



## Baseband Fading Simulator ABFS

Saving costs through real-world fading tests

- 2 fading channels  
(4 with option ABFS-B2)
- 12 propagation paths  
(24 with option ABFS-B2)
- Universal use in research, development and production
- Simulation of present and future communication systems thanks to flexible concept
- Receiver tests at I/Q level together with a baseband source
- Ease of operation
- High reliability



**ROHDE & SCHWARZ**

The characteristics of a radio channel may strongly impair signal transmission between a transmitter and in particular a moving receiver.

Baseband Fading Simulator ABFS generates signals which simulate real receive conditions in mobile applications. Thus, the response of receivers under real-world conditions can be checked already during development and QM acceptance testing. The simulation of fading signals at baseband level reduces costs.

## Advantages of fading simulation in baseband

Conventional fading simulators normally convert the signal of the radio channel to the IF, perform fading and then reconvert the signal to its RF frequency. It is however less costly to loop in the simulator prior to the first conversion to the carrier frequency, i.e. to simulate at baseband level (I and Q) and then convert to the correct frequency in the test system (see Fig. 2). Signals will therefore not be impaired by the effects of multiple conversion. Due to this baseband fading simulation an upgrade to new networks or standards is easy.

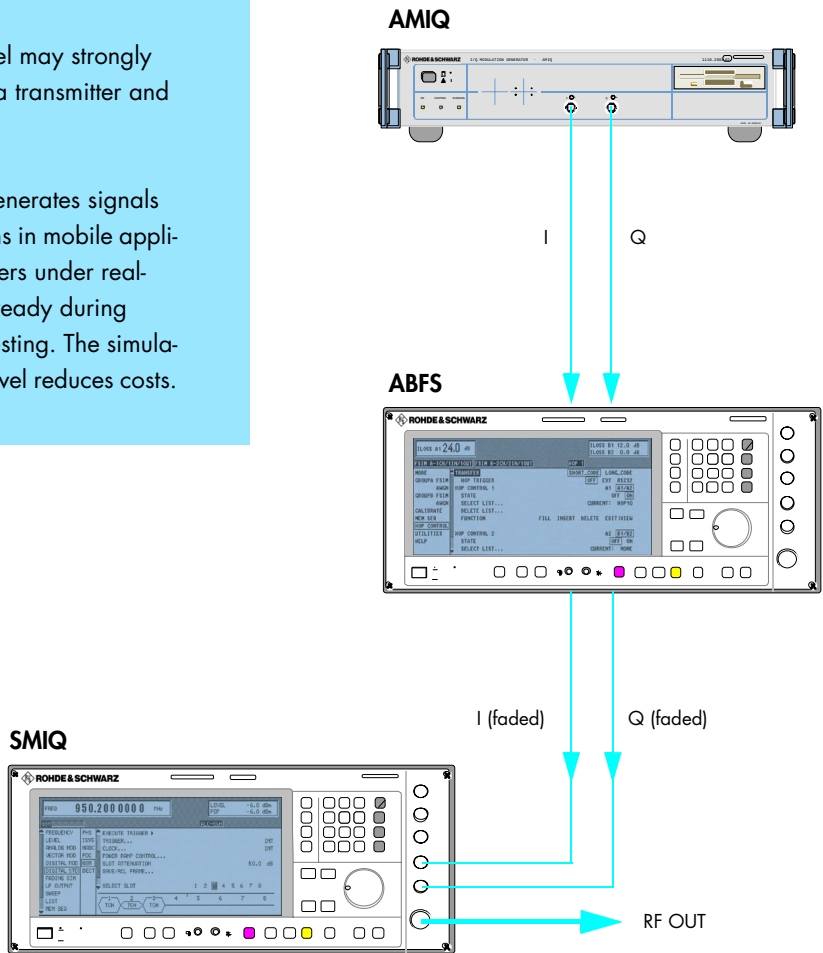
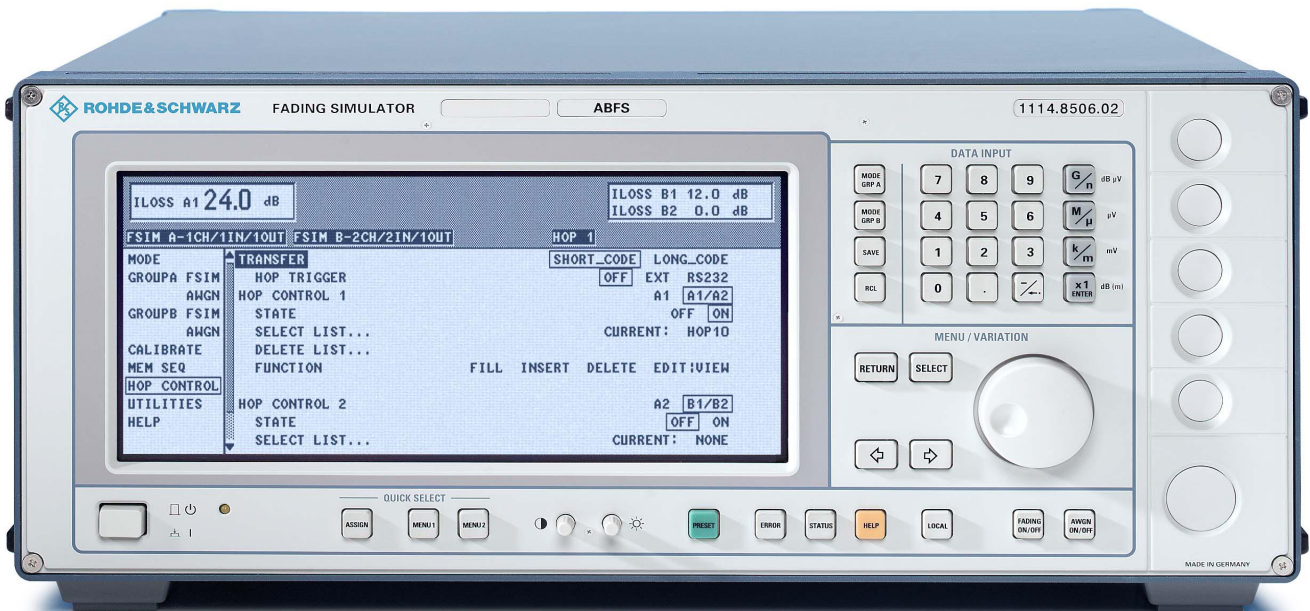


