R&S®TS-PFG
Function Generator
User Manual

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Test & Measurement

User Manual

ROHDE&SCHWARZ

This manual describes the following R&S®TS-PFG models:

- R&S®TS-PFG (1157.9610.02)

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The following abbreviations are used throughout this manual: R&S®TS-PFG is abbreviated as R&S TS-PFG.

Basic Safety Instructions

Always read through and comply with the following safety instructions!

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

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

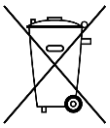
The product is used for its designated purpose if it is used in accordance with its product documentation and within its performance limits (see data sheet, documentation, the following safety instructions). Using the product requires technical skills and, in some cases, a basic knowledge of English.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

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

Safety labels on products

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

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

Symbol	Meaning	Symbol	Meaning
	Caution ! Hot surface		Alternating current (AC)
	Protective conductor terminal To identify any terminal which is intended for connection to an external conductor for protection against electric shock in case of a fault, or the terminal of a protective earth		Direct/alternating current (DC/AC)
	Earth (Ground)		Class II Equipment to identify equipment meeting the safety requirements specified for Class II equipment (device protected by double or reinforced insulation)
	Frame or chassis Ground terminal		EU labeling for batteries and accumulators For additional information, see section "Waste disposal/Environmental protection", item 1.
	Be careful when handling electrostatic sensitive devices		EU labeling for separate collection of electrical and electronic devices For additional information, see section "Waste disposal/Environmental protection", item 2.
	Warning! Laser radiation For additional information, see section "Operation", item 7.		

Signal words and their meaning

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

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

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

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

NOTICE Indicates information considered important, but not hazard-related, e.g. messages relating to property damage.
In the product documentation, the word ATTENTION is used synonymously.

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

Operating states and operating positions

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

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

Electrical safety

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

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

6. The product may be operated only from TN/TT supply networks fuse-protected with max. 16 A (higher fuse only after consulting with the Rohde & Schwarz group of companies).
7. Do not insert the plug into sockets that are dusty or dirty. Insert the plug firmly and all the way into the socket provided for this purpose. Otherwise, sparks that result in fire and/or injuries may occur.
8. Do not overload any sockets, extension cords or connector strips; doing so can cause fire or electric shocks.
9. For measurements in circuits with voltages V_{rms} > 30 V, suitable measures (e.g. appropriate measuring equipment, fuse protection, current limiting, electrical separation, insulation) should be taken to avoid any hazards.
10. Ensure that the connections with information technology equipment, e.g. PCs or other industrial computers, comply with the IEC 60950-1 / EN 60950-1 or IEC 61010-1 / EN 61010-1 standards that apply in each case.
11. Unless expressly permitted, never remove the cover or any part of the housing while the product is in operation. Doing so will expose circuits and components and can lead to injuries, fire or damage to the product.
12. If a product is to be permanently installed, the connection between the protective conductor terminal on site and the product's protective conductor must be made first before any other connection is made. The product may be installed and connected only by a licensed electrician.
13. For permanently installed equipment without built-in fuses, circuit breakers or similar protective devices, the supply circuit must be fuse-protected in such a way that anyone who has access to the product, as well as the product itself, is adequately protected from injury or damage.
14. Use suitable overvoltage protection to ensure that no overvoltage (such as that caused by a bolt of lightning) can reach the product. Otherwise, the person operating the product will be exposed to the danger of an electric shock.
15. Any object that is not designed to be placed in the openings of the housing must not be used for this purpose. Doing so can cause short circuits inside the product and/or electric shocks, fire or injuries.
16. Unless specified otherwise, products are not liquid-proof (see also section "Operating states and operating positions", item 1). Therefore, the equipment must be protected against penetration by liquids. If the necessary precautions are not taken, the user may suffer electric shock or the product itself may be damaged, which can also lead to personal injury.
17. Never use the product under conditions in which condensation has formed or can form in or on the product, e.g. if the product has been moved from a cold to a warm environment. Penetration by water increases the risk of electric shock.
18. Prior to cleaning the product, disconnect it completely from the power supply (e.g. AC supply network or battery). Use a soft, non-linting cloth to clean the product. Never use chemical cleaning agents such as alcohol, acetone or diluents for cellulose lacquers.

Operation

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

2. Before you move or transport the product, read and observe the section titled "Transport".
3. As with all industrially manufactured goods, the use of substances that induce an allergic reaction (allergens) such as nickel cannot be generally excluded. If you develop an allergic reaction (such as a skin rash, frequent sneezing, red eyes or respiratory difficulties) when using a Rohde & Schwarz product, consult a physician immediately to determine the cause and to prevent health problems or stress.
4. Before you start processing the product mechanically and/or thermally, or before you take it apart, be sure to read and pay special attention to the section titled "Waste disposal/Environmental protection", item 1.
5. Depending on the function, certain products such as RF radio equipment can produce an elevated level of electromagnetic radiation. Considering that unborn babies require increased protection, pregnant women must be protected by appropriate measures. Persons with pacemakers may also be exposed to risks from electromagnetic radiation. The employer/operator must evaluate workplaces where there is a special risk of exposure to radiation and, if necessary, take measures to avert the potential danger.
6. Should a fire occur, the product may release hazardous substances (gases, fluids, etc.) that can cause health problems. Therefore, suitable measures must be taken, e.g. protective masks and protective clothing must be worn.
7. Laser products are given warning labels that are standardized according to their laser class. Lasers can cause biological harm due to the properties of their radiation and due to their extremely concentrated electromagnetic power. If a laser product (e.g. a CD/DVD drive) is integrated into a Rohde & Schwarz product, absolutely no other settings or functions may be used as described in the product documentation. The objective is to prevent personal injury (e.g. due to laser beams).
8. EMC classes (in line with EN 55011/CISPR 11, and analogously with EN 55022/CISPR 22, EN 55032/CISPR 32)
   - Class A equipment:
     Equipment suitable for use in all environments except residential environments and environments that are directly connected to a low-voltage supply network that supplies residential buildings
     Note: Class A equipment is intended for use in an industrial environment. This equipment may cause radio disturbances in residential environments, due to possible conducted as well as radiated disturbances. In this case, the operator may be required to take appropriate measures to eliminate these disturbances.
   - Class B equipment:
     Equipment suitable for use in residential environments and environments that are directly connected to a low-voltage supply network that supplies residential buildings

Repair and service

1. The product may be opened only by authorized, specially trained personnel. Before any work is performed on the product or before the product is opened, it must be disconnected from the AC supply network. Otherwise, personnel will be exposed to the risk of an electric shock.

2. Adjustments, replacement of parts, maintenance and repair may be performed only by electrical experts authorized by Rohde & Schwarz. Only original parts may be used for replacing parts relevant to safety (e.g. power switches, power transformers, fuses). A safety test must always be performed after parts relevant to safety have been replaced (visual inspection, protective conductor test, insulation resistance measurement, leakage current measurement, functional test). This helps ensure the continued safety of the product.

Batteries and rechargeable batteries/cells

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

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

Transport

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

Waste disposal/Environmental protection

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

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

Instrucciones de seguridad elementales

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

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

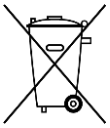
Además queda en la responsabilidad del usuario utilizar el producto en la forma debida. Este producto está destinado exclusivamente al uso en la industria y el laboratorio o, si ha sido expresamente autorizado, para aplicaciones de campo y de ninguna manera deberá ser utilizado de modo que alguna persona/cosa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

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

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

Señalización de seguridad de los productos

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

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

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

Palabras de señal y su significado

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

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

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

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

Indica información que se considera importante, pero no en relación con situaciones de peligro; p. ej., avisos sobre posibles daños materiales.
En la documentación del producto se emplea de forma sinónima el término CUIDADO.

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

Estados operativos y posiciones de funcionamiento

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

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

Seguridad eléctrica

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

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

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

Funcionamiento

1. El uso del producto requiere instrucciones especiales y una alta concentración durante el manejo. Debe asegurarse que las personas que manejen el producto estén a la altura de los requerimientos necesarios en cuanto a aptitudes físicas, psíquicas y emocionales, ya que de otra manera no se pueden excluir lesiones o daños de objetos. El empresario u operador es responsable de seleccionar el personal usuario apto para el manejo del producto.
2. Antes de desplazar o transportar el producto, lea y tenga en cuenta el capítulo "Transporte".
3. Como con todo producto de fabricación industrial no puede quedar excluida en general la posibilidad de que se produzcan alergias provocadas por algunos materiales empleados —los llamados alérgenos (p. ej. el níquel)—. Si durante el manejo de productos Rohde & Schwarz se producen reacciones alérgicas, como p. ej. irritaciones cutáneas, estornudos continuos, enrojecimiento de la conjuntiva o dificultades respiratorias, debe avisarse inmediatamente a un médico para investigar las causas y evitar cualquier molestia o daño a la salud.
4. Antes de la manipulación mecánica y/o térmica o el desmontaje del producto, debe tenerse en cuenta imprescindiblemente el capítulo "Eliminación/protección del medio ambiente", punto 1.
5. Ciertos productos, como p. ej. las instalaciones de radiocomunicación RF, pueden a causa de su función natural, emitir una radiación electromagnética aumentada. Deben tomarse todas las medidas necesarias para la protección de las mujeres embarazadas. También las personas con marcapasos pueden correr peligro a causa de la radiación electromagnética. El empresario/operador tiene la obligación de evaluar y señalizar las áreas de trabajo en las que exista un riesgo elevado de exposición a radiaciones.
6. Tenga en cuenta que en caso de incendio pueden desprenderse del producto sustancias tóxicas (gases, líquidos etc.) que pueden generar daños a la salud. Por eso, en caso de incendio deben usarse medidas adecuadas, como p. ej. máscaras antigás e indumentaria de protección.
7. Los productos con láser están provistos de indicaciones de advertencia normalizadas en función de la clase de láser del que se trate. Los rayos láser pueden provocar daños de tipo biológico a causa de las propiedades de su radiación y debido a su concentración extrema de potencia electromagnética. En caso de que un producto Rohde & Schwarz contenga un producto láser (p. ej. un lector de CD/DVD), no debe usarse ninguna otra configuración o función aparte de las descritas en la documentación del producto, a fin de evitar lesiones (p. ej. debidas a irradiación láser).
8. Clases de compatibilidad electromagnética (conforme a EN 55011 / CISPR 11; y en analogía con EN 55022 / CISPR 22, EN 55032 / CISPR 32)
   - Aparato de clase A:
     Aparato adecuado para su uso en todos los entornos excepto en los residenciales y en aquellos conectados directamente a una red de distribución de baja tensión que suministra corriente a edificios residenciales.
     Nota: Los aparatos de clase A están destinados al uso en entornos industriales. Estos aparatos pueden causar perturbaciones radioeléctricas en entornos residenciales debido a posibles perturbaciones guiadas o radiadas. En este caso, se le podrá solicitar al operador que tome las medidas adecuadas para eliminar estas perturbaciones.
   - Aparato de clase B:
     Aparato adecuado para su uso en entornos residenciales, así como en aquellos conectados directamente a una red de distribución de baja tensión que suministra corriente a edificios residenciales.

Reparación y mantenimiento

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

Baterías y acumuladores o celdas

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

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

Transporte

1. El producto puede tener un peso elevado. Por eso es necesario desplazarlo o transportarlo con precaución y, si es necesario, usando un sistema de elevación adecuado (p. ej. una carretilla elevadora), a fin de evitar lesiones en la espalda u otros daños personales.

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

Eliminación/protección del medio ambiente

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

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

Quality management and environmental management

Certified Quality System
ISO 9001

Certified Environmental System
ISO 14001

Sehr geehrter Kunde,
Sie haben sich für den Kauf eines Rohde&Schwarz Produktes entschieden. Sie erhalten damit ein nach modernsten Fertigungsmethoden hergestelltes Produkt. Es wurde nach den Regeln unserer Qualitäts- und Umweltmanagementsysteme entwickelt, gefertigt und geprüft. Rohde&Schwarz ist unter anderem nach den Managementsystemen ISO 9001 und ISO 14001 zertifiziert.

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

Dear customer,
You have decided to buy a Rohde&Schwarz product. This product has been manufactured using the most advanced methods. It was developed, manufactured and tested in compliance with our quality management and environmental management systems. Rohde&Schwarz has been certified, for example, according to the ISO 9001 and ISO 14001 management systems.

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

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

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

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Customer Support

Technical support – where and when you need it

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

Up-to-date information and upgrades

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

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ROHDE&SCHWARZ

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Contents

1 Use

1.1 General

This manual describes the function and operation of the ROHDE&SCHWARZ function generator module R&S TS-PFG for use in the test system versatile platform R&S CompactTSVP. The hardware is implemented as a CompactPCI board that occupies only one slot on the front side of the TSVP. The associated R&S TS-PDC rear I/O module (DC/DC converter module) is inserted at the same slot on the rear side.

The ROHDE&SCHWARZ function generator module R&S TS-PFG can be used wherever the simulation of single-channel or multichannel, analog output signals is required.

The floating output of the signals prevents any interference on the device under test (DUT), thereby ensuring that the application can be simulated under conditions that are very close to actual.

The high dynamic range of the output voltage and the high sample rate allow output signals with an extremely high resolution to be achieved. The module can generate standard signal forms, such as sine-wave, square-wave,triangular and ramp, as well as arbitrary signal forms. These can be output continuously or in pulsed mode.

Commercially available waveform editors can be used for defining the signal curves (e.g. Analog Waveform Editor from National Instruments). Comprehensive trigger options with local trigger and marker signals or the PXI trigger bus enable synchronization with other R&S measurement, stimulus or switch modules and PXI modules from other manufacturers.

A LabWindows IVI-C software driver is available for the general waveform generation functions of the R&S TS-PFG module. Other hardware functions are controlled using specific extensions of the driver. As is usual for a LabWindows driver, function panels and online help are available.

The R&S TS-PFG module is inserted into the front of the R&S CompactTSVP chassis. It uses the cPCI/PXI standard. The front connector is flush with the front panel of the R&S CompactTSVP chassis and is used for connecting DUTs or measurement sensors. At the back, the R&S TS-PFG module is connected to the cPCI control bus and the PXI trigger bus. As an alternative to the front connector, analog measurement signals can be tapped at the analog measurement bus of the R&S CompactTSVP.

The voltage supply of the R&S TS-PFG is made available to the module via the R&S TS-PDC rear I/O module with DC/DC converters.

The R&S TS-PFG module can only be used in the R&S CompactTSVP (TSVP = Test System Versatile Platform).

1.2 Features

Features of the R&S TS-PFG function generator module

- 2-channel arbitrary function generator (both channels can be operated as independent generators)
- Floating signal generation (max. 125 V working voltage)
- Resolution (16 bit)
- Sample rate up to 25 Msample/s per channel
- Output voltage up to 40 Vpp per channel
  (channels can be cascaded)
- Output current up to ±250 mA per channel
- Memory depth of 1 Msample per channel
- Waveform linking and looping
- Sample-synchronous marker signal can be configured
- Synchronization via PXI trigger bus
- Channels can be optionally switched to 8 analog buses/outputs
- Self-test capability in conjunction with R&S TS-PSAM module
- LabWindows IVI-C driver available
- Used in R&S CompactTSVP

1.3 Possible Applications

The R&S TS-PFG function generator module can be used for tasks such as the following:

- Generation of sine-wave, square-wave, ramp and triangular signals
- Generation of concatenated waveforms of any type
- Sensor simulation (floating stimulation)
- Generation of arbitrary signals
- Stimulation of low-frequency digital signals with variable level
- Programmable clock-pulse generators
- Generation of DUT supply voltages

If the application requires additional stimulus channels, this can be achieved by adding further R&S TS-PFG function generator modules and synchronizing them via the PXI trigger bus.

