z_diode_list
  | transistor_list
  | jumper_list
  | ic_list
  | connector_list
  | black_box_list
  | track_list
  | node_list
}* ;
```

8.2.1.1 Resistor List

resistor_list:

```
"RESISTOR"
{ res_element }* ;

res_element :
  element_name
  {
    { part_id }
    | { "VALUE" uns_real ! Must be present
      [ "K" | "M" ] [ "OHM" ] }
    | { "TOL+" uns_real [ "%" ] } ! Default 10
    | { "TOL-" uns_real [ "%" ] } ! Default 10
    | { "PIN_1" node_name }
    | { "PIN_2" node_name }
    | { "I_LIM" uns_real [ "MA" ] } ! Default 100
    | { err_msg }
  }* ; ! Each parameter only once
```

8.2.1.2 Variable Resistor List

var_res_list :

```
"VAR_RES"
{ var_res_element }* ;

var_res_element :
element_name
{
    { part_id }
    | { "VALUE"          uns_real          ! Must be present
      ["K" | "M"] ["OHM"] }
    | { "TOL+"          uns_real ["%"] } ! Default 10
    | { "TOL-"          uns_real ["%"] } ! Default 10
    | { "SETUP"         uns_real
      ["K" | "M"] ["OHM"]
      ["ADJ" | "FIX"] } ! Default FIX
    | { "PIN_1"         node_name }
    | { "PIN_2"         node_name }
    | { "I_LIM"         uns_real ["MA"] } ! Default 100
    | { err_msg }
} * ; ! Each parameter only once
```

8.2.1.3 Potentiometer List

poti_list :

```
"POTI"
{ poti_element }* ;

poti_element :
element_name
{
    { part_id }
    | { "VALUE"          uns_real          ! Must be present
      ["K" | "M"] ["OHM"] }
    | { "TOL+"          uns_real ["%"] } ! Default 10
    | { "TOL-"          uns_real ["%"] } ! Default 10
    | { "R_2_3"         uns_real
      ["K" | "M"] ["OHM"]
      ["ADJ" | "FIX"] } ! Default FIX
    | { "PIN_1"         node_name }
    | { "PIN_2"         node_name }
    | { "PIN_3"         node_name }
    | { "I_LIM"         uns_real ["MA"] } ! Default 100
    | { err_msg }
} * ; ! Each parameter only once
```

8.2.1.4 Resistor Array List

res_array_list :

```

"RESISTOR_ARRAY"
{ res_array_element }* ;

res_array_element :
  element_name
  {
    |      {      part_id }
    |      {      "ARRAY"      uns_integer      ! Must be present
    |      {      "X"          uns_real          ! Resistor value
    |      |                                     ! Must be present
    |      |                                     ["K" | "M"] ["OHM"] }
    |      {      "TOL+"      uns_real ["%"] }      ! Default 10
    |      {      "TOL-"      uns_real ["%"] }      ! Default 10
    |      {      "I_LIM"     uns_real ["MA"] }      ! Default 100
    |      {      "PIN_"      uns_integer_node_name }*
    |      { err_msg }
  };
                                     ! Each parameter only once

```

8.2.1.5 Capacitor List

cap_list :

```

"CAPACITOR"
{ cap_element }* ;

cap_element :
  element_name
  {
    |      {      part_id }
    |      {      "VALUE"      uns_real          ! Must be present
    |      |                                     [ "M"
    |      |                                     | "U"
    |      |                                     | "N"
    |      |                                     | "P"
    |      |                                     ]
    |      |                                     ["F"] }
    |      {      "TOL+"      uns_real ["%"] }      ! Default 10
    |      {      "TOL-"      uns_real ["%"] }      ! Default 10
    |      {      "PIN_1"     node_name }
    |      {      "PIN_2"     node_name }
    |      {      "FREQ"      uns_real ["KHZ"] }
    |      { err_msg }
  };
                                     ! Each parameter only once

```

8.2.1.6 Pol. Capacitor List

pol_cap_list :

```

"POL_CAP"
{ pol_cap_element }* ;

pol_cap_element :
  element_name
  {
    | { part_id }
    | { "VALUE"          uns_real          ! Must be present
      [ "M"
      | "U"
      | "N"
      | "P"
      ]
      [ "F" ] }
    | { "TOL+"          uns_real [ "%" ] } ! Default 10
    | { "TOL-"          uns_real [ "%" ] } ! Default 10
    | { "PIN_A"         node_name }
    | { "PIN_C"         node_name }
    | { "FREQ"          uns_real [ "KHZ" ] }
    | { err_msg }
  }* ;
! Each parameter only once

```

8.2.1.7 Inductor List

inductor_list :

```

"INDUCTOR"
{ ind_element }* ;

ind_element :
  element_name
  {
    | { part_id }
    | { "VALUE"          uns_real          ! Must be present
      [ "M" ] [ "H" ]
    }
    | { "TOL+"          uns_real [ "%" ] } ! Default 20
    | { "TOL-"          uns_real [ "%" ] } ! Default 20
    | { "PIN_1"         node_name }
    | { "PIN_2"         node_name }
    | { "DC_RES"        uns_real } [ "OHM" ] } ! Default 1,0
    | { "R_TOL+"        uns_real [ "%" ] } ! Default 30
    | { "R_TOL-"        uns_real [ "%" ] } ! Default 30
    | { "FREQ"          uns_real [ "KHZ" ] }
    | { err_msg }
  }* ;
! Each parameter only once

```



8.2.1.8 Diode List

diode_list :

```

"DIODE"
{ diode_element }* ;

diode_element :
  element_name
  {
    |      { part_id }
    |      { "VALUE"      uns_real ["V"] }      ! Default 0.7
    |      { "TOL+"      uns_real ["%"] }      ! Default 25
    |      { "TOL-"      uns_real ["%"] }      ! Default 25
    |      { "PIN_A"     node_name }
    |      { "PIN_C"     node_name }
    |      { "I_DCS"     uns_real } ["MA"] }    ! Default 100
    |      { "I_DIO"     uns_real } ["MA"] }    ! Default 10
    |      { err_msg }
  }* ;
! Each parameter only once

```

8.2.1.9 LED List

led_list :

```

"LED"
{ led_element }* ;

led_element :
  element_name
  {
    |      { part_id }
    |      { "VALUE"      uns_real ["V"] }      ! Default 1.2
    |      { "TOL+"      uns_real ["%"] }      ! Default 25
    |      { "TOL-"      uns_real ["%"] }      ! Default 25
    |      { "PIN_A"     node_name }
    |      { "PIN_C"     node_name }
    |      { "I_DCS"     uns_real } ["MA"] }    ! Default 100
    |      { "I_DIO"     uns_real } ["MA"] }    ! Default 10
    |      { err_msg }
  }* ;
! Each parameter only once

```

8.2.1.10 Zener Diode List

z_diode_list :

```

"Z_DIODE"
{ z_diode_element }* ;

z_diode_element :
  element_name
  {
    |      { part_id }
    |      { "VALUE"      uns_real ["V"] }      ! Must be present
    |      { "TOL+"      uns_real ["%"] }      ! Default 10
    |      { "TOL-"      uns_real ["%"] }      ! Default 10
    |      { "PIN_A"     node_name }
    |      { "PIN_C"     node_name }
    |      { "I_Z"       uns_real } ["MA"] }
    |      { "R_Z"       uns_real } ["OHM"] }
    |      { err_msg }
  }* ;
! Each parameter only once

```

8.2.1.11 Transistor List

transistor_list :

```

"TRANSISTOR"
{ trans_element }* ;

trans_element :
  element_name
  {
    | { part_id }
    | { "NPN" | "PNP" } ! Must be present
    | { "UBE" uns_real ["V"] } ! Default 0.6
    | { "TOL+" uns_real ["%"] } ! Default 30
    | { "TOL-" uns_real ["%"] } ! Default 30
    | { "BETA" uns_integer } ! Default 10
    | { "PIN_E" node_name }
    | { "PIN_B" node_name }
    | { "PIN_C" node_name }
    | { "UCE" uns_real ["V"] } ! Default 5.0
    | { "I_C1" uns_real ["MA"] } ! Default 9.0
    | { "I_C2" uns_real ["MA"] } ! Default 11.0
    | { "I_LIM" uns_real ["MA"] } ! Default 100
    | { err_msg }
  }* ; ! Each parameter only once

```

8.2.1.12 Jumper List

jumper_list :

```

"JUMPER"
{ jumper_element }* ;

jumper_element :
  element_name
  {
    | { part_id }
    | { "PIN_1" node_name }
    | { "PIN_2" node_name }
    | { "OPEN" | "CLOSED" } ! Default CLOSED
    | { err_msg }
  }* ; ! Each parameter only once

```

8.2.1.13 IC List

ic_list :

```

"IC"
{ ic_element }* ;

ic_element :
  element_name
  {
    | { part_id }
    | { "TYPE" type_name } ! Must be present
    | { "PINS" uns_integer } ! Must be present
    | { "PIN_" uns_integer node_name }*
    | { err_msg }
  }* ;

```

8.2.1.14 Connector List

connector_list :

```
"CONNECTOR"
{ connector_element }* ;

connector_element :
  element_name
  {
    | { part_id }
    | { "TYPE" type_name }
    | { "PINS" uns_integer } ! Must be present
    | { "PIN_" uns_integer node_name }*
    | { err_msg }
  }* ;
```

8.2.1.15 Black Box List

black_box_list :

```
"BLACK_BOX"
{ black_box_element }* ;

black_box_element :
  element_name
  {
    | { part_id }
    | { "TYPE" type_name }
    | { "PINS" uns_integer } ! Must be present
    | { "PIN_" uns_integer node_name }*
    | { err_msg }
  }* ;
```

8.2.1.16 Track List

track_list :

```
"TRACK"
{ track_element }* ;

track_element :
  element_name
  {
    | { node_name }* ! At least 2 nodes
    | { "PINS" uns_integer }
    | { err_msg }
  }* ;
```




```

message :
    ""
    { printable }%           ! max. 63 characters
    "" ;

uns_real :
    { uns_integer [ "." |
                    "." uns_integer ] }
| { "." uns_integer }
[ "E" [ "+" | "-" ] uns_integer ] ;

uns_integer :
    { dd } % ;

dd :
    "0" | ... | "9" ;

printable :
    " " | ... | "&" | "(" | ... | "~" ; !all printable ASCII characters with the exception of the
                                        !quotation mark "'"

node_chars :
    "A" | ... | "Z" | "a" | ... | "z" | "0" | ... | "9" |
    "_" | "." | "!" | "#" | "$" | "%" | "&" | "*" | "+" | "-" |
    "/" | "\" | ":" | "?" | "@" | "^" | "|" | "~" |
    "(" | ")" | "{" | "}" | "[" | "]" | "<" | ">" ;

```

8.2.1.19 FET List

fet_list :

```

"FET"
{ fet_element }* ;

fet_element :
    element_name
    { { part_id }
      | { "JFET" | "DEP_MOSFET | ENH_MOSFET" } ! Must be present
      | { "N_CHANNEL" | "P_CHANNEL" } ! Must be present
      | { "VGS_OFF" real_num ["V"] } ! Default depends on FET type; see
                                      semantics description
      | { "VGS_ON" real_num ["V"] } ! Default depends on FET type; see
                                      semantics description
      | { "RDS_ON" uns_real ["OHM"] } ! Default depends on FET type; see
                                      semantics description
      | { "PIN_D" node_name }
      | { "PIN_G" node_name }
      | { "PIN_S" node_name }
      | { err_msg }
    }* ; ! Each parameter only once

```

8.2.2 Semantics

8.2.2.1 General

Components of the same type can be combined into lists in the external circuit description. A list of components is started using the related keyword. The individual list elements are separated by the component identifier (name). For this reason the name of the component must always be given at the start of a component description. All other parameters in a component description can occur in any order, however they can occur a maximum of once.

The component identifier is marked by the keyword NAME and comprises a maximum of 15 characters that are enclosed in single quotation marks.

In all component descriptions except TRACK and NODE, the PART_ID parameter is available for identifying the item number. The item number can comprise a maximum of 15 characters that are enclosed in single quotation marks.

Circuit information on components is started using the keywords PIN_x (x = see syntax for the related component description). The keyword is followed by a node name. The circuit information in the component description is optional. A node name in circuit information comprises a maximum of 80 characters and is placed in parentheses using "".

A node name is only allowed to contain the following characters:

"A"..."Z"	uppercase letter
"a"..."z"	lowercase letter
"0"..."9"	digit
"_"	underscore
"."	decimal point/period
"!"	exclamation mark
"#"	number sign
"\$"	dollar sign
"%"	percent
"&"	ampersand
"*"	asterisk
"+"	plus
"-"	minus
"/"	slash
"\"	backslash
":"	colon
"?"	question mark
"@"	at sign



"^"	caret
" "	vertical bar
"~"	tilde
"("	opening paranthesis
")"	closing paranthesis
"{"	opening curly brace
"}"	closing curly brace
"["	opening square bracket
"]"	closing square bracket
"<"	opening angle bracket/less than
">"	closing angle bracket/greater than

Using the keyword ERR_MSG you can define for a component a message text that is output in addition to the standard messages on the occurrence of an error. Such messages could, for example, relate to the position of the component or special repair instructions. The message text is allowed to comprise a maximum of 63 characters that are enclosed in single quotation marks.

8.2.2.2 Resistor List

A resistor list is started using the keyword RESISTOR. The individual elements in the list then follow.

VALUE

The keyword VALUE identifies the value for the resistor. A resistor value is represented by a 'uns_real', followed optionally by unit of measure information K (Kilo) or M (Mega). The numerical representation is not allowed to exceed 6 characters. The unit of measure information OHM is only used for improved readability, it is optional.

TOL+, TOL-

These keywords identify the tolerance of the resistor in percent. The tolerance of the resistor is represented by a 'uns_real'. The numerical representation is not allowed to exceed 3 characters, the unit of measure information % is only used for improved readability, it is optional.

I_LIM

This parameter specifies the maximum current in milliamps that is allowed to be applied to the resistor during the test. The current value is represented by a 'uns_real'. The numerical representation is not allowed to exceed 5 characters. The unit of measure information MA (milliamp) is only used for improved readability, it is optional. If the parameter is not listed, the default value of 100 MA is assumed.

```

RESISTOR
NAME 'R1'  PART_ID 'Part_no_r1'
          VALUE 10.0 K OHM TOL+ 5% TOL- 5%
          PIN_1 'Node_r1.1'
          PIN_2 'Node_r1.2'
          I_LIM 10 MA
          ERR_MSG 'Fault at location A-17'
NAME 'R2'  PART_ID 'Part_no_r2'
          VALUE 1.4
          PIN_1 'Node_r2.1'
          PIN_2 'Node_r2.2'
    
```

Table 8-1 BDL example RESISTOR

8.2.2.3 Variable Resistor List

A list of variable resistors is started with the keyword VAR_RES. The individual elements in the list then follow.

VALUE	The parameter VALUE defines the maximum resistance of the component. The information is given in a similar manner to that for RESISTOR (see section 8.2.1.1).
TOL+, TOL-	Tolerance of the variable resistor. The same information as for RESISTOR apply (see section 8.2.1.1).
I_LIM	This parameter specifies the maximum current in milliamps that is allowed to be applied to the resistor during the test. The same information as for RESISTOR applies (see section 8.2.1.1).
SETUP	This parameter defines the presetting for the resistor. The resistor value is represented by a 'uns_real', followed optionally by unit of measure information K (Kilo) or M (Mega). The numerical representation is not allowed to exceed 6 characters. The unit of measure information OHM is only used for improved readability, it is optional.
ADJ/FIX	The parameter ADJ/FIX is not required in R&S EGTSL and is only present for reasons of compatibility with TSS. If the parameter is given in R&S EGTSL, it is only allowed to be FIX .

```

VAR_RES
NAME 'VR1'  PART_ID 'Part_vr1'
            VALUE 5.0 K OHM TOL+ 5% TOL- 5%
            SETUP 1.45 KOHM
            PIN_1 'Node_vr1.1'
            PIN_2 'Node_vr1.2'
            I_LIM 50 MA
            ERR_MSG 'Fault at location C-5'
NAME 'VR2'  PART_ID 'Part_vr2'
            VALUE 1.0 M
            SETUP 400 K
            I_LIM 50 MA
            ERR_MSG 'Fault at location R-43'

```

Table 8-2 BDL example VAR_RES

8.2.2.4 Potentiometer List

A list of potentiometers is started using the keyword POTI. The individual elements in the list then follow.

Parameters

The same information as for VARIABLE RESISTOR applies (see section 8.2.2.2).

R_2_3

The keyword SETUP is replaced by the keyword R_2_3 for improved understanding. The parameter R_2_3 defines the presetting for the resistor between the pins PIN_2 (wiper) and PIN_3.

```
POTI
NAME 'Poti1' PART_ID 'Part_p1'
      VALUE 5.0 K OHM TOL+ 5% TOL-5%
      R_2_3 1.45 K OHM
      PIN_1 'Node_p1.1'
      PIN_2 'Node_p1.2' 'Node_p1.3'
      I_LIM 50 MA
      ERR_MSG 'Fault at location
G-29'
NAME 'Poti2' PART_ID 'Part_p2'
      VALUE 1.0 M
      R_2_3 400 K
      PIN_1 'Node_p1.1'
      PIN_2 'Node_p1.2' 'Node_p1.3'
      I_LIM 50 MA
      ERR_MSG 'Fault at location I-2'
NAME 'Poti3' R_2_3 400 K
      VALUE 2 K
      PIN_1 'Node_p1.1'
      PIN_2 'Node_p1.2' 'Node_p1.3'
NAME 'Poti4' VALUE 5.0 K TOL+ 10% TOL- 10%
      R_2_3 1 K
      PIN_1 'Node_p1.1'
      PIN_2 'Node_p1.2' 'Node_p1.3'
```

Table 8-3 BDL example POTI



8.2.2.5 Resistor Array List

A list of resistor networks is started using the keyword RESISTOR_ARRAY. The individual elements in the list then follow.

ARRAY

The keyword ARRAY identifies the size of the resistor network, i.e. the number of resistors in the network. The size of the array is limited to 127 resistors. The number of resistors implicitly defines the number of pins on the network. Here the following applies: ARRAY n corresponds to n resistors and n+1 pins. PIN_1 is the common pin for the network.

X

The number of resistors is followed by the keyword "X", followed by the resistor value in Ω , $k\Omega$ or $M\Omega$. The information on the resistor value is given as 'uns_real', followed optionally by the unit of measure information K or M. The entry of the code OHM is optional, it is only used for improved readability.

TOL+, TOL-

These keywords identify the tolerance of the resistor in percent. The tolerance of the resistor is represented by a 'uns_real'. The numerical representation is not allowed to exceed 3 characters, the unit of measure information % is only used for improved readability, it is optional.

I_LIM

This parameter specifies the maximum current in milliamps that is allowed to be applied to the resistor during the test. The value for the current is represented by a 'uns_real'. The numerical representation is not allowed to exceed 5 characters. The unit of measure information MA (milliamp) is only used for improved readability, it is optional. If the parameter is not listed, the default value of 100 MA is assumed.


```
RESISTOR_ARRAY
  NAME 'R137'      PART_ID '111,222'
  ARRAY 11 X 1 OHM
  TOL+ 10  TOL- 10
  I_LIM 100.0 MA
  PIN_1  'A1_1'
  PIN_2  'A1_2'
  PIN_3  'A1_3'
  PIN_4  'A1_4'
  PIN_5  'A1_5'
  PIN_6  'A1_6'
  PIN_7  'A1_7'
  PIN_8  'A1_8'
  PIN_9  'A1_9'
  PIN_10 'A1_10'
  PIN_11 'A1_11'
  PIN_12 'A1_12'
  ERR_MSG 'ERROR in R137'
```

Table 8-4 BDL example RESISTOR_ARRAY



8.2.2.6 Capacitor List

A list of capacitors is started using the keyword CAPACITOR. The individual elements in the list then follow.

VALUE

The parameter VALUE defines the value of the capacitor. The value is represented by a 'uns_real' followed optionally by unit of measure information M (Milli), U (Micro), N (Nano), P (Pico). The numerical representation is not allowed to exceed 6 characters. The unit of measure information F is only used for improved readability, it is optional.

TOL+, TOL-

These keywords identify the tolerance of the component in percent. The tolerance is represented by a 'uns_real'. The numerical representation is not allowed to exceed 3 characters. The unit of measure information % is only used for improved readability, it is optional. If a parameter does not occur in the component description, then a default tolerance of 10 % is assumed.

FREQ

This parameter specifies the test frequency in KHZ at which the test on the capacitor is to be performed. The information on a test frequency is optional. The test frequency is represented by a 'uns_real'. The numerical representation is not allowed to exceed 4 characters. Only the frequencies 0.1 KHZ, 1.0 KHZ and 10.0 KHZ are allowed. To avoid errors in the real number arithmetic, variations of up to 10 % from the setpoint in each case is allowed. The unit of measure information KHZ is only used for improved readability, it is optional.

```

CAPACITOR
NAME 'C1'  PART_ID 'Part_vr1'
           VALUE 5.0 N F TOL+ 15% TOL- 15%
           PIN_1 'Node_c1.1'
           PIN_2 'Node_c1.2'
           FREQ 1.0 KHZ
           ERR_MSG 'Fault at location A-32'
NAME 'C2'  VALUE 0.5 M TOL+ 5% TOL- 5%
           PIN_1 'Node_c2.1'
           PIN_2 'Node_c2.2'
           PART_ID 'Part_c2'

```

Table 8-5 BDL example CAPACITOR

8.2.2.7 Pol. Capacitor List

A list of polarized capacitors with poles is started using the keyword POL_CAP. The individual elements in the list then follow.

The same information as for CAPACITOR applies (see section 8.2.2.6).

```

POL_CAP
NAME 'ELKO1'  PART_ID 'Elko_1'
                VALUE 5.0 N F TOL+ 15% TOL- 15%
                PIN_A 'Node_pc1.1' PIN_C 'Node_pc1.2'
                FREQ 1.0 KHZ
                ERR_MSG 'Fault at location F-22'
NAME 'ELKO2'  VALUE 0.5 M TOL+ 5% TOL- 5%
                PIN_A 'Node_pc2.1' PIN_C 'Node_pc2.2'
                PART_ID Elko.-2'
    
```

Table 8-6 BDL example POL_CAP

PIN_A = Anode = positiv pole of the polarized capacitor

PIN_C = Cathode = negative pole of the polarized capacitor

8.2.2.8 Inductor List

A list of inductors is started using the keyword **INDUCTOR**. The individual elements in the list then follow.

VALUE	The parameter VALUE defines the inductance of the component. The value is represented by a 'uns_real', followed optionally by unit of measure information M (Milli). The numerical representation is not allowed to exceed 6 characters. The unit of measure information H is only used for improved readability, it is optional.
TOL+, TOL-	These keywords identify the tolerance of the component in percent. The tolerance is represented by a 'uns_real'. The numerical representation is not allowed to exceed 3 characters. The unit of measure information % is only used for improved readability, it is optional. If a parameter does not occur in the component description, then the default tolerance of 20 % is assumed.
DC_RES	This parameter defines the DC resistance of the component in OHM . The resistance value is represented by a 'uns_real'. The numerical representation is not allowed to exceed 5 characters. The unit of measure information OHM is only used for improved readability, it is optional. If a parameter does not occur in the component description, then the default resistance of 1.0 OHM is assumed.
R_TOL+, R_TOL-	These keywords identify the tolerance on the DC resistance of the component in percent. The tolerance is represented by a 'uns_real'. The numerical representation is not allowed to exceed 3 characters. The unit of measure information % is only used for improved readability, it is optional. If a parameter does not occur in the component description, then the default tolerance of 30 % is assumed.
FREQ	This parameter specifies the test frequency KHZ at which the test is to be performed on the component. The information on a test frequency is optional. The test frequency is represented by a 'uns_real'. The numerical representation is not allowed to exceed 4 characters. Only the frequencies 0.1 KHZ , 1.0 KHZ and 10.0 KHZ are allowed.

```

INDUCTOR
NAME 'I1'  PART_ID 'Part_i1'
           VALUE 50.0 M H TOL+ 10% TOL- 10%
           DC_RES 20 OHM R_TOL+ 15% R_TOL- 15%
           FREQ 10.0 KHZ
           PIN_1 'Node_i1.1' PIN_2 'Node_i1.2'
           ERR_MSG 'Fault at location K-10'
NAME 'I2'  PART_ID 'Part-i2'
           VALUE 0.1 TOL+ 5% TOL- 5%
           PIN_1 'Node_i2.1' PIN_2 'Node_i2.2'
NAME 'I3'  VALUE 0.02 H TOL+ 10 TOL- 10
           DC_RES 5 R_TOL+ 10% R_TOL- 10%
           PIN_1 'Node_i3.1' PIN_2 'Node_i3.2'
           ERR_MSG 'Fault at location D-23'

```

Table 8-7 BDL example INDUCTOR



8.2.2.9 Diode List

A list of diodes is started using the keyword DIODE. The individual elements in the list then follow.

VALUE	The parameter VALUE defines the knee voltage of the diode in V. If the parameter is missing in the component description, then a knee voltage of 0.7 V is assumed. The value is represented by a 'uns_real'. The numerical representation is not allowed to exceed 3 characters. The unit of measure information V is only used for improved readability, it is optional.
TOL+, TOL-	These keywords identify the tolerance on the knee voltage in percent. The tolerance is represented by a 'uns_real'. The numerical representation is not allowed to exceed 3 characters. The unit of measure information % is only used for improved readability, it is optional. If parameter does not occur in the component description, then the default tolerance of 25 % is assumed.
I_DCS	This parameter defines the maximum permissible total current during the test on the diode in milliamps. The value is represented by a 'uns_real'. The numerical representation is not allowed to exceed 5 characters. The unit of measure information MA is only used for improved readability, it is optional. If the parameter is missing in the component description, then a current limit of 100 MA is assumed.
I_DIO	This parameter defines the maximum permissible diode current in milliamps. The value is represented by a 'uns_real'. The numerical information is not allowed to exceed 4 characters. The unit of measure information MA is only used for improved readability, it is optional. If the parameter is missing in the component description, then a maximum diode current of 10 MA is assumed.

```

DIODE
NAME 'D1'  PART_ID 'Part_d1'
           VALUE 0.4 V TOL+ 15% TOL- 15%
           I_DCS 50 MA
           I_DIO 5.0 MA
           PIN_A 'Node_d1.1'
           PIN_C 'Node_d1.2'
           ERR_MSG 'Fault at location H-19'
NAME 'D2'  PART_ID 'Part_d2'
           VALUE 0.4
           I_DCS 20 MA
           PIN_A 'Node_d2.1'
           PIN_C 'Node_d2.2'

```

Table 8-8 BDL example DIODE

PIN_A = Anode

PIN_C = Cathode

8.2.2.10 LED List

A list of light emitting diodes is started using the keyword LED. The same information as for diodes applies (see section 8.2.2.9), only the default value for VALUE here is 1.2 V.

8.2.2.11 Zener Diode List


NOTE:

A zener diode test is only generated if a R&S TS-PSU or R&S TS-PSU12 module is configured in the PHYSICAL.INI file. Otherwise, only a diode forward test is inserted.

A list of zener diodes is started using the keyword Z_DIODE. The individual elements in the list then follow.

VALUE

The parameter VALUE defines the nominal voltage of the zener diode in V. The value is represented by a 'uns_real'. The numerical information is not allowed to exceed 4 characters. The unit of measure information V is only used for improved readability, it is optional.

TOL+, TOL-

These keywords identify the tolerance on the nominal voltage in percent. The tolerance is represented by a 'uns_real'. The numerical representation is not allowed to exceed 3 characters. The unit of measure information % is only used for improved readability, it is optional. If a parameter does not occur in the component description, then a default tolerance of 10 % is assumed.

I_Z

This parameter defines the zener current of the diode in milliamps. The information on the zener current is optional. The value is represented by a 'uns_real'. The numerical information is not allowed to exceed 4 characters. The unit of measure information MA is only used for improved readability, it is optional.

R_Z

This parameter defines the zener resistance of the diode in OHM. The information on the zener resistance is optional. The value is represented by a 'uns_real'. The numerical information is not allowed to exceed 4 characters. The unit of measure information OHM is only used for improved readability, it is optional.


```

Z_DIODE
NAME 'Z1'  PART_ID 'Part_z1'
           VALUE 10.0 V TOL+ 15% TOL- 15%
           I_Z 5 MA
           R_Z 1.0 OHM
           PIN_A 'Node_z1.1'
           PIN_C 'Node_z1.2'
           ERR_MSG 'Fault at location E-9'
NAME 'Z2'  PART_ID 'Part_z2'
           VALUE 5.0 V
           I_Z 10 MA
           PIN_A 'Node_z2.1'
           PIN_C 'Node_z2.2'

```

Table 8-9 BDL example Z_DIODE

PIN_A = Anode

PIN_C = Cathode

8.2.2.12 Transistor List

A list of transistors is started using the keyword TRANSISTOR. The individual elements in the list then follow.



NOTE:

A transistor beta test is only generated if a R&S TS-PSU or R&S TS-PSU12 module is configured in the PHYSICAL.INI file. Otherwise, only a simple transistor test is inserted

NPN, PNP

These parameters identify the type of the transistor. The two parameters are mutually exclusive.

UBE

The parameter UBE defines the base-emitter voltage of the transistor in the forward bias region in V. If the parameter is missing, then a base-emitter voltage of 0.6 V is assumed. The value is represented by a 'uns_real'. The numerical information is not allowed to exceed 4 characters. The unit of measure information V is only used for improved readability, it is optional.

TOL+, TOL-

These keywords identify the tolerance on the base-emitter voltage in percent. The tolerance is represented by a 'uns_real'. The numerical representation is not allowed to exceed 3 characters. The unit of measure information % is only used for improved readability, it is optional. If a parameter does not occur in the component description, then the default tolerance of 30 % is assumed.

BETA

This parameter defines the minimum current gain of the transistor. If the parameter is missing, a gain of 10 is used. The gain is represented by a 'uns_integer'. The numerical information is not allowed to exceed 3 characters.

UCE

This parameter defines the collector-to-emitter voltage in V for the transistor test. If the parameter is missing, a voltage of 5.0 V is used. The value is represented by a 'uns_real'. The numerical information is not allowed to exceed 4 characters. The unit of measure V is only used for improved readability, it is optional.

I_C1, I_C2

These two parameters define the collector-to-emitter currents in milliamps at which the transistor gain is to be measured in the test. The default settings for the two currents are 9.0 MA for I_C1 and 11.0 MA for I_C2. The value is represented by a 'uns_real'. The numerical information is not allowed to exceed 5 characters. The unit of measure MA is only used for improved readability, it is optional.

I_LIM

This parameter specifies the maximum current from the DC voltage source (DCS) in milliamps that is allowed to be applied during the test on the transistor. The value for the current is represented by a 'uns_real'. The numerical representation is not allowed to exceed 5 characters. The unit of measure information MA (milliamp) is only used for improved readability, it is optional. If the parameter is not listed, the default value of 100 MA is assumed.

```

TRANSISTOR
NAME 'T1' PART_ID 'Part_t1'
      PNP
      UBE 0.8 V TOL+ 20% TOL- 20%
      I_LIM 50 MA
      PIN_E 'Node_t1.e' PIN_B 'Node_t1.b' PIN_C 'Node_t1.c'
      ERR_MSG 'Fault at location D-4'
NAME 'T2' PART_ID 'Part-t2'
      NPN
      UBE 0.4 V
      PIN_E 'Node_t2.e' PIN_B 'Node_t2.b' PIN_C 'Node_t2.c'

```

Table 8-10 BDL example TRANSISTOR



8.2.2.13 Jumper List

A list of jumpers is started using the keyword JUMPER. The individual elements in the list then follow.

OPEN, CLOSED

The parameters define whether the jumper is OPEN or CLOSED. The two parameters are mutually exclusive. If the parameter is missing, the CLOSED state is assumed.

```
JUMPER
NAME 'JMP1' PART_ID 'Part_jmp1'
          PIN_1 'Node_J1.1' PIN_2 'Node_J1.2' OPEN
          ERR_MSG 'Fault at location C-15'
NAME 'JMP2' PART_ID 'Part_jmp2'
          PIN_1 'Node_J2.1' PIN_2 'Node_J2.2'
```

Table 8-11 BDL example

8.2.2.14 IC List

A list of ICs is started using the keyword IC. The individual elements in the list then follow.

TYPE	This parameter defines the type of IC. A type identifier comprises a maximum of 15 characters and is placed in parenthesis using "". Within the type identifier there must not be any "" or spaces.
PINS	This parameter defines the number of pins on the IC. The number is represented by a 'uns_integer'. The numerical representation must not exceed 3 characters. The number of pins is not allowed to exceed 999. In the circuit information, the related pin number is not allowed to exceed the number of pins on the IC.

```

IC
NAME 'IC1' PART_ID 'Part-IC1'
      TYPE '74LS02'
      PINS 14
      PIN_1 'IC1.1' PIN_2 'IC1.2' PIN_3 'IC1.3' PIN_4 'nc'
      PIN_5 'nc' PIN_6 'IC1.6' PIN_7 'VCC' PIN_8 'IC1.8'
      PIN_9 'nc' PIN_10 'nc' PIN_11 'IC1.11'
      PIN_12 'nc' PIN_13 'IC1.13' PIN_14 'GND'

```

Table 8-12 BDL example IC

ICs and the connections on the ICs are taken into account during the **Contact** and **Short** tests. IC pins are specially protected by the Automatic Test Generator ATG.



8.2.2.15 Connector List

A list of connectors is started using the keyword CONNECTOR. The individual elements in the list then follow.

TYPE

This parameter defines the type of connector. The information on the type is optional here. A type identifier comprises a maximum of 15 characters and is placed in parenthesis using "". Within the type identifier there must not be any "" or spaces.

PINS

This parameter defines the number of pins on the connector. The number is represented by a 'uns_integer'. The numerical representation must not exceed 3 characters. In the circuit information, the related pin number must not exceed the number of pins on the connector.

```
CONNECTOR
NAME 'CON-1' PART_ID 'Part-CON-1'
PINS 4
PIN_1 'CN1.1' PIN_2 'CN1.2'
PIN_3 'CN1.3' PIN_4 'CN1.4'
```

Table 8-13 BDL example CONNECTOR

8.2.2.16 Black Box List

A list of black boxes is started using the keyword BLACK_BOX. The individual elements in the list then follow. A black box can be used to insert a placeholder test for user-defined test methods.

TYPE	This parameter defines the type of black box. The information on the type is optional here. A type identifier comprises a maximum of 15 characters and is placed in parenthesis using "". Within the type identifier there must not be any "" or spaces.
PINS	This parameter defines the number of pins on the black box. The number is represented by a 'uns_integer'. The numerical representation must not exceed 3 characters. The number of pins is not allowed to exceed 999. In the circuit information, the related pin number is not allowed to exceed the number of pins on the black box.

```

BLACK_BOX
NAME 'Bl1' PART_ID 'Part-bl-1'
      TYPE 'BOX-1'
      PINS 14
      PIN_1 'BL1.1' PIN_2 'BL1.2' PIN_3 'BL1.3'
      PIN_4 'nc' PIN_5 'nc' PIN_6 'BL1.6'
      PIN_7 'VCC' PIN_8 'BL1.8' PIN_9 'nc'
      PIN_10 'nc' PIN_11 'BL1.11' PIN_12 'nc'
      PIN_13 'BL1.13' PIN_14 'GND'
      ERR_MSG 'Fault at location L-16'
  
```

Table 8-14 BDL example BLACK_BOX

Black boxes and the connections on black boxes are taken into account during the **Contact** and **Short** tests.

In addition, a contact test is inserted for the black box as a placeholder.

8.2.2.17 Track List

A list of tracks is started using the keyword TRACK. The individual elements in the list then follow.

The parameter is a list of node names that are connected to the track. At least 2 nodes must be allocated to the track.

