PROJECT PRESENTATION
ON
POWERLINE COMMUNICATIONS

In partial fulfillment of the requirements for the award of the degree of bachelor of engineering in electronics and communications engineering

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ABSTRACT

- In the latest generation of home automation systems, appliances can exchange information by transmitting data over the domestic mains wiring. As a result there is no need to install extra control cables and appliances can be connected to the network simply by plugging them into the nearest wall socket.

- Microcontroller can easily be used in conjunction with X- 10 technology to create home automation applications.A PIC uC or an AVR uC can be selected for this application because of its versatility as a general purpose microcontroller, its FLASH program memory(for ease of development), data EEPROM, and ample I/O ports.

- Several ready to use powerline modem chips can also be used to implement a full power line communications systems like the TDA5051AT which will be discussed in a later section or the MAX20340 IC used in DC power line communications

POWER LINE COMMUNCIATIONS

Power Line Communication (PLC) is a data transmission technology using existing cables such as power lines, coaxial cables, twisted pair cables, etc.

By using existing cables as a transmission medium, it is possible to quickly build a network at a low cost.

In the case of using power lines, power and data transmission can be done with a single cable, which can reduce the types of cables in a network.

PLC is a technology which has been in use since years but came now in more demand after the launch of new communication technologies which are being supported by PLC i.e. PLC would be a reliable communication medium for applications like Internet-of-things (IoT)

TYPES OF POWERLINE COMMUNICATION

Basically, there are four types of PLC:

- **In-house networking**: High-speed data transmission can be provided for home networking using the In-House mains power wiring.
- **Broadband over Power Line**: Broadband internet access can be offered through the outdoor mains power wiring.
- **Narrowband in-house applications**: Low bit rate data services like home automation and intercoms can be controlled and used for communication through the In-house power mains which is the main focus of our project
- **Narrowband outdoor applications**: Narrowband outdoor applications can be used for automatic meter reading and remote surveillance or control.

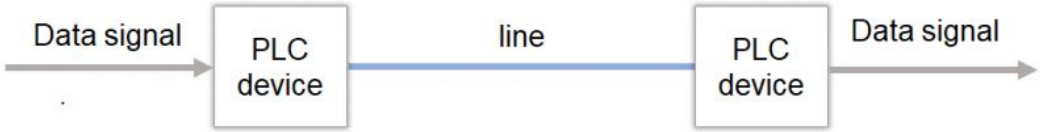
HOW DOES PLC WORK

The basic principle of Power Line Communication is the following.

When transmitting and receiving data between two devices, the data is modulated on the transmitter, and the modulated signal is superimposed on the AC or DC power supply voltage.

In the receiver, the data is extracted by separating the power supply voltage and the modulated signal with a filter and demodulating the modulated signal.

PLC can be used on AC power lines, but keep in mind that it can also be used on DC power lines. For example, it can be used for storage batteries, lighting, EV charging, etc.



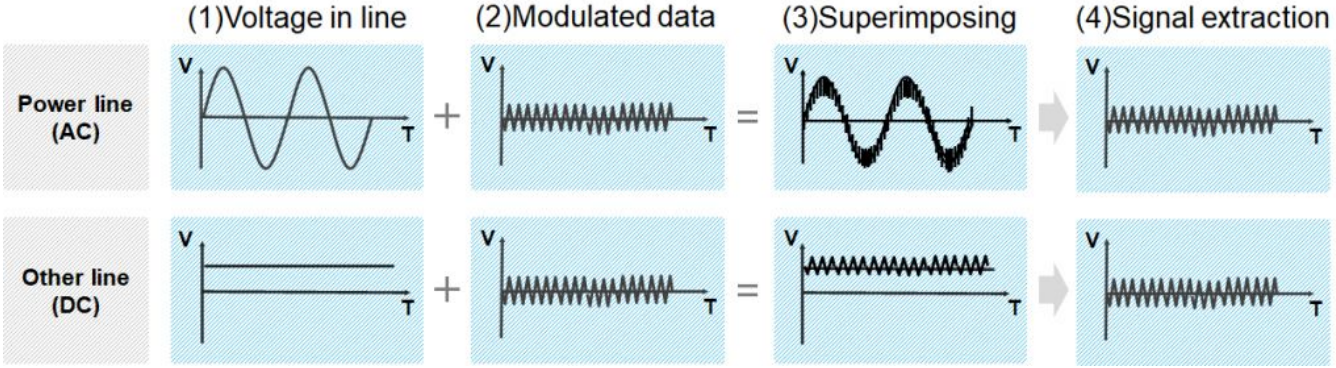


Illustration of a basic PLC system

ADVANTAGES AND DISADVANTAGES OF PLC

You can compare PLC to Wi-Fi and Ethernet from several viewpoints.

PLC has advantages and disadvantages compared to them, and it enables you to build a network with a moderate performance at a low cost.

note that the advantages and disadvantages of PLC are not fixed and depend on what you are comparing.

An advantage compared to Wi-Fi can be a disadvantage compared to Ethernet (and vice versa, of course).

Advantages :

Vs. Wi-Fi

- Higher security – There is little risk of data eavesdropping and falsification.
- Stability – The change of transmission characteristics due to the surrounding environment is small, so a constant performance is maintained.
- Complementary to Wireless – Data transmission using existing cables installed there is possible even in areas where radio waves are hard to reach (e.g., underground, elevator, steel ship, etc.).

Vs. Ethernet

- Lower installation cost – Installing new cables and HUBs for relaying is not needed.

Disadvantages

Vs. Wi-Fi

- Lower speed – Maximum speed in the standard is lower than Wi-Fi (9.6 Gbps).
- Mobility – The place of the communication equipment is fixed.

Vs. Ethernet

- Lower speed – Maximum speed in the standard is lower than Ethernet (10 Gbps).
- Unstable environment – The influence of noise from connected devices exists in the case of using power lines.

APPLICATIONS FOR PLC SYSTEMS

PLC technology is widely used in the following systems to empower Smart Building, Smart Factory, Smart Grid, and Smart City, etc., as a solution to reduce network construction costs.