The analog bus and a R&S switching module (e.g. R&S TS-PMB) can be used to multiplex the output signals over a very high number of DUT pins.

Complex test operations can be performed using the digital marker signal which is output sample-synchronously with the analog signal. Using a switchable connection of the two output channels, the output voltage range can be doubled and/or DC signals generated with up-modulated AC signals.

The extremely compact design with primary matrix and signal conditioning occupies just a single CompactPCI/PXI slot width, making it possible to create space-saving yet very powerful measurement and stimulus systems.

A self-test of the R&S TS-PFG function generator can be run in conjunction with the R&S TS-PSAM analog measurement and stimulus module. Diagnostic LEDs in the front panel indicate the current status of the module.

1.4 Safety Instructions

NOTICE

Damage to device or individual modules due to excessive operating voltage

The R&S CompactTSVP/R&S PowerTSVP production test platform and the R&S TS-PFG function generator module are designed for operating voltages up to 125 V. If this operating voltage is exceeded, the device and the individual modules can be damaged.

It is also important to ensure that this limit is not exceeded at any time, even after summation of voltages, between floating measurement or stimulus instruments and GND.

⚠ WARNING

Risk of injury from electric voltage

To prevent injury caused by electric voltage, it is important to observe the requirements specified in EN61010-1 concerning operation with "hazardous active" voltages.

Figure 1-1 shows a number of typical permissible voltage configurations between the analog buses and ground.

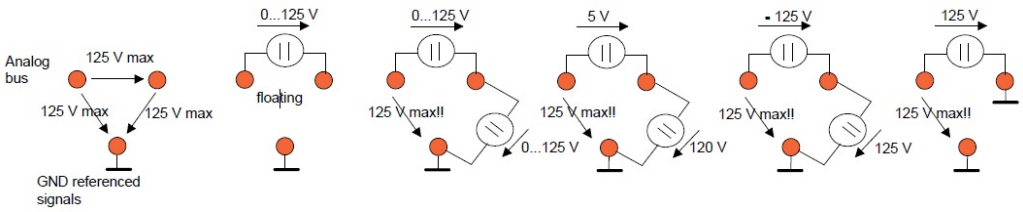

Figure 1-1: Permissible voltages on analog bus lines

2 View

Figure 2-1 shows the R&S TS-PFG function generator module without the associated R&S TS-PDC rear I/O module. The R&S TS-PDC rear I/O module is shown in Figure 2-2.

Figure 2-1: View of R&S TS-PFG module

Figure 2-2: View of R&S TS-PDC rear I/O module

3 Block Diagrams

The following section provides a functional block diagram of the R&S TS-PFG module as well as a detailed block diagram.

Figure 3-1 shows the functional block diagram of the R&S TS-PFG module.

Figure 3-2 shows a detailed block diagram of the R&S TS-PFG module.

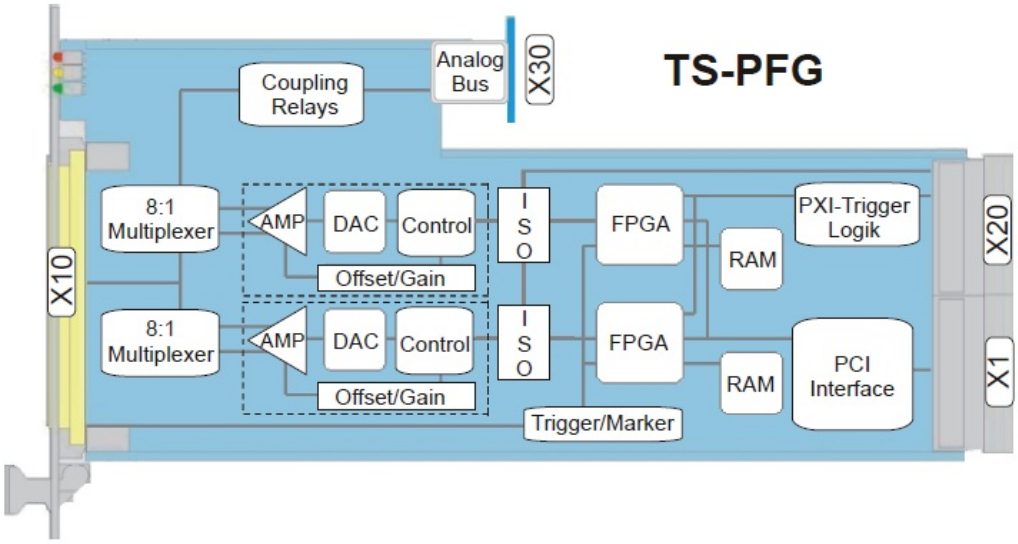

Figure 3-1: Functional block diagram of R&S TS-PFG module

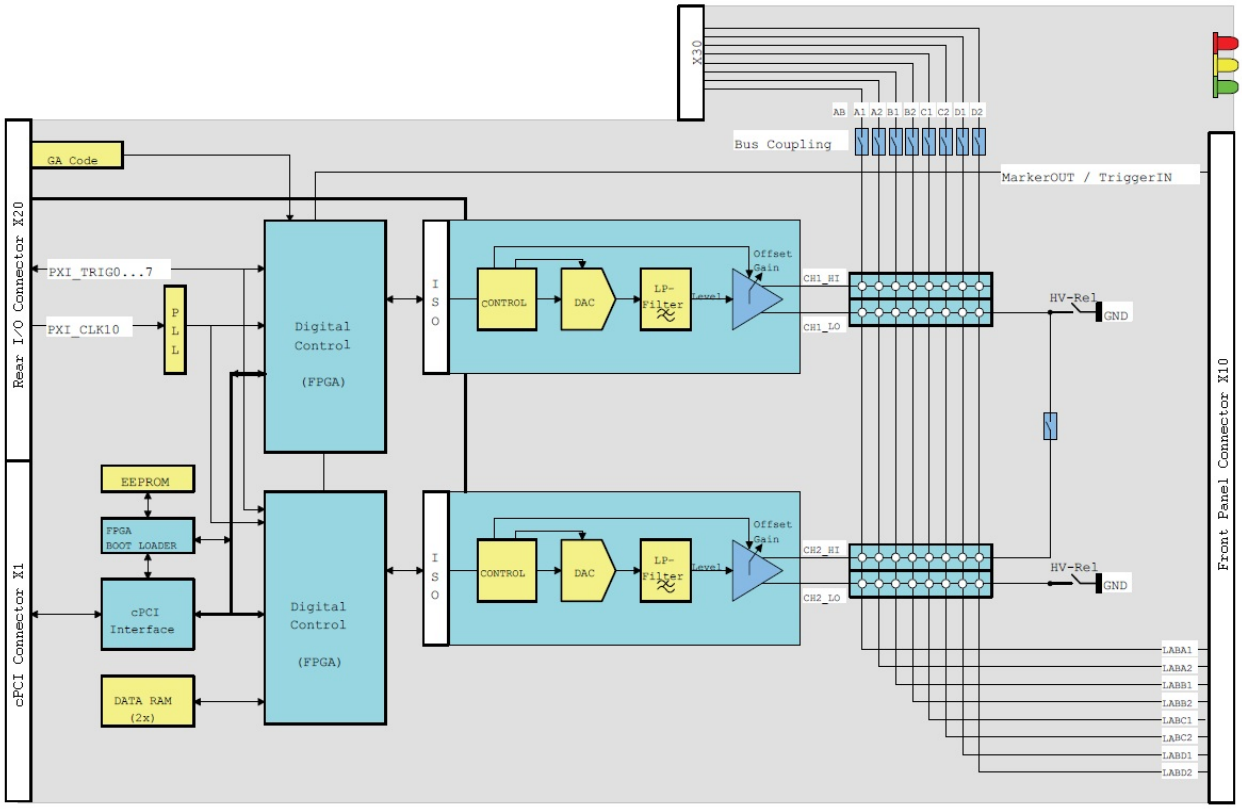

Figure 3-2: Detailed block diagram of R&S TS-PFG module

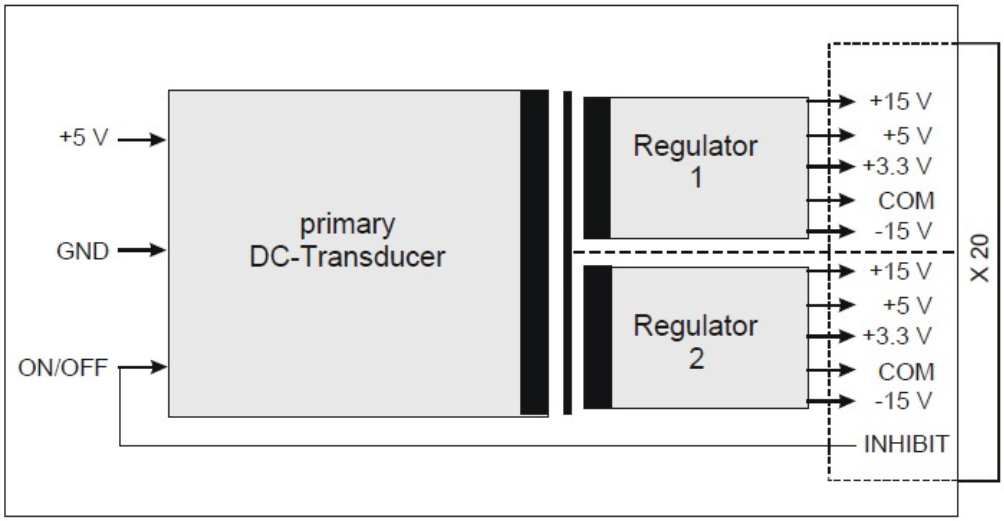

Figure 3-3: Block diagram of R&S TS-PDC rear I/O module

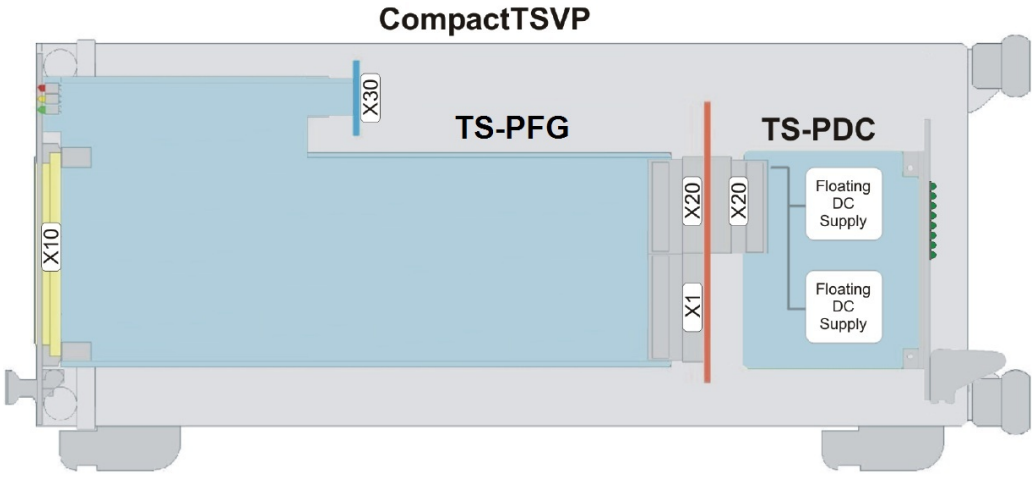

Figure 3-4: R&S TS-PFG and R&S TS-PDC modules in R&S CompactTSVP

4 Design

4.1 R&S TS-PFG

4.1.1 Mechanical Design

The R&S TS-PFG module is designed as a **long cPCI plug-in module** for mounting in the front of the R&S CompactTSVP.

The height of the module's board is 3 HU (134 mm). The front panel is provided with a locating pin to ensure that the module is correctly inserted into the R&S CompactTSVP. The module is secured using the two fastening screws on the front panel.

The front interface X10 is used for connecting DUTs. Interface X30 connects the R&S TS-PFG module to the analog bus backplane in the R&S CompactTSVP. Interfaces X20/X1 connect the R&S TS-PFG module to the cPCI backplane/PXI control backplane.

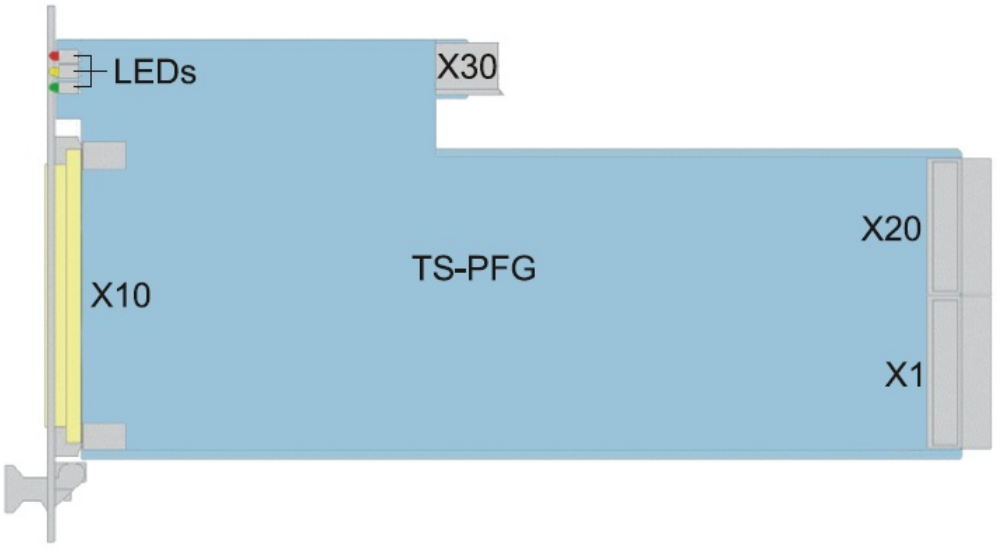

Figure 4-1: Layout of interfaces on R&S TS-PFG module

4.1.2 Interfaces

Table 4-1: Interfaces on R&S TS-PFG

Designation	Use
X1	cPCI bus backplane
X10	Device under test (DUT)

Designation	Use
X20	Backplane extension (PXI), rear I/O
X30	Analog bus

A detailed interface description with signal assignment to the connectors can be found in Chapter 9, "Interface Description", on page 50.

