Experiment 9

Objective

To study the various carrier modulation and demodulation techniques:

A. ASK
B. FSK
C. PSK

Theory

CARRIER MODULATION SCHEMES:

Digital Communication is the technique by which all the information is represented in terms of binary digits, i.e., `ones' and `zeros'. These digits are represented by discrete voltage levels and the clock frequency of a digital communication scheme is generally low. For long distance transmission, the data is made to modulate a continuous wave (sine wave) carrier. These techniques are called Carrier Modulation Techniques. The various types of Carrier Modulation Techniques normally adopted in practice fall under three broad categories.

a) Amplitude Shift Keying (ASK)
b) Frequency Shift Keying (FSK)
c) Phase Shift Keying (PSK)

Equipments

DCS kit
Connecting Chords
Power supply
20 MHz Dual Trace Oscilloscope
Power connection cables

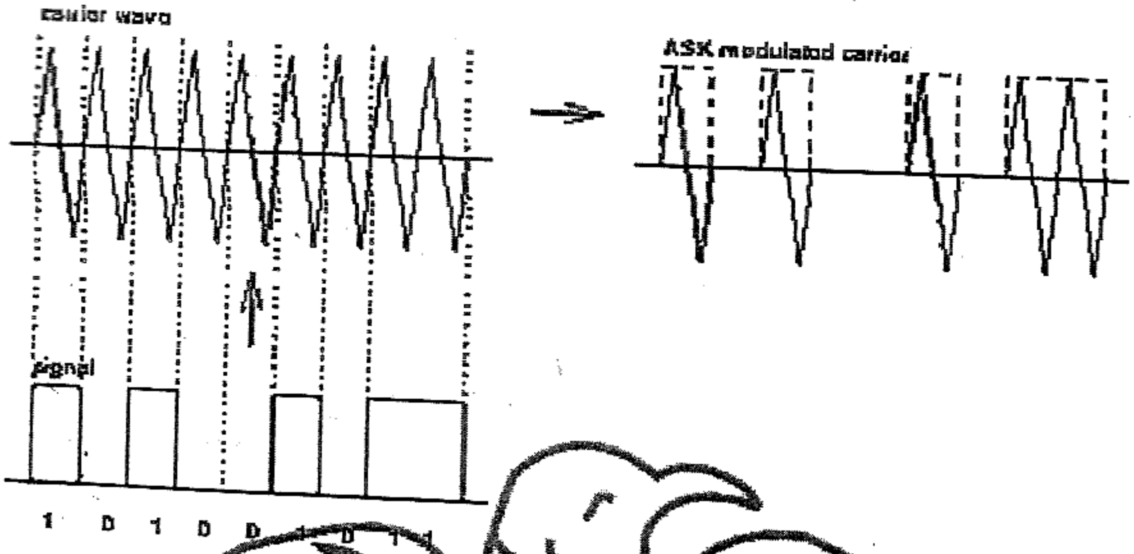


FIGURE: AMPLITUDE SHIFT KEYING

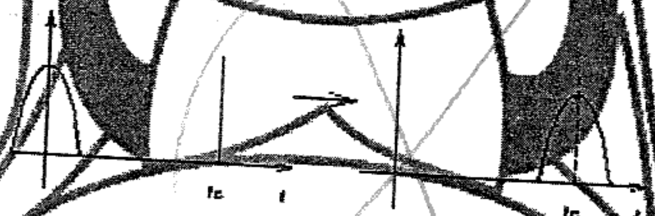


Figure: Amplitude shift keying -- frequency domain

9A. ASK MODULATION AND DEMODULATION

Theory

For all types of Carrier Modulation, the Carrier frequency should be at least 2 times the base band of the modulating signal.

Assuming that the modulated carrier is a sine wave represented by the following equation,

C (t)	=	A (t) cos wt
Where C (t)	=	Carrier sine wave.
A (t)	=	Time varying amplitude.
wt	=	Time varying angle.