- Advanced Metering Infrastructure (AMI) systems
- Elevators
- Storage batteries
- Smart street lights
- Lighting control systems
- Security camera systems

CHANNEL CHARACTERISTICS

Multipath effect caused by impedance mismatches, causing :
- intersymbol interference .
- frequency selectivity.

Attenuation, depends on :
- distance between the TX and RX.
- Number and position of reflection points(branches).

Frequency dependent Signal to Noise Ratio (SNR).

Types of Noise:

- Colored background, due to different low-power noise sources.
- Narrowband interferences,caused by radio broadcasters.
- Impulsive noise such as :-
    - synchronous, generated by rectifier diodes used in electrical appliances.
    - asynchronous, caused from switching transients (This is the most detrimental type of noise).

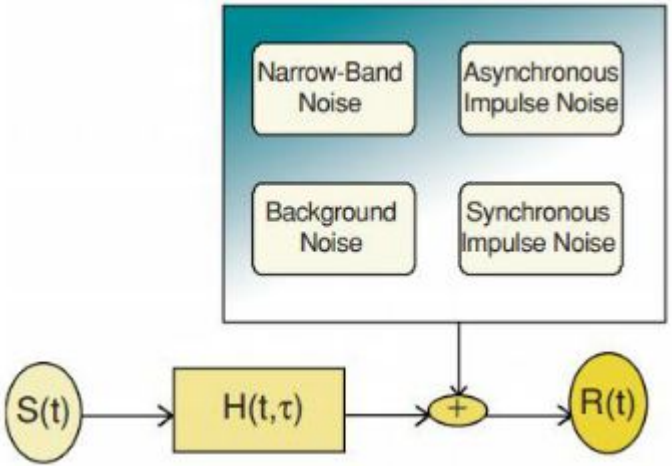


Fig . Channel model

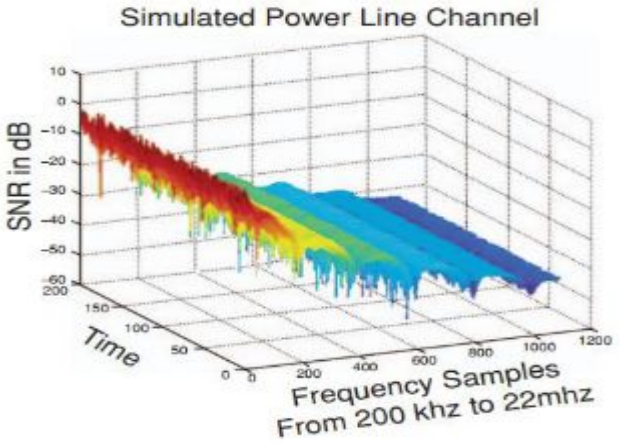


Fig . Simulated power line channel

Communication Techniques

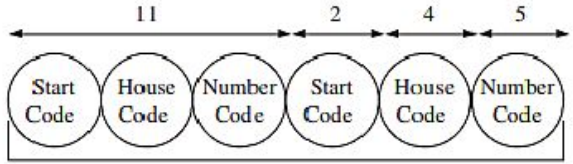
- FSK, Low spectral efficiency (suitable for low data rate application such as power line protection and telemetering).
- For data rates up to 1Mbps, the CDMA technique may provide an effective solution.
- The symbol duration is so small that delayed versions of one symbol - due to multi-paths - gets smeared over a large number of other symbols.
- With OFDM, since the data is split among N sub-carriers, the symbol duration for each sub-carrier increases N times, moreover a cyclic prefix is applied with length longer than longest delay path. This solves the intersymbol interference.
- OFDM, we can avoid transmitting at frequencies in deep fade.

X-10 PROTOCOL

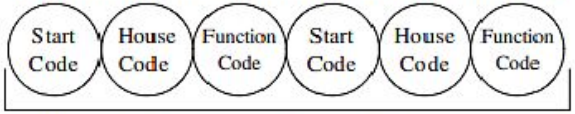
- Narrowband protocol
- Rate(bit/sec) = 60
- Most popular

X10 limitations

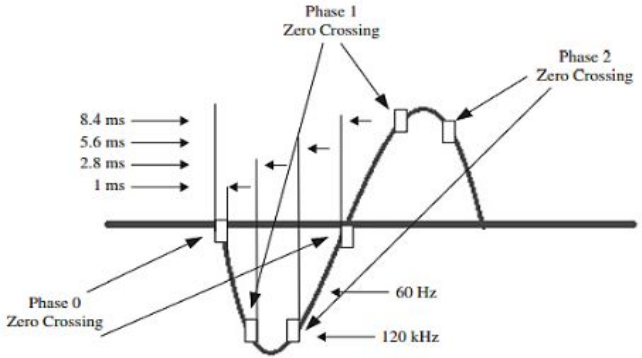
- The high attenuation in wires and transformer winding(especially, between different phases).
- Slow Rate.



Code transmitted when a number button is pressed

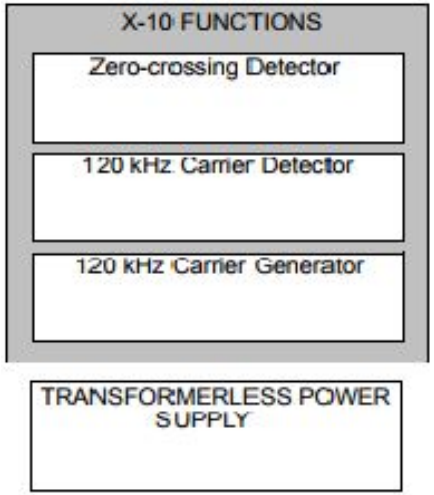


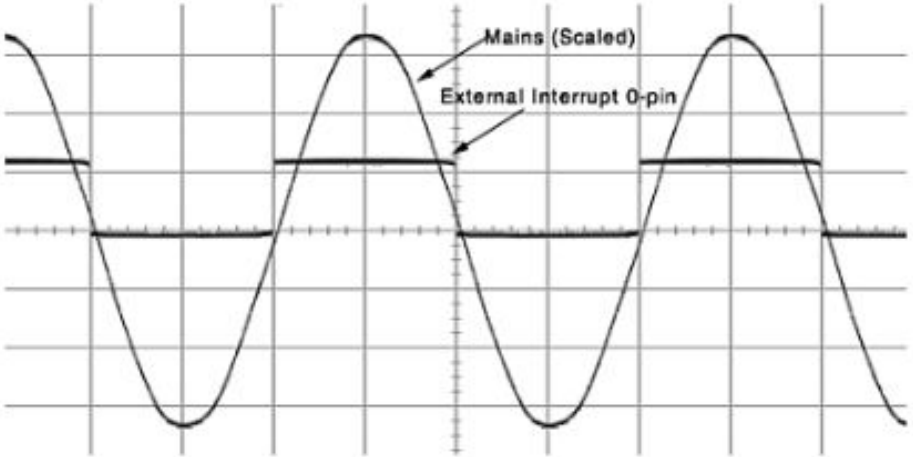
Code transmitted when a function button is pressed



