Implementation of OFDM System for Power Line Communication Using Analog Devices EZ-LITE 21061Kit

This project discuss the implementation of OFDM system over power lines as a communication technique capable of removing the effects of multi path fading

The main idea of the project is to build two separate power line systems, one utilizing the ordinary FSK modulator with a simple coupling equipment, the second is OFDM system over power lines and compare the performance for both of the two cases.

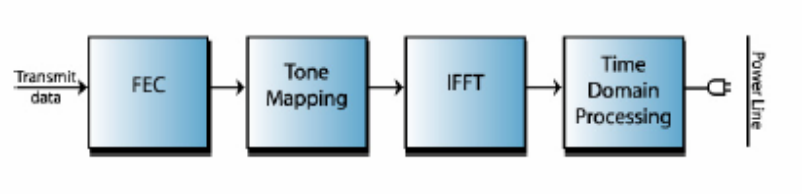
The project can be divided into the following phases :

1. reading the different specification of the power lines like :
    - physical parameters, impedance, capacitance, radiation
    - noise analysis, this was hard to be done by ourselves due to the shortage in modern oscilloscopes which limits the ability to take noise readings, the readings were obtained from a governmental project implemented in * Sweden
    - analyzing the different standards for frequency band and implementation

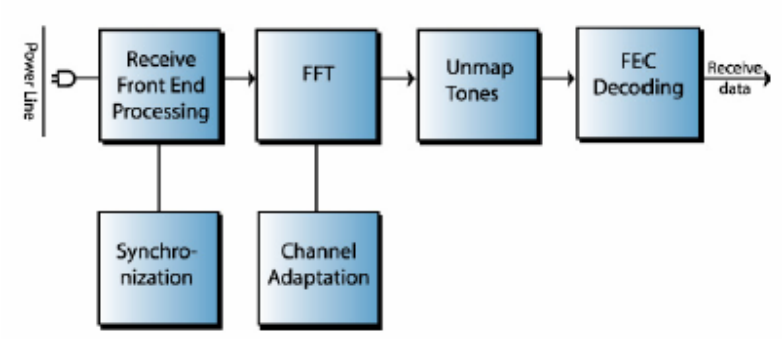
2-implementing the system over DSP kit was divided into 2 phases, software and hardware:

- software: the code for OFDM with convolutional encoding & the software for transmission and reception of the data
- hardware :

Digital communication system block diagram



OFDM Transmitter



OFDM receiver

1. Hardware for connecting the OFDM system on the DSP to the power lines :

This was divided into 4 circuits all have been implemented and tested separately :

- Low pass filter, to filter the high frequency noise over the bandwidth required for transmission (1 MHZ), the

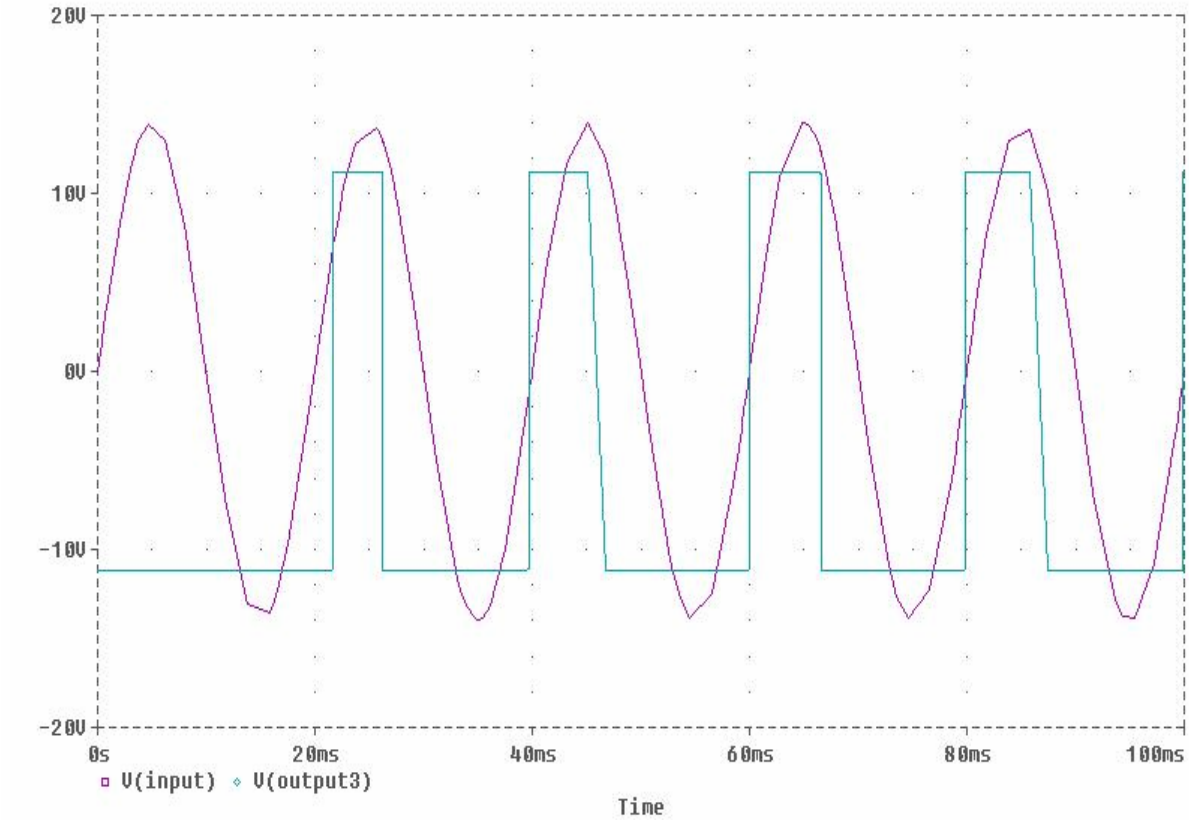
- High pass filter, this was designed to remove the components of the power signal and its higher order harmonics, the cutoff frequency of this filter is 100 KHZ to remove the first 100 KHZ band which suffer from a high noise levels.

