Correlated Receiver Diversity Simulations with R&S®SFU

Application Note

Products:

- R&S®SFU
- R&S®SFE
- R&S®SFE100
- R&S®SFC
- R&S®SMU200A

Receiver diversity improves reception quality by using multiple antennas with a preferably low correlation factor between each other. This results in a more robust handling of multipath signals, since a deep fade will then not affect all received signals at the same time.

However, the compact dimensions of handheld devices can introduce unwanted correlation due to their dense antenna spacing. In this case, the popular diversity test setup consisting of several independent transmitters will no longer serve the needs of a realistic simulation, since correlation effects have to be taken into account here.

A clever solution is to operate the R&S®SFU in split-fading mode in combination with a second transmitter. This can be another R&S®SFU, the R&S®SFE, the R&S®SFE100, the R&S®SFC or the R&S®SMU200A.

In this way, two diversity signals of adjustable correlation for any common broadcast standard are coded in realtime, while their individual multipath profile is precisely specified by the extensive features of the R&S®SFU fader module.

Application Note

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10.2012-7BM76_2E

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1 Overview

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In this way, two diversity signals of adjustable correlation for any common broadcast standard are coded in realtime, while their individual multipath profile is precisely specified by the extensive features of the R&S®SFU fader module. This module is described in detail in the R&S®SFU manual.

This Application Note is structured as follows: First, Section 2 presents the test setup and its device and option requirements. Next, Section 3 explains the configuration of the R&S®SFU and the second transmitter step by step. Finally, Section 5 contains the ordering information.

2 Test Setup

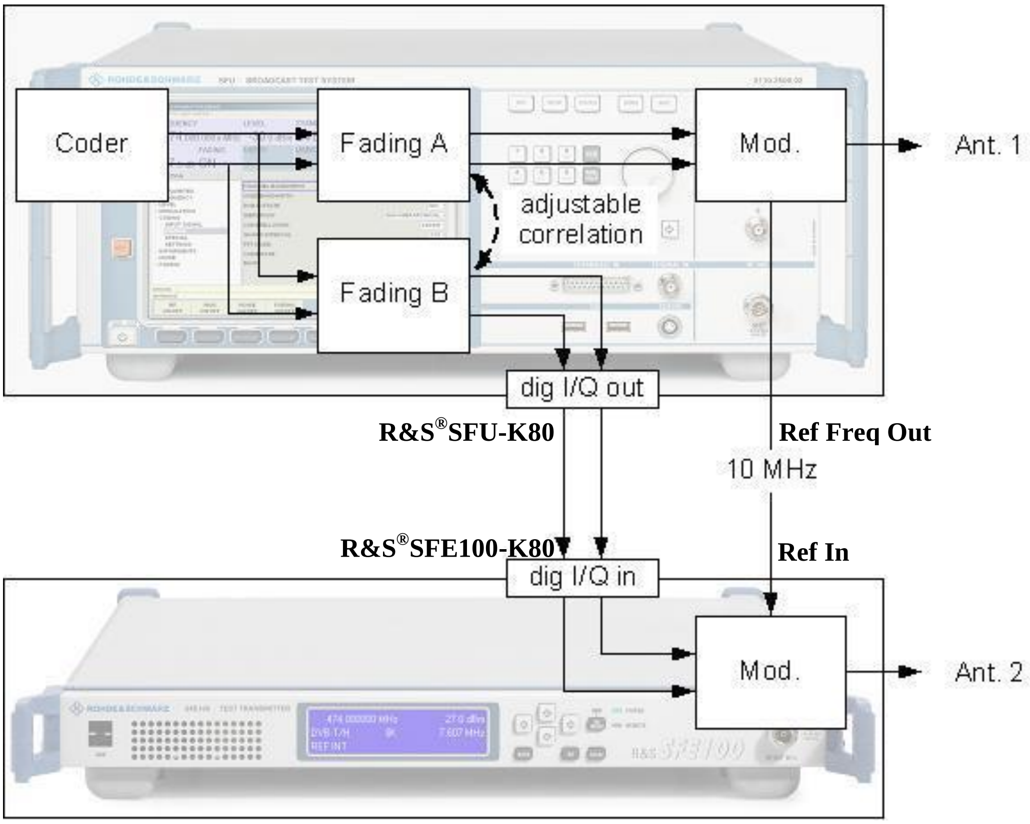

Fig. 1: Test setup for diversity simulations with adjustable correlation

The setup consists of the R&S®SFU and a second transmitter. The R&S®SFE100 is used here as an example, but all referenced interfaces and connections are also valid for the R&S®SFC, the R&S®SFE, the R&S®SMU200 or another R&S®SFU.

