

R&S® TS-PFG

Function Generator

User Manual



1152382012
Version 13

This manual describes the following R&S®TSVP module:

- R&S®TS-PFG (1157.9610.02)

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1152.3820.12 | Version 13 | R&S®TS-PFG

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

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1 Safety information (multilingual)

This option or accessory is designed for a specific Rohde & Schwarz product. Multilingual safety information is delivered with the product. Follow the provided installation instructions.

Esta opción o este accesorio están diseñados para un producto Rohde & Schwarz concreto. El producto va acompañado de información de seguridad en varios idiomas. Siga las instrucciones de instalación puestas a disposición.

Diese Option oder dieses Zubehör ist für ein bestimmtes Rohde & Schwarz Produkt vorgesehen. Mit dem Produkt werden mehrsprachige Sicherheitsinformationen geliefert. Befolgen Sie die mitgelieferten Installationsanweisungen.

Cette option ou cet accessoire est conçu pour un produit Rohde & Schwarz spécifique. Des informations de sécurité multilingues sont fournies avec le produit. Suivez les instructions d'installation fournies.

Questa funzione opzionale o accessoria è progettata per un prodotto Rohde & Schwarz specifico. Con il prodotto sono fornite informazioni sulla sicurezza in formato multilingue. Seguire le istruzioni di installazione allegate.

Esta(e) opção ou acessório foi concebida(o) para um produto específico da Rohde & Schwarz. Serão fornecidas informações de segurança multilingues com o produto. Siga as instruções de instalação fornecidas.

Αυτή η προαιρετική επιλογή ή εξάρτημα έχει σχεδιαστεί για συγκεκριμένο προϊόν Rohde & Schwarz. Μαζί με το προϊόν παρέχονται πληροφορίες ασφαλείας σε πολλές γλώσσες. Ακολουθήστε τις παρεχόμενες οδηγίες εγκατάστασης.

Din l-għażla jew aċċessorju huma mfassla għal prodott Rohde & Schwarz speċifiku. L-informazzjoni multilingwi dwar is-sikurezza hija pprovduta mal-prodott. Segwi l-istruzzjonijiet ipprovduti għall-installazzjoni.

Deze optie of dit accessoire is ontwikkeld voor een specifiek product van Rohde & Schwarz. Het product wordt geleverd met veiligheidsinformatie in meerdere talen. Volg de meegeleverde installatie-instructies.

Denne mulighed eller tilbehørsdel er designet til et specifikt Rohde & Schwarz produkt. En flersproget sikkerhedsanvisning leveres sammen med produktet. Følg de medfølgende installationsanvisninger.

Detta tillval eller tillbehör är avsett för en särskild produkt från Rohde & Schwarz. Säkerhetsinformation på flera språk medföljer produkten. Följ de medföljande installationsanvisningarna.

Tämä vaihtoehto tai lisävaruste on suunniteltu tietyille Rohde & Schwarz -yrietyksen tuotteelle. Tuotteen mukana on toimitettu monikieliset turvallisuusohjeet. Noudata annettuja asennusohjeita.

Dette alternativet eller ekstrautstyret er utformet for et spesifikt Rohde & Schwarz produkt. Flerspråklig sikkerhetsinformasjon leveres med produktet. Overhold installasjonsveiledningen som følger med.

See valik või lisaseade on mõeldud konkreetsele Rohde & Schwarz tootele. Tootege on kaasas mitmekeelne ohutusteave. Järgige kaasasolevaid paigaldusjuhiseid.

Ští opcija vai piederums ir izstrādāts īpaši Rohde & Schwarz produktam. Produktam pievienota drošības informācija vairākās valodās. Ievērojiet sniegtos uzstādīšanas norādījumus.

Ši parinktis ar priedas skirti konkrētam Rohde & Schwarz gaminiui. Su gaminiu pateikiama saugos informācijas keliomis kalbomis. Laikykitės pateikiamų montavimo nurodymų.

Þessi auka- eða fylgibúnaður er hannaður fyrir tiltekna Rohde & Schwarz vöru. Öryggisupplýsingar á mörgum tungumálum fylgja með vörunni. Fylgið meðfylgjandi uppsetningarleiðbeiningum.

Tá an rogha nó an oiriúint seo ceaptha le haghaidh táirge Rohde & Schwarz sonrach. Cuirtear eolas sábháilteachta ilteangach ar fáil leis an táirge. Lean na treoracha suiteála a thugtar.

Эта опция или принадлежность предназначена для конкретного продукта Rohde & Schwarz. В комплект поставки продукта входят инструкции по технике безопасности на нескольких языках. Соблюдайте прилагаемые инструкции по установке.

Ця опція або приладдя призначені для конкретного виробу Rohde & Schwarz. Інструкції з техніки безпеки кількома мовами постачаються разом із виробом. Дотримуйтеся наданих інструкцій зі встановлення.

Ta opcja lub akcesorium jest przeznaczona do określonego produktu Rohde & Schwarz. Dostarczany produkt zawiera informacje w wielu językach dotyczące bezpieczeństwa. Należy postępować zgodnie z dostarczonymi instrukcjami instalacji.

Tato varianta nebo příslušenství je určeno pro konkrétní produkt Rohde & Schwarz. S produktem jsou dodávány vícejazyčné bezpečnostní informace. Řiďte se příloženými pokyny k instalaci.

Táto verzia alebo príslušenstvo je navrhnutá pre špecifický výrobok Rohde & Schwarz. S výrobkom sa dodávajú viacjazyčné bezpečnostné pokyny. Riadte sa dodanými pokynmi na inštaláciu.

Ta možnost ali dodatek je zasnovan za določen izdelek podjetja Rohde & Schwarz. Izdelku so priložena varnostna navodila v več jezikih. Upoštevajte priložena navodila za namestitev.

Ezt a beállítást vagy tartozékot egy adott Rohde & Schwarz termékhez tervezték. A termékhez többnyelvű biztonsági információt mellékelünk. Kövesse a mellékelt szerelési utasításokat.

Тази опция или аксесоар са проектирани за специфичен продукт на Rohde & Schwarz. Многоезикова информация за безопасност се доставя с продукта. Следвайте предоставените инструкции за монтаж.

Ova opcija ili oprema namijenjena je za određeni proizvod tvrtke Rohde & Schwarz. Uz proizvod su dostavljene sigurnosne napomene na više jezika. Pratite isporučene upute za ugradnju.

Ova opcija ili pribor je dizajniran za određeni Rohde & Schwarz proizvod. Proizvodu su priložene sigurnosne informacije na više jezika. Slijedite priložena uputstva za instalaciju.

Ova opcija ili dodatni pribor je projektovan za određeni Rohde & Schwarz proizvod. Bezbednosne informacije na više jezika se isporučuju uz proizvod. Sledite dostavljena uputstva za instalaciju.

Această opțiune sau acest accesoriu a fost conceput pentru un produs specific Rohde & Schwarz. Informațiile multilingve privind siguranța sunt livrate împreună cu produsul. Urmați instrucțiunile de instalare furnizate.

Ky opsion ose aksesori është krijuar për një produkt specifik Rohde & Schwarz. Bashkë me produktin jepen edhe informacionet e sigurisë në shumë gjuhë. Ndiqni udhëzimet e dhëna të instalimit.

Оваа опција или додаток се наменети за одреден производ на Rohde & Schwarz. Со производот се испорачани повеќејазични безбедносни упатства. Следете ги дадените упатства за инсталација.

Bu opsiyon veya aksesuar, belirli bir Rohde & Schwarz ürünü için tasarlanmıştır. Çok dilli güvenlik uyarıları ürünle birlikte teslim edilir. Size sağlanan kurulum talimatlarına uyun.

אפשרות זו או האביזר מיועדים למוצר ספציפי של Rohde & Schwarz. מידע רב-לשוני בנושא בטיחות מצורף למוצר. יש לפעול בהתאם להנחיות ההתקנה המצורפות.

تم تصميم هذا الخيار أو الملحق لمنتج معين من منتجات Rohde & Schwarz. يتم تزويد معلومات السلامة متعددة اللغات مع المنتج. اتبع تعليمات التركيب الموضحة.

این قابلیت یا وسیله جانبی منحصرأ برای محصول به خصوص Rohde & Schwarz طراحی شده است. اطلاعات ایمنی چندزبانه همراه این دستگاه ارائه شده است. دستورالعمل‌های نصب ارائه شده را دنبال کنید.

اسن اختیار یا حصے کو مخصوص Rohde & Schwarz پروڈکٹ کے لئے تیار کیا گیا ہے۔ پروڈکٹ کے ساتھ کثیر السانی زبانوں میں تحفظ کی معلومات فراہم کی جاتی ہیں۔ فراہم کردہ تنصیب کی ہدایات پر عمل کریں۔

Šu opsiya ýa-da esbap Rohde & Schwarz anyk önüm üçin niýetlenilen. Dürli dildäki howpsuzlyk barada maglumat önüm bilen bile üpjün edilýär. Üpjün edilen gurnama ugrukdymalaryny ýerine ýetiriň.

इस विकल्प या एक्सेसरी को एक विशेष Rohde & Schwarz उत्पाद के लिए डिज़ाइन किया गया है. उत्पाद के साथ बहुभाषी सुरक्षा जानकारी दी जाती है. प्रदान किए गए इंस्टालेशन अनुदेशों का पालन करें.

本选项或附件专门设计用于特定的 Rohde & Schwarz 产品。产品随附多种语言版本的安全资讯。谨遵文件中的安装说明。

本オプションアクセサリは、特定の Rohde & Schwarz 製品向けに設計されています。多言語で記載された安全情報が製品に付属します。付属のインストール手順に従ってください。

이 옵션 또는 액세서리는 특정 Rohde & Schwarz 제품용으로 설계되었습니다. 제품과 함께 다국어로 작성된 안전 정보가 제공됩니다. 함께 제공된 설치 지침을 따르십시오.