```

TRACK
NAME 'TRACK-1'
  PINS 4
    'Node_1.1' 'Node_1.2' 'Node_1.3' 'Node_1.4'
  ERR_MSG 'Fault at location B-3 to B-22'
NAME 'TRACK-2'
  PINS 2
    'Node_2.1' 'Node_2.2'
  
```

Table 8-15 BDL example TRACK

8.2.2.18 Node List

A list of nodes is started using the keyword **NODE**. The individual elements in the list then follow.

DEV_NAME

This parameter identifies the logical name of the component that is connected to this node.

```

NODE

NAME 'NODE1'
    DEV_NAME 'IC' PIN_1
    DEV_NAME 'IC' PIN_2
    DEV_NAME 'IC' PIN_3
    DEV_NAME 'Transistor-1' PIN_A
    DEV_NAME 'LED_1' PIN_A

NAME 'NODE2'
    DEV_NAME 'LED_1' PIN_C
    DEV_NAME 'Transistor-1' PIN_B

NAME 'NODE3'
    DEV_NAME 'Transistor-1' PIN_C
    
```

Table 8-16 BDL example **NODE**

8.2.2.19 FET List

A list of transistors is started using the keyword FET. The individual elements in the list then follow.

**JFET,
DEP_MOSFET,
ENH_MOSFET**

Defines the type of field-effect transistor (FET). Junction field-effect transistors (junction-fet; JFET) and metal oxide semiconductor field-effect transistors (MOSFET) are distinguished. For MOSFETs there are additionally the depletion-mode MOSFET (DEP_MOSFET) and enhancement-mode MOSFET (ENH_MOSFET) types.

**N_CHANNEL,
P_CHANNEL**

Defines the channel type of a field-effect transistor.

VGS_OFF

Defines the gate-source voltage at which the transistor insulates (FET). If the parameter is omitted, the following default values will be used:

```
JFET
  N_CHANNEL:    -5  V
  P_CHANNEL:     5  V
```

```
DEP_MOSFET
  N_CHANNEL:    -5  V
  P_CHANNEL:     5  V
```

```
ENH_MOSFET
  N_CHANNEL:     0  V
  P_CHANNEL:     0  V
```

VGS_ON

Defines the gate-source voltage at which the transistor conducts. If the parameter is omitted, the following default values will be used:

```
JFET
  N_CHANNEL:     0  V
  P_CHANNEL:     0  V
```

```
DEP_MOSFET
  N_CHANNEL:     0  V
  P_CHANNEL:     0  V
```

```
ENH_MOSFET
  N_CHANNEL:     5  V
  P_CHANNEL:    -5  V
```

RDS_ON

Defines the drain-source resistance on condition switched on. If the parameter is omitted, the following default values will be used:

```
JFET:                               1000 Ohm
DEP_MOSFET, ENH_MOSFET:             0.1 Ohm
```

8.3 Important additional Information

8.3.1 Node List

The Automatic Test Generator ATG generates the relevant node list from the component data if no node list is given in the BDL file.

The node list must be completely and stable if it is given in the BDL file. The Automatic Test Generator ATG compares only the content of the BDL file data with the node list entries. When there differences will be detected the ATG generates an error message.

8.3.2 Treatment of specific Pins

When naming nodes, it must be observed that the following 2 node names will be treated separately by Automatic Test Generator ATG because they are very important for a correct test generation.

VCC...

If the node name initials are VCC or vcc it means that it is a power supply node.

GND...

If the node name initials are GND or gnd it means that it is a ground node.

VCC and GND nodes will particularly be considered on capacitor discharging (Test Step Discharge by ATG).



9 Automatic test generation with ATG

9.1 Function

Using the Automatic Test Generator ATG utility, an executable ICT program that can be run in Enhanced Generic Test Software Library R&S EGTSL is generated from circuit description and the description of the hardware available. Figure 9-1 shows the general sequence for automatic test generation using the Automatic Test Generator ATG.

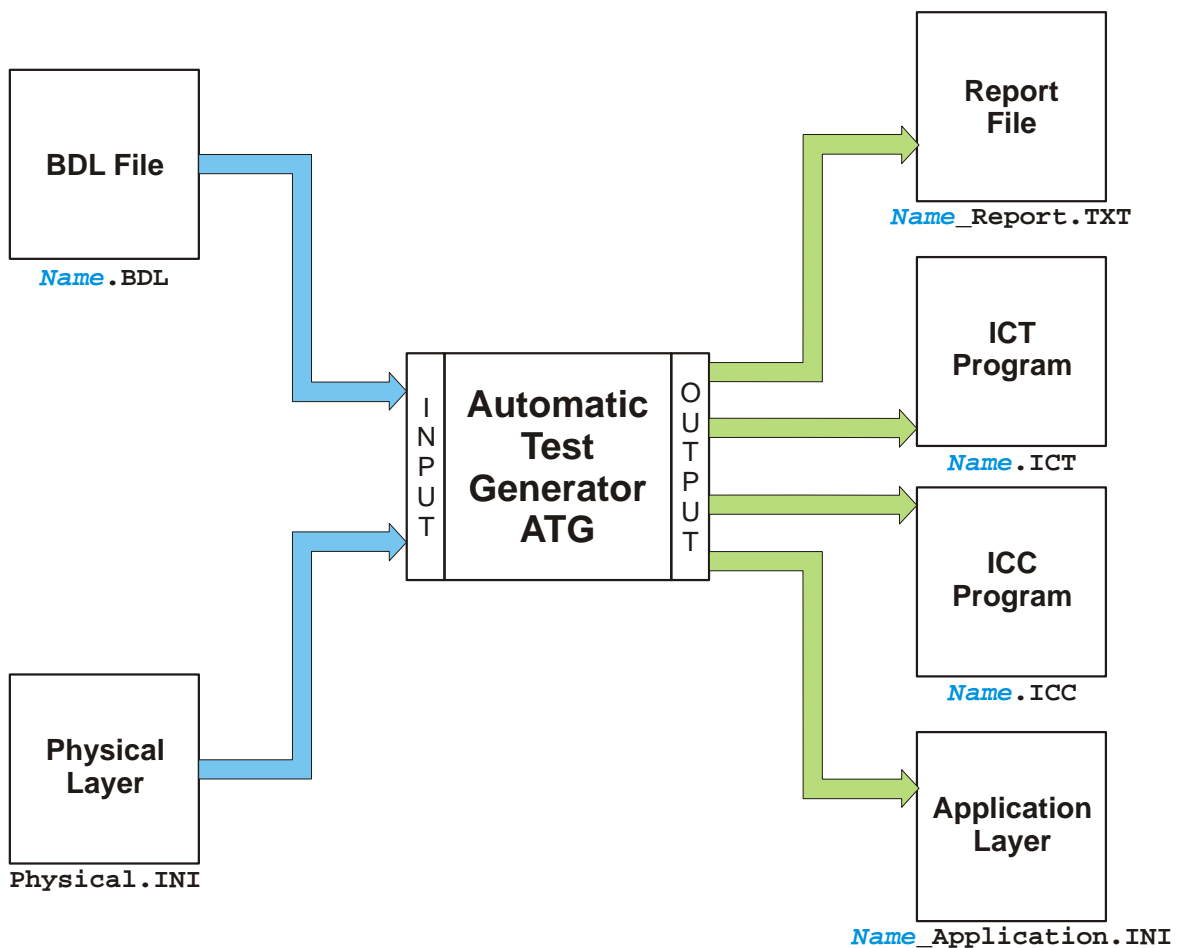


Figure 9-1 ATG sequence

The circuit description must be available in the BDL circuit description language (on this topic, see also section 8.2). The test hardware available is described using the Physical Layer Configuration File (on this topic, see also section 7.2). When the ATG is started, the file names for the BDL file (*Name.BDL*) and the file name for the Physical Layer

Configuration File (`Physical.INI`) must be given.

Following the generation process, the ATG creates the following files:

- `Name_Report.TXT`
Report with the data on the generation process
- `Name.ICT`
ICT program for execution in R&S EGTSL
- `Name.ICC`
ICC program for execution in R&S IC-Check
- `Name_Application.INI`
Application Layer Configuration File for the execution of the ICT program generated in R&S EGTSL

Any errors that have occurred during the generation process are indicated in the report using error messages and warning messages. The ICT program and the ICC program is only created when there are no more error messages.

The result of the automatic test generation is essentially defined by realistic entry of the circuit description. The circuit description must correspond to the actual topology of the circuit. Otherwise, it cannot be ensured that the automatically generated ICT and ICC programs will work.



NOTE:

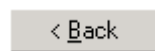
The circuit description (BDL object) from which the automatically generated ICT and ICC programs are to be generated must be free of logical data entry errors and the circuit entered must correspond as far as possible to reality.

9.2 Starting the Automatic Test Generator ATG



Start the Automatic Test Generator ATG using **Start -> Programs -> GTSL -> Automatic Test Generator**.

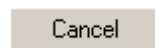
The following buttons have the same function in all windows of the ATG:



The entries made in the current window are discarded and the previous ATG window is opened.



The entries made are applied and the next ATG window is opened.



The ATG is stopped. All entries made are discarded.

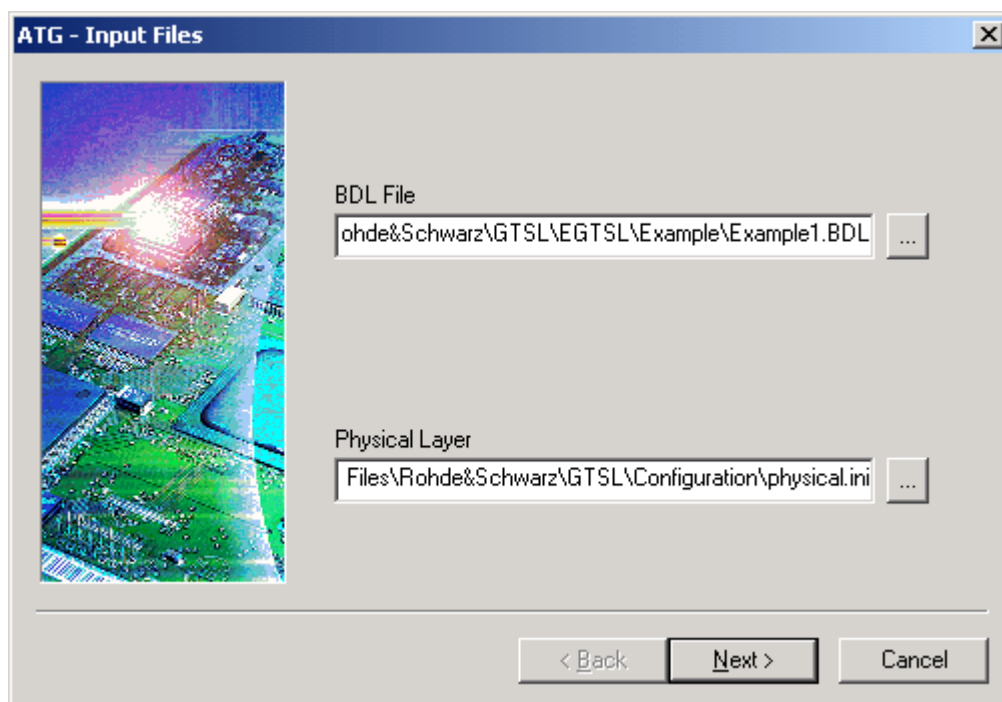


Figure 9-2 ATG - input files

BDL File

The path and the file name for the BDL input file required by the ATG are displayed in this field. The information can be edited in the field.

Physical Layer

The path and file name of the Physical Layer Configuration File required by the ATG are displayed in this field. The information can be edited in the field.



Opens the standard Windows dialog box for opening files. The save path and the file name for the input files can be selected in this dialog box. The file selected including the save path are displayed in the related field.

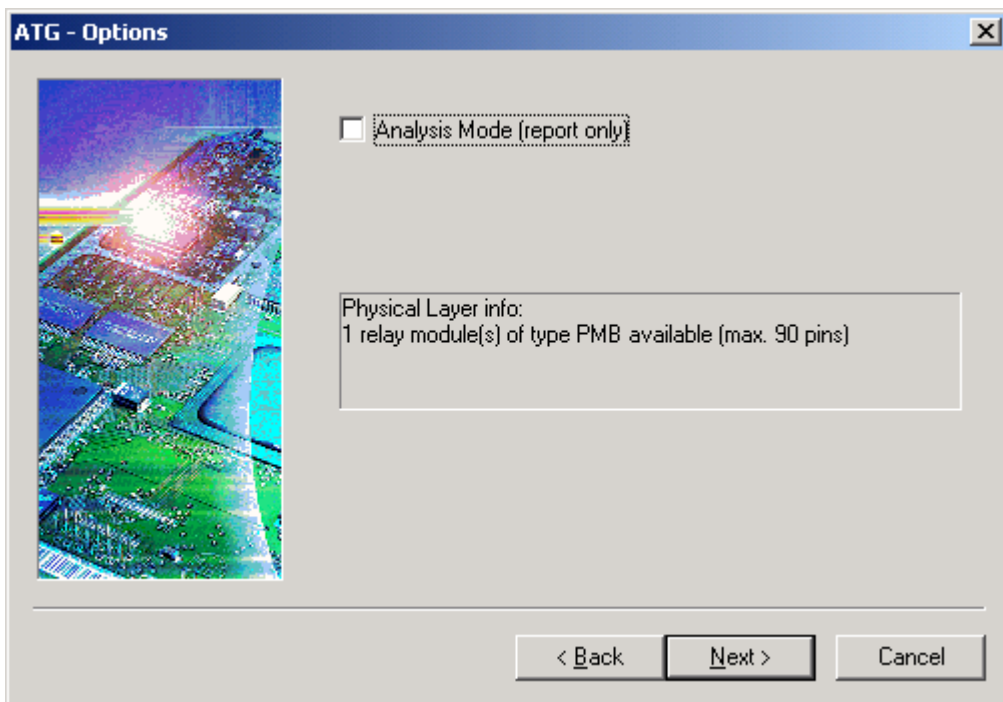


Figure 9-3 ATG - Options

Analysis Mode (report only)

With this function activated the entire generation process is performed. However only a report file with the data on the generation process is created. No ICT program, no ICC program and no Application Layer Configuration File are created.

Physical Layer Info:

The hardware information given in the Physical Layer Configuration File is displayed in this field.

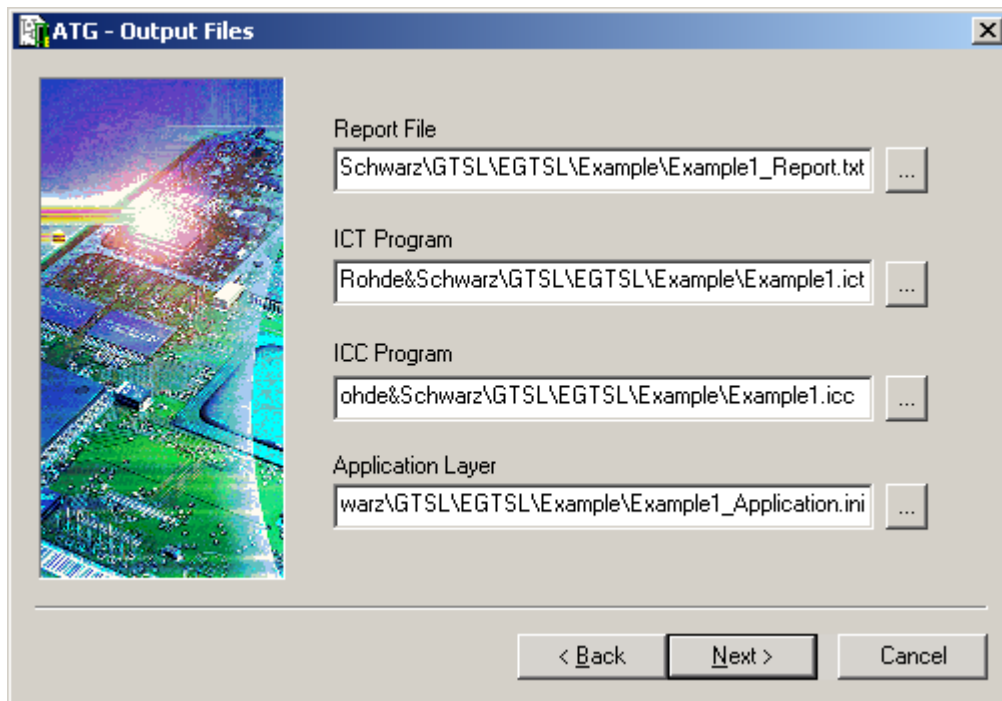



Figure 9-4 ATG - Output Files

- | | |
|---|--|
| Report File | The save path and the file name of the report file generated by the ATG are displayed in this field. The information can be edited in the field. |
| ICT Program | The save path and the file name of the ICT program generated by the ATG are displayed in this field. The information can be edited in the field. |
| ICC Program | The save path and the file name of the ICC program generated by the ATG are displayed in this field. The information can be edited in the field. |
| Application Layer | The save path and the file name of the Application Layer Configuration File are displayed in this field. The information can be edited in the field. |
|  | Opens the standard Windows dialog box for opening or adding files. The save path and the file name for the output files can be selected using this dialog box. It is also possible to add a new output file. The file selected or added is displayed in the related field. |

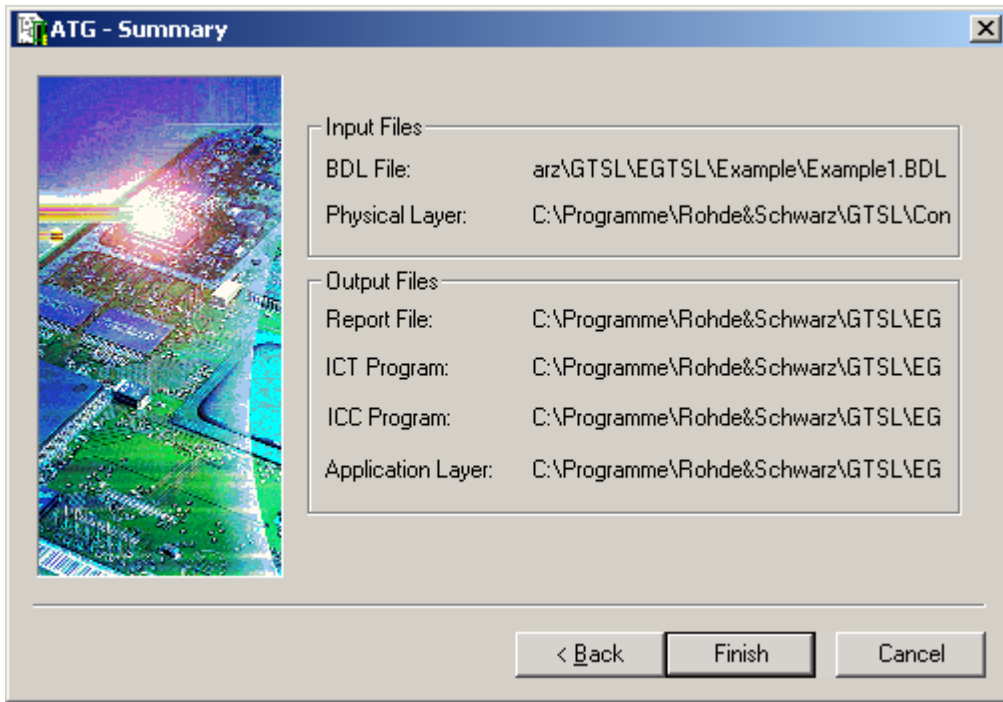


Figure 9-5 ATG - Summary

All information on the input files and the output files is displayed once again in this window for a last check.



The ATG generation process is started.

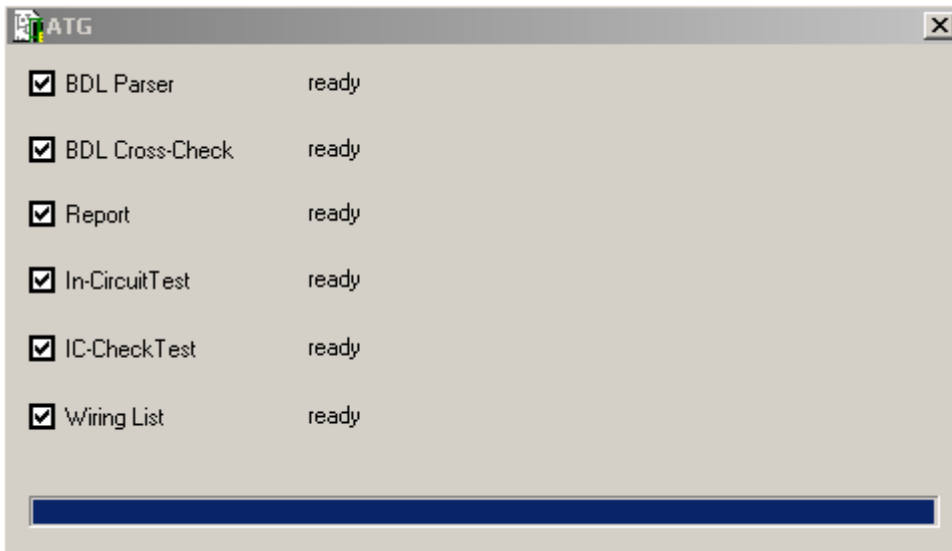


Figure 9-6 ATG Process

The generation process progress is displayed with the individual steps. If an error should occur in a step during the generation process, execution is stopped immediately. A report file with the related error message is generated when the generation is stopped.

If no errors occur during the generation process, the three output files are generated by the ATG. The report file generated can be displayed directly in both cases (error, no error).

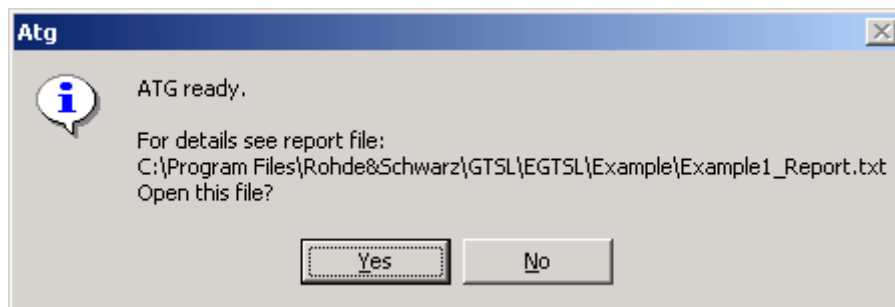


Figure 9-7 ATG Finish

9.3 Output Files

9.3.1 ICT program

9.3.1.1 General

The objective of the Automatic Test Generator ATG is to generate an ICT program for the in-circuit test of a circuit board.

The ICT program to be generated by the ATG contains test steps for discharging capacitors, the contact test, the short-circuit and connection test and the analog test in a specific order.

The automatically generated test program can be run immediately after generation. A prerequisite is an error-free circuit description (BDL object).

A bed of nails adapter is required for the test.

9.3.1.2 Layout of the test program

The layout of the ICT program generated automatically is defined by a structure anchored in the ATG. In principle, the fully generated test program has the following layout:

1. Capacitor discharging (Discharge)
2. Contact test (Contact)
3. Continuity and short-circuit test (Short)
4. Group of analog tests (In-Circuit)

9.3.1.3 State of the automatically generated test program

The vast majority of the automatically generated test steps can be used without further changes. There are, however, certain topological conflicts that cannot be solved by the ATG that must be edited when debugging the ICT program.

These test conflicts are prepared by the ATG such that they can be addressed by the user as easily as possible. The aids generated by the ATG for this purpose comprise the comments in the ATG report and test proposals in the ICT program that can be applied by the user after review.

Test conflicts can, for example, be:

- Direct parallel component paths (SHUNTS)
- Very small nominal values
- Very small parallel resistors
- Forward biased, parallel diode paths
- Hazards for components

All the above mentioned problems are detected by the network analysis in the ATG and processed accordingly.

9.3.1.4 Program groups generated

9.3.1.4.1 Capacitor discharging (Discharge)

The capacitor discharging is intended to prevent discharge currents from capacitors producing incorrect measurements or damaging the relays in the switching matrix.

The pins in the **Reference Pin List** are short-circuited at the start of the discharging. The pins in the **Test Pin List** are individually discharged to the reference pin potential and then connected to the potential of the **Reference Pin List**.

The ATG uses the following strategy for the layout of the pin lists:

- The **Reference Pin List** contains the ground nodes with the largest number of component connections (ground nodes always start with "GND" or "gnd").
- The **Test Pin List** contains
 - All other ground nodes.
 - All nodes that start with "VCC" or "vcc".
 - All nodes between which there is a total capacitance of 8 μ F or more.

9.3.1.4.2 Contact test (Contact)

The contact test is intended to exclude the possibility of missing nail contacts resulting in inappropriate error messages.

In the contact test generated by the ATG, all nodes on the circuit board for which there is a corresponding entry in the related BDL object, i.e. in the table of nail allocations, are always checked. During this process the connection to all other nodes in their entirety is tested. The resist-



ance between a node and all others must not exceed the value of 1 M Ω (default value). This is defined by the parameter **Resistor Limit** in the contact test.

If there are isolated nodes in the circuit to be tested, i.e. nodes that do not have a connection to any other point on the circuit board, these must be removed from the contact test using the **All but not** function.

9.3.1.4.3 Continuity and short-circuit test (Short)

For closed jumpers and tracks connection tests are integrated into the ICT program by the ATG. During this process the jumper and track nodes are tested for the existence of the nominal connection; the limit for a connection that is still valid is preset in the **Resistor Limit** parameter to 10 Ω .

For open jumpers and connectors short-circuit tests are integrated into the ICT test by the ATG. In contrary to the connection test, in this case the nodes given are tested for mutual short-circuits. If a short-circuit is found, i.e. a connection with less than 10 Ω (default value), the result will be a FAIL.

A global short-circuit test is always generated over all nodes on the unit under test by the ATG in the test program. During the generation of the global short-circuit test, nodes that have a nominal connection (e.g. closed jumpers, tracks or coils) are recorded by the ATG and removed from the short-circuit test using the **All but not** function.

9.3.1.4.4 The automatically generated analog test

Automatic test generation is possible for the following components that can be given in the circuit description language BDL.

Description in BDL	Test method
Resistor	Resistor or Continuity
Resistor Array	
Potentiometer	Resistor
Variable Resistor	
Capacitor	Impedance or Short
Pol. Capacitor	Impedance or Short
Inductor	Impedance or Continuity
Diode	Diode
LED	
Z_Diode	ZenerDiode or Diode
Transistor	TransistorBeta or Transistor
Jumper	Continuity or Short
IC	No test
Connector	Short
Black Box	Contact (placeholder)
Track	Continuity
FET	FET (field-effect transistor)

Table 9-1 Possible analog tests

Tests on the same analog component types are combined by the ATG and generated together. Thus, in an automatically generated test you will find all resistor tests, capacitor tests, etc. combined into groups. The order of the individual tests within a group corresponds to the entry in BDL.

9.3.1.5 Automatic determination of the guard points in the analog test

Measuring errors can occur due to currents flowing parallel to the component paths to be tested; these errors can degrade the effectiveness of an analog test. To prevent this problem occurring, the **Guarding** process is used in the analog in-circuit test. During this process specific nodes (guard points) on the circuit are selected and brought to a potential with the measuring point. In this way it is ensured that the current measured corresponds to that which is flowing through the component path to be measured.

The relevant guard points are determined automatically by the ATG. During this process, those nodes that are in close proximity to the component to be tested are preferably accepted as guard points. This condition is met,

- When the topological distance between measuring and stimulation point is not larger than one branch and
- When the guard point is within a feedback branch to the component to be measured, that is within the same cluster.

9.3.1.6 Safety against destruction of components during the test

During the circuit analysis and the editing of analog component tests, the ATG monitors the following possible hazards:

- Application of a voltage > 0.7 V to an IC that is not supplied with power.
- Possible forward biasing of a diode in the vicinity of an IC during the test on a component connected to the diode.
- Reverse polarization of an electrolytic capacitor during a test on an adjacent component by more than 0.5 V.

If a hazard is found, the corresponding test configuration is skipped by the ATG and, if possible, a different configuration selected. A further possibility is the listing of such hazards in the ATG report with the corresponding comments.

9.3.1.7 Taking account of topological problems

The ATG detects and processes the following circuit situations:

- Direct and indirect parallel circuit paths
- Orientation of parallel diode paths

During the generation of an analog component test, the measuring configurations that permit measurement on the component despite a topological problem are initially preferred. In the case of a parallel diode, e.g., the direction in which the voltage is applied is changed to utilize the higher resistance when the diode is reverse biased.

9.3.2 ATG report

In the ATG all special aspects that are found by the ATG during the generation of the program are listed. Here all messages are allocated precisely to those components for which the generation of the test produced the related messages. At the same point, the warnings that are generated by the ATG in case of components at risk are given.

Example (without warnings):

```

                        ATG REPORT
                        =====

Created:                2009-08-12 15:00:08
ATG Version:           ATG 02.83
EGTSL Version:         EGTSL 02.83

Input:
-----
Board Description:     'C:\Program Files\Rohde&Schwarz\GTSL\EGTSL\Example\Example1.BDL'
Physical Layer:       'C:\Program Files\Rohde&Schwarz\GTSL\EGTSL\Example\Example_Physical.ini'

Output:
-----
ICT Program:          'C:\Program Files\Rohde&Schwarz\GTSL\EGTSL\Example\Example1.ict'
ICC Program:          'C:\Program Files\Rohde&Schwarz\GTSL\EGTSL\Example\Example1.icc'
Application Layer:    'C:\Program Files\Rohde&Schwarz\GTSL\EGTSL\Example\Example1_Application.ini'
Report:               'C:\Program Files\Rohde&Schwarz\GTSL\EGTSL\Example\Example1_Report.txt'

BDL Parser: 0 error(s) and 0 warning(s).

BDL cross check: OK.

>>> Message from TR1                                     <<<
TS-PSU not configured in 'physical.ini', simple transistor test inserted

Test coverage report

```

	Number	Weight	Coverage
Components	8		
Regular tests	7	1	87.5%
Reduced tests	1	0.5	6.25%
Short/Contact test only	0	0.1	0%
Total test coverage			93.8%

```

Wiring List info: Nodes mapped to a total number of 7 pin(s).

```

9.3.2.1 Typical warning messages

Example 1

BDL entry

```

NAME 'R1'
      VALUE 10 kOHM                               Statement with Error
      TOL+ 10% TOL- 10%
      I_LIM 100.0 MA
      PIN_1 'VCC'
      PIN_2 'MESS1'

```

Error message in the ATG report

lexical error (NO BDL keyword) in line 4: k
 BDL Parser: 1 error(s) and 0 warning(s).

```

ERRORS OCCURRED DURING TEST GENERATION:
-----
ERROR: BDL Parser: syntax errors detected.

```

Error rectification

In BDL it is only allowed to use upper case.

Example 2

BDL entry

```

NAME 'R2'
      VALUE 100 OHM
      TOL+ 10% TOL- 10%
      I_LIM 100.0 MA
      PIN_1 'VCC'
      PIN_3 'GND'                               Statement with Error

```

Error message in the ATG report

line 15: syntax error, unexpected PIN_3.
 BDL Parser: 1 error(s) and 0 warning(s).

```

ERRORS OCCURRED DURING TEST GENERATION:
-----
ERROR: BDL Parser: syntax errors detected.

```

Error rectification

Keyword `PIN_3` is not defined for this component. For this component there is only `PIN_1` and `PIN_2`.

Example 3

BDL entry

```
NAME 'R3'
    VALUE 330 OHM
    TOL+ 10% TOL- 10%
    I_LIM 100.0 UA
    PIN_1 'MESS1'
    PIN_2 'GND'
```

Statement with Error

Error message in the ATG report

line 20: syntax error, unexpected 'U'.

BDL Parser: 1 error(s) and 0 warning(s).

ERRORS OCCURRED DURING TEST GENERATION:

```
-----
ERROR: BDL Parser: syntax errors detected.
```

Error rectification

In the entry `I_LIM` only the unit `MA` (mA) is allowed, not `UA` (µA).

9.3.2.2 Alternative proposals from the ATG

In some cases the ATG generates alternative proposals for measurements, e.g., for guarded resistor measurements or the measurement of very low value resistors. It generates a standard test with higher error limits and, as an alternative, a more exact test with lower error limits.



NOTE:

The following example information relates to example 2 in appendix B.

The proposals for the individual components are listed in the ATG report.

Example:

- Guarded measurement of the resistor R1 (10 kΩ)
- Measurement of the low value resistor R4 (10 Ω)



BDL Parser: 0 error(s) and 0 warning(s).

BDL cross check: OK.

```
>>> Message from R1 6-Wire Test Proposal <<<
Total error for 3-wire mode: 25.52 %
                6-wire mode: 3.1255%
```

```
>>> Message from R1 <<<
Test only possible by exceeding the error limits
Guarding error limiting test quality
```

```
>>> Message from R4 4-Wire Test Proposal <<<
Total error for 2-wire mode: 24,336%
                4-wire mode: 1 %
```

```
>>> Message from R4 <<<
Test only possible by exceeding the error limits
Test limits include system residuals of 2.4 Ohms
```

Wiring List info: Nodes mapped to a total number of 8 pin(s).

Resistor R1

For the measurement of the resistor R1 the ATG proposes two measuring methods.

- Guarded 3-wire measurement

The standard measurement (3-wire mode) can be performed with three test points (nodes). A disadvantage of the guarded 3-wire measurement is a larger measuring tolerance. The measurement proposed is only possible according to the ATG report if the component tolerances given are exceeded.

- Alternative: guarded 6-wire measurement

The alternative proposal of a guarded 6-wire measurement has a considerably lower measuring tolerance. However, the guarded 6-wire measurement requires three additional test points (nodes) in the adapter.

Resistor R4

The ATG proposes two measuring methods for the measurement of the resistor R4.

- 2-wire measurement

The standard measurement (2-wire mode) requires two test points (nodes). A disadvantage of the 2-wire measurement is a larger

measuring tolerance. The measurement proposed is only possible according to the ATG report if the component tolerances given are exceeded.

- Alternative: 4-wire measurement

The alternative proposal of a 4-wire measurement has a significantly lower measuring tolerance. However, the 4-wire measurement requires two additional test points (nodes) in the adapter.



NOTE:

During the generation of the ICT program by the ATG, both the standard measurement and the alternative measurement are generated as test steps.

The alternative measurements are marked in the ICT program as “Proposal” variants.

In the Application Layer Configuration File, the additional test points (nodes) required for the alternative measurement are specially marked.

Here it is important that the decision on whether a standard measurement or an alternative measurement (e.g. 2- or 4-wire measurement) is to be performed is made before the adapter is manufactured. In this way additional test points (nodes) required can be taken into account during the manufacture of the adapter.

9.3.2.3 Test Coverage Report

The Test Coverage Report gives an overview of test coverage provided by ATG.