The two instruments are cabled with each other in the following way:

- The Digital I/Q output of the R&S®SFU is connected to the Digital I/Q input of the second transmitter via the R&S®LVDS BU-BU cable shown in Fig. 2.

- The Ref Freq output of the R&S®SFU is connected to the 10 MHz Ref input of the second transmitter.

Fig. 2: R&S®LVDS BU-BU cable for connecting the Digital I/Q interfaces

This test setup results in device and option requirements listed below:

– Test transmitter 1:
  R&S®SFU with options

  - R&S®SFU-B30 (fading simulator)
  - R&S®SFU-B31 (fading simulator extension)
  - R&S®SFU-K80 (extended I/Q)

  Additionally, the arbitrary waveform generator (R&S®SFU-K35) or a combination of transport stream generator (R&S®SFU-K20) and realtime coder is recommended for baseband signal creation.

  Note: The interferer management function (R&S®SFU-K37) cannot be used during split-fading mode.

– Test transmitter 2:
  R&S®SFE, R&S®SFE100 (model 02), R&S®SFC, R&S®SMU200 or R&S®SFU with

  - Option K80 (extended I/Q)

  Additionally, basic options such as the realtime coder or the arbitrary waveform generator will be required.

– R&S®LVDS BU-BU Digital I/Q connection cable

Further information is provided in Section 5 "Ordering Information".

3 Device Configuration

This section describes step by step, how the two instruments introduced in the test setup have to be configured. Concerning the screenshots, the R&S®SFE100 is assumed to be the second transmitter, but the settings for the R&S®SFE, R&S®SFC, R&S®SMU200 or another R&S®SFU are made in the same way.

3.1 R&S®SFU Configuration

The following description concentrates on the special settings necessary for the diversity test setup. Basic settings such as signal source, modulation type, frequency and RF level are expected to be already configured.

3.1.1 Activating the Split-Fading Mode

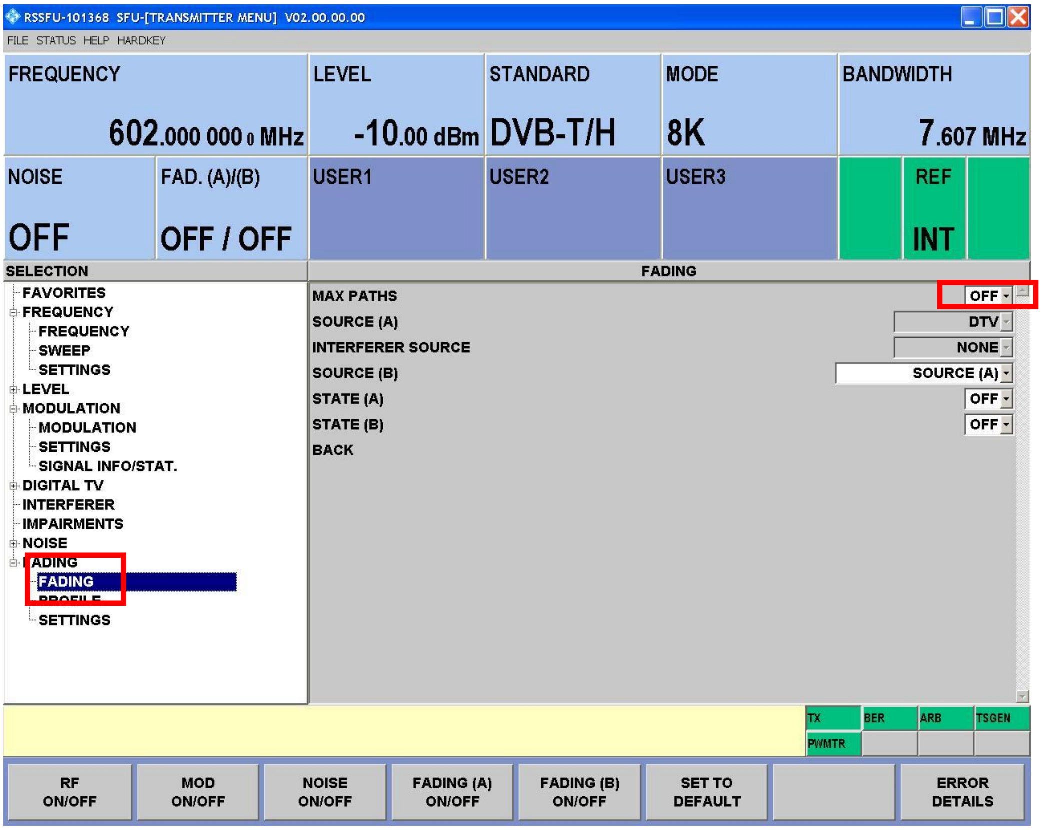

Fig. 3: Set MAX PATHS to "OFF" to enable the split-fading mode

a. From the FADING menu, select the FADING submenu.

b. On the right, set MAX PATHS to “OFF” as highlighted in the red box.

