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Applications of SDR for Optimized Configurable Architecture of Modulation Techniques

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Abstract: A software defined radio (SDR) is a hardware device in which the functionality can be change with the help of software. Hence defining the difference in behavior for various technologies in software,it removes the need for hardware changes during a technology upgrade. The role of modulation techniques in an SDR is very important but hard since modulation techniques define the core part for any wireless technology. Implementation of modulation techniques with the approach of optimizing the architecture, implemented on FPGA and modelsim, finally helps in reducing the architecture of SDR. The paper describes modulation techniques FSK and QPSK when configured together yields max optimization with good features such as improvement in frequency, optimization of area & improvement in BER.
Keywords: Advanced Modulation Techniques, Configurable Architecture, Field Programmable Gated Array, Software Defined Radio.

I. INTRODUCTION

Software-defined radio or cognitive radio has a lot of attention in academic research in recent years. This type of reconfigurable radio architecture demands high performance, high bandwidth analog / RF front-ends to support some proposed algorithms. Designing Optimized Configurable Modulation Techniques will contribute major to SDR as the whole system. Selection of modulation techniques for making it configurable is tricky as we need to target that modulation technique which has the best outcome when configured and also the optimization parameter be taken care of the digital modulation techniques. When FSK and QPSK configured together yields good results. This paper shows the complete design of configurable architecture of FSK/QPSK modulation techniques and can be applied to optimize the architecture of SDR to increase the outcome of the complete system. FSK/QPSK Modulator is implemented on the VirtexFPGA and Demodulation **.**To design configurable modulation techniques is a complex process since one needs to select such techniques having maximum common hardware as well along with quite few of other features and advantages over the other combinations. We will present a few combinations of techniques that can be combined and conclude with the comparative chart showing the compatibility of them.

A. ASK and FSK as configurable techniques

Amplitude shift keying in the context of digital communications is a modulation process, which imparts to a sinusoid two or more discrete amplitude levels. These are related to the number of levels adopted by the digital message. For a binary message sequence there are two levels, one of which is typically zero. Thus the modulated waveform consists of bursts of a sinusoid. Signal has been not band limited & there are sharp discontinuities shown at the transition points. These result in the signal having an unnecessarily wide bandwidth. Band limiting is generally introduced before transmission, in which case these discontinuities would be 'rounded off'. The band limiting may be applied to the digital message, or the modulated signal itself. The data rate is often made a sub-multiple of the carrier frequency. One of the disadvantages of ASK, compared with FSK and PSK, for example, is that it has not got a constant envelope. This makes its processing more difficult, since linearity becomes an important factor. However, it does make for ease of demodulation with an envelope detector. As discussed earlier Amplitude Shift Keying (ASK) is a simplest digital modulation technique. When combined with FSK which is one other simple modulation technique the configurable hardware is simplest to implement and but our main concern is on the spectral efficiency, data rate and such other features.

B. MSK and FSK

MSK & FSK as configurable techniques Minimum shift keying (MSK) is a special type of continuous phase-frequency shift keying (CPFSK) with h=0.5. A modulation index of 0.5 corresponds to the minimum frequency spacing that allows two FSK signals to be coherently orthogonal, and the name minimum shift keying implies the minimum frequency separation (i.e. bandwidth) that allows orthogonal detection. In traditional FSK we use signals of two different frequencies of f0 and f1 and to transmit a message m=0 or m=1 over a time of Tb seconds, We assume that f0>f1>0. If we choose the frequencies so that in each time interval Tb there is an integer number of periods Figure 1 shows an example of a signal that is discontinuous, a signal with discontinuous phase and a signal with continuous phase. As phase-continuous signals in general have better spectral properties than signals that are not phase-continuous, we prefer to transmit signals that have this property. Minimum Shift Keying can be considered as continuous phase FSK. Hence we can consider MSK as one form of FSK. So the Bandwidth requirement of MSK increases. While combining this technique with FSK leads to improved probability of Bit error but the Spectral efficiency decreases so the energy per bit increases as M increases for a given probability of bit error.