本選配或配件專門設計用於特定的 Rohde & Schwarz 產品。產品隨附多種語言版本的安全資訊。遵守文件中的安裝說明。

Tùy chọn hoặc phụ kiện này dành riêng cho một sản phẩm Rohde & Schwarz cụ thể. Thông tin an toàn đa ngôn ngữ được cung cấp kèm theo sản phẩm. Thực hiện theo hướng dẫn lắp đặt kèm theo.

ตัวเลือกหรืออุปกรณ์เสริมนี้ออกแบบมาสำหรับผลิตภัณฑ์ Rohde & Schwarz โดยเฉพาะ โดยจะมีการจัดส่งข้อมูลด้านความปลอดภัยหลายภาษามาให้พร้อมกับผลิตภัณฑ์ ปฏิบัติตามคำแนะนำในการติดตั้งที่ให้ไว้

Pilihan atau aksesoris ini direka bentuk untuk produk Rohde & Schwarz yang tertentu. Maklumat keselamatan berbilang bahasa disertakan bersama produk. Ikut arahan pemasangan yang diberikan.

Opsi atau aksesoris ini dirancang untuk produk Rohde & Schwarz tertentu. Informasi keamanan dalam beberapa bahasa juga disertakan bersama produk. Ikuti petunjuk pemasangan yang disediakan.

Esta opción o este accesorio están diseñados para un producto Rohde & Schwarz en concreto. El producto va acompañado de información de seguridad en varios idiomas. Siga las instrucciones de instalación proporcionadas con el producto.

Esta opção ou acessório foi desenvolvido para um produto Rohde & Schwarz específico. Informações de segurança em vários idiomas acompanham o produto. Siga as instruções de instalação disponibilizadas.

2 Documentation overview

This section provides an overview of the R&S TSVP (test system versatile platform) user documentation.

All documents are delivered with the Generic Test Software Library ("R&S GTSL") installation package. After installing the software, you can open all the documentation from the Windows "Start" menu. Additionally, you can find detailed information about the software interfaces in the "R&S GTSL Help" folder in the Windows "Start" menu.

The user documentation and "R&S GTSL" installation package are also available for download in GLORIS at:

<https://gloris.rohde-schwarz.com/>

For details, see the R&S TSVP Getting Started manual.

2.1 Getting started manual

Introduces the R&S TSVP (test system versatile platform) and describes how to set up and start working with the product. It includes safety information.

A printed version is delivered with the instrument.

2.2 User manuals

Separate manuals are provided for the base units, the individual plug-in module types, as well as for the control software and the calibration tool:

- Base unit manual
The base unit user manuals introduce the base units and describes how to set up and operate the product. It includes safety information and information on maintenance and instrument interfaces. It includes the contents of the getting started manual.
- Plug-in module manuals
Contain the description of the specific modules. Basic information on setting up the R&S TSVP (test system versatile platform) is not included.
- In-System calibration user manuals
Provide all the information required for installation and operation of the in-system calibration R&S TS-ISC solution.
- Control software
 - R&S GTSL
Generic Test Software Library
 - R&S EGTSL
Enhanced Generic Test Software Library
 - R&S IC-Check

Generic Test Software Library

2.3 System manual

Describes the complete R&S TSVP (test system versatile platform) as a whole, including the combined use of R&S CompactTSVP and R&S PowerTSVP, plug-in modules and generic test software. It also includes typical use cases.

Additionally, it describes known installation problems (hardware and software) along with possible solutions.

2.4 Service manual

Describes the self-test to check correct operation, troubleshooting and fault elimination, and contains mechanical drawings and spare part lists.

2.5 Printed safety instructions

Provides safety information in many languages. The printed document is delivered with the product.

2.6 Brochures and specifications

Separate brochures are provided for the base unit, the individual plug-in module types, as well as for the control software. The brochures provide an overview of the base units and each additional module, and also contain the technical specifications. They also list the hardware options and their order numbers, and optional accessories.

2.7 Release notes and open source acknowledgment

The release notes list new features, improvements and known issues of the current software version. In addition, the available firmware versions and the firmware update procedure for plug-in modules are described.

The open-source acknowledgment document provides verbatim license texts of the used open source software.

3 Welcome to the R&S TS-PFG

This manual describes the function and operation of the function generator module R&S TS-PFG for use in PXI based R&S TSVP base units. The hardware is implemented as a PXI board that occupies only one slot on the front side of the R&S 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 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. 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 base unit. The front connector is flush with the front panel of the base unit chassis and is used for connecting DUTs or measurement sensors. As an alternative to the front connector, analog measurement signals can be tapped at the analog measurement bus of the base unit.

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

- 2-channel arbitrary function generator (both channels can be operated as independent generators)
- Floating signal generation (max. 120 V working voltage)
- Resolution (16 bit)
- Sample rate up to 25 Msample/s per channel
- Output voltage up to 40 V_{pp} 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

Features of the R&S TS-PDC module

The Rear I/O Module R&S TS-PDC is used as a floating DC voltage source for the Analyzer Module R&S TS-PFG . It contains two identical DC/DC converters. The following floating voltages are obtained from an input voltage of 5 VDC:

- +15 VDC $\pm 5\%$, 0,5 A (2x)
- -15 VDC $\pm 5\%$, 0,5 A (2x)
- +5 VDC $\pm 5\%$, 0,5 A (2x)
- +3,3 VDC $\pm 5\%$, 0,25 A (2x)

4 Module tour

4.1 R&S TS-PFG

The R&S TS-PFG module is designed as a long plug-in module for mounting in the front of PXI based base units.

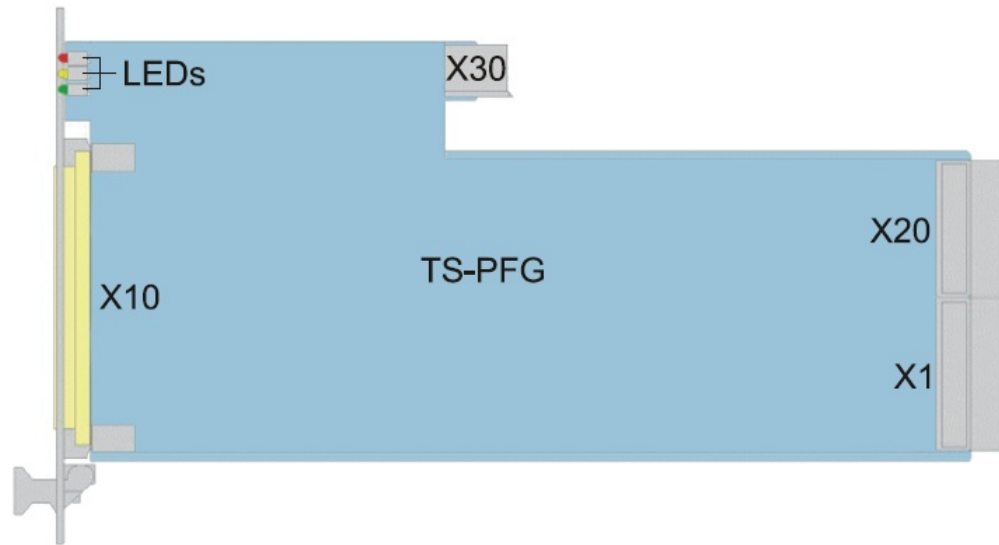


Figure 4-1: Overview of interfaces on R&S TS-PFG module

LEDs = [Chapter 4.1.1, "Status LEDs"](#), on page 13

X1 = [Chapter 4.1.2, "Connectors X1 and X20"](#), on page 13

X10 = [Chapter 4.1.3, "Connector X10"](#), on page 14

X20 = [Chapter 4.1.2, "Connectors X1 and X20"](#), on page 13

X30 = [Chapter 4.1.4, "Connector X30"](#), on page 14

4.1.1 Status LEDs

The LEDs on the front indicate the current status of the module.

- "PWR" (green LED)
Indicates that all necessary supply voltages are present.
- "COM" (yellow LED)
Indicates data exchange via the interface.
- "ERR" (red LED)
Indicates an error condition if illuminated.

4.1.2 Connectors X1 and X20

Type: PXI bus

Interface to connect the module to the backplane of PXI based base units.

See [Chapter C.1.4, "Connector X1"](#), on page 57 and [Chapter C.1.2, "Connector X20"](#), on page 55 for a detailed description of the connectors.

4.1.3 Connector X10

Interface to connect test objects and UUTs to the module.

See [Chapter C.1.1, "Connector X10"](#), on page 53 for a detailed description of the connector.

4.1.4 Connector X30

Type: Analog bus

Interface to connect the module to the analog bus backplane of the base unit.

See [Chapter C.1.3, "Connector X30"](#), on page 56 for a detailed description of the connector.

4.2 R&S TS-PDC

The R&S TS-PDC is a rear panel I/O module that you must connect with the R&S TS-PFG in a PXI based base unit.



The module R&S TS-PDC exists in 3 different models:

- Grouted in a black housing - version up to 1.8 (1157.9804.02 obsolete)
- Encapsulated in metal housing with cooling fins - version 1.9 (1157.9804.02 obsolete)
- Without case - version from 2.0 (1157.9804.12 current version)

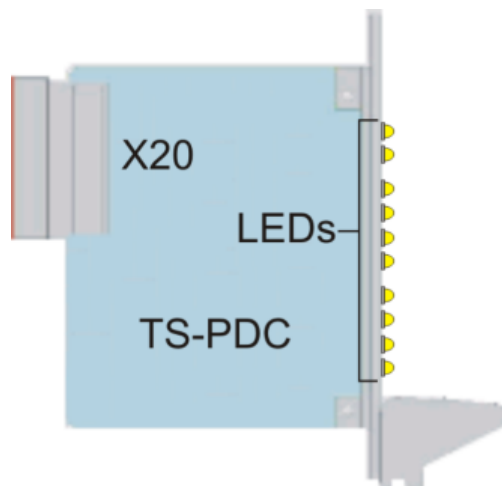


Figure 4-2: Overview of the connector and LEDs on the R&S TS-PDC module

LEDs = [Chapter 4.2.1, "Status LEDs"](#), on page 15

X20 = [Chapter 4.2.2, "Connector X20"](#), on page 16

4.2.1 Status LEDs

The meaning of the status LEDs depend on the module version.

