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Simulink-Based Digital Communication System Using BCH(15,5) and 64-QAM for Marathi Speech and SMS Data

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Problem Statement

In view of the increasing demand for digital wireless communication, the channel bandwidth is reducing. This can lead to loss of speech quality and data integration. Simulate a better digital communication link in Simulink (using transmitter and receiver, and assuming free space) with the following parameters:

- **Speech:** Language Marathi
- **Data:** Max SMS length = 50 Char., Language - English Text
- **Source coding for voice**: CELP
- **Source coding for data:** Huffman
- **Channel coding:** BCH (15,5)
- **Modulation scheme:** 64 QAM
- **Channel:** Rician
- **Ground station A:** Pune
- **Ground station B:** Nashik
- **Satellite:** GSAT29

Introduction

This project simulates a digital communication system that transmits Marathi speech and English text between Pune and Nashik via the GSAT-29 satellite. Using Simulink, we implement CELP for speech compression, Huffman coding for text, BCH(15,5) for error correction, and 64-QAM modulation. The signal is transmitted over a Rician fading channel to reflect real-world wireless conditions. System performance is evaluated using metrics like BER, SNR, throughput, and delay.

System Specifications

COMPONENT	SPECIFICATION
Speech Input	Marathi language, recorded at 8 kHz sampling rate 16 bit
Text Input	English, max 50 characters per message
Voice Source Coding	CELP (Code-Excited Linear Prediction)
Text Source Coding	Huffman Encoding
Channel Coding	BCH (15,5)
Modulation Scheme	64-QAM (6 bits/symbol)
Channel	Rician fading
Simulation Tool	MATLAB Simulink
Link Path	Ground Station A (Pune) ↔ Ground Station B (Nashik) via GSAT-29
System Goal	Low BER, high quality, and data transmission

Data Collection Methods

- **Speech:**

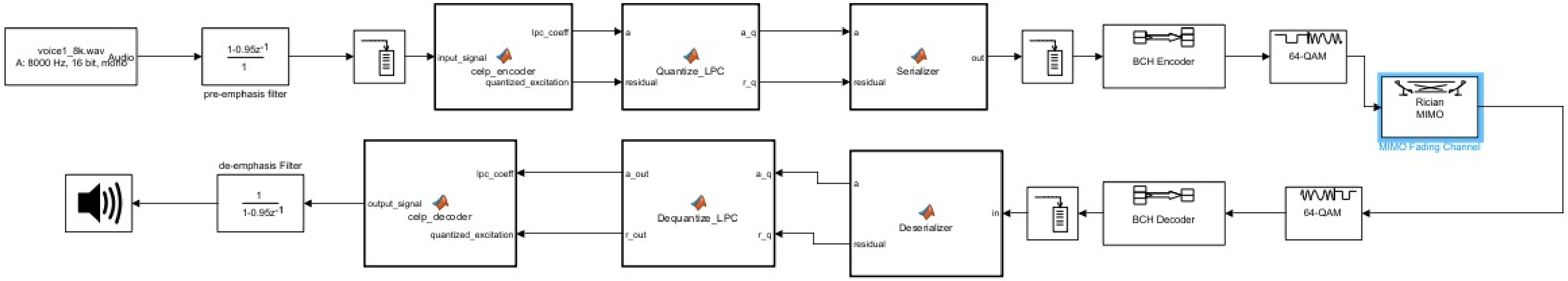
1. Language – Marathi
2. Input – Audio from people of different age groups and genders
3. Store – .wav file

- **Text:**

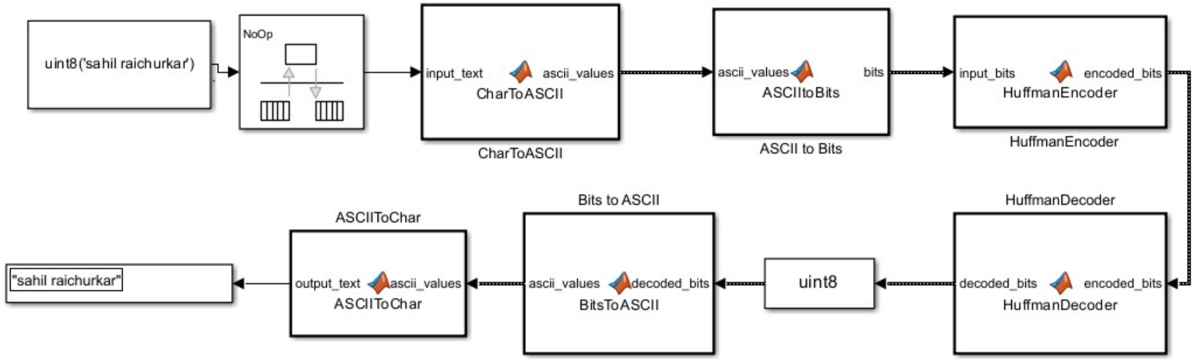
1. Content – Short English messages (≤ 50 characters)
2. Input Method – Manually typed

Block Diagram

Speech Block Diagram:



Text Block Diagram:



Text encoding using Huffman

- Huffman encoding compresses data by replacing characters with variable-length binary codes based on their frequencies—more frequent characters get shorter codes
- Lets take an example : “hello how are you?”