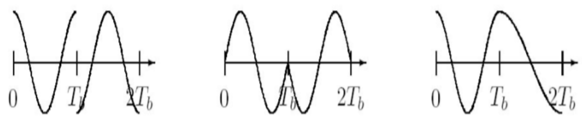

Fig 1.Signals with different degrees of discontinuity

C. QPSK and FSK as configurable techniques

QPSK is one of the most popular digital modulation techniques used for Satellite communication and sending data over cable networks. Its popularity comes from both its easy implementation and resilience to noise. The implementation of QPSK involves changing the phase of the transmitted waveform. Each finite phase change represents unique digital data. A phase modulated waveform can be generated by using the digital data to change the phase of a signal while its frequency and amplitude stay constant. A QPSK modulated carrier undergoes four distinct changes in phase that are represented as symbols and can take on the values of /4, 3/4, 5/4, and 7/4. Each symbol represents two binary bits of data. The constellation diagram of a QPSK modulated carrier knows everyone. The PSD of a QPSK signal has a null-to-null bandwidth that is equal to the bit rate Rb, which is half that of a BPSK signal. Therefore, QPSK has twice the bandwidth efficiency of BPSK, since 2 bits are transmitted in a single modulation symbol instead of 1 bit for BPSK. Further, the bit error

III. CONFIGURABLE ARCHITECTURES

A. FSK and QPSK configurable transmitter architecture Figure 2 shows the design of configurable architecture of the FSK and QPSK transmitter. A switch is used to configure the whole architecture either as FSK or as QPSK. This architecture design is the optimized design for the configurable transmitter.

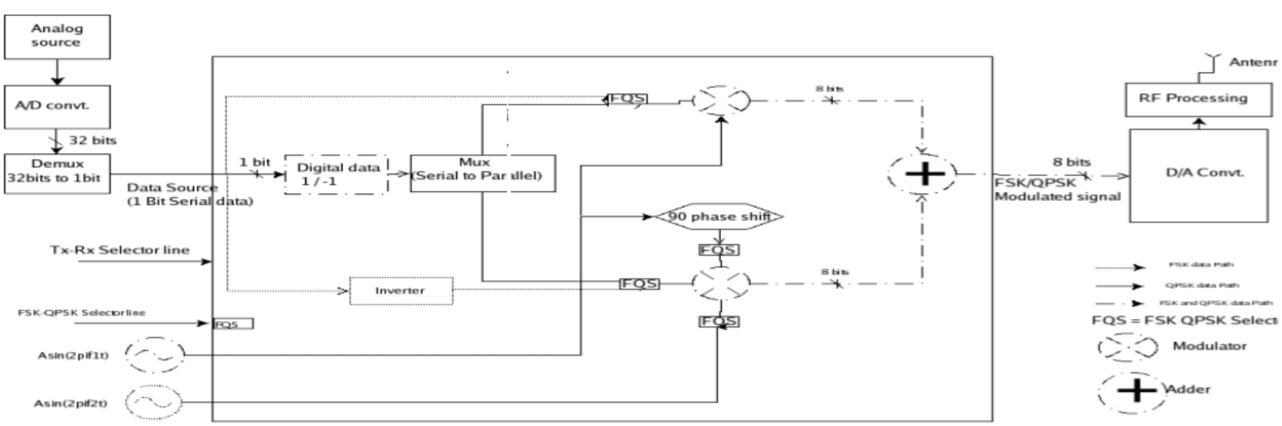

Figure 2.FSK and QPSK configurable transmitter architecture

Figure 3 shows the FSK and QPSK configurable transmitter architecture designed to implement on the FPGA. Two selection lines are used to select the Tx-Rx part and either FSK or QPSK part. The implementation of an analog sinusoidal signal is done by generating a Look up Table. The I0 and I(1)0 are the look up table for two different frequencies of the FSK carrier signal. The remaining three look up table are for three different angles viz. 90, 180, 270 degree for the QPSK signal as QPSK signal has a quadrature phase. The data mapper is nothing but converts our serial digital data into parallel i.e. odd and even data for in phase and quadrature components. The Tx-Rx selector line will configure the FPGA either a transmitter or a receiver depending on the selection.The modulated signal is then sent to digital to analog converter which is then transmitted via antenna. Figure 4 show the simulated result on modelsim