Fig. 1: Fading of a baseband signal from AMIQ with Fading Simulator ABFS



## Fit for the future

Baseband Fading Simulator ABFS is suitable for universal mobile radio applications in research, development and production. It comprises all scenarios and statistical models for simulating sporadic fading as specified in the test regulations of mobile radio standards (eg GSM, IS-54/US-136 or IS-95 CDMA).

The flexible concept of ABFS allows the simulation of radio channels of existing and future communication systems (eg mobile radio, broadcasting, flight telephone, WLL, or WLAN systems).

ABFS can also simulate frequency hopping systems. ABFS is fast enough to follow the frequency hopping of a test system for example within a frame of 4,616 ms (GSM frame time).

Furthermore, an offset voltage for each I and Q input or output can be entered to compensate external DC offset voltages.

Together with a baseband source (eg I/Q Modulation Generator AMIQ from Rohde & Schwarz, see Fig. 1 on the left) receiver tests can be performed at I/Q level even if the corresponding RF link is not available. During the development of receivers or correction circuits in the receiver (eg equalizer), the effects of fading can thus be checked at a very early stage.

The basic model of ABFS comes with two independent channels for 6-path fading. The two channels can be interconnected as follows (see Fig. 3):

- Distribution of an input to two outputs (eg with different fading profiles). This feature makes it possible to simulate the signal of two antennas with different characteristics or frequency diversity methods
- Simulation of two channels with individual profiles and addition at output. Cell change or superposition of interferers can be tested with this configuration
- Coupling of two channels so that a channel with 12 propagation paths is obtained (Fig. 4 gives a more detailed insight how the fading simulator works).

