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Design Of Qpsk Superregenerative Receiver Used In Advanced Communication Receiver

C.Thamizhini, P. Geethabai

Abstract— A bit-synchronous super regenerative receiver suitable for QPSK modulation. The superregenerative receiver is a detector it is used to detect the modulated signal. Because some of the modulated signal has noise or interference. Superregenerative receiver generates pulse which preserves the modulated signal. The mode of operation has several benefits. Firstly, the traditional problem of poor frequency selectivity in this type of receiver is large extend to overcome. Secondly, considerably higher data rates can be achieved than classical receiver. Thirdly bit envelope can be matched to the superregenerative oscillator, which improves the sensitivity. The complexity of all digital demodulation scheme is extremely low in the superregenerative receiver by taking up very few resources on the low-end FPGA prototyping board is used.

Keywords- Low-power communication receivers, QPSK Demodulation, RF receivers, Super Regenerative Receiver(SRR).

I. INTRODUCTION

In digital radio communications, a radio receiver is an electronic device that receives radio waves and extracts the desired information and carried by the radio waves. The receiver uses filters to separate the wanted radio frequency signal from other signals also an electronic amplifier is used to increase the power of the signal for further processing and finally recovers the desired information through demodulation.

The world's first radio receiver known as "Thunderstorm Register" was designed by Alexander Stepanovich Popov in 1896. In 1916 Lee de forest invented a vacuum tube that relatively amplifies weak electrical signals. At the same time Tuned Radio Frequency Receiver (TRF) was invented by Ernst Alexanderson showed major improvement in performance over other receivers that was available before, but the inherent working of the TRF, where all the tuned stages of the radio must track and tune to the desired reception frequency made the receiver cumbersome and a power hungry device. In 1920, an American inventor Edwin Howard Armstrong invented and patented Super Regenerative (SR) Receiver required fewer components than other types of receiver circuit used during that time. Superregenerative receivers are an attractive alternative for low-power wireless data links because of its reduced complexity, which is easily translated into low cost and low power consumption.

The core of generated RF pulse in the receiver called SRO. The SRR circuits were mainly used as narrow band AM receivers since its invention in the 1922. The success for its are due to the simplicity of the design, low cost, high gain, high efficiency, low power and its ability to operate at high Radio Frequencies (RF). These features enabled an attractive architecture for low power wireless receivers. The commercial applications SRR are used sensor networks, short distance telemetry, home automation, biomedicine, remotely controlled systems.

II. PROPOSED QPSK SUPER REGENERATIVE RECEIVER

The Proposed system of Super Regenerative QPSK Receiver is designed. The Super Regenerative Receiver (SRR) detects the modulated signal. Because some of the modulated signal has weak input signal or noisy signal they are detected and overcome by using SRR.

It receive only strongest signal and ignore the other signal. Sometimes information is loosed by nose or interference the loss information is recollects or regenerates by SRR. It easily operates at microwatt power level. Conventional receiver operation aimed at detecting BPSK modulations or, in the digital case, OOK (on-off keying) modulations, makes use of a quench signal of considerably higher frequency than the actual information bandwidth. In this approach, the dependence of the SRO envelope on the input amplitude is used to effectively oversample the envelope of the incoming RF signal. A final low-pass filter is then able to reconstruct the transmitted signal.

Low performance in terms of the required signal-to-noise ratio (SNR) for proper operation. This drawback may be overcome making use of a bit-synchronous quench signal, The conventional receivers suffer from poor frequency selectivity when they are applied to narrowband communication.

This receiver not suffer from the poor frequency selectivity because it successively matched with the bit-synchronous and bit envelope matched to Super Regenerative Oscillator(SRO), which improves the sensitivity[7]. The SRR has SRO. The SRO generate the pulse, the generated pulses preserve the input information.