Module version < 2.0 (1157.9804.02)

Eight green LEDs indicate the status of the module. Each LED indicates the presence of an output voltage.

In fault free operation all 8 LEDs must light up simultaneously.

Module version \geq 2.0 (1157.9804.12)

Ten LEDs indicate the status of the module. The LEDs have the following meaning.

- "PWR" (green color)
Indicates that the module is on and running.
- "ERR" (orange color)
Indicates that the module has shut down because of an overload or a temperature that is too high.
- "<xx> V" (eight LEDs in green color)
Indicate the presence of an output voltage.
In fault free operation all 8 voltage LEDs must light up simultaneously.

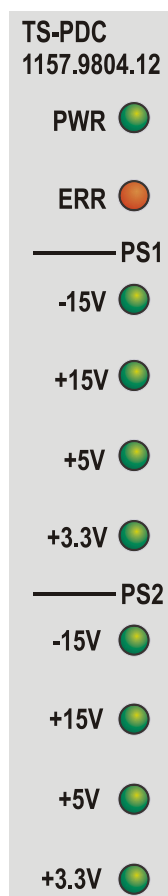


Figure 4-3: LEDs on the R&S TS-PDC module from Version 2.0

4.2.2 Connector X20

Interface to connect the R&S TS-PDC to the backplane in the PXI based base unit.

See [Chapter C.2, "R&S TS-PDC"](#), on page 58 for a detailed description of the connector.

5 Installing the module

The R&S TS-PFG is a module installed on the front panel of PXI based base units. It requires a TS-PDC rear I/O supply module.

1. Install the R&S TS-PFG front module as described in the user manuals for the base units.
2. Install the R&S TS-PDC supply module in the matching rear I/O slot as described in the user manuals for the base unit.
3. **WARNING!** Risk of electric shock. The test environment, e.g the UUT or additional power supplies, can supply high voltages to the instruments. In this case, the voltage can also apply to the signal output connectors of the R&S TSVP, in particular the analog bus connector X2.

Therefore, do not connect or disconnect devices from the X2 connectors while connected to an external power supply or UUT.

Always connect both ends of the cable connecting the R&S CompactTSVP and R&S PowerTSVP. Thus, you avoid the risk of touching the X2 connector with a possibly hazardous voltage applied.

Take the system into operation as described in the user manuals for the base unit.

6 Typical 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.

7 Functions

7.1 R&S TS-PFG

7.1.1 Overview

7.1.1.1 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.

7.1.1.2 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.

7.1.1.3 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.

7.1.2 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). The local analog bus lines are available at the front connector X10.

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

Both generator channels can be connected to ground.

Figure 7-1 shows a number of typical permissible voltage configurations between the analog buses and ground.

