Correlated Receiver Diversity Simulations with R&S®SFU Application Note

Products:

- | R&S[®]SFU
- | R&S[®]SFC
- | R&S[®]SFE
- R&S[®]SMU200A
- | R&S[®]SFE100

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 Not

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1 Overview

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. 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

🚸 RSSFU-101368 SFU-[TRANSMITTER MENU] V02.00.00.00								
	DKEY	LEVEL	e.		MODE	DAN		
FREQUENCI		LEVEL	3	TANDARD	NIODE	DAN		
60	2.000 000 0	MHz -1	0.00 dBm [OVB-T/H	8K		7.607	7 MHz
NOISE	FAD. (A)/(B)	USER1	U	ISER2	USER3		REF	
OFF	OFF / O	FF					INT	
SELECTION				F	ADING			
FREQUENCY FREQUENCY FREQUENCY SETTINGS LEVEL MODULATION SETTINGS SIGNAL INFO% DIGITAL TV INTERFERER MARMENTS NOISE SOISE SETTINGS	STAT.	MAX PATH SOURCE (, INTERFER SOURCE (I STATE (A) STATE (B) BACK	IS A) ER SOURCE B)					COFF V
						TX BE	RARB	TSGEN
	1			1 1				1
RF ON/OFF	MOD ON/OFF	NOISE ON/OFF	FADING (A) ON/OFF	FADING (B) ON/OFF	SET TO DEFAULT		ERR(DETA	OR ILS

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.

♦ RSSFU-101368 SFU-[TRANSMITTER MENU] V02.00.00.00							
FILE STATUS HELP HARD	KEY						
FREQUENCY		LEVEL	STANDARD	MODE	BANDWIDTH		
60	2.000 000 o MI	lz -10.00 dBm	DVB-T/H	8K	7.607 MHz		
NOISE	FAD. (A)/(B)	USER1	USER2	USER3	REF		
OFF	OFF / OFI	•			INT		
SELECTION			SET	TTINGS			
FREQUENCY FREQUENCY SWEEP SETTINGS LEVEL MODULATION MOULATION MOULATI MOULATION MOULATION MOULATION MOULA	IAT.	MODULATOR LEVEL I/Q WIDEBAND IN CRES' I/Q WIDEBAND RF FILTE I/Q DIGITAL IN MODE I/Q DIGITAL OUTPUT BACK	T FACTOR RING		AOTO		
RF ON/OFF	MOD ON/OFF	NOISE FADING (J ON/OFF ON/OFF	A) FADING (B) ON/OFF	TX PWMT	BER ARB TSGEN		

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.

FREQUENCY		LEVEL	LEVEL STANDARD MODE					
602	2.000 000 о мн	z -10.00 dBm	DVB-T/H	8K	7.607 MHz			
NOISE	FAD. (A)/(B)	USER1	USER2	USER3	REF			
OFF	OFF / OFF				INT			
SELECTION			SE	TTINGS				
		IGNORE RFCHANGES < IGNORE RFCHANGES <	5% (A) 5% (B)					
SWEEP		SIGNAL (A) DEDICATED						
		SIGNAL (B) DEDICATED	2ND RF SFE					
MODULATION		SIGNAL (B) DELAY SHIFT BASEBAND						
SETTINGS		VIRTUAL RF (A)						
SIGNAL INFO/ST	AT.	VIRTUAL RF (B)						
INTERFERER IMPAIRMENTS		INSERTION LOSS MODE (A) NORMAL						
NOISE		INSERTION LOSS MODE (B) NORMAL						
		INSERTION LOSS (A)	•••		0.0 dB			
PROFILE								
SETTINGS		CLIPPED SAMPLE (A)						
				TX PWI	ARB TSGEN			
RF ON/OFF	MOD ON/OFF	NOISE FADING (ON/OFF ON/OFF	A) FADING (B) ON/OFF	SET TO DEFAULT	ERROR DETAILS			

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.