3.1.2 Configuring the Digital I/Q Output

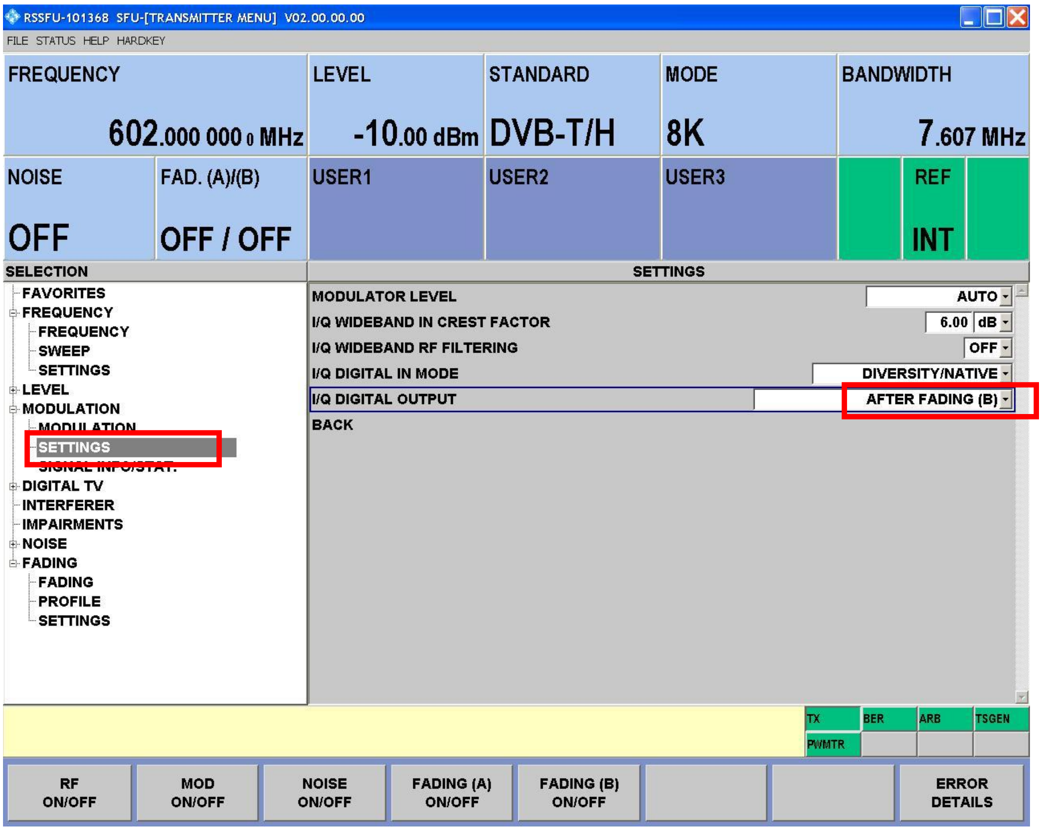

Fig. 4:Set I/Q DIGITAL OUTPUT to "AFTER FADING (B)"

a. From the MODULATION menu, select the SETTINGS submenu.

b. On the right, set I/Q DIGITAL OUTPUT to "AFTER FADING (B)".

3.1.3 Specifying Signal Routing

This setting is required to route the fader outputs correctly and to account for the different signal processing times in the two transmitters.

