Short Messaging Control Mechanism for CAN Bus Architecture

EE 6900 – Software Defined Radio and IoT

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INTRODUCTION

The focus of the project is to create a Simulink model that will reliably transmit and receive a short length message that can be applied to a variety of use cases. Use cases for a SDR in these applications might range from safety control systems inside of an Oil rig or refinery, Military, Medical, Home, Emergency Responders, Automotive Civilian, Automotive Commercial and many more industries or consumer quality of life improvements. Example for these messages in an Emergency Responder case might be the siren, civilians near the emergency responder can hear and see it clearly but every second matters when responding to an emergency. Thus, an emergency Responder could be transmitting a short radio signal that the civilian cars can interpret and then over the sound system or instrument panel warn the drivers of an emergency vehicle approaching their position and to move to the side. The use cases are only limited by the integrator's imagination. Furthermore, the use of an SDR can lower the cost, remove proprietary barriers, and increase freedom of design and implementation only limited by the designer's knowledge.

CONVERSION OF BUS DATA

A major key in our model will be the conversion and encryption of the data from hexadecimal values to waveform signals. Due to safety criticality, encryption must be done to prevent hackers from activating functions irresponsibly. Depending upon the length of the data message, there are various options such as Triple Data Encryption Standard (3DES), Advanced Encryption Standard (AES), Rivest Shamir Adleman (RSA), Blowfish and Twofish [4]. For our project proof of concept, we are utilizing a CAM message of no more than 64 bits. To prevent overcomplicating the simple data input, an encryption method will be chosen based upon the overall bit count of the output.

For the conversion of the data, there are many popular digital modulation methods such as amplitude-shift keying (ASK), frequency-shift keying (FSK), on-off keying (OOK) and binary phase-shift keying (BPSK) [3]. While there are more digital modulation methods that boast higher data rates, the use cases of our project do not require large volumes of data to be transferred. Therefore, the models will utilize simpler modulation techniques as proof of concept. From another aspect, signal integrity is key for transmitting short messages. Once again, safety criticality requires a level of reliability that a bad transmission will not result in a potentially catastrophic action on the receiver end. Our model needs a reliable modulation method that is least impacted by the noise most likely seen in the field. Due to these requirements of the system, we will assess using BPSK or FSK digital modulation methods.

SIMULINK MODEL

As our proof of concept, an end-to-end model will be created using Matlab code and Simulink models. The model will take a sample data input from a CAN bus and send it to the SDR. The SDR will encrypt the data and modulate the signal for transmission. Models of the transmitter and receiver will be utilized to simulate sending the signal. On the receiver end, the data will be demodulated and decrypted. Lastly, the data will be converted using a lookup table to a common data output that is recognized across different CAN systems. The conversion to common data can occur on either the transmitter or receiver side.

A block diagram of our proposed Simulink model is found in Figure 1. The simulation model will utilize the existing transmitter and receiver Simulink blocks found in the Phased Array System Toolbox [5]. Depending upon the encryption algorithm and digital signal modulation selected, custom Simulink blocks, or S-function blocks, will be created if pre-existing Simulink models [2]. A short, custom block will be created to convert the specific model-based CAM data into a common data output that is usable across multiple platforms. The block will utilize a pre-defined lookup table to convert the data. The data input itself will be a simple vector of hexadecimal values, representing CAM data.

Figure 2 shows our current Simulink Model to test aspects of our proof of concept. The model is currently able to take a column matrix of binary numbers and convert them from a binary form to a decimal form. This data is passed to a transmitter that has a power of 1W and a gain of 0. The output is given as an amplified form of the input and connected to a simple subtract block for us to obtain the proper ASCII conversion. Please note, the conversions currently planned using SDR are not implemented in this architecture yet, as they require more design choices.

