Baseband Fading Simulator ABFS

Reduced costs through baseband simulation

Radio channel characteristics can seriously impair signal transmission between a transmitter and a receiver, in particular a mobile one. The new Baseband Fading Simulator ABFS from Rohde & Schwarz generates signals allowing simulation of real receiving conditions in mobile applications. In this way receivers can be checked for practical performance during development and acceptance testing. The fact that ABFS simulates signals at baseband level also cuts costs.

Photo 43 346/2

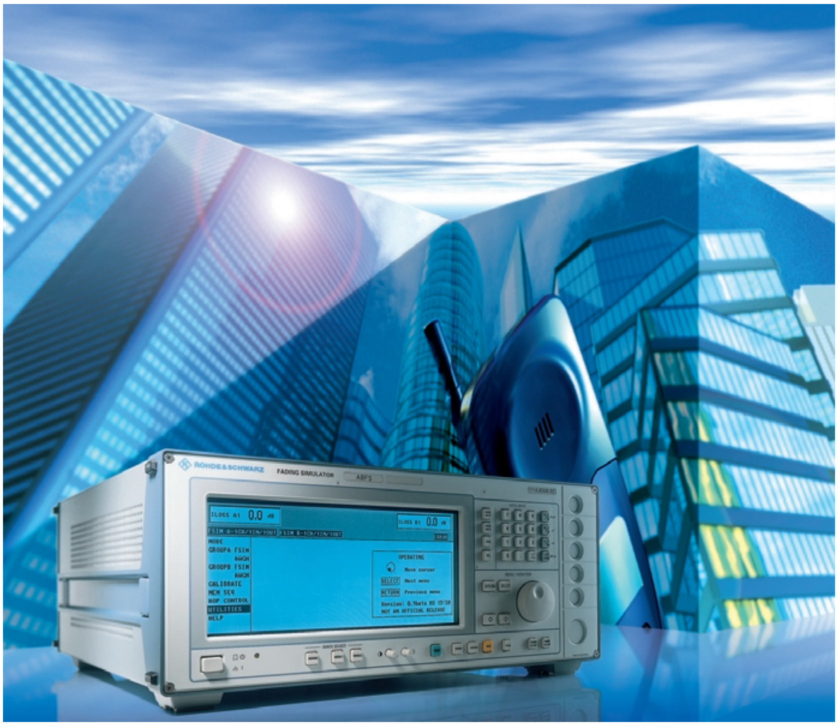


FIG 1 Baseband Fading Simulator ABFS – flexible radio channel simulation for all communication systems

Benefits of baseband simulation

Most fading simulators convert the signal of the radio channel to the IF, then perform fading and subsequently reconvert to the correct frequency. But it is more cost-effective to connect the simulator **prior** to the first conversion to the carrier frequency in the transmitter, ie to simulate at baseband level (I and Q) and perform conversion to the correct frequency in the test system afterwards. In this way there is no signal degradation through multiple conversion.

Fit for the future

Baseband Fading Simulator ABFS (FIG 1) is **a universal instrument for research, development and production** in the field of digital mobile radio. It encompasses all simulation scenarios as well as mathematical-statistical models for simulating sporadic fading as stipulated in mobile radio standards (eg GSM, IS-54/US-136, IS-95). Its open concept allows **radio channel simulation of today's and future communication systems**, no matter if required for mobile radio, broadcasting, flight telephone, WLL or WLAN systems.

The baseband fading simulator is a cost-effective solution not only for protocol tests in conjunction with a test system but also for testing under difficult receiving conditions. **Frequency hopping systems** can also be simulated, ABFS being fast enough, for example, to follow frequency hopping of the test system within a response time of only 4 ms (GSM frame time).

Applications

Receiver tests at I/Q level can be performed together with a baseband source (eg I/Q Modulation Generator AMIQ [1] from Rohde & Schwarz) even if the corresponding RF link is not available. The ruggedness of receive algorithms to different fading conditions can thus already be tested during the development phase of a receiver (see box on next page). The same applies to correction circuits in the receiver, eg for the equalizer.

Even in its basic configuration ABFS offers **two independent channels for six-path fading** that can be interconnected as required (FIG 2), eg:

- One input (with different fading profiles) is split to two outputs. Several antennas with different characteristics or frequency diversity methods can be simulated.
- Simulation of two inputs with individual profiles and then addition at the output. This configuration is of interest for testing cell handover or for the superimposition of interferers.
- The two channels can also be fully coupled to produce a channel with twelve paths.