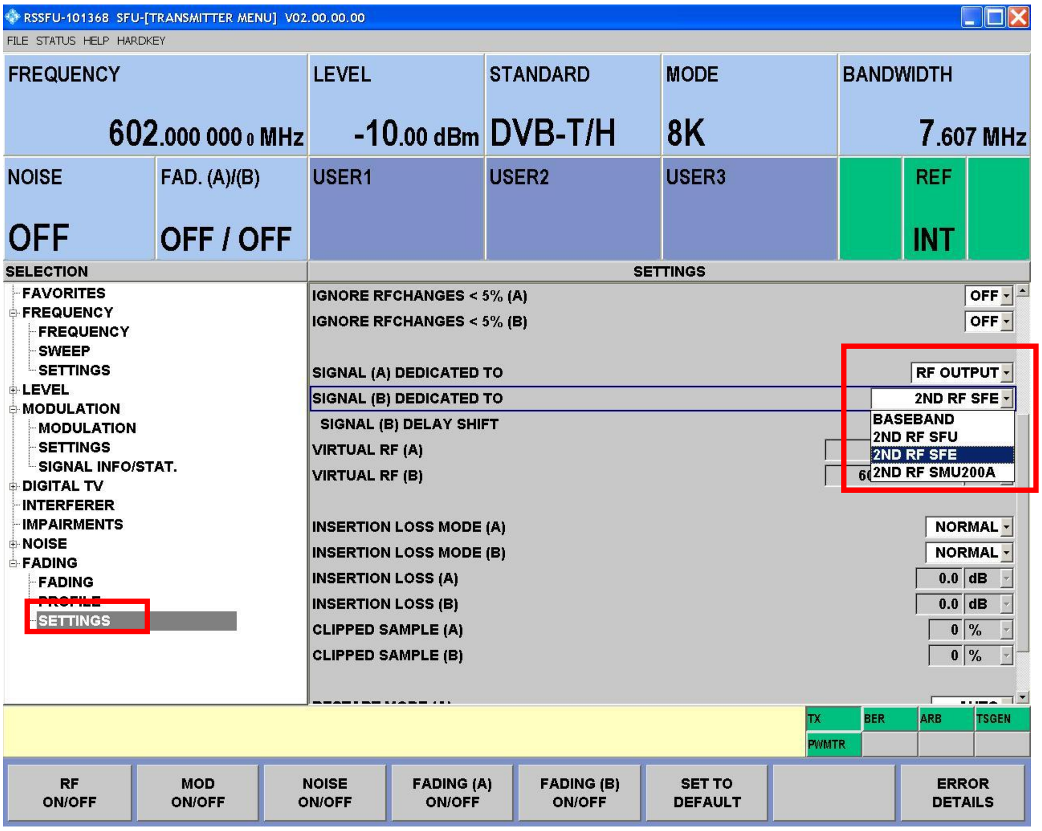

Fig. 5: Set SIGNAL (A) DEDICATED TO "RF OUTPUT" and SIGNAL (B) DEDICATED TO according to the type of the second transmitter

a. From the FADING menu, select the SETTINGS submenu.

b. On the right, set SIGNAL (A) DEDICATED TO to "RF OUTPUT".
Select SIGNAL (B) DEDICATED TO depending on the type of the second transmitter being used. The setting "2ND RF SFE" also holds true for the R&S®SFE100 and R&S®SFC, as all three models handle their digital input in the same way.

c. Ensure VIRTUAL RF (A) and VIRTUAL RF (B) match the selected transmit frequency.

