

MATLAB Simulink 사용법

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순서

- Introductions
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- Simulink 기본
- Simulink 연습
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Introductions

- Communication Blockset
 - Type “commlib” in the MATLAB workspace
- Online interactive example
 - Type “commgui”
- To view all MATLAB functions in the toolbox
 - Type “help comm”
- Communication Toolbox is divided into
 - comm : MATLAB functions
 - commsim : Simulink block library
 - commsfun sublibrary : S-function files

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MATLAB Simulation vs. Simulink (1)

- MATLAB Simulation
 - MATLAB Function을 사용하여 직접 코딩

The image shows a screenshot of the MATLAB Editor window. The title bar reads "Editor - D:\정보통신공학과\강의관련\CD\지열통신\MATLAB 실". The menu bar includes "File", "Edit", "Text", "Cell", "Tools", "Debug", "Desktop", "Window", and "Help". The toolbar contains various icons for file operations, editing, and debugging. The code area shows the following MATLAB script:

```
1
2- G=[1 1 0; 0 1 1; 1 1 1; 1 0 1], eye(4)];
3- [K, N] = size(G);
4- msg = randint(K+200, 1, 2);
5- code = encode(msg, N, K, 'linear', G);
6- code_noise=rem(code+rand(N+200, 1)>.95, 2);
7- rcv = decode(code_noise, N, K, 'linear', G);
8- disp(['Error rate in the received code: ', ...
9-      num2str(symerr(code, code_noise)/length(code))])
10- disp(['Error rate after after decode: ', ...
11-      num2str(symerr(msg, rcv)/length(msg))])
```

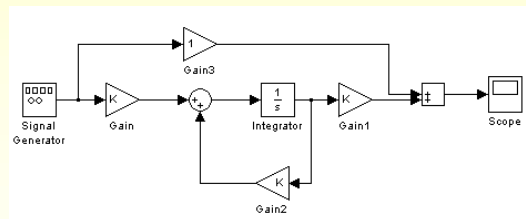
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MATLAB Simulation vs. Simulink (2)

- Simulink란?
 - Dynamic 시스템을 컴퓨터를 사용하여 모델링하고 시뮬레이션하여 시스템을 해석하기 위해서 MATLAB에 포함된 패키지
- How to start?
 - Type "simulink" or icon 클릭



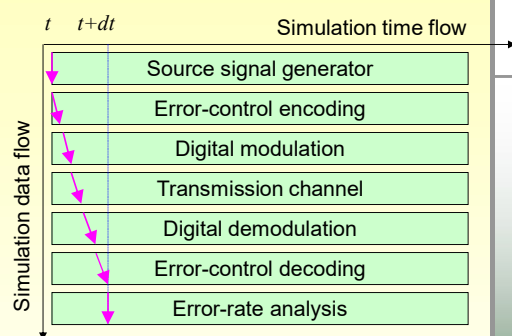
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MATLAB Simulation vs. Simulink (3)

- MATLAB simulation
 - Data flow simulation
- Simulink
 - Time flow simulation
- 결과는 오차범위 내에서 유사한 결과를 도출
- 동전 던지기에서 앞면, 뒷면 발생확률을 확인하는 실험
 - 1개씩 1000번을 던짐 : Simulink
 - 1000개를 한번에 던짐 : MATLAB 시뮬레이션



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Simulink 기본(1)

■ Matlab 및 Simulink 버전 확인 방법

■ Type “ver”

```
>> ver
```

```
MATLAB Version 7.0.1.24704 (R14) Service Pack 1  
MATLAB License Number: 234589  
Operating System: Microsoft Windows XP Version 5.1 (Build 2600: Service Pack 2)  
Java VM Version: Java 1.4.2.04 with Sun Microsystems Inc. Java HotSpot(TM) Client VM
```

MATLAB	Version 7.0.1	(R14SP1)
Simulink	Version 6.1	(R14SP1)
Aerospace Blockset	Version 1.6.1	(R14SP1)
Bioinformatics Toolbox	Version 1.1.1	(R14SP1)
CDMA Reference Blockset	Version 1.1	(R14SP1)
Communications Blockset	Version 3.0.1	(R14SP1)
Communications Toolbox	Version 3.0.1	(R14SP1)
Control System Toolbox	Version 6.1	(R14SP1)

