

R&S® M3SR Series4100 HF Broadband System Flexible and modular multiline radio system





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R&S®M3SR Series4100 HF Broadband System At a glance

The HF broadband system is a flexible and modular multiline radio system for the HF frequency range. The applications range from navy ships to shore radio stations with up to 32 radio lines. The system's excellent scalability makes it suitable for use on board a wide range of ships, from Corvette-class vessels to aircraft carriers as well as for shore stations.

The system offers the full range of R&S®M3SR Series4100 modulation modes and waveforms, from simple SSB operation and ALE to EPM (ECCM) radio line. Intelligent radio line management provides flexible and dynamic allocation of transmit power, from a few watts to several kilowatts, to support a variety of missions.

Example: HF broadband system with one four-line block.

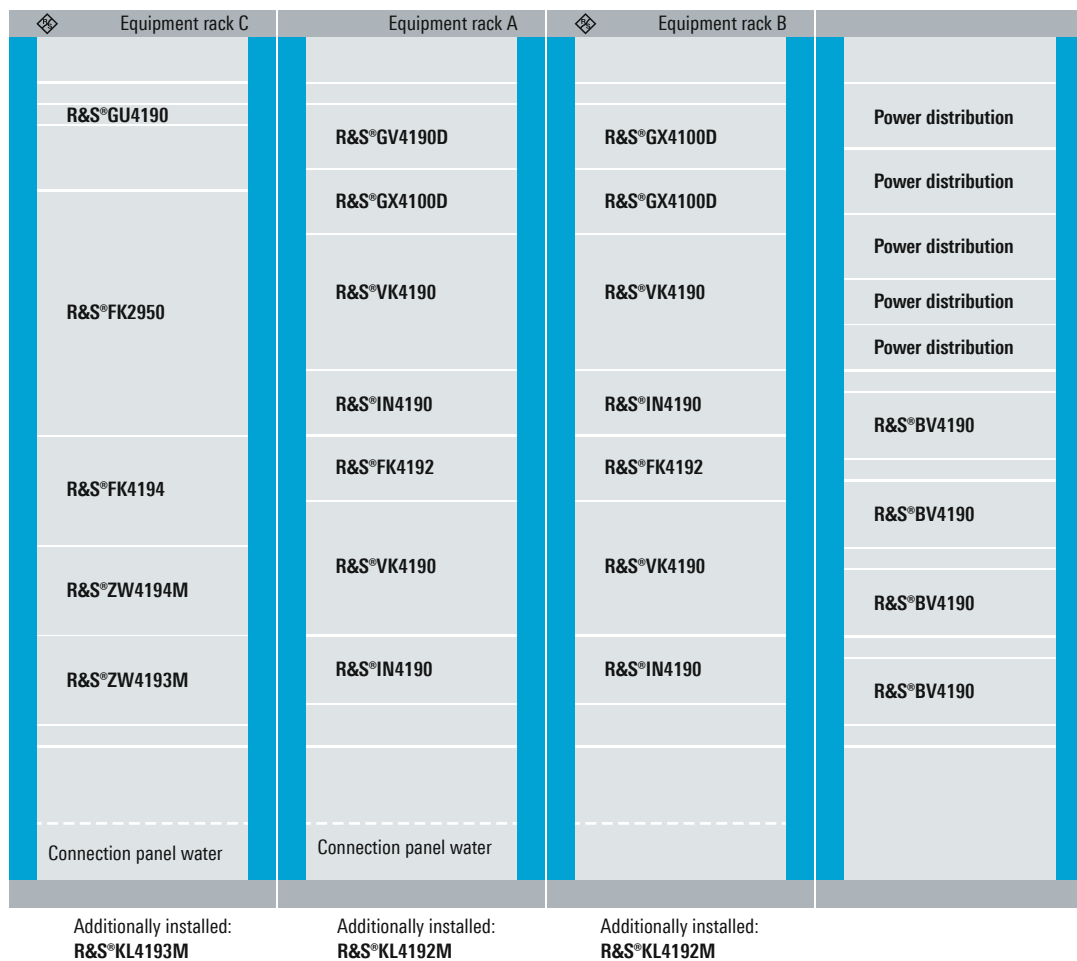


HF broadband system – a future-ready investment

The system is based on the principle of combining ship-board HF radio lines with the help of highly linear, passive line couplers and then transmitting the combined signal using a broadband antenna system. The system covers the entire HF frequency band from 2 MHz to 30 MHz and consists of separate broadband antennas, each covering a subband. A diplexer or triplexer selects each antenna segment.

The antenna system contains no switched elements. The broadband capability of the antennas eliminates the need for antenna tuning units. Since only passive components such as couplers and filters are used, the result is a low-maintenance system with superior reliability.

Example rack layout



System configuration of the HF broadband system

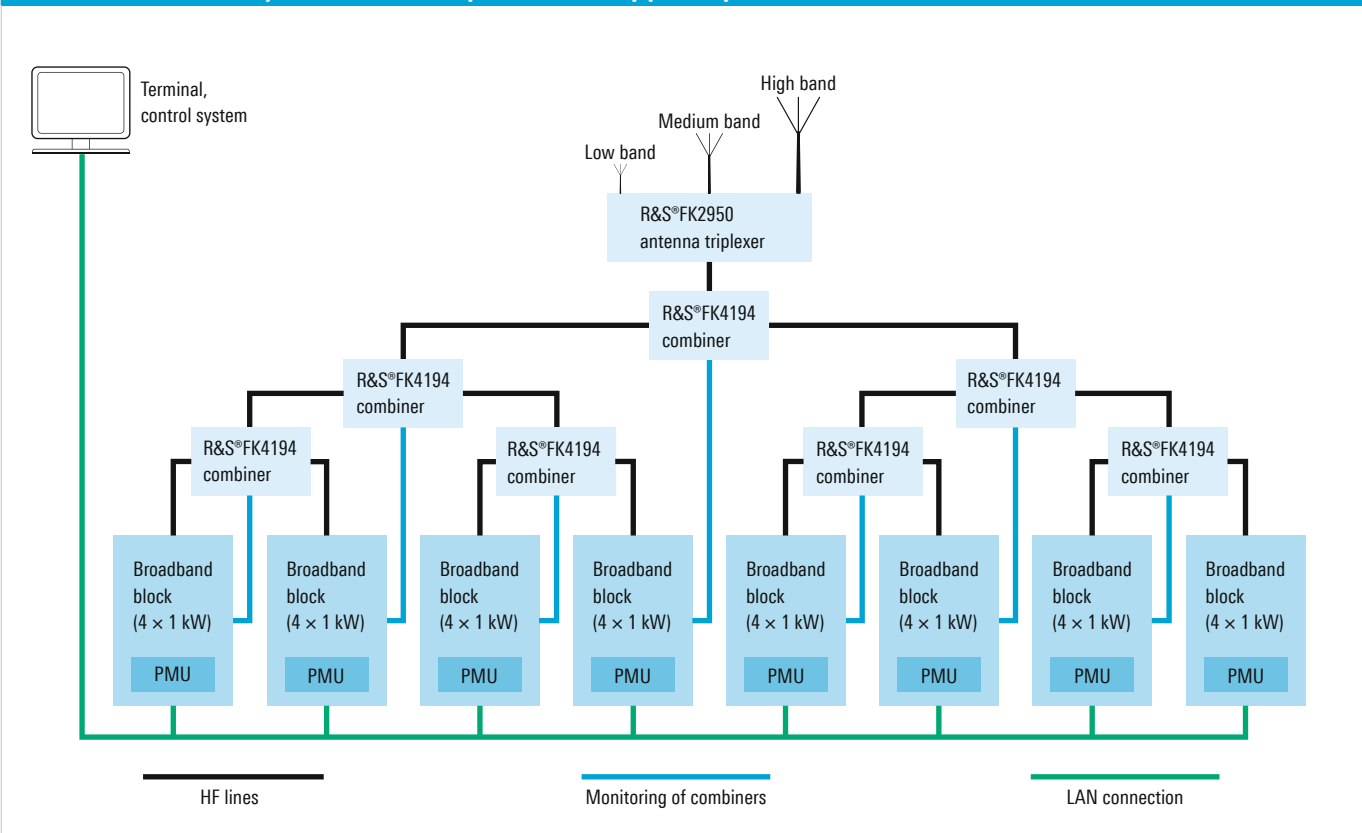
A broadband system can consist of up to 32 radio lines which are connected to a broadband antenna system. The channel spacing between adjacent radio lines can be adjusted to a minimum of one percent. The individual radio lines can be occupied by any of the waveforms supported by the R&S®M3SR Series4100 including:

- ▮ Voice (SSB, AM, FM)
- ▮ Radio teletype (RATT)
- ▮ Modem (e.g. STANAG 4285, STANAG 4539)
- ▮ Automatic link establishment (ALE-2G/3G)
- ▮ Tactical data links (e.g. LINK11, LINK22)
- ▮ EPM (ECCM) paths

Broadband block

The broadband block is a modular component of the HF broadband system. It consists of four 1000 W transceiver systems, the appropriate passive, highly linear power combiner and the R&S®GV4190D power management unit (PMU). The PMU allocates the radio signals of each of the connected receivers/exciter to one, two or four power amplifiers at the small signal level. It also permanently monitors status reports from system components such as amplifiers, power supplies, power combiners and filters. In the case of coherent power addition, the PMU also ensures that the signals to be added are in phase.

