Filters and combiners are inevitable system components
– to enable and
– to improve
quality radio communications and their integration is a must for any responsible consultant or system engineer. This responsibility extends from failure-free system operation to that over the life of aircraft passengers when a vital ground-to-air ATC communication is interfered in a critical flight situation or when an avionics system is disturbed.

Definition: In the following »filters« are understood to be manually or automatically tuned system components operating on the wanted receive and/or transmit frequency. Not described are bandpass, highpass or lowpass filters. In contrary to bandpass limited receive only multicouplers (such as the Rohde & Schwarz types VE340F2/F4/F6) »Multicouplers« are defined here as highly selective filter-combiners tuned to the exact operating frequency and combining several radio units to one antenna.
VHF/UHF Filters/Multicouplers

Filters/multicouplers have manifold functions and benefits. Because of the importance of the topic the functions and benefits are described in the following in general and in detail:

In general
Highly selective filters and multicouplers ...

- Protect and improve the operational quality of the customer’s own VHF/UHF radio installations
- Protect the own radio system from externally generated interfering signals from all kind of civil or military in-band or out-of-band radio installations, including broadcasting, TV, microwave links or radar
- Protect other electromagnetically sensitive radio, navigation (DF, VOR, ILS etc.) or radio monitoring installations under the responsibility of the own or other services
- Provide frequency economy in an environment with high frequency congestion – filters/combiners make the use of already or newly assigned and critically spaced frequencies possible
- Provide space economy by installation of antennas on limited space – eg on the tower cabin roof, at the only available radio center, on board of a ship or in mobile or transportable systems (eg mobile towers)

In detail and in terms of communications engineering RF filters improve the characteristics of transmitting and receiving systems – depending on the RF path they are integrated into – as follows:

Receive filter benefits – in detail
- Suppression of out-of-band based intermodulation products by additional attenuation of all signals and their harmonics which are outside of the receiving range and – due to nonlinearities and mixing – could cause intermodulation products to fall within the useful VHF or UHF band and interfere the reception
- Suppression of third-order cross-modulation products by the attenuation of strong interfering signals which could transfer their modulation to the wanted – but possibly weak – signal
- Increase of image-frequency rejection by the additional attenuation of signals defined as image frequency relative to the received frequency
- Increase of intermediate frequency (IF) rejection by additional attenuation of interfering signals on one of the intermediate frequencies
• Prevention of desensitization (reciprocal mixing) by the attenuation of strong interfering signals which could otherwise transfer the noise sidebands of the receiver oscillator, mixed onto the interfering signal, to the useful band, thus reducing sensitivity
• Prevention of blocking by the attenuation of strong interfering signals which could reduce the amplitude of the useful IF signal by overdriving the mixer stage

Transmit filter benefits – in detail
• Attenuation of broadband transmitter noise caused by the exciter oscillator or power amplifiers
• Suppression of spurious emissions, mainly occurring in the small-signal stages during frequency conditioning
• Suppression of harmonics, mainly generated in the power stages

• Attenuation of transmitter (backward) intermodulation products of the 3rd or higher order: these are generated – within a simultaneously operating system with co-sited transmitters – by the radiation of transmitter signals via the antennas into the output of an other transmitter. In this case the attenuation of the filter at the transmission end is effectively doubled and adds to the antenna-decoupling factors.

Practical effects of improvement
Optimized radio installations using filters help to achieve the offer following vital operational benefits:

System engineering note
In addition to the use of filters described here, the following tools shall be taken into consideration to master challenges by collocation:

Benefits by filters – in sum

<table>
<thead>
<tr>
<th>Benefits by filters – in sum</th>
<th>Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>No irritation of the operator</td>
<td>By unwanted response of the receiver carrier squelch</td>
</tr>
<tr>
<td>No degradation of the receive sensitivity</td>
<td>Also with weak wanted receive signals</td>
</tr>
<tr>
<td>No irritation of the operator by spurious reception (phantom signals)</td>
<td>Such interferences may be generated by signals identical with the image frequencies or the intermediate frequency</td>
</tr>
<tr>
<td>No RF output power reduction of the transmitter</td>
<td>Interfering signals entering via the antenna socket influence the VSWR depending gain control loop</td>
</tr>
<tr>
<td>No radiation of unwanted and interfering signals</td>
<td>Radiated TX intermodulation products may lead to self-jamming of the own receive system or to irritations of the aircraft pilot</td>
</tr>
</tbody>
</table>
Quick type guide and basic specifications

The following guide helps by comparison to identify the right filter or multicoupler for the actual system requirement. For additional specifications and ordering information please refer to the type-specific »supplementary information«.

