Wireless Indoor Solutions
Application Examples
The most RF broadband passive distributed antenna system (DAS)

- CELLFLEX and CELLFLEX LITE low loss feeder cables
- High performance RADIAFLEX radiating cables
- Broadband and ultra-broadband indoor antennas
- Broadband and ultra-broadband, low insertion loss, indoor passive RF components (couplers, splitters)
In-building coverage solutions for building scenarios - DAS

ボール in class coverage systems for commercial and for mission critical multi-carrier / multi-service applications of building scenarios
In-building coverage solutions for building scenarios - DAS

ClearFill Line
Cables, antennas, components

All kind of building scenarios, e.g.
- Small, mid-size and large buildings
- Office buildings
- Hotels
- Industrial plants
- Campus areas,
- Hospitals
- Airports
- Mines
- Ships
- Vessels

Ultra – wideband solutions for all kind of services, frequencies, e.g.
- FM
- VHF
- UHF
- TETRA
- GSM900, GSM1800, UMTS, LTE
- CDMA
- WLAN 2.4 GHz and 5 GHz
- WiMAX

FUTURE – PROOF SOLUTION!
In-building coverage solutions for building scenarios - DAS

Typical In-building scenario for cellular services GSM900 / GSM1800 / UMTS
Solution by use of dedicated Antennas

Single and/or multiple Operators possible

For multiple Operators / multiband application please note
RFS Broadband Coupler series BBC44*

Wide variety of
- Diplexers
- Triplexers
- Multiband / Broadband Combiner
- Splitters (Reactive and Wilkinson)
- Directional couplers
- Tappers available

Trilexer MBCS-9/18/21
900/1800/2100 MHz

to DAS

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In-building coverage solutions for building scenarios - DAS

Typical In-building scenario for cellular services GSM900 / GSM1800 / UMTS
Solution by use of dedicated Antennas

2-way, 3-way and 4-way splitters for equal splitting

Directional couplers (coupling values 5dB, 6dB, 7dB, 8dB, 10dB, 15dB, 20dB, 30dB) for unequal splitting to compensate feeder cable loss at higher floors

RF distribution via Coaxial Feeder cable, e.g. CELLFLEX cable LCF 12-50 JFN
Other types (LCF78-50JFNA, LCF114-50JFNA) can be used for loss reduction

Broadband and Ultra-broadband omnidirectional and directional antennas available
(e.g. 800 MHz-2700 MHz
698 MHz – 2700 MHz
350 MHz – 6000 MHz)

from/to Triplexer / RF source (BTS, OAR, etc)
In-building coverage solutions for building scenarios - DAS

Typical In-building scenario for cellular services GSM900 / GSM1800 / UMTS
Solution by use of dedicated Antennas

Basic Indoor Link Budget

- Coverage for 50 by 50 meters
- 1, 2 or 4 antenna set-up
- 1 antenna for open space
- 2 antenna for moderate dense
- 4 antenna for heavy dense

<table>
<thead>
<tr>
<th>No of antennas per building block</th>
<th>1</th>
<th>2</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Level @ Building Block Input [dBm]</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>2 Way Power Splitter Loss [dB]</td>
<td>-3.5</td>
<td>-7</td>
<td></td>
</tr>
<tr>
<td>4 Way Power Splitter Loss [dB]</td>
<td>-2.7</td>
<td>-4.04</td>
<td>-5.4</td>
</tr>
<tr>
<td>LCF12-50JFN, 25m, Loss [dB]</td>
<td>-2.7</td>
<td>-4.04</td>
<td>-5.4</td>
</tr>
<tr>
<td>LCF12-50JFN, 37.5m, Loss [dB]</td>
<td>-2.7</td>
<td>-4.04</td>
<td>-5.4</td>
</tr>
<tr>
<td>LCF12-50JFN, 50m, Loss [dB]</td>
<td>-2.7</td>
<td>-4.04</td>
<td>-5.4</td>
</tr>
<tr>
<td>Antenna feeding power level [dBm]</td>
<td>7.3</td>
<td>2.5</td>
<td>-2.4</td>
</tr>
</tbody>
</table>

Common Pathloss Model

| Antenna Gain [dBi] | 2 | 2 | 2 |
| Path Loss for 35m (LOS), [dB] | -70 | 2 | 2 |
| Path Loss for 28m (LOS), [dB] | -68 | 2 | 2 |
| Path Loss for 18m (LOS), [dB] | -64 | 2 | 2 |
| Reflection Fading Margin [dB] | -6 | -6 | -6 |
| Wall loss inside building block [dB] | -20 | -10 | 0 |

Predicted Reception Level @ Mobile [dBm]

-86.7 | -79.5 | -70.4

Typical attenuation values

<table>
<thead>
<tr>
<th>Type of Material</th>
<th>Attenuation [dB] @ 900MHz</th>
<th>Attenuation [dB] @ 1850MHz</th>
<th>Attenuation [dB] @ 2400MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basement or foundation wall</td>
<td>13</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Brick, concrete and concrete block</td>
<td>13</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Cubicle wall</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
</tr>
<tr>
<td>Drywall or sheetrock</td>
<td>2</td>
<td>2.5</td>
<td>3</td>
</tr>
<tr>
<td>Elevator or metallic obstacle</td>
<td>5</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Glass door or window, no tint</td>
<td>2</td>
<td>2.5</td>
<td>3</td>
</tr>
<tr>
<td>Metallic rack</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Wooden door</td>
<td>2</td>
<td>2.5</td>
<td>3</td>
</tr>
</tbody>
</table>

