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# COMMUNICATION SYSTEMS IN POWER SECTOR

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***Abstract -*** In this paper, the aim is to design 300/600 band modem using FSK modulator to convert digital information to frequency in the range of 2200-3600 Hz which can be used with PLCC to transmit the required data of substation or generating station to load dispatch centre. In Power Sector Digital data can be encoded and transmitted via carrier wave by shifting the carrier's frequency among a predefined set of frequencies- a technique known as Frequency Shift Keying (FSK).

***Keywords-*** Frequency Shift Keying (FSK), Fiber Optic Communication, Modulation, Demodulation, Multiplexing, Phase-locked loop (PLL), Voltage Controlled Oscillator (VCO), Power Line Carrier Communication (PLCC).

## I. Introduction

Communication has become one of the major requirements in the present era of technological world. It is used for the operation and management of high-tension wires and distribution network. It is also used for the coordination of load dispatch centers and boundary meter reading.

There are two types of communication techniques in the power sector.

1. Fiber Optic Communication (FOC)
2. Power Line Carrier Communication

Communication can be defined as the process of exchange of information through means such as words, actions, signs, etc., between two or more individuals.

## II. Modulation Techniques

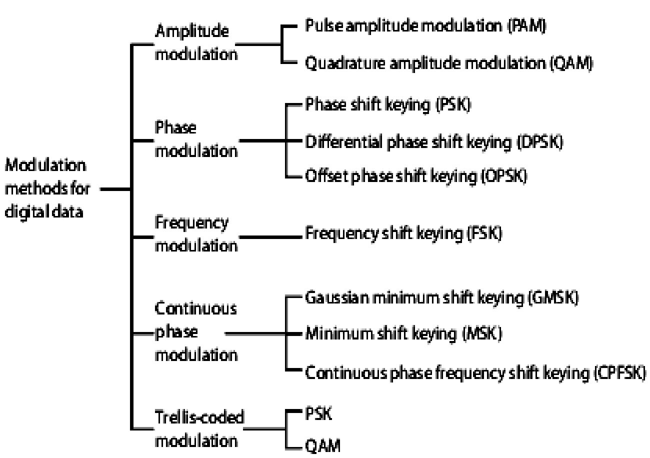


Fig 1: Modulation Methods of Digital Data

### A. Amplitude-Shift Keying

Amplitude-shift keying (ASK) is a form of amplitude modulation that represents digital data as variations in the amplitude of a carrier wave. In an ASK system, the binary symbol 1 is represented by transmitting a fixed-amplitude carrier wave and fixed frequency for a bit duration of T seconds. If the signal value is 1 then the carrier signal will be transmitted; otherwise, a signal value of 0 will be transmitted. [3]

Any digital modulation scheme uses a finite number of distinct signals to represent digital data. ASK uses a finite number of amplitudes, each assigned a unique pattern of binary digits. Usually, each amplitude encodes an equal number of bits. Each pattern of bits forms the symbol that is represented by the particular amplitude. [3] The demodulator, which is designed specifically for the symbol-set used by the modulator, determines the amplitude of the received signal and maps it back to the symbol it represents, thus recovering the original data. Frequency and phase of the carrier are kept constant.

Like AM, an ASK is also linear and sensitive to atmospheric noise, distortions, propagation conditions on different routes. Both ASK modulation and demodulation processes are relatively inexpensive. The ASK technique is also commonly used to transmit digital data over optical fibre. For LED transmitters, binary 1 is represented by a short pulse of light and binary 0 by the absence of light. Laser transmitters normally have a fixed "bias" current that causes the device to emit a low light level. This low level represents binary 0, while a higher-amplitude light wave represents binary 1. The simplest and most common form of ASK operates as a switch, using the presence of a carrier wave to indicate a binary one and its absence to indicate a binary zero. This type of modulation is called on-off keying (OOK), and is used at radio frequencies to transmit Morse code (referred to as continuous wave operation). [3]

## III. Frequency Shift Keying

Frequency-shift keying (FSK) is a frequency modulation scheme in which digital information is

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transmitted through discrete frequency changes of a carrier signal. The technology is used for communication systems such as amateur radio, caller ID and emergency broadcasts. The simplest FSK is binary FSK (BFSK). BFSK uses a pair of discrete frequencies to transmit binary (0s and 1s) information. With this scheme, the "1" is called the mark frequency and the "0" is called the space frequency. [2] [3]

## IV. FSK Modem

The system consists of two modem units (1 and 2) linked through a single line. At rst, the link in the lab will simply be a pair of wires one for the signal, and one for the common ground. The most common example for an actual link between the modems would be through telephone lines.