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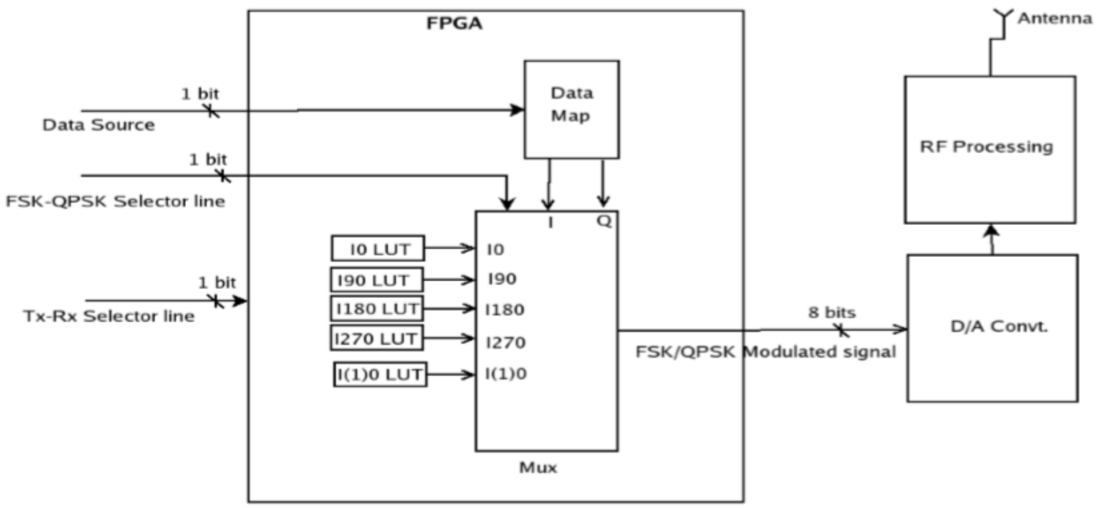