(source: Wireless Valley)
Typical In-building scenario for cellular services GSM900 / GSM1800 / UMTS
Solution by use of RADIAFLEX® Radiating cables

Single and/or multiple Operators possible

Triplexer MBCS-9/18/21
900/1800/2100 MHz

to DAS – Radiating cable

Wide variety of
- Diplexers
- Triplexers
- Multiband / Broadband Combiner
- Splitters (Reactive and Wilkinson)
- Directional couplers
- Tappers available

For multiple Operators / multiband application please note
RFS Broadband Coupler series
BBC44*

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In-building coverage solutions for building scenarios - DAS

Typical In-building scenario for cellular services GSM900 / GSM1800 / UMTS
Solution by use of RADIAFLEX® Radiating cables
In-building coverage solutions for building scenarios - DAS

Typical In-building scenario for cellular services GSM900 / GSM1800 / UMTS
Solution by use of RADIAFLEX® Radiating cables

**Antennas (Omni- and/or Panel) can be used in combination with the RADIAFLEX cable**

**RF distribution via Coaxial Feeder cable, e.g. CELLFLEX cable LCF 12-50 JFN**
Other types (LCF78-50JFNA, LCFS114-50JFNA) can be used for loss reduction

2-way, 3-way and 4-way splitters for equal splitting

**Directional couplers (coupling values 5dB, 6dB, 7dB, 8dB, 10dB, 15dB, 20dB, 30dB) for unequal splitting to compensate feeder cable loss at higher floors**

**RADIAFLEX® Radiating cables** operate as dedicated antennas, providing a homogenous, equal coverage along the cable run and are RF broadband. Therefore, they are highly applicable for coverage extension in confined areas.

For in-building applications, our RADIAFLEX cable types RLKW12-50; RLKW78-50, RLKU12-50, RLKU78-50, RCF12-50, RCF78-50 and RLKD12-50 are the best suitable selection.
## RADIAFLEX® Radiating Cables – Basic Link Budget UMTS

<table>
<thead>
<tr>
<th>Component</th>
<th>Loss Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Output Power (CPICH) per channel</td>
<td>+ 20 dBm</td>
</tr>
<tr>
<td>Triplexer loss</td>
<td>- 1.3 dB</td>
</tr>
<tr>
<td>Directional coupler (6 dB)</td>
<td>- 6.5 dB</td>
</tr>
<tr>
<td>2-way Splitter</td>
<td>- 3.5 dB</td>
</tr>
<tr>
<td>Feeder Cable Loss</td>
<td>- 1.5 dB</td>
</tr>
<tr>
<td>Input Power at beginning of Radiating cable</td>
<td>+ 7.2 dBm</td>
</tr>
</tbody>
</table>

As per data sheet (RLKU78-50JFNA):

- Longitudinal loss per 100 m = 10 dB
- Consequently at 100 m System Length -10 dB
- Coupling Loss in 2 m distance (95%): - 69 dB
- Received signal strength level (CPICH) @ 2m distance: - 71.8 dBm
In-building coverage solutions for building scenarios - DAS

Typical In-building scenario for mission critical services TETRA 400 MHz
Solution by use of RADIAFLEX® Radiating cables

Single and/or multiple Operators

TETRA
BTS / OAR

to DAS – Radiating cable
In-building coverage solutions for building scenarios - DAS

Typical in-building scenario for mission critical services TETRA 400 MHz
Solution by use of RADIAFLEX® Radiating cables
In-building coverage solutions for building scenarios - DAS

Typical In-building scenario for mission critical services TETRA 400 MHz
Solution by use of RADIAFLEX® Radiating cables

Directional couplers (coupling values 5dB, 6dB, 7dB, 8dB, 10dB, 15dB, 20dB, 30dB) for unequal splitting to compensate feeder cable loss at higher floors

RF distribution via Coaxial Feeder cable, e.g. CELLFLEX cable LCF 12-50 JFN
Other types (LCF78-50JFNA, LCFS114-50JFNA) can be used for loss reduction

Antennas (Omni- and/or Panel) can be used in combination with the RADIAFLEX cable

2-way, 3-way and 4-way splitters for equal splitting

RADIAFLEX®- Radiating cables operate as dedicated antennas, providing a homogenous, equal coverage along the cable run and are RF broadband. Therefore, they are highly applicable for coverage extension in confined areas.

For In-building applications, our RADIAFLEX cable types RLK / RLKW12-50; RLK / RLKW78-50, RLKU12-50, RLKU78-50, RCF12-50, RCF78-50 and RLKD12-50 are the best suitable selection.

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RADIAFLEX® Radiating Cables – Basic Link Budget 400 MHz

RF Output Power per channel: + 30 dBm
Directional coupler (6 dB): - 6.5 dB
2-way Splitter: - 3.5 dB
Feeder Cable Loss: - 0.5 dB
Input Power at beginning of the Radiating cable: + 19.5 dBm

As per data sheet (RLK78-50JFLA):
Longitudinal loss per 100 m = 2,7 dB
Consequently at 100 m System Length - 2,7 dB
Coupling Loss in 2 m distance (95%): - 59 dB

Received signal strength level @ 2m distance: - 42,2 dBm
In-building coverage solutions for building scenarios - DAS

Typical In-building scenario for cellular services GSM900 / GSM1800 / UMTS
Solution by use of RADIAFLEX® Radiating cables

**RADIAFLEX® Radiating Cables, selected items for In-building scenarios**

**RLK series:**

For applications in tunnels and buildings where low coupling loss variations are required.