4.1.3 Display Elements

On the front panel of the R&S TS-PFG are three light emitting diodes (LEDs) which have the following meaning:

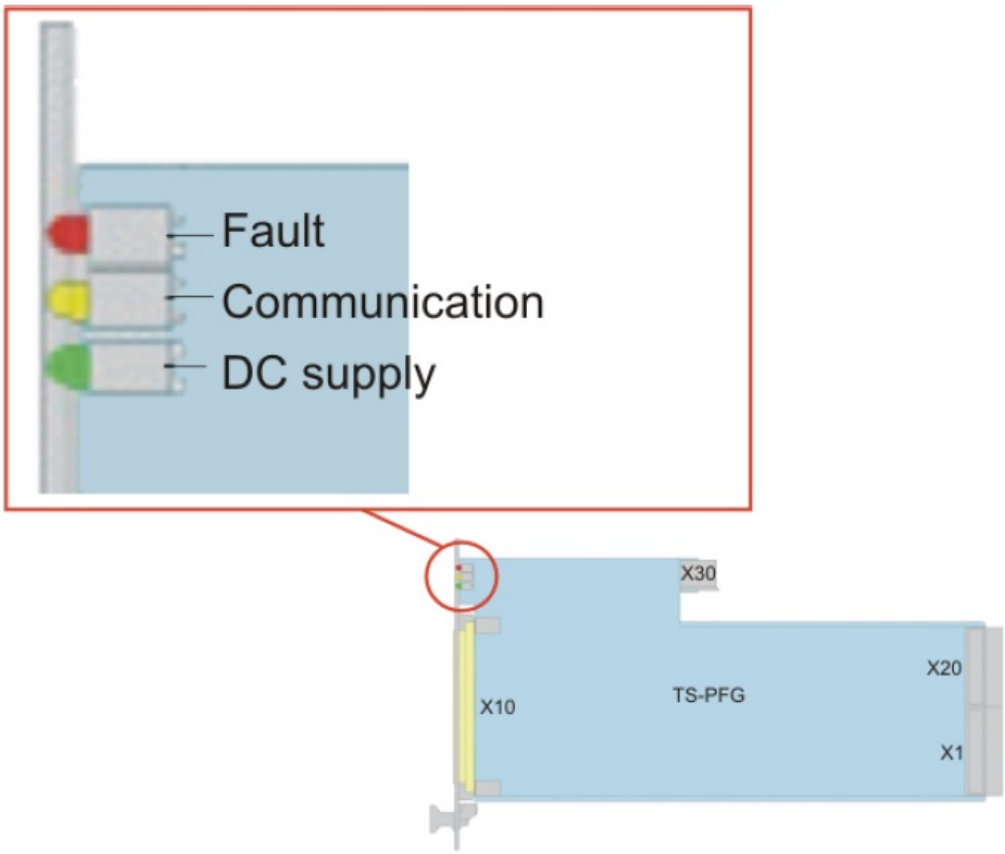

Figure 4-2: LED indicators of R&S TS-PFG

Table 4-2: Display elements of R&S TS-PFG

LED	Description
ERR (red)	Error condition: Lights up if, after the supply voltage is switched on, a fault is detected on the R&S TS-PFG during the power-on test.
COM (yellow)	Communications: Lights up when data is being exchanged via the interface.
PWR (green)	Supply voltage: Lights up when all the necessary supply voltages are present.

4.2 R&S TS-PDC

4.2.1 Mechanical Design

The R&S TS-PDC module is a **rear I/O module** for mounting in the back of the R&S CompactTSVP. The height of the module's board is 3 HU (134 mm). The module is secured using the two fastening screws on the front panel. Connector X20 connects the R&S TS-PDC module to the backplane in the R&S CompactTSVP.

NOTICE

Damage to R&S TS-PFG and R&S TS-PDC modules

Incorrect connection of the R&S TS-PFG and R&S TS-PDC modules to the backplane of the R&S CompactTSVP can result in damage to the two modules.

The R&S TS-PDC module must always be inserted into the corresponding rear I/O slot of the R&S TS-PFG module.

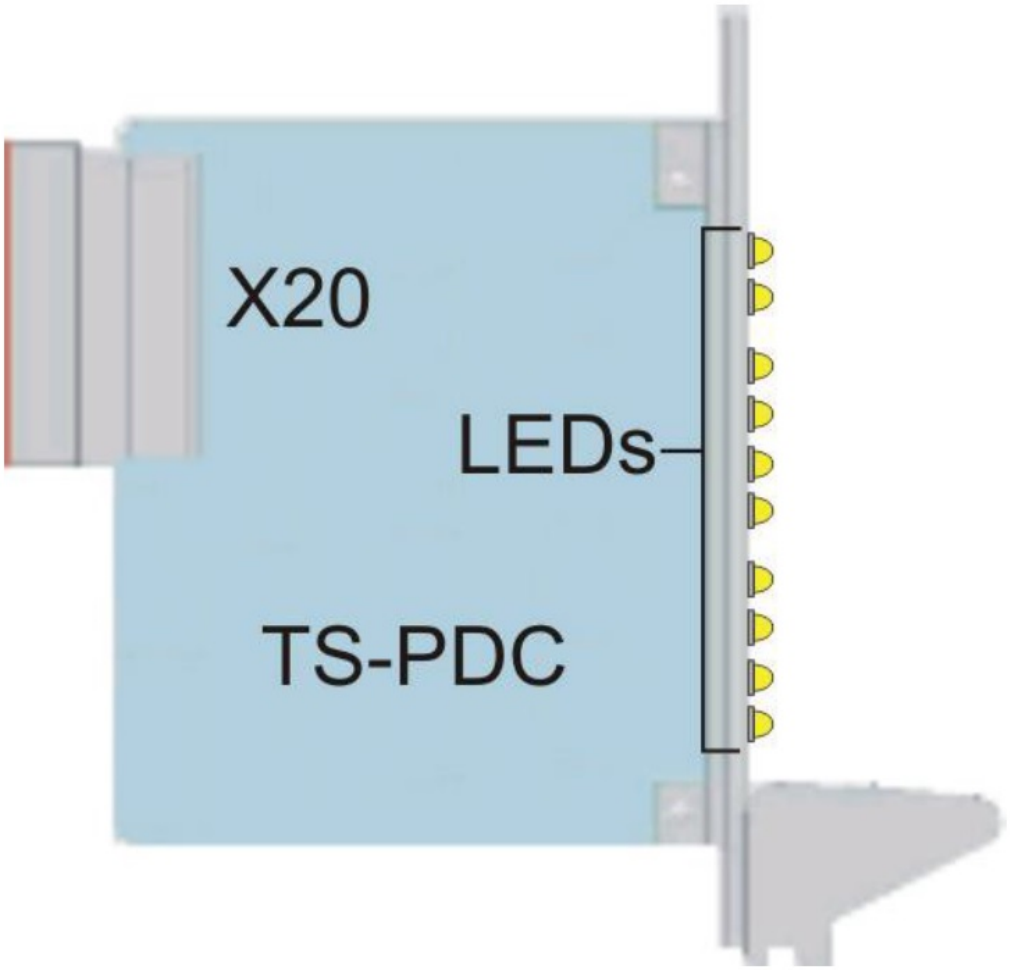

Figure 4-3: Connectors and LEDs on R&S TS-PDC module

4.2.2 Interfaces

Table 4-3: Interfaces on R&S TS-PDC

Designation	Use
X20	Backplane extension (rear I/O)

A detailed interface description with signal assignment to the connector can be found in Chapter 9, "Interface Description", on page 50.

4.2.3 Display Elements

4.2.3.1 R&S TS-PDC up to Version 2.0 (R&S No. 1157.9804.02)

The current status of the module is indicated by means of 8 green LEDs, whereby each LED indicates the presence of an output voltage.

If the module is operating properly, all 8 LEDs must light up simultaneously.

4.2.3.2 R&S TS-PDC from Version 2.0 (R&S No. 1157.9804.12)

The current status of the module is indicated by means of 10 LEDs.

In the switched-on state, the green PWR LED indicates the power-on state. If the module is operating properly, the 8 green LEDs for each generated output voltage also light up.

In the case of overload or overtemperature, the module shuts down automatically. The fault is indicated by means of the red ERR LED.

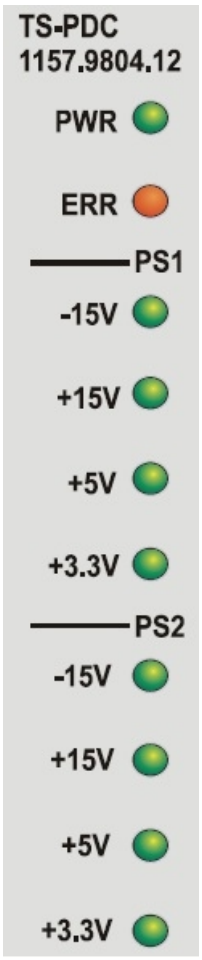

Figure 4-4: LEDs on R&S TS-PDC module from version 2.0

5 Functional Description

5.1 R&S TS-PFG

5.1.1 Overview

5.1.1.1 Analog Hardware of Module

Two independent channels each with its own voltage supply are used to output the analog stimulus values. Both output channels are identical structure.

Each channel has a fast D/A converter downstream of which three lowpass filters and a differential power amplifier with four level ranges are connected.

The ground-referenced control unit (FPGA) transmits the digital data at the maximum possible data rate via an insulated parallel interface. The FPGA updates the D/A converter for each individual channel according to the selected sample rate.

All of the necessary digital control signals (system clock, update signal, gain setting) are generated by the FPGA and also passed to the analog section via isolation transformers.

The voltage supply of the analog front end is made available to the module via a rear I/O module (R&S TS-PDC) with DC/DC converters.

The analog signals are tapped via matrix relays at the front connector (X10) of the module and fed to the analog measurement bus of the R&S CompactTSVP via further coupling relays. Fixed current limiting is provided.

Higher output voltages can be generated by cascading the individual, electrically isolated channels.

5.1.1.2 Synchronization

Triggers can be received to allow synchronization with other devices, especially with analyzer modules or digital measurement modules.

The trigger signals of the PXI trigger bus and two ground-referenced trigger input signals are provided for this purpose.

In addition, a phase-synchronous marker signal can be generated when arbitrary waveforms or arbitrary sequences are output.

5.1.1.3 Special Features for Standard Waveforms

The standard waveforms (sine-wave, square-wave, triangular, ramp) can be generated using the R&S TS-PFG module to match the frequency extremely precisely. In the case of waveforms with steep edges (square-wave, ramp), however, shifts may occur at the edges that are not visible with the other waveforms. The shift (jitter) corresponds to one sampling interval, i.e. 40 ns at signal frequencies above 1 kHz.

For jitter-free signal generation, the signal frequency must be selected such that the period duration or the pulse width (in the case of a square wave) is an integer multiple of 40 ns, or the signal must be programmed as an arbitrary waveform.

5.1.2 Relay Matrix and Analog Bus

Using a full matrix, the two stimulus channels can be optionally connected to a local analog bus (8-line LABx).

Connection to the analog bus of the R&S CompactTSVP is possible via separate bus coupling relays.

Both generator channels can be connected to ground.

Example:

- Channel 1 of the R&S TS-PFG is connected to the local analog bus via matrix relays.
- The coupling relays are also used to connect the local analog bus lines to the analog bus of the R&S CompactTSVP.
- A ground connection is set up on channel 1.

The corresponding function calls of the IVI-C device driver are:

- `rspfg_Connect` to connect the matrix relays
- `rspfg_ConfigureCoupling` to connect the coupling relays
- `rspfg_ConfigureGround` to connect the ground relay

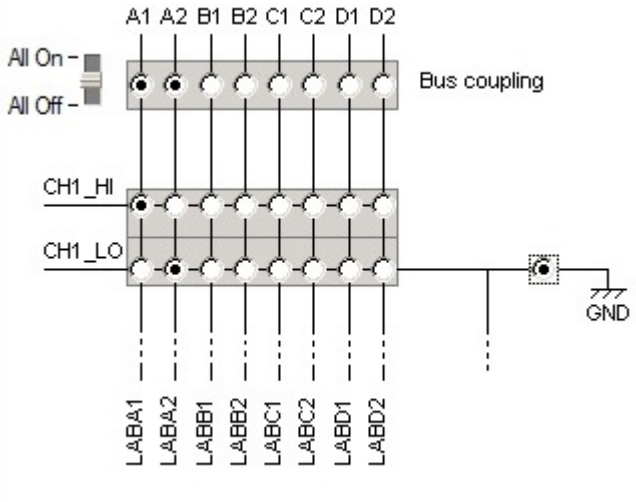

Figure 5-1: Example showing relay connection on R&S TS-PFG channel 1

5.1.3 Cascading of Both Channels

Both channels of the R&S TS-PFG can be cascaded using one relay. In this way, it is possible to place the sum of both channel voltages on the analog bus.

Example:

The high output of channel 2 is connected to the low output of channel 1.

The corresponding function call of the IVI-C device driver is:

```
rspfg_Connect(vi, "CH1_LO", "CH2_HI");.
```

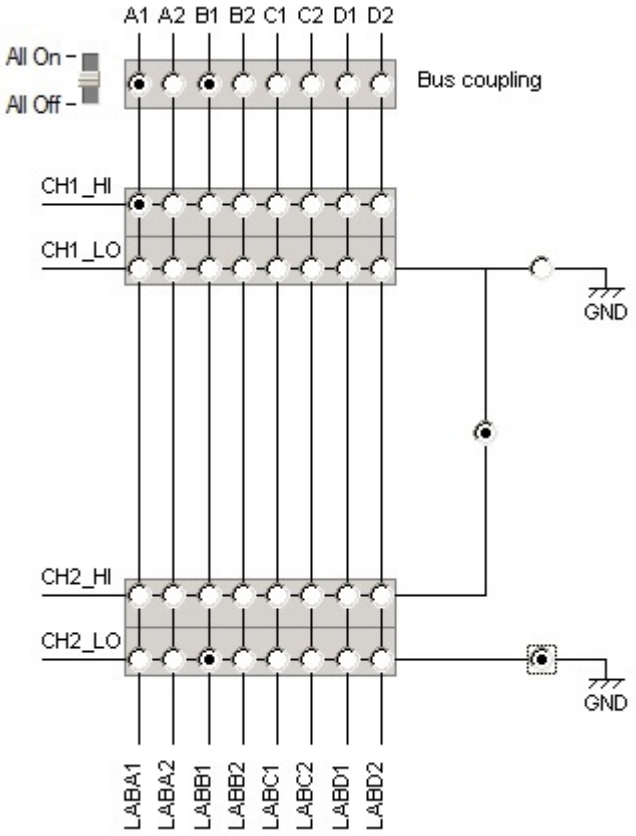

Figure 5-2: Example showing cascading of both R&S TS-PFG channels

5.1.4 Output of Standard Waveforms

In order to configure and output standard waveforms, the R&S TS-PFG must be switched to the corresponding mode. For this purpose, the parameter `RSPFG_VAL_OUTPUT_FUNC` is passed to the IVI-C function `rspfg_ConfigureOutputMode`. This affects both channels. If only one channel is to be configured, the `rspfg_ConfigureOutputModeChannel` function must be used.

Opening the device driver or resetting the driver causes both channels of the R&S TS-PFG to be set to `RSPFG_VAL_OUTPUT_FUNC` mode.

Standard waveforms can either be output continuously, or the number of signal periods after which output of the signal stops can be configured. For further information, see Chapter 5.1.8, "Operating Mode", on page 29.

5.1.4.1 Waveforms

The following standard waveforms can be generated using the R&S TS-PFG:

- Sine-wave
- Triangular
- Square-wave
- Ramp (rising)
- Ramp (falling)

A DC voltage offset can be added to all waveforms. It is also possible to output a constant DC voltage only.