The actual signal path through the telephone line is much more complicated that the simple pair of wires in the lab, but the modem operating principles are nevertheless the same. Other real-world links may include RF or optical. Each modem has a transmitter and a receiver.

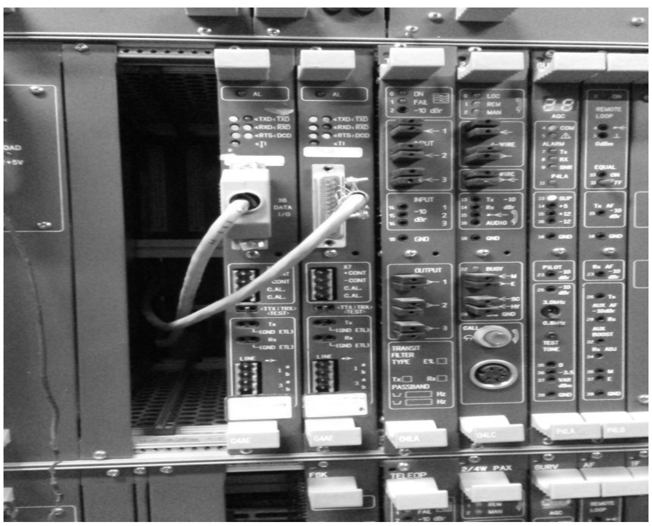

Fig 2: FSK Modem

The transmitter takes serial binary data $T_x$ from a data source (typically from a computer serial port). The data is a sequence of logic 1's and 0's, as shown in Fig. 1. In the lab, for test purposes, we can generate the data from a lab pulse generator. Each bit of data, 1 or 0, lasts for t seconds. [3]

The data transmission speed Br =1=t, is called the baud rate in bits per seconds ($b_{ps}$). If the transmitted signal is periodic, such as it would be if obtained from a simple pulse generator, the maximum fundamental frequency $f_s$ of the signal is obtained for the periodic sequence. [3]

$$(f_s)_{Max} = 1/2(\text{delta }(t)) = B_r/2$$

Fixed levels, $f_H$ and $f_L$. In the modems of Fig. 1, the binary $T_x$ signal determines the frequency of the line signal. Logic 1 corresponds to $f_H$, and logic 0 corresponds to $f_L$ . The FSK signal on the line is a waveform with frequency equal to $f_H$ or $f_L$ depending on the binary input $T_x$.

### A. FSK Modulation

The purpose of the frequency modulation is two-fold:rst, it shifts the spectrum of the transmitted signal to a range within the pass band of the link between the modems. For a standard telephone line, the pass band is approximately between 300Hz and 4kHz, and so $f_H$ and $f_L$ are selected to be in this range. [2]

The second purpose of the frequency modulation is to allow data to be transmitted in both directions through the same line at the same time. This is accomplished by assigning one pair of frequencies ($f_H$A, $f_L$A) for the data transmitted from modem 1 to modem 2, and another pair ($f_{HB}$, $f_{LB}$) for the data transmitted in the opposite direction, from modem 2 to modem 1. Because of this assignment, each of the two signals uses about one half of the full bandwidth of the line, and the two signals can be transmitted, separated and demodulated independently. In communication theory, this technique is known as frequency division multiplexing.