III. SYSTEM DESCRIPTION

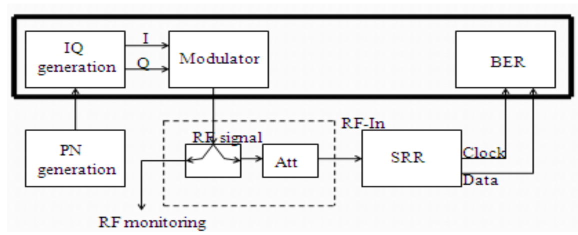

Fig.1. Block diagram of proposed transmitter and QPSK superregenerative receiver

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In Figure.1 shows the overall block diagram of proposed transmitter and QPSK super regenerative receiver. It consists of data generation block, modulator, SRR, bit error rate block. IQ signals on the desired shape and modulate them onto a carrier signal. The RF signal is split into two paths with a power divider. The first path is used for signal monitoring and second path reaches the SRR fixed 60db attenuator. The SRR has a sampling and

correlation process, the sampling and correlation process used to sample the noise and allow the original signal to the output. SRR produce the output of ber-clock and ber-data signals that are fed to Bit Error Rate (BER) block.

A. QPSK Implementation in Super Regenerative Receiver

Binary data is often conveyed with the following signals

$$So(t) = \sqrt{2E_b}\cos(2\pi f_c + \pi) \qquad (1)$$
$$= -\frac{\sqrt{E/b}}{\sqrt{T_b}}\cos(2\pi f_c t)$$

Where FC is the frequency of the carrier wave. Hence, the signal-space can be represented by the single basis function

For Binary 0

$$S_1(t) = \frac{\sqrt{2E_b}}{T_b}\cos(2\pi f_c t) \qquad (2)$$

For Binary 1

$$\emptyset(t) = \frac{\sqrt{2}}{\sqrt{T/b}}\cos(2\pi f_c t) \qquad (3)$$

Where 1 is represented $\sqrt{E/b}\,\emptyset(t)$ by and 0 is represented by $Eb\varphi$t, This assignment is, of course, arbitrary. QPSK modulated signal with a symbol rate $f_{s=\frac{1}{T_S}}$ around a carrier w_c may be return as

$$x(t) = \sum_{n=-\infty}^{\infty} p_c(t - nT_s)\cos(w_c t + \varphi_n) \qquad (4)$$

With the pulse corresponding to the n-th symbol given by

$$\varphi_n = \{0, \frac{\pi}{2}, \pi, \frac{3\pi}{2}\} \text{ and } p_c(t) = \prod(t).$$

$$S(t) = K|H(w_c)| \sum_{n=-\infty}^{\infty} p(t - nT_q) \times \cos(w_0(t) + n(w_c - w_0)T_q + \angle H(W_c))$$

T_q is the receiver quench period, w_0 is the SRO oscillation frequency,$H(w_c)$ is a frequency response term. Depending on the carrier frequency, and $p(t)$ is the normalized pulse.Consider the phase term of the n-th pulse.

$$\varphi_n(t) = w_0(t) + n(w_c - w_0)T_q + \varphi_n + \angle H(w_c) \qquad (5)$$

The phase difference between the consecutive n-th and (n-1)-th pulse becomes refer the Equation 6

$$\Delta\varphi = \varphi_n(t) - \varphi_{n-1}(t - T_q)$$
$$= \varphi_n - \varphi_{n-1} + w_c T_q \qquad (6)$$

It is usual to choose the symbol during $T_c = \frac{1}{f_c} = 2\frac{\pi}{w_c}$ ensuring that a CW signal is generated if a symbol is repeated indefinitely. $w_c T_q$ is a multiple of 2π and phase difference

$$\Delta_\varphi = \varphi_n - \varphi_{n-1} \qquad (7)$$

B. QPSK Signal in the Time Domain

The Modulated signal is shown in Figure.2 a short segment of a random binary data-stream. The two carrier waves are a cosine wave and a sine wave, as indicated by the signal-space. Here, the odd-numbered bits have been assigned to the in-phase component and the even-numbered bits to the quadrature component. The total signals the sum of the two components. Jumps in phase can be seen as the PSK changes the phase on each component at the start of each bit-period.