■ 모델 생성 및 저장

- 모델 생성 방법 : Simulink 윈도우의 “create a new model” 클릭
- 모델 저장 방법 : *.mdl 파일이 생성됨
 - 시스템의 사용자 정보가 “영어”로 표기되어 있어야 함
 - 한글이면 저장 오류 발생 → OS를 re-install or the other method

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Simulink 기본(2)

■ 모델이 저장되지 않을 경우

- 작성한 모델에서 File → Model Properties → history 클릭
- “Read Only” 선택을 해제한 후 “Last saved by” 과 “Created by”을 영문이름으로 변경.
- Apply → OK 를 클릭함
- 모델 저장

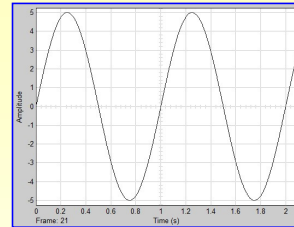
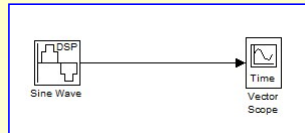
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Simulink 연습 (1)

■ 정현파 생성 및 측정



- Sine wave와 Vector scope는 모두 Signal processing block
- Sine wave 블록의 amplitude(5), frequency(30), samples per frame(100) 값을 변경
- ~~Vector scope를 사용하는 경우에는 samples per frame 값을 1보다 큰 값으로 설정해야 함(ex. 100)~~
- ~~Vector scope 블록의 "Time display span"은 결과 그림 하단에 있는 frame 값으로 설정해야 전체 파형이 출력됨~~

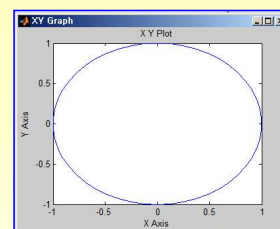
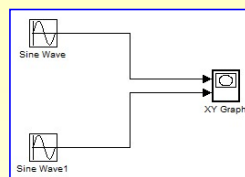
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Simulink 연습 (1-1)

■ 정현파 생성 및 측정



- Sine wave와 XY Graph는 모두 Simulink block
- Sine wave 블록의 amplitude(1), frequency(2π), phase($\pi/2$), Simulation time(1)

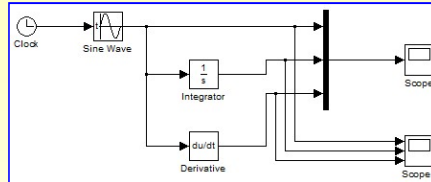
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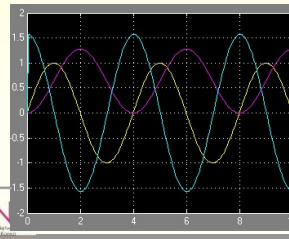
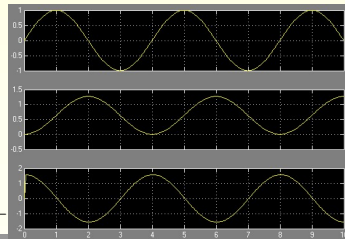
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Simulink 연습 (1-2)

정현파 생성 및 측정



- Sine wave 블록의 amplitude(1), frequency(1/4 Hz), Simulation time(10)



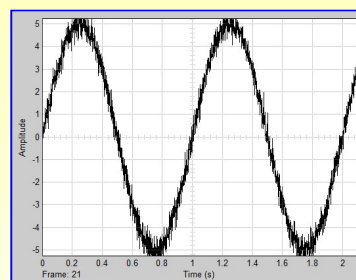
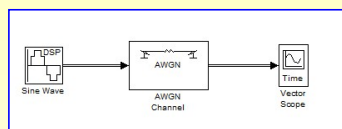
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MCNL

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Simulink 연습 (2)

정현파 + Noise



- AWGN 채널 파라미터

Parameters

Initial seed: 37

Mode: Signal to noise ratio (SNR)