Now in amplitude shift keying, the carrier is being transmitted only when the modulating data is `one'. When the data is `zero' the carrier is rejected from transmission. Thus the resulting modulated output of this type of modulation can be represented as follows:

M (t)	=	f (t) C (t)	
Where M (t)	=	Modulated Carrier	
f(t)	=	Time varying modulating data which is either `one' or `zero'	
Now M (t)	=	A (t) cos wt	when the modulating data is one.
		0	when the modulating data is zero.

An Envelope detector is used to recover the data from the modulated carrier.

ASK describes the technique in which the carrier wave fc(t) is multiplied by the digital signal f(t). Mathematically, the modulated carrier signal is given by the equation,

$$s(t) = f(t)\sin(2\pi f_c t + \phi) \qquad (21)$$

It is a special case of **amplitude modulation (AM)**. Amplitude modulation has the property of translating the spectrum of the modulation f(t) to the carrier frequency. The bandwidth of the signal remains unchanged.

The fact that AM simply shifts the signal spectrum is often used to convert the carrier frequency to a more suitable value without altering the modulation. This process is known variously as **mixing, up-conversion** or **down-conversion.** Some form of conversion will always be present when the channel carrier occupies a frequency range outside the modulation frequency range.

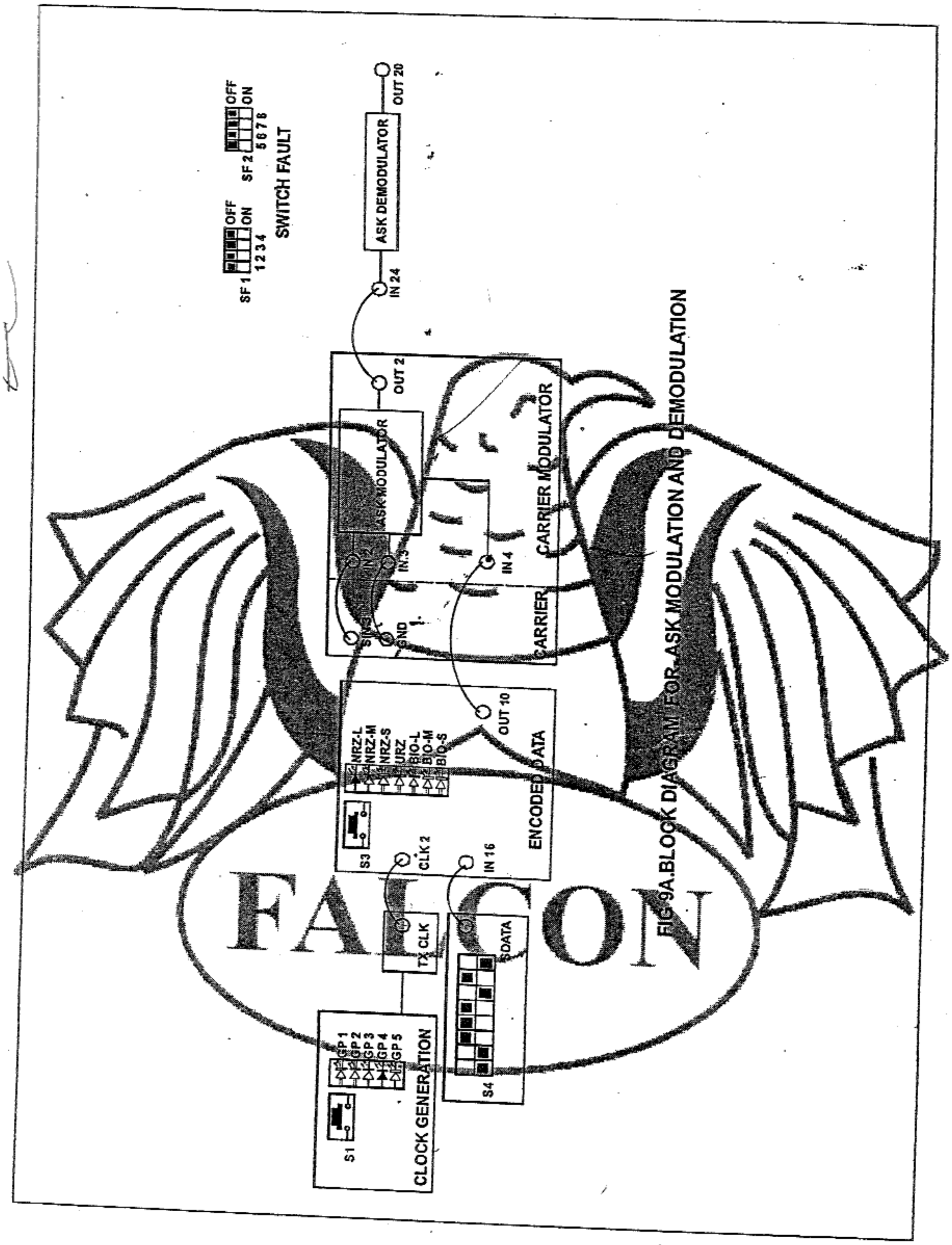


FIG 9A.BLOCK DIAGRAM FOR ASK MODULATION AND DEMODULATION

Procedure

1. Ensure that the group 4 (**GP4**) clock is selected in the Clock Generation section. Selection is done with the help of switch **S1**. Observe the corresponding LED indication.
2. Observe the transmitter clock of frequency **250KHz** at **TXCLK** post.