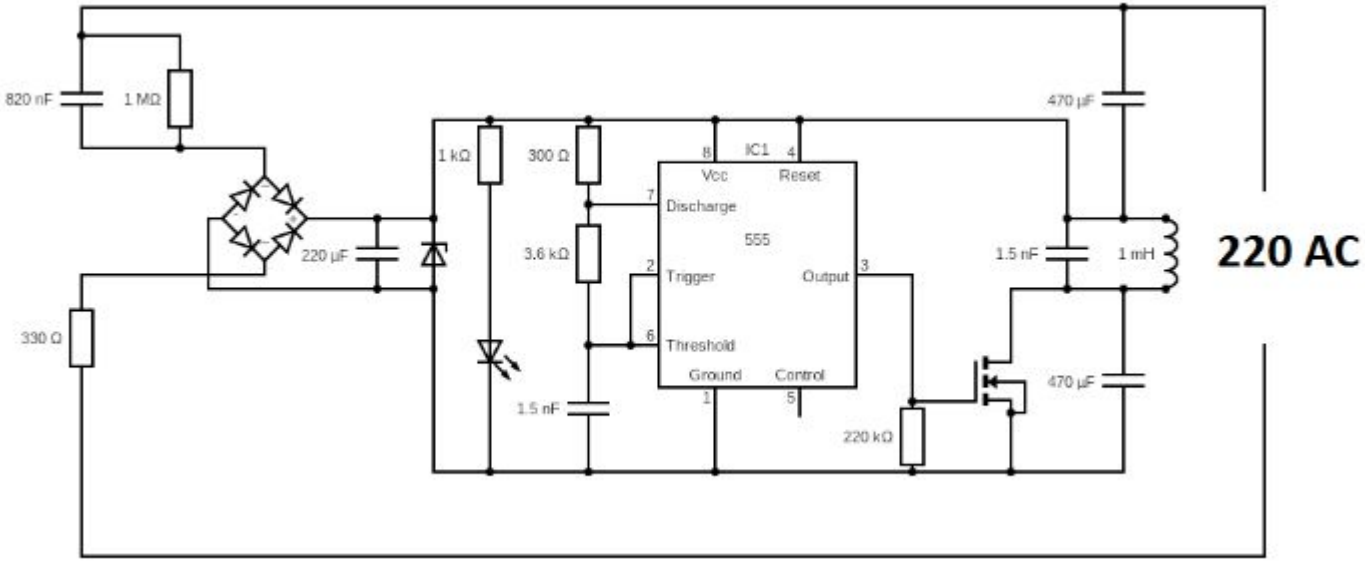
Hardware Description

- Zero-crossing detector.
- 120 kHz carrier detector.
- 120 kHz signal generator.