Figure 3. FSK and QPSK configurable transmitter architecture on FPGA

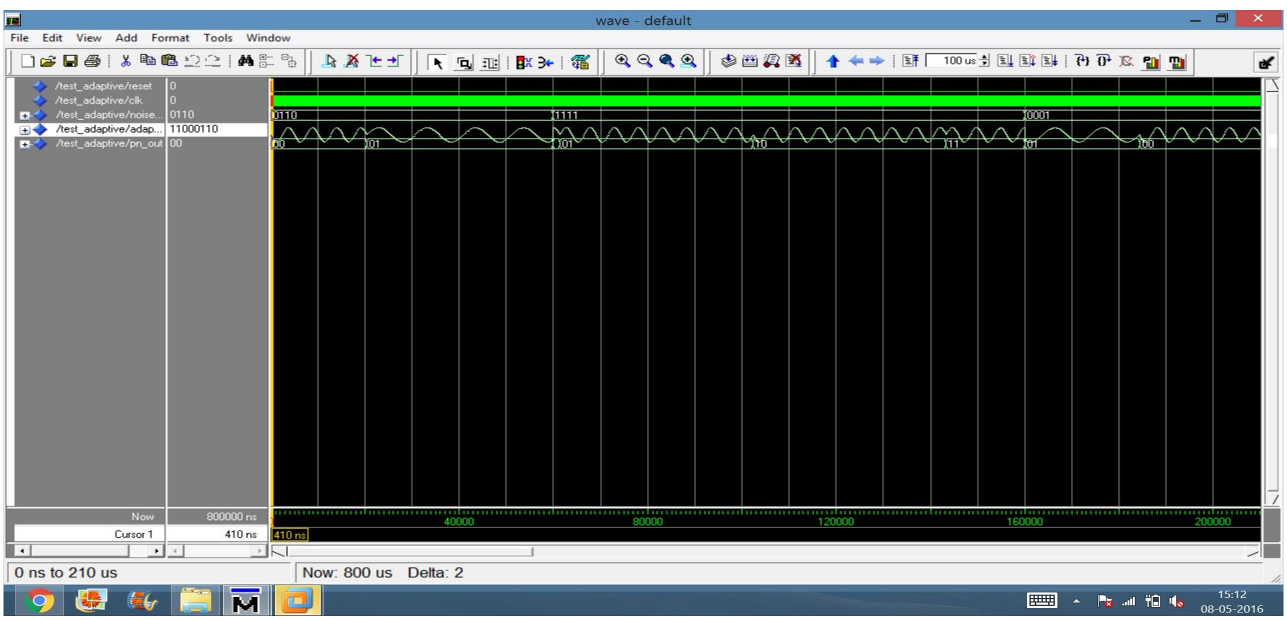

Figure 4 simulated result on modelsim

B. FSK and QPSK configurable receiver architecture -

Figure 5 shows the design of configurable architecture of the FSK and QPSK receiver. The antenna receives the modulated signal which is then converted to digital data using analog to digital converter. The data then multiplied with the sinusoidal career with f1 frequency on the upper half and the same data via the inverter is modulated with f2 frequency in the lower half part. The result data out form the product is then integrated to remove the career frequency components present in it and compared with a threshold value to reject any noise component in it. Hence output is the resultant original digital data signal with that was transmitted from the transmitter.Similarly for the QPSK case the modulated data is multiplied with the In-phase and quadrature components and then data is integrated to remove the career frequency components present in it which is then compared to a threshold value. The resultant output is then converted from parallel to serial which will give our resultant digital information which was transmitted. A switch is used to differentiate the path of FSK and QPSK. The improve in frequency & Area can shown by figure 6 & figure 7 respectively

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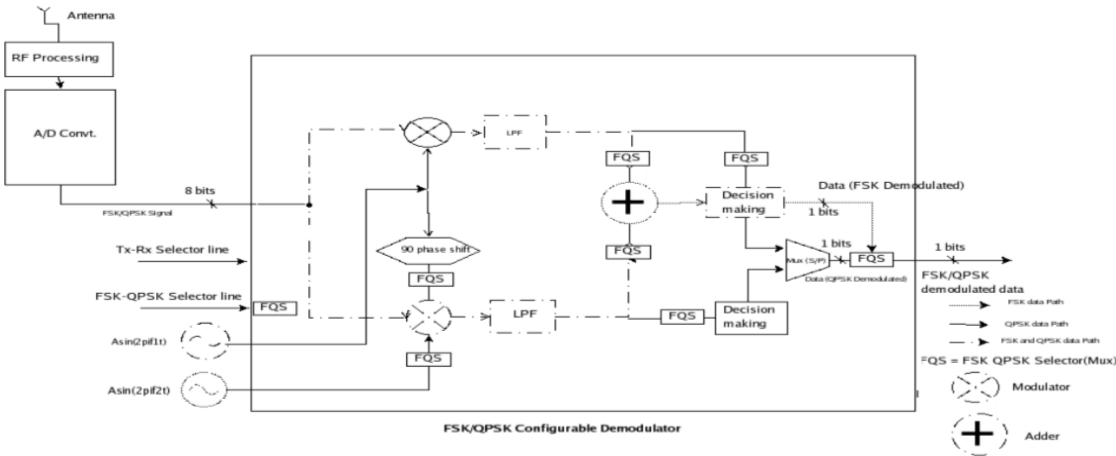