SNR (dB): 10

Input signal power (watts): 1

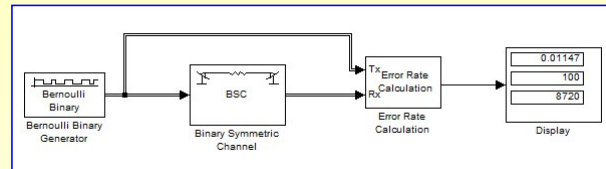
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Simulink 연습 (3)

Channel noise model



- MATLAB command window에 “commstartup” 입력
- BSC
 - Error probability: 0.01
- Error rate calculation
 - Output data: Port
 - Check “Stop simulation”
 - Total number of errors: 100
 - Maximum number of symbols: 1e6

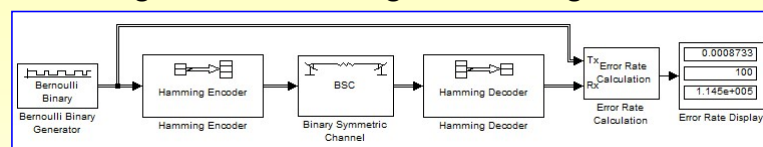
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Simulink 연습 (4)

Reducing Error Rate using a Hamming code



- Bernoulli Binary
 - Frame-based outputs, samples per frame = 4
- Bit error rate: $0.0009 \ll 0.01$
- Displaying frame size
 - Display → Signals & Ports → signal dimensions

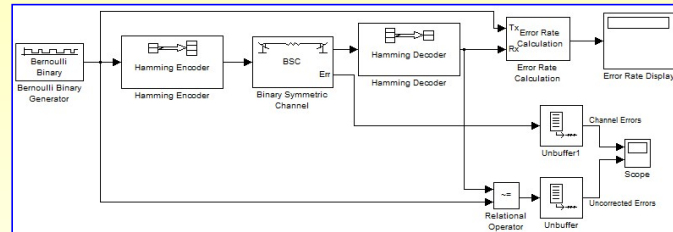
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Simulink 연습 (5)

■ Adding Scope to the model



BSC channel

- Select "Output error vector"

Error Rate Calculation

- Clear "Stop simulation"

Relational Operator

- Relational operator: "~="

Scope block

- Parameters : "Number of axes" = 2
- Parameters : "Time range" = 5000
- Data history : "Limit data points to last" = 30000
- Right-click the vertical axis → Handle "Axes properties"

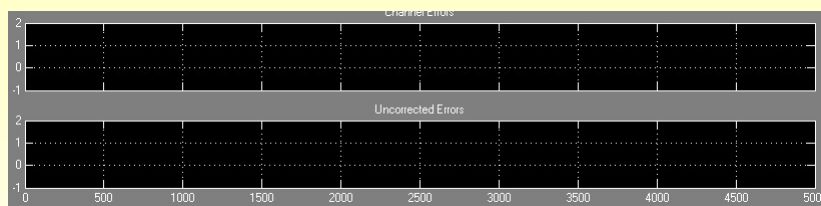
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Simulink 연습 (5-1)

■ Example of scope



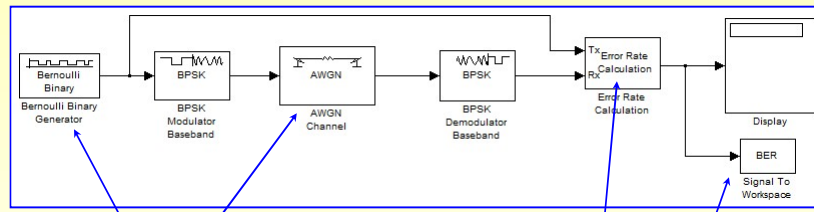
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Simulink 연습 (6)

Channel with Modulation



AWGN

- E_b/N_0 [dB]: EbNo

Bernoulli Binary

- To reduce run time
- Samples per frame: 1,000

Error Rate Calculation (stop simulation)

- Target number of errors: maxNumErrors
- Maximum number of symbols: maxNumBits

Signal to Workspace (DSP)