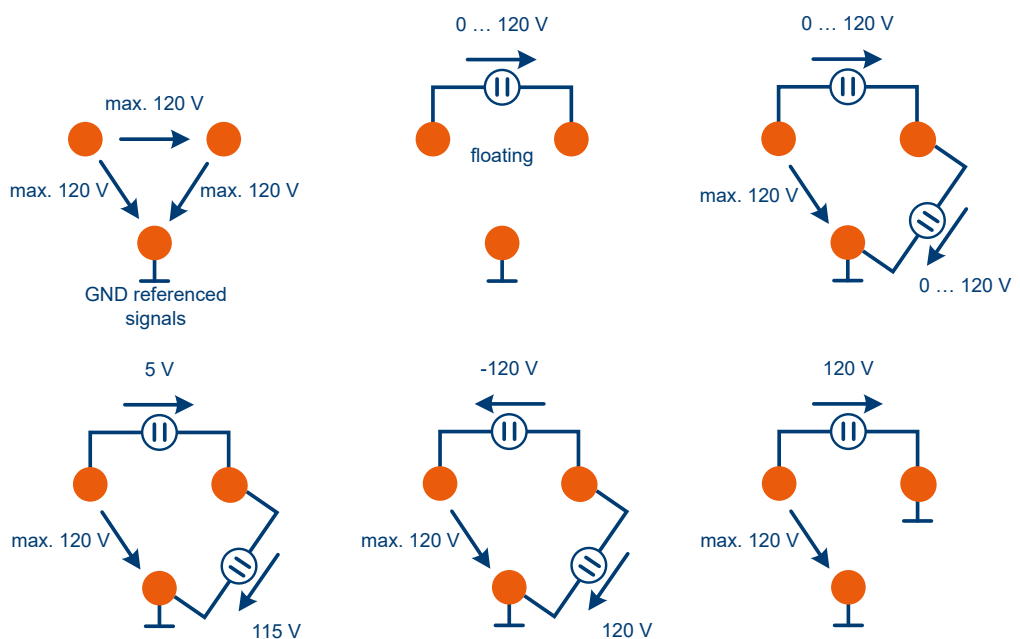


Figure 7-1: Permissible voltages on analog bus lines

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

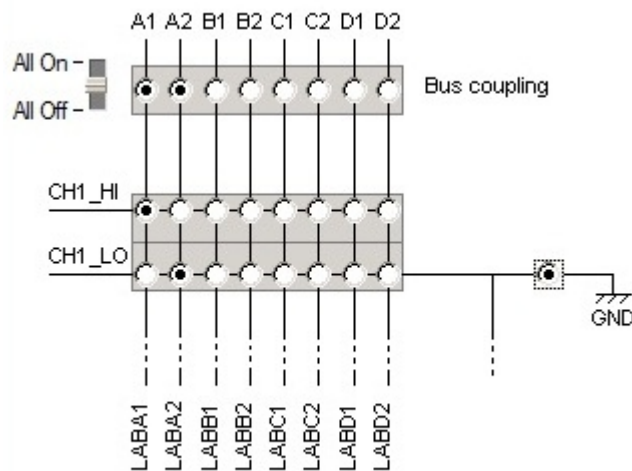


Figure 7-2: Example showing relay connection on R&S TS-PFG channel 1

7.1.3 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");.
```

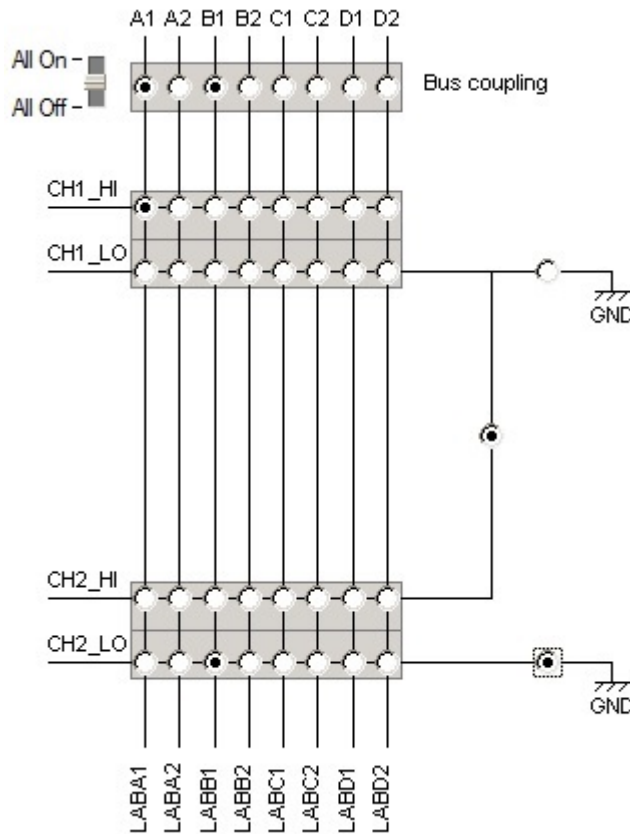


Figure 7-3: Example showing cascading of both R&S TS-PFG channels

7.1.4 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 7.1.8, "Operating mode"](#), on page 29.

7.1.4.1 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.

7.1.4.2 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.

7.1.5 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 7.1.8, "Operating mode"](#), on page 29.

7.1.5.1 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. $+1.0$.

7.1.5.2 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 $n = 0, 1, 2, 3, \dots$

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.

7.1.5.3 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`.

7.1.5.4 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

7.1.5.5 Download optimization

The SSRAM of the TS-PFG includes an optimization for the handling of the waveforms from driver version 01.59 (GTSL 3.40). For compatibility reasons it is partly deactivated by default. To benefit from the full optimization the attribute "RSPFG_ATTR_WFM_TRANSFER_OPTIMIZED" must be set. The transferred waveforms will then be saved in the SSRAM memory, until explicitly deleted by the user (`rspfg_ClearArbWaveform`). A full memory error might occur. This error does not occur when the optimization is switched off, because the waveforms are constantly being transmitted to the starting address of the memory. The function `rspfg_reset` does not reset the attribute "RSPFG_ATTR_WFM_TRANSFER_OPTIMIZED". It is sufficient to set the condition during the initialization.

For the optimization to work flawlessly, firmware version 03.04 must be installed on the TS-PFG. This version is part of GTSL 3.41 and is available as a subsequent firmware update from this version.

7.1.6 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.

7.1.6.1 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.

7.1.6.2 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 $n = 0, 1, 2, 3, \dots$

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.

7.1.6.3 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 7.1.5.3, "Addition of markers"](#), on page 25.

7.1.6.4 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

7.1.6.5 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.

An additional improvement in performance can be obtained by optimizing the download process (see [Chapter 7.1.5.5, "Download optimization"](#), on page 25).

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.

7.1.7 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 XT11 and XT12.

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.

7.1.8 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.

7.1.8.1 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.

7.1.8.2 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.

7.1.9 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 ($11 \text{ V} / 20 \text{ V} * 10 \text{ V}$).
- 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 than 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. $\pm 250 \mu\text{V}$ 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. $\pm 5 \text{ mV}$.

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`.

7.1.10 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:

<code>rspfg_AbortGeneration</code>	R&S TS-PFG outputs 0.0 V constantly
<code>rspfg_ConfigureStandardWaveform</code>	E.g. 10.0 Vpp are configured, R&S TS-PFG continues to output 0.0 V
<code>rspfg_ConfigureDynamicACAmplitude</code>	E.g. 2.0 Vpp are configured, R&S TS-PFG continues to output 0.0 V
<code>rspfg_InitiateGeneration</code>	R&S TS-PFG starts output of a standard waveform with ampl. 2.0 Vpp
<code>rspfg_ConfigureDynamicACAmplitude</code>	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.

7.2 R&S TS-PDC

The Rear I/O Module R&S TS-PDC is configured as a primary switched DC/DC converter. The input voltage (5 VDC) is transferred to two secondary potentials and rectified to the nominal voltage by line controllers. The status of the output voltage is displayed in each case by an LED.

The following DC voltages are generated:

- +15 VDC, 0,5 A (2x)
- -15 VDC, 0,5 A (2x)
- +5 VDC, 0,5 A (2x)
- +3,3 VDC, 0,25 A (2x)

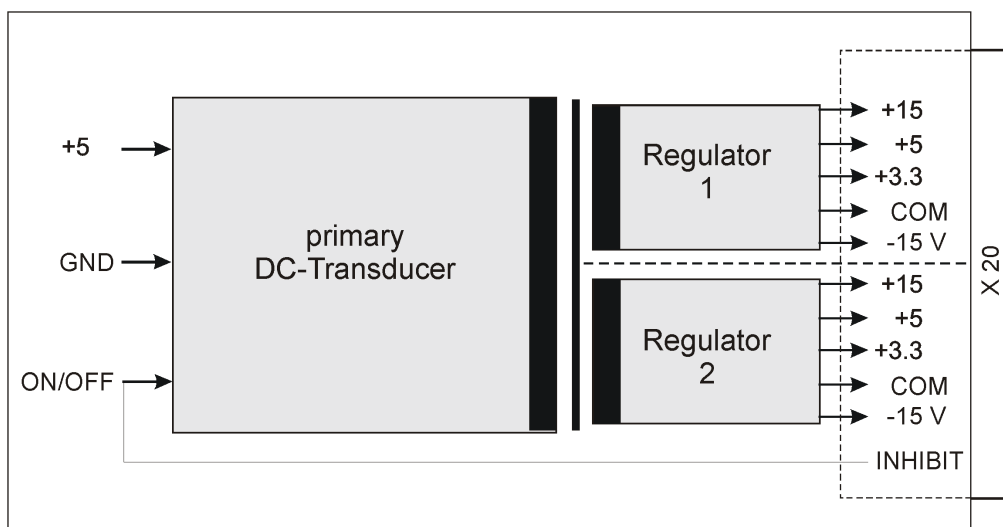


Figure 7-4: Block schematic diagram of Rear I/O Module R&S TS-PDC

8 Software

8.1 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 8-1: Driver installation – R&S TS-PFG

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



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

8.2 Soft panel

The software package of the R&S TS-PFG module includes a soft panel (see [Figure 8-1](#)). The soft panel is based on the IVI driver and enables interactive operation of the module on the screen using the mouse.

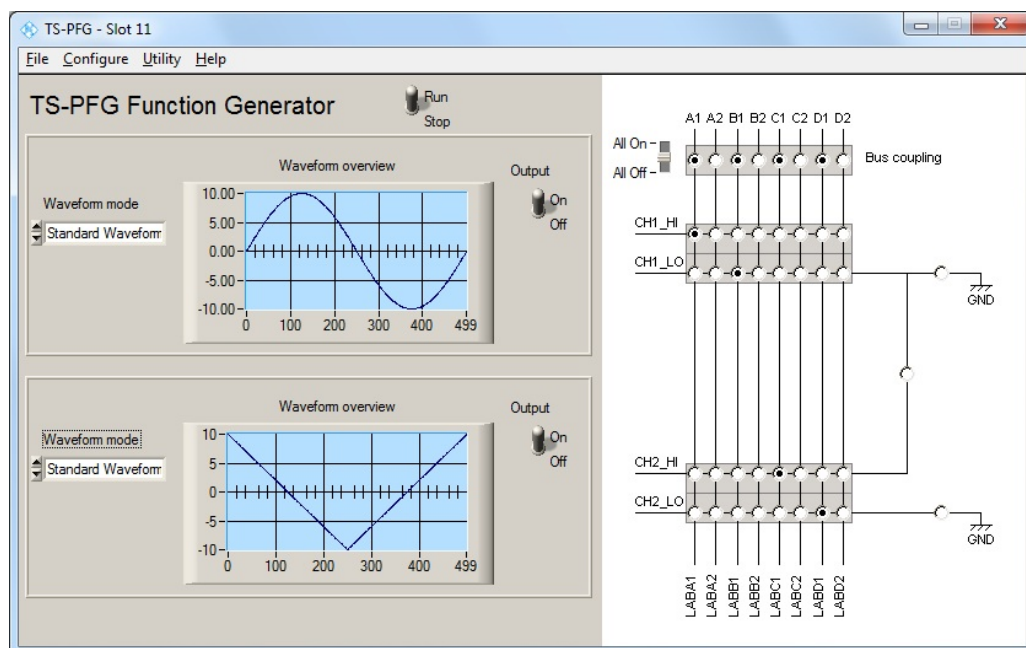


Figure 8-1: Soft panel of R&S TS-PFG



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.

8.3 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);
```

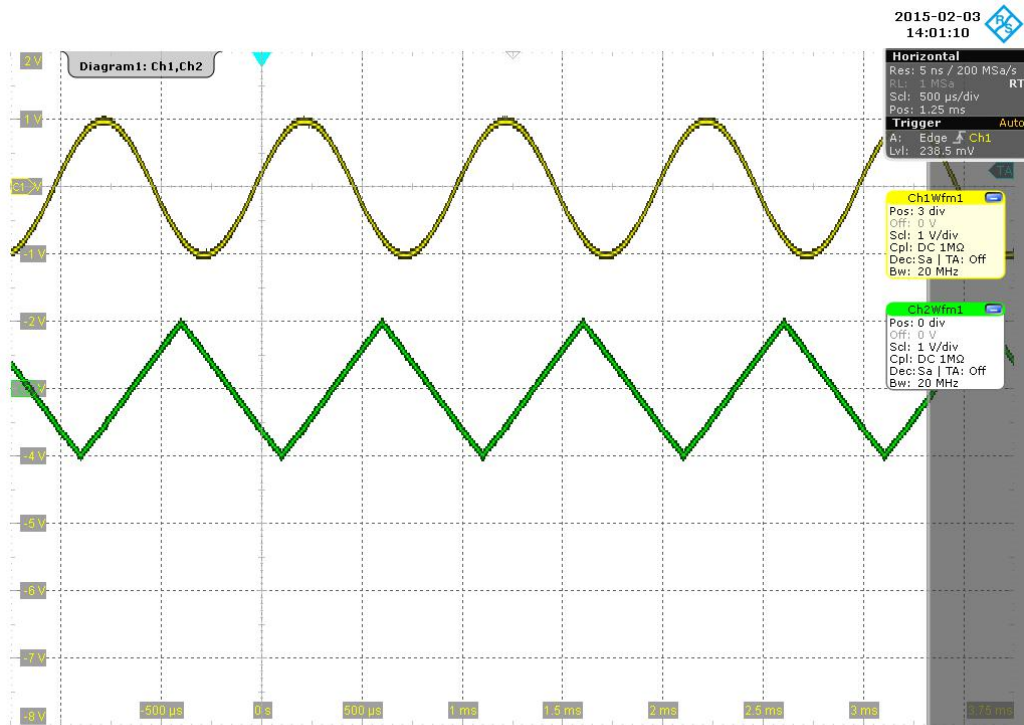


Figure 8-2: Oscilloscope: Standard signals on both channels, not synchronous

```

*/
/*
Note that both channels haven't been started 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);

/*

```

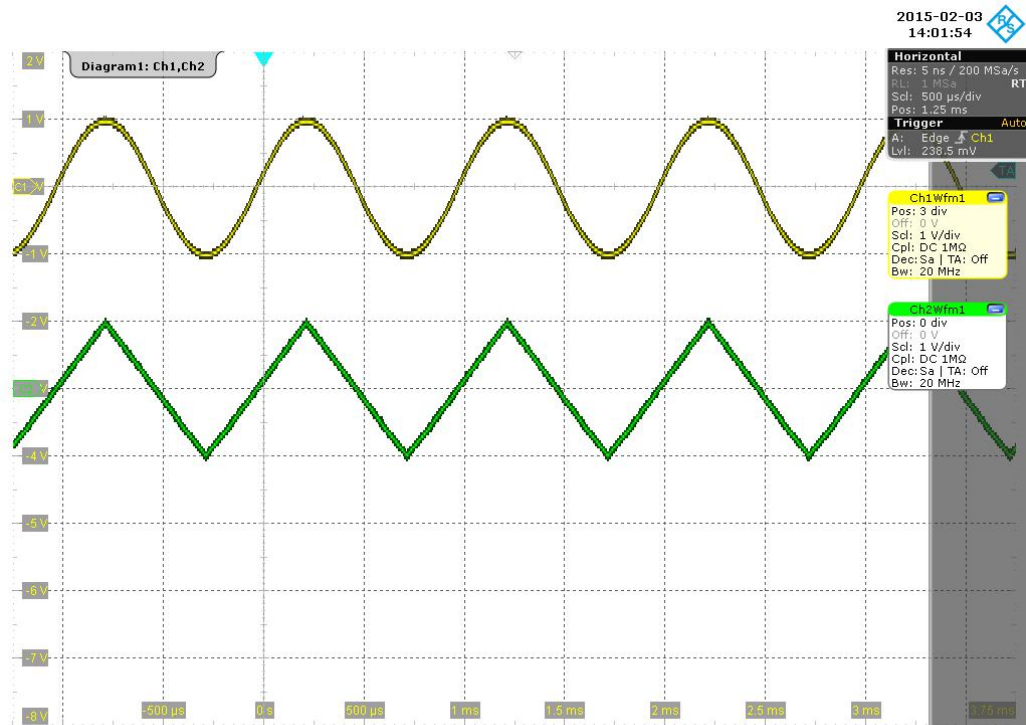


Figure 8-3: Oscilloscope: Standard signals on both channels, synchronous

```

*/

/*
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);

/*