- RLK12-50JFNA (JFLA), up to 980 MHz
- RLK78-50JFNA (JFLA), up to 980 MHz
- RLKW12-50JFNA (JFLA), up to 1950 MHz
- RLKW78-50JFNA (JFLA), up to 1950 MHz
- RLKU12-50JFNA (JFLA), up to 2700 MHz
- RLKU78-50JFNA (JFLA), up to 2700 MHz
- RLKD12-50JFNA (JFLA), up to 6000 MHz
In-building coverage solutions for building scenarios - DAS

Typical In-building scenario for cellular services GSM900 / GSM1800 / UMTS
Solution by use of RADIAFLEX® Radiating cables

RADIAFLEX® Radiating Cables, selected items for In-building scenarios

RCF series:

For applications where particularly small bending radii are required for heavy-duty applications (e.g. mines, ships, vessels).

RCF12-50JFN (JFL), up to 6000 MHz
RCF78-50JFNA (JFLA), up to 2650 MHz
RSF12-50JFN (JFL), up to 6000 MHz

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In-building coverage solutions for building scenarios - DAS

Typical In-building scenario for cellular services GSM900 / GSM1800 / UMTS
Solution by use of RADIAFLEX® Radiating cables

RADIAFLEX® Radiating Cables, selected items for In-building scenarios

<table>
<thead>
<tr>
<th>Description</th>
<th>RFS Model-Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>RADIAFLEX-cable 1/2&quot; RLK* - series (foil cable) and accessories for In-building scenarios</td>
<td></td>
</tr>
<tr>
<td>Radiaflex® cable 1/2&quot;, RLK / RLKW-series</td>
<td>RLK12-50JFLA / RLKW12-50JFLA</td>
</tr>
<tr>
<td>Radiaflex® cable 1/2&quot;, RLKU-series</td>
<td>RLKU12-50JFLA</td>
</tr>
<tr>
<td>Connector N-female</td>
<td>NF-RA12-012</td>
</tr>
<tr>
<td>Connector N-male</td>
<td>NM-RA12-011</td>
</tr>
<tr>
<td>Round base, 80 mm, flame retardant</td>
<td>RB-80-4</td>
</tr>
<tr>
<td>Clic-clamp, flame retardant, for 1/2&quot; cables</td>
<td>CC-12-2</td>
</tr>
<tr>
<td>Nylon plug, 6 x 30 mm</td>
<td>PLUG-6-1</td>
</tr>
<tr>
<td>Screw 4.5 x 125 mm, for plastic plug</td>
<td>SC-45125-2</td>
</tr>
<tr>
<td>Terminating resistance, N-male, 1 W</td>
<td>N-TER-01</td>
</tr>
</tbody>
</table>

RADIAFLEX-cable 7/8" RLK* - series (foil cable) and accessories for In-building scenarios

<table>
<thead>
<tr>
<th>Description</th>
<th>RFS Model-Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiaflex® cable 7/8&quot;, RLK / RLKW-series</td>
<td>RLK78-50JFLA / RLKW78-50JFLA</td>
</tr>
<tr>
<td>Radiaflex® cable 7/8&quot;, RLKU-series</td>
<td>RLKU78-50JFLA</td>
</tr>
<tr>
<td>Connector 716-female</td>
<td>NF-RA78-016</td>
</tr>
<tr>
<td>Connector 716-male</td>
<td>716F-RA78-016</td>
</tr>
<tr>
<td>Round base, 80 mm, flame retardant</td>
<td>RB-80-4</td>
</tr>
<tr>
<td>Clic-clamp, flame retardant, for 7/8&quot; cables</td>
<td>CC-78-2</td>
</tr>
<tr>
<td>Nylon plug, 6 x 30 mm</td>
<td>PLUG-6-1</td>
</tr>
<tr>
<td>Screw 4.5 x 125 mm, for plastic plug</td>
<td>SC-45125-2</td>
</tr>
<tr>
<td>Terminating resistance, N-male, 1 W</td>
<td>N-TER-01</td>
</tr>
</tbody>
</table>
**RADIAFLEX® Radiating Cables, selected items for In-building scenarios**