Manually tuned

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency Range (MHz)</th>
<th>Tuning</th>
<th>RF Input Power AMc = AM carrier</th>
<th>3 dB BW (in % of f₀ or in MHz)</th>
<th>Selectivity ¹</th>
<th>Insertion Loss (filter)</th>
<th>Remarks, Multicoupler Capability: S = Starpoint T = T-coupler N = no</th>
</tr>
</thead>
<tbody>
<tr>
<td>FU220, FU220Wx</td>
<td>100 to 162.025¹</td>
<td>manual</td>
<td>200 W AMc 800 W PEP 300 W FM</td>
<td>≥0.05%</td>
<td>20 dB: ≤±0.4% 40 dB: ≤±1.0% 60 dB: ≤±4.0%</td>
<td>≤2.0 dB (0 to +40°C) ≤2.5 dB (-20 to +55°C) additional 0.5 dB at ≤108 MHz</td>
<td>S: Up to 4 radios are combinable to one antenna (FU220W4)</td>
</tr>
<tr>
<td>FD220, FD220Wx</td>
<td>225 to 399.975</td>
<td>manual</td>
<td>200 W AMc 800 W PEP 300 W FM</td>
<td>≥0.05%</td>
<td>20 dB: ≤±0.4% 40 dB: ≤±1.0% 60 dB: ≤±4.0%</td>
<td>≤2.0 dB</td>
<td>S: Up to 4 radios are combinable to one antenna (FD220W4)</td>
</tr>
<tr>
<td>FD225, FD225Wx</td>
<td>225 to 399.975</td>
<td>manual</td>
<td>200 W AMc 800 W PEP 300 W FM</td>
<td>≥0.05%</td>
<td>20 dB: ≤±0.4% 40 dB: ≤±1.0% 60 dB: ≤±4.0%</td>
<td>≤2 dB</td>
<td>T: Up to 8 (FD225W8) or even more ³) radios are combinable to one antenna</td>
</tr>
<tr>
<td>Filters with 1 x HS9043/9 per port</td>
<td>100 to 156.000</td>
<td>manual</td>
<td>50 W AMc</td>
<td>≥0.2% (k3)</td>
<td>≥14 dB: 1% (k3) × 2.0 dB (k3) ≤0.5 dB (k10)</td>
<td>S ²)</td>
<td></td>
</tr>
<tr>
<td>Filters with 1 x HS9043/0 per port</td>
<td>225 to 399.975</td>
<td>manual</td>
<td>50 W AMc 100 W FM</td>
<td>≥0.2% (k3)</td>
<td>≥17 dB: 1% (k3) × 2.0 dB (k3) ≤0.5 dB (k10)</td>
<td>S ²)</td>
<td></td>
</tr>
<tr>
<td>Filters/ Multicouplers with 1 or 2 x HS9043 per radio port</td>
<td>see above</td>
<td>manual</td>
<td>see above</td>
<td>≥0.25% (k5)</td>
<td>see above 1 x HS9043 per port: see above 2 x HS9043 per port: VHF: ≥22 dB: 1% (k5); UHF: ≥32 dB: 1% (k5)</td>
<td>see above A great variety of special filter and multicoupler combinations – with n radio ports and – with 1 or 2 cavity filters per radio port are combinable; details for project-specific solutions on request</td>
<td></td>
</tr>
</tbody>
</table>