```

Test coverage report
Number  weight  coverage
Components                129
Regular tests              110          1      85.3%
Reduced tests               3          0.5    1.16%
Short/Contact test only    16          0.1    1.24%
Total test coverage                        87.7%
    
```

Test coverage is calculated by the number of tests generated in reference to the number of components in the BDL file. Tests that are generated are categorised in one of three classes and weighted according to their quality.

Components

The number of components in the BDL file (NODE entries are not counted).



Regular tests	The number of regular tests generated by ATG. Regular tests are rated with a factor of 1.0.
Reduced tests	<p>The number of reduced tests generated by ATG. These include:</p> <ul style="list-style-type: none">• 0-Ohm resistors, because a continuity test is inserted instead of a resistor test.• Resistor arrays, if a test was not able to generate all resistors in the array.• Inductors, if a continuity test was generated instead of an impedance test.• Diodes and LEDs, if it was not possible to generate any reverse test (current measurement).• Zener diodes, if only a simple diode test could be generated.• Transistors, if only a simple transistor test and no transistor beta test could be generated. <p>Reduced tests are rated with a factor of 0.5.</p>
Short / contact test only	The number of components for which no test could be generated by ATG. Generally this includes ICs and Black Boxes . The pins of these components are, however, taken into account in the Contact and Short test. These components are rated with a factor of 0.1.
Total test coverage	Complete test coverage is calculated as a percentage from:

$$coverage = \frac{regular + 0.5 * reduced + 0.1 * shortcontact}{components} * 100$$

9.3.3 Application Layer Configuration File

In the Application Layer Configuration File, the specific information for the use of the hardware is compiled by the ATG for the ICT program and the ICC program generated. On the execution of the ICT program or the ICC program, the name of the Application Layer Configuration File generated must be given.

You will find further information on the Application Layer Configuration File in section 7.3.

Example:

```
[ResourceManager]
; general trace settings (normally off)
Trace           = 0
TraceFile       = %GTSLROOT%\resmgr_trace.txt

;-----
[LogicalNames]
ICT             = bench->ICT

;-----
[bench->ICT]
Description     = ICT bench generated from ATG
Simulation      = 0
Trace           = 0
ICCDDevice      = device->psam
ICTDevice1      = device->psam
ICTDevice2      = device->pict
SwitchDevice1   = device->pmb1
AppChannelTable = io_channel->ICT
AppWiringTable  = io_wiring->ICT

[io_channel->ICT]
GND             = pmb1!P1
INPUT           = pmb1!P2
OUTPUT          = pmb1!P3
TR1.B           = pmb1!P4
TR1.C           = pmb1!P5
TR1.E           = pmb1!P6
VCC             = pmb1!P7

;-----
[io_wiring->ICT]
GND             = F1 S15 X10A1
INPUT           = F1 S15 X10A2
OUTPUT          = F1 S15 X10A3
TR1.B           = F1 S15 X10A4
TR1.C           = F1 S15 X10A5
TR1.E           = F1 S15 X10A6
VCC             = F1 S15 X10A7

