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A Novel Method for Binary Phase Shift Keying (BPSK) Transmitter

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***Abstract*—Modern mobile communication systems use digital modulation techniques. Advancements in very large-scale integration (VLSI) and digital signal processing (DSP) technology have made digital modulation more cost effective than analog transmission systems. In this paper, an effort has been made to construct a BPSK transmitter using available Integrated circuits (ICs) and other active and passive circuit components/devices. The output voltage of various sections of the constructed system has been observed using dual trace Oscilloscope.**

Keywords—Digital Modulation, BPSK, DSP, VLSI, IC, Dual-in-line, Multiplexing, AWGN channel, Q-function, Oscilloscope.

I. INTRODUCTION

Digital modulation offers many advantages over analog modulation. Some advantages include greater noise immunity and robustness to channel impairments, easier multiplexing of various forms of information (e.g., voice, data, and video), and greater security **[1]**. It is desirable that the digital modulation scheme to be implemented would provide low bit error rates at low received signal-to-noise ratios **[2]**, perform well in multipath and fading conditions and occupy a minimum bandwidth **[3]**. Existing modulation scheme do not simultaneously satisfies all of these requirements. Some modulation schemes are better in terms of the bit error rates performance **[4]**, while others are better in terms of bandwidth efficiency **[5]**. The performance of a modulation scheme is often measured in terms of its power efficiency and bandwidth efficiency **[6]**. Power efficiency describes the ability of a modulation technique to preserve the fidelity of the digital message at low power levels **[7]**. In a digital communication system, in order to increase noise immunity, it is necessary to increase signal power **[8]**. However, the amount by which the signal power should be increased to obtain a certain level of fidelity (i.e. an acceptable bit error probability) depends on the particular type of modulation employed.

II. BPSK MODULATION

In binary phase shift keying (BPSK), the phase of a constant amplitude carrier signal **[9]** is switched between two values according to the two possible signals m_1 and m_2 corresponding to the binary 0 and 1 respectively. Generally, the two phases are separated by 180^0. If the sinusoidal carrier has an amplitude A_c and according to **[10],** energy per bit $E_b = \frac{1}{2} A_c^2 T_b$, then the transmitted BPSK signal is defined either as **[11]**

$$S_{BPSK(t)} = \sqrt{\frac{2E_b}{T_b}} \cos[2\Pi f_c t + \theta_c] \qquad (1.1)$$

For $0 \le t \le T_b$ (binary 1)

or

$$S_{BPSK(t)} = \sqrt{\frac{2E_b}{T_b}} \cos\left[2\Pi f_c t + \pi + \theta_c\right] = -\sqrt{\frac{2E_b}{T_b}} \cos\left[2\Pi f_c t + \theta_c\right] \qquad (1.2)$$

For $0 \le t \le T_b$ (binary0)

It is often convenient to generalize m_1 and m_2 as a binary data signal m(t) which takes on one of the possible two pulse shapes. Then the transmitted signal can be expressed as **[12]**

$$S_{BPSK(t)} = m(t)\sqrt{\frac{2E_b}{T_b}} \cos\left[2\Pi f_c t + \theta_c\right] \qquad (1.3)$$

The BPSK signal is equivalent to a double sideband suppressed carrier amplitude modulated waveform **[13]** where, $\cos(2\Pi f_c t)$ is applied as the carrier and the data signal m(t) is applied as the modulating waveform. The probability of bit error for much modulation schemes in an AWGN channel **[14]** is found using Q-function **[15]** of the distance between

the signal points. From the constellation diagram of a BPSK signal shown in **Fig. 1.**

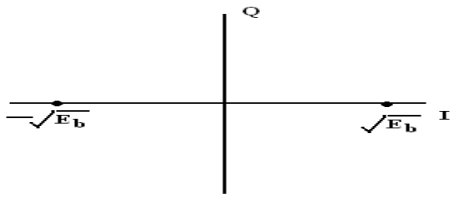


Fig. 1: Constellation diagram of BPSK signal

it can be seen that the distance between adjacent points in the constellation is $2\sqrt{E_b}$. The Probability of bit error is obtained as **[16]**

$$P_{e,BPSK} = Q\left(\sqrt{\frac{2E_b}{N_0}}\right) \quad (1.4)$$

III. DISCRIPTION OF THE USED ICS

This section has been provided the information about pin configuration and characteristic features of various ICs which used in this constructed BPSK transmitter circuit.