¹) Selectivity: AM carrier
²) Additional information for filters with HS9043/9 per port
³) Additional information for filters with HS9043/0 per port
<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency Range (MHz)</th>
<th>Tuning</th>
<th>RF Input Power</th>
<th>3 dB BW (in % of f₀ or in MHz)</th>
<th>Selectivity ¹)</th>
<th>Insertion Loss (filter)</th>
<th>Remarks, Multicoupler Capability:</th>
</tr>
</thead>
<tbody>
<tr>
<td>FU214A</td>
<td>100 to 162.025</td>
<td>auto</td>
<td>50 W AMc 100 W FM</td>
<td>≤0.5 MHz</td>
<td>20 dB: ≤±2 MHz</td>
<td>≤1.5 dB (+10 to 40°C)</td>
<td>N: Filter with integrated bypass for distress channel</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35 dB: ≤±5 MHz</td>
<td>2.0 dB (-30 to +55°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40 dB: ≤±7 MHz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FD213A</td>
<td>225 to 399.975</td>
<td>auto</td>
<td>50 W AMc 100 W FM</td>
<td>≥1 MHz</td>
<td>20 dB: ≤3 MHz</td>
<td>≤1.5 dB (+10 to 40°C)</td>
<td>N: Filter with integrated bypass for distress channel</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35 dB: ≤7 MHz</td>
<td>2.0 dB (-30 to +55°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40 dB: ≤11 MHz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FD213A2</td>
<td>225 to 399.975 (2x)</td>
<td>auto</td>
<td>50 W AMc 100 W FM (per radio)</td>
<td>≥1 MHz</td>
<td>20 dB: ≤3 MHz</td>
<td>≤1.5 dB (+10 to 40°C)</td>
<td>N: Dual filter for 2 independently operating UHF radios; with integrated bypass for UHF distress channel</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35 dB: ≤7 MHz</td>
<td>2.0 dB (-30 to +55°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40 dB: ≤11 MHz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FT213A</td>
<td>100 to 162.025 and 225 to 399.975</td>
<td>auto</td>
<td>50 W AMc 100 W FM</td>
<td>VHF: ≥0.5 MHz</td>
<td>VHF: 20 dB: ≤±2 MHz</td>
<td>≤1.5 dB (+10 to 40°C)</td>
<td>N: Combined VHF/UHF filter with integrated bypass for VHF and UHF distress channels</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>UHF: ≥1 MHz</td>
<td>35 dB: ≤±5 MHz</td>
<td>≤2.0 dB (-30 to +55°C)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40 dB: ≤±7 MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>UHF: 20 dB: ≤3 MHz</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35 dB: ≤7 MHz</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40 dB: ≤11 MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FU221</td>
<td>100 to 162.025</td>
<td>auto</td>
<td>200 W AMc 800 W PEP 300 W FM</td>
<td>≥0.05%</td>
<td>20 dB: ≤±0.4%</td>
<td>≤2.0 dB (0 to +40°C)</td>
<td>S: Up to 4 radios are combinable to one antenna (FU 221W4)</td>
</tr>
<tr>
<td>FU221Wx</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40 dB: ≤±1.0%</td>
<td>≤2.5 dB (-20 to +55°C)</td>
<td>Additional 0.5 dB at ≤108 MHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>60 dB: ≤±4.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FD221</td>
<td>225 to 399.975</td>
<td>auto</td>
<td>200 W AMc 800 W PEP 300 W FM</td>
<td>≥0.05%</td>
<td>20 dB: ≤±0.4%</td>
<td>≤2.0 dB</td>
<td>S: Up to 4 radios are combinable to one antenna (FD 221W4)</td>
</tr>
<tr>
<td>FD221Wx</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40 dB: ≤±1.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>60 dB: ≤±4.0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹) Attenuation at x % frequency separation from center frequency f₀.
²) HS9043 filters have variable coupling degree (k1 to k10).
³) With lower RF input power.
⁴) Nominal value is 162.025 MHz, but operation is guaranteed up to 162.975 MHz.
VHF Filters FU220
UHF Filters FD220
VHF Multicouplers FU220W( )
UHF Multicouplers FD220W( )

- Manually tuned
- High RF power
- High selectivity
- 4 ports or less

Design and features

The filters FU220 and FD220 are made up of two coaxial resonators, fixed coupled to form a compact two-section filter plug-in. Tuning is performed manually by altering the length of the longitudinally adjustable inner conductors via a gearing common to both resonators. From the gear unit, two axles are led outward through the front panel on which the tuning knobs for coarse and fine tuning are fixed. The axles are connected each with a scale for manual tuning.

A robust and mechanically stiff layout and the use of temperature-stable INVAR (iron-nickel alloy) for filter bodies, spindles and coupling loup in connection with silver-coating guarantee the specifications

• throughout the entire temperature range and
• under 100% duty-cycle high-power operation.

Multicoupler capability

To form a multicoupler (combining filter) to operate a number of either transmitters or receivers via a single antenna only up to 4 filters can be combined via a VHF or UHF 2- or 4-way combining array for rack integration. This array consists of a starpoint and a multistage quarter-wave transformation line towards the common antenna ensuring good matching of the filter inputs to the input impedance of the antenna over the entire VHF or UHF band. The multicouplers are thus suitable for operation at any frequency in the band.

Please note:

• Two differing filter models for standalone (screw-type RF sockets) or multicoupler use (plug-in type RF sockets)
• Different filter arrangement in multicouplers for VHF (filters in horizontal position) or UHF (filters in vertical position: two upper and two lower units). The reason for this is the necessary short connection to the 2- or 4-way combining array.
• Extension models of multicouplers available, prepared by 100% for a later upgrading to 4 ports maximum. For such details please refer to ordering information.