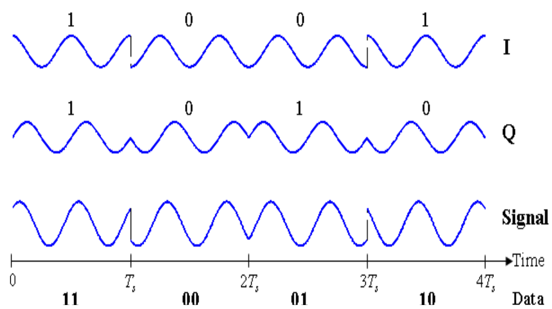

Figure.2 Timing digram

The two signal components with their bit assignments are shown in Figure.2

C. Sampling and Correlation Process

Modulated signals are fed into sampling and correlation process sampling and correlation shown in Figure.3. has Multiplexer, D flip-flop, Sh/Ro controller, clock signal and shift register multiplexer select the input signal and selected signal given to the D flip-flop. The D flip-flop used to sample and stores the decided bit, which is less complex than analog envelope detection and ulterior sampling and the vector of the N samples quantized with one single bit, corresponding to the n -th symbol will be called s_n. The changes in phase may be easily detected comparing vectors s_n and $s_{n-1.}$ Once the vector of current samples s_n is stored, it is compared S_{n-1} to the vector of the previous samples, and the displacement that provides highest correlation is found. This is achieved by circularly rotating s_n by K positions and counting the number of 1 in the comparison with the previous vector S_{n-1}.

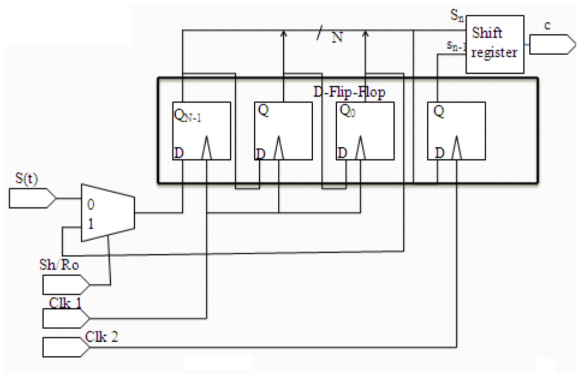

Figure.3.Sampling and correlation process

The computation is carried out very efficiently storing the received samples in a shift register. Then, when all positions are filled, the shift register is successively rotated and the comparison with the previous register is carried out.

D. Bit Error Rate

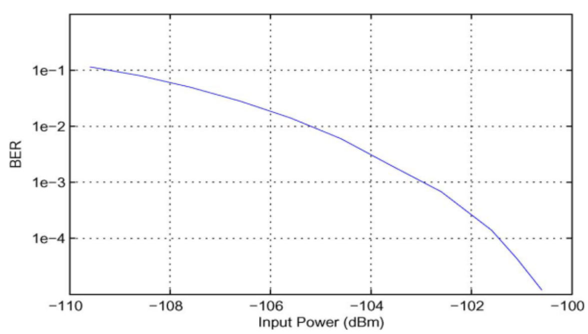

Figure.4. BER vs. RF-input power

In Figure. 4. among other signals, the SRR outputs BER-CLK and BER-DATA signals that are fed into a Bit Error Rate (BER) analyzer, properly adjusted for the PN9 sequence used in this test. A measure of the quality of the decisions, directly related to input signal quality and to the resulting BER, is obtained by the time average of the elements. The distribution of the decisions which are offset ± 2 and ± 1 from $\{0, \frac{\pi}{2}, \pi, \frac{3\pi}{2}\}$provide an information that is qualitatively equivalent to the BER.

The bit error rate of the receiver calculated by BER vs. Modulated signal $bk = ek \oplus ek-1$.The error-rate is approximately doubled.