A. *741 IC*

741 IC is an 8-pin dual-in-line package **[17]** and according to **[18]** pin descriptions are given bellow:
Pin 1: Offset null.
Pin 2: Inverting input terminal.
Pin 3: Non-inverting input terminal.
Pin 4: –VCC (negative voltage supply).
Pin 5: Offset null.
Pin 6: Output voltage.
Pin 7: +VCC (positive voltage supply).
Pin 8: No Connection.

B. *74LS04 IC*

According to **[19],** Pin Description
Pin 1 & 2: Input/output of 1st inverter.
Pin 3 & 4: Input/output of 2nd inverter.
Pin 5 & 6: Input/output of 3rd inverter.
Pin 7: Ground (0V)
Pin 8 & 9: Output/input of 4th inverter.
Pin 10 & 11: Output/input of 5th inverter.
Pin 12 & 13: Output/input of 6th inverter.
Pin 14: Supply voltage; 5V (4.75-5.25V).

C. *CD4016 IC*

According to **[20],** Features of **CD 4016 IC**

- Quad Bilateral Switch for the Transmission or Multiplexing or Analog or Digital Signals.
- High Frequency Response to 40MHz.
- Wide Operating Voltage Range.
- Operating Temperature to 85oC.
- Low Power TTL.

D. *ADC 0804IC*

According to **[21],** features of ADC 0804 IC

- Bus Compatible - No Interfacing
- Logic Required
- Conversion Time . . . . . <100µs
- Easy Interface to Most Microprocessors
- Will Operate in a “Stand Alone” Mode
- Differential Analog Voltage Inputs
- Works with Band gap Voltage References
- TTL Compatible Inputs and Outputs
- On-Chip Clock Generator
- Analog Voltage Input Range
- (Single + 5V Supply) . . . . . 0V to 5V
- No Zero-Adjust Required.

E. *Data Selector (74LS151)*

According to **[22]**, features of 74LS151 IC

- Schottky Process for High Speed
- Multifunction Capability
- On-Chip Select Logic Decoding
- Fully Buffered Complementary Outputs
- Input Clamp Diodes Limit High Speed Termination Effects

IV. CIRCUIT DESCRIPTION

The constructed project consists of various sections. A brief description is given below

A. *Dual Power Supply*

The fig. 2 shows a schematic of a 5V dual power supply using 7805 and 7905 voltage regulator ICs. The LM7805 is a positive voltage regulator IC while the LM7905 is a negative voltage regulator IC. Both the ICs are packed with many built in features like over heat protection, short circuit protection etc. The circuit is using a 230V AC OR 110V AC to 9V-0-9V step down center tapped transformer to step down the mains voltages. Four 1N4001 diodes are used for rectification of the AC voltage to DC. Two 2200 μF / 25V electrolytic capacitor and two 0.01 μF is used for the filter the voltage coming from the diodes and other capacitors are used for decoupling. The output of this dual power supply circuit is up to 1.5A. Therefore these types of power supply can be used for any project, which require current under 1.5A.

B. *Colpitt`s Oscillator*

Colpitt`s oscillator is a sinusoidal oscillator used to produce sustained well shaped sine wave oscillations. It is used for different applications such as local oscillator for synchronous receivers, musical instruments, study purposes etc.

The Colpitt’s circuit, like other LC oscillators, consists of a gain device, such as a transistor or vacuum tube, with its output connected to its input in a feedback loop containing a parallel LC circuit (tuned circuit) which functions as a band pass filter to set the

frequency of oscillation. The Circuit diagram is shown in fig. 3.

In Colpitt's oscillator, the feedback signal is taken from an "inductive" voltage divider consisting of two coils in series (or a tapped coil. L and the series combination of C1 and C2 form the parallel resonant tank circuit which determines the frequency of the oscillator. The frequency of oscillation is approximately the resonant frequency of the LC circuit) which is the series combination of the two capacitors in parallel with the inductor.

Frequency of oscillation:

$$f_0 = \frac{1}{2\pi\sqrt{L(\frac{C_1 C_2}{C_1 + C_2})}} \qquad (1.5)$$

For f_o = 1.361 MHz,

Where, C1=0.001 μF , C2=0.01 μF and L=15 μH .