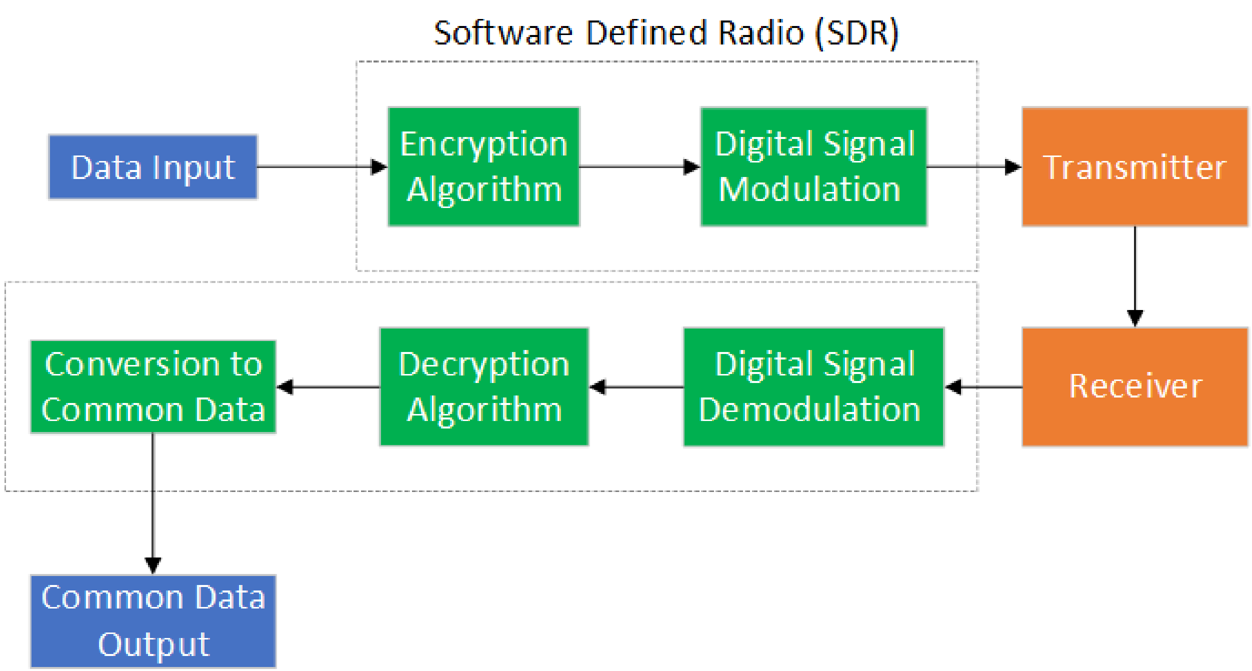

Figure 1: Proposed Simulink Model Block Diagram

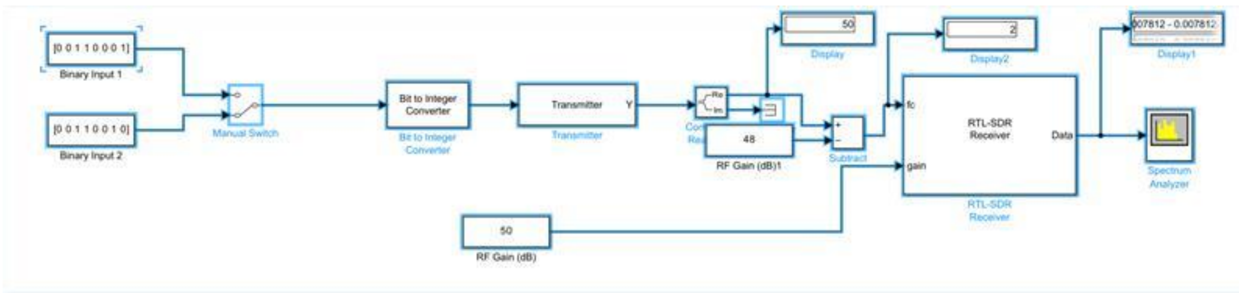

Figure 2: Current Simulink Model

ASSESSMENT AND CONTINGENCY PLANS

To define a successful simulation, the SDR transmitter must correctly encrypt input data, send the signal to a modeled receiver, and properly convert the data. The modeled transceiver and receiver must have a repeatable pattern of behavior when encrypting and decrypting the data that was sent and received. Our simulation testing will consist of multiple sample CAN data inputs and verify the common output data is correct.