5.1.4.2 Configuration of a Standard Waveform

The following parameters can be set using the `rspfg_ConfigureStandardWaveform` function of the IVI-C driver for the R&S TS-PFG:

- Waveform type
- Amplitude
- DC component
- Frequency
- Start phase

The highest voltage value of a waveform that consists of a DC component plus a variable waveform component must not be higher than +20.0 V on one channel. The lowest voltage value of the output signal must not be lower than –20.0 V.

The adjustable frequency range is between 1.0 Hz and 1.0 MHz.

In the case of the *"square-wave"* waveform, the duty cycle value (ratio of high component to low component within the period duration) can be set in steps of one percent using the `rspfg_ConfigureDutyCycle` function.

5.1.5 Output of Arbitrary Waveforms

In order to configure and output arbitrary waveforms, the R&S TS-PFG must be switched to the corresponding mode. For this purpose, the parameter `RSPFG_VAL_OUTPUT_ARB` is passed to the IVI-C function `rspfg_ConfigureOutputMode`. This affects both channels. If only one channel is to be configured, the `rspfg_ConfigureOutputModeChannel` function must be used.

Arbitrary waveforms can either be output continuously, or the number of signal periods after which output of the signal stops can be configured. For further information, see Chapter 5.1.8, "Operating Mode", on page 29.

5.1.5.1 Creation of Waveform

By calling the `rspfg_CreateArbWaveform` function, an arbitrary waveform can be generated and stored in the waveform memory of the R&S TS-PFG. The return value of this function allows an existing waveform to be referenced again at a later time by other functions of the IVI-C driver.

The size of the waveform memory is max. 1 Msample per channel.

It is also possible to store several smaller waveforms in the memory at the same time.

The data array comprising floating point numbers which is passed to the `rspfg_CreateWaveform` function must consist of standardized values, i.e. values from min. −1.0 to max. +1.0.

5.1.5.2 Configuration of an Arbitrary Waveform

In order for a standardized arbitrary waveform that is already present in the waveform memory to be output at a certain amplitude, a gain factor must be specified using the `rspfg_ConfigureArbWaveform` function. This factor, multiplied by the standardized values of the waveform, then gives the level of the individual waveform points (samples) in volts.

This function is also used to configure a DC voltage component (if applicable). As with the standard waveforms, the sum of DC component plus variable waveform component must not be higher than +20.0 V on one channel. The lowest voltage value of the arbitrary output signal must not be lower than −20.0 V.

If multiple arbitrary waveforms are present in the memory of the R&S TS-PFG, the last waveform to be configured using the `rspfg_ConfigureArbWaveform` function (and therefore activated) is output.

The output speed of the waveform is set for both channels using the `rspfg_ConfigureSampleRate` function or for one channel using `rspfg_ConfigureSampleRateChannel`. The slowest possible output speed is one sample per second. The fastest possible output speed is 25 Msample/s. Not all sample rates between these values are possible. The possible sample rates apart from 25 Msample/s can be calculated using the following formula:

Sample rate in seconds = 1.0 / (100.0e-9 + n * 20.0e-9), where n = 0, 1, 2, 3,…

If sample rates that are between the possible values are configured, the IVI-C driver sets a possible adjacent value automatically.

Alternatively, the output speed can also be set using the `rspfg_ConfigureArbFrequency` function. This function can be used to set the frequency at which the entire arbitrary waveform is to be repeated. The arbitrary frequency is linked to the arbitrary sample rate by means of the following formula:

Arbitrary frequency = Arbitrary sample rate / Number of waveform samples

With the variant of the R&S TS-PFG function generator module (R&S No. 1157.9610.02), it is important to note that an arbitrary waveform must consist of at least 18 samples if they are to be output with the maximum sample rate of 25 Msample per second. At lower sample rates, there is no limit with regard to the minimum length of the waveform.

5.1.5.3 Addition of Markers

When arbitrary signals are output, the individual samples can also be linked to marker signals. These markers allow, for example, other devices to be synchronized with certain sections of an arbitrary waveform.

For each of the two channels of the R&S TS-PFG, a marker output with the two possible output voltages 0.0 V and 3.3 V is provided at the front connector X10.

An existing arbitrary waveform can be linked to a marker data array by calling the IVI-C function `rspfg_ConfigureArbMarker`.

5.1.5.4 Filtering of Output Signal

Arbitrary output signals can be smoothed using a downstream lowpass filter. Each of the two channels of the R&S TS-PFG has its own filter.

The following three filter frequencies can be set using the IVI-C driver function `rspfg_ConfigureFilter`:

- 3 kHz
- 100 kHz
- 3 MHz

5.1.6 Output of Arbitrary Sequences

In order to configure and output arbitrary sequences, the R&S TS-PFG must be switched to the corresponding mode. For this purpose, the parameter `RSPFG_VAL_OUTPUT_SEQ` is passed to the IVI-C function `rspfg_ConfigureOutputMode`. This affects both channels. If only one channel is to be configured, the `rspfg_ConfigureOutputModeChannel` function must be used.

If multiple arbitrary waveforms are present in the memory of one channel of the R&S TS-PFG, they can be joined together to form a sequence and then output. A sequence can consist of up to 256 consecutively called arbitrary waveforms. It is possible to repeat each subwaveform up to 16382 times. The complete sequence can then be output only once. It must then be restarted again.

Continuous, automatically repeating output of an arbitrary sequence is not possible.

5.1.6.1 Creation of a Sequence

By calling the `rspfg_CreateArbSequence` function, an arbitrary sequence can be generated and stored in the waveform memory of the R&S TS-PFG. The return value of this function allows this sequence to be referenced again at a later time by other functions of the IVI-C driver.

Two data arrays of the same length are passed to the function. The first array consists of reference values (handles) to existing arbitrary waveforms. In the sequence, all waveforms are played back in the order in which they are listed in this array. The second array consists of integer values that indicate how often the waveform of the first array with the same array index is to be played back.

Multiple arbitrary sequences can be defined at the same time and stored in the memory of the R&S TS-PFG.

5.1.6.2 Configuration of an Arbitrary Sequence

To enable an arbitrary sequence that consists of standardized arbitrary waveforms to be output at a certain amplitude, a gain factor must be specified using the `rspfg_ConfigureArbSequence` function. This factor, multiplied by the standardized values of the waveforms, then gives the level of the individual waveform points (samples) in volts.

This function is also used to configure a DC voltage component (if applicable). As with the standard and arbitrary waveforms, the sum of DC component plus variable waveform component must not be higher than +20.0 V on one channel. The lowest voltage value of the arbitrary output signal must not be lower than −20.0 V.

If multiple arbitrary sequences are present in the memory of the R&S TS-PFG, the last waveform to be configured using the `rspfg_ConfigureArbSequence` function (and therefore activated) is output. The output speed of the waveform is set for both channels using the `rspfg_ConfigureSampleRate` function or for one channel using `rspfg_ConfigureSampleRateChannel`. The slowest possible output speed is one sample per second. The fastest possible output speed is 25 Msample/s. Not all sample rates between these values are possible. The possible sample rates apart from 25 MS/s can be calculated using the following formula:

Sample rate in seconds = 1.0 / (100.0e-9 + n * 20.0e-9), where n = 0, 1, 2, 3,…

If sample rates that are between the possible values are configured, the IVI-C driver sets a possible adjacent value automatically.

With the variant of the R&S TS-PFG function generator module (R&S No. 1157.9610.02), it is important to note that each subwaveform of the arbitrary sequence must consist of at least 18 samples if the sequence is to be output with the maximum sample rate of 25 Msample per second. At lower sample rates, there is no limit with regard to the minimum length of the subwaveforms.

5.1.6.3 Marker Signals in Arbitrary Sequences

All marker signals that have been defined for the individual arbitrary waveforms of which the arbitrary sequence consists, are also output at the front connector X10 of the R&S TS-PFG when the sequence is output.

Information on how to add marker signals to arbitrary waveforms can be found in Chapter 5.1.5.3, "Addition of Markers", on page 25.

5.1.6.4 Filtering of Output Signal

As with arbitrary output signals, arbitrary sequences can also be smoothed using a downstream lowpass filter. Each of the two channels of the R&S TS-PFG has its own filter.

The following three filter frequencies can be set using the IVI-C driver function `rspfg_ConfigureFilter`:

- 3 kHz
- 100 kHz
- 3 MHz

5.1.6.5 Improved Performance from Using Arbitrary Sequences

In some cases, skillful use of an arbitrary sequence can result in a considerable improvement in performance with regard to program execution speed compared to using an arbitrary waveform.

The following example is intended to demonstrate the effective use of an arbitrary sequence:

Example:

A bit sequence is to be generated at the output of the function generator, whereby the high bits are to consist of 70 sine-wave periods with a frequency of 125 kHz. A level of 0.0 V is output for all low bits.

If a sine-wave period is formed from ten waveform points, a total of 700 samples will be required for a high bit. At a constant sample rate, this means that 700 samples of the 0.0 V level are also required for the low bit. If a bit sequence consisting of 100 bits is to be output, the total number of samples to be output will be 70000.

Loading an arbitrary waveform consisting of 70000 waveform points to the sample memory of the R&S TS-PFG will take approx. 360 ms (if, for example, the R&S CompactTSVP is controlled by an external PC via a PCI bridge).

The same waveform output can be achieved by using an arbitrary sequence. In this way, it is possible to reduce the time required to configure the R&S TS-PFG to approx. 15 ms. Here, two different arbitrary waveforms are defined first of all:

- One sine-wave period consisting of ten samples.
- One waveform consisting of one single 0.0 V sample.

In the next step, the arbitrary sequence is defined by specifying in a data array the waveforms which are to be output and the order in which they are to be output.

In a second data array with the same length, it is specified how often the waveform of the corresponding array position is to be repeated. In our example, the length of the two data arrays is max. 100 because 100 bits are to be output. If there are sections in the waveform to be output which contain several identical bits that are to be output consecutively, it is also possible to reduce the length of the two data arrays. For this purpose, the number of repetitions of the arbitrary waveform is simply multiplied at the corresponding sections.

This method means that instead of the previous 70000 waveform points only 11 waveform points plus the data arrays with the information on how the sequence is structured then need to be sent to the R&S TS-PFG. In this example, the time required for configuration of the function generator is reduced by 96 percent.

5.1.7 Triggering

The output of waveforms on one channel or the synchronized output on both channels of the R&S TS-PFG function generator can be started by means of trigger events. One of eight PXI trigger lines available in the R&S CompactTSVP can be used as the trigger input.

In this case, a different plug-in board (e.g. the analog stimulus and measurement module R&S TS-PSAM) which is installed in the R&S CompactTSVP and which can generate PXI trigger signals, functions as the trigger source.

It is also possible to trigger the R&S TS-PFG via an external TTL signal fed in at the front connector X10. Both channels can be triggered by trigger inputs XTI1 and XTI2.

The third way in which the beginning of signal output can be started is software triggering. Here, signal output on a channel of the R&S TS-PFG is started from a software application by means of the IVI-C driver function call

rspfg_SendChannelSoftwareTrigger from a software application. Both channels can be started synchronously using the rspfg_SendSoftwareTrigger function, which does not act on a specific channel.

The IVI-C driver function rspfg_ConfigureTriggerSource is used to configure which of the three described trigger sources is to be implemented. After the device driver is opened or the driver is reset, "software triggering" is set at the trigger source for both channels of the R&S TS-PFG.

If signal output is to be delayed after a trigger event has occurred, this delay can be configured using the rspfg_ConfigureTriggerDelay function.

Following configuration of the trigger source and trigger delay, the R&S TS-PFG is switched to the "ready to receive trigger signals" state by calling the rspfg_InitiateGeneration function and then waits for the trigger event.

If the rspfg_AbortGeneration function is called before a trigger event occurs, the function generator is switched back to the "insensitive to trigger signals" state. If a trigger event has already occurred thereby starting signal output, this function causes signal output to be aborted.

5.1.8 Operating Mode

The two channels of the R&S TS-PFG function generator can be used in two different operating modes: continuous mode or burst mode.

Either the RSPFG_VAL_OPERATE_CONTINUOUS or RSPFG_VAL_OPERATE_BURST parameter is passed to the rspfg_ConfigureOperationMode function.

Opening the device driver or resetting the driver causes both channels of the R&S TS-PFG to be set to the RSPFG_VAL_OPERATE_CONTINUOUS operating mode.

5.1.8.1 Continuous Mode

In continuous mode, the previously configured signal is output continuously immediately after the device driver function rspfg_InitiateGeneration is called. In this operating mode, the trigger source which the user has configured for the used channel is irrelevant. In this mode, the trigger source is always set internally to the software trigger and, at the end of the rspfg_InitiateGeneration function, a software trigger is automatically sent to each channel that is in continuous mode.

After initialization of the device driver by means of the rspfg_init and rspfg_InitWithOptions function or after resetting of the R&S TS-PFG with the rspfg_reset function, both channels of the function generator remain in continuous mode and output 0.0 V DC as the signal.

A continuously output waveform can be aborted using the rspfg_AbortGeneration function. Here, it is important to note that only the variable component of the waveform is ended, i.e. drops to 0.0 V. If a DC voltage component of the wave has been configured, this continues to be applied at the channel output.

Unlike the standard waveforms and arbitrary waveforms which can be output continuously, the arbitrary sequence behaves differently in continuous mode. An arbitrary sequence cannot be output continuously. Once it has been output, renewed output must be restarted using the `rspfg_InitiateGeneration` function.

5.1.8.2 Burst Mode

In burst mode, it is possible to determine how often a certain waveform is to be output consecutively. This is determined using a parameter of the device driver function `rspfg_ConfigureBurstCount`. The permissible value range of the parameter is from 1 to 16382. The value 0 (defined as `RSPFG_VAL_BURST_COUNT_INFINITE`) is also permitted. In this case, the signal is output continuously.

Unlike in continuous mode, signal output in burst mode is only started by a trigger event which must occur after the `rspfg_InitiateGeneration` function is called. This can be a software trigger, a PXI trigger or an external TTL trigger signal at the front connector of the R&S TS-PFG. The `rspfg_ConfigureTriggerSource` function is used to determine which of these three trigger types is to be used. When waveform output has been completed, the voltage level of the last trace point continues to be applied at the channel output of the function generator.

Once again, the arbitrary sequence behaves differently here. It cannot be output continuously and also cannot be output multiple times in succession. Once it has been output, renewed output must be restarted using the `rspfg_InitiateGeneration` function and a subsequent trigger event.

5.1.9 Fixing of DC Offset Range

The hardware of the R&S TS-PFG contains four gain ranges for the DC voltage component of a waveform (DC offset). These ranges are 20 V, 10 V, 5 V and 1 V. To output a DC voltage component programmed by the user, the optimum gain range must first be set at the hardware and then the appropriate D/A converter value must be calculated.

If the DC voltage component is to be changed and the new value is in a different gain range, slight voltage jumps will occur when the switchover takes place at the output of the corresponding R&S TS-PFG channel, because activation of the new gain range and programming of the associated A/D converter value can only occur in sequence.