3.1.4 Configuring the Fading Profiles

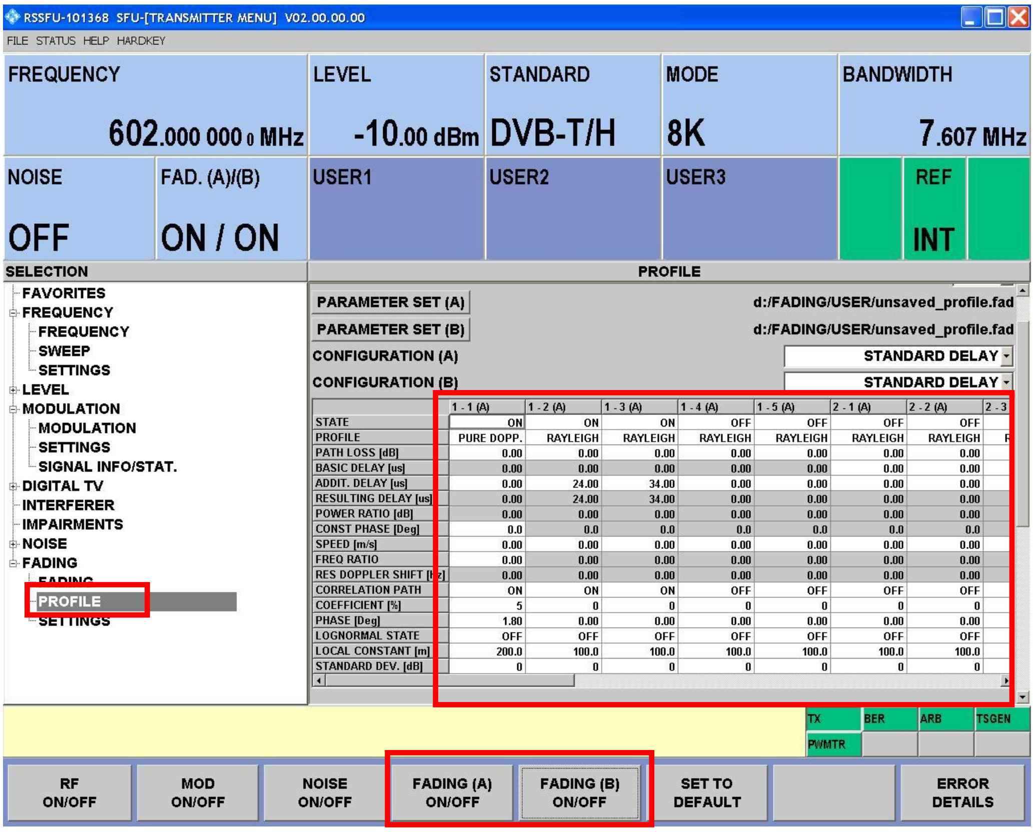

Fig. 6: Configure the fading profiles accordingly

a. From the FADING menu, select the FADING submenu. This results in two fading profile tables (A&B) being shown on the right, one above the other, according to the two diversity signals.

b. Start by configuring the top table (Fader A), which corresponds to this R&S®SFU transmitter because of the signal routing set in Section 3.1.3. Define PATH LOSS, DELAY and other parameters as desired. Further information about the particular fading settings is provided in the R&S®SFU manual.

c. For all correlated paths, switch CORRELATION PATH to "ON". This will copy their parameters to Fader B. Furthermore, those parameters being changed later will then automatically be updated in the other fader as well. To control the amount of correlation of these paths, use the COEFFICENT settings to define the ratio of matching samples and PHASE to determine the static phase shift between both signal paths.

d. Next, add additional non-correlated paths to Fading Profile B, if necessary.

e. Switch both Fader A and Fader B to "ON".

3.2 Configuration of the Second Transmitter

The following description concentrates on the special settings necessary for the diversity test setup. Basic settings such as RF level and frequency are expected to be already configured. The RF frequency should, however, match that of the first transmitter.

Concerning the screenshots, the R&S®SFE100 is assumed to be the second transmitter, but the settings for the R&S®SFE, R&S®SFC, R&S®SMU200 or another R&S®SFU are made accordingly.

3.2.1 Activating the Reference Frequency Coupling

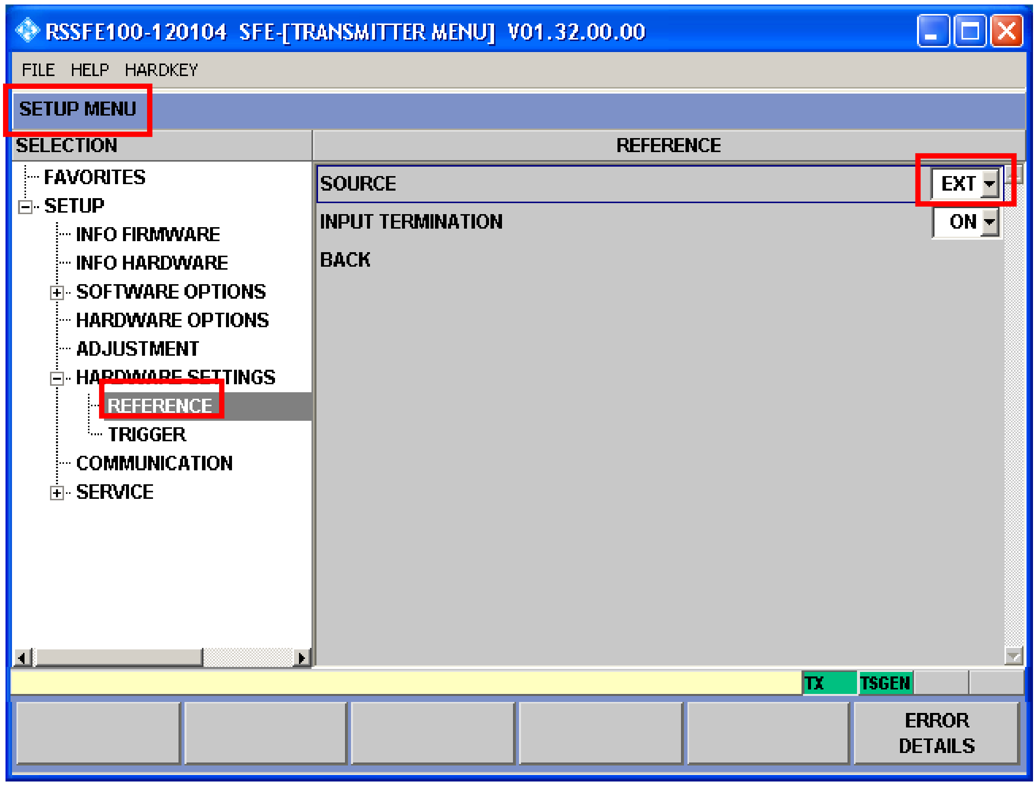

Fig. 7: Set REFERENCE SOURCE to "EXT"

a. From the SETUP menu, select the REFERENCE submenu located beneath HARDWARE SETTINGS.

b. On the right, set SOURCE to "EXT".

