Analog Channel of Electronics Remote end Switchers System

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Abstract – **The article examines the problem of development of System of remote end switchers. Some investigation, analysis and experimental work concerning Home Control systems have been done. A comparison between the two most widely used methods for development of such systems is given. On the basis of the analysis and comparison done certain approach for remote control of end switchers based on X10 protocol was chosen.**

Keywords – Home control, Powerline communication, X10-UPB standards

I. INTRODUCTION

The main use of the power distribution network is to deliver an electrical energy to certain power loads. In general the output points of the network are the wall-outlets in the house. This output points poses certain properties: they are connected in parallel to the live and neutral lines; they are distributed in all the rooms of the dwelling. These properties reveal their potential as a very convenient tool for data exchange over the house. There are even some more advantages: there is no need for any extra wiring as the already installed power lines between the wall-outlets is used; normally the devices involved in the communication are already connected to the power lines.

There are many standards for data transfer over the power lines. The first one of them is the so called X10 protocol introduced in 1975 [1]. The protocol is specifically aimed for controlling home and industrial appliances and devices.

Another similar protocol is Universal Powerline Bus (UPB) developed by Powerline Control Systems. The protocol was released in 1999 [2].

A. X-10 data protocol

X-10 transmission is based on a 120 kHz signal burst, transmitted in the power line with 1ms duration. The moment of emission should be synchronized with the zero crossing point of the AC power line. The goal should be to transmit as close to zero crossing point as possible but certainly within 200 μs of that point. Fig. 1 shows the moments of signal transmission related to the AC power line waveform.

For clarity the signals shown on Fig. 1a are given in form like they have been past through a HPF. Indeed the impulses are superimposed on the AC power line wave form and the time diagram looks more like that shown in Fig. 1b. In case of 3 phase power line applications the generation of three consequential spaced bursts is a must. Moreover the individual bursts should be offset to 3.3 ms (the phase shift between the three AC waveforms) in order for correct operation.

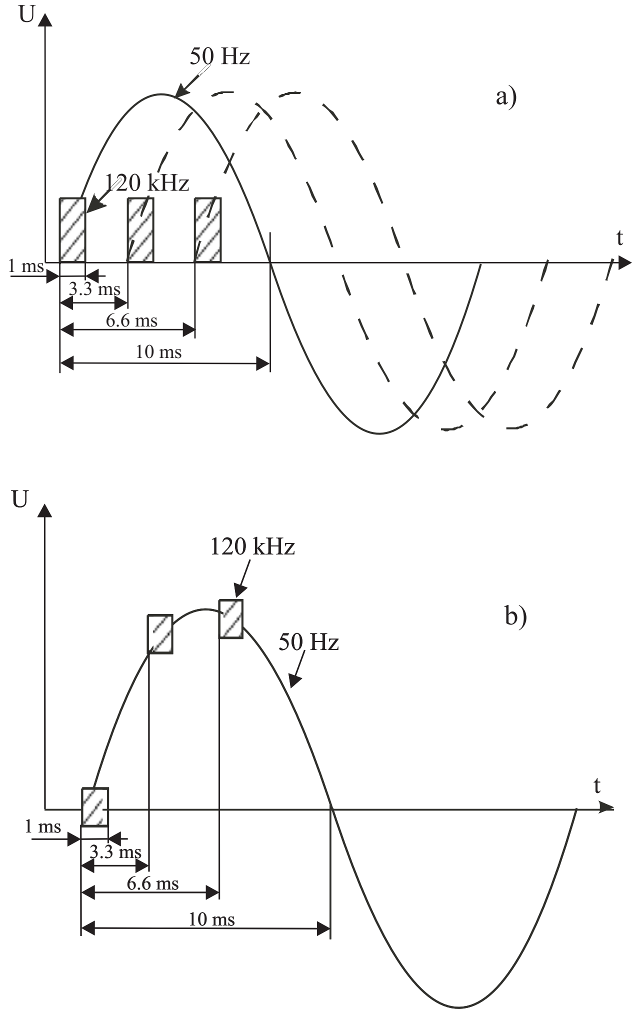

Fig. 1. X-10 modulation in 3 phase Powerline

For clarity the signals shown on Fig. 1a are given in form like they have been past through a HPF. Indeed the impulses are superimposed on the AC power line wave form and the time diagram looks more like that shown in Fig. 1b. In case of 3 phase power line applications the generation of three consequential spaced bursts is a must. Moreover the individual bursts should be offset to 3.3 ms (the phase shift between the three AC waveforms) in order for correct operation.