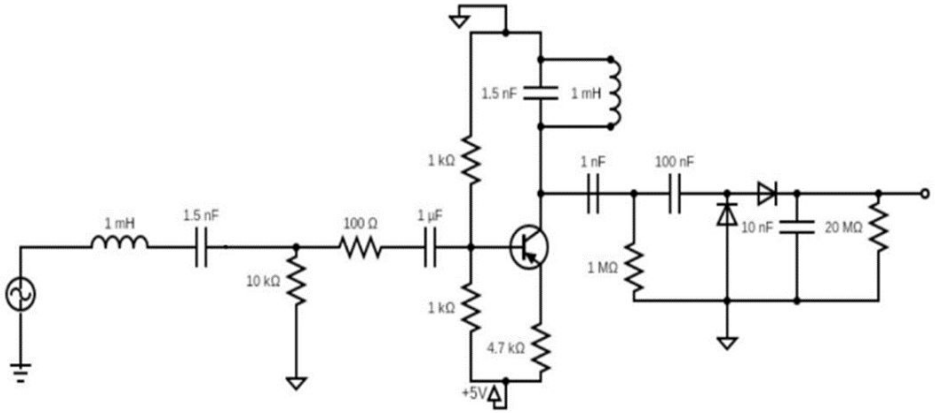


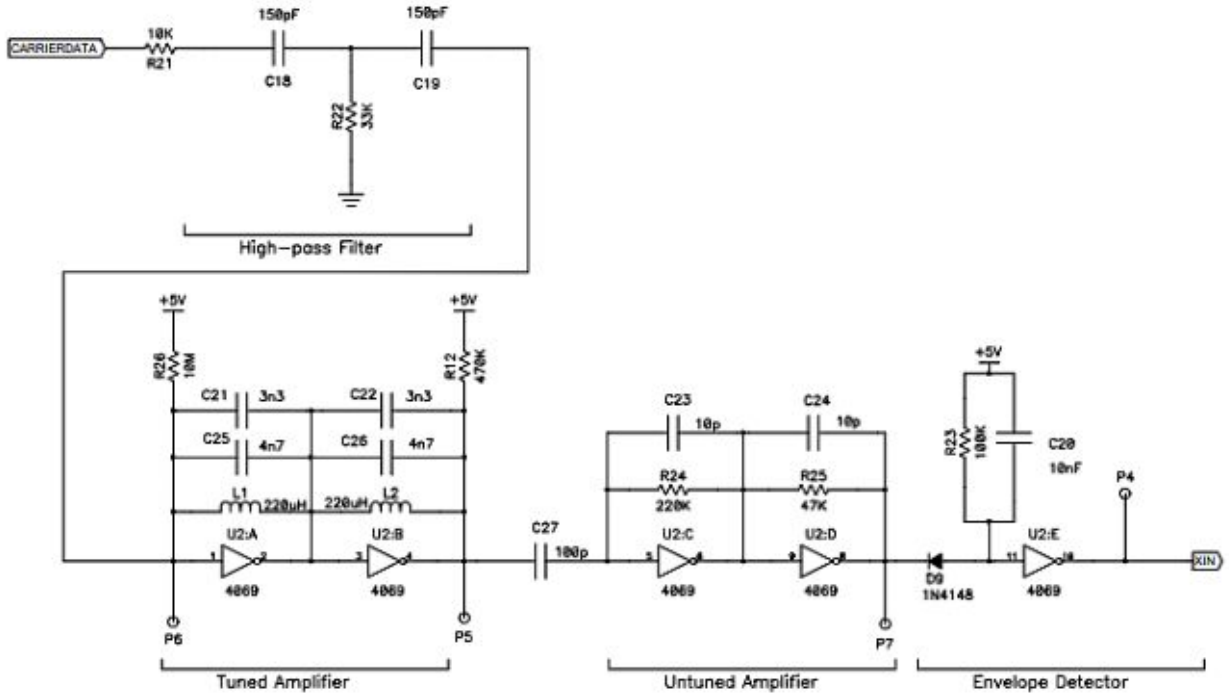


Test Circuits For PLC



Transmitter


1.5 nF
1 mH
1 kΩ
1 nF
100 nF
1 mH
1.5 nF
100 Ω
1 µF
10 nF
20 MΩ
10 kΩ
1 MΩ
1 kΩ
4.7 kΩ
+5V



Carrier Detector

TDA5051AT POWER LINE MODEM

PLC Modem is device which is useful to send and receive serial data over the existing AC mains domestic power lines.The TDA5051A is a modem IC, specifically dedicated to ASK transmission by means of the home power It operates from a single 5 V supply.

Device features

- Powered from 5V supply
- Transmit and receive data from 600 baud rate up to 1200
- Full digital carrier generation and shaping
- Modulation/demodulation is performed inside the IC
- Built-in Digital filtering and rejection of aliasing components
- Requires few external components for low cost applications

PLC Modem

The module is designed to provide simplex (one way) communication over the mains of the 220V AC and for a frequency of 50 Hz or 60 Hz

The module is divided into two sides , the transmitter side and the receiver side

A pair of decoder/encoder IC's are used to parse the data for transmission to a specific address and to encode the transmitted data at the transmitter side , while a decoder is used at the receiver side to decode the incoming data

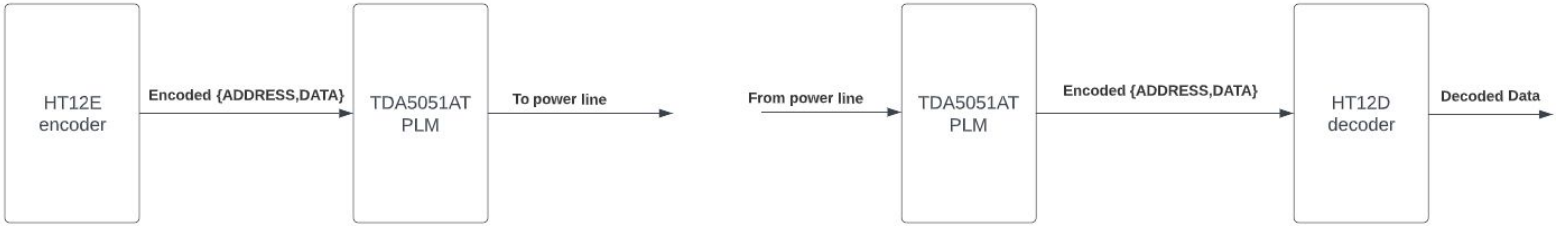
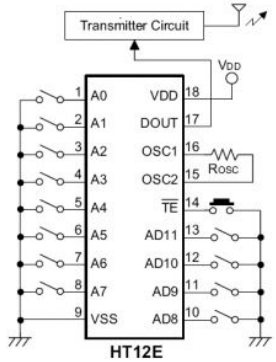
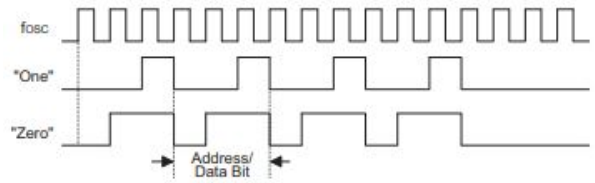


Fig : Application diagram of PLC modem

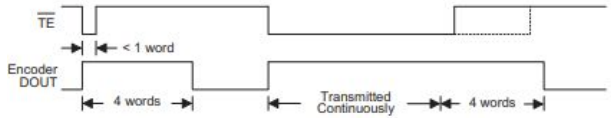
Transfer of information through the PLC modem transmitter side

- In our application the user interfaces with the HT12E IC by selecting the address of the unit he wishes to communicates with using an 8 dip switch and then selecting the data he wants to send on a 4 DIP switch connected to pins AD8~AD11 .
- The HT12E IC provides us with 8 bits for address and 4 bits for data .
- We can connect up to 256 different receiver units .
- We have up to 16 different commands.
- When the TE pin is pulled low the HT12E begins transmission of a total of 13 bits to the transmitter circuit , a start bit , 8 address bits and 4 data bits .