3.2.2 Setting the Modulation Mode to Digital In

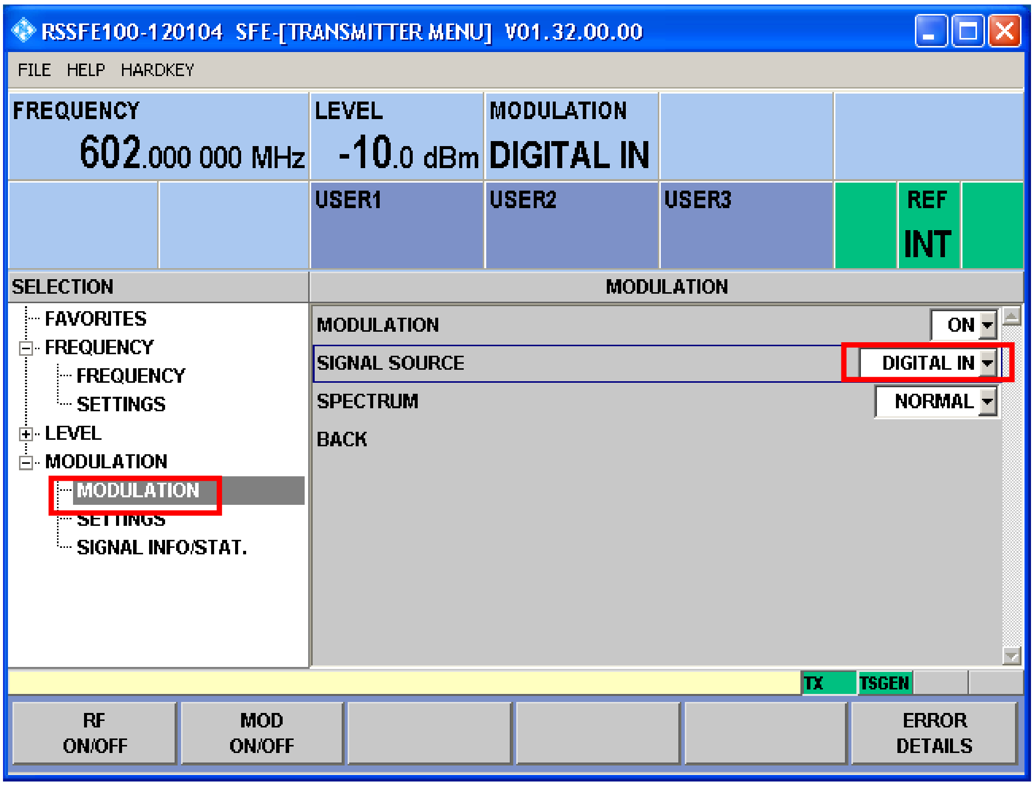

Fig. 8: Set SIGNAL SOURCE to "DIGITAL IN"

a. From the MODULATION menu, select the MODULATION submenu.

b. On the right, set SIGNAL SOURCE to "DIGITAL IN".