3. Set the data pattern-using switch **S4** as per the given block diagram.
4. Observe the 8-bit data pattern at **S DATA** post.
5. Observe the carrier sine wave of frequency **1MHz** at **SIN3** post in the carrier section.
6. Connect **SIN3** post to the **IN2** post and **IN3** post to the Ground in carrier modulation section
7. Connect **SDATA** to **IN16** post and **TXCLK** to **CLK2** post of the Encoded Data section.
8. Select **NRZ-L** data with the help of the switch **S3** and observe the corresponding LED indication in the Encoded Data section.
9. Connect **OUT10** post of the Encoded Data section to **IN4** post as a control input for the carrier modulator section.
10. Observe the ASK modulated signal at the **OUT2** post of the Carrier modulator section.
11. For the demodulation of the ASK modulated data, connect the **OUT2** post of the carrier modulator to the **IN24** post of the ASK demodulator section.
12. Observe the ASK demodulated data at **OUT20** post of the ASK demodulator section.
13. Verify the recovered data with the S DATA.

Observations

1. Input **NRZ-L** Data at **IN 4**
2. Carrier frequency **SIN 3**
3. ASK modulated signal at **OUT 2**
4. ASK Demodulated signal at **OUT 20**

...clusion

It has been observed that there is a very small time lag between the modulating data and the recovered data.

9B. FSK MODULATION AND DEMODULATION

Theory

In this type of modulation, the modulated output shifts between two frequencies for all the 'one' to 'zero' transitions.

Let the carrier frequencies be represented by w1 and w2. Thus, we have,

M (t)	=	A (t) Cos w1t if data is 'One'
		A (t) Cos w2t if data is 'Zero'
Where A (t)	=	Time varying amplitude of the sine wave
M (t)	=	Modulated carrier

FSK Demodulator employs PLL logic for the recovery of data.