<table>
<thead>
<tr>
<th>Description</th>
<th>RFS Model-Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RADIAFLEX-cable 1/2&quot; RCF®</strong> - series (corrugated cable) and accessories for In-building scenarios</td>
<td></td>
</tr>
<tr>
<td>Radiaflex® cable 1/2&quot;, RCF-series</td>
<td>RCF12-50JFN</td>
</tr>
<tr>
<td>Connector 7/16 male for RCF12-50</td>
<td>716M-LCF12-D01</td>
</tr>
<tr>
<td>Connector N male for RCF12-50</td>
<td>NM-LCF12-D01</td>
</tr>
<tr>
<td>Round base, 50 mm, flame retardant</td>
<td>RB-50-4</td>
</tr>
<tr>
<td>Clic-clamp, flame retardant, for 1/2&quot; cables</td>
<td>CC-12-2</td>
</tr>
<tr>
<td>Nylon plug, 6 x 30 mm</td>
<td>PLUG-6-1</td>
</tr>
<tr>
<td>Screw, 4.5 x 95 mm, for plastic plug</td>
<td>SC-45195-1</td>
</tr>
<tr>
<td>Terminating resistance, N-male, 1 W</td>
<td>N-TER-01</td>
</tr>
<tr>
<td><strong>RADIAFLEX-cable 7/8&quot; RCF®</strong> - series (corrugated cable) and accessories for In-building scenarios</td>
<td></td>
</tr>
<tr>
<td>Radiaflex® cable 7/8&quot;, RCF-series</td>
<td>RCF78-50JFNA</td>
</tr>
<tr>
<td>Connector 7/16 male for RCF78-50</td>
<td>716M-LCF78-D01</td>
</tr>
<tr>
<td>Connector N male for RCF78-50</td>
<td>NM-LCF78-D01</td>
</tr>
<tr>
<td>Round base, 50 mm, flame retardant</td>
<td>RB-50-4</td>
</tr>
<tr>
<td>Clic-clamp, flame retardant, for 7/8&quot; cables</td>
<td>CC-78-2</td>
</tr>
<tr>
<td>Nylon plug, 6 x 30 mm</td>
<td>PLUG-6-1</td>
</tr>
<tr>
<td>Screw, 4.5 x 95 mm, for plastic plug</td>
<td>SC-45195-1</td>
</tr>
<tr>
<td>Terminating resistance, N-male, 1 W</td>
<td>N-TER-01</td>
</tr>
</tbody>
</table>
In-building coverage solutions for building scenarios - DAS

Typical In-building scenario for cellular services GSM900 / GSM1800 / UMTS
Solution by use of RADIAFLEX® Radiating cables

More details for RADIAFLEX® Radiating Cables and accessories can be found in the chapter Coverage solutions for tunnels.
Coverage solutions for Tunnel scenarios

Best in class coverage systems for commercial and for mission critical multi-carrier / multi-service applications of metro, rail and road tunnels
Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX®- Radiating cables operate as dedicated antennas, providing a homogenous, equal coverage along the cable run and are RF broadband. Therefore, they are highly applicable for coverage extension in train tunnels, metros, road tunnels, station areas, etc.

Coaxial Feeder cables, e.g. CELLFLEX cable LCF 12-50 JFN.
Other types (LCF78-50JFNA, LCFS114-50JFNA; LCF158-50JFNA) can be used for loss reduction.
**Coverage solutions for Tunnel scenarios**

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables – Link budget

<table>
<thead>
<tr>
<th>Commercial Services</th>
<th>Downlink / Tunnel</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>GSM-R</strong></td>
<td><strong>PMR (TETRA)</strong></td>
<td></td>
</tr>
<tr>
<td>Output power level at RU per Carrier, composite</td>
<td>37.0 dBm</td>
<td>37.0 dBm</td>
<td></td>
</tr>
<tr>
<td># of carriers</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Pilot Power Level</td>
<td>0.0 dB</td>
<td>0.0 dB</td>
<td></td>
</tr>
<tr>
<td>Jumper Loss, LCF12-50, 2m</td>
<td>-0.2 dB</td>
<td>-0.1 dB</td>
<td></td>
</tr>
<tr>
<td>Jumper Loss, LCF78-50, 80m</td>
<td>-3.0 dB</td>
<td>-2.2 dB</td>
<td></td>
</tr>
<tr>
<td>DC Block RF Loss</td>
<td>-0.2 dB</td>
<td>-0.2 dB</td>
<td></td>
</tr>
<tr>
<td>Jumper Loss, LCF12-50, 2m</td>
<td>-0.2 dB</td>
<td>-0.1 dB</td>
<td></td>
</tr>
<tr>
<td>Splitter Loss, 1:4</td>
<td>-6.5 dB</td>
<td>-6.5 dB</td>
<td></td>
</tr>
<tr>
<td>Input Power Level at radiating cable per carrier</td>
<td>20.9 dBm</td>
<td>21.9 dBm</td>
<td></td>
</tr>
<tr>
<td>Radiating Cable RAY114-50JFLA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of radiating cable section (maximum!)</td>
<td>500.0 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longitudinal Loss per 100m</td>
<td>3.8 dB</td>
<td>1.9 dB</td>
<td></td>
</tr>
<tr>
<td>Total longitudinal loss</td>
<td>19.0 dB</td>
<td>9.5 dB</td>
<td></td>
</tr>
<tr>
<td>Coupling Loss (95% value)</td>
<td>65.0 dB</td>
<td>70.0 dB</td>
<td></td>
</tr>
<tr>
<td>Fading margin</td>
<td>6.0 dB</td>
<td>6.0 dB</td>
<td></td>
</tr>
<tr>
<td>Reception power level outside train</td>
<td>-66.1 dBm</td>
<td>-63.6 dBm</td>
<td></td>
</tr>
<tr>
<td>Target reception power level</td>
<td>-85.0 dBm</td>
<td>-85.0 dBm</td>
<td></td>
</tr>
<tr>
<td>Margin to design requirements</td>
<td>15.9 dB</td>
<td>21.4 dB</td>
<td></td>
</tr>
</tbody>
</table>
### Coverage solutions for Tunnel scenarios

**Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables – Link budget**

<table>
<thead>
<tr>
<th>Commercial Services</th>
<th>GSM900</th>
<th>GSM1800</th>
<th>UMTS2100</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Downlink / Tunnel</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output power level at RU per Carrier, composite</td>
<td>37.0 dBm</td>
<td>37.0 dBm</td>
<td>40.0 dBm</td>
</tr>
<tr>
<td># of carriers</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Pilot Power Level</td>
<td>0.0 dB</td>
<td>0.0 dB</td>
<td>-10.0 dB</td>
</tr>
<tr>
<td>Jumper Loss, LCF12-50, 2m</td>
<td>-0.2 dB</td>
<td>-0.2 dB</td>
<td>-0.3 dB</td>
</tr>
<tr>
<td>Jumper Loss, LCF78-50, 80m</td>
<td>-3.0 dB</td>
<td>-3.0 dB</td>
<td>-5.6 dB</td>
</tr>
<tr>
<td>DC Block RF Loss</td>
<td>-0.2 dB</td>
<td>-0.2 dB</td>
<td>-0.2 dB</td>
</tr>
<tr>
<td>Jumper Loss, LCF12-50, 2m</td>
<td>-0.2 dB</td>
<td>-0.2 dB</td>
<td>-0.3 dB</td>
</tr>
<tr>
<td>Splitter Loss, 1:4</td>
<td>-6.5 dB</td>
<td>-6.5 dB</td>
<td>-6.5 dB</td>
</tr>
<tr>
<td><strong>Input Power Level at radiating cable per carrier</strong></td>
<td>17.9 dBm</td>
<td>17.9 dBm</td>
<td>8.1 dBm</td>
</tr>
<tr>
<td><strong>Radiating Cable RAYS158-50JFLA</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of radiating cable section (maximum!)</td>
<td>250.0 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longitudinal Loss per 100m</td>
<td>2.8 dB</td>
<td>3.9 dB</td>
<td>4.3 dB</td>
</tr>
<tr>
<td>Total longitudinal loss</td>
<td>7.0 dB</td>
<td>9.8 dB</td>
<td>10.8 dB</td>
</tr>
<tr>
<td>Coupling Loss (95% value)</td>
<td>64.0 dB</td>
<td>65.0 dB</td>
<td>68.0 dB</td>
</tr>
<tr>
<td>Fading margin</td>
<td>6.0 dB</td>
<td>6.0 dB</td>
<td>6.0 dB</td>
</tr>
<tr>
<td><strong>Reception power level outside train</strong></td>
<td>-59.1 dBm</td>
<td>-62.9 dBm</td>
<td>-76.7 dBm</td>
</tr>
<tr>
<td>Target reception power level</td>
<td>-85.0 dBm</td>
<td>-85.0 dBm</td>
<td>-90.0 dBm</td>
</tr>
<tr>
<td>Margin to design requirements</td>
<td>25.9 dB</td>
<td>22.1 dB</td>
<td>13.3 dB</td>
</tr>
</tbody>
</table>
Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Radiating Cables

- The most appropriated system solution for all kind of tunnels, station areas, mines, ships, vessels, and specific In-building areas is the installation of RFS RADIAFLEX®-cables.

- The RADIAFLEX®-cable functions as a distributed antenna to provide communications in tunnels, mines and large building complexes and is the solution for any application in confined areas.

- Slots in the copper outer conductor allow a controlled portion of the internal RF energy to be radiated into the surrounding environment. Conversely, a signal transmitted near the cable will couple into the slots and be carried along the cable lengths.

- RADIAFLEX®-cables are used for both one-way and two-way communication systems and because of its broadband capability, a single radiating cable can handle multiple communication systems simultaneously. By combining passive devices (e.g. splitters) and radiating cables improve and extend coverage in an cost optimized way.
Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Radiating Cables

- RFS RADIAFLEX: World's largest portfolio of radiating cables; global leadership (technology, market share)
- Lower cost/best service:
  - Multi-band
  - Future-proof
- Best coverage:
  - No shading by vehicles
  - Smooth everywhere, even in trains
  - Proven safety: low smoke, flame & fire retardance
  - Better reliability vs antennas
  - Tested up to 6 GHz
  - DVB-H, DVB-SH, WiMAX, LTE ready
  - Live test environment in Hanover metro
  - Not sensitive to reflection
  - Less sensitive to wind

Typical environments

- Many curves, Small tunnel cross section
Coverage solutions for Tunnel scenarios

RADIAFLEX®-radiating cables operate as dedicated antennas and are RF broadband. Therefore, they are highly applicable to extend the coverage and offer many important advantages:

- Homogenous coverage along the RADIAFLEX®-cable
- Can be installed in accordance to the shape of the building
- Lower dynamic range compared with an antenna solution
- Multi-band solution
- Multi-operator solution
- Easy to upgrade
- Easy system planning
- Controlled coverage
- Better network security
- Minimized interference

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables
Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Radiating Cables vs Antennas

Cons:
- Not broadband
- Not upgradeable
- Low frequencies
- Line of sight

Pros:
- Good for large cross-sections
- Installation effort
Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Radiating Cables: Features/Benefits

- RFS RADIAFLEX: World's largest portfolio of radiating cables; global leadership (technology, market share)
- Lower cost/best service:
  - Multi-band
  - Future-proof
- Best coverage:
  - No shading by vehicles or additional walls
  - Smooth everywhere, even in trains
  - Proven safety: low smoke, flame & fire retardance
  - Better reliability vs antennas
  - Tested up to 6 GHz
  - DVB-H, DVB-SH, WiMAX, LTE ready
  - Live test environment in Hanover metro
  - Not sensitive to reflection
  - Less sensitive to wind

Typical environments

- Multiband applications
- FM / VHF / UHF applications
- Building structures with many lossy walls
- Building / tunnels with many curves
- Small tunnel cross sections
- Industrial plants with metallic high rise racks
- Ships/Vessels with metallized wall
Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Radiating Cables, selected items for In-building scenarios

RLK series:

For applications in tunnels and buildings where low coupling loss variations are required.