Example:

The DC voltage component of a waveform is to be reduced from 11 V to 9 V:

- The device driver first switches the gain range of the DC voltage component from 20 V to 10 V. As the A/D converter value is still unchanged, this causes the voltage at the output of the R&S TS-PFG channel to drop briefly to approx. 5.5 V (11 V/ 20 V * 10 V).
- In the second step, the A/D converter value which corresponds to an output voltage of 9 V in the 10 V gain range is then set. The voltage at the channel output of the R&S TS-PFG now increases from 5.5 V to the desired 9 V.

In some cases, these effects are undesirable during switchover of the gain range. In such cases, there is the possibility of fixing the gain range of the DC voltage component. This is done using the `rspfg_ConfigureDCOffsetRange` function and the passed parameter `offsetRange`, e.g. 20.0 V. The 20 V range is then used even if a DC voltage component of less then 10 V is set.

The disadvantage of this method is that the available D/A converter resolution is lower, which in turn means lower accuracy of the output voltage at low voltage values. If an output voltage of 0.5 V is configured and the 1 V gain range is active, the output voltage will deviate by a maximum of approx. +/−250 µV from the nominal value. In the 20 V gain range, the output voltage of 0.5 V can only be set with an accuracy of approx. +/−5 mV.

After initialization of the device driver by means of the function `rspfg_init` or `rspfg_InitWithOptions` or after resetting of the R&S TS-PFG using the `rspfg_reset` function, automatic switchover of the DC voltage gain range is configured on both channels. This corresponds to calling the `rspfg_ConfigureDCOffsetRange` function with the value 0.0 V (defined as `RSPFG_OFFSET_RANGE_AUTO`) which is passed as the parameter `offsetRange`.

5.1.10 Dynamic Adaptation of Waveform Amplitude

The functionality described in this chapter is only supported by the variant of the R&S TS-PFG function generator module with R&S No. 1157.9610.02. Firmware version 3.03 or higher is required.

The amplitude of the standard waveform to be output is determined using the `rspfg_ConfigureStandardWaveform` function. For this purpose, the software driver sets the most suitable of the four different gain ranges 20 V, 10 V, 5 V or 1 V at the hardware and calculates the appropriate waveform points which are then written to the waveform memory of the R&S TS-PFG.

If the amplitude of the waveform is to be changed by calling the `rspfg_ConfigureStandardWaveform` function again, the individual points must be recalculated for the waveform memory. This leads to interruption of signal output until writing to the waveform memory has been completed. Only then is output of the waveform with the new amplitude restarted.

In some cases, interruption of the output waveform when the amplitude is changed is undesirable. For this reason, the software driver provides a function with which the individual waveform points of the memory can be multiplied dynamically in the FPGA of the R&S TS-PFG by a factor between 0.0 and 1.0 and thereby reduced. The name of this function is `rspsfg_ConfigureDynamicACAmplitude`. A desired amplitude value which must be less than or equal to the amplitude value that was previously set using the `rspfg_ConfigureStandardWaveform` function is passed as the parameter.

A typical program execution sequence could be as follows:

`rspfg_AbortGeneration`	R&S TS-PFG outputs 0.0 V constantly
`rspfg_ConfigureStandardWaveform`	E.g. 10.0 Vpp are configured, R&S TS-PFG continues to output 0.0 V
`rspfg_ConfigureDynamicACAmplitude`	E.g. 2.0 Vpp are configured, R&S TS-PFG continues to output 0.0 V
`rspfg_InitiateGeneration`	R&S TS-PFG starts output of a standard waveform with ampl. 2.0 Vpp
`rspfg_ConfigureDynamicACAmplitude`	Seamless changeover to output of the standard waveform with a changed amplitude of e.g. 5.0 Vpp

Calling the `rspfg_ConfigureStandardWaveform` function again ends the mechanism for dynamic amplitude adjustment. A waveform with the passed amplitude is output on the corresponding channel of the R&S TS-PFG.

With the output of arbitrary waveforms or sequences consisting of arbitrary waveforms, the magnitude of the output levels can be changed dynamically using the `rspfg_ConfigureDynamicACAmplitude` function in the same way as for standard waveforms. In the program execution sequence shown above, the functions `rspfg_ConfigureArbWaveform` and `rspfg_ConfigureArbSequence` would simply need to be used instead of the `rspfg_ConfigureStandardWaveform` function. In these two functions, the gain factor in volts by which the individual points of the arbitrary waveform (values between 0.0 and 1.0) are multiplied is specified instead of the amplitude of a waveform. The amplitude passed in the `rspfg_ConfigureDynamicACAmplitude` function must be between 0.0 V and the previously configured gain factor for arbitrary waveforms.

Dynamic amplitude control using the `rspfg_ConfigureDynamicACAmplitude` function only affects the variable component of a waveform (AC amplitude). The DC voltage component (DC offset) of the output waveform remains unchanged.

6 Startup

6.1 Installation of R&S TS-PFG Module

To install the R&S TS-PFG plug-in module, proceed as follows:

NOTICE

Damage to backplane caused by bent pins

Bent pins can cause permanent damage to the backplane.

Check the backplane connectors for bent pins.

Any bent pins must be straightened.

When inserting the plug-in module, guide it with both hands and carefully push it into the backplane connectors.

1. Power down and switch off the R&S CompactTSVP.
2. Select a suitable front-side slot.
3. Remove the corresponding section of the front panel from the TSVP chassis by undoing the screws.
4. Push in the plug-in module using moderate pressure
5. The upper catch pin of the plug-in module must be inserted into the right hole in the TSVP chassis and the lower catch pin into the left hole.

   The module is correctly located when a distinct "stop" can be felt.
6. Securely tighten the screws at the top and bottom of the front panel of the plug-in module.

6.2 Installation of R&S TS-PDC Module

To install the plug-in module, proceed as follows:

NOTICE

Damage to backplane caused by bent pins

Bent pins can cause permanent damage to the backplane.

Check the backplane connectors for bent pins.

Any bent pins must be straightened.

When inserting the plug-in module, guide it with both hands and carefully push it into the backplane connectors.

The R&S TS-PFG module must already have been installed.

1. Select the corresponding rear I/O slot for the R&S TS-PFG module.
2. Remove the corresponding section of the rear panel from the R&S CompactTSVP chassis by undoing the two screws.
3. Push in the plug-in module using moderate pressure

   The module is correctly located when a distinct "stop" can be felt.

   Note: The R&S TS-PDC module must be inserted with particular care, making certain that the connector is correctly guided into the socket opening in the backplane – it must not be inserted at an angle or with incorrect alignment, etc. The short printed board guides alone do not ensure absolutely reliable guiding.
   Multiple adjacent R&S TS-PDC modules should always be inserted in the order "from left to right" and removed in the reverse order. As the spaces are so narrow, care must be taken not to damage any components on the solder side of the module.
4. Tighten the two fastening screws on the front panel of the module.

7 Software

7.1 Driver Software

A LabWindows IVI driver which supports the classes `IVI FGEN` and `IVI SWITCH` is provided to enable actuation of the R&S TS-PFG function generator module. All additional functions of the hardware are controlled using specific extensions of the driver. The driver is part of the R&S GTSL software. All the functions of the driver are described fully in the online help and in the LabWindows/CVI function panels. The following software modules are installed during driver installation:

Table 7-1: Driver installation – R&S TS-PFG

Module	Path	Remarks
`rspfg.dll`	`<GTSL directory>\Bin`	Driver
`rspfg.chm`	`<GTSL directory>\Bin`	Help file
`rspfg.fp`	`<GTSL directory>\Bin`	LabWindows/CVI function panel file, function panels for CVI development environment
`rspfg.sub`	`<GTSL directory>\Bin`	LabWindows/CVI attribute file. This file is required by some "function panels".
`rspfg.lib`	`<GTSL directory>\Bin`	Import library
`rspfg.h`	`<GTSL directory>\Include`	Header file for driver

The IVI and VISA libraries from National Instruments are needed to run the driver.

7.2 Soft Panel

The software package of the R&S TS-PFG module includes a soft panel (see Figure 7-1). The soft panel is based on the IVI driver and enables interactive operation of the module on the screen using the mouse.

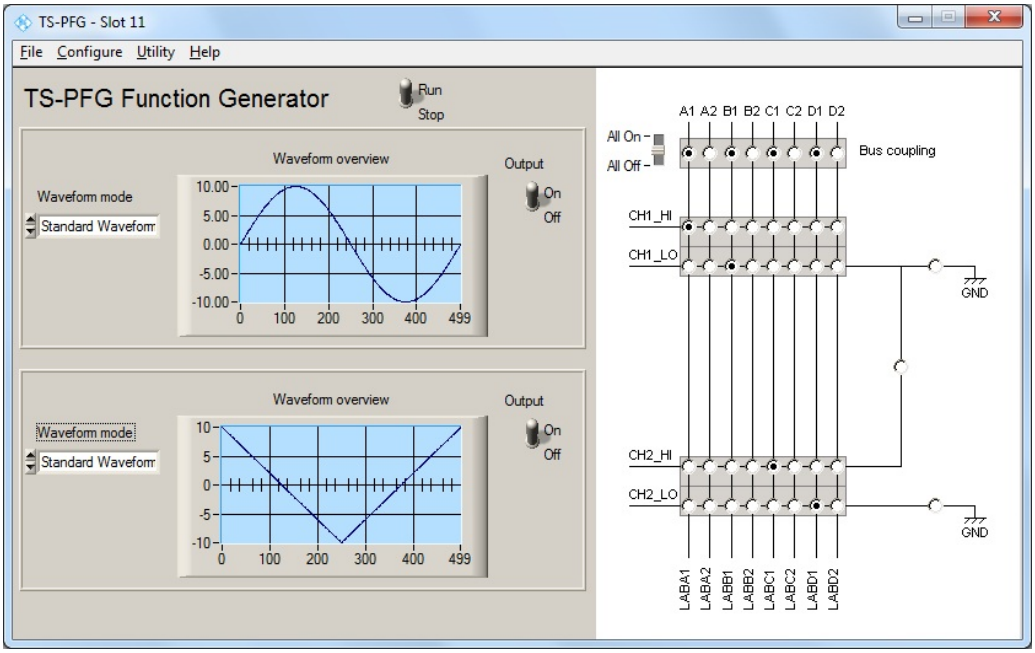

Figure 7-1: Soft panel of R&S TS-PFG

Operation of the soft panels is described in "Software Description for R&S GTSL".

In the R&S TS-PFG soft panel, arbitrary waveform data can be loaded by reading in external files. This data can exist in four different formats: "ASCII", "Binary Little Endian", "Binary Big Endian" and "AWD". The value range of the data is allowed to be greater than +/−1.0 volt as the import function of the soft panel can perform a standardization routine. Only values between −1.0 volt and +1.0 volt can be passed to the functions of the R&S TS-PFG IVI-C driver which are used for creating arbitrary waveforms.

- **ASCII data format**
  The individual waveform points are stored in a text file with the extension `.txt` as floating-point numbers or integer values without specification of the unit "volt". A line break is used as the separator. All lines that do not begin with a number are interpreted as a comment. Space characters at the beginning of a line are ignored.
- **Binary Little Endian**
  Data format of a binary file with the extension `.bin`. A waveform point is represented by two bytes that form a 16-bit integer value. The least significant byte is stored first, i.e. at the smaller memory address.
- **Binary Big Endian**
  Data format of a binary file with the extension `.bin`. A waveform point is represented by two bytes that form a 16-bit integer value. The most significant byte is stored first, i.e. at the smaller memory address.
- **AWD**

Data format of a binary file with the extension `.acv`. The file begins with a comment that ends with a new-line character (0x0a). This is followed by the waveform points, each consisting of four bytes. The arrangement of the four bytes corresponds to the float data type.

7.3 R&S TS-PFG Programming Example

```
/*
   Generating different output signals with and without trigger conditions.
   The different examples just show the order of function calls used to output
   a special signal.
   Error handling is not considered in this example in order to keep it easy to read.
   The return status should be checked after each device driver call.
*/


/* rspfg ivi-driver header file  */
#include "rspfg.h"

static ViSession     s_VI;
static ViStatus      s_Status;

main()
{
   double    arb_wfm_A[] = {-0.9,  0.8, -0.7,  0.6, -0.5,  0.4, -0.3,  0.2, -0.1,  0.0};
   double    arb_wfm_B[] = { 0.5,  0.6,  0.7,  0.8,  0.9,  0.9,  0.8,  0.7,  0.6,  0.5};
   ViInt32   arb_wfm_A_handle;
   ViInt32   arb_wfm_B_handle;

   double    marker_wfm[] = { 0.0, 0.0, 1.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0};

   ViInt32   arb_seq[3];
   ViInt32   arb_seq_loop_array[3];
   ViInt32   arb_seq_handle;



   /*
      The resource descriptor must be adapted to the system.
      Init the rspfg driver.
      After the fuction call the module will generate a dc voltage output
      signal of 0 volts on both channels.
   */
   s_Status = rspfg_InitWithOptions ( "PXI6::12::0::INSTR", VI_TRUE, VI_TRUE, "", &s_VI);

   /* Connect channel 1 to front connector X10. */
   s_Status = rspfg_Connect (s_VI, "CH1_Lo","ABa2");
   s_Status = rspfg_Connect (s_VI, "CH1_Hi","ABa1");
```

```
/* Connect channel 2 to front connector X10. */
s_Status = rspfg_Connect (s_VI, "CH2_Lo","ABb2");
s_Status = rspfg_Connect (s_VI, "CH2_Hi","ABb1");

/* Open ground relays of both channels */
s_Status = rspfg_ConfigureGround(s_VI, "CH1", VI_FALSE);
s_Status = rspfg_ConfigureGround(s_VI, "CH2", VI_FALSE);

/* Wait until switching relays are settled. */
s_Status = rspfg_WaitForDebounce (s_VI, 1000);

/*
   The following three function calls are optional at this place,
   because this values are default values which have been already
   set in the functions rspfg_InitWithOptions().
*/

/* Configure continuous generation of the output signal. */
s_Status = rspfg_ConfigureOperationMode (s_VI, "CH1", RSPFG_VAL_OPERATE_CONTINUOUS);

/* Configure continuous generation of the output signal. */
s_Status = rspfg_ConfigureOperationMode (s_VI, "CH2", RSPFG_VAL_OPERATE_CONTINUOUS);

/* Configure standard function output for both channels. */
s_Status = rspfg_ConfigureOutputMode (s_VI, RSPFG_VAL_OUTPUT_FUNC);


/*
   Configure sine wave output on channel 1 and triangle output on channel two with
   2.0 volts amplitude peak to peak,
   frequency: 1000 Hz,
   phase: 0 Hz,
   dc offset voltage: 0.0 volt.
*/
s_Status = rspfg_ConfigureStandardWaveform (s_VI, "CH1", RSPFG_VAL_WFM_SINE,
                                            2.0, 0.00, 1000, 0.00);
s_Status = rspfg_ConfigureStandardWaveform (s_VI, "CH2", RSPFG_VAL_WFM_TRIANGLE,
                                            2.0, 0.00, 1000, 0.00);
```

