FPGA BASED SECURED SDR

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Abstract— this paper contains the design and construction of an SDR. Software Defined Radio (SDR) is a radio communication system where components are implemented mainly in software instead of hardware. It ensures flexible, long life radio communication. The security of data is given by using an encryption scheme called Baker mapping and a secret key, which helps to identify the authenticity of the message. The encrypted message also adds as another layer of security. Here encryption, decryption, digital up conversion and down conversion are done in FPGA.

Keywords— FPGA, encryption, decryption, SDR.

I. INTRODUCTION

A radio is any kind of device that wirelessly transmits or receives signals in the radio frequency part of the EM spectrum to facilitate the transfer of information. With the exponential growth in the ways and means by which people need communicate each other, it is very essential to modify these existing radio devices. So modifying radio devices easily and cost-effectively has become business critical. There lies the importance of SDR. Software defined radio (SDR) technology brings the flexibility and cost efficiency.

SDR is a radio communication system where components that are implemented in hardware are implemented by means of software on a PC or embedded system. It is flexible and upgradeable and serves as longer lifetime radio equipment. The SDR provides a versatile wireless communication solution for a wide range of applications.

Traditional radio communication systems needs a lot of hardware components which make the platform cost very high, high noise and less flexible. SDR receiver is able to decode all the signals so they are more flexible. The data that is transmitting must be secured throughout the transmission. For security of data an encryption mechanism is also provided. So our objective is to design of SDR transceiver in FPGA design and provide an encryption mechanism for the data transmission in the SDR.

Software Defined Radio proposed in the paper consists of transmitter and receiver and they are interfaced digitally. Two FPGA boards are used here, one will be working as a transmitter and the other one will act as receiver.

II. BLOCK DIAGRAM

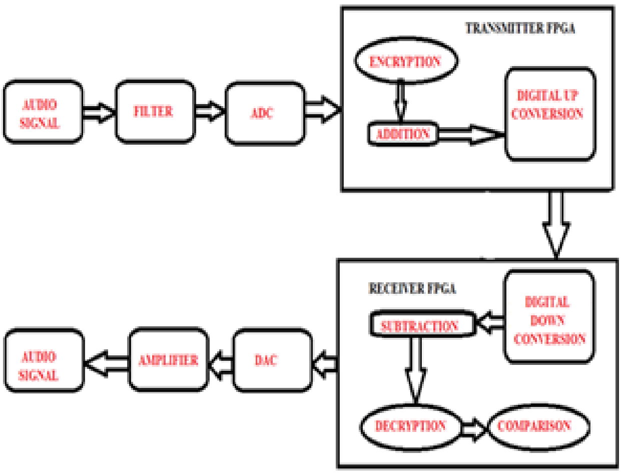


Fig1: Block Diagram

For the transmitter it needs an audio input which is analog and must be converted to digital form for processing in FPGA, since FPGA works only in digital domain .The audio signal is taken from an MP3 player via a RCA jack. The digital input audio signal, is added with a message which is encrypted using an encryption technique called baker mapping. This added up signal is digitally up converted and transmitted.

At receiver end this signal is digitally down converted and taken out for further processing after decryption. The decrypted message is checked and verified for the authenticity of the transmitted signal. An indication for the security is given at the hardware section for this authenticity.

III. TRANSMITTER

The audio signal is taken from an MP3 player via an RCA jack and is connected to FPGA board. The audio signal is filtered out by using AD8606 filter IC. The filtered output is given to AD7476A.

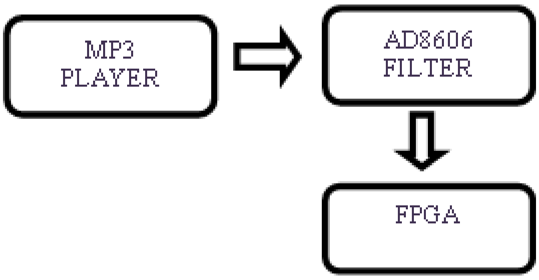


Fig 3: Transmitter side

In the transmitted side FPGA the digital audio signal is added with the encrypted authentication message. For encryption baker mapping can be used. This is done using a key, the same key is needed at the receiver end for decryption. So without the reverse algorithm and same key we can't decrypt the authentication message.

After the encryption, the signal will be digitally up converted at a rate of 16.This section consists of 3 comb filter stages followed by an upsampler followed by 3 integrator stages.

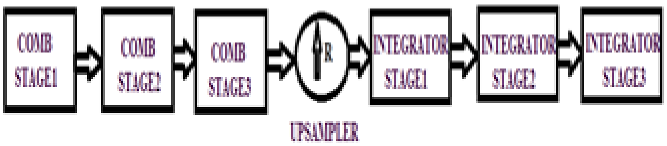


Fig4: Digital Up Conversion

The resultant interpolated signal will be transmitted to the receiver.