RLK12-50JFNA (JFLA), up to 980 MHz
RLK78-50JFNA (JFLA), up to 980 MHz
RLKW12-50JFNA (JFLA), up to 1950 MHz
RLKW78-50JFNA (JFLA), up to 1950 MHz
RLKU12-50JFNA (JFLA), up to 2700 MHz
RLKU78-50JFNA (JFLA), up to 2700 MHz
RLKD12-50JFNA (JFLA), up to 6000 MHz
Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Radiating Cables, selected items for In-building scenarios

**RCF series:**

For applications where particularly small bending radii are required for heavy-duty applications (e.g. mines, ships, vessels).

- RCF12-50JFN (JFL), up to 6000 MHz
- RCF78-50JFNA (JFLA), up to 2650 MHz
- RSF12-50JFN (JFL), up to 6000 MHz
Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Radiating Cables, selected items for Tunnel scenarios

RLK series (RLK, RLKL, RLKW, RLKU):

For applications in tunnels and buildings where low coupling loss variations are required.

RLKW78-50JFNA (JFLA), up to 1950 MHz
RLKW114-50JFNA (JFLA), up to 1950 MHz
RLKU78-50JFNA (JFLA), up to 2700 MHz
RLKU114-50JFNA (JFLA), up to 2700 MHz
RLKU158-50JFNA (JFLA), up to 2700 MHz
Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Radiating Cables, selected items for Tunnel scenarios

RAY series (RAY, RAYU, RAYS):

For applications in tunnels and buildings where low coupling loss variations are required.

RAY78-50JFNA (JFLA), up to 1000 MHz
RAY114-50JFNA (JFLA), up to 1000 MHz
RAY158-50JFNA (JFLA), up to 1000 MHz
RAYS158-50JFNA (JFLA), up to 2700 MHz
Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Radiating Cables, selected items for Tunnel scenarios

RLF series (RLF, RLFW, RLFU, ALFU):

For heavy-duty wideband and multi-use applications in all kind of tunnels. Due to widely separated slot-groups very insensitive against environmental influences (esp. Salt).

RLF78-50JFNA (JFLA), up to 1000 MHz
RLF114-50JFNA (JFLA), up to 1000 MHz
RLF158-50JFNA (JFLA), up to 1000 MHz
RLFU78JFNA, (JFLA), up to 2400 MHz
RLFU114-50JFNA (JFLA), up to 2400 MHz
RLFU158-50JFNA (JFLA), up to 2400 MHz
Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Radiating Cables, selected items for Tunnel scenarios

**RCF series (RCF, RSF, RHCA):**

For applications where particularly small bending radii are required for heavy-duty applications (e.g. mines, ships, vessels).

- **RCF12-50JFN (JFL), up to 6000 MHz**
- **RCF78-50JFNA (JFLA), up to 2650 MHz**
- **RSF12-50JFN (JFL), up to 6000 MHz**
Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Clamps

Plastic dowel Ø 6mm
(hole Ø 6mm, 40mm deep)
(Plug-6-1)

Round base H = 50mm (RB-50-4)
Round base H = 80mm (RB-80-4)

Clic clamp
(CC-38-2, CC-12-2, CC-58-2,
CC-78-2, CC-114-2, CC-158-2)

Screw (SC-4595-1)
(for 50mm Round base)

Screw (SC-45125-2)
(for 80mm Round base)

For some cable series the round base with height of 80mm has to be used!
Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Clamps

Plug for 50mm Round base (Plug-6-3S)
Plug for 80mm Round base (Plug-6-4S)

Round base H = 50mm (RB-50-4)
Round base H = 80mm (RB-80-4)

Clic clamp (CC-38-2, CC-12-2, CC-58-2, CC-78-2, CC-114-2, CC-158-2)

Clic flat nut M6 (CS-6-1)

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Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Clamps

Example for installation on anchor bar

Round base
H = 50mm or H = 80mm

M4 nut

Clic clamp

M4 Torx screw
for Round Base H = 50mm: M4 x 75
for Round Base H = 80mm: M4 x 105

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Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Clamps: Heavy Duty Clamp HDC for 350km/h

HDC-*** are special clamps for train speed up to 350km/h

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Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Clamps: Heavy Duty Clamp HDC for 350km/h

Available for the cable sizes of 11/4“ & 15/8“ of the cable series RLF, RLK, RLV and RAY.

Optional up to 4 additional clic-clamps could be mounted e.g. optic backbone cables. Suitable types are CC-12-2, CC-58-2 & CC-78-2
Coverage solutions for Tunnel scenarios

RADIAFLEX® Clamps: Heavy Duty Clamp HDC for 350km/h

Fixing with approved stainless steel plug

HDC clamp
(HDC-114-110-01
or
HDC-158-110-01)

Plug for HDC clamp (Plug-6-5S)

Washer (W-64-1)

Nut (N-M6-1)

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Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Clamps: Fire protection clamp

Special solution for fire protecting.

Installation recommended every 8-10m

In case of fire the resistant part of the fixing will hold the cable in position and enables the cable to keep in operation as long as the cable itself allows. It also prevents the cable from detaching from the wall that might block any escape route.