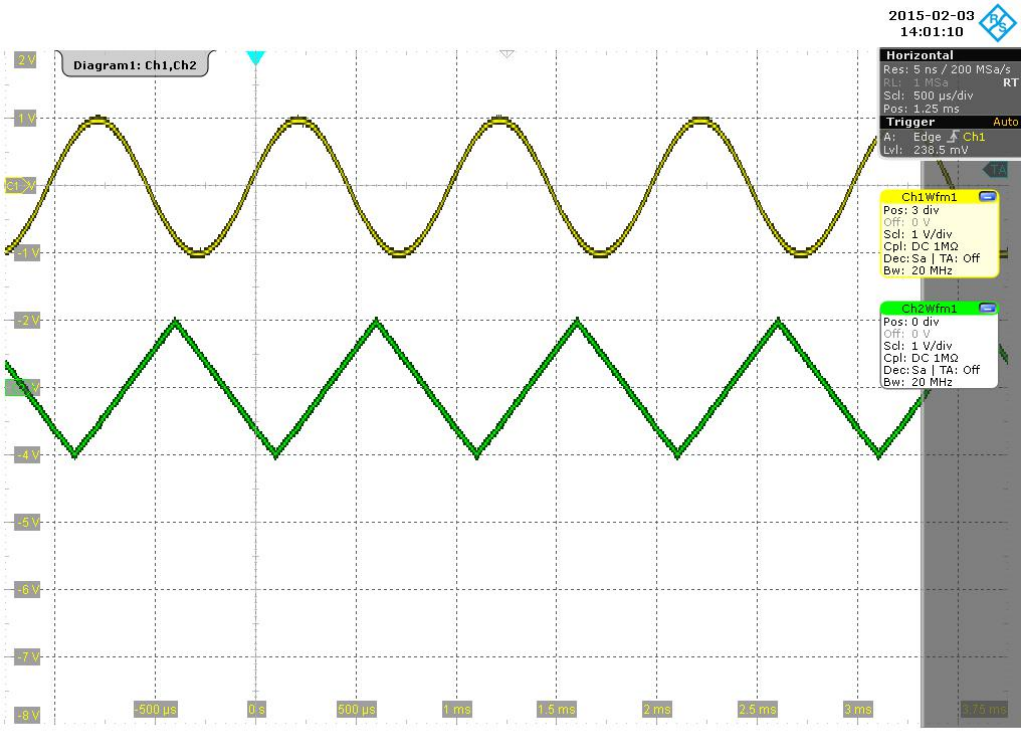

Figure 7-2: Oscilloscope: Standard signals on both channels, not synchronous

```
*/
   /*
      Note that both channels haven't been startet at the same moment.
      The signals are phase locked but they show a phase shift to each other.
      To start both channels of the function generator synchronously at the same
      moment, first prevent the generator from generating an output signal with
      function rspfg_AbortGeneration(), then optionally set or change output
      settings and subsequently start signal generation on both channels with
      function rspfg_InitiateGeneration().
   */

   /* Stop generation of output signals */
   s_Status = rspfg_AbortGeneration(s_VI);

   /*
     Start generation of output signals synchronously on both channels.
     In CONTINUOUS mode the generator will immediately output signals without
     any trigger event.
   */
   s_Status = rspfg_InitiateGeneration(s_VI);

   /*
```

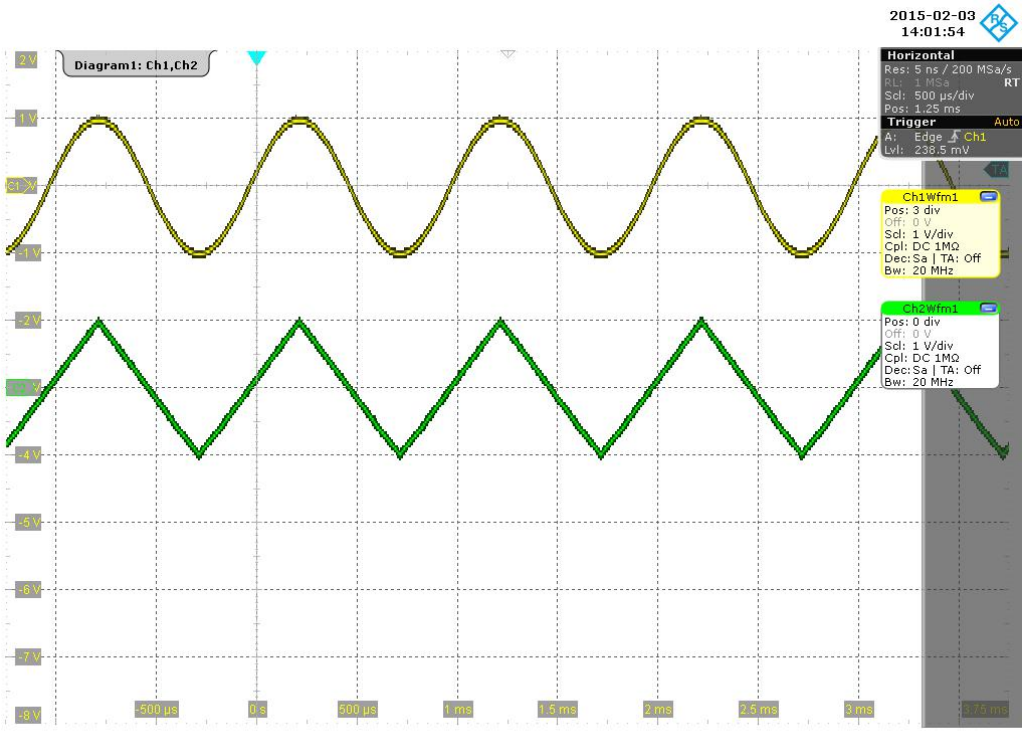

Figure 7-3: Oscilloscope: Standard signals on both channels, synchronous

```
*/

   /*
      Switch to burst mode. Only the configured number of waveforms
      will be output at a specified trigger event. After initialization of the
      device driver, the default trigger source is set to software trigger.
   */

   /* Stop generation of output signal.*/
   s_Status = rspfg_AbortGeneration (s_VI);

   /* Configure number of bursts. */
   s_Status = rspfg_ConfigureBurstCount (s_VI, "CH1", 2);
   s_Status = rspfg_ConfigureBurstCount (s_VI, "CH2", 1);

   /* Configure burst generation of the output signal. */
   s_Status = rspfg_ConfigureOperationMode (s_VI, "CH1", RSPFG_VAL_OPERATE_BURST);
   s_Status = rspfg_ConfigureOperationMode (s_VI, "CH2", RSPFG_VAL_OPERATE_BURST);

   /*
      Configure sine wave output on channel 1 with 1.0 volts amplitude peak to peak,
      with
      frequency: 2000 Hz,
      phase: 0 Hz,
```

```
   dc offset voltage: 0.0 volt.
*/
s_Status = rspfg_ConfigureStandardWaveform (s_VI, "CH1", RSPFG_VAL_WFM_SINE,
                                            2.0, 0.00, 2000, 0.00);

/* Configuration of channel 2 is not changed */

/*
   Initiate generating signal generator output.
   Channel 1 waits for the software trigger event and then shows 2 signal bursts.
   Channel 2 waits for the software trigger event and then shows 1 signal burst.
*/
s_Status = rspfg_InitiateGeneration (s_VI);

/* Start generating signal generator output. */
s_Status = rspfg_SendSoftwareTrigger (s_VI);

/*
```

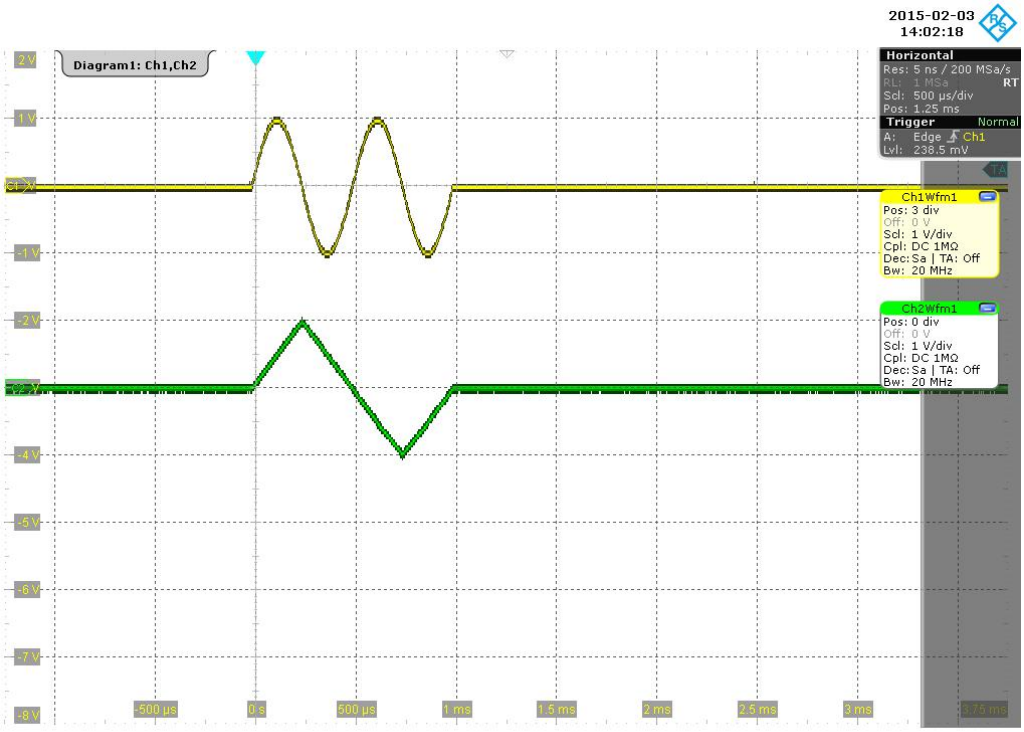

Figure 7-4: Oscilloscope: Bursts consisting of standard signals on both channels

```
*/


   /*
      Output of an arbitrary waveform on channel 2
   */
```

```
/* Stop generation of output signal.*/
s_Status = rspfg_AbortGeneration (s_VI);

/* Create the arbitrary waveform */
s_Status = rspfg_CreateArbWaveform(s_VI, 10, arb_wfm_A, &arb_wfm_A_handle );

/* switch to arbitrary waveform mode */
s_Status = rspfg_ConfigureOutputModeChannel(s_VI, "CH2", RSPFG_VAL_OUTPUT_ARB );

/* Configure the arbitrary waveform on channel 2 */
s_Status = rspfg_ConfigureArbWaveform(s_VI, "CH2", arb_wfm_A_handle, 1.0, 0.0 );

/* Configure sample rate on channel 2 */
s_Status = rspfg_ConfigureSampleRateChannel(s_VI, "CH2", 1.0e4 );

/* Initiate generating signal generator output.
   Channel 1 waits for the software trigger event and then shows 2 sine wave
   signal bursts.
   Channel 2 waits for the software trigger event and then shows 1 arbitrary
   signal burst.
*/
s_Status = rspfg_InitiateGeneration (s_VI);

/* Start generating signal generator output. */
s_Status = rspfg_SendSoftwareTrigger (s_VI);

/*
```

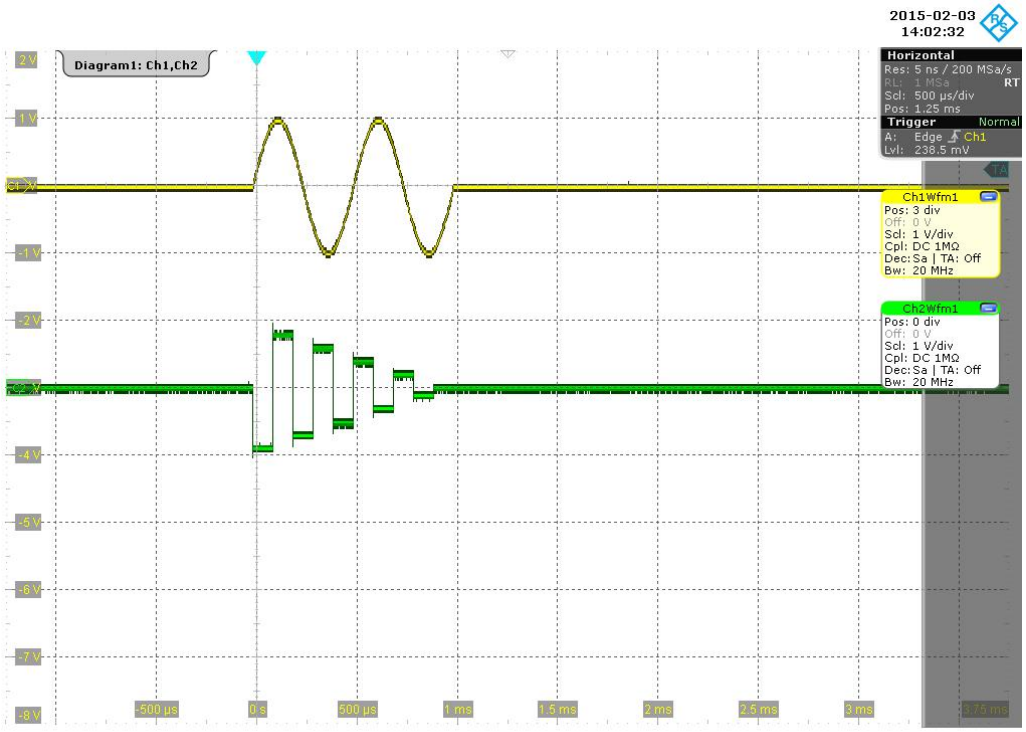

Figure 7-5: Oscilloscope: Burst of an arbitrary signal on channel 2 (green)

```
*/
   /*
      Switch channel 2 to continuous output of the arbitrary wavefrom.
      Continuous mode doesn't need any trigger event.
      The arbitrary signal is immediately output continuously.
   */
   s_Status = rspfg_ConfigureOperationMode (s_VI, "CH2", RSPFG_VAL_OPERATE_CONTINUOUS);

   /*
      Initiate generating signal generator output.
      Channel 1 waits for the software trigger event and then shows 2 sine wave
      signal bursts.
      Channel 2 is already running but it is restarted and outputs the arbitrary
      signal continuously now.
   */
   s_Status = rspfg_InitiateGeneration (s_VI);

   /* Start generating signal generator output. */
   s_Status = rspfg_SendChannelSoftwareTrigger (s_VI, "CH1");

   /*
```