The HF broadband system can be expanded to support up to 32 radio lines



R&S®FK2950 antenna triplexer, R&S®FK2960 antenna diplexer

The HF broadband antenna system may consist of an R&S®FK2950 antenna triplexer and a three-section broadband antenna.

A two-section antenna (e.g. twin fan) and an R&S®FK2960 antenna diplexer may be used for smaller systems or ships.

An antenna mismatch of up to VSWR 3:1 can be tolerated without loss of power. For land-based installations, single broadband antennas (e.g. log-periodic antennas) from 2 MHz to 30 MHz can be used.

Local control

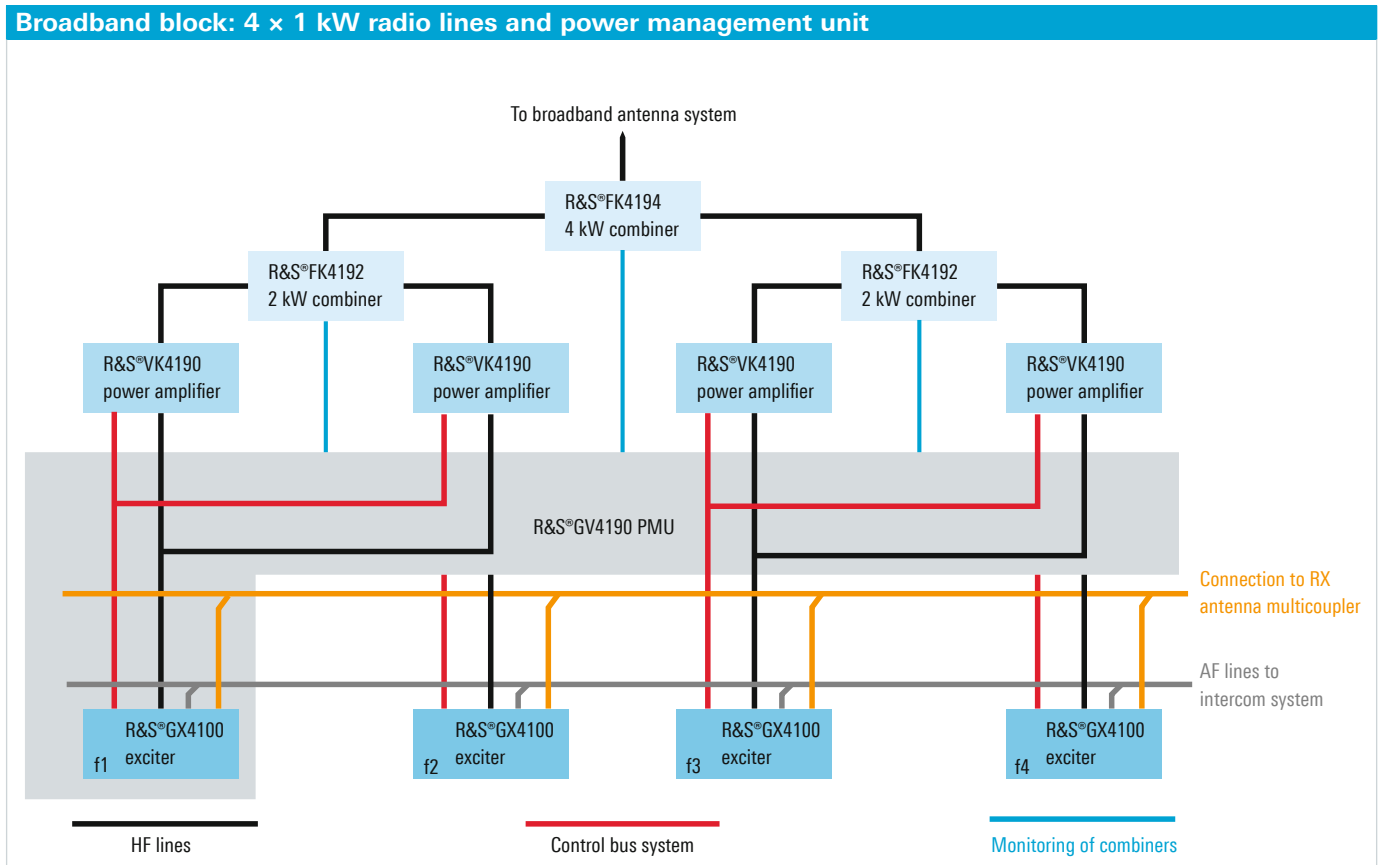
Broadband blocks can be locally configured and controlled with the R&S®GB4000C local control panel. The PMU offers a selection of operational modes to ensure a defined logical allocation between the receivers/exciter and the power amplifiers. These modes are especially suitable for locally controlling 4 kW transmitter/receiver systems such as those deployed at shore stations.

Flexible, logical allocation of connected receivers/exciter and power amplifiers

Through the right combination of coherent and non-coherent signal paths, the number of radio lines in operation and their output power can be varied over a wide range.

Coherent mode means that the output power of two radio lines can be arithmetically added (without taking into account coupler loss). This requires that both line coupler input signals have identical frequencies and phase angles.

If the input signal frequencies or phase angles are not identical, this is referred to as non-coherent mode and results in attenuation of the input power by 3 dB (= factor of 2).



R&S®FK4192/R&S®FK4194 passive HF power combiners

- R&S®FK4192: 2 kW
- R&S®FK4194: 4 kW

The power combiner section consists of three individual couplers, arranged at two levels so as to maximize the power management possibilities. The individual couplers are zero-degree couplers. This ensures perfect power combination if the two inputs are in phase (coherent combining). The coupling device is designed as a four-port system, which provides two inputs, one RF signal output, and one output to the balance load. The following simple example clarifies this function:

Two exciter signals (P1 and P2) are applied to the inputs of the coupler, which behaves differently according to whether the two signals are:

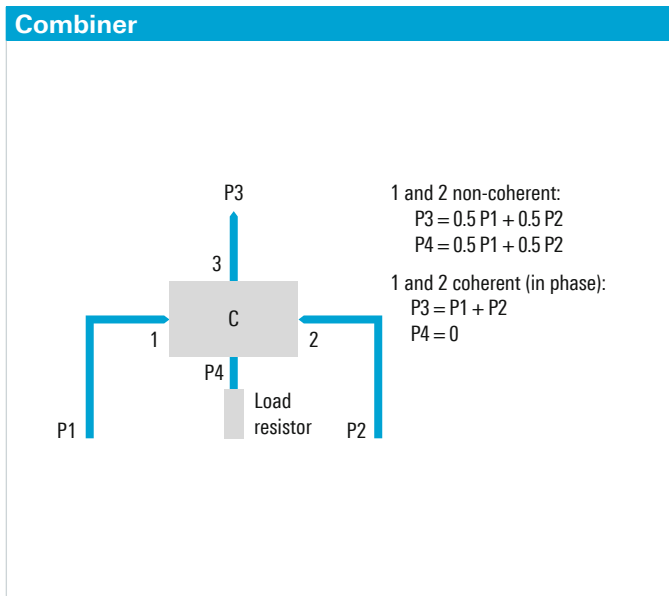
- A: identical, coherent
- B: not identical, not coherent

Coherent means that the signals originate from the same source (modulator) and are in phase:

Case A: At the output of the coupler is the sum of the powers of the two signals ($P_3 = P_1 + P_2$). The residual loss is typically less than 0.4 dB.