```

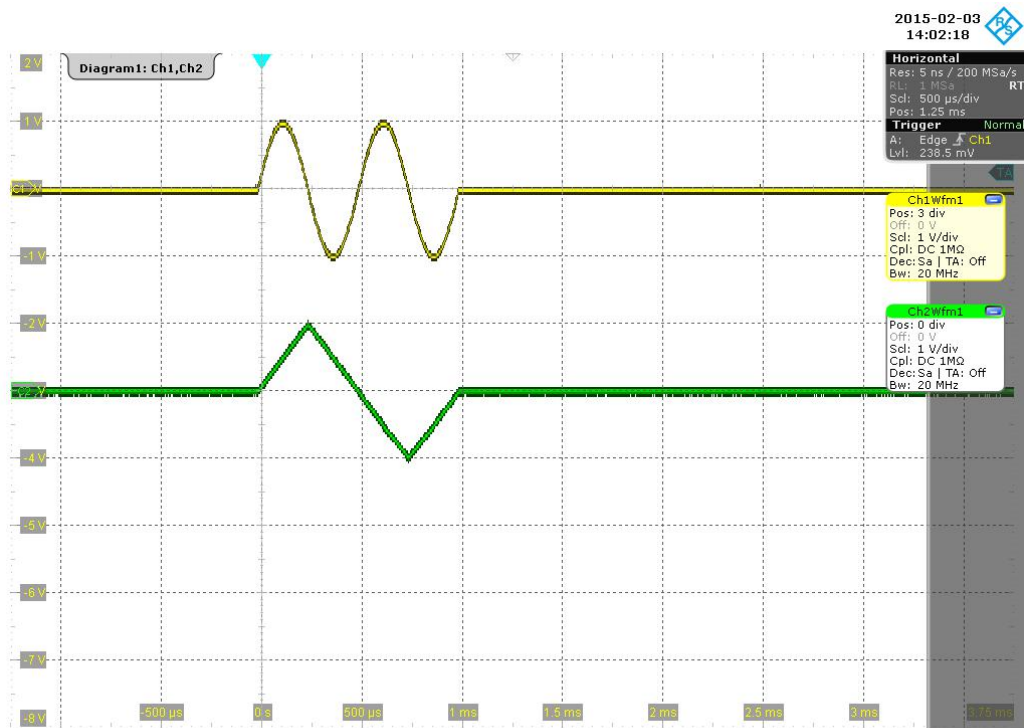


Figure 8-4: Oscilloscope: Bursts consisting of standard signals on both channels

```

*/

/*
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);

/*
```

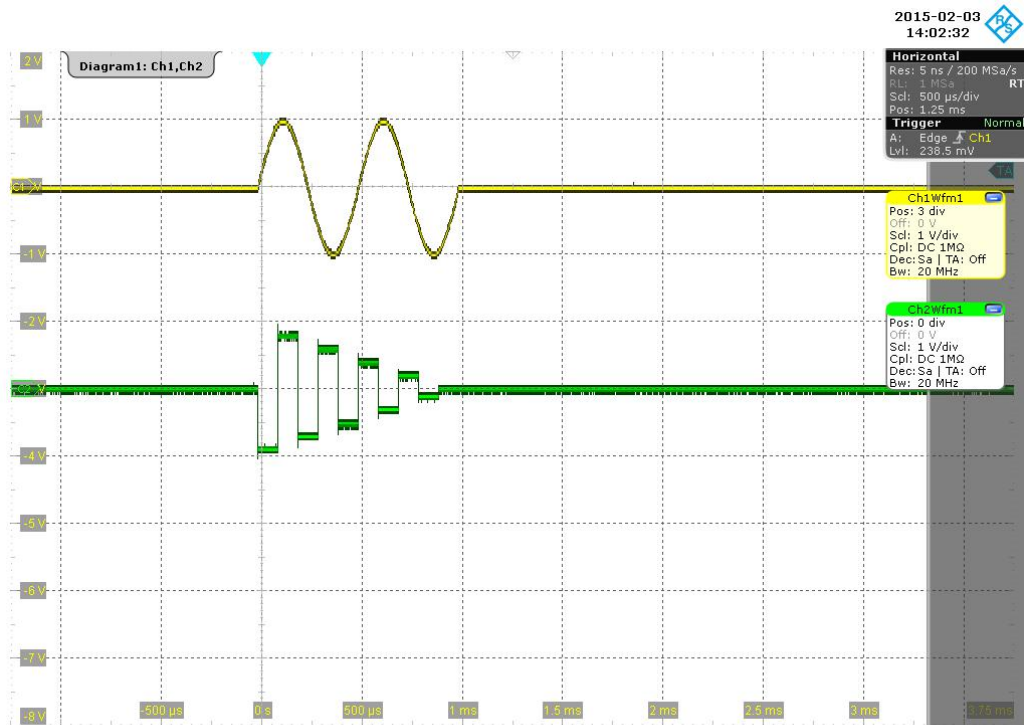


Figure 8-5: Oscilloscope: Burst of an arbitrary signal on channel 2 (green)

```

*/
/*
Switch channel 2 to continuous output of the arbitrary waveform.
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");

/*

```

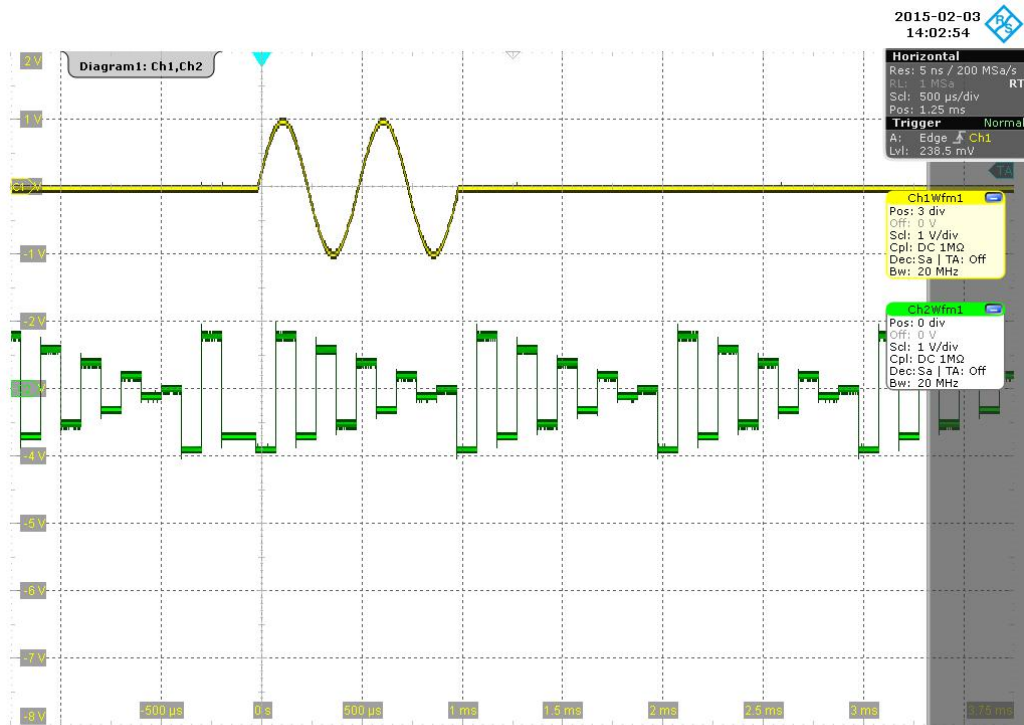


Figure 8-6: Oscilloscope: Continuous arbitrary signal on channel 2 (green)

```

*/
/*
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");

/*