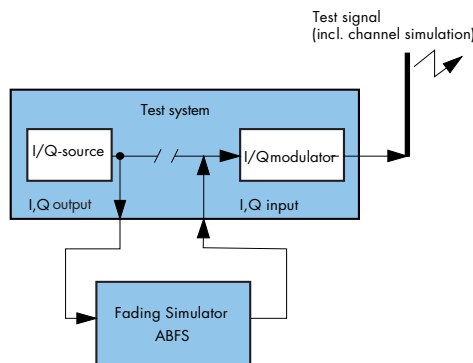


Fig. 2: Fading simulation in baseband

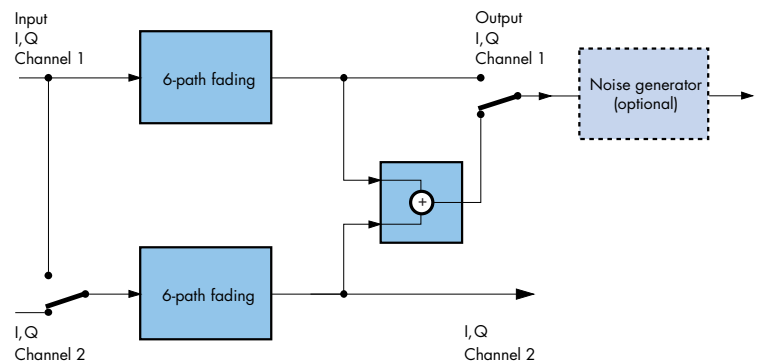
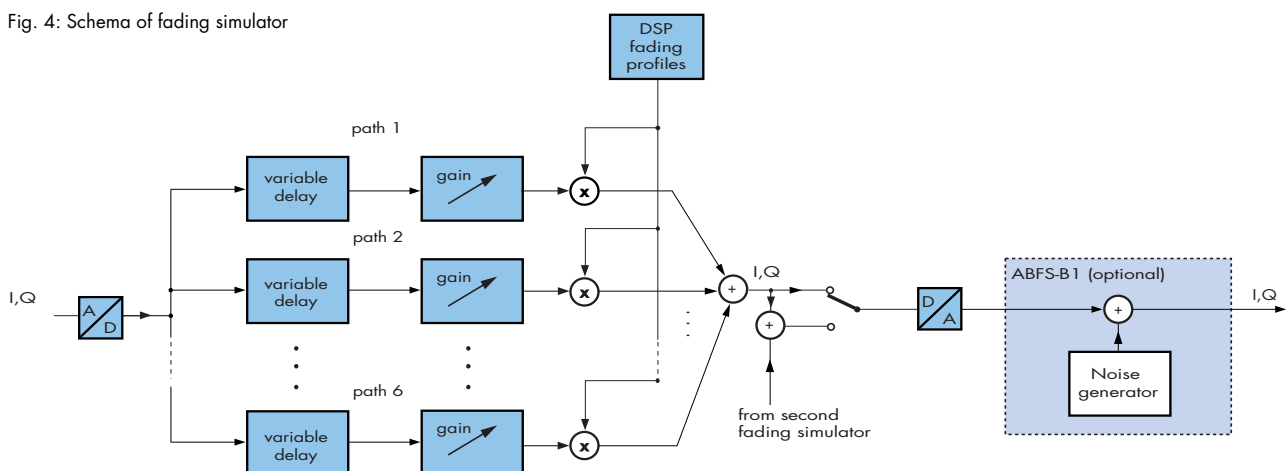


Fig. 3: Interconnections of ABFS

Fig. 4: Schema of fading simulator



## High versatility by options

**Noise Generator ABFS-B1** adds a noise source to the output of the first channel (see Fig. 3) so that noise can be simulated in the frequency band used. The noise generator can be switched on or off irrespective of the operating modes of the basic version.

**Second Fading Simulator ABFS-B2** offers two extra channels with the same characteristics in addition to the two channels of the basic model.

**Second Noise Generator ABFS-B3** represents an additional noise source for a further output. This second noise generator is either assigned to the second channel of the basic ABFS (with first noise generator ABFS-B1 for the first channel) or to the first channel of the second fading simulator ABFS-B2.

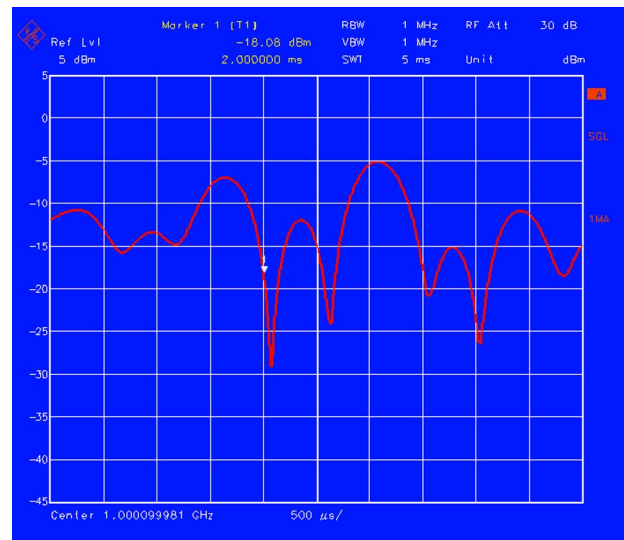
Fading profiles of the Rayleigh, Rician, Pure Doppler, Lognormal or Suzuki method can be assigned to each of the propagation paths irrespective of the selected circuit (see Fig. 3).