FSK describes the modulation of a carrier (or two carriers) by using a different frequency for 1 or 0. The resultant modulated signal may be regarded as the sum of two amplitude modulated signals of different carrier frequency (Figures _ and _).

$$s(t) = f_1(t)\sin(2\pi f_{c1}t + \phi) + f_2(t)\sin(2\pi f_{c2}t + \phi) \qquad (22)$$

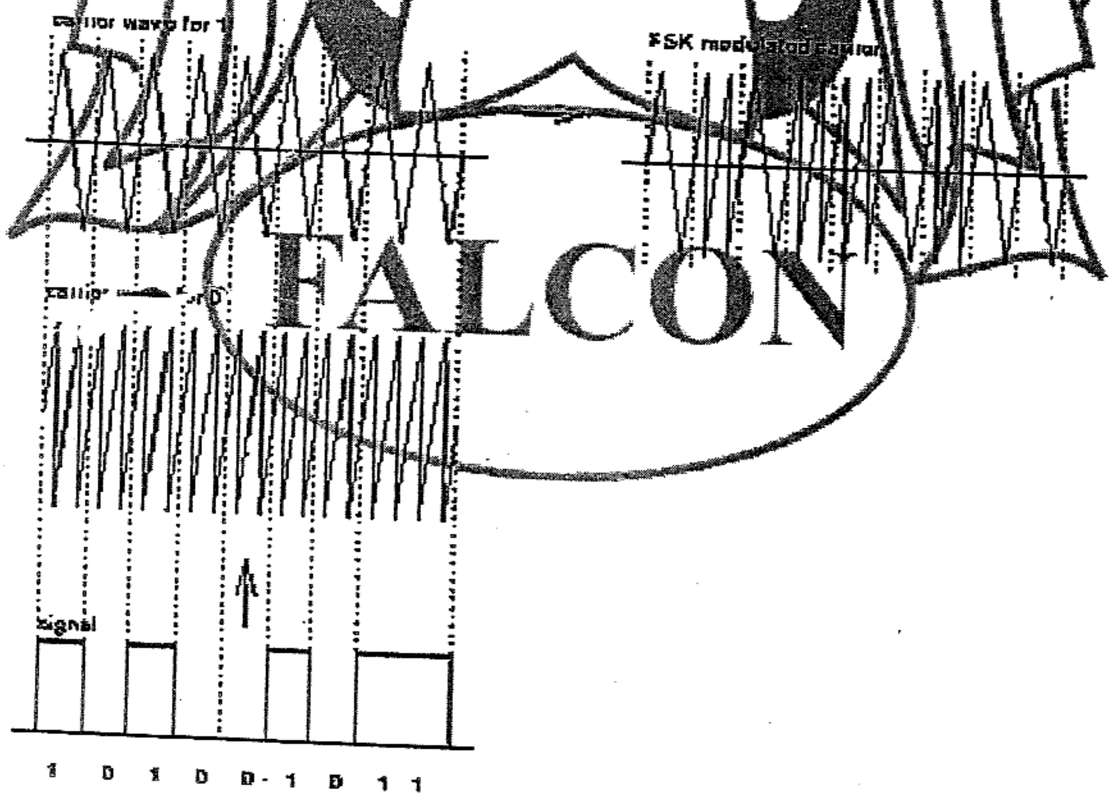
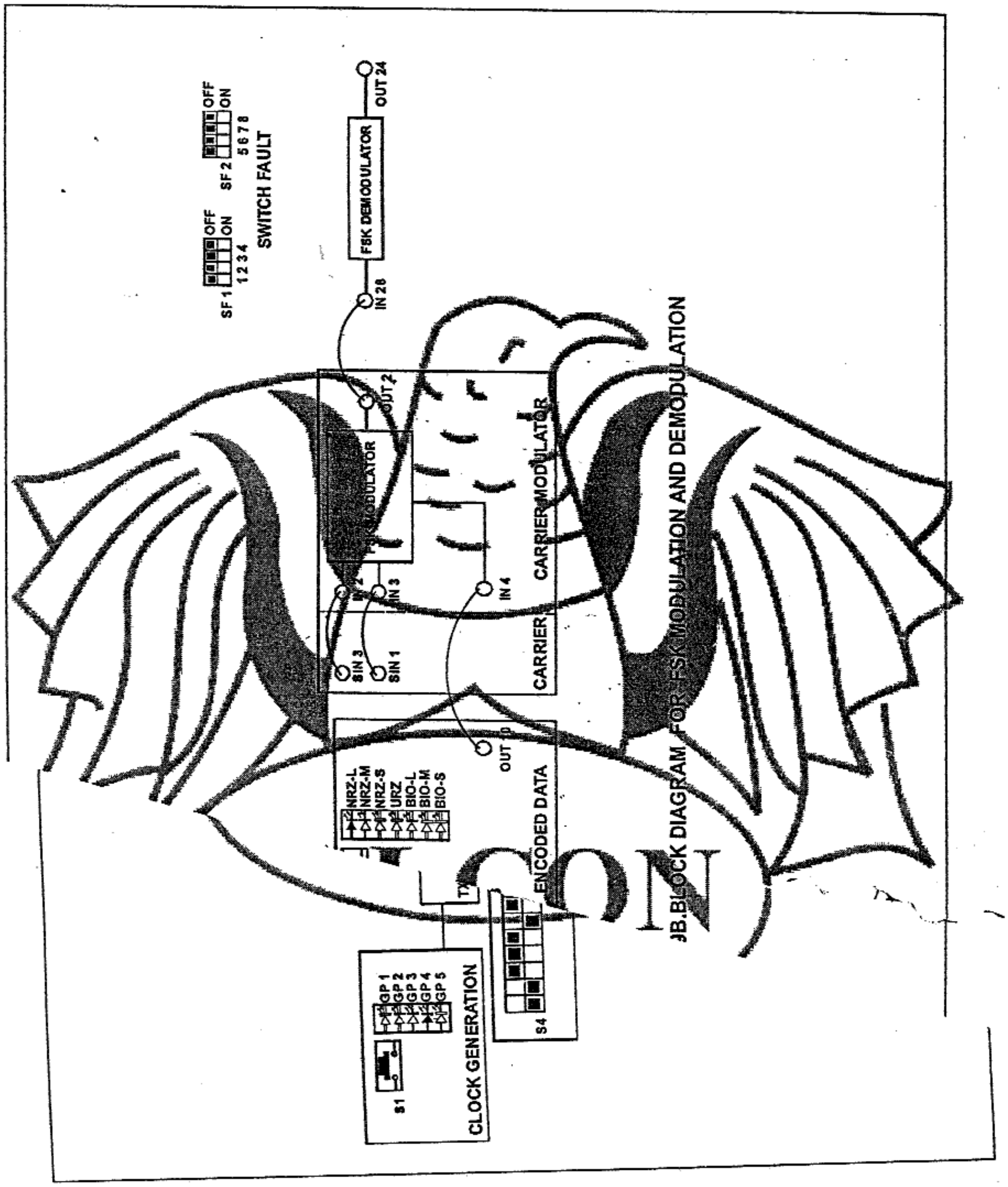