A single bit-error is

$$P_b \approx \frac{1}{k} P_s \tag{8}$$

The bit error rate (BER) of SRR is given below

$$E_b N0 - \text{ratio} = 10^{(E_b N0 - \frac{eqn}{10}) E_s N0} - \text{ratio}$$

$$= k * E_b N0 - \text{ratio} \times \text{sqrt}\left(3 * E_S N0 - \frac{\text{ratio}}{M} - 1\right) \tag{9}$$

E_b = Energy –per- bit
K= With k bits per symbol,
N0 = Noise power spectral density (W/Hz)
P_b=Probability of bit error

IV. SUPERREGENERATIVE RECEIVER WITH A DIGITALLY SELF-QUENCH LOOP

The Super Regenerative Receiver minimize the overall power consumption by generating a self-quench signal digitally for a superregenerative oscillator[6].

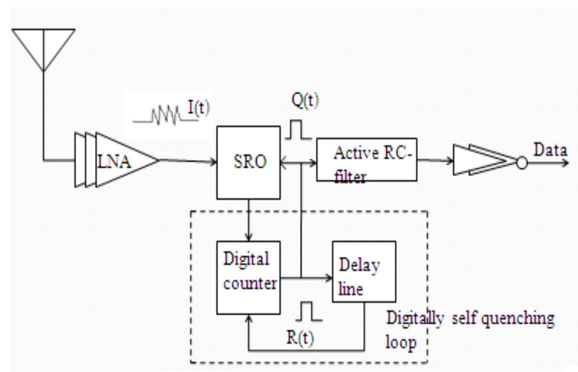

Figure. 5. SRR with a digitally self-quenching loop

In Figure.5. A block diagram of the receiver, consisting of low-noise amplifier (LNA), DSQL, a super regenerative oscillator (SRO), and an active RC-filter with two inverters as the output buffer.

The counter in the DSQL counts the number of crests of the SRO output and generates a quench pulse when the counter is full. The reset signal R(t) is a short time-delayed pulse of Q(t), which resets the counter immediately after a quench signal is issued. This process is repeated and the DSQL generates a periodic quench signal Q(t).

Therefore, the SRO periodically starts up and shuts off according to the DSQL and the period of the quench signal is dependent on the start-up time of the SRO. When the RF signal I(t) is injected into the SRO by the LNA, the Q(t) period is decreased. The data is recovered by monitoring the dc level at the output of the active RC-filter.

V. SYNCHRONOUS SUPERREGENERATIVE RECEIVER

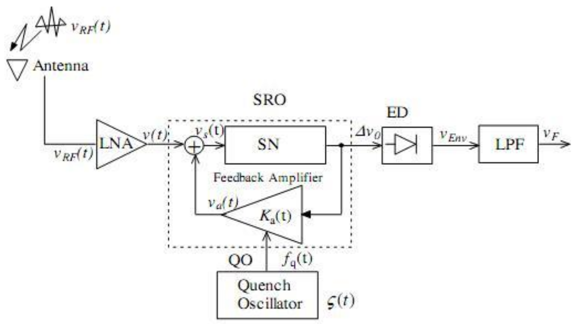

Figure.6 Block diagram of Synchronous Super Regenerative Receiver

In Figure.6 the receiver part is a classical Super Regenerative Receiver which comprises of a super regenerative oscillator which is modeled as a frequency selective network with a feedback loop along with a variable gain amplifier.

A quench oscillator controls the gain of the super regenerative oscillator. The quench oscillator is followed by an envelope detector and a low pass filter. Super regenerative receiver operates in 2 modes the linear mode and the logarithmic mode. In the linear mode the super regenerative oscillator does not reach equilibrium during the quench period, the amplitude of the RF oscillations are measured before they reach equilibrium.

In the logarithmic mode, the oscillations are allowed to reach its maximum value during each quench cycle and the detection is based on calculating the energy of the oscillations. The role of the quench signal in the super regenerative receiver is very important to understand the operation of the receiver.

VI. SIMULATION RESULTS

1. Information Transmitting Result

The data generator, generate information and transmit by transmitter, transmitted information goes through the serial to parallel converter. Information transmitting result as shown in Figure.7.