In addition to the fading profiles mentioned, the following parameters can be defined for each propagation path:

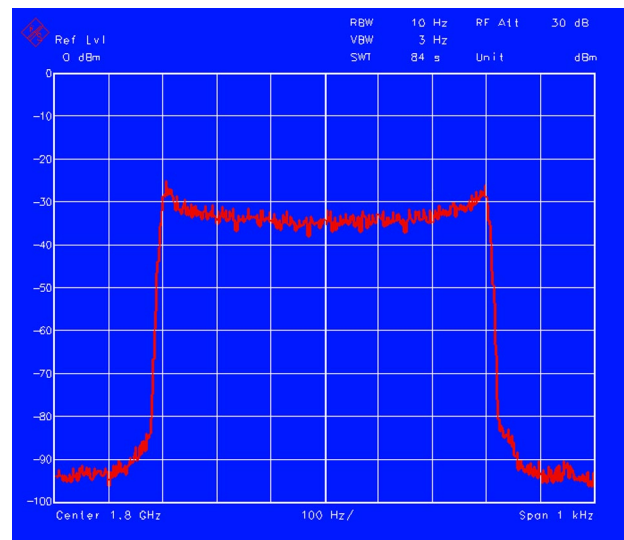
- Path attenuation
- Delay time
- Doppler frequency or speed between transmitter and receiver
- Coupling to another channel

Many fading models (eg GSM Rural Urban, Typical Urban) have already been programmed in ABFS. The user can quickly recall these default settings and also modify the parameters.

Typical Rayleigh fading profile



Rayleigh fading (Doppler spectrum), generated at a speed of 180 km/h (RF = 1.8 GHz)



## Why fading tests?

Short-time signal fading, as caused by multipath propagation, strongly affects the error rate of the received signal due to the short symbol periods in digital mobile radio

Modern digital systems overcome these problems with the aid of appropriate error control coding methods as well as algorithms for delay equalizing.

Interleaving is employed to overcome the problem of losing large parts of the messages.

Resistance to fading is an essential quality criterion of digital mobile radio systems and means a considerable competitive advantage for the manufacturer.

Tests with real-world signals using fading simulators are a must to spot the weak points in new concepts at an early stage so that appropriate modifications can be made.

## Specifications

### IQ inputs and outputs

|                                    |                                    |
|------------------------------------|------------------------------------|
| Impedance                          | 50 Ω                               |
| Input voltage for full-scale level | $\sqrt{I^2 + Q^2} = 0.5 \text{ V}$ |
| Residual DC voltage at output      | <2 mV, fine tuning by software     |
| Insertion loss of basic unit       | 0.3 dB                             |