Figure: Frequency shift keying



JB.BLOCK DIAGRAM FOR FSK MODULATION AND DEMODULATION

Procedure

1. Ensure that the group 4 (**GP4**) clock is selected in the Clock Generation section. Selection is done with the help of switch **S1** and observes the corresponding LED indication.
2. Observe the transmitter clock of frequency **250 KHz** at **TXCLK** post.
3. Set the data pattern using switch **S4** as per the given block diagram.
4. Observe the 8-bit data pattern at **S DATA** post.
5. Observe the carrier sine wave of frequencies **500 KHz** at **SIN1** post and **1MHz** at **SIN3** post in the carrier section.
6. Connect the **SIN1** post to the **IN3** post and **SIN3** post to the **IN2** post of the Carrier modulator section.
7. Connect **SDATA** to **IN16** post and **TXCLK** to **CLK2** post of the Encoded Data section.
8. Select NRZ-L data with the help of the switch **S3**, and observe the corresponding LED indication in the Encoded Data section.
9. Connect **OUT10** post of the Encoded Data section to **IN4** post as a control input for the carrier modulator section.
10. Observe the FSK modulated signal at the **OUT2** post of the Carrier modulator section.
11. For the demodulation of the FSK modulated data, connect the **OUT2** post of the carrier modulator to the **IN28** post of the FSK demodulator section.
12. Observe the FSK demodulated data at **OUT24** post of the FSK demodulator section.
13. Verify the recovered data with the S DATA.