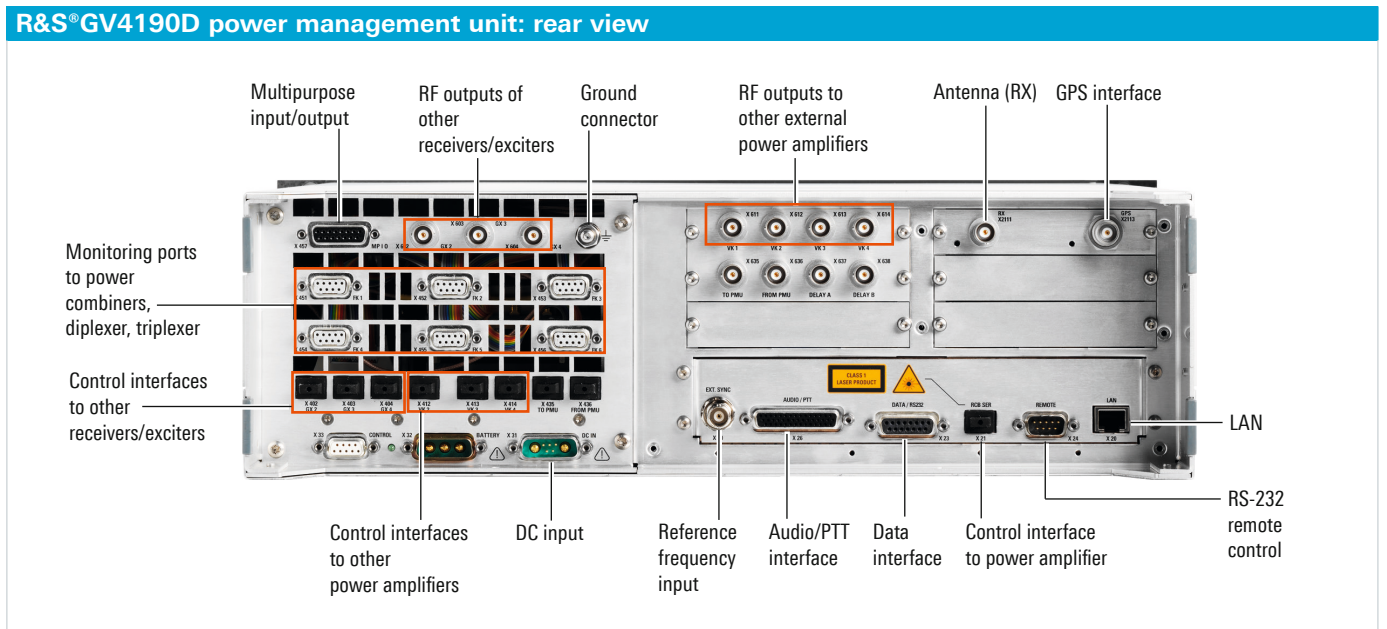
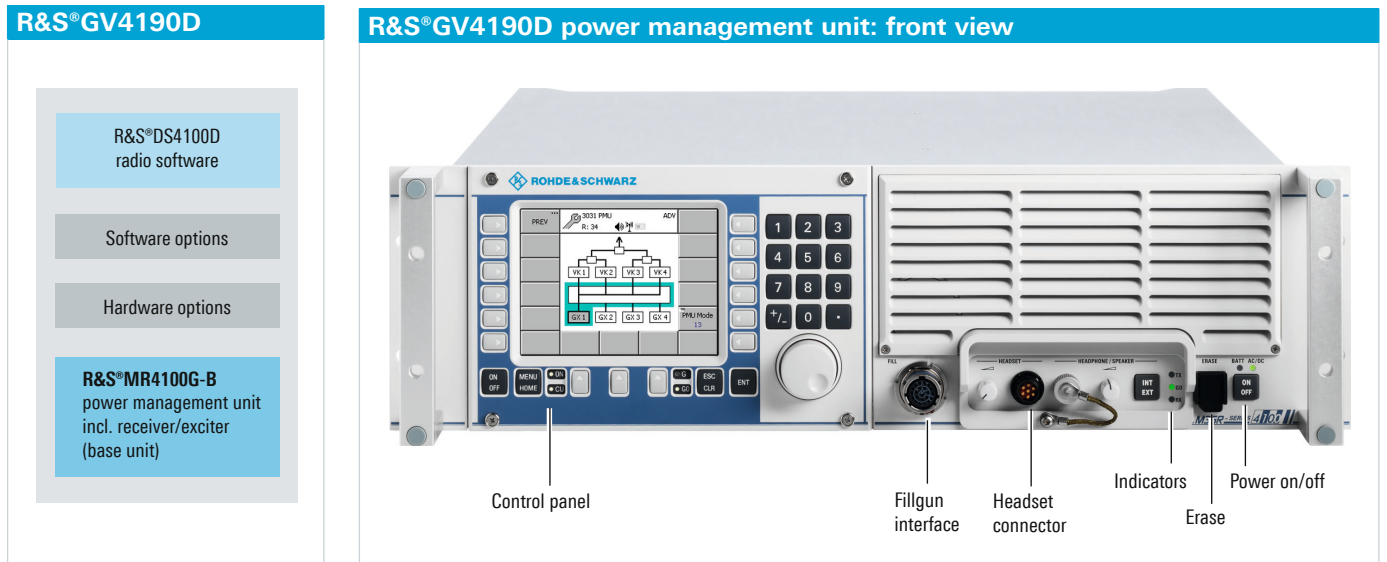
Case B: At the output of the coupler is the sum of the half powers of the two signals ($P_3 = 0.5 \times P_1 + 0.5 \times P_2$). The loss of one signal is typically between 3.2 dB and 3.4 dB. The loss of 3 dB, which is caused by the non-coherent combination, is dissipated in a load resistor connected to the fourth port of the coupler.

The second noteworthy property of a zero-degree power coupler is its isolation. This means that a signal P1 fed into one input (e.g. input 1) appears at output 3, not at input 2. The two power sources are decoupled, and intermodulation between the signals is virtually eliminated.



R&S®GV4190D power management unit

In addition to power management capability, the R&S®GV4190 offers embedded receiver/exciter functionality.



Water cooling equipment

System components

HF broadband (HFBB) systems are integrated into the on-board systems of naval vessels and are used to reduce the total number of required antennas. In larger HF broadband systems (more than four 1 kW transceivers), a water cooling system is required to reduce the wild heat in the equipment room. The main parts of HF broadband systems that produce heat are the transceivers due to their power amplifiers, power supplies and dummy loads (absorbers for the required R&S®FK4192 or R&S®FK4194 RF power combiners).

Most HFBB systems consist of eight or more transceivers, subdivided into blocks of four radios each (broadband blocks).