- Variable name: BER
- Limit data points to last: 1

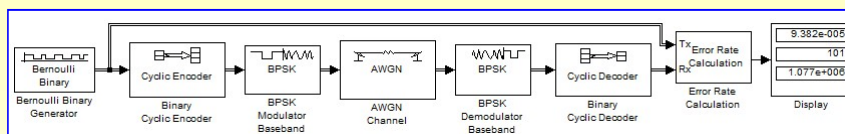
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Simulink 연습 (7)

Channel with Modulation and Cyclic coding



Bernoulli Binary

- Frame-based outputs
- Sample per frame=21

AWGN

- $E_s/N_0 = 7 + 10 \cdot \log_{10}(21/31)$
- Symbol period = 21/31

Cyclic Encoder

- Codeword length $N = 31$
- Message length $K = 21$

Error Rate Calculation

- Maximum number of symbols = 1e7

In case of error

- Tools → Fixed point setting → Logging mode: Force off

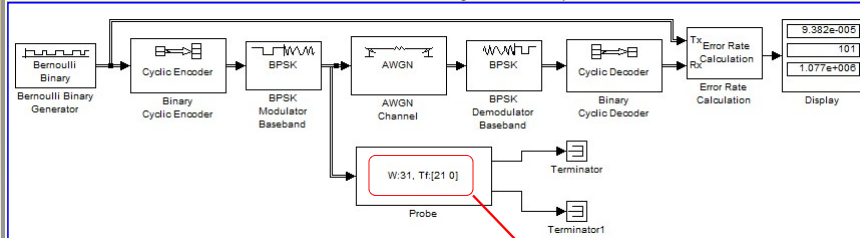
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Simulink 연습 (7-1)

Probe block to determine symbol period



Probe block

- Clear: Probe complex signal, Probe signal dimensions, Delete framed signal
- Check: Probe width, Probe sample time

The others

- Connect every block as the above figure
- Edit → Update diagram

Frame size, frame period

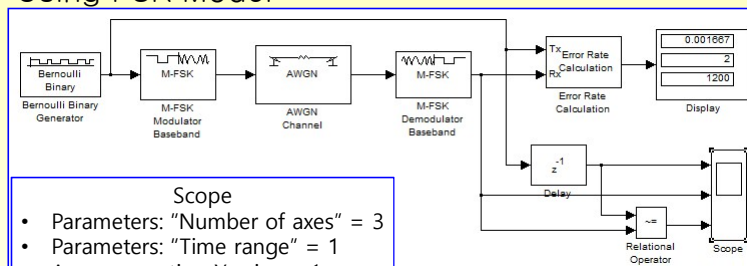
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Simulink 연습 (8)

Using FSK Model



Scope

- Parameters: "Number of axes" = 3
- Parameters: "Time range" = 1
- Axes properties: Y-min = -1
- Axes properties: Y-max = 2

AWGN

- Symbol period = 1/1200

Error Rate Calculation

- Receiver delay = 1
- Output data = port

Bernoulli Binary

- Probability of a zero = 0.5
- Sample time = 1/1200

M-FSK

- M-ary number = 2
- Frequency separation = 1000
- Samples per symbol = 5

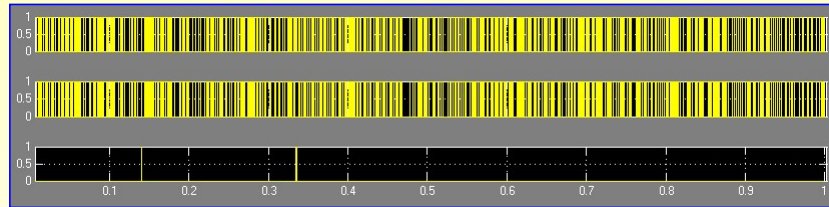
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Simulink 연습 (8-1)

Scope output



Scope

- Top window: transmitted signal
- Middle window: received signal
- Bottom window: agree(0), differ(1)

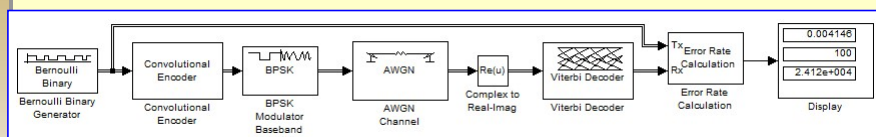
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Simulink 연습 (9)

