Systems of Synchronous and Asynchronous Communication

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Resumo **- Os sistemas de comunicação têm dois diferentes tipos, nomeadamente o tipo síncrono e o tipo assíncrono.**

No tipo síncrono os relógios emissor e receptor estão em perfeito sincronismo, por isso eles são rigorosamente iguais e dependentes.

Contudo, no tipo assíncrono os relógios emissor e receptor não estão em perfeito sincronismo, por isso eles podem ser ligeiramente diferentes e independentes.

O nosso principal objectivo são os sistemas de alta velocidade, por isso aqui, nós evidenciamos os sistemas síncronos.

Palavras chave: **Sincronismo em Comunicações Digitais**

Abstract **- The communication systems has two different types, namely the synchronous type and the asynchronous type.**

In the synchronous type the emitter and receiver clocks are in perfect synchronism, therefore they are rigorously equals and dependents.

However, in the asynchronous type the emitter and receiver clocks are not in perfect synchronism, therefore they can be slightly different and independents.

Our main objective are the high speed communication systems, therefore here, we evidence the synchronous systems.

Key words: **Synchronism in Digital Communications**

I. INTRODUCTION

The communication systems has two different transmission types, witch are the synchronous mode and the asynchronous mode.

In the synchronous transmission mode all the transmitted bits are part of the information block. and therefore the transmission efficiency is 100%.

However, in the asynchronous transmission mode not all the transmitted bits are part of the information block since the start and stop bits must be added and therefore the transmission efficiency is lesser than 100%.

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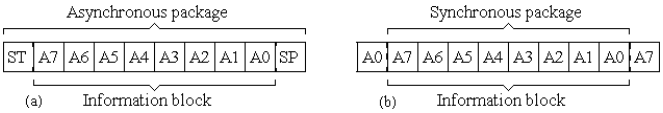

Fig.1 Synchronous emission (a), asynchronous emission (b)

So, in the synchronous mode, with 8 bits word blocks, the efficiency is 8/8= 100%. In the asynchronous mode with the more two bits start and stop the efficiency is 8/(8+2) = 80%.

In the two cases, the efficiency can be reduced when transmission coding (3B4B, etc) and encrypting is used.

In the synchronous case the receiver clock is recovered with phase and frequency feedback of all information bits.

Whereas, in the asynchronous case only the start bit adjusts the receiver clock phase, staying after in its own free frequency. The stop bit in the block end make possible disadjustments.

After, we present with more details, the synchronous and asynchronous systems and its operation modes..

Then, we show the function of the synchronizer or clock recovery in a synchronous system.

Finally, we present the main conclusions.

II. SYNCHRONOUS AND ASYNCHRONOUS TYPES

We go firstly present the general aspect of the two communication systems, witch are the synchronous and the asynchronous type.

After, we give special emphasis and development to the synchronous type due to its bigger efficiency and consequently higher transmission speed for the same operation frequency [4].

A. Synchronous system

In the synchronous operation mode, the emitter and receiver clocks are phase and frequency dependents.

Here, in the receiver there is a synchronizer or clock recovery that extracts a similar version of the emitter clock. This receiver clock, similar with the emitter clock, is used to sample and process the incoming data, see following figure

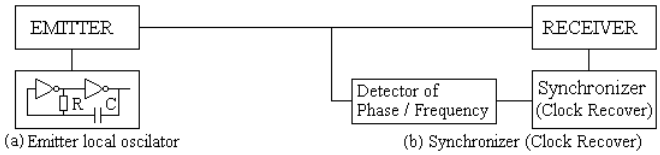

Fig.2 Synchronous communication system

The emitter and receiver oscillators don't need to be equals because the receiver synchronizer has the phase and frequency observation capacity to obtain a clock in perfect synchronism with the received data.

B. Asynchronous system

In the asynchronous communication mode the emitter and receiver clocks are phase and frequency independents.

However, there is a local mechanism that uses the start and stop bits to adjust the local oscillator phase. See following figure

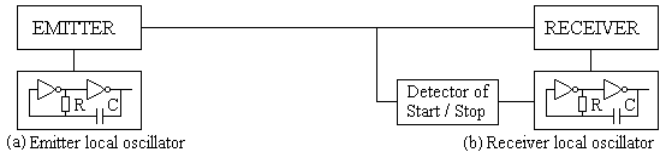

Fig.3 Asynchronous communication system

The emitter oscillator (a) and receiver oscillator (b) are the most equal possible.

The receiver oscillator has an input control to adjust its phase in the stop bit and restart correctly in the start bit. After, it oscillates freely in the information bits block. There is no synchronism problem if the phase error is lesser than 180º.

III. A GENERAL SYNCHRONOUS SYSTEM

Here, we present the synchronous system due to its bigger efficiency in terms of transmission speed [4].