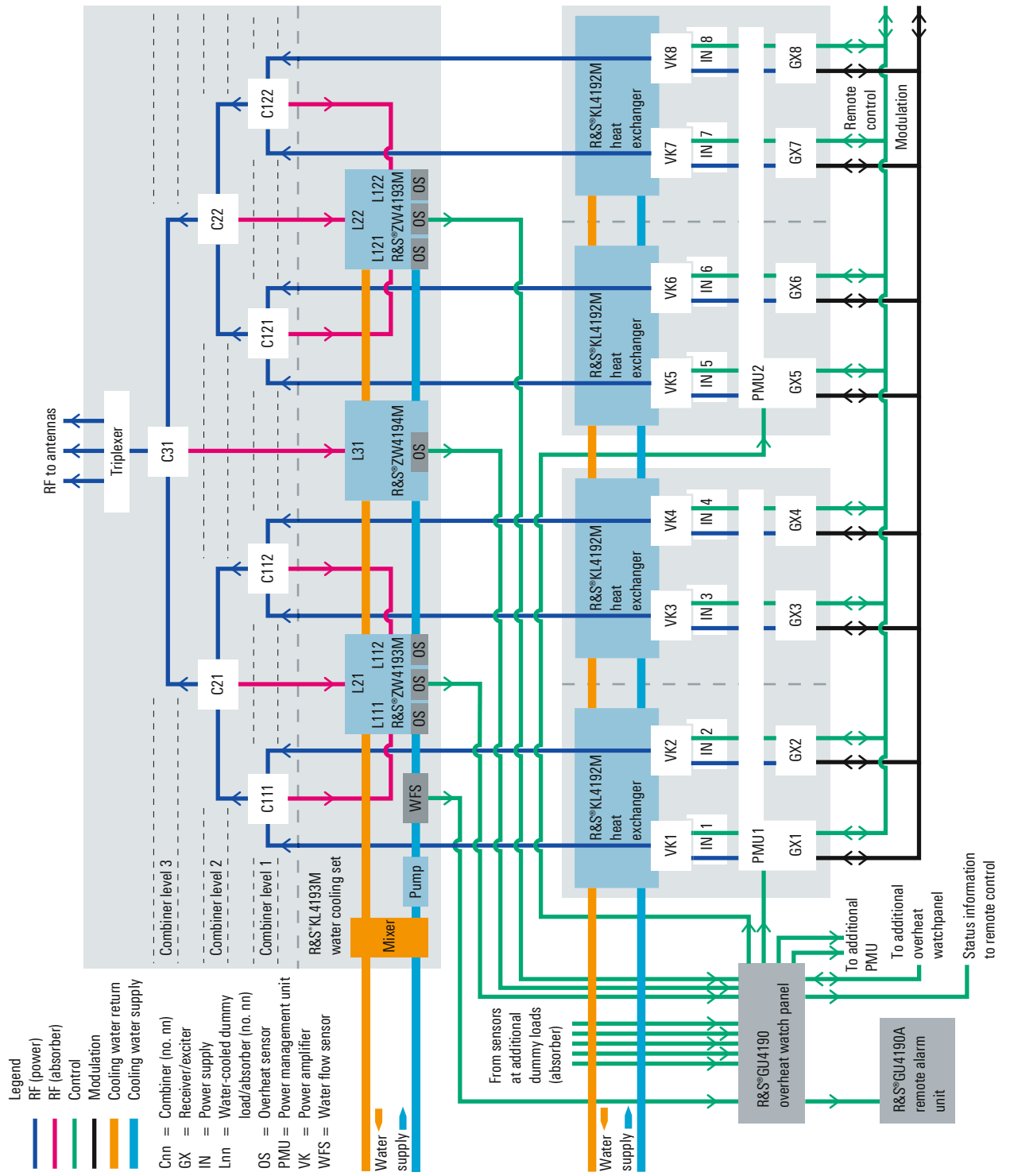
The following components are required for water cooling the HFBB system (see rack layout drawing for an eight-line HFBB system):

- R&S®KL4192M heat exchanger for equipment rack
- R&S®KL4193M water cooling set for equipment rack
- R&S®ZW4193M water-cooled dummy load (1+2+1 kW)
- R&S®ZW4194M water-cooled dummy load (4 kW)
- R&S®GU4190 overheat watch panel
- R&S®GU4190A remote alarm unit to R&S®GU4190 overheat watch panel (for external installation)



Example of an equipment rack type C with R&S®KL4193M water cooling set installed.

Water-cooled HF broadband system (two blocks consisting of four radios each = eight lines)



R&S®KL4192M heat exchanger

Brief description

The task of the R&S®KL4192M heat exchanger is to ensure the required operating conditions for two R&S®M3SR Series4100 radios, preventing excess heat dissipation in the room that houses the system.

The heat exchanger is used to cool the warm air generated by the following units:

- Two R&S®VK4190 power amplifiers
- Two R&S®IN4190 power supplies

These units have to be installed in a single equipment rack. A broadband block (the smallest version available for broadband systems), for example, requires two equipment racks (racks A and B), each equipped with an R&S®KL4192M heat exchanger. The R&S®KL4192M consists of the following main components:

- One heat exchanger
- One automatic air-release valve

It also includes an installation kit with connection pipes (flexible tubes), condensation drain and two manual valves.

Key facts

- For the installation of two R&S®VK4190 power amplifiers (1 kW), two R&S®IN4190 power supplies (1 kW) and one R&S®FK4192 RF power combiner (total of 21 HU)
- For installation in standard 19" equipment racks (width × depth: 600 mm × 800 mm)
- For installation on board ships with unreliable water quality

Electrical design

The R&S®KL4192M heat exchanger has no electrical components.

Mechanical design

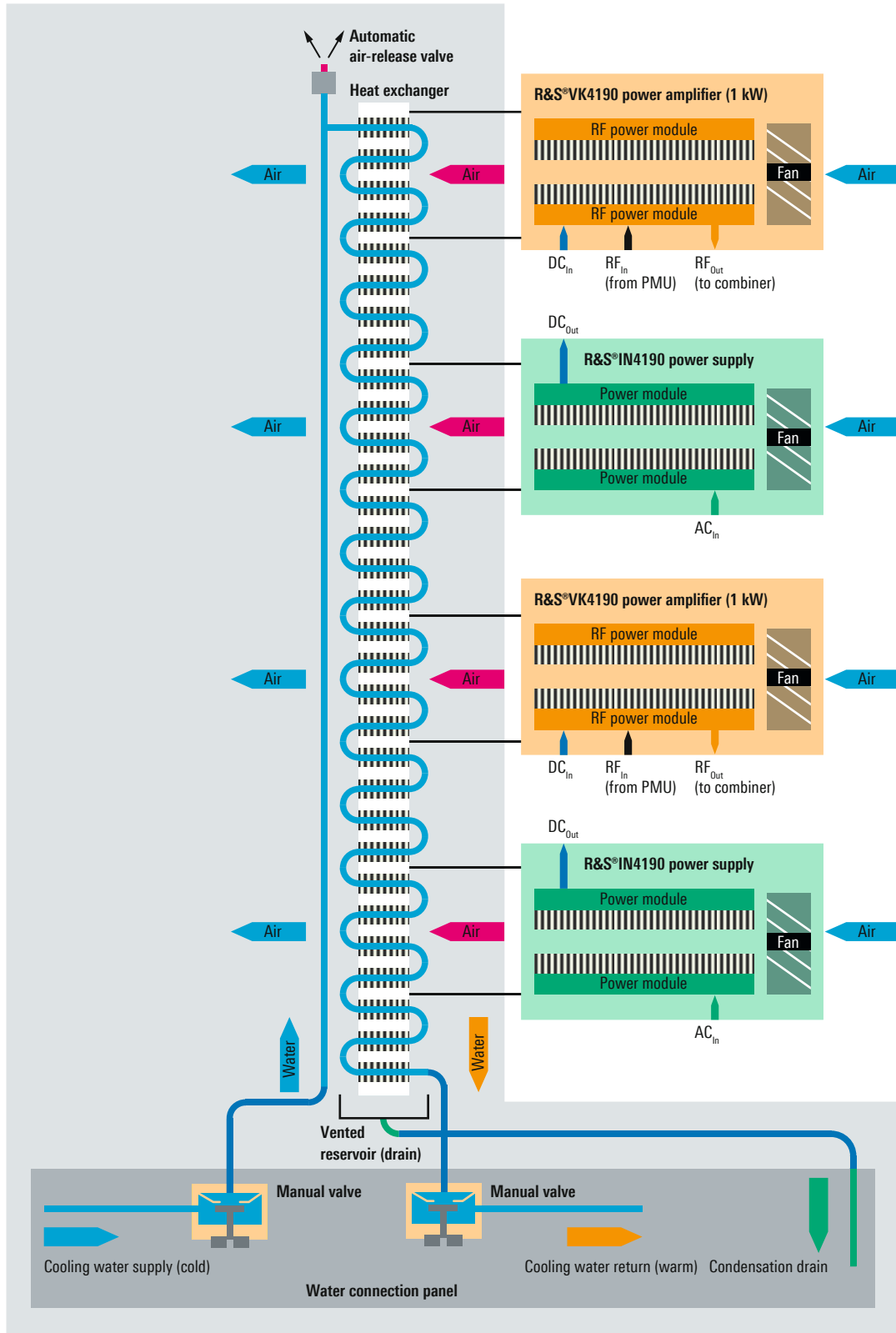
The R&S®KL4192M heat exchanger comprises four blocks, as shown in the schematic diagram on the next page:

- The heat exchanger allows conversion of calorimetric energy from an air stream passing the heat exchanger into calorimetric energy that is dissipated in water supplied as cooling water
- The automatic air-release valve in the pipe feeding into the heat exchanger releases any air that may be inside the pipe system
- Two manual valves are installed into each of the pipes for the cooling water supply and the cooling water return. The manual valves are also the connection point to the ship's water cooling system
- The "vented reservoir" is installed beneath the heat exchanger. It collects condensation water which is conducted by a flexible tube to the drain connection point of the ship's water cooling system

Detailed view of heat exchanger.