Observations

1. INPUT **NRZ-L** DATA AT IN 4
2. Carrier frequency **SIN 1** and **SIN 3**
3. FSK modulated signal at **OUT 2**
4. FSK DEMODULATED SIGNAL AT **OUT 24**
5. Observe output of **PHASE DETECTOR**, **LPF**, **VCO** on test points provided

Conclusion

A small phase lag exists between the modulating data and the recovered data because of the limitation of the tracking ability and the time response of PLL.

9 C. PSK MODULATIONS AND DEMODULATION

Theory

In the PSK modulation or phase shift keying, for all the `one' to `zero' transitions of the modulating data, the modulated output switches between the in phase and out of phase components of the modulating frequency. If the modulated carrier is represented by,

M (t)	=	A (t) Cos (wt + Phase)
Where A (t)	=	Time varying amplitude
wt	=	Time varying angle
M (t)	=	Modulated carrier

PSK describes the modulation technique that alters the phase of the carrier. Mathematically,

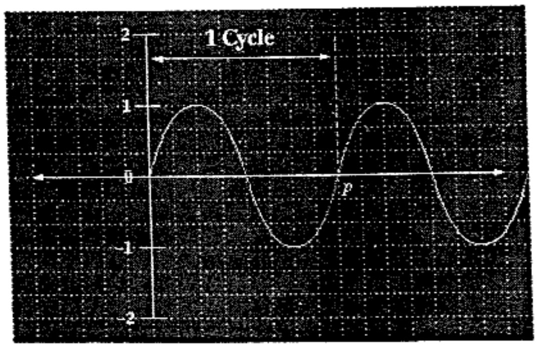
$$s(t) = \sin(2\pi f_c + \phi(t)) \quad (23)$$

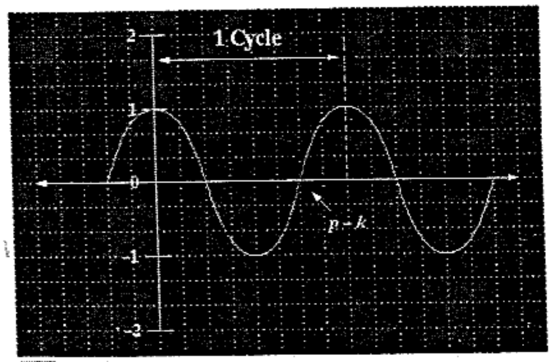
1. In angle modulation, the phase of the carrier is discretely varied in relation either to a reference phase or to the phase of the immediately preceding signal element, in accordance with data being transmitted.

2. In a communication system, the representation of characters, such as bits or quaternary digits, is done by a shift in the phase of an electromagnetic carrier wave with respect to a reference, by an amount corresponding to the symbol being encoded. *Note 1:* For example, While encoding bits, the phase shift could be 0° for encoding a "0," and 180° for encoding a "1," or the phase shift could be -90° for "0" and +90° for a "1," thus making the representations for "0" and "1" a total of 180° apart.

Note 2: PSK systems are designed so that the carrier can assume only two different phase angles, each change of phase carries one bit of information, *i.e.*, the bit rate equals the modulation rate. If the number of recognizable phase angles is increased to 4, then 2 bits of information can be encoded into each signal element; likewise, 8 phase angles can encode 3 bits in each signal element.

Phase shift keying is a technique which shifts the period of a wave.