```

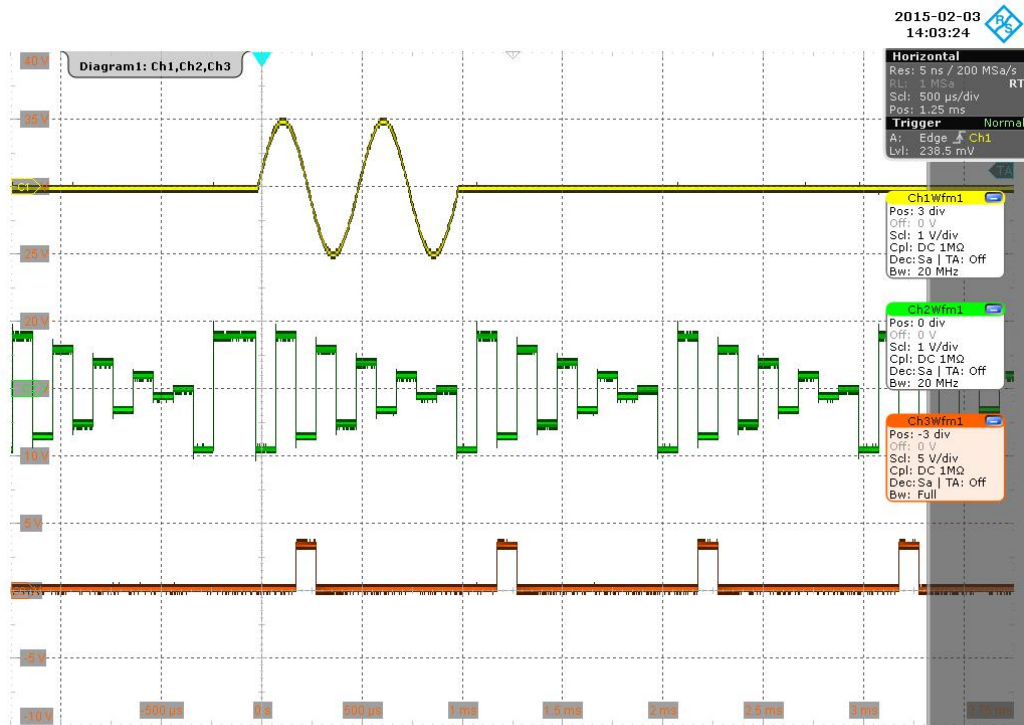


Figure 8-7: Oscilloscope: Marker signal (brown) of arbitrary signal on channel 2 (green)

*/

/*

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 outputs the arbitrary
  signal continuously.
*/
s_Status = rspfg_InitiateGeneration ( s_VI );

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

/*

```

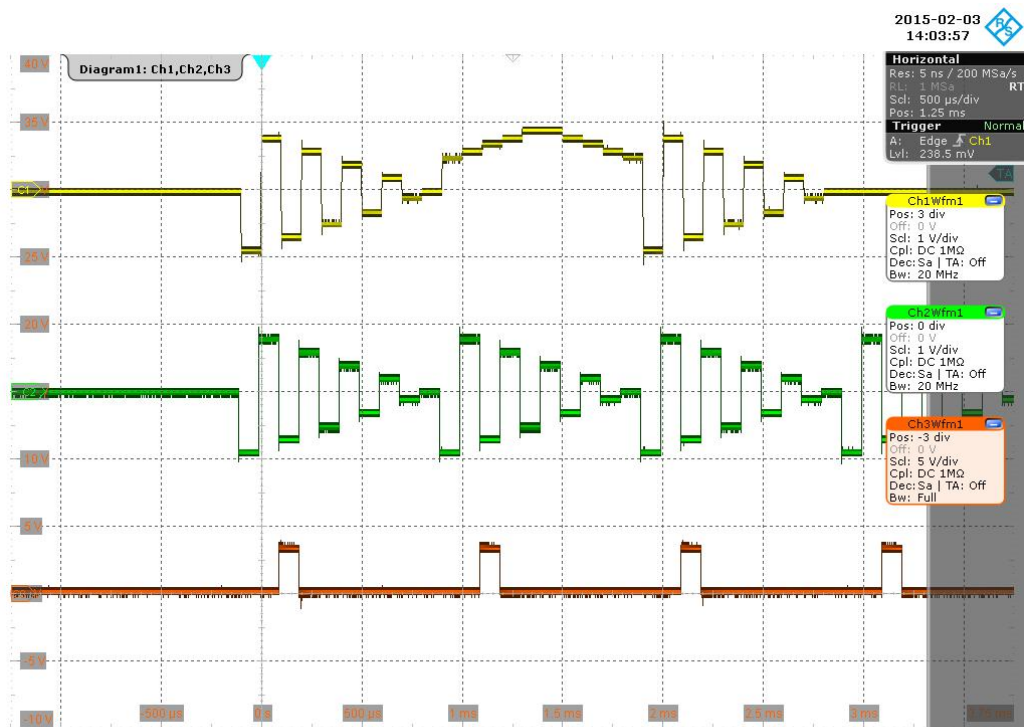


Figure 8-8: Oscilloscope: Arbitrary sequence on channel 1 (yellow)

```

*/

```

```

/*

```

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);

/*

```

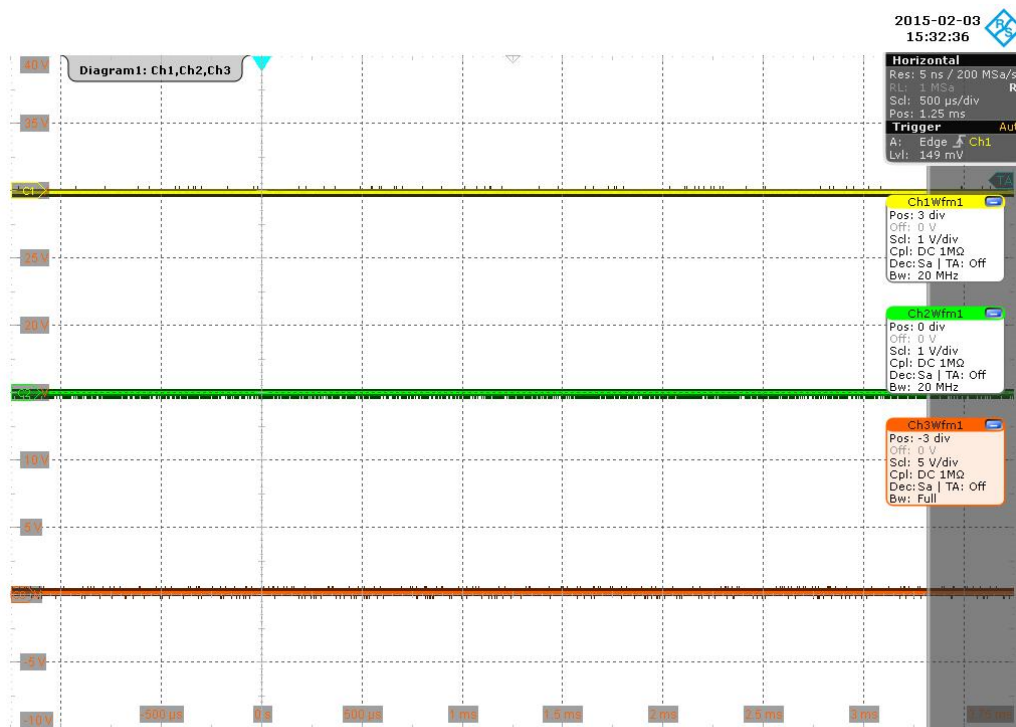


Figure 8-9: Oscilloscope: All variable signals have been switched off

```

*/

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

```

9 Troubleshooting

If the system is not running properly, try to find the problem with the following tests. If the tests do not help to locate the problem, contact your Rohde & Schwarz service representative.

- [LED test](#)..... 47
- [Power-on test](#).....47
- [R&S TSVP self-test](#).....48
- [Contacting customer support](#)..... 48

9.1 LED test

The module has three LEDs on its front panel that indicate its status.

After turning on the system, all LEDs light up for a short time to indicate that the power supply is present and that all LEDs are working.

- A single LED does not light up in that time frame:
Indicates a faulty LED or faulty LED control.
- All LEDs do not light up during that time frame:
Indicates that the power supply for the module is faulty.
Check the status LEDs of the main power supply module in slot A3 and A4.

For rear modules, you have to check the LEDs separately, see "[Power-on test for modules with a rear I/O supply module](#)" on page 48.

9.2 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.

- "PWR LED" (green LED) = on
Indicates that all power supply voltages are present.
- "PWR LED" (green LED) = off
Indicates that at least one power supply voltage is missing.
- "ERR LED" (red LED) = off
If the green LED is illuminated at the same time, indicates that the system is working without any errors.
- "ERR LED" (red LED) = on (or blinking)
Indicates a hardware problem.

Power-on test for modules with a rear I/O supply module

If the green LED indicates a problem with the supply voltage, check the LEDs of the corresponding rear I/O supply module separately. If the LEDs on the rear I/O module also indicate a supply voltage failure, replace the rear I/O module.

9.3 R&S TSVP self-test

The R&S TSVP self-test is an extensive test procedure for the whole system or individual components. After the test is done, you receive a test report for all components that have been tested.

The self-test uses the R&S TS-PSAM module as a measurement unit. The functionality of the modules in the system is ensured by measurements via the analog measurement bus.

For more information about running the system self-test and the test procedures, refer to the R&S TSVP service manual.

9.4 Contacting customer support

Technical support – where and when you need it

For quick, expert help with any Rohde & Schwarz product, contact our customer support center. A team of highly qualified engineers provides support and works with you to find a solution to your query on any aspect of the operation, programming or applications of Rohde & Schwarz products.

Contact information

Contact our customer support center at www.rohde-schwarz.com/support, or follow this QR code:



Figure 9-1: QR code to the Rohde & Schwarz support page

Annex

A Specifications

For an overview of technical specifications of the R&S TS-PFG module, refer to the corresponding product brochure / data sheet.

