IZT S1000 Maximum Ratio Combining Tests





Maximum Ratio Combining (MRC) is a variant of diversity combining, that is a method to combine two or more received signals in order to improve the quality of the resulting signal from more antennas. MRC can be used to improve the reception quality for wireless communications and a variety of broadcasting standards such as DVB-T, DAB and HD Radio.

TECHNICAL BACKGROUND

Different kinds of diversity can be used to improve the quality of a received signal. Common diversity schemes include:

- Time diversity (FM diversity)
- Frequency diversity: different frequencies are used for transmission to overcome frequency-selective fading, for example combining the two HD Radio OFDM+ sidebands or spread spectrum
- Space diversity: several propagation paths, for example by using antenna diversity (multiple transmission or reception antennas)

The MRC technique can be used to make use of antenna diversity at the receiver to increase the overall received signal-to-noise ratio to improve performance during fading and nonuniform interference. This is achieved by calculating a weighted sum of all input channels where the gain of each channel is proportional to the RMS level and inversely proportional to the mean square noise in the respective channel.

ANTENNA DIVERSITY SIMULATION

To simulate antenna diversity, it is required to simulate the transmission paths of each channel. This includes the simulation of fading effects and incoherent noise generators for each channel. The output signal from each transmission path needs to be fed to a separate RF output of a signal generator.

CONVENTIONAL APPROACH

Conventional signal generators usually contain only one RF output. In consequence, one separate device is required for each simulated transmission path. They share the same data source as common input. Each device applies fading effects and noise to the respective transmission signals. The devices need to be synchronized to achieve a controlled phase relation among the signal generators.

Figure 1 shows a conventional setup consisting of two synchronized signal generators.

ANTENNA DIVERSITY SIMULATION WITH THE IZT S1000 SIGNAL GENERATOR

The IZT S1000 not only includes 31 Virtual Signal Generators, but also provides two independent RF outputs for diversity testing (Figure 2). With the built-in incoherent noise sources for each RF output and the flexible independent fading generator a very compact setup can be achieved.



FIGURE 1: BLOCK DIAGRAM OF A CONVENTIONAL APPROACH TO MRC



FIGURE 2: BLOCK DIAGRAM OF A SINGLE IZT S1000 WITH TWO RF OUTPUTS FOR MRC - (REQUIRED EQUIPMENT: S1000, OPTIONAL MEMORY EXTENSION)

() S1000 Signal					Int RF1 Stream RF2	
		Signal 1		Signal 2		
	Format	HD Radio FM		HD Radio FM		
	Sampling Rate	744187.50000 Hz		744187.50000 Hz		
Spectrum		Mer	nory	Memory		
	Filename	D: IB_FMr440_e1wfr12	279.bin	D: IB_FMr440_e1wfr1279.bin		
	Length	237.772 з		237.772 s		
	Skip & Duration	0.000 s	-1.000 s	0.000 s	-1.000 s	
	Delay	0.000 ns		0.000 ns		
		Harc	ldisk	Hard	ddisk	
	Filename	Choose a file		Choose a file		
Impairment	Length	0.000 s				
	Skip & Duration	0.000 s	-1.000 s	0.000 s	-1.000 s	
	Streaming Time	Immediately		Immediately		
	Streaming Offset	0.000 ns		0.000 ns		
	Loops	0			-1	
	Time	0.000 s			0.000 s	
	Progress					
Non-Linearity	Source	Memory		Memory i		
	Mode	On		On		
	Impairments	On		On	6	
	Output	RF1		RF2		
		RF 1	RF 2	RF 1	RF 2	
	Frequency Name	Select			Select	
	Frequency	102.100000000 MHz			102.10000000 MHz	
video	Gain Control	Manual				
	Power	-50.0 dBm			-50.0 dBm	

FIGURE 3: SIGNAL CONFIGURATION USING TWO SIGNALS ON RF1 AND RF2

	ment	i		1			Int 🚥	RF1 Stream RF2
101000104 million	Signal 1	Tap 1			Tap 2	1	Тар 3	
	Mode	On		On		On		
	Delay	0 ps		100000 ps		200000 ps		
	Gain	0.0 dB		0.0 dB	-4.0 dB	-4.0 dB	-8.0 dB	
	Offset	0.000000 MB	łz	0.000000 MHz	0.000000 MHz	0.000000 MHz	0.000000 MI	Hz
			Channel S	Simulation	Channe	Simulation		Chanr
	Mode	Rice		Rayleigh		Rayleigh		
	Filename	Choose a fi	ile		Choose a file		Choose a f	ile
	Loss (Re, Im)	1.000		0.000	1.000	0.000	1.000	
	Loss Correction	-7.782 dB						
G.	Phase	Normal		Normal		Normal	-	
	Doppler	11.35230 Hz		11.35230 Hz		11.35230 H	z	
	Speed	33.33334 m/s		33.33334 m/s		33.33334 m,	/ s	
	Rice K	0.00		0.00	0.00			
	Rice Angle	0.000 degre	e		0.000 degree		0.000 degre	ee
			Frequen	cy Profile	Freque	ncy Profile		Freq
	Mode	Off			Off		Off	
	Filename	Choose a file		Choose a file		Choose a f.	ile	
	Hopper	No		No		No		
		Power Profile		Power Profile			Por	
	Mode	Off			Off		Off	
	Filename	Choose a fi	ile		Choose a file .		Choose a f	ile
			Delay I	Profile	Dela	y Profile		De
	Mode	Off			Off		Off	
	Filename	Choose a fi	ile	•	Choose a file .		Choose a f	ile
		Non-Linearity		Non-Linearity			No	
	Mode	Off			Off		Off	