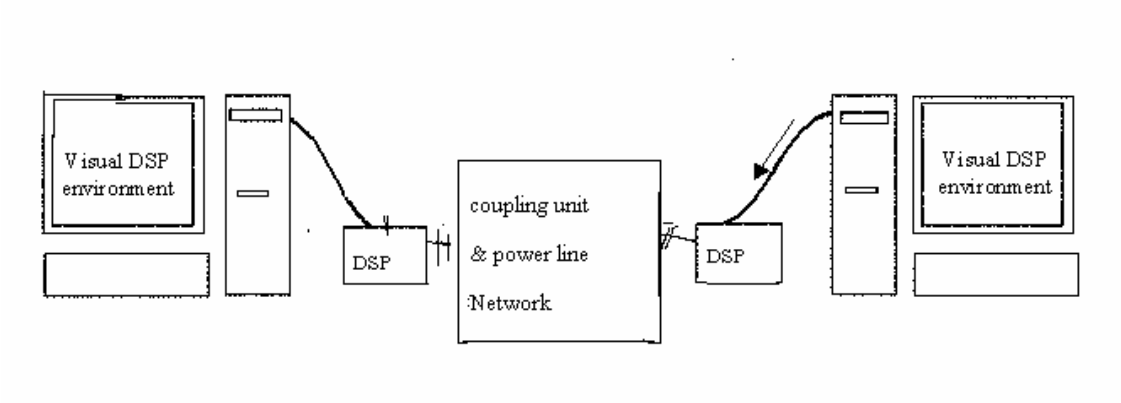
- Synchronization circuit: this circuit was made in order to give the two DSP kits an external interrupt signal to start transmission and reception at the zero crossing of the power signal, this circuit consisted of 3 stages:

- Low pass filter with cutoff frequency 70 HZ to filter the higher order harmonics of the power line signal
- Comparator to generate a clock signal with the frequency of the 50 HZ signal, this comparator have been impelemented with hysteresys range of 1- to 1 v, this is done according to the relation :

Vl_= - L+ (R1/ R2) , by choosing R1 and R2 with ration 1/12, we achieve the required range , this range is necessary to overcome small noise ripples

- We needed signal condition after the synchronization circuit, we made buffer and inverters to adjust the clock in the digital level (c to 5v) and to separate the circuit from the DSP





the synchronization circuit was intended to be the guide for both the transmitter and receiver to start transmitting and receiving data, this is to try to send near the zero crossing of the power signal where the noise level reaches its minimum (due to the periodic background noise level in its minimum).

The synchronization circuit is fed from a transformer that transform the power signal of 220 VAC to a suitable AC signal of 12 V ($12\sqrt{2}$ v) before inputting to the input stage of the filter, all amplifiers are JFET differential stage OP-amplifiers to be able to bear large current on its input gate without breaking down

- Coupling and protection circuit:

This circuit is implemented to couple the data signal over the power line signal, this is done using simple transformer and capacitor of high value (to block the 50 HZ signal) this capacitor is chosen such that when it fails it fails as open circuit, which provide more protection

The circuit was provided with a pulse transformer, the frequency range of this pulse transformer is from 100 KHZ to about 1 MHZ and so it provides more filtering and protect the circuits behind the coupling from any failure

The circuit was supported with two stabilizers in order to overcome high level spikes, as those spikes have very small duration and may pass though the pulse transformer to

damage the circuit, those stabilizers represent last stage of protection for the digital circuits behind the coupling

Finally, at the input of the coupling unit, the output of the DSP line should be connected, the left channel to the signal line, the ground to the other line .

Important note: the ground of the digital signal shouldn’t be unified with the ground of the power signal after step down transformer, this could dangerously damage all the equipment in case of failure of the transformer

2. The hardware for the Power line modems (FSH modems)

Those modems are ready made, we got them in order to compare their results with the results we obtain from the OFDM system , they are equipped with simple interface to the power line that consists of a transformer and a capacitor to make a band pass filter with resonance frequency at the transmission frequency (132.45 KHZ)