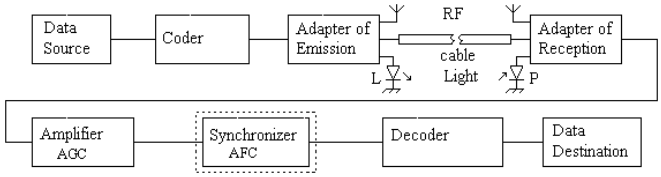

Fig.4 Synchronous system with its synchronizer

The synchronizer is a little part or block of the synchronous system.

We develop the synchronizer because its quality determines in good part the final performance of the global system.

IV. FUNCTIONS OF THE SYNCHRONIZER

The synchronizer takes the received data with attenuation and distortion giving back the emitter original data format.

The synchronizer has two distinct functions witch are optimizing the data sampling with minimum bit error rate and retiming correctly the signal [4].

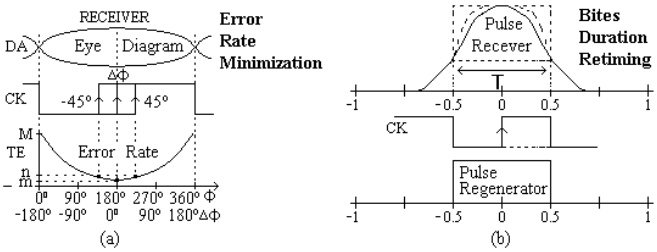

Fig.5 Correct sampling (a) and correct retiming (b)

The correct sampling minimizes the bit error rate BER and the correct retiming returns the original data bit duration of one period 1T. synchronism problem if the phase error is lesser than 180º.

V. SYNCHRONIZER COMPOSITION

The synchronizer can be composed of three fundamentals blocks witch are the clock recovery, the phase corrector and the decisor [4].

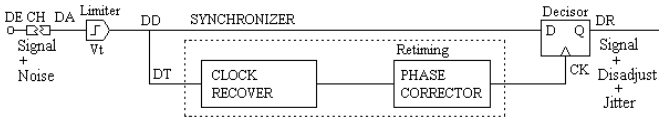

Fig.6 Synchronizer block diagram

The clock recovery gets a signal clock similar with the emitter one, the phase corrector corrects the clock phase and the decisor samples the incoming data in the maximum eye opening.

VI. SYNCHRONIZER CLASSES

The synchronizer can be characterized according three different classes witch are: open loop (ol), mixed loop (ml) and closed loop (cl) [4].

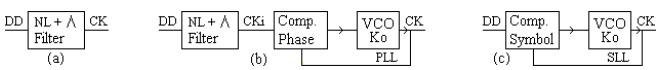

Fig.7 Open loop (a), mixed loop (b) and closed loop (c)

In the open loop all the blocks are outside of the loop, in the mixed loop there are some blocks inside of the loop and others outside and in the closed loop all the blocks are inside of the loop. As we know the loop improves the synchronizer performance.

A. Open loop

The following figure shows the synchronizer that represents the open loop class [1, 2].

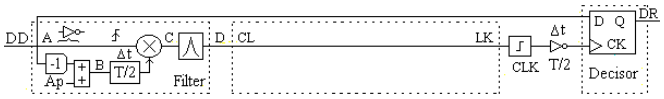

Fig.8 Open loop

All the blocks are outside of the loop. Then, it hasn't any benefit of the loop.

B. Mixed loop

The following figure shows the synchronizer that represents the mixed loop class [3].

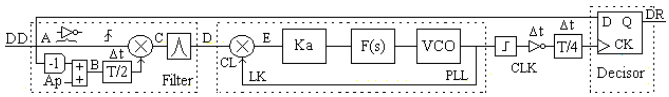

Fig.9 Mixed loop

There are some blocks inside and others outside of the loop. Then, it has some benefit of the loop.

C. Closed loop

The following figure shows the synchronizer that represents the closed loop class [4].

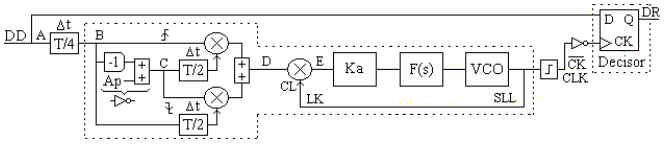

Fig.10 Closed loop

All the blocks are inside of the loop. Then, it has a total benefit of the loop.

VII. TESTS, DESIGN AND RESULTS

We go present the tests, the design and the results of the mentioned synchronizers [5].

A. Tests

The following setup was used to test the different synchronizers.

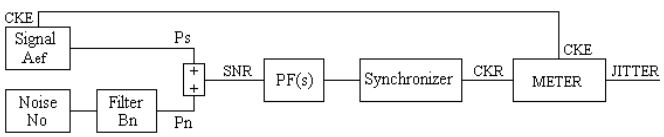

Fig.11 Block diagram of the test setup

The receiver recovered clock is compared with the emitter original clock, producing the received clock jitter.