A binary ‘1’ is represented by 1ms burst of 120 kHz at the zero crossing point (maximum delay should not exceed

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200 μs.) – shown on Fig. 2. Binary ‘0’ is represented by the absence of this signal.

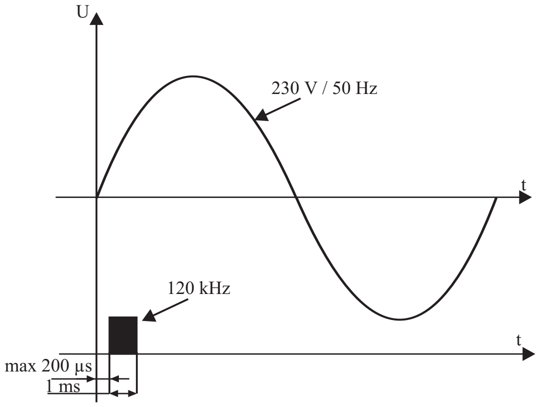

Fig. 2. X-10 zero cross synchronization

B. UPB data protocol

The UPB standard offers a way for data exchange over the power line based on a transmission of synchronized, high voltage pulses with a short duration. These pulses are capable traveling large distances over the Powerline and even coupling through the power transformer to the other side of a split phase power arrangement. The receiving UPB devices can easily detect and analyze these signals. Fig. 3 shows the AC waveform with the UPB pulses superimposed on it.

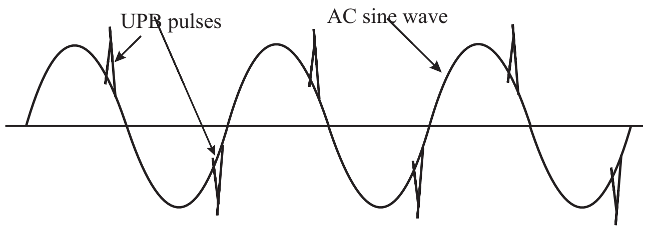

Fig. 3. UPB pulses superimposed on the AC waveform

UPB Pulses are generated by a capacitor recharged to a high voltage and then discharged into the Powerline at a specified time. The transmission of the pulses is done in special predefined position in the AC waveform called UPB frame. The frame is located toward the end of the AC waveform due to the lower noise characteristics, which makes the data exchange more reliable.

The UPB pulse could occupy four different positions in the frame and these four logical states could be encoded (‘00’, ‘01’, ‘10’, ‘11’). This method of encoding data to a relative position of a pulse is well known in electronics and communications as Pulse Position Modulation. Since the UPB pulses could be transmitted in the both half-cycles of the AC waveform the UPB communication has a raw speed of 200 bits per second (at 50 Hz power line supply).

The UPB pulses could occur in one of four different positions in the UPB frame. Each position is marked with a number from 0 to 3 and is spaced 160 μs apart from the next one. UPB transmitter must generate each UPB Pulse at the intended position ±40 μs. Fig. 4 shows the location of the UPB frame and the positions of the UPB pulses.

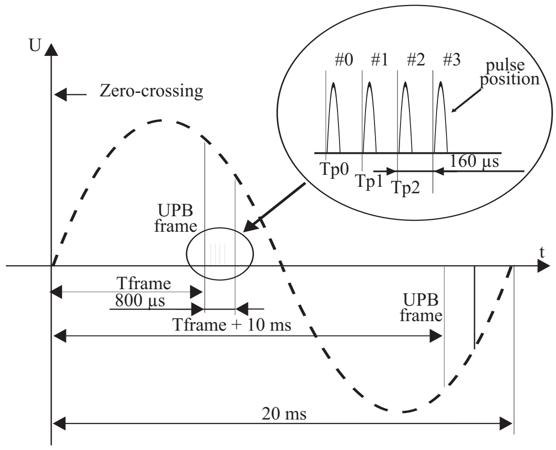

Fig. 4. UPB synchronization

By taking into account the overview and the comparison, made above, between the two main standards for home automation over the power line X-10 became the protocol of choice. The primary reasons for that decision are: firstly the wider spread of the standard mention and secondly the varied different realizations already existed.