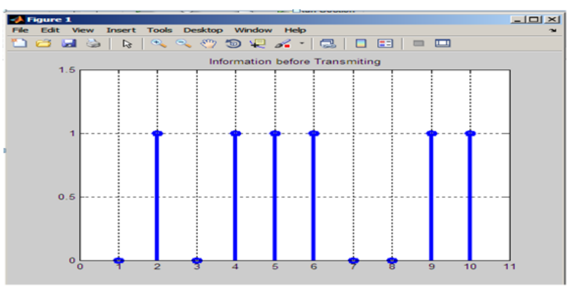

Figure.7 Simulation result of Information transmitting

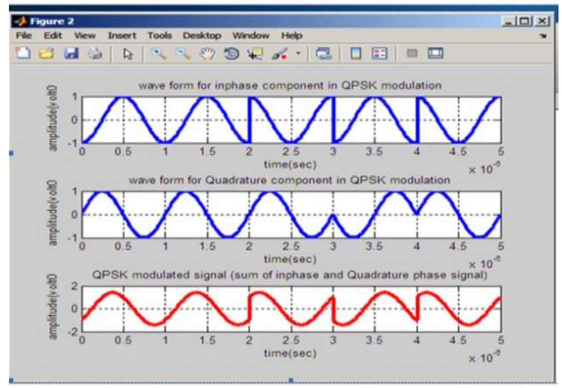

Fig.8 Simulation result of QPSK modulation output

2. QPSK Modulation Result

Even and odd bits are separately modulated by modulator. The QPSK has in phase and qudrature phase component. In phase component multiplied by cosine basis and qudrature phase component multiplied by sine basis both of them summed to produce the QPSK signal as shown in Figure.8.

3. Received Signal Result

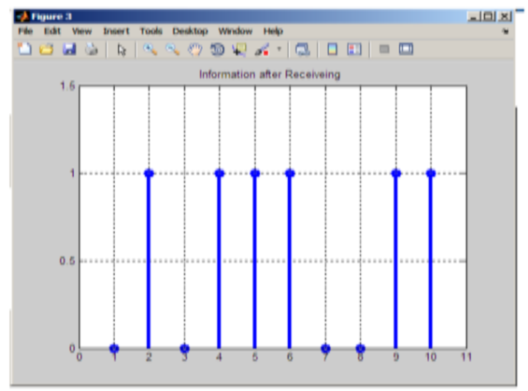

Figure.9 Simulation result of Received modulated signal output

The receiver receive the modulated signal and receiver detect the modulated signal have any noise or interference. The noise or interference signal overcome by using sampling and correlation process. Received signal output is shown in Figure.9.

4. Sampling and Correlation Process Result

The received QPSK modulated signal fed into the multiplier. The multiplier selects the modulated signal, the signal fed into D flip-flop. The D flip-flop used to sample and store the decided bit. Once the vector of current samples is stored, it is compared to the vector of the previous samples, and the displacement that provides highest correlation is found.