R&S®KL4192M heat exchanger (schematic diagram)



R&S®KL4193M

water cooling set

Brief description

The task of the R&S®KL4193M water cooling set is to provide the necessary infrastructure for the water-cooled dummy loads to protect them from damage caused by thermal overload. The R&S®KL4193M also prevents excess condensation water occurring with dummy loads in operating modes where RF power dissipation is not necessary.

RF power is fed from the combiners into the respective dummy load via a coaxial cable and converted into heat.

The R&S®KL4193M water cooling set is designed primarily for use on board ships but can also be used in any system where cooling water is supplied. The R&S®KL4193M provides the operating conditions required by the R&S®ZW4193M/R&S®ZW4194M water-cooled dummy loads. It consists of the following main components:

- One temperature-controlled mixing valve
- One 115 V circulating pump
- One water flow sensor

It also includes an installation kit, including distribution tubes, automatic air-release valves, connection pipes (flexible tubes) and condensation drain.

Key facts

- Connection for two sets of R&S®ZW4193M water-cooled dummy load (1+2+1 kW) (each with two absorbers for level 1 combiners and one absorber for level 2 combiners)
- Connection for one R&S®ZW4194M water-cooled dummy load (4 kW) (absorber for level 3 combiner)
- For use in systems with more than two broadband blocks: sufficient cooling capabilities for connecting an additional R&S®ZW4194M water-cooled dummy load (4 kW; absorbers for level 4 or level 5 combiners)
- Circulating pump with 115 V supply voltage
- Temperature-controlled mixing valve to prevent excess condensation in the components
- Equipped with one water flow sensor (for connecting to R&S®GU4190 overheat watch panel) for monitoring whether the circulating pump is working
- For installation in standard 19" equipment racks (width × depth: 600 mm × 800 mm)
- For installation on board ships with unreliable water quality

Electrical design

Water-cooled dummy loads

The R&S®ZW4193M and R&S®ZW4194M water-cooled dummy loads are not part of the R&S®KL4193M water cooling set. They are described on pages 16 and 18.

Circulating pump

A 115 V circulating pump installed in the "internal" cooling circuit supplies the water-cooled dummy loads with cooling water. The flow rate can be adjusted manually on the circulating pump.

Water flow sensor

For monitoring the circulation of cooling water through the dummy loads, a water flow sensor is installed in the pipe feeding the dummy loads. The water flow sensor is a compact, single-point flow monitor. The water flow sensor monitors the flow rate by measuring the temperature difference of the water flowing from the tip. The amount of thermal energy that is dissipated at the tip determines the local flow rate. This temperature-based operating principle makes it possible to reliably monitor the water flow. The sensor tip contains a heating element and two sensing elements: One sensing element is located close to the flowing water to detect changes in water flow velocity; the other is affixed to the cylindrical wall to detect changes in water temperature.

Mechanical design

Temperature-controlled mixing valve

The main component of the R&S®KL4193M water cooling set is a temperature-controlled mixing valve. This valve makes it possible to combine the "internal" cooling circuit with the circulating pump.

The temperature-controlled mixing valve consists of a three-way valve with thermostat, capillary tube and temperature sensor. The temperature sensor can be separated from the three-way valve and is installed in the pipe feeding the water-cooled dummy loads. It is connected with the capillary tube to the three-way valve. No electrical control is needed for regulating the temperature.

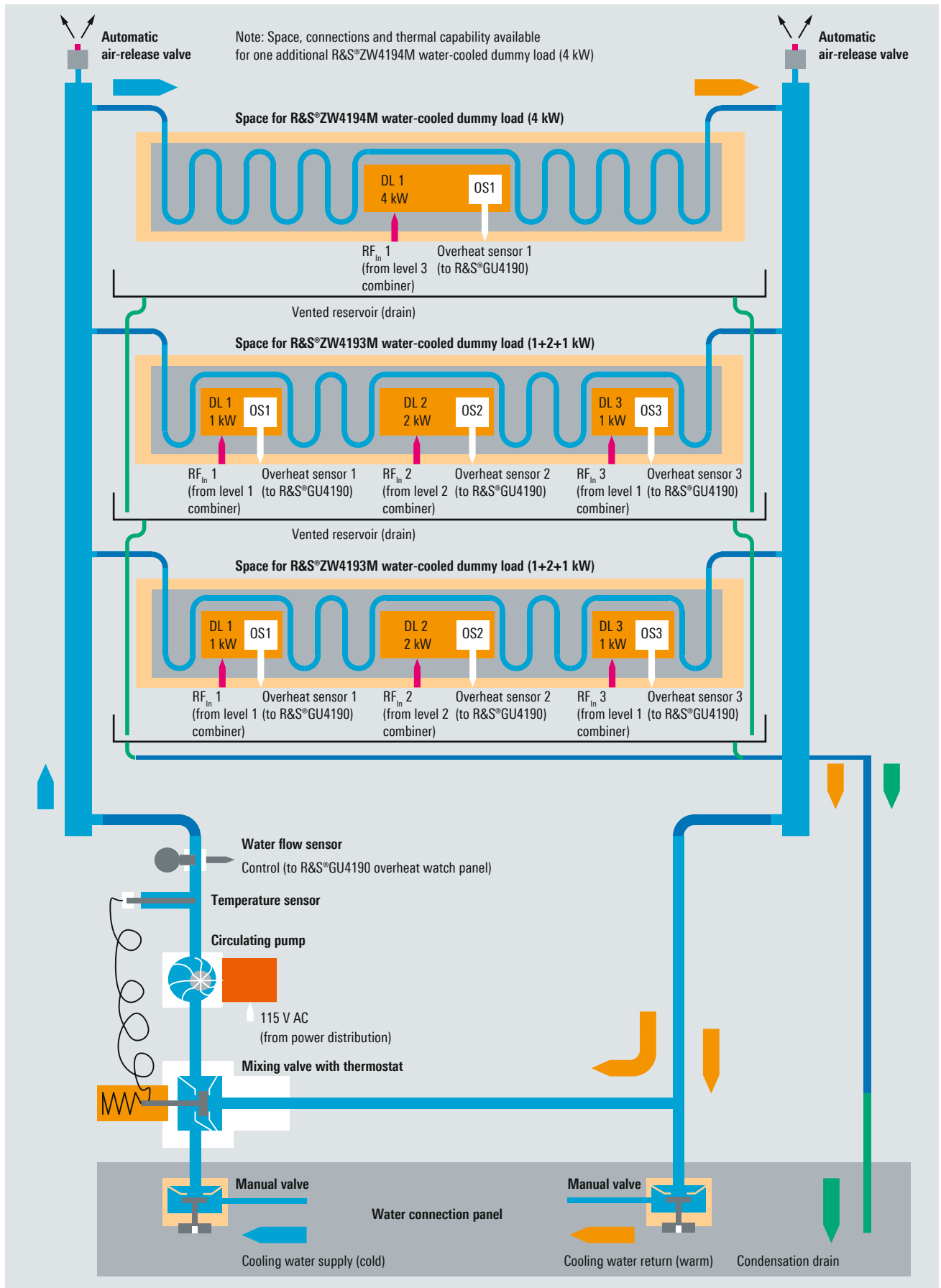
Circulating pump

A circulating pump with an operating voltage of 115 V is installed in the "internal" cooling circuit to supply the water-cooled dummy loads with cooling water. The flow rate can be adjusted manually on the circulating pump.

Water flow sensor

To monitor the water circulation through the dummy loads, a water flow sensor is installed in the pipe feeding the dummy loads.

R&S®KL4193M water cooling set (schematic diagram)



R&S®ZW4193M water-cooled dummy load (1+2+1 kW)

Brief description

The R&S®ZW4193M water-cooled dummy load (1+2+1 kW) includes two dummy loads (absorbers) for level 1 combiners (see figure, dummy loads 1 and 3 on left and right) and one for a level 2 combiner (see figure, dummy load 2 in middle). All these combiners are part of a four-line broadband block, which is the smallest type of broadband system.