Building Convolutional code model



- #### Bernoulli Binary
- Frame-based output

- #### AWGN
- Es/No = -1
 - Symbol period = 1/2

- #### Error Rate Calculation
- Receive delay = 96
 - Check "Stop simulation"
 - Target number of errors = 100

- #### Viterbi Decoder
- Traceback depth = 96

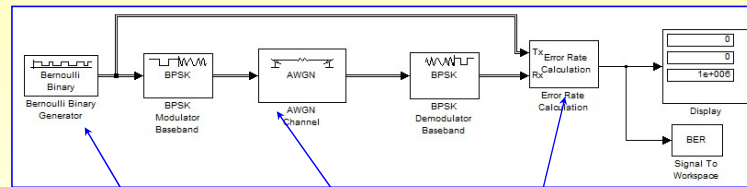
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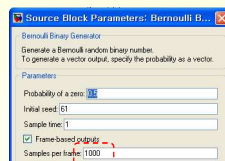
Running Multiple Simulations(1)

Building test model (my_example.mdl)



Bernoulli Binary

- Frame-based output



한번에 처리하는 프레임 단위

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Error Rate Calculation

- Check "Stop simulation"
- Target number of errors = 500
- Maximum number of symbols = 1e7

AWGN

- $E_s/N_0 = E_b/N_0$

Signal To Workspace

- Variable name = BER



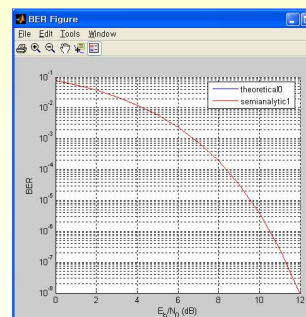
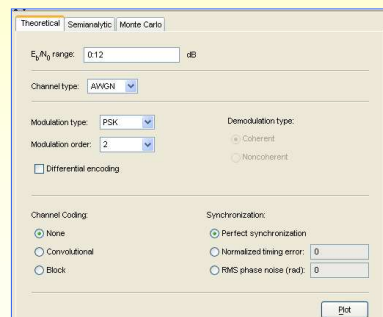
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Running Multiple Simulations(2)

Open BERTool and Enter Parameter

■ bertool [enter]

Theoretical results 만드는 방법



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Running Multiple Simulations(3)

- Running the Semianalytic Example
 - Set up the transmitted and received signals
 - Open BERTool and go to the Semi-analytic panel
 - Set parameters as shown below
 - Click Plot

The screenshot shows the 'Semianalytic' tab of the BERTool interface. The parameters are as follows:

- E_b/N_0 range: 0:12 dB
- Channel type: AWGN
- Modulation type: PSK
- Modulation order: 2
- Differential encoding: ☐
- Samples per symbol: 1
- Transmitted signal: `rectpulse(pskmod(randint(16, 1, 2, 9973), 2), 16)`
- Received signal: `rectpulse(pskmod(randint(16, 1, 2, 9973), 2), 16)`
- Receiver filter coefficients:
 - Numerator: `ones(16, 1)/16`
 - Denominator: 1

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Running Multiple Simulations(4)

- Running the Monte Carlo Simulation

The screenshot shows the 'Monte Carlo' tab of the BERTool interface. The parameters are as follows:

- E_b/N_0 range: 0:3:12 dB
- Simulation M-file or model: `\\Matlab 사용법 강의자료\사용예제\my_example.mdl` (with a 'Browse...' button)
- BER variable name: BER
- Simulation limits:
 - Number of errors: 500
 - or
 - Number of bits: $1e7$
- Buttons: Run, Stop