IV. ENCRYPTION AND DECRYPTION

For encryption baker mapping is used. The authentication message chosen here is a 1 bit 8 × 8 message and which can be extended as the power of 2, such as 8, 16, 32, 64 etc. The encryption is done by using a key. The same key is needed at the receiver end to decrypt the message. If another key is lost then the authentication is lost and for that the decrypted message is compared with the stored original authentication message. If both are same it or not is indicated by a led.
The key selection is done by the following criteria's

- The elements sum must be 8
- 1 is not taken as element
- 8/each element must be perfectly divisible

8 is taken since the message is 8 × 8 size which can be varied according to the message size. As the message size is increased the no of keys that can be used will also increase and this will increase the degree of security. As 8 is the size here up to 5 keys can be used for a 16 ×16 size the no of keys can be used increased 5 to 6 times.

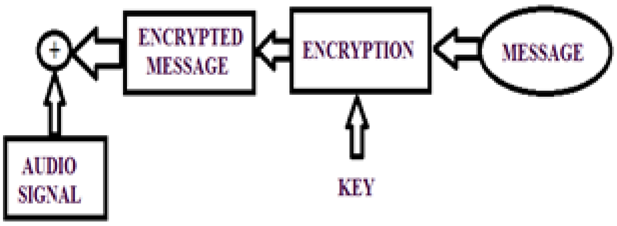


Fig 5: Encryption

The encrypted message is added to the LSB of the audio signal. And at the receiver from the LSB the message is extracted and decrypted using same key. And the decrypted message is compared with the original one.

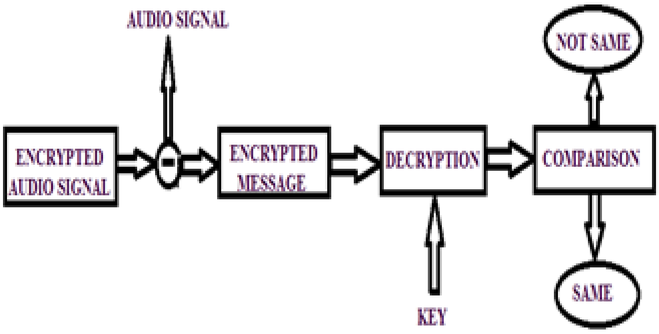


Fig 6: Decryption

Baker mapping is the processes of mapping a message to it self. The equation used for baker mapping is given below in equation one

$$X' = \frac{N}{n_i} * (X - N_i) + \ Y \bmod \left(\frac{N}{n_i}\right)$$

$$Y' = \frac{n_i}{N} * \left(Y - Y \bmod \left(\frac{N}{n_i}\right)\right) + N_i$$

Equation(1)

Each element in the matrix will be shifted to another cell according to the key. And using the same key at the receiver end the elements will brought back to their original positions if same key is not used at the receiver end the elements will not fall on the same place and when we compare them with the original one they will not be same

V. RECEIVER

The received digital signal is down converted. The digital signals are down converted and subtracted. Digital down conversion is the reverse operation of digital up conversion. At the receiver side we are decreasing the sample rate. So Digital down conversion starts with three integrator stages followed by a down sampler followed by three comb stages

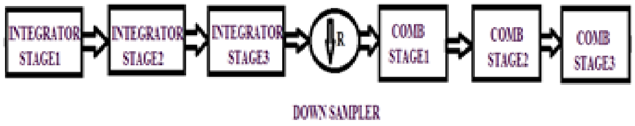


Fig 7: Digital Down Conversion

The audio signal is taken out and given for further processing. The remaining signal after subtraction is decrypted using the same key as used in the transmitter. It is compared with the original message stored and checked for authentication.

The digital signal is converted to analog using a DA121S101 DAC. Then the signal is amplified and fed to the speaker.

VI. RESULTS

In the figure 8 the yellow one is the input signal at the transmitter and after encryption, interpolation, decimation and decryption the signal we get is the green wave at the receiver.

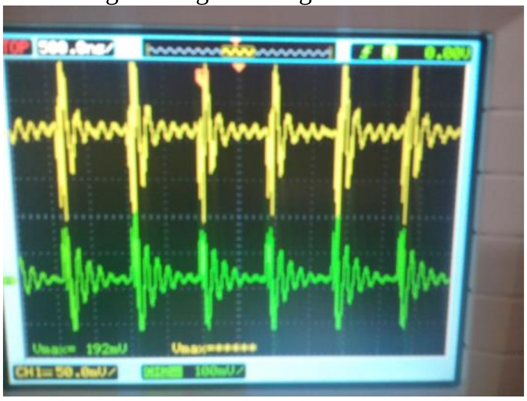


Fig 8 input output waveforms

The hardware setup is given in the fig 9 the left side board is used as the transmitter and the right side one is the receiver