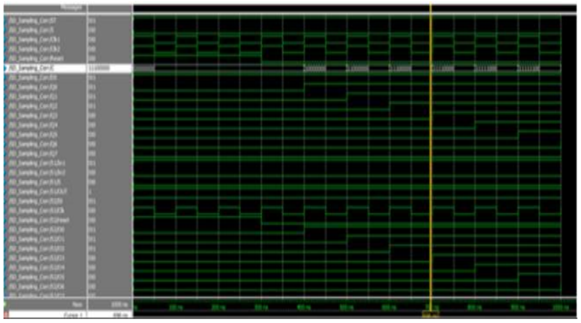

Figure.10 Simulation result of Sampling and correlation output

5. Bit Error Rate Result

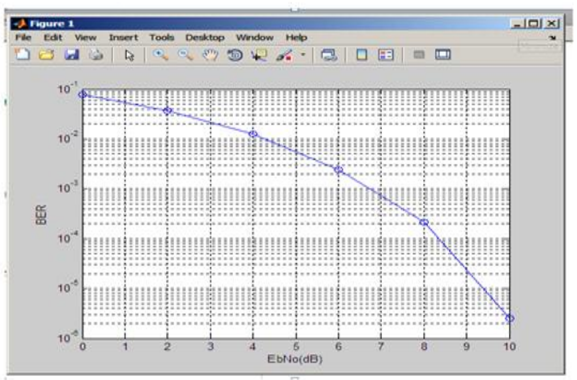

Fig.11 Simulation result of Bit error rate output

Bit error calculation obtained by BER vs. input signal it achieve the 10 db or less than transmitted power as shown in Figure.11**.**

The clock signal for the D flip flop is generated from the sinusoidal quench signal, which is squared by a comparator and delayed τ seconds to effectively sample the SRO signal at a relative maximum or minimum.

To investigate the true sensitivity that may be achieved with the current receiver design, set up a bit error rate (BER) test making use of a PN9 bit pattern.

A graph of the measured BER as a function of the input signal power is from this, it follows that the receiver sensitivity.

The SRR outputs BER-CLK and BER-DATA signals that are fed into a Bit Error Rate (BER) analyzer, properly adjusted for the PN9 sequence used in this test.

Receiver has sensitivity of approximately-103 dBm for the usual specification of BER=1×10^{-3}.

The -3dB bandwidth of the receiver is 97 KHZ, which is reasonable given the high gain associated with the logarithmic operation mode.

A measure of the quality of the decisions, directly related to input signal quality and to the resulting BER, is obtained by the time average of the elements.

The distribution of the decisions which are offset ± 2 and ± 1 from $\{0,\frac{\pi}{2},\pi,\frac{3\pi}{2}\}$provide an information that is qualitatively equivalent to the BER.

The bit error rate of the receiver calculated by BER vs. Modulated signal $bk=ek\oplus ek-1$.The error-rate is approximately doubled.

A single bit-error is

$$P_b \approx \frac{1}{k} P_s$$

SRR receiver able to efficiently demodulate QPSK signals. RF signal phase is preserved by an SR oscillator. The complexity of the all-digital demodulation scheme is extremely low.

The SRR provide a measure of the received signal quality in terms of bit error probability.

VII. COMPARISON OF EXISTING SYSTEM AND PROPOSED SYSTEM

PARAMETER	EXISTING SYSTEM	PROPOSED SYSTEM
Modulation	1. In this type of SRR used to detect the BPSK modulation.	1. In this type of SRR used detect the QPSK modulation.
Frequency selectivity	2. When they are applied to narrowband communication poor frequency selectivity.	2. Not suffer from the poor quency selectivity. Because this type of receiver ccessfully matched with the -synchronous.
Performance	3. BPSK not better than QPSK. It transmit only one bit at a time.	3. QPSK is far better than SK because average symbol ergy is double than BPSK and transmitting two bit nultaneously.
Symbol energy	4. Average symbol energy of BPSK is $E_s = E[C(i)^2] = A^2$.	4. Average symbol energy QPSK is $E_s = E\|C(i)^2\| =$ ^{2}

VIII. CONCLUSION

SRR able to efficiently demodulate QPSK signals. Based on the well known but usually unexploited fact that the information contained in the RF signal phase is preserved by an SR oscillator, we have proposed a simple post-processing scheme that allows signal demodulation. The post-processing scheme consists in sub sampling the RF pulses generated in the SR oscillator. The vector of the 1-bit quantized samples corresponding to the current.

Symbol is correlated to the vector corresponding to the past symbol. From this information the phase change and, hence, the transmitted data is inferred. The complexity of the all-digital demodulation scheme is extremely low, taking up very few resources on the low-end FPGA prototyping board used. With a suitable number of samples for each symbol, the proposed approach is also able to provide a measure of the received signal quality in terms of bit error probability and an indication of sign and magnitude of possible frequency drifts. These features are not directly available in conventional SR receivers intended for ASK-Modulated signal.

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