II. Implementation

According to the specification of the X10 standard and the point of the current system under development generalized block diagram are shown on Fig. 5. Fig. 6 represents block diagram of a individual device from the system based on the X-10 standard.

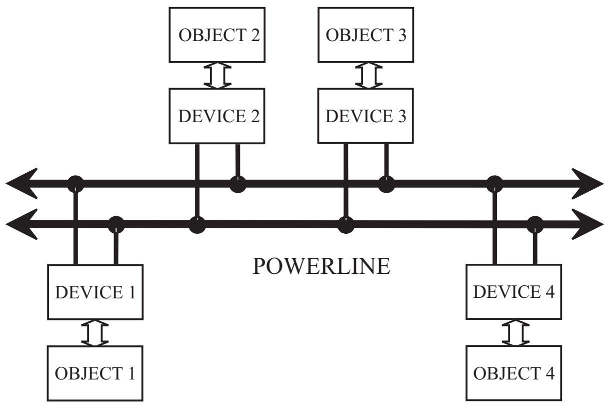

Fig. 5. Generalized block diagram of electronics remote end switchers system

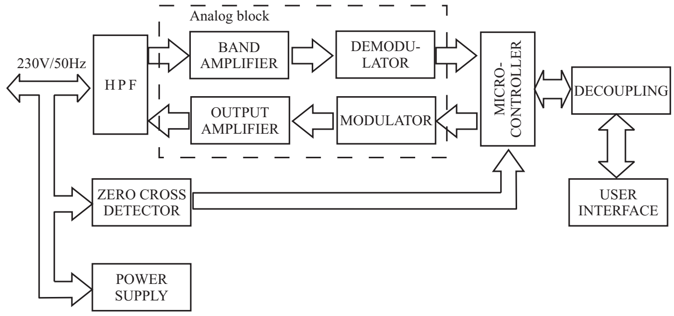

Fig. 6. Extended block diagram of a device based on X-10 standard

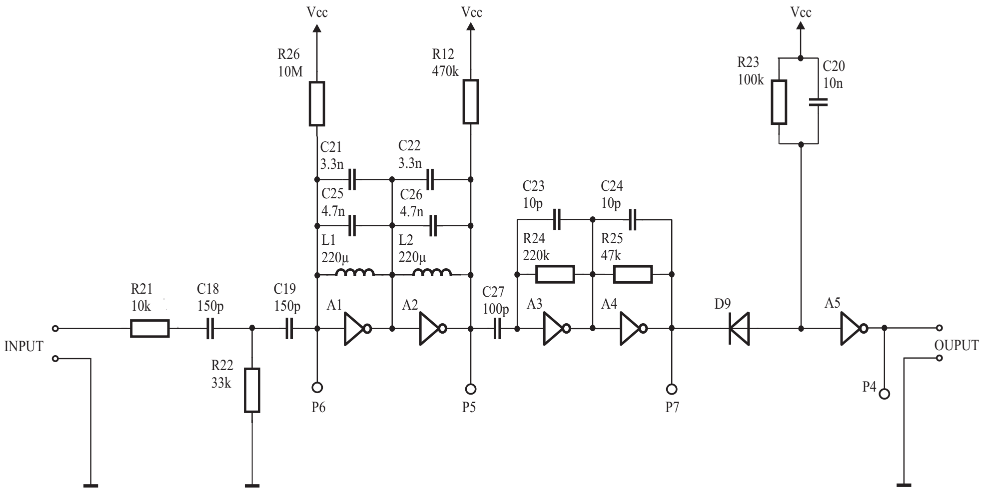

Fig. 7. Analog channel

The realization of the system development is described in the document AN236 by Microchip Technology [5]. Fig. 7 shows the schematic of the 'Analog channel'.