### Fading simulation

|                                                                                                            |                                                                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Number of propagation paths and fading channels                                                            |                                                                                                                                                                                                                                                        |
| Basic model                                                                                                | 1 channel with 12 paths or<br>2 channels with 6 paths each<br>2 channels with 12 paths each or<br>4 channels with 6 paths each                                                                                                                         |
| with option ABFS-B2                                                                                        |                                                                                                                                                                                                                                                        |
| Insertion loss between input and output at 0 dB path attenuation                                           | min. 9 dB                                                                                                                                                                                                                                              |
| Frequency response<br>up to 5 MHz offset from carrier frequency (corresponding to 10 MHz system bandwidth) | +0.1 dB to -0.6 dB                                                                                                                                                                                                                                     |
| Path attenuation                                                                                           |                                                                                                                                                                                                                                                        |
| Range                                                                                                      | 0 to 50 dB                                                                                                                                                                                                                                             |
| Resolution                                                                                                 | 0.1 dB                                                                                                                                                                                                                                                 |
| Error in range 0 to 20 dB                                                                                  | <0.3 dB                                                                                                                                                                                                                                                |
| Path delay                                                                                                 |                                                                                                                                                                                                                                                        |
| Range                                                                                                      | 0 to 1600 μs                                                                                                                                                                                                                                           |
| Resolution                                                                                                 | 50 ns                                                                                                                                                                                                                                                  |
| Error                                                                                                      | <5 ns                                                                                                                                                                                                                                                  |
| Doppler shift                                                                                              |                                                                                                                                                                                                                                                        |
| Frequency range                                                                                            | 0.1 to 1600 Hz                                                                                                                                                                                                                                         |
| Speed range                                                                                                | $v_{\min} = \frac{0.03 \cdot 10^9 \text{ m/s}^2}{f_{\text{RF}}}$ $v_{\max} = \frac{479 \cdot 10^9 \text{ m/s}^2}{f_{\text{RF}}}$<br>For example at $f_{\text{RF}} = 1 \text{ GHz}$ :<br>$v_{\min} = 0.1 \text{ km/h}$ , $v_{\max} = 1724 \text{ km/h}$ |
| Resolution                                                                                                 | 0.1 km/h, m/s, mph                                                                                                                                                                                                                                     |
| Error                                                                                                      | <0.13 %                                                                                                                                                                                                                                                |
| Rayleigh fading                                                                                            |                                                                                                                                                                                                                                                        |
| Pseudo noise interval                                                                                      | >372 h                                                                                                                                                                                                                                                 |
| Deviation from theoretical CPDF <sup>1)</sup> at $P_{\text{avg}} = 0 \text{ dB}$                           |                                                                                                                                                                                                                                                        |
| in range -20 dB to +10 dB                                                                                  | <1 dB, typ. <0.3 dB                                                                                                                                                                                                                                    |
| in range -30 dB to -20 dB                                                                                  | <2 dB, typ. <0.3 dB                                                                                                                                                                                                                                    |
| Rice fading                                                                                                |                                                                                                                                                                                                                                                        |
| Power ratio <sup>2)</sup>                                                                                  |                                                                                                                                                                                                                                                        |
| Range                                                                                                      | -30 dB to +30 dB                                                                                                                                                                                                                                       |
| Resolution                                                                                                 | 0.1 dB                                                                                                                                                                                                                                                 |
| Frequency ratio                                                                                            |                                                                                                                                                                                                                                                        |
| Range                                                                                                      | -1 to +1                                                                                                                                                                                                                                               |
| Resolution                                                                                                 | 0.05                                                                                                                                                                                                                                                   |
| Lognormal fading, Suzuki fading                                                                            |                                                                                                                                                                                                                                                        |
| Standard deviation                                                                                         |                                                                                                                                                                                                                                                        |
| Range                                                                                                      | 0 to 12 dB                                                                                                                                                                                                                                             |
| Resolution                                                                                                 | 1 dB                                                                                                                                                                                                                                                   |
| Local constant                                                                                             | $l_{\min}$ to 200 m, $l_{\min} = \frac{12 \cdot 10^9 \text{ m/s}}{f_{\text{RF}}}$                                                                                                                                                                      |
| Correlation                                                                                                | paths 1 to 6 with paths 7 to 12 of a channel (A or B)                                                                                                                                                                                                  |
| Range for magnitude                                                                                        | 0 to 100 %                                                                                                                                                                                                                                             |
| Resolution                                                                                                 | 5 %                                                                                                                                                                                                                                                    |
| Range for phase                                                                                            | 0 to 360°                                                                                                                                                                                                                                              |
| Resolution                                                                                                 | 1°                                                                                                                                                                                                                                                     |
| RF setting                                                                                                 | setting of the RF results in an automatic calculation and display of the Doppler frequency according to the set motion speed <sup>3)</sup>                                                                                                             |
| Range (for each fading channel)                                                                            | 5 MHz to 8.5 GHz                                                                                                                                                                                                                                       |
| Frequency hopping mode                                                                                     | RF can be stored in a list and quickly set via a serial interface                                                                                                                                                                                      |
| Interface                                                                                                  | RS 232, 1 byte with start and stop bit                                                                                                                                                                                                                 |
| Addressing of frequency list                                                                               | 8 or 16 bit as address for each fading channel                                                                                                                                                                                                         |
| Setting time after frequency change during Rayleigh fading                                                 | <3.5 ms                                                                                                                                                                                                                                                |