Application example for 4-port multicoupler
Specifications

Basic specifications
- Frequency range
- RF Power Handling
- Bandwidth
- Selectivity
- Insertion loss
  see introductory «Quick type guide»

Additional specifications
Circuit design characteristics
Fixed-coupled 2-circuit (resonator) type
Input impedance (radio port)
50 Ω, VSWR ≤ 1 : 1 [0 to +40°C]
≤ 2 : 1 [-20 to +55°C]
Output impedance (antenna port)
50 Ω
RF connectors (radio or antenna port)
N-type socket

Different specifications for multicouplers
Number of inputs (radio ports)
2 to 4 depending on type and model
Maximum total RF input power
2 to 4 x 200 W AM carrier, 100% mod.
2 to 4 x 300 W FM
Maximum total RF output power
800 W AM carrier, 100% mod.; 1200 W FM
Insertion loss
FD220W2/W4
≤ 2.5 dB [20 to +55°C]
≤ 2.5 dB [0 to +40°C]
≤ 3.0 dB [20 to +55°C]
additional 0.5 dB at f ≤ 108 MHz
FU220W2/W4
≤ 2.0 : 1 [0 to +40°C]
≤ 2.5 : 1 [-20 to +55°C]
Input impedance (radio port)
50 Ω, VSWR ≤ 1.6 : 1 (0 to +40°C)
≤ 2.0 : 1 [-20 to +55°C]
Output impedance (antenna port)
50 Ω
RF connectors (radio or antenna port)
N-type socket

General data
EMC
MIL-STD-461/462
Environmental testing
VG 95332
page 22, grade 4 (-55°C)
Storage at low temperature
page 23, grade +75°C
Storage in dry heat
Operating temperature
cold testing
page 3, grade -20°C
dry heat
damp heat
page 5, grade 8 (-40°C)
Mechanical vibration
page 24, group A [10 to 55 Hz], grade 2; unit in position of use for the whole test period of 30 min
Dimensions W x H x D (in mm)
FU220
483 x 220 x 560 (seated depth)
FD220
483 x 220 x 500 (seated depth)
FD220W2 (02)
550 x 445 x 592 (rack requirement)
FD220W4 (02)
550 x 890 x 592 (rack requirement)
Weight
FU/FD220
-30 kg
FU/FD220W2 (02)
-65 kg
FU/FD220W4 (02)
-130 kg

Note: Specifications refer to filters and multicouplers, if not stated otherwise, and to nominal RF terminations (50 Ω).

Ordering Information

VHF Filter
Standard filter 1)
FD220
0636.9010.02
Spare model for multicoupler W2
FD220
0636.9010.03
Spare model for multicoupler W2 or W4
FD220
0643.2017.02
UHF 4-Port Multicoupler
Standard type, 19" 20 HU 4)
FD220W4
0643.4010.02
Special model 5)
FD220W4
0643.4010.12
UHF 3-Port Multicoupler
Special model, 19" 20 HU, extendable to 4 ports by FD220 (04) 6)
FD220W4
0643.4010.04
VHF Filter
Standard filter 1)
FU220
0635.0019.02
Spare model for multicouplers W2 or W4
FU220
0635.0019.03
UHF 2-Port Multicoupler
Extension model for W4 7)
FU220W2
0643.3013.02
UHF 4-Port Multicoupler
Standard type, 19" 10 HU
FD220W4
0643.5016.02
Special model, 19" 20 HU 7)
FD220W4
0643.5016.03
VHF 2-Port Multicoupler
Special model, 19" 20 HU, extendable to 4 ports 6)
FD220W4
0643.5016.04
VHF 3-Port Multicoupler
Special model, 19" 20 HU, extendable to 4 ports 6)
FD220W4
0643.5016.04

For multicoupler configuration examples please refer to page 15: the photo shows automatically tuned 4-port multicouplers, but manually tuned FD220W4 or FU220W4 look similar.

1) Horizontal 19" 5 HU rack plug-in with standard (screwed) RF connectors, for stand-alone filter (not multicoupler) use.
2) Vertical 1/2 19" 10 HU plug-in with plug-in type RF connectors for automatic connection with the multicoupler combining array.
3) FD220W2 (02) is consisting of two UHF Filters FD220 (03) and one UHF 2-way combining array.
4) FD220W4 (02) is consisting of two upper filter plug-ins FD220 (03) side-by-side, two lower filter plug-ins FD220 (04) side-by-side and one UHF 4-way combining array. For logistics advantage: see Note 5.
5) FD221W4 (12) can be used as special alternative to model 02: it includes 4 identical Filters FD221 (03) – putting up with 2 head-standing filters in respect of the panel description.
6) Delivered with 50 Ω terminations for empty extension port(s).
7) FU220W4 (02) is consisting of four VHF Filters FU220 (03) and one VHF 4-way combining array.