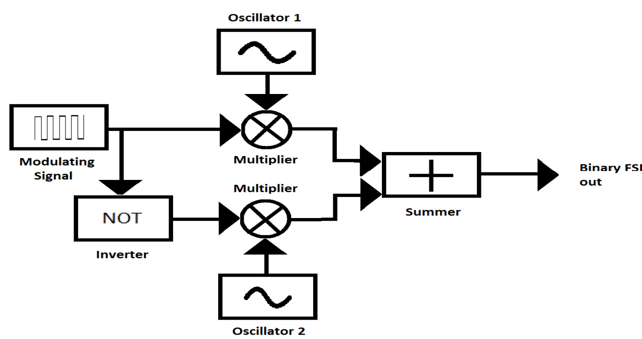


Fig 3: Block diagram of FSK Modulation

The simultaneous data transmission in both directions over the same line is called full duplex. We can identify two communication channels: channel A, which corresponds to data transmission from modem 1 to modem 2, and channel B for data transmission in the opposite direction.

The receiver in the modem takes the signal from the line, extracts the portion that corresponds to the signal transmitted from the opposite side, and removes the portion that corresponds to the signal of the transmitter on the same side. Then, the receiver demodulates the incoming signal, generating logic 1 level when the incoming signal frequency is $f_H$, and logic 0 level when the incoming signal frequency is $f_L$.The received output is a binary sequence Rx, which is (if there are no errors) exactly the same as the original sequence Tx. As shown in

Fig. 1, each of the two modems (1 and 2) has a transmitter and a receiver. Ideally, if there are no errors, the Rx2 sequence is the same as the Tx1 sequence and Rx1 is the same as Tx2.

### B. FSK Demodulation

A phase-locked loop or phase lock loop abbreviated as PLL is a control system that generates an output signal whose phase is related to the phase of an input signal. It is easy to initially visualize as an electronic circuit consisting of a variable frequency oscillator and a phase detector. The oscillator generates a periodic signal, and the phase detector compares the phase of that signal with the phase of the input periodic signal, adjusting the oscillator to keep the phases matched. Bringing the output signal back toward the input signal for comparison is called a feedback loop since the output is "fed back" toward the input forming a loop.

Keeping the input and output phase in lock step also implies keeping the input and output frequencies the same. Consequently, in addition to synchronizing signals, a phase-locked loop can track an input frequency, or it can generate a frequency that is a multiple of the input frequency. These properties are used for computer clock synchronization, demodulation, and frequency synthesis.

Phase-locked loops are widely employed in radio, telecommunications, computers and other electronic applications. They can be used to demodulate a signal, recover a signal from a noisy communication channel, generate a stable frequency at multiples of an input frequency (frequency synthesis), or distribute precisely timed clock pulses in digital logic circuits such as microprocessors. Since a single integrated circuit can provide a complete phase-locked-loop building block, the technique is widely used in modern electronic devices, with output frequencies from a fraction of a hertz up to many gigahertz

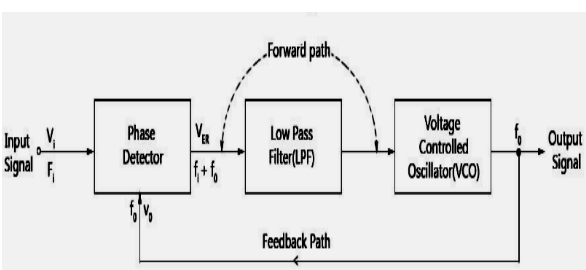


Fig 4:PLL Block Diagram

## V. Implementation (Analytical Calculation)

### A. FSK Modulation Using 555 Timer

The 555 in astable operation adding a second resistor, RB, to the circuit and connecting the trigger input to the threshold input causes the timer to self-trigger and run as a multi-vibrator. The capacitor C charges through RA and RB and then discharges through RB only. Therefore, the duty cycle is controlled by the values of RA and RB. [1]