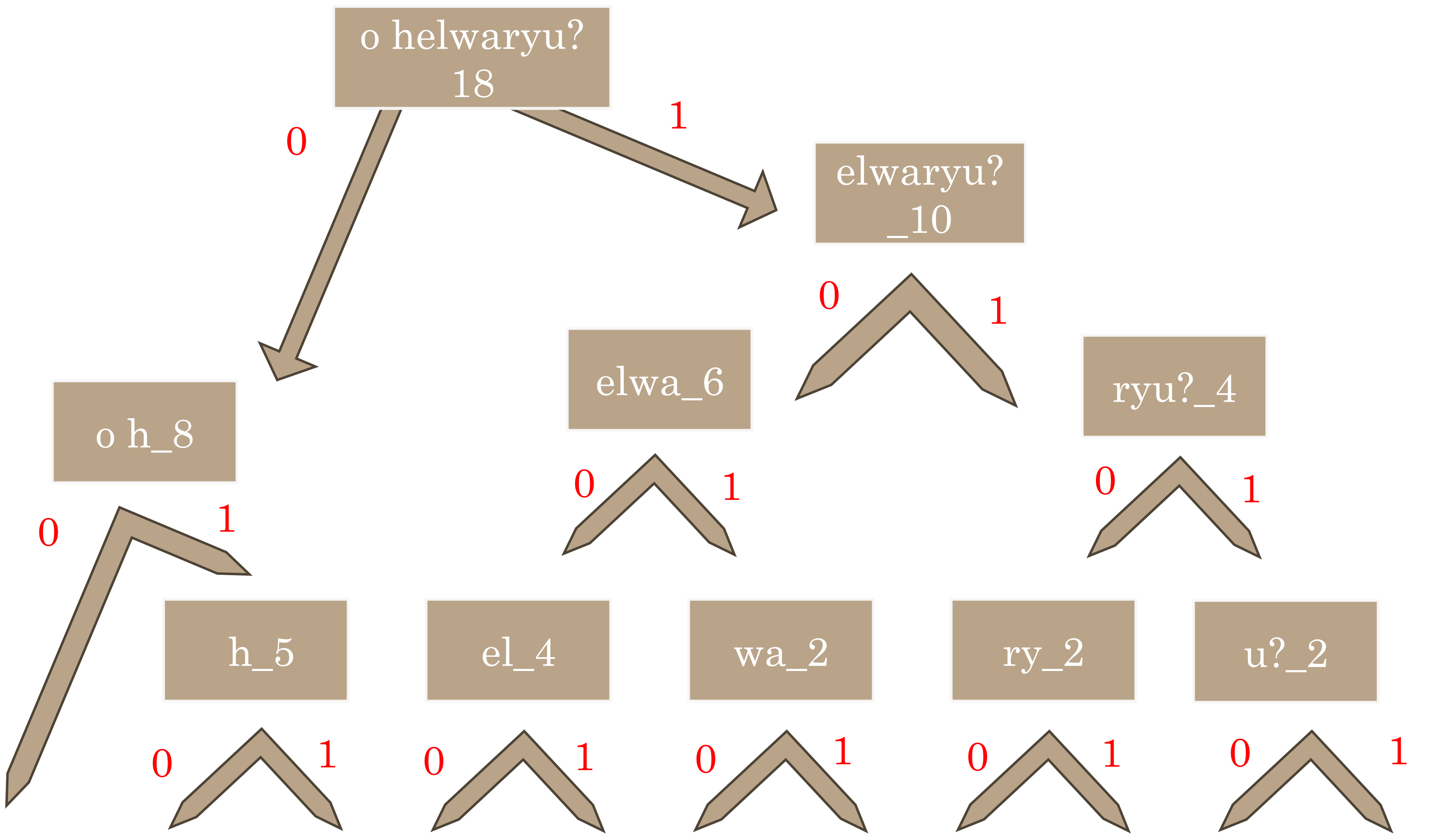
h	e	l	o	w	a	r	y	u	?	“ ”
2	2	2	3	1	1	1	1	1	1	3