VHF/UHF Filters/Multicouplers 7

1) Horizontal 19" 5 HU rack plug-in with standard (screwed) RF connectors, for stand-alone filter (not multicoupler) use.
2) Vertical 1/2 19" 10 HU plug-in with plug-in type RF connectors for automatic connection with the multicoupler combining array.
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5) FD221W4 (12) can be used as special alternative to model 02: it includes 4 identical Filters FD221 (03) – putting up with 2 head-standing filters in respect of the panel description.
6) Delivered with 50 Ω terminations for empty extension port(s).
7) FU220W4 (02) is consisting of four VHF Filters FU220 (03) and one VHF 4-way combining array.
VHF/UHF Filters/Multicouplers

**UHF Filters FD225**
**UHF Multicouplers FD225W(.)**

- Manually tuned
- High RF power
- High selectivity
- Up to 8 or more ports

**Design and features**

The design of the FD225 corresponds in principle to that of the 2-circuit resonator filter type FD220, where the tuning is performed by alternating the length of the inner conductors, but with the essential T-coupler add-on, integrated at the left end of the 19" 5 HU filter plug-in. For the design and features of the basic 2-circuit filter details please refer to FD220.

**Multicoupler capability**

The integrated T-coupler device enables the coupling of 8 high-power (or even more medium power) transmitters to one common antenna where one single TX antenna is. More than 8 transmitters can be combined for extremely concentrated applications taking into account engineering aspects like additional insertion loss per channel, maximum output power-handling, standby concept or rack height.

Exact adjustment of each filter output to the antenna is performed manually from the filter front panel by tuning the T-coupler to minimum VSWR (shown on the TX-integrated indication). For the electrical multicoupler configuration RF cables of the filters FD225 are required only (in addition to a short circuit termination for the T-coupler of the first filter). A complete UHF 8-port Multicoupler FD225W8 eg consists of 8 filters FD225, a rack mounting kit (rugged mechanical support structure to guarantee the rack statics, matching the dimensions of the 19" rack as contracted under an extra item), a RF cable set, accessories, compilation and a protocolled subsystem test.
Specifications

Basic specifications
- Frequency range
- RF Power Handling
- Bandwidth
- Selectivity
- Insertion loss
  see introductory «Quick type guide»

Additional specifications
Circuit design characteristics
- Fixed-coupled 2-circuit (resonator) type with integrated T-coupler
- Input impedance (radio port) 50 Ω, VSWR ≤ 1.6 : 1 (0 to +40°C)
  ≤ 2.0 : 1 (−20 to +55°C)
- Valid for filters; multicouplers see below
- Output impedance (antenna port) 50 Ω
- RF connectors
  - radio port N-type socket
  - T-coupler ports (for next T-coupler or antenna) 7/16 type sockets

Different specifications for multicouplers
- Number of inputs (radio ports) 2 to 8 (or >8) depending on summarized power at the antenna port. Easy expansion capability eg from a 6-port to a 8-port multicoupler due to the modular and broadband design
- Maximum total RF output power (antenna port) 1600 W FM
- Insertion loss ≤ 2.0 dB
- Filter loss ≤ 0.1 dB per channel
- Additional loss by T-coupler
- Input impedance (radio port) 50 Ω, VSWR: ≤ 2.0 : 1 (0 to +40°C)
  ≤ 2.5 : 1 (−20 to +55°C)

General data
- EMC MILSTD-461/462
- Environmental testing VG 95332
- Storage at low temperature page 22, grade 4 (−55°C) page 23, grade −15°C
- Storage in dry heat page 3, grade 6 (−30°C)
- Operating temperature cool testing dry heat
- damp heat
- Mechanical vibration
- Dimensions (FD225) W x H x D 483 mm x 220 mm x 500 mm (seated depth), 19" 5 HU plug-in
- Weight (FD225) 30 kg

Note: Specifications refer to filters and multicouplers, if not stated otherwise, and nominal RF terminations (50 Ω).

Ordering Information
- **UHF Filter**
  - Spare/extension model for multicouplers FD225 6004.4009.02
  - UHF 8-port Multicoupler Standard type FD225W8 6004.6301.02
- **UHF n-port Multicoupler**
  - Standard type with n ports on request FD 225W( .)
  - For n=2, 3 and 4 compare also the starpoint multicouplers FD220W2 and W4.
The cavity filters HS9043 are proven »working horses« and used already over decades of years with unbroken actuality. Their

- excellent mechanical precision
- versatility in use for multi-port filters or multicouplers
- reasonable size and
- good price/performance ratio

make these filters very attractive. They are applied to single-channel systems where both, medium power handling and medium selectivity, are sufficient. For more stringent requirements, however, the filters FD/FU220 or FD225 are unbeatable to overcome co-site conditions requiring highest selectivity and/or in connection with high RF power rating.