This a stable connection results in capacitor C charging and discharging between the threshold-voltage level (≈ 0.67 × VCC) and the trigger-voltage level (≈ 0.33 × VCC). As in the mono-stable circuit, charge and discharge times (and, therefore, the frequency and duty cycle) are independent of the supply voltage.[3][8] The output high-level duration $t_H$ and low-level duration $t_L$ can be calculated as follows:

$$t_H=0.693(R_A+R_B)C$$

$$t_L=0.693(R_B)C$$

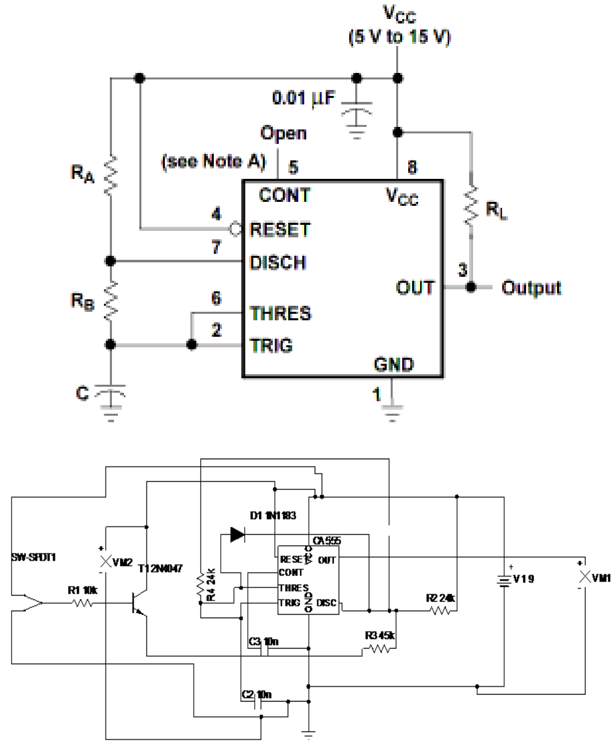


Fig 5: FSK Modulator Block Diagram and Schematic using IC555

Other useful relationships are shown below:

$$\text{period} = t_H+t_L= 0.693(\ 0.693(R_A+2R_B)C\ )$$

$$\text{frequency} \sim 1.44/(R_A+2R_B)C$$

$$\text{Output driver duty cycle} = t_L/t_H + t_L = R_B/R_A + 2R_B$$

$$\text{Low-to-high ratio} = t_L/t_H = R_B/R_A + R_B$$

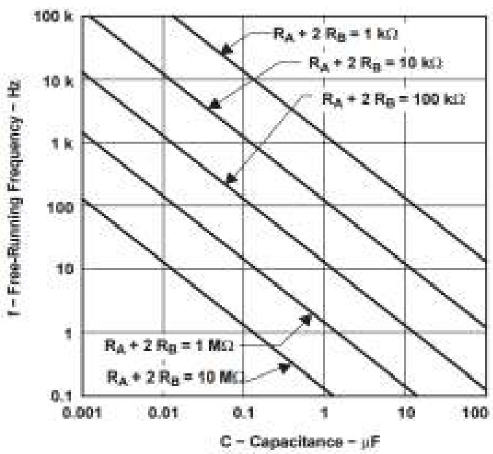


Fig 6: Data Sheet To find values of R and C

## B. FSK Demodulation Using 565 PLL

The LM565 and LM565C are general purpose phase locked loops containing a stable, highly linear voltage modulation, and a double balanced phase detector with good carrier suppression.

The VCO frequency is set with an external resistor and capacitor, and a capacitor. The characteristics of the closed loop pull in range may be adjusted over a wide range with an external resistor and capacitor. The loop maybe broken between the VCO and the phase detector for insertion of a digital frequency divider to obtain frequency multiplication. [5][6]

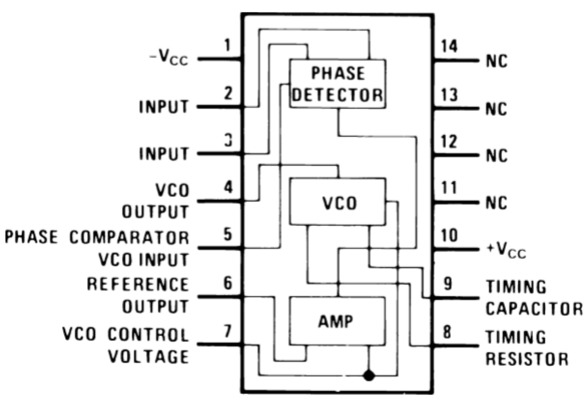


Fig 7:565 IC Internal Diagram [1]