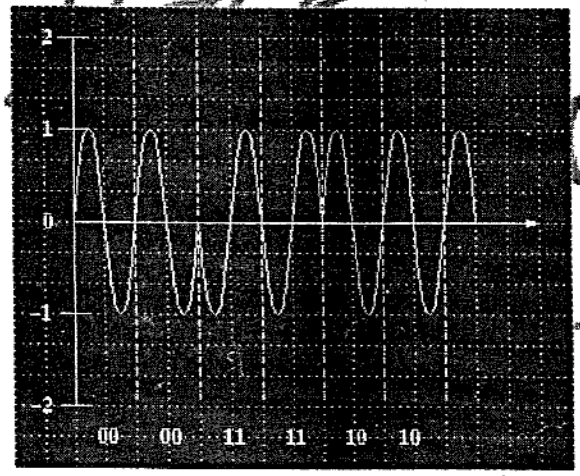


Wave 1 **Wave 2**

This wave 1 has a period of *p*, noted above. Also notice that the start of the wave's period is at 0.

Wave 2 is the same wave as the first, but its phase has been **shifted**. Notice that the period starts at the wave's highest point (1). So what's the point? Such a behavior is seen because we have shifted this wave by **one quarter** of the wave's full period. We can shift it to another quarter if we want to, so the original wave would be shifted by **half** its period. And, we could do it one more time, so that it would be shifted **three quarters** of its original period.

This means that, we have 4 separate waves. So why not let each wave stand for some binary value? Since there are 4 waves, we can let each wave signify 2 bits (00, 01, 10, 11):



Bit value	Amount of shift
00	None
01	1/4
10	1/2
11	3/4

This technique of allowing each shift of a wave represent some bit value is **phase shift keying.** But, the real key is to shift each wave relative to the wave that came before it. An example can be seen in the above diagram.

Please note that when binary values were chosen randomly, for each wave, the values shown are incorrect. Thus, the correct pattern should be: 00 00 10 00 10 00.

Procedure

1. Ensure that the group 4 (**GP4**) clock is selected in the Clock Generation section. Selection is done with the help of switch **S1** and observes the corresponding LED indication.
2. Observe the transmitter clock of frequency **250 KHz** at **TXCLK** post.
3. Set the data pattern-using switch **S4** as per the given block diagram.
4. Observe the 8-bit data pattern at **S DATA** post.
5. Observe the carrier sine waves of frequencies **1MHz** at **SIN2** post and 1MHz with 180° phase at **SIN3** post in the carrier section.
6. Connect the **SIN2** post to the **IN1** post and **SIN3** post to the **IN2** post of the Carrier modulator section.
7. Connect **SDATA** to **IN16** post and **TXCLK** to **CLK2** post of the Encoded Data section.
8. Select **NRZ-L** data with the help of the switch **S3** and observe the corresponding LED indication in the Encoded Data section.
9. Connect **OUT10** post of the Encoded Data section to **IN4** post as a control input for the carrier modulator section.
10. Observe the PSK modulated signal at the **OUT2** post of the Carrier modulator section.
11. For the demodulation of the PSK modulated data, connect the **OUT2** post of the carrier modulator to the **IN30** post of the PSK demodulator section.
12. Observe the PSK demodulated data at **OUT27** post of the PSK demodulator section.
13. Verify the recovered data with the S DATA.

Observations

Input **NRZ-L** Data at **IN 4**
Carrier frequency **SIN 2** and **SIN 3**
PSK modulated signal at **OUT 2**
PSK Demodulated signal at **OUT 27**
Observe the output of the **SINE TO SQUARE CONVERTOR, SQUARING LOOP, DIVIDE BY 2** on the test points provided

Conclusion

It is observed that the successful operation of the PSK detector is fully dependent on the phase components of the transmitted modulated carrier. If the phase reversal of the modulated carrier, along with the rising and falling edges of the data are not proper, then the efficient detection of data from PSK modulated carrier becomes impossible.