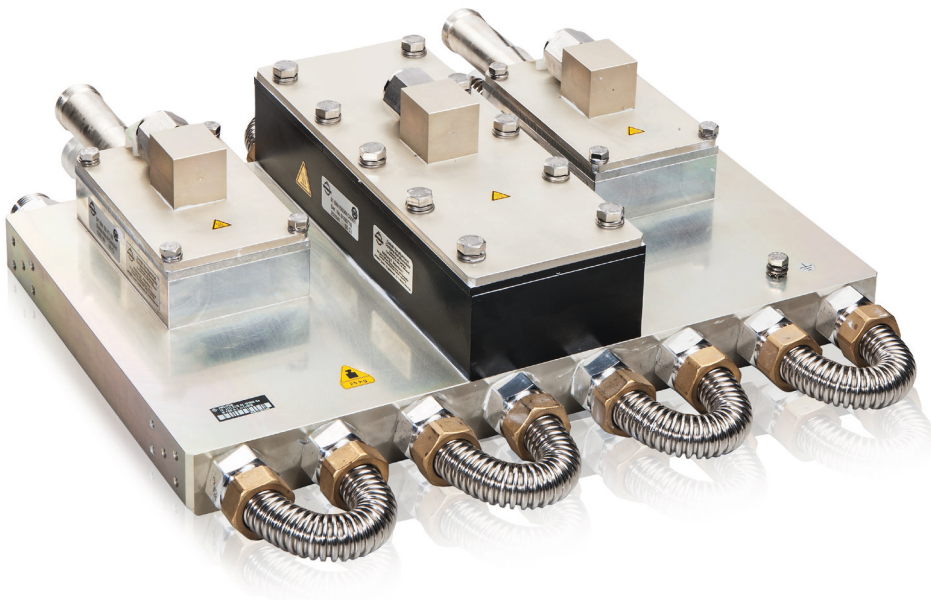
RF power is fed from the combiners into the respective dummy load via a coaxial cable and converted into heat. To prevent thermal overloading of the dummy loads, the heat has to be dissipated by the cooling water. To protect the R&S®ZW4193M from overheating (for example, if the water flow has stopped or is insufficient for the RF power that is supplied), the device is equipped with three overheat sensors (one at each dummy load/absorber).

These overheat sensors have to be connected to the R&S®GU4190 overheat watch panel, which detects overheating on the R&S®ZW4193M and controls the associated R&S®GV4190D power management unit (PMU), which is the main component of a four-line broadband block.

Key facts

- No power supply required
- Similar to a 19" unit with 4 HU for installation in standard equipment racks equipped with an R&S®KL4193M water cooling set
- For installation on board ships with unreliable water quality
- Developed for navy ships (fixed installation on surface ships, metallic, below deck)

R&S®ZW4193M water-cooled dummy load (1+2+1 kW)
(with cooling block below; vented reservoir not shown).



Electrical design

Dummy loads

The dummy loads are designed for dissipating the rated power:

- Dummy load 1 and 3: 1.25 kW
- Dummy load 2: 2.5 kW

Overheat sensors

The R&S®ZW4193M is equipped with overheat sensors (bimetallic switches with automatic reset) to monitor the maximum permissible temperature. These sensors have a breaking contact that opens at +80°C. Because different dummy loads can be supplied with RF power independently of each other, one overheat sensor is installed for each dummy load.

Mechanical design

Dummy loads

The dummy loads are installed on top of a cooling block that has holes for circulating cooling water.

Cooling block

The cooling block serves as the base for the mechanical installation of the dummy loads. It is a metal block with drill holes connected via U-tube elements, which creates a meandering pipe system for the cooling water. Water supply and water return connections are at the rear of the cooling block. The dummy loads are installed onto the cooling block. The complete section can be installed as a 19" unit into a standard equipment rack, which must be equipped with an R&S®KL4193M water cooling set to establish the water cooling infrastructure. This infrastructure includes circulating pump, temperature controlled mixing valve, water supply and water return. Water connections to R&S®KL4193M are realized by flexible tubes.

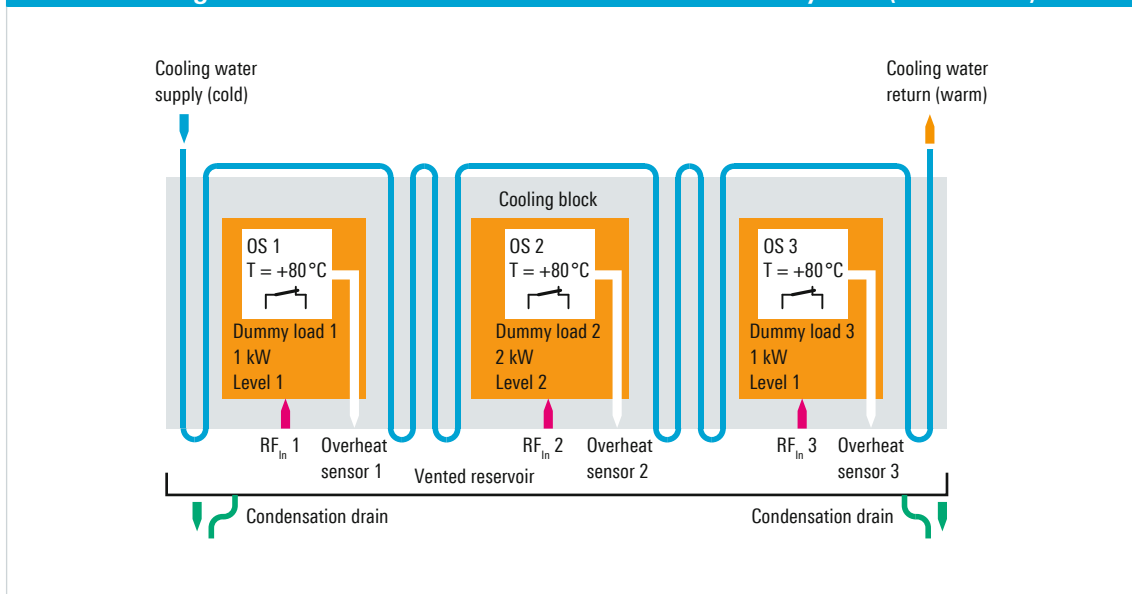
Overheat sensors

Three overheat sensors are installed, each on the surface of one dummy load, to monitor the maximum permissible temperature of the water-cooled dummy load. The sensors are installed on the top of the dummy load, where the temperature is highest.

Vented reservoir

A vented reservoir is installed beneath the cooling block. It collects condensation water which is conducted by flexible tubes via the drain connection of the R&S®KL4193M to the drain connection point of the ship's water cooling system.

Schematic diagram of the R&S®ZW4193M water-cooled dummy load (1+2+1 kW)



R&S®ZW4194M water-cooled dummy load (4 kW)

Brief description

The R&S®ZW4194M water-cooled dummy load (4 kW) includes one dummy load for the level 3 combiners. These are the highest level combiners in a system with two four-line broadband blocks (eight lines). The largest broadband block system has eight four-line blocks, i.e. with additional combiners at levels 4 and 5. The R&S®ZW4194M water-cooled dummy load (4 kW) is also applicable as absorbers for the combiners at levels 4 and 5.

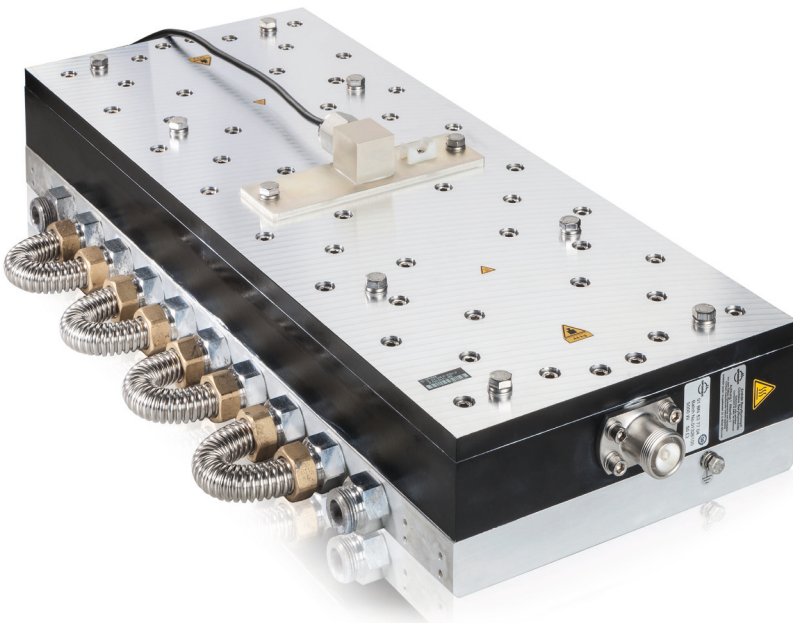
RF power is fed from the combiner into the dummy load and converted into heat. The R&S®ZW4194M is equipped with one overheat sensor to prevent it from overheating (e.g. if the water flow has stopped or is insufficient for the RF power that is supplied).