III. Experimental Study - 'Analog Channel' Exploration

In the time of study of 'System of remote end switchers' some experiments related to the properties of some individual blocks of its structure were made. In order of experiment realization the fallowing equipment was used:

- Experimental board based on the realization [5]
- Isolating power transformer-output is 230/130 V, 150 VA
- Oscilloscope Tektronics TDS320
- Waveform generator

A. 'Band Amplifier' Block Exploration

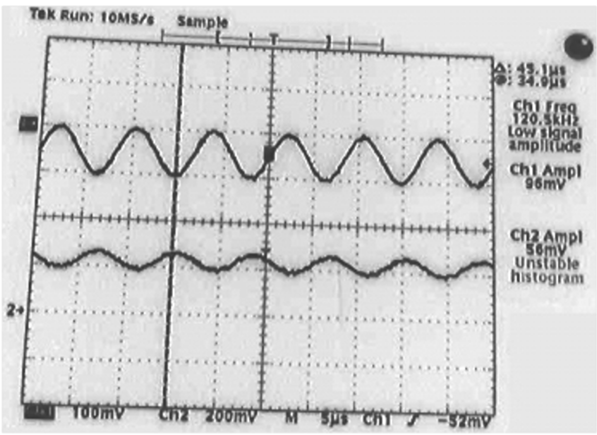

Fig. 8. test point P6

Fig. 8 shows the oscillograme in test point P6. The input signal is depicted on Channel – a sine wave with frequency f = 120 kHz and swing Vp-p = 960 mV. Channel 2 represents the signal measured in the test point. As can be seen the swing of the signal is Vp-p = 560 mV.

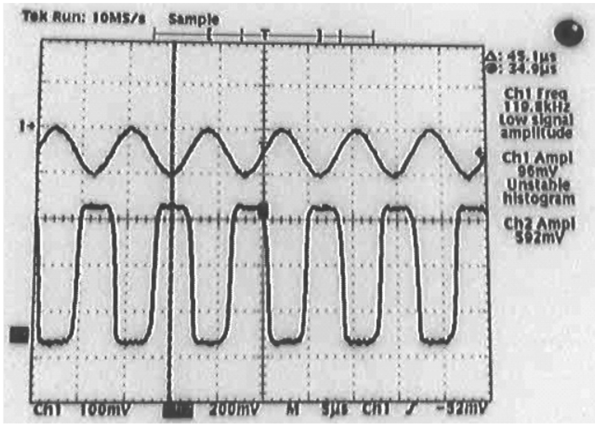

Fig. 9. - test point P7

On the oscillograme shown on Fig. 9 channel 1 represent the input signal and Channel 2 shows the signal as it comes out from the amplifying section constituted by A3 and A4. The swing of the output signal is Vp-p = 5.9 V.

B. '120 kHz Carrier Generator' Exploration

The experiment studies the signal in Test Point P8 (fig. 10). Channel 1 shows the wave form of the power line AC - f = 50 Hz, Vp-p = 31,6 V. Channel 2 shows the output signal constituted by 1ms bursts of 120 kHz at the zero crossing of the power line AC.

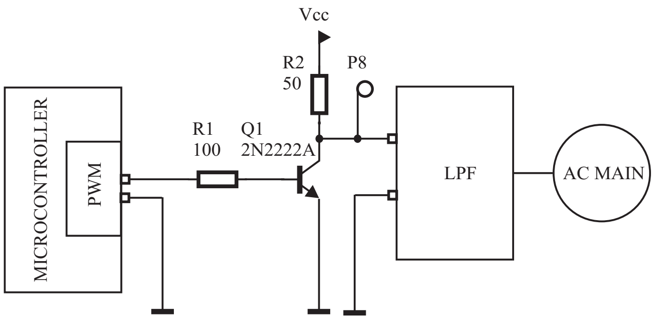

Fig. 10. Carrier generator 120 kHz

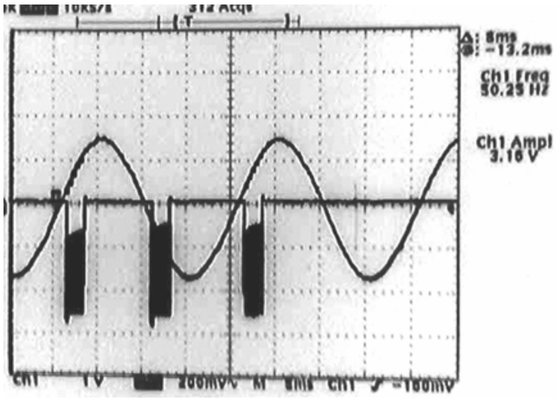

Fig. 11. Test point P8

C. Frequency Response of 'Band Amplifier' Block

The frequency response in Test Points – P5, P6 and P7 has been measured. The experimental results are shown in table below. The signal gain in the 120 kHz region can be seen in the graph.