There are 2 basic types: the VHF Filter HS9043/9... and the UHF Filter HS9043/0... which are equal in design and function principle, they only differ in specifications and dimensions. The expression »HS9043« is standing for both types.

The HS9043 is cylinder-shaped and designed as coaxial resonant-line circuit with an inner and outer conductor. Between the free end of the inner conductor and the outer conductor is – in axle direction – a variable capacitance which is designed like a coaxial tubular capacitor with contact springs to the outer conductor. By tuning the spindle with the scale knob one can vary the sunken depth of the capacitor along its longitudinal axis and adjust to the wanted resonance frequency. The input and output coupling is made with variable coupling loops which can be rotated separately to vary the coupling degree (k) and thus the selectivity of the filter.

Special filter and multicoupler capability

The HS9043 can be configured to

- special filter types, eg
  - with 3-ports for 3 radios and 3 antennas or
  - with 2 filters per port (double-section filter) to increase the selectivity
- starpoint-type multicouplers.

The corresponding number of cavity filters HS9043 is assembled together with a mechanical slide-in unit, special coaxial 2-, 4- or 8-way starpoints, RF cables, transformation stages etc. to form a compact 19” plug-in for rack integration.
Specifications

Basic specifications
- Frequency range
- RF Power Handling
- Bandwidth
- Selectivity
- Insertion loss
see introductory »Quick type guide«

Additional specifications
Circuit design characteristics Variable-coupled cavity resonator type filters
Input and output coupling degree manually settable for both: k £ 10
Input impedance (radio port) 50 W, VSWR:
of a single-section filter £ 1.1 : 1 (f_o)
£ 2.0 : 1 (f_o – 0.1% at coupling degree k5), valid for filters; multicouplers see below
Input impedance (radio port) 50 W, VSWR:
of a double-section filter £ 1.2 : 1 (f_o)
£ 1.5 : 1 (f_o – 100 kHz)
Output impedance (antenna port) 50 W
RF connectors (radio or antenna port) N-type socket
Effect of temperature £ 3 kHz/°C
Maximum ambient temperature + 55°C

Different specifications for multicouplers
Number of inputs (radio ports) Up to 8 depending on type and model
Total RF input power Up to 8 x 50 W AM carrier, 100% mod. (VHF)
Up to 8 x 30 W AM carrier, 100% mod. (UHF)
Insertion loss Depending on project-specific filter settings

General data
Max. operating temperature + 55°C
Dimensions W x H x D (in mm)
HS9043/9 [VHF] 148 x 446 (diameter x length)
HS9043/0 [UHF] 148 x 290 (diameter x length)
VHF Filter or multicoupler with 3 x HS9043/9, 19" 4 HU rack plug-in 483 x 177 x 446
UHF Filter or multicoupler with 3 x HS9043/0, 19" 4 HU rack plug-in 483 x 177 x 446
Filter/multicoupler configurations with n x HS9043
n = 4 to 6: 19" 8 HU
n = 7 to 9: 19" 12 HU
Weight HS9043/9 [VHF] –7 kg
HS9043/0 [UHF] –7 kg

Note: Specifications refer to filters and multicouplers, if not stated otherwise, and to nominal RF terminations [50 W].

Ordering Information
VHF Cavity Type Filter
HS9043/9 0138.5746.02
UHF Cavity Type Filter
HS9043/0 0156.5738.02
VHF Filter and Combiners, configuration examples
19" plugin assemblies with several ports
VHF 1-Port Filter
1 x HS9043/9 FU432W1 0712.4602.05
VHF 2-Port Filter
1 x HS9043/9 per port FU256 0682.7016.02
VHF 2-Port Filter
2 x HS9043/9 per port FU255 0679.8815.02
UHF Filter and Combiners, configuration examples
19" 4 HU rack plug-in
UHF 1-Port Filter
1 x HS9043/0 FD256 0682.7216.11
UHF 2-Port Filter
1 x HS9043/0 per port FD256 0682.7216.02
UHF 3-Port Filter
1 x HS9043/0 per port FD256 0682.7216.13
UHF 2-Port Filter
2 x HS9043/0 per port FD255 0679.8515.02
UHF 3-Port Filter
1 x HS9043/0 per port FD432W4 0745.6504.02
UHF 4-Port Multicoupler
1 x HS9043/0 per port FD432W4 0745.6504.03
UHF 4-Port Multicoupler
1 x HS9043/0 per port FD432W4 0745.6504.04
etc. further types TBD
Design and features

This filter series has outstanding features such as:
- Compact 19" 3 HU design
- Combined VHF/UHF type available
- Integrated bypass for receiving the VHF, UHF or both distress frequencies

A combined VHF/UHF Filter FT213A eg includes per frequency range two capacitively tuned coaxial resonators to form a two-section filter for the operating frequency. Tuning is carried out by means of a common axle which is driven and controlled by a microprocessor-controlled stepping motor by way of a gearing. Following a frequency change input from the radio, the filter tuning axle is first driven to the normal start (HOME) position. It is then moved to an angular position corresponding to the new frequency. The tuning is supported by a sophisticated and optically assisted motor control. If the frequency change is less than 100 kHz, retuning does not take place. The emission of RF power during the automatic tuning process is prohibited.