;-----
```

In the [io_channel->ICT] section of the Application Layer Configuration File, the test points (nodes) are allocated to the I/O channels on the R&S TS-PMB Matrix Module B. The information on which matrix modules are available in the test system is read from the Physical Layer Configuration File.

9.3.4 Adapter manufacture

**NOTE:**

The information necessary for the manufacture of the adapter is in the **Application Layer Configuration File** generated (`[io_channel->ICT]` and `[io_wiring->ICT]`) (see section 9.3.3).

9.3.5 ICC program

The Automatic Test Generator ATG generates an ICC program for the IC-Check test of a circuit board.

An IC-Check program file is a test file with the extension `.icc`. It can be created or edited using any text editor. The logical structure of the ICC program file is made up of information blocks on ICs to be tested. Each information block begins with the name of the block in square brackets. All the subsequent lines begin with a keyword and either describe the measurement configuration to be applied to test the individual pins of the IC or the names of the pins and reference pins to be tested. All pins of the BDL files having the letter sequence "GND", "VSS" or "VCC" (case insensitive) are listed in the IC-Check program file as reference pins.

Refer to chapter "8 R&S IC-Check Test Programs" of the document "Software Description IC-Check" for a detailed description of the contents and usage of an ICC program file.

10 Test methods

10.1 Test hardware

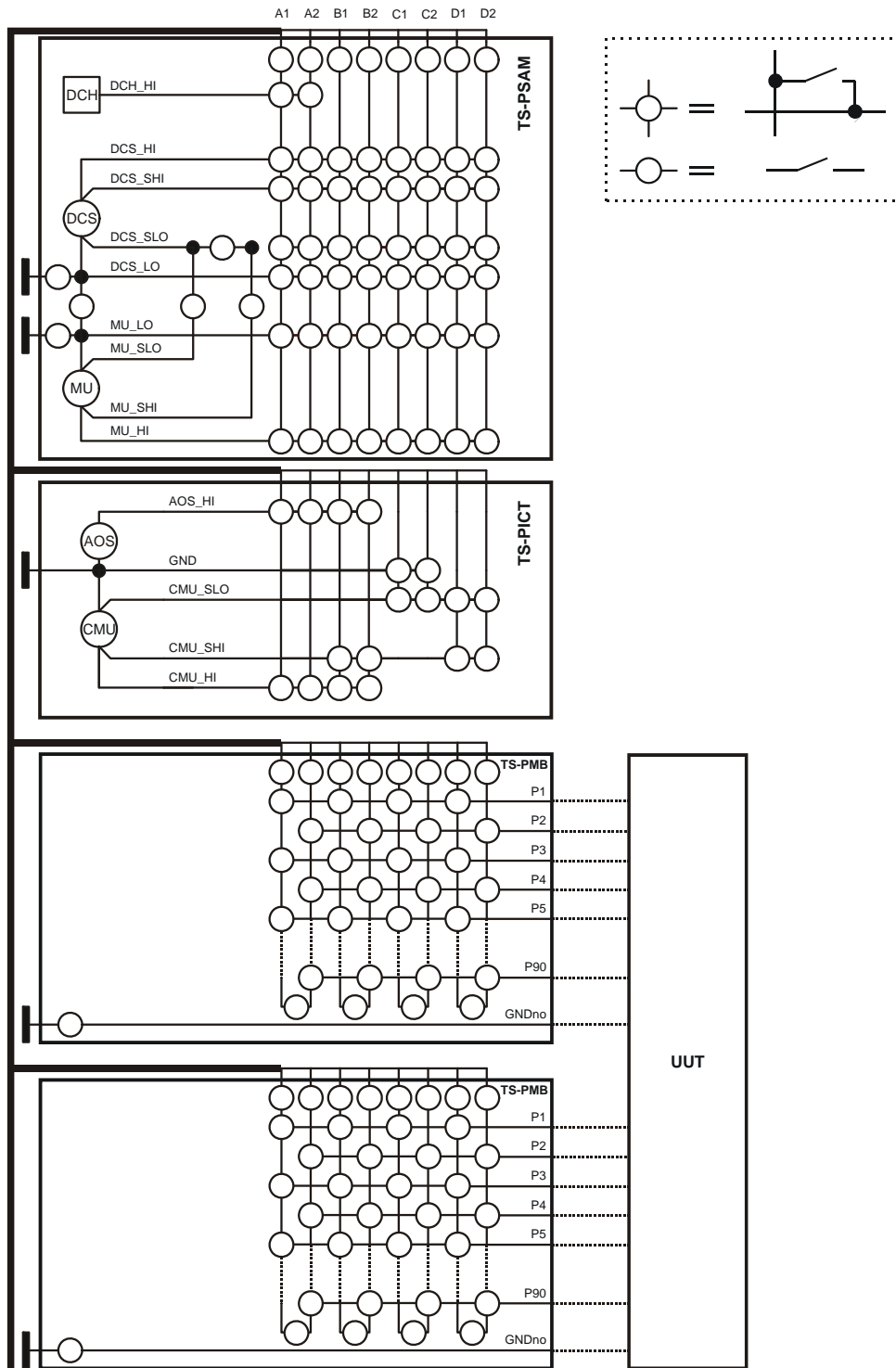


Figure 10-1 Test hardware



The following test hardware is required to perform the individual tests (see Figure 10-1):

- **R&S TS-PSAM Source and Measurement Module**

- DC stimulation source (DCS)

max. voltage	5 V
max. current	100 mA

The current limit is adjustable

- Voltage and current measurement unit (MU)

Voltage measuring range DC	10 mV to 125 V
Voltage measuring range AC	20 mV rms to 90 V rms
Current measuring range DC	1 μ A to 1 A
Current measuring range AC	100 μ A to 1 A

Recording the voltage curve during an impedance measurement

- Discharge unit DCH

max. voltage	30 V
max. current	400 mA

- **R&S TS-PICT In-Circuit Test Module**

The R&S TS-PICT In-Circuit Test Module is only required for the diode test, the impedance test and the guarded resistor test.

- AC voltage source (AOS)

max. voltage AC (rms)	1 V at 100 Hz, 1 kHz, 10 kHz
max. voltage DC	5 V
max. current DC	50 mA

- Current Measuring Unit (CMU)

Current measuring range AC 5 μ A to 250 mA

- **R&S TS-PSU Power Supply/Load Module**

- **R&S TS-PSU12 Power Supply/Load Module 12V**

The R&S TS-PSU Power Supply/Load Module / R&S TS-PSU Power Supply/Load Module 12V is only required for the zener diode test and the transistor beta test.

max. voltage TS-PSU	50 V (single) 100 V (cascaded)
max. voltage TS-PSU12	12 V (single) 24 V (cascaded)
max. current	100 mA

- **R&S TS-PMB Matrix Module B**

- Connection of the individual measuring pins (nodes)

The measuring and stimulation hardware are connected to the Unit Under Test (UUT) using the R&S TS-PMB and the analog bus.



NOTE:

The exact function and the technical data on the measuring and stimulation hardware are described in detail in the user manuals and the data sheets for the individual modules.

10.2 Ground wiring

During the in-circuit tests, the UUT (Unit Under test) must be floating, i.e. it must not be connected with the ground of the test system.

The correct ground wiring is shown in Figure 10-1. The ground of the UUT is connected with the GNDno connectors of the matrix card. This can be connected through a relay with the system ground GND. During the in-circuit tests, these relays must be opened. For the function test, they can be closed.

10.3 Contact test

License required: R&S TS-LEGT or R&S TS-LEG2

Test hardware	Module
DCS	R&S TS-PSAM
MU	R&S TS-PSAM

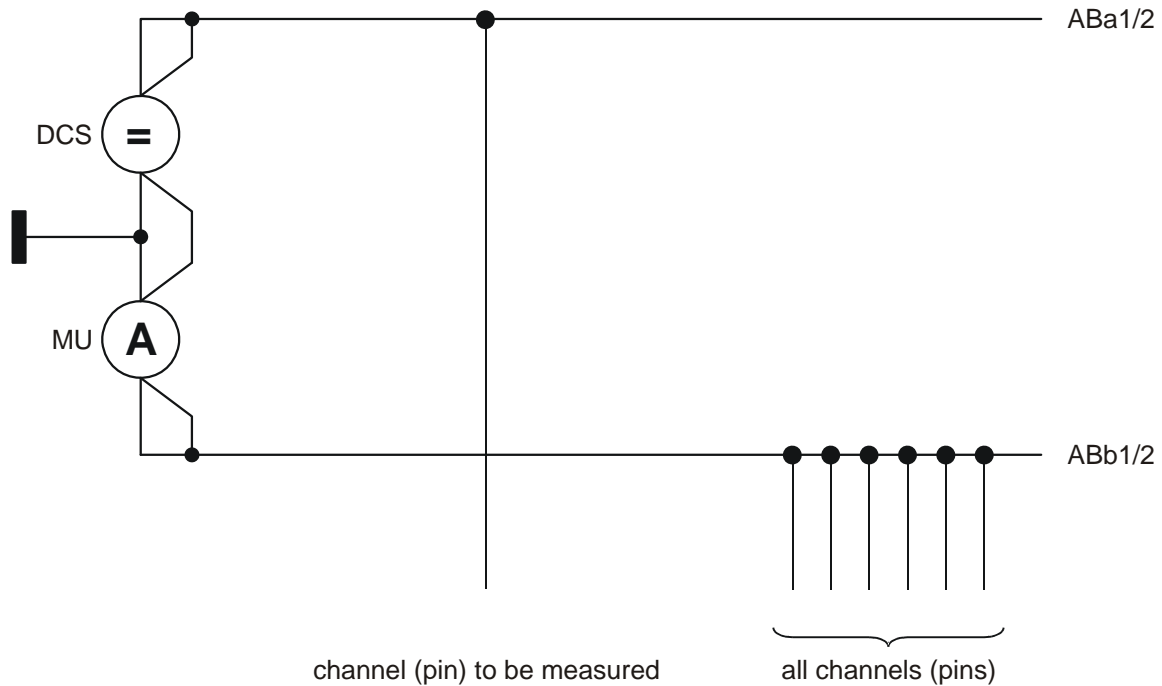


Figure 10-2 Connection for contact test

During the contact test it is to be checked whether there is a contact between all channels (pins) on the list and the unit under test. For this purpose, in principle the resistance between a channel (pin) to be tested and all other channels (pins) is measured.

The contact test is intended to ensure that, at the start of a test program, any errors produced subsequently are not due to poor contacts. It is thus reasonable to stop the test program after contact errors so that the subsequent tests such as the short-circuit test, continuity test and the component test are not performed.

The maximum permissible resistance or the minimum current necessary can be adjusted in the contact test. If the measured resistance is above the threshold value, it is assumed that there is no contact.

The voltage for the measurement is selected such that any diode paths present are forward biased (e.g. $U_{set} = 2.5\text{ V}$). If no current flow can be detected during the first measurement, then the poles of the source are reversed so that any diode paths present are forward biased. During

this process the current must be limited such that the components in the circuit are not destroyed (e.g. $I_{\text{max}} = 50 \mu\text{A}$).

The smallest measurable resistance is thus given by $U_{\text{set}} / I_{\text{max}}$. For smaller resistances, the DC source reaches the current limit and the resistance cannot be determined from the current measurement only.

Case 1: low resistance connection

The DC source reaches the current limit. The resistance cannot be determined because the voltage of the source is unknown. The current measured corresponds to the current limit. However, the resistance is certainly smaller than $U_{\text{set}} / I_{\text{max}}$. ($2.5 \text{ V} / 50 \mu\text{A} = 50 \text{ k}\Omega$).

Case 2: high resistance connection or open circuit

The DC source is not at the current limit. The resistance can be determined as follows:

$$R = U_{\text{set}} / I_{\text{meas}}$$



NOTE:

In the report on the contact test, the pins without contact are listed. All pins are tested, however a maximum of 10 pins without contact are listed.

10.4 Continuity test

License required: R&S TS-LEGT or R&S TS-LEG2



NOTE:

The connection for the continuity test is made in a similar manner to the connection for the contact test (see Figure 10-2). However, only two pins (pin pair) are ever connected to the analog bus.

With the aid of the continuity test it is checked whether there is continuity between a list of nodes (pins).

There is continuity when the resistance between two nodes (pins) is less than a defined value.

For the continuity test the voltage is selected such that diode paths are reverse biased (e.g. $U_{\text{set}} = 0.2 \text{ V}$). The current limit is set to the maximum possible value. In this way capacitors in the circuit are charged more quickly. During the charging process, a large current flows than could also be interpreted as continuity. If there is no continuity, then after the charging time the current will drop to an acceptable, stable value. If there is continuity, the DC source is either at the current limit and supplies the programmed current, or a current limited by the system residuals (approx. 1.2Ω) flows.

If the DC source is not at the current limit, the resistance of the continuity can be determined as follows:

$$R = U_{\text{set}} / I_{\text{meas}} - R_{\text{resid}}$$



NOTE:

The low resistance continuities or networks are listed in the report on the continuity test.

Example for report entry:

P1 P2/P3 . . . between P2 and P3 there is no continuity

10.5 Diode test

License required: R&S TS-LEGT

Test hardware	Module
DCS	R&S TS-PSAM
MU	R&S TS-PSAM
CMU	R&S TS-PICT

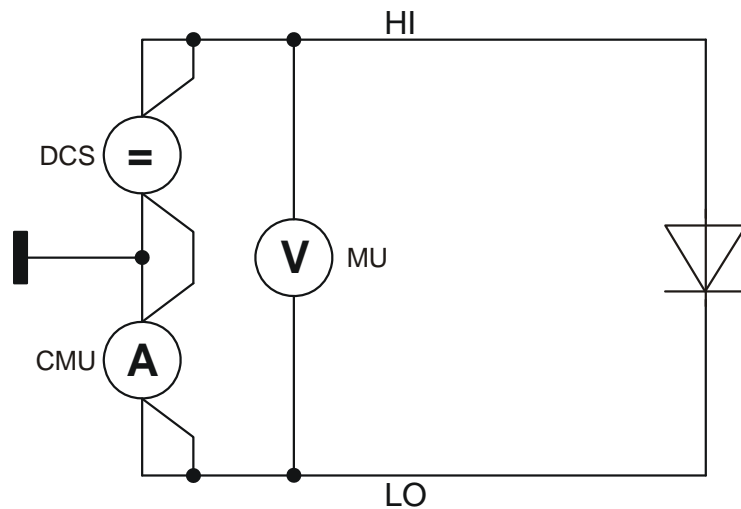


Figure 10-3 Diode test (forward bias voltage + reverse bias current)

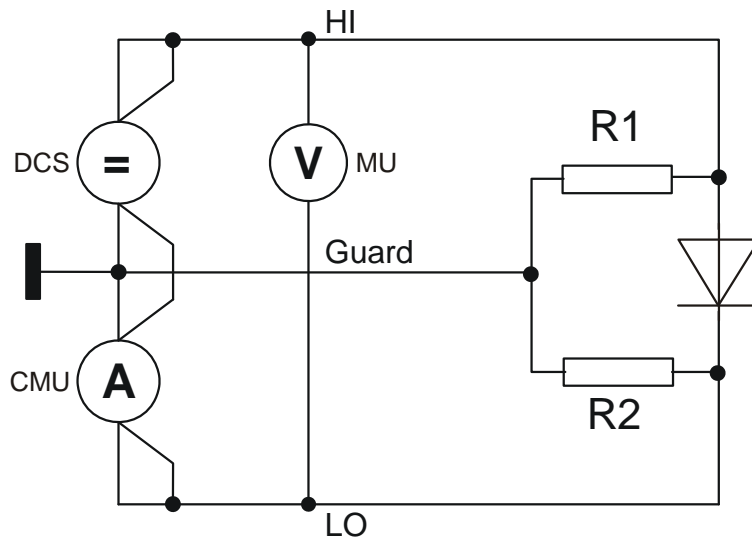


Figure 10-4 Diode test with guarding (forward bias voltage + reverse bias current)

During the diode test, the following tests are performed:

- Forward bias voltage (knee voltage) test
- Reverse bias current test



The same connection between measuring and stimulation hardware and the component to be tested is used for both tests. Only the settings for the test hardware are changed. This measuring process also applies for the diode test with guarding.

10.6 Discharging capacitors

License required: R&S TS-LEGT or R&S TS-LEG2

Test hardware	Module
DCH	R&S TS-PSAM
DCS	R&S TS-PSAM
MU	R&S TS-PSAM

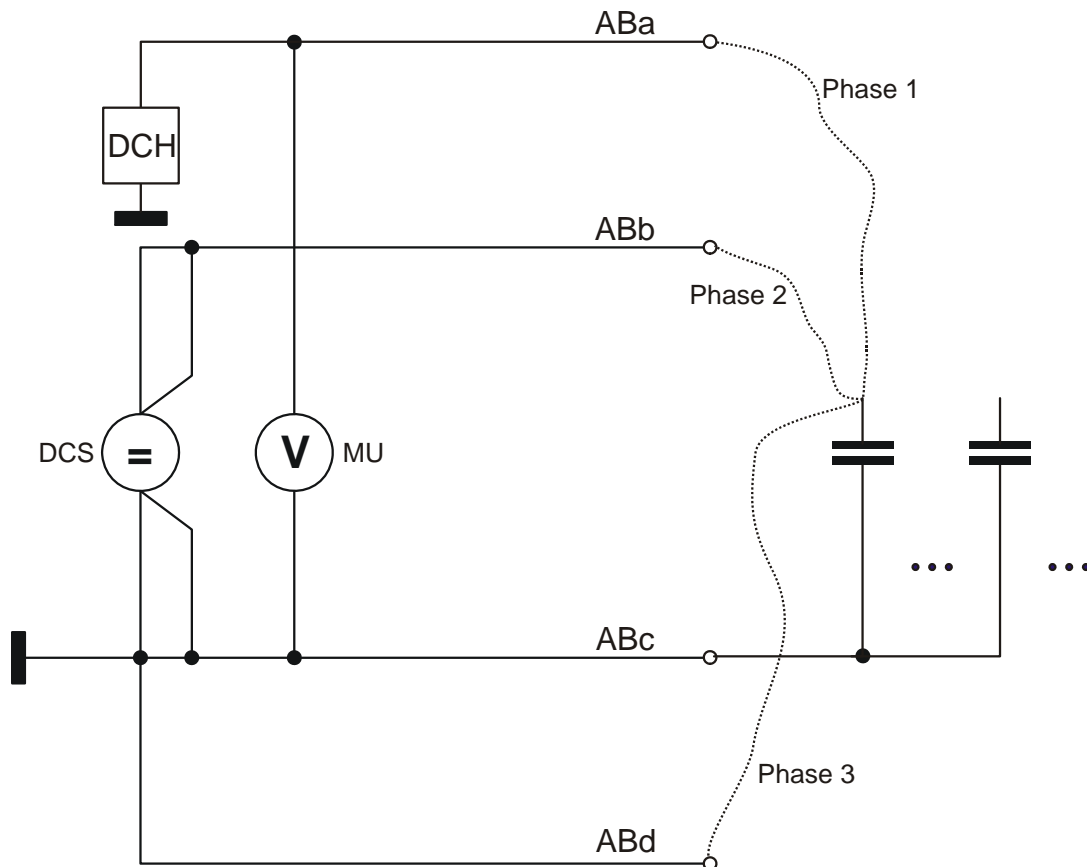


Figure 10-5 Discharge test

The capacitors are discharged in several phases. The main discharge is performed using the discharge circuit (DCH) on the R&S TS-PSAM.

Phase 1

The node / capacitor to be discharged (*test pin*) is connected using the analog bus A (ABa). The node / capacitor is discharged via the discharge circuit (DCH). The voltage at ABa is now measured cyclically. When the measured voltage drops below a defined value, phase 1 is complete.



Phase 2 The node / capacitor to be discharged(*test pin*) is switched from analog bus A (ABa) to analog bus B (ABb) and thus to the DC source (DCS). The discharge is now performed using the DCS at 100 mA. Phase 2 is complete when the DCS is no longer at the current limit.

Phase 3 The node / capacitor to be discharged (*test pin*) is switched to analog bus D (ABd) and thus shorted to the *reference pin*. During this phase the capacitor discharges via the cable resistances on the switching matrix.

If the maximum duration for the discharging of all nodes / capacitors (*test pins*) is exceeded, the test pins that have not yet been discharged are listed in the report. The pin on which the measuring time expired during discharging and for which the discharge process was not completed is also listed.

10.7 FET test

License required: R&S TS-LEGT

Test hardware	Module
DCS	TS-PSAM
VMU	TS-PSAM
AOS	TS-PICT

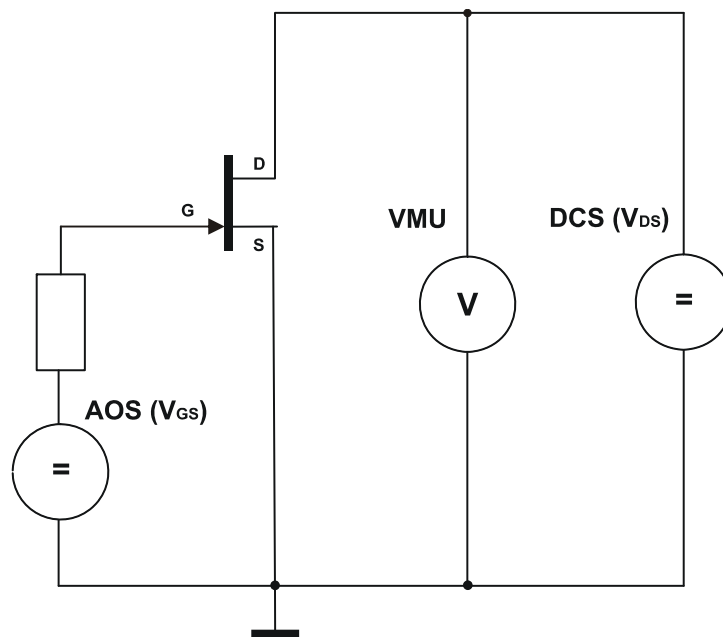


Figure 10-6 FET test

The AOS voltage source generates a voltage between the gate and source of a field-effect transistor. The DCS voltage source generates a voltage between the drain and the source. The value of the drain-source voltage is measured with the VMU voltmeter.

The gate-source voltage is first selected such that the drain-source channel of the FET is blocked (FET off). The set current limiting of the DCS voltage source does not respond. The DCS is in the constant-voltage mode. Voltmeter VMU is used to measure the voltage value set at the DCS.

In a second measurement, the voltage generated by the AOS between the gate and the source is selected such that the drain-source channel of the FET becomes conductive (FET on). The DCS voltage source switches to voltage limiting, i.e. the voltage of the DCS is reduced to the extent that exactly the current flows that is set via the voltage limiting value. Voltmeter VMU will now measure voltage that is considerably lower than the voltage set at the DCS.

10.8 Impedance test

The impedance test is used for components that cannot be measured using DC. These include capacitors and inductors. Using the AOS (AC-Offset Source) a sinusoidal voltage is applied, the current is measured using the CMU (Current Measurement Unit). At the same time the voltage applied to the measured object is measured using the MU (Measurement Unit). The complex resistance (= impedance) is determined from the two signal curves measured. The measured impedance can be represented as magnitude and phase, e.g. IMP-MAG and IMP-PHASE. It is also possible to represent the impedance as the real and imaginary parts, e.g. RES-SER, REAC-SER.

This impedance can be represented by a serial or parallel equivalent circuit. For a fixed frequency, both the serial and parallel equivalent circuit can be used. The actual component L or C can be calculated from the frequency (e.g. RES-PAR, CAP-PAR). Which equivalent circuit is more relevant to the practical situation depends on the specific case.

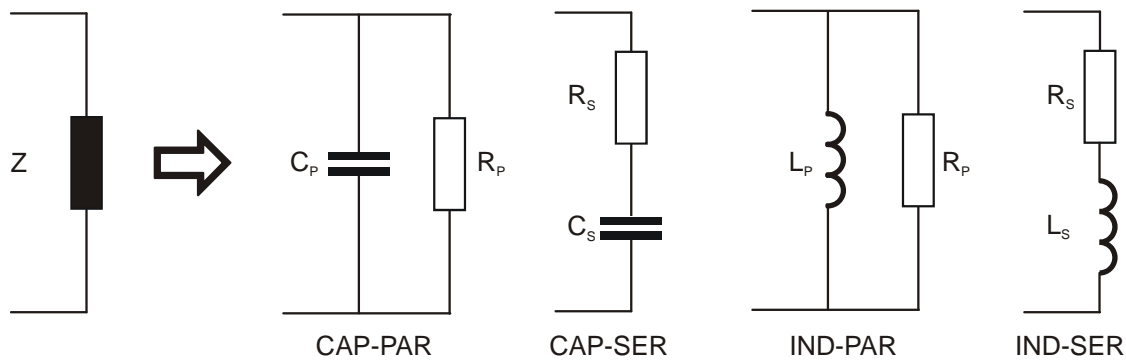


Figure 10-7 Equivalent circuit diagrams for determination of measured value

The values for the individual components vary depending on equivalent circuit. In practice the circuits drawn are often used. Here C_p and C_s (L_p and L_s) are relatively equal, while R_p has a very high value, and R_s has a very low value. Nevertheless, the related circuits have the same impedance.

10.8.1 2- and 4-wire measurement

License required: R&S TS-LEGT

Test hardware	Module
AOS	R&S TS-PICT
CMU	R&S TS-PICT
MU	R&S TS-PSAM

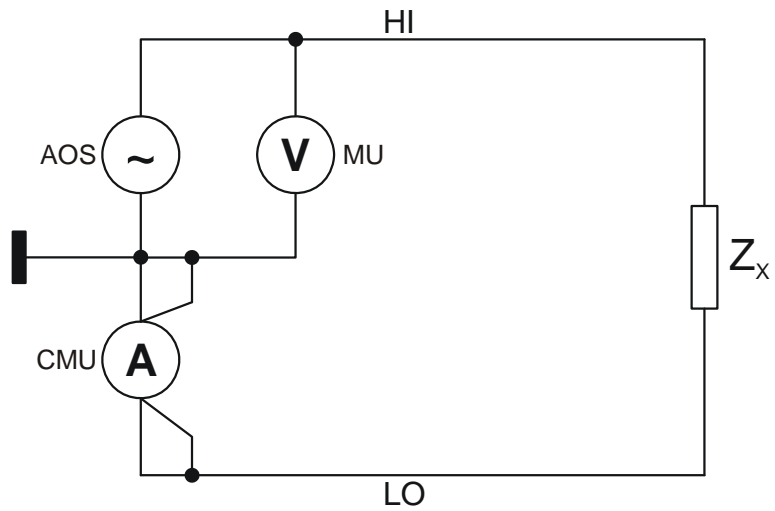


Figure 10-8 2-wire impedance measurement (mode V)

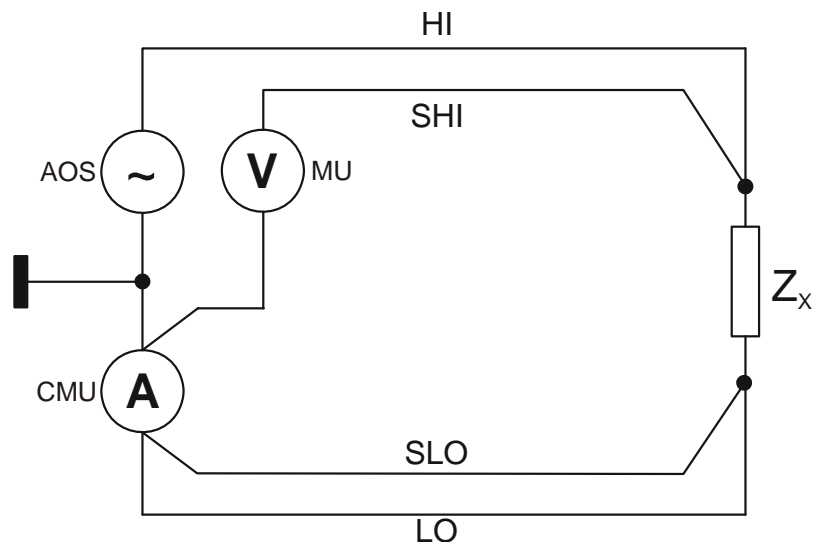


Figure 10-9 4-wire impedance measurement (mode VS)

On the R&S EGTSL in conjunction with the Test System Versatile Platform R&S CompactTSVP TS-PCA3 (R&S PowerTSVP TS-PWA3), all impedances are measured in mode V or VS, this means that a voltage is applied and the current is measured. To determine in particular the exact phase, the voltage must also be measured at the same time. In mode V the measuring instruments are connected directly together and two measuring wires fed from here to the unit under test (see Figure 10-8). During this simple 2-wire impedance measurement, all impedances in series are included as errors. You can compensate for this situation by connecting the voltmeter to the unit under test using separate wires and measuring the voltages directly (see Figure 10-9). For this purpose, four wires to the unit under test and the four nails in the bed of nails adapter are necessary (4-wire impedance measurement, also called Kelvin measurement).

10.8.2 Guarded measurement

License required: R&S TS-LEGT

Test hardware	Module
AOS	R&S TS-PICT
CMU	R&S TS-PICT
MU	R&S TS-PSAM

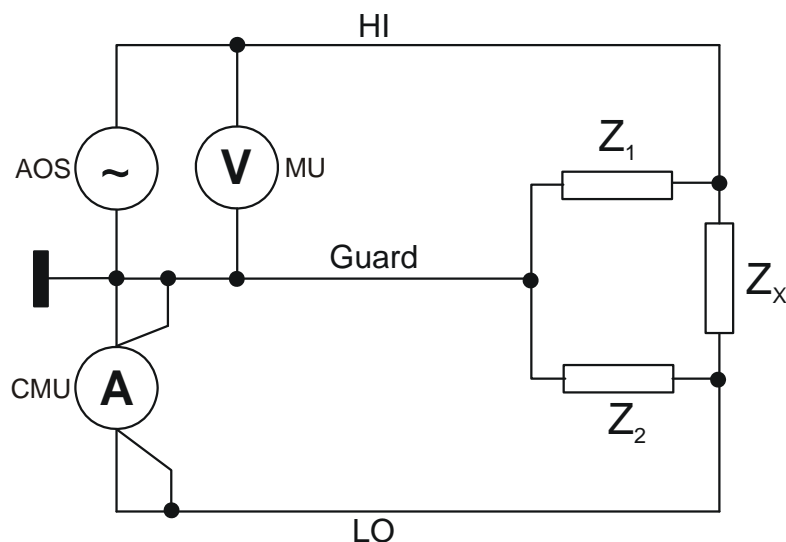


Figure 10-10 Guarded 3-wire impedance measurement

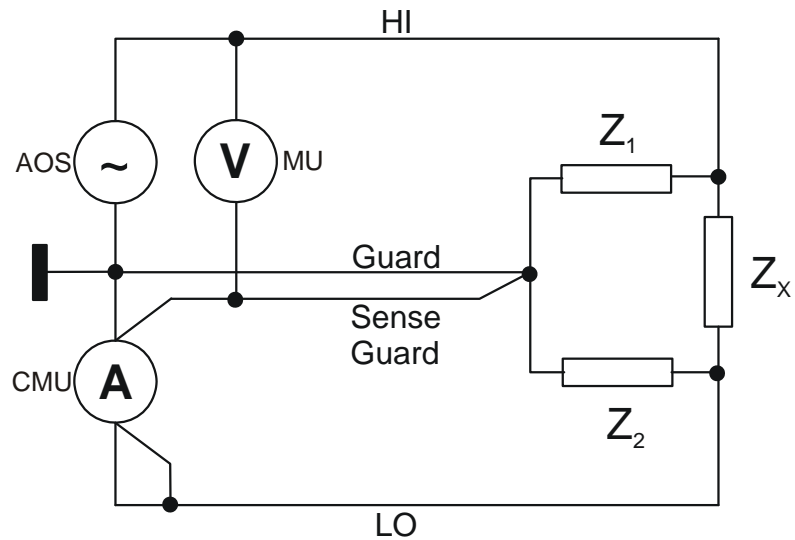


Figure 10-11 Guarded 4-wire impedance measurement

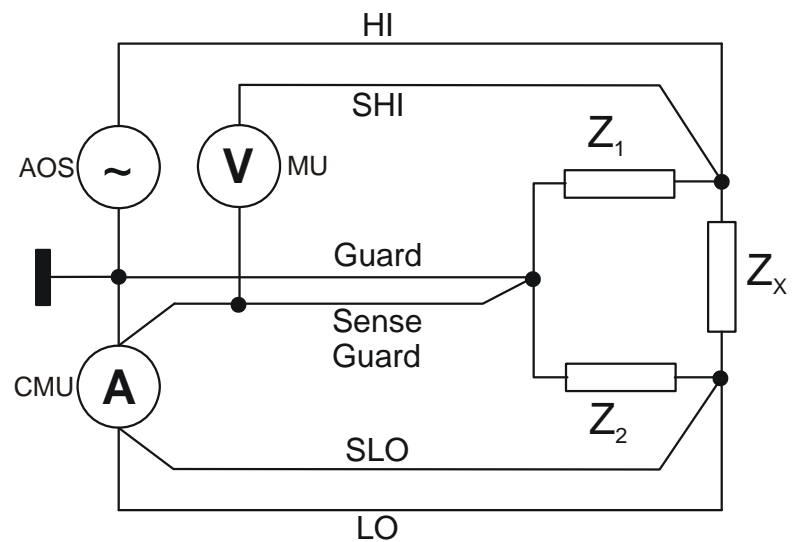


Figure 10-12 Guarded 6-wire impedance measurement

If there are several parallel branches on the unit under test, the parallel components can be electrically isolated (“guarding”). This is possible when each parallel path comprises at least two serial components. All these components can be combined to the components Z_1 and Z_2 (see Figure 10-10). The CMU ensures electronically that at Z_2 the voltage 0 V is present and in this way no current flows through Z_2 . In this way the CMU can measure exactly the current that also flows through Z_X . The current through Z_1 does not interfere with the measurement. This method is called guarding or 3-wire measurement.

In reality the wires are, however, not ideal such that voltage drops are produced on the wires due to the resistances of the wires (“residuals”). You can compensate for this problem by connecting separate sensor wires directly to the unit under test and measuring the voltage there. (Guarded 6-wire impedance measurement, see Figure 10-12). However, 6 nails must also be provided and the tester must also provide six pins. The main error on this measurement is produced by the guard path. For this reason there is a simplified guard measurement that only senses the guard branch (guarded 4-wire impedance measurement). This compromise only requires four nails (see Figure 10-11) The measuring accuracy achievable is between the guarded 3-wire impedance measurement and the guarded 6-wire impedance measurement. The guarded 4-wire impedance measurement must not be confused with the 4-wire impedance measurement (mode VS).

The lower the value of the impedances Z_1 or Z_2 referred to Z_x , the more difficult the measurement becomes. Guard ratios of up to 1:1000 can be measured ($Z_1 : Z_x$ or $Z_2 : Z_x = 1 : 1000$). However, with these guard ratios, a considerable compromise on measuring accuracy must be made.

During the circuit analysis by the Automatic Test Generator ATG such difficult measurements are detected and marked in the generation report with messages and alternative proposals.

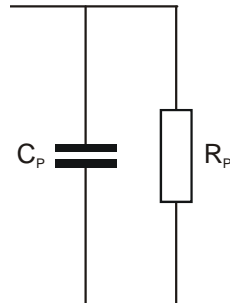
In practice the guarded 6-wire impedance measurement is used where high accuracy is required. The sensing requires

- More nails.
- More wiring in the adapter.
- A larger test setup (number of pins).

Overall the measurement becomes slower, the measurement throughput thus reduces.

10.8.3 Correct phase impedance measurement

The correct phase impedance measurement enables components directly in parallel to also be measured within limits.



The accuracy is best when the contributions for the real and reactive elements are of the same order of magnitude. At a low frequency R_p can be measured very precisely, as in this case the reactive element of C_p increases. R_p can be determined even better with a pure DC measurement.

10.8.4 System residuals

A basic problem is the differing system residuals depending on the system configuration. Every additional module connected to the analog bus changes the residuals by a few pF. A special correction method is used so that test programs run the same on different systems. Using the program ICT Correction all impedance measurements on a “typical pin” can be corrected. In this way different configurations and module fits can be corrected.

10.8.5 Measuring small capacitors

A particular challenge is the measurement of small capacitors, particularly in the range of 10 pF and smaller. Here there are capacitances (typically 60 pF to 90 pF) on the switching panel and analog bus in parallel that introduce errors directly into the measurement. In addition, there is scatter on the capacitances between two pins due to the switching panel and the adapter wiring. Only the scatter between switching panel pins is included in the measurement. These errors can be determined by reference measurements and taken into account in the measured result.



10.8.6 Measurement of polarized capacitors/electrolytic capacitors

Electrolytic capacitors only have their defined capacitance when a DC test voltage with the correct polarity is applied. For this reason electrolytic capacitors are stimulated with an AC voltage with an additional DC offset. Pole reversal up 0.5 V is allowed.

10.9 Resistor test

10.9.1 2-wire measurement

License required: R&S TS-LEGT or R&S TS-LEG2

Test hardware	Module
DCS	R&S TS-PSAM
MU	R&S TS-PSAM

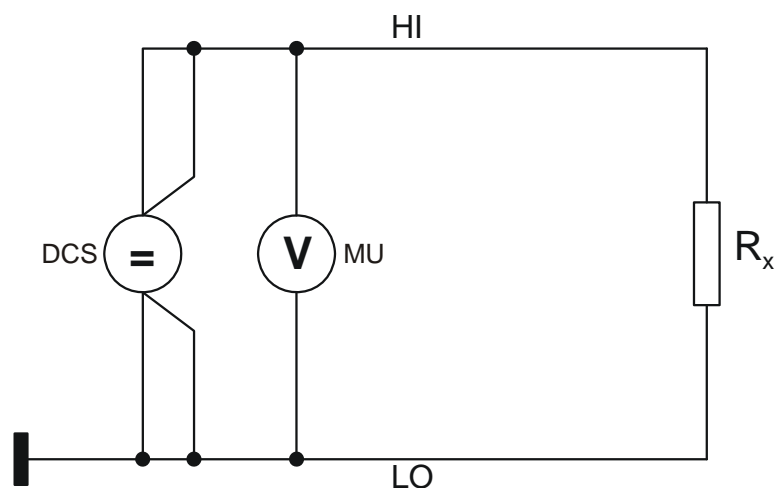


Figure 10-13 2-wire resistor measurement mode C

Mode C = application of current with voltage measurement

Mode C is intended for the measurement of low value resistors (<10 Ohm) with low accuracy requirements.



NOTE:

To keep the errors low, low value resistors should always be measured using the 4-wire resistor measurement mode C.

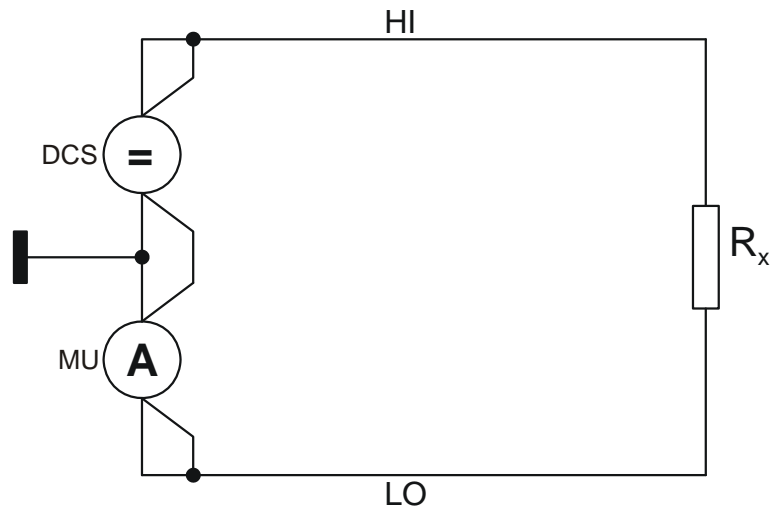


Figure 10-14 2-wire resistor measurement mode V

Mode V = application of voltage with current measurement

The 2-wire resistor measurement mode V is the standard measuring method for high value resistors. The 2-wire resistor measurement mode V is also used for the measurement of resistors in a range from 100 Ω to 1 M Ω if medium measuring accuracy is sufficient. The measurement is faster than the 4-wire measurement mode VS.

Due to the application of voltage, mode V has the advantage that capacitances on the Unit Under Test (UUT) are charged quickly and the measuring speed is thus increased. Due to the defined voltage that always remains the same, parallel diode paths and ICs are not forward biased or are only evenly slightly forward biased. This increases the reproducibility of the measurement.

10.9.2 4-wire measurement

License required: R&S TS-LEGT or R&S TS-LEG2

Test hardware	Module
DCS	R&S TS-PSAM
MU	R&S TS-PSAM

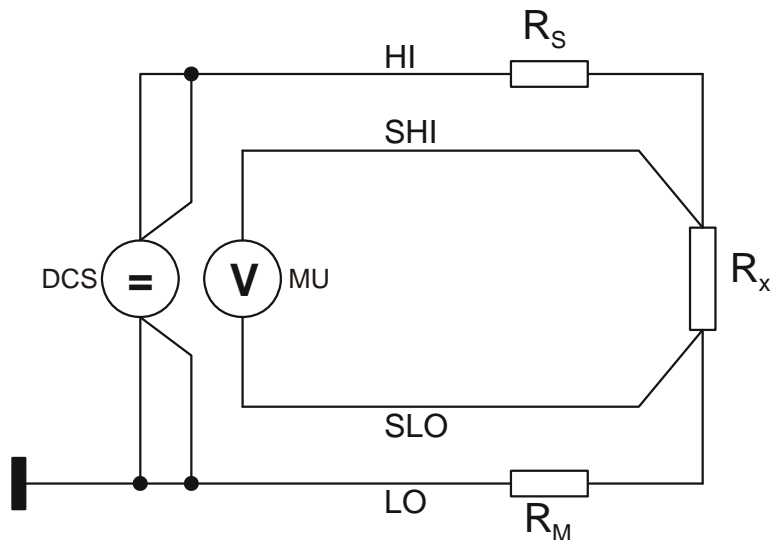


Figure 10-15 4-wire resistance measurement mode CS

Mode C = application of current with voltage measurement

The 4-wire resistance measurement mode CS is intended for resistors in the range 0.01 Ohm to 10 Ohm.

By measuring the voltage directly at the component to be tested, voltage drops on the wires do not affect the result of the measurement.

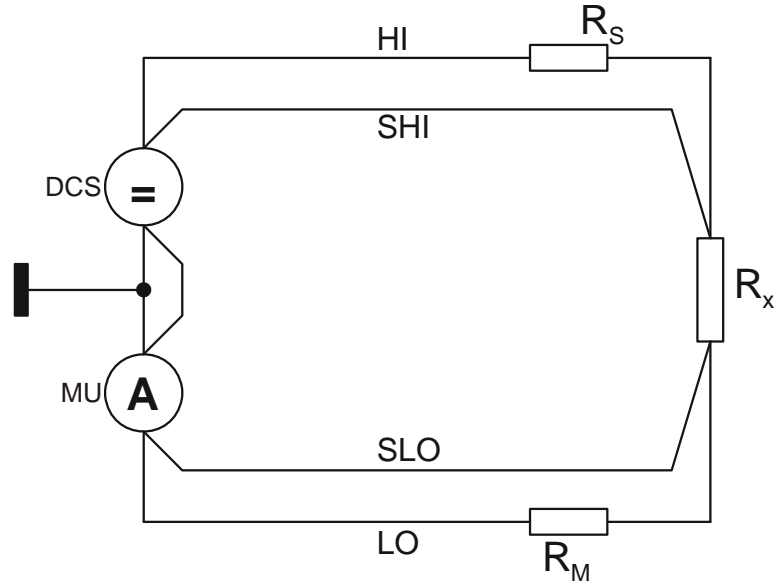


Figure 10-16 4-wire resistor measurement mode VS

Mode V = application of voltage with current measurement

The 4-wire resistor measurement mode VS is intended for resistors in the range 10 Ohm to 10 kOhm.

Scattering on the switching paths can be almost completely compensated by sensing. The measuring speed is however lower than for measurement without sensing.

10.9.3 Guarded measurement

License required: R&S TS-LEGT

Test hardware	Module
DCS	R&S TS-PSAM
CMU	R&S TS-PICT



NOTE:

All guarded measurement take place in mode V (application of voltage with current measurement).

The same requirements as for the 2-wire and the 4-wire measurement apply.

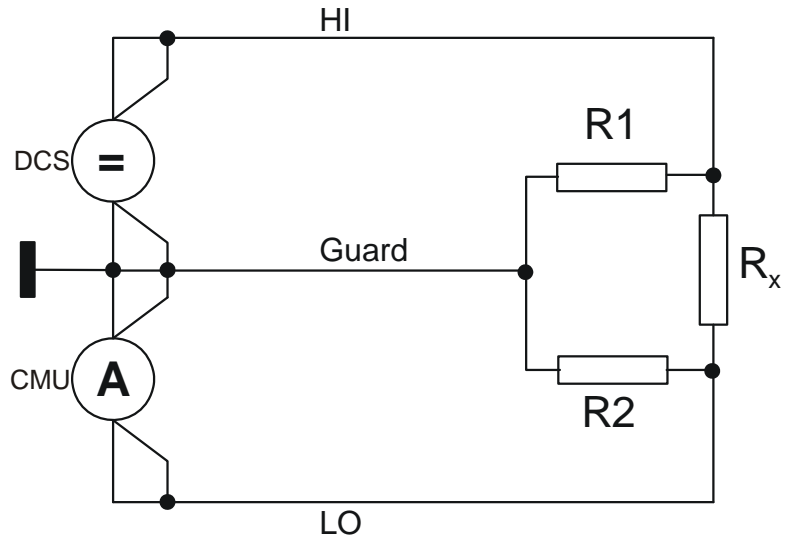


Figure 10-17 Guarded 3-wire resistor measurement

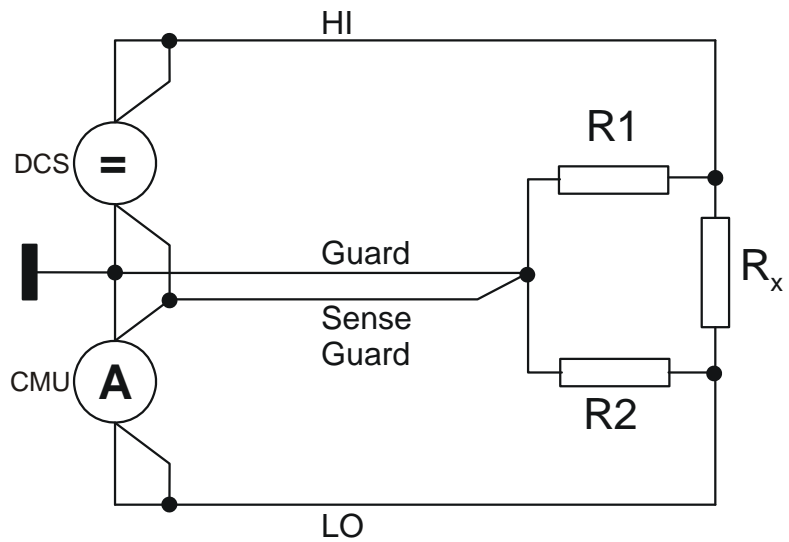


Figure 10-18 Guarded 4-wire resistor measurement

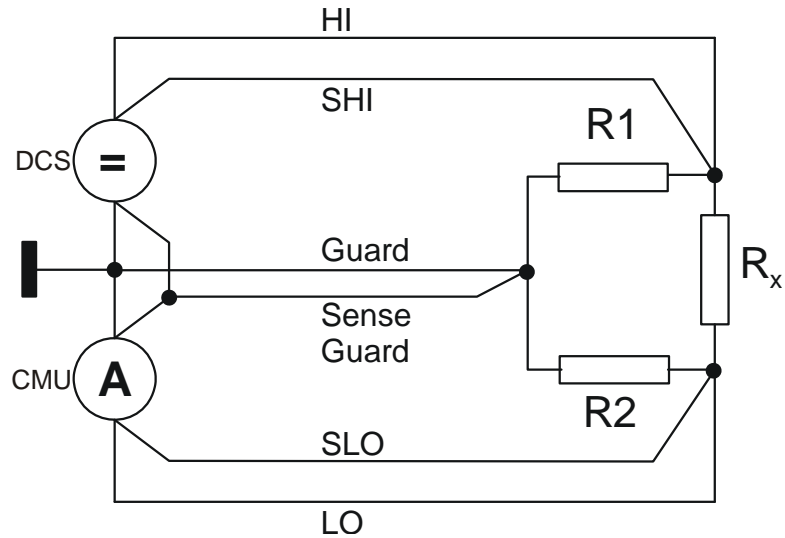


Figure 10-19 Guarded 6-wire resistor measurement

The mode V method (application of voltage with current measurement) has the same advantages for guarded resistor measurements (speed and reproducibility) as for unguarded resistor measurements. For this reason, mode C (application of current with voltage measurement) is not used for guarded resistor measurements.

The system residuals (series resistors and series inductors) can be compensated by sensing. The error due to the guard path is in general an order of magnitude higher than the error on the stimulation and measuring path.

The most precise measuring method “guarded 6-wire resistor measurement” also requires the most effort for test nails in the test adapter and tester setup. The “guarded 4-wire resistor measurement” is a compromise here, as only the particularly high guard error is removed. However, only 4 nails are needed for this measurement.

10.10 Short-circuit test

License required: R&S TS-LEGT or R&S TS-LEG2



NOTE:

The connection of the short-circuit test is performed in exactly the same manner as for the connection of the contact test (see Figure 10-2)

With the aid of the short-circuit test (short) it is intended to detect short-circuits between two nodes (pins) on an assembly.

There is a short-circuit when a resistance that is less than a defined resistance threshold is measured between a channel (pin) and all other channels (pins).

During this test the voltage is selected such that diode paths are not forward biased (e.g. $U_{\text{set}} = 0.2 \text{ V}$). The current limit is set to the maximum possible value. In this way capacitors in the circuit are charged more quickly. During the charging process, a large current flows that could also be interpreted as a short-circuit. If there is no short-circuit, then after the charging time the current will drop to an acceptable, stable value. If there is a short-circuit, the DC source is either at the current limit and supplies the current programmed, or a current limited by the system residuals flows.

To perform this measurement at maximum speed, it is necessary to monitor the transient process (timing). As long as the DC source is at the current limit, or the current flow is changing, capacitances are still being charged or there is a short-circuit. Only if the flow of current drops to a value under the threshold after a certain amount of time is there no short-circuit. The response time is essentially dependent on the capacitances present, the wire resistances, the parallel resistance and the programmed current limit.

The short-circuit test implemented in R&S EGTSL features high test speed and high reliability at the same time. This is achieved by using a two-stage test method.

In the first stage, each pin (test point, node) is checked against all other pins. However due to the parallel switching used during this process, a large number of pseudo short-circuits (e.g. due to capacitors) are detected that are not actually “real” short-circuits. R&S EGTSL therefore only considers these “suspicious pins”.

In the second stage these “suspicious pins” are tested again. In this

stage the “timing” parameters for the short-circuit test are applied. Finally, only real short-circuits (connections or networks) are listed in the report

10.11 Transistor test

License required: R&S TS-LEGT

Test hardware	Module
DCS	R&S TS-PSAM
MU	R&S TS-PSAM

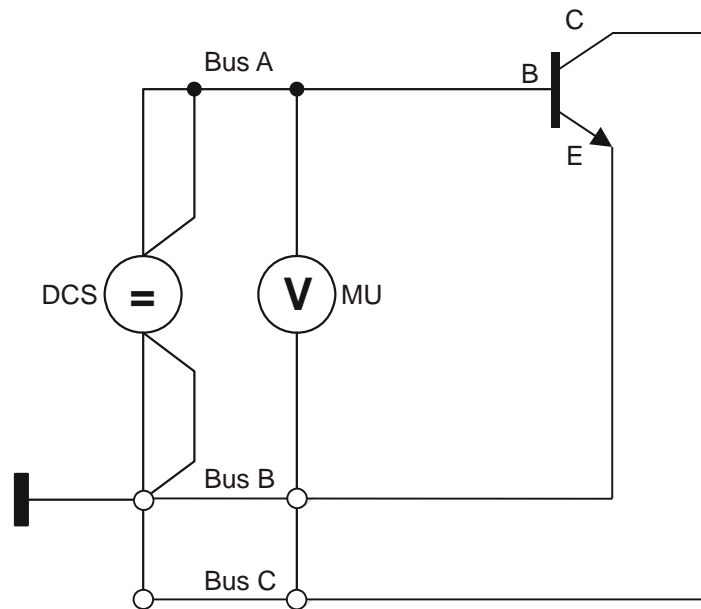


Figure 10-20 Transistor test (voltage measurements)

During the transistor test the forward bias voltage (knee voltage) for the base-emitter diode and the base-collector diode are measured. Guarding is not performed.

Using the transistor test, pins that are not soldered and incorrectly positioned components (e.g. PNP instead of NPN) can be found. A beta test is not performed.

10.12 Transistor Beta

License required: R&S TS-LEGT

Test hardware	Module
CH2	R&S TS-PSU / R&S TS-PSU12 (channel 2)
DCS	R&S TS-PSAM
VMU	R&S TS-PSAM
CMU	R&S TS-PICT

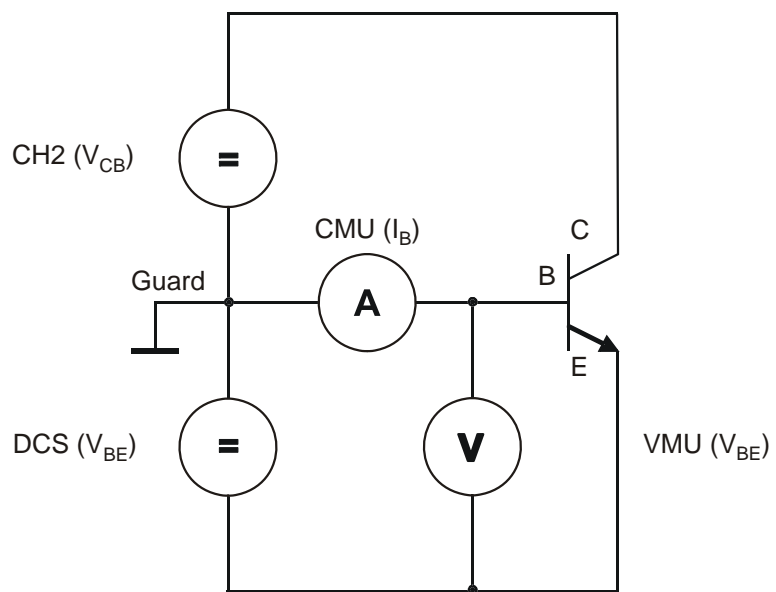


Figure 10-21 Transistor Beta test

The voltage source R&S TS-PSU / R&S TS-PSU12 generates a voltage between the base and collector of the transistor. Current limiting must be set high enough so that the source can provide sufficient current for the transistor and any branches wired in parallel that may be present.

The voltage source DCS generates a voltage between the base and emitter of the transistor. Current limiting must be adjusted so that the source is working in constant current mode.

The forward bias voltage (knee voltage) over the base emitter diode is measured in the first measurement (voltage V_{BE} , see Figure 10-21).

A constant current I_E is impressed in the emitter branch with the DCS for the measurement of the current gain (Beta β , see Figure 10-21). At the same time the current I_B is measured in the base branch. Then the emitter current is changed by a small amount and a second measurement of the base current is performed. The dynamic current gain Beta β is calculated from these measurements as follows:

$$\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{\Delta I_E - \Delta I_B}{\Delta I_B}$$

The current gain Beta β is calculated from the ratio of the change in current in the collector circuit to the change in current in the base circuit. The collector current can be expressed as the difference between the emitter current and the base current.

In the event of a guarded measurement, all guard points are connected with the ground reference point.

The measurement for PNP transistors runs in the same manner, with the difference that the polarity of the two voltage sources is reversed.

10.13 Zener Diode

License required: R&S TS-LEGT

Test hardware	Module
CH1/CH2	R&S TS-PSU / R&S TS-PSU12
MU	R&S TS-PSAM

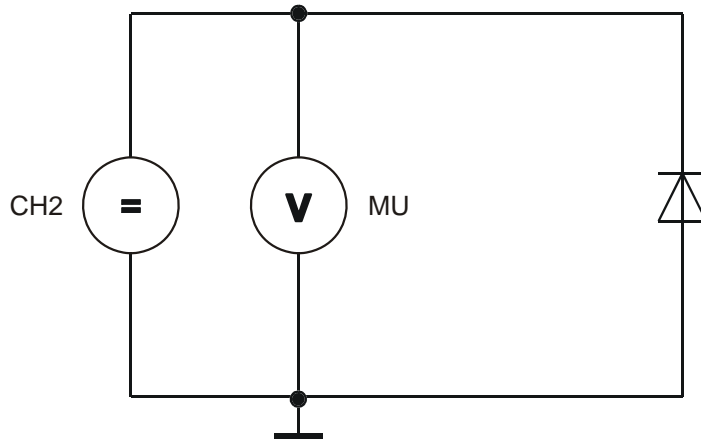


Figure 10-22 Zener Diode test

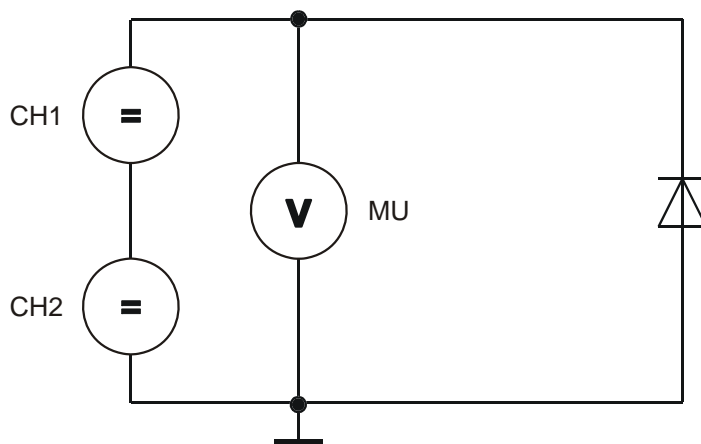


Figure 10-23 Zener Diode test (> 50 V / 12 V, cascaded)

During the zener diode test, the voltage source R&S TS-PSU / R&S TS-PSU12 generates a voltage in the reverse direction of the diode which is somewhat above the Zener voltage. Current limiting must be adjusted so that the voltage source is working in constant current mode. Now the working voltage (zener voltage) can be adjusted by the zener diode and measured with a voltmeter.


WARNING!

It is essential in Zener diode tests to ensure that no components of the Unit Under Test can be damaged by the high stimulus voltages!

An individual channel of the voltage source R&S TS-PSU can produce a maximum of 50 V (R&S TS-PSU12 : 12 V). To be able to test Zener diodes with higher voltages, both channels of the R&S TS-PSU / R&S TS-PSU12 must be cascaded (see Figure 10-23). This cascading is not possible on the module itself. It must be provided in the test adapter.

The connection is produced with the front multiplexer of the two channels CH1 and CH2. To do this, outputs CH2_HI4 and CH1_LO4 on front connector X10 of the R&S TS-PSU / R&S TS-PSU12 module must be connected with each other (see Figure 10-24).

The multiplexer outputs represented with Figure 10-24 hatched lines must not be used if channels will be cascaded for a Zener diode test.


ELECTROCUTION HAZARD!

When the two output channels are cascaded, voltages up to 100 V and dangerous to touch may occur! The adapter must be equipped with the appropriate warning signs.

For measurements in circuits with voltages $V_{rms} > 30$ V, suitable measures should be taken to avoid any hazards.

(using, for example, appropriate measuring equipment, fusing, current limiting, electrical separation, insulation).

	A	B	C
1	LABA1	GND	LABA2
2	LABB1	GND	LABB2
3	LABC1	GND	LABC2
4	LABD1	GND	LABD2
5			
6	CH1_HI1	CH1_HI1	CH1_HI1
7	CH1_LO1	CH1_LO1	CH1_LO1
8	CH1_HI2	CH1_HI2	CH1_HI2
9	CH1_LO2	CH1_LO2	CH1_LO2
10	CH1_HI3	CH1_HI3	CH1_HI3
11	CH1_LO3	CH1_LO3	CH1_LO3
12	CH1_HI4	CH1_HI4	CH1_HI4
13	CH1_LO4	CH1_LO4	CH1_LO4
14	CH1_SHI1		CH1_SLO1
15	CH1_SHI2	CH1_MHI	CH1_SLO2
16	CH1_SHI3	CH1_MLO	CH1_SLO3
17	CH1_SHI4		CH1_SLO4
18	CH2_HI1	CH2_HI1	CH2_HI1
19	CH2_LO1	CH2_LO1	CH2_LO1
20	CH2_HI2	CH2_HI2	CH2_HI2
21	CH2_LO2	CH2_LO2	CH2_LO2
22	CH2_HI3	CH2_HI3	CH2_HI3
23	CH2_LO3	CH2_LO3	CH2_LO3
24	CH2_HI4	CH2_HI4	CH2_HI4
25	CH2_LO4	CH2_LO4	CH2_LO4
26	CH2_SHI1		CH2_SLO1
27	CH2_SHI2	CH2_MHI	CH2_SLO2
28	CH2_SHI3	CH2_MLO	CH2_SLO3
29	CH2_SHI4		CH2_SLO4
30			
31	XTI1	XTI2	GND
32	XTO1	XTO2	CHA_GND

X10 C 13

X10 C 24

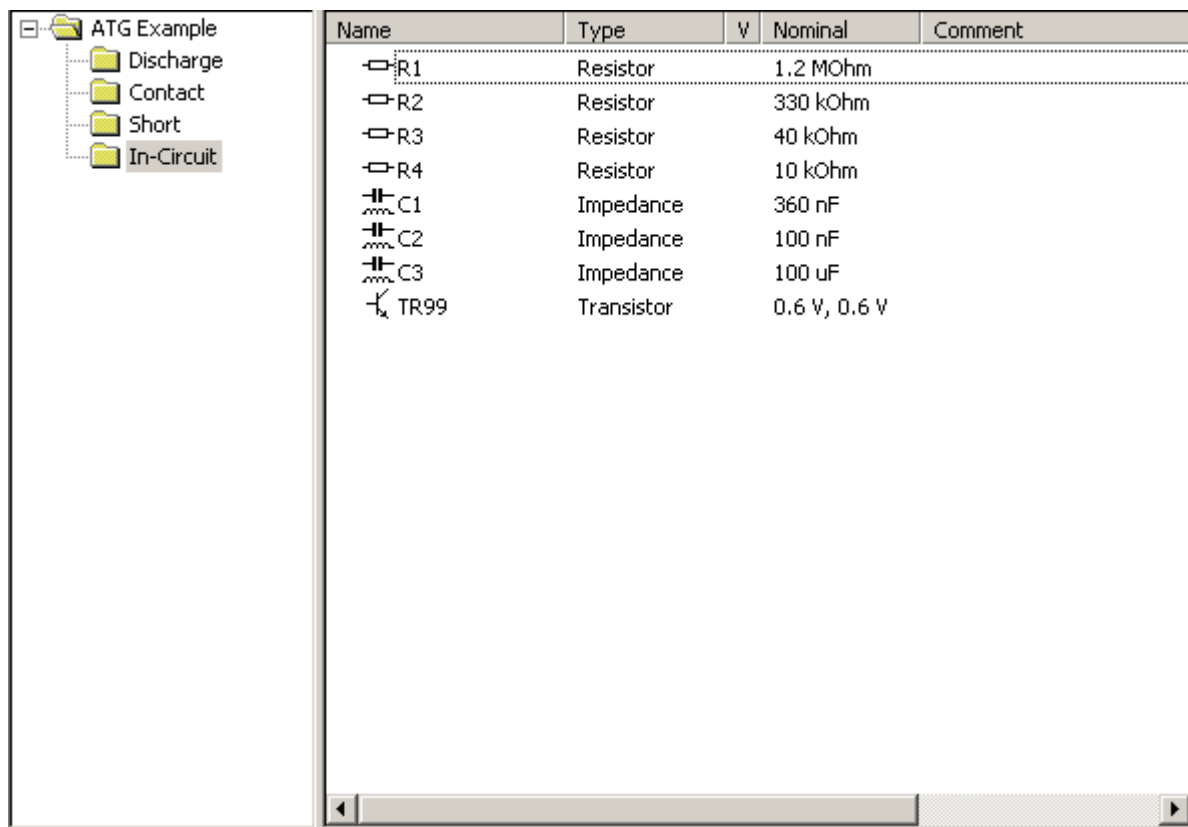
Figure 10-24 Zener Diode Test, Adapter Cabling for Voltage > 50 V



11 Creating test programs

11.1 Program groups

It is practical to divide the ICT program into several program groups. This is done automatically when an ICT program is created with the Automatic Test Generator ATG (see section 9.3.1 ff.).



Name	Type	V	Nominal	Comment
R1	Resistor		1.2 MOhm	
R2	Resistor		330 kOhm	
R3	Resistor		40 kOhm	
R4	Resistor		10 kOhm	
C1	Impedance		360 nF	
C2	Impedance		100 nF	
C3	Impedance		100 uF	
TR99	Transistor		0.6 V, 0.6 V	

Figure 11-1 Program sub-window

When an ICT program is started with a function call of the ICT test library (e.g. from C-Program in production mode) the executable program group can be transferred as a parameter. Only the selected program group is executed. If, during the running of the program group, one or more errors occur (e.g. if the discharge or the contact for the unit under testing have failed), the testing of the unit can be immediately aborted. The ICT program does not have to run to the end. This way, unnecessary testing time can be avoided.

Through the **<Step Properties>**, the **Fail Count** function can be activated for the program group (see section 5.6.2.3).



The call is made either through the menu command **<Edit><Step Properties>**, the key combination **[Alt+Enter]**, the button **Step Properties** or the context menu.

When the **Fail Count** function is activated, the erroneous test steps in a program group are counted. If the given number of erroneous test steps is reached, none of the subsequent test steps in the program group are executed. The **Fail Count** function is only active when an ICT program is started through the functions of the ICT test library.

An example of combining individual test steps into a program group and working with the **Fail Count** function is the testing of resistor arrays. A test step is created for each individual resistor of the resistor array. The individual test steps are combined into a program group. The **Fail Count** of the program group is set to the value „1“. If a resistor of the resistor array tests as „Failed“, the testing of the other resistors in the program group is cancelled and the measured result of the entire program group is set to „Failed“.

A further example of the use of the **Fail Count** function is the activation at the highest program group, i.e. for the entire ICT program. For the ICT program in Figure 11-1, this is the program group **“ATG Example”**. As soon as an error occurs in one of the program groups lower in the hierarchy, the testing of the further program groups is cancelled and the ICT program is terminated with the result **“Failed”** for the unit under test.

11.2 Variants

11.2.1 Use

By using variants, units under test which show only small deviations from one another can be tested with the same ICT program. Using a single ICT program has the following advantages:

- One uniform ICT program for the same test steps or same test parts.
- Changes need only be carried out in one ICT program.
- Only one ICT program needs to be tested (Debugging).

Test steps (or groups) with variant definitions are used in the following cases in the ICT program:

- A component is assembled in the original version but not in the variant XYZ. The test step is only executed in the original version.
- A component has a different value range in the original version than in the variant XYZ. Thus, other measuring tolerances will result for the test step. In an extreme case, another test method is defined for the test step in the variant XYZ.
- When using special test strategies, it may be practical to test a component with various test methods and measuring tolerances.
- Using your own variant definition, test steps can be activated and deactivated while debugging the ICT program.
- Variants can be defined for comments and non-executable test steps.
- During the automatic generation of an ICT program with the Automatic Test Generator ATG, the alternative proposals for measurements created by the ATG are identified as variants (variant name: *Proposal*). Also see section 9.3.2.2.

11.2.2 Definition

Before a variant can be used, it must be defined in the <Program Properties> (see section 5.6.1.6). The call is made using the menu command <File><Program Properties>.

A name and a short description are entered for the variant. The defined variants are valid for the entire ICT program.

11.2.3 Assignment

A variant can be assigned to a test step or a group. The assignment is made through **Variant Selection** in <Step Properties> (see section 5.6.2.3.).



The call is made through either the menu command <Edit><Step Properties>, the key combination **[Alt+Enter]**, the **Step Properties** button or the context menu.

Test steps or groups to which a variant is assigned are identified in the debug mode (R&S EGTSL IDE) in the program sub-window with a „V“ in the variant column.

Name	Type	V	Nominal	Comment
Zx	Impedance		1 uF	
Diode	Diode		0.7 V, -5 uA	
Transistor T7000	Transistor	V	0.7 V, 0.7 V	Testtransistor
Transistor T7000	Transistor	V	0.7 V, 0.7 V	Testtransistor
Transistor T7000	Transistor	V	0.7 V, 0.7 V	Testtransistor
RTest	Resistor		500 Ohm	
Contact	Contact			
Zx	Impedance		1 uF	
Diode D25	Diode		0.7 V, -5 uA	Testdiode
Continuity	Continuity			
Rx	Resistor		100 Ohm	

Figure 11-2 Variant identification

In the program sub-window, the deactivated variants are shown as crossed through.

Name	Type	V	Nominal	Comment
Zx	Impedance		1 uF	
Diode	Diode		0.7 V, -5 uA	
Transistor T7000	Transistor	V	0.7 V, 0.7 V	Testtransistor
Transistor T7000	Transistor	V	0.7 V, 0.7 V	Testtransistor
Transistor T7000	Transistor	V	0.7 V, 0.7 V	Testtransistor
RTest	Resistor		500 Ohm	
Contact	Contact			
Zx	Impedance		1 uF	
Diode D25	Diode		0.7 V, -5 uA	Testdiode
Continuity	Continuity			
Rx	Resistor		100 Ohm	

Figure 11-3 Deactivated variants

11.2.4 Execution

When an ICT program is started through the functions of the ICT test library (e.g. from C-Program in production mode), the executable variant can be transferred as a parameter. The ICT program is executed with the selected variant.

When an ICT program is started in debug mode (R&S EGTSL IDE), the executable variant is displayed in the **Debug** sub-window in the **Variant** menu. Also see section 5.4.6.

11.3 Limit Files

Through the use of limit files, it is possible to separate the limit values from the ICT program. The limit files can be stored and processed in a central place. By calling different limit files with different limit values in an ICT program, a more detailed report on the unit under test is possible (e.g. narrower measuring tolerances).

By using different limit values for an ICT program, variant control is also possible. Thus, identical units under test which differ from one another simply in the tolerances of the assembled components, can be tested with the same ICT program.

Before an ICT program is started through the functions of the ICT test library, one or more limit files can be loaded (e.g. from C-Program in production mode). The ICT program is executed with the loaded limit values.



CAUTION!

In the limit files, only the limit values without units of measurement are stored. The units of measurement are stored in the ICT program.

When the limit files are loaded, only the limit values which are entered in the limit files are temporarily changed in the ICT program. Test steps for which no limit values are entered in the limit files remain unchanged.

Further information for loading, import and export of the limit values in debug mode (R&S EGTSL IDE), and the format of the limit files can be seen in section 5.6.1.7.

11.4 Multiple panel testing

If components are manufactured in multiple panels, one ICT program is created for all panels. This process does not differ from the creation of an ICT program for a single unit (e.g. creation by the Automatic Test Generator ATG). It is not practical to create a separate ICT program for each unit of the multiple panel. Using only one ICT program has the following advantages:

- One uniform ICT program for all panels.
- Changes need only be carried out in one ICT program.
- Only one ICT program needs to be tested (Debugging).

Because, as a rule, the design and the assembly of the individual panels is identical, only the individual different contacts need to be adjusted.

The control of the ICT program for the individual panels is done through bench entries in the Application Layer Configuration File (see example in section 11.4.1). Each panel is assigned its own bench entry with its own I/O channel list. In the I/O channel lists, the different I/O channels of the matrix cards R&S TS-PMB are assigned to the identical test points (nodes). When possible, a unique matrix card R&S TS-PMB should be used for the wiring of each individual panel.

When the ICT program is loaded, the bench which is to be executed must be entered. This also applies to a call through the functions of the ICT test library (e.g. from C-Program in production mode), and to a call through the R&S EGTSLloader (R&S EGTSL IDE in debug mode). Thus, all panels can be tested by calling the same ICT program with different benches assigned.

11.4.1 Example of an Application Layer Configuration File for Multiple Uses

When an ICT program is created by the Automatic Test Generator ATG, only one bench with one I/O channel list is generated. For use during a multiple panel test, the Application Layer Configuration File must be processed in a text editor. The bench generated by the ATG must be copied and the individual entries adjusted.