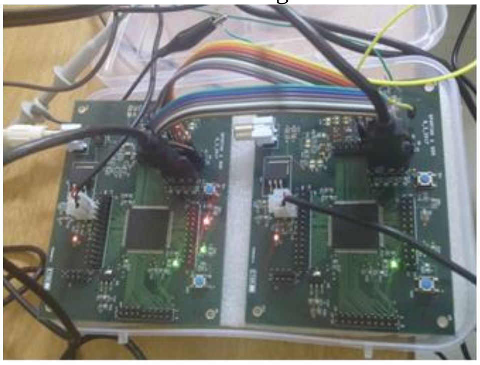
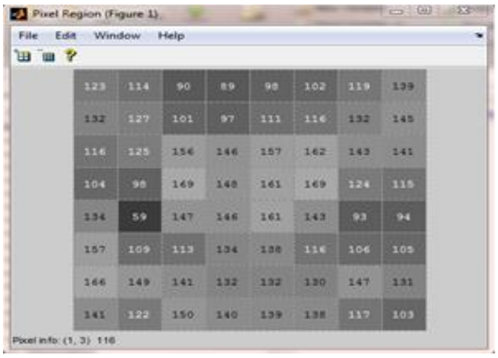


Fig 9 Hardware

The baker mapping is checked using matlab and implemented in verilog. The results we obtained when done it in matlab are in the below figures.

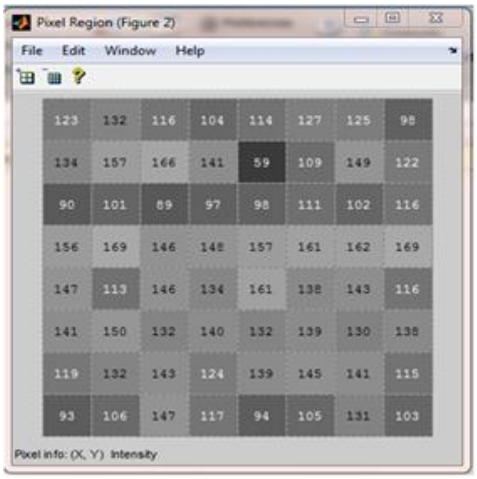
In fig 10 the authentication message used is given. After encrypting using a key the baker mapped message is included in the fig 11. At the receiver the decrypted message is given in the figure 11. When compare the fig 10 and 11 both are same so the data is authenticated.



123	114	90	89	98	102	119	139
132	127	101	97	111	116	132	145
116	125	156	146	157	162	143	141
104	98	169	148	161	169	124	115
134	59	147	146	161	143	93	94
157	109	113	134	138	116	106	105
166	149	141	132	132	130	147	131
141	122	150	140	139	138	117	103

Pixel info: (1, 3) 116

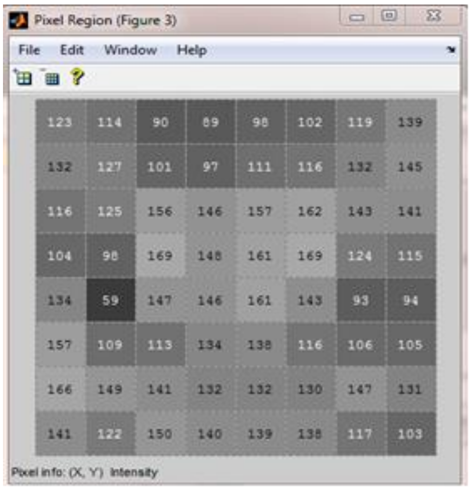
Fig 10: Message before baker mapping



123	132	116	104	114	127	125	98
134	157	166	141	59	109	149	122
90	101	89	97	98	111	102	116
156	169	146	148	157	161	162	169
147	113	146	134	161	138	143	116
141	150	132	140	132	139	130	138
119	132	143	124	139	145	141	115
93	106	147	117	94	105	131	103

Pixel info: (X, Y) Intensity

Fig 10 Encrypted mesasage



123	114	90	89	98	102	119	139
132	127	101	97	111	116	132	145
116	125	156	146	157	162	143	141
104	98	169	148	161	169	124	115
134	59	147	146	161	143	93	94
157	109	113	134	138	116	106	105
166	149	141	132	132	130	147	131
141	122	150	140	139	138	117	103

Pixel info: (X, Y) Intensity

Fig 11 Decrypted message

CONCLUSION

Successfully designed and made hardware of SDR transceiver. Provided an authentication message along with audio signal with encryption using baker mapping. And checked and verified the authenticity of transmitted data. Security can be made strong by increasing number of keys and size of the authentication message. Another watermarking scheme can be included to provide better security.

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