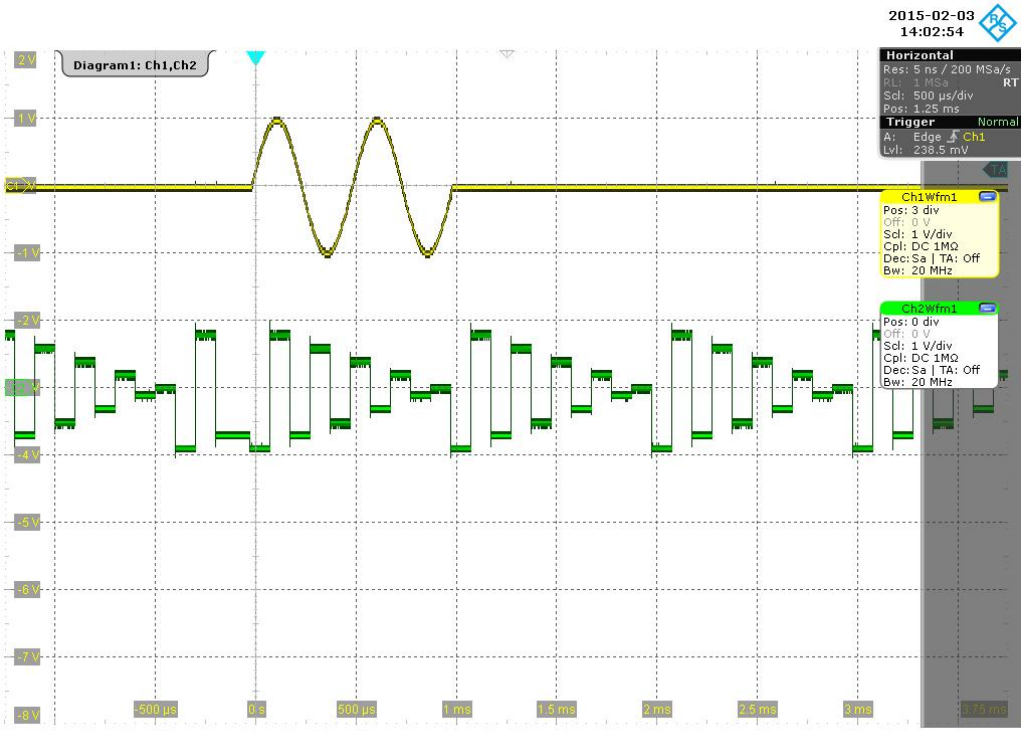

Figure 7-6: Oscilloscope: Continuous arbitrary signal on channel 2 (green)

```
*/
   /*
      Add a marker signal to the arbitrary waveform of channel 2.
      The marker signal shows up at the third sample of the arbitrary waveform
   */

   /* Associate the marker waveform to an existing arbitrary waveform */
   s_Status = rspfg_ConfigureArbMarker(s_VI, arb_wfm_A_handle, 10, marker_wfm);

   /* Configure the marker: enable the marker and set it polarity to high */
   s_Status = rspfg_ConfigureMarkerOutput(s_VI, "CH2", VI_TRUE,
                                          RSPFG_VAL_MARKER_POL_HIGH_ACTIVE);

   /* Initiate generating signal generator output. */
   s_Status = rspfg_InitiateGeneration (s_VI);

   /* Start generating signal generator output. */
   s_Status = rspfg_SendChannelSoftwareTrigger (s_VI, "CH1");

   /*
```

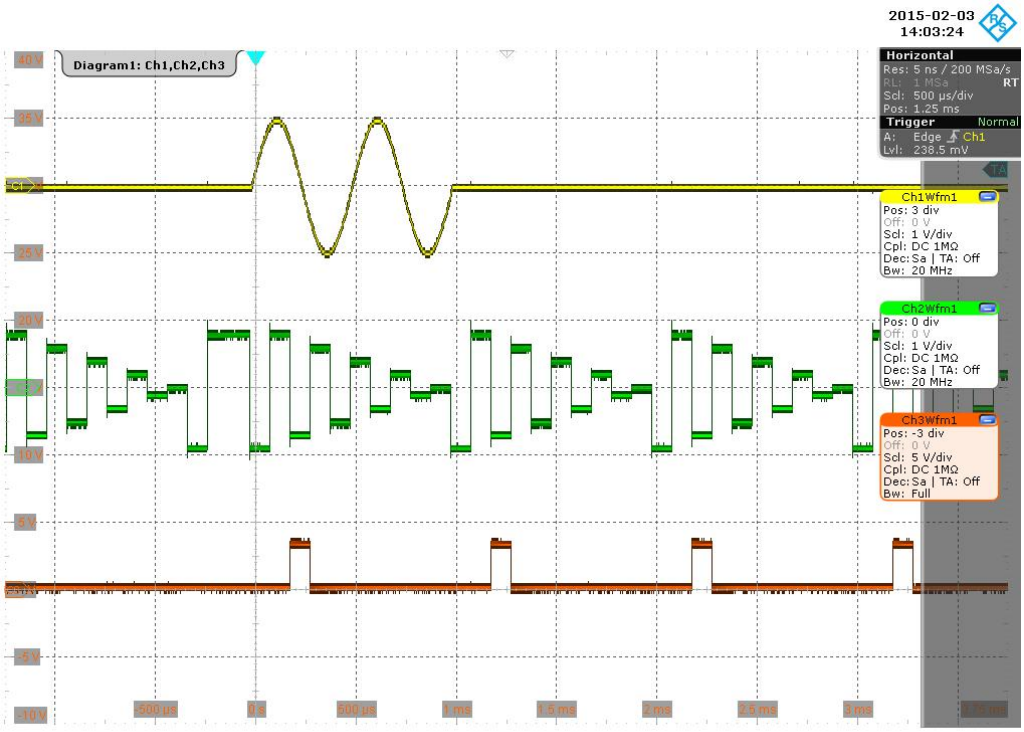

Figure 7-7: Oscilloscope: Marker signal (brown) of arbitrary signal on channel 2 (green)

```
*/

   /*
      Output of an arbitrary sequence on channel 1
   */

   /* Stop generation of output signal.*/
   s_Status = rspfg_AbortGeneration (s_VI);

   /* Create the second arbitrary waveform */
   s_Status = rspfg_CreateArbWaveform(s_VI, 10, arb_wfm_B, &arb_wfm_B_handle );

   /* Create an arbitrary sequence from both arbitrary waveforms */
   arb_seq[0]            = arb_wfm_A_handle;
   arb_seq[1]            = arb_wfm_B_handle;
   arb_seq[2]            = arb_wfm_A_handle;
   arb_seq_loop_array[0] = 1;
   arb_seq_loop_array[1] = 1;
   arb_seq_loop_array[2] = 1;
   s_Status = rspfg_CreateArbSequence(s_VI, 3, arb_seq, arb_seq_loop_array, &arb_seq_handle );

   /* switch to arbitrary sequence mode */
   s_Status = rspfg_ConfigureOutputModeChannel(s_VI, "CH1", RSPFG_VAL_OUTPUT_SEQ );
```

```
   /* Configure the arbitrary waveform sequence on channel 1 */
   s_Status = rspfg_ConfigureArbSequence(s_VI, "CH1", arb_seq_handle, 1.0, 0.0 );

   /* Configure sample rate on channel 1 */
   s_Status = rspfg_ConfigureSampleRateChannel(s_VI, "CH1", 1.0e4 );

   /*
      Initiate signal generator output.
      Channel 1 waits for the software trigger event and then shows the
      arbitrary sequence once.
      Channel 2 was stopped but it is restarted and ouputs the arbitrary
      signal continuously.
   */
   s_Status = rspfg_InitiateGeneration (s_VI);

   /* Start generating signal generator output on channel 1. */
   s_Status = rspfg_SendSoftwareTrigger (s_VI);

   /*
```

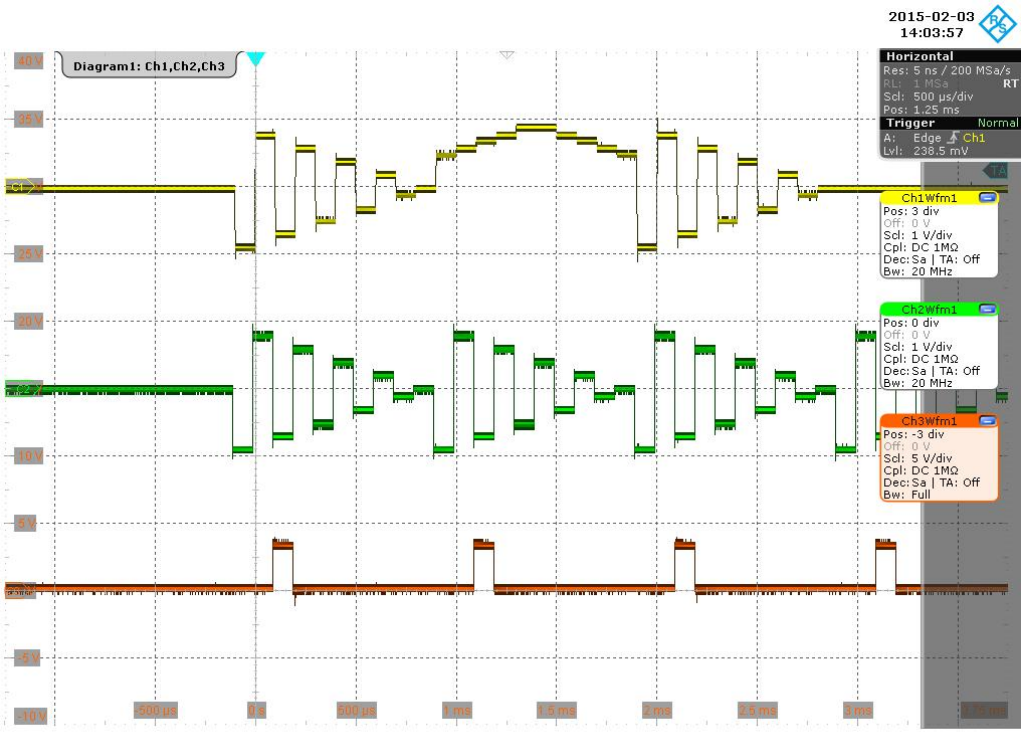

Figure 7-8: Oscilloscope: Arbitrary sequence on channel 1 (yellow)

```
*/

   /*
      Please note: An arbitrary sequence can only be output once.
      It doesn't matter if the R&S TS-PFG channel is in CONTINUOUS mode or
```

```
      in BURST mode.
   */

   /* Stop generation of output signal. */
   s_Status = rspfg_AbortGeneration (s_VI);

   /*
```

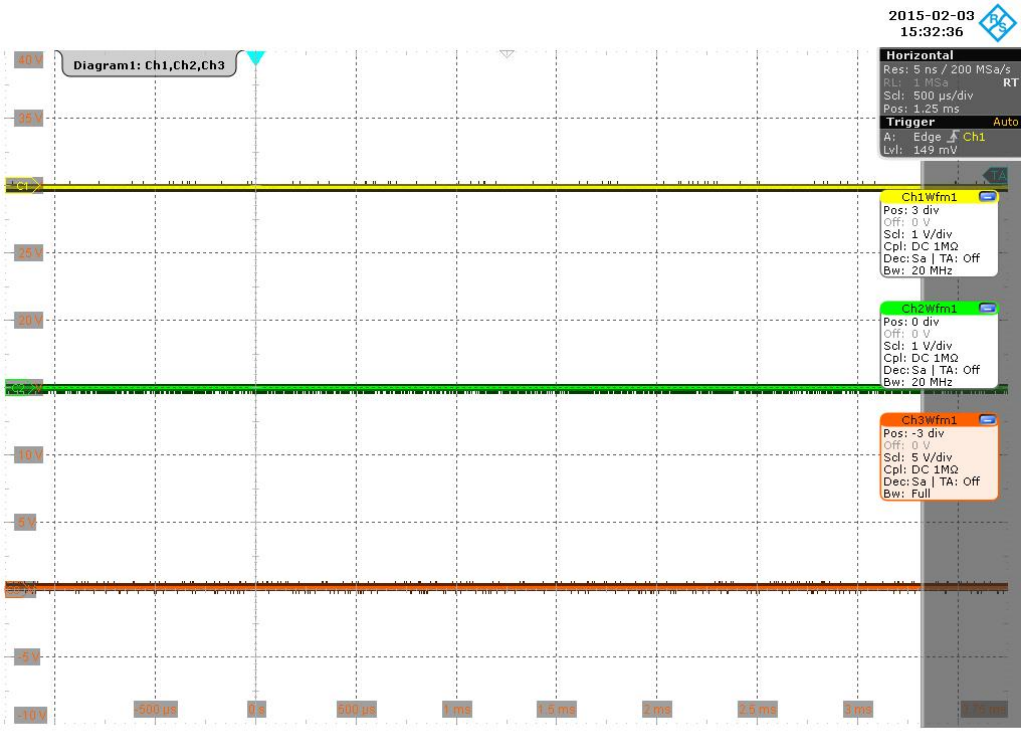

Figure 7-9: Oscilloscope: All variable signals have been switched off

```
*/

   /* Close the device driver */
   s_Status = rspfg_close (s_VI);
}
```

8 Self-Test

The R&S TS-PFG function generator has an integrated self-test capability. The following tests are possible:

- LED test
- Power-on test
- TSVP self-test

8.1 LED Test

When the device is switched on, all three LEDs light up for approx. one second. This indicates that the 5 V supply voltage is present and all LEDs are OK. The following statements can be made regarding the different LED states:

Table 8-1: Statements regarding LED test

LED	Description
One LED does not light up	Hardware problem on the module; LED defective
No LEDs light up	No +5V supply

If diagnostics suggest a problem with the supply voltage, the LEDs for the associated R&S TS-PDC rear I/O module must be inspected visually. If a supply voltage failure is confirmed, the R&S TS-PDC module must be replaced.

8.2 Power-On Test

The power-on test runs at the same time as the LED test. The following statements can be made regarding the different display states of the LEDs:

Table 8-2: Statements regarding power-on test

LED	Description
PWR LED (green) ON	All supply voltages are present
PWR LED (green) OFF	At least one supply voltage is missing
ERR LED (red) OFF	If the green LED is lit at the same time, there are no detectable faults
ERR LED (red) ON	There is a hardware fault. The power-on test has detected a fault on the R&S TS-PFG.

8.3 TSVP Self-Test

The TSVP self-test runs an in-depth test on the R&S TS-PFG module and generates a detailed log. This is done using the "Self-Test Support Library".

The R&S TS-PSAM analog stimulus and measurement module is used as a measurement unit in the TSVP self-test. Correct operation of the modules in the system is ensured by measurements on the analog bus.

Information about starting the self-test and about the sequence of the necessary steps can be found in the GTSL software description or GTSL online help.

A detailed description of the checked parameters and processes can be found in the service manual for the R&S CompactTSVP / R&S PowerTSVP.