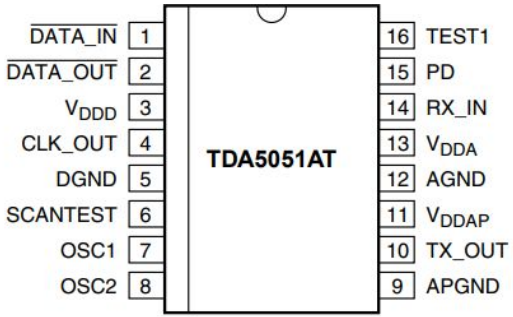


Address/Data bit waveform for the HT12E

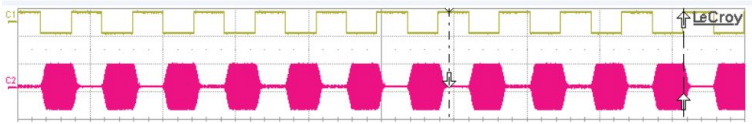


Transmission timing for the HT12E

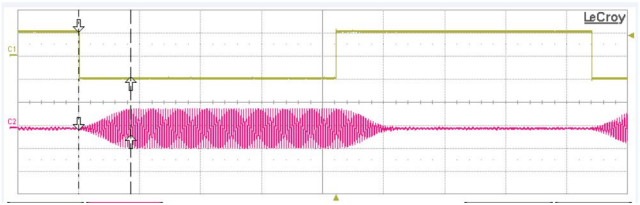
- The TDA5051AT receives the incoming bitstream that is to be transmitted on its DATA_IN pin
- Amplitude shift keying is then performed on the incoming bitstream , the modulated output is then generated on the TX_OUT pin to be coupled with the mains voltage
- The data input (DATA_IN) is active LOW: this means that a burst is generated on the line (pin TX_OUT) when DATA_IN pin is LOW. Pin TX_OUT is in a high-impedance state as long as the device is not transmitting.
- There is about 169.95 us input to output delay

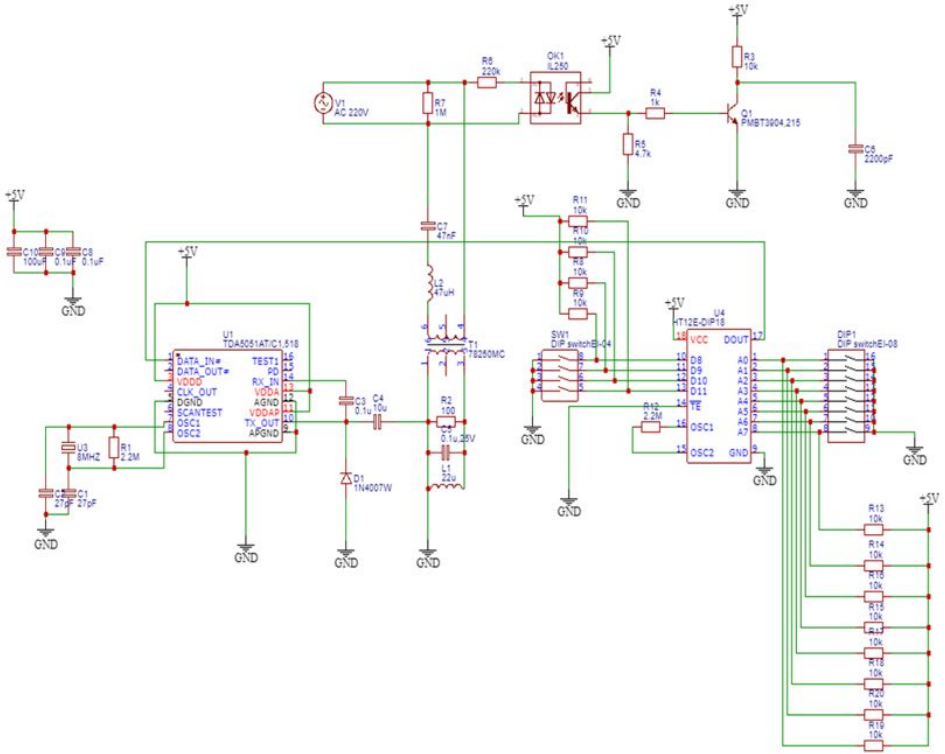


TDA5051AT PINOUT



C1 DATA_IN, C2 TX_OUT

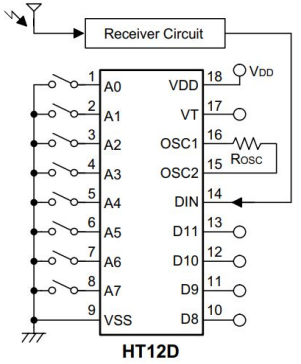




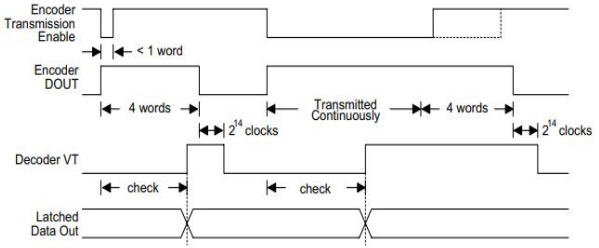
Circuit diagram of the transmitter side

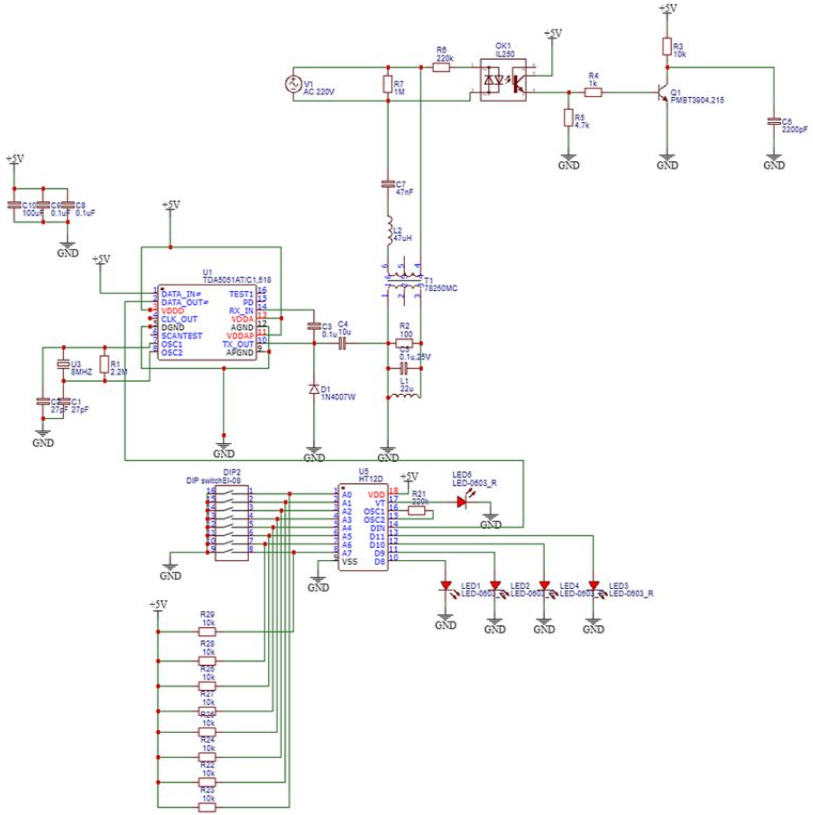
Transfer of information at the receiver side