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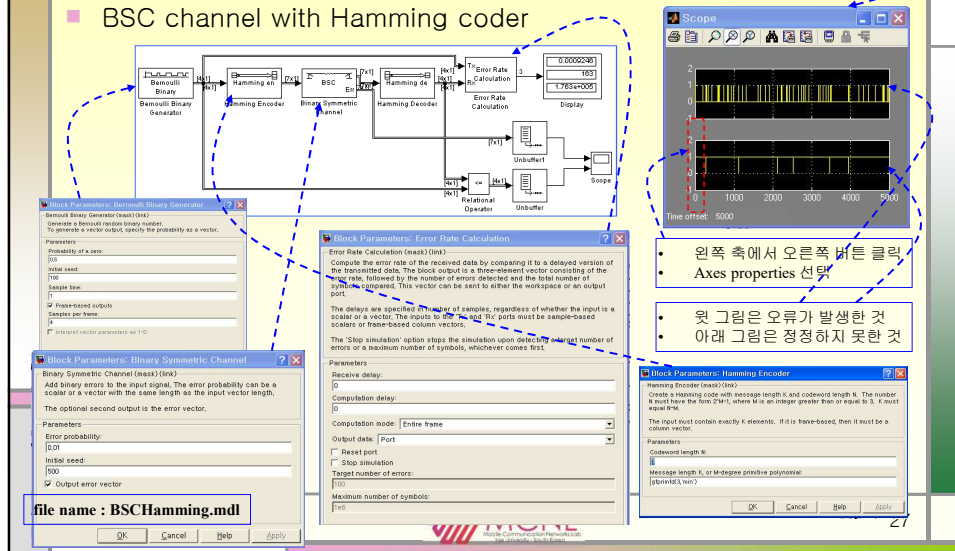


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Examples (1)

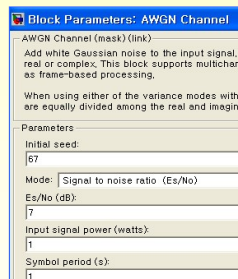
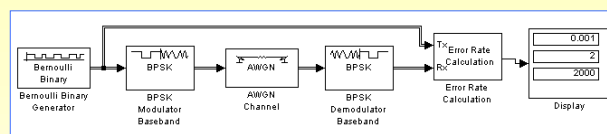
- Time range : 5000
- Limit data points to last : 30000

- Before starting to build the model, enter [commstartup]
- BSC channel with Hamming code



Examples (2)

- BPSK without Channel coding

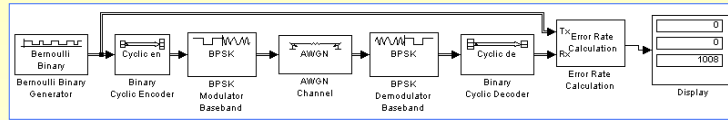


file name : my_bpsk.mdl

Examples (3)

BPSK with Cyclic coding

file name : my_bpskcyclic.mdl



Block Parameters: Bernoulli Binary Generator (mask) (link)
Generate a Bernoulli random binary number. To generate a vector output, specify the number of samples per frame.
Parameters
Probability of a zero: 0.5
Initial seed: 61
Sample time: 1
☒ Frame-based outputs
Samples per frame: 21
☐ Interpret vector parameters as 1-D

Block Parameters: Binary Cyclic Encoder (mask) (link)
Create a systematic cyclic code with message length N. The number N must have the form $2^M - 1$, where M is an integer.
Parameters
Codeword length N: 31
Message length K, or generator polynomial: 21

Block Parameters: AWGN Channel (mask) (link)
Add white Gaussian noise to the input signal. The input can be real or complex. This block supports multichannel input and output.
When using either of the variance modes with complex input, the real and imaginary parts are equally divided among the real and imaginary parts of the output.
Parameters
Initial seed: 61
Mode: ☐ Signal to noise ratio (Es/No)
Es/No (dB): 7.1010 (10/10/10/10/10)
Input signal power (watts): 1
Symbol period (s): 21/31

Block Parameters: Error Rate Calculation (mask) (link)
Compute the error rate of the received data by comparing the received data with the transmitted data. The block output is a three-element vector, followed by the number of errors detected, followed by the number of errors detected symbols compared. This vector can be sent to either port.
Parameters
Receive delay: 0
Computation delay: 0
Computation mode: ☐ Entire frame
Output data: ☐ Port
☐ Reset port
☒ Stop simulation
Target number of errors: 100
Maximum number of symbols: 1e7