The overheat sensor has to be connected to the R&S®GU4190 overheat watch panel, which detects whether the R&S®ZW4194M is overheating and switches off the RF power fed to the dummy load. The overheat watch panel is controlled by all the overheat sensors on the water-cooled dummy loads. It controls the respective R&S®GV4190D power management unit (PMU), which is the main component of a four-line broadband block.

Key facts

- No power supply required
- Similar to a 19" unit with 4 HU for installation in standard equipment racks with R&S®KL4193M water cooling set
- For installation on board ships with unreliable water quality
- Developed for naval ships (fixed installation on board ships, metallic, below deck)

R&S®ZW4194M water-cooled dummy load (4 kW)
(with cooling block below; vented reservoir not shown).



Electrical design

Dummy load

The dummy load is designed for 5 kW dissipation.

Overheat sensor

The R&S®ZW4194M is equipped with an overheat sensor (bimetallic switch with automatic reset) to monitor the maximum permissible temperature. The sensor has a breaking contact, which opens at +80 °C.

Mechanical design

Dummy load

The dummy load is installed on top of a cooling block, which has holes for circulating cooling water.

Cooling block

The cooling block serves as the base for the mechanical installation of the dummy load. It is a metal block with drill holes connected via U-tube elements, which form a meandering pipe system for the cooling water. Water supply and water return connections are at the side of the cooling block. The dummy load is installed onto the cooling block. The complete section can be installed as a 19" unit into a standard equipment rack, which must be equipped with an R&S®KL4193M water cooling set establishing the water cooling infrastructure. This infrastructure includes circulating pump, temperature-controlled mixing valve, water supply and water return. Water connections to R&S®KL4193M are realized by flexible tubes.

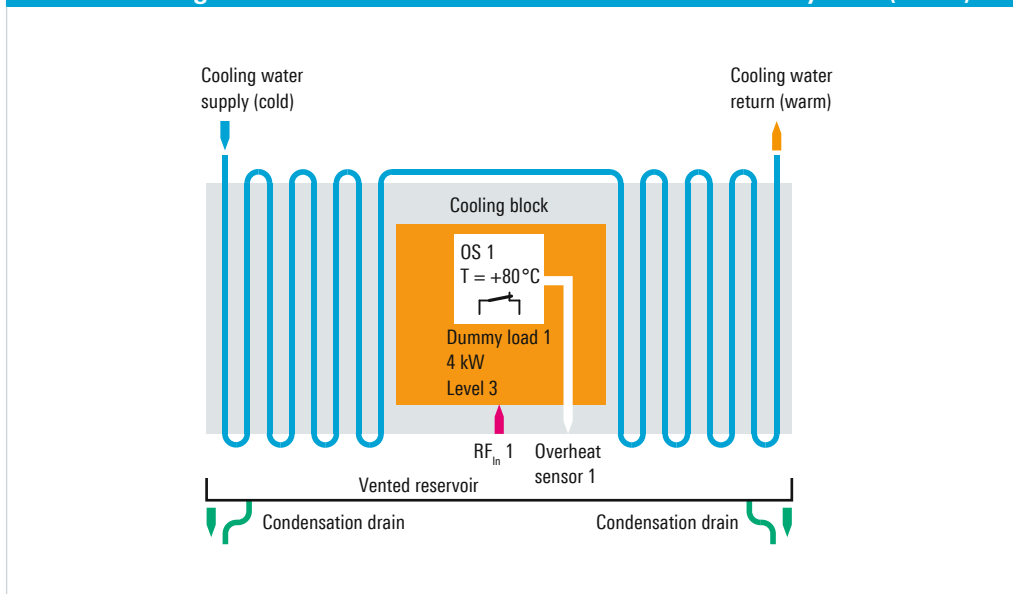
Overheat sensor

The dummy load has an overheat sensor on its surface for monitoring the maximum permissible temperature of the water-cooled dummy load. The overheat sensor is installed on the top of the dummy load, where the temperature is highest.

Vented reservoir

A vented reservoir is installed beneath the cooling block. It collects condensation water which is conducted by flexible tubes via the drain connection of the R&S®KL4193M to the drain connection point of the ship's water cooling system.

Schematic diagram of the R&S®ZW4194M water-cooled dummy load (4 kW)



R&S®GU4190 overheat watch panel, R&S®GU4190A remote alarm unit

Brief description

The R&S®GU4190 overheat watch panel (OWP) monitors the water cooling components and protects them from overloading. The OWP is controlled by overheat sensors at the water-cooled dummy loads and controls the R&S®GV4190D power management units (PMUs), which are the main components of a four-line broadband block. The task is to ensure that dummy loads are always protected against damage caused by thermal overload while at the same time preventing transmissions from being aborted unnecessarily.

If one of the connected dummy loads is overloaded, the overheat watch panel indicates this state to the PMU. This interrupts all transmission from the connected radios. The front panel of the overheat watch panel is equipped with LEDs that indicate which overheat sensor has triggered and which PMU has been disabled. The signaling of

the disabled PMUs has a four-level hierarchy (level 1 + 2, level 3, level 4 and level 5), which is necessary for systems with more than four four-line broadband blocks (two OWP required). In applications with two four-line blocks per OWP, the required hierarchy levels are limited (level 1 + 2 and level 3).

The overheat watch panel is additionally equipped with an input for a water flow sensor (WFS) which is installed in the R&S®KL4193M water cooling set. It is located in the water supply of the water-cooled dummy loads. The sensor indicates whether the required volume of water is circulating throughout the dummy loads. If this is not the case, the overheat watch panel indicates this state to a connected remote alarm unit (RAU). The RAU signals this state with both an acoustic and visual alarm. The acoustic alarm can be reset on the RAU by pressing a reset button. The RAU shows the visual alarm and that the acoustic alarm has been reset. An additional interface at the overheat watch panel with a relay contact is provided to indicate alarms triggered by the water flow sensor on other equipment such as a remote control system.

Key facts

- Monitors one water flow sensor (WFS)
- Controls one remote alarm unit
- Remote control (RC) interface signaling WFS status information
- Monitors up to eight overheat sensors at water-cooled dummy loads:
 - Four at level 1 + 2
 - Two at level 3
 - One at level 4
 - One at level 5
- Controls up to four R&S®GV4190 power management units (PMU)
- Provides an interface for interconnecting several R&S®GU4190 overheat watch panels (required for large systems with more than four four-line blocks)
- Power supply, 100 V to 240 V AC
- Secondary power supply, 19 V to 32 V DC
- 19" unit, 1 HU



R&S®GU4190A remote alarm unit.



R&S®GU4190 overheat watch panel.

Electrical design

Backplane

The backplane is a circuit board installed in the rear panel. It includes all connectors for interfacing with the HF broadband system and also the logic of the unit.

AC power supply

The AC power supply is the main supply for the unit.

Connection board

The connection board is placed between the backplane and the front panel. This board also has a DIP switch register that has to be set in accordance with the respective system layout.

Rear panel elements

All connectors for the HF broadband system and for the power supply are on the rear panel. The power switch for the AC supply is part of the power supply. All connectors can be secured against falling off.