RSSFU-101368 SFU-[]	🚯 RSSFU-101368 SFU-[TRANSMITTER MENU] V02.00.00.00										
FILE STATUS HELP HARDK	EY										
FREQUENCY		LEVEL		STAP	STANDARD		MODE		BANDWIDTH		
602	2.000 000 0 MHz	-10.00	dBm	DV	′B-T/H	ł	8K		7.607 M		7 MHz
NOISE	FAD. (A)/(B)	USER1		USEI	R2		USER3			REF	
OFF	ON / ON									INT	
SELECTION						PR	OFILE				
		PARAMETER SET	Г (А) Г (В)					d:/FADING/U d:/FADING/U	USER/unsa USER/unsa	ived_pro ived_pro	file.fad file.fad
		CONFIGURATION	(A) (B)						STAN	DARD DE DARD DE	LAY -
		STATE	1 - 1 (/	A) · ON	1-2 (A) 1 ON	I - 3 (A)	1 - 4 (A) ON OFF	1 - 5 (A) : OFF	2 - 1 (A) OFF	2 - 2 (A) 0	2 - 3 FF
SETTINGS SIGNAL INFO/ST	AT.	PATH LOSS [dB] BASIC DELAY [us]	PURI	0.00 0.00	0.00 0.00	RAYLEI 0 0	GH RAYLEIGH .00 0.00 .00 0.00	0.00 0.00	RAYLEIGH 0.00 0.00	RAYLEI	GH F .00 .00
DIGITAL TV INTERFERER		ADDIT. DELAY [us] RESULTING DELAY [us] ROMER RATIO (dB)		0.00	24.00 24.00	34 34	.00 0.00 .00 0.00	0.00	0.00	0	.00
• IMPAIRMENTS • NOISE		CONST PHASE [Deg] SPEED [m/s]		0.0	0.0	0	.00 0.0 0.0 0.0 .00 0.00	0.0	0.00 0.00	0	0.0
		FREQ RATIO RES DOPPLER SHIFT (CORRELATION PATH	2]	0.00 0.00 ON	0.00 0.00 ON	0	.00 0.00 .00 0.00 ON OFF	0.00 0.00 OFE	0.00 0.00 OFE	0	.00 .00
-PROFILE		COEFFICIENT [%] PHASE [Deg]		5 1.80	0 0.00	0	0 0	0 0.00	0 0.00	0	0
		LOGNORMAL STATE LOCAL CONSTANT [m] STANDARD DEV. [dB]		200.0 0	0FF 100.0 0	10	0.0 100.0 0 0	0FF 100.0 0	0FF 100.0 0	10	0.0
		1									<u>}</u>
								тх	BER	ARB	TSGEN
RF ON/OFF	MOD ON/OFF	NOISE FAI DN/OFF O	DING (A N/OFF	4)	FADING (I ON/OFF	B)	SET TO DEFAULT	PWMT		ERR DET/	OR

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

♦ RSSFE100-120104_SFE-[TRANSMITTER MENU]_V01.32.00.00									
FILE HELP HARDKEY									
SETUP MENU									
SELECTION	REFERENCE								
- FAVORITES	SOURCE EXT -								
	INPUT TERMINATION ON								
- INFO HARDWARE	BACK								
SOFTWARE OPTIONS									
- AD.IIISTMENT									
COMMUNICATION									
	TX TSGEN								
	ERROR								
	DETAILS								

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".

♦ RSSFE100-120104 SFE-[TRANSMITTER MENU] V01.32.00.00									
FILE HELP HARDKEY									
FREQUENCY 602.000 000 MHz	LEVEL -10.0 dBm	MODULATION							
	USER1	USER2	USER3	REF INT					
SELECTION		MODU	ILATION						
FAVORITES	MODULATION ON								
FREQUENCY	SIGNAL SOURCE								
SETTINGS	SPECTRUM NORMAL V								
±. LEVEL	BACK								
MODULATION									
<u> </u>									
			X	TSGEN					
RF MOD ON/OFF ON/OFF				ERROR DETAILS					

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".

♦ RSSFE100-120104 SFE-[TRANSMITTER MENU] V01.32.00.00									
FILE HELP HARDKEY									
FREQUENCY 602.0	00 000 MHz	LEVEL - 10 .0 dBm	MODULATION						
		USER1	USER2	USER3	REF INT				
SELECTION			SET	TINGS					
FREQUENCY FREQUENCY SETTINGS LEVEL MODULATION MODULATION SETTINGS	CY I ION FO/STAT.	DIGITAL IN MODE BACK			DIVERSITY/NATIVE				
					TX TSGEN				
RF ON/OFF	MOD ON/OFF				ERROR DETAILS				

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.

Image: Second state of the se								
FREQUENCY 602.000 000 MHz		LEVEL -10.0 dBm	MODULATION					
		USER1	USER2	USER3		RI IN	≡F IT	
SELECTION			SIGNAL INF	O/STATISTICS				
SELECTION FAVORITES FREQUENCY LEVEL SETTINGS MODULATION MODULATION SIGNAL INFO/STAT.		BASEBAND SIGNAL RMS VALUE PEAK VALUE I/Q SYMBOLRATE REFRESH BACK		<u>Г</u>	100.00	-8.75 -0.59 00 000 1	ABFS ABFS MS/s	
	-				TX	TSGEN		
RF ON/OFF	MOD ON/OFF					EF DE	IROR TAILS	

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 <u>http://www.rohde-schwarz.com</u>. Please send any comments or suggestions about this Application Note to

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

5 Ordering Information

Designation	Туре	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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Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established 75 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

Environmental commitment

- Energy-efficient products
- Continuous improvement in environmental sustainability
- ISO 14001-certified environmental management system



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