HOW TO CONFIGURE THE IZT \$1000

- 1. Configure two signals using the same test vector or signal (e.g. HD Radio)
- 2. Configure first signal on RF1 output and second signal on RF2 output
- 3. Simulate fading effects with channel simulator, e.g. TU6 Profile for both outputs
- 4. Effects will be simulated independently for both RF outputs
- 5. Activate incoherent noise for both RF outputs
- 6. Configure effective bandwidth and C/N for each signal

FIGURE 4: ACTIVATE MULTIPATH FADING ON RF1

S1000 Signal Im	pairment					Int Int RF1 RF1 RF2
	Signal 2 Tap 1			Tap 2		Tap 3
	Mode	On 0 ps		On		On
	Delay			100000 ps		200000 ps
	Gain	0.0 dB	0.0 dB	-4.0 dB	-4.0 dB	-8.0 dB
	Offset	0.000000 MHz	0.000000 MHz	0.000000 MHz	0.000000 MHz	0.000000 MHz
		Channel Simulation		Channe	Channel Simulation	
	Mode	Rice		Rayleigh	Rayleigh	
	Filename	Choose a file .		Choose a file .		Choose a file
	Loss (Re, Im)	1.000	0.000	1.000	0.000	1.000
Loss Correction		-7.782 dB				-7.782 dB
	Phase		Normal		Normal	
	Doppler	ppler 11.35230 Hz eed 33.33334 m/s		11.35230 Hz	11.35230 Hz	
	Speed			33.33334 m/s		33.33334 m/s
	Rice K	0.00		0.00		0.00
	Rice Angle	0.000 degree Frequency Profile		0.000 degree		0.000 degree
				Frequency Profile		Freq
	Mode	Off		Off		Off
	Filename	Choose a file		Choose a file .	Choose a file	
Hopper		No		No		No
		Power Profile		Power Profile		Po
	Mode	Off		Off		Off
	Filename	Choose a file Delay Profile		Choose a file .	Choose a file	
				Delay Profile		De
	Mode	Off		Off		Off
	Filename	Choose a file		Choose a file		Choose a file
		Non	Linearity	Non	Non-Linearity	
	Mode	Off		Off		Off
						15:48

FIGURE 5: ACTIVATE MULTIPATH FADING ON RF2

				RF1 RF2	Int LAN Stream RF1 Stream RF2
101000110000		DF 1	DF 2		
	Mode	On	On		
	Power Density (No) -174.0 dBm/Hz	-174.0 dBm/Hz	•	
	Configuration	Bandwidth			
	Bandwidth	10.0 MHz			
	Frequency Offset	0.0 MHz			
	Center Frequency	100.0 MHz			

FIGURE 6: USE INCOHERENT NOISE SOURCE FOR RF1 AND RF2

Power	-50.0 dBm	-134.0 dBm	-134.0 dBm	-50.0 dBm	
Gain					
Eff. Bandwidth	396.80400000 kHz		396.80400000 kHz		
C/N	68.0 dB			68.0 dB	
C/No	124.0 dBHz	40.0 dBHz		124.0 dBHz	

FIGURE 7: C/N CAN BE CONFIGURED TO ADAPT THE NOISE LEVEL

REQUIRED HARDWARE AND SOFTWARE CONFIGURATION

- 2 RF outputs [option IZT S1000-RF3]
- Fading generator (channel simulator) [option IZT \$1000-304]
- HD Radio
 [option IZT \$1000-220]
- DAB/DVB-T
- [option IZT \$1000-403 / IZT \$1000-408]
- Memory Extension for live streaming of test vectors [option IZT S1000 Memory Extension]
- High speed LAN streaming (needed with IZT S1000 Memory Extension)
 [option IZT S1000-120]

CONCLUSIONS

Antenna diversity can greatly improve performance under multipath fading conditions. To ensure maximum performance of receivers the use of the diversity is an essential technical feature which has to be tested thoroughly and this comes with some efforts.

Compared to conventional approaches, the IZT \$1000 Signal Generator provides two independent RF outputs for diversity testing. This leads to a very compact, costeffective stand-alone solution. In addition, the IZT \$1000 Signal Generator can be easily configured and used in automated test setups.



INNOVATIONSZENTRUM FÜR TELEKOMMUNIKATIONSTECHNIK GMBH IZT AM WEICHSELGARTEN 5 · 91058 ERLANGEN, GERMANY GENERAL MANAGER: RAINER PERTHOLD · TEL: +49 (0)9131 9162-0 · FAX: -190 · SALES@IZT-LABS.DE · WWW.IZT-LABS.DE

91058 ERLANGEN, GERMANY Innova WWW.IZT-LABS.DE Telekommunik