```
[ResourceManager]
; general trace settings (normally off)
Trace           = 0
TraceFile       = %GTSLROOT%\resmgr_trace.txt

;-----
[LogicalNames]
ICT = bench->ICT_Panel_1
ICT = bench->ICT_Panel_2
ICT = bench->ICT_Panel_3
ICT = bench->ICT_Panel_4

;-----
[bench->ICT_Panel_1]
Description     = ICT bench Panel 1 (Simulation)
Simulation      = 1
Trace           = 0
ICTDevice1     = device->psam
ICTDevice2     = device->pict
SwitchDevice1  = device->pmb1
AppChannelTable = io_channel->ICT_Panel_1

[io_channel->ICT_Panel_1]
GND             = pmb1!P1
INPUT           = pmb1!P2
OUTPUT         = pmb1!P3
TR1.B          = pmb1!P4
TR1.C          = pmb1!P5
TR1.E          = pmb1!P6
VCC            = pmb1!P7

;-----
[bench->ICT_Panel_2]
Description     = ICT bench Panel 2 (Simulation)
Simulation      = 1
Trace           = 0
ICTDevice1     = device->psam
ICTDevice2     = device->pict
SwitchDevice1  = device->pmb2
AppChannelTable = io_channel->ICT_Panel_2

[io_channel->ICT_Panel_2]
GND             = pmb2!P1
INPUT           = pmb2!P2
OUTPUT         = pmb2!P3
TR1.B          = pmb2!P4
TR1.C          = pmb2!P5
TR1.E          = pmb2!P6
VCC            = pmb2!P7

;-----
[bench->ICT_Panel_3]
Description     = ICT bench Panel 3 (Simulation)
Simulation      = 1
Trace           = 0
ICTDevice1     = device->psam
ICTDevice2     = device->pict
SwitchDevice1  = device->pmb3
AppChannelTable = io_channel->ICT_Panel_3

[io_channel->ICT_Panel_3]
GND             = pmb3!P1
INPUT           = pmb3!P2
OUTPUT         = pmb3!P3
TR1.B          = pmb3!P4
TR1.C          = pmb3!P5
TR1.E          = pmb3!P6
```




```
VCC          = pmb3!P7

;-----
[bench->ICT_Panel_4]
Description   = ICT bench Panel 4 (Simulation)
Simulation    = 1
Trace        = 0
ICTDevice1   = device->psam
ICTDevice2   = device->pict
SwitchDevice1 = device->pmb4
AppChannelTable = io_channel->ICT_Panel_4

[io_channel->ICT_Panel_4]
GND          = pmb4!P1
INPUT       = pmb4!P2
OUTPUT      = pmb4!P3
TR1.B      = pmb4!P4
TR1.C      = pmb4!P5
TR1.E      = pmb4!P6
VCC        = pmb4!P7

;-----
```



12 Debugger

12.1 Overview

The debugging of an ICT program in the Enhanced Generic Test Software Library is done in the R&S EGTSL-user interface (*R&S EGTSL IDE*). In the debug mode of the *R&S EGTSL IDE*

- the ICT program can be executed test step by test step.
- the measured results can be analysed.
- corrections can be made in the ICT program.

The ICT program is immediately ready to be executed after the changes, without having to be compiled and restarted.

The following actions are possible in debug mode:

- starting and stopping of the ICT program
- stepwise execution of the ICT program
- continuation the ICT program at another position
- repeated execution of test steps in a loop
- entering and immediately executing test steps
- setting of stop conditions and breakpoints
- changing of measurement parameters
- analysis of measured values



NOTE:

In the following, the R&S EGTSL- user interface (*R&S EGTSL IDE*) is referred to as the debugger.

12.2 Starting and Terminating the Debugger

For the debugging of an ICT program, the R&S EGTSL- user interface (debugger) must be started. The debugger can be started in two ways.

1. Start the debugger from a test sequence through a function call from the ICT Test Library (see section 13.1)
2. Start the debugger through the R&S EGTSL loader (see section 13.2)

When the debugger is started from a test sequence, the ICT program is automatically opened with the appropriate bench. When the debugger is started through the R&S EGTSL loader, the ICT program must be manually opened with the menu command **File -> Open**. When the ICT file is opened, the appropriate bench for the execution of ICT program must be entered.

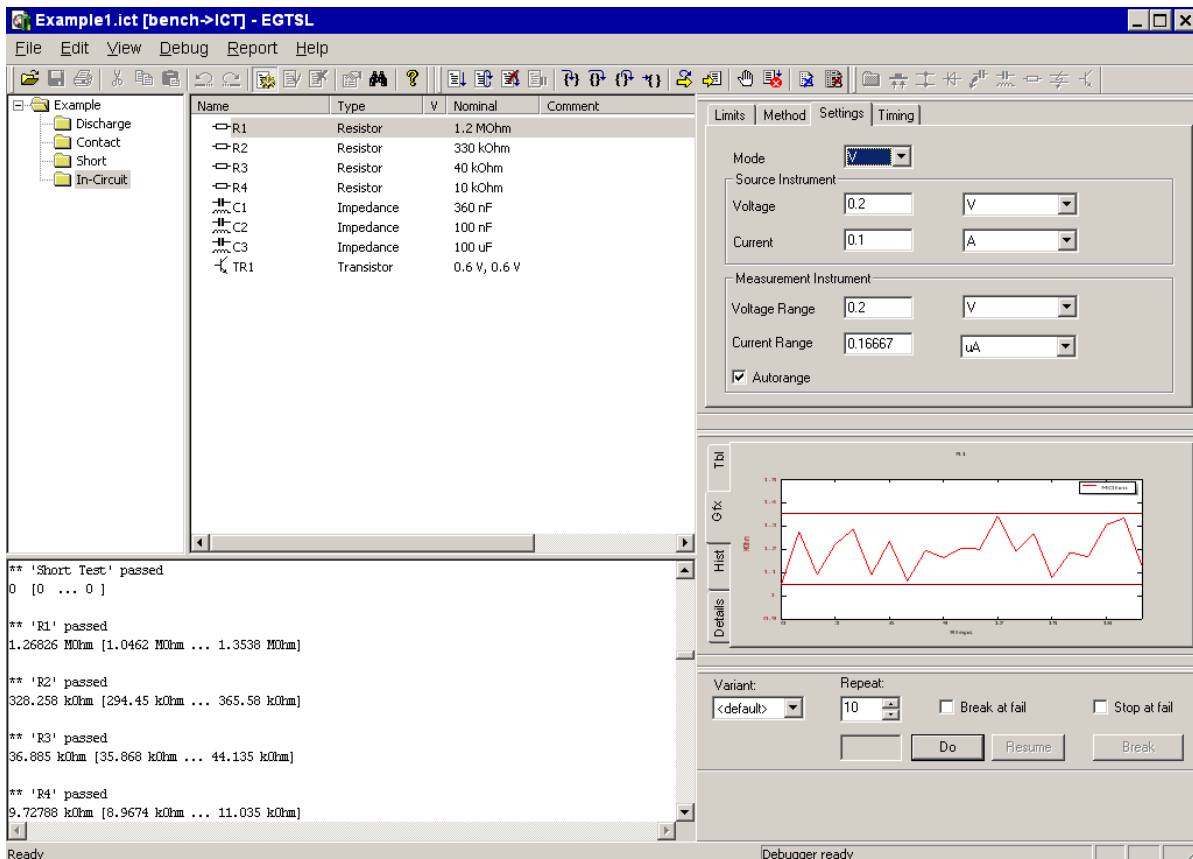


Figure 12-1 Debugger


NOTE:

The individual screens and functions of the debugger (*R&S EGTSL IDE*) are described in Chapter 5.

The debugger is terminated with the menu command (also see section 5.6.1.10).

12.3 Debug Status

The status of debugger is shown by messages in the status bar.

Debugger ready

The debugger is activated. One or more test steps, program groups or the entire ICT program can be executed (see section 12.4).

Debugger deactivated

The debugger is deactivated. The ICT program or test steps cannot be executed.

ICT is running

One or more test steps, program groups or the entire ICT program are executed with the given number of repetitions.

Total execution time for the last executed debugger command is shown in the status bar.

12.4 Using the debugger

The debugger is operated through the commands from the main menu item , or through buttons, function keys or key combinations.

If the debugger has stopped the ICT program, a yellow arrow on the left side points to the test step to be executed next. The execution of the program will be continued at this point.

The debugger stops the ICT program, if

- the command has been executed, for example, a single step.
- a breakpoint is reached.
- a stop condition is fulfilled.
- a runtime error has occurred

Go
[F5]



Executes the ICT program once from the test step marked with the yellow arrow (current debugger execution point) to the end. If the debugger is deactivated, the ICT program is executed from start to finish.

Restart
[Ctrl+Shift+F5]



With the debugger activated, executes the ICT program from the start to the finish.

Terminate
[Shift+F5]



Stops the execution of the ICT program. The marking with the yellow arrow (current debugger execution point) is removed. The debugger is deactivated.

Break

Interrupts the execution of the ICT program. The test step at which the interruption takes place is marked with the yellow arrow (current debugger execution point) and displayed. Using the **Go** command the execution of the ICT program can be continued.

Repeat
[F4]

With the debugger activated, starts the execution of the test steps marked (test steps with a color background) with the number of repetitions given.

Resume
[Shift+F4]


Continues the execution of the marked test steps (test steps with a color background) following an interruption using the **Break** button.

Step Into
[F11]




Executes the ICT program from the test step marked with the yellow arrow (current execution point of the debugger) in single steps. If the test step is a group, automatically each test step of the group will be executed in single steps.


- Step Over**
[F10]




Executes the ICT program from the test step marked with the yellow arrow (current execution point of the debugger) in single steps. If the test step is a group, all test steps in the group are performed automatically.
- Step Out**
[Shift+F11]




If the test step marked with the yellow arrow (current execution point of the debugger) is in a group, the group is left with this button. The test steps that follow in the group are performed automatically. If the test step marked with the yellow arrow (current execution point of the debugger) is at the top program level, all following test steps including groups are executed.
- Run to Cursor**
[Ctrl+F10]




Executes the ICT program from the test step marked with the yellow arrow (current execution point of the debugger) to the test step marked with the cursor. The test step marked by the position of the cursor is marked as the next test step that can be executed using the yellow arrow.
- Set Next Step**
[Ctrl+Shift+F10]




Marks the position of the cursor as the test step that is to be executed next. A yellow arrow is displayed on the left beside the test step marked. The debugger is activated.
- Show Next Step**
[Alt+F10]



Jumps to the current debugger execution position (test step marked with the yellow arrow). The test step is the next that is executed.
- Toggle Breakpoint**
[F9]



Sets a breakpoint at the cursor position. The breakpoint is deactivated when you click the button again. The third time you click the button, the breakpoint is deleted (see also section 5.6.2.4).
- Stop At Fail**



With this function activated, the ICT program execution is stopped when the test step result was “Fail”. The program stops at the erroneous test step. The **Stop at fail** function applies to all debug commands with the exception of the **Repeat** function.
- Break At Fail**

With this function activated, the execution of the ICT program (test steps marked) is interrupted when the test step result was “Fail”. The program stops at the erroneous test step. The **Break at fail** function applies only to the **Repeat** function.

12.5 Breakpoints

The execution of the program in the debugger can be interrupted at predetermined points (test steps or program groups) by using the breakpoints. The debugger stops the ICT program at this point, before it executes the test step which has been assigned an activated breakpoint.

Toggle Breakpoint [F9]



Breakpoints are set, deactivated or deleted through the menu command , the function key **[F9]** or the **Toggle Breakpoint** button.

Breakpoints are displayed on the left in the program sub-window next to the marked test step or on the left next to the marked program group. The debugger does not stop at deactivated breakpoints.



activated breakpoint



deactivated breakpoint

Using the menu command or the key combination **[Alt+F9]**, a list of all breakpoints set in the ICT program can be displayed. In the editing window, the breakpoints can be individually or totally deleted. In addition, you can jump to a selected breakpoint. Also see section 5.6.2.4.

12.6 Stop conditions

The execution of the program in the debugger can be interrupted when specified conditions occur.

Stop At Fail



With this function activated, the ICT program execution is stopped when the test step result was “Fail”. The program stops at the erroneous test step. The **Stop at fail** function applies to all debug commands with the exception of the **Repeat** function.

Break At Fail

With this function activated, the execution of the ICT program (test steps marked) is interrupted when the test step result was “Fail”. The program stops at the erroneous test step. The **Break at fail** function applies only to the **Repeat** function.

12.7 Typical debugging procedure

The optimum procedure for testing an ICT program (debugging) is different for each unit under test and thus for each ICT program. The debugging of a new ICT program should be done with a reference unit under test (Reference UUT).

The following steps should only be used as a reference for a debugging procedure. The steps described apply to an ICT program created „by hand“ as well as to one generated by the Automatic Test Generator ATG.

1. Open a new ICT program with corresponding bench in the debugger.
2. Check the proposals created as variants by the Automatic Test Generator ATG and select the best variants for the test procedure as the standard test steps (also see section 9.3.2.2).
3. Activate the function **Stop At Fail** and start the ICT program with the function **GO** (menu item, button or function key *[F5]*).
4. The debugger interrupts the execution of the ICT program at the **Failed** test step. The test step is shown by the yellow arrow (current execution position of the debugger).
5. Repeat the **Failed** test step with the function **Repeat** (menu item, button or function key *[F4]*) (more than once, if necessary).
6. Check the measured results with the information from the **Report** sub-window and the **Results Tbl**, **Results Gfx**, **Results Hist** and **Results Details** sub-windows.
7. Based on the information from the **Report** sub-window and the **Results** sub-window, adjust the measurement parameters of the test step.
8. Start the further execution of the ICT program with the function **GO** (menu item, button or function key *[F5]*).
9. Repeat steps 4. to 8. until the ICT program runs without errors.
10. Start the ICT program with the function **GO** several times (menu item, button or function key *[F5]*) and let it run through (without errors).
11. Check the measured results for the entire ICT program with the information from the **Report** sub-window and the **Results Tbl**, **Results Gfx**, **Results Hist** and **Results Details** sub-windows (see section 12.9).

12. If the ICT program with the reference unit under test (Reference UUT) functions without error, the step must be repeated with other units under test (UUT) until the ICT program also runs without errors with these units under test.
13. If the ICT program can be run for several units under test (UUT) without the error, a measuring time optimization can be carried out as a last step (see section 12.8).

12.8 Measuring time optimization

Through an exact analysis of the measured results in the **Results Details** sub-window, information on the measuring time (duration) and the status of the measuring hardware used for the measurement can be ascertained.

A measuring time optimization can be achieved by:

- Optimum selection of the measurement range of the measuring hardware used at each test step.
- Adjustment of the timing settings (Delay, Max.Wait Interval, Max.Wait accuracy, Average, Sample Interval) at each test step.
- Selection of the appropriate testing method (2-wire measurement, 4-wire measurement, guarding) for each test step.

12.9 Interpretation of the Results sub-window

The graphical display of the measured results of the individual test steps in the Results Gfx and Results Hist sub-windows gives important information for optimization of the individual measuring procedures. A few typical examples are shown below.

12.9.1 Results Gfx sub-window

Example 1:

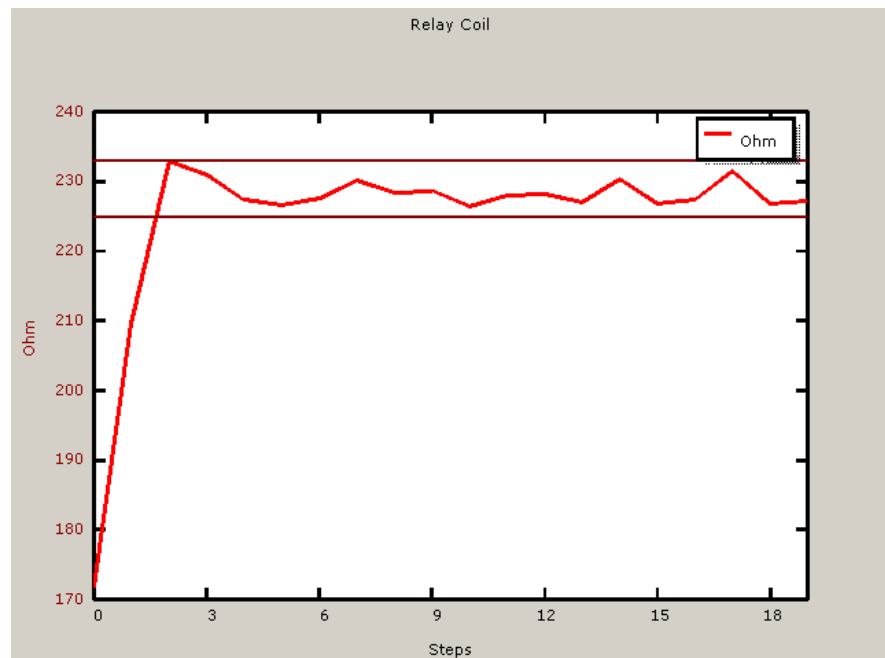


Figure 12-2 Measurements with transient process

The graph in Figure 12-2 shows a measurement with transient process. The measured results are stable and lie within the given measuring tolerances only after the third run of the test step. For the optimization of this test step, the auto-delay technique would be useful (see section 5.5.12.1). By using this, you can ensure that a correct measured result is obtained even for the first run of the test step.

Example 2:

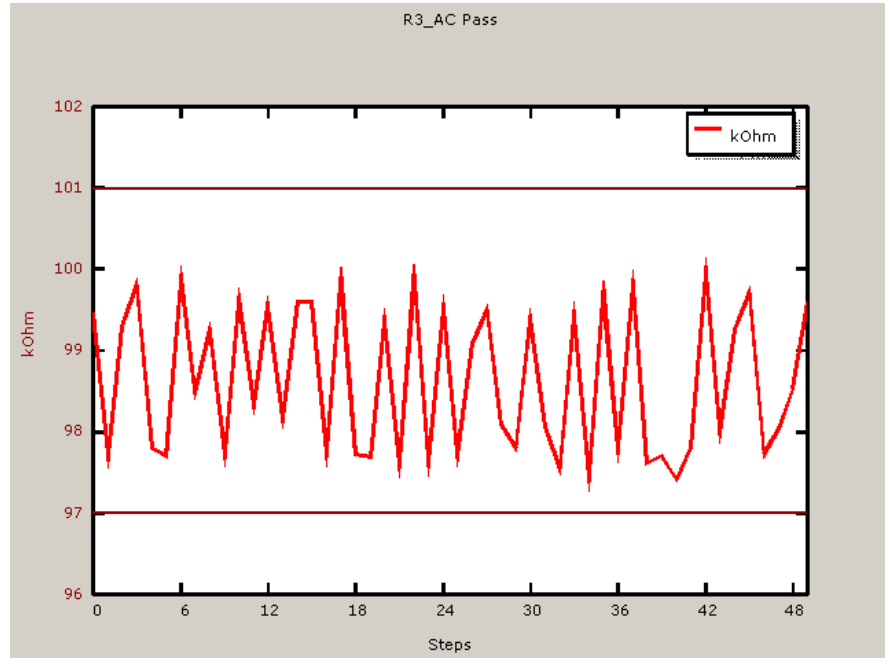


Figure 12-3 Measurement with superimposed interference

The graph in Figure 12-3 displays a measurement with superimposed interference signal. Through an exact circuit analysis, the source of interference can be determined and eliminated with appropriate measures (e.g. another test method).

12.9.2 Results Hist Sub-window

Example 3:

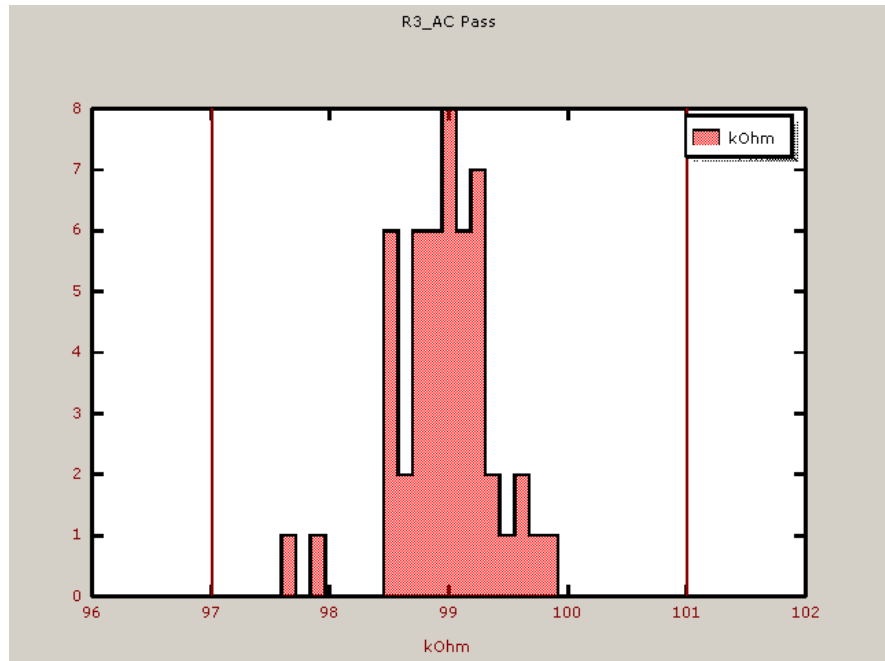


Figure 12-4 Measurements with wide scatter

Example 4:

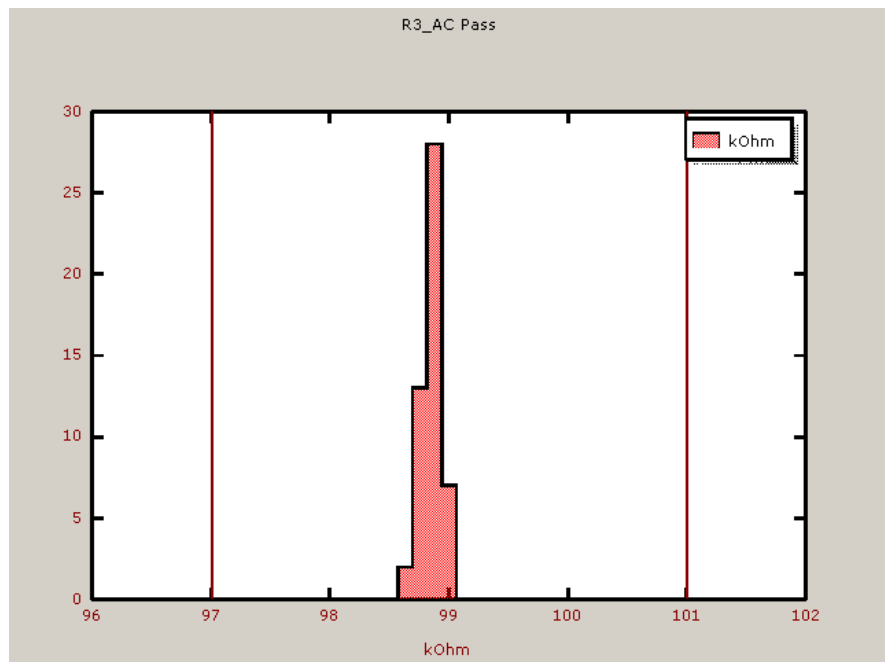


Figure 12-5 Measurements with narrow scatter



The graphs in Figure 12-4 and Figure 12-5 show the distribution of the measured values of a test step. The scatter of the measured results for the measurements in Figure 12-4 is too wide. The cause of this wide scatter could be superimposed interference or non-optimum timing settings. The measurement can be improved with **Max. Wait** or **Average** settings (see section 5.5.12.1).

13 Running R&S EGTSL IDE

The Enhanced Generic Test Software Library R&S EGTSL can be executed in two ways:

1. By opening a function from the ICT test library.
2. Using the R&S EGTSL Loader.

13.1 Starting using a function call from the ICT test library

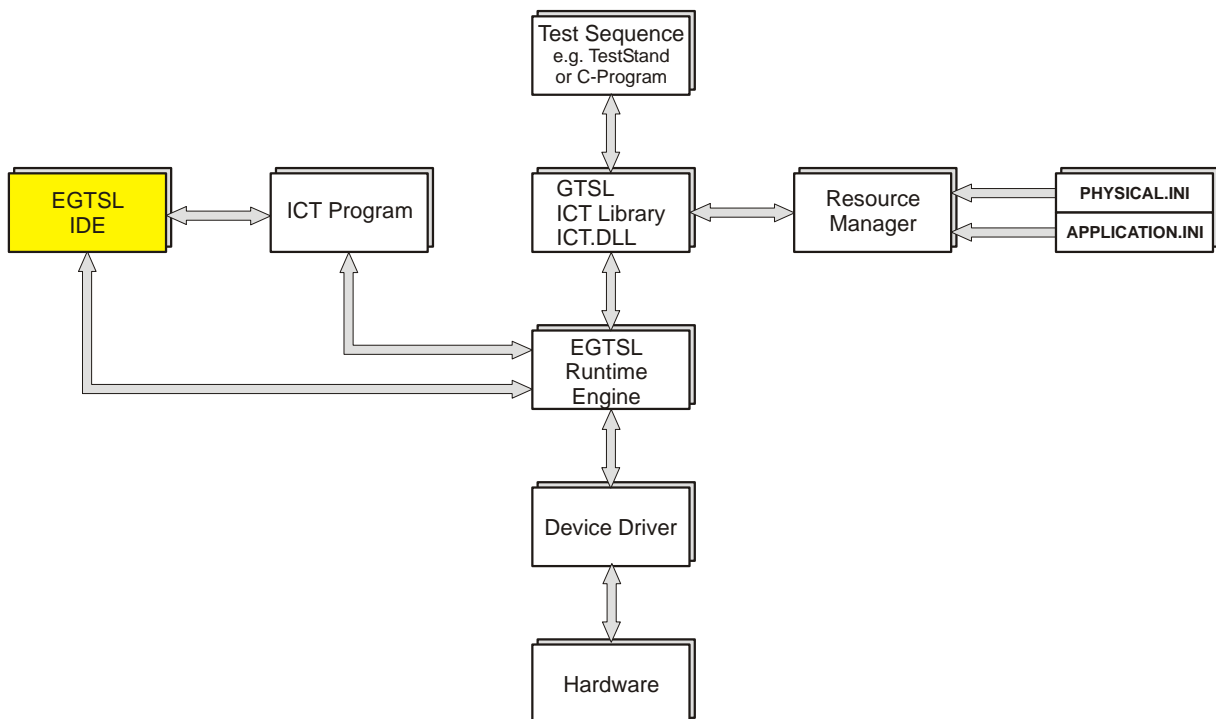


Figure 13-1 Opening R&S EGTSL IDE using test library (software structure)

Functions from the ICT test library are opened from the test sequence (e.g. test sequence in test stand or a dedicated C program). The test hardware available is managed using the resource manager with the aid of the configuration files (PHYSICAL.INI and APPLICATION.INI). The R&S EGTSL runtime engine now opens the R&S EGTSL user interface (R&S EGTSL IDE) and the corresponding ICT program. The ICT program opened can now be debugged in the R&S EGTSL user interface (R&S EGTSL IDE). Using the R&S EGTSL runtime engine the ICT program can be executed on the test hardware directly from the R&S EGTSL user interface.



13.1.1 Example

In the following example, functions from the ICT test library are opened from the C program. Among other aspects, the R&S EGTSL user interface (R&S EGTSL IDE) can be opened.