Figure 5.FSK and QPSK configurable receiver architecture

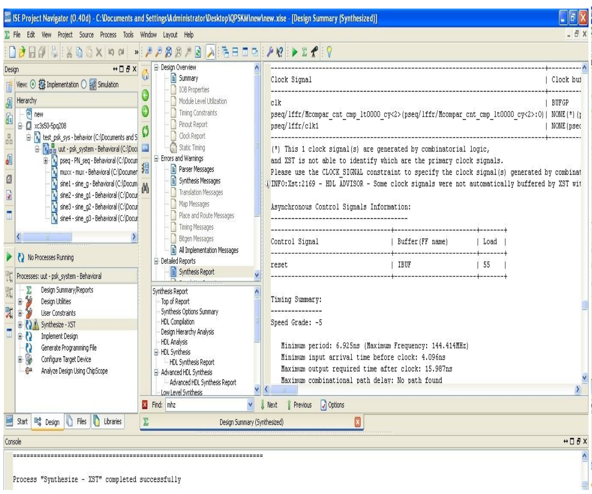

Figure 7. Improvement in Frequency

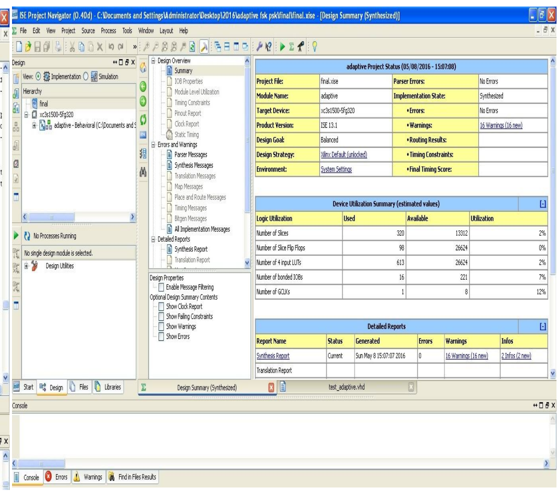

Figure 8.Optimization of Area

Comparison between various modulation Techniques:

		Modulation Techniques			
		ASK+FSK	**MSK+FSK**	**QPSK+FSK**	**QAM+FSK**
FEATURES	**Bandwidth**	Requires lesser bandwidth compared to other combination of modulation techniques	Requires Higher bandwidth compared to other techniques stated	***Only highest bandwidth is that of the FSK signal which is very less compared to other techniques used.***	Bandwidth is lesser and is approximately equal to QPSK+FSK
	SNR	Signal to Noise ratio is very less compared to other techniques	Higher Signal to Noise ratio	***Higher Signal to Noise ratio***	Lower Signal to Noise ratio
	Data Rate	Lesser Data rate	Higher Data rate	***Higher Data rate***	Highest Data rate
	Applications	Can be used in Limited Applications	Can be used in Wide Applications	***Can be used in Wide Applications***	Can be used in Wide Applications
	PB v/s Eb/No	Requires Higher Eb/No for a given value of PB	Requires Higher Eb/No for a given value of PB	***As QPSK is Combined Requires Lesser Eb/No for a given value of PB***	Requires Higher Eb/No for a given value of PB
	Reliability	Lower Compared to Other	Higher	***Higher***	Higher
	Hardware Complexity	Simple Compared to others	More Complex	***Less Complex***	More Complex
	Hardware Cost	Less Cost	Costly	***Costly***	Costly
	Implementation on FPGA	Easier to implement on FPGA	Relatively More Complex to implement on FPGA	***Less Complex Compared to MSK+FSK and QAM+FSK***	Relatively More Complex to implement on FPGA

IV. CONCLUSION

The modulation technique FSK and QPSK when configured together yields the maximum common architecture such asimprovement in BER and gives reliable features when compared to other modulation techniques with optimization of area & improvement in frequency. Hence in a Software defined radio applications we can combine these techniques for optimized hardware.

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