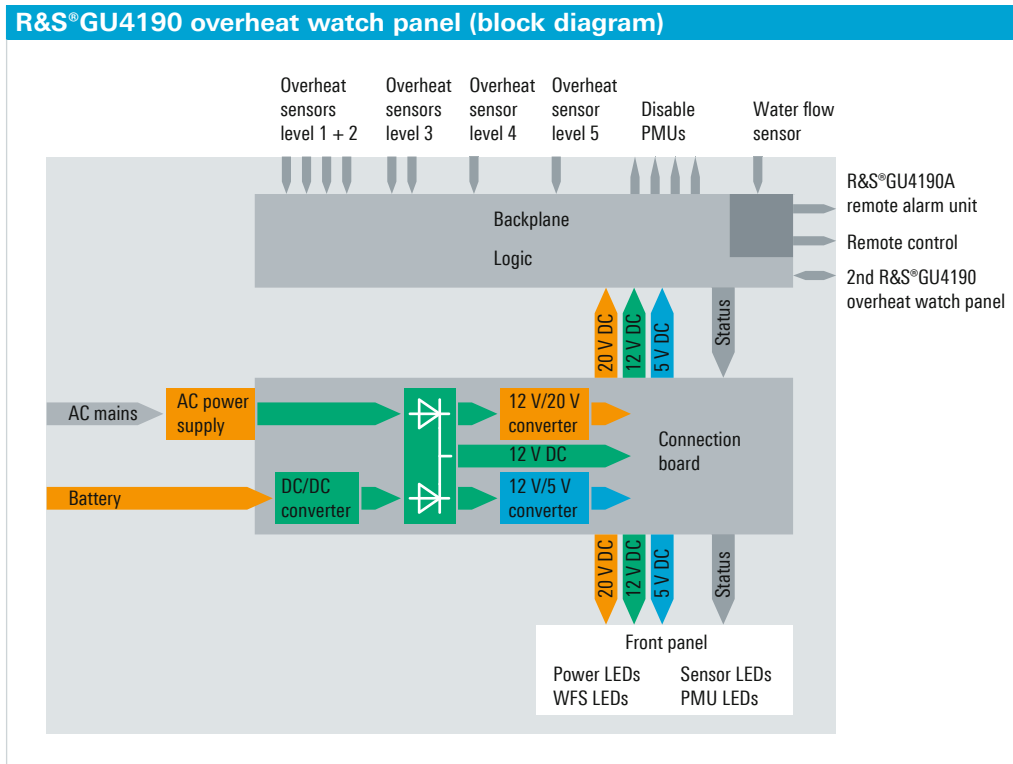
Front panel elements

The front panel has a circuit board with the following LED status indicators:

- Power 12 V
- AC supply
- Battery
- WFS OK
- WFS error
- Overheat level 1 + 2 (four LEDs)
- Overheat level 3 (two LED)
- Overheat level 4 (one LED)
- Overheat level 5 (one LED)
- Disabled PMUs 1 to 4 (four LEDs)

Application

The R&S®GU4190 overhear watch panel can be used for a variety of applications. For installation in a system as described here, a single OWP is used to control up to two broadband blocks (eight lines) and one water flow sensor. As many as four OWPs can be combined to accommodate configurations with more than eight lines.



Rear view of the R&S®GU4190 overhear watch panel.

Product overview

HF broadband system

| Designation | Type |
|---|---------------|
| Base units | |
| Power Management Unit, incl. HF receiver/exciter functionality, base unit, DC, without local control panel and radio software | R&S®MR4100G-B |
| HF Receiver/Exciter, base unit: DC, without local control panel and radio software | R&S®MR4100G |
| Radio software | |
| Software CD without export restriction | R&S®DS4100A |
| Software CD with export restriction | R&S®DS4100D |
| Hardware options | |
| Local Control Panel (without audio, incl. software and LAN) | R&S®GB4000C |
| Digitally Tuned RF Selection, 40 dB, functional for transmitting and receiving section (mandatory option) | R&S®FK4140 |
| NMEA (DSC) Interface, for connection to an external DSC controller (GMDSS) | R&S®GS4102 |
| Power amplifier | |
| 1000 W HF Power Amplifier, prepared for R&S®ZW2910 option | R&S®VK4190 |
| Termination Resistor, 200 W, for receive path incl. connecting cable (mandatory option) | R&S®ZW2910 |
| Power supply units | |
| Power supply, 115 V AC, 1 phase + N or 230 V AC, 1 or 3 phases + N/208 V AC, 3-phase Δ | R&S®IN4190 |
| Power Supply, 440 V AC, 3 phases (used together with R&S®BV4190 transformer) | R&S®IN4190 |
| Transformer, 440 V AC, 3-phase Δ | R&S®BV4190 |
| System components | |
| Power Combiner, 2 kW | R&S®FK4192 |
| Power Combiner, 4 kW | R&S®FK4194 |
| Antenna Triplexer | R&S®FK2950 |
| Antenna Diplexer | R&S®FK2960 |

Water cooling equipment for HF broadband systems

| Designation | Type |
|------------------------------------|-------------|
| Heat Exchanger | R&S®KL4192M |
| Water Cooling Set | R&S®KL4193M |
| Water-Cooled Dummy Load (1+2+1 kW) | R&S®ZW4193M |
| Water-Cooled Dummy Load (4 kW) | R&S®ZW4194M |
| Overheat Watch Panel | R&S®GU4190 |
| Remote Alarm Unit | R&S®GU4190A |

Software options and auxiliary equipment are described in the R&S®M3SR Series4100 product brochure (see PD 5213.9557.12 and www.rohde-schwarz.com).

The radio systems described are hardware- and software-configurable. The system delivered has the configuration as confirmed in the order.

Your local Rohde&Schwarz expert will help you determine the optimum solution for your requirements.

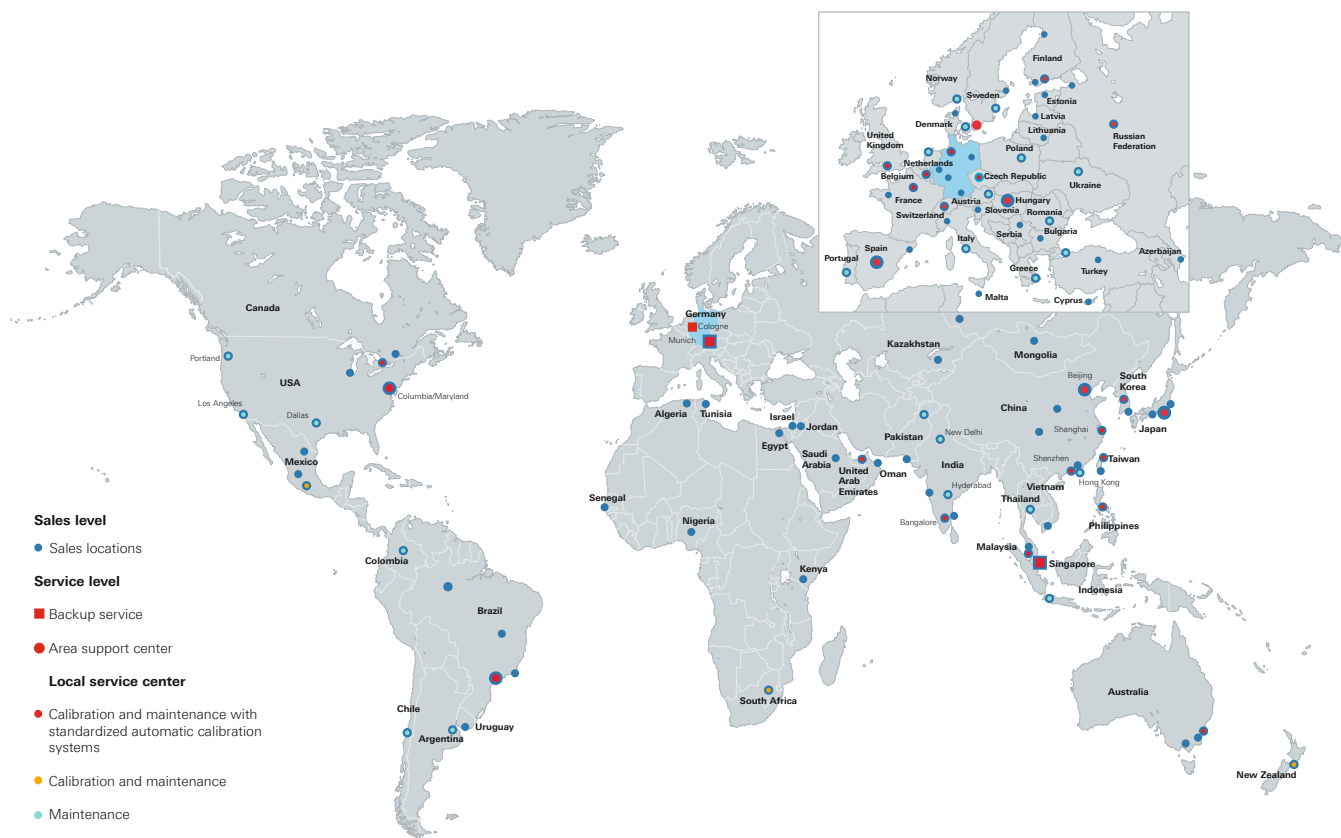
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www.sales.rohde-schwarz.com

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Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established more than 75 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

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Certified Quality System
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