```
#include <cviauto.h>
#include <ansi_c.h>
#include <userint.h>
#include <cvirte.h>
#include "ict.h"

// defines the drive and path for the example files
#define PATH "C:\\Program Files\\Rohde&Schwarz\\GTSL\\EGTSL\\example\\"

int main (int argc, char *argv[])
{
    short errorOccurred = FALSE;
    long  errorCode;
    char  errorMessage[GTSL_ERROR_BUFFER_SIZE] = "";
    char  userMessage[1024];
    long  resourceId = -1;
    long  programId = -1;
    long  compileErrors;
    long  failCount;
    int   response = 0;

    // ActiveX must be initialized if the ICT library is used
    CA_InitActiveXThreadStyleForCurrentThread (0, COINIT_APARTMENTTHREADED);

    // load the configuration files
    if ( ! errorOccurred )
    {
        RESMGR_Setup (0, PATH "example_physical.ini",
                     PATH "example1_application.ini",
                     &errorOccurred, &errorCode, errorMessage);
    }

    // load the ICT library
    if ( ! errorOccurred )
    {
        ICT_Setup (0, "bench->ICT",
                  &resourceId,
                  &errorOccurred, &errorCode, errorMessage);
    }

    // load the ICT program
    if ( ! errorOccurred )
    {
        ICT_Load_Program (0, resourceId,
                         PATH "example1.ict",
                         "bench->ICT",
                         &programId,
                         &compileErrors,
                         &errorOccurred, &errorCode, errorMessage);
    }

    do
    {
        // start the program
        if ( ! errorOccurred )
        {
            if ( 1 == ConfirmPopup ( "EGTSL", "Start in debug mode?" ) )
            {

```




```
// debug the program with EGTSL IDE
ICT_Debug_Program (0, resourceId,
                  programId,
                  "", // no variant specified
                  "", // no subtree, run complete program
                  1, // stop at start of program
                  1, // stop at end of program
                  0, // don't stop at fail
                  &failCount,
                  &errorOccurred, &errorCode, errorMessage);
}
else
{
    // run the program without EGTSL IDE
    ICT_Run_Program (0, resourceId,
                   programId,
                   "", // no variant specified
                   "", // no subtree, run complete program
                   &failCount,
                   &errorOccurred, &errorCode, errorMessage);
}
}

// write the report to a text file
if ( ! errorOccurred )
{
    ICT_Write_Report (0, resourceId,
                    programId,
                    "ictreport.txt",
                    0, // 0 = overwrite, 1 = append
                    &errorOccurred, &errorCode, errorMessage);
}

// ask the user to run the program again
if ( ! errorOccurred )
{
    sprintf ( userMessage, "%d tests failed\n\nTry again?", failCount );
    response = ConfirmPopup ("EGTSL", userMessage );
}
else
{
    break;
}

} while (1 == response);
// error handling
if ( errorOccurred )
{
    sprintf ( userMessage, "Error Code %d:\n\n%s", errorCode, errorMessage );
    MessagePopup ( "EGTSL", userMessage );
}

// unload the program
if ( programId >= 0 )
{
    ICT_Unload_Program (0, resourceId,
                      programId,
                      &errorOccurred, &errorCode, errorMessage);
}

// release ICT library
if ( resourceId >= 0 )
{
    ICT_Cleanup (0, resourceId, &errorOccurred, &errorCode, errorMessage);
}

// close resource manager
```



```
RESMGR_Cleanup (0, &errorOccurred, &errorCode, errorMessage);
```

```
return 0;  
}
```

13.2 Starting using the R&S EGTSL Loader

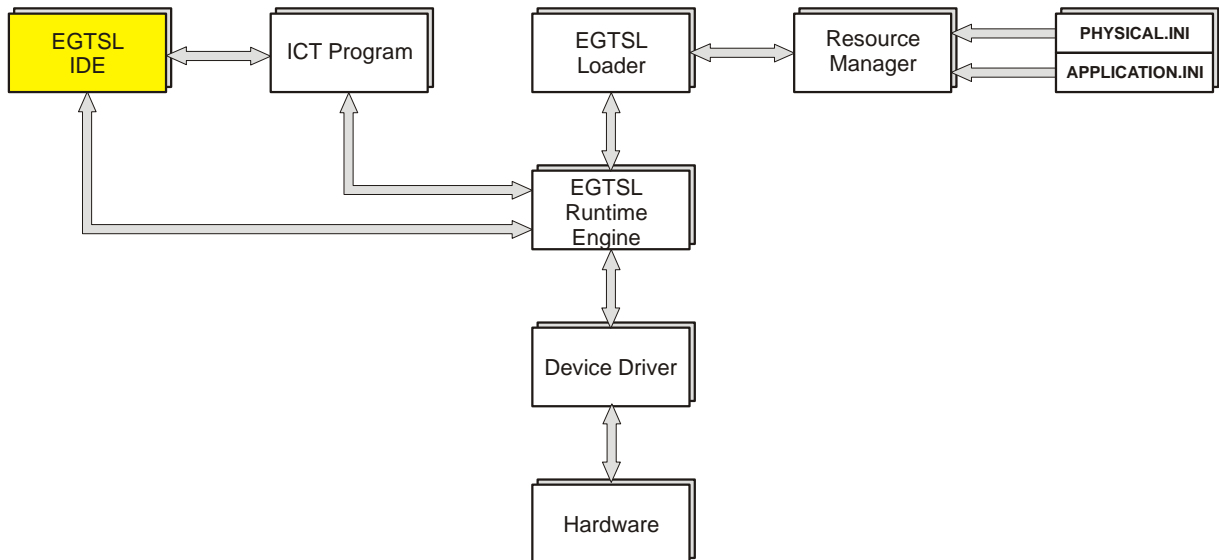


Figure 13-2 Opening R&S EGTSL IDE using R&S EGTSL Loader (software structure)

The R&S EGTSL Loader replaces the function calls from the ICT test library. In the R&S EGTSL Loader the names of the configuration files (**PHYSICAL.INI** and **APPLICATION.INI**) must be given. Hardware management is also performed using the resource manager. The R&S EGTSL runtime engine now opens the R&S EGTSL user interface (R&S EGTSL IDE) and the corresponding ICT program. The ICT program opened can now be debugged in the R&S EGTSL user interface (R&S EGTSL IDE). Using the R&S EGTSL runtime engine the ICT program can be executed on the test hardware directly from the R&S EGTSL user interface.

13.2.1 R&S EGTSL Loader, starting

To open the R&S EGTSL user interface (R&S EGTSL IDE) in the standalone mode, perform the following steps:



1. Start the R&S EGTSL Loader using **Start -> Programs -> GTSL -> EGTSL**.



NOTE:

If there is no valid license for the test libraries used, the R&S EGTSL user interface (*R&S EGTSL IDE*) is opened in the demo mode. The execution of the ICT programs opened is simulated.

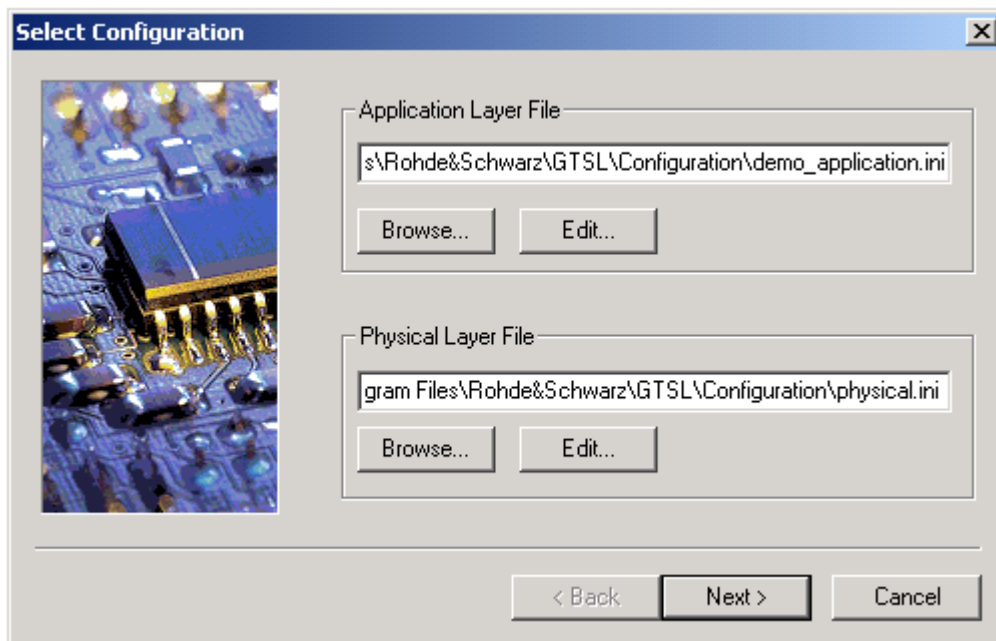


Figure 13-3 R&S EGTSL Loader Select Configuration

2. Using the dialog box (**Browse...** button), select the appropriate Application Layer Configuration File for the ICT program. The save path and the file name for the selected Application Layer Configuration File are displayed.
3. Using the dialog box (**Browse...** button), select the appropriate Physical Layer Configuration File for the ICT program. The save path and the file name for the Physical Layer Configuration File selected are displayed.

Browse...

Opens the standard Windows dialog box for opening files. In the dialog box select the appropriate configuration file for the ICT program.

Edit...

The configuration file displayed is opened in the editor and can be edited.

Cancel

Quits the R&S EGTSL Loader.

Next >

4. Using the **Next** button, load the configuration given.

In accordance with the information from the configuration files given

- A The R&S EGTSL user interface (R&S EGTSL IDE) is opened (continue with point 5.) or
- B The dialog box for the **vacuum control** is opened (see Figure 13-4).

If, in the Application Layer Configuration File, there is an entry for the vacuum library in at least one bench, the dialog box for the vacuum control is opened

Example:

```
[bench->ict]
ICTDevice1 = device->psam
ICTDevice2 = device->pict
VacuumControl1 = device->psys1
VacuumControl2 = device->psys2
SwitchDevice1 = device->pmb1
... etc.
```

(continue with point 6.)

- 5. In the R&S EGTSL user interface opened, it is now possible to load and debug and ICT program.
- 6. In the Vacuum Control window (see Figure 13-4) you can enter information on the vacuum control for the test adapter.

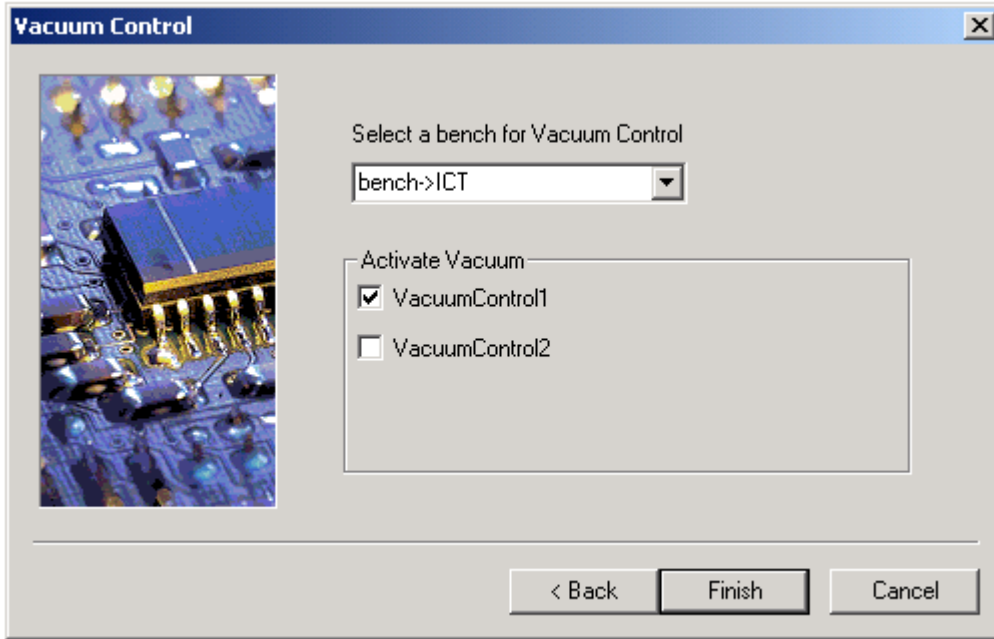


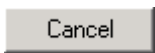
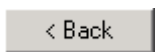
Figure 13-4 R&S EGTSL Loader Vacuum Control

Select a bench for Vacuum Control

7. Select the bench for the vacuum control.
All benches for this Application Layer Configuration File with at least one vacuum control entry are displayed in the drop-down list box. In the list box select the bench that is to be relevant for the ICT program to be loaded.

Activate Vacuum

8. Activate vacuum valves.
The vacuum control entries in the selected bench are listed. A maximum of four entries can be listed. By selecting the check box you can activate the corresponding vacuum valve.
9. Using the **Finish** button, open the R&S EGTSL user interface (R&S EGTSL IDE).



The **Select Configuration** window (see Figure 13-3) is opened again.

Quits the R&S EGTSL Loader.



Once the R&S EGTSL user interface has been quit, the opening dialog box (*R&S EGTSL Loader Select Configuration* or *R&S EGTSL Loader Vacuum Control*) is displayed again. Using the **Cancel** button the R&S EGTSL Loader is quit.



ROHDE & SCHWARZ

Running R&S EGTSL IDE

Enhanced Generic Test Software Library R&S EGTSL

14 Report Format

For each test step, a report entry is created in the Report sub-window. This consists of the following entries:

1. Header

The following entries are listed in the header:

- Test Step name
- ID number
- Part ID
(the entry is only displayed if a Part ID is entered in the “Step Properties”.)
- Pass/Fail result

2. Measured result

The measured result consists of the measured value and the units as well as (in square brackets) the lower and upper limit.

During the Diode and Transistor test steps, two lines with measured results are listed, because two measurements are carried out during these tests.

3. Error text (displayed only in case the test step result was “Failed”)

In case the test step result was “Failed”, a line with the error text is listed. The Contact, Continuity, Discharge and Short test methods display information on the pins. All other test methods list the “Report Text” from the “Step Properties”.

Examples:

Contact

```
** 'Contact'[70] failed <-----<<<
2 [0 ... 0 ]
P22, P27
```

Measured result: The number of the pins which have no contact is displayed. The lower and upper limits are zero.

Error text: The error text displays the names of the pins which have no contact. A maximum of 10 pin names are displayed.

**Continuity**

```
** 'GND track'[77] failed <----<<<
1 [0 ... 0 ]
P12 P13 / P89 P90
```

Measured result: The number of interruptions is displayed. The lower and upper limits are zero.

Error text: The error text displays the names of the pins of the Contact test. Interruptions are marked with a slash.

Diode

```
** 'D1'[76] (123.456) failed <----<<<
-0.769865 V [-0.8 V ... -0.6 V]
-0.00103737 uA [0.2 uA ... 1 uA]
D1 failed
```

Measured result 1: The measured forward bias voltage (knee voltage) and, in brackets the lower and upper limit, are displayed.

Measured result 2: The measured reverse bias current and, in brackets the upper and lower limit, are displayed.

Error text: The text which has been entered in the “Step Properties” in the “Report Text” field is displayed.

Discharge

```
** 'Discharge'[18] failed <----<<<
1 [0 ... 0 ]
Timeout; DCH pin 'P13'
```

Measured result: The number of the pins which could not be discharged is displayed. The lower and upper limits are zero.

Error text: The error text displays the pin which was being discharged when the timeout occurred.

Fet

```
** 'FET4'[71] passed
4.9725 V [4.5 V ... 5.5 V]
0.0213 V [-0.5 V ... 0.5 V]
```

Measured result 1: The measured drain-source voltage of the FET while the FET is in switched off state, and in brackets the lower and upper limits, are displayed.

Measured result 2: The measured drain-source voltage of the FET while the FET is in switched on state, and in brackets the lower and upper limits, are displayed.

Impedance

```
** 'Zx'[15] passed
0.924677 uF [0.9 uF ... 1.1 uF]
```

Measured result: The measured value of the impedance measurement, and in brackets the upper and lower limit, are displayed.

Resistor

```
** 'Rx'[30] (1234.5678.90) passed
100.073 Ohm [99.9 Ohm ... 100.1 Ohm]
```

Measured result: The measured value of the resistance measurement and, in brackets the upper and lower limit, are displayed.

Short

```
** 'Short 10'[71] failed <----<<<
5 [0 ... 0 ]
P12 P13 P6 / P89 P90
```

Measured result: The number of the pins involved in the short circuit is displayed. The lower and upper limits are zero.

Error text: The error text displays the names of the pins which have mutually short circuited. Short circuits are separated from one another by a slash.

Transistor

```
** 'Transistor'[18] passed
0.618934 V [0.6 V ... 0.8 V]
0.760869 V [0.6 V ... 0.8 V]
```

Measured result 1: The measured forward bias voltage (knee voltage) of the base-emitter diode, and in brackets the lower and upper limit, are displayed.

Measured result 2: The measured forward bias voltage (knee voltage) the base-collector diode, and in brackets the lower and upper limit, are displayed.

Transistor Beta

```
** 'TR5'[97] passed
0.722228 V [0.42 V ... 0.78 V]
245.464 [100 ... 300 ]
```

Measured result 1: The measured forward bias voltage (knee voltage) of the base-emitter diode, and in brackets the lower and upper limit, are displayed.

Measured result 2: The measured current gain (beta), and in brackets the lower and upper limit, are displayed.



Zener Diode

```
** 'ZD2'[95] passed  
27.3080 V [24.3 V ... 29.7 V]
```

Measured result: The measured Zener working voltage, and in brackets the lower and upper limit, are displayed.

User-defined test

```
'Filter'[15] failed  
-4.32 dB [-3.1 dB ... -2.9 dB]  
Filter attenuation test failed
```

Measured result: The measured value of the user-defined measurement, and in brackets the upper and lower limit, are displayed. The unit is specific to the user-defined test method.

Error text: The error text is specific to the user-defined test method.

15 ICT correction data

Due to the system residuals, the test system itself produces measuring errors. Using the program *ICTCorrection* all impedance measurements on a “typical pin” can be corrected. The data determined by the program are saved in an INI file and used for the correction of the measured values during the impedance measurements. As rule the *ICT Correction* program must be started only once for each test system configured. Only when the configuration is changed is it necessary to run the program again, e.g.

- On the replacement of a
 - R&S TS-PSAM Source and Measurement Module
 - R&S TS-PICT In-Circuit Test Module
- On the addition or removal of a R&S TS-PMB Matrix Module B.
- On the addition or removal of modules that access the analog bus.



ICTCorrection

Start the program *ICTCorrection* using

Start -> Programs -> GTSL -> Tools -> ICT Correction..

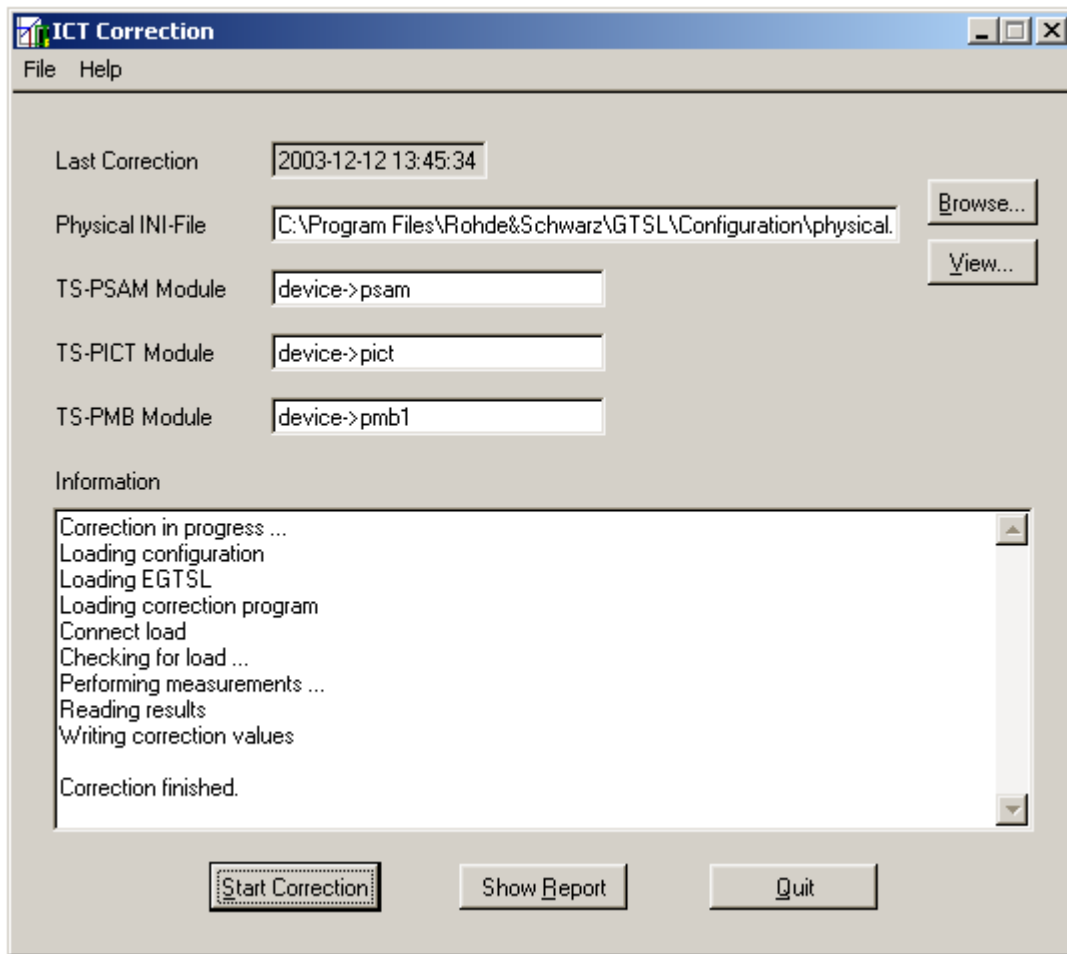


Figure 15-1 ICT Correction



NOTE:

A special test adapter is required for the determination of the correction data for the R&S TS-PMB Matrix Module B using the *ICTCorrection* program.

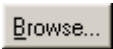
The test adapter (ICTCorrection Load, SN. XXXX.XXXX.XX) is included with the R&S TS-PICT In-Circuit Test Module.

Last Correction

Indicates the date and time the last time the program *ICT Correction* was run.

Physical INI-File

Indicates the save path and the file name for the selected Physical Layer Configuration File for the test system to be calibrated. The information in the field can be edited.



Opens the standard Windows dialog box for opening files. The Physical Layer Configuration File to suit the configured test system is selected in the dialog box.



The Physical Layer Configuration File indicated is opened in an editor and can be edited.

TS-PSAM Module

The device entry (section) from the Physical Layer Configuration File for the R&S TS-PSAM Source and Measurement Module must be entered in this field. As a rule there is only one R&S TS-PSAM in the test system. If there are several R&S TS-PSAM modules, the module used for the determination of the correction data must be given.

TS-PICT Module

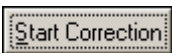
The device entry (section) from the Physical Layer Configuration File for the R&S TS-PICT In-Circuit Test Module must be entered in this field. As a rule there is only one R&S TS-PICT in the test system. If there are several R&S TS-PICT modules, the module used for the determination of the correction data must be given.

TS-PMB Module

The device entry (section) from the Physical Layer Configuration File for the R&S TS-PMB Matrix Module B must be entered in this field. As there are generally several R&S TS-PMB modules in the test system, the module for which the correction data are to be determined must be given.

Information

The program progress is indicated in this window. Any errors that occur are also displayed.



Starts the *ICTCorrection* program.



Opens the report generated after the *ICTCorrection* program is run.



Quits the *ICTCorrection* program.



The following steps are necessary to determine the correction data:

1. Start *ICTCorrection* program.
2. Select the Physical Layer Configuration File for the test system to be calibrated.
3. Make device entries for the R&S TS-PSAM, R&S TS-PICT and R&S TS-PMB modules.
4. Using the **Start Correction** button, start the program.
5. When the program is running, you will be prompted to fit the special test adapter to the R&S TS-PMB module for which the correction data are to be determined.
6. If the program is run without errors, the file `ICTCorrection.ini` with the correction data is generated and saved.
7. Quit the program using the **Quit** button.

While the program is running, an Application Layer Configuration File is generated from the data given (Physical Layer Configuration File and device entries). Using the information from the Physical Layer Configuration File and the Application Layer Configuration File, a saved ICT program (`ICTCorrection.ict`) is opened automatically. Using this ICT program the correct function of the test adapter is checked and the correction data determined for various frequencies.

The following information is saved in the file `ICTCorrection.ini` :

- The values measured by the ICT program (`ICTCorrection.ict`)
- The correction factors determined
- The entries made in the *ICTCorrection* program

Before a new `ICTCorrection.ini` file is created, a backup of the previous version is saved as `ICTCorrection.bak` .

16 Error messages

16.1 Compile errors

Compile errors can occur in the following situations during the creation of the metacode:

- At the opening of an ICT program.
- At the creation or running of test steps. During the execution of the **Apply** (or **Auto apply**) function, a compile error is displayed for an erroneous test step.

Compile errors are displayed as text in the Report sub-window. Erroneous test steps are marked in red in the Program sub-window.

The following list shows some common compile errors.

Unknown pin X

- A pin name was entered incorrectly.
- The pin name is not listed in the `application.ini` file.

<Parameter> is out of range

The value of the parameter entered lies outside the permissible value range

No complementary path found for pins X and Y

For 6-wire measurements, the „even/odd rule“ for Force and Sense pins was not adhered to. The entered pins have either both even or both odd pin numbers.

Device type 'pict' is missing

The test method requires a R&S TS-PICT module which was not configured in the bench as an ICT device.

TS-LEGT license required

For the test method, a R&S TS-LEGT license is required.

-
-
-

16.2 Runtime Errors

Runtime errors occur during the execution of the program and are displayed in separate error windows.

Examples

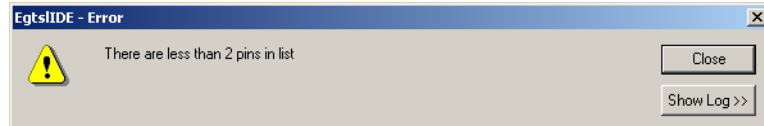


Figure 16-1 Runtime Error window (Example 1)

Show Log >>

With the **Show Log** button, an expanded view of the error message can be displayed.

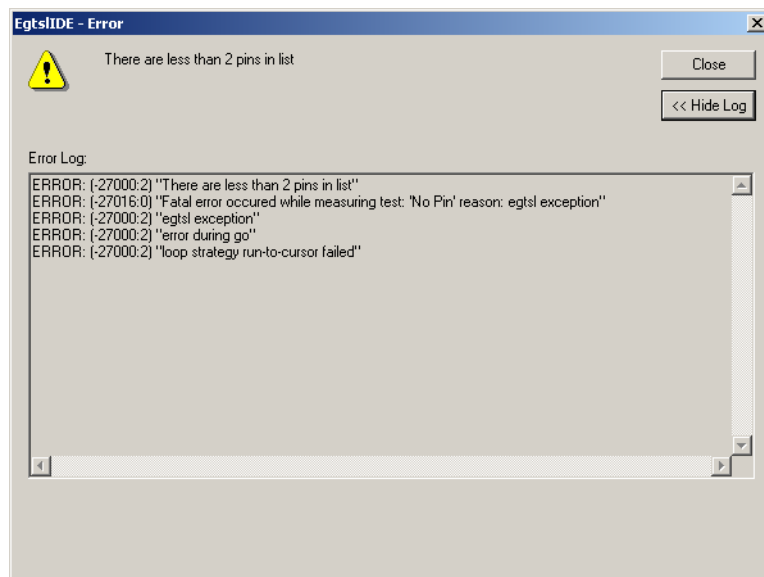


Figure 16-2 Error window, expanded view (Example 1)

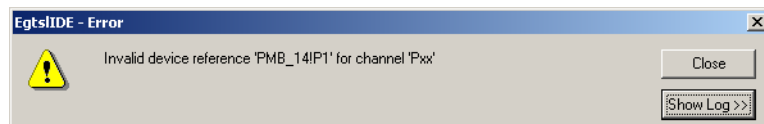


Figure 16-3 Runtime Error window (Example 2)

This difference between the two types of runtime errors is:

1. Runtime errors which frequently occur through incorrect entries and which can be easily corrected:
 - "There are less than 2 pins in list"
The error occurs during the short circuit test or contact test if there are not at least two pins listed in the pin list.
 - "No pin in list"
The error occurs during the contact test or the discharge if the pin list is empty.
2. Error in `application.ini` and `physical.ini`
 - "Invalid device reference "PMB2!P1" für channel "XYZ"
The entered switch device PMB2 does not exist or is not configured as „SwitchDevice...“ for the bench.
 - "No channel id for channel "XYZ"
The physical channel name for „XYZ“ does not exist (e.g. channel "P99" for a R&S TS-PMB)
 - "Invalid physical channel name "PMB2.P1" for channel "XYZ"
The syntax of the physical channel name (here: PMB2.P1) is incorrect. PMB2!P1 would be correct.

**NOTE:**

Other than the runtime errors shown above, most are hardware or software problems and should be reported to ROHDE & SCHWARZ.



17 ICT Extension Libraries

17.1 Overview

17.1.1 Objective

R&S EGTSL already offers a series of in-circuit test methods that can be used to test standard components such as resistors, capacitors, coils, semiconductors, etc. The ICT extension libraries also make it possible to develop own user-specific test methods and make them available in R&S EGTSL. Then special components can be tested within the R&S EGTSL in-circuit tests.

17.1.2 Functionality

User-specific test methods are fully integrated into R&S EGTSL so that they behave exactly like integrated test methods in terms of operation and functionality. All debugging options such as displaying the results of measurements in table format or graphically are also available for user-specific test methods. In addition, user-specific test methods make it possible to integrate additional measurement hardware into the in-circuit test. Of course the standard measurement modules of R&S EGTSL (R&S TS-PSAM, R&S TS-PICT and the matrix modules R&S TS-PMB) can also be used.

Parameters can be set for each user-specific test method covering a specifically defined number of properties. These properties could be setting parameters such as voltage, current or frequency. They could also be pin names for connecting measurement modules to the test object.

Sub-windows for user-specific test methods are shown in Section 5.5.13.



17.2 Using Extension Libraries

17.2.1 Configuration

Extension libraries must be configured before they can be used in an application. This is done by declaring them for the application in the Application Layer Configuration file (APPLICATION.INI).

The [extIct] section (see Section 7.1.6) contains one entry for each ICT extension library with the key word "UserDefinedDll", which contains the path and filename of the DLL.

Example:

```
[ExtIct]
UserDefinedDll = C:\IctExtensionDlls\MyOpAmp.dll
UserDefinedDll = %GTSLROOT%\EGTSL\ExtIct\RSSample\RSSample.dll
UserDefinedDll = MyRelay.dll
```

R&S EGTSL replaces the character sequence %GTSLROOT% with the installation path of R&S GTSL (normally "C:\Program Files\Rohde&Schwarz\GTSL").

If only a filename is specified with no path, the DLL must reside in a directory that is included in the environment variable PATH.

When the R&S EGTSL user interface starts, the extension libraries are loaded and their corresponding icons appear in the toolbar.

17.2.2 Documentation

Every extension library has a documentation file associated with it, which must be in the same directory as the DLL itself. The documentation can be called from the R&S EGTSL user interface with the **Help** button in the **Info** sub-window of **Test Properties**.

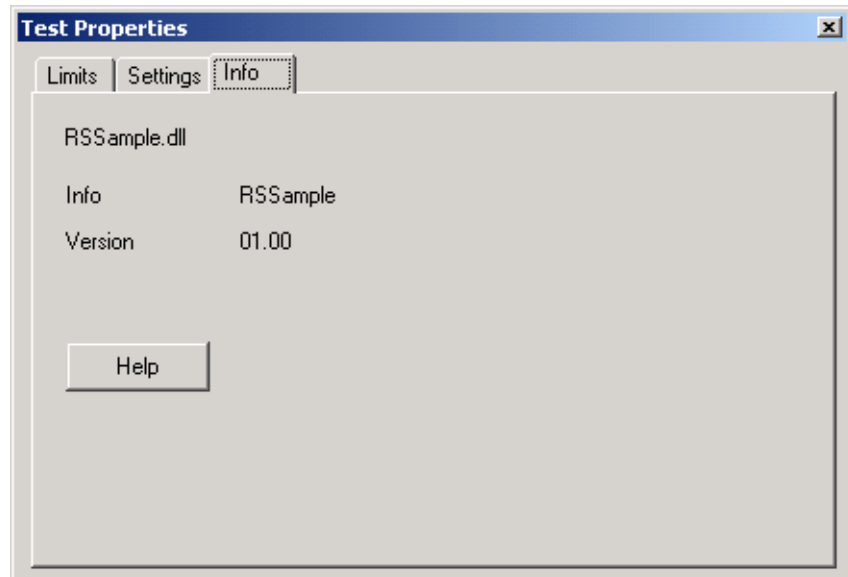


Figure 17-1 Test Properties Info

17.2.3 Inserting Test Steps

You can insert user-defined tests by clicking on the corresponding icon in the toolbar.



NOTE:

If the user-specific toolbar is not displayed, you can make it visible with the menu command <View><User-defined Toolbar>.



The icon that is displayed is different for each user-specific test method. The same icon also appears in the program sub-window before the corresponding test step.



If no separate icon is available for a test method, a standard icon is displayed.

It is also possible to insert user-defined tests with menu command <Edit><Insert><Name of test method>.



17.2.4 Grouping Test Steps

To ensure the fastest possible execution time for the in-circuit test, user-defined test methods should be combined into groups of similar test methods if possible. The reason for this is that device settings are made when switching between different test methods, and this requires additional time (see also Section 17.3.7.5).

17.2.5 Running and Debugging Test Steps

Running and debugging test steps of user-defined test methods is no different than R&S EGTSL-internal test methods. The process described in Chapter 12 also applies to this case.

17.3 Creating Extension Libraries

17.3.1 Overview

17.3.1.1 Software Structure

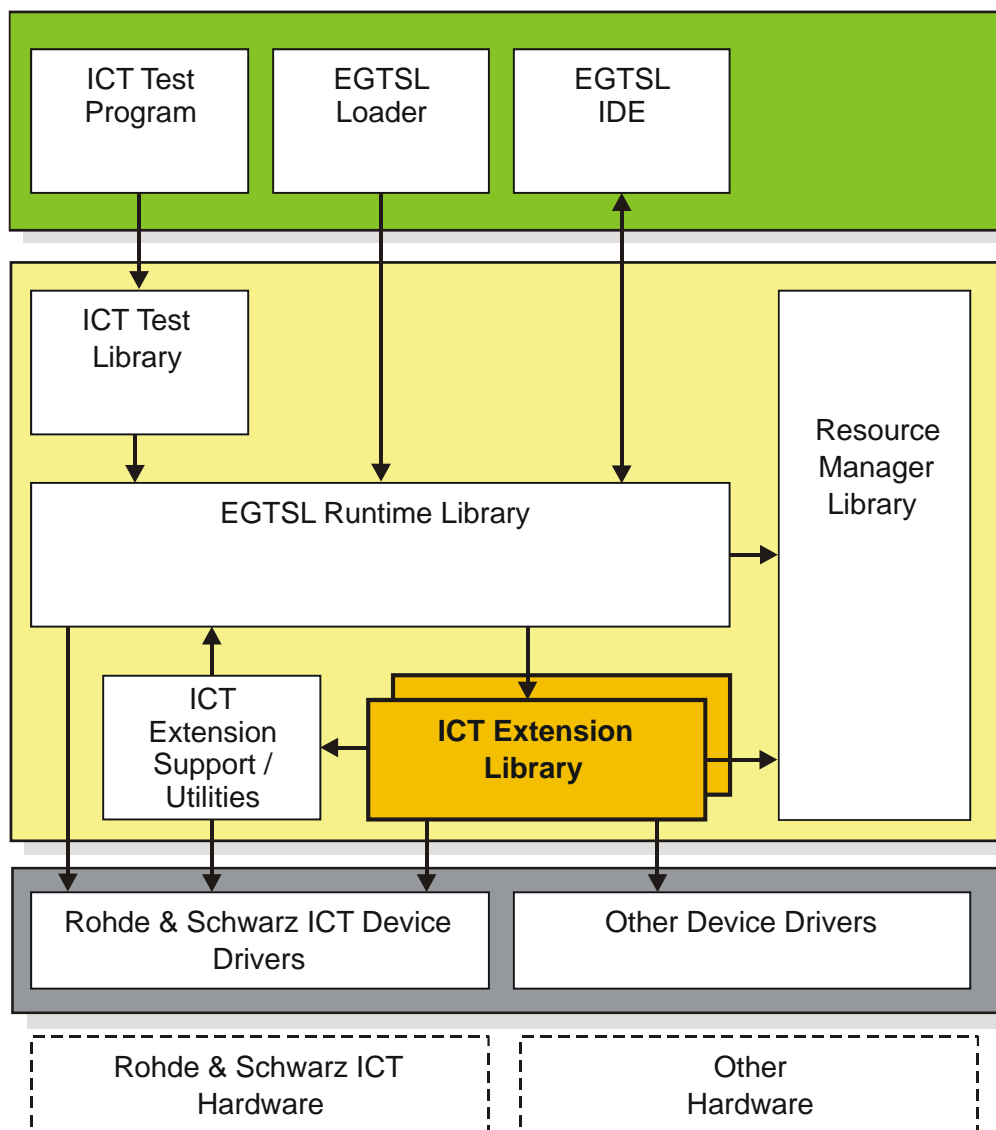


Figure 17-2 Software structure

The ICT extension libraries are loaded and called by the R&S EGTSL Run-time Library. The extension libraries use ICT hardware device drivers (R&S TS-PSAM, R&S TS-PICT, R&S TS-PMB) as well as other devices. The functions of the Resource Manager and ICT Extension Support Library can also be used.

17.3.1.2 Working Principle

Every ICT extension library is implemented as a Dynamic Link Library (DLL). This DLL makes a defined set of functions available that are called by the R&S EGTSL runtime library at the appropriate time. Of course the most important of these functions are responsible for performing the measurements and connections. The tasks of the remaining functions are to initialise and prepare hardware modules, verify user entries and prepare the measurement value for display.

17.3.1.3 Integrating Hardware Modules

In the standard configuration, the ICT modules administered by R&S EGTSL, R&S TS-PSAM and R&S TS-PICT plus the matrix modules R&S TS-PMB are available for measurements and connections. They are already initialized and administered by R&S EGTSL, so there is no additional software overhead required in the ICT extension library.

The ICT Extension Support Library also offers functions for quickly connecting test object pins to the analog busses of the R&S CompactTSVP using the R&S TS-PMB matrix modules.

In addition, other measurement and stimulus modules can also be integrated. That could include R&S CompactTSVP modules such as the R&S TS-PFG function generator, but also any other modules or external devices such as power supply units.

17.3.1.4 File Structure

An ICT extension library generally consists of three files.

- The Dynamic Link Library (DLL), which makes functionality available.
- A bitmap file with the same name and filename extension `.BMP`, containing the icon associated with the test method.
- A file containing the documentation for the test method. Any file format can be selected (for example HTML, PDF, HLP, CHM), provided there is a program on the target system that is linked with that format and is able to display it.

When assigning names to ICT extension libraries, care must be taken to ensure the names are unique. We therefore recommend prefixing an abbreviation for your company to the beginning of the name. This is the reason the sample project included with delivery is called “RSSample”, with RS standing for Rohde & Schwarz.

ICT extension libraries should be stored in a common directory (for example `C:\IctExtensionDlls\`). The directory should not be created within the R&S GTSL installation directory. This will prevent files from being overwritten when R&S GTSL is updated or reinstalled.

Since the full directory name is generally listed in the `APPLICATION.INI` file, make certain the directory is always in the same place for different test systems. Otherwise the ICT extension libraries cannot be loaded on another test system.

17.3.2 Sample Projects

Two sample projects for ICT extension libraries are stored in the source code in folder `...GTSL\EGTSL\ExtIct`.

17.3.2.1 RSSample

The `RSSample` project is a fully functional example of an ICT extension library using modules `R&S TS-PSAM` and `R&S TS-PFG`.

The `R&S TS-PSAM` module is an example of modules administered by `R&S EGTSL`, and is relatively easy to use. The `R&S TS-PFG` module is not administered by `R&S EGTSL` and therefore requires greater programming overhead in `RSSample`. The files for this project reside in folder `...GTSL\EGTSL\ExtIct\RSSample`.

File	Description
<code>RSSample.c</code>	Source code of <code>RSSample</code> library
<code>RSSample.dll</code>	Executable code of <code>RSSample</code> as Dynamic Link Library
<code>RSSample.lib</code>	Link library of <code>RSSample</code>
<code>RSSample.bmp</code>	Bitmap file for the library's icon
<code>RSSample.pdf</code>	Description of <code>RSSample</code> library for the user
<code>RSSample.prj</code>	LabWindows/CVI project <code>RSSample</code>
<code>RSSample.dsp</code>	Microsoft Visual Studio project <code>RSSample</code>
<code>ExtIctUtil.c</code> , <code>ExtIctUtil.h</code>	Source and header file for support functions (see Section 17.3.3.4)



17.3.2.2 RSSamplePSU

The RSSamplePSU project is similar to the RSSample project, but uses the R&S TS-PSU module instead of the R&S TS-PFG module.

This project is simpler than the RSSample project because the TS-PSU and TS-PSAM are both administered by R&S EGTSL.

The files for this project reside in folder

...GTSL\EGTSL\ExtIct\RSSamplePSU.

17.3.2.3 Framework

The Framework project represent a framework for an ICT extension library which users can use to develop their own libraries.

Copy the files to a separate directory and change the filenames as appropriate to start the development of a new ICT extension library.

Places to be completed are identified by the comment

`/* TO BE DONE ... */`

File	Description
Framework.c	Source code of the frame
Framework.bmp	Bitmap file for the library's icon
Framework.prj	LabWindows/CVI project Framework
Framework.dsp	Microsoft Visual Studio project Framework
ExtIctUtil.c, ExtIctUtil.h	Source and header file for support functions (see Section 17.3.3.4)

17.3.3 Internal Structure

Studying the two sample projects RSSample and Framework is a good way to learn the internal structure of an ICT extension library.

17.3.3.1 Project Structure

An ICT extension library can be created with different compilers. Project files for LabWindows/CVI and Microsoft Visual Studio for the two samples are included with delivery.

A LabWindows/CVI project for an ICT extension library contains the following files:

- Source file(s) for the extension library (* .c)

- Source file for support functions (ExtIctUtil.c)
- Header file for the extension library (ExtIctTestDll.h)
- Function panel for the support library (ExtIctSupport.fp)
- Function panel for the resource manager (Resmgr.fp)
- Function panel for each device driver that is used (*.fp)

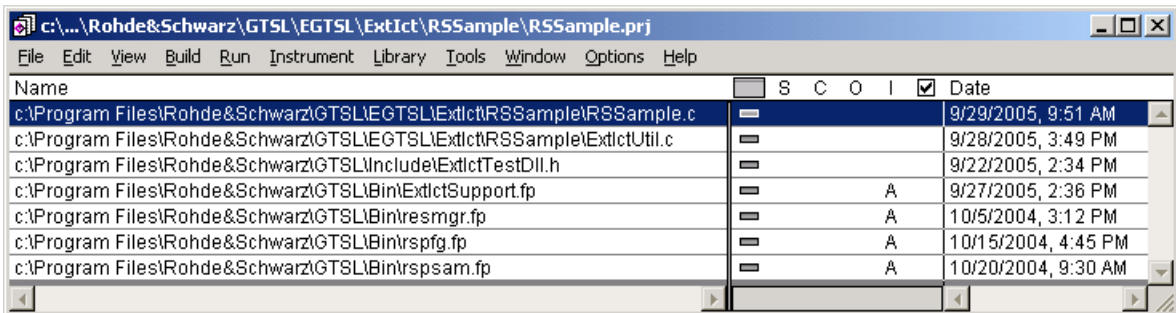


Figure 17-3 LabWindows CVI, project window

If the extension library is created with a compiler other than LabWindows/CVI, the Function Panel files (*.fp) must be replaced by the Link Libraries (*.lib) of the same name. The *.fp and *.lib files reside in folder ...\GTSL\Bin.

The project must be configured so that a Dynamic Link Library (DLL) is generated.

With LabWindows/CVI the DLL export options are set so that the symbols specified in the include file will be exported:

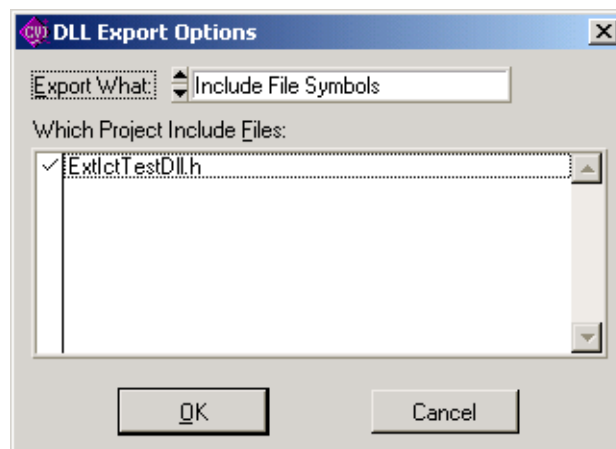


Figure 17-4 LabWindows/CVI, DLL Export Options

17.3.3.2 Export interface

The export interface of an ICT extension library, i.e. the exported functions and variables, is identical for all extension libraries. These functions and variables are defined in the header file `ExtIctTestDll.h`. This file resides in folder `...\GTSL\include`.

The names of all exported functions and variables comply with the following naming convention:

“extict” + <subject> + <name>

“extict” is the name prefix for the ICT extension library, <subject> identifies the group to which the function belongs, for example “Info” for all variables or “Test” for some functions. <name> is the descriptive name of the function. The function performing the measurement is therefore given the name **extictTestMeasure()**.

For functions that are listed to be correctly exported by the ICT extension library, the `EXTICTTESTDLL_EXPORTS` symbol must be defined before the include of the header file `ExtIctTestDll.h`:

```
#define EXTICTTESTDLL_EXPORTS
#include "ExtIctTestDll.h" /**< ExtIct  data types and export interface
*/
```

This definition ensures that the ICT extension library will **export** the functions and other code modules (which have not defined the symbol) will **import** the functions.

Each ICT extension library must implement all functions defined in `ExtIctTestDll.h`. Otherwise R&S EGTSL reports an error if one of the functions or variables is not present.

17.3.3.3 Data Structures

Special data structures are used to transfer parameters between R&S EGTSL and the ICT extension libraries. They are defined in `ExtIctTestDll.h`. The names of these data structures begin with the prefix “Extlct”, followed by the name of the data type.

17.3.3.3.1 Strings

There are three data structures that write strings of differing length:

<code>ExtlctString</code>	Strings with max. 256 characters, for example properties and values
<code>ExtlctInfoString</code>	Strings with max. 1024 characters, for error messages
<code>ExtlctBigString</code>	Strings with max. 4096 characters, for debug details.

```
typedef struct tagExtIctString
{
    char text[EXTICT_MAXSTRINGLENGTH];
} ExtIctString;
typedef struct tagExtIctInfoString
{
    char text[EXTICT_MAXINFOSTRINGLENGTH];
} ExtIctInfoString;
typedef struct tagExtIctBigString
{
    char text[EXTICT_MAXBIGSTRINGLENGTH];
} ExtIctBigString;
```

There are support functions for writing these strings to ensure the maximum length is not exceeded.

17.3.3.3.2 Status

The `ExtIctStatus` structure is composed of a numeric error code and an error message. This data structure is returned with most functions of the ICT extension library as the result.

An error code of = 0 means that a function has been successfully completed. Errors are reported as negative values.

In the case of success, the error message is empty. Otherwise the error text is entered.

```
typedef struct tagExtIctStatus
{
    int error;
    ExtIctInfoString message;
} ExtIctStatus;
```

17.3.3.3.3 Test Result

The structure `ExtIctTestResult` is composed of a status structure and the measurement result. This structure is returned as the result of function `extictTestMeasure`.

The structure indicates whether the measurement function was completed successfully. The error code is not set if a measurement value is outside the expected limits, however. Its purpose is rather to signal runtime errors.

If the measurement is successful, the variable “value” contains the result value. It is compared with the upper and lower limit by R&S EGTSL. The comparison result in an evaluation of whether a test step is a “Pass” or a “Fail”.

In addition to the measurement value, the unit of measure (for example “mV”, “kHz” or an empty string in some cases) is transferred in the variable “unit”. The character sequence “info” can optionally be used to transfer non-numeric information. This information is added to the test report in the event a test fails (see also Section 17.3.8.2).

```
typedef struct tagExtIctTestResult
{
    ExtIctStatus status;
    double value;
    ExtIctString unit;
    ExtIctString info;
} ExtIctTestResult;
```


17.3.3.3.4 Properties

The structure `ExtIctPropertyList` contains a list of all setting parameters and their values. This structure contains an array of elements of the structure `ExtIctPropertyItem`. The content of this structure is shown in the R&S EGTSL user interface (see Section 5.5.10.2).

`ExtIctPropertyItem` is a pair of two strings. The variable “name” contains the name of the property and “value” contains its value.

`ExtIctPropertyList` contains a list of 256 of these properties in addition to the nominal value (“nominal”), the unit (“unit”) and the number of properties actually used (“size”).

```
typedef struct tagExtIctPropertyItem
{
    ExtIctString name;
    ExtIctString value;
} ExtIctPropertyItem;
typedef struct tagExtIctPropertyList
{
    double nominal;
    ExtIctString unit;
    int size;
    ExtIctPropertyItem items[EXTICT_MAXNUMPROPERTIES];
} ExtIctPropertyList;
```

17.3.3.3.5 Administrative Data

When an ICT extension library is loaded and a test step is created, additional data structures are also created. Their main purpose is for storing internal data.

A structure `ExtIctTestInstance` is created for each test step. In addition to properties, it also contains a pointer to an internal data structure. This data structure is described in Section 17.3.4.3.1.

The structure `ExtIctSetup` is created once for each test method. It contains the resource ID of the ICT program and also a pointer to an internal data structure. This data structure is described in Section 17.3.4.3.2.

```
typedef struct tagExtIctTestInstance
{
    void *userData;
    ExtIctPropertyList properties;
} ExtIctTestInstance;
typedef struct tagExtIctSetup
{
    void *userData;
    int resourceId;
} ExtIctSetup;
```



17.3.3.4 Support Functions

Two support libraries are available to support ICT extension libraries:

- The ICT Extension Support Library (`ExtIctSupport.dll`)
- The ICT Extension Utilities (`ExtIctUtil.c`)

The **ICT Extension Support Library** offers functions of the R&S EGTSL Runtime Library for use in ICT extension libraries. This includes especially connections of matrix modules. The functions of this library are described in the corresponding online help `ExtIctSupport.hlp` in directory `... \GTSL \Bin`.

The **ICT Extension Utilities** offer functions to make it easy to handle special `ExtIct` data types. In some cases they also use the ICT Extension Support Library. By contrast, the ICT Extension Utilities are integrated into the source code. The functions of this library are described in source file `ExtIctUtil.c`. This file resides in folder `... \GTSL \EGTSL \ExtIct \Framework`.

To create a new ICT extension library, `ExtIctUtil.c` can be copied and easily expanded if additional functions are required.

`ExtIctUtil` contains functions for:

- Setting and chaining strings, taking into consideration the maximum length.
- Handling error messages.
- Converting property values (Strings) into numeric or Boolean values.
- Handling pin names.

17.3.3.5 Bitmap

Each ICT extension library can make its own icon available in a bitmap file. This icon is displayed in the R&S EGTSL user interface for each test step of this test method. The icon also appears in the toolbar.

The bitmap must be 16 x 16 pixels in size and can have a colour depth of 16 or 256 colours. The lowest row of pixels is not displayed, i.e. the available surface is 16 x 15 pixels:

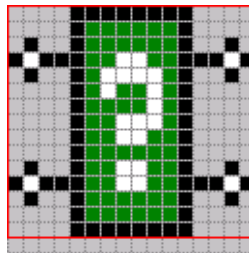


Figure 17-5 Bitmap Layout

If the bitmap file is not available, R&S EGTSL shows a default icon.

17.3.4 Description of Function

17.3.4.1 Header Files

An ICT extension library includes the following header files:

```
#define EXTICTTESTDLL_EXPORTS
#include "ExtIctTestDll.h" /**< ExtIct  data types and export interface
*/
#include "ExtIctSupport.h"      /**< ExtIct  support library */
#include "ExtIctUtil.h"        /**< ExtIct  utilities */

#include "resmgr.h"            /**< GTSL  Resource Manager */

#include "rspsam.h"           /**< TS-PSAM  device driver */
#include "rspfg.h"           /**< TS-PFG  device driver */
```

`ExtIctTestDll.h` exports the interface of the ICT extension library and defines the necessary data types.

`ExtIctSupport.h` and `ExtIctUtil.h` import the support functions.

`resmgr.h` imports the functions of the resource manager.

The corresponding header file is included for each device driver that is used, thus in the example above for R&S TS-PSAM and R&S TS-PFG.

The header files reside in folder `...\GTSL\include` with the exception of `ExtIctUtil.h`, which is in the project folder.

17.3.4.2 Exported Variables

Each ICT extension library exports the following variables, whose names begin with `extictInfo`:

```
/** test name */
EXTICTTESTDLL_API char extictInfoTestName[] = "RSSample";

/** component version */
EXTICTTESTDLL_API char extictInfoVersion[] = "01.00";

/** help file for this component */
EXTICTTESTDLL_API char extictInfoHelpFileName[] = "RSSample.pdf";

/** component bitmap is loaded from a file */
EXTICTTESTDLL_API int extictInfoIconBitMap = -1;
```

17.3.4.2.1 extictInfoTestName

This string variable contains the unique name of the test method. This name appears in the program sub-window with each test step and is displayed in the **Test Properties Info** window (see Figure 17-1).

To ensure the name is unique system-wide, we recommend making it begin with the company initials or abbreviation. This is the reason the sample project included with delivery is called “RSSample”, with RS standing for Rohde & Schwarz.

17.3.4.2.2 extictInfoVersion

This string variable contains the version number of the ICT extension library. It is displayed in the **Test Properties Info** window (see Figure 17-1).

17.3.4.2.3 extictInfoHelpFileName

This string variable contains the name of the documentation file for the ICT extension library. This file must reside in the same directory as the DLL. You can display it by clicking the Help button in the **Test Properties Info** window (see Figure 17-1).

The documentation can be available in any file format. The only thing that is important is that a program that is called to display the file is linked with the file ending. Bringing up the documentation file from the R&S EGTSL user interface corresponds to double clicking this file in the Windows Explorer. The following common file formats are suitable for a documentation file:

File ending	Linked display program
.pdf	Adobe Reader
.html, .htm	Internet Explorer
.hlp	Windows Help
.chm	HTML Help Executable

17.3.4.2.4 extictInfoIconBitmap

This integer variable normally contains the value -1. That value means that the icon for the ICT extension library is present as a *.BMP file. In that case R&S EGTSL loads the bitmap from the file.

If the ICT extension library is generated with Visual Studio, it is also possible to create the bitmap as a resource and add it to the DLL. In that case the resource ID of the bitmap resource is assigned to `extictInfoIconBitmap`. In that case R&S EGTSL extracts the bitmap from the DLL.

On the format of the bitmap, see Section 17.3.3.5.

17.3.4.3 Local Data Structures

An ICT extension library generally uses the following local data structures:

17.3.4.3.1 SetupUserData

This data structure is defined specifically for each ICT extension library. It contains information related to the entries in files `PHYSICAL.INI` and `APPLICATION.INI`. The data structure is dynamically allocated and filled in function `extictConfigSetup` and freed again in function `extictConfigCleanup`. A structure like this is created for each ICT program that is loaded.

In the `RSSample` project, the structure contains the following data items:

```
typedef struct
{
    int tracing;           /**< trace flag */
    int simulation;       /**< simulation flag */
    ViSession viPsam;     /**< session handle for TS-PSAM (=0 in simulation mode) */
    ViSession viPfg;     /**< session handle for TS-PFG (=0 in simulation mode) */
    int lockedPfg;       /**< lock flag for TS-PFG (=1 when locked) */
} SetupUserData;
```

`tracing` and `simulation` contain the values of the two entries “Tracing” and “Simulation” from file `APPLICATION.INI`.

`viPsam` and `viPfg`: For each hardware module that is used, the corresponding session handle of the device driver is stored in the structure. In Simulation mode, 0 is assigned to the handles.

`lockedPfg` is a flag that is created for each module not controlled by R&S EGTSL.

17.3.4.3.2 TestUserData

This data structure is defined specifically for each ICT extension library. It contains information related to the settings and measurement results of the test step. The main purpose of this structure is to move data between different processing steps of a test (compiling, measuring, displaying results).

The data structure is dynamically allocated in function `extictTestConstruct` and freed again in `extictTestDestruct`.

In the `RSSample` project, the structure contains the following data items:

```
typedef struct
{
    /* Source property values */
    E_SOURCE_MODE sourceMode;    /**< "Source Mode" decoded property value */
    double voltage;              /**< "Voltage" property value, in Volts */
    double offset;               /**< "Offset" property value, in Volts */
    double frequency;           /**< "Frequency" property value, in Hertz */

    /* Measurement property values */
    E_MEAS_FUNCTION measFunction; /**< "Measurement Function"
                                     decoded property value */
    double range;                /**< "Range" property value in V, A, or Ohms */
    int autoRange;               /**< "Autorange" property value - as Boolean */
    double filter;               /**< "Filter" property value in Hertz */
    double delay;                /**< "Delay" property value in seconds */
    int average;                 /**< "Average" property value */
    double sampleInterval;       /**< "Sample Interval" property value */

    /* Measurement data */
    E_MEAS_STATE measState;      /**< state of the measurement */
    double measuredValue;        /**< measured value, dependent on measFunction,
                                     in units of nominal value */
    double measuredRange;        /**< range in which measurement was taken,
                                     in units of nominal value */
    double scalingFactor;        /**< the value by which the measured value must
                                     be multiplied to obtain the value in the
                                     desired unit */
    double duration;             /**< duration of measurement */
    int simulationMode;          /**< 1 if simulation, 0 otherwise */

    /* Switching information */
    char busSourceHi [BUS_LEN];  /**< bus name for Pin Source HI */
    char busSourceLo [BUS_LEN];  /**< bus name for Pin Source LO */
    char busMeasHi [BUS_LEN];    /**< bus name for Pin Meas HI */

```

```
char busMeasLo [BUS_LEN]; /**< bus name for Pin Meas LO */

} TestUserData; /**< test user data */
```

The elements of this structure can mainly be divided into three groups:

Sections “Source property values” and “Measurement property values” contain values of the setting values already converted into target format. Function `extIctTestCompile` converts values and checks for valid value ranges. If the measurement function

`extIctTestMeasure` is called, values stored here can be transferred directly to the device driver. This ensures optimal performance, since the conversion and check are eliminated each time the measurement is performed.

Section “Measurement data” contains data from the last measurement. The data is stored here in the function `extIctTestMeasure`. It is prepared for display in function `extIctTestGetDebugDetails`.

The last group, “Switching Information”, contains information about the correct switching path. This information is also determined earlier during `extIctTestCompile` so that it can be transferred directly to the device drivers for `extIctTestMeasure`, thus guaranteeing a short execution time.

17.3.4.3.3 Table of Properties

All properties and their default values are combined together in a table.

The table appears as follows in the `RSSample` project:

```
/** table with properties and default values */
static const ExtIctPropertyItem s_properties[] =
{
    /* property name          default value */
    { "Source Mode",         "DC"           },
    { "Voltage",             "0.0"          },
    { "Offset",              "0.0"          },
    { "Frequency",           "1000.0"       },
    { "Measurement Function", "VDC"          },
    { "Range",               "10.0"         },
    { "Autorange",           "On"           },
    { "Filter",              "40.0e3"       },
    { "Delay",               "0.0"          },
    { "Average",             "1"            },
    { "Sample Interval",     "1.0e-3"       },
    { "Pin Source HI",       ""              },
    { "Pin Source LO",       ""              },
    { "Pin Meas HI",        ""              },
    { "Pin Meas LO",        ""              },
};
```



```
/** number of property entries in s_properties table */  
#define NUM_PROPS (sizeof(s_properties)/sizeof(s_properties[0]))
```

On the left side are the names of properties in the order in which they are also displayed in the R&S EGTSL user interface. On the right side are their default values. When a new test step is created, all properties contain the corresponding default values. Because of that, the default values specified here must be valid values.

Values are generally stored as `ExtIctString`, i.e. as a string with a maximum of 256 characters. The data type for the individual properties is derived from the context, i.e. during the conversion and check in function `extictTestCompile`. Different types of data can be seen in the example, for example Voltage as a real number, Average as an integer, Autorange as a Boolean value and Source Mode as text.

Since it is not possible to specify default values for pin names, empty strings are assigned to them.

The `NUM_PROPS` macro automatically calculates the number of entries in the `s_properties` table.

A data type `PROP_INDEX` is defined for access to the property table. It defines constants for the indices of table entries. If changes are made to the `s_properties` table, `PROP_INDEX` must also be adjusted accordingly.

```
/** property enumeration = index into s_properties  
    must be kept consistent with the s_properties table !  
*/  
typedef enum  
{  
    PROP_UNIT = -1,          /* special value, see decodePropertyStringVal */  
  
    PROP_SOURCE_MODE = 0,   /* 0 = first index in s_properties table */  
    PROP_VOLTAGE,  
    PROP_OFFSET,  
    PROP_FREQUENCY,  
    PROP_MEAS_FUNCTION,  
    PROP_RANGE,  
    PROP_AUTO_RANGE,  
    PROP_FILTER,  
    PROP_DELAY,  
    PROP_AVERAGE,  
    PROP_SAMPLE_INTERVAL,  
    PROP_PIN_SOURCE_HI,  
    PROP_PIN_SOURCE_LO,  
    PROP_PIN_MEAS_HI,  
    PROP_PIN_MEAS_LO  
} PROP_INDEX;
```

17.3.4.3.4 Tables for Value Conversions

As already explained in the previous section, values of properties are transferred as strings. The strings are not converted to their actual data type until during a test step is “compiled”. The code module `extIctUtil.c` makes conversion functions available for numeric data types (int, double) that check the converted value against both an upper and a lower limit.

Properties that allow a selection of multiple strings as a value are treated with special conversion tables. Examples of these properties are mode settings (“Off”, “AC”, “DC”) or physical units (“ μ V”, “mV”, “V”). A conversion table is created for each of these properties that assigns an integer number to each permissible string value.

```
/**
 * @brief Property string value -> integer conversion table.
 * This table type holds pairs of permissible value strings
 * and associated integer values. The table must end with an entry
 * containing a NULL pointer for stringVal.
 */
typedef struct
{
    int          intVal;          /**< The associated integer value */
    const char * stringVal;      /**< The property value string */
} ExtIctUtilPropTableEntry;
```

In the `RSSample` project, for example, the following conversion tables are defined:

```
/** property value table for Source Mode */
static const ExtIctUtilPropTableEntry s_propsSourceMode[] =
{
    { SOURCE_MODE_AC,      "AC"  },
    { SOURCE_MODE_DC,      "DC"  },
    { SOURCE_MODE_OFF,     "OFF" },
    { 0,                   NULL  } /**< always terminate the table with
a NULL entry */
};

/* property value table for Voltage units */
static const ExtIctUtilPropTableEntry s_propsVoltageUnits[] =
{
    /* scaling exponent,  unit */
    { 0,                  "V"   },
    { -3,                 "MV"  },
    { -6,                 "UV"  },
    { 0,                  NULL  } /**< always terminate the table with
a NULL entry */
};
```

The last entry in the tables must contain a NULL string.

Table `s_propsSourceMode` assigns an “enum” constant to each mode. Table `s_propsVoltageUnits` assigns an exponent to each unit. The exponent is used to calculate the scaling factor.

(1 mV = 10^{-3} V, 1 μ V = 10^{-6} V).

Function `decodePropertyStringValue` from `extIctUtil.c` uses these tables to convert and check properties.

17.3.4.4 Configuration functions

Configuration functions are used to prepare hardware for use or to take them to a defined state after use.

All configuration functions have a pointer to a data structure `ExtIctSetup` as a parameter and return `ExtIctStatus` as a result.

17.3.4.4.1 `extIctConfigSetup`

```
ExtIctStatus extIctConfigSetup ( ExtIctSetup * pSetup )
```

The Setup function is called by R&S EGTSL when a test program is loaded. R&S EGTSL transfers the resource ID of the test program to `pSetup->resourceId`.

Tasks performed by function `extIctConfigSetup`

- Allocate and initialise data structure `SetupUserData` and save its pointer to `pSetup`.
- Determine configuration data from `APPLICATION.INI` and `PHYSICAL.INI` and store in `SetupUserData`, for example flags “Trace” and “Simulation”.
- Determine session handles for hardware modules administered by R&S EGTSL and save in `SetupUserData`.
- Initialisation of device drivers for hardware modules not administered by R&S EGTSL.

Very little new code needs to be created for these tasks, with the exception of the last. Only in the case of loading and initialising device drivers not administered by R&S EGTSL is more overhead required. See also Section 17.3.7.

17.3.4.4.2 `extIctConfigCleanup`

```
ExtIctStatus extIctConfigCleanup ( ExtIctSetup * pSetup )
```

The Cleanup function is called by R&S EGTSL when a test program is unloaded.



Tasks performed by function `extIctConfigCleanup`

- Closing device drivers for hardware modules not administered by R&S EGTSL.
- Freeing the data structure `SetupUserData`.

Handling of device drivers for hardware module not administered by R&S EGTSL is described in detail in Section 17.3.7.

17.3.4.4.3 extIctConfigProlog

```
ExtIctStatus extIctConfigProlog ( ExtIctSetup * pSetup )
```

The purpose of the Prolog function is to prepare hardware modules to perform the next test step.

R&S EGTSL calls this function each time before executing a block of identical test steps.

Tasks performed by function `extIctConfigProlog`:

- Call Prolog function of R&S EGTSL.
- Locking of modules not administered by R&S EGTSL
- Reset of modules not administered by R&S EGTSL
- Preparing modules for the following test steps, for example closing the bus coupling relays, configuring the ground relay, switching the measurement and stimulus modules to the analog bus, any settings that are the same for all test steps.

See also Section 17.3.7.5.

17.3.4.4.4 extIctConfigEpilog

```
ExtIctStatus extIctConfigEpilog ( ExtIctSetup * pSetup )
```

The purpose of the Epilog function is to reset hardware modules to a defined state after the test steps have been performed.

R&S EGTSL calls this function each time after executing a block of identical test steps.

Tasks performed by function `extIctConfigEpilog`:

- Reset of modules not administered by R&S EGTSL
- Unlock modules not administered by R&S EGTSL
- Call Epilog function of R&S EGTSL.

See also Section 17.3.7.5.

17.3.4.4.5 extictConfigErrorCleanup

```
ExtIctStatus extictConfigErrorCleanup ( ExtIctSetup * pSetup )
```

The purpose of the `ErrorCleanup` function is to reset hardware modules to a defined state after a runtime error.

R&S EGTSL calls this function when a runtime error has occurred in a test step of this ICT extension library.

Tasks performed by function `extictConfigErrorCleanup`:

Normally `extictConfigErrorCleanup` calls the two functions `extIctConfigEpilog` and `extIctConfigProlog` one after the other to make certain the hardware modules, coming from an unknown state, are prepared for the following test step.

17.3.4.5 Test-related functions

The purpose of test-related functions is to check the settings for a test step, perform the test step and prepare the results for display.

17.3.4.5.1 extictTestConstruct

```
ExtIctStatus extictTestConstruct ( ExtIctTestInstance * pNewInstance,  
                                double * pLowerLimit,  
                                double * pUpperLimit )
```

The purpose of the `Construct` function is to create data structures for a new test step.

R&S EGTSL calls this function if a new test step is inserted into the program or if a test step is loaded from an ICT file.

Tasks performed by function `extictTestConstruct`

- Allocate and initialise data structure `TestUserData` and save its pointer to `pNewInstance`.
- Copy content of table `s_properties` (property names and default values) to `pNewInstance`.
- Set default values for nominal value, unit, upper and lower limit.

17.3.4.5.2 extIctTestDestruct

```
ExtIctStatus extIctTestDestruct ( ExtIctTestInstance * pTestInstance )
```

The purpose of the `Destruct` function is to free data structure `TestUserData`.

R&S EGTSL calls this function if a test step has been deleted from the program and when the ICT program is closed.

Tasks performed by function `extIctTestDestruct`

- Free data structure `TestUserData`.

17.3.4.5.3 extIctTestCompile

```
ExtIctStatus extIctTestCompile ( ExtIctTestInstance * pTestInstance,
                                ExtIctSetup * pSetup )
```

The purpose of the `Compile` function is to “compile” a test step, i.e. check the properties for valid values and store the converted values in the `TestUserData` structure.

R&S EGTSL calls this function if a test step has been inserted or changed and when an ICT program is loaded.

Tasks performed by function `extIctTestCompile`

- Check whether the required hardware modules are present
- Check the values of properties to ensure they are valid
- Check the values of properties for consistency among each other
- Search for switching paths for matrix modules
- Prepare structure `TestUserData` to perform the test.

17.3.4.5.4 extIctTestMeasure

```
ExtIctTestResult extIctTestMeasure ( ExtIctTestInstance * pTestInstance,
                                      ExtIctSetup * pSetup )
```

The purpose of the `Measure` function is to configure and connect the instruments, perform the measurement and return the measurement results to R&S EGTSL.

R&S EGTSL calls this function when a test step is being performed.

Tasks performed by function `extIctTestMeasure`

- Perform settings for hardware modules
- Create connection to test object
- Perform measurement
- Disconnect connection to test object

- Store data for “Debug Details” display in `TestUserData`
- Return measurement results to R&S EGTSL

17.3.4.5.5 `extIctTestGetDebugDetails`

```
ExtIctBigString extIctTestGetDebugDetails ( ExtIctTestInstance *  
pTestInstance )
```

The purpose of the `GetDebugDetails` function is to prepare details of the last measurement for output in the Debug Details window.

R&S EGTSL calls this function when a test step is being displayed.

Tasks performed by function `extIctGetDebugDetails`

- Prepare data from the last measurement from `TestUserData` for output.

The following data items can be collected during the measurement and sent to Debug Details:

- Status information from stimulus devices, for example current limiting active.
- Status information from measurement devices, for example over-range/underrange.
- The measurement range within which the measurement was performed (important for auto-ranging).
- Duration of the measurement.
- Any additional information that may help users to optimise and speed up measurements.

17.3.4.5.6 `extIctTestGetResultDescription`

```
ExtIctString extIctTestGetResultDescription ( ExtIctTestInstance *  
pTestInstance )
```

The purpose of the `GetResultDescription` function is to prepare the text for the “Nominal” column in the program sub-window.

R&S EGTSL calls this function when a test step is being displayed.

Tasks performed by function `extIctGetResultDescription`

- Return nominal value and unit as a string

Special test cases that return a non-numeric result (for example the contact test) can return an empty string.

17.3.4.6 Functions for displaying results

These functions are responsible for generating the table in the “Result Tbl” sub-window.

Time	Result	Unit	Lower Limit	Upper Limit
✓ 13:32:26.296	0.5	V	0	1

Figure 17-6 Result Tbl sub-window

- Column heading (“Result”) :
`extIctResultTableGetValueCaption`
- Result value (“0.5”) :
`extIctResultTableFormatValueString`
- Unit (“V”) : `extIctResultTableFormatUnitString`

17.3.4.6.1 `extIctResultTableGetValueCaption`

```
ExtIctString extIctResultTableGetValueCaption ( void )
```

Function `extIctResultTableGetValueCaption` returns the column heading of the table’s second column in the “Result Tbl” sub-window.

- The column heading should indicate what a test method returns, for example “Frequency” or “Resistance”.
- If a test method can return different results, for example RSSample, the default heading “Result” is used.

17.3.4.6.2 `extIctResultTableFormatValueString`

```
ExtIctString extIctResultTableFormatValueString ( double value )
```

Function `extIctResultTableFormatValueString` returns the content of the table’s second column in the “Result Tbl” sub-window as a string. The current measurement value is transferred in the parameter “value”.

- Normally the measurement value is formatted and returned as text with a function such as `sprintf`.

17.3.4.6.3 extIctResultTableFormatUnitString

```
ExtIctString extIctResultTableFormatUnitString ( char * unit )
```

Function `extIctResultTableFormatUnitString` returns the content of the table's third column in the "Result Tbl" sub-window as a string. The current unit is transferred in the parameter "value".

- Normally the unit that is transferred is returned as text.

17.3.5 Details of implementation

17.3.5.1 Error handling

Most functions of an ICT extension library return an `ExtIctStatus` structure as the result. The error code is set to 0 and the error message is set to an empty string at the beginning of each function.