From the gear unit, an additional axle is led outward on which a manual tuning knob can be fixed in the event of automatic tuning failure, supported by the integrated scales and tuning control meter.

The robust design and the use of selected temperature-stable materials and low-loss (silver-coated) surfaces guarantee the specifications:
- throughout the entire temperature range and
- under 100% duty-cycle operation.

The control cable between filter and radio unit provides the operating DC voltage as well as necessary frequency and other control information.

Bypass and mobile benefits

The 121.5 MHz bypass or 243 MHz bypass (VHF or UHF guard receiver bypasses) bridges the guard frequency across to the receiver by active extraction. During transmit operation the bypass is disabled electronically by means of control information from the radio. Thus distress channel reception is possible automatically without any manipulations.
Specifications

Basic specifications
- Frequency range
- RF Power Handling
- Bandwidth
- Selectivity
- Insertion loss
see introductory «Quick type guide»

Additional specifications

Circuit design characteristics
Fixed-coupled 2-circuit (resonator) type
Input impedance (radio port)
50 Ω, VSWR:
≤ 1.6 : 1 (+10 to +40°C)
≤ 2.0 : 1 (+30 to +55°C)
Valid for filters; multicouplers see below
Output impedance (antenna port)
50 Ω
RF connectors
N-type sockets
Tuning control
Interface control from the radio via the optional Series 400U Filter/PA Interface GI414U or Series 200 multi-channel radios
Code
BCD, TTL positive logic
Start
Automatic start by change of BCD information
Power supply
Interface DC supply from radio via GI414U (see above)
Voltage
28 (+2/-6) VDC, negative to ground
Current during tuning
≤ 2.0 A
Quiescent current
≤ 0.7 A

Bypass filter characteristics and mutual influences

Insertion loss
≤ 1 dB
Additional attenuation of bypass filter by main filter (with frequencies close together)
≤ 10 dB for worst cases [details on request]
Additional attenuation of main filter by bypass filter (with frequencies close together)
≤ 10 dB for worst cases [details on request]
Attenuation in stop band
at ≥8 MHz from 243.0 MHz
> 30 dB
at ≥4 MHz from 121.5 MHz
> 30 dB
Isolation
> 50 dB

General data

EMC
MILSTD-461/462
Environmental testing
VG 95332
Storage at low temperature
page 22, grade 4 (−55°C)
Storage in dry heat
page 23, grade −75°C
Operating temperature
cold testing
dry heat
damp heat
Mechanical vibration

Dimensions W x H x D (in mm)
for standard models (19" 3 HU)
485 x 132 x 450 (seated depth)
485 x 200 x 450
for shockmount models
Weight for standard models
FT213A
– 18 kg
FD213A
– 11 kg
FD213A2
– 18 kg
FU214A
– 15 kg
Weight for shockmount models, in addition
– 4.5 kg

Note: Specifications refer to filters and multicouplers, if not stated otherwise, and to nominal RF terminations (50 Ω).

Ordering information

UHF Filter
FD213A
0637.4311.05
UHF Filter (2 x UHF)
FD213A2
0632.5815.05
VHF Filter
FU214A
0637.4611.05
VHF/UHF Filter
FT213A
0637.4011.05
Standard models for 19" rack installation
Control Cable
FU214Z1
0637.4811.09
2 m with 37-pin D-SUB and MIL connectors
VHF Filters FU221
UHF Filters FD221
VHF Multicouplers FU221W( )
UHF Multicouplers FD221W( )

- Automatically tuned
- High RF power
- High selectivity
- 4 ports or less

Design and features

The Filters FU221 and FD221 are made up of two coaxial resonators, fixed coupled to form a compact two-section filter plug-in. Tuning is performed manually by altering the length of the longitudinally adjustable inner conductors via a gearing common to both resonators.

The gear is driven by a microprocessor-controlled stepping motor. Following a frequency change input from the radio, the inner conductors of the cavity resonators are first driven to their start (HOME) position in mechanic mid-position. Subsequently, the automatic tuning is continued by counting the frequency-specific definite angle of rotation of the stepping motor which is supported by a sophisticated and optically assisted motor control and electronically stored frequency characteristic and built-in tests. Two light barriers prevent the filters from moving against the two stops. From the gear unit, an additional axle is led outward on which a manual tuning knob can be fixed in the event of automatic tuning failure.