Drill out if necessary (8.5 mm)

Screw M8 x 65 (S-865-1)
or M8 x 95 (S-895-1)

Washer W-84-1

Round base RB-50-4
or RB-80-4

Metal dowel PLUG-8-2

Setting tool TOOL-2
Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Clamps: Messenger wire installation

Special solution for external messenger wire
Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

Termination Loads, selected items

Two different Groups

- Low power 1W - 50W
- High power > 50W (on request)
- Low PIM (on request)

N-TER-01
N-TER-10
N-TER-50
Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

Accessories: Grounding kits, DC-Blocks, EMP-protectors, selected items

- DC-Block to protect equipment and personnel due to induced voltages from the catenary/overhead line
- EMP-Protector (Surge-Suppressor) for lightning to protect equipment and personnel
- DC-Block to protect equipment and personnel due to induced voltages from the catenary/overhead line
- EMP protector is recommended whenever an outdoor device is linked

Coaxial Feeder cables, e.g. CELLFLEX cable LCF 12-50 JFN, or factor-fitted Jumper cables.

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## Coverage solutions for Tunnel scenarios

**Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables**

**RADIAFLEX® Radiating Cables, selected items for Tunnel scenarios**

<table>
<thead>
<tr>
<th>Description</th>
<th>RFS Model-Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><em><em>RADIAFLEX-cable 7/8” RLK</em>, RAY</em> - series (foil cable) and accessories for Tunnel scenarios**</td>
<td></td>
</tr>
<tr>
<td>Radiaflex® cable 7/8”, RLKW-series</td>
<td>RLKW78-50JFLA</td>
</tr>
<tr>
<td>Radiaflex® cable 7/8”, RLKU-series</td>
<td>RAY78-50JFLA</td>
</tr>
<tr>
<td>Radiaflex® cable 7/8”, RAY-series</td>
<td></td>
</tr>
<tr>
<td>Connector N-female</td>
<td>NF-RA78-016</td>
</tr>
<tr>
<td>Connector 7-16-female</td>
<td>716F-RA78-016</td>
</tr>
<tr>
<td>Round base, 80 mm, flame retardant</td>
<td>RB-80-4</td>
</tr>
<tr>
<td>Clic-clamp, flame retardant, for 7/8” cables</td>
<td>CC-78-2</td>
</tr>
<tr>
<td>Nylon plug, 6 x 30 mm</td>
<td>PLUG-6-1</td>
</tr>
<tr>
<td>Screw, 4.5 x 125 mm, for plastic plug</td>
<td>SC-45125-2</td>
</tr>
<tr>
<td>Terminating resistance, N-male, 1 W</td>
<td>N-TER-01</td>
</tr>
<tr>
<td><strong>RADIAFLEX-cable 1 1/4” and accessories (foil cable) and accessories for Tunnel scenarios</strong></td>
<td></td>
</tr>
<tr>
<td>Radiaflex® cable 1 1/4”, RLKW-series</td>
<td>RLKW114-50JFLA</td>
</tr>
<tr>
<td>Radiaflex® cable 1 1/4”, RLKU-series</td>
<td>RAY114-50JFLA</td>
</tr>
<tr>
<td>Radiaflex® cable 1 1/4”, RAY-series</td>
<td></td>
</tr>
<tr>
<td>Connector 7-16-female</td>
<td>716F-RA114-016</td>
</tr>
<tr>
<td>Round base, 80 mm, flame retardant</td>
<td>RB-80-4</td>
</tr>
<tr>
<td>Clic-clamp, flame retardant, for 1 1/4” cables</td>
<td>CC-114-2</td>
</tr>
<tr>
<td>Nylon plug, 6 x 30 mm</td>
<td>PLUG-6-1</td>
</tr>
<tr>
<td>Screw, 4.5 x 125 mm, for plastic plug</td>
<td>SC-45125-2</td>
</tr>
<tr>
<td>Terminating resistance, N-male, 1 W</td>
<td>N-TER-01</td>
</tr>
</tbody>
</table>
Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Radiating Cables, selected items for Tunnel scenarios

<table>
<thead>
<tr>
<th>Description</th>
<th>RFS Model-Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>RADIAFLEX-cable 1 5/8&quot; and accessories (foil cable) and accessories for Tunnel scenarios</td>
<td></td>
</tr>
<tr>
<td>Radiaflex® cable 1 5/8&quot;, RLKW-series</td>
<td>RLKW158-50JFLA</td>
</tr>
<tr>
<td>Radiaflex® cable 1 5/8&quot;, RLKU-series</td>
<td>RLKU158-50JFLA</td>
</tr>
<tr>
<td>Radiaflex® cable 1 5/8&quot;, RAY-series</td>
<td>RAY158-50JFLA</td>
</tr>
<tr>
<td>Radiaflex® cable 1 5/8&quot;, RAYS-series</td>
<td>RAYS158-50JFLA</td>
</tr>
<tr>
<td>Connector 7-16-female</td>
<td>716F-RA158-016</td>
</tr>
<tr>
<td>Round base, 80 mm, flame retardant</td>
<td>RB-80-4</td>
</tr>
<tr>
<td>Clic-clamp, flame retardant, for 1 5/8&quot; cables</td>
<td>CC-158-2</td>
</tr>
<tr>
<td>Nylon plug, 6 x 30 mm</td>
<td>PLUG-6-1</td>
</tr>
<tr>
<td>Screw, 4.5 x 125 mm, for plastic plug</td>
<td>SC-45125-2</td>
</tr>
<tr>
<td>Terminating resistance, N-male, 1 W</td>
<td>N-TER-01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>RFS Model-Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>RADIAFLEX-cable 7/8&quot; RCF* - series (corrugated cable) and accessories for In-building scenarios</td>
<td></td>
</tr>
<tr>
<td>Radiaflex® cable 7/8&quot;, RCF-series</td>
<td>RCF78-50JFNA</td>
</tr>
<tr>
<td>Connector 7/16 male for RCF78-50</td>
<td>716M-LCF78-D01</td>
</tr>
<tr>
<td>Connector N male for RCF78-50</td>
<td>NM-LCF78-D01</td>
</tr>
<tr>
<td>Round base, 50 mm, flame retardant</td>
<td>RB-50-4</td>
</tr>
<tr>
<td>Clic-clamp, flame retardant, for 7/8&quot; cables</td>
<td>CC-78-2</td>
</tr>
<tr>
<td>Nylon plug, 6 x 30 mm</td>
<td>PLUG-6-1</td>
</tr>
<tr>
<td>Screw, 4.5 x 95 mm, for plastic plug</td>
<td>SC-45195-1</td>
</tr>
</tbody>
</table>