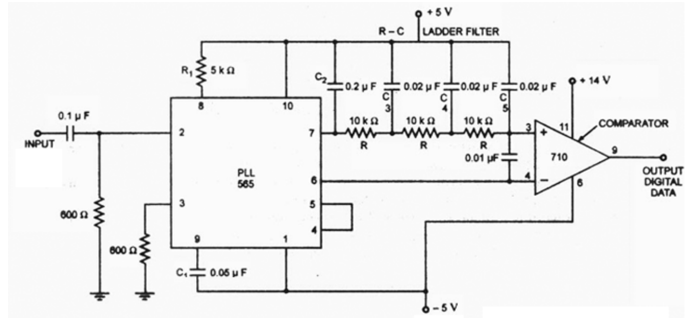


Fig 8: FSK Demodulator Schematic using IC565

## VI. Results

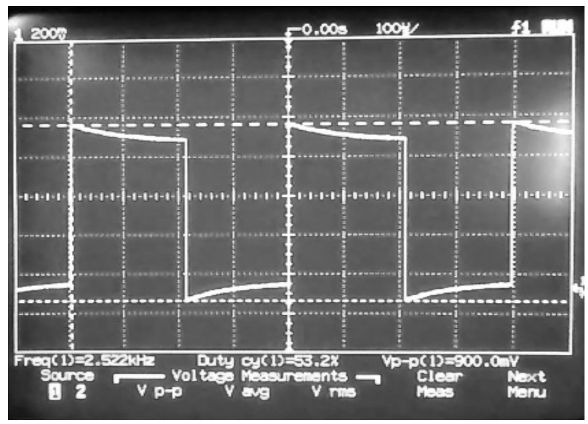


Fig.9 : Modulator Output for Input 0

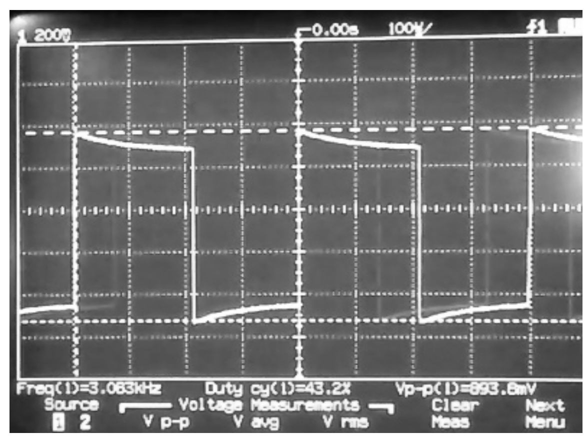


Fig.10: Modulator Output for Input 1

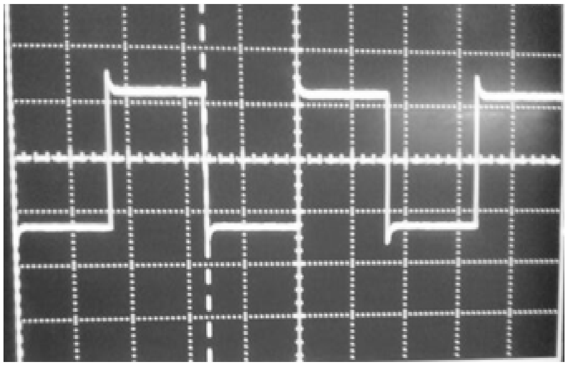

Fig. 11 : Demodulator Output

## VII. Conclusion

The FSK modulator and demodulator have been designed for generation of frequency and is used with PLCC to transmit the required data of substation or generating station to load dispatch centre. This can be used instead of fiber optic communication in rural areas because it is more cost effective and can be used in the existing infrastructure. The data sent is highly secured because it is sent through the power lines.

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