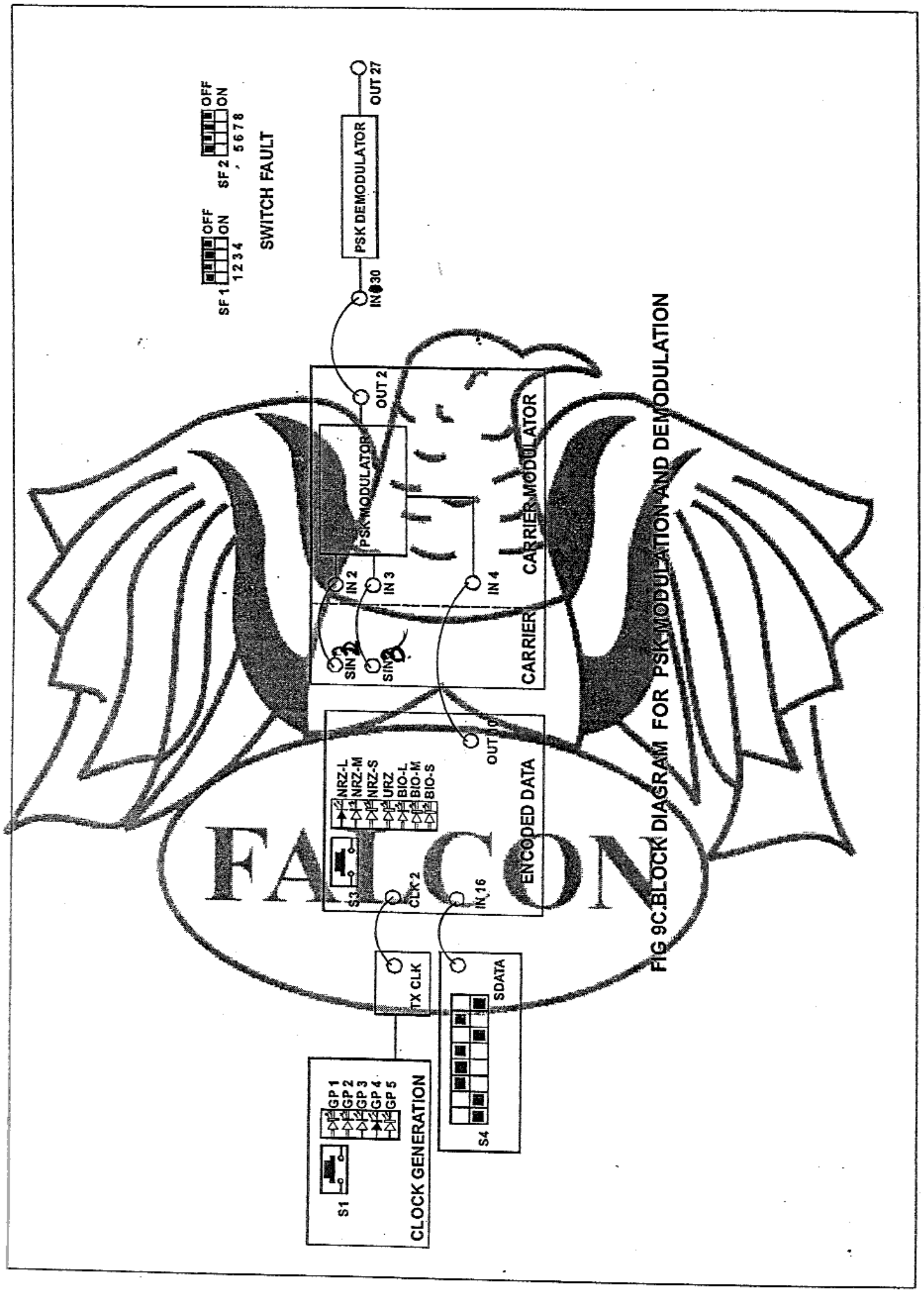


FIG 9C.BLOCK DIAGRAM FOR PSK MODULATION AND DEMODULATION