C. *Binary Phase shift keying Transmitter*

An Op amp inverting amplifier with gain 1 is used to invert the phase of the input sine wave. Sine wave can be obtained from a function generator or by using a RC phase shift oscillator. Two switches inside the quad analog switch CD 4016 are used in the circuit. When the enable input of one gate is high, the input will appear at the output. When the binary data is 1, sine wave is switched to output because the sine wave is connected to 1st switch and the binary data is applied to enable pin (13th pin) of 1st switch. When binary data is 0, the 1st switch is disabled and 2nd switch is enabled using NOT gate arrangement.
Thus we get an inverted sine at the output. The output pins of both first and second switches are shorted and the output is taken from it.

D. *Voice Signal Interfacing*

Basically voice signal is analog in nature. An Analog-to-Digital converter has been used for analog voice signal to digital conversion. An ideal A/D converter takes an input analog voltage and converts it to a perfectly linear digital representation of the analog signal. In this project work, an 8-bit A/D converter has been used. The binary representation in 8-bit binary number takes any one of the 2^8 or 256 different analog values. If the voltage ranges are assigned as 0 and 5 volts, then

0 VOLTS	0000 0000
5 VOLTS	1111 1111

Circuit arrangement of Analog-To-Digital Converter is shown in fig. 4.

V. SYSTEM DESCRIPTION

In binary phase shift keying (BPSK), the phase of a carrier is changed according to the digital pulses signal. BPSK modulator is a phase modulator. Here the transmitted signal is a sinusoid of fixed amplitude. It has one fixed phase when the data is at one level and when the data is at the other level, phase is shifted by 180 degree.

Here is the block diagram and practical circuit of BPSK shown in fig. 5 and fig.6 respectively, it is built around CD4016 and 741 Op amps. Op amp inverting amplifier with gain 1 is used to invert the phase of the input sine wave. Sine wave can be obtained from a function generator or using a colpitt's oscillator. Two switches inside the quad analog switch CD 4016 are used in the circuit. When the binary input of one gate is at high, then the input will appear at the output.

This binary input obtains from voice signal which is first fed to an A/D Converter. Output of A/D converter is then fed to a data selector which gives binary input according to voice signal.

When the binary data is 1, sine wave is switched to output because the sine wave is connected to 1st switch and the binary data is applied to enable pin (13th pin) of 1st switch. When binary data is 0, the 1st switch is disabled and 2nd switch is enabled using NOT gate arrangement.

Thus we get inverted sine at the output. The output pins of both first and second switches are shorted and the output is taken from it.

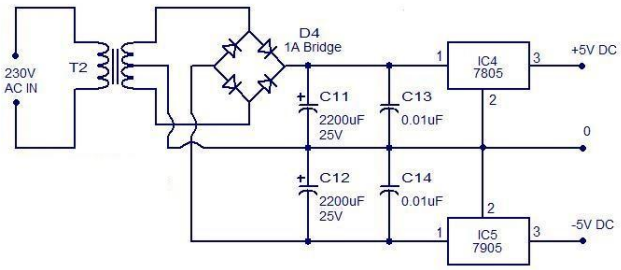


Fig.2 Dual power supply.

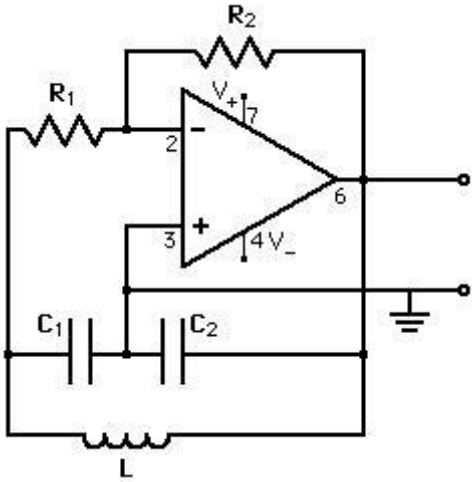


Fig. 3 Colpitt's oscillator.