In case of difficulties with the Simulink models misbehaving or not having a clear or sound pattern of behavior when encrypting or decrypting the messages there is a backup of performing this broadcasting and receiving of the messages over binary (1 and 0) and then those values can be generated from encryption methods. In this case the SDR will be performing almost exclusively the transmission and receiving of the radio signals with no smarts of encryption or decryption of the data that was broadcasted. Our current plan is to perform functional tests on the transmitter and receiver data conversions before full system testing. This will give us a chance to mitigate any risks of improper modeling while isolated from the rest of the system.

FINAL REPORT

The final report will show the functionality of the system by successful simulation of the data transmission and receiving. The simulation results will be analyzed to assess the overall accuracy of the system and feasibility of our modeled solution. Improvements or any possible method issues that might be present will be addressed and if possible, solutions will be provided.

PROJECT SUMMARY

At this current moment SDR technology hasn't seen wide adoption outside of the hobbyists and enthusiasts. These use cases presented in this project may open the possibilities of cheap and readily available hardware to be utilized in industries where development of new proprietary technology might be a drawback. More and more consumers and companies are looking for cheap and effective ways of performing automation or improvements to their daily operations and SDR may be an appropriate path for some of those situations. However, the higher likelihood is that this concept and method of controlling systems may be used by the open-source community with a lot of bright minds being able to adopt this concept to serve some need for their projects or improvement features for projects that already exist.

REFERENCES

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[2] Design and Create a Custom Block - Matlab & Simulink, www.mathworks.com/help/simulink/ug/tutorial-creating-a-custom-block.html. Accessed 4 Mar. 2024.

[3] Frenzel, Lou. "Understanding Modern Digital Modulation Techniques." Electronic Design, Electronic Design, 12 Jan. 2023, www.electronicdesign.com/technologies/communications/article/21798737/electronic-design-understanding-modern-digital-modulation-techniques.

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PROJECT GANTT CHART

PROJECT: Short Messaging Control Mechanism for CAN Bus Architecture

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Project start date: 1/31/2024

Scrolling increment: 25

Legend: On track | Low risk | Med risk | High risk | Unassigned

Milestone description	Category	Assigned to	Progress	Start	Days
Milestone Reports					
#2 - Project Proposal	Milestone	All	100%	3/4/2024	1
#3 - Progress Report	Milestone	All	0%	4/1/2024	1
#4 - PowerPoint Presentation	Milestone	All	0%	4/15/2024	1
#5 - Project Report	Milestone	All	0%	4/29/2024	1
Project Selection					
Define Project Goals	On Track	All	100%	2/28/2024	1
Develop Proposal Documentation	On Track	All	100%	2/29/2024	5
Collect References	On Track	All	100%	2/29/2024	5
Simulation Development					
Detail encryption from CAN data to transmitted signal	On Track	Andrew Cline	0%	3/5/2024	21
Model the Transmitter and Receiver in Simulink	On Track	Clifford Gilbert	0%	3/5/2024	14
Model the Signal Processing Conversion in Matlab/Simulink	On Track	Goran Novakovic	0%	3/10/2024	21
Create CAN data test cases for Simulation	On Track	Clifford Gilbert	0%	3/19/2024	7
Develop Progress Report Documentation	On Track	All	0%	3/25/2024	7
Simulation Testing					
Test run Transmitter Conversion Model	On Track	Goran Novakovic	0%	3/31/2024	7
Test run Receiver Conversion Model	On Track	Andrew Cline	0%	3/31/2024	7
Update the Simulink Model based on Test Runs	On Track	All	0%	4/7/2024	10
Run the CAN data through the Simulink Model	On Track	Clifford Gilbert	0%	4/17/2024	1
Create Project Report Draft	On Track	All	0%	4/16/2024	7
Result Analysis					
Review the Results of the Simulink Model	On Track	All	0%	4/18/2024	2
Calculate the success rate of the Simulink Model	On Track	Goran Novakovic	0%	4/20/2024	2
Develop Diagrams of Results	On Track	Andrew Cline	0%	4/20/2024	3
Develop PowerPoint Presentation	On Track	All	0%	4/23/2024	7
Develop Project Report Documentation	On Track	All	0%	4/23/2024	7