A robust and mechanically stiff layout and the use of temperature-stable INVAR (iron-nickel alloy) for filter bodies, spindles and coupling loup in connection with silver-coating guarantee the specifications

- throughout the entire temperature range and
- under 100% duty-cycle high-power operation.

The control cable between filter and the radio unit provides the operating DC voltage as well as necessary frequency and other control information.
Multicoupler capability

To form a multicoupler (combining filter) to operate a number of either transmitters or receivers via a single antenna only up to 4 filters can be combined via a VHF or UHF 2- or 4-way combining array for rack integration. This array consists of a starpoint and a multistage quarter-wave transformation line towards the common antenna ensuring good matching of the filter inputs to the input impedance of the antenna over the entire VHF or UHF band. The multicouplers are thus suitable for operation at any frequency in the band.

Please note:
- Two differing filter models for standalone (screw-type RF sockets) or multicoupler use (plug-in type RF sockets)
- Different filter arrangement in multicouplers for VHF (filters in horizontal position) or UHF (filters in vertical position: two upper and two lower units). The reason for this is the necessary short connection to the 2- or 4-way combining array.
- Extension models of multicouplers available, prepared by 100% for a later upgrading to 4 ports maximum. For such details please refer to ordering information.

Specifications

Basic specifications
- Frequency range
- RF Power Handling
- Bandwidth
- Selectivity
- Insertion loss
see introductory «Quick type guide»

Additional specifications
- Circuit design characteristics: Fixed-coupled 2-circuit (resonator) type
- Input impedance (radio port): 50 Ω, VSWR:
  - ≤1.6:1 [0 to +40°C]
  - ≤2.0:1 [-20 to +55°C]
- Output impedance (antenna port): 50 Ω

VHF/UHF radio station with Series 400 multi-channel transmitters and 4-port Multicouplers FU221W4 (VHF, right) and FD221W4 (UHF, left)
**Ordering Information**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FD221</td>
<td>UHF Filter</td>
</tr>
<tr>
<td>FU221W2</td>
<td>Spare model for multicoupler W2</td>
</tr>
<tr>
<td>FD221W4</td>
<td>UHF 4-Port Multicoupler</td>
</tr>
<tr>
<td>FD221W2</td>
<td>UHF 2-Port Multicoupler</td>
</tr>
<tr>
<td>FD221W3</td>
<td>UHF 3-Port Multicoupler</td>
</tr>
<tr>
<td>FU221</td>
<td>VHF Filter</td>
</tr>
<tr>
<td>FU221W4</td>
<td>Spare model for W2 or W4</td>
</tr>
<tr>
<td>FU221W2</td>
<td>VHF 2-Port Multicoupler</td>
</tr>
<tr>
<td>FD221W6</td>
<td>VHF 4-Port Multicoupler</td>
</tr>
<tr>
<td>FU221W6</td>
<td>VHF 2-Port Multicoupler</td>
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<tr>
<td>FU221W4</td>
<td>VHF 3-Port Multicoupler</td>
</tr>
<tr>
<td>FU221W5</td>
<td>VHF 4-Port Multicoupler</td>
</tr>
</tbody>
</table>

**General Data**

- **EMC:** MIL-STD-461/462
- **Environmental testing:** VG 95332
- **Storage at low temperature:** page 22, grade 4 (-55°C)
- **Storage in dry heat:** page 23, grade +75°C
- **Operating temperature:** page 2, 4 to 300 W FM
- **Antenna ports:**
  - **Insertion loss:**
    - FD221W2/W4: ≤2.5 dB (-20 to +55°C)
    - FU221W2/W4: ≤2.5 dB (-20 to +55°C)
    - Additional 0.5 dB at f = 108 MHz
- **Input impedance (radio port):** 50 Ω, VSWR ≤2:1 (0 to +40°C), ≤2:5:1 (20 to +55°C)
- **Mechanical vibration:** page 24, group A (10 to 55 Hz), grade 2, unit in position of use for the whole test period of 30 min
- **Dimensions W x H x D (in mm):**
  - FD221: 483 x 220 x 560 (sealed depth)
  - FU/DF221W2/02: 483 x 220 x 500 (sealed depth)
  - FU/DF221W1/02: 550 x 445 x 392 (rack requirement)
  - FU/DF221W1/02: 550 x 890 x 392 (rack requirement)
- **Weight:**
  - FU/DF221: ~30 kg
  - FU/DF221W2/02: ~65 kg
  - FU/DF221W1/02: ~130 kg

**Note:** Specifications refer to filters and multicouplers, if not stated otherwise, and to nominal RF terminations (50 Ω).