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

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

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

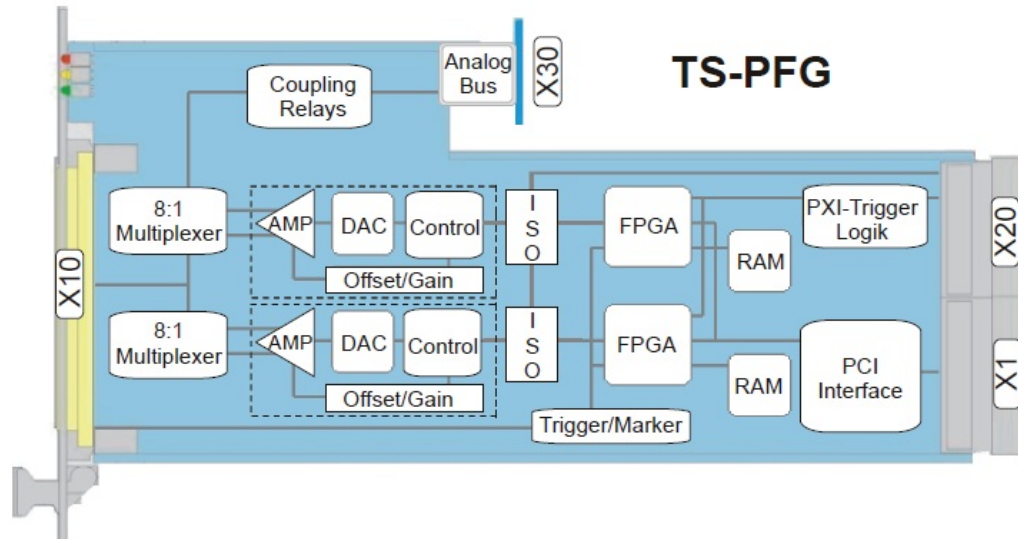


Figure B-1: Functional block diagram of R&S TS-PFG module

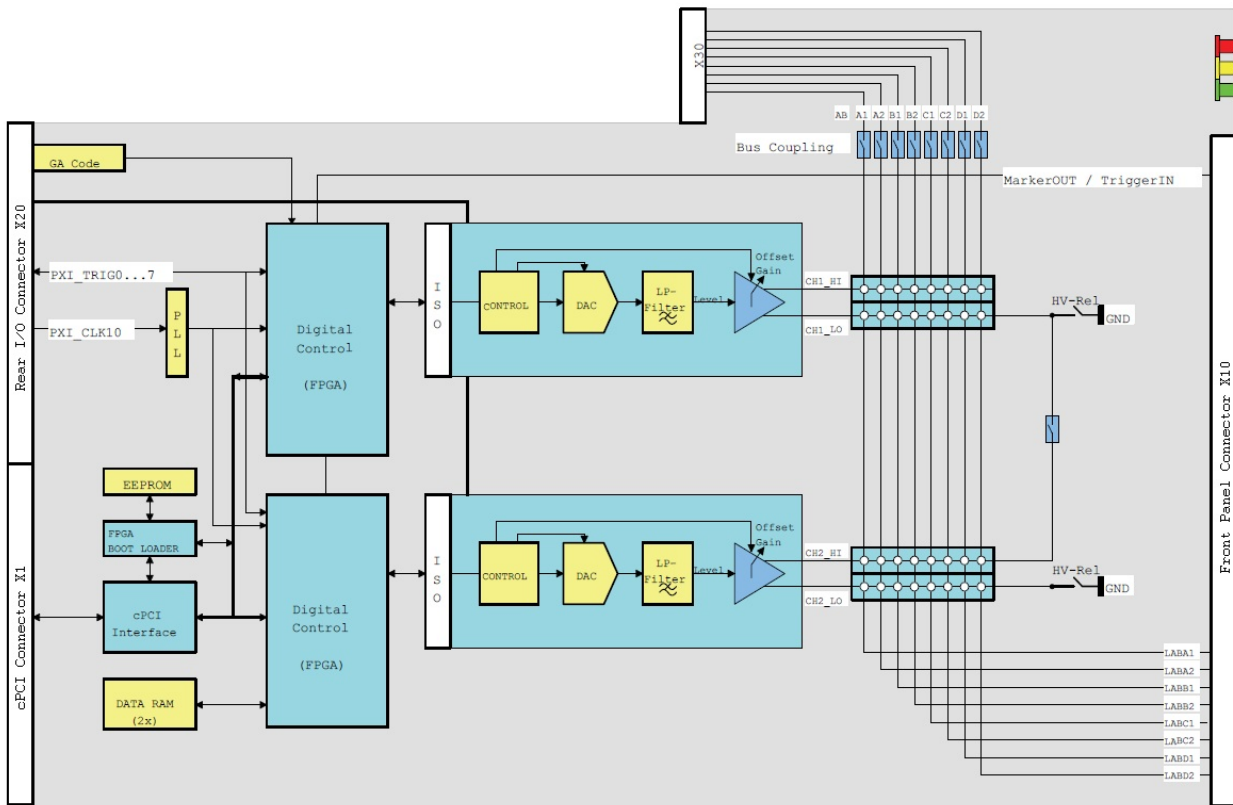


Figure B-2: Detailed block diagram of R&S TS-PFG module

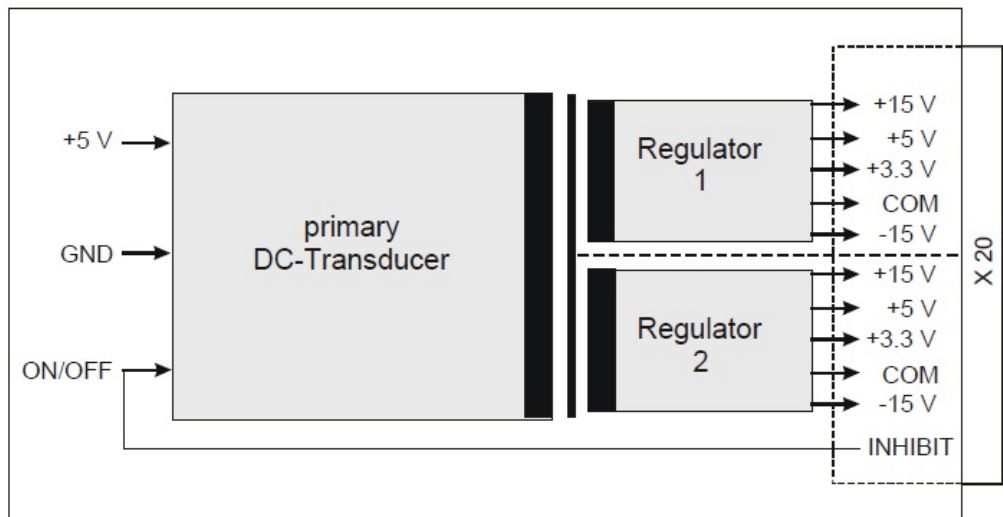


Figure B-3: Block diagram of R&S TS-PDC rear I/O module

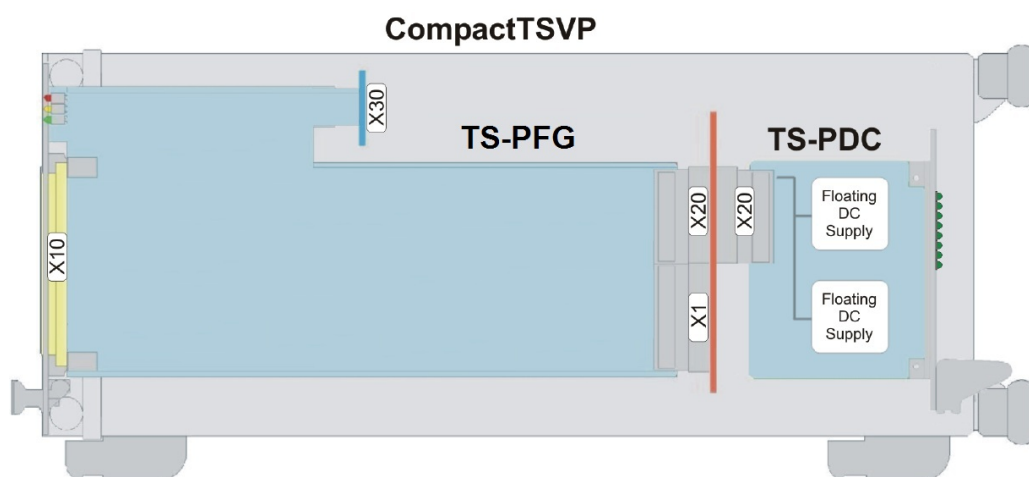


Figure B-4: R&S TS-PFG and R&S TS-PDC modules in R&S CompactTSVP

C Interface description

C.1 R&S TS-PFG

C.1.1 Connector X10

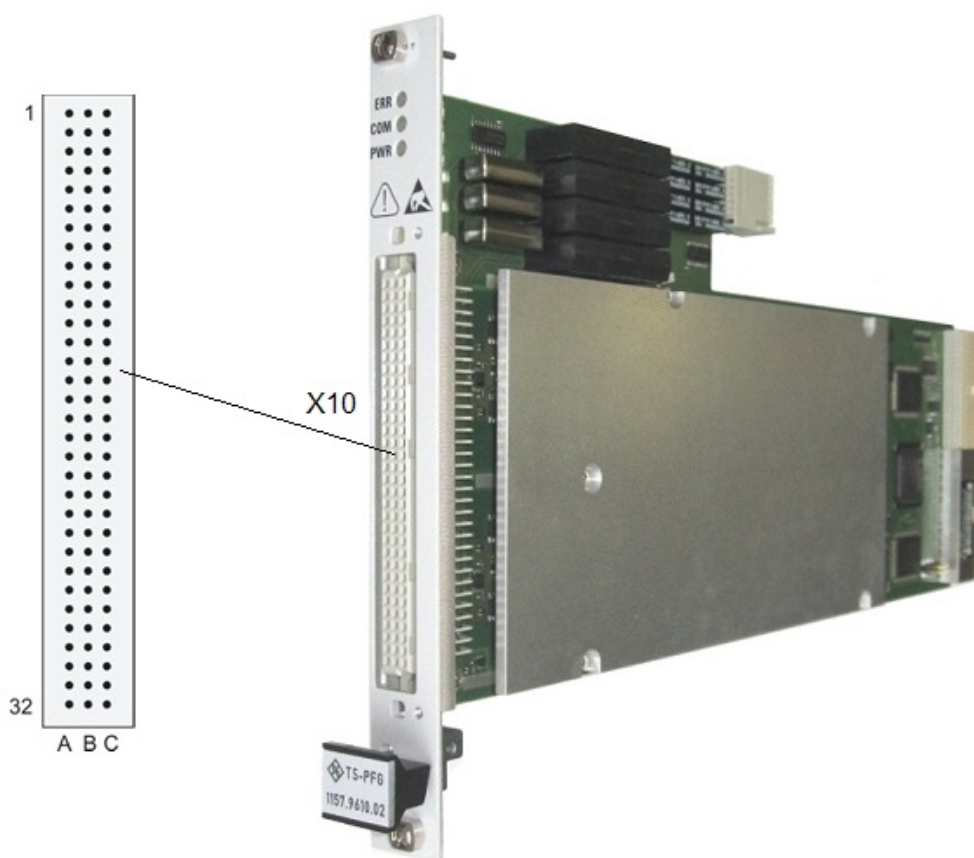


Figure C-1: R&S TS-PFG connector X10

Table C-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

C.1.2 Connector X20

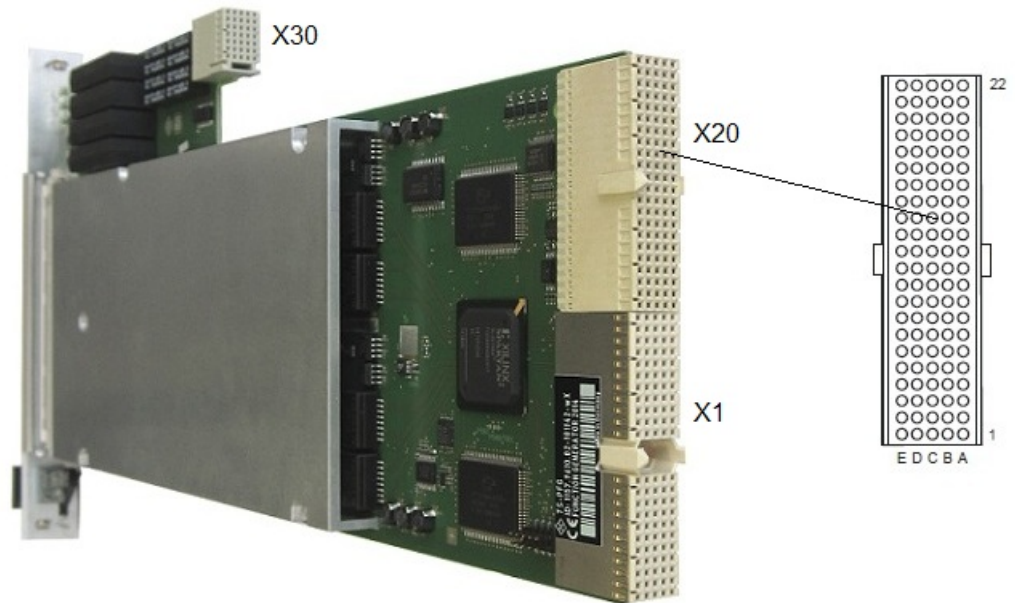


Figure C-2: R&S TS-PFG connector X20

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

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

C.1.3 Connector X30

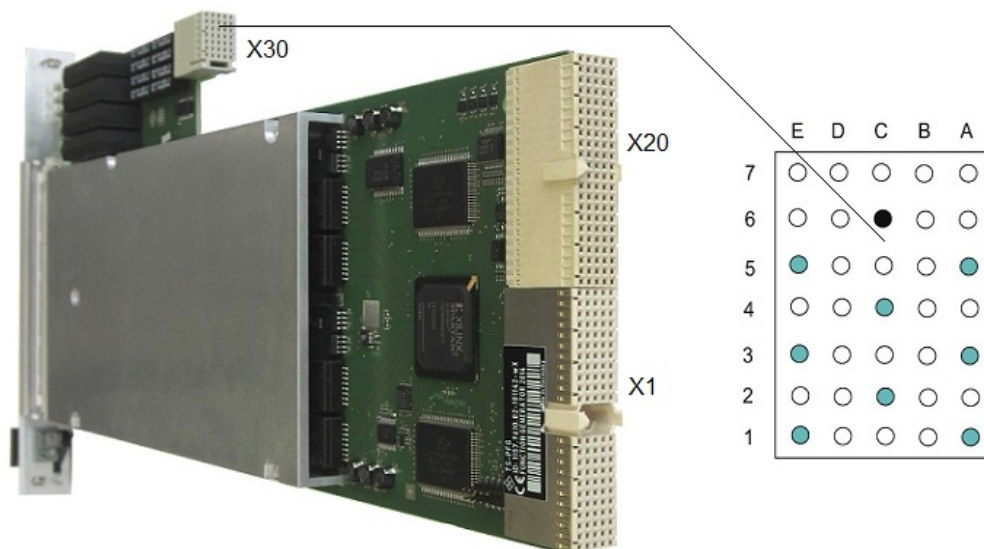


Figure C-4: R&S TS-PFG connector X30

Table C-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

C.1.4 Connector X1

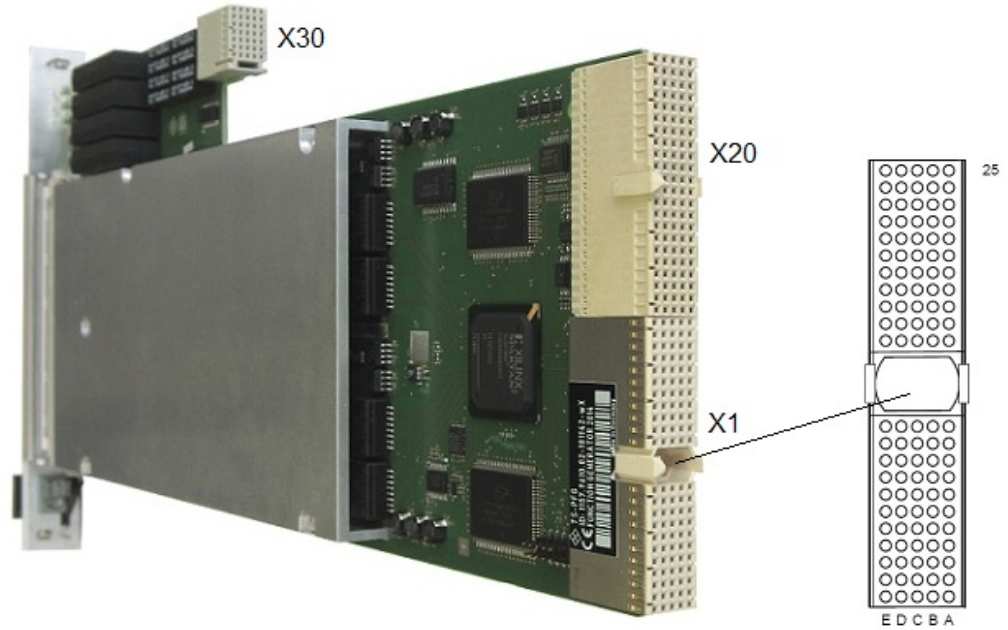


Figure C-5: R&S TS-PFG connector X1

Pin	F	E	D	C	B	A		
25	GND	5V	3.3V	ENUM#	REQ64#	5V	X1 C O N N E C T O R	
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#		
17	GND	PERR#	GND	IPMB_SDA	IPMB_SCL	3.3V		