3.2.3 Configuring the Digital In Interface

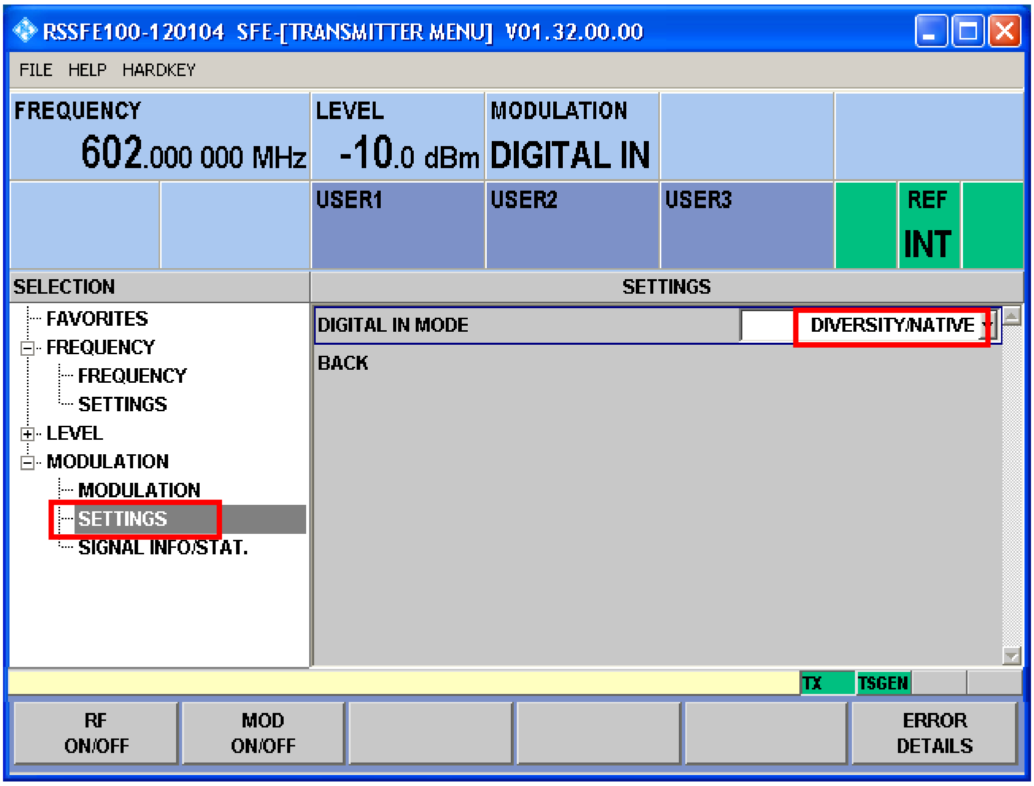

Fig. 9: Set DIGITAL IN MODE to "DIVERSITY/NATIVE"

a. From the MODULATION menu, select the SETTINGS submenu.

b. On the right, set DIGITAL IN MODE to "DIVERSITY/NATIVE".

3.2.4 Level Optimization

A change in fading profiles can affect the baseband and RF level of the second transmitter. That is why the use of the Digital I/Q Input Refresh function is recommended afterwards to ensure internal RF level optimization.

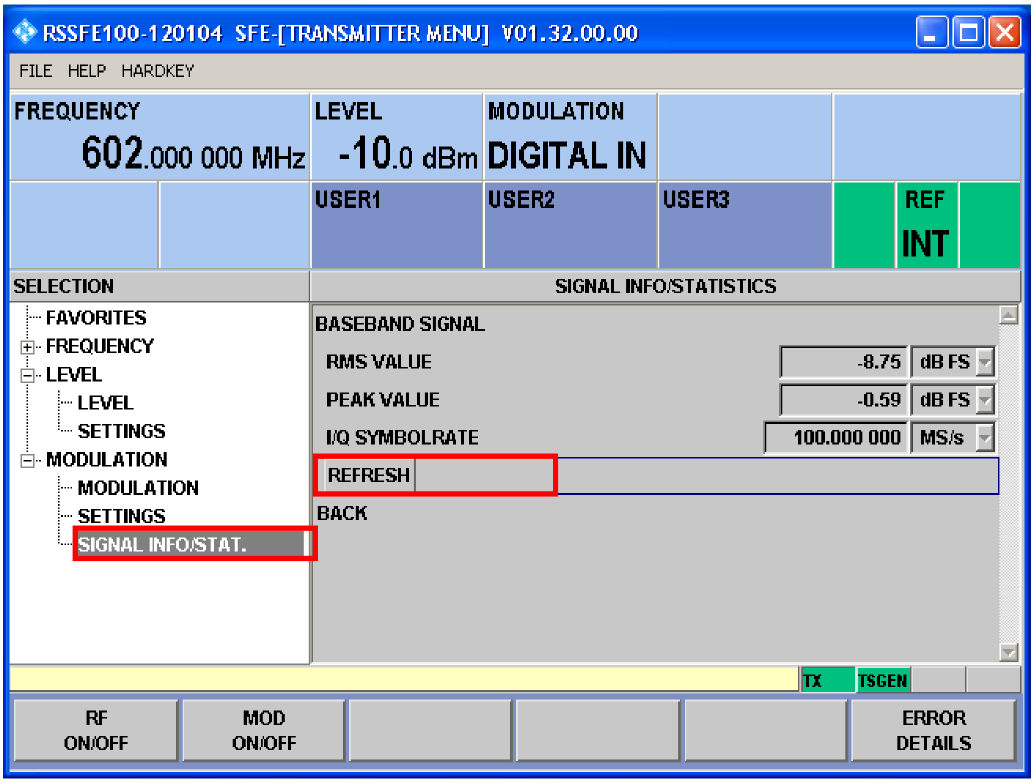

Fig. 10:The Digital I/Q Input Refresh function

a. From the MODULATION menu, select the SIGNAL INFO/STAT. submenu.

b. On the right, click REFRESH.

3.3 Delay Fine Tuning

Even though the different processing times within the two transmitters are already accounted for by the settings presented in Section 3.1.3, it may happen that one instrument is some I/Q samples ahead of the other one.