- The data is received on the RX_IN pin which is coupled to the mains voltage
- The data is then filtered and demodulated on chip
- The demodulated output is generated on the DATA_OUT pin , the demodulated data then needs to be decoded since it was encoded by the HT12E chip
- An HT12D decoder IC is used to decode the received bitstream from the TDA5051AT
- The HT12D first receives the address bits decodes them and compares the received address bits to the local address which is set by an 8 DIP switch
- If the address received matches the local address the HT12D IC decodes the data bitstream and they are then latched to the output pins D8~D11
- The VT (Valid transmission) pin is set HIGH when the data is received correctly



Decoder timing

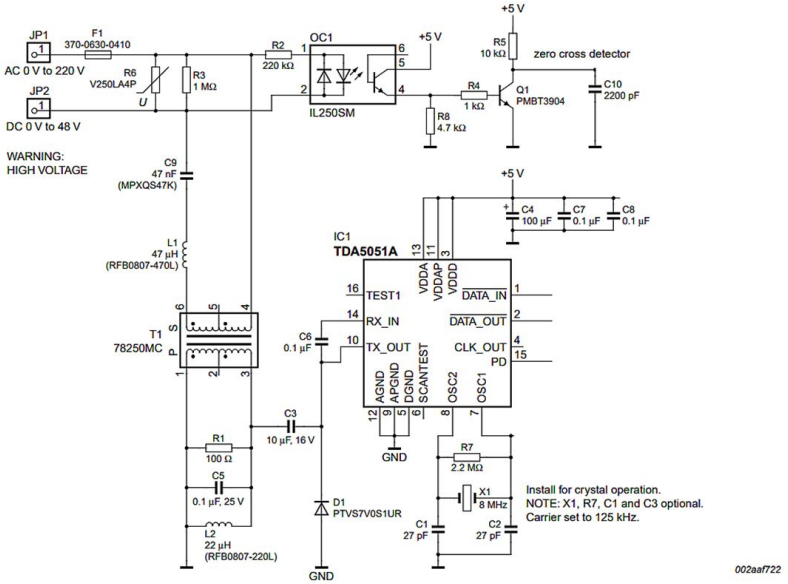




Circuit diagram of the receiver side

Interfacing TDA5051A with the power line

- 78250MC isolation transformer is used in conjunction with an LC network to couple the TX and RX pins of the TDA5051AT to the mains voltage
- The isolation transformer is used to isolate the IC from the AC power source for safety reasons or to reduce transients and harmonics and to suppress electrical noise in the device
- An Optocoupler IL250SM is used in conjunction with a transistor PMBT3904 to generate a zero crossing detection signal that is reserved for future use
- The Optocoupler provides isolation from the mains voltage



Testing of the TDA5051AT circuit

POWER LINE MODEM WITH FEEDBACK

We can reconfigure the circuit design of the power line modem by adding a few extra components to make the power line modem a half duplex communication system instead of a simplex system.

Another pair of encoder/decoder ICs are used with a pair of inverters to generate a feedback signal from the receiver side.

The modifications are made such that only one TDA5051AT is transmitting at a time and the other is listening

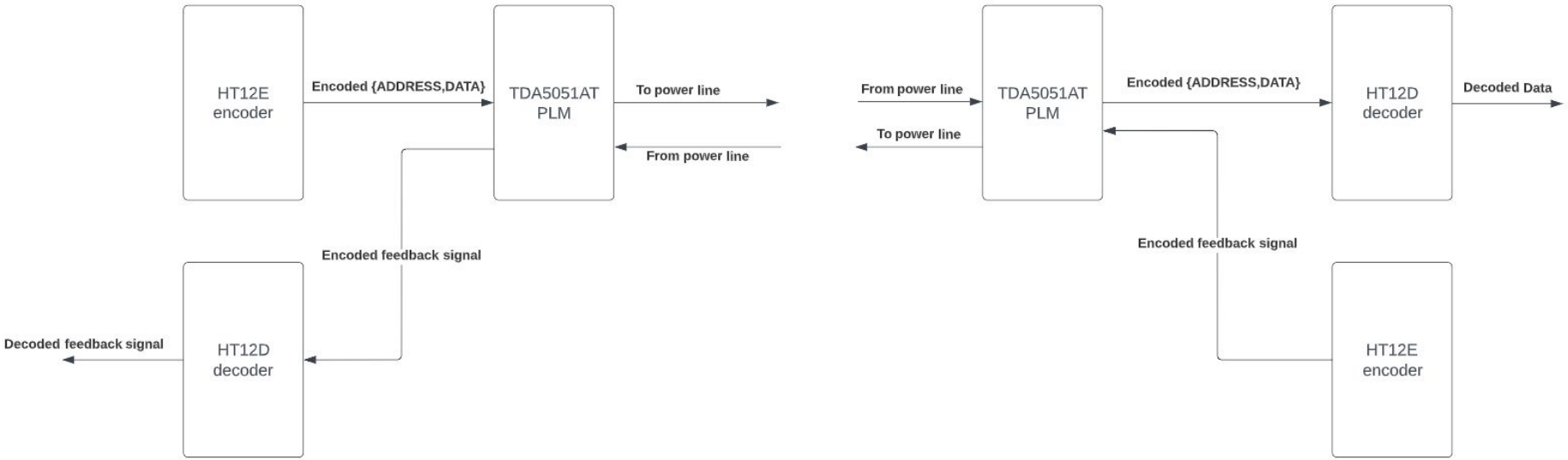
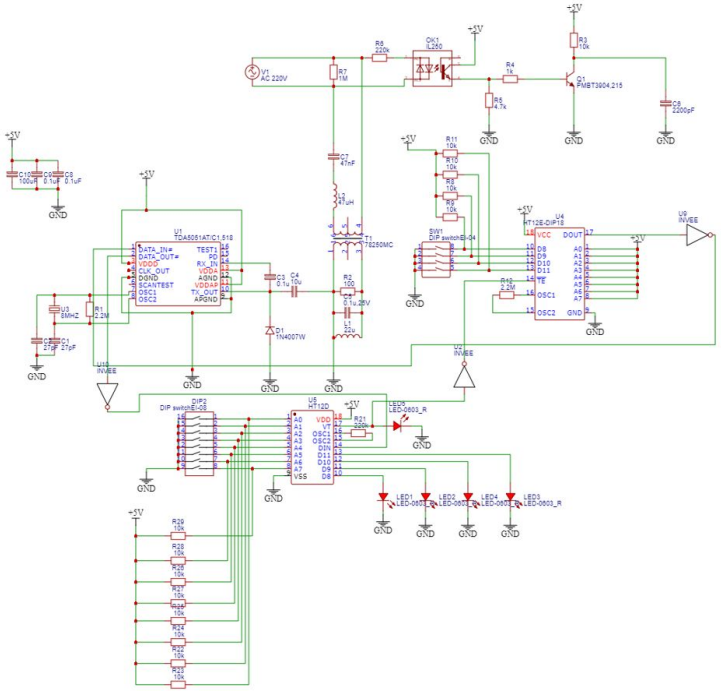