16	GND	LOCK#	STOP#	V(I/O)	GND	DEVSEL#		
15	GND	TRDY#	BD_SEL#	IRDY#	FRAME#	3.3V		
12..14	Key Area							
11	GND	C/BE[2]#	GND	AD[16]	AD[17]	AD[18]		
10	GND	AD[19]	AD[20]	3.3V	GND	AD[21]		
9	GND	AD[22]	GND	AD[23]	IDSEL	C/BE[3]#		
8	GND	AD[24]	AD[25]	V(I/O)	GND	AD[26]		
7	GND	AD[27]	GND	AD[28]	AD[29]	AD[30]		
6	GND	AD[31]	CLK	3.3V	GND	REQ#		
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 C-6: Pin assignment of R&S TS-PFG connector X1

C.2 R&S TS-PDC

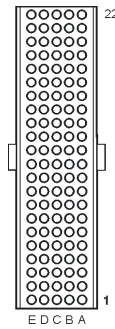


Figure C-7: Connector X20 (R&S TS-PDC mating side)

Pin	Z	A	B	C	D	E	J20 C O N N E C T O R
22	GND						
21	GND		GND or NC *3)				
20	GND			+5V *1)	GND	+5V *1)	
19	GND		GND	+5V *1)			
18	GND				GND or NC *4)		
17	GND		GND	+5V *2)	+5V *2)		
16	GND			+5V *2)	GND		
15	GND		GND	+5V *2)	+5V *1)		
14	NC						
13	NC						
12	NP	+15V_1	-15V_1	+5V_1	+3.3V_1	COM_1	
11	NP						
10	NC	+15V_2	-15V_2	+5V_2	+3.3V_2	COM_2	
9	NC						
8	NC	COM_1	COM_1	COM_1	COM_1	COM_1	
7	NC						
6	NC	COM_2	COM_2	COM_2	COM_2	COM_2	
5	NC						
4	NC						
3	GND		GND		RRST#		
2	GND	RCLK			RSDI		
1	GND	RCS#	GND			+5V *1)	
Pin	Z	A	B	C	D	E	

- *1) TS-PDC Version 1.0 is supplied via these pins from +5V, for backplanes up to Version 3.x
 *2) TS-PDC Version 1.1 or higher is supplied via these pins or pins from *1)
 *3) TS-PDC Version 1.3 or higher: This pin is not connected
 *4) TS-PDC Version 1.4 or higher: This pin is not connected

Figure C-8: Pin assignment for connector X20 (R&S TS-PDC)