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Coverage solutions for Tunnel scenarios

Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables

RADIAFLEX® Radiating Cables accessories, selected items for Tunnel scenarios

<table>
<thead>
<tr>
<th>Description</th>
<th>RFS Model-Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accessories for RADIAFLEX - Heavy Duty Clamp</strong></td>
<td></td>
</tr>
<tr>
<td>Heavy Duty Clamp for RADIAFLEX Cable RLK158, RLKU158, RLF158, RLFW158, RLFU158, RLV158, RLVU158, RAY158, RAYS158</td>
<td></td>
</tr>
<tr>
<td>Heavy duty clamp for 1 5/8&quot;</td>
<td>HDC-158-110-01</td>
</tr>
<tr>
<td>Plug 6 x 110.5 mm, set for HDC 114/158 (Kit of 150 pcs.)</td>
<td>PLUG-6-5S</td>
</tr>
<tr>
<td>Nut DIN0985 M06 A2 6kt ssi</td>
<td>N-M6-1</td>
</tr>
<tr>
<td>Washer, inner dia. 6.4 mm, stainless steel</td>
<td>W-64-1</td>
</tr>
<tr>
<td><strong>Accessories for RADIAFLEX - Heavy Duty Clamp</strong></td>
<td></td>
</tr>
<tr>
<td>Heavy Duty Clamp for RADIAFLEX Cable RLK114, RLKW114, RLKU114, RLF114, RLFW114, RLFU114, RLV114, RLVU114, RAY114</td>
<td></td>
</tr>
<tr>
<td>Heavy duty clamp for 1 1/4&quot;</td>
<td>HDC-114-110-01</td>
</tr>
<tr>
<td>Plug 6 x 110.5 mm, set for HDC 114/158 (Kit of 150 pcs.)</td>
<td>PLUG-6-5S</td>
</tr>
<tr>
<td>Nut DIN0985 M06 A2 6kt ssi</td>
<td>N-M6-1</td>
</tr>
<tr>
<td>Washer, inner dia. 6.4 mm, stainless steel</td>
<td>W-64-1</td>
</tr>
</tbody>
</table>
**Coverage solutions for Tunnel scenarios**

**Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables**

**RADIAFLEX® Radiating Cables accessories, selected items for Tunnel scenarios**

### Accessories for RADIAFLEX - Fire protection clamp

<table>
<thead>
<tr>
<th>Fire Protection Clamp for RADIAFLEX Cable RLK158, RLKU158, RLF158, RLFW158, RLFU158, RLV158, RLVU158, RAY158, RAYS158</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSB-Clip for 158 (kit of 10)</td>
</tr>
<tr>
<td>Round base, 80 mm, flame retardant</td>
</tr>
<tr>
<td>Metal plug, 8 x 30 mm, stainless steel</td>
</tr>
<tr>
<td>Screw, 8.0 x 95 mm, for metal plug</td>
</tr>
<tr>
<td>Washer, inner dia. 8.4 mm, stainless steel</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fire Protection Clamp for RADIAFLEX Cable RLK114, RLKW114, RLKU114, RLF114, RLFW114, RLFU114, RLV114, RLVU114, RAY114</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSB-Clip for 114 (kit of 10)</td>
</tr>
<tr>
<td>Round base, 80 mm, flame retardant</td>
</tr>
<tr>
<td>Metal plug, 8 x 30 mm, stainless steel</td>
</tr>
<tr>
<td>Screw, 8.0 x 95 mm, for metal plug</td>
</tr>
<tr>
<td>Washer, inner dia. 8.4 mm, stainless steel</td>
</tr>
</tbody>
</table>
# Coverage solutions for Tunnel scenarios

**Typical Tunnel scenario - Solution by use of RADIAFLEX® Cables**

**RADIAFLEX® Radiating Cables accessories, selected items for Tunnel scenarios**

<table>
<thead>
<tr>
<th>Accessories for RADIAFLEX - DC Block</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DC-Blocks</strong></td>
</tr>
<tr>
<td>DC block, 15 kV, 180-2500 MHz, 7-16 male - 7-16 female, IP65</td>
</tr>
<tr>
<td>DC block, 4 kV, 160-2500 MHz, 7-16 male - 7-16 female, IP65</td>
</tr>
</tbody>
</table>
Production facilities and offices
Represented on six continents - 9 manufacturing centers-of-excellence and 35 technical support and sales offices in 23 countries throughout the world.

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Coconut Creek
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Meriden
Naperville
San Jose

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