Fig shows basic block diagram of PLC module with feedback

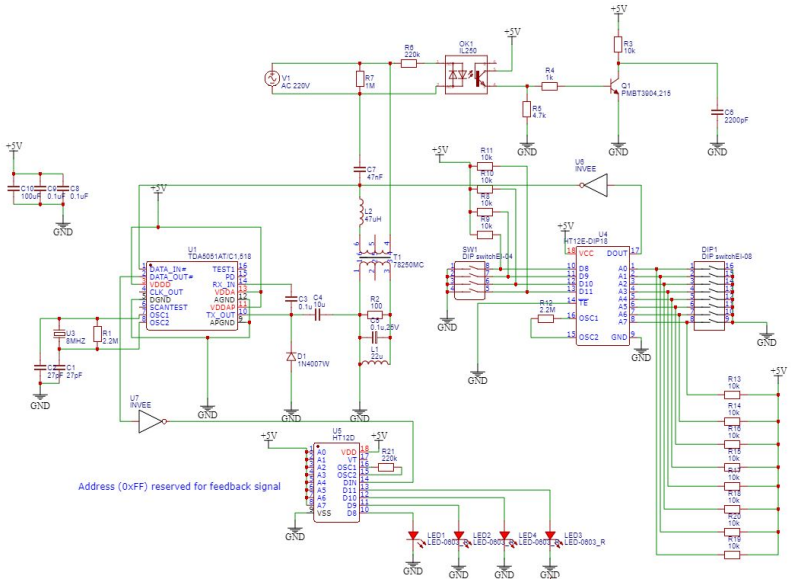
Reconfiguring receiver side to generate feedback signal

- An HT12E encoder IC is installed at the receiver side to generate the feedback signal
- When the transmitter sends a packet the receiver responds with this feedback signal if the packet was received correctly
- After a packet is received at the receiver side the HT12D's VT pin is set high for a short duration
- This short signal can be used to automatically send a confirmation or a feedback signal back to the transmitter side
- Since the HT12E's TE(transmission enable) pin is active low an inverter is used to invert the VT output and feed it into the TE pin of the HT12E
- When the receiver receives data correctly the VT pin goes high in turn causing the HT12E to start transmitting
- The output pin of the HT12E is inverted and then fed into the DATA_IN pin of the TDA5051AT
- Its inverted since that the default level of HT12E's output at standby mode is set to low and in order to disable transmission at the receiver side while the transmitter is sending we have to set the DATA_IN pin high
- The feedback signal could be any arbitrary bits we choose from the 4 data bits
- For our purposes we choose address 0xFF and data 0x0F to represent the feedback signal



Reconfiguring transmitter side to receive feedback signal

- For the transmitter side to receive a feedback signal we have to add another HT12D decoder IC to decode the incoming feedback signal
- We also have to disable transmission while the feedback signal is being sent from the receiver
- To disable transmission an inverter is placed between the DOUT pin of the HT12E and DATA_IN pin of the TDA5051
- By doing so the DATA_IN pin is pulled high effectively disabling transmission and only enabling it when the HT12E begins transmission
- We have already established that after a message is sent from the transmitter the receiver side automatically generates a feedback signal
- This signal is then received at the transmitter side
- But since that it was already inverted we have to invert it again to receive correct encoded feedback signal
- The encoded feedback signal is then fed into an HT12D IC to decode it
- If the feedback signal is received correctly the VT pin goes high and the feedback signal is displayed on LEDs at the 4 output pins of the HT12D



DC POWER LINE COMMUNICATIONS

The popularity of PLC adoption in smart grid applications has led to significant focus on PLC over AC power lines. However, narrowband PLC over DC lines is also gaining ground in home networking, lighting and solar applications as well as in transportation vehicles (electronic controls in airplanes, automobiles and trains). The use of PLC in these applications reduces wiring complexity, weight, and ultimately cost of communications

CONTROLLING 16x2 LCD OVER POWER LINE

16x2 LCD is too traditional and still very much popular in the world of electronics and embedded system

It requires 4 bit data lines plus additional 2 control pins, a total of 6 minimum signal pins and obviously additional 2 mandatory power wires +5v and GND, so a total of 8 wires