Total characters : 18

Write allt hese numbers in decreasing order

o	“ ”	h	e	L	w	a	r	y	u	?
3	3	2	2	2	1	1	1	1	1	1

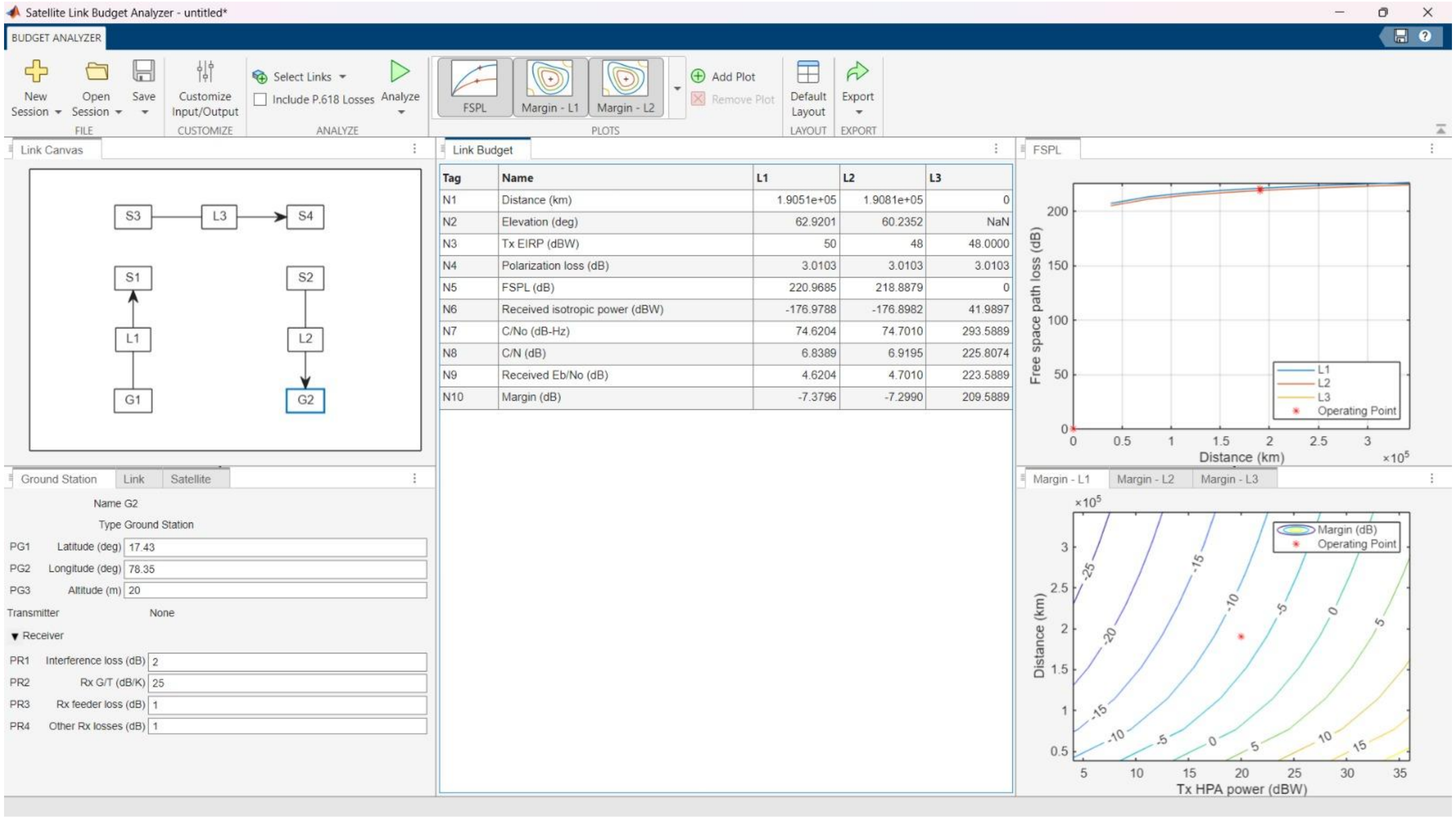
Huffman Encoding and decoding



o	“ ”	h	e	l	w	a	r	y	u	?
3	3	2	2	2	1	1	1	1	1	1

symbol	Code
o	00
“ ”	010
h	011
e	1000
l	1001
w	1010
a	1011
r	1100
y	1101
u	1110
?	1111

Satellite Link Budget



Working

- The system takes two inputs: Marathi speech sampled at 8 kHz and English text messages up to 50 characters.
- For speech, a pre-emphasis filter is first applied to enhance high-frequency components, followed by CELP encoding, quantization, and serialization.
- Text is compressed using Huffman encoding.
- Both data streams are then passed through a BCH (15,5) encoder to add redundancy for error correction.
- The encoded bitstream is modulated using 64-QAM and transmitted through a Rician fading channel.
- At the receiver, the signal is demodulated and BCH-decoded.
- Speech data is then deserialized, dequantized, passed through a de-emphasis filter, and CELP-decoded to reconstruct the original audio. Text data is Huffman-decoded.
- System performance is evaluated using BER, SNR, MOS, PESQ, throughput, and delay.

Conclusion

- The system successfully integrates speech and text communication using efficient CELP and Huffman source coding techniques. Robust error correction is achieved with BCH (15,5) channel coding, while 64-QAM modulation combined with a Rician fading channel effectively models realistic wireless conditions. Performance evaluations demonstrate reliable transmission with high data integrity and excellent speech quality, confirming the system's suitability for practical communication applications.

Thank you