### Noise generator with options ABFS-B1 or ABFS-B3

|                        |                                                 |
|------------------------|-------------------------------------------------|
| Amplitude distribution | Gaussian, statistically independent for I and Q |
| Crest factor           | 14 dB                                           |

Noise power level in relation to full-scale level

|                                       |                                              |
|---------------------------------------|----------------------------------------------|
| Range                                 | -17 to -50 dBfs                              |
| Resolution                            | 0.05 dB                                      |
| Error                                 | <0.3 dB                                      |
| Output level at full-scale level (AC) | $\sqrt{I^2 + Q^2} = 0.5 \text{ V}$ (= 4 dBm) |

Insertion loss between input and output

|                                                                 |                                   |
|-----------------------------------------------------------------|-----------------------------------|
| Output spectrum                                                 | white noise                       |
| Bandwidth                                                       | depending on set system bandwidth |
| Frequency response<br>up to 0.7 x system bandwidth (max. 5 MHz) | <0.5 dB                           |
| RF system bandwidth <sup>4)</sup>                               | bandwidth determining noise power |
| Setting range                                                   | 10 kHz to 10 MHz                  |
| Resolution                                                      | 1 %                               |
| Memory for device settings                                      | 50                                |
| Storable settings                                               | -0.2 dB to -0.6 dB                |
| Frequency response                                              |                                   |

### Remote control

|                      |                                               |
|----------------------|-----------------------------------------------|
| System               | IEC 625 (IEEE 488)                            |
| Command set          | SCPI 1993.0                                   |
| Connector            | Amphenol 24-pin                               |
| IEC/IEEE-bus address | 0 to 30                                       |
| Interface functions  | SH1, AH1, T6, L4, SR1, RL1, PP1, DC1, DT1, C0 |

### General data

|                               |                                                                                                                       |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Power supply                  | 90 V to 132 V (AC), 47 Hz to 440 Hz, 180 V to 265 V (AC), 47 Hz to 440 Hz, autoranging, max. 300 VA                   |
| Electromagnetic compatibility | meets EN 50081-1 and EN 50082-2                                                                                       |
| Environmental conditions      |                                                                                                                       |
| Operating temperature range   | 0 to 45°C, meets IEC68-2-1 and IEC68-2-2                                                                              |
| Storage temperature range     | -40 to +70°C                                                                                                          |
| Climatic resistance           | 95% rel. humidity, cyclic test at +25/+40°C, meets IEC68-2-30                                                         |
| Mechanical resistance         |                                                                                                                       |
| Vibration, sinusoidal         | 5 Hz to 150 Hz, max. 2 g at 55 Hz, 55 Hz to 150 Hz, 0.5 g const., meets IEC68-2-6, IEC1010-1 and MIL-T-28800D class 5 |
| Vibration, random             | 10 Hz to 300 Hz, acceleration 1.2 g (rms)                                                                             |
| Shock                         | 40 g shock spectrum, meets MIL-STD-810D, MIL-T-28800D, class 3 and 5                                                  |
| Safety                        | meets EN 61010-1                                                                                                      |
| Dimensions (W x H x D)        | 435 mm x 192 mm x 460 mm                                                                                              |
| Weight                        | 20 kg when unit is fully equipped                                                                                     |

## Ordering information

|                           |                               |              |
|---------------------------|-------------------------------|--------------|
| Baseband Fading Simulator | ABFS                          | 1114.8506.02 |
| Accessories supplied      | power cable, operating manual |              |
| <b>Options</b>            |                               |              |
| Noise Generator           | ABFS-B1                       | 1115.0009.02 |
| Second Fading Simulator   | ABFS-B2                       | 1115.0309.02 |
| Second Noise Generator    | ABFS-B3                       | 1115.0609.02 |
| <b>Recommended extras</b> |                               |              |
| 19" Rack Adapter          | ZZA-94                        | 0396.4905.00 |
| Service Kit               | SM-Z3                         | 1085.2500.02 |
| Trolley                   | ZZK-1                         | 1014.0510.00 |
| Transit Case              | ZZK-944                       | 1013.9366.00 |
| Service Manual            | ABFS                          | 1114.8564.94 |

<sup>1)</sup> CPDF: cumulative probability distribution function

<sup>2)</sup> Ratio between discrete and distributed component

<sup>3)</sup> The phase differences between paths caused by different settings of path delay are taken into account when the RF is modified. This applies to frequency hopping mode only

<sup>4)</sup> 0.5 x system bandwidth is used for baseband



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