B. Design

To have guaranteed results is necessary to dimension all the synchronizers with equal conditions. Then is necessary to design all the loops with identical linearized transfer functions.

The loop gain is Kl=Kd.Ko=Ka.Kf.Ko where Ka is the control amplification factor, Kf is the phase comparator gain and Ko is the VCO gain.

For analysis facilities, we use a normalized transmission rate tx=1baud what implies also normalized values for the others dependent parameters. So, the nominal clock frequency is fCK=1Hz.

We choose an external noise bandwidth Bn = 5Hz and a loop noise bandwidth Bl = 0.02Hz.

Now, we will apply a signal to noise ratio SNR related with the signal Aef, noise spectral density No and external noise bandwidth Bn as follow SNR = $A^2_{ef}/(No.Bn)$. But No can be related with the noise variance σn and inverse sampling Δτ=1/Samp, then $No=2\sigma n^2.\Delta\tau$, so $SNR=A^2_{ef}/(2\sigma n^2.\Delta\tau.Bn) = 0.5^2/(2\sigma n^2*10^{-3}*5)= 25/\sigma n^2$.

- 1st order loop:

The loop filter F(s)=1 with cutoff 0.5Hz (Bn=0.5Hz is 25 times bigger than Bl=0.02Hz) eliminates only the high frequency, but maintain the loop characteristics.

The transfer function is

$$H(s)=\frac{\mathrm{G(s)}}{1+\mathrm{G(s)}}=\frac{KdKoF(s)}{s+KdKoF(s)}=\frac{KdKo}{s+KdKo} \qquad (1)$$

the loop noise bandwidth is

$$Bl=\frac{KdKo}{4}=Ka\frac{KfKo}{4}=0.02Hz \ = 0.02\mathrm{Hz} \qquad (2)$$

Then, for open loop, the bandwidth filter

$$Br=Bl=0.02Hz \qquad (3)$$

For mixed loop

$$\begin{aligned} &Br=Bl=0.02Hz \\ &Bl=0.02=KaKfKo/4, \\ &Kf=KmA.B=1\times0.5\times0.5=0.25,\ K0=2\pi \\ &Ka\times0.25\times2\pi/4=0.02\ \therefore\ Ka=0.08/2\pi \end{aligned} \qquad (4)$$

For closed loop

$$Bl = 0.02 = KaKfKo / 4,$$

$$Kf = KmA.B = 1 \times 0.5 \times 0.45 = 0.25,\ K0 = 2\pi \qquad (5)$$

$$Ka \times 0.5 \times 0.45 \times 2\pi / 4 = 0.02 \therefore Ka = 0.08 \times 2.2 / 2\pi$$

The jitter depends on the loop noise bandwidth Bl, on the power spectral density No and RMS signal Aef.

For analog PLL the jitter is

$\sigma\phi^2 = Bl.No/Aef^2 = Bl.2.\sigma n^2.\Delta\tau = 0.02*10^{-3}*2\sigma n^2/0.5^2 = 16*10^{-5}.\sigma n^2$

For the others PLLs the jitter formula is more complicated

- 2nd order loop:

The second order loop is not considered here, but the results are similar with the ones obtained above.

D. Results

We present synchronizer results that represent each one of the three refereed classes: open loop (ol), mixed loop (ml) and closed loop (cl).

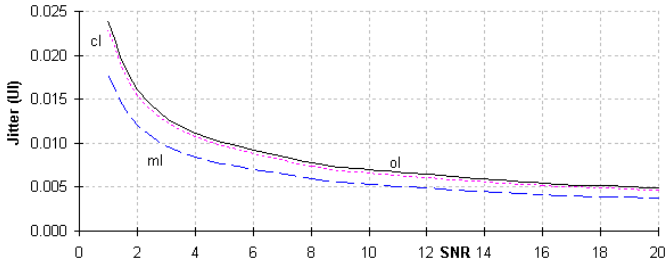

Fig.12 Jitter curves of the synchronizers (ol, ml, cl)

We verify that if the open loop bandwidth Br is equal to the mixed loop noise bandwidth, then the jitter noise curves are identical.

The jitter-noise curve of the mixed loop, with same Br and Bl, is slightly better than the others due to its duple tuning Br and Bl.

VIII. CONCLUSIONS

We saw that the synchronizers communication systems have better efficiency than the asynchronous one, since all the bits are information bits.

We studied 3 synchronizer classes namely the open loop (ol), the mixed loop (ml) and the closed loop (cl), we verify that with the same bandwidth Br or same loop noise bandwidth Bl all them have similar jitter-noise curves.

The mixed loop synchronizer (ml) possesses a slightly advantage over the others due to its duple tuning, firstly the filter Br and after the own loop Bl.

IX. ACKNOWLEDGMENTS

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