This static shift can, however, be compensated with the aid of a dual channel oscilloscope connected to both RF outputs. This oscilloscope is required to determine the actual delay between the two transmitter signals. To account for the measurement instrument's possible bandwidth limitation, lower the RF frequency on the two transmitters temporarily to 10 MHz. Make sure that only one static path is active in both faders, so that identical signals are processed in the two different modulators. With those RF waveforms on the screen, the temporal offset can then be gradually decreased by changing the SIGNAL (B) DELAY SHIFT setting in the R&S®SFU menu shown in Fig. 5. Each step equals one sample duration and therefore comprises 10 ns.

Optimum screen resolution is gained by choosing an R&S®SFU baseband signal of high temporal activity. If the R&S®SFU is equipped with the arbitrary waveform generator (R&S®SFU-K35), a special file is available for this purpose:

D:\ARB\WAVEFORMS\diversity\dirac.wv

Based on this signal, Fig. 11 illustrates how an initial temporal transmitter offset of over 40 ns is compensated in this way.

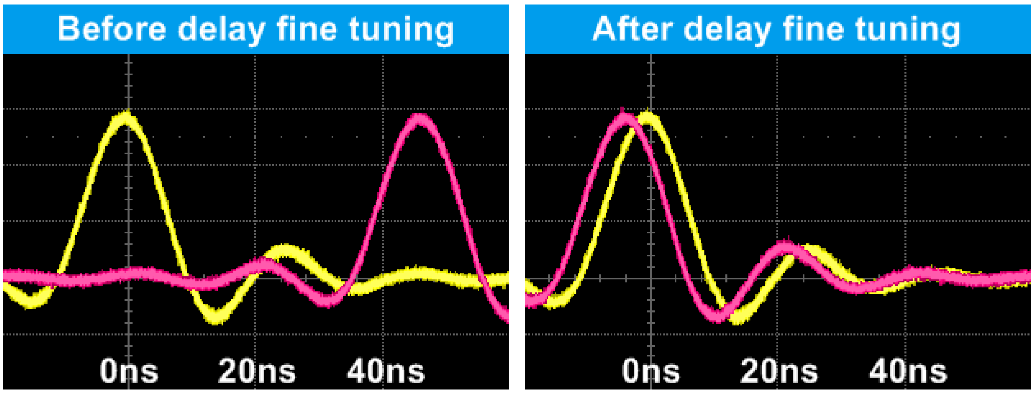

Fig. 11: Benefit of delay fine tuning

4 Additional Information

Our Application Notes are regularly revised and updated.
Check for any changes at http://www.rohde-schwarz.com.
Please send any comments or suggestions about this Application Note to

Broadcasting-TM-Applications@rohde-schwarz.com.

5 Ordering Information

Designation	Type	Order-No.
R&S®SFU Broadcast Test System		
Broadcast Test System	R&S®SFU	2100.2500.02
DVB-TH Coder (*)	R&S®SFU-K1	2100.7301.02
Extended I/Q	R&S®SFU-K80	2100.7953.02
Fading Simulator	R&S®SFU-B30	2100.7530.02
Fading Simulator Extension to 40 Paths	R&S®SFU-B31	2100.7547.02
Recommended		
TS Generator including SDTV streams	R&S®SFU-K20	2110.7476.02
ARB Generator	R&S®SFU-K35	2110.7601.02
R&S®SFE Broadcast Tester		
Broadcast Tester	R&S®SFE	2112.4300.02
DVB-TH Coder (**)	R&S®SFE-K1	2113.4010.02
Extended I/Q Input	R&S®SFE-K80	2113.5251.02
R&S®SFE100 Test Transmitter		
Test Transmitter	R&S®SFE	2112.4100.02
DVB-TH Coder (**)	R&S®SFE100-K1	2113.4003.02
Extended I/Q Input	R&S®SFE100-K80	2113.5245.02
R&S®SFC Compact Modulator		
Compact Modulator	R&S®SFC	2115.3510.02
DVB-TH Coder (**)	R&S®SFC-K1	2115.5271.02
Extended I/Q Input	R&S®SFC-K80	2115.5771.02
R&S®SMU200A Vector Signal Generator		
Vector Signal Generator(***)	R&S®SMU200A	1141.4100.02
Digital I/Q connection cable		
LVDS Cable for digital I/Q input/output (2 m)	R&S®LVDS BU-BU 26-pol. 2 m	1130.1302.00

(*) Depending on the desired digital TV standard, a corresponding coder can be configured accordingly.
(**) Any coder (or ARB) can be selected for this application.
(***) Refer to datasheet for detailed configurations

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