D. Frequency Response of 'Demodulator' block.

Fig. 9 shows the frequency response the Demodulating block comprised by the D9, R23 and C20 components (see fig. 7). The moments of activation of the output inverter A6 are also shown.

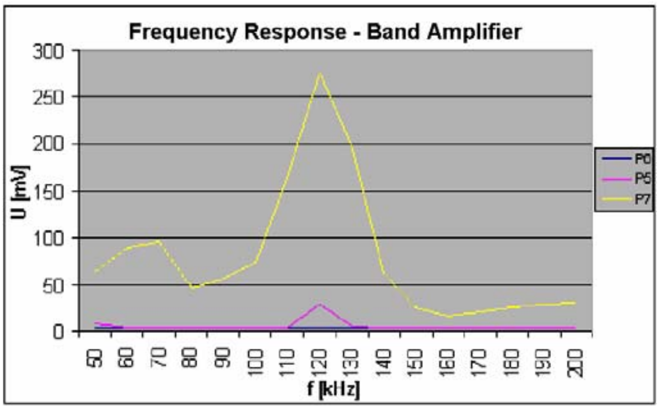

Fig. 12. FR 'Band Amplifier'

E. 'Band Amplifier' block delay investigation.

A 120 kHz signal is applied to the 'Band Amplifier' input (Test point P6) with 1 ms duration. Fig. 14 shows the input burst and the corresponding output signal from the 'Demodulator' block. It can be seen that the output signal is activated 21,5 µs after the input burst has been applied and became inactive again 580 µs after the burst has been stopped.

IV. Conclusion

In the current article a study on the analog channel of system of remote end switchers, using the power line as a medium for data transfer was made. Some properties of the medium used are described, also two related standards are presented. After comparative study between the two standards, X10 is selected for base protocol of choice. Block diagrams of generalized system and device incorporate the protocol are shown. Chapter III presents some experimental work on the analog channel of device incorporate communication over the power line.

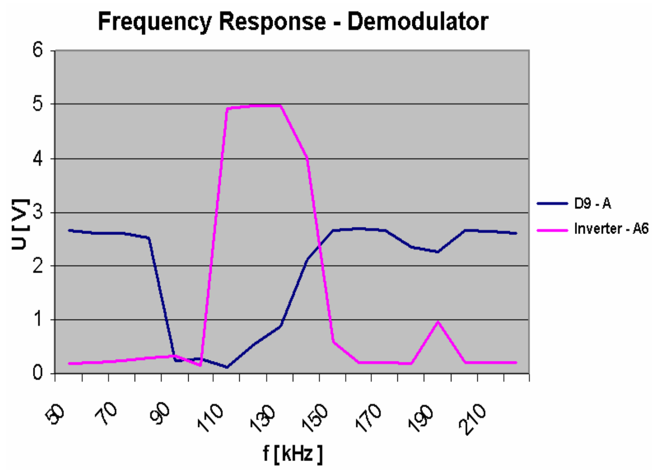

Fig. 13. FR 'Demodulator'

The information will be used for future assessment and planning for the purposes of speed and signal band determination, as well as extra digital filtration. Moreover determining the signal generation and detection delay and generator output resistance adjustment are also of interest

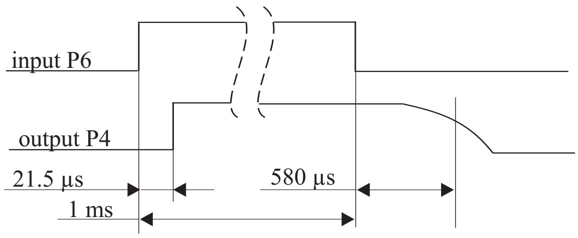

Fig. 14. - Band Amplifier + Demodulator Delay

Acknowledgement

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