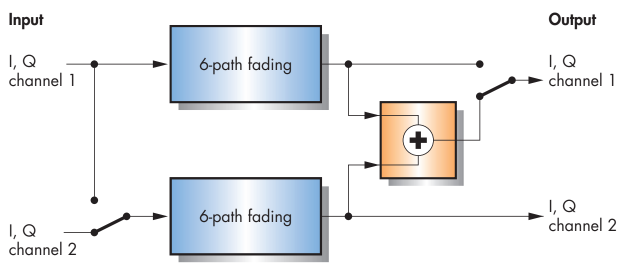


FIG 2 Example of ABFS channel interconnection to perform different measurements

By integrating ABFS into test systems for digital mobile radio, it is possible to perform tests under fading conditions. The sole prerequisite is that the test system have an I/Q output and input, between which ABFS is then connected (FIG 3).

More versatility through options

- **Noise Generator ABFS-B1**
  Adds an extra noise source to the output of the first channel. This allows simulation of interferers in the frequency band examined.
- **Second Fading Simulator ABFS-B2**
  Two additional channels with the same characteristics in addition to the two channels of the basic configuration.
- **Second Noise Generator ABFS-B3**
  Second noise source for an additional output.

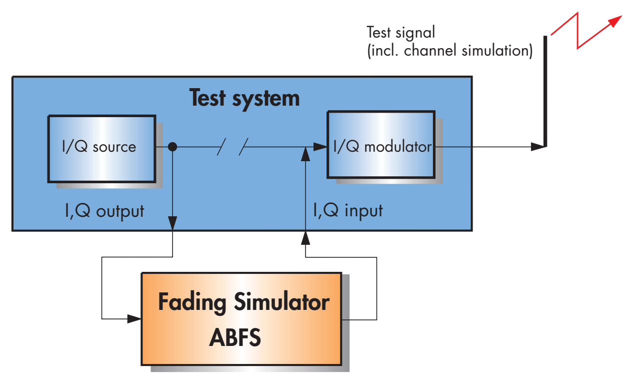
One of the fading profiles (Rayleigh, Rician, pure doppler, lognormal or Suzuki) can be assigned to each of the paths irrespective of the selected circuit [2].

In addition to the kinds of fading mentioned above, the following characteristics can be defined for each path:
- attenuation,
- delay,
- doppler frequency or speed between transmitter and receiver,
- coupling to another channel.

To simplify the use of this variety of parameters, complete default settings are ready programmed for many channel models, eg rural and typical urban GSM. The settings can be quickly called up for the particular tests and also modified.

Wolfgang Kufer

FIG 3 Integration of Baseband Fading Simulator ABFS into test system



How the transmission channel is influenced by multipath reception

The characteristics of the radio channel vary with time and frequency, which gives rise to time and frequency-selective fading. The receive signal is influenced mainly by the following factors:

Multipath propagation (multipath fading) Due to reflection and diffraction a signal formed by several paths (up to twelve) is obtained at the receiver. These paths have different delays, amplitudes and phases, which may lead to signal cancellation. As a rule the delay difference is greater than the symbol period.

Signal loss Depending on the delay, narrowband, frequency-selective notches can be caused within the bandwidth of the communication channel. These notches also occur if the receiver is stationary.

Delay spread A time spread of the receive signal (time dispersion) is caused by multipath reception.

Intersymbol interference If delay differences are greater than the symbol period, impairments are caused by the components of previously sent symbols.

Local dispersion (local scattering) A large number of waves are produced by scattering in the immediate vicinity of the receiver. Thus, for each path, a cluster of signals of low delay differences is taken to the receiver. Due to the arbitrarily changing amplitudes and phases of the individual echoes, time-selective fading **(fast fading)** is caused in mobile receivers.

Doppler shift Moving the receiver results in frequency shifts. At the same time, signals arriving from different directions are spread in the frequency range **(doppler spread)**.

Slow signal variations (longterm fading, slow fading) Field strength variations caused by shadowing in hilly environments.

And how mobile radio systems can be protected

Mobile radio systems are designed so that they are not impaired by any anomalies of the radio channel. The following techniques are used to eliminate the effects of multipath reception:
- forward error correction,
- algorithms for delay compensation (equalizing),
- interleaving of message contents,
- frequency matching circuits.

REFERENCES

[1] Kernchen, W.; Tiepermann, K.-D.: I/Q Modulation Generator AMIQ – Convenient generation of complex I/Q signals. News from Rohde & Schwarz (1998) No. 159, pp 10–12

[2] Lüttich, F.: Signal Generator SMIQ + SMIQ-B14 – Fading simulator and signal generator in one unit. News from Rohde & Schwarz (1997) No. 155, pp 9–11

Condensed data of Baseband Fading Simulator ABFS

Bandwidth	7 MHz (ie RF bandwidth of 14 MHz)
Channels	2 (4 with option ABFS-B2)
Paths	12 (24 with option ABFS-B2)
Max. number of paths per channel	12
Path loss	0 to 50 dB, resolution 0.1 dB
Path delay	0 to1600 µs, resolution 50 ns
Doppler shift	0 to 600 Hz
Fading profiles	Rayleigh, Rican, pure doppler, lognormal, Suzuki

Reader service card 163/03