동일한 Es/No 값에 대하여 Cyclic 코드를 사용할 경우 SER 값이 개선됨을 확인할 수 있음

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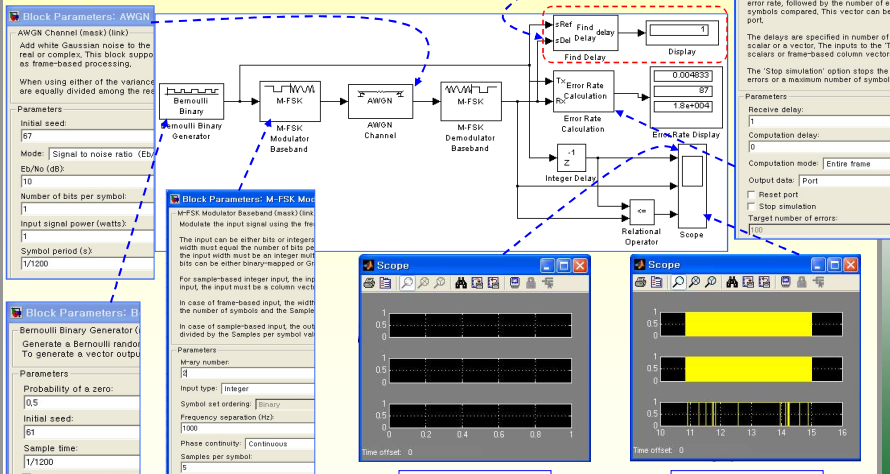
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Examples (4)

file name : my_fsk.mdl

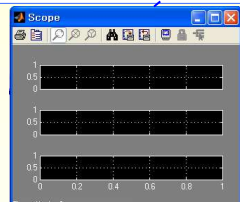
FSK without Channel coding

Delay를 찾는 모듈

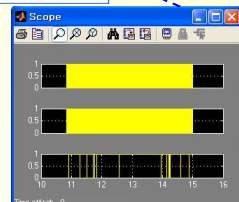


Block Parameters: Bernoulli Binary Generator (mask) (link)
Generate a Bernoulli random binary number. To generate a vector output, specify the number of samples per frame.
Parameters
Probability of a zero: 0.5
Initial seed: 61
Sample time: 1/1200
☒ Frame-based outputs

Block Parameters: M-FSK Modulator Baseband (mask) (link)
Modulate the input signal using the frequency separation (Hz).
Parameters
Binary number: 4
Input type: ☐ Integer
Symbol set ordering: ☐ Binary
Frequency separation (Hz): 1000
Phase continuity: ☐ Continuous
Samples per symbol: 5



Scope 모듈 설정



Scope 출력

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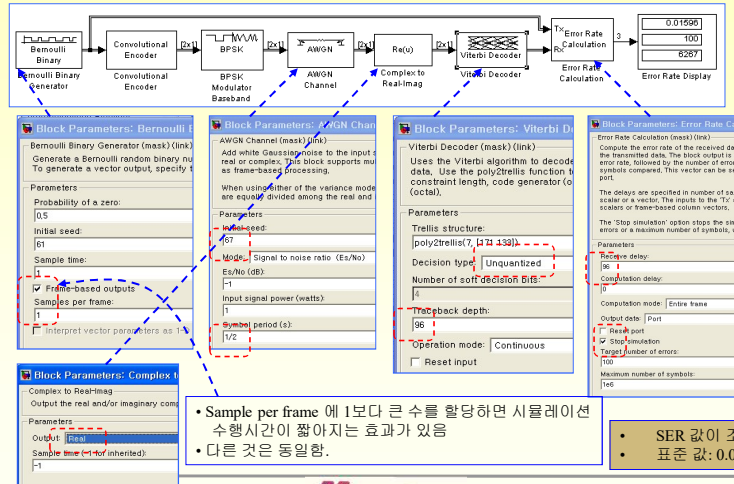


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Examples (5)

■ BPSK with Convolutional code

file name : my_bpskcc.mdl



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기타

■ 기 생성된 참조모델은

Program Files/MATLAB/R2007a/toolbox/commblks/commblksdemos 에 있음

■ [주의사항]

- 기 작성된 참조모델을 사용할 경우에는 반드시 해당 파일을 복사한 뒤 개인 폴더에 옮겨놓고 작업할 것

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