```
ExtIctStatus status = { 0, "" };
```

If an error occurs while a function is running, function `setError` from `extIctUtil.c` can be used to transfer an error code and an error message:

```
setError ( &status, ERR_MEMORY_ALLOCATION_FAILED,
          "SetupUserData memory allocation failed" );
```

The constants for error codes are defined at the beginning of the C module. The beginning of the numbering is based on `GTSL_ERROR_BASE_EXTICT_USER`. Starting at this number, error codes are reserved specially for ICT extension libraries:

```
/* Error codes, based on GTSL_ERROR_BASE_EXTICT_USER = -300000 */
#define ERR_INTERNAL_ERROR          (GTSL_ERROR_BASE_EXTICT_USER )
#define ERR_MEMORY_ALLOCATION_FAILED (GTSL_ERROR_BASE_EXTICT_USER - 1)
#define ERR_MODULE_REQUIRED        (GTSL_ERROR_BASE_EXTICT_USER - 2)
#define ERR_INVALID_NUM_PROPERTIES (GTSL_ERROR_BASE_EXTICT_USER - 3)
#define ERR_FUNCGEN_CONFIGURATION  (GTSL_ERROR_BASE_EXTICT_USER - 4)
```

Error messages from R&S GTSL libraries such as the Resource Manager are forwarded directly to `setError`:

```
RESMGR_Lock_Device ( 0, pSetup->resourceId, RESMGR_KEY_FUNCTION_GENERATOR,
                    LOCK_TIMEOUT, &errorOccurred, &errorCode, errorMessage );
if ( 0 != errorCode )
{
    setError ( status, errorCode, errorMessage );
}
```

Error messages from device drivers are somewhat more difficult to handle, since the driver only returns an error code. This error code must be converted into an error message in an additional driver call. A function of this type, `driverErrorXYZ` is implemented in the `RSSample` project for each device driver:

```
driverStatus = rspsam_ConfigureGround ( viPsam, VI_TRUE );
if ( VI_SUCCESS != driverStatus )
{
    driverErrorPsam ( &status, viPsam, driverStatus, "rspsam_ConfigureGround" );
}
```

To make certain the following code is no longer executed after an error, the code is divided into sections. The program checks whether an error has already occurred before each section is executed:

```
if ( 0 == status.error )
{
    RESMGR_Lock_Device ( 0, pSetup->resourceId, RESMGR_KEY_FUNCTION_GENERATOR,
                        LOCK_TIMEOUT, &errorOccurred, &errorCode, errorMessage );
    if ( 0 != errorCode )
    {
        setError ( &status, errorCode, errorMessage );
    }
    else
    {
        deviceLocked = 1;
    }
}

if ( 0 == status.error )
{
    /* etc. */
}
```

Error messages are handled differently depending on the function that returns them (see also Chapter 16):

`extictTestCompile`: The error message is generated as a “Compile Error” in the sub-window report.

`extictTestMeasure`: The error is reported as a runtime error. Execution of the test is aborted. In this case the status of the hardware modules is undetermined. Because of this, `extictConfigErrorCleanup` is called next.

`extictConfigProlog`: The error is reported as a runtime error. Execution of the test is aborted.

`extictConfigSetup`, `extictTestConstruct`: The error is reported as a runtime error. The ICT program cannot be loaded.

An error message is ignored and not displayed in the remaining func-

tions.

Error messages should preferably be generated in `extictTestCompile`. They will be reported there as compile errors and that is where the user most expects to find them. Runtime errors should be avoided if possible, because they interrupt the test program that is running or may even prevent it from being able to load.

That means the values of all setting parameters should already be tested for the hardware's permissible upper and lower limits in `extictTestCompile` to avoid a driver error while `extictTestMeasure` is running.

We also recommend not reporting errors in `extictConfigSetup` at all. Errors in `extictConfigSetup` prevent the ICT program from being able to load. Then the user is no longer able to change the program to prevent the error from occurring. Errors in `extictConfigSetup` in the `RSSample` project are only written to the trace file. If a hardware module cannot be configured or initialised, the only response is that its session handle is set to 0 in the `SetupUserData`. Then the `extictTestCompile` function subsequently checks whether the session handles of the required device are non-zero. If they are equal to zero, a compile error is generated. This makes it possible to delay reporting errors that occur in `extictConfigSetup` until later in `extictTestCompile`.

17.3.5.2 Simulation

All R&S GTSL libraries as well as R&S EGTSL support a simulation mode. Users can turn simulation mode on in the `APPLICATION.INI` file. Simulation mode is also automatically set by R&S EGTSL, however, if there is no R&S TS-LEGT or R&S TS-LEG2 license in the system. Simulation mode is a good option for demonstrating software if no hardware is available.

No device drivers may be called when simulation mode is active. Libraries simulate the hardware and return a simulated measurement result.

The ICT extension libraries should also implement simulation mode. For this purpose, the simulation flag is read in `extictConfigSetup` and stored in the `ConfigUserData` structure:

```
pSetupUserData->simulation = EXTICTSUPPORT_SimulationMode ( pSetup->resourceId );
```

The session handles of device drivers should also be set to 0 when simulation mode is active.

This will cause device drivers to be called in all subsequent `extict` functions only if no errors have occurred up to that point and the corresponding session handle is not 0:

```
if ( 0 == status.error && 0 != viPsam )
{
    driverStatus = rspsam_ConfigureGround ( viPsam, VI_TRUE );
    if ( VI_SUCCESS != driverStatus )
    {
        driverErrorPsam ( &status, viPsam, driverStatus, "rspsam_ConfigureGround" );
    }
}
```

In this manner, driver calls will not be executed in simulation mode.

Function `extictTestMeasure` should return the nominal value as a result in simulation mode. (The result of the measurement seems even more realistic if some “background noise” is overlaid).

```
if ( pSetupUserData->simulation )
{
    /* pass nominal value and unit as result in simulation mode */
    testResult.value = pTestInstance->properties.nominal;
    testResult.unit = pTestInstance->properties.unit;
    pTestUserData->measuredValue = testResult.value;
}
```

17.3.5.3 Tracing

In addition to simulation, tracing is a standard feature of R&S EGTSL. Trace outputs of all R&S GTSL and R&S EGTSL libraries are recorded in a central file.

ICT extension libraries should also support tracing, since it represents an easy method of troubleshooting. For this purpose, the trace flag is read in function `extictConfigSetup` and stored in the `ConfigUserData` structure:

```
int traceFlag = EXTICTSUPPORT_TracingEnabled ( pSetup->resourceId );
pSetupUserData->tracing = traceFlag;
```

If tracing is active, output can be generated with the `RESMGR_Trace` function.

```
if ( traceFlag )
{
    RESMGR_Trace ( ">>extictConfigSetup RSSample" );
}
```

Formatted output is first formatted into a local buffer and then passed to `RESMGR_Trace`:

```
sprintf ( traceBuffer, "RSSample Version %s", extictInfoVersion );
RESMGR_Trace ( traceBuffer );
```

For more information on trace output options, please refer to Online Help in the Resource Manager (file `RESMGR.HLP`).

17.3.5.4 Locking

All R&S GTSL libraries and R&S EGTSL are designed for multithreading. That means several threads can run in parallel within a process and hardware modules can be controlled by different threads. Since one hardware module cannot be used by two threads at the same time, however, there is an option to reserve it exclusively for a thread.

The Resource Manager makes the two functions

`RESMGR_Lock_Device` and `RESMGR_Unlock_Device` available for this purpose. `RESMGR_Lock_Device` is used to request exclusive access to a hardware module. If the function returns successfully, no other thread is able to access the module, i.e. the same call from another thread will result in an error. `RESMGR_Unlock_Device` is used to unlock the module again.

ICT modules R&S TS-PSAM, R&S TS-PICT and matrix modules R&S TS-PMB in R&S EGTSL are locked as long as the in-circuit test is running. R&S EGTSL-internal Prolog and Epilog functions call `RESMGR_Lock_Device` and `RESMGR_Unlock_Device` for these modules.

ICT extension libraries should also implement these lock mechanisms for all hardware modules not administered by R&S EGTSL. To do this, `RESMGR_Lock_Device` must be called for each hardware module not administered by R&S EGTSL in `extictConfigProlog` and `RESMGR_Unlock_Device` must be called for each one in `extictConfigEpilog`.

17.3.6 R&S EGTSL-internal Hardware Modules

It is relatively easy to use hardware modules administered by R&S EGTSL, R&S TS-PSAM, R&S TS-PICT and R&S TS-PMB, in an ICT extension library, since R&S EGTSL is already responsible for opening and closing the device drivers. The `ExtIctSupport` library makes functions available for determining session handles. The ICT extension library uses these session handles for all calls to the device driver.

The following additions to file `Framework.c` are all that is required to control an R&S EGTSL-internal hardware module:

- Add an `#include` for the device driver's header file
- Insert the device driver's `.FP` file into the project
- Call `EXTICTSUPPORT_GetSessionHandle` to determine the session handle
- Insert the device driver calls for settings and measurements in `extictTestMeasure`.
- If necessary, insert calls to device drivers for general settings in `extictConfigProlog`.

The R&S TS-PSAM module is used as an example of an R&S EGTSL-internal module in the `RSSample.c` project.

17.3.7 Additional Hardware Modules

Additional code must be created for hardware modules that are not administered by R&S EGTSL for example function generator R&S TS-PFG, since the device driver must be initialised and closed in the ICT extension library.

The R&S TS-PFG module is used as an example of a module monitored by R&S EGTSL in the `RSSample.c` project.

The following additions to file `Framework.c` are required to control a hardware module not administered by R&S EGTSL:

- Add an `#include` for the device driver's header file
- Insert the device driver's `.FP` file into the project
- Open and close the device driver in `extictConfigSetup` and `extictConfigCleanup`, taking into consideration the co-operative session concept (see Section 17.3.7.2).
- Prepare the module settings in `extictConfigProlog` and reset

the module in `extictConfigEpilog` (see Section 17.3.7.5).

- Insert the device driver calls for settings and measurements in `extictTestMeasure`.

17.3.7.1 Configuration of Hardware Modules

Before an ICT extension library can use a hardware module that is not administered by R&S EGTSL, it must first collect information about the module from the `APPLICATION.INI` file.

The hardware modules and switching modules administered by R&S EGTSL are declared with the keywords `ICTDevice` and `SwitchDevice`. Keywords must be defined separately for additional hardware modules. There are two ways to make this definition:

- For hardware modules that are also used in R&S GTSL libraries, keywords are available that are used by the libraries. Thus `RSSample` uses keyword **FunctionGenerator** for generator R&S TS-PFG because it is also used by R&S GTSL library `FUNCGEN`.
- New keywords can be defined specifically for hardware modules that are not used in R&S GTSL libraries. The name of the ICT extension library can be used as a prefix and a descriptive suffix can be added, for example **RSSampleSource**.

Example:

```
--- APPLICATION.INI ---

[bench->ICT]
Simulation          = 0
Trace               = 1
ICTDevice1         = device->PSAM
ICTDevice2         = device->PICT
FunctionGenerator = device->PFG
; alternatively:
RSSampleSource   = device->PFG
SwitchDevice1     = device->PMB1
AppChannelTable   = io_channel->ICT

--- PHYSICAL.INI ---

[device->PFG]
Description = "TS-PFG Module 1"
Type      = PFG
ResourceDesc = PXI7::12::INSTR
DriverDll   = rspfg.dll
DriverPrefix = rspfg
```



```
DriverOption = "Simulate=0"  
SFTDll       = sftmpfg.dll  
SFTPrefix    = SFTMPFG
```

17.3.7.2 Co-operative Session Concept

Device drivers are generally opened in `extictConfigSetup` and closed in `extictConfigCleanup`. This applies only for the simple case, however, where they are not already open somewhere else in the test application. That case only occurs when a test program consists of both an in-circuit test and a function test part and the function test also uses the hardware module (for example the function generator R&S TS-PFG). Then the device driver cannot simply be opened and closed with no further consideration, since two instances of the same driver would then be open for the same hardware module.

The same rules thus apply to ICT extension libraries as to R&S GTSL libraries (see “Software Description R&S GTSL”, Section 8.5.2). They must follow the co-operative session concept. That concept has two rules:

- Only one single instance of a driver may be open within an application for each hardware module.
- A device driver may only be closed if it is no longer required by any other R&S GTSL library or ICT extension library.

To ensure these rules are observed, opening and closing the device driver must be logged in to a central instance. The Resource Manager Library RESMGR is responsible for this task. It is used by all R&S GTSL and R&S EGTSL components.

Before a device driver can be opened, function `RESMGR_Open_Session` must be called. This function reports whether the device driver is already open. If it is, it returns the session handle for the device driver. If the driver hasn't been opened yet, it must be now. The session handle returned by the driver function must be transferred to the resource manager so it will be available for subsequent calls of `RESMGR_Open_Session`.

The process for closing a device driver is the same but in reverse order: First the driver session is logged out with `RESMGR_Close_Session`. This function reports whether any other sessions are still logged in. If any are, no further action is required. If the last session has just been logged out, however, the device driver must then be closed.

These actions are performed in the functions `extictConfigSetup` and `extictConfigCleanup`. In the `RSSample.c` project, sub-functions `openFuncGenSession` and `closeFuncGenSession` are responsible for these tasks.

17.3.7.3 Setup

Function `openFuncGenSession` in `RSSample.c` is called by `extictConfigSetup`. It uses function generator R&S TS-PFG as an example of how a hardware module not administered by R&S EGTSL must be initialised in an ICT extension library. An outline of the sequence follows:

1. Find the “FunctionGenerator” entry in the bench
2. Check if the device type is “PFG”
3. Lock the device
4. Open a resource manager session. If a session already exists, proceed with 9.
5. Get the resource descriptor (mandatory) from the configuration file
6. Get the option string (optional) from the configuration file
7. Initialise the device driver
8. Store the session handle in the resource manager
9. Unlock the device

17.3.7.4 Cleanup

Function `closeFuncGenSession` in `RSSample.c` is called by `extictConfigCleanup`. It uses function generator R&S TS-PFG as an example of how a hardware module not administered by R&S EGTSL must be closed in an ICT extension library. An outline of the sequence follows:

1. Lock the device
2. Close the resource manager session. If this was not the last session, proceed with 4.
3. Close the device driver
4. Unlock the device

17.3.7.5 Prolog and Epilog

The purpose of the Prolog and Epilog functions is to place the hardware modules in a known state.

The functions are called by R&S EGTSL as soon as a block of identical test steps starts or ends.

Name	Type	V	Nominal
Contact	Contact		
Short	Short		
R1	Resistor		100 Ohm
Relay K1	RSSample		1 Ohm
Relay K2	RSSample		1 Ohm
Relay K3	RSSample		1 Ohm
OP Off	MyOpAmp	0 V	
OP Hi	MyOpAmp	5 V	
OP Lo	MyOpAmp	-5 V	

Figure 17-7 ICT program with 3 blocks

A program is shown in Figure 17-7 that consists initially of three R&S EGTSL-integrated test steps (Contact, Short, Resistor). This is followed by three test steps of type “RSSample” and three test steps of type “MyOpAmp”.

R&S EGTSL combines the test methods together in blocks to execute the program. All integrated test methods form a single block and each user-specific test method forms its own block.

Before a block is executed, its Prolog function runs, followed by the Epilog function as illustrated in Figure 17-7.

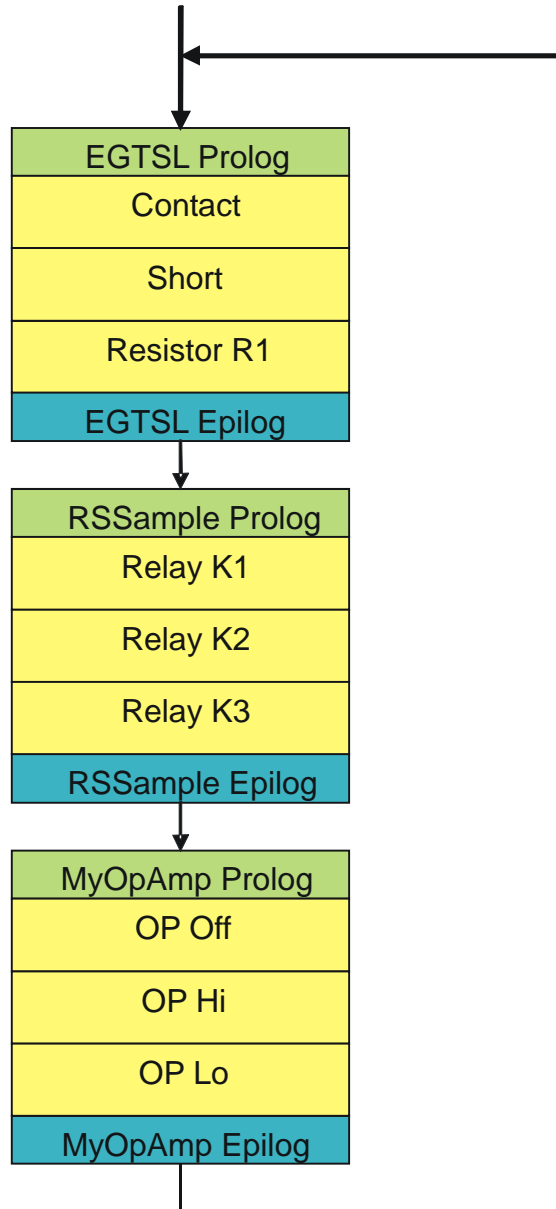


Figure 17-8 Block formation with Prolog/Epilog

Before the first test step (contact) is performed at the beginning of the in-circuit test, the status of the hardware modules is undetermined. The R&S EGTSL Prolog function must therefore run first to set the desired hardware state. Then the test steps of the first block (R&S EGTSL internal test methods Contact, Short, Resistor R1) can be performed. The R&S EGTSL Epilog function runs at the end of the first block. It again leaves the hardware modules in a defined state.

Before the block with the RSSample test steps, the Prolog function is

called by RSSample. The hardware modules are reset at the end of the block using the RSSample Epilog function.

This is repeated for the block with the “MyOpAmp” test steps.

The Prolog and Epilog functions of a test method ensure in this manner that all necessary modules of a block are set correctly and that they assume a known state after the last test step.

To ensure an in-circuit test program runs as fast as possible, the test steps of ICT extension libraries must be combined together in blocks so that the Prolog/Epilog functions are not called more often than needed. In other words, blocks should be as long as possible.

17.3.8 Advanced Topics

17.3.8.1 Debugging ICT Extension Libraries

Because they are Dynamic Link Libraries rather than executable files, ICT Extension Libraries cannot be started directly in the development environment. To be able to debug an ICT extension library, the following settings must therefore be made:

For LabWindows/CVI

In the project under menu item **<Run><Select External Process...>**, enter file `...\GTSL\bin\EGTSLLoader.exe`.

For Visual Studio

In the project settings under **<Project><Settings><Debug>** enter file `...\GTSL\bin\EGTSLLoader.exe` as “Executable for debug session”.

Then the R&S EGTSL Loader can be started from the development environment.

When making an “UserDefinedDll” entry in the APPLICATION.INI file, make certain the correct path is entered to the ICT extension library to be debugged.

17.3.8.2 Non-numeric Test Results

The measurement function of the ICT extension libraries returns a numeric value to R&S EGTSL as the result. It is also easy to imagine tests that do not return a numeric result. An example of this is the contact test in R&S EGTSL. In the event of an error, the contact test returns a list of pins that had no contact. In the case of “Pass”, the list is empty.

In principle, however, the contact test also returns a numeric result like any other test that is compared against an upper and lower limit. A look at the report makes this clear:

```
** "Contact"[70] failed <----<<<
2 [0 ... 0 ]
P22, P27
```

The result of the contact test is a dimensionless number representing the number of pins without contact. The upper and lower limit value is 0, i.e. as soon as a pin without a contact is found, the test fails. In the case of “Fail”, the contact test also returns a text containing the name of the pin that failed.

The same process can also be used in ICT extension libraries that return non-numeric results. The function `extictTestMeasure` returns the following results in this case:

- `testResult.value` returns the “number of errors”
- `testResult.unit` is an empty string
- `testResult.info` contains the test result as text in the case of “Fail”

The following adjustments are also required:

- 0 is assigned to the two limits in `extictTestConstruct`
- `extictTestGetResultDescription` returns an empty string, so the “Nominal” column in the display remains empty.

The text in `testResult.info` is only generated in the report by R&S EGTSL if the test step was “Fail”. If `testResult.info` contains an empty string in this case, the text that is entered under “Step Properties, Test” is generated (see Figure 5-69).

17.3.8.3 Time Optimisation

The goal of a good ICT extension library is to achieve the fastest measurement time possible. R&S EGTSL already offers the necessary support for this. The following items contribute to optimal performance:

- Separating the “compile” and “execution” of a test step
- Fast switching functions for R&S TS-PMB modules
- Block formation with Prolog/Epilog

The measurement should use as little time as possible for checking the setting values or converting strings into numeric values. Because of this, the “compile” and “measure” tasks are distributed over two differ-

ent functions. The purpose of function `extictTestCompile` is to convert the user's entries and check them to make certain they are valid. Therefore it only needs to be called if a new test step is being entered or if an existing test step is being changed. If `extictTestCompile` has run with no errors, the values are correct and are available in the best format for further processing. Function `extictTestMeasure` does not require any additional tests. It forwards the checked values directly to the device driver.

The ICT Extension Support Library makes functions available to ensure rapid connection of R&S TS-PMB switching modules. Connection tasks are split up between `extictTestCompile` and `extictTestMeasure`. During the "compile" task, pin names are checked to ensure they are valid and the program searches for suitable switching path. The connections are made in `extictTestMeasure` by the ICT Extension Support Library without any time-consuming checks.

The distribution of tasks between the Prolog and the measurement function also contributes to the fastest possible execution time of measurements. Settings that are the same for all test steps of an ICT extension library can already be performed in the Prolog. Then they apply to all subsequent test steps. These settings also include above all connecting stimulus and measurement devices to the analogue bus. The purpose of the Epilog function is then to undo that connection. The more test steps are included in these blocks formed by Prolog/Epilog, the more time is saved.

17.3.8.4 Aspects of Compatibility

When developing an ICT extension library, there is no way to avoid making additions or correcting errors after ICT programs have already been written for the library. When this happens, a few points must be observed so programs that already exist can still be used.

If changes are made to an ICT extension library, the version number should be incremented in variable `extictInfoVersion`. The version number serves as information for the user, but it is not stored in the ICT program.

Existing property names must not be deleted or renamed. The names are stored in the ICT program and are assigned to the properties of an ICT extension library when the program is loaded. If it is not possible to make an assignment, an error message is generated and the ICT program cannot be loaded.

The order of entries in the property list is not critical. It can be changed without thereby making any existing ICT programs incompatible.

New properties can be added later. If an ICT program is loaded that does not contain these properties yet, its default values are assigned to it as defined in `extIctTestConstruct`.

When an ICT program is saved, all of its properties are saved with it. This makes it impossible to load that program after that with an old version of the ICT extension library if a property has been added in the new version. ICT program are thus upwardly compatible, but not downwardly.

17.3.8.5 Communication between ICT Extension Libraries

Test steps in R&S EGTSL are created according to the concept so that they stand by themselves, i.e. independent of the preceding test steps of a measurement. If it should nevertheless become necessary to exchange information between the test steps of an ICT extension library or even between different libraries, the following options are available:

The most important functions of an ICT extension library have as a parameter a pointer to data structure `ExtIctSetup`. This data structure contains a pointer "userData" to an additional data structure that is the same for all test steps of an ICT as a extension library. Data elements to handle the exchange of information between test steps of the same ICT extension library can be created in this structure.

The shared memory of the resource manager library is suitable for data exchange between different ICT extension libraries. These functions can be used to create global data structures with system-wide unique names that can be exchanged between libraries.



A Example 1



NOTE:

All files for example 1 are saved in the folder
 ... \GTSL\EGTSL\Example .

A.1 Circuit for example 1

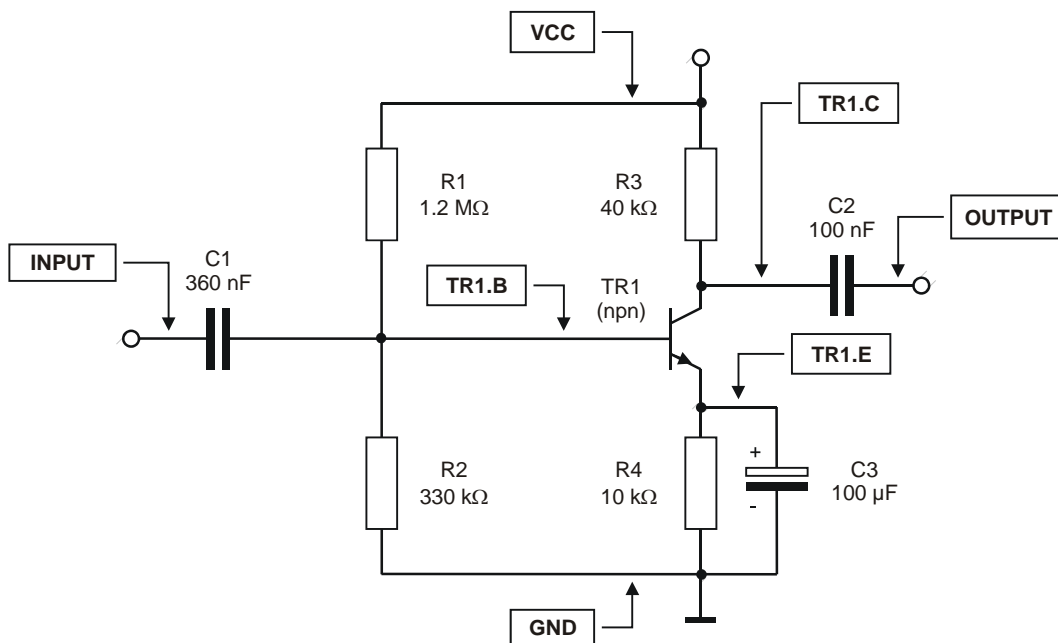


Figure A-1 Circuit, example 1

A.2 BDL file for example 1

Example1.BDL

```

RESISTOR

NAME 'R1'
VALUE 1.2 MOHM
TOL+ 10% TOL- 10%
I_LIM 100.0 MA
PIN_1 'VCC'
PIN_2 'TR1.B'

NAME 'R2'
VALUE 330 KOHM
TOL+ 10% TOL- 10%
I_LIM 100.0 MA
PIN_1 'TR1.B'
    
```



```
PIN_2 'GND'  
  
NAME 'R3'  
VALUE 40 KOHM  
TOL+ 10% TOL- 10%  
I_LIM 100.0 MA  
PIN_1 'VCC'  
PIN_2 'TR1.C'  
  
NAME 'R4'  
VALUE 10 KOHM  
TOL+ 10% TOL- 10%  
I_LIM 100.0 MA  
PIN_1 'TR1.E'  
PIN_2 'GND'  
  
CAPACITOR  
  
NAME 'C1'  
VALUE 360 NF  
TOL+ 10% TOL- 10%  
PIN_1 'INPUT'  
PIN_2 'TR1.B'  
  
NAME 'C2'  
VALUE 100 NF  
TOL+ 10% TOL- 10%  
PIN_1 'TR1.C'  
PIN_2 'OUTPUT'  
  
POL_CAP  
  
NAME 'C3'  
VALUE 100 UF  
TOL+ 10% TOL- 10%  
PIN_A 'TR1.E'  
PIN_C 'GND'  
  
TRANSISTOR  
  
NAME 'TR1'  
NPN  
UBE 0.6 V  
TOL+ 30% TOL- 30%  
PIN_E 'TR1.E'  
PIN_B 'TR1.B'  
PIN_C 'TR1.C'  
  
NODE  
  
NAME 'TR1.E'  
DEV_NAME 'R4' PIN_1  
DEV_NAME 'C3' PIN_A  
DEV_NAME 'TR1' PIN_E  
  
NAME 'TR1.B'  
DEV_NAME 'R1' PIN_2  
DEV_NAME 'R2' PIN_1  
DEV_NAME 'C1' PIN_2  
DEV_NAME 'TR1' PIN_B  
  
NAME 'TR1.C'  
DEV_NAME 'R3' PIN_2  
DEV_NAME 'C2' PIN_1  
DEV_NAME 'TR1' PIN_C  
  
NAME 'GND'
```

```

DEV_NAME 'R2' PIN_2
DEV_NAME 'R4' PIN_2
DEV_NAME 'C3' PIN_C

NAME 'OUTPUT'
DEV_NAME 'C2' PIN_2

NAME 'INPUT'
DEV_NAME 'C1' PIN_1

NAME 'VCC'
DEV_NAME 'R1' PIN_1
DEV_NAME 'R3' PIN_1

```

A.3 ICT report generated for example 1

Example1_Report.txt

```

ATG REPORT
=====

Created:          2005-12-27 15:00:08
ATG Version:      ATG 02.10
EGTSL Version:    EGTSL 02.10

Input:
-----
Board Description: 'C:\Program Files\Rohde&Schwarz\GTSL\EGTSL\Example\Example1.BDL'
Physical Layer:   'C:\Program Files\Rohde&Schwarz\GTSL\EGTSL\Example\Example_Physical.ini'

Output:
-----
ICT Program:      'C:\Program Files\Rohde&Schwarz\GTSL\EGTSL\Example\Example1.ict'
Application Layer: 'C:\Program Files\Rohde&Schwarz\GTSL\EGTSL\Example\Example1_Application.ini'
Report:          'C:\Program Files\Rohde&Schwarz\GTSL\EGTSL\Example\Example1_Report.txt'

BDL Parser: 0 error(s) and 0 warning(s).

BDL cross check: OK.

>>> Message from TR1                                     <<<
TS-PSU not configured in 'physical.ini', simple transistor test inserted

Test coverage report

          Number  Weight  Coverage
Components                8
Regular tests              7      1    87.5%
Reduced tests              1    0.5    6.25%
Short/Contact test only    0    0.1     0%
Total test coverage                93.8%
Wiring List info: Nodes mapped to a total number of 7 pin(s).

```



A.4 Application Layer Configuration File generated for example 1

Example1_Application.ini

```
[ResourceManager]
; general trace settings (normally off)
Trace           = 0
TraceFile       = %GTSLROOT%\resmgr_trace.txt
```

```
;-----
[LogicalNames]
ICT             = bench->ICT
```

```
;-----
[bench->ICT]
Description     = ICT bench (Simulation)
Simulation      = 1
Trace          = 0
ICTDevice1     = device->psam
ICTDevice2     = device->pict
SwitchDevice1  = device->pmb1
AppChannelTable = io_channel->ICT
AppWiringTable = io_wiring->ICT
```

```
[io_channel->ICT]
GND             = pmb1!P1
INPUT          = pmb1!P2
OUTPUT         = pmb1!P3
TR1.B          = pmb1!P4
TR1.C          = pmb1!P5
TR1.E          = pmb1!P6
VCC            = pmb1!P7
```

```
;-----
[io_wiring->ICT]
GND            = F1 S15 X10A1
INPUT          = F1 S15 X10A2
OUTPUT         = F1 S15 X10A3
TR1.B          = F1 S15 X10A4
TR1.C          = F1 S15 X10A5
TR1.E          = F1 S15 X10A6
VCC            = F1 S15 X10A7
```

```
;-----
```

B Example 2



NOTE:

All files for example 2 are saved in the folder
 ... \GTSL\EGTSL\Example .

B.1 Circuit for example 2

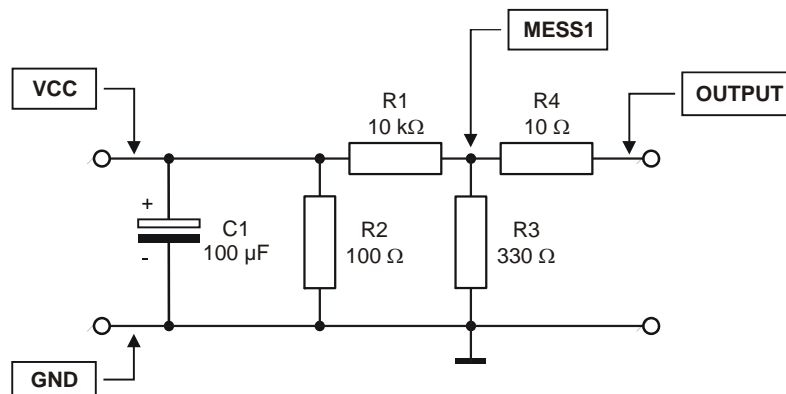


Figure B-1 Circuit, example 2

B.2 BDL file for example 2

Example2.BDL

```

RESISTOR

NAME 'R1'
  VALUE 10 KOHM
  TOL+ 10% TOL- 10%
  I_LIM 100.0 MA
  PIN_1 'VCC'
  PIN_2 'MESS1'

NAME 'R2'
  VALUE 100 OHM
  TOL+ 10% TOL- 10%
  I_LIM 100.0 MA
  PIN_1 'VCC'
  PIN_2 'GND'

NAME 'R3'
  VALUE 330 OHM
  TOL+ 10% TOL- 10%
  I_LIM 100.0 MA
  PIN_1 'MESS1'
  PIN_2 'GND'
  
```



```
NAME 'R4'  
  VALUE 10 OHM  
  TOL+ 10% TOL- 10%  
  I_LIM 100.0 MA  
  PIN_1 'MESS1'  
  PIN_2 'OUT'  
  
POL_CAP  
  
NAME 'C1'  
  VALUE 100 UF  
  TOL+ 10% TOL- 10%  
  PIN_A 'VCC'  
  PIN_C 'GND'  
  
NODE  
  
NAME 'GND'  
  DEV_NAME 'C1' PIN_C  
  DEV_NAME 'R2' PIN_2  
  DEV_NAME 'R3' PIN_2  
  
NAME 'OUT'  
  DEV_NAME 'R4' PIN_2  
  
NAME 'VCC'  
  DEV_NAME 'C1' PIN_A  
  DEV_NAME 'R1' PIN_1  
  DEV_NAME 'R2' PIN_1  
  
NAME 'MESS1'  
  DEV_NAME 'R1' PIN_2  
  DEV_NAME 'R4' PIN_1  
  DEV_NAME 'R3' PIN_1
```

B.3 ICT report generated for example 2

Example2_Report.txt

ATG REPORT
 =====

Created: 2005-12-27 15:02:19
 ATG Version: ATG 02.10
 EGTSL Version: EGTSL 02.10

Input:

Board Description: 'C:\Program Files\Rohde&Schwarz\GTSL\EGTSL\Example\Example2.BDL'
 Physical Layer: 'C:\Program Files\Rohde&Schwarz\GTSL\EGTSL\Example\Example_Physical.ini'

Output:

ICT Program: 'C:\Program Files\Rohde&Schwarz\GTSL\EGTSL\Example\Example2.ict'
 Application Layer: 'C:\Program Files\Rohde&Schwarz\GTSL\EGTSL\Example\Example2_Application.ini'
 Report: 'C:\Program Files\Rohde&Schwarz\GTSL\EGTSL\Example\Example2_Report.txt'

BDL Parser: 0 error(s) and 0 warning(s).

BDL cross check: OK.

>>> Message from R1 6-Wire Test Proposal <<<
 Total error for 3-wire mode: 23.351%
 6-wire mode: 3.1255%

>>> Message from R1 <<<
 Test only possible by exceeding the error limits
 Guarding error limiting test quality

>>> Message from R4 4-Wire Test Proposal <<<
 Total error for 2-wire mode: 21.576%
 4-wire mode: 1 %

>>> Message from R4 <<<
 Test only possible by exceeding the error limits
 Test limits include system residuals of 2.124 Ohms

Test coverage report

	Number	Weight	Coverage
Components	5		
Regular tests	5	1	100%
Reduced tests	0	0.5	0%
Short/Contact test only	0	0.1	0%
Total test coverage			100%

Wiring List info: Nodes mapped to a total number of 8 pin(s).



B.4 Application Layer Configuration File generated for example 2

Example2_Application.ini

```
[ResourceManager]
; general trace settings (normally off)
Trace           = 0
TraceFile       = %GTSLROOT%\resmgr_trace.txt

;-----
[LogicalNames]
ICT             = bench->ICT

;-----
[bench->ICT]
Description     = ICT bench (Simulation)
Simulation      = 1
Trace           = 0
ICTDevice1     = device->psam
ICTDevice2     = device->pict
SwitchDevice1  = device->pmb1
AppChannelTable = io_channel->ICT
AppWiringTable = io_wiring->ICT

[io_channel->ICT]
GND             = pmb1!P1
MESS1          = pmb1!P2
OUT            = pmb1!P3
VCC            = pmb1!P4

; nodes used for test proposals, which may be deleted, if the proposals are discarded
; -----
GND.Sense      = pmb1!P6
MESS1.Sense    = pmb1!P5
OUT.Sense      = pmb1!P7
VCC.Sense      = pmb1!P9

;-----
[io_wiring->ICT]
GND            = F1 S15 X10A1
MESS1          = F1 S15 X10A2
OUT            = F1 S15 X10A3
VCC            = F1 S15 X10A4

; nodes used for test proposals, which may be deleted, if the proposals are discarded
; -----
GND.Sense      = F1 S15 X10A6
MESS1.Sense    = F1 S15 X10A5
OUT.Sense      = F1 S15 X10A7
VCC.Sense      = F1 S15 X10A9

;-----
```