9 Interface Description

9.1 R&S TS-PFG

9.1.1 Connector X10

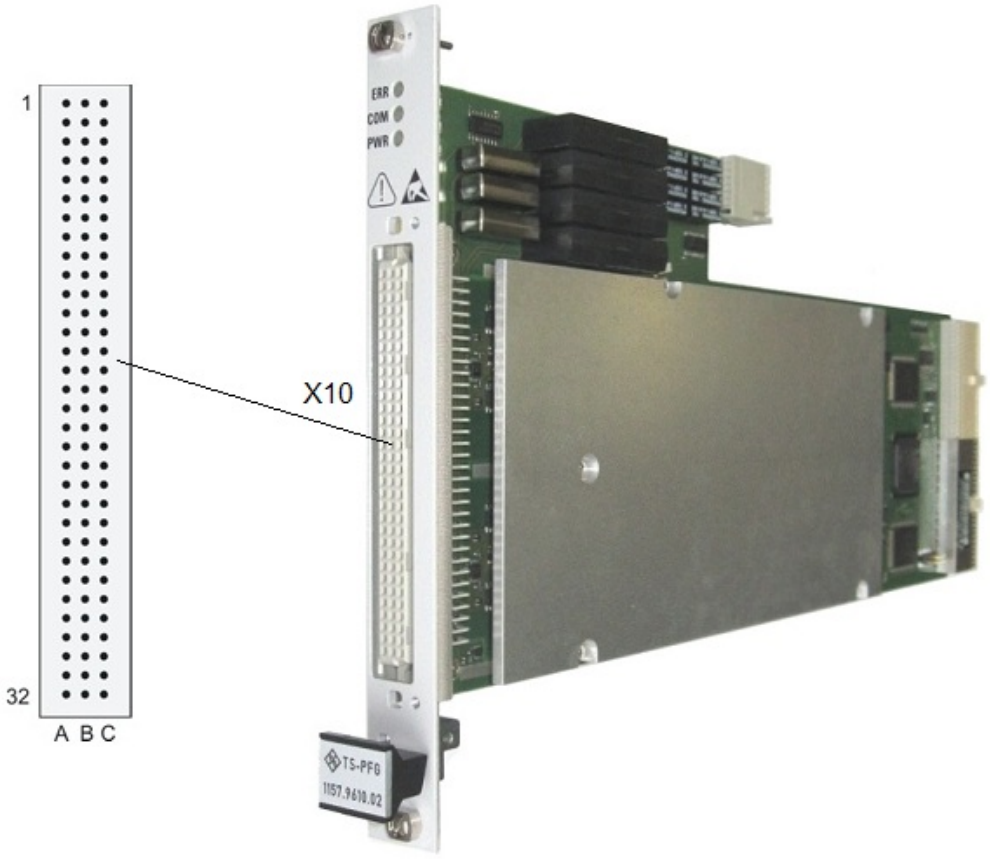

Figure 9-1: R&S TS-PFG connector X10

Table 9-1: Pin assignment of R&S TS-PFG connector X10

	A	B	C
1	LABA1		LABA2
2	LABB1		LABB2
3	LABC1		LABC2
4	LABD1		LABD2
5			

6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28	GND	GND	GND
29	MO1	GND	MO2
30	XTI1	GND	XTI2
31	GND	GND	GND
32	GND	GND	CHA-GND

9.1.2 Connector X20

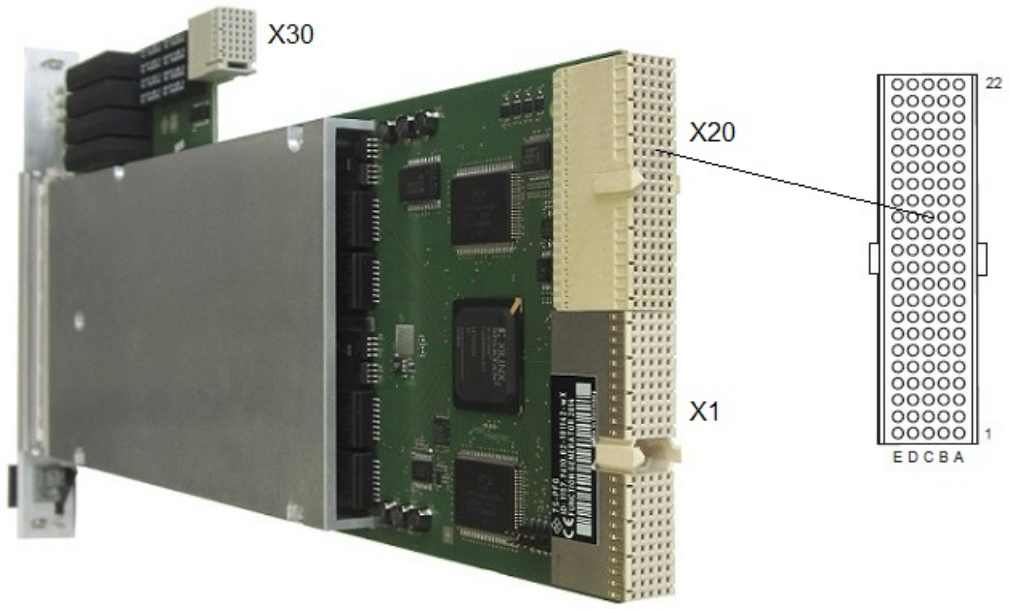

Figure 9-2: R&S TS-PFG connector X20

Pin	F	E	D	C	B	A	
22	GND	GA0	GA1	GA2	GA3	GA4	
21	GND				GND		
20	GND		GND				
19	GND				GND		
18	GND	PXI_TRIG6	GND	PXI_TRIG5	PXI_TRIG4	PXI_TRIG3	X20
17	GND	PXI_CLK10			GND	PXI_TRIG2	
16	GND	PXI_TRIG7	GND		PXI_TRIG0	PXI_TRIG1	
15	GND				GND		
14	NC						C
13	NC						O
12	NP	AGND_CH1	+3V3_CH1	+VCC2_CH1	-VCC1_CH1	+VCC1_CH1	N
11	NP						N
10	NC	AGND_CH2	+3V3_CH2	+VCC2_CH2	-VCC1_CH2	+VCC1_CH2	E
9	NC						C
8	NC						T
7	NC						O
6	NC						R
5	NC						
4	NC						
3	GND	RSA0	RRST#		GND	RSDO	
2	GND		RSDI	RSA1		RSCLK	
1	GND				GND	RCS#	

Figure 9-3: Pin assignment of R&S TS-PFG connector X20

9.1.3 Connector X30

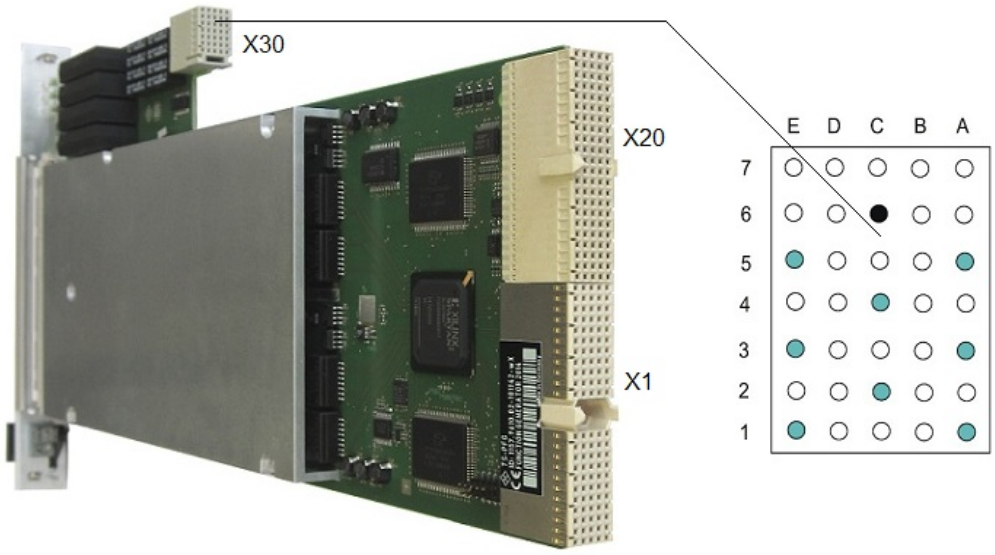

Figure 9-4: R&S TS-PFG connector X30

Table 9-2: Pin assignment of R&S TS-PFG connector X30

	E	D	C	B	A
7					
6			GND		
5	ABC1				ABA1
4			ABB1		
3	ABC2				ABB2
2			ABA2		
1	ABD2				ABD1

9.1.4 Connector X1 (cPCI Bus)

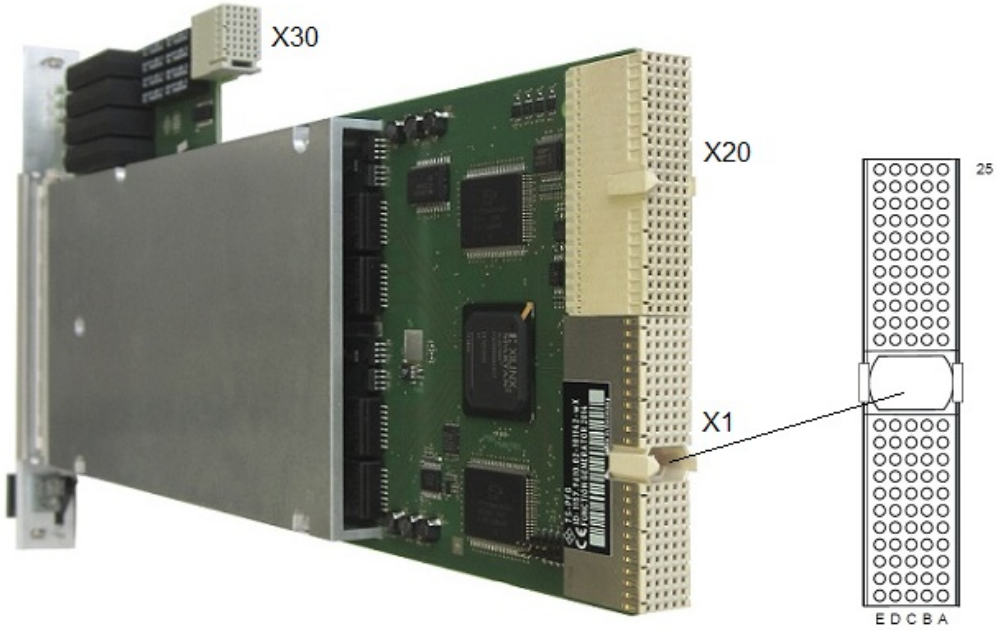

Figure 9-5: R&S TS-PFG connector X1

Pin	F	E	D	C	B	A	
25	GND	5V	3.3V	ENUM#	REQ64#	5V	
24	GND	ACK64#	AD[0]	V(I/O)	5V	AD[1]	
23	GND	AD[2]	5V	AD[3]	AD[4]	3.3V	
22	GND	AD[5]	AD[6]	3.3V	GND	AD[7]	
21	GND	C/BE[0]#	M66EN	AD[8]	AD[9]	3.3V	
20	GND	AD[10]	AD[11]	V(I/O)	GND	AD[12]	
19	GND	AD[13]	GND	AD[14]	AD[15]	3.3V	
18	GND	C/BE[1]#	PAR	3.3V	GND	SERR#	X1
17	GND	PERR#	GND	IPMB_SDA	IPMB_SCL	3.3V	
16	GND	LOCK#	STOP#	V(I/O)	GND	DEVSEL#	C
15	GND	TRDY#	BD_SEL#	IRDY#	FRAME#	3.3V	O
12..14				Key Area			N
11	GND	C/BE[2]#	GND	AD[16]	AD[17]	AD[18]	N
10	GND	AD[19]	AD[20]	3.3V	GND	AD[21]	E
9	GND	AD[22]	GND	AD[23]	IDSEL	C/BE[3]#	C
8	GND	AD[24]	AD[25]	V(I/O)	GND	AD[26]	T
7	GND	AD[27]	GND	AD[28]	AD[29]	AD[30]	O
6	GND	AD[31]	CLK	3.3V	GND	REQ#	R
5	GND	GNT#	GND	RST#	BSRSV	BSRSV	
4	GND	INTS	INTP	V(I/O)	HEALTHY#	IPMB_PWR	
3	GND	INTD#	5V	INTC#	INTB#	INTA#	
2	GND	TDI	TDO	TMS	5V	TCK	
1	GND	5V	+12V	TRST#	-12V	5V	

Figure 9-6: Pin assignment of R&S TS-PFG connector X1

9.2 R&S TS-PDC

9.2.1 Connector X20

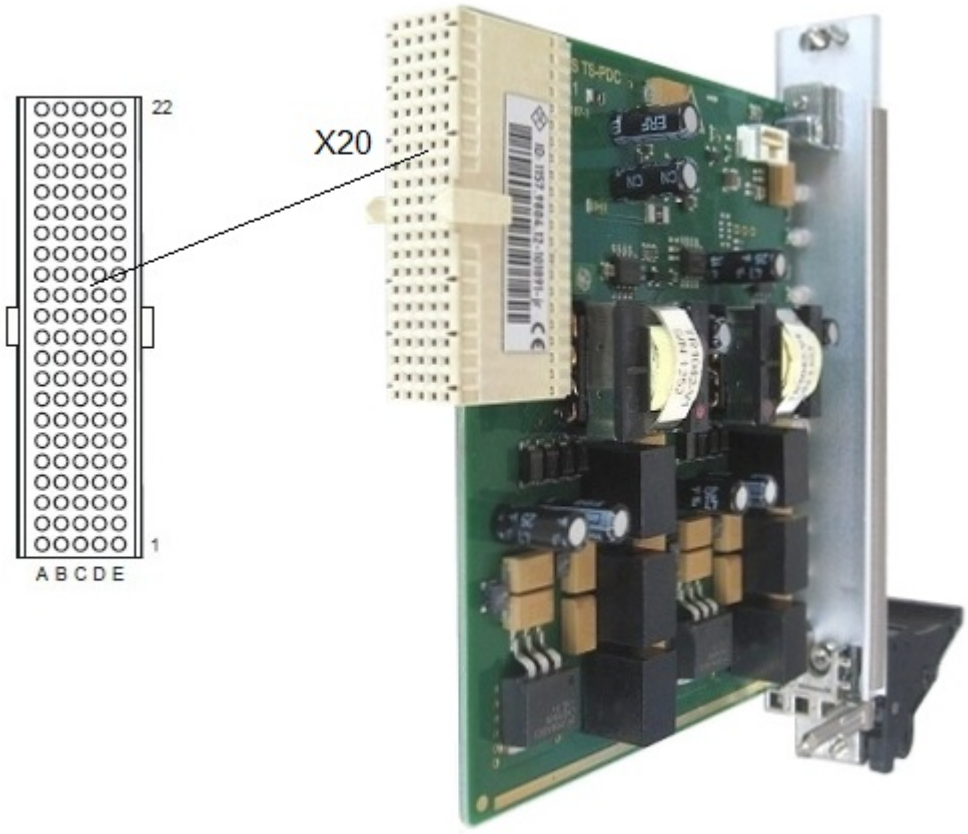

Figure 9-7: R&S TS-PDC connector X20 (viewed from mating side)

Pin	Z	A	B	C	D	E	
22	GND						
21	GND						
20	GND			+5V	GND	+5V	
19	GND		GND	+5V			
18	GND						
17	GND		GND	+5V	+5V		X20
16	GND			+5V	GND		
15	GND		GND	+5V	+5V		
14	NC						C
13	NC						O
12	NP	+15V_1	-15V_1	+5V_1	+3.3V_1	COM_1	N
11	NP						N
10	NC	+15V_2	-15V_2	+5V_2	+3.3V_2	COM_2	E
9	NC						C
8	NC	COM_1	COM_1	COM_1	COM_1	COM_1	T
7	NC						O
6	NC	COM_2	COM_2	COM_2	COM_2	COM_2	R
5	NC						
4	NC						
3	GND		GND		RRST#		
2	GND	RSCLK			RSDI		
1	GND	RCS#	GND			+5V	
Pin	Z	A	B	C	D	E	

Figure 9-8: R&S TS-PDC – assignment of connector X20

10 Specifications

The specifications for the R&S TS-PFG module are given in the corresponding data sheets.

If discrepancies exist between the data given in this manual and the values in the data sheet, the values in the data sheet take precedence.