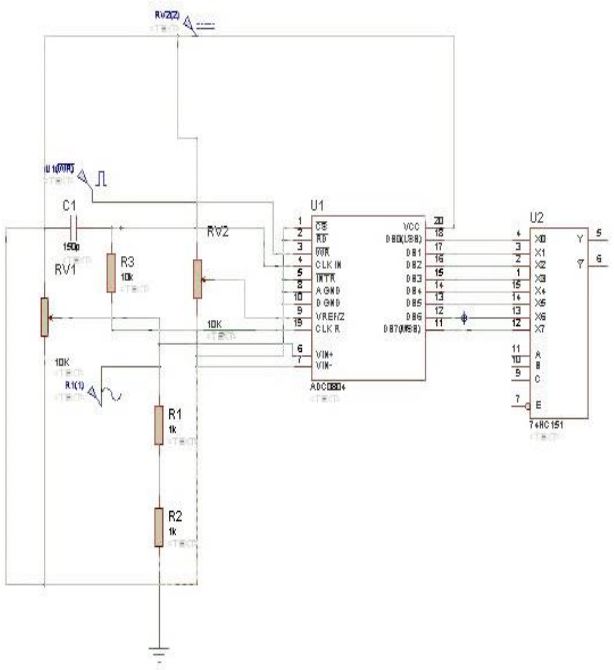


Fig. 4 Voice Signal Interfacing

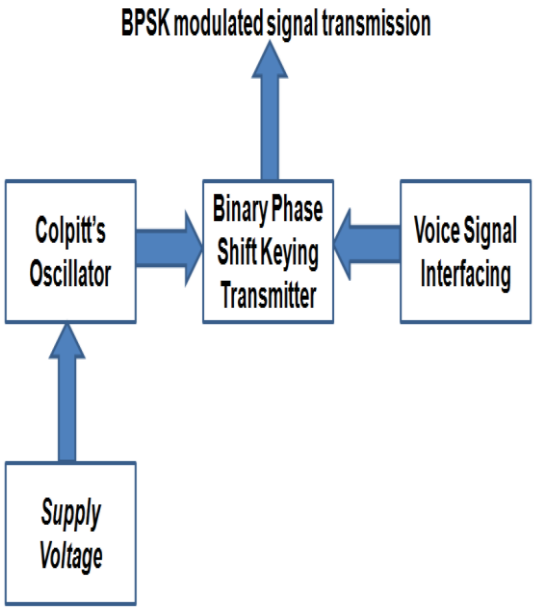


Fig.5 Block diagram of BPSK transmitter.

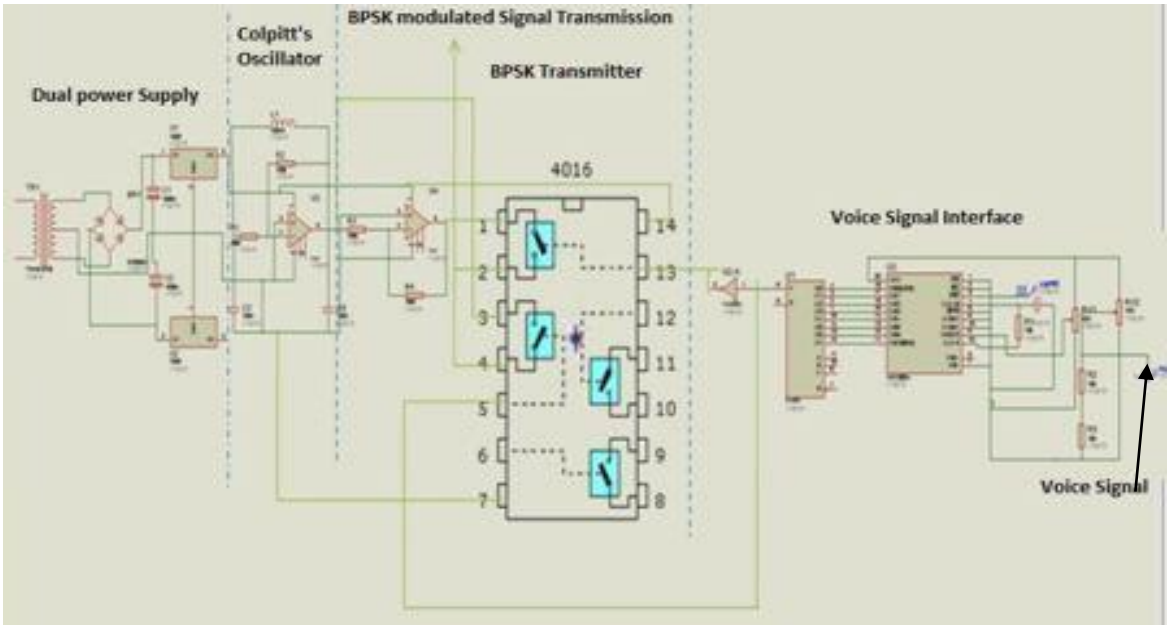
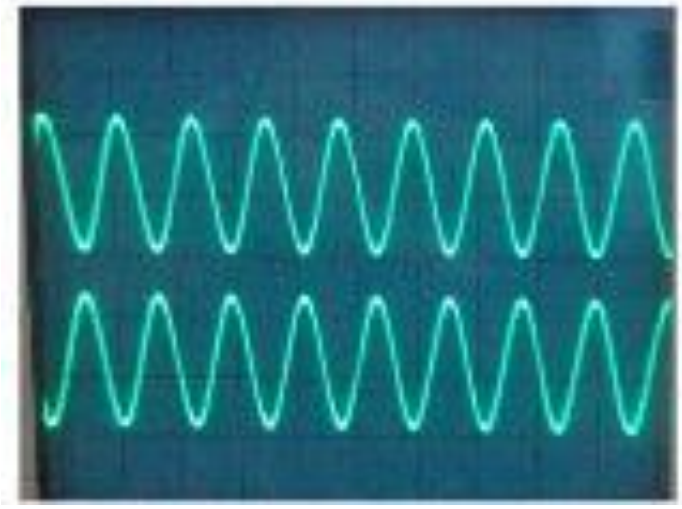