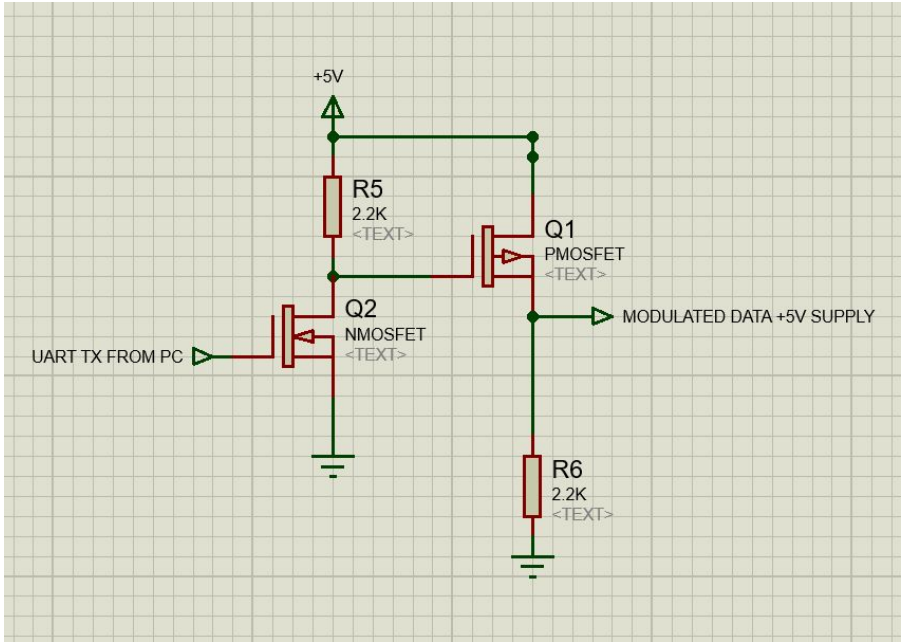
If this display is designed in 2019, for sure it will have only Vcc, GND and a single wire data pin or in worst case the 2 wire i2c or TWI.

Then we thought why even 1 wire for data? Because we can easily multiplex the 1 wire data line with the Vcc line by keeping a diode plus capacitor combination towards the LCD power supply pin.

First we have a modulator that is connected to the TX pin of the UART which is transmitting data from a PC using a USB to UART converter

The modulator modulates the incoming data from the UART and superimposes it on the +5V supply line

The data we are sending from the PC are LCD initialization commands and the data to be displayed

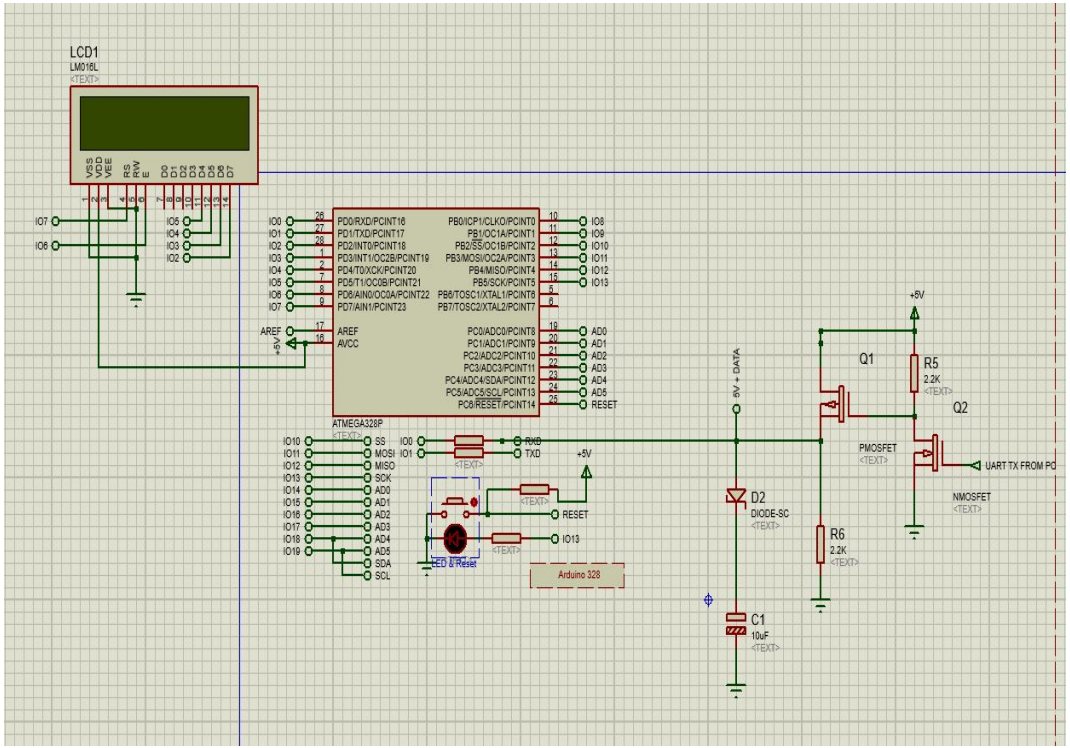


Second we have an arduino mini , its RX pin is connected to the output of the modulator

The arduino receives the incoming data on the +5V and converts the incoming serial data into parallel data to be fed to the LCD

we haven't written any LCD related initialization in the arduino,we just used it for serial to parallel conversion plus backlight LED contrast control. So the entire display initialization could be sent from current-buffered UART port

we are using a USB to UART converter to connect the device to a PC. A python script is doing the LCD initialization and data streaming over the UART



Default level of UART TX is high. So the left mosfet will be ON by default which turns ON the right side P-channel mosfet. This provides 5V power to the output, when uart TX sends any bytes, it starts lowering the TX pin and that will cut the 5V power and the 2.2K output resistor will pull the power rail to zero.

This zero is reflected to the arduino RX pin, but since there is a diode and a capacitor, the capacitor holds enough power to maintain the display circuitry to work when the power input is modulated to zero by the UART.

The role of diode is to prevent reverse discharge of the capacitor and there by allowing the diode front-end voltage to follow the UART TX by not corrupting it.

the RX pin sees the signal as pure incoming UART bytes the arduino receives the data and decodes it and then outputs that data to the LCD

a simple python script from PC side can imitate the LCD command and data along with the EN and RS control

Thank You