Fig. 6 Arrangement of Binary Phase Shift Keying (BPSK) Transmitter Using Voice signal interfacing.

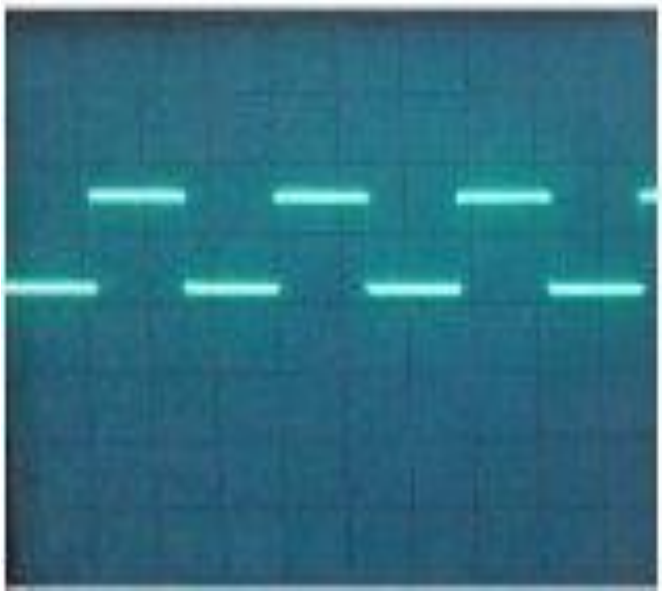
VI. RESULT AND DISCUSSION

In my implemented system, various waveforms (see fig.7) of its different sections visualized in dual trace oscilloscope were captured by digital camera. In spite of required better circuit components, the system was found to have produced BPSK digitally modulated signal.

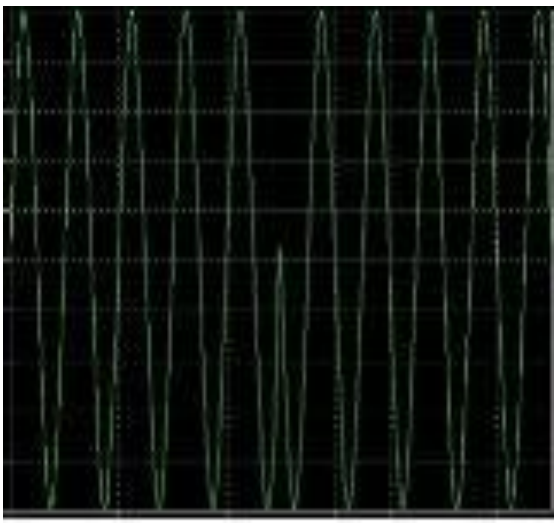


(a) Output of power supply and Colpitt's oscillator.

(b) Input signal of A/D converter which is output of microphone.



(c) Output signal of Data Selector (74LS151).



(d) BPSK modulated signal.

Fig. 6 Different section's waveform of the implemented system.

VII. APPLICATION

In evaluating the performance of the simplified circuit for a BPSK transmitter, it is noticeable that because of its simplicity BPSK is appropriate for low-cost digital transmitters, and is used in RFID standards such as ISO/IEC 14443 which has been adopted for biometric passports, credit cards such as American Express's Express Pay, and many other applications.

VIII. CONCLUSION

My hypothesis was that reduced cost for digital modulation transmitters that are very useful for our daily life. My results do support my hypothesis.

In this paper, a novel method for Binary Phase Shift keying (BPSK) Transmitter has been developed using voice signal interface. The performance of the implemented system has been evaluated using different voice frequency signal.

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